Applicability of Acceptable Levels of Impact methodology in an international context

A short memo

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1 The international scenario

1.1 Introduction & assignment

The KEC (Dutch: *Kader Ecologie en Cumulatie*) assessment quantifies the ecological effects of the plans for wind energy production on the North Sea on populations of several seabird species (Rijkswaterstaat 2025). The KEC addresses both collision impacts and habitat loss effects (see Soudijn et al. 2025; IJntema et al. 2025 for most recent updates), and in both assessments, population effects of the additional mortality that birds may suffer from offshore wind farms (OWFs) are quantified using population models. Subsequently, the effects are evaluated using the Acceptable Levels of Impact (ALI) methodology (Hin et al. 2024).

In the most recent KEC assessment, the potential population effects of four different (future) OWF scenarios were assessed: three national scenarios focusing on the Dutch Continental Shelf (DCS), and a single international scenario focusing on the Southern and Central North Sea. However, the ALI test was not performed for the international scenario, because there was no information on the variability of bird distributions outside the DCS, and this information was required to quantify uncertainty in population impacts. Furthermore, the ALI methodology was primarily based on Dutch conservation status (Dutch: *Staat van Instandhouding*), and there are currently no internationally accepted ALI threshold values.

In this memo we describe the requirements to develop an international version of the ALI methodology. We first shortly summarize the Dutch national KEC assessment approach and the ALI methodology.

1.2 Overview of the KEC assessment & ALI methodology

1.2.1 Summary of KEC assessment methodology

For a detailed description of the KEC methodology for seabirds we refer to Soudijn et al. (2025) for habitat loss effects, and IJntema et al. (2025) for collision effects. In short, both assessments use bird distribution maps to calculate the expected number of bird casualties per year. Bird distribution maps of the DCS are used for the national (Dutch) scenarios, while international bird distribution maps (mostly from Waggitt et al. 2020) were used for the international scenario (see also Van Donk et al. 2024; Van Donk 2024). In the assessment for habitat loss effects, the mortality calculation is done using the *displacement matrix approach* (Searle et al. 2025), and the assessment of collision effects uses a stochastic version of the Band collision risk model (Caneco et al. 2022). Both approaches yield an estimate of additional OWF-induced mortality.

Projections using stage-based population models are then used to quantify the impacts of OWF-mortality on the population. Lastly, the ALI methodology (Hin et al. 2024) compares the outcome of population projections with OWF impacts against otherwise identical projections without such impacts. The ALI test is probabilistic and uses a species-specific threshold value (X) for the relative difference in population outcome between unimpacted and impacted projections, and another threshold value (Y) for the probability that this difference is exceeded. The population effects of OWFs are unacceptable according to the ALI test if the probability of finding a relative difference in population abundance larger than X, exceeds Y. The threshold values for X and Y are defined by policy (ministry of LVVN) based on expert advice provided by Sovon (Schekkerman 2024).

1.2.2 Quantifying uncertainty in bird distributions

In assessments on ecological effects of OWFs, not properly accounting for the various sources of uncertainty might result in false negative outcomes, *i.e.* wrongly evaluating impacts as acceptable while they are not. An appropriate assessment framework for estimating the impacts of OWFs has to deal with various sources of uncertainty and natural variability (Searle et al. 2023; Croll et al. 2022). The probabilistic nature of the ALI methodology requires that uncertainties are quantified and propagated among the different steps of the assessment framework (Soudijn et al. 2025; Hin et al. 2024). The distribution of seabirds is highly variable in space and time (van Bemmelen et al. 2025) and seabird distribution maps based on habitat suitability modelling generally have low explanatory value and contain a large random spatio-temporal effect (Van Donk et al. 2024). Because these distribution maps provide the foundation of the KEC assessments for seabirds, it is crucial that the variability and uncertainty in bird distributions is properly accounted for. With the current ALI methodology, there is a risk that OWF impacts get falsely evaluated as acceptable (false negative) if uncertainties are not properly accounted for (Hin et al. 2024).

For the last KEC assessment a new methodology was developed to deal with uncertainty in the distribution of seabirds that inhabit the Dutch Continental Shelf (DCS). Habitat suitability models (HSM) were fitted to bird survey data (MWTL data of the DCS) and a species-specific selection of abiotic variables (Van Donk et al. 2024; Van Donk 2024). Subsequently, 1,000 different bird distribution maps were sampled from the fitted HSM for each species and two-monthly period. Each map is a single possible representation of the bird distribution on the DCS, and the total set of 1,000 maps represent the total uncertainty in bird distribution as estimated with the HSM. The 1,000 maps were used to propagate uncertainty across the entire assessment framework. See Van Donk et al. (2024) and Soudijn et al. (2025) for more details. The HSMs were only created for the Dutch part of the North Sea (DCS), and the uncertainty methodology could therefore only be applied to the national scenarios. Note that this new methodology only applies to local seabirds. For migratory birds, no density maps are available; for these species, the estimated collision victims per wind farm are based on information of the size of the flyway population, if relevant combined with general knowledge of flight routes.

For the international scenario, the last KEC relied predominantly on seabird distribution maps from Waggitt et al. (2020). These maps contain estimates for the fitted spatial distributions and their 5% and 95% confidence intervals. However, the underlying HSM that was used to generate these maps were unavailable. Therefore, we did not have sufficient information to generate 1,000 samples of bird distributions. Consequently, uncertainty in the international bird distributions could not be properly quantified. It was therefore decided that the ALI test could not be performed for the international scenario.

1.2.3 International conservation targets

Besides the lack of sufficient information on the variability of bird distributions in an international context, the ALI threshold values were primarily based on the Dutch conservation status (Dutch: *Staat van Instandhouding: SvI*), and therefore thought to apply to the Dutch situation. However, apart from the Dutch conservation status, the suggestions for X and Y were also based on KRM/OSPAR indicators for seabirds in the International North Sea (indicators 'abundance of seabirds' and 'productivity of seabirds'), the IUCN status of European populations, and the extent to which bird populations suffered from the highly pathogenic avian influenza (Schekkerman 2024). The advice on the X and Y threshold values was therefore based on expert judgement that weighted all these indicators, although more weight was attributed to the Dutch conservation status (SvI).

1.3 Possibility to apply the ALI to the international scenario

To apply the ALI methodology to the international OWF scenario, two obstacles need to be tackled:

1) The uncertainty of international bird distributions needs to be quantified
2) ALI threshold values need to be determined for an international context

To solve 1) requires either the statistical models (HSMs) that were used to create the maps of Waggitt et al. (2020), or create new habitat suitability models for the OSPAR Greater North Sea Area and use those to sample 1,000 maps per species and period. It is currently not possible to quantify variability of uncertainty in bird distribution of the entire North Sea based on the information provided with the Waggitt et al. (2020) publication (mean fitted distributions and their 5% and 95% confidence levels). Currently, new bird distribution maps are being developed through the UK POSEIDON project, but these only cover UK waters.

As far as we are aware, there are currently no ongoing efforts to produce new North Sea wide bird distribution maps. A third possibility would be to make an inventory of the most recent bird distribution maps that cover territorial waters of various countries (UK, Norway, Denmark, Netherlands, Germany, Belgium) and develop a method to combine these into North Sea wide distribution maps. This approach would however need to deal with differences in the statistical methods that were used to create the different national bird distribution maps, and relies on the availability of uncertainty of each individual map. The most straightforward approach would therefore be to create new bird distribution maps that cover the wider North Sea area (OSPAR Greater North Sea).

The second point could potentially be addressed by defining separate ALI threshold values for the international scenario, and determine these on the basis of internationally recognised conservation targets, specifically the combination of the IUCN Red List status of European seabird populations and the OSPAR indicators for seabird abundance and productivity. These international threshold values would exist in parallel to the already defined national threshold values, which rely primarily on the national conservation status. The OSPAR indicators are aimed at measuring 'good environmental status'. For seabirds, the criteria D1C2 (seabird abundance) and D1C3 (seabird productivity) were consulted to inform the expert advice on the ALI threshold values (Schekkerman 2024). This abundance indicator compares the number of breeding pairs around the North Sea in the most recent six-year period against a reference value derived from the early 1990s. The OSPAR abundance indicator is evaluated as 'favourable' if the current level is at least 80% (for species that produce 1 egg per season per breeding pair), or 70% (for species that produce >1 egg per season per breeding pair) of the level in the reference period (Dierschke et al. 2022; Schekkerman 2024). The indicator on breeding productivity supplements the abundance indicator and provides an early warning signal for future changes in seabird abundance (Frederiksen et al. 2023).

The IUCN-status for protected species classifies bird species into distinct categories from 'Least concern' to 'Critically Endangered' and ultimately 'Extinct'. The categories 'Least concern' and 'Near-threatened' indicate a favourable status, and all other categories an unfavourable status.

Note that the OSPAR seabird abundance indicator uses an absolute number of breeding pairs as threshold value, while the ALI methodology evaluates the difference between impacted and unimpacted population projections and therefore evaluates the relative impact of OWF developments. This is a fundamentally different comparison to a criteria that assesses whether the abundance level will fall below an absolute abundance threshold. The ALI measures impacts relative to an unimpacted scenario and is therefore only indirectly linked to absolute conservation thresholds such as minimum viable population sizes. An ALI exceedance does not necessarily imply that a population will fall below a favourable status, nor does the absence of an ALI exceedance guarantee that populations with an unfavourable status are sufficiently protected.

A complementary framework to evaluate whether offshore wind impacts lead to violations of conservation status is currently under development and is similarly relevant for the international application. Within this approach the international scenario will also be considered.

1.4 Conclusions

To be able to apply the ALI methodology on the ecological effects of OWFs on protected seabird species on an international scale, requires a proper quantification of uncertainty in bird distributions for the entire North Sea, together with ALI threshold values that are based on internationally accepted conservation targets. To achieve this, new bird distribution maps should be made for the OSPAR Greater North Sea region. In addition, ALI threshold values should be defined based on internationally accepted conservation targets. The OSPAR indicators are the most suitable candidate for this. These internationally defined threshold value should coexist with the national threshold values that relate to the Dutch conservation status (*Staat van Instandhouding*).

2 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. The organisation has been certified since 27 February 2001. The certification was issued by DNV.

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Justification

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The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

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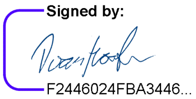
Signature:	
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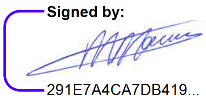
Signature:	
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