National Environmental Research Institute
Ministry of the Environment · Denmark

# Final results of bird studies at the offshore wind farms at Nysted and Horns Rev, Denmark

*NERI Report*
*Commissioned by DONG energy and Vattenfall A/S*
*2006*

# Summary

This report presents data on monitoring investigations of birds carried out during 1999-2005 in relation to the construction of the world's first two large offshore wind farms at Horns Rev and Nysted in Denmark. We consider the hazards turbines posed to birds and the physical and ecological effects that these cause. We propose a series of hypotheses relating to these effects on birds at the two sites, testing to see if birds do indeed show reactions to the turbines once erected, relative to their "unaffected" behaviour we monitored during pre-construction baseline studies. In this way, the effects of the construction of the wind farms at sea could be predicted from our hypotheses and validated by post construction monitoring and data collection which was a condition of planning permission for the Danish projects. Throughout, we have restricted our studies primarily to waterbirds, because these are the species that exploit the offshore environment in general and the two study areas in particular, because Denmark has a special responsibility for the maintenance of their populations and the habitat that they use and because long lived birds with relatively low annual breeding success (which include many waterbirds) are those most susceptible to additional mortality. This does not mean that other species (such as many bird of prey and short-lived land birds that pass through the areas on migration) are not important, but their study was generally beyond the scope of these investigations.

In general terms, the potential effects of the construction of a wind farm on birds were considered to arise from three major processes:

1. A behavioural element caused by birds avoiding the vicinity of the turbines as a behavioural response to a visual (or other) stimulus. This can have two effects:
   - a barrier effect affecting bird movement patterns, potentially increasing costs
   - the displacement of birds from favoured distribution, equivalent to habitat loss
2. Physical changes due to construction (physical habitat loss, modification to bottom flora and fauna and creation of novel habitats, e.g. for resting on the static superstructure).
3. A direct demographic element resulting from physical collision with the superstructure (mortality).

We investigated each of these elements at both wind farms collecting data prior to and post construction as outlined under the following headings.

1a) At Horns Rev and Nysted, the barrier effect was studied by mapped bird migration routes combining radar techniques by day and night with specific species identification during daylight hours using telescopes. Radar tracks were entered to a GIS platform to compare the base-line with subsequent post-construction monitoring results. Emphasis was placed upon three key variables:

I. the orientation of migration routes for waterbirds and terrestrial species to measure potential avoidance responses and response distances,
II. the probability that waterbirds will pass through the wind farm area to measure waterbird responses to the entire wind farm,
III. migration intensity, measured by the number of bird flocks that pass into the wind farm area, to measure the effect of avoidance responses on the volume of migration within the wind farm area post construction.

Comparisons of these key variables between individual base-line years were undertaken by controlling for various factors such as weather conditions, season and time of day using multi-factor analysis of variance (ANOVA) and regression analyses.

Results showed birds generally avoided Horns Rev and Nysted wind farms, although responses were highly species specific. Some species (e.g. divers and Gannets) were almost never seen flying between turbines, others rarely (e.g. Common Scoter) whilst others showed little avoidance behaviour (e.g. Cormorants and gulls). Overall, at Horns Rev, 71-86% of all bird flocks heading for the wind farm at 1.5-2 km distance avoided entering into the wind farm between the turbine rows patterns confirmed at Nysted (78%), predominantly amongst waterbirds. There was considerable movement of birds along the periphery of both wind farms, as birds preferentially flew around rather than between the turbines. Such avoidance was calculated to add an additional period of flight equivalent to an extra 0.5-0.7% on normal migration costs of Eiders migrating through Nysted. Changes in flight direction tended to occur closer to the wind farm by night than day at both sites, but avoidance rates remained high in darkness, when it was also shown birds tend to fly higher. Few data on avoidance behaviours were available during conditions of poor visibility, because intense migration generally slows and ceases during such conditions.

1b) Comparison of pre- and post construction aerial surveys of waterbird abundance and distribution in and around the two Danish offshore wind farms generally showed that they avoided the turbines (at least during the three years following construction), although responses were highly species specific. Divers at Horns Rev showed complete avoidance of the wind farm area during the three years post construction period, despite being present in average densities prior to construction. Common Scoter were absent from Horns Rev pre-construction, but occurred in large numbers in the vicinity of the wind farm, but were almost never seen within the turbines despite up to 381,000 in the general area. Terns and auks also occurred in the area but were almost never seen within

the Horns Rev wind farm post erection. Long-tailed Ducks showed statistically significant reductions in density post construction in the Nysted wind farm (and in sectors 2 km outside) where they had shown higher than average densities prior to construction. This strongly suggests major displacement of this species from formerly favoured feeding areas, although the absolute numbers were relatively small and therefore of no significance to the population overall. No bird species demonstrated enhanced use of the waters within the two Danish offshore wind farms after the erection of turbines, but it was clear, for example amongst Cormorants at Nysted, that the wind farm area was used occasionally for social feeding by very large numbers of birds post construction. Although bird displacement (as a result of behavioural avoidance of wind farms) represents effective habitat loss, it is important to assess the relative loss in terms of the proportion of potential feeding habitat (and hence the proportion of birds) affected relative to the areas outside of the wind farm. For most of the species considered here, the proportion is relatively small and therefore likely of little biological consequence. However, the additional cost arising from the construction of many other such wind farms may constitute a more significant effect. Hence, consideration of such cumulative effects of many such developments along an avian flyway represents an important priority in the future.

2) Physical habitat loss and gain was considered trivial, since even accounting for the anti-scour structures, the extent of the change equated to less that 1% of the total area of marine substrate enclosed within the total wind farm. Their effects would therefore be small and difficult to distinguish from other distributional effects described by monitoring changes in bird densities, except for the arrival of new species (which was not observed during these two studies) attracted to novel habitats post construction.

3) The avoidance responses documented above mean that although turbine construction at sea has a major effect on the local (i.e. wind farm project level) distribution, abundance and flight patterns of birds, the corollary is that many fewer birds come within the risk zone of the rotor blade sweep zone. Radar study results demonstrated that birds may show avoidance responses up to 5 km from the turbines, and that >50% of birds heading for the wind farm avoid passing within it. Radar studies at Horns Rev and Nysted also confirm that many birds entering the wind farm reorientate to fly down between turbine rows, frequently equidistant between turbines, further minimising collision risk. The Nysted Thermal Animal Detection System (TADS a remote infra red video monitoring system) and radar studies confirmed that waterbirds (mostly Eider) reduced their flight altitude within the wind farm, flying more often below rotor height than they did outside the wind farm. A stochastic predictive collision model was developed to estimate the numbers of Eiders, the most common species in the area, likely to collide with the sweeping turbine blades each autumn at the Nysted wind farm. Using parameters (including those described above) derived from radar investigations and TADS, and 1,000 iterations of the model, it was predicted with 95% certainty that out of 235,000 passing birds, 0.018-0.020% would collide with all turbines in a single autumn (41-48 individuals), equivalent to less than 0.05% of the annual hunt in Denmark (currently c. 70,000 birds). With such a low level of probability of collision expected at any one turbine, it was predicted that the TADS monitoring system would fail to detect a single collision of a waterbird during more than 2,400 hours of monitoring that was undertaken at the site, and this proved to be the case. This level of monitoring resulted in a mere 11 bird detections well away from the sweep area of the turbine blades, 2 passing bats, two passing objects that were either small birds or bats, a moth and one collision of a small bird.