Cumulative effects of wind farms in the Dutch North Sea on bird populations

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Abstract

In order to assess the potential impacts of multiple wind farms within the Dutch North Sea on bird populations, a two-step modelling approach was applied: Step one involved constructing matrix-based population models for bird species occurring within the Dutch North Sea. Step two involved assessing the effects of increased mortality on these populations. The bird populations assessed included both seabirds and coastal species breeding around the North Sea region, as well as key passage migrants from a wider area. Two wind farm scenarios were modeled in order to provide estimates of the potential impact of mortality due to collisions (which was considered to have a far greater influence on mortality than disturbance or barrier effects in the specific Dutch situation). Field data collected with radar and visual observations at the OWEZ wind farm helped to inform these models. The additional mortality was then applied to the population models. For those species that are currently stable or increasing, the influence of this additional mortality was very limited. Also for the species currently in decline the additional mortality contributed little to these trends.

Introduction

In order to increase the supply of renewable energy in the Netherlands, the Dutch government has supported the construction of a near-shore wind farm of 36 Vestas V90/3MW wind turbines 10-15 km off the coast of Egmond aan Zee, in the Netherlands (OWEZ, Offshore Wind farm Egmond aan Zee). This project served as a demonstration project to build up knowledge and experience with the construction and exploitation of large-scale offshore wind farms. In order to collect this knowledge, an extensive Monitoring and Evaluation Program (MEP-NSW) has been designed in which the economical, technical, ecological and social effects of the wind farm are gathered. Within this framework a baseline (Krijgsveld *et al.* 2005, Leopold *et al.* 2005) and an effect study (Leopold *et al.* 2010, Krijgsveld *et al.* 2011) have been carried out to measure the impact of this single offshore wind farm on birds. In the present study we attempt, for the first time, to estimate the cumulative effects of multiple offshore wind farms in part of the North Sea on the population levels for a range of bird species. This study has been carried out by means of creating population models for different bird species. The effects of wind farms on these species, as the (estimated) number of victims, was fed into the population models. Most of these estimates were based on the radar measurements and field observations, including a ship-based monitoring program, gathered in and around OWEZ in 2007-2010.

Cumulative effects of offshore wind farms

The offshore wind farm at Egmond aan Zee was the first offshore wind farm built in the Netherlands, with a second one completed one year later (but not studied as part of the OWEZ report). The Dutch government supports plans to build more turbines at sea in the coming years. A single wind farm will have certain effects on birds by means of collision, disturbance and/or barrier effects. Single wind farms might have a minor impact on the reproduction and survival (and thus population sizes) of birds as shown in several studies on single wind farms (see for a summary Drewitt & Langston 2006). Numerical impacts are mainly on a local scale by changes in distribution. The greater the effect, in terms of a decrease in reproduction and/or survival, the greater the impact will be on the population size. However, the construction of multiple wind farms at sea has the potential to reach a threshold above which survival and reproduction could be significantly affected, potentially leading to a decrease in population levels at the wider (international) scale. With plans and proposals for expanding the number of wind farms in the Dutch part of the North Sea, the question of this study is what are the cumulative effects (as quantitative as possible) of multiple wind farms in the Dutch North Sea on the population levels of bird species?

Limitations

For the Dutch breeding birds, but also for foreign breeding populations, it is only possible to make predictions of population growth at a relatively large spatial scale. On a scale such as at a colony or regional level the calculation of cumulative effects using population models is not possible as often relevant data for every individual colony are largely unknown. A second important limitation concerns the spatial restriction of the calculation by cumulative scenarios of wind power development for only the Dutch North Sea. This limitation is mainly caused by the lack of an international overview on how offshore wind farms are being developed. It is clear that in a wider international context it is desirable to initiate further investigation on the cumulative effects of multiple wind farms in within the total distribution range of species, or in case of waterbirds and other migrant species in the entire flyway of a species, as many bird species migrate long distances.

General approach

The cumulative effects on birds, as estimated in this study, are derived on the basis of impacts measured at the wind farm OWEZ. In this study these effects are extrapolated in order to represent multiple wind farms on the Dutch continental shelf. We consider two scenarios, the first with multiple wind farms near-shore (all comparable in their effects with OWEZ) and the second with multiple wind farms scattered across the Dutch North Sea area, thus a proportion in deeper offshore areas (partly comparable with OWEZ and partly corrected for differences in species composition and abundance). The current study focuses on seabirds and to a lesser extent also deals with migrant species (passerines, waders, etc.). The seabirds considered are those that breed in coastal areas in the Netherlands (e.g. cormorants, gulls and terns) and those that regularly migrate or winter in the Dutch North Sea (e.g. divers, fulmars, gannets, ducks, gulls and alcids).

The cumulative effects were assessed for a selection of the most relevant and vulnerable bird species and were assessed at the population level with the aid of population models. The approach consisted of constructing population models, which were tested alongside known population trends. The data used in constructing the models were obtained from both published and unpublished field studies and from the relevant populations, and included parameters such as reproduction rate, mortality by age class, age at first breeding, proportion of non-breeding birds, etc (figure 1). The potential effects of a number of wind farms, such as an increase in mortality, could then be applied to these populations. The potential effects of a number of wind farms were calculated based on the results obtained from the study at OWEZ. To this end the scenarios of multiple wind farms were based on the having a number of wind farms with the same configuration of OWEZ.

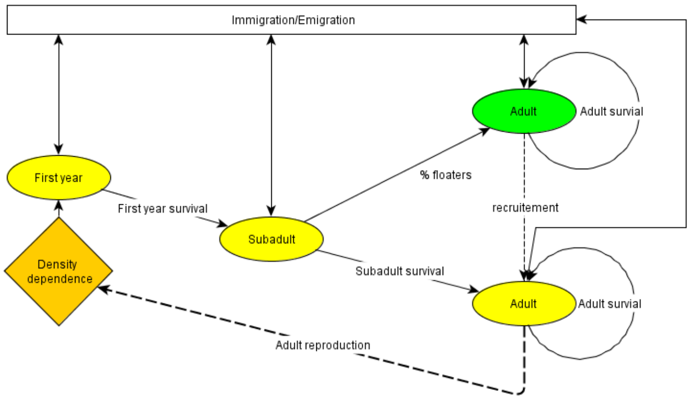

Figure 1 Population models were used with density dependence and non-breeding adults, based on Leslie matrix models (e.g. Caswell 2001).

Population models were based on Leslie matrix models (e.g. Caswell 2001), a proven simple and robust way of modelling animal populations. In this study we have followed a worst case scenario approach based on an array of assumptions. For those we refer to Poot *et al.* (2011).

Effects of offshore the OWEZ wind farm

Species differ in their response to wind farms; some fly straight through it, whereas at the other extreme, others avoid it entirely. These responses may also affect the foraging behaviour of birds in the area of the wind farm. Consequently, three types of potential negative effects on birds have been identified, collision of flying birds; disturbance or displacement; and barrier effects. All these effects may have a negative impact on the survival and/or reproductive output of individuals, which in turn could be reflected in their populations. This may especially be true if numerous wind farms are present within the distribution range or flyway of a species.

Estimates for the numbers of collision victims for each species for each scenario were calculated using the SNH-Band model (SNH 2010). The SNH-band model calculates the probability of collision of a certain species on the basis of the physical characteristics of the wind turbines and the species in question. The single most important aspect in calculating this collision probability is the level of avoidance that the bird shows. In general, estimates for the levels of avoidance of birds are largely based on estimated figures and seldom on field studies, particularly in the case of offshore situations. In the OWEZ field studies both radar and visual data were used to determine the level of avoidance at an offshore wind farm. This was combined with species- and species-group- specific fluxes determined with the same combination of visual and radar observations, meaning that realistic data from an actual and relevant situation were used.

Results – cumulative effects at the population level

To assess the sensitivity of the modelled populations to the potential effects of multiple wind farms a number of scenarios were calculated with respect to collision victims. During surveys of local birds around OWEZ, no significant avoidance of the wind farm by foraging birds was identified in the most numerous species groups cormorants and gulls, while for scoters, divers, alcids and gannets it was determined that flight paths have been altered due to presence of the wind farm (macro-avoidance 64 – 71 %) (figure 2). Of the birds entering the wind farm, at least 97.6 % avoided flying in the rotor-swept area (micro-avoidance). Combining macro-avoidance and micro-avoidance figures yielded overall horizontal avoidance figures varying between 98.0 % (in gulls and cormorants) and 99.3 % (in scoters). This high figures result in low collision risks of course (see for more details on field methods and results Krijgsveld et al. (2011)). The observations gathered around OWEZ are not suitable for assessing the consequences of barrier effects at the population level. Little is known over barrier effects, although the increased energetic costs of flying around a wind farm or the possibility that birds decide not to utilise the area beyond a wind farm may reduce their reproductive output or in extreme cases reduce survival, however, compared to the direct mortality associated with collisions with turbines the consequences of barrier effects are considered to be negligible.

When the extrapolated numbers of victims calculated for multiple offshore wind farm scenarios are applied to the population models, those species that currently have a stable or increasing population trend do not show any decline in numbers (see figure 3 Sandwich Tern as an example). For these populations the influence of the additional mortality resulting from victims of the wind farms is very limited. Instead, the population trends appear to be dominated by ecological changes in the environment, such as is known from the decline in the numbers of kittiwakes in Scotland in response to changes in food availability (figure 3).

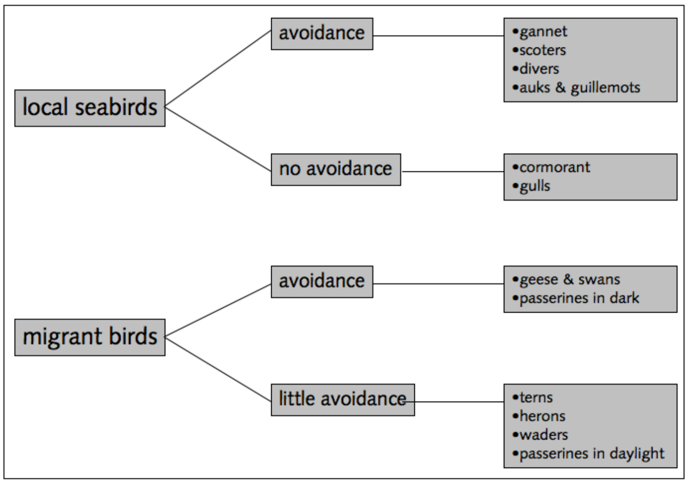

Figure 2 Schematic overview of macro-avoidance of the OWEZ offshore wind farm, separated into mostly local seabird species and migrating land birds. Note that high avoidance figures imply relatively low collision risks, see further text, also on the distinction between macro- and micro-avoidance (figure reproduced from Krijgsveld et al. (2011), figure 15.1).

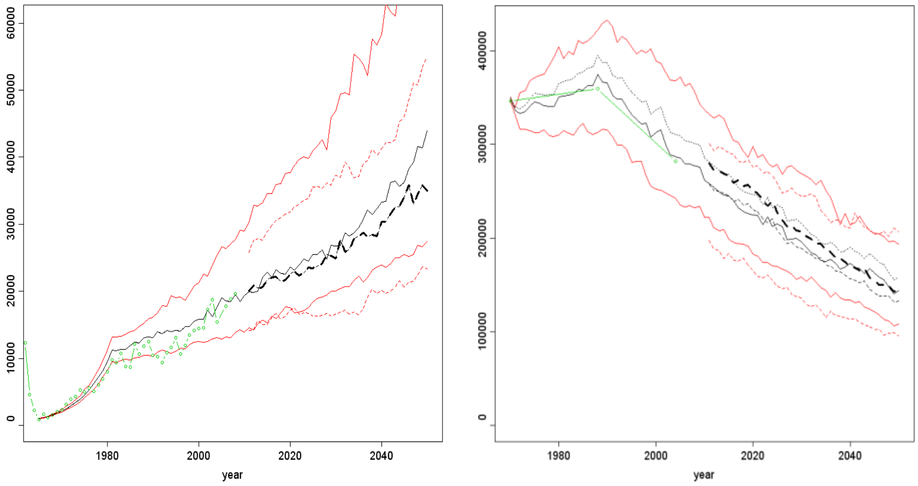

Figure 3 Reconstruction of the trend of the Dutch breeding population of Sandwich Tern (left) and the Scotish East coast population of Kittiwake (right). Green dots with lines indicate true figures of counted breeding pairs up to 2010. Solid black (median) and red (25 and 75 percentile) lines illustrate the modelling outcome before and after 2010 without offshore windfarms. Dashed lines depict the outcome of the modelling with a calculated number of yearly collision victims (using SNH 2010) of respectively 155 Sandwich Terns and 345 Kittiwakes based on a scenario of a total of 11 offshore windfarms after 2010. For further details on methods and results, see Poot et al. (2011).

In this study two of the populations studied are currently undergoing an even stronger decline, namely the international Bewick's swan population and the Dutch breeding population of the herring gull. The population model outcomes in these two species also show that the influence of the calculated increased mortality due to new offshore wind farm developments is relatively small in relation to their current trends. We conclude that stochastic incidents are not likely to be more influential in situations with co-current impacts, including offshore wind farms. In the case of long-lived bird species as those evaluated in this study, such scenarios with strong declines are due to ecological factors, such as low food availability with the consequence of low reproduction and/or survival or human induced phenomena like persecution and large scale habitat changes.

Scope of the findings

The fluxes and densities of local seabirds as measured by the effect studies have proven to be location-specific; especially based on the ship-based surveys that were conducted across a much larger area than OWEZ itself. Furthermore, the findings of this study can certainly not be extrapolated if future new offshore wind farm developments deviate strongly from the two scenarios now evaluated (e.g. wind farms with an other configuration of turbines than OWEZ). The number of wind farms, the location of the wind farms, the size and configuration of the individual wind farms will ultimately determine the scale of impacts relative to what is presented in this study. The quantitative effects of other configurations of (international) offshore wind farms should be determined first before such an exercise is possible. This limits the certainty with which the findings from OWEZ can be applied to other locations.

Conclusions

This study represents the first attempt to estimate the cumulative effects of multiple offshore wind farms in part of the North Sea on the population levels of a range of species. The analyses in this study have shown that the effects of the multiple offshore wind farm scenarios are far away from the levels above which decreasing trends occur and as such, this might be representative for multiple wind farms in the Dutch North Sea. Emphasis should be placed on the fact that calculations were carried out conservatively and followed precautionary assumptions. Future research related to monitoring the effects around new offshore wind farms in deeper waters would likely yield results to confirm that in this study a worst-case approach has been followed.

It is strongly recommended that in a wider international context further investigations are initiated on the cumulative effects of multiple wind farms. The urgency for such collaborative studies is clear as many bird species migrate long distances and this study is still one of the few studies addressing the issue of cumulative effects. Furthermore, in many countries around the North Sea, plans and developments in offshore wind energy are currently strongly progressing. The acquisition of local (national) knowledge on the population dynamics of critical bird species in the different countries involved in this case around the North Sea is a first step. On one hand, basic information on numbers, trends, life history traits and movements should be gathered and analysed. On the other, measured effects of existing offshore wind farms and realistic scenarios of wind farm developments should be brought together in order to make an assessment possible of the cumulative impacts of multiple wind farms within the total flyway of a range of species. This type of evaluation can greatly contribute to management strategies in order to avoid or mitigate cumulative impacts on a large international scale.

This study was commissioned by 'Noordzeewind' (a joint venture of Nuon and Shell Wind Energy). The report of this study can be downloaded from www.buwa.nl or www.noordzeewind.nl.

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