

Effects on birds of an offshore wind park at Horns Rev: Environmental impact assessment

NERI Report

2000

Commissioned by Elsamprojekt A/S 2000





Ministry of Environment and Energy
National Environmental Research Institute

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Data Sheet

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Synopsis

This report presents the technical background to the ornithological environmental impact assessment for the construction of an offshore windpark at Horns Rev, 14 km west-south-west of Blåvandshuk, Denmark. Construction of the park is planned to commence in 2001. The park will consist of c. 80 wind turbines, each of at least 1.8 MW, and cover an area of 27.5 km² (including the 200 m exclusion zone around the park).

The inner Danish waters and the eastern part of the North Sea constitute major staging and wintering grounds for huge numbers of water- and seabirds. The present gross estimate, to be regarded as a minimum estimate, is that 5-7 million birds of more than 30 species winter in these areas, and that even larger numbers stage or pass through on migration. These numbers, which for several species constitute more than half of the northwest Palearctic breeding or flyway populations, are of international importance for the conservation of waterfowl populations. As a consequence, Denmark has obligations under both the Ramsar and Bonn Conventions and the EU-Birds Directive to protect and maintain these populations. For this reason, investigations of the impacts of offshore wind parks on water- and seabirds have been made a requirement of the project.

Detailed knowledge exists concerning the numbers of birds roosting at and migrating past the westernmost point of Jutland, Blåvandshuk. In relation to the Ramsar Convention, an area is of international importance for a flyway population of a species, if 1% or more of the individuals are present in the area at some time during an annual cycle. According to this criterion, the area is of international importance to divers, Eider, Common Scoter, Common Tern, and Sandwich Tern. A number of other species, e.g. Guillemots and Razorbills, are present in the area in significant numbers as well, though these numbers do not make up 1% of the population.

Previous counts have been carried out almost exclusively from the coast. Thus the distribution of birds in the area around and at Horns Rev remained virtually unknown. Therefore, transect counts from aircraft and ship were initiated in April 1999 and have been continued up to May 2000. So far, nine aerial and three shipbased counts have been carried out, covering an area of 1,700 km² centred on the Horns Rev project area.

From the aerial counts, precise information about the distributions of birds in the area has been obtained. In all counts, the two species feeding on the bottom fauna (Eider and Common Scoter) were found almost exclusively along the coast (within the 6 m depth contour), and only in a few cases more than 10 km offshore. Very few individuals of either species have been observed within 2-4 km of the pro-

jected wind park area. The only species recorded offshore in significant numbers were fish-eaters, divers, Gannets, auks and terns, plus large numbers of gulls, often concentrating around fishing vessels. The distribution of fish-eating species was highly variable, probably because distributions and densities of fish were variable in both space and time.

Assuming a random distribution of birds in the surveyed area, c. 1% of the total numbers recorded would be predicted to be present in the area of the projected wind park. Only divers (8 of 554 recorded individuals) and Kittiwake (11 of 1,118 recorded individuals) approached this threshold, though they did not exceed it significantly. All other species abundant in the general area were present in the projected park zone in lower than expected numbers. From this it is concluded that the specific construction area of the projected wind park is of very limited significance for water- and seabirds judged by their overall distribution in the waters around Horns Rev.

Analysis of both aerial and ship counts showed that the probability of detecting flocks of birds decreases rapidly with distance from the observer. For divers, detection probability from ship was reduced to 50% at a distance of 150 m. Estimates of densities and total numbers depend on the precision of being able to correct for birds overlooked by the observers. It is concluded that aerial counts provide objective data on bird distribution and of the minimum number in the area, but that further development of statistical methodology - considered outside the scope of the present study - is needed in order to calculate definite densities and total estimates.

As a result of the comparisons between the results of the aerial and ship surveys, preference is given to the former. Both methods have statistical problems associated with the conversion of count data into density and abundance measures. However, because a total aerial survey can be carried out in one day, whereas a ship survey (under ideal circumstances) takes four days to cover the same area, there is a much higher probability that birds will move inside the count area during the survey, and thus potentially may be counted twice or missed altogether.

Impacts on birds resulting from construction work are expected to be temporary and limited. The effect of laying the cable to land is also considered to be temporary and minimal in two proposed scenarios.

Potential permanent impacts on seabirds resulting from the long-term operation of the wind park are identified under three main headings:

1. Physical changes of the habitat
2. Disturbance effects resulting from avoidance of the turbines, equivalent to the loss of potential to exploit the otherwise available habitat
3. Collision risk

Physical changes of the habitat include 1) the loss of the bottom area which supports the turbine foundations, 2) the provision of new underwater substrate for the settlement of larvae of marine invertebrates, and 3) the provision of platforms for birds to sit or perch on.

Loss of bottom substrate comprises less than 0.3% of the wind park area and is not expected to lead to measurable impacts. Settlement of fauna will mainly involve *Balanus* and some Polychaete colonisation that do not represent significant food items for birds, hence it is not expected that these modifications of the habitat will lead to any significant changes in bird numbers and distributions in the area. The provision of platforms for sitting/perching may attract some gulls and possibly Cormorant to the wind park area.

The degree of avoidance of wind turbines structures in the open sea have not been investigated for the species present in the area. Previous investigations of Eiders and geese show that avoidance of wind turbines is limited to distances within a range of 100-500 m. Even in a 'worst possible case' scenario (assuming birds completely avoid the wind park area up to a distance of 4 km) habitat loss within the total investigated area will not exceed 10% for most of the species involved.

A number of case studies carried out in terrestrial environments demonstrate that the collision risk of wind turbines is limited. Even at night, studies suggest that flights of Eiders and Common Scoters in inshore waters tend to avoid wind turbines. Most studies concerning collision risk cover situations with migrating land birds. Only a single study dealing with foraging birds of prey documents a relatively high number of collisions indicating that some raptors are less able to avoid turbines when foraging. For Gannets, terns and skuas, it is not possible to completely rule out the potential risk of collisions by these birds when foraging in the area. Similarly, the mounting of light on the turbines for ship navigation may attract nocturnal migrants during conditions of poor visibility. With the existing knowledge of the birds species in the area and of their reactions towards turbines, the possibility of some collision risk between birds and turbines cannot be ruled out.

Dansk Resume

Denne rapport udgør den tekniske baggrundsrapport for den ornitologiske VVM-vurdering for opstilling af den havbaserede vindmøllepark på Horns Rev, 14 km vest-sydvest for Blåvandshuk, Danmark. Anlæggelse af vindmølleparken er planlagt til at begynde i 2001. Parken vil bestå af ca. 80 vindmøller, hver på mindst 1,8 MW, og vil dække et område på 27,5 km² (inklusive en friholdt zone på 200 m omkring parken).

De indre danske farvande og den østlige del af Nordsøen udgør et væsentligt raste- og overvintringsområde for et stort antal vandfugle. Det nuværende skøn som antages at være et minimum, anslår at 5-7 millioner fugle af mere end 30 arter overvintrer i disse områder, og at et større antal raster eller passerer på træk. Disse forekomster som for flere nordvest Palearktiske arter udgør mere end halvdelen af yngle- eller flywaybestandene, er af international betydning for bevarelse af vandfuglebestandene. I konsekvens af disse forekomster har Danmark forpligtigelse til, gennem både Ramsar og Bonn konventionerne og EF Fugle beskyttelsesdirektivet, at beskytte og bevare disse bestande. På den baggrund er det i principgodkendelsen af vindmølleparken anført at der gennemføres undersøgelser af offshore vindmøllers påvirkning af vandfugle.

Der eksisterer et detaljeret kendskab til antallet af fugle der raster og trækker forbi Jyllands vestligste punkt, Blåvandshuk. I henhold til Ramsar konventionen er et område af international betydning for en fugleart hvis 1% eller mere af bestanden forekommer på et givent tidspunkt af året. Ifølge dette kriterium er området af international betydning for lommer, Ederfugl, Sortand, Fjordterne og Splitterne. Andre arter, f.eks. Lomvie og Alk, forekommer i betydelige antal, men udgør mindre end 1% af bestandene.

De hidtidige registreringer af fugle er næsten udelukkende foretaget fra land. Kendskabet til fordelingen af fugle i området omkring og på selve Horns Rev er derfor meget mangelfuldt. Som følge heraf blev der i april 1999 påbegyndt transekttællinger. Indtil maj 2000 er der gennemført ni flytællinger og tre skibstællinger som har dækket et område på 1.700 km² omkring det udpegede mølleområde på Horns Rev.

På baggrund af flytællingerne er der tilvejebragt detaljeret information om fordelingen af fugle i området. Tællingerne viste at arter der fouragerer på bundlevende dyr (Ederfugl og Sortand) udelukkende forekom kystnært (inden for 6 meter dybdekurven), og kun i få tilfælde forekom mere end 10 km fra kysten. Meget få individer af disse arter blev observeret inden for 2-4 km fra mølleområdet. De eneste arter der blev observeret i væsentlige antal langt fra kysten var fiskeædere, lommer, Sule, alkefugle og terner, samt et stort antal måger,

som ofte var koncentreret omkring fiskerbåde. Fordelingen af fiskeædende arter var meget variabel, sandsynligvis som følge af en rumlig og tidsmæssig variation i fordelingen og tætheden af fisk.

Under antagelse af en tilfældig fordeling af fugle i det optalte område, forventedes ca. 1% af det totale antal observerede fugle at forekomme i selve det projekterede mølleområde. Kun for lommer (8 ud af 554 registrerede individer) og Ride (11 ud af 1.118 registrerede individer) nærmede andelen i mølleområdet sig denne tærskelværdi på 1%, uden at overskride den signifikant. For de øvrige talrige arter i undersøgelsesområdet forekom alle i mølleområdet i antal der lå under det forventede. På baggrund heraf kan det konkluderes at mølleområdet er af begrænset betydning for vandfugle.

Analyse af både fly- og skibstællinger viste at sandsynligheden for at observere flokke af fugle faldt med afstanden til observatøren. For lommer faldt registreringsandsynligheden med 50% ved en afstand af 150 m. Beregning af tætheder og totale antal afhænger af præcisionen i at kunne korrigere for fugle som er overset af observatørerne. Det kunne konkluderes at der ved flytællinger blev opnået brugbare/objektive data for fordelingerne af fugle og for minimums antal i området. Imidlertid har det vist sig, at der er behov for yderligere udvikling af de bagvedliggende statistiske metoder til mere præcise beregninger af tætheder og estimering af totale antal i området.

I denne rapport er der lagt størst vægt på flytællingerne. Dette skyldes hovedsageligt at en optælling af hele undersøgelsesområdet kan foretages på én dag fra fly hvor det fra skib i bedste fald tager fire dage, med risiko for at nogle fugle flytter rundt inden for området og derved potentielt kan blive registreret flere gange eller slet ikke registreres.

Påvirkning af fugle fra anlægsarbejdet forventes at være af kort varighed og meget begrænset. Påvirkning af fugle fra udlægning af søkablet til land forventes også at være kortvarigt og minimalt for de to foreslåede kabelføringer.

Potentielle permanente påvirkninger af fugle i perioden hvor møllerne er aktive kan opstilles under tre hovedoverskrifter:

1. Fysisk ændring af habitat
2. Forstyrrelseseffekter som medfører at fuglene undgår møllerne, hvilket er det samme som tab af potentiel udnyttelse af et normalt tilgængeligt område
3. Kollisions risiko

Fysisk ændring af habitat omfatter 1) tab af bundareal hvor møllefundamenter opstilles, 2) forekomst af et nyt undervandsområde (møllefundamenter) hvor marine invertebrater kan leve, og 3) forekomst af platforme (møller) hvorpå fugle kan sidde eller hvile.

Tab af bundareal omfatter mindre end 0,3% af mølleområdet og forventes ikke at medføre målbare påvirkninger. En stigning i forekomsten af invertebrater forventes hovedsageligt at dreje sig om balanoider og enkelte polychaeter, som ikke udgør væsentlige byttedyr for fugle, og det forventes derfor ikke at habitatændringerne vil medføre væsentlige ændringer i antallet og fordelingen af fugle i området. Muligheden for at kunne sidde på møllerne eller møllefundamenterne vil kunne tiltrække måger og muligvis skarver til mølleområdet.

Det har ikke været muligt at undersøge i hvilken grad de fuglearter der forekommer i det undersøgte område vil undgå mølleparken. Tidligere undersøgelser har vist en effekt på 100-500 m for ederfugle og gæs. Selv under en 'værst tænkelig situation' (hvor fuglene antages fuldstændigt at undgå området ud til 4 km fra møllerne) vil det samlede habitattab inden for det undersøgte område ikke overskride 10% for hovedparten af de registrerede arter.

De hidtidige undersøgelser af vindmøller opstillet i terrestriske miljøer har vist at kun forholdsvist få fugle kolliderer med møllerne. Undersøgelse af Tunø Knob vindmøllepark viste at både ederfugle og sortænder under natlige flyvninger, i stor udstrækning undgik vindmøllerne. For fødesøgende rovfugle er det vist at de forholdsvist ofte kolliderer med vindmøller hvilket formentlig skyldes at de under jagten på byttedyr er mindre agtpågivende over for mulige faremomenter (rotorbladene) og derfor hyppigere kolliderer. For sule, terner og kjøver kan det derfor ikke udelukkes på forhånd at der kan være en vis risiko for kollision med vindmøllerne under fouragering i Horns Rev området. Lys på møllerne til brug for skibstrafikken kan tiltrække nattrækkende fugle i situationer med dårlig sigtbarhed. Med den nuværende viden om fuglene i området og deres reaktioner over for vindmøller er det ikke muligt at udtale sig mere præcist om omfanget af kollisionsrisikoen mellem fugle og vindmøller.

1 Introduction

1.1 Background

In February 1998, the Danish Ministry of Environment and Energy requisitioned proposals from Elsam I/S and Eltra A.m.b.a. to construct two offshore wind parks, capable of producing 2x150 MW. Construction areas were designated at Horns Rev in the North Sea and south of Læsø in the Kattegat. Since the concept of constructing offshore wind parks on this scale was entirely new, the projects were, in combination with three additional parks, to be constructed by SEAS Distribution in south-east Denmark, given the status of 'demonstration modules'. Hence, a major goal in these projects is to gain experience and know-how to serve as a basis for decisions regarding future electric power production in the offshore environment.

In June 1999, the Ministry of Environment and Energy gave a principal approval for the resulting applications. The conditions imposed specified environmental impact assessments (EIAs) relating to the projects and explicitly formulated specifications for establishing before-after comparison to demonstrate any potential impacts.

The inner Danish waters, including the eastern parts of the North Sea, constitute major staging and wintering grounds for huge numbers of water- and seabirds. The present gross estimate, to be regarded as a minimum-estimate, is that 5-7 million individuals of more than 30 bird species winter in these areas, and that even larger numbers exploit them for staging on migration. In several cases, these concentrations constitute the entire breeding- or flyway populations of north-west Palearctic species and are of major international importance (Rose & Scott 1994, 1997, Laursen et al. 1997a). As a consequence, Denmark has obligations under international legislation and as a signatory to international conventions, such as the African - Eurasian Migratory Waterbird Agreement under the Bonn Convention, the Ramsar Convention and the EU Bird directive (see App. I). Such agreements and legislation require states to protect the habitats of, and maintain the populations of, migratory birds using the territory of those states. For this reason, a full investigation of the potential impacts of constructing offshore parks of wind turbines on water- and seabirds in Denmark has been made a requirement of the construction projects.

1.2 The Horns Rev Project

In April 1998, Elsam and Eltra formally applied to the Energy Agency

for permission to construct an experimental wind park, capable of generating up to 150 MW in the Horns Rev area. The application was accepted in June 1999, provided that a number of conditions are fulfilled, including the preparation of an EIA-report. Elsamprojekt A/S has subsequently been appointed as consultants to establish the wind park.

The wind park will be located on the southern side of the Horns Rev, c. 14 km west-south-west of Blåvandshuk (Fig. 1a-b). Geomorphologically, the Horns Rev formation can be described as a terminal moraine ridge, consisting of relatively well-sorted sediments of gravel and sand (Danish Hydraulic Institute 1999). The water depth within the park area varies from 6.5 m to 13.5 m.

The wind park will have a capacity of c. 150 MW and will comprise a maximum of 80 turbines. The distance between adjacent turbines and the turbine rows will be 560 m giving an open space of nearly 500 m between the turbines. The height of the turbine tower will be 60-70 m and the rotor diameter 66-80 m resulting in a maximum height to the upper wing tip of 110 m. The minimum free height from sea level to lower wing tip will be 27 m. A transformer substation of 20 x 28 m on three poles and 14 m above sea level will be built north of the most north-eastern wind turbine. The turbines will be equipped with white flashing light about 10 m above sea level for ship traffic and with permanent or flashing light at the top of the turbines for air traffic.

The wind park will include a 200 m exclusion zone around the park, and hence the wind park will cover an area of 27.5 km² in all (see Fig. 1a-b).

The type of foundation to be used for the turbines has not yet been decided, but in all cases the total physically occupied area will constitute a maximum of 0.3% of the total wind park area. Cables between the turbines and from the wind park to land will be bedded down c.

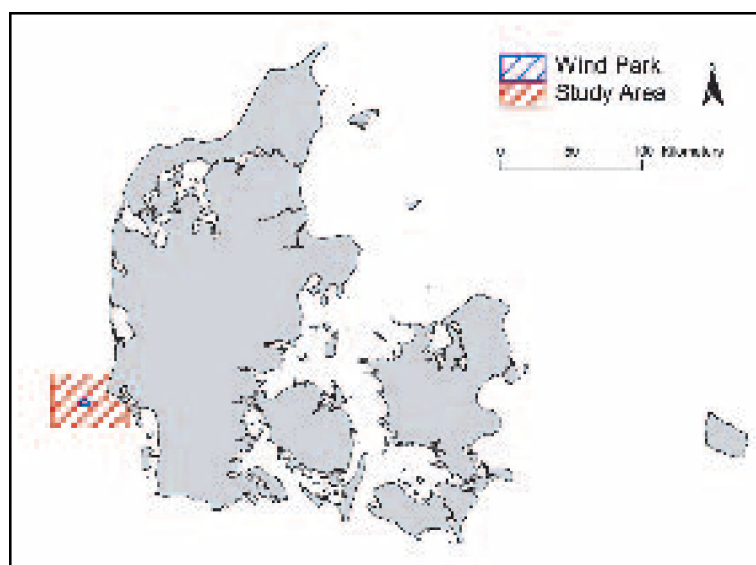


Figure 1a. Map of Denmark with the study area.

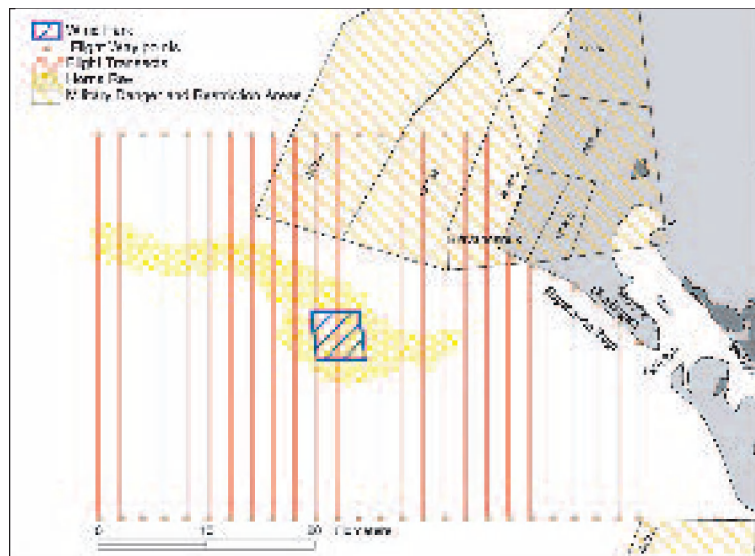


Figure 1b. Study area (hatched) including transects (thin lines north-south) for aerial bird surveys. Military restriction areas are shown (e.g., EK R 33).

1 m into the substrate. Five different land connection routes for the cable have been proposed, of which two, the Hvidbjerg Strand and the Sædding Strand alternatives, have been subject to impact assessment on birds.

Service and maintenance of the turbines are calculated to constitute 150 days per year and will be carried out partly from ship and partly from helicopter.

Building of the transformer substation will, according to the current time schedule, start in 2001, and installation of the wind turbines will (according to the current time schedule) take place in the 2nd and 3rd quarter of year 2002 and the park is expected to start to operate in the 4th quarter of 2002.

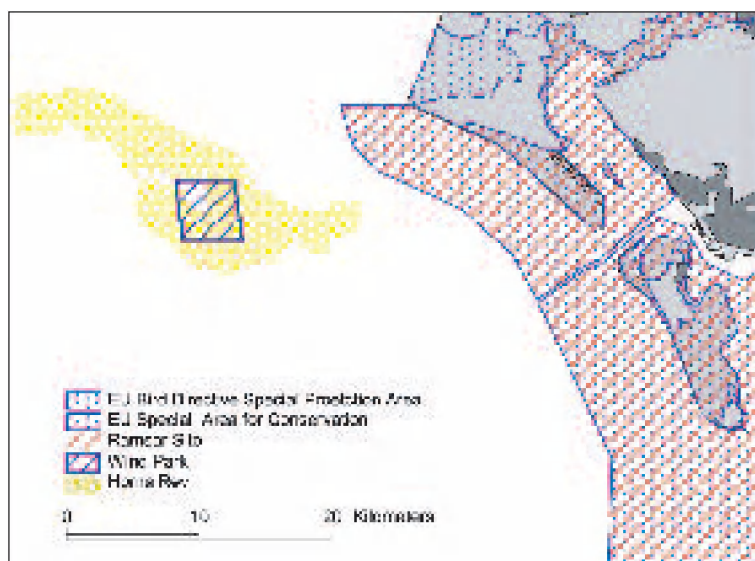


Figure 2. Protected areas (Ramsar and EU bird and habitat areas) in the vicinity of the Horns Rev wind park.

The proposed wind park site is situated outside areas covered by special protection measures in relation to bird conservation. However, the first 5 km of the cable from land passes through areas which are subject to protection. The Wadden Sea and neighbouring land areas constitute Ramsar area no. 27, and are also designated as Special Protection Areas under the EU Birds Directive (nos. 49, 50, 51, 52, 53, 55, 57, 60, 65 and 67) and as Special Areas for Conservation under the EU Habitats Directive (nos. 73, 78 and 90) (Fig. 2). Furthermore, the Wadden Sea also has the status of a Game Reserve (no. 48) with regulations concerning nature conservation and public access. For a more detailed description of the different protective measures and their effects, see Appendix I.

1.3 Environmental impact assessment

From the outset, the definitive predictive assessment of impacts on birds is severely hindered by two major disadvantages:

- Due to remoteness and working in a harsh environment with difficult operating conditions, the numbers and ecology of birds exploiting the offshore environment are far less well known than for species exploiting inshore or terrestrial environments.
- Even if our general knowledge relating to the impacts of wind parks on birds has greatly improved in recent years, the bird species occurring in the offshore environments and their behaviour have not been included in these studies.

Hence, the numbers, precise distributions and ecology of seabirds, and their reactions to wind turbine parks remain very poorly known.

In order to assess the potential impacts from offshore wind parks on bird numbers and distribution, Elsamprojekt A/S has in 1999 contracted the National Environmental Research Institute (NERI), Department of Coastal Zone Ecology, to take responsibility for studies to assess the possible impact of the wind park on birds. In this capacity, this NERI contribution will feed into the general EIA submitted by Elsamprojekt A/S in May 2000.

Inevitably, the scope and depth of the discussions relating to the impacts upon any particular taxon is limited, when included in a general EIA comprising all other known technical and environmental aspects of the wind park. For this reason, it was decided to contribute to the general EIA on birds by means of a technical background report.

This report presents the full description of the basis for the general EIA in terms of observations, calculations and assessments.

Furthermore, it was decided to make the report in English, in preparation for submission to international peer review. For this purpose, too, detailed reviews of some aspects of the methodology have been presented at this stage.

1.4 Conditions of approval

The approval given by the Energy Agency laid down the following specifications for the programme to be designed for monitoring impacts:

1. Elsamprojekt A/S is required to develop a programme for monitoring environmental impacts during the construction and the following initial phase of operation.
2. The programme should cover: 1) The area of construction, i.e. the area of the wind park and cables with land connections, 2) The so-called area of impact, i.e. the area where impacts during construction and operation are expected, and 3) The area of reference, i.e. one or more otherwise comparable areas, without impacts from wind turbines on the environment.
3. It is emphasised in the conditions several times that particular attention must be drawn to waterbirds and migrating birds and, through specific studies, provide impact assessment analyses for these species.
4. Elsamprojekt A/S is required to develop a dynamic monitoring programme, capable of demonstrating positive and negative impacts on the environment resulting from the construction and operation of the wind park. It is considered of decisive importance that the programmes documenting the base-line conditions in the area are sufficiently comprehensive to rule out the possibility that so-called 'natural variability' will not subsequently mask the impacts the programme is designed to document.

1.5 Scope of the present study

In order to fulfil the obligations laid down in the approval in relation to evaluating the impact of the wind park on birds, NERI has designed a study programme containing the following elements:

1. Reviewing existing literature with the aim of presenting information about the occurrence, abundance and distribution of birds in the Horns Rev - Blåvandshuk area and to document the importance of the area concerning birds.

2. Monitoring of the occurrence, abundance and distribution of birds in the construction area, impact area, and reference area with the aim of providing base line material.
3. Providing an impact assessment analysis for staging birds and migratory birds passing through the area.

Designing of a dynamic monitoring programme to measure impacts on birds during the construction and initial operation phases is outside the scope of the present report and is thus not included. However, a future proposal will be prepared as a special report to Elsamprojekt A/S.

2 Methods

2.1 Introduction

The process of assessing the environmental impacts of offshore wind parks on birds involves two stages. In the first step, bird numbers and distributions in the wind park area and its surroundings must be mapped and documented, by means of compilation of literature and/or undertaking new counts. In the second stage, specific reactions to the projected turbines must be predicted. For obvious reasons, this prediction can only be based on previous experience and compiled from the literature.

2.1.1 Development of methodology

Counts of migrating birds have been carried out from the coast at Blåvandshuk since the 1950s, and this provides a very important historical background, which demonstrates the importance of the Horns Rev-Blåvandshuk area to birds. However, the offshore distribution of birds was not known at the start of the investigation. The few counts from an earlier period (1987-1989) that had been done from ship and aircraft in the area did not have the necessary accuracy in positioning to offer a meaningful baseline. This meant that the importance of the projected area for the wind park, relative to the general area, could not be assessed on the basis of existing data.

Funded by the Danish Energy Agency, NERI developed a differential GPS-system to be installed in an aircraft during 1997-1998. This enable the position of all birds recorded from the aircraft could be mapped with a degree of accuracy not previously possible.

This system has been used throughout the investigation period during April 1999-April 2000. However, as data on bird numbers have accumulated, the methodology has been adjusted, both with respect to the area covered and transect band width. For this reason, the first year of observations, presented in this report, inevitably has had the nature of a pilot study.

Seabirds in offshore areas can only be counted from either aircraft or from ships. Both methods have advantages and disadvantages, but are considered to provide reliable data on the relative distribution of bird species and of bird numbers, given that experienced observers are used. From the outset, it was decided, in consultation with Elsamprojekt A/S, to include both methods in the study and eventually to compare them.

2.1.2 Species identification

It was known in advance that several pairs of birds or groups of bird species closely resembling each other occur in the study area. These comprise Red- and Black-throated Diver, Guillemot and Razorbill, Arctic, Pomarine, and Long-tailed Skua, and Arctic and Common Tern. All of these species can only be discriminated at close range and under good visual conditions, and generally the knowledge of the species composition of these groups can only be considered approximate.

With respect to the problem in question, however, there is no *a priori* reason to expect that impacts from a wind park should differ between similar species. Moreover, designing a realistic monitoring programme that can demonstrate differential impacts between, e.g., Red- and Black-throated Divers would be nearly impossible. The extra effort expended in differentiating these species is unlikely to be worth the investment, since it is not expected there would be any difference between species response to the park. For this reason, the similar species are considered as grouped data throughout the report.

2.2 Bird numbers and ecology in the area

The Horns Rev - Blåvandshuk area is internationally known for its

concentrations of migrating, staging and wintering birds. In relation to the Horns Rev wind park, these concentrations are most suitably split into two subgroups, viz. species that moult, stage and winter in the area, i.e. exploit the habitat for foraging, and species that mainly pass over the area during migration. For the latter group, only the collision risk is considered relevant.

The reason that migrating birds concentrate at Blåvandshuk is that birds follow the coastline as a migration guide, particularly during autumn migration. Since autumn population sizes are generally larger than at all other times of the year, due to the presence of young of the year, concentrations of migrants are highest during autumn. A bird observatory was established by the Danish Ornithological Society at Blåvandshuk in 1963, and observations from more than 35 years provide a detailed basis for assessing the phenology, numbers and species migrating over and migrating through the area (Jakobsen in prep., Kjær 2000). Thus, a substantial literature exists, covering the volume and phenology of bird migration in this area, which includes species mainly associated with both marine and terrestrial habitats.

NERI's general monitoring of the Wadden Sea includes coastal areas south of Blåvandshuk but not areas closer than c. 10 km to the wind park area. Thus, to date, data existed from only 2-3 surveys from ship and aircraft during 1987-1989 that cover Horns Rev (Laursen 1989, Laursen et al. 1992, Skov et al. 1995 & Laursen et al. 1997a).

2.3 Mapping of distributions 1999-2000

For a detailed evaluation of the occurrence of birds and their use of the wind park area, the existing data were supplemented with aerial and ship surveys, carried out from April 1999 to April 2000, in order to obtain more precise information about species composition, numbers and distribution.

The aim was to provide detailed knowledge on the abundance and distribution of birds in the area, but also to provide data in such a way that a statistical assessment of potential impacts from disturbance effects could be obtained if future surveys are performed. Likewise, the pilot study was designed in a way that enabled determination of the size of the impact area with statistical confidence.

2.3.1 Choice of study area

The conditions of the wind park approval document state that the impact assessment analyses should include a construction area, an impact area, and one or more reference areas.

Determination of a reference area where the only parameter different from the construction and impact area is the wind park is difficult to set up for birds due to large year to year variation in numbers and distribution. The size of the impact area is dependent upon the nature of the possible disturbance effects (see Chapter 5), which at present are unknown for most species of seabirds. In order to analyse different scenarios for disturbance effects two areas, including the wind park area plus the adjacent 2 and 4 km, respectively, have been designed.

The original design of aerial transect counts made in April 1999 attempted to adapt to these concepts, covering the Horns Rev area from the projected wind park to the west-northwest. The conceptual framework was that the area west-northwest of the projected park would serve as the reference area. The two sets of initial counts, however, clearly demonstrated that densities of birds on Horns Rev were low, and that proper mapping of distributions in the area necessitated a considerably extended level of coverage.

For this reason, the area covered was extended to embrace a total area of approximately 1,700 km² (38 x 52 km excluding the land area at Blåvandshuk) around the wind park. The extent of the chosen area is basically determined by the c. 800 km that can be covered during one day of flight observations, since extension of one count episode which involves flying more than one day may be biased by bird movements. For example, birds resting at sea may drift several kilometres during the night due to wind and current, and they are known to compensate for this displacement by dawn flights. Dawn movements normally last 1-1½ hours, which means that a bird flying at ground-speed of 50 km/h may move 50-75 km. This seems to correspond to the potential range of nocturnal drift with a speed of 3.7 km/hour (2 knots); birds resting on the water will drift 60 km during a 16 hour winter night. Moreover, radar investigations at the Tunø Knob experimental wind park have demonstrated that, particularly during moonlit conditions, birds will also fly during the night (Tulp et al. 1999). Hence, a bird with a flight speed of 50 km/hour can move from any position to another inside the study area in less than 1½ hour.

In the present study, the total area included is defined as the reference area, while the area of turbine construction is referred to as the turbine or wind park area.

2.3.2 Aerial surveys

Aerial surveys were commenced in April 1999. Only experienced observers familiar with species identification were used. Based on the experiences from the first two surveys, the extent of the area counted was increased and transect orientation changed. Based on an increasing understanding of the recording probabilities of the bird species most often observed in the area, transect width was changed on two occasions to optimise survey data.

The whole study area was covered by a total of 26 north-south oriented, parallel transects, flown at 2 km intervals from Skallingen in the east, westwards to a point 37 km off Blåvandshuk (see Fig. 1b). The transects covered a total linear track of 821 km. Transect endpoints were entered into the aircraft GPS as way points, used for navigation along the transect tracks. The covered area was further divided into grids of 2x2 km.

Surveys were conducted from a high winged, twin-engined Partenavia P-68 Observer, designed for general reconnaissance purposes. Following the results of test flights in the Kattegat in August 1999, flight altitude during surveys was 78 m (250 feet) and cruising speed approximately 185 km/h (100 knots).

During surveys, two observers covered each side of the aircraft. All observations were continuously recorded on dictaphone, giving information on species, number, behaviour, transect band and time. Transect bands were determined by use of an inclinometer (predetermined angles below the horizontal measured abeam flight direction), and included three bands on each side of the aircraft. Beneath the aircraft, a band of 49 m on each side of the flight track could not be observed. Transect widths used during the aerial surveys are shown in Table 1. The behaviour of observed birds included the activities: sitting (on the water), diving, flushing or flying.

During aerial surveys a computer logged flight track data from a differential GPS at five second intervals. Each record contained longitude, latitude, altitude and time. Accuracy of GPS longitude and latitude was normally considered to be within 2 m.

After the completion of a survey, tables of observation data and flight track data were created from the transcription. A combination of ArcView, GIS and TurboPascal software was used to add a position to

Table 1. Summary of the different transect widths used on different aerial survey dates, and the total distance of transect surveyed (including counts from both sides of the aircraft).

Date	Transect A	Transect B	Transect C	Km transect covered (both sides)
20 April 1999	49-300 m	>300 m		497
4 May 1999	49-300 m	>300 m		618
3 August 1999	49-250 m	>250 m		1273
3 September 1999	49-174 m	175-459 m	>459 m	1449
12 November 1999	49-174 m	175-459 m	>459 m	1467
17 February 2000	49-174 m	175-459 m	>459 m	1642
21 February 2000	49-174 m	175-459 m	>459 m	1154
19 March 2000	49-174 m	175-459 m	>459 m	1642
27 April 2000	49-174 m	175-459 m	>459 m	1441

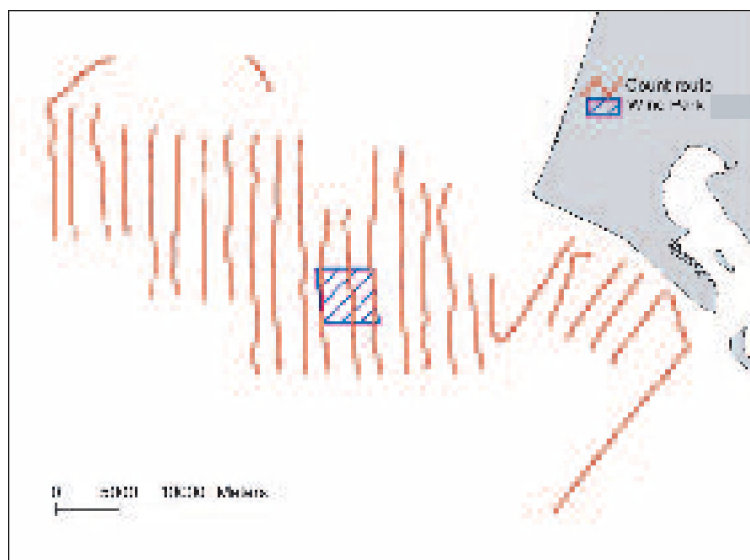


Figure 3a. Count route for the aerial survey 20 April 1999.

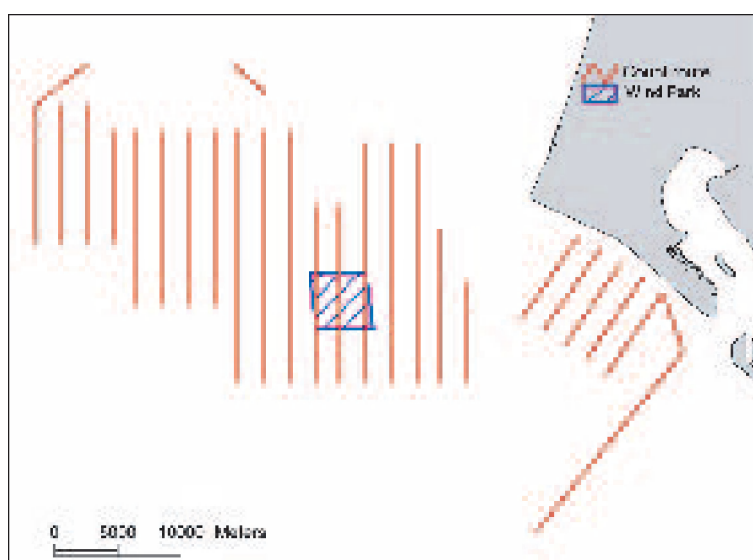


Figure 3b. Count route for the aerial survey 4 May 1999.

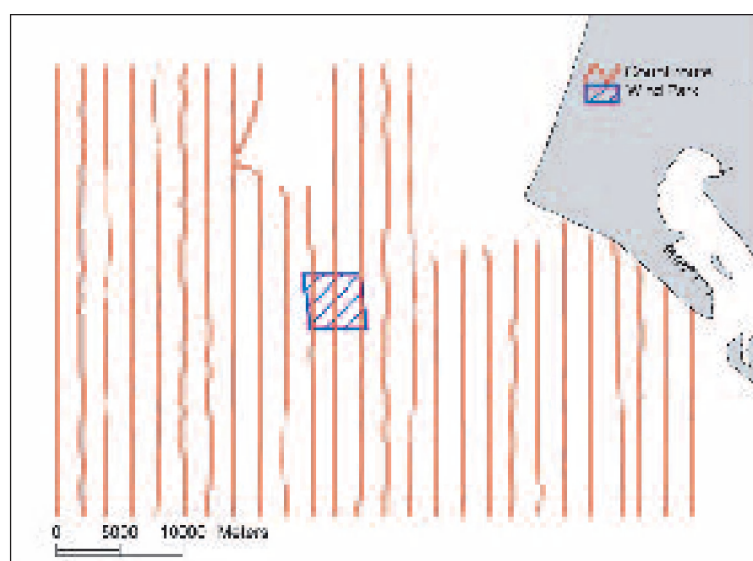


Figure 3c. Count route for the aerial survey 3 August 1999.

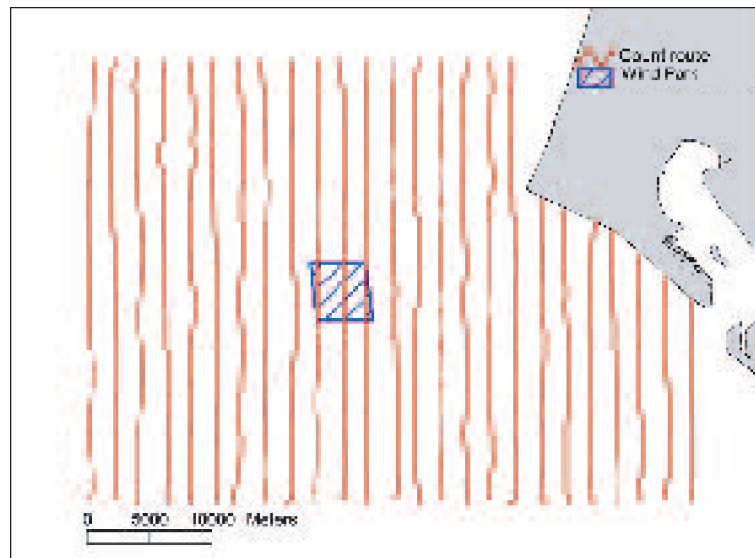


Figure 3d. Count route for the aerial survey 3 September 1999.

each record of observation data, assigning observations to transect band and side of flight track.

The majority of observations were considered to be accurate within 4 seconds. In situations where high densities of birds were encountered, multiple observations may all have a common time reference. Grouping of observations very rarely extended over a period of more than 10 seconds. Hence, overall, the positional accuracy on the longitudinal axis was in most cases within less than 206 m of actual, but could potentially in cases of grouped observations, for 10 seconds extend to 515 m.

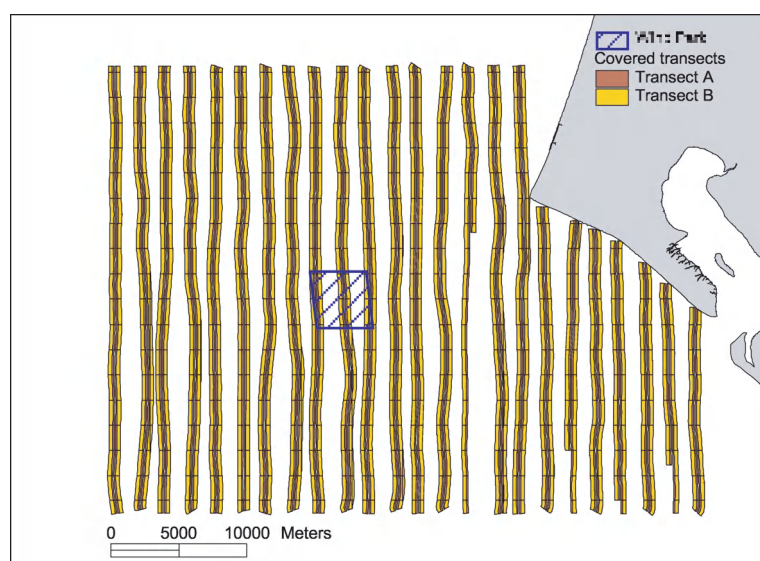


Figure 3e. Count route for the aerial survey 12 November 1999. The inner (A) and outer (B) transects are shown. At some parts of a few transects counts were only carried out to one side of the aircraft.

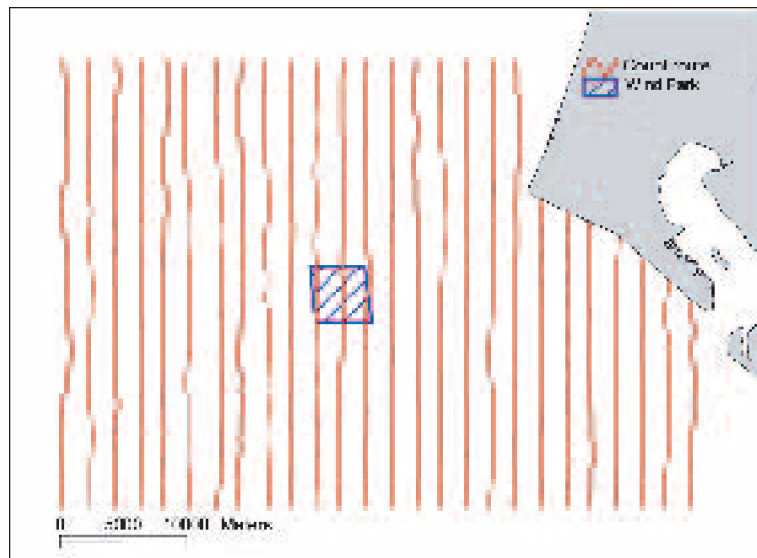


Figure 3f. Count route for the aerial survey 17 February 2000.

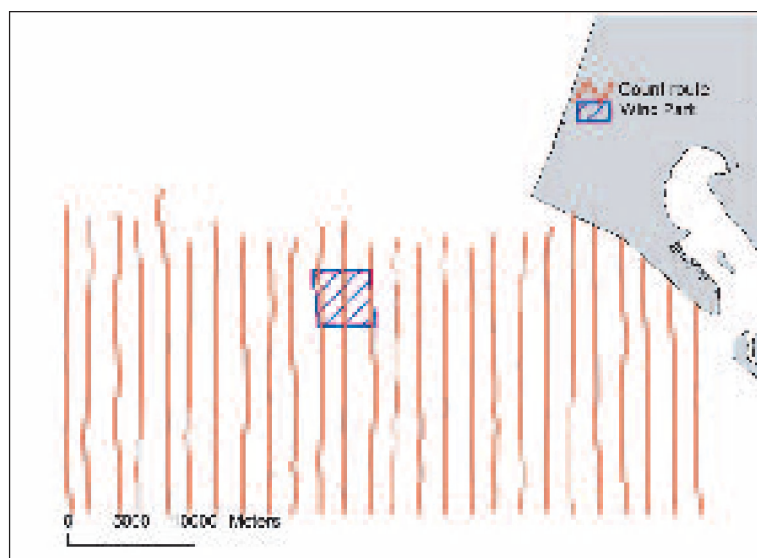


Figure 3g. Count route for the aerial survey 21 February 2000.

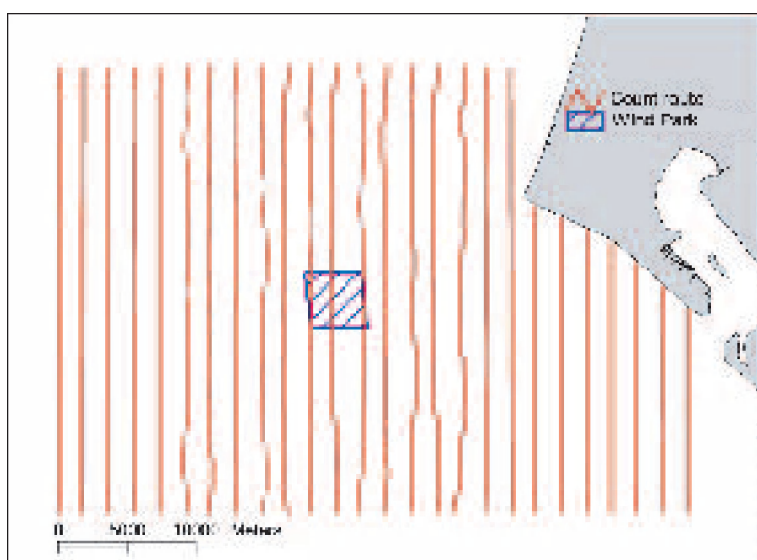


Figure 3h. Count route for the aerial survey 19 March 2000.

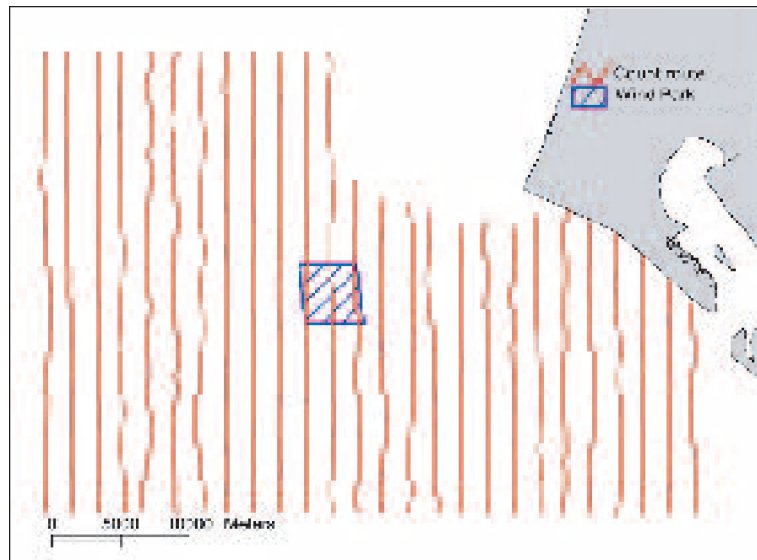


Figure 3i. Count route for the aerial survey 27 April 2000.

During the survey on 4 May 1999 the GPS failed during track-logging. Observation positions in this case were calculated from the known time of passage at the way points that were used for navigation and from the cruising speed of the aircraft. This was also the case for some transects on the 19 March 2000 survey. In these cases the spatial accuracy of the observation data is somewhat reduced.

Survey results are highly sensitive to weather conditions. Surveys were not carried out when wind speed exceeds 6 m/s, when detectability of birds on the sea surface was severely reduced. Low visibility or glare also reduced detectability. In cases of severe glare, observations from one side of the aircraft were temporarily discontinued (see Fig. 3e).

The coverage on each survey is shown in Fig. 3a-i. Military activity

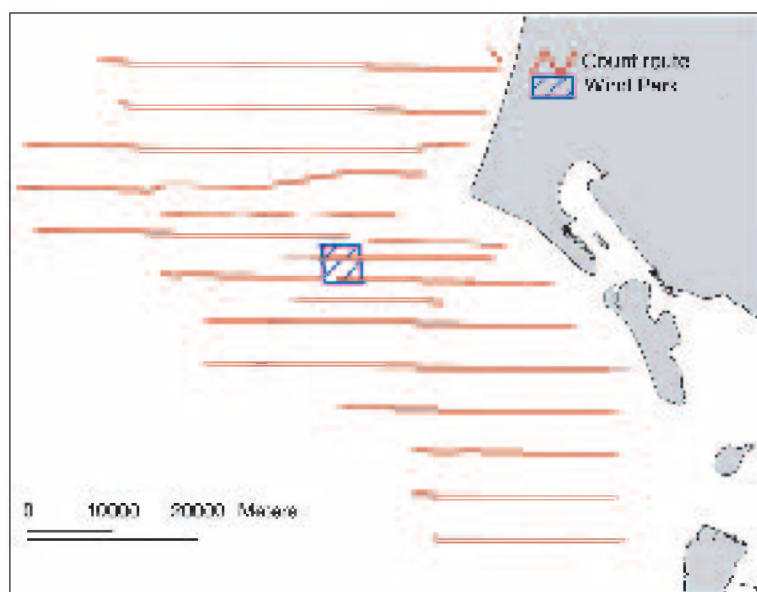


Figure 4a. Count route for ship survey April-May 1999.

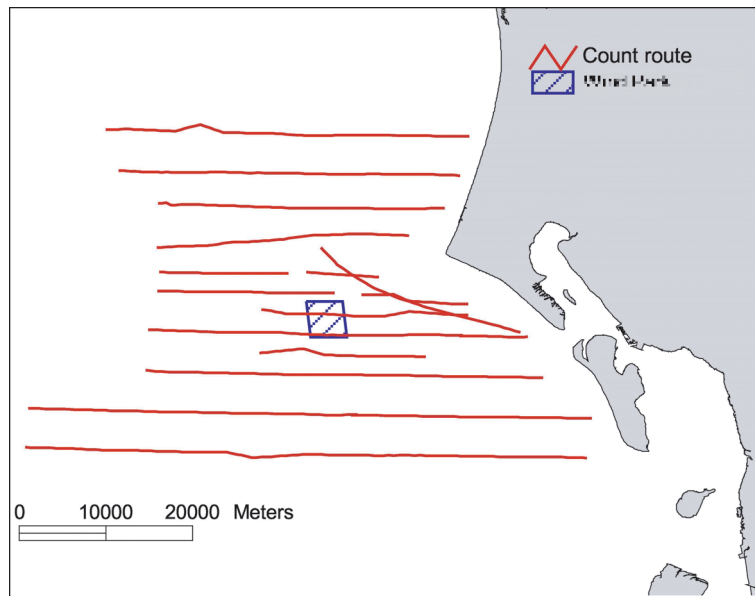


Figure 4b. Count route for ship survey August 1999.

prevented full coverage of the north-eastern part of the reference area on some days. In the analysis of bird numbers and distributions, only the six most homogenous surveys, i.e. those of 3 August, 3 September, 12 November, 17 February, 19 March, and 27 April were used.

2.3.3 Ship surveys

Ship surveys were performed by Ornis Consult A/S in April/May, August, and November 1999. Only experienced observers were used. The surveys included a total of 12 east-west orientated, parallel transects, at 5 km intervals. The transects extended from southern Fanø in the south to Henne Strand in the north, and westwards to a distance of 51 km from Blåvandshuk. In the area around the wind

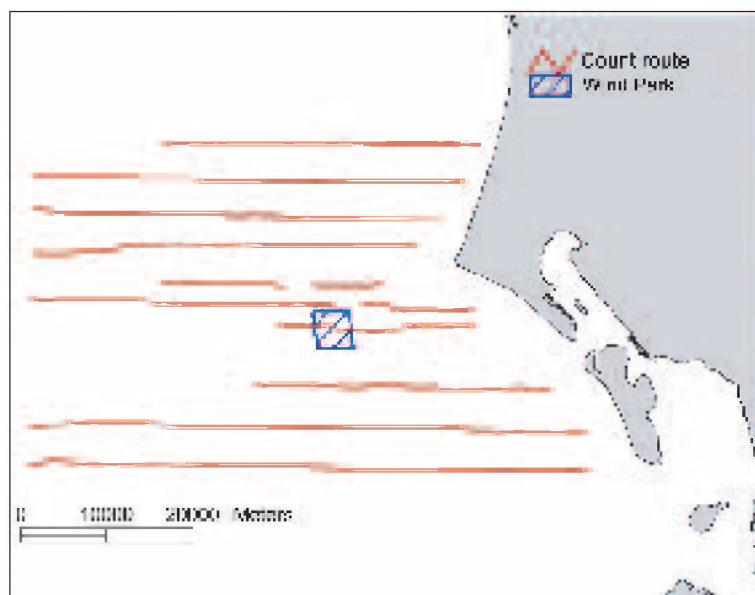


Figure 4c. Count route for ship survey November 1999.

park extra transects were added, reducing the distance between transects to 2.5 km (Fig. 4a-c).

Observations were carried out from a 360 gross registered tonnes stern trawler with a cruising speed of 18-20 km/hour (10-11 knots). Counts were made from a shelter 7 metres above sea level. Waters less than 6 m depth could not be surveyed due to the draught of the ship.

Surveys were conducted exclusively in good weather conditions, with wind less than 8 m/s and visibility more than 1 km. Counting techniques followed a modified version of the international standards for shipbased seabird surveys (Webb & Durinck 1992) that includes birds flushing in front of the vessel. Two observers counted a 300 m wide band on one side of the vessel, perpendicular to its cruise direction. Observations were made in a 90° search angle, extending from the cruise direction to abeam. All observations were grouped into 2 minutes intervals, and separated into four transect bands (Table 2). Correct designation to transect bands was made possible by use of binoculars and range finder (Webb & Durinck 1992), and in cases when birds flushed in front of the vessel by use of an angle-distance calibration (Durinck et al. 1993). The spatial accuracy was approximately 650 m.

3 General occurrence of birds in the Blåvandshuk area

3.1 Introduction

Information on seasonal occurrences, peak migration periods and peak numbers of species was primarily based on counts from Blåvandshuk (Jakobsen in prep., Kjær 2000), supplemented by results from ship

Table 2. Ship survey data showing transect width used and the total distance of transects surveyed (observations were only made on one side of the ship).

Month/Year	Dates	Transect A	Transect B	Transect C	Transect D	Kilometre transect covered
April/May 1999	24. 25. 30. 05.	0-50	50-100	100-200	200-300	569
August 1999	24. 29. 30.	0-50	50-100	100-200	200-300	533
November 1999	11. 12. 15.	0-50	50-100	100-200	200-300	471

and aerial surveys from 1987-1989 (Laursen et al. 1997a). Information relating to the ecology and biology of the most commonly occurring species is presented in Appendix II.

For each species the importance of the area is assessed. Based on the Ramsar Convention (see Appendix I), an area is considered of international importance if more than 1% of the world or flyway population are present in the area at some time of the annual cycle. Population estimates were obtained from Rose & Scott (1994, 1997).

Several bird species are listed on the Danish red-list and yellow-list. The red-list includes breeding species that are uncommon, or immediately threatened (Stoltze & Pihl 1998a), while the yellow-list includes breeding and non-breeding species, which are potentially threatened, or species that occur in numbers that Denmark has a special obligation to protect (Stoltze & Pihl 1998b). Of red-listed species occurring in the Horns Rev area are Little Gull, Guillemot and Razorbill. Red-throated Diver, Eider, Common Scoter, Guillemot and Razorbill occur on the yellow-list. For those species that breed in Denmark, only parts of the Danish populations occur, or may occur, in the Horns Rev area.

Based on existing knowledge from Blåvandshuk and from the offshore surveys there follows a summary of the status of birds occurring around Horns Rev. The species are divided into two groups:

- birds utilising the area for staging, wintering or moulting (divers, grebes, seabirds, Gannet, sea ducks, auks, skuas, terns and gulls),
- birds passing through the area on migration (virtually all species that have been regularly recorded in Denmark).

3.2 Divers *Gaviidae*

Four species of divers have been recorded in the area. In general, however, divers are difficult to identify to species in the field, and most observations could only be assigned to either 'large divers' (Great Northern Diver *Gavia immer* or White-billed Diver *Gavia adamsii*) or 'small divers' (Red-throated Diver *Gavia stellata* or Black-throated Diver *Gavia arctica*). The two former species occur in Danish waters in very low numbers and will not be dealt with further.

Based on the results from the ship surveys in 1999, 78% of the identified divers were Red-throated and 22% Black-throated Divers. These figures are consistent with earlier findings (Joensen & Hansen 1977, Jakobsen in prep.).

3.2.1 Red- *Gavia stellata* and Black-throated Diver *G. arctica*

Spring migration at Blåvandshuk takes place during April-May with up to 5,500 divers passing per day. Autumn migration takes place during October-November and is less concentrated with up to 1,000 birds per day (Jakobsen in prep.). Observations of 5,000-6,000 divers per day in March migrating south are considered to be wintering birds compensating for nocturnal drift caused by wind and current.

Aerial and ship surveys carried out during 1987-1989 demonstrated that the area off the Wadden Sea north and south of Horns Rev (c. 6,000 km²) held internationally important numbers of divers during autumn, winter and spring (Laursen et al. 1997a). The estimated autumn population was 1,700-2,200 birds. During winter up to 4,500 individuals have been estimated in the southeast North Sea (Laursen & Frikke 1987), while in spring, up to 28,500 birds were estimated to be present in the area (Laursen et al. 1997a).

Rose & Scott (1997) estimated flyway population sizes at 75,000 Red-throated and 170,000 Black-throated Divers.

3.3 Grebes *Podicipitidae*

3.3.1 Great Crested Grebe *Podiceps cristatus*

The Great Crested Grebe occurs as an autumn migrant at Blåvandshuk, with occasional records of winter movements during periods of cold spells (Jakobsen in prep.).

3.3.2 Red-necked Grebe *Podiceps grisegena*

Red-necked Grebe is the most numerous grebe recorded on migration at Blåvandshuk. Most birds are recorded during autumn migration during September-November (Kjær 2000). Highest number recorded has been 107 birds/day (Jakobsen in prep.).

The area off Blåvandshuk was previously considered an important wintering area for Red-necked Grebe. Skov et al. (1995) estimated a wintering population of ca. 200 birds in the area of Horns Rev, while Laursen et al. (1997a) found a density of 0.1-0.99 birds/km², suggesting that up to c. 650 Red-necked Grebes could winter in the area.

Rose & Scott (1997) estimated a flyway population size at 15,000 Red-necked Grebes.

3.4 Gannet *Sula bassanus*

At Blåvandshuk the first Gannets are observed in July and the peak migration takes place September-October with up to 4,000 birds/day (Jakobsen in prep.). The occurrence at the coast is primarily related to periods of strong westerly winds pushing the birds close to Blåvandshuk. It is assumed that some movements in the area take place in relation to food availability (following shoals and the local abundance of fish), since a substantial proportion of the birds is flying north (Jakobsen in prep.).

According to Laursen et al. (1997a) the Gannet is widespread in the North Sea outside the winter. In the Danish part of the North Sea in the late 1980s the estimated number of birds ranged from none in winter to 22,000 birds in late summer and autumn. The estimate of 22,000 birds is probably an overestimate as the Gannet may be attracted to the ships used in surveys (Laursen et al. 1997a).

3.5 Eider *Somateria mollissima*

The Eider occurs in the Wadden Sea area and at Blåvandshuk at all times of the year. Staging and wintering birds are rarely observed north of Blåvandshuk. The species has a rather coastal distribution and a large part of the birds are found in the waters between the mainland and the islands of Fanø, Møn, and Rømø (Laursen et al. 1997a).

During the winter period up to 35,000 Eiders have been recorded in the Blåvandshuk area, with highest numbers occurring during severe winters (Jakobsen in prep.). Up to 40,000 Eiders were present in the southeastern part of the North Sea during the severe winter of 1986 (Laursen & Frikke 1987). The number and distribution of wintering birds are probably influenced both by winter conditions (ice cover in the Wadden Sea forcing the birds into deeper offshore waters), and availability of the main prey, Common Mussel *Mytilus edulis*, in the Wadden Sea (Jakobsen in prep.), but probably also affected by ice cover in the inner Danish waters (Laursen & Frikke 1987). At Blåvandshuk, the Eider migration takes place during February-March and October-November, which may account for up to 30,000 birds/day (Jakobsen in prep.).

Rose & Scott (1997) estimated the flyway population size at 1.35 - 1.7 million Eiders.

3.6 Common Scoter *Melanitta nigra*

The Common Scoter occurs in the Wadden Sea area and at Blåvandshuk at all times of the year. During June-July thousands of Common Scoters undertake a moult migration to the area west of the Wadden Sea and Skallingen where they moult their flight feathers and other parts of their plumage and are flightless for a period of 2-3 weeks. Joensen (1973) recorded 100,000-150,000 flightless Scoters in late July 1963 in the area between Blåvandshuk and Rømø, while Laursen et al. (1997a) estimated 11,400-70,900 moulting Scoters in the area west of the Danish Wadden Sea during 1987-1989. Moulting birds are normally to be found in remote offshore waters far from the coast. Pre-moulting Common Scoters have been observed at Blåvandshuk in numbers up to 20,000 birds in June (Jakobsen in prep.).

After completion of moult, a substantial part of the aggregation is assumed to migrate further south along the west coast of Europe (Laursen et al. 1997a). The area west of the Wadden Sea is, however, an important staging area during autumn migration, supporting more than 100,000 Common Scoters (Laursen et al. 1997a). At Blåvandshuk autumn migration peaks during August-September with a daily maximum record of 60,000 birds (Jakobsen in prep.). Laursen et al. (1997a) report that - although numbers fluctuate - up to 120,000 birds may winter off the Wadden Sea, while observations at Blåvandshuk show a more stable number of 25,000-40,000 Common Scoter in this area visible from land (Jakobsen in prep.). Laursen et al. (1997a) report that the highest numbers occur off the Wadden Sea during severe winters, which is the factor assumed to be responsible for the maximum numbers recorded (>200,000) at Blåvandshuk in 1984 and 1985 (Jakobsen in prep.) and 170,000 counted from aircraft in the southeast North Sea during the severe winter of 1986 (Laursen & Frikke 1987).

Spring migration of Common Scoters in Denmark takes place in the period March-May according to Salomonsen (1972). However, spring migration is less pronounced, since the majority of Common Scoters migrate directly over land from the Wadden Sea to the Baltic Sea during the night (Cramp & Simmons 1977). Laursen et al. (1997) estimated that up to 50,000 Common Scoters were present in the area west of the Wadden Sea in spring.

Based on the numbers recorded during the 1987-1989 surveys (Laursen et al. 1997a), the offshore area from Blåvandshuk to Rømø has been assigned as an internationally important staging area for moulting, autumn migrating and wintering Common Scoters, but is a less important staging area in spring.

Rose & Scott (1997) estimated the flyway population size at 1.6 million Common Scoters.

3.7 Skuas *Stercoraridae*

Four species of skuas occur regularly in the North Sea. Of these, Arctic Skua *Stercorarius parasiticus* is by far the most numerous species, but is, however, difficult to distinguish from both Pomarine Skua *Stercorarius pomarinus* and Long-tailed Skua *Stercorarius longicaudus*. 86 records of positively identified skuas from the ship surveys resulted in 75 (87%) Arctic Skuas, 10 (12%) Pomarine Skuas and 1 (1%) Long-tailed Skua, while no separation was made during aerial surveys.

At Blåvandshuk skuas are observed in relatively small numbers with Arctic Skua as the most common with up to 200 birds/day in late August - mid September (Jakobsen in prep.). Great Skua *Stercorarius skua* is regularly observed during late summer and autumn with 20 birds as a daily maximum. Pomarine Skua and Long-tailed Skua are only observed irregularly, but may in some years occur in high numbers.

3.8 Gulls *Larinae*

Gulls are widely distributed and occur in large numbers in the Horns Rev and Blåvandshuk area at all times of the year. The Black-headed Gull *Larus ridibundus* is primarily associated with inshore waters. Little Gull *Larus minutus*, Common Gull *Larus canus*, Herring Gull *Larus argentatus*, Lesser Black-backed Gull *Larus fuscus*, and Great Black-backed Gull *Larus marinus* occur both in inshore and offshore waters. Kittiwake *Rissa tridactyla* occurs mainly in offshore waters, but with strong westerly winds many birds show up at Blåvandshuk.

3.8.1 Little Gull *Larus minutus*

The Little Gull occurs in the North Sea only in the area west-north-west of Blåvandshuk. Based on the offshore surveys during 1987 to 1989, the estimated numbers in this area reached 3,100 individuals in autumn and 850 in winter and spring (Laursen et al. 1997a). At Blåvandshuk up to 200 birds/day passing in January-April are considered as wintering birds, since spring migration takes place during late April and May. Autumn migration takes place in October-November with a maximum of 600 birds/day (Jakobsen in prep.).

Rose & Scott (1997) estimated the Central/Eastern European population to be 60,000-90,000 Little Gulls. The birds wintering in the North Sea region originate from this population.

3.8.2 Herring Gull *Larus argentatus*

The Herring Gull is very common in the area. At Blåvandshuk 15,000-20,000 can be seen during winter. Spring migration starts in late February, but the numbers remain high until May with up to 5,000-7,000 birds/day due to the presence of non-breeding immature and sub-adult birds. From late summer the numbers increase until November, with a maximum peak of 23,000 birds/day (Jakobsen in prep.).

Rose & Scott (1997) estimated the northwestern European population to be 1.4 million Herring Gulls.

3.8.3 Great Black-backed Gull *Larus marinus*

The Great Black-backed Gull occurs at Blåvandshuk throughout the year. Highest numbers are recorded during summer and autumn with up to 750 birds/day present (Jakobsen in prep.). The species seems to be more pelagic during autumn and winter than during spring and summer (Skov et al. 1995).

Rose & Scott (1997) estimated the northeastern Atlantic population to be 480,000 Great Black-backed Gulls.

3.8.4 Kittiwake *Rissa tridactyla*

The estimated number of Kittiwakes in the North Sea in late summer is 13,000-34,000 birds, in autumn 45,000-115,000 birds, and in winter 34,000-95,000 birds. Highest densities normally occur in the northern parts of the North Sea along the Norwegian Trench (Laursen et al. 1997a). Kittiwakes are observed at Blåvandshuk mainly during summer and autumn when up to 5,000 birds/day may be seen from late August to late October (Jakobsen in prep.). In spring, the occurrence of Kittiwake is normally associated with strong westerly winds (Skov et al. 1995).

Rose & Scott (1997) estimated the eastern Atlantic population at 8.4 million Kittiwakes.

3.9 Terns *Sterninae*

Discrimination between Arctic *Sterna paradisaea* and Common Tern *Sterna hirundo* is only possible at close range and under optimal conditions. Of 346 identified terns during the ship surveys 209 (60%) were Arctic Tern and 137 (40%) were Common Tern. Although there is some difference in their temporal occurrence, observations of the two species are lumped.

3.9.1 Arctic *Sterna paradisaea* and Common Tern *S. hirundo*

The Arctic and Common Tern arrive in Danish waters in April, and spring migration peaks in late April - early May, when up to 5,000 birds/day can be observed at Blåvandshuk (Jakobsen in prep.). Autumn migration occurs in July-August with records of up to 17,000 birds/day (Kjær 2000).

Rose & Scott (1997) estimate the European population of Common Tern to be 780,000 birds. There is no estimate for the Arctic Tern available.

3.9.2 Sandwich Tern *Sterna sandvicensis*

The Sandwich Tern normally occurs at Blåvandshuk from March to October. Highest numbers are observed during migration with up to 1,800 birds/day in April-May and up to 6,000 birds/day in July-August (Jakobsen in prep.). The species breeds on Langli in Ho Bight with up to 1,350 pairs in 1997 and 1998 (Laursen 1999) and birds from the colony probably forage in the North Sea off Skallingen and Blåvandshuk.

Rose & Scott (1997) estimated the western European and western African population at 150,000 Sandwich Terns.

3.10 Auks *Alcidae*

Of 812 positively identified individuals during the ship surveys, 57% was Guillemots *Uria aalge* and 43% Razorbills *Alca torda*. Although identification was assumed to be more difficult from aircraft, similar proportions were obtained from 30 individuals identified during aerial surveys (see Table 3).

3.10.1 Guillemot *Uria aalge* and Razorbill *Alca torda*

According to Laursen et al. (1997a) the Guillemot is more abundant and widely distributed in the North Sea than the Razorbill. In the German Bight the late summer population was estimated to be 4,500-20,000 Guillemots increasing to 15,000-30,000 birds in autumn. The numbers of Razorbill were estimated at 100-1,700 birds during autumn, increasing to 4,200 birds in winter.

At Blåvandshuk both Guillemot and Razorbill are most numerous during October-November with up to 1,500 birds/day counted. Smaller numbers occur during winter from December to February (Jakobsen in prep.).

According to Lloyd et al. (1991) the northwestern European population of Guillemots is estimated to be 1.5 million birds and that of Razorbill 200,000 birds.

3.11 Occurrence of birds in the vicinity of alternative cable laying routes

3.11.1 Hvidbjerg Strand alternative

The coastal zone of Esperance Bugt, including Hvidbjerg Strand, is known to support large numbers of Common Scoter, Eider, gulls and terns at certain times of the annual cycle. Divers may also be present in lower concentrations during late winter.

The area is used for feeding by pre-moulting Common Scoters in June-July, before they disperse offshore to moult during July-September. Between 70,000 and 150,000 Common Scoters have been previously recorded in the area between Blåvandshuk and Rømø (Joensen 1973, Laursen et al. 1997a). Eiders exploit the coastal zone mainly during autumn and winter, but the occurrence is highly variable, depending especially on winter conditions (Jakobsen in prep.).

Gulls may occur in high numbers at all times of the year, while terns are most numerous during the late summer/autumn migration period.

3.11.2 Sædding Strand alternative

Laying the cable to Sædding Strand will involve crossing areas of Hobo Dyb and Langli Sand. The most common bird species in these areas are Eider, shorebirds, gulls and terns.

Eiders occur during winter in the deeper parts of Hobo Dyb, Grådyb and Hjerting Løb, where they exploit mussels (Laursen et al. 1997b). Shorebirds, gulls and terns mainly use Langli Sand during high-tide roosts. The sediment of Langli Sand is unstable due to its exposed position and hence has a relatively poor benthic fauna making it unimportant as feeding area for migrating birds.

Eiders do not normally occur in high numbers in the proposed cable route, but the number of roosting birds on Langli Sand may include up to 5,000 Oystercatcher *Haematopus ostralegus*, 10,000 Dunlin *Calidris alpina*, 1,000 Bar-tailed Goodwit *Limosa lapponica*, 10,000 Black-headed Gull, 5,000 Herring Gull, 1,500 Sandwich Tern and 5,000 Common/Arctic Tern (Thalund 1995, Hansen 1997, Laursen 1999).

On days with extreme high tides Langli Sand is fully flooded. On

such days, birds are known to move to alternative roosting sites in the region, e.g., Grønningen at Fanø (Hansen 1997).

4 Bird numbers and distribution recorded 1999-2000

4.1 Introduction

The existing literature is sufficient to document numbers and phenology of birds in the general area. However, almost all observations from the Horns Rev area have been made from the coast, and virtually nothing was known of bird distributions and their ecological exploitation of the offshore habitat. For this reason, detailed counts were initiated in 1999. The objectives of the counts were to obtain data that allow comparison between an expected impact zone around the wind park with a 'reference area' (in this case, the reference area is the peripheral area around the wind park), and to obtain data on which assessment of the relative importance of the entire area have to birds can be made. For these reasons, the main purposes of the counts were to:

1. Map the distributions of birds in the area, preferably throughout an annual cycle.
2. Assess densities and numbers of different species.

In order to interpret the bird distributions in relation to the potential food resources, the following section treats the various species according to whether they feed on fish, bottom fauna or other food resources.

4.2 Species recorded

Species and numbers recorded during the nine aerial surveys carried out between April 1999 and April 2000 are shown in Table 3. A few observations of migrating bird species that do not belong to the marine environment (e.g. shorebirds) are omitted.

Table 3. Number of birds observed during the aerial surveys during April 1999 - April 2000 in the Horns Rev area.

Species	20 April 1999	4 May 1999	3 Aug. 1999	3 Sep. 1999	12 Nov. 1999	17 Feb. 2000	21 Feb. 2000	19 Mar. 2000	27 April 2000
Red-throated Diver					15			12	
Red-/Black-throated Diver	62	52	23	5	56	314	106	129	113
Great Northern-/White-billed Diver	1						1		
Fulmar	6	1	3	16					
Gannet			25	266	2			6	7
Cormorant			3	2	1				2
Eider	6			5	458	2,114	181	476	97
Common Scoter	75		68	119	10,231	7,190	3,861	10,459	9,230
Velvet Scoter	60	4			28				16
Red-breasted Merganser						3		1	
Arctic/Pomarine/Long-tailed Skua				20	1				1
Great Skua			1	1	1				1
Little Gull					8			5	
Black-headed Gull		8	8	13		1	1	14	
Common Gull		5	110		38		13	3	27
Lesser Black-backed Gull		1	9	1				3	1
Herring Gull	350	78	254	699	235	4,025	3,327	1,857	112
Great Black-backed Gull	51	55	19	129	21	4	14	31	11
Kittiwake	16	3	186	324	520	18	41	70	2
Gull sp.	200	503		13		2	4	1	
Sandwich Tern	22	21	48	12				1	12
Common Tern					5				
Common/Arctic Tern	79	135	692	100				1	545
Guillemot				4	3	3	4	2	
Razorbill					9		3		2
Guillemot/Razorbill	1	2		59	372	59	67	18	3
Little Auk		1							

Species and numbers recorded during the three ship surveys carried out in April/May, August, and November 1999 are shown in Table 4. As for the aerial surveys, a few species (e.g. Starling and Woodcock) have not been included.

4.3 Distributions of birds using the Horns Rev area

4.3.1 Fish-eating species

4.3.1.1 Red- *Gavia stellata* and Black-throated Diver *G. arctica*

During the aerial counts, a total of 887 divers were recorded. The highest numbers occurred during late winter and spring, which is consistent with earlier findings. The observed distributions varied con-

Table 4. Number of birds observed during the ship surveys in April/May, August, and November 1999 in the Horns Rev area.

Species	April/May 1999	August 1999	November 1999
Red-throated Diver	30		27
Black-throated Diver	13		3
Red-/Black-throated Diver	298	2	55
Great Northern Diver	1		
Red-necked Grebe			3
Fulmar	4	5	12
Gannet	17	464	21
Eider	7		12
Common Scoter	405	4,749	1,398
Velvet Scoter	2		4
Red-breasted Merganser			1
Pomarine Skua		3	7
Arctic Skua	11	55	9
Long-tailed Skua		1	
Arctic/Pomarine/Long-tailed Skua		95	2
Great Skua		3	
Little Gull	8		42
Black-headed Gull	1		
Common Gull	29	18	197
Lesser black-backed Gull	92	52	
Herring Gull	115	246	101
Great black-backed Gull	22	27	41
Kittiwake	7	100	375
Gull sp.	255	50	350
Sandwich Tern	81	39	
Common Tern	20	117	
Arctic Tern	179	30	
Common/Arctic Tern	78	41	
Guillemot	7	106	354
Razorbill			352
Guillemot/Razorbill			95
Little Auk			8
Puffin			6

siderably. In most cases, divers were observed scattered over the general area, though with a tendency for fewer observations in the shallows at the reef, but on 17 February 2000 high concentrations were encountered around Blåvandshuk (Fig.5a-d).

The ship transect count April-May 1999 likewise indicated a scattered distribution, but with a tendency for lower concentrations at the reef proper (Fig. 6).

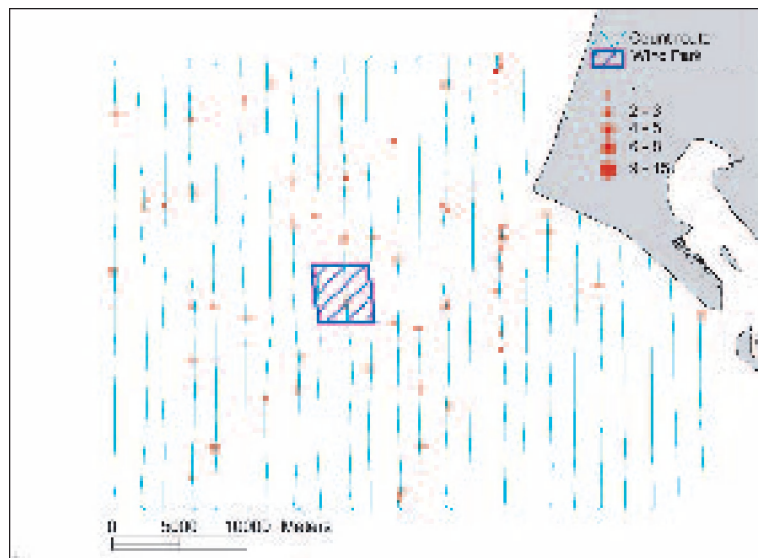


Figure 5a. Distribution of 71 divers, observed from aircraft 12 November 1999.

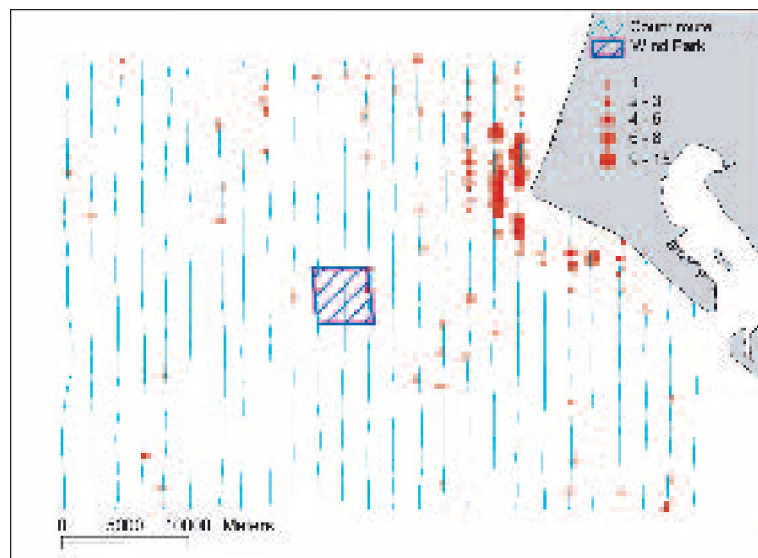


Figure 5b. Distribution of 314 divers, observed from aircraft 17 February 2000.

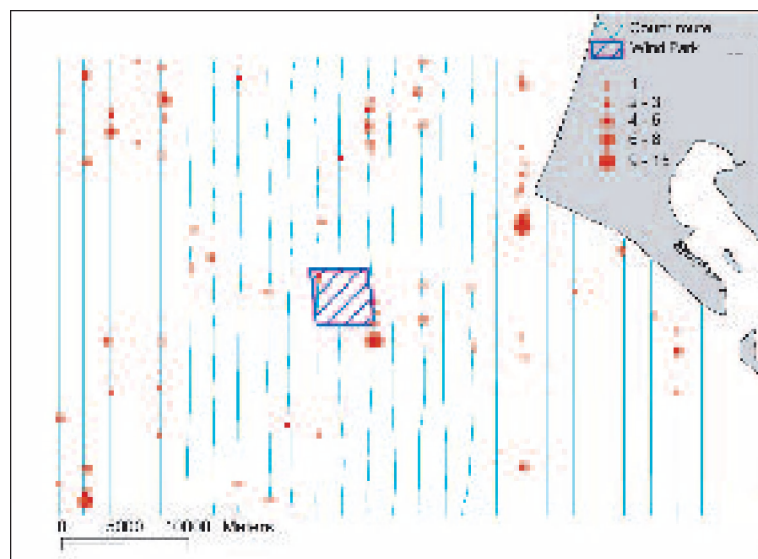


Figure 5c. Distribution of 141 divers, observed from aircraft 19 March 2000.

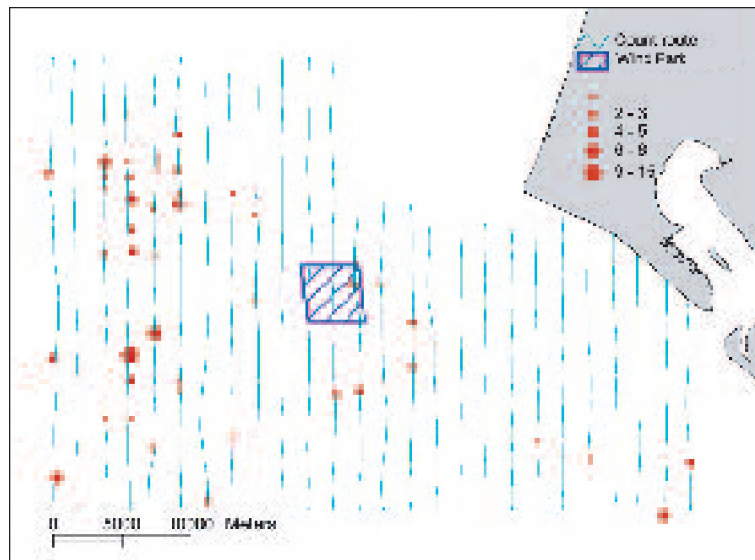


Figure 5d. Distribution of 113 divers, observed from aircraft 27 April 2000.

4.3.1.2 Red-necked Grebe *Podiceps griseigena*

No Red-necked Grebes were recorded during the aerial surveys. During the November 1999 ship transect count, 3 birds were recorded. Thus, even if a number of Red-necked Grebes have been observed both during earlier ship transect counts (in 1987-1989) and from Blåvandshuk, there are no indications in the present material that the waters around Horns Rev are of ecological importance for the species.

4.3.1.3 Gannet *Sula bassanus*

During the aerial counts 306 Gannets were recorded. Most were seen in August-September, with a few records in March and November.

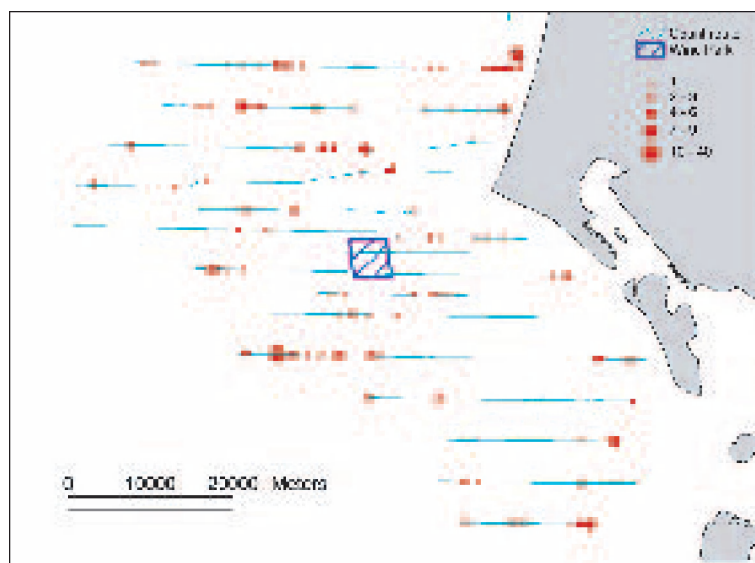


Figure 6. Distribution of 342 divers, observed from ship April/May 1999.

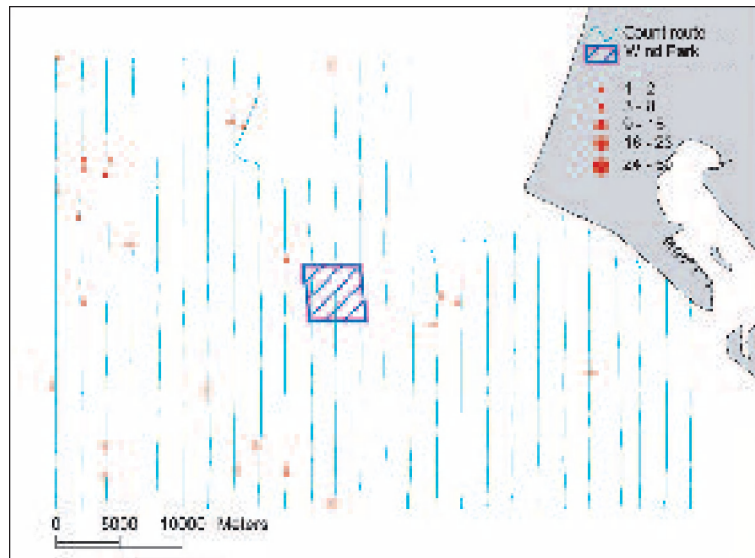


Figure 7a. Distribution of 25 Gannets, observed from aircraft 3 August 1999.

This phenological pattern is consistent with earlier findings. Gannets were recorded in groups of up to 50 individuals. In August, the rather few Gannets observed were scattered far offshore (Fig. 7a). During the September count, the highest numbers were seen at Horns Rev, northwest of the area projected for the wind park (Fig. 7b).

4.3.1.4 Arctic *Sterna paradisaea* and Common Tern *S. hirundo*

A total of 1,557 Arctic/Common Terns were recorded during the aerial counts. Most were observed in April-May and in August, consistent with earlier findings. Both in the April, May, and August aerial counts, highest numbers were observed north and west of Horns Rev (Fig. 8a-c).

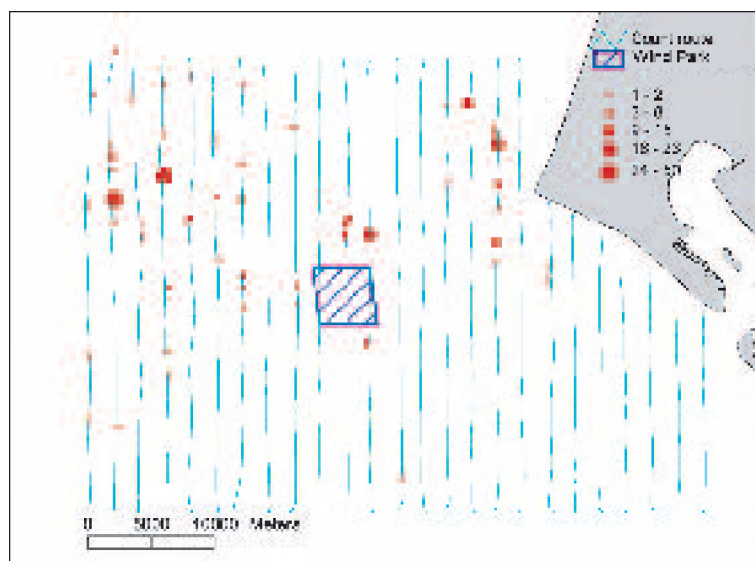


Figure 7b. Distribution of 266 Gannets, observed from aircraft 3 September 1999.

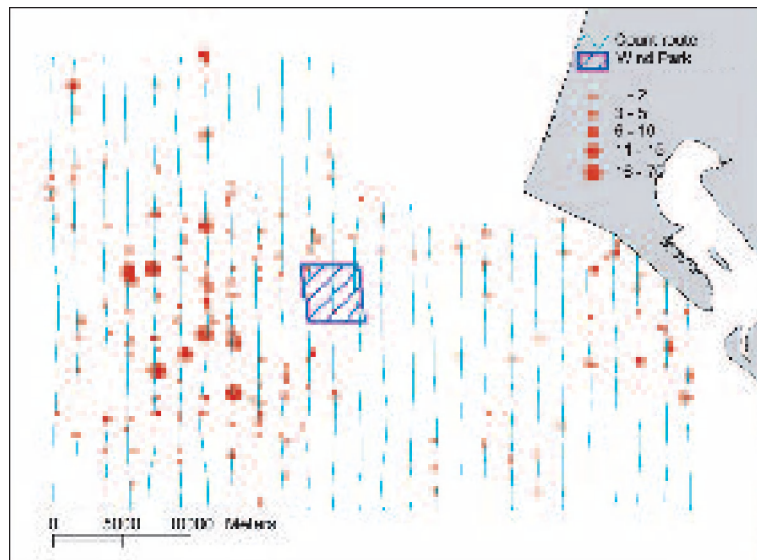


Figure 8a. Distribution of 545 Arctic/Common Terns, observed from aircraft 27 April 2000.

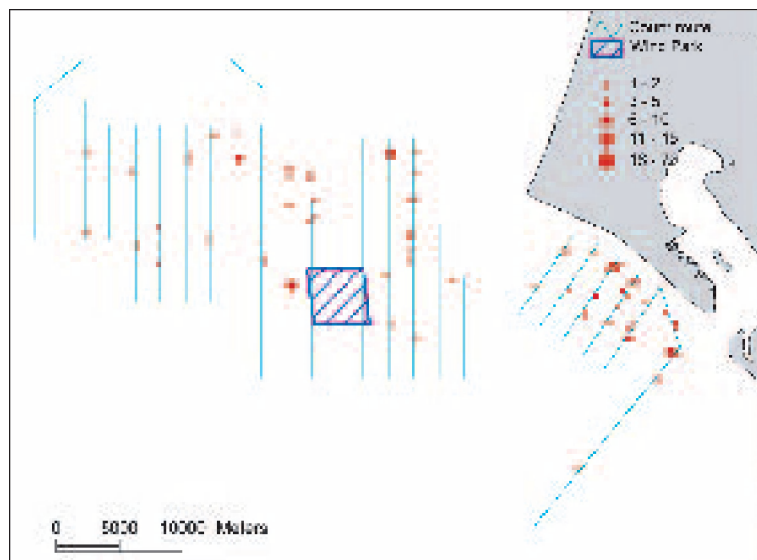


Figure 8b. Distribution of 117 Arctic/Common Terns, observed from aircraft 4 May 1999.

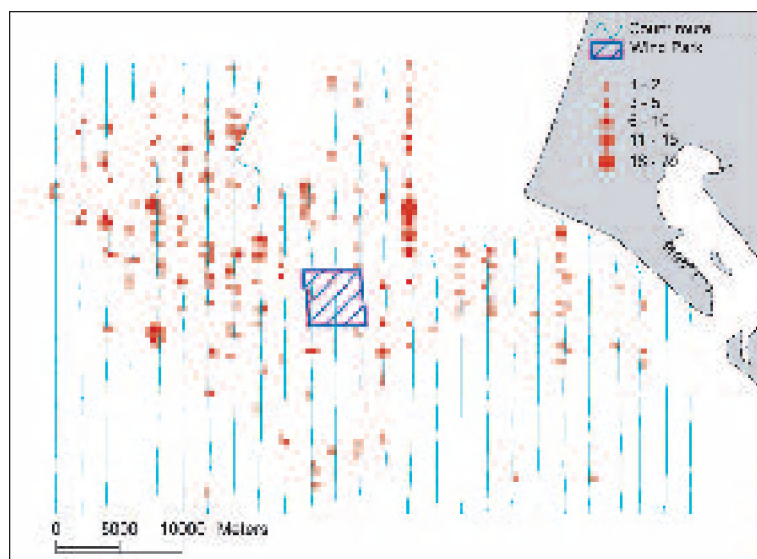


Figure 8c. Distribution of 692 Arctic/Common Terns, observed from aircraft 3 August 1999.

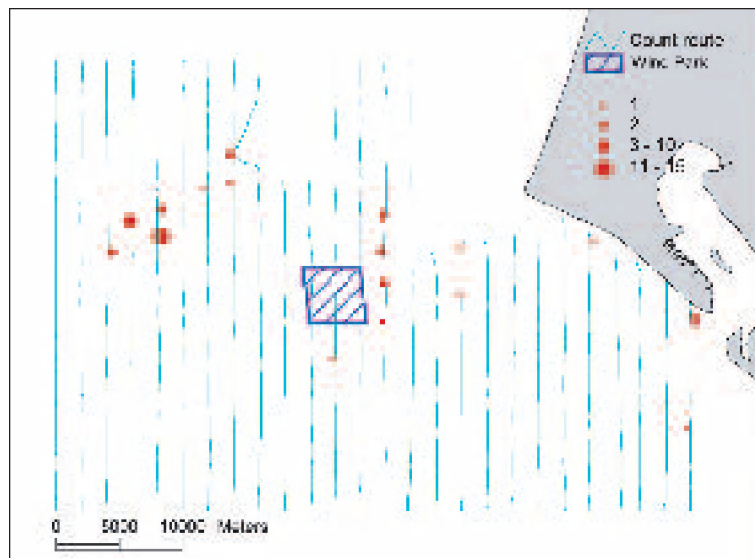


Figure 9. Distribution of 48 Sandwich Terns, observed from aircraft 3 August 1999.

4.3.1.5 Sandwich Tern *Sterna sandvicensis*

A total of 116 Sandwich Terns were recorded during the aerial counts. Highest number was observed in August, consistent with earlier findings.

In the August survey, most Sandwich Terns were recorded over Horns Rev, in particular west of the designated wind park area (Fig. 9). Due to military activity, the August survey did not include the coastal zone at Blåvandshuk.

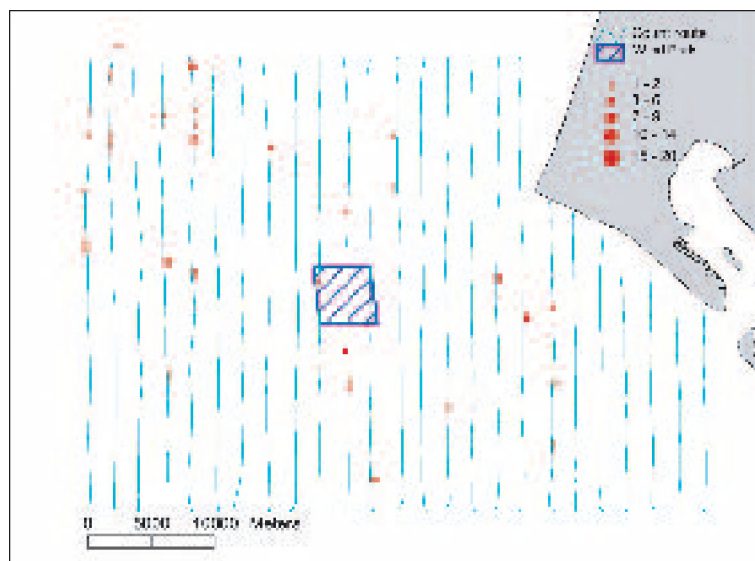


Figure 10a. Distribution of 63 Alcids (Guillemot/Razorbill), observed from aircraft 3 September 1999.

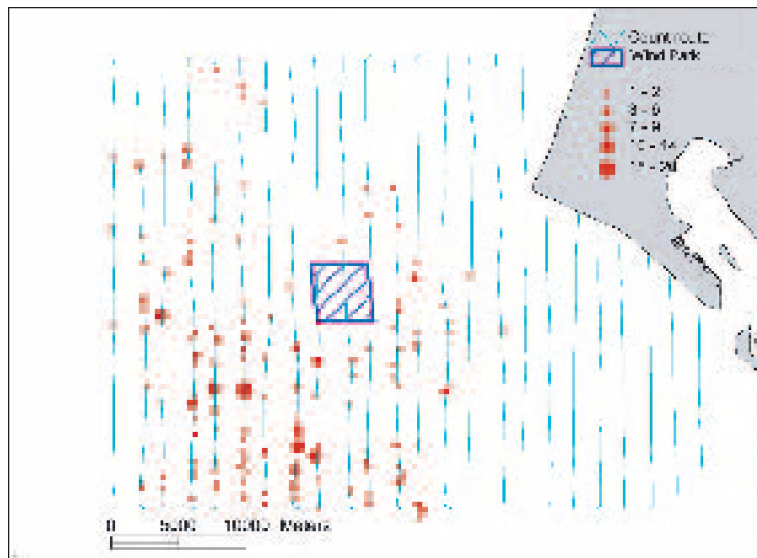


Figure 10b. Distribution of 384 Alcids (Guillemot/Razorbill), observed from aircraft 12 November 1999.

4.3.1.6 Guillemot *Uria aalge* and Razorbill *Alca torda*

During the aerial counts a total of 611 alcids were recorded, the highest counts being in November, consistent with earlier findings. The birds were mostly observed singly or in small groups in the offshore parts of the reference area (Fig. 10a-c). In the November count, maximum numbers of alcids were south of Horns Rev (Fig. 10b).

Observations from ship in late August showed that Guillemots were associated in family-groups and the adults were in moult. In August, Guillemots were found mainly in the area north of Horns Rev (Fig. 11a). In November, most were located northwest and south of Horns Rev (Fig. 11b).

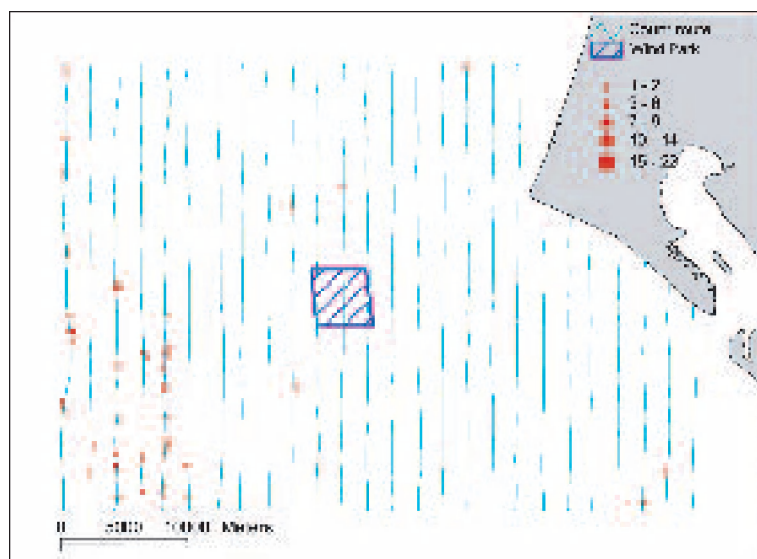


Figure 10c. Distribution of 62 Alcids (Guillemot/Razorbill), observed from aircraft 17 February 2000.

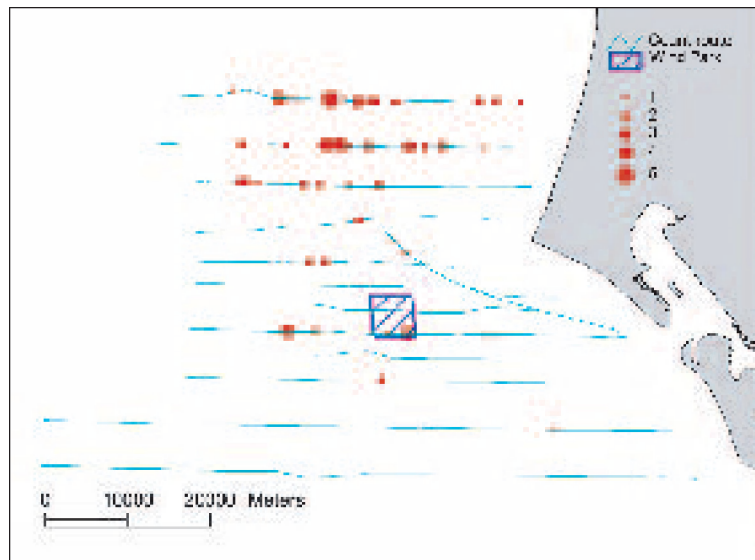


Figure 11a. Distribution of 106 Guillemot, observed from ship August 1999.

4.3.1.6 Herring Gull *Larus argentatus*

From the aerial counts in 1999-2000 a total of 10,937 Herring Gulls was recorded. Highest numbers were observed during late winter and lowest numbers during spring and summer. Most birds were recorded in the south-eastern parts of the area, south of Blåvandshuk/Skallingen and off the Wadden Sea (Fig. 12a-c). The gulls often gathered around fishing vessels and in the tidal zone during the falling tide.

4.3.1.7 Great Black-backed Gull *Larus marinus*

From the aerial counts in 1999-2000 a total of 335 Great Black-backed

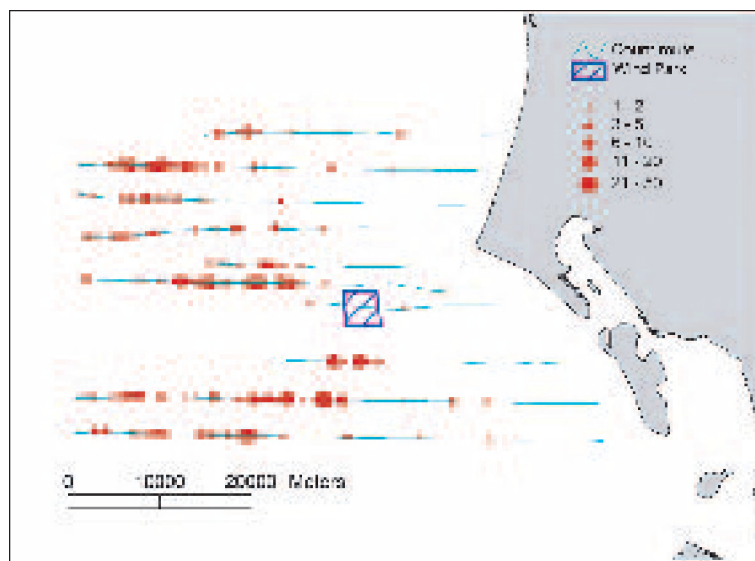


Figure 11b. Distribution of 801 Alcids (Guillemot/Razorbill), observed from ship November 1999.

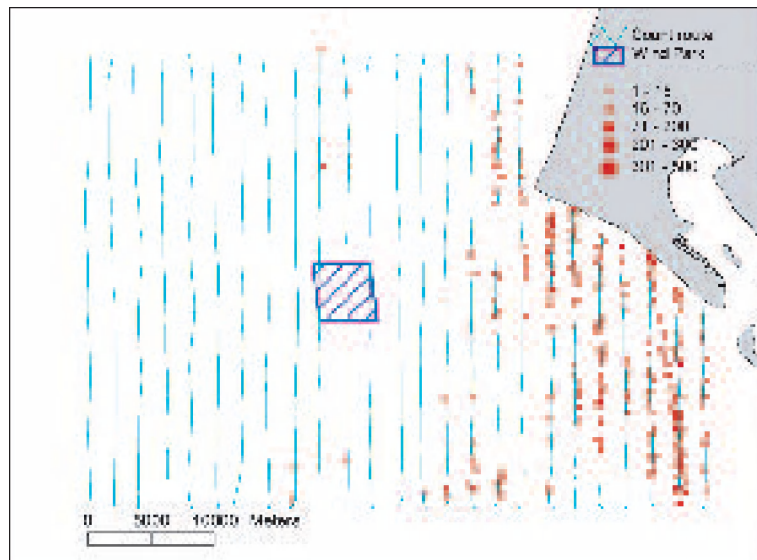


Figure 12a. Distribution of 699 Herring Gulls, observed from aircraft 3 September 1999.

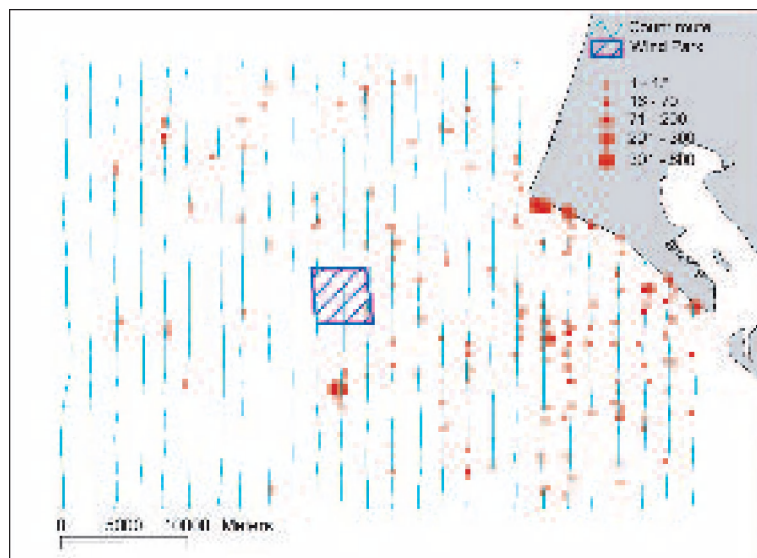


Figure 12b. Distribution of 4,025 Herring Gulls, observed from aircraft 17 February 2000.

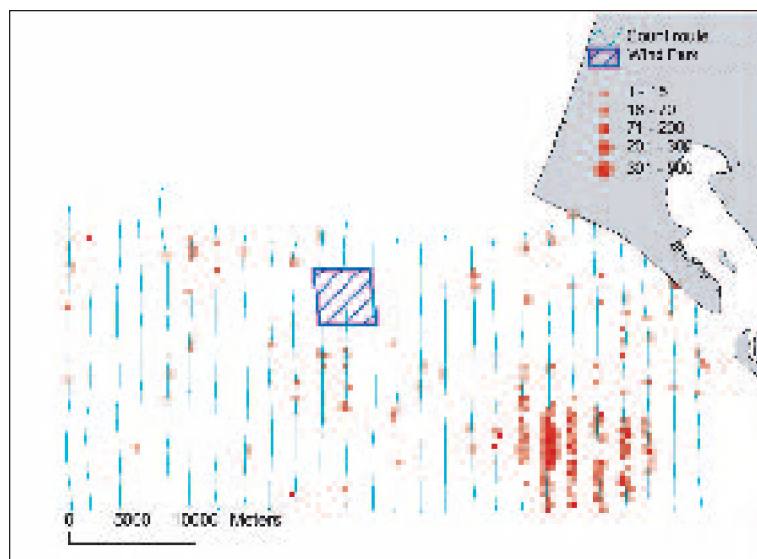


Figure 12c. Distribution of 3,327 Herring Gulls, observed from aircraft 21 February 2000.

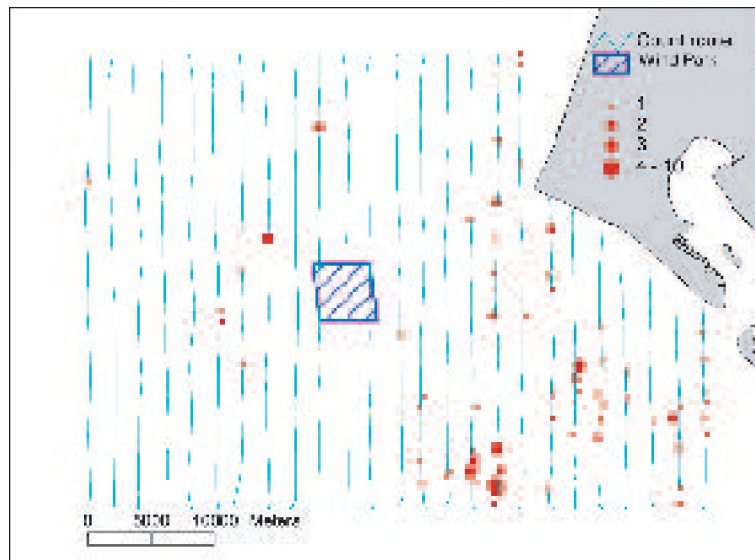


Figure 13a. Distribution of 129 Great Black-backed Gulls, observed from aircraft 3 September 1999.

Gull was recorded. Distributions varied, highest numbers being observed in the south-eastern parts of the area in September (Fig. 13a) and in the south-western parts in November (Fig. 13b).

4.3.1.8 Kittiwake *Rissa tridactyla*

From the aerial counts in 1999-2000 a total of 1,180 Kittiwakes were recorded. Most birds were observed in autumn with only few observations in late winter. The distributions varied markedly between counts. The August 1999 count found most in the north-western parts of the area (Fig. 14a). In September 1999 most were recorded closer

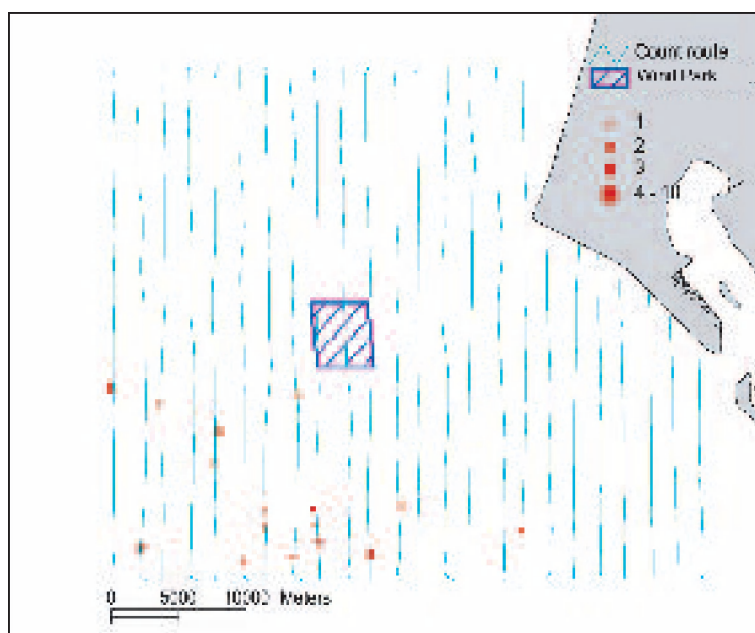


Figure 13b. Distribution of 21 Great Black-backed Gulls, observed from aircraft 12 November 1999.

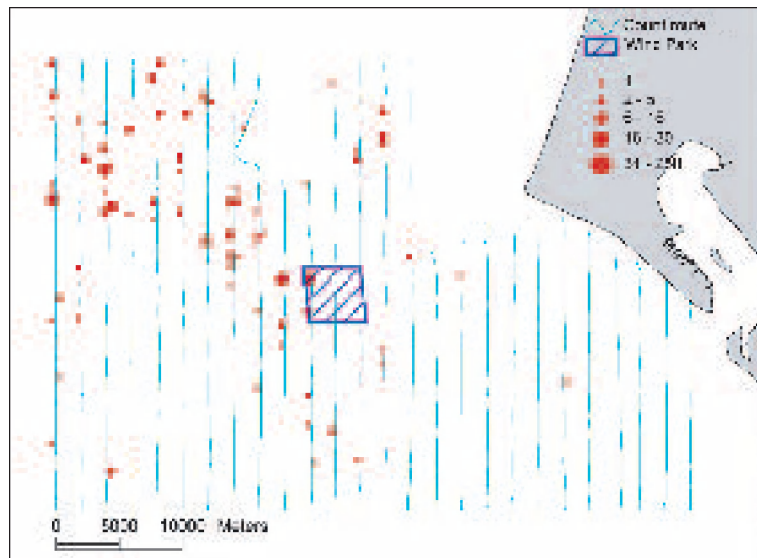


Figure 14a. Distribution of 186 Kittiwakes, observed from aircraft 3 August 1999.

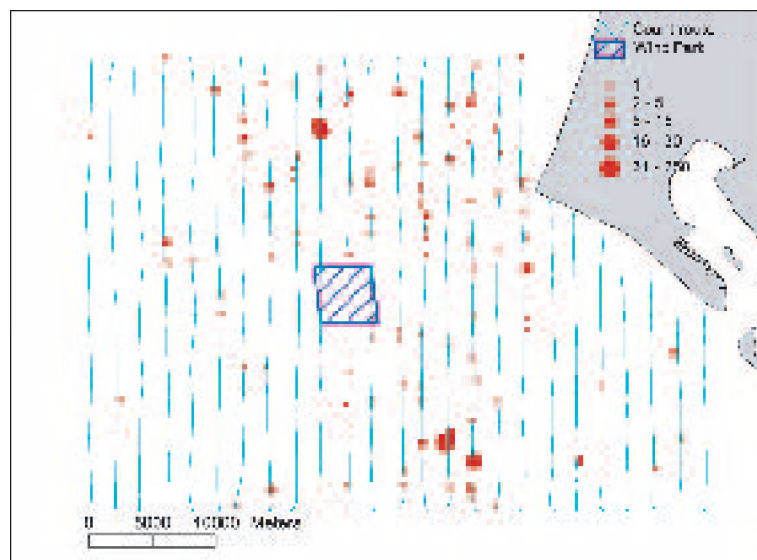


Figure 14b. Distribution of 324 Kittiwakes, observed from aircraft 3 September 1999.

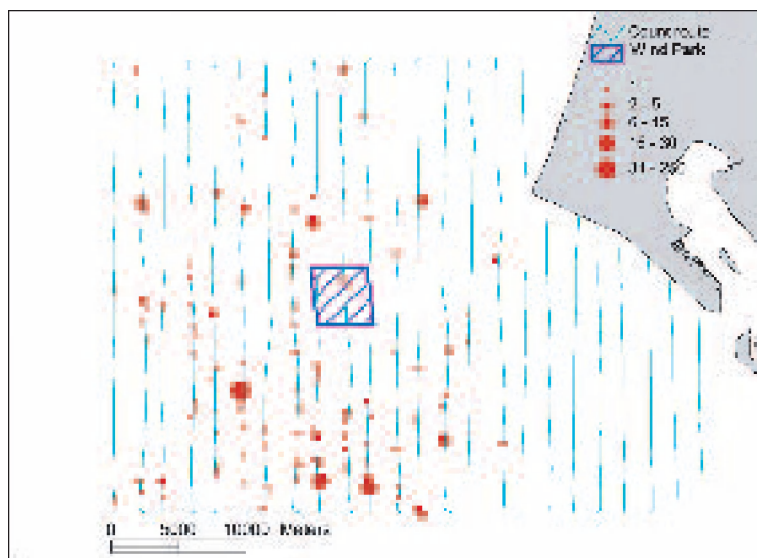


Figure 14c. Distribution of 520 Kittiwakes, observed from aircraft 12 November 1999.

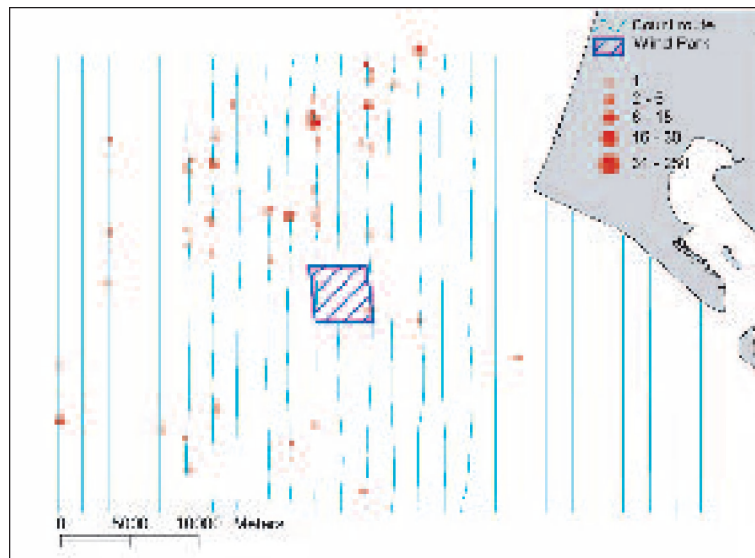


Figure 14d. Distribution of 70 Kittiwakes, observed from aircraft 19 March 2000.

inshore, both north and south of Horns Rev (Fig. 14b). In November 1999, large numbers were counted in the south-western parts of the area (Fig. 14c), and in March 2000 most were seen north of Horns Rev (Fig. 14d).

4.3.1.9 Skuas *Stercorarius* sp.

Only a few skuas were recorded on the aerial surveys with most (21 birds) on 3 September 1999 (Fig. 15a). The ship survey in August 1999 recorded a total of 157 skuas (Fig. 15b). Arctic Skua was the most frequent with 55 birds. Of the three other species, Pomarine, Long-tailed, and Great Skua, 1-3 individuals were recorded. Unidentified skuas comprised 95 birds. Due to their kleptoparasitic behaviour,

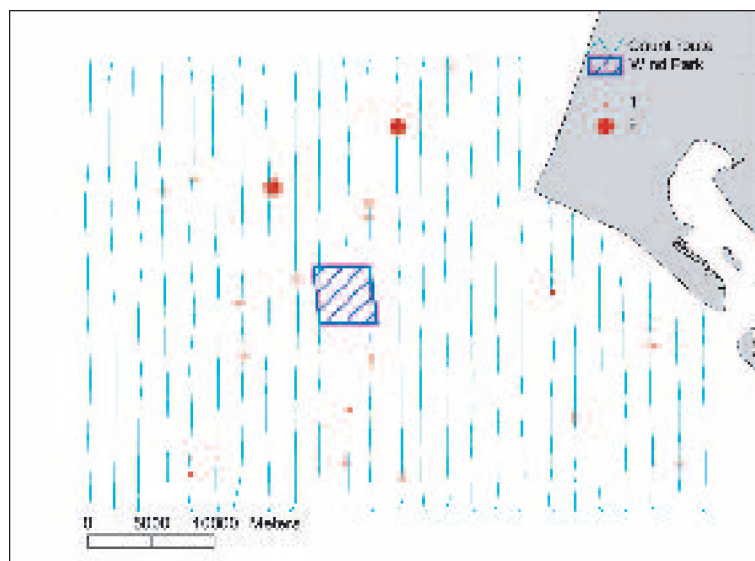


Figure 15a. Distribution of 21 skuas (all species), observed from aircraft 3 September 1999.

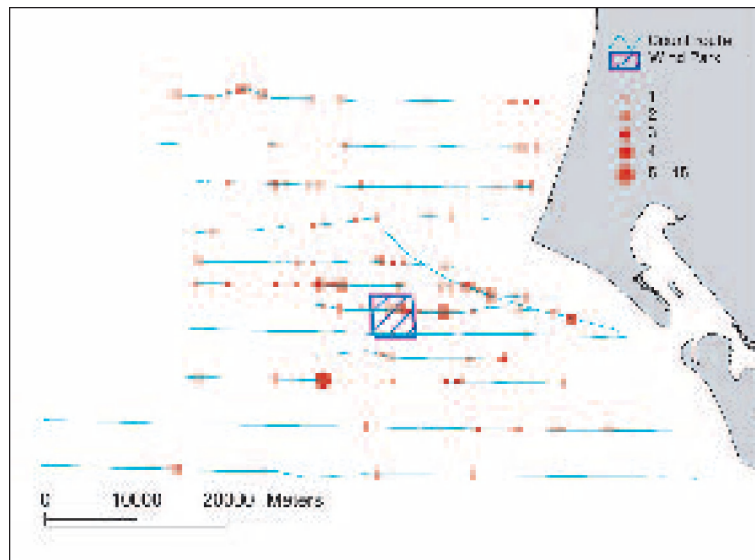


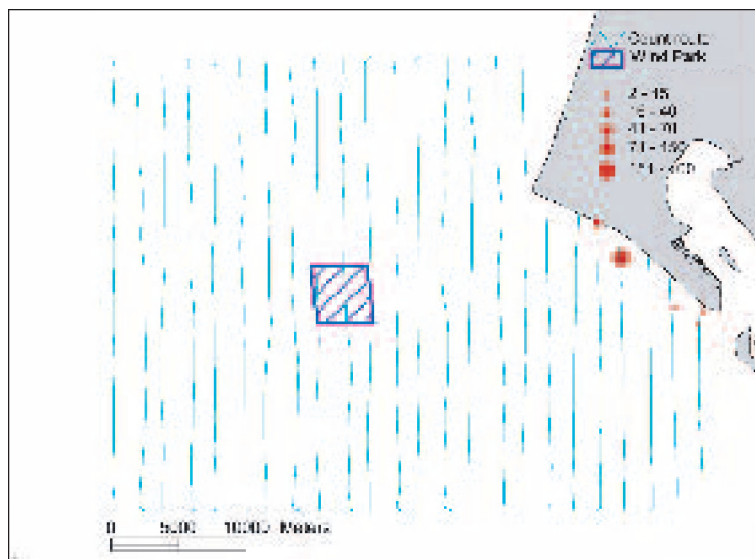
Figure 15b. Distribution of 157 skuas (all species), observed from ship August 1999.

skuas show an inconsistent distribution, chasing other bird species like terns and gulls, reflecting their feeding abundance at the time of the survey.

4.3.2 Species foraging on benthic fauna

4.3.2.1 Eider *Somateria mollissima*

During the aerial counts a total of 3,337 Eiders was recorded. Highest numbers were counted during winter and spring with maximum numbers in February, consistent with earlier findings. Eiders were generally recorded in large flocks, with only a few observations of solitary birds.



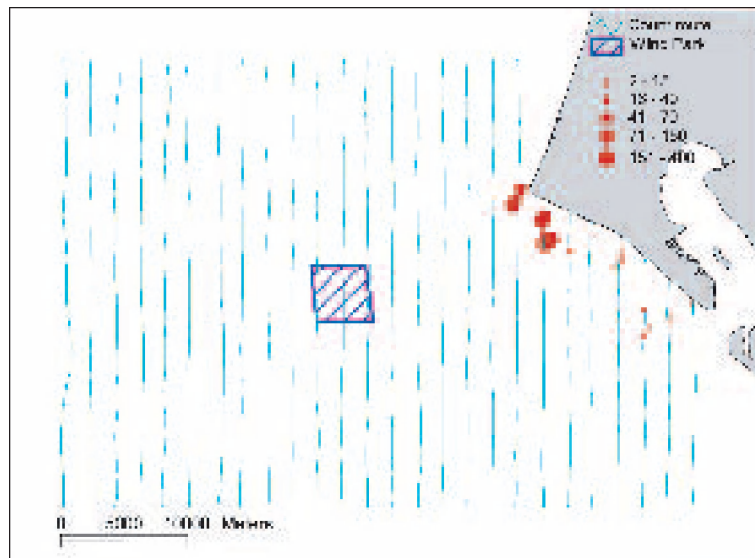


Figure 16b. Distribution of 2,114 Eiders, observed from aircraft 17 February 2000.

During all surveys the majority of Eiders was found within the 6 m depth contour, from Blåvandshuk to Skallingen/Grådyb (Fig.16a-c).

4.3.2.2 Common Scoter *Melanitta nigra*

During the aerial surveys, 41,233 Common Scoters were recorded within the surveyed area. The highest numbers were recorded in November and February-April. The Common Scoter was the most numerous species recorded during the surveys.

The distribution of Common Scoters showed a consistent pattern. The birds were seen in large numbers in the area northwest of Blåvandshuk, in the area south-southwest of Blåvandshuk, and in

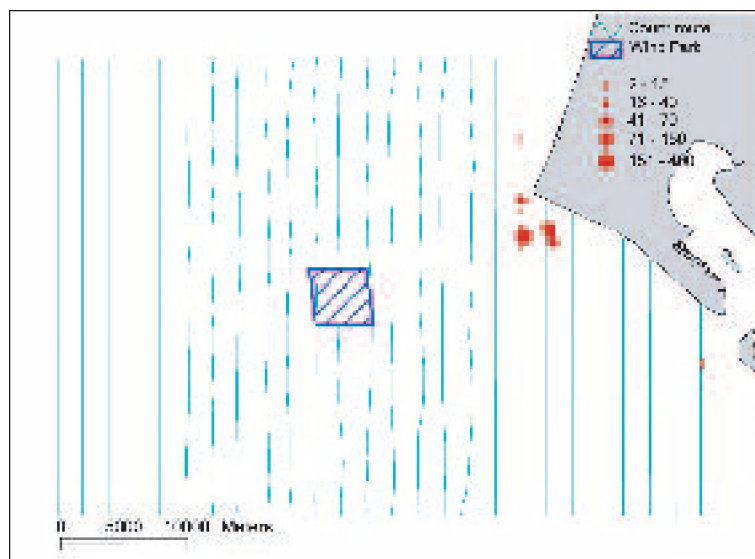


Figure 16c. Distribution of 476 Eiders, observed from aircraft 19 March 2000.

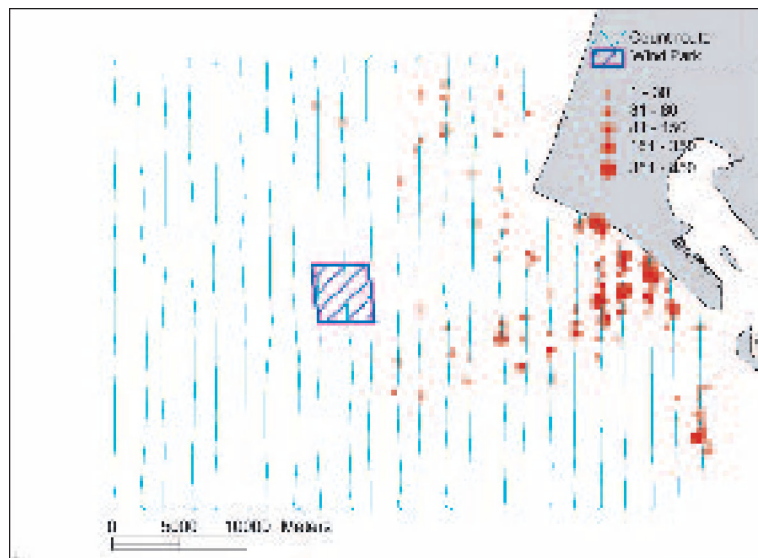


Figure 17a. Distribution of 10,231 Common Scoter, observed from aircraft 12 November 1999.

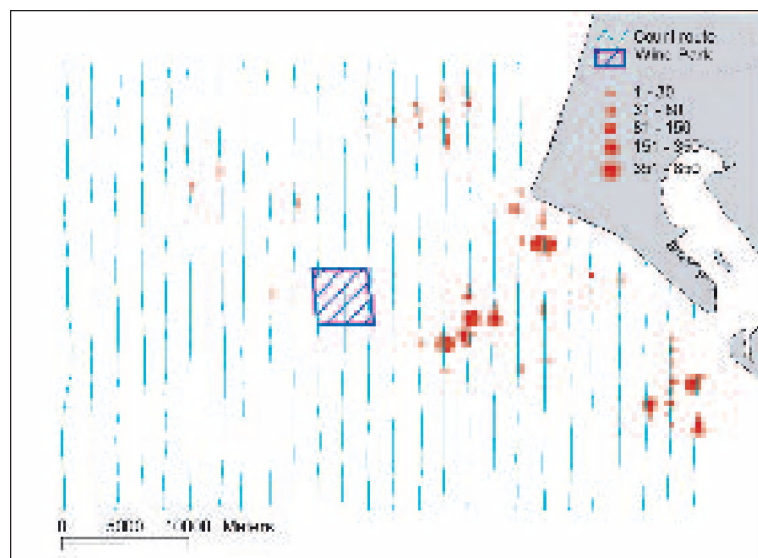


Figure 17b. Distribution of 7,190 Common Scoter, observed from aircraft 17 February 2000.

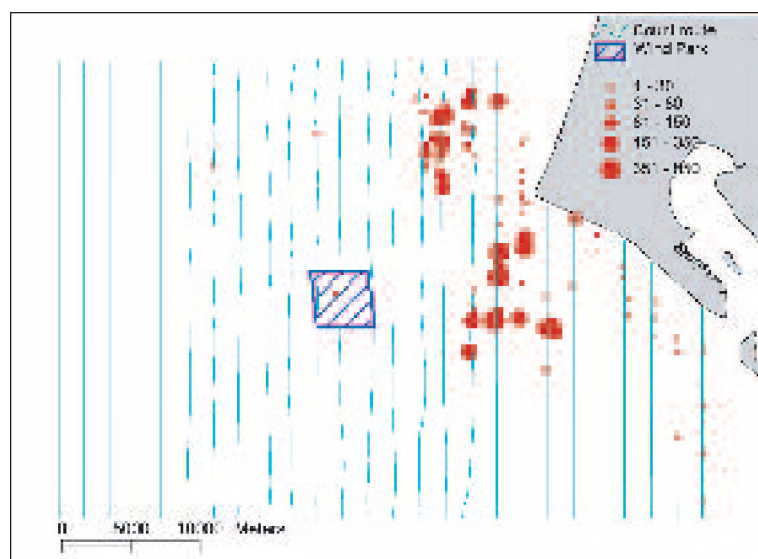


Figure 17c. Distribution of 10,459 Common Scoter, observed from aircraft 19 March 2000.

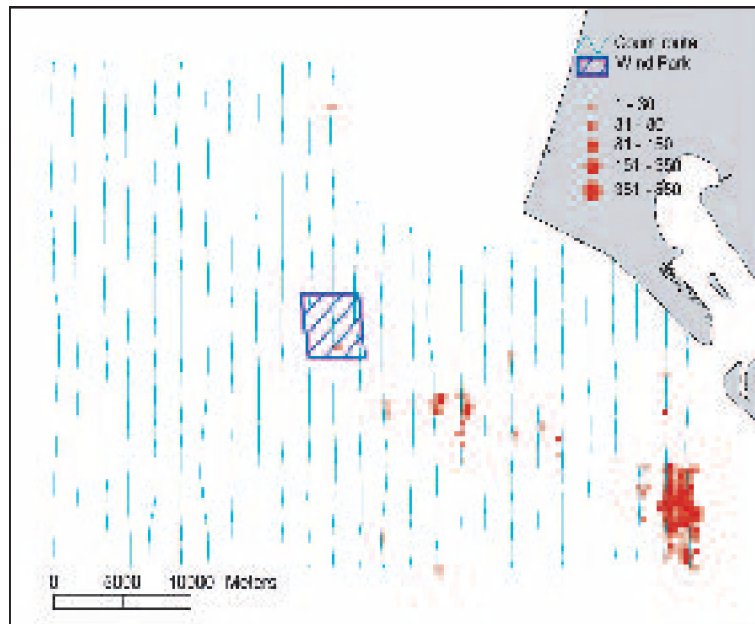


Figure 17d. Distribution of 9,230 Common Scoter, observed from aircraft 27 April 2000.

the area west of Fanø. In November, however, most Common Scoters were recorded in the southern part of Esperance Bugt, where they exhibited a tendency to occur in small and dispersed groups in the offshore parts (Fig. 17a-d). Common Scoters generally occurred in large flocks, with only a few observations of solitary birds.

4.3.3 Other species

A number of other species are recorded irregularly and in small numbers during the surveys in 1999-2000, but will not be described in detail here (see Tables 3 and 4).

4.4 Seabird use of the Horns Rev area

From the results of these counts, the following conclusions can be made:

Firstly, the two species foraging on bottom fauna, the Eider and the Common Scoter, have been observed at Horns Rev only in a very few cases. The general distribution of these species is more coastal, generally inside the 6 m depth contour, and in most cases close to Blåvandshuk or off Skallingen.

Secondly, the species that occur most numerous further offshore are those foraging on fish (including gulls). Generally, the occurrence of these species within the area is variable. During some counts, highest

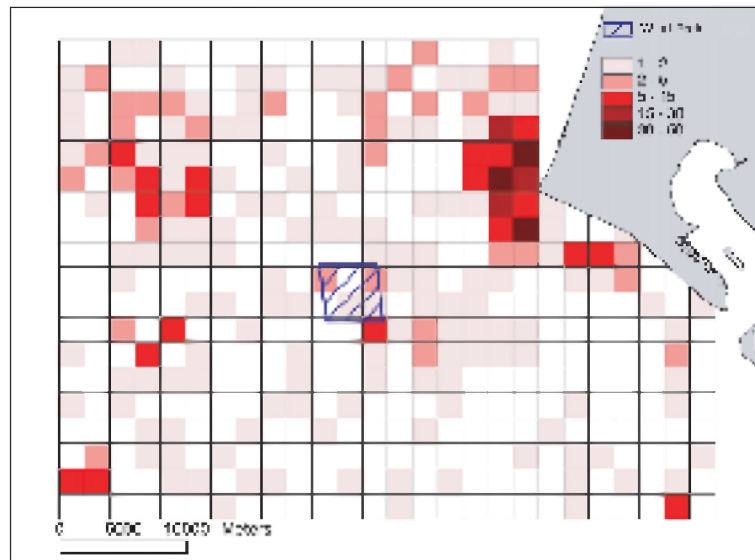


Figure 18. Cumulative numbers of divers in 2 x 2 km grids based on six aerial surveys (3 August 1999, 3 September 1999, 12 November 1999, 17 February 2000, 19 March 2000, and 27 April 2000).

numbers have been observed north of Horns Rev, in other cases the highest numbers have been observed south of the Horns Rev.

The two types of pattern can be deduced by pooling of counts. We used the counts from 3 August 1999, 3 September 1999, 12 November 1999, 17 February 2000, 19 March 2000, and 27 April 2000 to assess the general exploitation of the area by summing observations in 2x2 km grid squares. Based on this data, divers showed a scattered and erratic distribution pattern (Fig. 18) demonstrating that the observations cannot support a spatial resolution of 2x2 km, due to the small numbers recorded per unit.

Compared to the divers, the distribution of Common Scoters was much more consistent (Fig. 19).

We interpret these patterns as being consistent with the foraging ecology of the different species. Diving ducks forage on bottom invertebrates, mainly mussels, with a highly constant pattern of distribution. Hence, diving ducks will tend to exhibit relatively consistent distribution patterns, reflecting the parts of the area where bivalves occur in abundance. The almost complete absence of Eiders and Common Scoters within the planned wind park area is thus considered to reflect the very low densities of bivalves found in this area (Bio/Consult A/S 2000).

Fish-eating species utilise a food resource that is mobile, and prone to variable patterns in distribution and density. With the exception of the Gannet, the species of birds eating fish in this area (divers, alcids, terns and to some extent gulls) take relatively small food items such as gobies *Gobiidae* sp., small cods *Gadiidae* sp., Eel Pout *Zoarces viviparus*, Three-spined Stickleback *Gasterosteus aculeatus*, Greater Sandeel *Hyperoplus lanceolatus*, Sprat *Sprattus sprattus*, and Herring

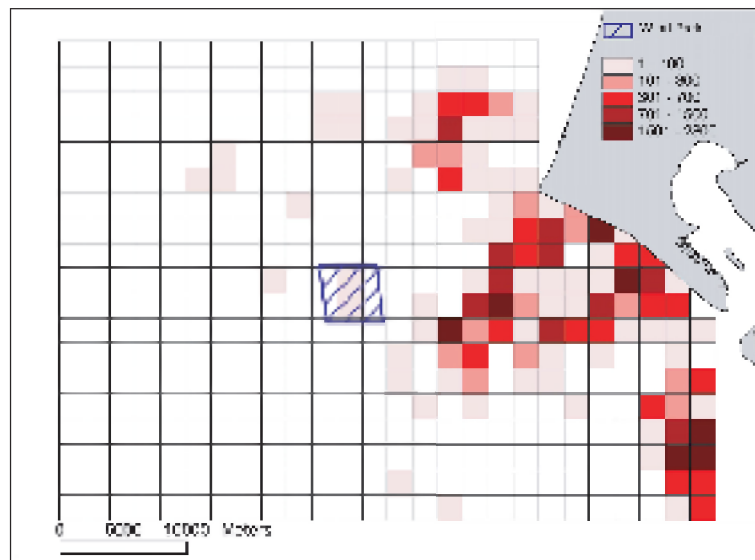


Figure 19. Cumulative numbers of Common Scoter in 2 x 2 km grids based on six aerial surveys (3 August 1999, 3 September 1999, 12 November 1999, 17 February 2000, 19 March 2000, and 27 April 2000).

Clupea harengus (Madsen 1957). In the offshore habitat, the species of fish taken mainly occur in the water column, rather than being bottom dwellers. These fish species tend to be mobile and to have variable distributions within the area. Hence, we contend that the variability in the observed patterns of fish-eating species to a high degree is caused by variability in the distribution and density of their food items.

4.5 Estimation of densities and total numbers

The calculation of bird numbers seen per kilometre transect flown and hence the total numbers per unit area would be straightforward, provided all individuals were seen and recorded during the counts. This is, however, not often the case, and a major problem arises, namely that of correcting observed numbers to generate absolute density estimates, i.e. to estimate a correction factor to convert the observed data into estimated abundance measures.

A general theory has been developed to cope with this problem (Burnham et al. 1980, Seber 1982, Buckland 1985). The standard methodology is to record not only observed individuals, but also their distance from the transect line, often in terms of grouped data ('transect bands'). A model of decreasing detection probability with increasing distance from the observer is then fitted to the data, and by backwards extrapolation this model is used to estimate the actual numbers or densities present along the transect line proper at the time of the count.

These models rest on at least four assumptions (Burnham et al. 1980):

1. Birds encountered directly on the line will never be missed (i.e. they are seen with probability 1.0).
2. Encounters with birds are recorded only at the initial sighting position: They do not move before being detected and none are counted twice.
3. Distances and angles are measured exactly; thus, neither measurement errors nor rounding errors occur.
4. Sightings are independent events.

These four assumptions, moreover, are made for the situation where the individuals of the species concerned are only encountered singly. If flocks rather than individuals are detected, the general method can be applied to estimate densities of flocks. To obtain densities of individuals from flock recordings, it must further be assumed that:

5. The probability of sighting a flock is independent of flock size.
6. No uncertainty is present in counts of flock size.

Of these six assumptions, only one (no. 4) is likely to hold true for transect counts of birds. We give two examples to illustrate this. Divers are normally seen singly or in small flocks. Records of encounters in the inner and outer transect bands on 17 February 2000 are given in Table 5. Since the width of transect bands are 125 m for the inner and 285 for the outer band, an even distribution of the birds should result in 2.28 times more encounters in the outer than in the inner band. The observed number of flocks in the outer band was 60, compared with 233 expected if the detection rate was the same in the two bands.

Table 5. Distribution of flock sizes observed for Red- and Black-throated Divers from the aerial transect count 17 February 2000.

Flock size	50-174 m	175-459 m	Total
1	70	38	108
2	13	8	21
3	6	6	12
4	6	4	10
5	3		3
6	3	2	5
7			0
8	1		1
9			0
10			0
11			0
12		1	1
13			0
14			0
15	1		1
No. of flocks	102	60	162
No. of individuals	186	120	306
Mean flock size	1.82	2.00	1.89

Table 6. Distribution of flock sizes observed for Red- and Black-throated Divers from the ship survey April/ May 1999.

Flock size	0-50 m	51-100 m	101-200 m	201-300 m	> 300 m	Flying	Total
1	40	31	39	26	4	31	171
2	5	2	6	3		5	21
3	4	3	1	2	1	3	14
4	3		1	2			6
5	1						0
6		1					2
7							0
8	1						1
9	1						1
....							
40					1		1
No. of flocks	53	37	48	34	6	39	217
No. of individuals	80	50	66	55	47	50	348
Flock size	1.51	1.35	1.38	1.62	7.83	1.28	1.60

Similarly, 186 individuals were observed on the inner band, and 120 in the outer. From the width of the two bands, the expected number in the outer band (calculated from observations in the inner) would be 424 birds. This demonstrates a clear decrease in detection probability with distance.

Moreover, the observed flock size distribution has a higher proportion of single individuals on the inner transect band compared to the outer band (Table 5). Though not statistically significant, this may simply be due to the small number of flocks observed for these species (see Common Scoter below). Thus, assumption no. 5 may be violated by these data, too. Estimates of density depend critically on this very assumption.

For the ship transects counts, encounter distances were estimated to the nearest 50 or 100 m, enabling the pooling of the observed individuals into five distance groups (Table 6). From these counts, there is some correlation between flock size and distance, and a plot of observed numbers expressed as the percentage of expected numbers in each transect band (calculated from covered area with the 0-50 m band as reference = 100%), shows a relatively smooth decrease, suggesting that detection probability is reduced by 50% at a distance of 150 m (Fig. 20). Extrapolation of numbers to the line of the transect will depend critically on the type of function fitted (e.g. negative exponential or sigmoid), and both types of functions might be fitted to these data. This alone might introduce a systematic error in estimates of as much as 30-40%. Moreover, a total of 39 flocks (50 individuals) were detected when flying and could not be ascribed to any transect band. It might be expected that a relatively high proportion of these may have taken off from one of the inner bands or even the transect line, and these individuals thus introduce one more factor of uncertainty. Thus, although ship transect counts may turn out to be better suited

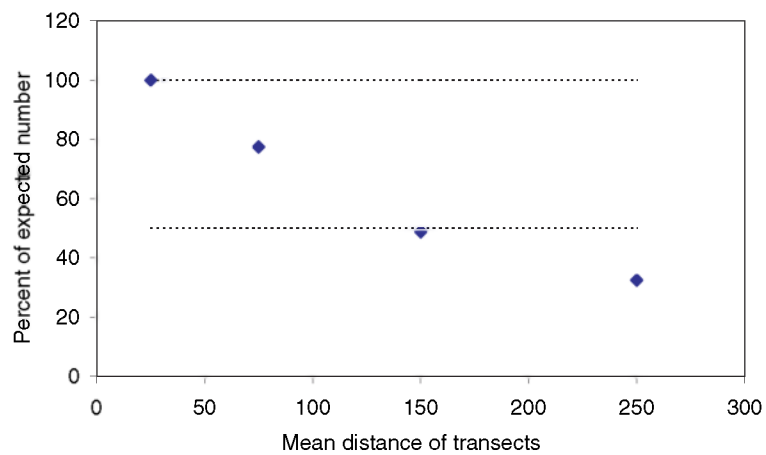


Figure 20. Recording probability of divers from ship in relation to distance of observation, expressed as the percentage of observed birds to expected numbers within each transect band (mean distance of transect A: 25m; transect B: 75m; transect C: 150m; transect D: 250m). Note that transect width differs.

for counts of divers, as the use of four discrete transect bands surely provides data that strengthen the assessment of the nature of the mathematical relationship between distance and detection probability, these four bands are still not enough to give a precise relationship. Consequently, calculation of density estimates should await a more carefully assessed and documented mathematical model.

Data for Common Scoter on one aerial transect count is given in Table 7. For this species the difference between flock size distributions for the inner and outer band is significant ($\chi^2 = 8.47$, $df = 2$, $P < 0.005$). More than two thirds of the individuals are actually seen in flocks of more than 100 individuals (Table 8). However, these 6,800 individuals were seen in a total of 21 flocks. Once more, estimation of a 'true' density at the transect band proper depends critically on the unknown relationship describing the decrease of detection probability with distance (see White et al. 1989 for a similar example), and the 21 observed flocks do not establish a firm basis for assessing such a relationship. Furthermore, since flock sizes are estimates and not accurate, the variance of a density estimate would be biased.

In conclusion, the assumptions that must be made in order to estimate densities are undoubtedly violated to some extent by both the ship and air transect counts carried out in the Horns Rev area. More

Table 7. Distributions of observed flock sizes of Common Scoter in the inner and outer transect bands for the aerial count 12 November 1999.

Flock size	50-174 m	175-459 m	Total
1-10	167	70	237
11-100	41	28	69
101-1000	9	12	21
Total	217	110	327
Mean flock size	25.7	35.5	29.1

Table 8. Numbers of individuals of Common Scoter in different flock sizes in the inner and outer transect bands from the aerial count on 12 November 1999.

Flock size	50-174 m	175-459 m	Total
1-10	480	210	690
11-100	1,190	787	1,977
101-1000	3,900	2,900	6,800
Total	5,570	3,897	9,467

detailed analyses, considered outside the scope of these environmental impact assessments, are needed before robust and dependable estimates of densities can be made. For this reason, we choose not to present calculations of densities in the present report since they may be misleading.

Hence, only rough indications of densities of the important species in the areas should be given. For divers, the maximum numbers observed was on 17 February 2000, for 1,642 transect kilometres flown. This indicates a density of approximately 1 individual per km² in the overall area, or c. 2,000 individuals being within it. For the ship surveys, maximum numbers were recorded on the 1999 April-May count, and - depending on the type of functional relationship between detection probability and distance - this would lead to estimates of densities between 2 and 3 individuals per km², or 4,000-6,000 divers being present within the overall reference area. Of these, the available material indicates that c. 75% are Red-throated and 25% Black-throated divers. Though these should be considered as very crude estimates, at least they can be taken to confirm earlier conclusions that the general Horns Rev area is of international importance to divers, since the 1% Ramsar criterion corresponds to 750 Red-throated and 1,750 Black-throated divers.

For Common Scoter, the 1% Ramsar criterion corresponds to c. 16,000 birds. Of nine aerial counts, more than 10,000 individuals were recorded in two instances, while in two other cases 7,000 and 9,000 were recorded. Even if the (conservative) assumption is made that all birds are seen, the two transect bands recorded cover a total of 820 m, with transects being spaced c. 2 km. Thus, direct correction for area covered to generate estimates implies that numbers counted should be multiplied by a factor of 2.44, which means that in four of nine counts throughout an annual cycle, numbers of international importance were present in the area.

Though abundant, Eiders and alcids were not recorded in numbers above 1% of the population estimates.

Assessment of numbers of gulls and terns within the reference area was not attempted for these species since large numbers may be roosting on the shore, and thus not included in the surveys.

4.6 Identification of species

In a number of cases, species that occur in the area are very similar, and difficult to identify except at close range and under good visual conditions. These cases include Red- and Black-throated Diver, Arctic, Pomarine, and Long-tailed Skua, Arctic and Common Tern, and Guillemot and Razorbill. Of these species pairs, larger numbers were identified from ship than from aircraft (Table 9).

The results from the ship surveys fit earlier findings that c. 75% of the divers in the area are Red-throated Divers (Joensen & Hansen 1977, Jakobsen in prep.). For the terns c. 60% were determined as Arctic Terns and c. 40% as Common Terns, which is similar to the ratios recorded at Blåvandshuk (Jakobsen in prep). For Guillemot and Razorbill, the proportions were 57% and 43%, respectively, for both aerial and ship surveys.

4.7 Comparison of air and ship transect counts

Because of the very limited knowledge of distributions and numbers of seabirds offshore in the Horns Rev area, the initial planning of the observations included surveys from both ship and aircraft. The first study year has shown that the two methods yield widely different results, and moreover that due to differential detection probabilities

Table 9. Number of identified and unidentified species observed during aerial and ship surveys of Horns Rev 1999-2000. Only species that are very difficult to separate from each other are included. The percentage of all observations (%A) and the percentage of identified species only (%B) is shown.

Recorded as	Aircraft			Ship		
	N	% ^A	% ^B	N	% ^A	% ^B
Red-throated Diver	12	1.6	100.0	57	11.4	78.1
Black-throated Diver	0	0.0		16	3.2	21.9
Red-/Black-throated Diver	747	98.4		428	85.4	
Arctic Skua	0	0.0		75	41.0	87.2
Pomarine Skua	0	0.0		10	5.5	11.6
Long-tailed Skua	0	0.0		1	0.5	1.2
Arctic/Pomarine/Long-tailed Skua	21	100.0		97	53.0	
Arctic Tern	0	0.0		209	44.9	60.4
Common Tern	0	0.0		137	29.5	39.6
Arctic/Common Tern	1007	100.0		119	25.6	
Guillemot	16	2.6	57.1	460	50.7	56.6
Razorbill	12	2.0	42.9	352	38.8	43.4
Guillemot/Razorbill	578	95.4		95	10.5	

and the fact that ship surveys extend over several days (even under optimal conditions) results should not be pooled.

In relation to investigating the impacts of an offshore wind park, the various parameters of interest are:

1. Distribution of birds.
2. Duration of survey.
3. Identification of bird species.
4. Total numbers/densities of birds.
5. Before-after comparisons.

With respect to the assessment of distributions of bird species in the area, surveys from aircraft are undoubtedly superior. The higher speed of the aircraft allows for a much denser coverage, and moreover the survey can be carried out in a single day. This not only minimises the, very real, possibility that distributional patterns vary between observation days, but also, because of the marginal sea state and weather conditions in the area optimises the potential number of complete counts that can be made within a year. In fact, though ship transects can be done in 3-4 days, they extended over periods of up to 13 days because of poor weather conditions.

With respect to identification of species, ship surveys are superior - partly because of the very short time birds are seen from an aircraft, and partly because identification from ship can be facilitated by using binoculars.

Both aerial and ship surveys suffer from the unknown relationship between birds actually present and birds detected by the observers. For species such as divers and alcids, ship surveys appear to have a considerably higher detection probability, but the opposite is the case for species like Eider and Common Scoter. Moreover, for a number of species such as gulls, ships may attract flying birds, thereby compromising density estimates, e.g., because of the potential for multiple counts of birds that follow the ship for shorter or longer periods. Also, density estimates from ship counts may to a certain extent be problematic because of the prolonged duration of counts and the inability of ships to cover the most shallow areas (< 6 m). As long as we do not have more precise knowledge about these relationships reliable estimates of total numbers and densities are not possible as well as comparison between data based on aerial and ship surveys, respectively.

In relation to investigating the impacts of an offshore wind park in the Horns Rev area, the main problem will be to determine whether distributions of birds change after construction of the park. Since estimation of densities and total numbers must inevitably be based on the actual observations, plus a number of more or less verifiable assumptions, comparison of densities or total numbers before and after construction of the park will inevitably be much less robust than comparisons of actual observations (density estimates by necessity being based on the actual records, they cannot contain more information).

Thus, the only sound approach to before-after comparisons will be non-parametric comparisons of actual observations. This problem relates in a much higher degree to distributions than to densities, since the generally low densities of birds in the wind park area necessitate the highest possible resolution for the purpose of before-after comparisons. In relation to this it is of less importance that a ship is a better platform than an aircraft for species identification.

For the pairs of species which cannot be distinguished effectively from the air there is no known *a priori* reason to expect differences in patterns of reactions to the wind park, nor is there reason to expect that such differences could be demonstrated even if they existed. Thus, it is concluded that in the present context air surveys will be the best method to detect impacts with respect to resolution and to resource demands.

5 Impact assessment

5.1 Potential impacts of offshore wind parks on birds

Based on existing experience the potential impacts on birds from offshore wind turbines are predicted to be:

- Physical change of the habitat where the turbines are erected.
- Disturbance/avoidance effects.
- Collision risk.

Impacts on birds related to disturbance effects from the wind park are expected during both construction and during operation. Disturbance effects related to the period of construction are of temporary duration and hence predicted to be of low impact if mitigating measures are taken. It is therefore expected that impacts, which may have implications for birds, will largely relate to the period when the turbines are operating. Assessments of disturbance effects to birds were consequently focused on impacts expected to occur in the period when the wind park is in operation.

The physical activities involved in laying the cable from the turbine area to the coast are predicted to have very limited impact on the birds if the cable to Hvidbjerg Strand is laid outside the moulting

period of Common Scoter (July - September). Cable laying activities will potentially reduce bird exploitation over a large area around the cable zone, as moulting birds are extremely sensitive to any kind of disturbance. There will most likely also be a similar low impact of cable laying in the Sædding Strand alternative if the cable is laid outside the peak period of shorebird occurrence at Langli Sand (July - October). The buried cables will involve a very small area and the associated laying activities will be of temporary duration. Hence, impacts on food resources for those species of waterfowl which prey on zoobenthos are expected to be small.

5.2 Physical change of habitat

The presence of 80 wind turbines in an offshore area may affect birds in several ways. Firstly, the turbines will reduce the available area by their physical presence. Secondly, the foundations of the turbines may create a new type of sublittoral habitat that may provide additional substrate for invertebrates that birds can feed on. Thirdly, the turbines may serve as platforms for perching and roosting birds, thereby attracting birds to the area that would not exploit it previously.

Depending on the choice of foundation, the actual area that will be covered by the turbines, will be either 1.5 ha or 16 ha. Considering that the total area of the wind park, including the 200 m exclusion zone, is 2,750 ha, the foundations will only cover a very limited area. The estimated loss of bottom fauna is c. 600 kg wet weight (Bio/Consult A/S 2000). Therefore, the habitat loss is expected to be negligible to birds.

Analyses of the hydrodynamic conditions have shown that the changes in sediment and current movements around the foundations will be very limited (Danish Hydraulic Institute 1999). It is therefore predicted that the bottom fauna in the area within the wind park will not change.

The foundations will provide substrate for the settlement of larvae of marine invertebrates, thus acting as an 'artificial reef'. It is predicted that settlement will mainly involve Balanoids and possibly some *Polychaetes*, but is unlikely to include mussels due to impact from waves. Even in that case, however, the extent of the food resource that might result for birds is far too small to serve as a basis for attracting larger numbers of birds.

For the fish-eating species, which are the most relevant in this context, numbers and distributions of fish in the wind park area seem to be rather low (Danmarks Fiskeriundersøgelse 2000). Hence, it is not expected that the habitat will be modified to an extent which will affect bird distribution and numbers. In addition, the data collected

in 1999-2000 indicate that most of these species are present at levels less than expected by change within the wind park area even before the establishment of the turbines.

The presence of the turbines may attract certain seabird species, like gulls and Cormorants, which may use the platforms offered by the turbines as perches. In addition, some of the bird species migrating over the area (see chapter 3), may under certain conditions - particularly situations with low visibility (haze or fog) - use the turbines for roosting. Diurnally migrating species such as Starlings, may be attracted to the turbines. White flashing light for ship navigation (visible at distances of minimum 3 nautical miles) will be mounted on the turbines at a height of c. 10 m above water level. For species which migrate at night, these lights may prove attractive, especially drawing tired and disoriented individuals during periods of poor visibility.

The bedding down of laid cables only causes physical impact along narrow corridors and, as nearly all excavated material will be redeposited in the same spot, it is expected that the nature of the bottom substrate, flora and fauna will re-establish within a year after the activity.

5.3 Disturbance effects

Even if the wind park does not result in a substantial impact on the food resources used by the birds *per se*, the turbines may themselves have an impact through the disturbance they cause by resulting in bird avoidance. In this way, the presence of turbines may limit accessibility to the wind park area. The only study so far undertaken involving waterfowl/seabirds, was that concerning Eider at Tunø Knob, that showed barely demonstrable impacts. However, that study concentrated upon only one less vulnerable species (Eiders are considered relatively robust to disturbance) and moreover involved a wind park consisting of only 10 turbines in two rows (Guillemette et al. 1999). Given that other species may exhibit more reluctance to fly between or near the turbines, and that even Eiders may possibly react differently to c. 80 turbines than to 10, the possibility that at least some species may be excluded from the area and possibly from the adjacent areas of the park, cannot be fully ruled out in advance. Comparisons of bird distributions before and after construction of the park will provide much needed data on this.

In terrestrial habitats, wind turbines have been shown to have an impact on the number of staging and foraging birds at distances up to 800 m from the turbines (references in Clausager & Nøhr 1995). There seems, however, to be species-specific differences in the sensitivity of birds to wind turbines. In spring, Pink-footed Goose *Anser*

brachyrhynchus will generally only forage to within 100 m of wind turbines on a line and 200 m of wind parks (Larsen & Madsen in prep.), whereas foraging Barnacle Goose *Branta leucopsis* on spring migration only showed a significant decline in density within 25 m of the wind turbines (Percival 1998). Even though wind turbines affected bird species differently and that impacts also may depend on the time of the year, some 'habitat loss' around turbines has been reported from all studies undertaken, due to avoidance of the area closest to wind turbines. Thus net habitat loss in the Horns Rev area is considered more likely to be the result of an avoidance effect than a result of direct habitat loss resulting from the turbine foundations.

From studies at Tunø Knob it was found that there was a minor decrease in the number of Eiders present inside the wind park (Guillemette et al. 1997, 1998 and 1999). A significant reduction in the number of birds landing at decoys placed 100 m from the turbines was also observed compared to decoys placed at distances of 300 and 500 m from the turbines (Guillemette et al. 1997 and 1998). Avoidance effects of large offshore parks could be greater than in case of small parks. Furthermore, the increased number of turbine units increases the necessary maintenance in large versus small parks, not least if carried out by helicopter, hence routine maintenance will exert stronger disturbance effects than at the Tunø Knob park. Helicopters are known to have a potentially strong disturbing impact on birds (Mosbech & Glahder 1991), even if it is also documented that birds to some extent may habituate to regular helicopter traffic (Kahlert pers. com.). The noise from operating wind turbines is expected to be negligible to birds.

In order to assess the magnitude of such potential impacts, we calculated:

1. The percentage of birds within the wind park area in relation to percentage of birds in the total investigated area,
2. The same relationship under the assumption that some species may show avoidance behaviour towards the turbines up to a distance of 2 km,
3. As 2., but assuming an avoidance distance of 4 km.

Given the previous results from land based wind parks and Tunø Knob, we consider the latter as a 'worst case' scenario on the very conservative side.

The construction area is planned to cover an area of 27.5 km² (incl. the 200 m exclusion zone). Based on its area relationship to the size of the total reference area used during the surveys, the turbine area constitutes c. 1% of the total area. Thus, any preference for the wind park area shown by any bird species (or groups of birds) can be assessed from the actual proportions of birds recorded within the area. If the proportion of a species is higher than 1%, then birds have a higher preference for the area than its surroundings. Conversely, the birds show a reduced preference for the area if the proportion of birds within

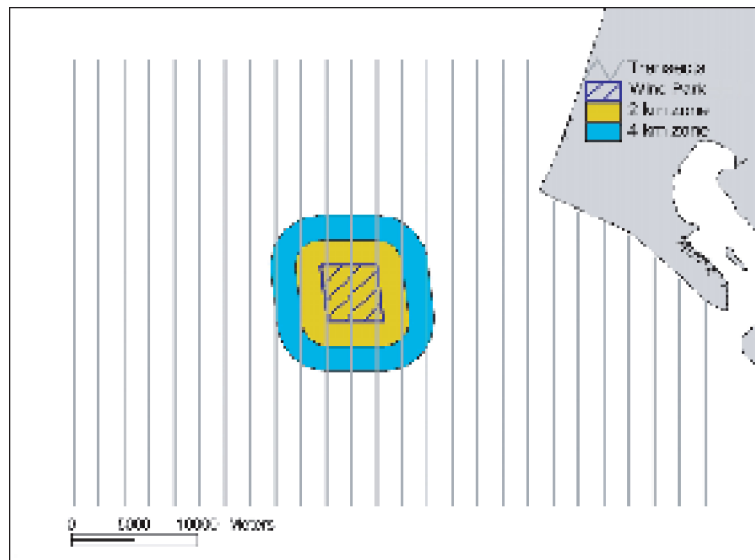


Figure 21. Wind park area showing the extent of zones covered if birds were to avoid turbines by 2 km (inner hatched area) or 4 km (outer hatched area).

the wind park area is lower than 1%. A similar relationship exists if the area is expanded to cover 4% and 8% by increasing the area by the 2 km and 4 km zones, respectively (Fig. 21).

The proportions of birds observed in the wind park area of the most abundant species are shown in Table 10. Of the most commonly occurring species three were never observed in the construction area and three species were observed as single individuals.

Table 10. Cumulative numbers of the most abundant species observed by the aerial transect counts: 3 August 1999, 3 September 1999, 12 November 1999, 17 February 2000 and 19 March 2000. For each species is shown: 1) Total number recorded, 2) Percentage of the total number observed within the wind park area (WP), 3) Percentage of the total number observed within 2 km of the wind park area (WP+2km), 4) Percentage of the total number observed within 4 km of the wind park area (WP+4km). + indicates that the species has been recorded within the wind park area, but that the number was < 0,05% of the total.

	Total number recorded	Percentage in the wind park area (WP)		
		WP	WP+2km	WP+4km
Divers	554	1.4	4.7	6,9
Gannet	299	0	2.0	13,4
Eider	3,053	+	+	+
Common Scoter	28,067	+	+	0.1
Common Gull	151	0.7	0.7	4.6
Herring Gull	7,070	+	0.3	0,8
Great Black-backed Gull	204	0	0.5	2.5
Kittiwake	1,118	1.0	3.0	7.1
Arctic/Common Tern	798	0.6	2.8	7.9
Sandwich Tern	61	0	4.9	9.8
Alcids	529	0.4	1.9	8.9

Within the designated wind park area, divers were the only species that occurred in proportions greater than expected based on the assumptions above. It should be noted, however, that the observed 1.4% corresponded to 8 out of 554 individuals, and that when this is compared to the expected value (5.5), the difference is not statistically significant (chi-square goodness of fit test, $\chi^2 = 0.39$ with Yates correction, $df = 1$, $P > 0.05$). Divers also occurred in higher proportions than expected when the area was expanded to 2 km from the wind park area, but occurred in lower proportion when a 4 km zone was included (38 observed against 44 expected records). In both situations, the differences were not significant (chi-square goodness of fit test, $P > 0.05$).

A total of 11 Kittiwakes was observed in the wind park area, which matched the expected number of 11.2 birds. Thus, the occurrence of Kittiwakes did not differ significantly from that expected (chi-square goodness of fit test, $\chi^2 = 0.004$ with Yates correction, $df = 1$, $P > 0.05$).

For the other species, only one case was found where the number occurring close to the wind park area was higher than the expected proportion (Gannet WP+4km: 40 observed, 23.9 expected; chi-square goodness of fit test, $\chi^2 = 11.0$ with Yates correction, $df = 1$, $P < 0.005$). Such comparison is not strictly valid because in the analysis, individuals rather than flocks were treated as independent entities. Nevertheless, it appears that Gannets may forage preferentially in the area, which lies within a distance of 4 km of the wind park area (cf. Fig. 7b). Also, although not statistically significantly, higher than the expected proportions, one or two counts were made where Arctic/Common Terns appeared to forage preferentially in the vicinity of the wind park area (cf. Fig. 8b).

Table 11. Number of birds per kilometre aerial transect surveyed in the wind park area (WP), in the wind park area plus 2 km (WP+2), in the wind park area plus 4km (WP+4) and for the total reference area. The number of birds is the total number recorded on the dates: 3 August 1999, 3 September 1999, 12 November 1999, 17 February 2000, and 19 March 2000. The relative importance of the WP, WP+2km and WP+4km is shown.

	Number per transect km (cumulated numbers)				The ratios of total area to the subareas		
	WP (112 km)	WP+2 (376 km)	WP+4 (792 km)	Total area (7474.5 km)	WP	WP+2	WP+4
Divers	0.0714	0.0691	0.0480	0.0741	0.96	0.93	0.65
Gannet	0.0000	0.0160	0.0505	0.0400	0.00	0.40	1.26
Scoter	0.0089	0.0000	0.0442	3.7550	0.00	0.00	0.01
Skuas	0.0000	0.0027	0.0025	0.0028	0.00	0.95	0.90
Common Gull	0.0089	0.0027	0.0088	0.0202	0.44	0.13	0.44
Herring Gull	0.0179	0.0559	0.0720	0.9459	0.02	0.06	0.08
Great Black-backed Gull	0.0000	0.0027	0.0063	0.0273	0.00	0.10	0.23
Kittiwake	0.0982	0.0878	0.0997	0.1496	0.66	0.59	0.67
Arctic/Common Tern	0.0446	0.0612	0.0795	0.1068	0.42	0.57	0.75
Sandwich Tern	0.0000	0.0080	0.0076	0.0082	0.00	0.98	0.93
Guillemot/Razorbill	0.0179	0.0266	0.0593	0.0708	0.25	0.38	0.84

The calculated number of birds per survey kilometre in the wind park area, in the area +2km and +4km, and the proportion in relation to the number per survey kilometre in the reference area is shown in Table 11. These numbers are compared to the number per survey kilometre for the entire reference area in order to obtain a relative estimate of the importance of the area to the different bird species. In the calculations, the ratios between the number recorded in the reference area and the number recorded in the turbine area should equal 1.0 if the species was distributed evenly over the entire reference area. If the proportion was higher or lower than 1.0, then the wind park area should be considered as more important or less important, respectively, than expected.

Based on numbers per survey kilometre no species occurred within the wind park area or +2 km in a higher than expected proportion. No species, except the Gannet, were found in higher numbers than expected when the area was expanded by 2 km and 4 km.

The data and calculations from the period April 1999-April 2000 indicate a general tendency for lower than expected numbers within the wind park area. Thus, we conclude that:

1. No data collected so far indicate that the wind park area is of any special importance to the seabirds' ecological exploitation of the Horns Rev area.
2. If seabirds avoid exploiting the habitat within the wind park, this will affect a maximum of 1% of the habitat within the reference area.
3. Even if a very conservative 'worst possible case' scenario is assumed, with birds showing avoidance behaviour at 4 km distance from turbines, i.e. far more than has been found in any previous study, the wind park is estimated to affect c. 13% of the Gannets and c. 0-10% of the remaining species exploitation of the reference area (cf. Table 10).

Given the temporal constraints of the investigations, data from only one year having been so far gathered and analysed, it is difficult to make predictions about year to year differences in species abundance and distribution. It is therefore necessary to assess the degree of variability between years with respect to bird distributions. Since biomass of bottom invertebrates was found to be very low within the wind park area (Bio/Consult A/S 2000), and since this is undoubtedly caused by the high degree of water turbulence over Horns Rev and the resultant instability of the bottom habitat, it can be assumed that the habitat is of very little importance for seaducks. For fish-eating species, the general tendency was that the bird distributions, even within the single year studied, were highly variable, and it is most likely that the fluctuations were caused by variations in abundance and distributions of the prey species. Also, for fish-eating birds, the numbers present in the Horns Rev habitat were generally lower than average, because the high turbulence in the water over the reef most likely would reduce the profitability of fishing by diving here (as a

result of low prey density and poor visibility in the water column. Only on a very limited number of days would the conditions be such that the area may attract fish-eating birds to forage by diving. In these respects, the investigated year is assumed to be representative.

5.4 Collision risk

Collisions between birds and wind turbines have been documented from terrestrial wind parks (Clausager & Nøhr 1995). No studies currently exist which attempt to document collisions probabilities for waterfowl encountering offshore wind turbines.

With the specification given for the wind turbines and wind park (see chapter 1.2), the area of collision risk (the area swept by turbine rotors) in a row of 8 turbines constitute 7% to 9% of the total area from sea level to the highest position of the rotors. Thus the probability that a flying bird passes the risk zone of the rotors will be less than 10%, assuming that no avoidance behaviours are taken and that birds are randomly distributed at all altitudes. At present, actual collision risk cannot be assessed, since this also depend on the probability that a bird flying through the risk zone actually will be hit by the rotor, which in turn, critically depends on factors such as bird size, wind speed (rotor speed), the birds flying speed and angle of bird passage.

Considering bird populations, collisions will act as an added source of mortality. This means that the potential impact of mortality through collision will vary with the population dynamics of the species. Species with a high reproductive output and a correspondingly low annual survival rate will be less sensitive to added mortality than species with a high annual survival rate and a low reproductive output. Most of the species occurring in the wind park area belong to the latter category.

With specific reference to the offshore wind park at Horns Rev, collisions are assessed to potentially occur in relation to:

- Annual migration of birds between breeding areas and winter quarters,
- Daily flights of birds between e.g. roosting sites and foraging areas,
- Active foraging flights,
- Birds flushed due to disturbance (e.g. turbine maintenance activities),
- Birds attracted to the wind park area during migration.

Generally, the flight altitudes of birds vary significantly between species. Some species fly at low altitudes, others at higher. The actual

weather influences the altitude and in general the flight altitude is higher in tailwind than in headwind. Some species migrate during the day, others at night, and some both during the day and night. Flight altitude may also be related to their activity at the time. Thus, for most species, the range of flight altitudes is large and for these there is a potential risk of collision if they fly in the interval of the turbine rotor (27-110 m). Some sea bird species, however, are so closely associated with the sea surface, that they only occasionally fly at altitudes where they are at risk of colliding with the rotor. Table 12 shows which of the most commonly occurring species that may or may not fly within altitudes of the turbine rotor during migration and during foraging. The main period of occurrence for each species recorded from Blåvandshuk is given together with maximum number recorded per day (Kjær 2000, Jakobsen in prep.).

Species of birds that are expected to occur at critical altitudes on migration are divers, Gannet, Cormorant, dabbling ducks, shorebirds, terns and gulls. Of these, Cormorant, shorebirds and dabbling ducks are not normally associated with substantial offshore migration, and will probably not occur in the turbine area in high numbers. However, it is not possible to assess to what extent nocturnal migrating

Table 12. Maximum occurrences (number/day) of the most numerous species and groups of species occurring at Blåvandshuk, periods of main occurrence and assessment of flight altitude during movements/migration and during foraging activity. Birds that normally fly at altitudes of 0-100 m or more, and thus are expected to occur at altitudes that may result in collisions with the turbine rotor are marked with '+'; birds that normally occur at altitudes of 0-5 m, are marked with '-'.

Species	Max. numbers per day	Main occurrence	Occurrence in rotor altitudes	
			Migration/movements	Foraging
Divers	6,000	Oct - Nov March - May	0	-
Grebes	< 200	Oct - Nov	-	-
Fulmar	7,000	Sep - Nov	-	-
Gannet	4,000	Sep - Nov	+	+
Cormorant	< 500	March - May July - Oct	+	-
Dabbling Ducks	6,000	Sep - Oct	+	-
Eider	30,000	Sep - Nov March	-	-
Common Scoter	40,000-60,000	July - Nov	-	-
Oystercatcher	8,000	July - Sep	+	-
Knot	3,500	July - Sep April - May	+	-
Dunlin	8,000	July - Sep	+	-
Other shorebirds	5,000	July - Sep	+	-
Auks	< 1,500	Sep - Dec	-	-
Arctic Skua	< 200	July - Oct	-	(+)
Terns	15,000	July - Sep	+	(+)
Gulls	25,000+	Aug - March	+	-

birds, such as shorebirds, are more abundant in offshore areas during the night compared to during the daytime.

The risk of collision of waterfowl and seabirds with wind turbines is poorly documented, and it is not possible to make a reliable assessment at present. Migrating birds appear to have the ability to avoid wind turbines at least to some extent (Pedersen & Poulsen 1991), and the study of Tulp et al. (1999) demonstrated that nocturnal flights of seaducks (Eider and Common Scoter) apparently avoided the Tunø Knob park during moonlit nights. In a Dutch study (Dirksen et al. 1998) of a wind turbine park in a tidal and semi-offshore area it was found that wintering diving ducks of the species Tufted Duck *Aythya fuligula*, Pochard *Aythya ferina*, and Scaup *Aythya marila* on their flights between roosting sites and foraging areas avoided the wind turbines. During moonless nights fewer birds approached the wind park than during moonlit nights. Most of the birds approaching the wind park did not pass in between the turbines but turned away, indicating that the wind park was acting as a barrier to the birds.

One study (Orloff & Flannery 1992 and 1996), however, found a relatively high frequency of collisions with birds of prey, and it was hypothesised that this was caused by the wind park being situated in an area where the birds foraged rather than passed through. At present, the possibility that awareness of obstacles is reduced during foraging compared to that during migratory flight cannot be ruled out. Gannets and terns catch their food by diving from above sea level. Terns normally dive from altitudes of 1-15 metres, while Gannets may dive from as much as 30-40 metres above sea level. When foraging on shoals of fish, Gannets may gather in flocks of more than 100 birds, which may follow the fish over long distances. Thus, if fish move through the wind park area, Gannets would be expected to follow as well, with a potential risk of colliding with the rotor blades.

Skuas obtain a substantial part of their food by stealing the food from gulls and terns. This behaviour often involves vigorous and intense flights where skuas chase their victim until they regurgitate their stomach contents. Such chases normally occur 5-20 metres above sea level, but may go far up in the air. A potential risk of collision for both skuas and their victims exists if such chases takes place within the turbine area.

Observations of diurnally migrating birds in an area with wind turbines have documented that birds generally avoid turbines, but that avoidance reactions tended to be less pronounced for nocturnally migrating birds (Pedersen & Poulsen 1991). Previous studies of nocturnal migration have been performed using radars which do not permit individual species identification. Positive identification of nocturnal migrating birds is only feasible when using infra-red recording equipment (Winkelman 1992) or sophisticated tracking-radars.

Although avoidance reactions should be less in nocturnally migrat-

ing birds, it has been shown that the flying altitude generally is higher at night than during the daytime (Eastwood 1965), and that nocturnal migrating birds are less likely to follow topographical features, e.g., coastlines, rivers, etc. To what extent such risk-reducing 'natural' behaviours exist in most of the bird species occurring in the Horns Rev area is for the moment unknown. In fact, the assessment of collision risk during both day and night time is greatly hampered by the lack of fundamental knowledge of the behaviour of birds shown towards wind turbines and wind parks in general for the species in question.

6 References

- Bio/Consult A/S 2000. Horns Rev Offshore Wind Farm. Environmental Impact Assessment of Sea Bottom and Marine Biology. Report to Elsamprojekt A/S.
- Buckland, S. T. 1985. Perpendicular distance models for line transect sampling. *Biometrics* 41: 177-195.
- Burnham, K.P., Anderson, D.R. & Laake, J.L. 1980. Estimation of density from line transect sampling of biological populations. - *Wildlife Monographs* 72: 1-202.
- Clausager, I. & Nøhr, H. 1995. Vindmøllers indvirkning på fugle. Status over viden og perspektiver. Danmarks Miljøundersøgelser. 51. pp. - Faglig rapport fra DMU, nr. 147.
- Cramp, S. & Simmons, K.E.L. 1977. The Birds of the Western Palearctic. Volume 1. - Oxford University Press, 722 pp.
- Danish Hydraulic Institute 1999. Horns Rev wind power plant: Environmental impact assessment of hydrography. - Report to Elsamprojekt A/S.
- Danmarks Fiskeriundersøgelser 2000. Effects of marine windfarms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. - Report to Elsamprojekt A/S.
- Dirksen, S., van der Winden, J. & Spaans, A.L. 1998. Nocturnal collision risk of birds with wind turbines in tidal and semi-offshore areas. - In Proceedings of the international workshop on windenergy and landscape. Genova, Italy, June 1997. P. 99-108.
- Durinck, J., Skov, H. & Andell, P. 1993. Seabird distribution and numbers in selected offshore parts of the Baltic Sea, winter 1992. - *Ornis Svecica* 3: 11-26.
- Eastwood, E. 1965. Some radar measurements of the altitude of bird flight. - *British Birds* 58: 393-426.
- Guillemette, M., Larsen, J.K. & Clausager, I. 1997. Effekt af Tunø Knob vindmøllepark på fuglelivet. - Faglig rapport fra DMU nr. 209. 33 pp.
- Guillemette, M., Larsen, J.K. & Clausager, I. 1998. Impact assessment of an offshore wind park on sea ducks. - Faglig rapport fra DMU nr. 227. 61 pp.
- Guillemette, M., Larsen, J.K. & Clausager, I. 1999. Assessing the impact of the Tunø Knob wind park on sea ducks: the influence of food resources. - Faglig rapport fra DMU nr. 263. 21 pp.
- Hansen, J.H. 1997. Årsrapport 1996. Langli. Naturovervågning. - Arbejdsrapport fra DMU nr. 47. 68 pp.
- Jakobsen, B. in prep.. Fuglene ved Blåvand 1963-1992. - Report from Danish Ornithological Society.
- Joensen, A.H. 1973. Moults Migration and Wing-feather Moults of Seaducks in Denmark. - *Danish Review of Game Biology* 8(4): 1-42.
- Joensen, A.H. & Hansen, E.B. 1977. Oil pollution and seabirds in Denmark 1971-1976. - *Danish Review of Game Biology* 10(5): 1-31.
- Kjær, P.A. 2000. Blåvand Fuglestation 1993-1999, en oversigt over observationer. - Report from Danish Ornithological Society.
- Larsen, J.K. & Madsen, J. (in prep.). Effects of wind turbines and other physical elements on field utilization by pink-footed geese (*Anser*

- brachyrhynchos*): a landscape perspective. Danmarks Miljøundersøgelser.
- Laursen, K. 1989. Estimates of Sea Duck Winter Populations of the Western Palearctic. - Danish Review of Game Biology 13 (6). 22 pp.
- Laursen, K. & Frikke, J. 1987. Vinterforekomster af dykænder, lommer og alkefugle i den sydøstlige del af Vesterhavet. - Dansk Orn. Foren. Tidskr. 81: 167-172.
- Laursen, K., Pihl, S. & Komdeur, J. 1992. New Figures of Seaduck Winter Populations in the Western Palearctic. - IWRB Seaduck Bulletin 1: 5-8.
- Laursen, K., Pihl, S., Durinck, J., Hansen, M., Skov, H., Frikke, J., & Danielsen, F. 1997a. Numbers and distributions of waterbirds in Denmark 1987-1989. - Danish Review of Game Biology 15 (1): 1-184.
- Laursen, K., Frikke, J. & Salvig, J. 1997b. Vandfugle i relation til menneskelig aktivitet i Vadehavet 1980-1995 med en vurdering af reservatbestemmelser. - Faglig rapport fra DMU, nr. 187. 73 pp.
- Laursen, K. (ed.) 1999. Overvågning af fugle, sæler og planter 1998-99, med resultater fra feltstationerne. - Faglig rapport fra DMU, nr. 304. 83 pp.
- Lloyd, C., Tasker, M. L. & Partridge, K. 1991. The status of seabirds in Britain and Ireland. Poyser, London. 355 pp.
- Madsen, F. J. 1957. On the Food Habits of some Fish-eating Birds in Denmark. - Danish Review of Game Biology 3 (2): 19-83.
- Mosbech, A. & Glahder, C. 1991. Assessment of the impact of helicopter disturbance on moulting Pink-footed Geese *Anser brachyrhynchus* and Barnacle Geese *Branta leucopsis* in Jameson Land, Greenland. - Ardea 79: 233-238.
- Orloff, S. & Flannery, A. 1992. Wind turbine effects on avian activity, habitat use, and mortality in altamont Pass and solano county wind resource areas 1989-91. - California Energy Commission, final report from Biosystems Analysis, March 1992.
- Orloff, S. & Flannery, A. 1996. A continued examination of avian mortality in the Altamont Pass Wind Resource Area. - California Energy Commission, report from Biosystems Analysis. 56 pp.
- Pedersen, M.B. & Poulsen, E. 1991. En 90 m/2 MW vindmølles indvirkninger på fuglelivet - Fugles reaktioner på opførelsen og idriftsættelsen af Tjæreborgmøllen ved det Danske Vadehav. - Danske Vildtundersøgelser 47: 1-44.
- Percival, S. 1998. Birds and wind turbines: Managing potential planning issues. - In Proceedings of the 20th British Wind Energy Association Conference. p. 345-350.
- Rose, P.M. & Scott, D.A. 1994. Waterfowl population estimates. - IWRB Publication 29. Slimbridge, UK. 102 pp.
- Rose, P.M. & Scott, D.A. 1997. Waterfowl population estimates. - Second Edition. Wetlands International Publ. 44, Wageningen, The Netherlands. 106 pp.
- Salomonsen, F. 1972. Fugletrækket og dets gåder. Munksgaard, København. 362 pp.
- Seber, G. A. F. 1982. The estimation of animal abundance. 2nd edition. London. 654 pp.
- Skov, H., Durinck, J., Leopold, M. F. & Tasker, M. L. 1995. Important Areas for seabirds in the North Sea, including the Channel and Kattegat. - Birdlife International, Cambridge.
- Stoltze, M. & Pihl, S. (Eds.) 1998a. Rødliste 1997 over planter og dyr i

- Danmark. - Miljø- og Energiministeriet, Danmarks Miljøundersøgelser og Skov- og Naturstyrelsen. 219 s.
- Stoltze, M. & Pihl, S. (Eds.) 1998b. Gulliste 1997 over planter og dyr i Danmark. - Miljø- og Energiministeriet, Danmarks Miljøundersøgelser og Skov- og Naturstyrelsen. 48 s.
- Thalund, J. 1995. Langli/Skallingen Vadehavet. Årsrapport over observationer 1991. - Skov- og Naturstyrelsen. 66 s.
- Tulp, I., Schekkerman, H., Larsen, J.K., van der Winden, J., van de Haterd, R.J.W., van Horssen, P., Dirksen, S., Spaans, A.L. 1999. Nocturnal flight activity of sea ducks near the windfarm Tunø Knob in the Kattegat. - Bureau Waardenburg, Culemborg, The Netherlands. 69 pp.
- Webb, A. & Durinck, J. 1992. Counting birds from ship. I: Manual for aeroplane and ship surveys of waterfowl and seabirds. Eds. J. Komdeur, J. Bertelsen & G. Cracknell. IWRB Spec. Publ. No.19: 24-37.
- White, G. C., Bartmann, R. M., Carpenter, L. H. & Garrott, R. A. 1989. Evaluation of aerial line transects for estimating Mule Deer densities. - Journal of Wildlife Management 53 (3): 625-635.
- Winkelman, J. E. 1992. De invloed van de Sep-proefindcentrale to Oosterbierum (Fr.) op vogels. 2. - Nachtelijke aanvaringskansen. (RIN-report 92/3) DLO-Instituut voor Bos- en Natuuronderzoek, Arnhem. 120 pp.

Appendix I

International conventions, directives and national legislation in relation to birds

Denmark has a central core position on the migratory flyways of the Western Palearctic. Huge numbers of birds pass annually on migration between breeding areas and winter quarters through Danish waters. Furthermore, the Danish marine waters are haunts for large concentrations of staging, wintering and/or moulting waterfowl. For some species more than half of the world or flyway population may occur in Danish waters at certain periods of the annual cycle (Rose & Scott 1997, Laursen et al. 1997a).

Denmark is obliged to protect and maintain large and healthy bird populations, having ratified international conventions and under various EU-directives. Denmark has also enacted a number of national conservation acts and orders under domestic legislation to protect the nature conservation interest of her waters and territories. These instruments are summarised below:

Ramsar Convention

Ratified by Denmark in 1977. An agreement concerning the conservation of wetlands of international importance, especially for waterfowl. Denmark has made a major commitment to implement protection for such areas. Wetlands include lakes, fjords, and shallow marine waters (<6 m) at low tide. Ramsar areas may also include neighbouring land areas where these contribute to the integrity of the site.

An area is identified as being of international importance if:

1. it regularly supports 20,000 waterfowl or,
2. it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity or,
3. where data are available, it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl.

Denmark has designated 27 areas covering a total of 7,350 km².

EU Birds Directive

The Directive was approved in 1979 and subsequently revised. The Directive commits Member States to protect wild birds and for particular threatened species also designate suitable areas for conservation. Denmark has designated 111 such areas covering a total area of 9,500 km².

EU Habitats Directive

The Directive was approved in 1992. The Directive commits Member States to protect wild species and the habitats of the groups: plants, mammals, reptiles, amphibians, fish, and invertebrates; and to conserve threatened types of habitats. Denmark has designated 194 areas covering a total of 10,000 km².

The areas designated in relation to the Ramsar Convention, the EU Birds Directive, and the EU Habitats Directive are in many cases the same.

Bonn Convention

Ratified by Denmark in 1982. The aim of the convention is conservation of those species of wild animals (including birds) that migrate across or outside national jurisdictional boundaries. Conservation may be exercised through protection of species and habitats and through agreement of management. Denmark is a signatory to the African-Eurasian Migratory Waterbird Agreement since 1999 which was established under the Bonn Convention.

Bern Convention

Ratified by Denmark in 1982. The aim of the convention is the conservation of wild European plants and animals and their habitats.

Nature Protection Act

Danish Act no. 835 of November 1st 1997, revised by Act of July 1st, 1998. The aim is the conservation of nature and the environment in a way that is compatible with the development of society on a sustainable basis, with respect to humans and the conservation of the flora and fauna.

Game Act

Danish Act no. 114 of January 28th 1997. The aim of the Act is to protect wildlife, especially during the breeding season, to safeguard the quantity and quality of habitats through establishment of game reserves, and in other ways to re-establish and protect habitats.

Game Reserves

Can be established under the Game Act. They vary much in size from small island reserves for breeding birds or seals to large waters for migrating and wintering waterfowl.

Appendix II

Annotated list of important bird species to be considered in relation to the offshore wind parks

This appendix describes the life-cycle, ecology and conservation status of bird species, genera or families, which have been identified as needing special consideration due to their occurrence and distribution in Danish waters in relation to the five projected offshore wind parks: Horns Rev, Rødsand, Omø Stålgrunde, Gedser, and Læsø.

Divers *Gaviidae* - Lommer

Breeding

Red-throated Diver *Gavia stellata* and Black-throated Diver *Gavia arctica* have a circumpolar distribution and breed in fresh-water habitats in boreal and low arctic regions north of the 55th latitude (Cramp & Simmons 1977). The current estimates of the European and West Siberian population are 75,000 Red-throated Divers and 120,000 Black-throated Divers (Rose & Scott 1997).

Moult, migration and wintering

Both species replace their flight feathers simultaneously and become flightless during this period. Adult Red-throated Diver moult flight feathers in autumn, while immature birds moult during late summer. Adult Black-throated Divers moult flight feathers during February-April, while immature birds moult during April-May (Cramp & Simmons 1977).

Autumn migration from breeding areas may take place as the young become of flight and until the fresh-water lakes freeze (late August-November). Spring migration is largely confined to April-May in western Europe (Cramp & Simmons 1977). Substantial spring migration of Red-throated Divers from the North Sea into Kattegat is recorded along the northwest coast of Denmark during April-May. Black-throated Divers in the North Sea probably migrate over land directly to the Baltic Sea (see Laursen et al. 1997).

The main wintering sites are found in areas below 30 m water depth in the southern part of the Baltic Sea, the North Sea and the Atlantic coasts around the British Isles. Wintering divers occur down to the Iberian Peninsula and the Mediterranean Sea (Cramp & Simmons 1977).

Occurrence in Danish waters

Red-throated and Black-throated Diver occur in Danish waters during most of the year. However, the largest numbers are observed during October-June. The largest concentrations are found west of the Wadden Sea, along the west coast of Jutland and in northern Kattegat. In the inner Danish waters large concentrations were recorded in Smålandsfarvandet south of Sealand and in the Rødsand area south of Lolland-Falster (Laursen et al. 1997). Large numbers of divers were recorded south of Bornholm during a severe winter (Laursen et al. 1997). Compared to the maximum spring estimates of 39,000 during 1987-1989, the estimate of c. 28,000 divers west of the Wadden Sea (Laursen et al. 1997) emphasises the importance of this area.

Food

The most frequently eaten fish is Cod *Gadus morhua*, Herring *Clupea harengus*, Sprats *Sprattus sprattus*, Sand Eels *Ammodytidae*, gobies *Gobiidae* and sticklebacks *Gasterosteus* (Cramp & Simmons 1977). During winter, fish are mostly captured during dives at 2-9 m water depth.

Behaviour

Both species are usually recorded as solitary individuals or in small flocks (< 10 individuals) during winter. Large flocks (> 10 individuals) are mainly observed during migration periods. During moult, divers are very sensitive to disturbances, and are probably distributed in distant undisturbed offshore waters.

Status and conservation

The populations of both Red-throated and Black-throated Divers are not currently threatened, although the wintering population of Red-throated Divers in northwestern Europe shows a decreasing trend (Rose & Scott 1997). A large proportion (85%) of the divers staging at the west coast of Jutland during spring was determined as Red-throated Diver, i.e. more than 20% of the entire population were present in Danish waters. For that reason Red-throated Diver was put on the so-called yellow list as a species which Denmark has a special obligation to protect (Stoltze & Pihl 1998a). The West Siberian population of Black-throated Divers is considered stable (Rose & Scott 1997).

Divers are not legal quarry in Europe. In Denmark, divers regularly occur in numbers of international importance in 6 Ramsar Sites for waterbirds and in 2-3 EU Special Protected Areas. However, numbers of divers occurring in protected areas are small compared to the total number of staging and wintering birds.

Red-necked Grebe *Podiceps grisegena* - Gråstrubet lappedykker

Breeding

The Red-necked Grebe breeds in small eutrophicated ponds or lakes. The core area for breeding Red-necked Grebes in western Palearctic *Podiceps grisegna grisegna* extends from Finland to Central Asia. Eastern Europe and Denmark constitute the western border of the breeding range where the breeding distribution shows a more scattered pattern. Based on winter counts the entire population of *P. g. grisegna* was estimated to be c. 40,000 individuals (Rose & Scott 1997). During the last 25 years the Danish population has increased markedly and was recently estimated to 1,500-2,000 pairs (Grell 1998).

Moult, migration and wintering

In the Baltic simultaneous wing moult is undertaken from July-September in remote offshore areas. In 1990 in two inshore Danish waters (Omø Stålgrunde and Sejerø Bight) about 1,500 Red-necked Grebes were estimated to moult which was about half of the Danish population (Pihl 1995). Hence, a diffuse moult migration occurs from inland areas. After wing moult the European Red-necked Grebes gather in the ice-free areas of the Baltic, the North Sea, in the Adriatic and Aegean Sea and in the Po Delta and stay in these areas until February-March, when they return to the breeding grounds. Cold spells may induce mid-winter migration from the most northerly wintering areas (Cramp & Simmons 1977) .

Occurrence in Danish waters

Outside the breeding season Red-necked Grebes are found in most Danish offshore waters. However, in a few areas several hundred individuals are found regularly. During moult, Smålandsfarvandet and Sejerøbugten are the most important areas. During autumn post-moulters are redistributed and most likely additional birds from other parts of the breeding range gather in Danish waters to winter. During autumn and winter, previous studies have shown that the largest concentrations were found between Læsø and Anholt, north of Djursland and off the west coast of Jutland and the Wadden Sea (Laursen et al. 1997). Probably about 25% of the *P. g. grisegna* population wintering in northwest Europe (15,000) winter in Danish waters.

Food

During the breeding season Red-necked Grebe mostly feed on freshwater invertebrates and insects (Cramp & Simmons 1977). Outside the breeding season when staging in marine areas Red-necked Grebes mainly sustain themselves on a variety of fish and Crustaceans (e.g. Madsen 1957).

Behaviour

After the breeding season, Red-necked Grebes are mostly observed as solitary individuals or in small flocks of less than ten individuals. When gathered in larger concentrations then feeding or resting usually occur in loose flocks.

Status and conservation

In recent years the number of breeding pairs has increased in Denmark and Finland, whereas a long-term decrease was observed in many eastern European countries (Hagemeijer & Blair 1997). Red-necked Grebe is yellow-listed in Denmark because of the large number of wintering birds (Stoltze & Pihl 1998a). In Europe the Red-necked Grebe is a non-quarry species. As the Red-necked Grebes redistribute to Kattegat and the North Sea during autumn and winter, progressively smaller numbers are found in protected areas.

Fulmar *Fulmarus glacialis* - Mallemuk

Breeding

Nominate race breeds in temperate to arctic regions from Iceland, the Faroe Islands to Novaya Zemlya in Russia, and from the Channel region and Britain to Svalbard. The estimated European breeding population is 6-10.5 million birds (Rose & Scott 1994). Breeding was first recorded at Bulbjerg, Denmark, in 1999.

Moult, migration and wintering

Fulmars are associated with saline waters, and become less numerous in waters of moderate and low salinity, e.g. in coastal areas of the Danish part of the North Sea and in inner Danish waters. An influx of Fulmar into the eastern North Sea during the summer (Tasker et al. 1987), may reflect a moult migration to this area of non-breeding birds, since the proportion of moulting birds was higher than in the breeding areas.

Outside the breeding period, Fulmars are found in all parts of the North Atlantic and North Sea throughout the year. Flight feathers are moulted simultaneously. Adults moult in late summer and early autumn after breeding. Juvenile and non-breeding birds moult between May and August (Cramp & Simmons 1977).

Occurrence in Danish waters

The largest concentrations of Fulmars are found along the southern and western edges of the Norwegian Trench, with an estimated number exceeding 100,000 in all seasons except spring (Laursen et al. 1997). The total estimated population in the North Sea and the

Skagerrak was between 370,000 and 450,000 birds, while incomplete spring surveys resulted in an estimated 35,000 birds in the North Sea (Laursen et al. 1997).

Food

Fulmars mainly feed on crustaceans and cephalopods, and less on fish. Fulmars are attracted by fishing trawlers and to fish offal and carrions (whales, seal etc.), on which several thousand birds may aggregate.

Behaviour

A tendency for nomadic behaviour often results in a constant change in numbers. The species is highly gregarious on good feeding areas, e.g. up-welling zones.

Status and Conservation

The populations in northwest Europe have shown a steady increase in most areas since 1949 (Cramp & Simmons 1977). The Fulmar is not legal quarry in Denmark. Normally, the Fulmar does not occur in protected areas in Danish waters due to its pelagic occurrence.

Gannet *Sula bassana* - Sule

Breeding

The Gannet is a colonial breeder on small uninhabited islands or inaccessible cliffs in the north Atlantic. Main colonies in Europe are generally old (> 50 years) and located in Britain, the Channel Islands and in Iceland. Smaller colonies exist on the Faroe Islands and in northern Norway. The current population estimate is 670,000-900,000 individuals (Rose & Scott 1994).

Moult, migration and wintering

Gannets moult primaries serially during July-December (Cramp & Simmons 1977), and are able to fly as moult progresses.

Gannets are partially migratory. Adults may stay within the breeding range during winter, but most immatures migrate southward as far as the tropical waters off West Africa (Cramp & Simmons 1977). Outside the breeding season, the Gannet is normally associated with continental shelf areas in the North Atlantic and North Sea. Autumn migration peak in northwest Europe during August-September.

Occurrence in Danish waters

In Denmark, the Gannet is numerous along the west coast of Jutland and in east Skagerrak during late summer and autumn until October. Wintering Gannets are rarely observed, but regular occurrences are recorded in spring at the North Sea coast. Based on surveys in 1987-89, Laursen et al. (1997) estimated the autumn population at 22,000 birds, mainly in the western part of the Danish North Sea.

Food

Mainly fish, which is taken by plunging from heights of 10-40 metres, or caught during dives from the surface (Cramp & Simmons 1977). Eats a variety of fish species most frequently shoaling species like Herring *Clupea harengus*, Capelin *Mallotus villosus*, Cod *Gadus morhua*, Coal-fish *Pollachius virens* and others (Cramp & Simmons 1977).

Behaviour

Outside the breeding season, Gannets are scattered over wide areas, but they often are recorded in high densities when feeding (Cramp & Simmons 1977).

Status and conservation

Up to 4% of the European population was estimated to be present in the Danish part of the North Sea (Laursen et al. 1997).

Cormorant *Phalacrocorax carbo* - Skarv

Breeding

The Danish Cormorants belong to the sub-species *Phalacrocorax carbo sinensis*, which is distributed in the temperate zone from Europe, Central Asia to the Kamchatka-peninsula. The present breeding population in Denmark is c. 40,000 pairs. The north- and central European population of *P. c. sinensis*, which could potentially visit Danish waters, has been estimated at 200,000 individuals in the mid-1990s (Rose & Scott 1997). However, the population has increased in recent years. During autumn and winter, the subspecies *P. c. carbo* occurs in Danish waters. These Cormorants breed along the Norwegian coast and to the Kola-peninsula. The population of *P. c. carbo* was estimated at 120,000 individuals (Rose & Scott 1997).

Moult, migration and wintering

Cormorants have sequential wing moult, hence they are able to fly throughout the moult period. Autumn migration of *P. c. sinensis* from northern Europe mainly proceeds to the Mediterranean during September-November. In northern Europe *P. c. sinensis* may be partially

migratory, i.e. a proportion of the Cormorant population stays close to the breeding site during winter or only disperses locally. *P. c. carbo* breeding in Britain and Norway disperses along the local coasts. However, the Norwegian birds may go as far south as the Baltic. The Cormorants return to the breeding colonies from January (southernmost populations) to April (Cramp & Simmons 1977).

Occurrence in Danish waters

During the breeding season Cormorants may travel considerable distances (up to 50 km) to feed. Hence, Cormorants are observed in most Danish waters in the breeding season. The number of Cormorants peaks during late summer, when dispersal from the breeding colonies in Denmark, southern Sweden and northern Germany occurs. The late summer numbers probably amount to about 200,000 individuals (T. Bregnballe pers. comm.). During this period the highest concentrations of comorants tend to be found along the Baltic coast of Funen and Lolland-Falster. Appr. 5-10% of the Danish Cormorants *P. c. sinensis* winter in Danish waters. From September onwards, *P. c. carbo* is observed in Denmark either as migratory or wintering. The wintering population of *P. c. carbo* probably constitutes 10-20,000 individuals (Laursen et al. 1997). The wintering Cormorants tend to concentrate in the southern part of Kattegat, yet flocks of Cormorants are observed throughout Denmark.

Food

Cormorants seem to feed on the fish stock which is available at the time. Hence, several fish species (marine and freshwater) has been found in the diet with significant seasonal and local differences.

Status and Conservation

The Cormorant population in Europe has increased dramatically during the last 20 years. The Danish breeding population of *P. c. sinensis* constitutes c. 25% of the entire European population. Therefore, Danish Cormorants were put on the yellow-list as a species, which Denmark has an international obligation to protect. Cormorants are hunted in many countries in northern and western Europe. However, in Denmark Cormorants are only allowed to be controlled at stationary fishing nets. Annually, c. 3,500 Cormorants are shot in Denmark (T. Bregnballe in litt.). Conflicts between Cormorants and fisheries are present in most countries. The coastal preference and the dispersive behaviour of Cormorants imply that most protected marine areas hold feeding Cormorants throughout the year.

Geese *Anserini* - Gæs

Breeding

Only Dark-bellied Brent Goose *Branta bernicla bernicla* and Barnacle Goose *Branta leucopsis* are commented in this section due to their migration routes, which should be considered in relation to the projected wind farms. Only, Barnacle Goose (50-60 pairs) breeds in Denmark. Both goose species have their main breeding area north of Denmark. The Barnacle Goose breeds from arctic Greenland to Novaya Zemlya extending down to the boreal and temperate zone in Europe. The west Siberian/Scandinavian population of Barnacle Goose occurring in continental Europe in winter is estimated at 176,000 individuals. In addition, the Svalbard and Greenland population wintering in Britain hold 12,000 and 32,000, respectively. The Brent Goose has a circumpolar breeding distribution in the arctic region. The population estimate of the nominate race *B. b. bernicla* occurring in West Siberia and Europe is 300,000 (Rose & Scott 1997).

Moult, migration and wintering

Barnacle geese and Brent geese shed their flight feathers synchronously and remain flightless for c. three weeks. During this period the non-breeding segment of the goose populations stays in remote and disturbance free areas. These sites may be situated several hundred kilometres from the breeding areas. In the most northerly populations autumn migration is initiated in August as snow cover makes feeding impossible. In northwest Europe the main migration period for Barnacle Goose and Brent Goose is in September-October. The winter range extends from southern Scandinavia and Britain down to France. Large numbers of both species gather in The Wadden Sea during April. Barnacle geese continue the spring migration from late April. Dark-bellied Brent geese depart the Wadden Sea in late May (Cramp & Simmons 1977).

Occurrence in Danish waters

No specific moult sites for Barnacle Goose are known for Denmark. During autumn and spring, significant migration occurs through Danish waters. In autumn, Brent geese are especially observed in large numbers in western Jutland, e.g. up to 1,000 Brent geese was observed in one day at Blåvandshuk. An important spring migration route of Dark-bellied Brent Goose (c. 15,000 ind.) exists over the southern part of Denmark. The migratory route goes from the Wadden Sea over the southern part of Jutland, southern Funen and Lolland-Falster. Barnacle geese also pass the southern part of Denmark during spring, however, the importance of this route seems to depend on weather conditions. Barnacle and Dark-bellied Brent geese pass over the southern part of Denmark again in September-October. Daily maximum numbers at observation sites at the Baltic Sea vary between 10,000-25,000. Geese do not stage or winter in open sea (Olsen 1992).

Food

Only Brent geese feed in marine habitats. As Brent geese are not able to dive, feeding is confined to the shallows (< 1 m), where beds of eelgrass and seagrasses are found. Barnacle geese usually feed on graminoids in terrestrial habitats.

Behaviour

Geese are highly gregarious outside the breeding season and may gather in flocks of several thousands.

Status and Conservation

The populations of Barnacle Goose and Dark-bellied Brent Goose has increased markedly during the last 20 years. Therefore the two species has contributed to the increasing problems with damage of agricultural crop. Except for local hunting of Dark-bellied Brent Goose in Germany, no hunting of the two species occurs. The Dark-bellied Brent Goose is yellow-listed because of its occurrence in terrestrial habitats (Stoltze & Pihl 1998a).

Eider *Somateria mollissima* - Ederfugl

Breeding

The Eider is a colonial breeder in Western Palearctic coastal and marine areas both in temperate, boreal and arctic regions. The breeding range extends from Iceland to Novaja Zemlya, and from the Netherlands to Svalbard. In 1990 the total breeding population was estimated at 23,000 pairs in Denmark (Lyngs 2000). The current total estimate of the Baltic, Danish and Dutch population is 1.35-1.70 mill. birds, while the Norwegian/Russian population is estimated at 0.30-0.55 mill. individuals (Rose & Scott 1997).

Moult, migration and wintering

Eiders are partially migratory and dispersive. Baltic breeding populations show the most extensive migration. Adult males and immature birds undertake moult migration from breeding areas in Finland and Sweden to coastal and offshore waters in the western Baltic, western Kattegat, and to the Wadden Sea during late summer. Eiders moult their flight feathers simultaneously. During wing moult, Eiders are flightless for two-three weeks and stay preferably in remote and undisturbed offshore areas. Breeding females moult near the breeding colonies. Females proceed with the autumn migration together with the young in September-November to the wintering areas in western Baltic, southwest Kattegat and in the Wadden Sea (Cramp & Simmons 1977).

Occurrence in Danish waters

The Eider is numerous and widespread around the Danish coasts. Highest concentrations occur in Kattegat north and south of Djursland, in the Belt areas and in the Wadden Sea (Laursen et al. 1997). In late summer, more than 100,000 birds moult in offshore Kattegat, while more than 5,000 birds moult in offshore parts of Lillebælt, Storebælt and the Wadden Sea (Laursen et al. 1997). From autumn to spring considerable seasonal variation in numbers was recorded for instance depending on the extent of ice formation (Noer 1991). During spring and autumn migration, a total of 1.5-2 million Eiders pass through Danish waters (Madsen et al. 1996), of which c. 800,000 are wintering (Laursen et al. 1997).

Behaviour

Eiders are highly gregarious and flocks numbering more than 5,000 individuals are regularly recorded.

Food

Eiders mainly feed by diving, but may also feed by dabbling in shallow waters. In winter, the diet is mostly benthic molluscs, especially Blue Mussels *Mytilus edulis* and Cockles *Cardium edule*. Crabs *Carcinus maenas*, crustaceans and other invertebrates are also consumed (Madsen 1954).

Status and conservation

Eider populations in Europe had increased since 1950, however this increase has apparently ceased in recent years (Madsen et al. 1996). The Eider is legal quarry in Denmark (annual bag c. 100,000, Madsen et al. 1996). Eiders are hunted in Sweden and Finland, and the annual bag is c 40,000-50,000 (Madsen et al. 1996).

Denmark is of international importance to Eiders. During the census 1987-1989, internationally important numbers of more than 20,000 birds (Rose & Scott 1994) were recorded in 21 areas (Laursen et al. 1997). For that reason, the Eider is yellow-listed.

Long-tailed Duck *Clangula hyemalis* - Havlit

Breeding

The Long-tailed Duck has a circumpolar breeding distribution. The birds, which are observed wintering in Danish waters, could potentially breed in West Siberia, the Kola-peninsula or in the tundra areas of Scandinavia. This population was estimated at 4.6 mill. individuals (Rose & Scott 1997). Another estimate calculated the wintering population in the Baltic Sea at 4.3 mill. (Durinck et al. 1994).

Moult, migration and wintering

The flightless period of wing moult probably occurs close to the breeding areas during the summer and early autumn. The main autumn migration from Siberia initiates in the beginning of October. Autumn migration tends to be slow and the main influx of Long-tailed Ducks in the wintering areas in the western part of the Baltic is in November and December. Wintering Long-tailed Ducks are also found off the Norwegian west coast and around the British Isles. However, numbers in these areas are small compared to the main wintering population in the Baltic. Spring migration back to the breeding areas occurs from mid-March but the arrival in the breeding areas may even be postponed to mid-June dependent on snow conditions (Cramp & Simmons 1977).

Occurrence in Danish waters

To some extent the occurrence of Long-tailed Ducks in Danish waters is dependent on the severity of the winter, i.e. in very mild winters, numbers are small and probably do not exceed 100,000 individuals. Although less than 5% of the wintering Long-tailed Ducks are found in the Danish part of the Baltic Sea, the Danish contribution probably amounts to more than 100,000 individuals in an average year (Laursen et al. 1997). The most important area is at Bornholm, but also the area east of Møn and the Fehmarn Belt tend to hold considerable numbers. In the northern part of Kattegat the estimates are in the order of magnitude of about 10,000, whereas less than 1,000 Long-tailed Ducks were found at the west coast of Jutland and the Wadden Sea.

Food

Variable diet which may include both animals and plants. However, molluscs and crustaceans tend to be the preferred food resource in Danish waters (Madsen 1954)

Behaviour

Long-tailed Ducks are highly gregarious both during migration and in the wintering areas. Evidence of segregation of sexes has been recorded in some areas of the winter range (Cramp & Simmons 1977).

Status and conservation

The European population of Long-tailed Duck is thought to be stable (Rose & Scott 1997). However, the species breeds in remote arctic and sub-arctic areas and winter at open sea and is therefore difficult to monitor. Long-tailed Duck is a legal quarry species in northern Europe during autumn and winter. However, the habitat choice of the species makes access to areas with high concentrations difficult for hunters. In Denmark the annual bag of Long-tailed Ducks varied be-

tween 2,500 and 7,500 in 1990s (Clausager 1999). Most protected areas are coastal. Thus, a negligible proportion of Long-tailed Ducks occurs in protected areas.

Common Scoter *Melanitta nigra* - Sortand

Breeding

Nominate race breeds in the boreal and into low-arctic tundra regions from Iceland to river Olenek in Siberia (Dement'ev et al. 1967). The southern border of the breeding range extends to Ireland, northern Britain, southern Norway, central Sweden, central Finland and northern Russia (Hagemeijer & Blair 1997). The current population estimate is 1.6 million birds based on mid-winter counts (Rose & Scott 1997).

Moult, migration and wintering

Common Scoter replace their flight feathers simultaneously, rendering them flightless for a period and highly sensitive to disturbance. The moulting period varies according to sex and age of the birds; in males, on average it occurs mid July - late August; amongst female late August - mid October. Adult males and non-breeding birds undertake moult migration from the breeding areas in mid June to early September to coastal and offshore waters in the Baltic and along parts of the Atlantic coast. The autumn migration of breeding females with young takes place in October-November. The entire population winters along coastal waters of Western Europe from Norway and Kattegat south along the Atlantic seaboard to Spain, and along the African coast to Mauritania (Cramp & Simmons 1977). Birds return on spring migration to summering areas during March-May, with large concentrations of birds amalgamating in the eastern Baltic early in May. Birds migrating over the sea typically fly at low altitudes whereas birds crossing larger landmasses fly high.

Occurrence in Danish waters

In Denmark, the Common Scoter is numerous and widespread around all coasts for most of the year, since many immature birds remain through spring and summer. Highest concentrations occur in the Kattegat, in the North Sea off the Wadden Sea coast, and Sejerø Bugten (Laursen et al. 1997). The geographical distribution varies during the year and may also vary from year to year. Up to a million birds have been estimated wintering in Danish Baltic waters (Pihl 1994) and 80,000 may occur in the Wadden Sea (Laursen et al. 1997). Moulting Common Scoter are extremely wary and difficult to count, but 500,000 individuals are thought to use Danish waters for the moult. During spring and autumn migration, several hundred thousand Common Scoters also use Danish waters.

Food

Common Scoters feed almost exclusively by diving. In winter, the diet is mostly benthic molluscs, taken in proportion to their abundance, but especially blue mussels *Mytilus edulis* and cockles *Cardium edule* and *Echinocardium nodosum* occasionally other aquatic invertebrates (crustaceans, worms, insects) and rarely small fish.

Behaviour

The species is highly gregarious and flocks numbering more than 10,000 individuals are regularly recorded. During moult, reaction to disturbance may start at distances of 3-5 km. In winter, the species is less sensitive, but remains one of the most wary of seaduck species to disturbance from vessels.

Status and conservation

The population is large and apparently not currently threatened. The species is legal quarry in Germany, where some 200 are killed annually (Bertelsen & Simonsen 1986), in Denmark, where the annual bag varied between 4,000 and 14,000 birds (Clausager 1999), in France with an annual kill <1,000 (Bertelsen & Simonsen 1986). The Common Scoter is yellow-listed (Stoltze & Pihl 1998a) as more than half of the total world population occurs in Danish waters. At present, Common Scoter occurs in numbers of international importance in 14 EU Special Protection Areas and 11 Ramsar Sites.

Velvet Scoter *Melanitta fusca* - Fløjlsand

Breeding

Velvet Scoter has an almost circumpolar breeding distribution on the northern hemisphere, however, it is not breeding in northeast Canada and Greenland. Isolated breeding populations have been found in Caucasus. In Europe the breeding range extends from West Siberia over northern Finland and down on the Scandinavian peninsula. Coastal breeding areas are found in the Gulf of Bothnia and in the Gulf of Finland. The European population was estimated at 1 mill. birds (Rose & Scott 1997).

Moult, migration and wintering

Moult migration is undertaken by males in July and August. Females mainly arrive to the moult sites in August and September. Velvet Scoters are known to moult at remote coastal and offshore habitats within the breeding range. However, a substantial proportion of the scoters undertake long distance moult migration south of the breeding range, e.g. to Danish waters. As the Common Scoter, Velvet Scoters are extremely shy during the moult period, when they are flightless for about three weeks.

Wintering Velvet Scoters occur along the Norwegian coast, in Danish waters, the Baltic, the Wadden Sea and even further south to Iberia and around the British Isles. Spring migration occurs from March to May (Cramp & Simmons 1977).

Occurrence in Danish waters

Aerial surveys in the late 1980s indicated that Danish waters have lost their importance for moulting Velvet Scoters (Laursen et al. 1997). In particular, Limfjorden used to hold up to 15,000 moulting individuals in the 1970s compared to a few hundreds in the late 1980s. The most important moult sites are Kattegat, Sejerøbugten and Smålandsfarvandet. During autumn and winter, the same areas tend to be the most important staging areas whereas some dispersal to sites south of Funen and Lolland-Falster seems to occur during spring. In the late 1980s, estimated numbers of Velvet Scoters in Danish waters were 22,000-100,000 (autumn), 109,000-130,000 (winter) and 27,000-90,000 (spring) based on aerial and ship surveys (Laursen et al. 1997).

Food

Velvet scoters feed on a variety of small molluscs but other food items such as crustaceans, annelids, fish and echinoderms may also be consumed.

Behaviour

During the non-breeding season, Velvet Scoters are highly gregarious.

Status and conservation

Although declines and redistribution of Velvet Scoters have occurred in Danish waters, the entire European/West Siberian population seems to be stable (Rose & Scott 1997). It is allowed to hunt Velvet Scoters in Denmark, Germany and France. During the 1990s, the annual bag varied between 1,500 and 4,000 (Clausager 1999).

Red-breasted Merganser *Mergus serrator* - Toppet Skallesluger

Breeding

Red-breasted Merganser breeds circumpolar in freshwater and marine habitats. In Europe, Denmark (min. 2,000 pairs) together with Baltic Germany mark the southern border of the breeding range. The northwest European population was estimated at 125,000 individuals (Rose & Scott 1997).

Moult, migration and wintering

Males moult from mid July-August whereas females moult one month later. Moult migration to remote offshore sites may be undertaken, however, small flocks of moulters (10-50 birds) may also be observed close to the coastal breeding areas. The northwest European population winter along the Norwegian coast, in the Baltic, in Danish waters, around the British Isles and down to the Garonne Delta. Red-breasted Mergansers from West Siberia winter in the eastern Mediterranean and the Black Sea. In Norway, Denmark and Britain Red-breasted Merganser are only partially migratory (Cramp & Simmons 1977).

Occurrence in Danish waters

The breeding population in Denmark rarely nests in freshwater lakes. Hence, the breeding population is dispersed in sheltered areas at the coasts and fjords. The traditional moult sites with large concentrations are Limfjorden, the waters around Funen, Smålandsfarvandet and Roskilde Fjord. The surveys in the late 1980s indicated a dramatic decline in the number of moulting Red-breasted Mergansers in Danish waters as less than 2,000 individuals were counted. This compares to c. 6,000 in the 1970s. During autumn and winter the largest numbers are observed in the same areas as during moult, except Roskilde Fjord. Occasionally large numbers occur in Kattegat. During spring, when Red-breasted Mergansers pair, dispersal along the coasts occurs to gradually reflect the breeding distribution.

Food

In Danish waters Red-breasted Merganser is mainly piscivorous. However, crustaceans, mysids, annelids, molluscs, insects and larvae are also included in the diet.

Behaviour

Red-breasted Merganser is highly gregarious especially at the moult sites and wintering areas where loose flocks of over 1,000 individuals may occur. Segregation of the sexes in the wintering areas has been reported from both Europe and North America.

Status and Conservation

The population of Red-breasted Merganser seems to be stable in northwest Europe. However, the number of breeding pairs may show huge variation locally (Bauer & Glutz 1969). Red-breasted Merganser is on the Danish yellow list as numbers of international importance occur on several sites in Danish waters (Stoltze & Pihl 1998a). Red-breasted Merganser may be hunted in Denmark except for the three southernmost counties where Red-breasted Merganser may be con-

fused with goosanders from the scarce Danish breeding population. The annual bag varied between 2,200 and 7,000 in 1990s (Clausager 1999).

Birds of prey *Falconiformes* - Rovfugle

Breeding

The raptors that migrate over Danish waters breed chiefly in Scandinavia (incl. Denmark) and northwestern Russia. A crude estimate for the total Scandinavian raptor population (all species combined) amount to 160,000-200,000 breeding pairs (Gensbøl 1987, Risberg 1990, Grell 1998). The most numerous species are Sparrowhawk *Accipiter nisus* (38,000 pairs), Buzzard *Buteo buteo* (34,000 pairs), Honey-buzzard *Pernis apivorus* (14,000 pairs), Merlin *Falco columbarius* (12,000 pairs) and Kestrel *Falco tinnunculus* (10,000 pairs).

Moult, migration and wintering

Birds of prey moult their flight feathers successively and are able to fly throughout the annual cycle. The spring migration in northern Europe starts in early February and continues until early July. The various species show specific peaks through out the spring migration period, e.g. Buzzard: late March; Sparrowhawk and Merlin: late April; Honey-buzzard: late May. The autumn migration begins in late August (adult Honey-buzzards) and proceeds to the end of October (Buzzards). Raptors can be divided in to three different categories based on their wintering area: 1) resident species that stay in the breeding area throughout the year (e.g. Danish Goshawks *Accipiter gentilis* and some of the Sparrowhawk populations); 2) short migrating species wintering in southern-Europe and around the Mediterranean (e.g. the populations of Buzzard and kestrel in northern Europe); and 3) long migrating species that winters in Africa, and hence, migrate over the Sahara desert (e.g. Honey-buzzard and Osprey *Pandion haliaetus*).

Occurrence over Danish waters

The raptors can be divided in to two distinct groups based on their flying technique: the soaring species (e.g. buzzards, harriers, and eagles) and actively flying species (e.g. hawks, falcons, and Osprey). Soaring raptors need the land-depended thermals for their migration, and are consequently, funnelled into places that give them the shortest route over water: e.g. via Skagen and Gilleleje in spring and Falsterbo and Gedser in autumn. Consequently, the migration routes over-water of these broad-winged birds of prey are relatively limited in space. By contrast, the strong fliers that rely on active flight are regularly crossing long stretches of water, resulting in a broad fronted migration pattern. Daily maximum numbers of 3,000-4,000 soaring Buzzards are recorded each spring in the eastern part of the country summing up to a countrywide spring total of 7,000-14,000 individuals (Olsen 1992). For active flyers such as Sparrowhawk and Merlin,

national spring totals amounts to 9,000-12,000 and 500-700 birds, respectively. The volume of spring migrating Honey-buzzards is highly variable, especially in the western part of Denmark where westerly winds reduce the numbers. At Falsterbo, Sweden up to 19,000 Buzzards, 30,000 Sparrowhawks, and 5,500 Honey-buzzards are heading for Denmark each autumn (mean numbers for 1986-98).

Food

The prey of raptors spans a variety of animals: e.g. terrestrial invertebrates, insects, passerines, carcasses, and small mammals. When migrating over water only the insect and passerine eating falcon species are capable of hunting en route.

Behaviour

Most of the raptor species are solitary migrants. Nevertheless, huge numbers may be observed simultaneously due to the described funnel effect on the soaring species, in particular. In these cases up to several hundred individuals of a few species can be seen utilising the same thermals. It is generally accepted that birds of prey mainly migrates at altitudes below 200 metres (Cooper & Ritchie 1995).

Status and protection

During the 1960s, many of the raptor populations in northern Europe declined rapidly. A change in hunting practice and limiting the spill of heavy metals, DDT etc. were suggested to have caused the present recovery of the raptor populations. In Denmark only Hobby *Falco subbuteo* and osprey are classified on the Danish Red List (Stoltze & Pihl 1998b) as "critically endangered breeding raptor species".

Waders *Haematopodidae*, *Recurvirostidae*, *Charadriidae*, *Scolopacidae* - Vadefugle

Breeding

Waders migrating through Denmark breed from Canada to the Tajmyr-Peninsula. Waders are traditionally divided into boreal breeding inland species and arctic breeding coastal species (Møltofte 1993). From Canada and Greenland only coastal waders pass Denmark, whereas both the coastal and boreal breeding species from Scandinavia and Russia migrate over Danish territories. It was estimated that up to 10 millions wintering coastal waders occur along the African and European coasts (Smit & Piersma 1989, Piersma et al. 1987, Møltofte 1993). However, the inland waders probably outnumber the coastal waders five-fold.

Moult, migration and wintering

The primaries of adult waders are successively moulted over a relative long period (Prater et al. 1987, Meltofte 1993), and thus, the waders are always capable of flight. The spring migration of waders in northern Europe occurs from early March to early June. However, the species specific migration periods are much narrower. The period of autumn migration starts by the end of July and continues through November (Meltofte 1993). The autumn migration is divided into an adult migration wave (in long jumps) and a later occurring juvenile movement (in small jumps) with a gap of c. one month between the two age groups. Waders which migrate along the east Atlantic flyway winter from northwest Europe to South Africa.

Occurrence in Danish waters

The coastal migration of waders in Denmark probably includes several hundred thousand individuals each spring and autumn. One of the most conspicuous migration routes goes along the west coast of Jutland with Oystercatcher *Haematopus ostralegus*, Dunlin *Calidris alpina* and Knot *Calidris canutus* as the most numerous species. In addition, the coastlines of the Baltic and inner Danish waters also act as leading lines for substantial numbers of waders. The Wadden Sea is one of the most important staging areas for waders in the western Palearctic.

Food

Waders prey predominantly upon marine and freshwater invertebrates when staging in areas with shallow water (0-30 cm) during the migration periods.

Behaviour

Waders live in pairs during the breeding season but become gregarious during migration; most pronounced among coastal waders. In the wintering areas coastal waders are predominantly social, whereas inland species tend to be more solitary. Among some of the larger coastal species (e.g. Whimbrel *Numenius phaeopus* and Grey Plover *Pluvialis squatarola*) individual feeding territories are established and defended throughout the winter (Zwarts 1990). Waders often migrate at high altitudes (up to 6,000 metres), where they try to benefit from favourable wind conditions (tail winds). However, in head winds and during bad weather (rain and fog) waders tend to fly at low altitudes following navigation features (e.g. coastlines) in the landscape.

Status and protection

None of the wader species migrating through Denmark are globally threatened. Nine wader species are red-listed in Denmark because of

small or extinct breeding populations (Stoltze & Pihl 1998b). Four wader population (Northern Dunlin *C. a. alpina*, Southern Dunlin *C. a. schinzii*, Golden Plover *Pluvialis apricaria* and Avocet *Recurvirostra avosetta* are yellow-listed as a large proportion of the entire breeding population occurs as breeding or staging in Denmark (Stoltze & Pihl 1998a). Thirteen species are legal quarry species in western Europe.

Skuas *Stercoraridae* - Kjøver

Breeding

Arctic Skua *Stercorarius parasiticus* has a circumpolar breeding distribution. It breeds in the western Palearctic on Iceland, the Faroe islands, Orkney, Shetland, Scotland and along the Atlantic coast of Sweden and Norway into northern Russia/Siberia (Cramp & Simmons 1983). Smaller number breeds at the Swedish and Finnish Baltic coast areas (probably 200-300 pairs). The current population size in the western Palearctic is unknown. However, it is probably less than 15,000 pairs. Nominate race of Great Skua *Stercorarius skua* breeds in the northeast Atlantic in Iceland, the Faroe islands, Shetland and northern Britain. More recently, some birds have bred on Spitsbergen and in Norway (Cramp & Simmons 1983). The population is estimated at 40,000-54,000 individuals (Tasker et al. 1985 and 1987, Lloyd et al. 1991). Pomarine Skua *Stercorarius pomarinus* and Long-tailed Skua *Stercorarius longicaudus* also occur in Northern Europe. However, their abundance in proximity to the five projected wind farms is negligible.

Moult, migration and wintering

Skuas moult their flight feather successively. Thus, skuas do not have a sensitive flightless period. The Arctic Skua is migratory. Some individuals winter in the north Atlantic, but most migrate transequatorially to waters off the coasts of West Africa and Argentina (Cramp & Simmons 1983). In northern Europe, migration of Arctic Skuas from the breeding grounds occurs through the Baltic Sea and the North Sea during August-October. Great Skuas disperse in the north Atlantic after breeding.

Occurrence in Danish waters

High numbers of Arctic Skuas occur on autumn migration August-October. Arctic Skua occurs in the Baltic Sea and Kattegat, but the highest numbers are recorded along the west coast of Jutland, where up to 1,500 birds are regularly counted at Blåvand (Jakobsen in prep.). In Danish waters Great Skuas are recorded almost exclusively during late summer and autumn. Highest densities are found at the Norwegian Trench and in the North Sea. Based on surveys during 1987-89, a total of 11,000-13,000 Great Skuas were estimated during late summer and 0-1,200 individuals estimated during autumn (Laursen et al.

1997). Periods of strong westerly winds generally result in large numbers of skuas in the Danish part of the North Sea.

Food

Skuas mainly feed on fish obtained by food-piracy of other seabirds. Skuas often pursue small gulls *Larus*, auks *Alcidae* and terns *Sternidae* (Cramp & Simmons 1983).

Behaviour

Outside the breeding season, the skuas are mostly solitary, but occur also in pairs and small flocks (Cramp & Simmons 1983). Higher numbers may occur in areas with large numbers of terns and gulls.

Status and conservation

The population of Arctic Skua is probably stable. The population of Great Skua is currently not threatened. Human persecution over most of the breeding range reduced the population size to a critical level during the 19th century. However, after protection of the Great Skuas, numbers increased to the current level. Years of population declines on Iceland were correlated with reduced activity in the fishing industry. Compared to the estimated population in northern Europe of 40,000-54,000 birds, the estimated number of 11,000-13,000 non-breeding birds during late summer at the Norwegian Trench constitutes a substantial part of the total population.

Gulls *Larinae* - Måger

Breeding

Among the gulls occurring in Denmark, only Herring Gull *Larus argentatus*, Kittiwake *Rissa tridactyla* and Little Gull *Larus minutus* are mentioned in this section due to their abundance at the five projected off-shore wind farms. Herring Gull (55,000-58,000 pairs), and Kittiwake (c. 625 pairs) breed regularly in Denmark, whereas Denmark constitutes the western border of the breeding range for Little Gull, breeding occasionally. Herring Gull is distributed over vast areas on the northern hemisphere from the arctic to sub-tropic and is divided into several sub-species. In northern Europe the nominate race *Larus argentatus argentatus* (1.4 mill.) and the 'British Herring Gull' *L. a. argenteus* (1.3 mill.) occur. The Kittiwake has a circumpolar breeding distribution down to 40°N on coastal cliffs. Similar to Herring Gulls, Kittiwakes may in the absence of natural habitats nest on buildings. The eastern Atlantic population of Kittiwakes was estimated to be 8.4 mill. Little Gull has four discrete breeding populations: North America, East Siberia, West Siberia (between Ob and Ural), and the northwest Russian/Baltic breeding population (60,000-90,000) which

occurs in northwest Europe outside the breeding season (Rose & Scott 1997).

Moult, migration and wintering

Wing moult in all gulls is sequential. In all three species moult is typically commenced in May and lasts several months before the last moulted primary is regrown. Herring Gulls are migratory in north-eastern Europe, whereas in the rest of Europe Herring Gulls are stationary or dispersive. The main migratory periods are September-October and March-April. Evidence of leap-frog migration insofar that Herring Gulls from southern Scandinavia winter in the nearby Danish waters whereas Herring Gulls breeding further north winter in the Channel area. Kittiwakes disperse over the North Atlantic when not breeding and become more coastal again towards the breeding season. The eastern European population of Little Gulls migrates west and southwest August-September to winter in the western part of the North Sea, the Irish Sea southward to the Mediterranean. Small numbers also winter in the Black Sea. Little Gulls return to the breeding areas March-May

Occurrence in Danish waters

Herring Gulls occur in Danish waters throughout the annual cycle around almost all coasts. During autumn, the dispersive segment of the Danish breeding population is replaced by Herring Gulls from northern and northeastern Europe. The total population in Danish waters from autumn onwards was estimated at 205,000-381,000 (Laursen et al. 1997). During autumn and winter, Kittiwakes occur in the North Sea, Skagerrak and Kattegat (estimated at 315,000 individuals). In particular, Kattegat shows high annual variation. The influx of Kittiwakes to Danish waters during autumn is observed as migratory movements, most conspicuous at the northwest coast of Jutland; up to 33,000 ind./day. The return to the breeding areas is in particular recorded at Skagen; up to 30,000 ind./day. Little Gulls are mostly observed during the migratory periods in the Baltic and west of Blåvandshuk. At Gedser a maximum of 3,600 migrating Little Gulls have been observed during autumn. In mild winters up to 1,200 Little Gulls may winter in Danish waters (Olsen 1992).

Food

Herring Gulls feed on a variety of animal food items which are obtained by predation, scavenging, pseudo-diving and kleptoparasitism. Kittiwakes feed on marine fish and invertebrates. Little Gulls mainly feed on insects and other terrestrial invertebrates during the breeding season and on migration. In the wintering areas Little Gulls are mainly piscivorous but may also feed on marine invertebrates.

Behaviour

All species are highly gregarious.

Status and conservation

Little Gull is red-listed because of its irregular breeding in Denmark (Stoltze & Pihl 1998b). Kittiwake is red-listed as a result of the small breeding population in northern Jutland. Both the Kittiwake and Little Gull population, which occur in Denmark outside the breeding season, seems to be stable. Contradictory statements about the overall population trend in Herring Gull may derive from large local fluctuations. In Denmark the breeding population has probably been stable in recent years. Herring Gull is a legal quarry species. The annual bag of gulls has declined from more than 200,000 in the early 1970s when the breeding population peaked in Denmark (>100,000 pairs), to less than 50,000 bagged birds in the late 1990s of which the Herring Gull constitutes 30,000-40,000 individuals (Clausager 1999).

Terns *Sterninae* - Turner

Breeding

Common Tern *Sterna hirundo* (1,000-1,500 pairs), Arctic Tern (8,000-9,000 pairs), Sandwich Tern *Sterna sandvicensis* (4,500 pairs), Little Tern *Sterna albifrons* (400-600 pairs), and Gull-billed Tern *Gelochelidon nilotica* (c. 10 pairs) breed in colonies in the coastal zone in Denmark. Black Tern *Chlidonias niger* (100 pairs) breeds almost exclusively on freshwaters and will not be considered further here. Other tern species occur only accidental in Danish waters. Common Tern and Arctic Tern have a circumpolar breeding distribution in the temperate and arctic zone. Arctic Tern breeds at higher latitudes than Common Tern. Arctic Terns prefer to breed in the coastal zone whereas Common Tern also breeds on freshwaters. Sandwich Tern, Little Tern, and Gull-billed Tern are distributed around the world in the temperate zone often in isolated populations. Population estimates are: Common Tern (780,000 ind., Europe), Arctic Tern (unknown but more than 100,000 pairs breed in northwest Europe). Sandwich Tern (150,000 ind., western Europe), Little Tern (34,000 ind., eastern Atlantic) and Gull-billed Tern (12,000, western Europe; Rose & Scott 1997).

Moult, migration and wintering

Terns have sequential wing moult and are able to fly during the entire moult period. None of the tern species occurring in Denmark winter within the borders of Europe. Common Tern, autumn migration in northern Europe (AM): July - September; wintering area (W): western Africa; spring migration (SM): April - May. Arctic Tern AM: July-September; W: Antarctica, South Africa; SM: April-May, Sandwich Tern AM: July-November; W: western Africa; SM: March-May. Little Tern AM: July-August; W: western Mediterranean and Africa; SM: April-May. In northern Europe there are no conspicuous migra-

tory movements of Gull-billed Terns as a result of the small population size. However, the species is observed in northern Europe from April-August. Gull-billed Terns winter in western Africa (Cramp & Simmons 1985).

Occurrence in Danish waters

During the breeding season terns are dispersed along the coasts as they make foraging trips from the breeding colonies to areas with shallow water. Gull-billed Tern feeds in terrestrial habitats such as saltmarshes, freshwater meadows and moors. Large numbers of Common Terns, Arctic Terns and Sandwich Terns pass Danish waters during the migration period. During spring, the migration of Common Terns is most notable with up to 15,000 migrating individuals at Skagen. The autumn migration tends to proceed at a slower pace. Hence, large concentrations of roosting terns are observed, in particular at the west coast of Jutland, e.g. up to 8,000 Common Terns at Langli, up to 17,000 Arctic and Common Terns (Kjær 2000) and up to 10,000 Sandwich Terns at Blåvandshuk (Olsen 1992). From the roosts daily foraging trips are undertaken by the terns to nearby waters.

Food

All tern species feed on small fish, crustaceans and insects, which they dive for or catch after aerial pursuit. Generally, Sandwich Terns is the most piscivorous species. At the other end of the food spectrum, the diet of Gull-billed Tern may contain a large proportion of terrestrial invertebrates.

Status and conservation

The Danish breeding population of Gull-billed Tern has declined dramatically in this century and is now red-listed as in danger of extinction. Gull-billed Tern only breeds in the Wadden Sea with Langli as the northernmost breeding site. Little Tern is also red-listed as a rare species, however not threatened by extinction (Stoltze & Pihl 1998b). Sandwich Tern is generally increasing in numbers in northwest Europe. However, in Denmark colonies have been abandoned and the population size is most likely declining. The overall population trends are not well-known for Common Tern and Arctic Tern. Surveys in the 1990s indicated that Common Tern may be declining in Denmark whereas Arctic Tern is probably increasing in numbers. A large proportion of the breeding terns nests in protected areas. However, conflicts with recreational activities occur.

Alcids *Alcidae* - Alkefugle

Breeding

Among the alcids, Razorbill *Alca torda* (c. 600 pairs), Guillemot *Uria*

aalge (2,000-3,000 pairs) and Atlantic Black Guillemot *Cepphus grylle atlantis* (c. 1,100 pairs) breed in Danish waters whereas Little Auk *Alle alle* and Puffin *Fratercula artica* occur in small numbers in Danish waters outside the breeding season and will not gain further attention in this section. In the western Palearctic the alcids have their main breeding distribution on rocky cliffs on the island in the North Atlantic over to Novaja Zemlya. The populations in the northeast Atlantic was estimated at 1.1 mill. Razorbills, 5.6 mill. Guillemots and 275,000 Atlantic Black Guillemots (Laurson et al. 1997)

Moult, migration and wintering

Alcids moult their flight feathers simultaneously and are thus flightless during progression of feather renewal, which probably takes 40-50 days and occurs from August-November. Outside the breeding season Razorbill and Guillemots may disperse over a vast range in the North Atlantic to moult or to stay during the winter.

Occurrence in Danish waters

The breeding populations of Razorbill and Guillemot are confined to Ertholmene whereas Black Guillemot breeds exclusively in the Kattegat and Great Belt area. Outside the breeding season conspicuous movements of Razorbill and Guillemot from the north Atlantic to Danish waters occur. During the summer, a substantial moult migration of c. 200,000 Guillemots occurs in Skagerrak and the northern part of Kattegat (Laurson et al. 1997). During autumn, Razorbills occur in large numbers in Kattegat as Guillemots also disperse further south in Kattegat and down the west coast of Jutland. In the 1980s, the autumn populations in Kattegat were estimated at 49,000-165,000 Razorbills and 30,000-45,000 Guillemots compared to 7,000-31,000 Razorbills and c. 200,000 Guillemots in the North Sea. Winter estimates of up to 290,000 Razorbills in Kattegat and 120,000 in the North Sea have been obtained. For Guillemots the winter estimates amounted to 120,000 in the North Sea and 175,000 in Kattegat. At least in the late 1980s notable numbers of wintering Black Guillemots were counted around Læsø (720-2,150). During severe winter up to 12,000 Baltic Black Guillemots *C. g. grylle* were observed mainly on Rønne Banke. However, Baltic Black Guillemots were also found in Fehmarn Belt. On at least two occasions during autumn and winter more than 100,000 alcids have been observed at the east coast of Djursland in one day (Olsen 1992).

Food

The diet mainly comprises fish, e.g. sand-eel *Ammodytidae*, Herring *Clupea harengus* and Sprat *Sprattus sprattus* and in shallow water (mostly Black Guillemot) e.g. Butterfish *Pholis gunnellus*, gobies *Gobiidae* and Blennies *Zoarcetes viviparus*.

Behaviour

Alcids are gregarious throughout the annual cycle and breed in dense colonies which may comprise several thousand nests. The fact that alcids undergo simultaneous wing moult could suggest that they are extraordinarily sensitive to disturbance during this period.

Status and conservation

Compared to the overall north Atlantic populations the breeding populations in Denmark are small. In fact, Razorbill is on the Danish red-list for the same reason (Stoltze & Pihl 1998b). Little is known about trends in population sizes. However, the numbers of Razorbills occurring in Danish waters are of international importance as potentially up to 36% and up to 15% of the north Atlantic population occur in Kattegat and the North Sea, respectively (Laursen 1997). Therefore, Razorbill was yellow-listed (Stoltze & Pihl 1998a).

Woodpigeon *Columba palumbus* - Ringdue

Breeding

Woodpigeon breeds in all kinds of woodland all over Europe and western Russia. In Denmark the population of wood pigeons was estimated at 291,000 pairs (Jacobsen 1997). In Sweden no national estimate is available. However, up to 200,000 individuals per year were recorded on autumn migration at Falsterbo (Risberg 1990).

Moult, migration and wintering

Woodpigeon has sequential wing moult. Hence, no specific moult migration is undertaken. In northern Europe the spring migration peaks from March-April, whereas the autumn migration peaks during October-November. Appr. 50% of the Danish breeding population are residents, whereas the Scandinavian migrants winter in western and southwestern Europe (Olsen 1992, Grell 1998).

Occurrence in Danish waters

The Scandinavian migrants must cross Danish waters. Although some diffuse migration may occur from many coasts in Denmark, Woodpigeons would try to avoid open water. Thus, high numbers of Woodpigeons are observed at places where Woodpigeons are funnelled into narrow land strips, peninsulas etc. Migratory movements of Woodpigeons are most conspicuous in eastern Denmark (Olsen 1992).

Food

Woodpigeons feed on various berries, buds and seeds with beechnuts and acorns as important food sources during autumn.

Behaviour

The Woodpigeon shows gregarious migration behaviour with flocks counting several thousands individuals. Migration often occurs at several hundred metres altitude above the clouds.

Status and protection

The European population was expanding continuously during the 20th century, both in terms of numbers and spatial distribution.

Woodpigeons are thought to benefit from the increasing production of grain, from hunting restrictions and afforestation (Grell 1998). The annual bag in Denmark amounts to 300,000 individuals.

Passerines - Spurvefugle

Breeding

Most of the passerine species that pass Denmark on migration breed in Scandinavia, the Baltic States and western Russia. Population estimates for this diverse group of birds vary considerably between species, amounting to millions of individuals for many of the species e.g. 10-16 mill. Willow Warblers *Phylloscopus trochilus* and 3-6 mill. Robins *Erithacus rubecula* in Sweden (Asbirk et al. 1998).

Moult, migration and wintering

Passerines are capable of flight throughout the annual cycle. In northern Europe the migration periods are March-May and August-November. Passerines prefer to fly over land, but cross over open sea when necessary, thus resulting in huge concentrations of migrating birds from peninsulas. Passerines passing Denmark on autumn migration disperse to wintering areas in northwestern (e.g. starlings *Sturnidae*) and southern Europe (e.g. thrushes *Turdidae*) and to the African continent (e.g. many warblers *Sylviidae* and swallows *Hirundinidae* (Salomonsen 1972, Lyngs et al. 1990, Olsen 1992).

Occurrence in Danish waters

Denmark is an area of greatest importance for passerines migrating from Scandinavia to continental Europe. The passerine spring migration in Denmark takes place from mid March to early June. The autumn migration occurs from early August to early November (Lyngs

et al. 1990, Olsen 1992). Compared to spring, the autumn migration is relatively more voluminous, as a result of the high number of juveniles in the post-breeding season. From Falsterbo peninsula, Sweden, more than 1.5 mill. passerines head towards Danish waters and land territory.

Food

Passerines find their food on land, and hence, do not feed during active migration with swallows *Hirundinidae*, swifts *Apodidae* and bee-eaters *Meropidae* as the only exceptions.

Behaviour

The flocking behaviour during migration varies considerably among the different species. For example finches *Fringillidae* and starlings *Sturnidae* show strong gregarious behaviour, whereas species such as larks *Alaudidae*, swallows, pipits and wagtails *Motacillidae* migrate solitary or in small flocks of less than 50 individuals. Some of the passerine species are primarily nocturnal migrants, e.g. warblers *Sylviidae*, flycatchers *Muscicapidae*, chats and thrushes *Turdidae*, whereas others prefer to fly at daylight, e.g. starlings *Sturnidae*, buntings *Emberizidae*, finches *Fringillidae*, wagtails and swallows. The flight altitude of migrating passerines varies among species and is also dependent on weather conditions and the nature of the landscape (Alerstam 1977). The majority of passerine migration takes place at 1-1,000 m altitude, but well-flying species like the Swift *Apus apus* are often registered at up to 2,300 m (Gustafson et al. 1977). Head wind, cloud cover, and fog all tend to lower the flight altitude of migrating birds. Generally, nocturnal passerine migration occurs at higher altitudes over sea compared to land (Alerstam 1977).

Status and protection

None of the passerine species migrating through Denmark are globally threatened. For the group as a whole, they live a relatively short life, and hence, are not so vulnerable to an additive human or weather induced adult mortality as e.g. the larger and more long-living waterfowl species. Several species are yellow- or red -listed in Denmark (see Stoltze & Pihl 1998a & 1998b). Corvids *Corvidae*, Starling *Sturnus vulgaris* and House Sparrows *Passer domesticus* are hunted in most of Europe (Bertelsen & Simonsen 1986).

Referencer

- Alerstam, T. 1977. Fågelsträckets höjd. - Anser 16: 189-202.
- Asbirk, S., Berg, L., Hardeng, G., Koskimies, P. & Petersen, A. 1998. Population sizes and recent trends in the Nordic countries 1978-1994. - Report from a working group under the Nordic Council of Ministers.
- Bauer, K.M. & Glutz, U.N. 1969. Handbuch der Vögel Mitteleuropas, band 3, teil 2. - Akademische Verlagsgesellschaft, Frankfurt am Main, 503 pp.
- Bertelsen, J. & Simonsen, N.H. 1986. Documentation on bird hunting and the conservation status of the species involved situation in 1986. - Game and Wildlife Administration, Denmark, 323 pp.
- Clausager, I. 1999. Vingeindsamling fra jagtsæsonen 1998/99 i Danmark. - Faglig rapport fra DMU nr. 282, 48 pp.
- Cooper, B.A. & Ritchie, R.J. 1995. The altitude of bird migration in east-central Alaska: a radar and visual study. - Journal of Field Ornithology 66(4): 590-608.
- Cramp, S. & Simmons, K.E.L. 1977. The Birds of the Western Palearctic. Volume 1. - Oxford University Press, 722 pp.
- Cramp, S. & Simmons, K.E.L. 1983. The Birds of the Western Palearctic. Volume 3. - Oxford University Press, 913 pp.
- Cramp, S. & Simmons, K.E.L. 1985. The Birds of the Western Palearctic. Volume 4. - Oxford University Press, 960 pp.
- Dement'ev, G.P., Gladkov, N.A., Isakov, Y.A., Kartashev, N.N., Kirikov, S.V., Mikheev, A.V. & Ptushenko, E.S. 1967. Birds of the Soviet Union Volume IV. Israel Program for Scientific Publications, Jerusalem, 683 pp.
- Durink, J., Skov, H., Jensen, F.P. & Pihl, S. 1994. Important marine areas for wintering birds in the Baltic Sea. - EU DG XI research contract no. 2242/90-09-01 Ornith Consult report, 110 pp.
- Gensbøl, B. 1987. Rovfuglene i Europa, Nordafrika og Mellemøsten. - Gads forlag, København, 384 pp.
- Grell, M.B. 1998. Fuglenes Danmark. - Gads Forlag, København, 825 pp.
- Gustafson, T.B., Lindkvist, L., Gotborn, R. & Gyllin, R. 1977. Altitude and flight times for Swifts *Apus apus*. - Ornis Scandinavica 8: 87-95.
- Hagemeijer, W.J.M. & Blair, M.J. 1997. The EBCC Atlas of European Breeding Birds; their abundance and distribution. - Poyser, London, 903 pp.
- Jacobsen, E.M. 1997. Hvor mange fugle yngler i Danmark? - Dansk Orn. Foren. Tidssk. 91: 93-100.
- Jakobsen, B. in prep.. Fuglene ved Blåvand 1963-1992. - Report from Danish Ornithological Society.
- Kjær, P.A., 2000. Blåvand Fuglestation 1993-1999, en oversigt over observationer. Dansk Ornitologisk Forening.
- Laursen, K., Pihl, S., Durink, J., Hansen, M., Skov, H., Frikke, J. & Danielsen, F. 1997. Numbers and distribution of waterbirds in Denmark, 1987-1989. - Danish Review of Game Biology 15 (1): 1-181.
- Lloyd, C., Tasker, M.L. & Partridge, K. 1991. The status of seabirds in Britain and Ireland. - Poyser, London, 355 pp.
- Lyngs, P., Faldborg, J., & Rasmussen, T. 1990. Trækfuglene på Christiansø 1976-1983. - Dansk Orn. Foren. Tidsskr. 84: 98-99.

- Lyngs, P. 2000. Status of the Danish breeding population of Eiders *Somateria mollissima* 1988-93. - Dansk Orn. Foren. Tidsskr. 94: 12-18
- Madsen, F.J. 1954. On the food habits of the diving ducks in Denmark. - Dan. Rev. Game Biol. 2: 157-266.
- Madsen, F.J. 1957. On the habits of some fish-eating birds in Denmark. Dan. Rev. Game Biol. 3: 19-83 pp.
- Madsen, J., Asferg, T., Clausager, I. & Noer, H. 1996. Status og jagttider for dansk vildtarter. - TEMA-rapport 1996/6, Danmarks Miljøundersøgelser, Miljø- og Energiministeriet, København, 112 pp.
- Meltofte, H. 1993. Vadefugletrækket gennem Danmark. - Dansk Orn. Foren. Tidsskr. 87: 1-180.
- Noer, H. 1991. Distributions and movements of Eider *Somateria mollissima* populations wintering in Danish waters, analysed from ring recoveries. Dan. Rev. Game Biol. 14: 1-32.
- Olsen, K.M. 1992. Danmarks fugle - en oversigt. - Dansk Ornithologisk Forening, 216 pp.
- Piersma, T., Beintema, A.J., Davidson, N.C., Münster, O.A.G. & Pienkowski, M.W. 1987. Wader migration systems in the East Atlantic. - Wader Study Group Bulletin. 49, Suppl./IWRB Special Publ. 7: 35-56.
- Pihl, S. 1994. Midwinter counts in the Baltic part of Denmark in 1992 and 1993. - IWRB Seaduck Research Group Bulletin 4: 39-41.
- Pihl, S., 1995. Post-breeding occurrence of the Red-necked Grebe *Podiceps grisegena* in two marine areas in Denmark. Dansk Orn. Foren. Tidsskr. 89: 83-86.
- Prater, A.J., Marchant, J.H. & Vuorinen, J. 1987. Guide to the identification and ageing of Holarctic Waders. - BTO Guide number 17, 168 pp.
- Risberg, L. (ed.) 1990. Sveriges fåglar. - Sveriges Ornitologiska Förening, 295 pp.
- Rose, P.M. & Scott, D.A. 1994. Waterfowl population estimates. - IWRB publication 29, Slimbridge, UK, 102 pp.
- Rose, P.M. & Scott, D.A. 1997. Waterfowl Population Estimates, Second Edition. - Wetlands International Publication 44. Wageningen, The Netherlands, 106 pp.
- Salomonsen, F., 1972. Fugletrækket og dets gåder. Munksgaard, København. 362 pp.
- Smit, C.J. & Piersma, T. 1989. Numbers, midwinter distribution, and migration of wader populations using the East Atlantic Flyway. In: Boyd, H. & Pirot, J.Y. (Eds.): Flyways and reserve networks for water birds. - IWRB Special Publ. 9.
- Stoltze, M. & Pihl, S. (Eds.) 1998a. Gulliste over planter og dyr i Danmark. - Miljø- og Energiministeriet, Danmarks Miljøundersøgelser og Skov- og Naturstyrelsen, 48 pp.
- Stoltze, M. & Pihl, S. (Eds.) 1998b. Rødliste 1997 over planter og dyr i Danmark. - Miljø- og Energiministeriet, Danmarks Miljøundersøgelser og Skov- og Naturstyrelsen, 219 pp.
- Tasker, M.L., Jones P.H., Blake, B.F. & Dixon, T.J. 1985. Distribution and feeding habits of the Great Skua *Catharacta skua* in the North Sea. - Seabird 8: 34-44.
- Tasker, M.L., Webb, A., Hall, A.J., Pienkowski, M.W. & Langslow, D.R. 1987. Seabirds in the North Sea. - Report from NCC, 336 pp.
- Zwarts, L. 1990. Increased prey availability drives premigration hyperphagia in whimbrels and allows them to leave the Banc D'Arguin, Mauritania, in time. - Ardea 78: 279-300.

National Environmental Research Institute

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