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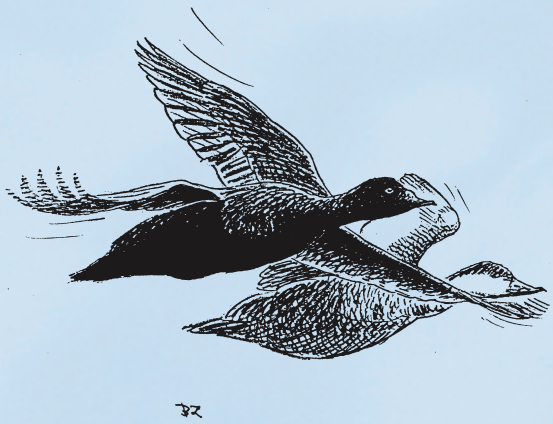
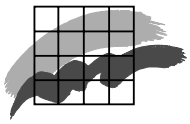
Status report of seabird surveys at Horns Rev, 2000-2001

NERI Report





National Environmental Research Institute
Ministry of Environment and Energy

Status report of seabird surveys at Horns Rev, 2000-2001

NERI Report
2002

Commissioned by Tech-wise A/S

Thomas Kjær Christensen
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Data Sheet

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Contents

Summary

The present report presents the results of three bird surveys conducted in the Horns Rev area during the second half of 2001. Due to poor weather conditions in December 2001, the last survey was, however, performed on 7 January 2002. The surveys are part of the base-line investigations of birds performed in relation to the proposed construction of an offshore wind farm at Horns Rev in the Danish part of the North Sea ca 14 km southwest of Blåvandshuk. The results of the surveys during August 2001 - January 2002 are presented together with the results obtained during the period August 2000 - April 2001, and are also compared to results obtained during the period August 1999 - April 2000 which have been reported by Noer et al. 2000 and Christensen et al. 2001.

Based on the distribution of the most abundant bird species recorded during 16 aerial surveys performed during August 1999 - January 2002, there were no indications that the wind farm area was of any particular importance to the birds' exploitation of the Horns Rev area. Fish-eating species like divers, gannet, terns, auks and gulls generally showed scattered and variable distributions, mainly occurring in the areas north and south of Horns Rev, and with low numbers on the reef proper and within the planned wind farm area. The distribution of benthic foraging species, eider and common Scoter, showed that they mainly exploited the coastal parts of the area off Blåvandshuk and Skallingen, although common scoter was found in relatively high numbers on the southeast slopes of the Horns Rev and within the wind farm area in the April 2001 survey. Common scoters occurred in very high numbers in January 2002. This was probably related to increased immigration of birds from the inner Danish waters during a cold period in late December 2001.

Preference analyses of bird exploitation of the Horns Rev area showed that if the birds completely avoid the wind farm area after erection of the wind turbines, this will affect less than 1% of the various species, except divers where 1.58% will be affected. If the birds avoid the wind farm area and an adjacent 4 km zone (worst case scenario), it is estimated to affect 8-11% of the common scoter, 10% of the gannet, 7-9% of the divers, alcids and velvet scoter and 0-6% of the remaining species.

The seasonal occurrence of the recorded species was fully comparable to the seasonal occurrence of these species recorded at Blåvandshuk since 1963. Year-to-year variation in abundance between the seasons August 1999 - April 2000 and August 2000 - April 2001 was mainly found in species that migrated through the Horns Rev area (terns, gannet, kittiwake), and with a less pronounced variation in staging and wintering species (divers, herring gull, common scoter).

1 Introduction

In granting permission to establish a wind farm of 80 turbines at Horns Rev in 2002, a number of conditions were laid down. These included programmes for establishing the environmental impacts of the construction of a wind farm and the following initial phase of operation. Particular emphasis was placed on the effects on bird species (migrating, staging and wintering) using the area, and, through specific studies, impact assessment analyses were to be provided for these species.

The contractor of the planned wind farm, Elsamprojekt A/S (now Tech-wise A/S) prepared an EIA-report supplemented by technical background reports including the NERI bird report (Noer et al. 2000).

NERI bird reports describing bird numbers and distributions in the Horns Rev area based on counts carried out during April 1999 - April 2001 have previously been published (Noer et al. 2000, Christensen et al. 2001). During autumn and winter 2001/2002 three additional surveys have been undertaken, and data collected during these surveys are presented in this report.

The objectives of the counts were to obtain data that enable comparisons between the expected impact zone around the wind farm and an area with no expected impact, and to assess the importance of the area to birds. The main purposes of the counts were to:

1. Map the numbers and distributions of birds in the area in selected periods of the year.

2. Assess the relative densities and numbers of different species present.

This report presents the results of the counts from three surveys performed in August and September 2001, and in January 2002. The January 2002 count was performed and included in this report, since poor weather prevented a planned count in December 2001. The present results are presented together with the results obtained during August 2000 - April 2001 that have been report by Christensen et al. (2001). Data from the period August 1999 - April 2000 are included in the result section. For a more detailed description of the scope for the bird studies and the methods used, see Noer et al. (2000).

2 Methods

2.1 Aerial surveys

Mapping of bird distributions followed the method applied during the 1999-2000 surveys. Data on bird numbers and distribution were obtained from a total of nine aerial surveys during August 2000 to January 2002 (Table 1). A total of 16 surveys have been performed since August 1999. The study area, approximately 1,700 km^2 (38 x 52 km, excluding the land area at Blåvandshuk), comprises the wind farm area (27.5 km^2) and the surrounding area. The study area was covered by a total of 26 north-south oriented, parallel transects, located with 2 km intervals from Skallingen in the east, westwards to a line 37 km off Blåvandshuk (Fig. 1). Military activity prevented full coverage of the northeastern part of the study area on some surveys. Varying transect length is a result of temporary discontinuations of observations during periods of severe glare.

2.2 Within-year and between-year variation in bird numbers

To illustrate the degree of variation in the distribution of the different bird species, the seasonal (within-year) and year-to-year (between-year) variation recorded within the total study period so far (August 1999-January 2002) are discussed. A preliminary analysis is constrained by variation in the aerial coverage, with only the months August, September, February, March and April covered more than once, while November, October and December were covered only once. It should be noted that the numbers in February 2000 represent the average of two counts (17 and 21 February).

Table 1. Transect widths used on aerial surveys in the period August 2000 - January 2002, and the total distance of transects surveyed (including counts from both sides of the aircraft). A band of 49 m on each side below the aircraft cannot be observed.

Date	Transect A	Transect B	Transect C	Transect length (km) covered (both sides)
21 August 2000	49-174 m	175-459 m	>459 m	1449
6 October 2000	49-174 m	175-459 m	>459 m	1467
22 December 2000	49-174 m	175-459 m	>459 m	1642
9 February 2001	49-174 m	175-459 m	>459 m	1154
20 March 2001	49-174 m	175-459 m	>459 m	1642
21 April 2001	49-174 m	175-459 m	>459 m	1441
22 August 2001	49-174 m	175-459 m	>459 m	1637
26 September 2001	49-174 m	175-459 m	>459 m	1523
7 January 2002	49-174 m	175-459 m	>459 m	1369

2.3 Distribution of birds using the Horns Rev area

The distribution of birds is presented as numbers of individuals recorded per transect kilometre covered within 2 x 2 km grid squares. These distributions include data obtained during the total study period August 1999 to January 2002 and thus represent the overall distribution of all data collected on the different bird species. Distributions recorded on individual counts are only presented for selected bird species on surveys large in number and/or conspicuous in distribution.

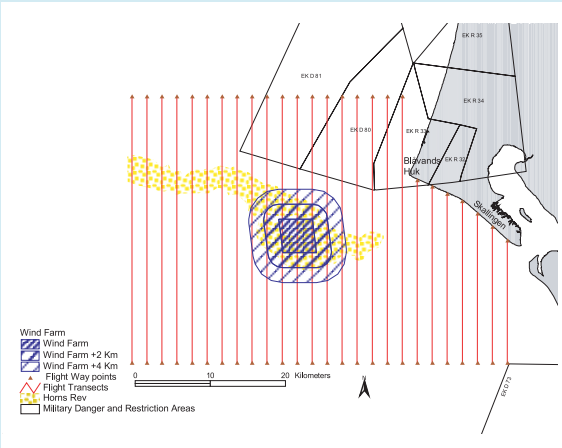

Figure 1. Study area including transects (thin lines north-south) for aerial bird surveys. The shallow of the reef proper and military restriction areas (e.g. EK R 33) are shown. The wind farm area and adjacent +2 km and +4 km zones are shown.

2.4 Assessment of potential disturbance effects

To quantify and assess the importance of the wind farm area to birds, 'Jacobs' selectivity index (D; Jacobs 1974) was calculated to describe the birds preference for the wind farm area compared to the surrounding area. The index (D), ranging from -1 (no birds in the wind farm area) to +1 (all birds in the wind farm area), can be tested by means of a one-sample χ^2-test. The underlying assumption is that birds show a 'geographically free' distribution, which means that the birds are equally distributed throughout the survey area (D = 0). Indices were also calculated for the wind farm area plus an adjacent 2 and 4 km zone, respectively (see Fig. 1).

3 Results

3.1 Bird species recorded during August 2000 - January 2002

Species and numbers recorded during the nine aerial surveys carried out between August 2000 and January 2002 are shown in Table 2. Bird species that are very difficult to separate during aerial surveys are grouped, while a few observations of migrating non-marine bird species (e.g. shorebirds) are omitted.

3.2 Bird numbers and distributions

3.2.1 Fish-eating species

Red- and black-throated diver (Gavia stellata/ arctica)

A total of 563 divers was recorded during August 2000 - January 2002. The highest numbers occurred during February and March 2001 (Table 2). There was no clear aggregation around Blåvandshuk during February and March 2001, as observed in 2000. In February 2001, the divers showed a very scattered distribution over the entire study area. In March 2001 the birds were located north and south of the Horns Rev, with relatively few birds in the central parts of the study area, a distribution also found in January 2002.

For the total period (August 1999 - January 2002), the seasonal and year-to-year occurrences were very consistent (Fig. 2). Divers were recorded in the smallest numbers during autumn and in the highest numbers during late winter and spring. The numbers peaked in February and decreased during March and April.

The distribution of all 1,331 divers recorded during August 1999 - January 2002 is shown in Fig. 3. In general, divers occurred scattered over the entire area, although there was a tendency to occur in highest numbers northwest of Horns Rev and north and south of Blåvandshuk.

Red-necked grebe (Podiceps griseigena)

One Red-necked Grebe was recorded (August 2000). Combined with previous observations (from the ship survey) of three birds (Noer et al. 2000), there are still no indications in the present material that the waters around Horns Rev are of ecological importance for the species.

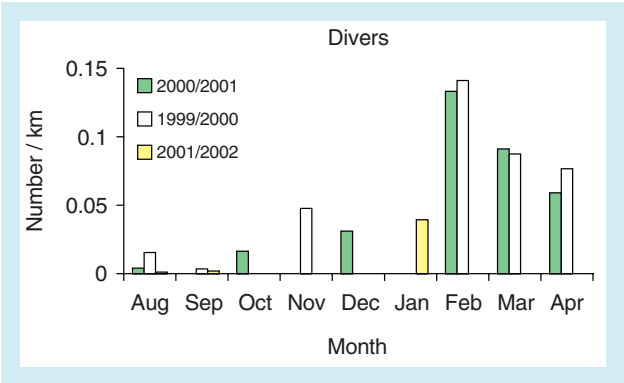

Figure 2. Numbers of divers per transect kilometre recorded in 16 aerial counts during August 1999 - January 2002.

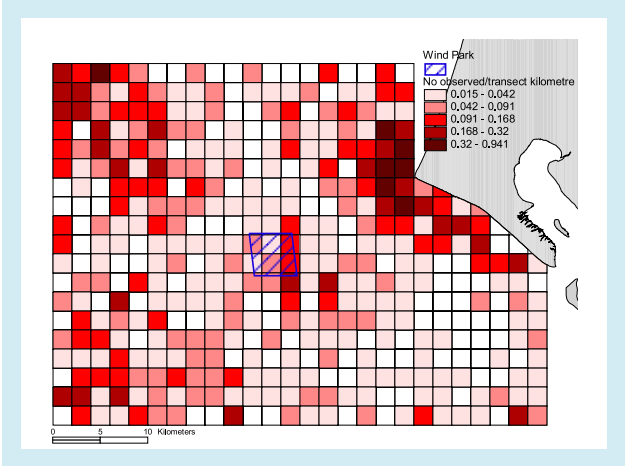

Figure 3. Geographical distribution of 1,331 divers recorded in 16 aerial counts during August 1999 - January 2002.

Table 2. Number of birds observed in the Horns Rev area during nine aerial surveys August 2000 - January 2002.

Bird species	21 Aug. 2000	6 Oct. 2000	22 Dec. 2000	9 Feb. 2001	20 Mar. 2001	21 Apr. 2001	22 Aug. 2001	26 Sep. 2001	7 Jan. 2002	Total
Fish-eating species										
Red-throated Diver *Gavia stellata*				9						9
Red-/Black-throated Diver *Gavia stellata/arctica*	6	23	38	192	149	87	2	3	54	554
Red-necked Grebe *Podiceps griseigena*	1									1
Fulmar *Fulmarus glacialis*	1	38			1			1	3	44
Gannet *Sula bassanus*	33	42			1	60	63	10		209
Cormorant *Phalacrocorax carbo*	80			1	20	2	25	32		160
Common/Arctic Tern *Sterna paradisea/hirundo*	175					40	843	4		1,062
Sandwich Tern *Sterna sandvicensis*	67					231	11	37		346
Guillemot *Uria aalge*	12	18			2	1	1			34
Razorbill *Alca torda*			1			1			5	7
Guillemot/Razorbill *Uria aalge/Alca torda*	48	162	35	32	14	8	16	36	104	455
Little Auk *Alle alle*		3								3
Red-breasted Merganser *Mergus serrator*					2	2				4
Arctic/Pomarine/Long-tailed Skua *Stercorarius* sp.	5						15	1		21
Little Gull *Larus minutus*			5	5	26	1		1	76	114
Black-headed Gull *Larus ridibundus*	164	1		3		253	69	13		503
Common Gull *Larus canus*	7	6	7	5	34	11	6	10	3	89
Lesser Black-backed Gull *Larus fuscus*	39	3				1	29	6		78
Herring Gull *Larus argentatus*	775	193	230	672	1,169	1,866	820	856	899	7,480
Great Black-backed Gull *Larus marinus*	55	24	2	5	3	56	96	59	27	327
Kittiwake *Rissa tridactyla*	579	35	17	30	14	108	183	251	142	1,359
Gull sp. *Larus* sp.	16	30	3			670		5		724
Benthic foraging species										
Eider *Somateria mollissima*	37	42	2,062	5,438	763	99	2	3	823	9,269
Common Scoter *Melanitta nigra*	283	2,208	8,436	11,041	13,295	16,902	319	4,661	30,483	87,628
Velvet Scoter *Melanitta fusca*		1	19	58	148	343	2	2	4	577

Gannet (Sula bassanus)

A total of 209 gannets was recorded during August 2000 - January 2002. Highest numbers were observed in August, September, October and in late April (Table 2). Gannets were generally recorded solitary or in loose groups. In August 2000, the gannets occurred scattered throughout the study area, while in April 2001, birds were only recorded west of the proposed wind farm area, with most birds located on the reef proper.

The seasonal occurrence of gannets (Fig. 4) reflects the peak migration periods (August-September, April-May; Jacobsen in prep.). Highest numbers were observed during autumn migration 3 September 1999, while a very low number was recorded 26 September 2001. Analyses of the between-year variation were, however, constrained by the lack of a count in September 2000.

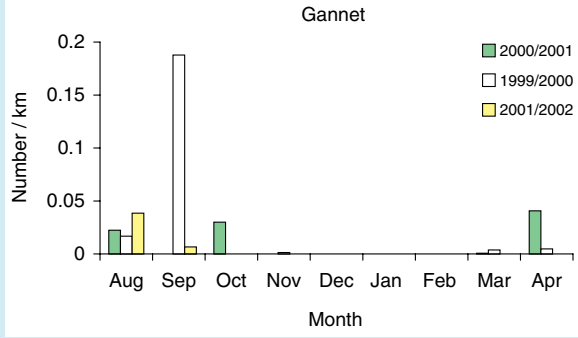

Figure 4. Numbers of Gannets per transect kilometre recorded in 16 aerial counts during August 1999-January 2002.

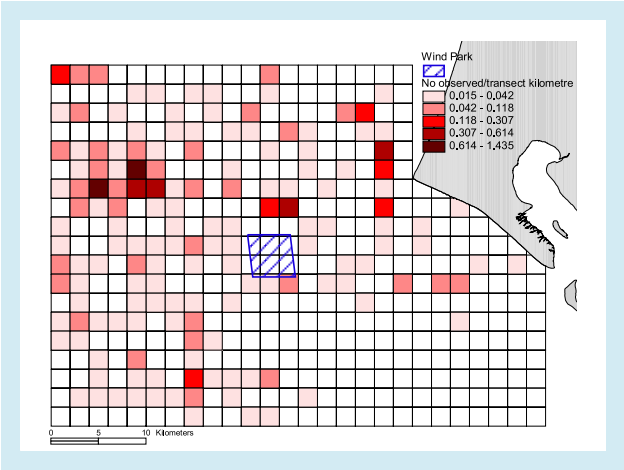

Figure 5. Geographical distribution of 515 gannets recorded in 16 aerial counts during August 1999 - January 2002.

The distribution of all 515 gannets recorded during August 1999 - January 2002 is shown in Fig. 5. There was a tendency that highest numbers were found off Blåvandshuk and in the western parts of Horns Rev. The phenological pattern matched the earlier findings (Noer et al. 2000).

Arctic/common tern (Sterna paradisaea/hirundo)

A total of 1,062 Arctic/common terns was recorded during August 2000-January 2002. The species were only observed in August, September and April (Table 2). In all counts, the birds were recorded rather scattered throughout the area, although the majority of the birds in August 2000 were observed in the area off Blåvandshuk, while in August 2001 they occurred over the entire study area.

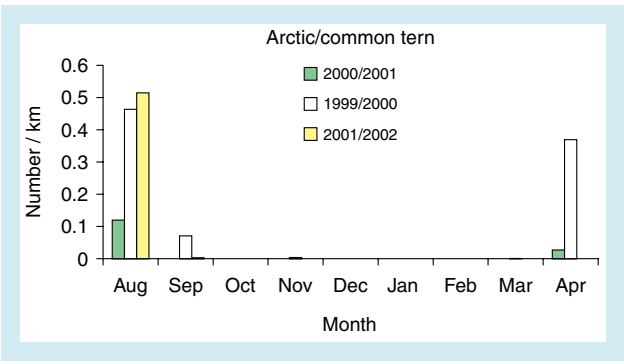

Figure 6. Numbers of Arctic/common tern per transect kilometre recorded in 16 aerial counts during August 1999 - January 2002.

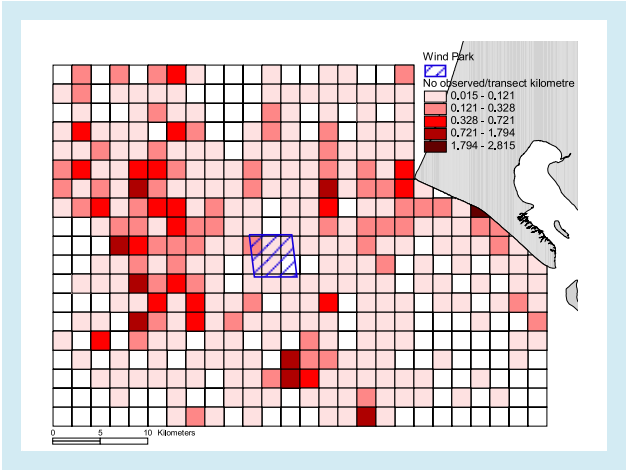

Figure 7. Geographical distribution of 2,407 Arctic/common tern recorded in 16 aerial counts during August 1999 - January 2002.

The seasonal occurrence of Arctic/common terns reflects the peak migration periods in autumn (August-September) and spring (April; Fig. 6). Large between-year variation is evident, with lowest numbers recorded in 2000/2001 and highest numbers in 1999/2000 and 2001/2002.

The distribution of all 2,407 Arctic/common terns recorded during August 1999 - January 2002 showed a scattered occurrence over the entire study area with a tendency of highest numbers in the coastal zone off Blåvandshuk and Skallingen and in the area west of the proposed wind farm (Fig. 7).

Sandwich tern (Sterna sandvicensis)

A total of 346 sandwich terns was recorded during August 2000 - January 2002. The species was

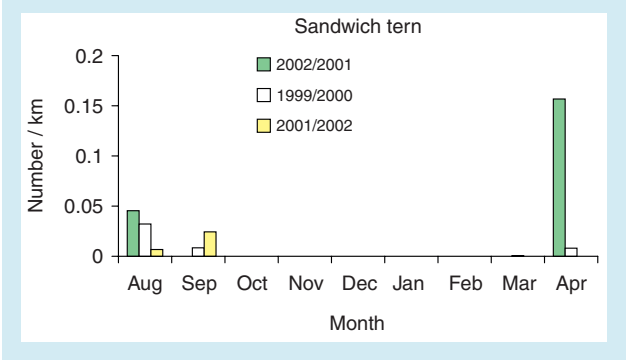

Figure 8. Numbers of sandwich tern per transect kilometre recorded in 16 aerial counts during August 1999 - January 2002.

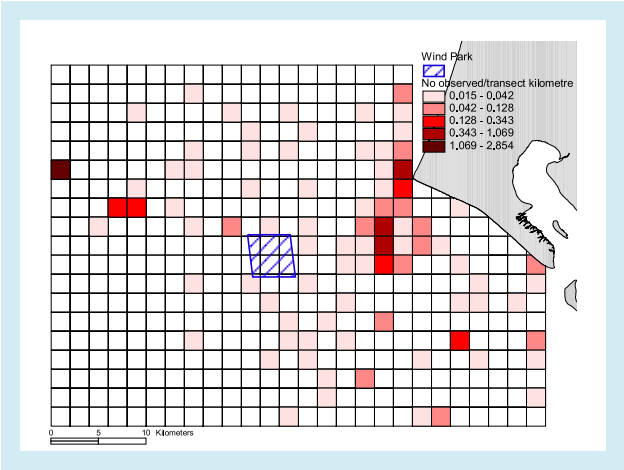

Figure 9. Geographical distribution of 419 sandwich tern recorded in 16 aerial counts during August 1999 - January 2002.

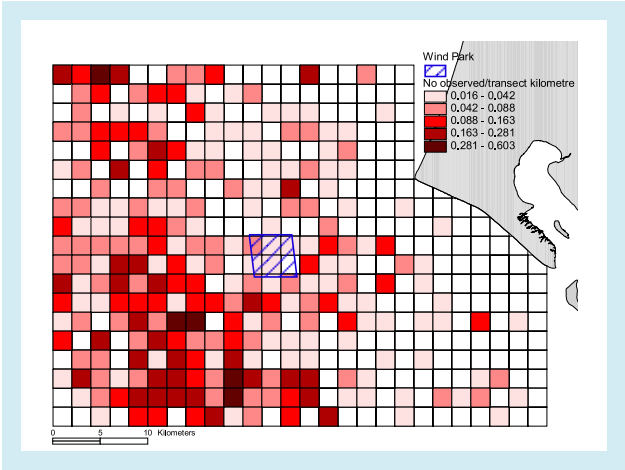

Figure 11. Geographical distribution of 1,104 alcids recorded in 16 aerial counts during August 1999 - January 2002.

only observed in August, September and April (Table 2). The highest number was observed in April 2001.

The seasonal occurrence of sandwich tern reflects the peak autumn (July-November) and spring (March-May) migration periods (Fig. 8). The April counts (27 April 2000 and 21 April 2001) documented large year-to-year variation.

The overall distribution of 419 sandwich terns recorded during August 1999 - January 2002 showed a very scattered pattern (Fig 9). There was, however, a tendency that birds occurred in higher numbers off Blåvandshuk, and on Horns Rev west of the proposed wind farm area, a distribution comparable to the distribution of Arctic/common tern.

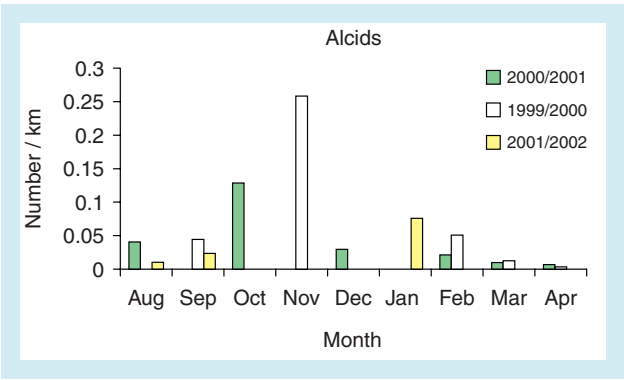

Figure 10. Numbers of alcids per transect kilometre recorded in 16 aerial counts during August 1999 - January 2002.

Guillemot/razorbill (Uria aalge/Alca torda)

A total of 496 alcids was recorded during August 2000 - January 2002. Highest numbers were recorded in October 2000 and January 2002. In the western half of the study area the birds were mostly recorded solitary or in small groups.

The seasonal occurrence of alcids showed the largest numbers during autumn (October-November) and the smallest numbers during spring (Fig. 10). Although constrained by the different timing of the autumn counts during the study period, the year-to-year pattern of the occurrence compliments each other.

The distribution of all 1,104 alcids recorded during August 1999 - January 2002 shows that alcids mainly exploited the offshore parts of the study area (Fig. 11). Most birds were found west, south and north of Horns Rev, and with few individuals observed over the reef proper.

Little gull (Larus minutus)

A total of 114 little gulls was recorded during August 2000 - January 2002. Highest numbers were observed in March 2001 (N = 26) and in January 2002 (N = 76). The distribution of all little gulls showed that most birds occurred north and south/southeast of the Horns Rev.

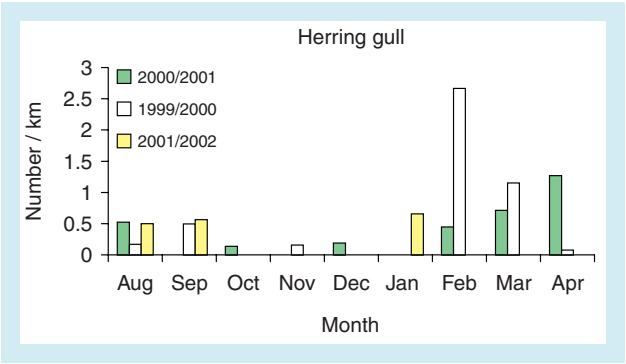

Figure 12. Numbers of herring gulls per transect kilometre recorded in 16 aerial counts during August 1999 - January 2002.

Herring gull (Larus argentatus)

A total of 7,480 herring gulls was recorded during August 2000-January 2002. Highest numbers were observed in March and April, and lowest number during autumn and winter (Table 2). Most birds were recorded in the southeastern parts of the study area, south of Blåvandshuk/ Skallingen and off the Wadden Sea. The gulls were often observed gathering around fishing vessels and in the coastal zone during low tide.

The seasonal occurrence of herring gulls showed that highest numbers occurred during late winter and spring and lowest numbers during autumn and early winter (Fig. 12). Great year-to-year variation in spring was evident in February and April.

The distribution of all 17,357 herring gulls recorded during August 1999 - January 2002 showed that most birds were observed in the eastern and southeastern parts of the study area, and generally in high numbers along the shoreline of Skallingen (Fig. 13).

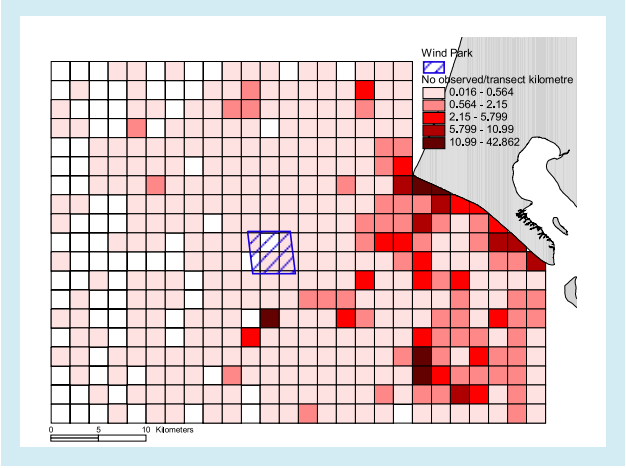

Figure 13. Geographical distribution of 17,357 herring gulls recorded in 16 aerial counts during August 1999 - January 2002.

Great black-backed gull (Larus marinus)

A total of 327 Great Black-backed Gulls was recorded during August 2000 - January 2002 (Table 2). Highest numbers were observed in August, September and April, where most birds were observed in the area off Blåvandshuk and in the southeastern parts of the study area. As also recorded during the previous study period (Noer et al. 2000), the distributions of the species showed seasonal variation. However, in late autumn counts (October 2000 and November 1999) the distribution tended to be less associated with the coastal parts of the area.

Kittiwake (Rissa tridactyla)

A total of 1,359 Kittiwakes was recorded during August 2000 - January 2002. Peak numbers were observed in August 2000 and September 2001 (Table 2), while in 1999 peak numbers occurred in November. The distributions varied markedly between the counts. In August 2000 and 2001 the species was scattered over most of the study area with highest numbers in the northern parts. In February and April 2001, birds were found more concentrated on the northern slope of the reef and with few birds in the outermost western area.

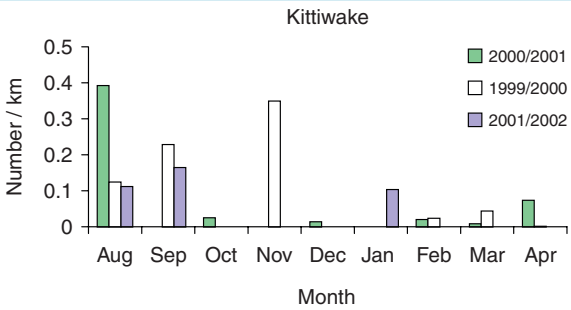

Figure 14. Numbers of kittiwakes per transect kilometre recorded in 16 aerial counts during August 1999 - January 2002.

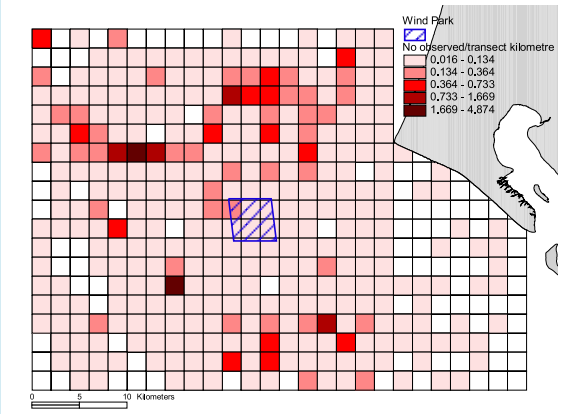

Figure 15. Geographical distribution of 2,518 kittiwakes recorded in 16 aerial counts during August 1999 - January 2002.

The occurrence of kittiwakes showed substantial seasonal and year-to-year variation (Fig. 14). Despite large between-year variation, the main period of occurrence in the Horns Rev area was August-November, while only small numbers were recorded during late winter and spring.

The distribution of all 2,518 kittiwakes recorded during August 1999 - January 2002 showed that the species occurred over the entire study area, but with a tendency for highest numbers to occur in the area north of Horns Rev and with lowest numbers in the southeastern parts (Fig. 15). Variable distributions were also the observed in the 1999/2000 study period (Noer et al. 2000).

Skuas (Stercorarius sp.)

A total of 21 skuas was recorded during August 2000 - January 2002. Of these, 20 were recorded in August and 1 recorded in September. The birds were not identified to species level, but were most likely Arctic skuas.

3.2.2 Species foraging on sessile benthic fauna

Eider (Somateria mollissima)

A total of 9,269 eiders was recorded during August 2000 - January 2002. The highest numbers were counted during winter and spring with a

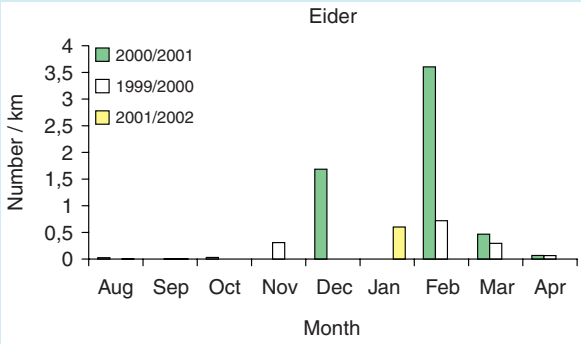

Figure 16. Numbers of eiders per transect kilometre recorded in 16 aerial counts during August 1999 - January 2002.

maximum in February 2001. Eiders were generally recorded in large flocks; solitary birds were only observed on a few occasions.

The seasonal occurrence of eiders showed a clear winter aggregation with highest numbers in December and February (Fig. 16). Great year-to-year variation in numbers was evident in February as opposed to March and April, when numbers converged to similar values.

The distribution of all 12,355 eiders recorded during August 1999 - January 2002 was very consistent. The species occurred in the coastal parts of the area off Blåvandshuk and Skallingen (Fig. 17). Only very few birds were observed offshore on depths of more than 6 m. The phenology and distributions obtained during August 2000 - January 2002 were comparable to the results ob-

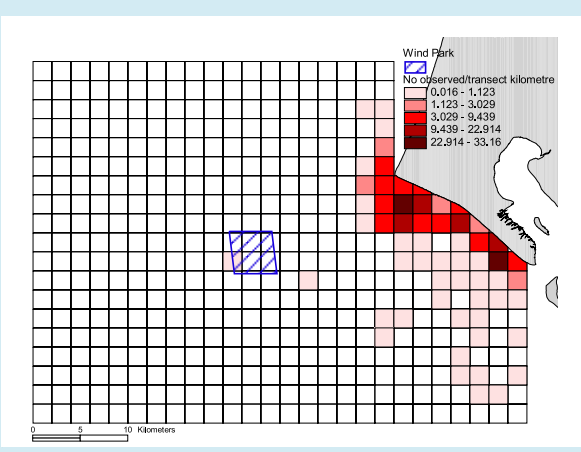

Figure 17. Geographical distribution of 12,355 eiders recorded in 16 aerial counts during August 1999 - January 2002.

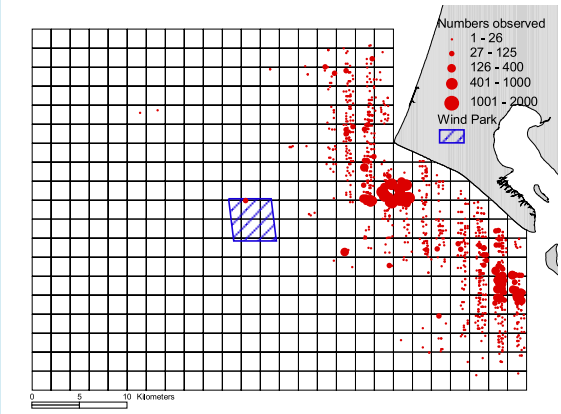

Figure 18a. Geographical distribution of 30,483 common scoters, observed from aircraft 7 January 2002.

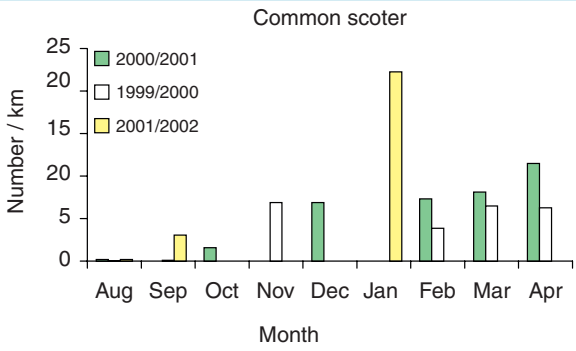

Figure 19. Numbers of common scoter per transect kilometre recorded in 16 aerial counts during August 1999 - January 2002.

tained during the 1999/2000 surveys (Noer et al. 2000).

Common scoter (Melanitta nigra)

A total of 87,628 common scoters was recorded during August 2000 - January 2002 and was thus the most numerously occurring species. Highest numbers were generally recorded in February, March and April. However, following a very cold period during late December 2001, a very high number was recorded in January 2002 (Table 2, Fig. 18a). High numbers of sea ducks are generally found in the Wadden Sea and at Blåvandshuk during cold winters, reflecting a movement from inner Danish waters to the North Sea (Laursen et al. 1997, Jacobsen in prep.). The distributions recorded from December to March were consistent with the distributions recorded in January 2002. In April 2001, however, the distribution was different from previous distributions with most birds found offshore at the southeast end of Horns Rev, further to the west than in the other surveys (Fig. 18b). In the April 2001 count, a total of 10,424 individuals was recorded within the proposed wind farm area including the adjacent 4-km zone, and 517 individuals within the proposed wind farm area itself.

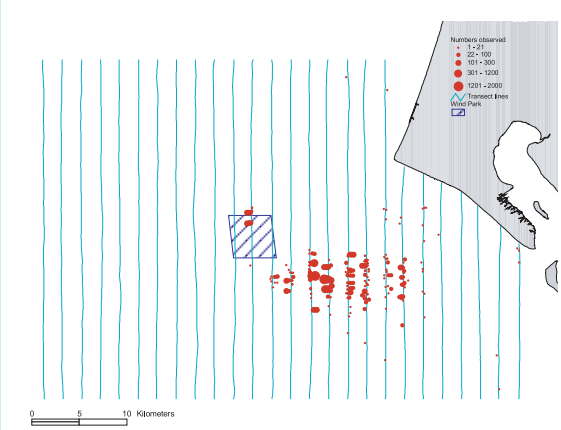

Figure 18b. Geographical distribution of 16,902 common scoters, observed from aircraft 21 April 2001.

Except for the high numbers in January 2002, the seasonal occurrence of common scoter was similar in all years, showing high numbers in the study area during winter and spring (November-April; Fig. 19). During the period February-April, numbers differed between years, being consistently lower during 1999/2000 than in 2000/2001.

The distribution of all 128,614 common scoters recorded during August 1999 - January 2002 showed a consistent pattern (Fig. 20). The species mainly occurred in the area southwest and south of Blåvandshuk and in the area west of Fanø. A slight tendency for an offshore aggregation at the southeast end of Horns Rev was, despite the April 2001 count, observed during several counts, and this area seems to be consistently exploited. The birds seem to exploit the western edge of the reef proper.

3.2.3 Other species

A number of other species were recorded irregu-

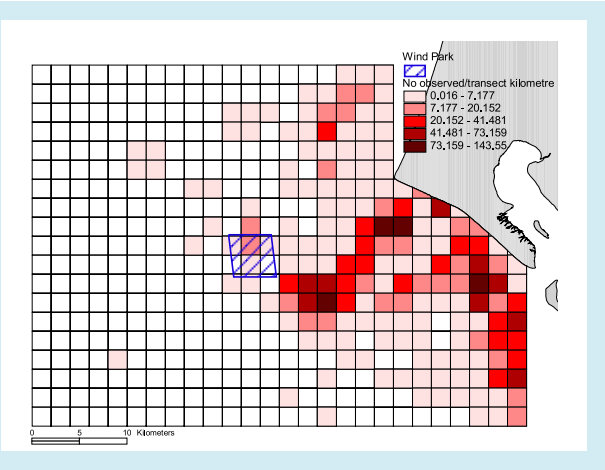

Figure 20. Geographical distribution of 128,614 common scoters recorded in 16 aerial counts during August 1999 - January 2002.

larly and in small numbers during the study period 2000/2001, and will not be described in detail here (see Table 2).

3.3 Disturbance effects

In order to assess the magnitude of the potential disturbance effect on bird populations analyses of their exploitation of the proposed wind farm area and the adjacent areas were made in accordance with the methodology used in the previous investigation (Noer et al. 2000). These analyses included calculations of:

1. The percentage of birds within the wind farm area in relation to the number of birds in the total study area.
2. The percentage of birds within the wind farm area and an adjacent zone of 2 km in relation to the total number of birds in the study area.
3. The percentage of birds within the wind farm area and an adjacent zone of 4 km in relation to the total number of birds in the study area.

The adjacent 2 and 4 km zones are arbitrarily

Table 3. The percentage of the total number of individuals recorded (August 1999 - January 2002) in the proposed wind farm area (WP), in the wind farm area and an adjacent 2 km zone (WP+2) and in the wind farm area and an adjacent 4 km zone (WP+4) respectively. The size of the area is expressed as the percentage of transect kilometres counted within each area as a proportion of the total number of transect kilometres counted within the total study area. The 'Jacobs' selectivity index (D; Jacobs 1974) is given; negative values indicate that the species avoid the area in question, positive values that the species show preference for the area. N is the total number of individuals of the different bird species observed during the 16 aerial counts. P is probability values for χ^2 one-sample test to compare values (WP column) with the values expected from a 'geographical free' distribution (*: P < 0.05; **; P < 0.01; ***: P < 0.001; n.s.: non significant).

Bird species	WP	D for WP+0	P	WP+2	D for WP+2	P	WP+4	D for WP+4	P	N
Fish-eating species										
Divers	1.58	-0.023	n.s.	4.88	-0.004	n.s.	7.51	-0.139	**	1,331
Gannet	0.00	-1.000	**	1.94	-0.446	**	9.51	-0.011	n.s.	515
Arctic/common tern[1]	0.87	-0.311	**	2.29	-0.377	***	5.28	-0.317	***	2,407
Sandwich tern	0.00	-1.000	*	1.67	-0.506	**	3.34	-0.513	***	419
Guillemot/razorbill	0.91	-0.294	n.s.	2.36	-0.364	***	7.79	-0.120	*	1,104
Herring gull	0.06	-0.933	***	0.36	-0.868	***	1.74	-0.717	***	17,357
Great black-backed gull	0.00	-1.000	**	1.44	-0.560	***	4.32	-0.409	***	556
Kittiwake	0.71	-0.399	***	2.66	-0.309	***	6.63	-0.204	***	2,518
Gull sp.	0.00	-1.000	***	0.13	-0.949	***	0.54	-0.904	***	744
Benthic foraging species										
Eider	0.01	-0.990	***	0.01	-0.997	***	0.01	-0.998	***	12,355
Common scoter	0.43	-0.588	***	2.44	-0.348	***	8.15	-0.095	***	128,614
Velvet scoter	0.00	-1.000	**	0.00	-1.000	***	8.05	-0.102	n.s.	621
Size of the area to the total area (% of transect km)	1.65			4.92			9.70			

[1] Including observations of 'terns sp.'

Table 4. Number of birds per kilometre aerial transect surveyed in the wind farm area (WP), in the wind farm area plus 2 km (WP+2), in the wind farm area plus 4 km (WP+4) and for the total study area. The number of birds is the total number recorded during 16 counts between August 1999 and January 2002. The relative importance of the WP, WP+2 km and WP+4 km is shown. The corresponding result for the period August 1999 - April 2001 is shown in brackets.

	Number per transect km (cumulated numbers from 16 counts)				The ratios of number per transect km of the sub-areas to the total area (relative importance)		
Bird species	WP (387.9 km)	WP+2 (1,157.8 km)	WP+4 (2,283.5 km)	Total area (21,248.7 km)	WP	WP+2	WP+4
Divers	0.0619	0.0613	0.0517	0.0626	0,99 (1.0)	0,98 (1.02)	0.82 (0.74)
Gannet	0.0000	0.0086	0.0215	0.0242	0.00 (0.00)	0.36 (0.32)	0.89 (1.04)
Arctic/common tern	0.0567	0.0570	0.0666	0.1133	0.50 (0.33)	0.50 (0.45)	0.59 (0.64)
Sandwich tern	0.0000	0.0060	0.0158	0.0197	0.00 (0.00)	0.31 (0.38)	0.80 (0.36)
Guillemot/razorbill	0.0258	0.0225	0.0377	0.0520	0.50 (0.64)	0.43 (0.56)	0.72 (0.84)
Herring gull	0.0284	0.0596	0.1428	0.8168	0.03 (0.02)	0.07 (0.06)	0.17 (0.14)
Great black-backed gull	0.0000	0.0069	0.0114	0.0262	0.00 (0.00)	0.26 (0.16)	0.44 (0.33)
Kittiwake	0.0464	0.0613	0.0758	0.1185	0.39 (0.50)	0.52 (0.65)	0.64 (0.78)
Common scoter	1.4359	2.7103	4.5912	6.0528	0.24 (0.34)	0.45 (0.67)	0.76 (1.14)

chosen and the latter (4 km zone) is considered as a 'worst case' scenario of potential habitat loss.

The analyses described above were repeated for the most abundant species including all 16 counts (Table 3). Furthermore, the selectivity index (D) of 'Jacobs' have been used to standardise the preference for the proposed wind farm area.

Within the proposed wind farm area, no species occurred in proportions higher than expected when assuming a 'geographical free' distribution in the study area. Most species showed a significant avoidance of the wind farm area (i.e. they occurred in lower numbers than expected). Divers and alcids occurred in numbers expected from a free distribution. Expanding the area with the adjacent 2-km zone provided a similar significant avoidance for all species, except divers, which again occurred in expected numbers. When the analyses included the adjacent 4-km zone, a significant avoidance was found in all species, except for gannet and velvet scoter, which occurred in numbers expected from a free distribution.

The calculated number of birds per survey kilometre in the wind farm area, in the area +2 km and +4 km is shown in Table 4. Compared to the number of birds per kilometre transect within the total study area, an estimate of the relative importance of these areas to the different bird species can be obtained. In these calculations, the ratios between the number of birds recorded in the wind farm area and the number of birds recorded in the surrounding area should be equal to 1.0 if there was no preference or avoidance to this area. If the ratio was higher than 1.0, the wind farm area should be considered more important than the rest of the study area. On the other hand, if the ratio was lower than 1.0, the wind farm area should be considered less important than the rest of the area.

Based on numbers of individuals per survey kilometre no bird species occur in the wind farm area or +2 km or +4 km in higher proportions

than expected. The results of the analyses of relative importance thus complement the results of the selectivity analyses in Table 3.

Compared to the corresponding results from the period August 1999-April 2001 (see Table 4), inclusion of the data from August 2001 - January 2002 results in a change in the distribution for a few species. The common scoter was found in lower numbers than during the previous surveys. However, tendencies for scoters to occur close to the wind farm have generally been those found during early spring. When including three autumn counts lower numbers are expected to occur close to the wind farm. In 1999/2000, gannets tended to occur in higher numbers than expected at a distance between 2 and 4 km from the wind farm area (Noer et al. 2000), but this tendency disappeared when including the observations from the period 2000/2001. The relative importance of the areas close to the wind farm was further reduced when including the autumn counts 2001.

4 Discussion and conclusions

4.1 Within-year and between-year variation in bird numbers at Horns Rev

In order to make as precise assessments as possible of the potential impacts on birds from operating offshore wind farms, knowledge of the within-year and between-year variation in bird numbers is essential, both within the wind farm area as well as in the adjacent areas.

In general, bird numbers of both migrating and wintering species may show large within-year and between-year fluctuations in abundance as well as in distribution (Laursen et al. 1997, Jacobsen in prep.). These variations may be related to factors such as reproductive success in the preceding breeding season, timing, duration and severity of winter, timing of spring and availability of food resources. As the study period so far only comprises two and a half year, it is difficult to assess whether the observed year-to-year variation in the abundance and the distribution of the species represent 'normal variation' in the Horns Rev area. This especially concerns species which have heir peak occurrence during spring, as the spring period has only been covered twice by the present study, whereas three autumn periods have been covered.

The within-year variation in the occurrence of the bird species in the Horns Rev area closely correlates to the phenology of the species recorded at Blåvandshuk (Jacobsen in prep.). Thus, the present investigation did not find any deviation in the seasonal occurrence of the recorded species from what was expected.

The year-to-year variation in the abundance of the birds in the Horns Rev area was generally found in species that migrated through the area, e.g. terns, gannets and kittiwakes, while less pronounced variation was found in staging and wintering species, e.g. divers, herring gulls and common scoters. Of the migrating species, both Arctic/common tern and sandwich tern have distinct migration periods (March-May and July-August) and the timing and intensity of migration in these species may vary in relation to the weather conditions. Gannets have a short intense migration period in autumn (September), and the recorded year-to-year variation in maximum occurrence of this species probably related more to the difference in the timing of the counts during this period than to any real differences in abundance between years. Of the wintering species, only the eider showed pronounced between-year variation in abundance in February. As previously mentioned, the occurrence of very high numbers of scoters in January 2002 is probably related to a period of cold weather during late December that have moved birds from the inner Danish waters to the North Sea.

4.2 Seabird use of the Horns Rev area

From the spatial distributions of birds obtained during the previous study periods (August 1999 - April 2000 and August 2000 - April 2001), the following conclusions were made.

Species foraging on fish (including gulls) were generally distributed in the offshore parts (more than ca 2 km from the coast) of the study area. The occurrence of these species was variable and all showed a more or less scattered distribution in the study area. During some counts, the highest numbers of, for example, gannets, alcids and kittiwakes, were observed north of Horns Rev, in other counts the highest numbers were observed south of Horns Rev. No species were found in high numbers on the shallow parts of Horns Rev (i.e. within the proposed wind farm area, *cf*. Table 3 and 4).

Of species foraging on sessile benthic fauna (eider and common scoter), only small numbers were observed at Horns Rev. The general distribution of these species was more coastal. In most cases the species were observed close to Blåvandshuk and Skallingen, although a relatively

high number of common ccoters were found exploiting the area southeast off Horns Rev in April 2001.

The inclusion of the results obtained from the three counts made during August 2001 - January 2002 did not compromise any of these conclusions with respect to both seasonal occurrence and distribution. Thus, based on the data and calculations obtained during the full study period, August 1999 - January 2002, a general tendency for lower than expected numbers within the wind farm area was found. Thus, it can be concluded that:

1. No data collected so far indicate that the planned wind farm area is of particular importance to bird species recorded in the Horns Rev area.
2. If the birds avoid exploiting the wind farm area, this will affect a maximum of 1% of the study area.
3. If the birds avoid the wind farm area the impact is estimated to affect less than 1% of the different species in the study area except divers where 1.58% may be affected (*cf*. Table 3).
4. Even if a very conservative 'worst possible case' scenario is assumed, with birds totally avoiding the wind farm area and the adjacent 4 km zone the impact is estimated to affect ca 8(-11)% of the common scoters, ca 10% of the gannets, 7-9% of the divers, alcids and velvet scoters, while the corresponding proportions of the remaining species in the study area will range between 0-6% (*cf*. Table 3).

With the possible exception of common scoter, which showed some variability in numbers and distribution, the data collected so far indicate that the bird distributions are relatively consistent when considering both the within-year and the between-year variation in abundance and distribution of the different species.

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