Roll out wind at sea with respect for nature

An analysis of potential risks to North Sea nature posed by the offshore wind energy transition

The North Sea Foundation, February 2022

www.noordzee.nl

The North Sea Foundation

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This research was made possible thanks to the support of the Flotilla Foundation and ASN bank.

Photo previous slide: The Rich North Sea
Photo this slide: Mart Smit

1. Executive summary

For a healthy North Sea, it is important that climate change and the degradation of North Sea nature are addressed. To tackle the climate crisis, the Dutch government has committed itself to the EU climate objective of 55% CO_2 reduction by 2030 compared to 1990. Therefore, in the coming years more offshore wind energy at sea will be realised. Currently, the capacity of Dutch wind farms is 2.5 gigawatt. The current planning predicts an increase to 21.5 gigawatt around 2030. In order to tackle the degradation of the North Sea nature, the Netherlands had to reach 'the good environmental status' by 2020, according to nature legislation: a state in which the sea is clean, healthy, productive, has great ecological diversity, and is used only sustainably.

According to The North Sea Foundation, offshore wind farms bring certain opportunities for underwater nature. There is relatively less (bottom) disturbance due to a ban on bottom trawl fisheries within Dutch wind farms. This offers opportunities for active nature enhancement and passive recovery. In addition, as the most important mitigation measure, Dutch wind farms are not being built in the most ecologically valuable areas, such as the Cleaver Bank and the Frisian Front. The government is setting up a major monitoring and research program with the aim of gathering the necessary knowledge so that the changing use of the North Sea remains within its ecological carrying capacity. This is guaranteed in the North Sea Agreement. A unique agreement between government, energy and nature stakeholders in which a new balance is found between the energy, nature and food transition, sparked by the arrival of wind farms at sea.

However, wind farms and their associated infrastructure also pose ecological risks. The most important risks have been identified in this report. The following challenges were found: 1) there are still many ecological knowledge gaps about the (cumulative) risks of offshore wind, especially in combination with other pressures, such as oil and gas, shipping, sand extraction and fisheries; 2) the necessity, methods and effect of mitigation measures have not yet been adequately mapped out; and 3) policy is already being drawn up for scaling up offshore wind after 2030, which means there does not seem to be time to implement the results of new studies in policy. There is a growing risk that the ambition for offshore wind will no longer fit within the ecological carrying capacity of the North Sea. As a result, the North Sea Foundation foresees a scenario in which the protection of North Sea nature and the attainment of climate targets will hinder each other.

Based in part on interviews with North Sea stakeholders, literature research, round table discussions and an expert session, the North Sea Foundation makes the following recommendations for policymakers:

1. **Accelerate the protection of valuable nature areas** to make North Sea nature more robust for the upcoming industrialisation.
2. **Accelerate and increase research into the ecological impact,** mitigation options and innovation of offshore wind farms and always apply the precautionary principle when knowledge gaps exist.
3. **Postpone further upscaling of offshore wind after 2030** until ecological research results show how this upscaling can be done responsibly.
4. **Develop an integral adaptive policy** whereby decisions can be adjusted in a timely manner if ecological research results give reason to do so.
5. **Include potential multi-use at an early stage** when designing future offshore wind farms.

Picture: The Rich North Sea

2. Motive and purpose of this research

In March 2022, the final North Sea Program 2022-2027 will be published, including the most recent research results on offshore wind, and the large-scale roll out of offshore wind becomes a reality. Wind farms at sea bring opportunities and risks for North Sea nature.

To meet the climate goals, ecological risks must now be taken. There is no avoiding this. Since the roll out of wind at sea is going very fast, the North Sea Foundation decided to investigate the potential ecological risks and the options for mitigation and compensation. At the end of this report, a series of recommendations are made to policy makers on what needs to be done to prevent a clash between nature and wind energy on the North Sea.

In this chapter:

- The current state of play and future outlook of offshore wind energy
- The legal friction between wind energy and nature goals
- Governmental research and the search for ecological space
- The status of nature conservation
- The North Sea Agreement and financers of offshore wind farms

Photo: Renate Olie

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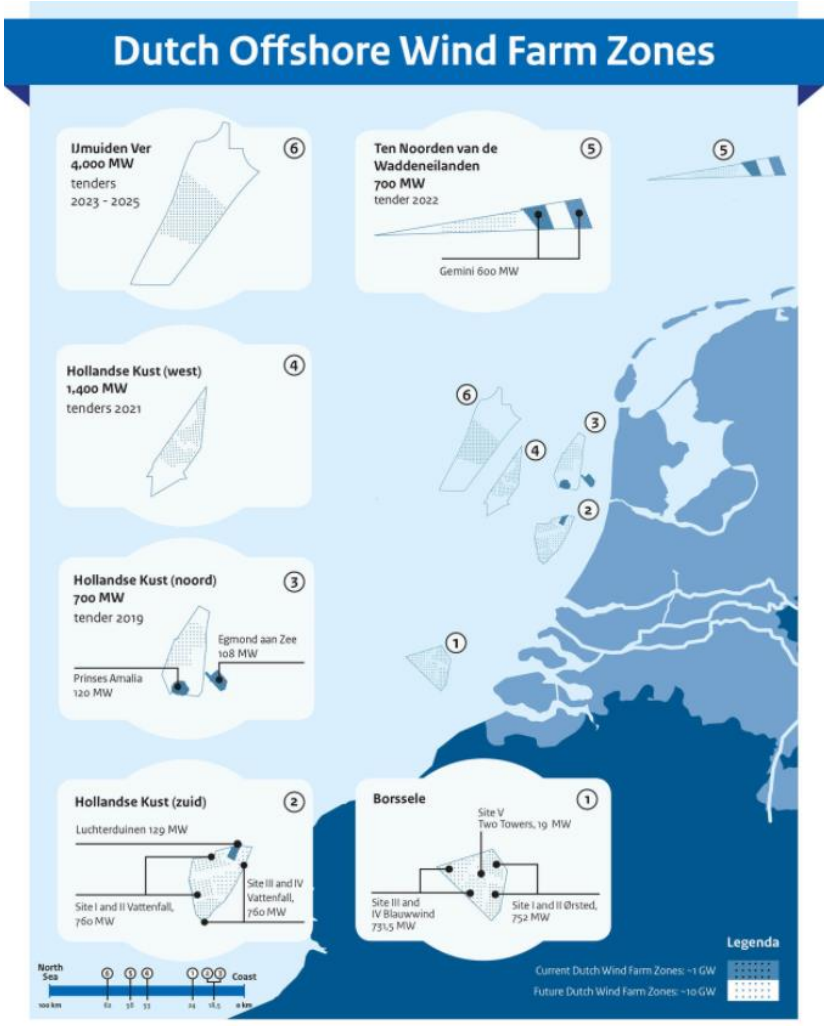
The current offshore wind roadmap 2030 foresees an upscaling to 11.5 GW

- Currently ± 2.5 GW of offshore wind energy is installed. This is about 3.3% of all energy in The Netherlands.
- In 2023 this will be ± 4.5 GW.
- By 2030, according to the current roadmap, this would have increased to 11.5 GW, with up to approximately 10.8 GW of ecological space having been found. It is expected that around 2030 around 70% of the current electricity consumption will come from solar and wind energy, more than half of which is produced by offshore wind farms.

Process

The cabinet develops a 'roadmap for offshore wind energy'. This contains the order of the tenders for the lots. The central government then issues a tender based on a wind farm site decision. This contains binding regulations and measures that the permit holder of the wind farm must comply with. The legal basis for a wind farm site decision is the Offshore Wind Energy Act. Wind farms have been built without subsidy since 2016, whereby ecological research and monitoring and the grid infrastructure came under the control of the state. As soon as the winner of the tender is known, this party receives the permit.

Ecology plays a very important role in the current Hollandse Kust West tender. The North Sea Foundation applauds this development and will strive to further embed this in the Offshore Wind Energy Act in the future.



Current roadmap for installed and planned wind farms up to 10.8 GW by 2030

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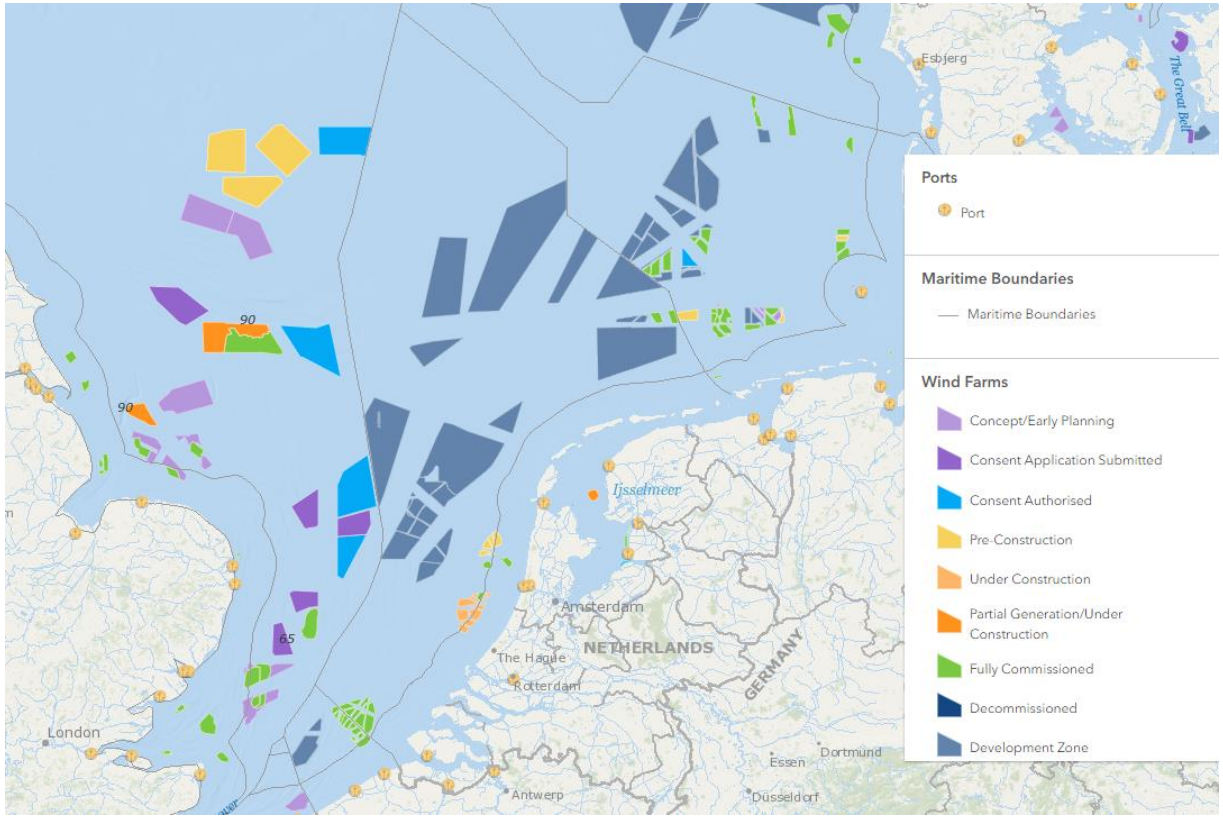
Sources: windenergie op zee, Noordzee Energie Outlook (2020)
Image: Dutch offshore wind farm zones 2030

Offshore wind energy production in the Netherlands will increase significantly to meet increased climate targets

- By 2030, an extra 10 GW (so 21.5 GW in total) of offshore wind will have to be realized in order to meet a 55% CO_2 reduction compared to 1990, as determined by the European Commission in its Green Deal and now also the goal of the Dutch government. This therefore deviates from the current 2030 offshore wind roadmap.
- By 2040 this will have increased to 38 GW (import dependent).
- By 2050 scenarios range between 38 GW and 72 GW (self-sufficient).

For the required rapid roll out, it is necessary to take into account, among other things: high costs for maintenance, the integration of very large amounts of electricity into the energy system, issues about offshore space use and safety (such as shipping), and possible **negative ecological effects**, to avoid restrictions. By 2030, the revenue model for offshore wind will come under pressure due to an increasing supply of offshore wind.



Installed and planned wind farms and search areas for wind in the southern North Sea

The North Sea Agreement tries to provide a solution.

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Sources: Noordzeeloket, wind farms in development, TKI Wind op Zee, Noordzee Energie Outlook, AFRY 2020

Image: 4c offshore

More wind at sea puts extra pressure on the ecosystem and can lead to legal friction and a possible standstill for both energy and nature goals

The climate crisis is bad for nature. But measures to counter this crisis, such as the extraction of wind energy, can in turn clash with nature conservation. This can lead to legal frictions, for example when legal concerns about the impact on certain species lead to the non-issue of a permit to build a wind farm.

Potential legal risks for the development of offshore wind farms and the associated infrastructure can be found in:

- Direct impact on protected species, due to non-compliance with legal requirements for protected areas and species.
- Indirect risks to protected species via effects on non-protected species (e.g. via the food web).

There is a risk that both the goals for sustainable energy production and those for nature protection will come to a clash. This underlines the need to find the best way of working to ensure that offshore wind activities are developed with respect for the ecological carrying capacity of the North Sea ecosystem.

Image: The North Sea Foundation

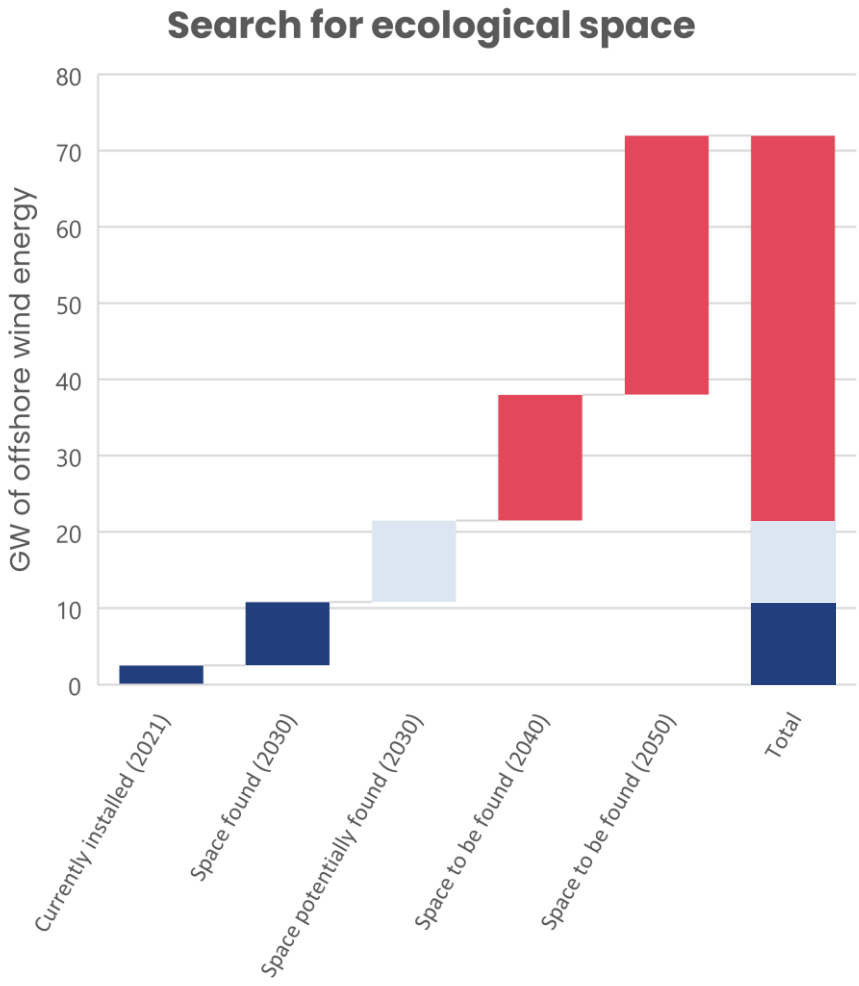
It will be a challenge to find more ecological space for the intended upscaling in the coming years

The government sees ecological space as the available area within which population declines are expected to remain below the legally established limits.

The government directs various programs that investigates ecological impacts. For example, Wind At Sea Ecological Program (WOZEP) has the objective to increase the knowledge base about the effects of wind farms on protected species and the ecosystem. This knowledge can be used, for example, during the preparation of roadmaps to make the best possible estimate of the effects on ecology. A cumulative impact assessment is conducted to test whether the proposed wind farms (in combination with existing and planned wind farms) have no significant effect on the conservation status of protected species. The cumulative impact assessment is done with the Framework for Assessing Ecological and Cumulative Effects (KEC).

The disadvantage of the KEC is that it only looks at the cumulative effects of offshore wind energy. There is no special ecological research program for other pressure factors. The MONS research program aims to help fill this gap, as determined in the North Sea Agreement.

In addition, an environmental impact assessment (EIA) is always conducted to obtain a permit for both an offshore wind farm and a grid connection. The EIAs describe the environmental effects that occur during the construction, operation and removal of wind turbines and infrastructure in the sites and play an important role in decision-making about the energy project in question.



The graph above assumes a (self-sufficient) scenario of 72GW.

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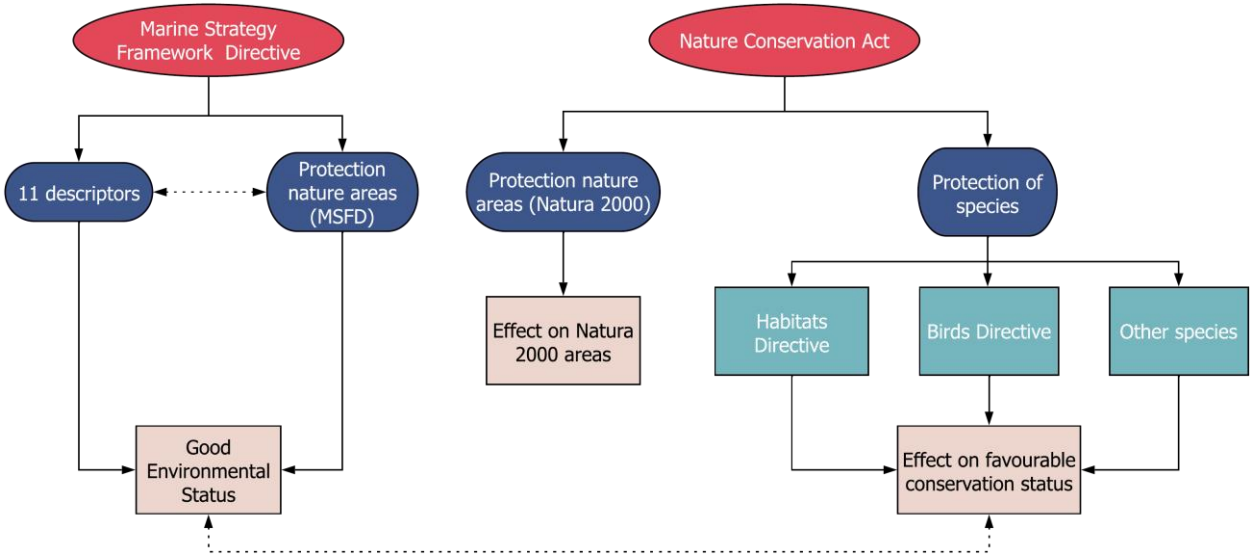
Sources: Additional Draft North Sea Program 2022-2027, WOZEP, definition ecological space from Directorate-General for Public Works and Water Management
Bar graph: The North Sea Foundation

Legal frameworks and the risks of the current approach within KEC

- Offshore wind farms must comply with the **Nature Conservation Act**; the national implementation of the European Habitats and Birds Directive.
- The KEC plays an important role in the assessment of the environmental impact assessment and in prescribing rules for the protection of nature in the site decisions.
- In 2010, the Netherlands incorporated the **European Marine Strategy Framework Directive (MSFD)** into the national Water Decree under the Water Act. This strategy is aimed at protecting, preserving and restoring the marine environment (good environmental status), while also ensuring sustainable use of the North Sea.

- Preliminary ecological research results (KEC 4.0) seem to have found space for the further roll out of wind at sea.
- KEC 4.0 seems to indicate that the limit for some bird species is already being exceeded. As a solution, it is envisaged that with further research and/or with the aid of flexible filling in of the designated areas and nature-enhancing measures, this limit will not be reached after all.
- The risk here is threefold:
    1. These species do not stand alone but are part of an ecosystem, in which they are inextricably linked.
    2. Additional research can also end up more negative.
    3. Cumulative effects are currently not calculated in combination with other economic developments, such as hydrogen, mining, fishing, etc. However, the Nature Conservation Act requires that the cumulative effects of all relevant activities are assessed, not just those of wind farms.

Final results of KEC 4.0 are expected in March 2022.



Sources: *Nature laws such as the Wet Natuurbescherming, KRM, OSPAR, Vogel- en Habitatrichtlijn, Aanvullende passende beoordeling 2021

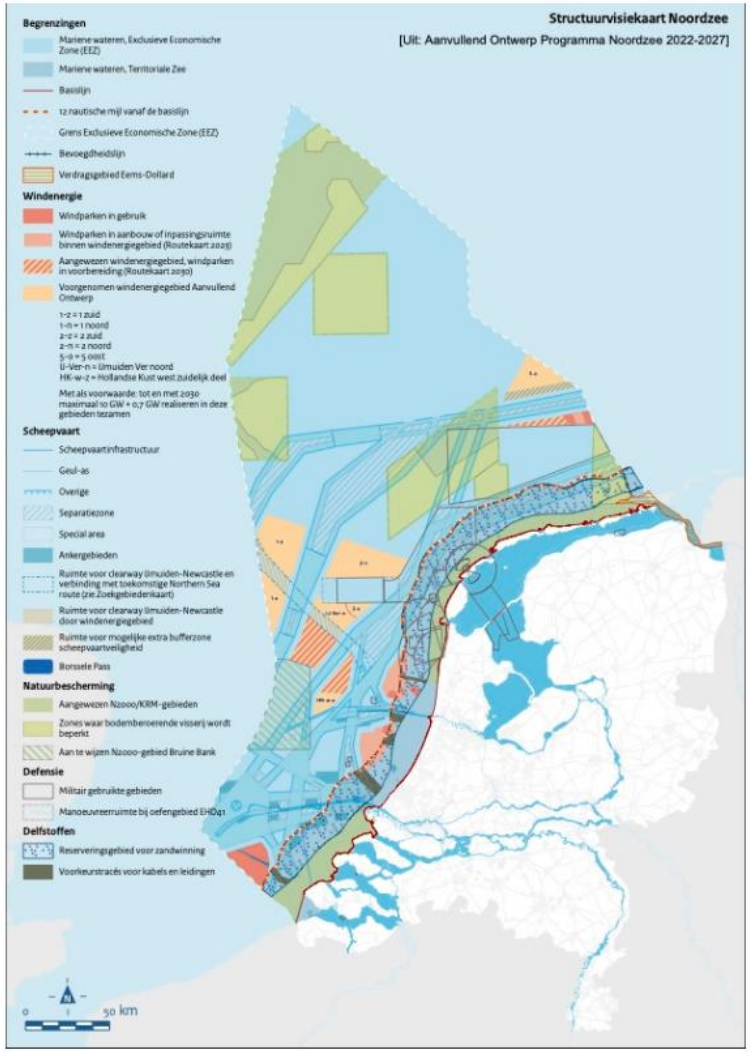
Image: The North Sea Foundation

The current coalition agreement focuses mainly on the climate crisis

- The North Sea plays an essential role in achieving the climate goals. The North Sea Foundation supports the government's ambition to achieve these climate goals.
- In the Coalition Agreement, however, the North Sea as such is only mentioned in relation to supporting gas extraction in Groningen.
- However, the space for the capture and underground storage of CO_2 (CCS) will be increased, as will the supply of renewable energy sources, such as the use of extra wind at sea.
- In the Coalition Agreement, protecting and enhancing nature seems to be limited to land.

Major efforts are now being made to scale up wind energy at sea in order to be able to make rapid progress towards CO_2 reduction. However, it is difficult to predict what the energy mix will look like in the longer term and how large the total demand for energy will be in the future.

Map on the right: Additional Draft North Sea Program 2022-2027 gives a good idea of how busy it is in the North Sea and how busy it will be. However, not all economic developments of the coming years have been included, such as CCS, solar energy at sea and hydrogen. The extra wind areas up to 2030 are indicated here.



Sources: Regeerakkoord 2021, Additional Draft North Sea Program 2022-2027

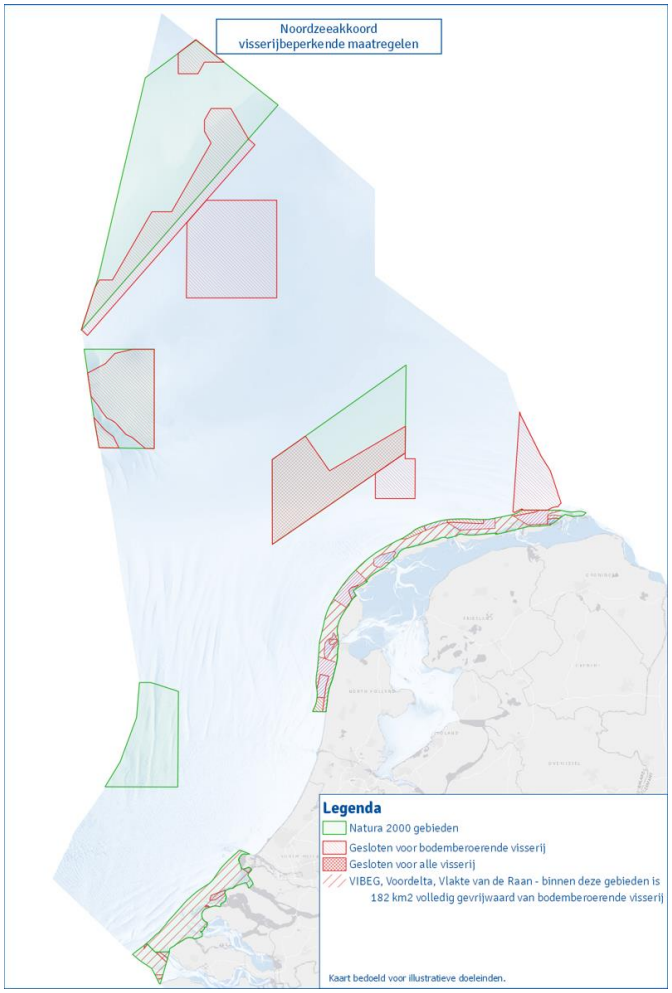
The nature transition is lagging behind the energy transition: accelerating the protection of ecologically valuable areas will strengthen nature and thereby reduce the pressure on the ecosystem

Benthic diversity has declined, habitat quality has degraded, seabirds are not doing well and the number of fish (especially large) fish, including sharks and rays, has reduced. Protecting areas from seabed-disturbing fisheries is not only important for nature, but also plays an important role in achieving climate goals as the seabed stores a lot of carbon.

However, the actual protection of these areas is slow: it does not enjoy the same priority as scaling up offshore wind energy. Despite years of planning and negotiation, only 0.3% of the Dutch North Seabed is truly protected. This is a missed opportunity, as research shows that protected areas provide economic, environmental and social benefits that more than offset the costs. That is why we are pushing for the rapid and effective implementation of protected areas, so that activities such as offshore wind can take place in a sustainable way.

The North Sea Agreement, which was adopted by the House of Representatives in January 2021, brings us one step closer to making room for nature in an increasingly crowded North Sea. Thanks to the North Sea Agreement, 15% of the Dutch North Seabed will be protected by 2030. It is very important that the agreements from the North Sea Agreement are implemented: we all have a great responsibility to ensure that these percentages are indeed achieved.

Figure on the right: N2000 and MSFD areas, areas that will be closed for bottom-trawling fisheries, areas that will be closed for all types of fisheries, area currently closed along the coast for bottom-trawling fisheries.



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Sources: Marine Strategy part 1, North Sea Agreement 2021, Sala et al., 2021, The North Sea Foundation 2018; 2020, WUR 2022,

Thanks to the North Sea Agreement an extensive ecological research and monitoring programme until 2030 is being setup

Thanks to the recently signed (Dutch) North Sea Agreement the government, together with stakeholders, is currently setting up an extensive €55 mio ecological research and monitoring programme until 2030 (Programma Monitoring, Research, Nature enhancement and Species protection plans (MONS)).

MONS, in close collaboration with WOZEP, will focus on stress factors related to nature, food and energy transitions that affect the North Sea ecosystem, including non-protected species. The North Sea Foundation supports this development and is actively involved in this process.

Some highlights of the Agreement that support both nature and offshore wind energy:

- **New designated wind farm zones for at least 20-40 GW**, as agreed upon in the Climate Agreement.
- In principle **no wind farms are built in areas that are or will be designated** based on the Birds and Habitats Directives and the Marine Strategy Framework Directive.
- The **wind farms in the southern part of the Dutch North Sea will remain closed to seabed disturbing fishery** until further notice.
- In **2023, 13.7%** of the Dutch North Sea within ecologically valuable areas will be fully **exempted from seabed disturbing fishery**. This percentage will increase to **15% by 2030**.
- In Appendix 2 (research & monitoring): **ecological carrying capacity is a precondition for the individual and cumulative use** of the North Sea by the various functions.

Source: North Sea Agreement (Jan 2021)

Financiers of wind farms are also making increasingly higher demands on nature

ASN Bank tekent convenant 'Biodiversiteit'

Wassenaar, 7 december 2021. Van links naar rechts: Dorien Ackerman (Natuur & Milieu), Albert Jaap van Santbrink (Stichting De Noordzee) en Arie Koomneef (ASN Bank) bij de Wassenaarse Slag, waar zij het convenant ondertekenden om de biodiversiteit bij de (toekomstige) aanleg van windparken op zee te beschermen. Phil Nijhuis

Persbericht – Natuurbeschermend en -versterkend bouwen het uitgangspunt bij de aanleg van windmolenparken en infrastructuur op zee.

10 december 2021 leestijd 2 minuten

Deze week plaatste ASN Bank als eerste financiële instelling haar handtekening onder het Convenant 'Biodiversiteit' van Stichting De Noordzee en Natuur & Milieu. Daarmee laat ASN bank zien dat financiers van windparken verdergaande eisen kunnen stellen aan natuurinclusief bouwen en spreekt de bank zich actief uit voor een duurzame Noordzee, waarin het opwekken van windenergie zoveel mogelijk hand in hand gaat met de bescherming en versterking van de natuur.

De komende jaren worden er nieuwe windparken in de Noordzee gebouwd om de klimaatdoelen te halen. Deze toename van windparken levert volop duurzame energie, maar kan ook negatieve gevolgen hebben voor de natuur. Om de onder- en bovenwaternatuur van de Noordzee te beschermen én de kansen voor versterking van de biodiversiteit te benutten, is het belangrijk dat natuurbeschermend- en versterkend bouwen als uitgangspunt wordt genomen bij de financiersaanvragen van windparken. Door het Convenant Biodiversiteit te ondertekenen, zeggen financiers van windparken dit toe.

More and more parties are committed to combating both the climate crisis and the degradation of nature. Financial institutions also bear a responsibility in this regard. Financiers and investors of wind farms can set more far-reaching requirements for nature-inclusive design. The sustainable ASN Bank was the first financial institution to sign the Biodiversity Covenant of the North Sea Foundation and Natuur & Milieu. This involves mitigating ecological risks and maximizing ecological opportunities as much as possible.

Designing wind farms and promoting biodiversity go hand in hand. Nature can be protected by, for example, limiting the impact of underwater noise as much as possible and even enhanced by building installations in such a way that oysters, for example, can attach themselves to the foot of a wind turbine. Offshore wind farms thus have the potential to become a breeding ground for biodiversity.

The North Sea Foundation and Natuur & Milieu will work hard in the coming year to get more financiers and investors to sign up to this covenant.

Sources: The North Sea Foundation 2021, ASN bank 2021

3. Introduction to the opportunities and risks posed by offshore wind farms

In February 2019, the North Sea Foundation published an introductory report about the opportunities and risks posed by offshore wind farms. Potential ecological opportunities by wind farms are a.o. further explored by The Rich North Sea program, which is a programme of The North Sea Foundation and Natuur & Milieu.

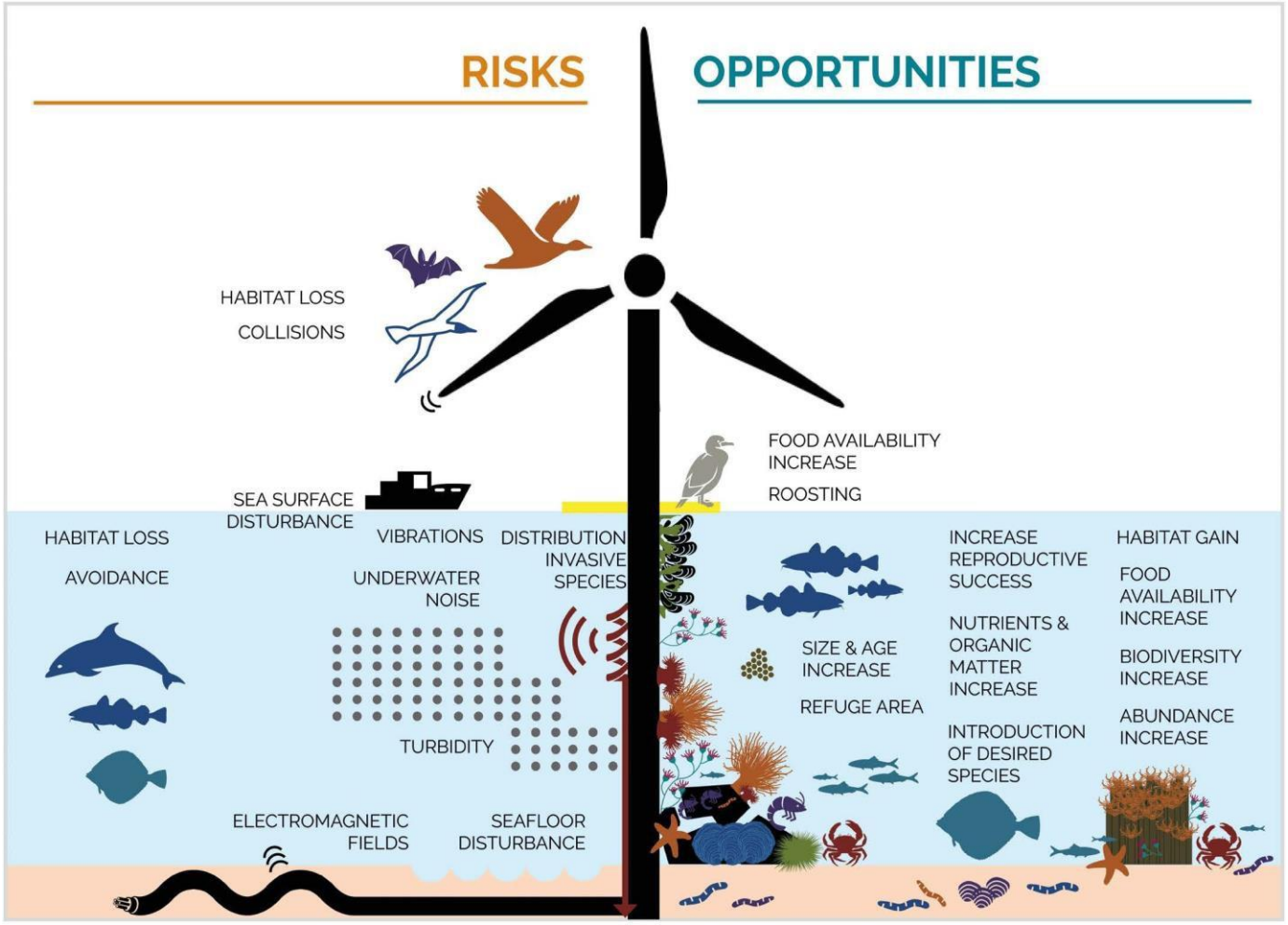
In this chapter:

- An overview of ecological opportunities and risks posed by offshore wind farms
- Ecological opportunities: The Rich North Sea program
- Ecological risks: direct and indirect

Photo: The Rich North Sea

The North Sea Foundation

Overview ecological opportunities and risks of offshore wind farms



Source: The North Sea Foundation (2019)
Author illustration: A.G.Rodriquez

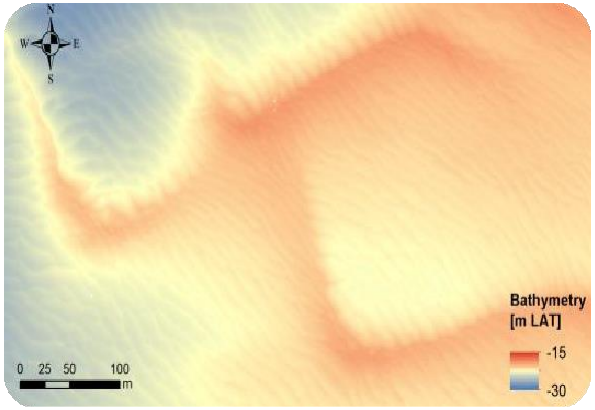
Wind farms have the potential to strengthen nature, support aquaculture and various forms of sustainable energy

- Wind turbine foundations and their scour protection may act as **artificial reefs**. They also provide a surface to which animals attach. This, in turn, attracts other (predatory) animals, such as fish and marine mammals. Result: more biodiversity and biomass.
- Wind farms, including their buffer zone, offer **protection from disturbance by other human activities.** There is a.o. little seabed disturbance thanks to bottom-trawl fisheries being prohibited in offshore wind farms.
- Possibility to combine offshore wind farms with **mariculture,** such as sustainable mussel, oyster, crab, lobster or seaweed production.
- Possibility to combine offshore wind farms with other forms of sustainable energy such as solar energy.

Picture: The Rich North Sea

The Rich North Sea program: underwater nature enhancement in wind farms

The Rich North Sea program (2019-2023) aims to make underwater nature enhancement standard for operators of offshore wind farms. The programme investigates various methods of nature enhancement and their monitoring, such as the (re)introduction of flat oysters, design of artificial reefs and the use of innovative monitoring techniques (f.e. Multibeam Echosounder).



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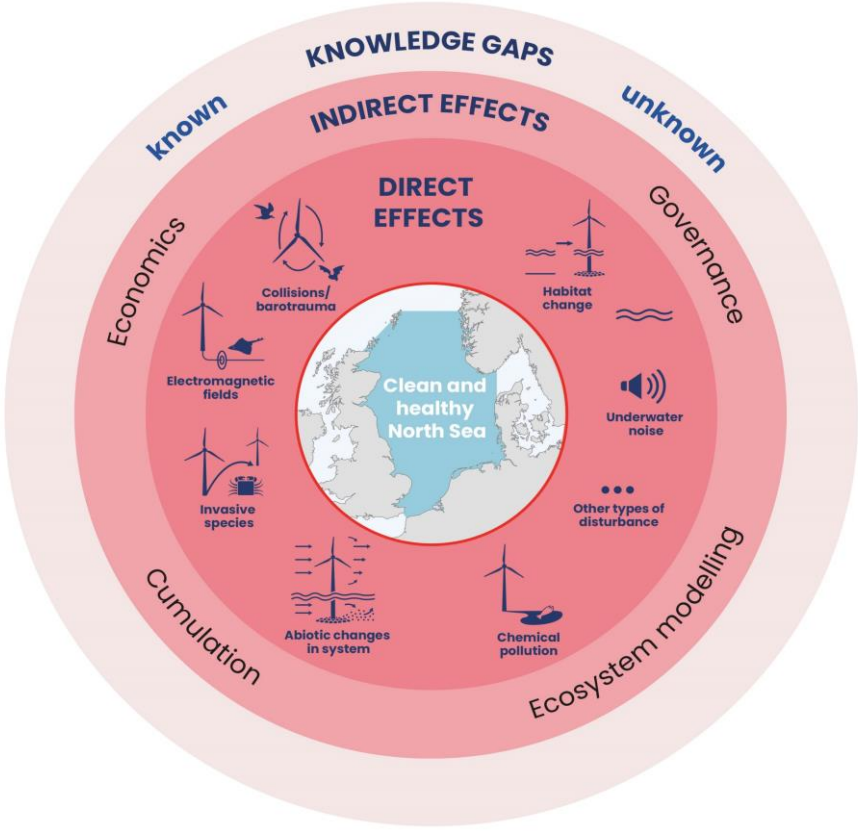
Sources: The Rich North Sea, DISCLOSE-project

Ecological changes due to offshore wind farms could lead to several types of risks

By **effect**, in this report we refer to the (primarily direct) consequence or result of a particular factor. **Ecological impact** is seen as an effect that leads to a definable change of an important parameter of the species or group, such as abundance or reproduction. These changes can be beneficial or adverse to the ecosystem.

The figure on the right is a representation of direct and indirect risks to the North Sea ecosystem. This report focuses on the direct risks. An example of an indirect risk is financial uncertainty (economics), which could lead to reservations about implementing mitigation measures or stimulating nature enhancement initiatives.

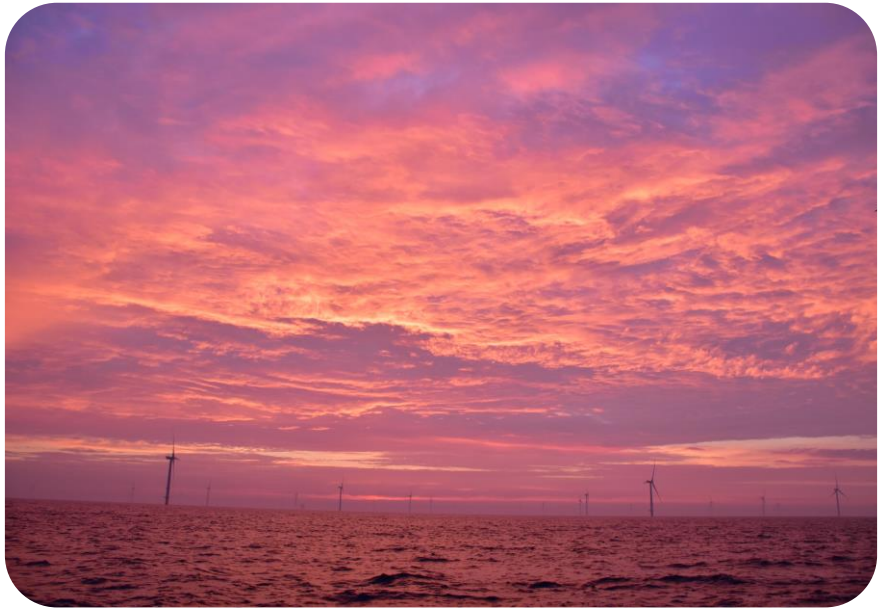
The risk of knowledge gaps is discussed in more detail on the next slide.



Sources: Perrow 2019, WOZEP
Illustration: Hendrik Gheerardyn

Knowledge gaps influence choices regarding risks of offshore wind

- Knowledge gaps can lead to inadequate environmental impact assessments or incomplete cumulative calculations, which are important for the permit to build a wind farm.
- Verification of modeling is missing or has not yet been done due to the lack of large offshore wind farms or due to high research costs. For specific species, models may overestimate or underestimate the effects of offshore wind energy. The high reliance on these types of models could be seen as an indirect risk. Whether this constitutes a legal risk depends on its seriousness and scope and on the possibility of taking (additional) mitigating measures.
- Methods for assessing cumulative effects have not yet been fully developed. For example: if a population continues to decline due to existing offshore wind farms, that effect is currently (in KEC 3.0) not included in the cumulation calculations. KEC 4.0 will probably improve this.
- Another example: the 'Potential Biological Removal' method used (e.g. bird strikes) appears to offer less certainty for some species because it takes little account of environmental variability and density dependence. That is why population models are now being used in KEC 4.0.



Source: Schippers et al., 2020

Photo: The Rich North Sea

4. Stakeholders expressed their views on the relationship between wind and nature

In the first quarter of 2020, at the beginning of this research, interviews were conducted. Aim: to get a better understanding of how key wind energy players perceive the potential clash between nature and wind energy. In the third quarter of 2020 a second round of interviews was held.

In this chapter:

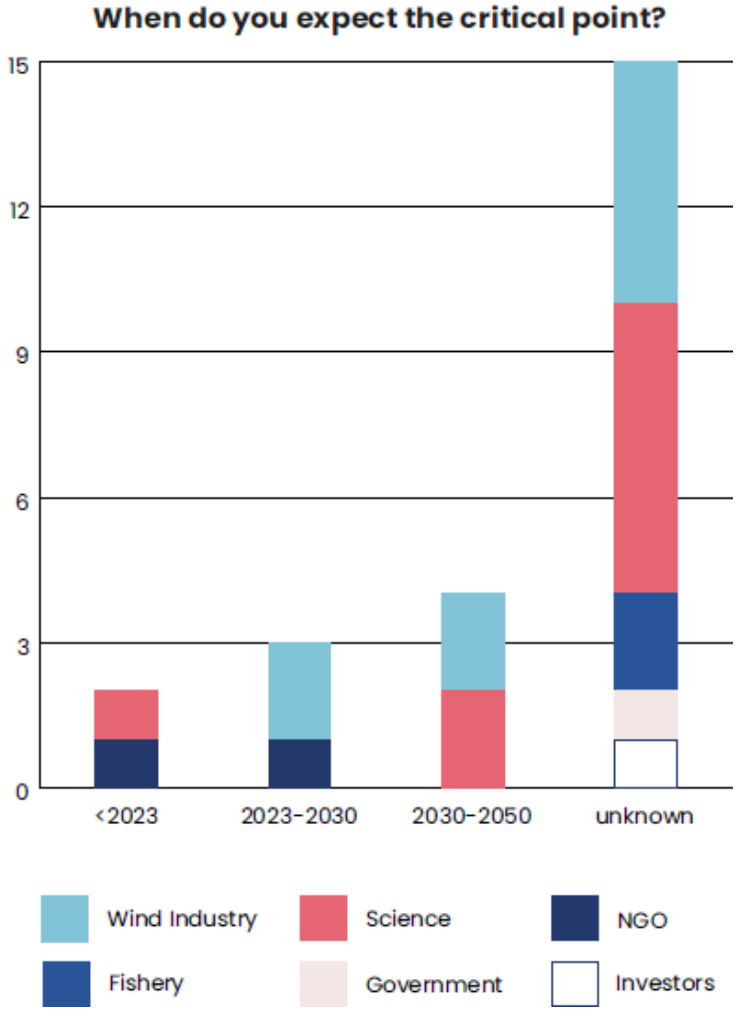
- How interviewed parties view wind energy developments and its effect on nature
- Other mentioned risks that could hamper the further roll out of offshore wind energy
- Best mitigation actions / strategies

Photo: Mart Smit

The North Sea Foundation

Wind at sea is necessary, but there is a limit to damage to nature

- During 26 interviews 35 people were questioned. In addition, a survey was conducted with 14 respondents.
- A shared view is that to achieve **climate goals**, a large roll out of offshore wind is needed, but not at the expense of North Sea nature.
- Most believe offshore wind can only expand if there is '**ecological space**'.
- Most **prominent ecological risks** are experienced differently per stakeholder: e.g. the wind industry puts bird and bat collisions as the highest risk, while scientists put the **cumulative effects (underwater)** and the **large-scale ecosystem effects** at the top. Large scale ecosystem effects include a.o. (local) climate and tidal effects (for example changes in the stratification pattern of water) as well as habitat loss, which will only become visible in the longer term.



Source: input received through interviews (2020)

More research and monitoring are essential

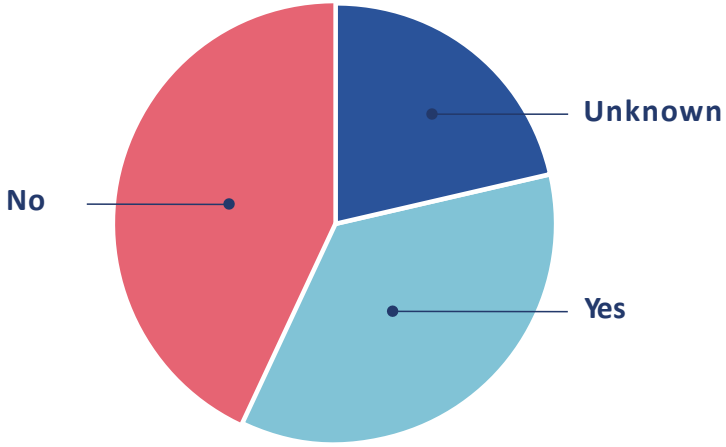
- All agreed that **monitoring and research** is needed to gain more ecological insights.
- Most believe a **clear connection between research and policy** is needed to make sure negative effects are avoided, mitigated and/or compensated.
- All agreed there is a lack of research and information on the **effects on underwater ecology**, including stratification and food web effects. These effects are also mentioned in relation to the development of wind farms by other North Sea countries.
- Some interviewees mentioned the need for a **standardised monitoring programme with other North Sea countries**.

Examples of wind farms not built over fears of severe environmental impact

In the **Netherlands**: the designated wind energy areas **Hollandse Kust** (northwest (0.7-1.4GW) and southwest (1.4GW)) were deleted as wind energy areas, due to the interests of fisheries, nature and shipping. Designating these areas will also not be reconsidered as part of the partial review for the period after 2030.

In the **United Kingdom:** the **Docking Shoal Wind farm** (500 MW) was refused planning consent in 2012. Reasons were for example concerns on impact on seabird populations; and cumulative impacts of neighbouring offshore wind project developments. In 2019, a proposed extension for the **Race Bank project** (573 MW) sitting within the Inner Dowsing, Race Bank and North Ridge Special Area of Conservation was not granted further leasing rights. It was not possible to rule out a negative environmental impact to this conservation area.

Is current legislation around the construction, operation and decommissioning of offshore wind farms enough to protect North Sea nature?



Reasons why respondents answered the question with "no" are, because they believe that there is too little knowledge about the cumulative impact and too little attention for nature-inclusive construction/design.

Sources: input received through interviews (2020), Additional Draft North Sea Program 2022-2027

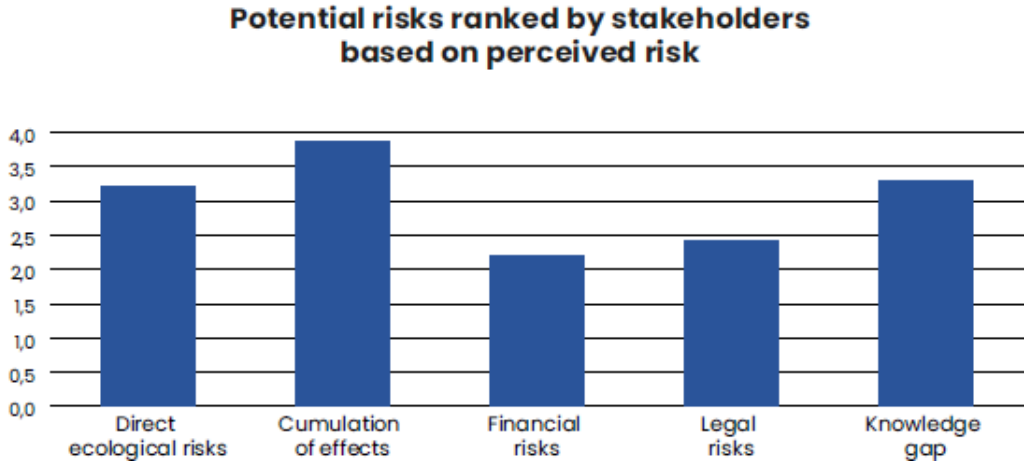
Besides ecological risks, other risks could also potentially hamper the roll out of offshore wind energy

Legislation

- **Opinions vary**. Some believe that legislation for underwater nature is insufficient. Others point to current legislation being rigid or even limiting.
- Current legislation **does not protect all species and habitats** that need protection.
- **Difference between rules and legislation in the Netherlands and other North Sea countries** (e.g. for underwater noise).
- Current legislation and regulations do not always offer the scope to respond directly to opportunities and risks, **which can slow down innovation and even stagnate further development of offshore wind.**

Other risks

- **Financial risks**. Such as the lack or use of subsidies and the fluctuating electricity price (mainly pointed out by the wind industry). Also: the potential lack of raw materials to build turbines.
- Current ecological research **focuses mainly on protected species** and **habitats, a smaller part focuses on other species and living conditions**. The latter, according to some, needs more attention.
- **Dependence on wind conditions** may pose a risk if too little wind is produced. Also, it is uncertain what the impact will be on weather patterns. **Incapability of innovations** keeping up to the need for mitigation.
- **Tension between setting the pace** with climate goals **and** the need for long-term **studies** and field measurements.
- Organising the offshore electricity **infrastructure** can be a risk in itself, given the apparent lack of ecological space on land and in the coastal zone.



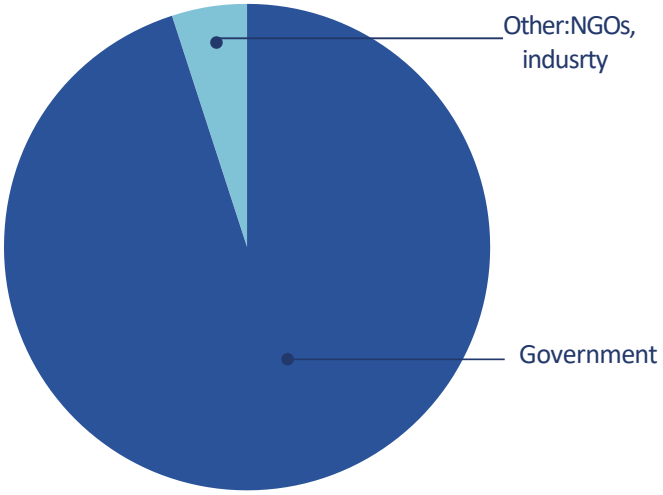
Source: input received through a questionnaire and interviews (2020)

The government must take a leading role and the choice of location in the North Sea should be the main risk mitigation measure

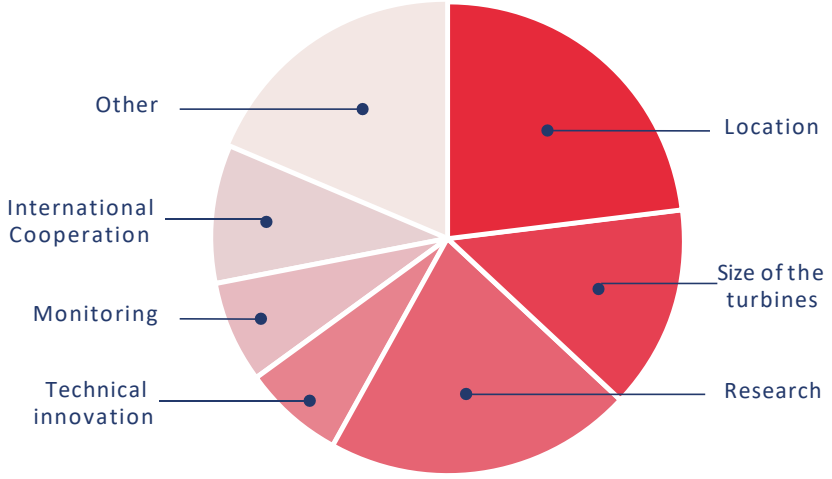
Mitigation

- 95% of the interviewees point to the **government as taking a leading role** in stimulating, deciding on and financing research and innovation as well as adapting legislation to new needs and sharing knowledge between countries.
- **Technical innovations** are needed to balance all needs and to keep up with the growing demands.
- All interviewees agree that the North Sea nature would benefit from a **joint international approach** to the further development of offshore wind energy.

Who should take a leading role in this issue?



What do you see as the most important mitigation measure?



Main source: input received through interviews (2020)

5. Literature study on potential direct ecological risks

In this chapter:

»Ecosystem effects
- Abiotic changes in the system
- Habitat loss (and gain)

»Underwater noise
- During construction
- During operation

»Collisions and barotrauma

»Electromagnetic fields

»Chemical pollution

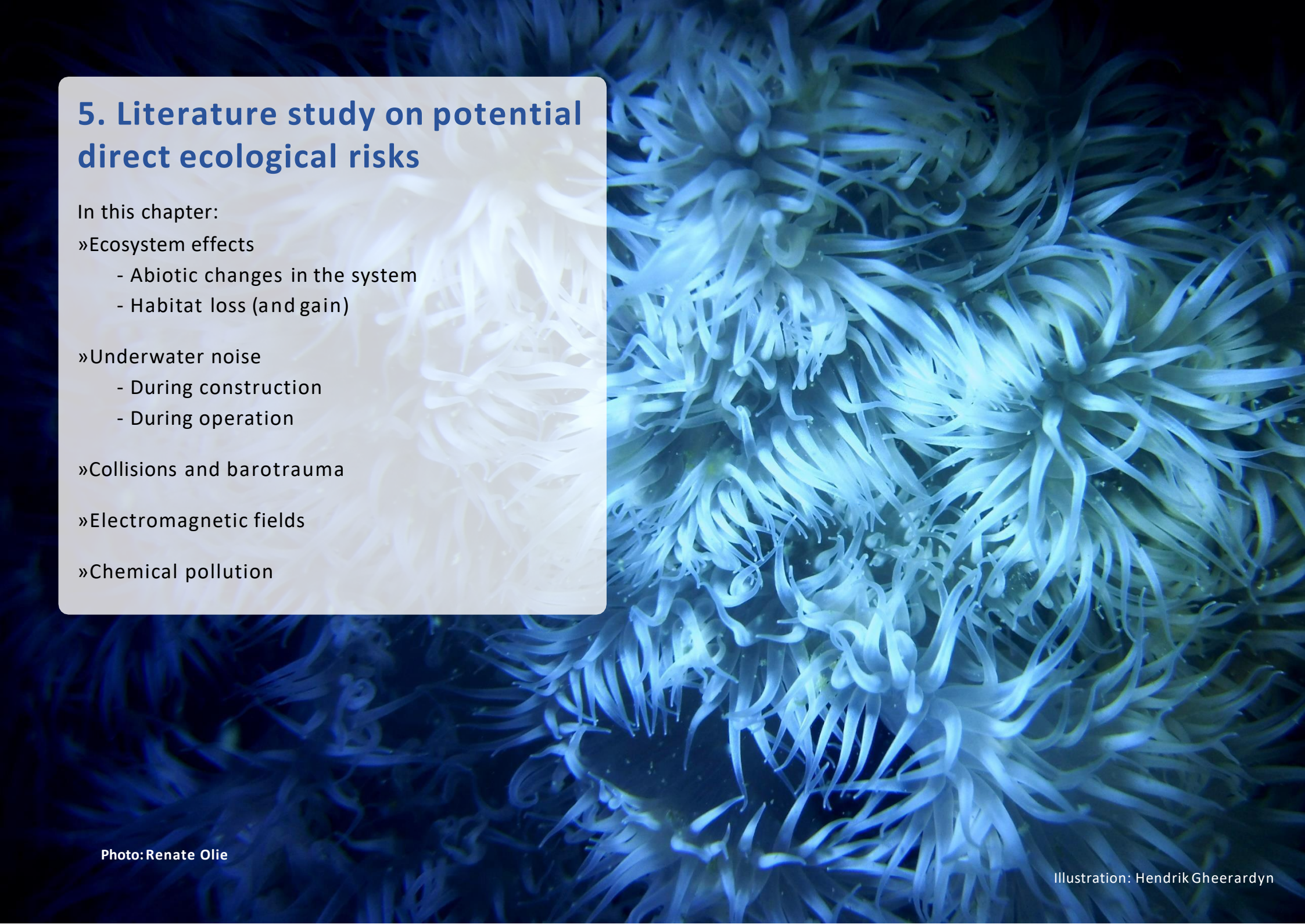
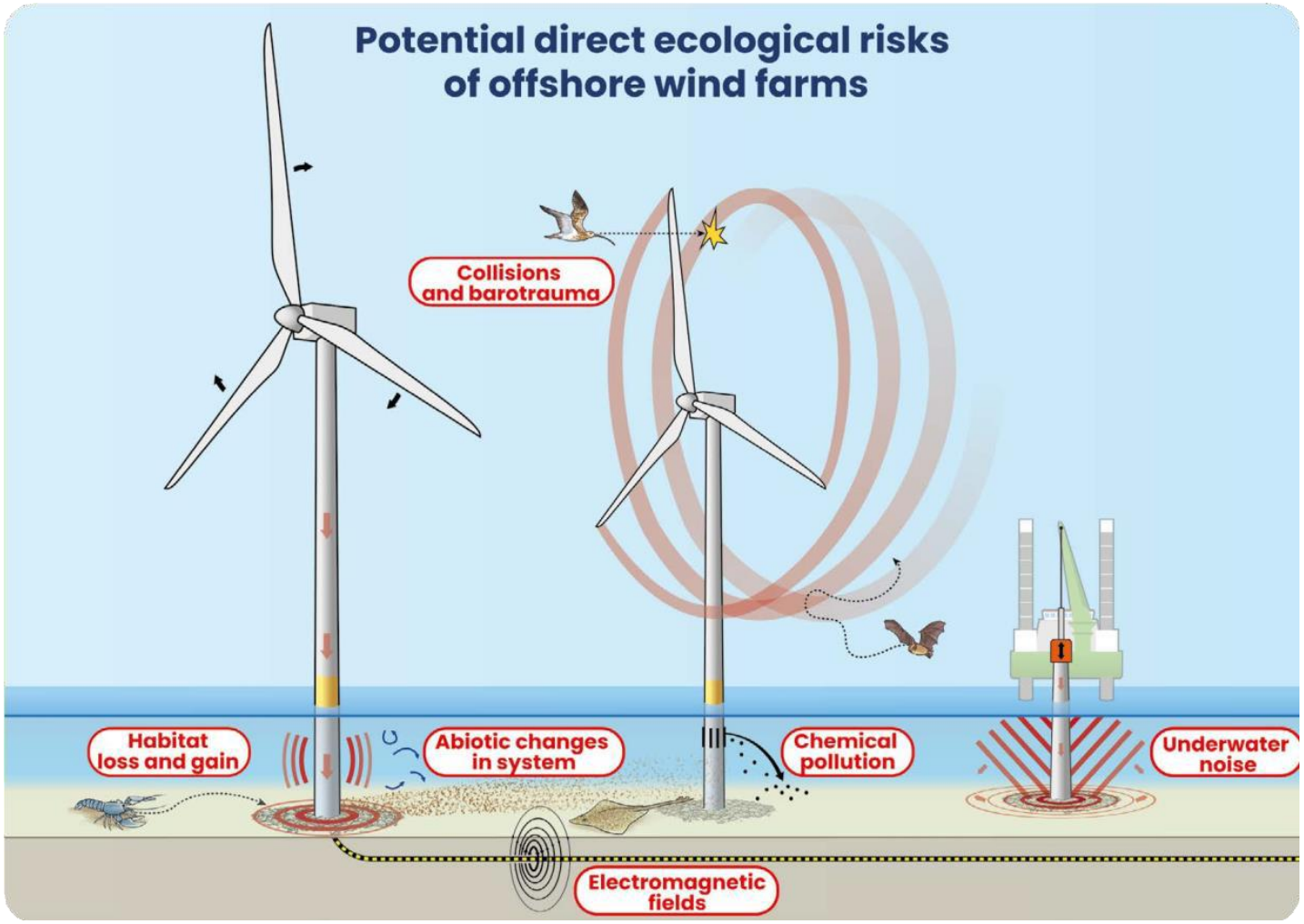


Photo: Renate Olie

Illustration: Hendrik Gheerardyn

New research results are leading for the further roll out of offshore wind until 2030

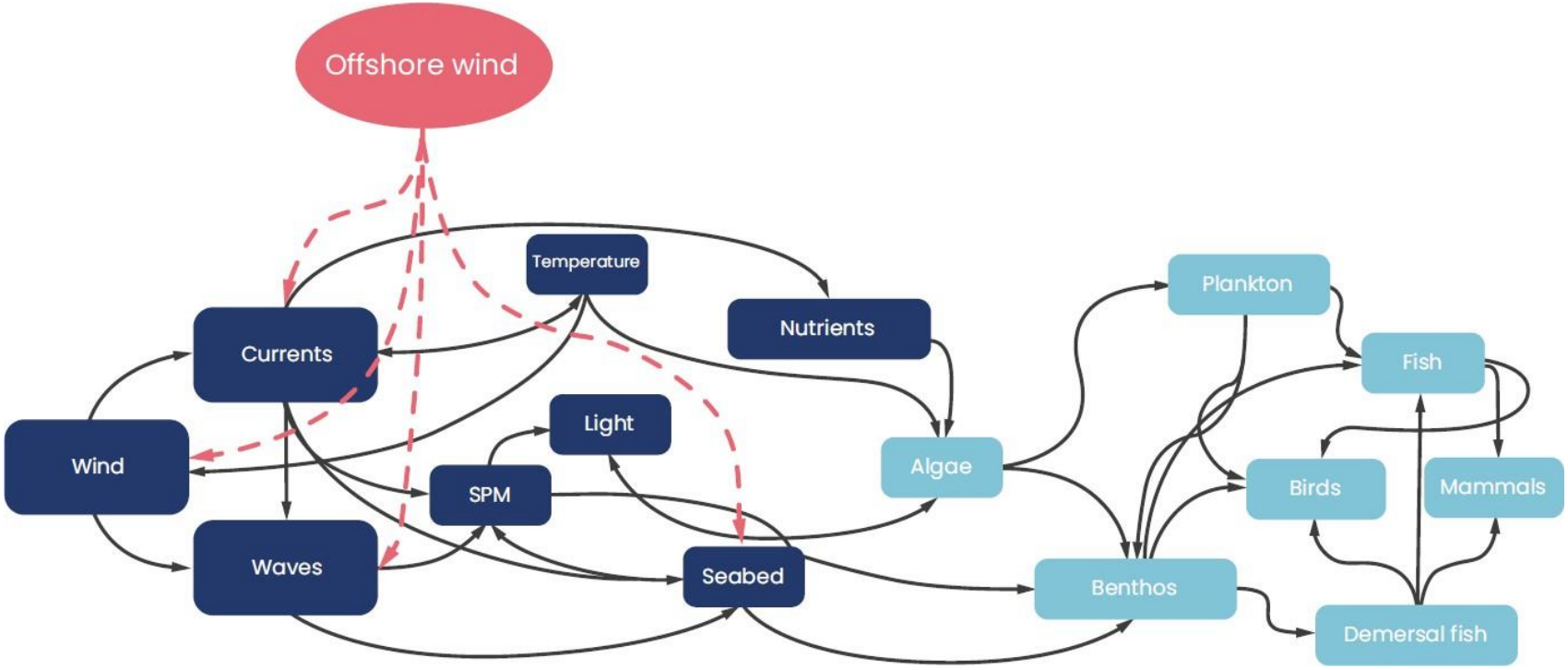


- In March 2022 the (Dutch) North Sea Programme 2022-2027 will be published. Part of this programme is the Additional Draft North Sea Programme 2022-2027, in which wind energy areas in the North Sea are designated to meet the 2030 climate targets.
- It is stipulated by law that a supplementary strategic environmental assessment (plan SIA) and a supplementary appropriate assessment are also published. The drafts of these documents are publicly available.
- These documents provide a glimpse into the update of the KEC (4.0). For example, this involves more work with population models and a new working standard is introduced: the Acceptable Level of Impact (ALI).
- The literature research carried out by The North Sea Foundation is based on published data. As a result, the KEC 3.0 is mainly relied upon.

Source: Additional Draft North Sea Program 2022-2027
Illustration: Hendrik Gheerardyn

The marine ecosystem is very complex and therefore difficult to study

Ecosystem effects entail effects on both biological communities (**biotic**) and their non-living (**abiotic**) environment that interact as a complex functional unit. Only limited field studies have been conducted on system effects so far. Therefore, most studies that point to changes are model-based, which are rarely extrapolated to large-scale ecosystem impacts. More data is needed to verify these models and find the actual effects on the North Sea ecosystem. The simplified picture below illustrates the complexity of system effects, leaving other pressure factors out of consideration.



Source: based on Boon et al., 2018

Offshore wind turbines will cause changes in the current habitat

- Depending on the energy scenarios import-dependent (38 GW) or self-sufficient (72 GW), an area requirement of 7% to 21% of the Dutch part of the North Sea is taken into account (assuming 10 MW/km^2).
- With the current turbines this means: one turbine per kilometer, with a tip height of approximately 200 metres. It is expected that the height will increase to approximately 250 meters and the number of turbines per km^2 will decrease.
- Under water, every kilometer of hard substrate in the form of a pile and erosion protection with a total diameter of 30 - 50 meters is applied. Power cables are laid within the park (inter-array cables) and between the park and land (export cable).
- Intertidal regions of hard substrate are added in an unusual environment.
- For species with narrow niches, these changes lead to habitat loss or fragmentation compared to their current habitat. While other species gain available space or adapt.
- These changes can lead to a shift in the distribution of certain (populations of) species.

Based on the interviews and literature review, effects on ecosystem functioning were identified as possibly the greatest risk of the increase in offshore wind energy, given the large-scale and long-term effects. The different effects are discussed in more detail on the next page.

Sources: based on Matthijsen, Dammers and Elzenga (2018); AFRY (2020), Noordzee Energie Outlook (2020)

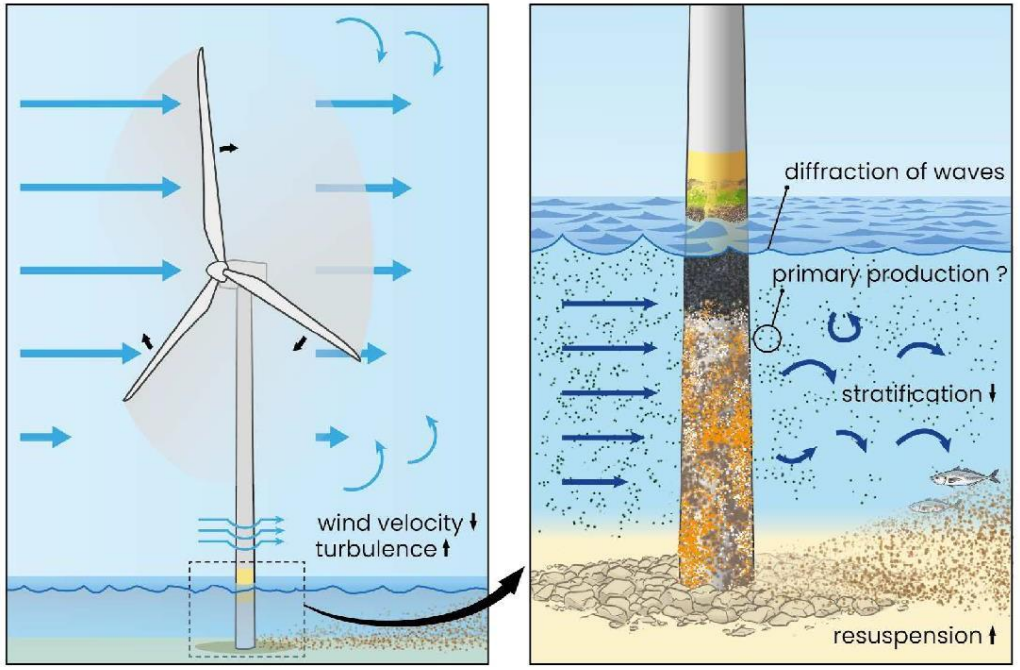
Abiotic changes in the system could cause large-scale effects on (the functioning of) the ecosystem

Above water / on the surface

The **wind velocity** decreases and is more disturbed downwind of wind turbines (**wind-wake effect)**. This leads to a decrease in wave height and diffraction of waves.

Underwater

- The turbulence can cause a change in flow dynamics and up- and downwellings. In stratified areas, this can lead to destratification.
- It also increases the **resuspension** of sediment (and nutrients). In the Dutch part of the North Sea this mainly means an increase in turbidity, which could reduce primary production.
- Also, **sediment transportation** can be altered, and sediment becomes finer and sometimes also richer in organic matter in the vicinity of wind turbines and their wake.
- **Food web dynamics** are prone to changes due to a modified primary production, species composition and nutrient availability.
- Environmental changes could alter **ecosystem services** such as nutrient cycling and food production.
- Direct effects on animals from cable burial and monopile construction (e.g. **turbidity**) are expected to be very local and temporary.



The North Sea Foundation

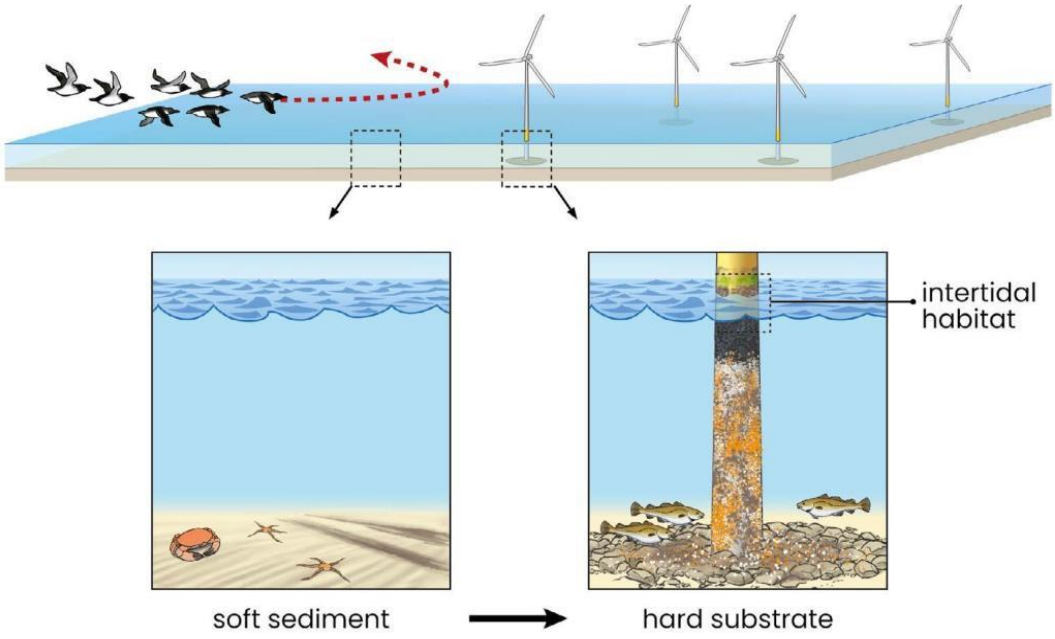
Main sources: Boon et al., 2018,, Broström 2008, Broström et al., 2019, Causon & Gill 2018, Coates et al., 2014, Paskyabi, 2015, Van Duren et al., 2021

Illustration: Hendrik Gheerardyn

Read more about this subject here.

Habitat loss so far seems to be temporary or on a minor scale

- National and international reductions in populations of **seabirds are predicted to stay below the agreed limits** of the 'Potential Biological Removal' (PBR). The most vulnerable species concerning habitat loss is the **razorbill** (27% of the PBR).
- **Bats** may lose space where they forage if they exhibit a strong avoidance of wind farms. This effect appears to be moderate, because the current wind farms do not appear to be located in an important foraging area, but knowledge about population size and use of the space above the sea is very limited.
- Temporary habitat loss has been found for **marine mammals** during the pile-driving of wind turbines caused by avoidance behaviour.
- A temporary decrease of **bottom dwelling fish** during construction has been reported.
- No statistically significant effect was found for **benthic invertebrates** that live on **soft-substrates.**



Main sources: Jak & Glorius 2017, KEC 3.0, Lagerveld et al., 2017, van Kooten et al., 2019, Vandendriessche 2014, Vallejo et al., 2017

Illustration: Hendrik Gheerardyn

Read more about this subject here.

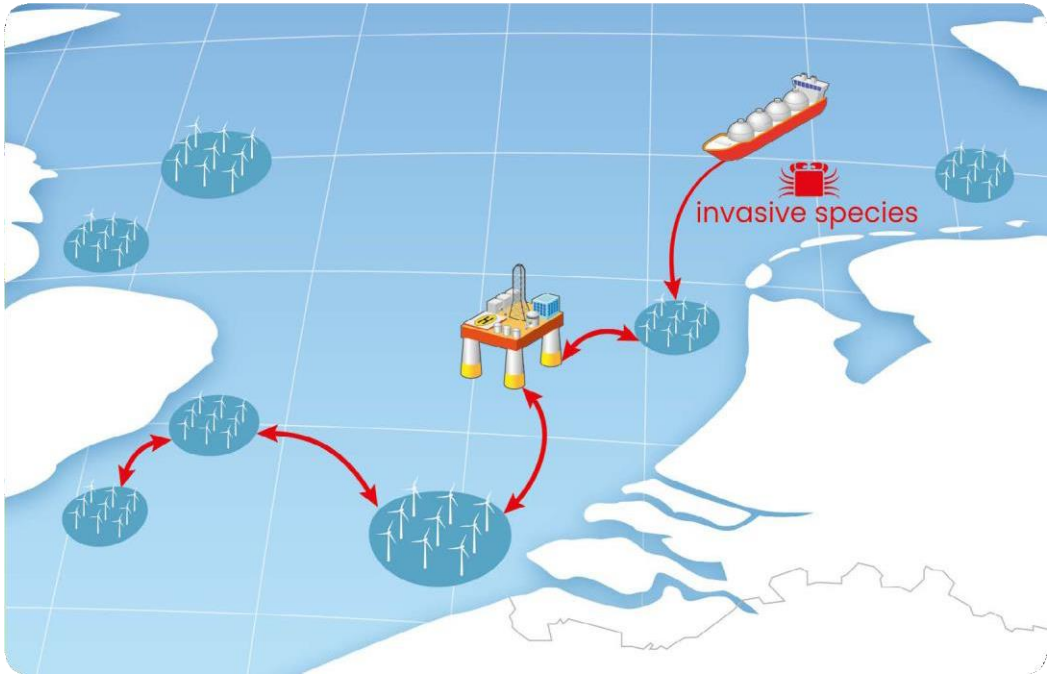
Some species will gain habitat, which affects food web dynamics and spreading of species to unusual areas

- More habitat will become available for **hard-substrate associated species** and species that adapt to the new circumstances. This (locally) affects the food web.

- Offshore wind farms could potentially act as refugia for several fish species. Attraction and sometimes increased reproduction has been shown for both hard- and soft substrate associated **fish species**.

- Some **bird species** use the increased food availability and roosting possibilities. They therefore benefit from the habitat change.

- Biodiversity increases, yet also the indirect (and minor) risk of spreading **non-native invasive species**, which could negatively affect other species. Within a healthy and biodiverse food web, outbreaks of such species could be naturally corrected.



Main sources: De Backer et al. 2019; 2020, Degraer et al. 2020, Reubens et al., 2014, Stenberg et al. 2015, van Hal et al., 2012; 2017
Illustration: Hendrik Gheerardyn

Read more about this subject here.

Underwater noise can be divided into construction and operational noise

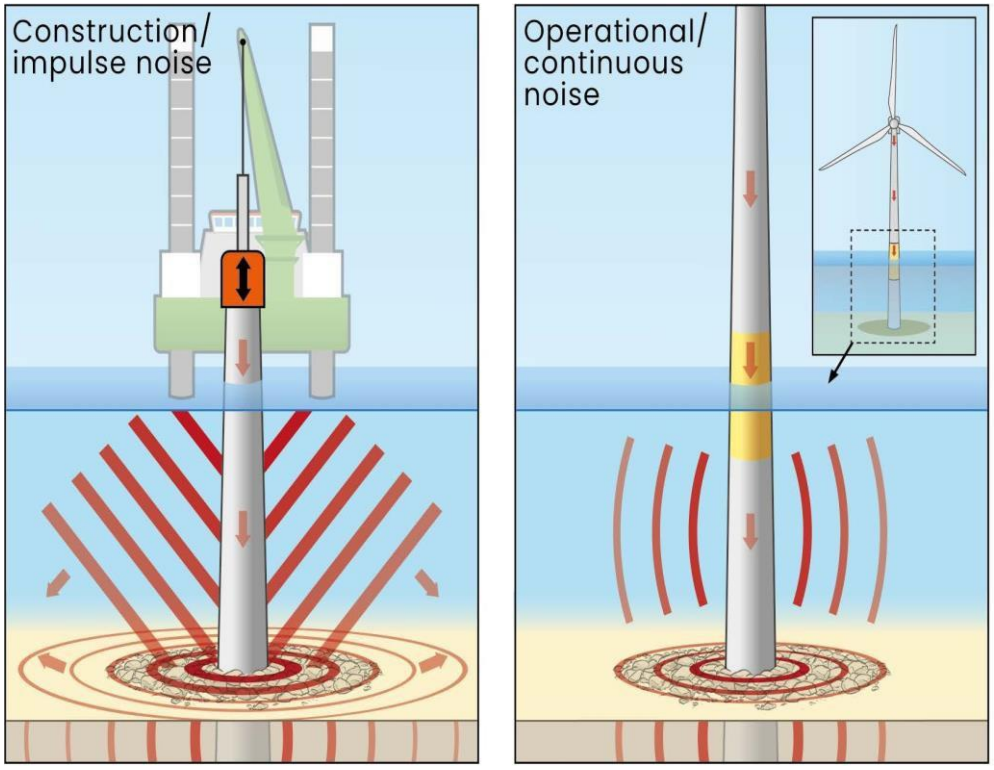
Differing noise sources occur from pre-construction (survey), construction (piledriving, dredging, rock-laying, shipping), operation (vessel traffic and blade rotation) through to decommissioning (shipping, seabed disturbance).

Construction noise – pile-driving

- Low frequency (<1 KHz), high intensity (unmitigated up to 220 dB re 1 µPa @ 1m), short duration (hours / days per turbine). Research by KEC 3.0 resulted in a threshold value for driving SELss (750 m) = 168dBre 1 µPa2s. This is recalculated in KEC 4.0 and will likely lead to a lower threshold of 160db.
- Research and policy is mainly focused on the harbour porpoise. The harbor porpoise is believed to be the most sensitive species based on hearing and likelihood of exposure to pile-driving noise, and current standards are therefore tailored to this species.

Operational noise – rotating wind turbine blades and operational work vessels

- Very low frequency (< 500Hz), low intensity (maximum of 153 dB re 1 µPa @ 1m), long duration (decades).
- Less well studied than pile-driving noise but can pose a threat to species with low frequency hearing such as seals and fish.
- Vessel traffic will potentially increase in the vicinity of a wind farm. This could lead to accumulation with other shipping noise and with operational wind turbine noise. The effect on marine wildlife from vessel noise is not clear.



In the KEC 4.0 update, the analysis of the cumulative effects of the construction of wind farms, in addition to harbour porpoises, also takes into account harbour seals and grey seals.

The North Sea Foundation

Main sources: Ainslie et al., 2017; Heinis et al., 2019, Nedwell 2004, Tougaard 2020

Illustration: Hendrik Gheerardyn

Read more about this subject here.

Underwater noise causes a range of behavioural and physiological effects at variable species levels

- Effects of underwater noise are generally **species- and hearing specific** and depend on **biotic and abiotic factors**. Particle motion plays an important role for fish and invertebrates but is still relatively unknown.
- **Behavioural effects and masking** (reduced communication) can lead to disrupted vital life functions (such as foraging and reproductive behaviours). For example, sole and cod has shown a significant movement response to pile-driving stimulus.
- **Stress responses**, which weaken overall health and fitness, have also been found to occur in various species such as mussels, oysters and hermit crabs subjected to pile-driving noise.
- **Physiological effects** of noise can cause temporary loss of hearing sensitivity or permanent loss of hearing. This effect is more likely to occur in short distances to pile-driving activities. The most recent studies show that, given the assumptions used and the noise threshold, permanent effects on the hearing of harbour porpoises and seals can be excluded.
- The effects of sound can accumulate **on other anthropogenic sound sources**. Moreover, since sound can travel over long distances, it can accumulate over national borders.

From an ecological perspective, noise pollution should therefore be minimized, especially in view of cumulative effects. When it comes to human activities, the North Sea is already one of the busiest seas in the world, and it will only get busier in the coming years, with the roll out of wind farms playing an important role. In The Netherlands, the noise standards for pile-driving have been set based on the goal that pile-driving will not reduce the porpoise population by more than 5% with 95% certainty. In the KEC 4.0 the same ecological threshold will be used for harbour seals and grey seals. Results of the calculations show that the accelerated construction of offshore wind energy in the period 2016-2030 would only be possible if the in the KEC 3.0 suggested threshold of 168 dB SEL1 (Sound Exposure Level) re 1µPa2·s at 750m would be made stricter. The results also indicate that cumulative effects on seals are not expected.

Main sources: Brandt et al. 2018, Bruintjes 2016, Heinis et al. 2022, Charifi et al. 2017, Roberts & Laidre 2019, Mueller-Blenke et al. 2010, Popper et al. 2019, Slabbekoorn et al. 2010; 2018, Spiga, Caldwell and Weilgart 2018

Photo: Renate Olie | Stichting Rugvin

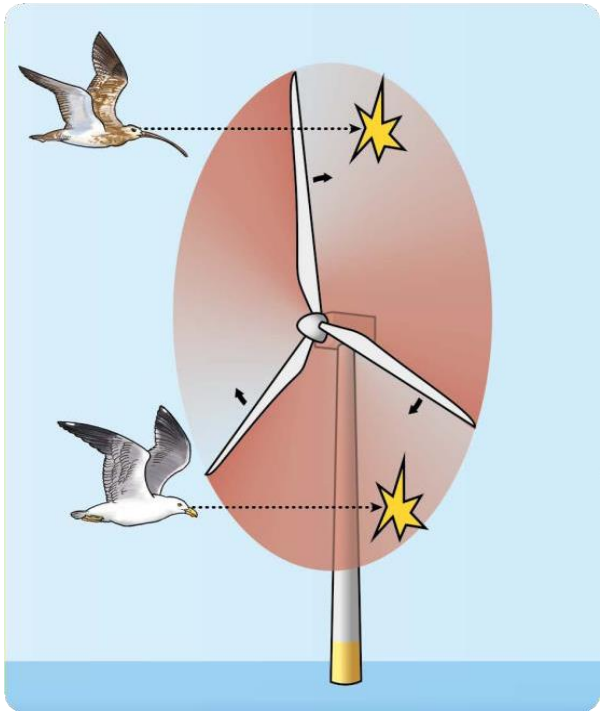
Read more about this subject here.

Bird collision victims are expected to stay within agreed limits in scenarios up to 10,8 GW, according to KEC 3.0

Birds

- Per examined species, a limit of additional mortality is set, the **Potential Biological Removal (PBR)**. Below this level, a population could still reach or maintain its optimum sustainable level.
- Most predictions on bird mortality due to offshore wind farms have become more accurate and the predicted amount of victims decreased over the last years due to increased knowledge.
- Although modelling being very conservative to guard against uncertainty, the number of predicted **victims** from collisions on both **migratory** and **seabirds** stay below the PBR.
- The impact on the Black Tern and Eurasian Curlew is the highest with respectively 98% and 64% of the PBR. Other migratory birds stayed at or below 10% of the PBR.
- For **seabirds**, the herring gull, lesser black-backed gull and kittiwake with respectively 33%, 21% and 15% of the PBR, appear to be most negatively affected.

Predictions on bird collisions are based on species-specific **models**. These can only be improved by gathering more and recent data on the specific parameters, such as flight height and avoidance rates. WOZEP is currently collecting this data, so effective mitigation strategies (e.g. standstill prescriptions) can be achieved. Due to a lack of validation, there is uncertainty on the reliability of the models used and therefore true collision rates.



New models, used in the update of the KEC 4.0, show that the ecological limits of the gannet and herring gull may be exceeded. KEC 4.0 indicates that this would also not fit in the current roadmap (10.8 GW).

The North Sea Foundation

Main sources: Bradbury et al., 2014, Gyimesi et al., 2018, Potiek et al., 2019, Additional Draft North Sea Program 2022-2027

Illustration: Hendrik Gheerardyn

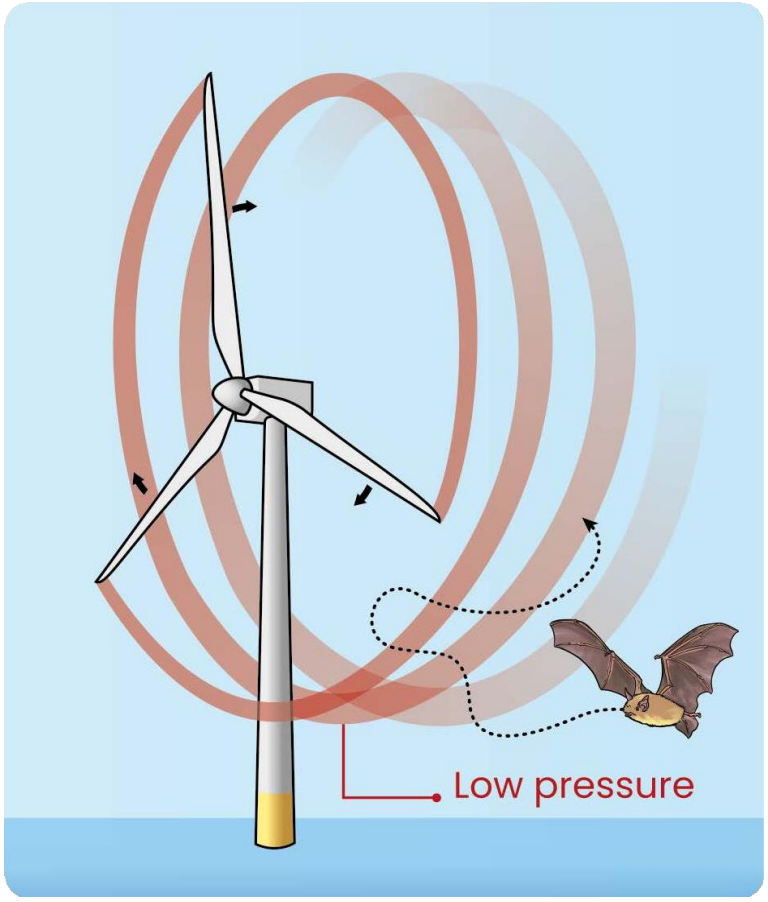
Read more about this subject here.

Barotrauma risk for bats are not modelled due to limited knowledge

Bats

Most **bat** victims are caused by **barotrauma**, due to the sudden decrease in air pressure in the vortex of the blades combined with their relatively weak lungs. Some migratory bats have been found to rest on or near offshore structures, increasing this risk. There are also bats that live in coastal areas and forage above the sea. However, most bats only migrate with low wind speeds.

Unfortunately, there are no predictions on bat victims due to a large knowledge gap in distribution and abundance data of the different bat species foraging or migrating above the North Sea. Therefore, the precautionary principle is used and mitigation measures are imposed whereby the blades start to turn at higher wind speeds during the period and circumstances in which bats migrate.



Main sources: Baerwald et al., 2008, Boonman, 2018, Lagerveld et al. ,2017

Illustration: Hendrik Gheerardyn

Read more about this subject here.

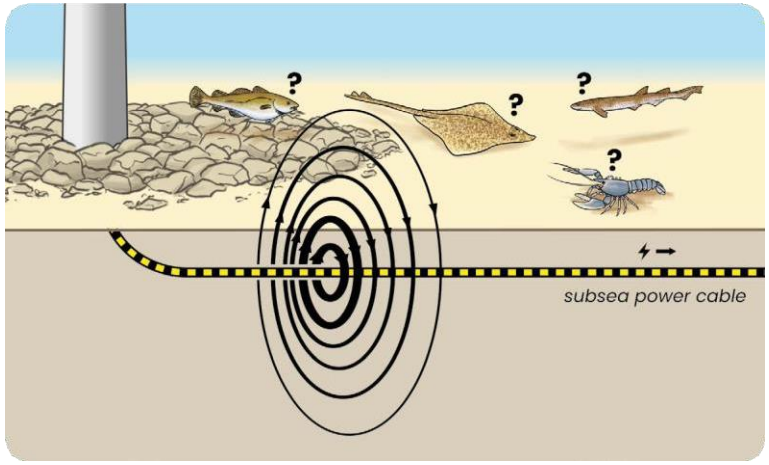
Lack of research on the ecological effects of EMFs could act as potential risk for expanding existing offshore wind infrastructure

Electromagnetic fields (EMFs), generated by offshore electrical cables, consist of **electric fields** (produced by electric charges) and **magnetic fields** (produced by the flow of electrical current). The direct electric fields are shielded by insulation of the cable. However, when magnetic fields are disturbed by water currents or organisms, induced electric fields occur.

Electromagnetic fields could cause **disturbance** of:

- Behavioural responses and movement: attraction / avoidance
- Navigation and migratory behaviour
- Predator/prey interactions and distribution of species
- Embryonic and cellular development

As the direct effects of EMFs are mostly unknown, the impact on species populations is a large knowledge gap. Some rays and several invertebrates showed for example attraction at certain EMF levels. This can have a negative effect when they forage less as a result.



The Elasmopower project (2020-2025) investigates the effects of electromagnetic fields from power cables on sharks and rays. The North Sea Foundation is one of the partners in this multi- year research project. Other partners in this project include a.o. TenneT (the offshore grid operator), Naturalis, Wageningen University & Research, Witteveen+Bos and RWS WOZEP.

The North Sea Foundation

Main sources: Elasmopower project, Hutchinson et al., 2018, Snoek et al. 2016 & 2020, Taormina et al., 2018
Illustration: Hendrik Gheerardyn

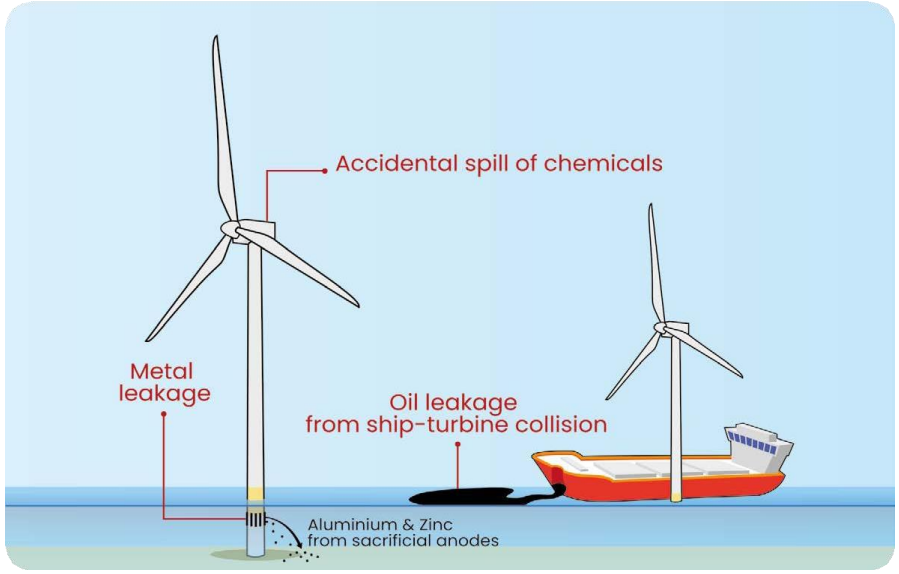
Read more about this subject here.

Chemical pollution has largely been understudied, therefore the potential impact is uncertain

Chemical pollution could do serious harm to the North Sea ecosystem, yet the scale of pollution from wind turbines has not been subject of much research and therefore constitutes an important knowledge gap. This research conducted by The North Sea Foundation focuses on direct ecological risks of wind farms in the North Sea and therefore leaves construction material and greenhouse gas emissions or leakage out of this scope.

Examples of chemical pollution

- Corrosion protection by sacrificial anodes releases tons of aluminum and zinc into the sea per turbine, but little relevant research on bioaccumulation. Newer methods, such as Impressed Current Cathodic Protection, are increasingly used and contaminates significantly less (± 12.5 g of metal oxides in 25 years). Besides food web accumulation, this massive influx of metals contributes to ocean pollution and does not support the 'good environmental status'.
- The highest chance for **oil leakage** to occur within wind farms is during a ship-turbine collision. This risk of occurrence is increasing, but chances are currently still low (a yearly frequency of 0.064 for the Greater North Sea, which includes the UK and Ireland).
- **Other chemicals**, for example from lubricants, grouts, paints, bisphenol A, and other materials used in the wind turbine and its foundation could incidentally contaminate the sea. Given the low occurrence and great dilution factor this is not expected to pose a significant risk. Research into these incidents might help to understand the full extent of effects.



The North Sea Foundation

Main sources: Caplat et al., 2010, Deborde et al., 2015, Kirchgeorg et al., 2018, Rees & Judd, 2019, Reese et al., 2019, Van der Tak et al., 2014

Illustration: Hendrik Gheerardyn

Read more about this subject here.

6. Expected cumulation of ecological effects

Until now, most research focused on the individual effects of the various risks of offshore wind energy on protected species. These effects, however, cannot be considered separately. After all, they can all affect the same species or ecosystem. There are also many knowledge gaps that still need to be addressed.

This chapter will cover:

- Ecosystem effects as biggest risk
- Cumulation of large roll out of offshore wind energy and other users

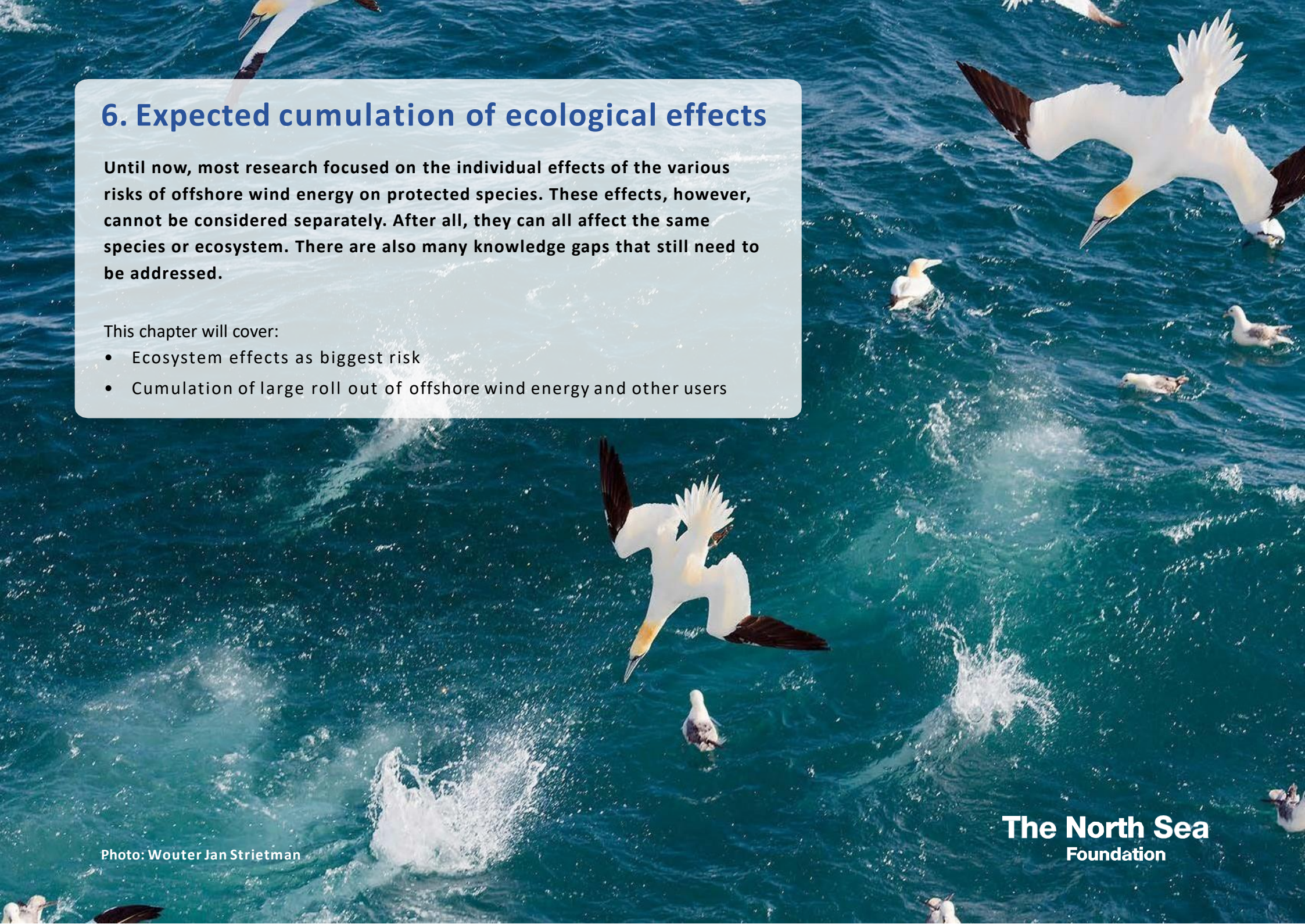
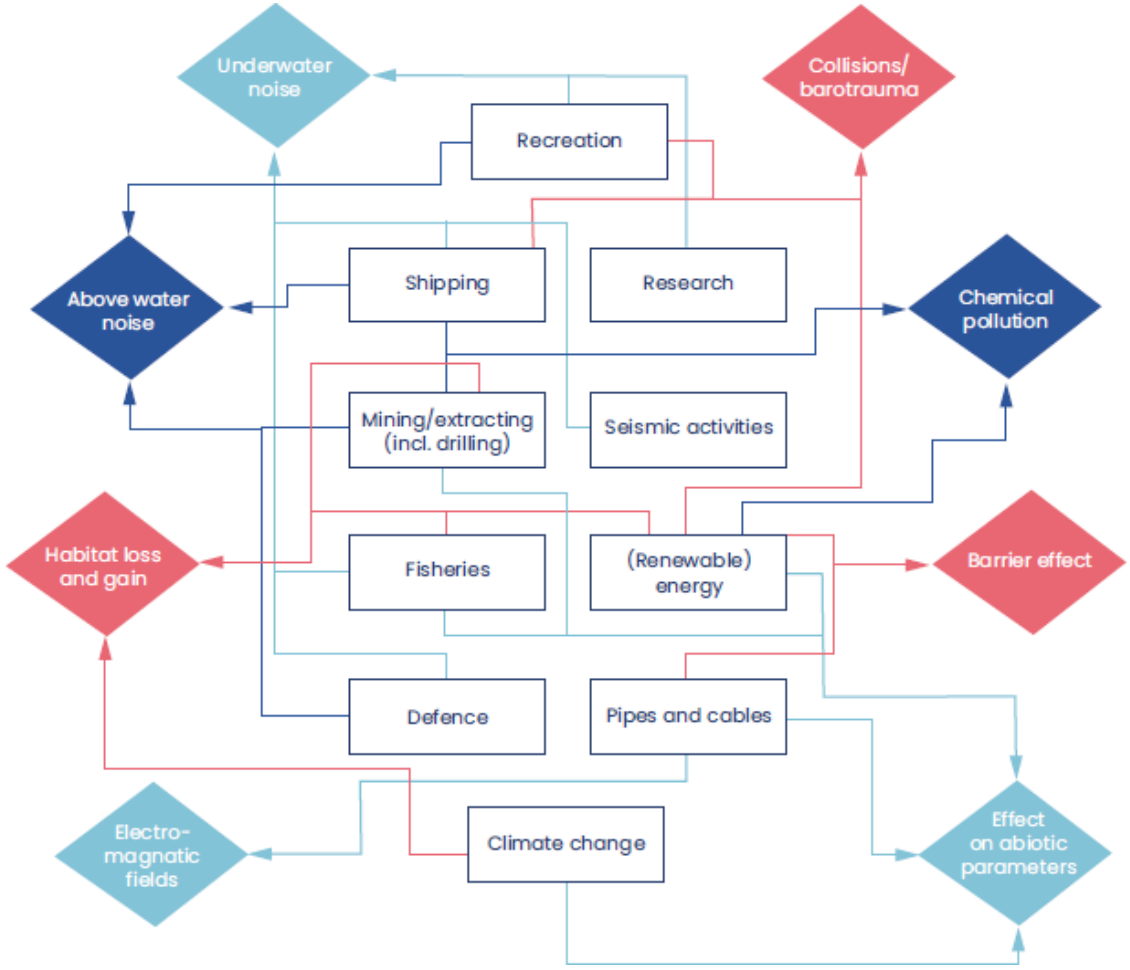


Photo: Wouter Jan Strietman

The North Sea Foundation

The North Sea Foundation foresees ecosystem effects to be the biggest risk for the expansion of offshore wind energy

- **Abiotic changes** are seen as the greatest individual risk of offshore wind in North Sea nature.
- Effects of **collisions and underwater noise** (during construction) can be mitigated, reducing the individual risks.
- The risks associated with **electromagnetic fields**, **underwater noise** during the **operational phase** and **chemical pollution** have not yet been properly assessed, but appear to be less significant than the aforementioned risks.
- However, the **cumulation of these effects** together is expected to be the **biggest risk**. The large-scale expansion of wind farms could lead to wide-ranging changes in the ecosystem.
- In addition, effects from **wind and other pressures** (as shown in the figure to the right) can accumulate, causing a greater overall impact at the ecosystem level than when assessed separately.



No extensive research was conducted into other factors. This figure could therefore be incomplete.

The North Sea Foundation

Sources: Goodale et al. 2016, KEC 3.0

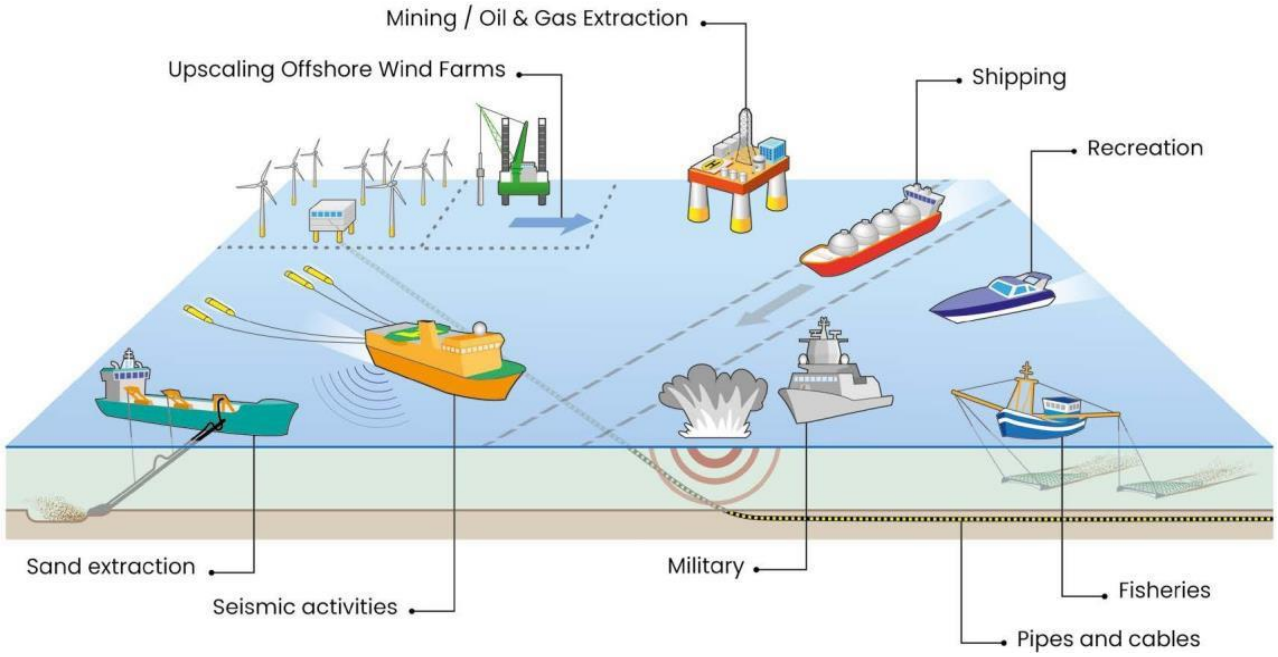
Figure: The North Sea Foundation

Knowledge gaps on cumulative effects

Knowledge on cumulative effects is still limited to date. In the Netherlands, the Framework for Assessing Ecological and Cumulative Effects (KEC) strives to calculate ecological and cumulative effects from offshore wind farms in the roadmap. However, it has **limitations** in its **scope**, for example because it does not consider wind energy production on land or non-protected species. Also, other stressors to the ecosystem, as illustrated here below, are not taken into account. The problem lies in the fact that there is not yet methodology to quantitatively make these calculations.

Examples of accumulating activities:

- Noise due to pile-driving, seismic surveys, military explosions and shipping (including recreational).
- Chemical pollution from wind turbines, shipping, mining / oil and gas extraction.
- Abiotic effects from the upscaling of wind farms (including at international level).



Sources: KEC 3.0

Illustration: Hendrik Gheerardyn

7. Stakeholder participation through round tables and an expert session

In the third and fourth quarter of 2020, The North Sea Foundation organised stakeholder sessions to further discuss the important subject of the potential clash between nature and wind energy, test our initial findings and mobilise and activate stakeholders.

This chapter covers:

- Outcome of round tables
- Findings of underwater noise expert session

Photo: The North Sea Foundation

The North Sea Foundation

Round tables reveal the value of the North Sea: industrialize to achieve climate targets, at the expense of nature?

In September 2020, The North Sea Foundation organised a panel discussion to discuss ecological risks related to offshore wind energy. In November 2020, this was followed by a high-level round table session. The main conclusions were:

- The urgency of climate change is so high, **we need to continue expanding sustainable energy**, including wind farms at sea.
- We are prepared to **take environmental risks** to meet our climate target. Yet, this means strengthening the ecosystem today to make it more robust for future negative effects. This also requires a solid form of adaptive management if research results reveal a larger negative effect than modelling suggests.
- **Adaptive management seems to be a good solution.** Yet poses financial and reliability issues. For example, in permits for players such as wind farm operators, the transmission system operator and the government on how to execute this retrospectively.
- For this reason, some are of the opinion that **mitigating measures** from new ecological research should **only** be applied to **future wind farms**, not retrospectively on existing wind farms.
- The **systematic monitoring of the ecological effects** of offshore wind is essential. Yet, opinions vary between the expectation that these insights will be more positive than expected and will therefore provide more ecological space. Others feel we should be vigilant as these insights might be more negative than expected and should therefore require a back-up plan.
- General agreement exists on allowing for **as much research** to be conducted as possible to provide better insights in where technological innovation is most needed to mitigate risks. Preferably before the large roll out of offshore wind energy starts.

Note on Springtij session: speakers represented the Ministry of Economic Affairs and Climate, Stichting Natuur & Milieu, Arcadis and a Dutch sustainability expert. In the audience were scientists, wind operators, NGOs and government officials.

Note on round table session: Invited were representatives from Stichting Natuur & Milieu, Ministry of Agriculture, Nature and Food Quality, Ministry of Economic Affairs and Climate, the Directorate-General for Public Works and Water Management, Netherlands WindEnergy Association, TenneT and ASN Bank and was chaired by The North Sea Foundation

Expert session underwater noise: pile-driving noise relatively well studied and mitigated, but uncertainty around potential impact of operational noise and cumulative effects remain

The North Sea Foundation organised an expert session in September 2020, with a specific focus on the relation between underwater noise and offshore wind energy developments. Amongst other topics, the following was discussed:

- The main risk from offshore wind was found to be the **lack of basic knowledge** about the ecology of our North Sea in general. There is a risk the development of wind farms continues until the ecological effects become unacceptable, including implications of underwater noise.
- This risk is the result of the **challenges of research at sea**, the fact that marine research is expensive and complex, the marine environment can be elusive, and noise is subject to many variables, making standardisation a challenge.
- It is **not always possible to associate impacts directly to a particular stressor** such as underwater noise. Data will therefore need to be collected consistently and a proper monitoring is vital to measure and mitigate effects as quickly as possible.
- Yet another risk may be that **wrong or too many mitigation measures** are taken due to knowledge gaps leading to a bottleneck for offshore wind development.
- Limited species-specific studies (mainly focused on harbour porpoises using unvalidated models) and mitigation are **not sufficient** to measure and mitigate for **large-scale cumulative ecosystem effects of underwater noise** (for example effects on other species and food web dynamics).
- Ecosystem wide impacts can lead to a **degraded system** that becomes accepted as the new ecosystem (shifting baselines), while on the contrary The Netherlands aspires to move towards a healthier and better protected sea.
- What is predominantly needed is **more monitoring, collaboration, innovation and a bridge to mitigation and policy, in which adaptive management is essential.**

Note: the expert panel consisted of experts from the Directorate-General for Public Works and Water Management, Wageningen University & Research, Royal Netherlands Institute for Sea Research (NIOZ), Netherlands Organisation for Applied Scientific Research (TNO), Heinis Waterbeheer en Ecologie, Institute of Biology Leiden (IBL) and the Scripps Institution for Oceanography. For further information: The North Sea Foundation; Weten we genoeg over onderwatergeluid in de Noordzee? (Sep 2020)

8. There is a strong need for mitigation and compensation

On the base of the ecological risks of offshore wind, the next step is to map current and potential mitigating measures. Where current mitigation measures seem insufficient, innovative techniques need to be identified. If not possible, the question must be asked what could be done to compensate for the risks.

In this chapter:

- Mitigation measures and innovative techniques
- Compensation

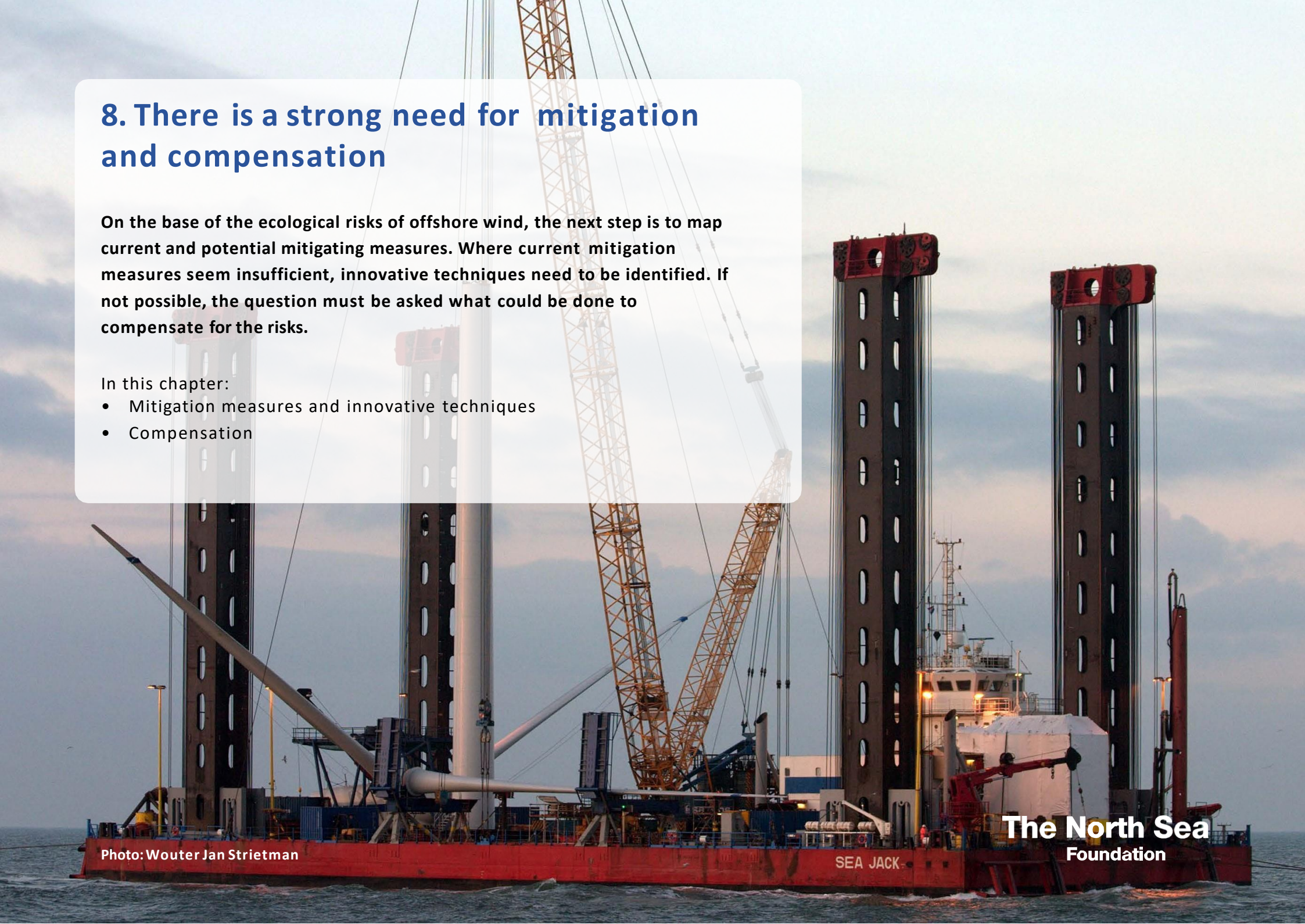


Photo: Wouter Jan Strietman

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Non-statutory best available techniques and good maritime spatial planning as standard mitigating measures

In general, the best mitigation measure is the choice of location. The North Sea Agreement provides that, in principle, no wind farms will be built in ecologically valuable areas, such as the Frisian Front and the Cleaver Bank. It has also been agreed that the most up-to-date, non-statutory best available techniques for mitigation, nature-enhancing construction and best environmental practice will be used. However, there is an economic limit to increased costs versus benefits for nature. Mitigation of effects must be geared to the results of monitoring and research, and to the specific characteristics of the wind farm. So far, the following mitigation options have been identified for each ecological risk, several of which are already being applied or under development.

Mitigation options for ecological risks	
(Impacts of) abiotic changes in the system	Wind farm location outside stratified waters, keeping maintenance and installation as short, silent and with the least amount of disturbance as possible (e.g. with Power Jetting cables instead of dredging).
Collisions and barotrauma	Temporary shutdown of turbines for large migrations of birds and bats based on prediction models, radars and sensors. Increase in tip depth. Research techniques such as two-blade turbines, painting turbine(blades) black, deterring methods and methods to increase detection of wind turbines.
Underwater noise (construction)	Pile-driving noise mitigation technology, legal noise thresholds, seasonal restrictions, acoustic deterrent devices and soft start.
Habitat loss (and gain)	Optimise wind farm design and location, e.g., foundation dimensions and number of turbines. Use good maritime spatial planning to avoid habitat of vulnerable species and consider the use of bird corridors.
Electromagnetic fields	Optimise cable design, burial depth and technology to lay cables.
Chemical pollution	Replacement of sacrificial anodes by corrosion protection methods that produce less discharge (ICCP). Create sufficient distance between shipping lanes, anchor areas and wind farms. Using biodegradable chemicals (if possible) to mitigate ecological consequences of a spilling event.

Main sources: Boonman 2018, Hutchinson et al., 2018, Kircheorg et al. 2018, May et al., 2020, Verfuss, Sinclair and Sparling, 2019

Measures for compensation of negative impact can be taken in-situ, on a certain species- or habitat level or on other forms of marine use

When it is not possible to reduce or avoid the effects from all ecological risks*, international agreements (European Habitats Directive) require compensatory measures for protected species and/or areas. The exact details of compensation are also not established and must be proposed by the applicant and approved by the competent authority.

Three ways that compensation can be applied:

1. **In-situ compensation:** creation of (protected) marine habitats within the offshore wind farms.
2. **Ecosystem restoration and specific species/habitat protection** in other areas to improve the overall carrying capacity and reduce the effects from offshore wind farms.
3. **Minimisation of intensive marine use** from other sectors as a form of compensation to reduce overall anthropogenic pressure on nature.

Above water effects cannot always be compensated by underwater measures. The creation of oyster reefs cannot compensate for bird mortality.

However, compensation can be applied per functional group and via an ecosystem-based approach.

A point of attention here is that compensation is currently only legally established for effects on Natura 2000 areas. Compensation for the (large-scale) loss of species and habitat outside these areas has not been established. Whether compensation on this scale is possible is unknown.

*In Dutch legislation, compensation is part of a broader assessment framework (ADC test); Are There Alternatives And Is There An Overriding Reason Of Overriding Public Interest? If those questions are answered with No and Yes, then the question arises of how and with which measures compensation can be provided.

Sources: CEEWEB (2012), European Commission, Lüdeke (2017)

9. Recommendations

Based on this study, the North Sea Foundation makes recommendations to policy makers. The recommendations address what needs to be done to ensure we can safely roll out our offshore wind energy plans while also respecting the ecosystem in which this growing economic activity takes place.

Photo: Wouter Jan Strietman

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We recommend the following to prevent a potential clash between offshore wind and nature (1/2)

1. **Accelerate the protection of valuable natural areas to make North Sea nature more robust for the upcoming industrialisation.**
    - Speed up the effective protection of ecologically valuable areas as much as the energy transition.
    - Use the protection of natural areas to help achieve climate goals by making use of ecosystem services such as CO_2 storage and strengthening the ecological capacity.
    - Anchor nature-protecting and nature-enhancing building further in the Offshore Wind Energy Act.

2. **Accelerate and increase research into the ecological impact, mitigation options and innovation of offshore wind farms and always apply the precautionary principle in the event of knowledge gaps.**
    - Invest more in fundamental research into species and ecology to better understand the effects of individual risks.
    - Invest in standardised monitoring of offshore wind farms before, during and after construction to evaluate effects.
    - Investigate mitigation and compensation strategies for the greatest risks and validate the effectiveness of these measures. Adaptive management is essential.

3. **Postpone further scaling up of offshore wind after 2030 until ecological research results show how this scaling up can be done responsibly.**
    - Ensure a clear link between ecological research and policy.
    - Create a nature roadmap that clearly indicates by when which knowledge must be developed and/or what degree of enhanced ecosystem must be achieved in order to take further steps in the offshore wind roadmap.
    - Promptly discuss with stakeholders within the North Sea Consultation what to do if the limits of the ecological space are reached, and the consequences of this for nature and climate.

We recommend the following to prevent a potential clash between offshore wind and nature (2/2)

4. **Develop an integral adaptive policy whereby decisions can be adjusted in a timely manner if ecological research results give reason to do so.**
   - Be prepared to adjust current offshore wind policy if new data shows a significant negative ecological impact on the ecosystem or specific species.
   - Intensify international cooperation and data exchange between North Sea countries and thereby act as a role model as the Dutch government for other North Sea countries, focusing on optimal system integration.
   - Ensure an integrated policy, in which the cumulative effect on ecology of all transitions and new developments in the coming years is provided.

5. **Include potential multi-use at an early stage when designing future offshore wind farms.**
   - Ensure that area passports are completed at the earliest possible stage, before allotment, in order to be able to apply shared use in wind farms as effectively as possible.
   - Ensure that in environmental impact assessments and appropriate assessments more emphasis is put on assessing the impact on nature in combination with other developments.

If you have any further questions following this presentation, please do contact us:

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The North Sea Foundation is an independent nature and environmental organisation and has been the go- to organisation for protection and sustainable use of the North Sea for over 40 years. Our main goals are to achieve sufficient space for nature in the form of marine protected areas, a clean sea, the production of sustainable food, and nature-friendly offshore energy.

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