Disclaimer with regard to translation
This Supplementary Strategic Environmental Assessment (SEA) for the Additional Draft North Sea Programme 2022-2027 was conducted and drafted by Pondera, in Dutch. Consequently, the summary of this document has been translated into English by *sbv anderetaal*. This English translation is suitable for international consultation. However, slight differences in the contents between the original Dutch text and this translation may occur, apart from grammatical imperfections. Therefore the only valid document is the Dutch version of this Supplementary Strategic Environmental Assessment. This implies that in the event of conflicting translations, the Dutch version of this assessment prevails over the English translation.

Summary of Supplementary Strategic Environmental Assessment (SEA)

For the Additional Draft North Sea Programme 2022-2027

Ministry of Infrastructure and Water Management

Summary

1. Background and aim of the additional draft North Sea Programme

Worldwide, climate change is having huge consequences, including flooding, severe drought and rising sea levels. The most recent report by the IPPC suggests that the limit agreed upon in the Paris Climate Agreement (2015) of an average global temperature rise of not more than 1.5 ºC will be reached some 10 years sooner than initially believed. To meet the Paris climate goals, we must reduce CO_2 emissions and the emissions of other greenhouse gases even faster. In April 2021, the European Union raised the CO_2 reduction target from 40% to 55% reduction of CO_2 emissions compared to the level of emissions in 1990. In the Netherlands, it still has to be decided whether the Dutch target (currently 49%) also needs to be raised.

In achieving the target and fulfilling the related acceleration challenge before 2030, offshore wind energy plays an important role. According to the *Stuurgroep Extra Opgave (Extra Task Steering Committee)*[1], 10 GW of offshore wind energy will be needed in order to achieve a 55% CO_2 reduction. Taking into account a preparation period of 8.5-10 years, it will be necessary to make spatial reservations for wind farm zones on time. The parliamentary motion submitted by Boucke c.s.[2] calls upon the Cabinet to designate wind farm zones with space for 10 GW.

The draft North Sea Programme (NSP) 2022-2027, an integral part of the National Water Programme (NWP), has mapped out eight search areas that are eligible for designation as wind farm zone in the North Sea by 2040. There are also four already designated but not yet utilised (parts of) wind farm zones that may or may not be reconfirmed. Designation of wind farm zones means that these zones are spatially reserved for the production of wind energy. This takes place in two stages:

1. In stage one, the space necessary for achieving the stricter EU climate targets of 55% CO_2 reduction by 2030 is designated. This designation is made in the additional draft North Sea Programme 2022-2027.
2. In stage two, the remaining space is designated that is subsequently necessary to arrive at the 27 GW total. This will require a partial revision of the North Sea Programme.

This Strategic Environmental Assessment (SEA) was drafted for this first step.[3] The proposed plan investigated in this SEA consists of two elements.

- Reservation of space to facilitate future site decisions for the remainder of the 49% target of 0.7 GW wind energy (Roadmap 2030) in existing wind farm zones.
- Reservation of space to facilitate future site decisions for a maximum of 10 GW additional offshore wind energy for the acceleration task (55% EU target) through to 2030.

The designation of wind farm areas is the first formal step in a process that leads to the construction of wind farms. During a second formal step, the exact location is defined within the designated wind farm zones. A location (site) is laid down in a site decision, in which the conditions imposed on the future wind farm on that site are also described. In these site decisions, for each site, a project SEA is undertaken that discusses in greater detail the expected impact of wind energy on the location in question. This underlying supplementary SEA shows a higher level of abstraction than the project SEAs for site decisions. In

[1] Recommendation *Stuurgroep Extra Opgave*, Parliamentary Papers II 2020-21, 32 813, no. 683.
[2] Motion by Boucke c.s., Parliamentary Papers II 2020-21, 35 668, no. 21.
[3] Supplementary SEA because an SEA was already drafted for the draft NSP.

addition to the two formal steps of designating wind farm areas and site decisions, there is an intermediate step. In this step, the Ministry of Economic Affairs and Climate Policy (EZK) draws up a Roadmap, together with other policy-making departments and in consultation with stakeholders. The Roadmap specifies the wind farm zones for which site decisions are to be prepared.

2. Narrowing down of areas for 10 GW

The specification of the search areas for wind energy was achieved in a three-stage policy-based narrowing down process, as outlined in figure S1. Below each step, the arguments are listed as to why areas are considered (less) suitable for the realisation of offshore wind energy in the period through to 2030. This narrowing down process revealed that in areas 1, 2, 5 east and IJmuiden Ver North, there is space for a maximum of 16 GW wind energy, 4 GW of which appear to be less viable, due to spatial or ecological restrictions. This then is more than the 10 GW needed for fulfilling the stricter EU climate target of 55% CO_2 reduction. For a map of the areas, see figure S2.

With sufficient space for 10 GW, the obvious step is not to reconfirm Hollandse Kust (northwest) and Hollandse Kust (southwest) in the NSP as designated wind farms, due to the potential negative impact on nature, fisheries and shipping.

Consideration could be given to introducing greater flexibility and designating more than 10 GW in these areas, so that in the further elaboration, spatial and ecological restrictions can be taken into account.

To achieve the remaining 0.7 GW for the 49% CO_2 reduction target, the southern section of the previously designated wind farm zone Hollandse Kust (west) is being considered. To retain this area for wind energy, reconfirmation will be needed in the North Sea Programme 2022-2027.

Figure S1 Diagrammatic representation policy-based narrowing down process for search areas for wind energy on the North Sea.

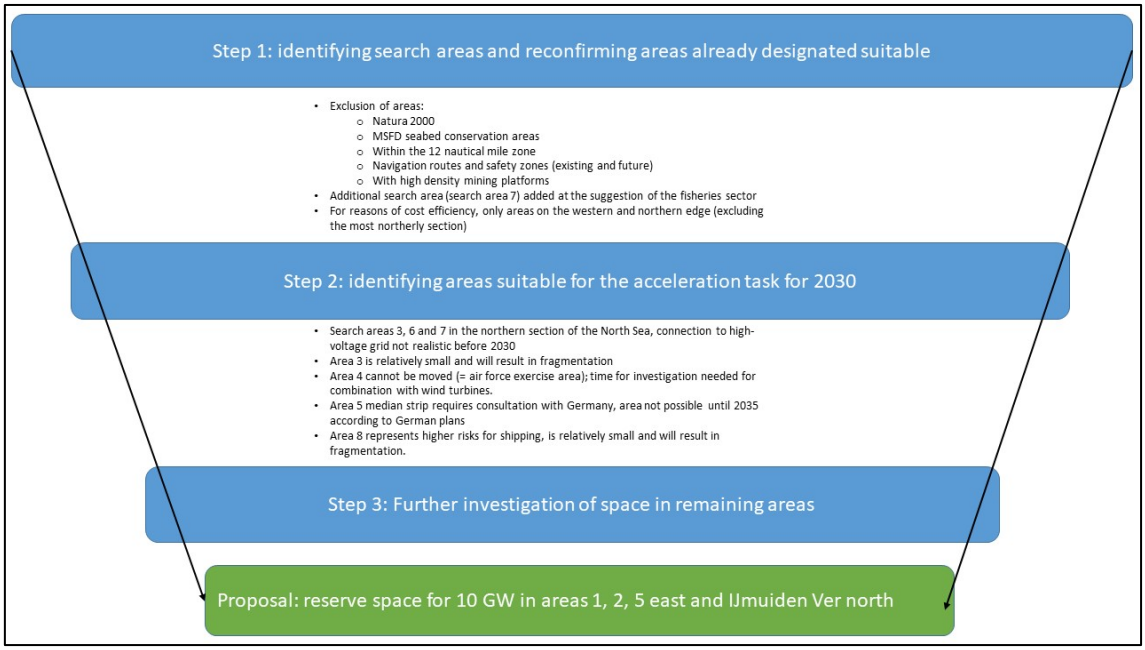
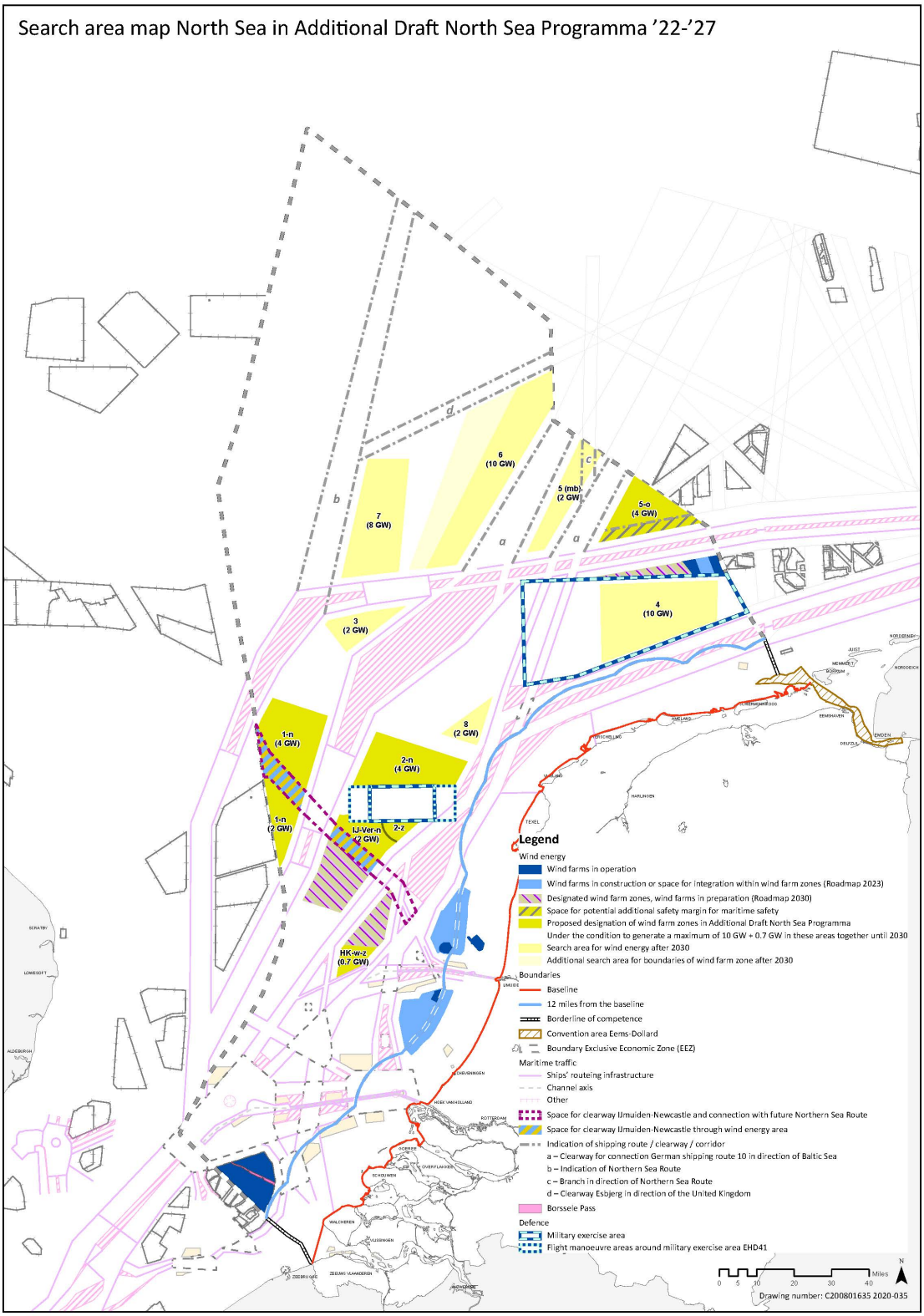


Figure S2 Search areas 1, 2, 5 east, IJmuiden Ver north and southern section of Hollandse Kust (west) to be further investigated.



3. Impact assessment approach

The impact assessment is based on the following approach:

- Wind turbines may be installed throughout search areas 1, 2, 5, east and IJmuiden Ver north and in the southern section of Hollandse Kust (west). Since these areas have space for a maximum of 16.7 GW wind energy power, the (cumulative) impact is overestimated when considering the effect of these search areas all together.
- The impact is determined both for each individual search area and for all search areas together. In calculating the ecological cumulative impact, the impact of existing plans and farms are accounted for in three calculation variants with 10.7, 12.7 and 16.7 GW. This is compared with the reference situation based on the existing wind farms and implementation of the 2030 Roadmap. In an international scenario, the impact of existing and planned farms in neighbouring countries were also considered.
- The aim of determining the impact in each area is twofold:
    1. The impact per area provides information on the impact of the proposed plan
    2. Not all areas are required for 10.7 GW, so certain areas will be dropped. Comparing the different areas with each other will be useful when deciding which areas to drop. The number of GW per area varies, and in conjunction with information about the impact per GW, the areas can be well compared. For that reason, both the overall impact per area and the (relative) impact per GW in the various areas were determined.
- If 16.7 GW in all search areas together deliver an acceptable impact, there will be flexibility in which areas are used to achieve the 10.7 GW.
- To determine the impact on birds and marine mammals, use is made of the results obtained from quantitative calculations of numbers of victims per search area (birds), disturbance days (marine mammals) and expected cumulative impact on populations (birds and marine mammals). These quantitative analyses were carried out on the basis of a Framework for Assessment of Ecological and Cumulative Effects (KEC) that was updated in 2021 using the most recent knowledge. This KEC 4.0 is due to be adopted in the spring of 2022. For this supplementary SEA, use was made of the public interim reports with descriptions of the results to date. This guarantees the contribution of up-to-date and recent knowledge in this SEA process.
- An essential element of updating the KEC is that the cumulative impact on birds is calculated at population level. The results of calculations for each species are compared with a working standard, the so-called Acceptable Level of Impact (ALI) at population level. The ALIs will be subjected to a further review, and will be adopted in policy in the spring of 2022. For marine mammals, too, the cumulative impact of all wind farms together is calculated at population level.
- The quantitative determination of the cumulative ecological impact took account of a number of calculation variants of different sizes (10.7 GW, 12.7 GW and 16.7 GW) as well as the reference situation. The southern section of Hollandse Kust (west) with space for 0.7 GW has been included in all calculated variants.
- The outcome of the cumulative calculations is used to determine which species are most critical. Numbers of victims per bird species or numbers of disturbance days for marine mammals do not in themselves provide a clear picture of the seriousness of the impact (after all, one species is more resilient than another), while the cumulative effect at population level does provide this picture.
- At this stage of making spatial reservations for future windfarms, environmental impacts are assessed on a strategic level for the additional draft NSP 2022-2027. A number of environmental aspects are not taken into account at this stage. There may be a number of reasons for this: the potential impact is limited, the knowledge required is so specific that it can only be taken into

account later at the stage of site decisions, or knowledge gaps make it impossible to reveal distinctive aspects between the areas. Therefore the impact on archaeology, sand extraction, pipes and cables, unexploded ordnance; aviation and the negative impact on bats, fish and seabed fauna has not been considered at this stage. These aspects will be investigated during the follow-up process leading to site decisions.

- The impact assessment of the southern section of Hollandse Kust (west) is based on the SEA Site VI Wind Farm Zone Hollandse Kust (west) (2020) and the SEA considering the National Structural Vision on Offshore Wind Energy Hollandse Kust (2014). This subarea was included when determining the cumulative ecological effects of all search areas. The same applies to the already planned sites in Hollandse Kust (west), since all wind farms planned in the framework of the Roadmap 2030 were taken into account in these cumulative calculations.

The table below lists the environmental aspects according to which areas 1, 2, 5 east and IJmuiden Ver north and the southern section of Hollandse Kust (west) are assessed in this supplementary SEA. An assessment was carried out both for the individual search areas and all areas together (cumulative impact).

Table S1 Environmental aspects Supplementary SEA

Environmental aspect	Explanatory notes
Wind energy power & avoided CO_2 emission	Wind energy power per search area assuming 10 MW/km^2. To a considerable extent, the installed wind energy power determines the quantity of avoided CO_2 emissions
Nature	Various notes for updating the KEC were used to determine the impact on birds, marine mammals, eco-systems for this supplementary SEA and the supplementary Appropriate Assessment. This supplementary SEA takes the following aspects into account: • Bird victims due to collisions and/or habitat loss in various species • Impact of underwater noise on marine mammals (harbour porpoises, common seal and grey seal) • Impact on conservation objectives for Natura 2000 areas (birds and marine mammals), impact on bats, fish and benthos • Qualitative assessment of ecosystem impact (e.g. destratification) • Potential for seabed fauna if future wind farms become inaccessible for seabed disturbing fishery. For negative impact on bats, fish and seabed fauna, there is no or very limited impact and/or there are knowledge gaps as a result of which given the current level of knowledge, no or little distinction can be made between the search areas.
Fisheries	(In)direct socioeconomic consequences for fisheries based on research by Wageningen Economic Research (Deetman et al., 2020).
Shipping	Consequences for shipping based on the vision of the *Scheepvaart Adviesgroep Noordzee* SAN (Shipping Advisory Group North Sea), MKEA study[4] and a quantitative risk analysis by MARIN.
Mining	Qualitative assessment whether search areas have an impact on mining (e.g. current and future gas fields and infrastructure) based on the current permits for exploration and production, platforms and pipelines.
Defence	Consequences for military exercise areas

To express the impact per area, use has been made of a five-point scale from highly negative (--) to negative (-), neutral (0), positive (+) and highly positive (++). Negative and positive should be interpreted

[4] Additional analysis of the economic impact of design variants on the North Sea up to 2040/2050, Wageningen Economic Research (Roebeling et al.), June 2021.

as: compared with the reference situation for that specific area. As the case arises, a score can also be allocated that is between the two scores referred to above, for example (0/-) or (-/--). Areas are compared with each other on each aspect in the assessment, a score of (--/-) means that an area has more negative impact than an area with a score (-) or (0) on that aspect. The scale of the scores can differ per aspect. When assessing ecological impact: a highly negative (--) score can only be given when the considered plan is exceeding (working) standards, according to the performed calculations.

4. Outcome of environmental impact assessment

4.1 Main points of the impact assessment

The main points of the impact assessment for each aspect are listed below. These are then followed by summary tables and an explanation of the impact assessment for each (sub) aspect.

- **Avoided CO_2 emissions.** Production of 10.7 GW of wind energy in the search area will result in a reduction of 29 Mton CO_2 per year.
- **Cumulative ecological impact.** Cumulative impact has been calculated for a number of breeding birds, sea birds (non-breeding birds) and migratory birds sensitive to habitat loss or whereby collision victims can occur, and for seals (grey seal and common seal) and for harbour porpoises. These were assessed against working standards at population level.
    - For the majority of species, at population level, the development of 10.7 GW will remain within the working standards for all combinations of the search areas examined. However, this does not apply to the northern gannet and the European herring gull. For these species, the working standards are exceeded both in respect of the three calculation variants and for the reference situation. However, there are uncertainties with respect to this outcome that will have to be investigated in the short term. It cannot be stated with any certainty with regard to the black-legged kittiwake and the great black-backed gull whether the cumulative impact remains within the working standards. The calculated variants for 10.7 GW and 12.7 GW do remain within these standards, but for other distributions within the available space, further calculations will be necessary.
    - For the grey and common seal, the development of all variants remains within the working standard for every combination of search areas, at a noise standard of SEL_{SS} (750 m) = 168 dB re 1 μPa^2s.
    - For the harbour porpoise, this only applies with a noise standard of SEL_{SS} (750 m) = 160 dB re 1 μPa^2s.
- **Ecosystem impact and opportunities for seabed fauna.** The risks of ecosystem impact are estimated to be highest in area 5 east. There are however numerous knowledge gaps. It is recommended that priority be given to research in and around area 5 east. There are opportunities for seabed fauna in all areas, if forms of seabed-disturbing fishery are excluded. Area 5 east offers the greatest opportunities.
- **Shipping** The impact on shipping will be minimal, subject to a number of conditions. Firstly, sufficient safety margins must be maintained. Secondly, space will be required for clearways from IJmuiden to the UK (through area 1 and IJmuiden Ver (north)) and to the Baltic Sea (along the periphery of area 5 east). Thirdly, sufficient mitigating measures will have to be taken to limit safety risks to shipping.
- **Fisheries.** The impact on fisheries will result in income losses totalling € 5.5 million per year; based on historical data and calculated according to utilisation of all investigated search areas (space for 16.7 GW).

- **Mining.** The impact on mining applies to specific areas; in particular in area 2 north it may be necessary to install less wind energy.
- **Defence.** Impact on defence is excluded because defence exercise areas will be kept clear of wind farms.

4.2 Summary tables

Below are two tables: one showing the outcome of the impact per area as a whole (with and without mitigating measures) and the second showing the relative impact, in other words per GW. The impact per GW can only be determined for the (sub) aspects for which a quantitative assessment has been made of the impact. These are the (sub) aspects: wind energy power and avoided CO_2 emissions, birds, marine mammals and fisheries. Below the tables, explanatory notes are provided for each environmental aspect. These explanatory notes discuss the impact per area and per GW, the (cumulative) impact of the total proposed plan and the mitigating measures.

It is useful to point out in this respect that the aim of this assessment is to allow comparison between the individual areas. In that sense, a score (-) for an area indicates only that areas with score (0/-) have less impact and areas with a score (-/--) have a greater impact. In other words, the scores reflect a degree of impact for that specific aspect. A score (-) on one aspect cannot be compared with a score (-) on another aspect. There is no standard based assessment for each area. Such an assessment is only carried out for all the areas together.

Table S2 Assessment of the impact of wind farms in search areas without mitigation and subject to full utilisation. Note that more space is utilised than necessary for 10 GW + 0.7 GW. The score between brackets is the impact assessed with mitigation, and is only mentioned if the score changes due to mitigating measures). Wherever possible, use is made of a quantitative assessment

	Area 1 (6 GW)	**Area 2 (4 GW)**	**Area 5 east (4 GW)**	**IJmuiden Ver north (2 GW)**	**Southern section HKW (0.7 GW)**
Assessment for wind energy power and avoided CO_2 emission	++	+/++	+/++	+	0/+
Assessment for birds					
Collision victims great black-backed gull	-/--	-/--	-/--	-	0/-
Collision victims European herring gull	-/--	-	-	0/-	0/-
Collision victims black-legged kittiwake	-/--	-	-	-	0/-
Collision victims northern gannet	-/--	-/--	0/-	-	0/-
Collision victims migratory birds	-/--	-/--	-/--	-	0/-
Habitat loss common guillemot	-/--	-	-	0/-	0/-
Habitat loss razorbill	-/--	-	-	-	0/-
Assessment for marine mammals[5]					

[5] The number of animal disruption days for common and grey seals is calculated assuming a noise standard of SEL_{SS} (750 m) = 168 dB re 1 μPa^2s. For harbour porpoises, a stricter noise standard is applied, namely SEL_{SS} (750 m) = 160 dB re 1 μPa^2s for the construction of wind farms from IJmuiden Ver (including IJmuiden Ver). If the 160 dB standard is also applied for seals, the number of disruption days will be fewer.

	Area 1 (6 GW)	Area 2 (4 GW)	Area 5 east (4 GW)	IJmuiden Ver north (2 GW)	Southern section HKW (0.7 GW)
Number of animal disturbance days harbour porpoise	-	-	-/--	0/-	0/-
Number of animal disturbance days common seal	-	-/--	-/--	-	0/-
Number of animal disturbance days grey seal	-	-/--	-	-	0/-
Assessment for ecosystem impact	0/-	0/-	-	0/-	0/-
Assessment of potential areas for seabed life following exclusion of seabed-disturbing fisheries in wind farms	+	+	++	+	+
Assessment for shipping	- (0/-)	- (0/-)	- (0/-)	- (0/-)	- (0/-)
Assessment for fisheries in income	- -	-	-	-	0/-
Assessment for mining	0/- (0)	- - (0)	- (0)	0/- (0)	0/- (0/-)
Assessment for Defence	0	0	0	0	0

Table S3 Relative assessment of search areas (impact per GW) without mitigation and subject to full utilisation. Note that in total more space is utilised than necessary for 10 GW + 0.7 GW

Relative assessment	**Area 1 (6 GW)**	**Area 2 (4 GW)**	**Area 5 east (4 GW)**	**IJmuiden Ver north (2 GW)**	**Southern section HKW (0.7 GW)**
Assessment for wind energy power and avoided CO_2 emission	++	++	++	++	++
Assessment for birds					
Collision victims great black-backed gull per GW	-	-	-/--	-	-
Collision victims European herring gull per GW	-	-	-	-/--	-
Collision victims black-legged kittiwake per GW	-	-	-	-	-
Collision victims northern gannet per GW	-	-	-	-/--	-/--
Collision victims migratory birds per GW	-	-	-	-	-
Habitat loss common guillemot per GW	-/--	-	0/-	-	0/-
Habitat loss razorbill per GW	-	-/--	0/-	-/--	-
Assessment for marine mammals					
Number of animal disturbance days harbour porpoise per GW	0/-	0/-	-/--	-	-
Number of animal disturbance days common seal per GW	0/-	-/--	-/--	0/-	0/-

Relative assessment	Area 1 (6 GW)	Area 2 (4 GW)	Area 5 east (4 GW)	IJmuiden Ver north (2 GW)	Southern section HKW (0.7 GW)
Number of animal disturbance days grey seal per GW	0/-	-/--	-	-	-
Assessment for fisheries in income per km^2 per year	-	-	0/-	-	-/--

4.3 Assessment of the aspect wind energy power & avoided CO_2 emission

The more power installed, the more electricity can be generated and the more CO_2 emissions can be reduced. Area 1 with 6 GW achieves a very positive score (table S1.2). Areas 2 and 5 east with 4 GW achieve a positive to very positive score (+/++), IJmuiden Ver north with 2 GW scores positive (+) and the southern section of Hollandse Kust (west) scores slightly positive (0/+). If we look at the impact per GW (table S1.3), the search areas achieved the same scores (++), because they each generate approximately the same amount of electricity per GW.

If 10 GW are installed in the areas, across all the areas approximately 46,000 GWh will be generated annually, using wind turbines. Roughly speaking this equates to a reduction of 29 Mton of CO_2 emissions, which would otherwise have been released if the same electricity were generated according to the current mix of electricity production primarily from coal and gas-fired power plants. At this stage, there are practically no differences between turbines in terms of electricity generated in the different areas; in the further elaboration, such discrepancies may emerge as a result of differences in wind supply, wind farm layout, turbine type, etc.

4.4 Assessment for the aspect nature

Birds

The calculations of cumulative impact on populations (see below) show that the black-legged kittiwake, the great black-backed gull, the European herring gull and the northern gannet are most critical in terms of collision victims. The black-legged kittiwake and the great black-backed gull are shown to meet the working standard in calculating the 10.7 and 12.7 GW calculation variants, but not for the 16.7 GW calculation variant. Neither the European herring gull nor the northern gannet meet these standards. However, in respect of these species, there are specific uncertainties about the density map for the European herring gull and the avoidance percentage for the northern gannet. These figures will be further investigated. In calculating the reference situation, working standards for these two species are also exceeded.

For bird species sensitive to habitat loss, the cumulative calculations at population level do not show any exceeding of the working standards so that the conservation status is not threatened. The majority of victims occur within the razorbill and the common guillemot populations. For migratory birds calculated in updating the Ecology and Cumulation Framework, to date, no standards have been exceeded.

If the search areas are considered individually, there are differences in numbers of victims between the areas, but areas with fewer or more victims differ for each critical species. At first glance, area 1 would appear to be the source of most victims, but (with space for 6 GW) it is also the largest area. Per GW, the score for IJmuiden Ver north is slightly poorer than for other areas. Nevertheless, following further research into the underlying density map, this conclusion may change for the European herring gull.

Collision victims and habitat loss per area

Below the impact scores are listed per area for the most critical species:

- For the collision victims for the most critical species and habitat loss, area 1 achieves a very negative score (-/--).
- Area 2 achieves a very negative score (-/--) for the collision victims great black-backed gull, northern gannet and migratory birds. For the collision victims European herring gull, black-legged kittiwake and habitat loss for the common guillemot and razorbill, area 2 achieves a negative score (-).
- For the collision victims great black-backed gull and migratory birds, area 5 achieves a very negative score (-/--). For the collision victims European herring gull, black-legged kittiwake, habitat loss for the common guillemot and the razorbill, area 5 east achieves a negative score (-) and for the collision victims northern gannet a slightly negative score (0/-).
- IJmuiden Ver north achieves a negative (-) score for the collision victims great black-backed gull, black-legged kittiwake, northern gannet, migratory birds and habitat loss for the razorbill. For the collision victims European herring gull and habitat loss for the common guillemot, IJmuiden Ver north achieves a slightly negative score (0/-).
- The southern section of Hollandse Kust (west) achieves a slightly negative score (0/-) for the most critical species and habitat loss.

Collision victims per GW

Below the impact scores are listed per GW for the most critical species:

- For the great black-backed gull, area 5 east achieves the most negative score per GW (-/--) while the score for the other areas is slightly better (-).
- The majority of European herring gull collision victims per GW fall in area IJmuiden Ver north (-/--). The other areas achieve a slightly better score (-).
- With regard to the black-legged kittiwake, there are relatively few differences in the number of collision victims per GW; all areas achieve a negative score (-).
- For the northern gannet, the majority of collision victims per GW occur in IJmuiden Ver north and the southern section of Hollandse Kust (west); both areas achieve a (-/--) score. The other areas achieve a better score (-).
- According to the calculations, wind farms in areas 1 and 2 cause most habitat victims among the common guillemot and razorbill; as a result they achieve the worst score of all areas. The lowest impact is expected in the southern section of Hollandse Kust (west); (score 0/-).

Mitigating measures

The impact of bird collisions is such that without mitigating or nature-enhancing measures, the favourable conservation status cannot be guaranteed for a number of bird species. For those birds for which the working standards are or could be exceeded, at present there are no mitigating measures although nature-enhancing measures may be taken. This will not so much reduce the impact of wind farms on numbers of victims, but will help strengthen vulnerable populations. It is difficult to express the impact of these measures in the assessment; further research will be needed into the expected impact and feasibility of nature-enhancing measures. Moreover, these measures are of benefit to all search areas.

There is of course the possibility of not designating those areas with the greatest impact on the named species at this time, or in the future to not utilise them or to utilise them to a lesser extent for wind energy, and instead to make more use of areas with lower impact. However, these are not the same areas for the different species.

Marine mammals

The cumulative calculations reveal that disturbance days due to pile driving noise will not result in any impact on the population of common and grey seals. As a consequence, the favourable conservation status is not threatened for seals, and significant negative impact on Natura 2000 areas subject to conservation objectives for seals can be excluded. The situation for harbour porpoises is different, and depends on the noise standard to be imposed. At a standard of SEL_{SS} (750 m) = 168 dB re 1 μPa^2s, it is not possible to guarantee that the imposed ecological standard will be met; there is a 5% probability that the harbour porpoise population will fall by more than 5% (namely 6.3% in calculation variant 16.7 GW). Significant negative impact on Natura 2000 areas can therefore not be excluded. At a standard of SEL_{SS} (750 m) = 160 dB re 1 μPa^2s, for the construction of wind farms from IJmuiden Ver (including IJmuiden Ver), the population reduction is estimated, with >95% certainty, at 2.9% (in the calculation variant for 16.7 GW) of the number of harbour porpoises on the Dutch Continental Shelf. This then will not exceed the ecological standard set for harbour porpoises. Significant negative impact on Natura 2000 areas can therefore be excluded. It is worth noting that the vast majority of disturbance days for harbour porpoises are caused by the construction of wind farms on the North Sea outside the Netherlands.

The number of disturbance days for harbour porpoises is substantially higher than the number of disturbance days for the common and the grey seal. The difference is around a factor of 10 for the common seal and a factor of 20 for the grey seal.

- For harbour porpoises, the majority of disturbance days are expected in area 5 east (score -/--), see table S1.2. The areas IJmuiden Ver north and the southern section of Hollandse Kust (west) achieve the best score in the areas under consideration (score 0/-) as they have the lowest number of disturbance days. In terms of disturbance days (and score), areas 1 and 2 are somewhere in between (score -).
- For the common seal, the majority of disturbance days are expected in areas 2 and 5 east (score -/--). The southern section of Hollandse Kust (west) achieves the best score (0/-), while in terms of disturbance days (and score) areas 1 and IJmuiden Ver north are somewhere in between (score -).
- For the grey seal, the majority of disturbance days are expected in area 2 (score -/--) and the lowest number in the southern section of Hollandse Kust (west) (score 0/-). In terms of disturbance days (and score) the remaining three areas are somewhere in between (score -).

When disturbance days per GW are viewed, the results of the assessment differ (see table S1.3).

- For harbour porpoises, the majority of disturbance days per GW can be expected in area 5 east (score -/--). Areas 1 and 2 achieve the best scores of the areas under consideration (score 0/-), due to the lowest number of disturbance days per GW. In terms of disturbance days (and score), the areas IJmuiden Ver north and the southern section of Hollandse Kust (west) are somewhere in between (score -).
- For the common seal, the majority of disturbance days per GW are expected in areas 2 and 5 east (score -/--). The other three areas have about the same number of disturbance days per GW, and achieve a considerably better score (score 0/-).
- For the grey seal, the majority of disturbance days per GW are expected in area 2 (score -/--) and the fewest in area 1 (score 0/-). In terms of disturbance days (and score) the remaining three areas are somewhere in between (score -).

Ecosystem impact

Search areas 1 and 2, IJmuiden Ver north and the southern section of the Hollandse Kust (west) are located in the sea region 'West Dutch Continental Shelf-Southern UK'. The following characteristics apply:

- Water layers are fully mixed.
- According to the model outcomes, some negative impact can be expected on primary production, as a consequence of the raised concentration of suspended particulate matter (SPM) in the upper water layers.

Search area 5 east is in the sea area 'German Bight'. The following characteristics apply:

- Stratification of water layers is common, but the degree of stratification is relatively weak.
- According to the model outcomes, there is contradictory impact, but the net effect of increased turbidity appears dominant.
- There will be a considerable delay in primary production.

Based on these outcomes, greater risks are expected in the German Bight (which includes area 5 east). According to the models (and observations), not only is this area susceptible to change; it is also the planned location for large numbers of wind farms in the German part of the North Sea. Large-scale implementation of wind energy will amplify the effect more than other types of effects. The first model results suggest that in the event of upscaling, wind farms will interact more heavily and the overall impact will be greater than the sum of the parts. This results in an additional risk in area 5 east. Based on the expert judgement, in area 5 east, a high risk is expected of ecosystem impact (-) with a lower risk (0/-) for the other areas.

Mitigating measures could be taken (for example taking into account the prevailing water flow in the wind farm layout) to reduce the impact. Further research will be required in this field as a result of which the scores for the areas remain the same, if mitigation is taken into account.

Potential for seabed fauna following the exclusion of seabed disturbing fisheries in wind farms.
All areas achieve a positive score for opportunities for the development of seabed fauna. Based on literature and expert judgement, the areas have been compared with one another. On the basis of this estimate, overall, area 5 east comes out most favourably.

In terms of species, the various areas demonstrate more differences in terms of potential. Areas 1 and 2 offer potential for the development of benthos and for honeycomb worms. Area 2 also offers potential for mussels and the possible presence of lesser sand eel. The score is positive (+). Area 5 offers considerable potential for the development of benthos with slight potential for the recovery of reef building species. The area also offers potential for mussels and is a habitat for ocean quahog. The score is very positive (++). IJmuiden Ver north and the southern section of Hollandse Kust (west) are difficult to score, and a positive (+) score has now been awarded. In the southern section of IJmuiden Ver, honeycomb worm reefs have been identified. Lesser sand eels may also be present and the area offers potential for mussels. In the southern section of Hollandse Kust (west) there are opportunities for sand mason worms and the area has potential for mussels. There is no additional cumulative impact from the designation of areas for wind energy.

4.5 Assessment for the aspect fisheries

For the fisheries sector, for all areas together a loss of income is expected of around € 5.6 million per year (in the event of utilisation of 16.7 GW). This expectation is based on a study by Deetman et al. (2020)

which reveals the economic value that the areas for offshore wind energy in the period 2030-2050 represented for Dutch fisheries in 2010-2019, and what this means for the loss of income in each area.

The assessment of the areas for the aspect fisheries is based on this study. The study shows that area 1 is the least favourable for the area as a whole and that the southern section of Hollandse Kust (west) is the least favourable in relative terms, per GW. The scores are negative (-) for area 2 (loss of income € 1.2 million per year), area 5 east (loss of income € 1.3 million per year) and IJmuiden Ver north (loss of income € 1 million per year), because fishing will no longer be possible in those areas. The highest income (loss of income € 1.8 million per year) is expected in search area 1, on the basis of historical data, and it is for that reason that area 1 achieves a very negative score (--). The southern section of Hollandse Kust (west), with a loss of income of around € 0.26 million per year, achieves a slightly negative score (0/-). The assessment per GW provides information about the loss of income per unit of surface area. For area 5 east, this score is least negative (0/-) followed by area 1, area 2 and IJmuiden Ver north, achieving a negative score (-). On this basis, the southern section of Hollandse Kust (west) is the most negative (-/--).

Loss of income for fisheries must be considered in a broader context than includes socio-economic costs and benefits in general. For individual fishermen, the above income losses can have considerable consequences if they generate their income in these specific areas. Moreover, the losses of income referred to are based on historical data. The construction of wind farms will result in changing fishing patterns. In addition, nature conservation areas will be closed to fishing, and comparable developments will take place on an international level as well. The reduction in size of fishing grounds will lead to increased fishing pressure in other areas. These displacement effects cannot be quantified at this time, and that makes it difficult to issue future predictions on the loss of income. Direct compensation is not possible. Instead it will be necessary to consider the possible mitigating measures, which also take indirect effects into account further down the chain and in fishing communities. A number of communities may benefit from employment opportunities arising from the construction and maintenance of wind farms. This could limit the socioeconomic impact but there will still be some impact on the fisheries sector. As a result, the score for fisheries remains the same, even with mitigating measures.

4.6 Assessment for the aspect shipping

In the process of narrowing down the search areas, it was decided to exclude Hollandse Kust (southwest) and (northwest) as wind farm areas, these will not be considered now or in the future. In defining the borders of search areas, account was taken of the design criteria with regard to the separation between wind farms and shipping routes.[6] In addition, reservations have been marked on the maps for future clearways. All in all, the impact of all areas combined generates an acceptable risk according to the North Sea Shipping Advisory Group (SAN), as long as sufficient mitigating measures will be taken.

The following applies to the individual areas:

- Area 1 and IJmuiden Ver (north) have risks that can be mitigated, if sufficient space is set aside for a clearway to the UK and for connection with the deep water route towards the Northern Sea Route (NSR).
- In area 2, navigation remains possible. From a shipping perspective it is recommended to avoid wind farms in search area 8.
- In planning the layout for area 5 east, further consultation with Germany will be necessary.

[6] This is based on the 'Assessment Framework for Defining Safe Distances between Shipping Lanes and Offshore Wind Farms' and the latest insights from the cumulative study *'Wind op zee 2030 Gevolgen voor scheepvaartveiligheid en mogelijke mitigerende maatregelen'* published by Marin (2019).

- Hollandse Kust (west) represents a relatively high overall risk, but the use of one additional site (HKW southern section) will ensure less fragmentation and is suitable for mitigation, because the unfavourable areas HK-ZW and HK-NW have been excluded. This makes it acceptable for the SAN.

Without mitigation, all areas receive a negative score (-). Based on the estimated risks to shipping safety, indicative measures have been mapped out, that will be further elaborated in the subsequent process. Following mitigation, the assessment of the impact in all areas is slightly negative (0/-).

4.7 Assessment for the aspect mining

With regard to mining, the total impact is the sum of all impact types per area. There is no additional cumulative impact. The following applies to the individual areas:

- Area 1 achieves a slightly negative score (0/-), because it is perfectly possible to take account of the presence of pipelines and platforms, producing fields and prospects. In addition, parts of the area are unlicenced, and it contains for the most part exhausted fields.
- The southern section of Hollandse Kust (west) achieves a slightly negative score (0/-) because the arrival of a wind farm complicates the operation of an oil field, but does not make it impossible.
- IJmuiden Ver north achieves a slightly negative score (0/-) because agreement will be needed for a producing and an undeveloped field, as well as for the presence of pipelines and a platform. Area 5 east achieves a negative score (-) because there are mining interests at several locations in the area (producing field and a pipeline). However, the actual impact will above all depend on the results of explorations because, based on those results, there may be more mining activities in the future.
- Area 2 achieves a very negative score (-/--), because of the presence of relatively large numbers of (existing) mining activities with current and potentially future platforms and pipelines that need to be taken into account.

In terms of airside accessibility, for approach and take-off procedures, an obstacle-free zone of 5 nautical miles around a mining platform with a helicopter deck must be maintained. This requirement can be deviated from if it is demonstrated that this will have no unacceptable consequences for flight safety and accessibility. This will have to be assessed and agreed for each location, and will depend heavily on the layout requirements and the conditions to be included in the site decision. For that reason, these aspects have not been considered here. This assessment will have to be carried out as part of the SEA for future site decisions.

It is possible to mitigate the impact on mining if site decisions take into account the presence of pipelines, platforms and current production areas or if there is an active search underway for prospects. This is only possible if wind farm zones are designated on a sufficiently large scale, so that parts of the zones can be excluded. Because the possibilities for wind energy can change as mining activities change (for example the installation of an additional platform for gas production or the dismantling of platforms following the end of production), a certain degree of flexibility is desirable. By increasing the size of the designated wind farm zones, this flexibility will be ensured, thereby offering capacity for the necessary customisation. For this reason, the score following mitigation is neutral (0). In the southern section of Hollandse Kust (west) there is less space for customisation, so the score remains unchanged at (0/-).

4.8 Assessment for the aspect defence

There are no military exercise areas in areas 1, 2, 5 east, IJmuiden Ver north and the southern section of Hollandse Kust (west). The score is therefore neutral (0). Areas 2 and IJmuiden Ver north also achieve a neutral score (0) because in demarcating these search areas, account was taken of the location of an exercise area and the manoeuvring space for an exercise area, respectively. For those same reasons, mitigating measures to reduce the impact are not necessary. There is no additional cumulative impact.

5. Outcome of the supplementary Appropriate Assessment

The supplementary Appropriate Assessment (appendix 2) demonstrates that the possibility of significant negative impact on the non-breeding birds northern gannet and European herring gull in Natura 2000 areas cannot be excluded. This conclusion is subject to specific uncertainties with regard to the density maps of the European herring gull and the avoidance percentage for the northern gannet. These aspects will be investigated. Significant negative impact on all other bird species can be excluded. Significant negative impact can also be excluded for bats, fish and benthos.

With a noise standard of SEL_{SS} (750 m) = 168 dB re 1 μPa^2s for the wind farms on the Roadmap 2030 including the construction of an additional 16.7 GW installed power (the proposed plan is for 10.7 GW), the possibility cannot be excluded that for the population of harbour porpoises on the Dutch Continental Shelf, the ecological standard of a maximum reduction of 5% (> 95% certainty) will be exceeded. As a consequence, according to that same noise standard, significant negative impact on Natura 2000 areas subject to conservation objectives for harbour porpoises cannot be excluded from the outset. With a stricter noise standard of SEL_{SS} (750 m) = 160 dB re 1 μPa^2s for the construction of wind farms from IJmuiden Ver onwards (including the wind farms in IJmuiden Ver), significant negative impact for harbour porpoises can be excluded, and hence also significant negative impact on the affected Natura 2000 areas.

For common and grey seals on the Dutch Continental Shelf, there will be no impact, and the assumed ecological standard will not be exceeded. Significant negative impact on Natura 2000 areas subject to conservation objectives for seals can be excluded.

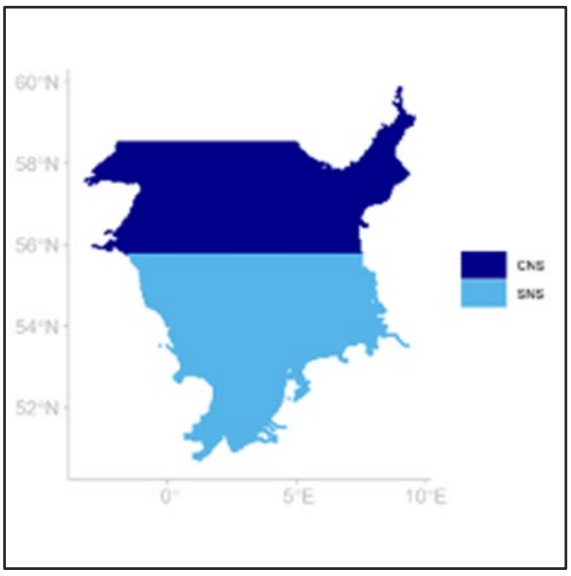
6. Cross-border impact

In terms of cross-border impact, impact is conceivable on nature, shipping safety and international accessibility. The extent to which this impact is to be expected has been investigated

Ecological impact.

The ecological cross-border impact for each sub aspect is listed below. For birds (with the exception of migratory birds) and marine mammals, the impact has been quantitatively calculated for the maximum calculation variant (16.7 GW) including planned and already existing wind farms in neighbouring countries. The results have been set against the impact on the international population, based on the Dutch (working) standards as the yardstick. The populations in the southern North Sea were considered, as demarcated in the figure below (light blue section). The other ecological aspects were viewed qualitatively.

Figure S3 Designation of the southern North Sea (light blue section)



Birds

- Significant negative impact on the calculated migratory birds are excluded, both nationally and internationally.
- Significant negative impact on achieving the conservation objectives for breeding birds in Natura 2000 areas are excluded with certainty, both nationally and internationally.
- According to the assessment of cumulative impact from the 16.7 GW calculation variant, including all international wind farm developments through to 2030, significant negative impact on the international population of European herring gull and northern gannet in the southern North Sea cannot be excluded. Significant negative impact on the international populations of the great black-backed gull and black-legged kittiwake is excluded.
- In the Natura 2000 areas Brown Bank, Seevogelschutzgebiet Helgoland, SPA Östliche Deutsche Bucht and Sydlige Nordsø, significant negative impact on the northern gannet as a non-breeding bird, and on the European herring gull as a non-breeding bird in the Natura 2000 areas Niedersächsisches Wattenmeer und angrenzendes Küstenmeer, SPA Östliche Deutsche Bucht and Ramsar-Gebiet S-H Wattenmeer und angrenzende Küstengebiete cannot be excluded.
- For all other species of calculated non-breeding birds, significant negative impact can be excluded.
- The calculations of cumulative impact on populations are based on the best available knowledge. There are uncertainties, for example about the extent to which the birds in question evade wind turbines. Specific uncertainties with regard to the European herring gull and the northern gannet are due to be investigated over the coming months. These uncertainties relate to the density map for the European herring gull and the avoidance percentage of the northern gannet.

Bats

By means of a shutdown procedure, significant negative impact on the population level can be excluded. Achieving the conservation objectives in Natura 2000 areas designated for bats is not at risk.

Fish and benthos

- Impact due to pile driving noise and seabed disturbance is temporary and local. Underwater noise can be mitigated during the construction phase. Although there are risks during the construction phase, in the event that seabed-disturbing fisheries are excluded, there are in fact opportunities

for nature recovery. Taking account of the temporary nature of the impact, it is not likely that fish and benthos communities in the North Sea will suffer any significant negative impact. Further research will be needed to gain a greater insight into the impact.
- Significant negative impact on achieving the conservation objectives for protected habitat types and Habitats Directive species in Natura 2000 areas can be excluded with certainty, both nationally and internationally.

Marine mammals

- In the period 2016 - 2030, disruption contours in a number of search areas may exceed borders with neighbouring countries during the construction of wind farms. The wind farms in question are Borssele, search area 1, IJmuiden Ver and search area 5. None of these search areas demonstrate any overlap of the disruption contours with foreign Natura 2000 areas subject to conservation objectives for harbour porpoises or seals. In other words, for these three species there is no evidence of a direct external effect (not even temporarily).
- The calculations reveal that there will be no impact from wind farm construction in the period 2016 - 2030 on common and grey seals on the Dutch Continental Shelf. The seals on the Dutch Continental Shelf are part of the international population of Dutch, German and Danish Delta waters and the Wadden Sea. Cross-border impact on the total population can therefore be excluded. Cross-border impact from the construction of wind farms on the Dutch Continental Shelf on British populations of common and grey seals can be excluded. Although there is some exchange between (in particular grey) seals between the United Kingdom and the international Wadden Sea and the Delta area, the numbers are so small that the probability that seals from these populations will be disturbed is negligible.
- Impact on the total harbour porpoise population cannot be excluded. Based on the starting points employed, it has been calculated that the North Sea population may shrink by a maximum of approx. 12%. Of this total, 3.1-3.9% will be due the construction of wind farms in the Dutch section of the international North Sea, which equates to a reduction in the total North Sea population of 0.4-0.5%. In respect of these results, it should be noted that the total impact of the international scenario on the North Sea population may have been overestimated. The estimated impact is above all a consequence of the relatively large contribution from the construction of wind farms in the United Kingdom. This is because in the construction of wind farms in the United Kingdom, no noise reduction measures are taken. As a result, the Aquarius 4 model has calculated disruption distances of more than 50 km, with very large numbers of disrupted harbour porpoises. It is unlikely that disruption distances of this kind are realistic, also because they are based on worst-case assumptions of sound frequencies from which marine mammals suffer nuisance. Further research will be needed into these aspects.

Shipping

The safety of shipping is safeguarded by:

a) Application of safety distances according to the assessment framework for defining safe distances between shipping lanes and offshore wind farms.
b) Reservation of space for various clearways.
c) Mitigating measures to be taken.

By reserving space for a clearway through IJmuiden Ver north and area 1 for shipping traffic between IJmuiden and Newcastle, the North Atlantic Ocean and the deep water route, international accessibility can be safeguarded. International coordination on these aspects will be pursued. For shipping safety,

conditions are imposed on the width of the clearway: at least 6,400 metres through IJmuiden Ver north and at least 7,400 metres through area 1 due to the continued presence of a mining platform.

To the northwest of area 5 east, space will be reserved for a clearway to the Baltic Sea. Area 5 east shares its southern boundary with the East Friesland route, which also borders wind farms planned on the German side. The safety margin to be applied between this wind farm zone and the shipping route will be further aligned with Germany during the routeing process. At present, Germany has maintained a greater safety margin on the southern side as an extension to area 5 east.

For the longer term, indications have been issued for a future Northern Sea Route. The location of this route will be discussed among others with Germany and Denmark.

7. Recommendations and gaps in knowledge

The impact assessment has delivered the following recommendations:

Non-ecological aspects

1. If the search areas are designated for wind energy, they can be closed off to (the majority of) commercial fisheries. This will result in a loss of income for the fisheries sector. Direct compensation is not possible. Consideration will have to be given to possible (mitigating) measures, taking into account indirect chain effects and effects on fishing communities as well. The affected local economies may benefit from measures that result in more employment opportunities relating to offshore wind energy.
2. Shipping: for safe shipping, mitigating measures will have to be further elaborated and subsequently taken. The measures already initiated for the Roadmap 2030 can be taken as the starting point. With regard to area 5 east, for the precise layout of the sites in the wind farm zone, agreement will have to be reached with Germany on the safety margins to be employed. It will also be necessary to further elaborate the spatial reservations for clearways in consultation with the neighbouring countries. This relates to a sufficiently wide clearway from IJmuiden to the UK and to the connections with the Northern Sea Route and a clearway to the Baltic Sea.
3. Mining: in identifying the sites in wind farm zones, account will have to be taken of present and future mining activities. The same applies to consultation about the approach and take-off procedures. By designating larger wind farm zones than strictly necessary for 10 GW, the necessary possibilities will be created.

Ecological aspects:

1. Birds:
    a. In respect of the conclusions for the European herring gull and northern gannet, there are uncertainties still to be investigated (density map for European herring gull and avoidance percentage for the northern gannet). There are also uncertainties regarding avoidance percentages of various other bird species. Further research will be necessary.
    b. It is also possible to take nature-enhancing measures, to reduce the impact of wind farms on the population.
    c. It is also possible to not designate those areas that have the greatest impact on the individual species, for use for wind energy. However, the extent of effects in the search areas considered differ for the various critical species. If multiple areas become unavailable, this could mean that the CO_2 reduction target of 55% will not be achieved by 2030.

2. Harbour porpoises: further research to reveal the possible presence of more ecological space. Consideration could also be given to reaching agreements with surrounding countries on noise reduction measures.
3. Ecosystem impact: more research will be needed into the expected impact and mitigating measures to be able to take account of any ecosystem impact. The recommendation is to postpone the construction of wind farms in areas with a very high risk, in this case search area 5 east, and to give priority to the relevant research work in the future.
4. Seabed life: more research is needed into the opportunities for various species in the affected areas, so that these aspects are taken into account in the drafting of the Roadmap and in the site decisions.

Gaps in knowledge

The table below shows the most important gaps in knowledge and the related recommendations:

Table S.3 Gaps in knowledge and recommendations for each environmental aspect

Environmental aspect	Most important knowledge gaps and recommendations
Wind energy power & avoided CO_2 emission	N/A
Nature *Birds*	• Obtaining more information about the connection of sea birds with specific areas in the North Sea and their use of these areas • Obtaining more information about migratory birds and migration routes • Obtaining more information about the impact of habitat loss and acclimatisation • Obtaining more information about avoidance percentages and collision risks • Gathering measurements from birds with GPS loggers, to make model calculations more reliable. In the absence of data, always assume worst case • Elaborating nature-enhancing measures to make populations more resilient.
Marine mammals	• Investigating possibilities taking into account the auditory sensitivity of harbour porpoises and the processing of frequency weighting in acoustic models: use of frequency weighting can result in far lower calculated disruption areas • Gathering and using data on seasonal variations in the distribution of harbour porpoises • Using data on the sub population • Translating harbour porpoise disruption into impact on vital rates • Supplementing assumptions on population development and demographic parameters (harbour porpoises) in the model • Gathering more information on the impact of alternative foundation methods and other underwater noise disruptions from operational wind farms
Other nature	• Broadening and deepening the knowledge base for ecosystem impact, including model (outcomes) and potential mitigating measures • Expanding knowledge on the impact of continuous underwater noise (management and maintenance movements in the operational phase) on seabed life, fish, marine mammals and birds • Obtaining more clarity on the biogeographical population number of expected victims among migratory bats • Obtaining more clarity on the impact of magnetic fields from undersea power cables on marine mammals, seabed life and fish • Obtaining more clarity on the presence of protected migratory fish species further offshore in the North Sea • Conducting additional research to gain a greater insight into the impact of noise disruption on fish species in the North Sea • For seabed life, in future stages in the process, a huge volume of new knowledge will be made available from already started studies and studies to be started in the future. It is recommended that the opportunities that exist for seabed life in the

Environmental aspect	Most important knowledge gaps and recommendations
	further elaboration of locations on the Roadmap and in site decisions be taken into account.
Fisheries	Given the numerous developments simultaneously facing the fisheries sector at the same time (e.g. Brexit, closure of nature conservation areas and climate change), the impact of the closure of wind farms cannot as yet be accurately predicted. This fact restricts the quantification of this impact on fisheries (in 2030-2050). Further research will be needed to gain a greater insight. It is also necessary to investigate the possible measures for mitigating the impact on the fisheries sector and fishing communities.
Shipping	Concluding quantitative and cumulative risk analyses necessary for the further elaboration of the Roadmap, during the allocation of sites, in further identifying the necessary mitigating measures and in the elaboration of routeing measures, such as clearways, routes and corridors
Mining	Discussion with the mining sector on the further layout of sites in site decisions on the extent to which new areas for production will be located. Investigating whether platforms can be reused for CO_2 storage
Defence	N/A