Review KEC 5.0 - Findings and recommendations

Report – final

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Contents

1 Introduction

Rijkswaterstaat Zee & Delta has asked Kate Searle (animal ecologist at the UK Centre for Ecology & Hydrology) and Saskia Mulder (marine ecologist at Seawhistle Advice in Norway) to review the KEC 5.0 documents. The objective of this review is to check the methodologies used in the various background reports, check the coherence between the reports and to assess whether there are important missing issues that should be included. The findings and recommendations will be used to improve the KEC instruments and to draft KEC 6.0.

In Section 2 the general findings and recommendations of all KEC documents are drafted. It gives insight in our findings on the used methodologies, the coherence between the reports and the missing issues. The section concludes with an overview of the general recommendations. The subsequent sections describe the results of the review of the various KEC documents. Every section starts with some general findings and recommendations. The subsequent paragraphs provide a detailed, paragraph-level analysis of the findings and recommendations. When there were no review comments in a section or paragraph, this section is not mentioned. Every paragraph has two numbers: the number of the current report and the number of the paragraph in the KEC document, thereby providing clear reference to the corresponding sections.

The level of detail of the review is not the same for all reports, because the background of the reviewers is different. Kate is an animal ecologist and has focused on the Birds – Habitat loss report, the bird sections in the Marine Strategy Framework Directive report and the Part A report. Saskia is a generalist in the field of marine ecology; she has reviewed all documents except the Birds – Habitat loss report. The level of detail of the review of these reports is less in-depth than the review that has been executed by Kate.

2 General findings and recommendations

2.1 Findings

2.1.1 Methodologies

The methods used seem well-considered and the advantages and disadvantages of every method are clearly articulated in all reports. The distinctions from KEC 4.0 are clearly presented.

The review on the report Birds - habitat loss includes a set of recommendations on the methodology that could contribute to improved outcomes and more robust assessments in future analyses.

2.1.2 Coherence between the reports

The Part B reports focus on different species/ subjects but roughly have the same set up. The most important aspect of coherence lies between the Part A report and the Part B reports. The Part A report provides insight into KEC as an instrument, including its scope and underlying assumptions. In our opinion the Part A report lacks a concluding section on the results and conclusions of the Part B reports. It is currently unclear what the implications of the findings in these reports are for the Roadmap, and what actions are being taken based on the results. This aspect is not addressed in the separate reports and therefore it would be reasonable to expect this to be addressed in the Part A report.

2.1.3 Missing issues

On a general level no missing issues are identified.

2.2 Recommendations

General recomendations are:

- Add a section in the Part A report what the implications of the findings in the Part B reports are for the Roadmap, and what actions are being taken based on the results.

3 KEC 5.0 Part A: Framework for Assessing Ecological and Cumulative Effects 5.0

3.1 General

The emphasis within the framework on the need to examine cumulative effects, whereby specific activities accumulate to produce larger or more damaging ecological and environmental impacts is important and places the framework at the forefront of other legislative approaches of which we are aware. This legislative requirement to consider both in-combination (i.e. multiple OWFs) effects as well as impacts from other stressors has identified knowledge gaps, which has led to the development of research programmes, both in the Netherlands, and in other geographically relevant countries such as the UK and Norway.

The development of the KEC to be consistent with use within a broader Cumulative Effects Analysis (CEA) is key to delivering this cumulative, ecosystem approach to assessing impacts from OW developments. We agree that the overarching focus of the KEC should be on the effects of OWFs on protected species, using best available science and models to estimate such impacts at the population level. This is consistent with legislative requirements for maintenance of the integrity of protected species as features of protected areas, and for the overall species network. It is also consistent with the wide degree of variation in the empirical evidence available for assessing OW impacts (and those of other stressors) at the species population level, in contrast to the wider ecosystem. Generally, good empirical evidence and modelling methods exist for determining OW impacts on protected species, particularly for well-studied seabird species. However, evidence pertaining to OW impacts on the wider ecosystem, and for estimating how OW impacts on lower trophic levels may propagate up to affect higher trophic levels such as seabirds and marine mammals is at an early stage of development. Therefore, the described separation and focus on species-level effects within the KEC, combined with a wider, perhaps more qualitative assessment of environment impacts seems appropriate for the current state of knowledge (e.g., alongside the development of the VECI approach for strategic assessments, particularly relating to future OW plans).

It is welcome to see the recognition that calculating cumulative effects of an OW development roadmap at an early stage is key to identifying and therefore mitigating or preventing significant negative cumulative effects on protected species. As noted, this approach also serves to highlight key knowledge gaps leading to large uncertainties in OW effects, potentially leading to very precautionary approaches to consenting. Identifying these gaps early on should promote the development of new evidence to reduce uncertainties, improving estimates of OW effects, and facilitating the roll out of developments to meet national renewable energy targets. Where such negative effects remain significant, this early assessment of cumulative effects for a development roadmap can also serve to identify key species and populations for which mitigation or compensatory measures may be required. Such early identification will be key to securing mitigation and compensation approaches that are effective in offsetting impacts. A critical component in successful mitigation will likely involve a strategic approach to delivery of mitigation and compensation. Such an approach would allow individual developments to share financial and technical burdens of mitigation. However, a strategic approach would also allow regulators to monitor and assess how effective proposed and on-going mitigation measures are in delivering to offsetting regional and national OW impacts, thereby ensuring that significant impacts on protected species and their networks are properly addressed.

Key to the successful implementation of the KEC lies in regular updating of the knowledge base and associated models and tools, so the description of the annual review process is very welcome (i.e. reviews between KEC 5.0 and 6.0). It is particularly important that regular review of relevant species to be considered in assessments occurs – even though some species may have

distributions that currently show little overlap with proposed developments, it is very likely that the distributions of many species will shift in coming decades alongside climate-driven changes to marine ecosystems.

The Part A report lacks a concluding section on the results and conclusions of the Part B reports. It is currently unclear what the implications of the findings in these reports are for the Roadmap, or what actions are being taken based on the results. This aspect is not addressed in the separate reports and therefore it would be reasonable to expect this to be addressed in the Part A report.

KEC is a living instrument that is regularly updated in line with new scientific knowledge of importance regarding the ecological themes in the framework, or new policy decisions regarding marine spatial planning developments on the North Sea. As said before this is the key to the successful implementation of the KEC. This may be the reason that some parts of the Part A report present challenges in readability, which could affect the clarity of the overall message. Implementing a comprehensive editorial review could substantially enhance the clarity and overall quality of the report.

Recommendations:
- Regular reviews of relevant species should take into account that the distributions of many species will shift in coming decades alongside climate-driven changes to marine ecosystems
- Add a section that elaborates on the implications of the findings in the Part B reports for the Roadmap
- Conduct a comprehensive editorial review to enhance the clarity and overall quality of the report

3.2 1. Introduction

It would be good to add a short paragraph to introduce the ecological threshold, it is now suddenly mentioned in paragraph 1.5 Structure KEC 5.0. It is also necessary to understand paragraph 2.1 better.

Recommendation:
- Add a paragraph to introduce the ecological threshold.

3.2.1 1.1 Background

'Other countries have also acknowledged the problem of identifying and assessing the effects (cumulative and otherwise) of offshore wind farms and have completed extensive research in recent years'. Reading this the question arises how KEC 5.0 is related to methods in other countries, it would be interesting to know whether similar tools are being used or not.

Recommendation:
- Elaborate on the relation of KEC 5.0 with methods in other countries.

3.2.2 1.3 Benefits of using the Framework for Assessing Ecological and Cumulative Effects

This paragraph is a bit hard to read. It seems as if a lot of thoughts are put together. What is the message of the paragraph? In my opinion:
- KEC 5.0 is a tool to check whether the Roadmap for Offshore Wind complies with the regulatory ecological conditions;
- The tool helps to get insight into the cause of exceeding ecological levels, is it caused by knowledge gaps and worst-case assumptions or ecological impact?;

- It steers the development of knowledge needed for the adjustment of worst-case assumptions to more realistic assumptions and reduce the potential effects;
- It is possible to determine in an early stage if and what mitigation measures are needed to be able to continue with the Roadmap.

Recommendation:
- Rewrite the paragraph to make clearer what the benefits of the KEC instruments are. The above-mentioned aspects could help to structure the paragraph.

3.2.3 1.4 KEC as a living document

'The VECI (Exploration of ecological cumulative impact) was therefore developed for strategic assessments'. It is not clear what the status is of this tool and how it is related to KEC 5.0. Has it been used already? Is this a Dutch tool or an international tool?

Recommendation:
- Explain the VECI tool in more detail, try to give an answer to the above-mentioned questions.

3.3 2. KEC building blocks

3.3.1 2.1 The KEC building blocks

Add a short introduction of MONS or at least explain the abbreviation.

The paragraph on the thresholds is hard to understand. First, it would help to introduce the subject in section 1. Second, describe for which species groups the thresholds are formulated. In the way it is described I think this is about the ALI for birds. But what about the 5% threshold for marine mammals? Third, be consistent; in section 4 the term ecological acceptable levels is suddenly used and later in section 4.4 the term ALI pops up.

Recommendations:
- Add a short introduction of MONS, or at least explain the abbreviation;
- Introduce the ecological thresholds in section 1;
- Describe for which species groups the thresholds are formulated;
- Be consistent in the terminology of the thresholds.

'If a new threshold is established, a run/execution of the calculations (building block 3) will always be needed'. This is unclear to me, why are new calculations needed? Is the threshold not being used as a level to check whether the outcome of the calculations is too high or not? This needs more explanation.

- Recommendation:Explain why new calulations are needed when a new threshold is established.

3.4 4. Scope and use of the Framework for Assessing Ecological and Cumulative Effects

3.4.1 4.2 The KEC calculations in relation to the legal framework

'The KEC therefore assesses the effects on the populations in the study area (DCS and international, see Section 6.2) and is not usable for assessing effects on Natura2000-area's'.
I think KEC 5.0 is usable for assessing effects on Natura 2000-areas, since marine mammals and birds are mobile and use a larger part of the North Sea than just the Natura 2000-site. An effect on population level also has an effect on the relevant Natura 2000-area. KEC 5.0 can be used to

take into account the North Sea effects on a population scale, in relation to the impact on a Natura 2000-area.

Recommendation:
- Change the text about KEC not being usable for assessing effects on Natura 2000-areas if the authors agree with that or explain in more detail why it is not usable.

'As mentioned in paragraph 4.1 KEC 5.0 looks at offshore wind farms only, not at wind farms on the coast. A later KEC update will investigate the possible ways of including coastal wind farms'.
Which OWFs are meant here, as there are no plans for coastal OWFs anymore? Or is this about other countries?

Recommendation:
- Make clear which coastal wind farms are meant here.

3.4.2 4.4 The KEC in relation to the EIAs and site decisions for offshore wind

'The realistic assumptions may differ from those in the actual site decisions since, for future wind farms, the assumptions are based on the precautionary principle and they therefore represent a realistic worst case. This implies that there may be a possible overestimation of effects. In the case of these worst-case assumptions, additional research will be conducted to produce more realistic assumptions'.
It is not clear what is meant by additional research, should this be conducted in relation to the EIA? Or will this be part of Wozep?

Recommendation:
- Make clear what is meant by additional research.

On page 20 the international scenario is mentioned for the first time, without explanation.

Recommendation:
- Add a short introduction to the international scenario in the first section.

'In the case of the international scenario, monitoring compliance involves making a comparison between the pressure of the national scenario on the population by comparison with the pressure of the international scenario on the population'.
It is not clear what is meant here, what does monitoring compliance relate to?

Recommendation:
- Make clear what is meant by monitoring compliance.

When ALI is mentioned in this paragraph, is this only about birds or also about mammals? In the next paragraph it is stated that ALI is used for birds. Does this mean that the paragraph about exceeding ALI in the national or international scenario is not applicable for mammals? It is recommended to be more clear on this and maybe add information on the ecological acceptable level for mammals.

Recommendations:
- Make clear that the ALI is the threshold for birds;
- Add information on the ecological acceptable level for mammals.

3.4.3 4.5 The use of the KEC calculations

Most part of this paragraph also seems to focus on the use of KEC (calculations) in EIA's, maybe it could be combined with paragraph 4.4.

The part about the explanation of ALI should be placed earlier in the report, for example in paragraph 2.1

Is Figure 1 only applicable on effects on birds or also on mammals?

Recommendations:
- Combine this paragraph with paragraph 4.4;
- Move the explanation of ALI to paragraph 2.1;
- Make clear whether Figure 1 is only applicable on effects on birds or also on mammals.

3.5 5. The DPSIR method in relation to the KEC

It is not clear why this section is added. Is it meant as a reading guide for the B documents? Or is it meant as a guide for drafting an EIA? It is recommended to add the purpose of this section in the first paragraph.

Furthermore, this section seems to be quite general and not much related to the part B reports. In my opinion this section could be taken out because it does not contain a lot of information that is needed to understand KEC 5.0. The essential information in this section could be placed in other paragraphs.

Recommendation:
- Reconsider the purpose of this paragraph.

3.6 6. Assumptions for the assessment of 'offshore wind-farm areas' in the KEC

3.6.1 6.2 identification of the study area

It is not clear why the calculation of the international scenario for harbour porpoises is based on the DSC population.

Recommendation:
- Make clear why the calculation of the international scenario for harbour porpoises is based on the DSC population.

4 Ecosystem effects: Impact of offshore wind farms on the North Sea ecosystem

4.1 General

The report is well-structured and accessible. It provides a clear overview of the potential impacts on various parameters across different regions and scenarios.
It is unclear what the implications are of the findings in this report and how these are or will be used in relation to the Roadmap.

Recommendations:

- Add a paragraph that further elaborates on the implications of the findings for the development of offshore wind
- When this report is not the place to do that, refer to Part A and include it there

4.2 2. Scenario choice

4.2.1 2.2 Base scenario

The note about the assessment area running further north is unclear, what is the assessment area that is used in this study?

4.3 6. Impact on water quality and ecology

4.3.1 6.5.1 Base scenario (for KEC 2031)

The conclusion on vertical gradients does not seem to be described in the results paragraph (6.3): *'The presence of OWFs can also lead to changes in vertical gradients of chlorophyll a and temporal dynamics (timing of the spring bloom)'.*

4.4 7. General discussion and conclusions

4.4.1 7.1 Regional patterns in environmental effects of offshore wind farms

In the previous study a picture with the regional patterns was shown. There may be a good reason not to show a picture like that in this study again, but I would like to mention that it was helpful to understand the geographical differences.

I am also curious to know what it means that the current set of scenarios broadly give the same type of environmental effects due to the presence of offshore wind farms in the different regions as were identified in the previous studies. Does that mean that the conclusions have a high degree of reliability? What does this mean for the development of offshore wind?

5 Birds - Collisions: Collision effects of North Sea wind turbines on bird species

5.1 General

The report is well-structured and clearly written, despite its technical content. The methodologies and data used are described transparently and are easy to follow. The methods used seem well-considered and the advantages and disadvantages are clearly articulated. Also, the differences with KEC 4.0 are very clear.

Compared to the description of the methods and analyses, the results and conclusions are described rather concisely. The report leaves readers with unresolved questions regarding the implications of the findings.

Recommendations:

- Add a paragraph that further elaborates on the implications of the findings for the development of offshore wind
- When this report is not the place to do that, refer to Part A and include it there

5.2 2. Overview and justification of methods used

Section 2 gives a good overview of all parts of the analysis, which is necessary for other parties than Waardenburg Ecology to perform these. Since the reviewer is not an ornithologist and does not perform these analyses it is not possible to check whether this overview is transparent and complete enough.

Recommendations:

- Consult avian specialists to assess whether the same analyses can be conducted using this information

5.3 3.2 Population size and calculation of mortality fraction

5.3.1 3.2.1 Seabirds

It was stated: *'The maps by van Donk et al. (2024) were explicitly developed for the KEC 5.0, using a new approach'*. It has not been explained which new approach was used. It is probably described in detail in van Donk et al. (2024), but it would be helpful to read a short explanation in this report.

Recommendation:

- Add a short explanation on the new approach for the density maps

5.4 Interpretation of results and recommendations

5.4.1 6.2 Reducing population level impacts

Different mitigation measures are discussed and set aside. But turbine shutdown on demand could effectively reduce the numbers of collisions during daytime. The report does not further elaborate on this aspect, despite it being, in my view, one of the most critical issues in relation to offshore wind development. Can any conclusions be drawn on the effectiveness of this measure for the relevant species? Would it be enough to mitigate the effects of the relevant scenarios, is it possible to calculate this?

Recommendation:

- When possible, give more insight into the effectiveness of the proposed mitigation measure or describe why this is not possible.

6 Birds - Habitat loss: Population level effects of displacement of marine birds due to offshore wind energy developments

6.1 General

The improvements made in KEC 5.0 are very welcome and the results are well presented and carefully visualised and explained. The following paragraphs give a detailed overview of considerations to improve the methodology further and recommendations for research.

6.2 3.2 Species selection

Regular, thorough reviews are needed to ensure that all seabird species at risk of OWF impacts are considered in the assessment. This is especially important as species' distributions are shifting, and space use is altering in response to climate driven changes to marine ecosystems. Therefore, a regular assessment of best available evidence on species distributions and overlap with operational and planned OWFs is required, as noted in the KEC. This is likely to be important for two of the species considered in KEC 4, but not in KEC 5 – northern fulmar and Atlantic puffin. This is because although these species are stated to occur in mainly the most northern part of Dutch waters, their distributions may be shifting over relatively short timescales in response to changes in prey, and because they are likely to be affected by OWFs outside of Dutch waters due to their wide-ranging distributions, particularly during the non-breeding season.

Recommendations:

- Consider including northern fulmar and Atlantic puffin in future assessments for the Dutch North Sea.

6.3 3.3 Model framework

It is notable that the potential adverse effects of OWFs as barriers to movement are currently not under consideration within KEC 5.0 due to a lack of knowledge on this subject – yet, ecologically, there will be considerable overlap between a 'loss of habitat' response and a 'barrier' response in seabirds. At its most simple, a bird that is unwilling to enter an OWF area and therefore subject to habitat loss, will also most likely suffer a barrier effect if part of its space use lies in areas where flightpaths or foraging activities are potentially impeded by the OWF location. The use of the Displacement Matrix as the sole means of assessing displacement effects on birds places a significant limitation on the ability of assessments to be made that consider both habitat loss and barrier effects. This is because the 'at risk' population of birds in the Displacement Matrix is determined by surveys of space use within and immediately around the OWF footprint. Such a method does, therefore, fail to detect birds that may not be using the OWF footprint and its immediate surroundings directly, but which are utilising habitat beyond the OWF footprint, to which access is impeded by the presence of the OWF. Given that there are now a range of alternative approaches available for assessing sub-lethal impacts of OWFs (via displacement *and* barrier effects) on seabirds, particularly a growing number of Individual Based Models (IBMs), the assessment of sub-lethal effects on seabirds should be broadened out to consider both habitat loss and barrier effects. Importantly, such IBMs can be used to assess the impacts of a single, or multiple in-combination OWFs on seabird populations, and IBM frameworks now exist for a range of species in both the breeding and non-breeding seasons.

It is also important to consider that the Displacement Matrix typically uses seasonal peak estimates of abundance derived from at-sea survey data to quantify the number of individuals at risk of displacement, which is difficult to relate to the true 'at risk' population of birds, due to the unknown hourly, daily and seasonal movements of individual birds observed in snapshot at-sea surveys. The true 'at risk' population of birds exposed to displacement effects might be expected

to be both systematically and potentially substantially larger than that used in the current Displacement Matrix approach – this is because defining the true 'at risk' population requires accounting for turnover in space use of birds at sea, e.g., by considering all individuals that ever use the windfarm footprint during a particular season or over the course of a year, whereas the Displacement Matrix definition focuses only on the number of individuals using the footprint at a particular point in time (albeit using peak abundance, amongst the points at which surveys occurred). Research is needed to address this knowledge gap, and in the breeding season would likely require new interrogation of GPS tracking data to estimate rates of fidelity in seabird species, including influence of environmental variation and seasonal variation, to be able to estimate such 'turnover' rates; and an examination of seabird time-activity budgets to understand influence of partitioning of behaviour between at-sea and colony behaviours and how this might be used to adjust at-sea survey data during the chick-rearing period. For the non-breeding period, interrogation of GLS data could aid in estimating turnover in space use in some species during this seasonal period (e.g., guillemot and razorbill).

Recommendations:

- The use of the Displacement Matrix as the sole means of assessing displacement effects on birds places a significant limitation on the ability of assessments to be made that consider both habitat loss and barrier effects. IBM approaches should be developed to overcome this limitation (e.g., HALOMAR).
- Consider adjusting bird density inputs to the Displacement matrix to account for the 'turnover' of space use in seabirds.

6.4 3.4 Input data and model parameters

The handling of data and parameter uncertainty is very welcome, particularly in relation to bird distribution maps, which are likely to contain significant uncertainty, and therefore potentially have a strong effect on impact outputs. Similarly, allowing casualty calculation parameters such as displacement rates and displacement mortality rates to vary across an estimated range allows for an improved, probabilistic approach to the treatment of uncertainty within the Displacement Matrix, which is an important addition to more standard methods. The current described approach regarding uncertainty in the displacement mortality rate could be improved further by simulating across a range of values in a more probabilistic way, in place of the presently described method of using constant, alternative values of 1%, 2%, 5% and 10%. This approach would more naturally capture the full uncertainty associated with this parameter and allow a fuller propagation of uncertainty in mortalities to be used within the PVA simulations. This would simplify outputs for end users, providing a more holistic approach without the need for comparison of alternative scenarios of different displacement mortality rates.

The use of varying boundary distances for alternative species is a welcome addition in methods for KEC 5, and this should be continuously reviewed and updated as new evidence emerges. A similar approach to uncertainty as that described above for the Displacement Mortality rate could also be used for this parameter, for instance by re-estimating the number of affected birds across a simulated range of boundary distances, particularly as new evidence emerges and studies shed light on the varying extent of displacement effects in different species.
The improvement in updating and including uncertainty in displacement rates in KEC 5 is also very welcome. Similarly, the new methods for determining population parameters are thorough and robust.

In relation to identifying source breeding populations for guillemots and razorbills observed in the southern North Sea, there is new empirical evidence on non-breeding distributions of these two species arising from a number of GLS tagging studies in the UK. Therefore, this new evidence should be reviewed and used to potentially increase the range of source populations, and associated demographic parameters used to parameterise population models in the assessment.

Recommendations:

- Uncertainty in the displacement mortality rate could be improved further by simulating across a range of values in a more probabilistic way, in place of the presently described method of using constant, alternative values of 1%, 2%, 5% and 10%.
- Replacing scenarios of alternative displacement mortality rates with a more probabilistic simulation approach would simplify outputs, thereby improving end user decision-making.
- Continuously review and update boundary distances for displacement effects as new evidence emerges.
- Improve treatment of uncertainty in boundary distances by re-estimating the number of affected birds across a simulated range of boundary distances across simulations and incorporating into results
- Review and consider new empirical evidence on non-breeding distributions and associated demographic rates for UK guillemot and razorbill populations using the Dutch North Sea.

6.5 3.5 Habituation

I agree with the conclusion that there is currently insufficient empirical evidence to conclude whether habituation is occurring in seabird species. It is also important to consider that observed use of some individuals within OWF areas may be unrelated to habituation per se, but rather related to intrinsic behavioural traits of those individuals, simply being less risk averse than other birds within the population. Such variation between individuals should ideally be captured within displacement rate estimates, but currently further research is required to better understand and parameterise both individual variation in responses to OWFs, and in levels of habituation over time.

Recommendation:

- Further research is required to better understand and parameterise both individual variation in responses to OWFs, and in levels of habituation over time. Availability of data in relation to variation in responses between individuals and to habituation should be reviewed for each future KEC. Where such evidence exists for individual species, it should be included in impact assessments via the underlying tools, whereby impacts (e.g., displacement rates or displacement mortality rates) can be modified over time according to emerging evidence (or lack thereof).

6.6 3.3.4 Uncertainty analysis

Using the described simulation-based approach to propagate uncertainty between individual assessment tools allows for a full propagation through all stages of modelling, greatly improving the transparency and clarity around uncertainty in OW impact assessments, and therefore improving the use of precaution. For example, such a simulation-based approach for propagating uncertainty should, in principle, allow application of precaution at each modelling step within the assessment process to be avoided. Propagating uncertainty through the whole process using a simulation-based approach should, therefore, allow precaution to only be considered at the final step in the chain of data and models (the PVA outputs), because the uncertainty at this final step has incorporated individual components of uncertainty from each earlier step in the assessment process.

However, there remains an important knowledge gap around developing methods to deal with the varying extent to which uncertainty is currently quantified by tools in the assessment process. For example, some components of uncertainty in the Displacement Matrix are currently dealt with in a non-probabilistic way (e.g., displacement mortality rates), and it is therefore difficult to combine with uncertainties obtained using probabilistic approaches, such as those often used in population modelling and PVAs.

Recommendation:

- More research is needed to better integrate different types of uncertainty quantification (e.g., qualitative versus quantitative) in components of the assessment process. Future KECs should include a clear summary section that describes how uncertainty quantification at each stage of the assessment process has been estimated, included and propagated. This will produce a clear roadmap for how uncertainty quantification could be improved in future KECs as new methods and data become available.

6.7 4.1 KEC assessment – Materials and Methods

The descriptions for the 'bird distribution maps', 'OWF scenarios' and calculation of 'OWF overlap' all utilise good methodology and best available data. The refinements to the Displacement matrix to use a more probabilistic approach are very welcome, and a nice advance upon previous methodology. The method could potentially be improved further by separating values used for 'displacement mortality risk' into different seasonal periods (as has been done for displacement rates), where such information is available, or via the use of expert elicitation around this variation. This would allow for a more nuanced capture of annual mortalities, rather than the current method where an annual average additional number of mortalities is derived by averaging over the casualties calculated for different bi-monthly periods ('mean number of casualties from displacement'). I think this is done because only a single, overall population size is available for each species (to convert mortalities into a rate to be used in population modelling), but it would be good if this could be made more explicit in the description. Importantly, more discussion is needed for how the use of the single 'maximum population size' derived from the predicted total number of birds on the map of the bimonthly period with the highest overall abundance for each species affects the estimate of the mortality rate used in subsequent population modelling. Particularly in relation to how the size of the denominator (N_{max}) may not reflect real monthly variation in the actual population size of birds using the area of interest relative across different monthly periods.

Recommendations:

- Consider separating values used for 'displacement mortality risk' into different seasonal periods (as has been done for displacement rates), where such information is available, or via the use of expert elicitation around this variation.
- More explicit explanation for the use of averaging over casualty estimates from different bi-monthly periods.
- More discussion is needed for how the use of the single 'maximum population size' derived from the predicted total number of birds on the map of the bimonthly period with the highest overall abundance for each species affects the estimate of the mortality rate used in subsequent population modelling.

6.8 4.1.5 Population Models

These are well described, and are appropriately designed for assessing impacts, noting the care that has gone into including various forms of stochasticity and in matching across baseline and impacts simulations. The lack of consideration of density dependence is in line with approaches taken in other countries and is presumably due to a lack of empirical data upon which to parameterise density dependent changes in demographic rates for different species and life stages.

6.9 4.1.7 Uncertainty propagation

Uncertainty has been handled thoughtfully and appropriately throughout. For future analyses, international maps are now available with uncertainty (bootstrapped samples), so this could be included in further assessments.

Recommendation:

- Consider including uncertainty in international bird distributions, now available as bootstrap samples (James Waggitt, Uni of Bangor, pers. comm.), or alternatively updated maps from the Offshore Wind Evidence for Change (OWEC) POSEIDON project - https://naturalengland.blog.gov.uk/2023/02/01/poseidon-offshore-wind-and-nature/).

6.10 4.2 Results

In general, the results are well presented and carefully visualised and explained.

6.11 4.3 Discussion

Perhaps some additional wording around the finding that populations of gannet, guillemot and razorbill are predicted to increase over time (with no OWFs) is needed. Each of these species face considerable pressures across the North Sea, including climate-driven changes to prey and increasing storm and marine heatwave events, therefore some caution around these projections is warranted.

Wider discussion of threats faced by North Sea seabirds and likelihood of potential declines in coming decades. The comparison to the previous use of ALI in KEC 4 is very helpful in this section. The section on potential inclusion of a wider range of species is important, particularly the diver species, kittiwake, fulmar and puffin. The discussion around the spatial bird distribution maps is well constructed and remains an area of likely strong improvement over the next several years as various research initiatives across a range of countries are generating revised or new seabird distribution maps for the North Sea from a range of data collection methods. The discussion around population modelling is also excellent, providing a thorough summary of the wider context and important caveats associated with the methodology.

Recommendation:

- The final statement, around modelled population trends having lower growth rates than observed trends should be substantiated.

Discussion of density dependent effects is also very helpful and includes recent literature with strong relevance to its inclusion in impact studies. It is important to highlight that this remains a key knowledge gap for impact assessments that rely on population modelling to derive impact metrics. The section on ALI methodology is again helpful, and the advance upon previous methods is welcome.

Recommendation:

- The latter section of this discussion needs more recognition and caveats around the current comparison between relative projected population sizes from the models, versus the nature conservation population targets.

Due to an inherent likelihood of potentially unrealistic population projections 40 years into the future (true of all population models in which detailed relationships between changing environmental factors and demographic processes cannot be fully captured), it does not seem appropriate to compare projected population sizes 40 years into the future with stated conservation objectives. Rather, it is more appropriate to focus on the **relative** differences between projected baseline and impacted populations, as is done in the ALI method. This has been discussed in previous literature (e.g., Cook & Robinson, 2016 - Testing sensitivity of metrics of seabird population response to offshore wind farm effects. JNCC Report No. 553, JNCC, Peterborough, ISSN 0963-8091; Cook & Robinson 2017, J Env Mgt; Jitlal et al. 2017 - Testing and

validating metrics of change produced by population viability analysis, Scottish Marine and Freshwater Science, 8: 210).

The discussion section on behaviour in response to OWFs is excellent, providing a nice summary of the wider context.

Recommendations:

- The latter section of this discussion needs more recognition and caveats around the current comparison between relative projected population sizes from the models, versus the nature conservation population targets. Therefore, this last section should be revised according to the above comments around population projections and the importance of focusing on relative comparisons between impacted and unimpacted population forecasts, not absolute forecasts.
-
- The last paragraph in section 4.3.9 (Ecological changes) is a key point to emphasize. The section on technological developments OWFs is a nice summary.

6.12 5. HALOMAR

The development of a non-breeding season IBM is an important advancement in refining estimates for impacts of displacement on seabirds. Knowledge and empirical evidence for non-breeding season distributions, time-activity and behaviour and energetics is accumulating for a number of seabird species, meaning that developing and parameterising a non-breeding season IBM should be a key focus for research and subsequent integration into assessment methodologies and guidance.

The HALOMAR model is a nice development and is distinct from other non-breeding season IBM approaches in its underlying methodology (e.g., Layton-Matthews et al, 2023). OW impacts are estimated via model fitting through the 'maintenance' parameter I the baseline scenario, and then through two scenarios about the effects of OW in foraging – firstly, by avoidance of OW locations for foraging, and secondly, through zero food intake on days when birds encounter OWFs at their chosen location.

Bird distribution maps are used to imply food availability – in common with other IBM approaches where empirical knowledge of prey is lacking. The IBM is simpler in structure than some of the breeding season IBMs that have been developed, as is appropriate for a time of the year for which there is less ecological knowledge and empirical data available for model parameterisation.

The sensitivity analysis is very useful in understanding the robustness of the model, and in highlighting key parameters for targeting in future research.

The summary of the model results and directions for future improvements is comprehensive and should be a key focus leading up to the next KEC. Capitalising on the IBM approach to more fully simulate over unknown parameters, such as reductions in foraging when displaced, will likely improve the realism of model outputs. Relating bird distribution to habitat quality (i.e. food availability) is a key knowledge gap, as well as birds' capacity to alter foraging in displaced locations to compensate for any loss of access to previous habitat now occupied by OWFs. The relative simplicity of the IBM approach used here lends itself well to exploring variation in these mechanisms and combining across simulations to produce estimates for impacts with wide, but hopefully realistic uncertainty. This will certainly aid in decision-making. Similarly, building in density dependent effects, particularly via increased competition when significant numbers of birds are displaced into small regions, will add more realism to the model, and help to identify key

processes likely to be driving displacement responses in seabirds, which should then be the target for future research.

Recommendation:

- Development of the HALOMAR IBM should be a key priority for the next KEC.

7 Marine mammals - KEC 5.0. Report Part B Marine Mammals

7.1 General

The report gives a very clear and detailed overview of the background, methods and results of the calculations. The methodologies applied are thoroughly considered and robust. The conclusions are, apart from the summary, a bit hard to find in the document.

Recommendations:

- Add a paragraph that gives a clear overview of the conclusions and maybe further elaborate on the implications of the findings for the development of offshore wind or add this in the Part A report.

7.2 Summary

It is very good to have an overview of the changes in the calculations and a clear overview of the results and the conclusions at the start of the document.

The summary does not say anything about the international scenario, which is understandable but also a bit strange.

Recommendation:

- Add a conclusion on the international scenario.

7.3 4. KEC Methodology

Section 4 is a bit confusing because it is very fragmented. It would be easier to read when all paragraphs on piling can be read after each other and then the paragraphs on geographical surveys and the paragraphs on UXO clearances. This may also count for section 5

Recommendation:

- Restructure the section by putting all information on piling together and not fragmented. This also counts for geographical surveys and UXO clearances.

7.4 5. KEC Calculations

Recommendation:

- Restructure the section by putting all information on piling together and not fragmented. This also counts for geographical surveys and UXO clearances.

7.4.1 5.3.1 Calculation of animal disturbance days

It is not very clear what the different ‘curves’ (scenarios?) in table 5.4 mean, there is some explanation in the text before and after the table, but why are Brandt et al. and Graham 1st pile + max. 26 km taken into account?

Recommendation:

- Add an explanation in the text on different ‘curves’ in table 5.4 and about the differences in the scenarios.

7.4.2 5.5 Population effect calculation

It is not clear what the results in table 5.7 mean. The results have not been elaborated upon, and no conclusion is added. What scenario offers the highest level of reliability? What does this mean? In paragraph 4.4 of Part A it is stated that in situations where the international scenario exceeds

the ecological limits, the Netherlands may take action, for example by informing the relevant competent authorities of the countries concerned. Is that the case here?

Recommendation:
- Elaborate on the results and add a conclusion.

There is also no clear discussion of the results or a conclusion based on table 5.8. What scenario offers the highest level of reliability? What does this mean?
In paragraph 5.6 a comparison with the ecological standard is made, which gives a bit more clarity. But here the comparison is done in numbers instead of percentages, which is confusing because the ecological standard is described in percentage in paragraph 4.8.1 and the results are also in percentage in tables 5.7 and 5.8.

Recommendation:
- Add a clear conclusion and make the comparison more consistent.

'Table 5.9 shows the results of iPCoD 6.0.2 calculations for the seal populations. The maximum calculated population decrease is less than 2%'. In the table the maximum decrease seems to be 2,7%. The results have not been elaborated upon.

Recommendation:
- Elaborate on the results and add a conclusion.

8 Marine Strategy Framework Directive Descriptors in relation to OWFs and Framework for Assessing Ecological and Cumulative Effects

8.1 General

It is very useful to have an assessment like this. However, it would be more useful when the impact would be related to the impact on the Good Ecological Status (GES). The structure of the sections is a bit confusing. Every subparagraph starts with a conclusion; however the content of this subparagraph is about possible effects and knowledge gaps but does not give a conclusion on the impact on the descriptor.

Often a reference to one of the KEC 5.0 documents is given, but the conclusions in these reports do not seem to be used in this assessment. I would expect a translation of the results and conclusions to the effect on GES

Most criteria cannot be assessed because there is a lack of information. What does this mean for the development of OW? How does the MSFD influence the development of OW and the research effort to fill in the knowledge gaps?

Recommendations:

- Make sure that the content of the subparagraph conclusions focuses on more clarity on the impact of OW on the descriptor, related to GES;
- Use the conclusions in the KEC 5.0 reports to draft a more concrete conclusion related to GES where possible;
- Add a list of the knowledge gaps in an annex, then it is easier to put them on the agenda.

8.2 2.1 D1 Marine biodiversity

8.2.1 Birds

The specification of three interlinked OW effects on birds – habitat loss, barrier effects and changes to habitat quality as key areas for future research is warranted. All three such potential impacts on birds arise through sub-lethal effects, which are accumulations of behavioural effects resulting in changes to time-energy budgets, giving rise to potential demographic consequences. Sub-lethal effects are, by their very nature, challenging to research and quantify, likely needed long-term studies to be able to link specific OW effects to subsequent changes to bird breeding success and survival against on-going environmental change.

Criterion D1C1 Incidental bycatch

The statement that OW development is neutral for this criterion is potentially premature. If significant changes to bird distribution arise from OW development (i.e. through displacement and habitat changes), then birds may come to overlap more with fisheries posing a bycatch risk. This increased overlap between birds and fisheries may be potentially exacerbated by a 'squeeze' on fisheries, whereby commercial fisheries are excluded from OWs by law, or through safety concerns.

Recommendation:

- The KEC should include a review of emerging research into whether seabird displacement from OWFs may result in changes to incidental fisheries bycatch due to shifts in spatial distribution and potential changes to overlap with fisheries activity. For example, there is a non-breeding season IBM available for several seabird species that predicts impacts on

survival and breeding success from both OW developments (collision and displacement) and by-catch (developed within the MARCIS project led by NINA - https://www.nina.no/english/Sustainable-society/Marcis).

Criterion D1C2 Population abundance

The description of potential mechanisms for OW impacts leading to decreases in bird population abundance are comprehensive.

Criterion D1C3 Demographic characteristics

The description for consideration under this criterion is a little confusing. It appears to focus on whether bird species with 'varying demographic backgrounds will experience OW effects differently. I would instead expect that this criterion should be considering whether the demographic rates of birds (especially productivity) are likely to be significantly affected by OW developments. This is clearly the case, as there is already evidence for collision mortalities from protected populations (thereby removing breeding adults from populations and potentially lowering productivity), and several modelling studies have resulted in predictions for decreased breeding success in species affected by displacement and barrier effects.
Consideration of the demographic rates of bird species is relevant to assessing OW impacts, particularly in relation to identifying species that may be more at risk should they be exposed to OW developments. For example, species with a low capacity to recover from OW-related mortalities via high productivity (e.g., many seabird species, where only one chick is produced per breeding pair) are potentially more vulnerable to OW impacts than those with a higher productivity rate. Similarly, in long-lived species such as many seabirds, which may often prioritise their own survival over that of their offspring, any reductions in adult survival are likely to have potentially profound consequences for future population sizes (D1C2). In general, however, such species-specific variation in demographic rates will be captured within Population Viability Analyses (PVAs) as part of an impact assessment and will therefore naturally be incorporated into risk assessments.

Recommendations:

- a clearer rationale for this section should be set out.
- more recognition should be given to how seabird demographic rates may affect their resilience to OW impacts, particularly in relation to species-specific differences in vulnerability to OW effects at the population level.

Criterion D1C4 Distribution area

I agree with the conclusion that the consequences of barrier effects are poorly understood at present, with most information arising from predictive models (e.g., Individual Based Models, IBMs), rather than empirical observations. Similarly, little empirical knowledge exists for the cumulative effects of habitat loss and barrier effects – again, to my knowledge, these have only been jointly examined in a cumulative manner via predictive models such as IBMs. Note that the term 'cumulative' here should refer to both the combined impacts from habitat loss *and* barrier effects, as well as the combined impacts from multiple OWFs on bird populations of interest.

Recommendation:

- clearer definition of 'cumulative effects' is needed for this section

Criterion D1C5 Habitat Quality

I agree that empirical evidence for the impacts of OW on habitat quality for seabirds is largely in its infancy, although some large-scale, long-term studies are now under way, particularly in the North Sea region. However, I do not agree that OW effects on habitat quality are '*not expected to have a proportionate effect on seabirds*'. As stated, there will likely be both positive and negative effects on habitat quality, mediated via changes to wind, oceanography and the introduction of

fixed and floating structures within OW footprints. However, such changes, particularly if related to seabird prey abundance, availability and quality could have large effects on seabird populations, especially at the cumulative scale over broad geographic regions used by seabirds in both breeding and non-breeding seasons.

Additional research is required to better understand these impacts, the balance between those impacts that are negative and positive for seabird habitat quality, and how such impacts differ across varying environmental and oceanographic conditions.

Recommendation:

- additional research is needed to understand impacts of OW on seabirds, via changes to habitat quality. There is currently insufficient evidence to conclude either way as to whether such effects will be positive or negative. It is therefore incorrect to state that OW effects on habitat quality are not expected to have a proportionate effect on seabirds.

8.3 2.4 D4 Food web

I agree very much with the conclusion – that more research and monitoring is required, across all trophic levels, in conjunction with oceanographic changes associated with OW, to better understand, model and measure how marine food webs will be affected by OW developments. Ideally, a strategic approach would be used, whereby different research projects and monitoring programmes would deliver to a strategic assessment of OW impacts on marine food webs over the North Sea ecosystem – capturing environmental, seasonal and inter-annual variation. Such a programme would ideally link up with existing ecosystem models for the North Sea, to improve data required for model runs, to provide data for model validation, and to allow for exploration of unintended consequences of OW impacts on one trophic level across the entire food web.
D4C4 Productivity of trophic guilds – there is a large amount of ongoing research in this area, specifically linked to OW development in the North Sea, primarily occurring through the UK's Natural Environment Research Council ECOWind programme (https://ecowind.uk/). These projects end in March 2027, and will produce datasets, modelled outputs, and improved modelling systems for understanding how OW developments affect stratification and productivity in the North Sea region.

It would be useful to compile a multi-national synthesis of all historic, current and on-going/planned monitoring programmes of all trophic levels in the North Sea ecosystem. Many individual countries have long-standing monitoring programmes across a range of trophic levels, from phytoplankton to marine mammals, but at present there is little synergy or cross-knowledge sharing between national programmes. A cross-boundary data library for all such information would greatly facilitate baseline understanding of the current status of marine food webs in the North Sea, as well as directing future research that could leverage existing knowledge and monitoring programmes to incorporate OW impacts.

The Deltares report on Ecosystem effects does give an idea of the impacts on primary production in the different wind farm areas. In my opinion this could be used to elaborate on the possible effects on the food web.

Recommendations:

- development of a strategic approach to assessing OW impacts on marine food webs in the North Sea, including use of ecosystem models.
- compilation of a multi-national synthesis of North Sea ecosystem monitoring data to develop baseline understanding of the current status of marine food webs and to direct future research and empower analytical methods and outputs.

8.4 2.5 D5 Eutrophication

This paragraph has a: different setup compared to the other paragraphs; there are no headings for conclusion and criteria.
In contrast to other descriptors there is a clear conclusion in relation to the descriptor: *the development of OWFs on its own does not lead to an input of nutrients into the water. Therefore, this descriptor is considered neutral for OWF development*.

Recommendation:

- Use the same setup for this paragraph as used in the other paragraph, but keep the conclusion as it is and make the conclusion more concrete in the other pragraphs.

8.5 2.6 D6 Seafloor Integrity

This paragraph gives some quantitative data on seabed loss. Unfortunately, it is not very clear how these numbers have been used for the conclusions. There are criteia for disturbance and loss of **seabed** and criteria for disturbance and loss of **habitat**. For D6C3 Physical disturbance of habitat the impact is described for seabed and habitat, it is not clear what the impact is on the habitat.

Recommendations:

- Make clear how the quantitative data on seabed loss is used in the impact assessment and the conclusions;
- Specify the impact on habitat for D6C3 Physical disturbance of habitat.

8.6 2.8 D8 Contaminants

The statement that there is no overview of coatings used on Dutch wind turbines available is surprising. Possibly every contractor knows what coatings are of will be used, so it should be possible, and it is necessary to get an overview.

Recommendation:

- Gather information on coatings used on Dutch wind turbines and use this for a better impact assessment.

8.7 2.11 D11 Energy Supply, including Underwater Sound

Criterion D11C1 Impulsive noise

The criterion is about the harbour porpoise but does not give a clear conclusion on the impact on GES based on the KEC document. Most text is about the impact on fish and benthos, which are not part of this indicator.

Recommendation:

- Use the conclusions in the Part B report on marine mammals to draft a more concrete conclusion related to GES;
- Explain why the impact on fish and benthos are assessed under this indicator.

8.8 3. Conclusion

It is stated that '*This assessment can be used as a more thorough analysis and guideline on how to take the MSFD into account in assessing the effects of offshore wind farm development*'.
The document is not a guideline to assess the impact on MSFD indicators, but more an answer to the question '*whether there is sufficient knowledge available to quantitatively or qualitatively verify potential effects on the MSFD descriptors and their underlying criteria*', as is also stated in this conclusion.

Recommendations:

- It would be useful to do a more thorough translation of the conclusions in the KEC documents to a conclusion on GES for the various indicators. This would help the future MSFD assessments as part of the EIA for individual OWs.
- Elaborate on the conclusion that at the moment it is not possible to be able to fully assess the effects for every descriptor and criterion. Try to give an answer to the following questions: What does this mean for the development of offshore wind? Who is responsible for conducting the research needed and how do we deal with MSFD assessments in the meantime?