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# FIRST OFF-SHORE SITE BIRD MONITORING IN POLAND (DEBKI-BIAŁOGÓRA, 2002–2004)

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## ABSTRACT

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Due to the presence along the Polish Baltic coast of migratory bird flyways from north-eastern European breeding grounds to wintering areas distributed on continental shelf waters of western and southwestern Europe, the area has been designated as a *NATURA 2000* site (PLB 990002). Therefore the site of a planned off-shore wind farm in this area requires monitoring as to its potential influence on birds. This was the first such monitoring performed in Poland. The expanse of water covered by the research included the planned location of the wind farm as well as adjacent areas. A series of 15 investigative cruises were undertaken from the beginning of October to the beginning of May. The period of observations was divided into five seasons: early autumn, late autumn, winter, early spring and late spring. The standard method of counting birds on transects in the form of strips reaching 300 m from the ship was used in the research, as well as the 'snapshot' technique (scan with bands transect with snapshot technique). Additional observations were made from a point on the shore.

In the study area maritime birds are present in low or moderate densities, with localized clusters. Two diving benthophagous species dominate: the Long-tailed Duck (58.9%) and the Velvet Scoter (34.3%). The next two commonest species have a share of over 1% within the community – the Common Scoter (3.2%) and the Herring Gull (2.4%). Other species are very uncommon. There is very high fluctuation in the number of birds both observed on the water surface and seen in the air. In the area studied no pronounced migratory passage of waterfowl was observed; the usual migratory flyways probably lie farther to the north and the birds observed in flight perform mainly local movements. Observed bird densities in the study area are considerably lower (52.0 ind./km$^2$) than those estimated for the entire *NATURA 2000* area (116.7 ind./km$^2$). In the area of the planned wind farm densities are even lower (36.1 ind./km$^2$, i.e. 31% of the *NATURA 2000* level), while densities in neighbouring areas are still below the *NATURA 2000* average.

In the subsequent administrative procedure the area was not accepted as the location of the planned wind farm.

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**Keywords:** bird monitoring, off-shore, wind-farm, waterfowl, distribution, seasonal dynamics

## INTRODUCTION

The Baltic Sea area is of great importance for several maritime bird species. These birds, breeding at high latitudes, migrate this way to moulting and wintering grounds located on the western and southern waters of the Baltic and the North Sea. The role of these areas has been described in a report addressed to the European Commission entitled '*Important Marine Areas for Wintering Birds in the Baltic Sea*' (Durinck *et al.* 1994). The '*Material*' chapter of this document provided data describing the basis for evaluation of different areas of the Baltic Sea for maritime birds. It can be seen here that the amount of original data collected in different parts of the area was highly varied, from single controls to detailed studies based on numerous observations made from the coast and from ships, as well as aerial censuses. The Polish coast was extremely under-studied – most evaluations were based on only one study cruise and only the Pomeranian Bay and Slupsk Bank were observed more than once. Therefore knowledge of the occurrence, distribution and migration of maritime birds in this area is insufficient for real evaluation of its importance for birds. Despite this, the entire area of Polish waters with water depths below 20 meters was designated as protected (OSO) under the NATURA 2000 project (PLB990002). This area is very large, covering 211,596 ha. The wintering population of birds was estimated at about 247,000 birds, which means an average density of about 117 ind./km$^2$.

Along the Baltic coasts there are migratory flyways from north-eastern European breeding grounds to wintering grounds distributed on the continental shelf waters of western and southwestern Europe. Migration – partly true migration and partly moult movements – begins as early as summer. As early as July one can observe the first migrating drakes of duck species that leave their breeding grounds after the females have started to breed. The most common duck species at this time is the Common Scoter, migrating to moult on shallow Danish waters. Knowledge of this migration is rather poor, but unpublished data show that it is not intensive on the southern Baltic waters. Migration of other waterfowl is very prolonged and lasts until the end of October or even the first half of November.

Spring migration of waterfowl is much quicker than in autumn and more intensive. The first migrating flocks can already be seen in the last days of February, and the peak of migration occurs in April. The latest migrants can be seen until the end of May, but are observed infrequently. Up to the time of the observations described here, research on spring migration on the Polish coast had been carried out only in 2000, near Rozewie (Meissner 2003). The number of migrating birds was rather high, on some days reaching as many as 1,500 individuals per hour. Ninety percent of all observed birds were gulls, and 80-90 percent of them flew within a 1 km strip from the shore. The only group of birds migrating at higher distances from land were divers (W. Meissner – unpublished data). These birds were observed mainly at distances of 500-1,500 meters from the beach. In this case the direction of flights was not parallel to the shoreline and the birds headed northeast from Rozewie. During 80 hours of observations 164 individuals were counted, including 34 Black-throated Divers, 64 Red-throated Divers and one Yellow-billed Diver (others were not identified). On average 2.1 ind./hour passed the observation stand. In comparison with Estonian observations (178 ind./h – Kontkanen 1996), intensity of migration on the Polish coast is rather low.

The Polish maritime area had not been exploited for wind farms before the beginning of the 21st century and therefore no studies on birds were carried out to evaluate potential conflicts between this method of energy production and birds using the area. This indicates the need for special studies in this regard at planned sites for wind farms. The first application for permission to build a wind farm, near Dębki and Karwieńskie Błota, necessitated adequate studies at this location.

The evaluation below is based on observations performed by a team from ECOTONE Enterprise, Sopot, guided by Prof. Włodzimierz Meissner (Department of Ecology and Zoology of Vertebrates, Gdańsk University). The raw data are presented in reports by ECOTONE: *'Report from studies on numbers and distribution of birds observed at the area of planned wind farm Debki-Jastrzebia Gora'*, and *'Report from observations of migrating birds at Jastrzebia Góra-Dębki'*. Limited evaluation of these data was published earlier by Meissner (Meissner 2010). It was directed to three most numerous species only and covered nine of 15 cruises.

It must be stressed that the evaluation is a study of the local situation in this area and cannot be applied to other parts of the Polish Baltic coast. This is only a snapshot from the initial period of research on the distribution of ducks along the Polish Baltic coast. Since that time the numbers have changed and general estimations indicate much lower numbers of birds observed along the southern Baltic coast.

## AREA AND METHODS

### Observations of numbers and distributions of birds

Observations of the species composition, number and the distribution of waterfowl in the region of the planned investment were carried out on a rectangular expanse of water defined by the following coordinates:
– NW: 54°58'00"N 18°00'00"E
– NE: 54°58'00"N 18°18'00"E
– SW: 54°50'50"N 18°00'00"E
– SE: 54°50'50"N 18°18'00"E

The expanse of water covered by the research included the planned location of the wind farm as well as adjacent areas. Transects ran north-south along meridians 18°18', 18°12', 18°06' and 18°00' and were 13.5 km in length. Each transect was divided into 6 sections of about equal length, numbered from the shore towards the open sea. The planned location of the wind power stations was within the second sections and a small part of the thirds sections of the two central transects, as shown in Figure 1.

As previously decided, 15 investigative cruises were conducted, from the beginning of October to the beginning of May. The period of observations was divided into five seasons as shown in Table 1. To control for inter-year fluctuations, late autumn controls were done in both 2003 and 2004.

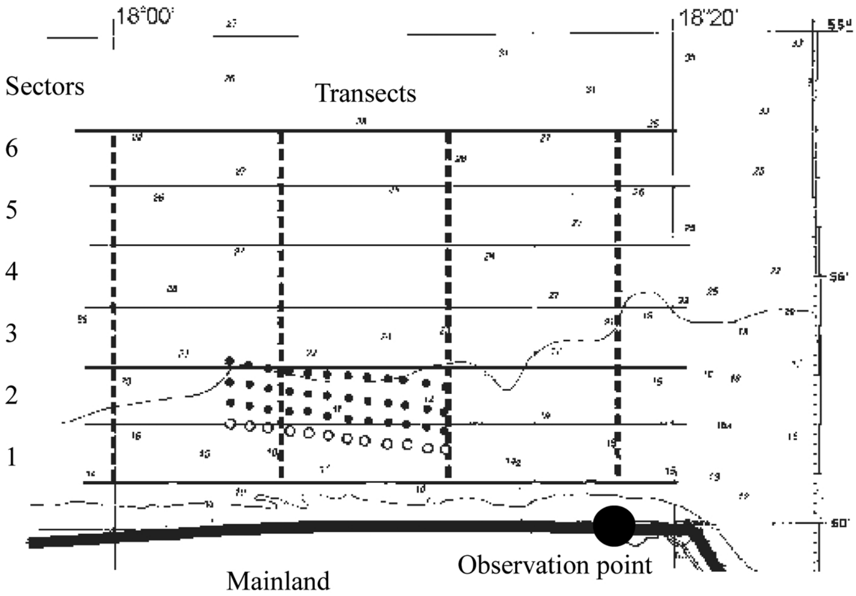


Fig. 1. The study area – summer observation point and ship cruises: vertical broken lines – transects, horizontal lines – observation sectors; ● – actual locations of wind turbines, ○ – line of wind turbines cancelled from building plans; isobaths of 10 and 20 m are shown as well as local depths.

Table 1
Phenological seasons and dates of exploration

| Season | Dates of cruises |
|---|---|
| Early autumn | 4 Oct. 2004 |
| | 25 Oct. 2004 |
| Late autumn | 4 Nov. 2004 |
| | 14 Nov. 2003 |
| | 28 Nov. 2003 |
| | 29 Nov. 2004 |
| Winter | 9 Dec. 2003 |
| | 30 Dec. 2003 |
| | 27 Jan. 2004 |
| | 27 Feb. 2004 |
| Early spring | 5 Mar. 2004 |
| | 28 Mar. 2004 |
| | 5 Apr. 2004 |
| Late spring | 20 Apr. 2004 |
| | 5 May 2004 |

The standard method of counting birds on transects in the form of strips reaching 300 m from the ship was used in the research, as well as the ‘snapshot’ technique (scan with bands transect with snapshot technique). This method is used nearly worldwide in this type of research. A detailed description of the method is found in a manual by Komdeur *et al.* 1992.

The control covered an area of 16.2 $km^2$, or 0.675 $km^2$ per sector. Detail description of the area was published by Meissner (2010).

## Observations of migration

The passage of waterfowl in the period from early autumn to late spring was observed during cruises aimed at estimating the density and distribution of birds (as above).

Summer observations were performed from a coastal stand on a 40 m cliff in Jastrzębia Góra, near Rozewie. This location is suitable for such observations due to its high elevation and open view of the sea, which make it possible to follow birds flying a few kilometres from the shore (up to 2-2.5 km). This point is located outside the planned wind farm area. However, most birds, except for divers, migrate there parallel to the coast line, so they pass both the farm area and the observation point area. Observations were aimed in particular at waterfowl, but other large birds were counted as well. Birds were noted in three strips: up to 500 m, 500-1,000 m and more than 1,000 m from the coast. The estimation of a distance based on relations between a horizon distance in relation to elevation of an observer (Heinemann 1981). As the planned wind farm is to be about 4 km from the shore, the most important results are those obtained for the third strip. The birds were counted on 12 days, three times daily: in the morning (7.00-9.00), around midday (11.00-13.00) and in the afternoon (15.00-17.00). Observations were conducted continuously for at least one hour using a 20-60x80 telescope or binoculars. Altogether birds were counted for 41 hours and 45 minutes (Table 2).

Table 2
Time spent at the passage observation point at Rozewie in 2002. Hours:minutes

| | Morning | Midday | Afternoon | **Total** |
|---|---|---|---|---|
| 27 July | 2:00 | 2:00 | 1:30 | **5:30** |
| 30 July | 1:45 | 1:30 | 1:00 | **4:15** |
| 2 August | 1:30 | 1:30 | 1:00 | **4:00** |
| 5 August | 1:30 | 1:00 | 1:00 | **3:30** |
| 9 August | 1:00 | 1:00 | 1:00 | **3:00** |
| 12 August | 1:00 | 1:00 | 1:00 | **3:00** |
| 16 August | 1:00 | 1:00 | 1:00 | **3:00** |
| 20 August | 1:00 | 1:00 | 1:00 | **3:00** |
| 24 August | 1:00 | 1:00 | 1:00 | **3:00** |
| 27 August | 1:00 | 1:00 | 1:00 | **3:00** |
| 31August | 1:00 | 1:00 | 1:00 | **3:00** |
| 4 September | 1:30 | 1:00 | 1:00 | **3:30** |
| **Total** | **15:15** | **14:00** | **12:30** | **41:45** |

Observations of migration of land birds were generally not conducted. Most land birds migrate over the sea during the night and at considerable heights. These observations require completely different techniques; moreover, migration normally takes place outside heights where collision with wind turbines may occur. Diurnal migration of land birds at heights comparable with those of windmill rotors could take place only rarely and in very special weather conditions, so the potential impact of the wind farm seems to be very low and cannot be properly estimated.

### Analysis of data

Numbers of birds observed on the water surface are given here as densities per 1 km$^2$. The raw data were analysed in SURFER 8.0 computer software and presented as isolines describing the distribution of birds within the study area. Numbers for all bird species together, as well as for the two commonest species separately, were analysed in the program. The total picture of the distribution of birds for all seasons together was based on a weighted average of means for all seasons (weighted for length of the season: early autumn – 1 month, late autumn – 2 months, winter – 3 months, early spring – 1 month, and late spring – 1 month).

Intensity of flights is expressed as numbers of individuals observed flying per hour of observation, irrespective of whether they were observed from the shore or from aship. This makes it possible to compare the results with literature data.

## RESULTS

### Numbers and distribution of birds

Altogether 11,116 maritime bird individuals were observed during the research cruises (Table 3). The two most common species – the Long-tailed Duck and Velvet Scoter – comprised 93.2% of all observed birds and attention was focused mainly on these species. Both species are diving benthophages, and the third most frequent species in the area, i.e. the Common Scoter (3.2% share in all maritime species), belongs to this ecological group as well. Diving ichthyophages (10 species) constitute less than 1% of birds observed in the area. Other species, apart from Herring Gull (1.2%), occur in negligible numbers.

Both total density and species densities fluctuate considerably between seasons (Table 4). The highest average density was found during early spring – it was about two times higher than in late autumn and winter and five times higher than in early autumn. This is a period of highly dynamic spring migration. Later in the year, during late spring, only small numbers of waterfowl were observed. However, Figure 2 shows that the average values may be not representative of the actual number dynamics, as control-to-control fluctuations in observed numbers are quite large. With only 15 controls conducted for all seasons together, a single observation of very high numbers could influence of the overall number dynamics and total densities. An example of this is the very high number of Long-tailed Duck observed on 14 November 2003 (119 ind./km$^2$, while the total average was only 29.1 ind./km$^2$). This is confirmed by the high standard deviation ($SD$ = 31.9) found for this species.

Table 3
Species composition and numbers of waterfowl in the area studied – total average.
+ – dominance less than 0.1%, density less than 0.1 ind./km²

| | Total number | Dominance [%] | Density [$n$/km$^2$] |
|---|---|---|---|
| **Diving benthophages** | | | |
| Long-tailed Duck *Clangula hyemalis* | 6551 | 58.9 | 28.4 |
| Velvet Scoter *Melanitta fusca* | 3817 | 34.3 | 16.5 |
| Common Scoter *Melanitta nigra* | 358 | 3.2 | 1.6 |
| Common Eider *Somateria mollissima* | 22 | 0.2 | 0.1 |
| **Diving ichthyophages** | | | |
| Black-throated Diver *Gavia arctica* | 2 | + | + |
| Red-throated Diver *Gavia stellata* | 2 | + | + |
| Divers *indet. Gavia sp.* | 1 | + | + |
| Great Crested Grebe *Podiceps cristatus* | 9 | 0.1 | + |
| Red-necked Grebe *Podiceps grisegena* | 1 | + | + |
| Cormorant *Phalacrocorax carbo* | 1 | + | + |
| Goosanger *Mergus merganser* | 7 | 0.1 | + |
| Red-necked Merganser *Mergus serrator* | 14 | 0.1 | 0.1 |
| Razorbill *Alca torda* | 29 | 0.3 | 0.1 |
| Common Guillemot *Uria aalge* | 4 | + | + |
| Black Guillemot *Cepphus grylle* | 3 | + | + |
| **Others** | | | |
| Great Black-backed Gull *Larus marinus* | 15 | 0.1 | 0.1 |
| Herring Gull *Larus argentataus* | 268 | 2.4 | 1.2 |
| Lesser Black-backed Gull *Larus fuscus* | 2 | + | + |
| Common Gull *Larus canus* | 3 | + | + |
| Black-headed Gull *Larus ridibundus* | 1 | + | + |
| Little Gull *Larus minutus* | 2 | + | + |
| Bean Goose *Anser fabalis* | 3 | + | + |
| Coot *Fulica atra* | 1 | + | + |
| **Total** | **11 116** | **100** | **48.2** |

Apart from the overall density of birds and their number dynamics, the local distribution of the bird flocks is of utmost importance for evaluation of the area in terms of the location of the wind farm, as well as for studies on the feeding behaviour of the species observed. The local distribution of birds in the area is significantly uneven; when these distributions are tested using the chi-squared test, the probabilities obtained are undistinguishable from 0, e.g. for winter chi-squared ($df$=23) = 382, while the border value for $p$ = 0.01 is only 41.6. It is generally accepted that densities of maritime birds, especially diving benthophages, depend on water depth. Verification of this statement on the data obtained, however, shows that this relation is not as clear and stable as might be expected. Table 5 shows that a negative correlation occurs between bird densities and the depth of the sea in autumn, but is absent in winter. This is true both for all bird species together and for the two most abundant species. Therefore, the most important variable for birds seems to be concentration of food resources and not water depth alone. It is possible that more accessible resources in shallower waters are already exploited in autumn, while in winter the birds must use resources from greater depths. This hypothesis seems the most probable for the Long-tailed Duck.

Table 4
Densities of waterfowl in the study area in different seasons.
+ – density less than 0.1 ind./km²

| | Seasons | | | | | **Total** |
|---|---|---|---|---|---|---|
| | Early autumn | Late autumn | Winter | Early spring | Late spring | |
| **Diving benthophages** | | | | | | |
| Long-tailed Duck *Clangula hyemalis* | 11.0 | 37.9 | 31.2 | 65.9 | 2.1 | **28.4** |
| Velvet Scoter *Melanitta fusca* | 8.1 | 20.4 | 20.4 | 32.7 | 3.0 | **16.5** |
| Common Scoter *Melanitta nigra* | 1.9 | 1.4 | 1.5 | 3.9 | 0.2 | **1.6** |
| Common Eider *Somateria mollissima* | 0.2 | 0.2 | | + | | **0.1** |
| **Density of diving benthophags** | **21.3** | **59.9** | **53.1** | **102.6** | **5.2** | **46.5** |
| **Diving ichthyophages** | | | | | | |
| Black-throated Diver *Gavia arctica* | + | + | | | | **+** |
| Red-throated Diver *Gavia stellata* | | + | + | | | **+** |
| Divers *indet. Gavia sp.* | | | | + | | **+** |
| Great Crested Grebe *Podiceps cristatus* | 0.1 | 0.1 | + | | | **+** |
| Red-necked Grebe *Podiceps grisegena* | | | + | | | **+** |
| Cormorant *Phalacrocorax carbo* | + | | | | | **+** |
| Goosanger *Mergus merganser* | | | 0.1 | | | **+** |
| Red-necked Merganser *Mergus serrator* | | 0.1 | 0.1 | | | **0.1** |
| Razorbill *Alca torda* | 0.2 | 0.3 | | 0.1 | | **0.1** |
| Common Guillemot *Uria aalge* | | 0.1 | | | | **+** |
| Black Guillemot *Cepphus grylle* | | | + | + | | **+** |
| **Density of diving ichthyophags** | **0.3** | **0.6** | **0.4** | **0.2** | **0.0** | **0.3** |
| **Others** | | | | | | |
| Great Black-backed Gull *Larus marinus* | 0.2 | 0.1 | + | | | **0.1** |
| Herring Gull *Larus argentataus* | 0.6 | 2.9 | 0.8 | 0.3 | 0.1 | **1.2** |
| Lesser Black-backed Gull *Larus fuscus* | | | | | + | **+** |
| Common Gull *Larus canus* | | + | + | | | **+** |
| Black-headed Gull *Larus ridibundus* | | | | + | | **+** |
| Little Gull *Larus minutus* | | | | | + | **+** |
| Bean Goose *Anser fabalis* | | | | | 0.1 | **+** |
| Coot *Fulica atra* | | | | | + | **+** |
| **Density of others** | **0.9** | **3.0** | **0.9** | **0.3** | **0.3** | **1.3** |
| **Total density** | **22.5** | **63.4** | **54.4** | **103.1** | **5.5** | **48.2** |

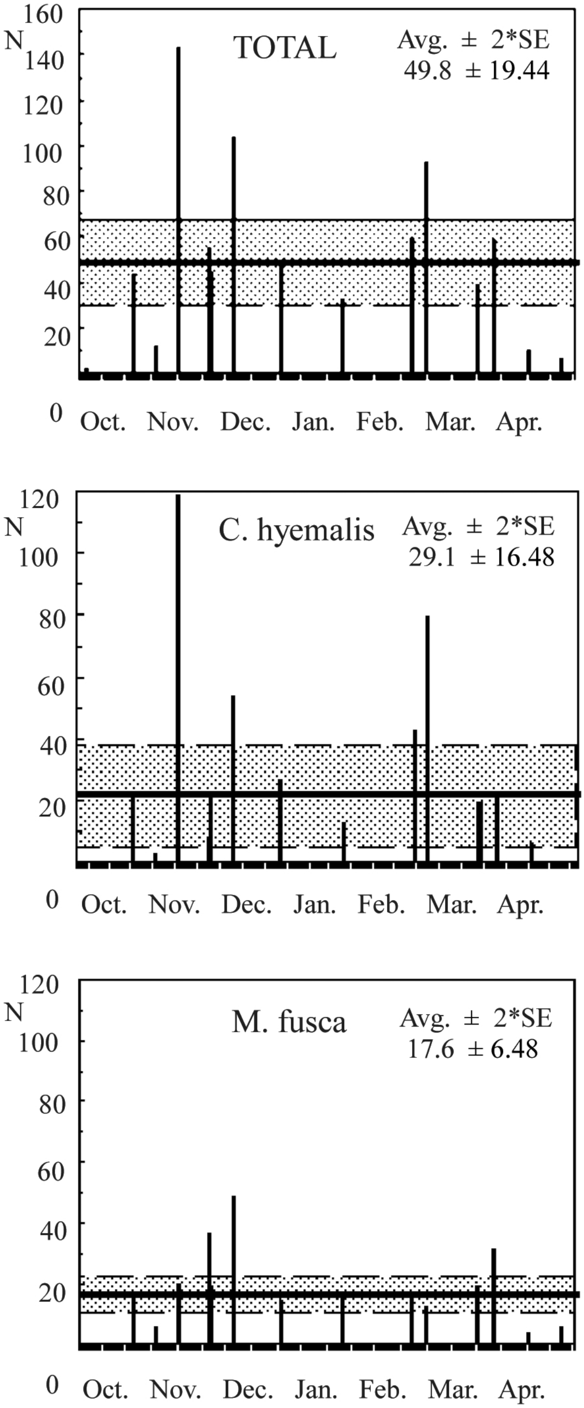


Fig. 2. Densities of birds observed in each control – for all species together (TOTAL) and for the two most common species. Averages (m) are shown as a line and a 0.05 confidence interval (± 2*SE) as a dotted area.

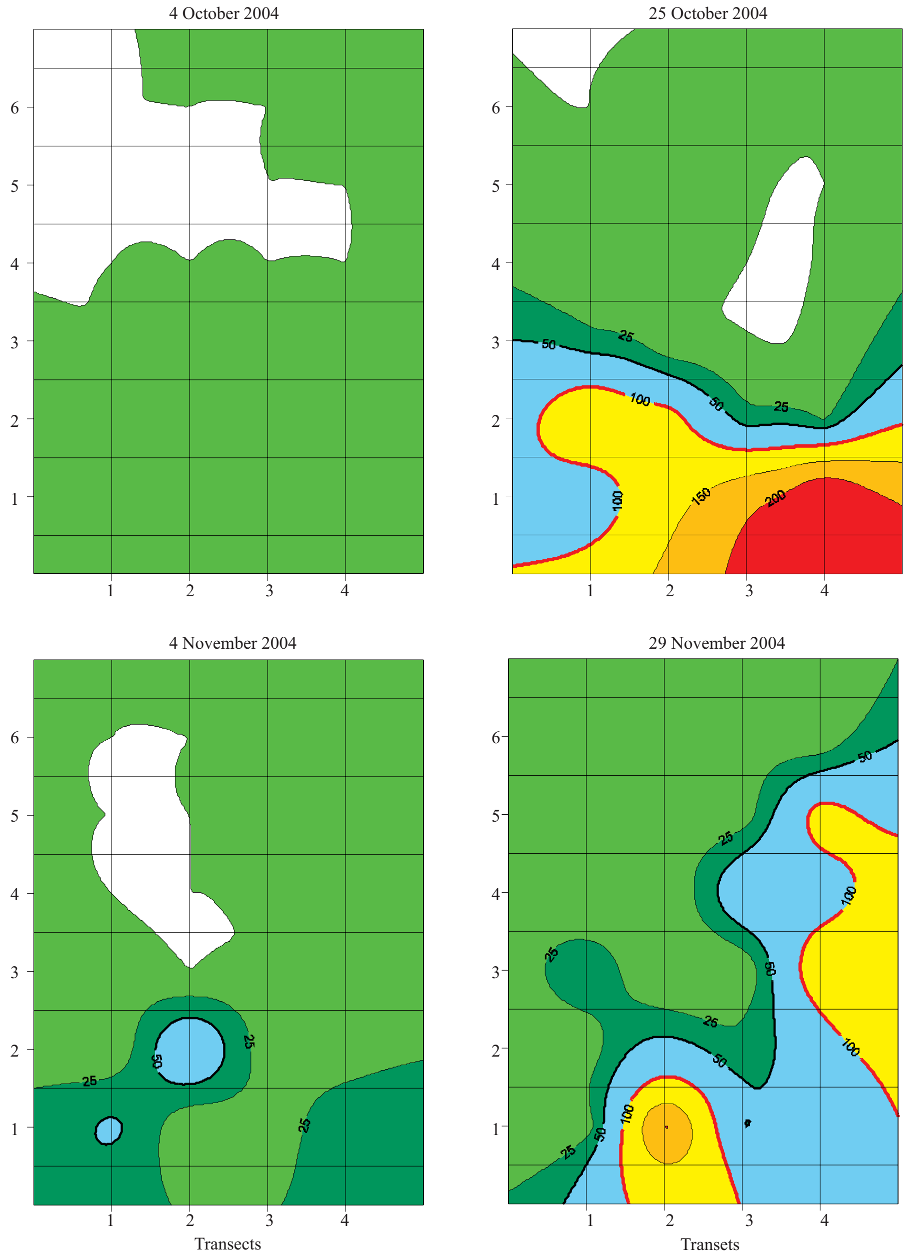


Fig. 3. Distributions of all birds observed in the area during four successive controls in autumn 2004. Computer estimation (using SURFER 8.0) based on the data collected – isolines of densities expressed as number of individuals per km².

Table 5
Correlation coefficients between sea depth and observed densities of birds. In bold – significant or highly significant correlations (< 0.05)

| | All species | Long-tailed Duck | Velvet Scoter |
|---|---|---|---|
| Early autumn | **-0.76** | **-0.61** | -0.21 |
| Late autumn | **-0.76** | **-0.60** | **-0.50** |
| Winter | 0.07 | -0.03 | 0.20 |
| Early spring | -0.13 | 0.16 | **-0.58** |
| Late spring | **-0.53** | -0.43 | -0.21 |

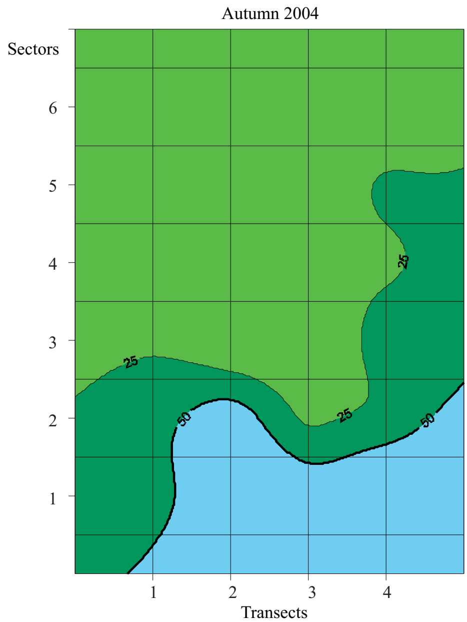


Fig. 4. Distribution of all birds observed in autumn 2004 – period average. Explanations as for Fig. 3.

Subsequent controls show pronounced variability of distribution of birds, which is clearly visible in Figure 3, where densities are presented as isolines of different densities – from very low (less than 10 ind./km$^2$) to large localized concentrations (over 200 ind./km$^2$). This can be explained by both feeding conditions and the social behaviour of the birds studied. Despite these substantial fluctuations, the average picture for a season is much less differentiated (Fig. 4). Comparison of the same season in two subsequent years (Fig. 5) shows pronounced variation between years, and it is difficult to say now whether this is mainly due to actual variation in numbers of birds visiting the area in different years or to an inadequate number of observations done in a period of very dynamic changes in migration intensity.

The total average bird distribution in the area is listed in Table 6 and illustrated in Figure 6. It can be seen here that densities occurring within each part of the area vary according to the season, especially in transects 2-3, sector 2. In spring (both early and

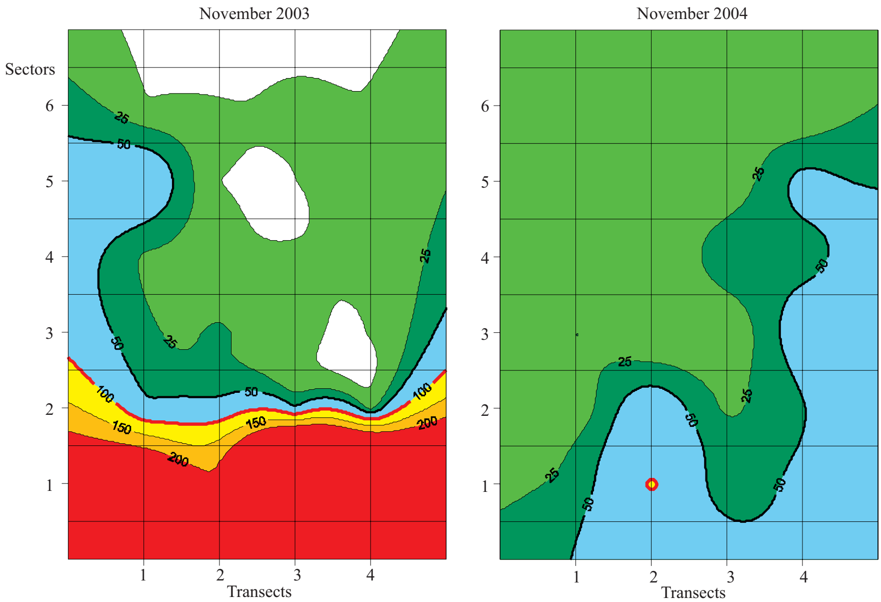


Fig. 5. Distributions of all birds observed in November 2003 and 2004 – period average. Explanations as for Fig. 3.

Table 6
Distribution of all birds in the study area in successive seasons.
Densities in sectors are given as numbers of individuals per km²

| Early autumn | | Transects | | | |
|---|---|---|---|---|---|
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 0.0 | 3.0 | 2.2 | 0.7 |
| | 5 | 0.7 | 3.0 | 0.7 | 0.0 |
| | 4 | 0.0 | 8.9 | 0.0 | 0.7 |
| | 3 | 16.5 | 4.4 | 2.2 | 4.4 |
| South | 2 | 76.3 | 57.8 | 17.0 | 10.4 |
| | 1 | 34.1 | 70.4 | 93.3 | 132.6 |

| Late autumn | | Transects | | | |
|---|---|---|---|---|---|
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 6.3 | 1.1 | 7.8 | 0.7 |
| | 5 | 48.1 | 0.4 | 2.5 | 34.4 |
| | 4 | 11.1 | 4.1 | 23.3 | 24.1 |
| South | 3 | 28.5 | 15.2 | 9.3 | 37.4 |
| | 2 | 33.3 | 73.0 | 36.7 | 31.5 |
| | 1 | 198.1 | 160.7 | 419.3 | 315.6 |

Table 6 cont.

| Winter | | Transects | | | |
|---|---|---|---|---|---|
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 11.9 | 57.0 | 45.6 | 103.0 |
| | 5 | 2.2 | 36.3 | 86.3 | 180.4 |
| | 4 | 34.8 | 71.1 | 29.3 | 223.3 |
| | 3 | 20.7 | 8.3 | 30.0 | 21.5 |
| South | 2 | 39.3 | 48.2 | 24.1 | 26.7 |
| | 1 | 31.9 | 85.9 | 124.8 | 36.7 |

| Early spring | | Transects | | | |
|---|---|---|---|---|---|
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 29.6 | 10.4 | 121.9 | 10.4 |
| | 5 | 7.4 | 8.5 | 10.7 | 158.5 |
| | 4 | 28.6 | 17.0 | 13.7 | 111.1 |
| | 3 | 57.8 | 27.8 | 41.9 | 80.4 |
| South | 2 | 40.0 | 19.6 | 29.3 | 68.5 |
| | 1 | 77.0 | 53.0 | 63.7 | 57.4 |

| Early autumn | | Transects | | | |
|---|---|---|---|---|---|
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 0.0 | 4.0 | 0.0 | 0.0 |
| | 5 | 4.0 | 3.0 | 0.0 | 2.5 |
| | 4 | 1.5 | 1.0 | 0.0 | 4.4 |
| | 3 | 3.0 | 21.7 | 4.9 | 3.0 |
| South | 2 | 8.4 | 5.9 | 12.8 | 0.0 |
| | 1 | 10.9 | 7.4 | 5.9 | 28.1 |

late) densities are low, in early autumn and winter they are partly low and partly moderate, and only in late autumn does about 25% of the farm area border on more significant densities. Average seasonal densities of the two most abundant species are listed in the Appendix – Tables I and II. Their distributions are varied (Fig. 7-8). In autumn the Long-tailed Duck can be found in high concentrations close to the shore and more to the east of the study area. In winter and spring the highest concentrations of this species can be found farther from the shore, in the easternmost parts of the study area and far from the wind farm location. The water depth in these parts is about 25 m. The Velvet Scoter occurs in early autumn in higher numbers at distances from the shore, but more to the west. Eastern parts of the area are used by this species rather infrequently. In late autumn a high concentration of this species occurs

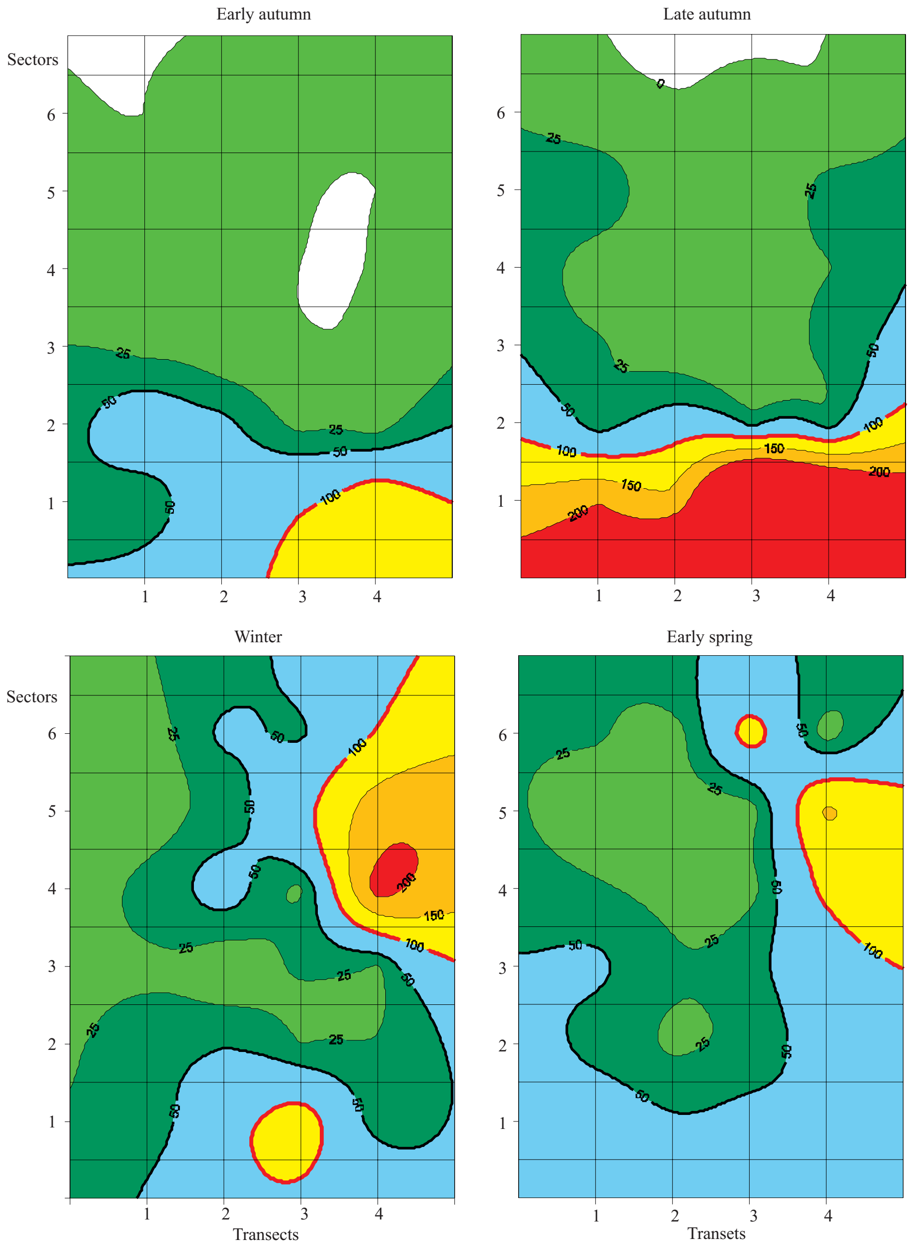


Fig. 6. Distributions of all birds observed in the area in successive seasons – period averages. Other explanations as for Fig. 3.

near the shore, a bit more to the west. In winter the situation of this species clearly changed, as moderate clusters of this duck were observed only in the northern and north-eastern parts of the study area. In early spring distribution of this species is similar to that observed in autumn, but the numbers are several times lower, reaching

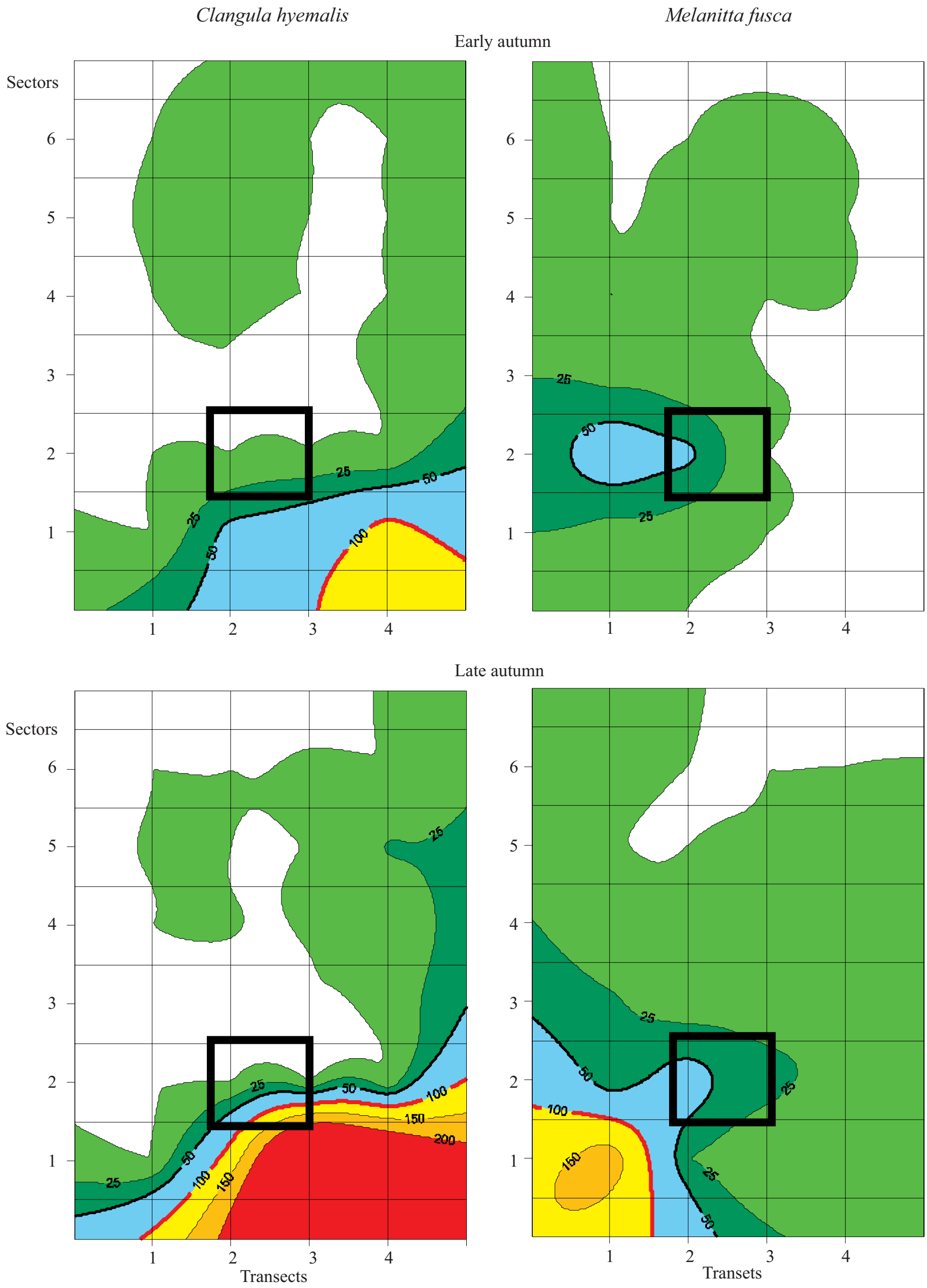


Fig. 7. Distribution of the two commonest species in autumn – period averages. The wind farm location is shown as a rectangle. Other explanations as for Fig. 6.

less than 25 ind./km². In late spring numbers of both species are very low (not more than 10 ind./km²).

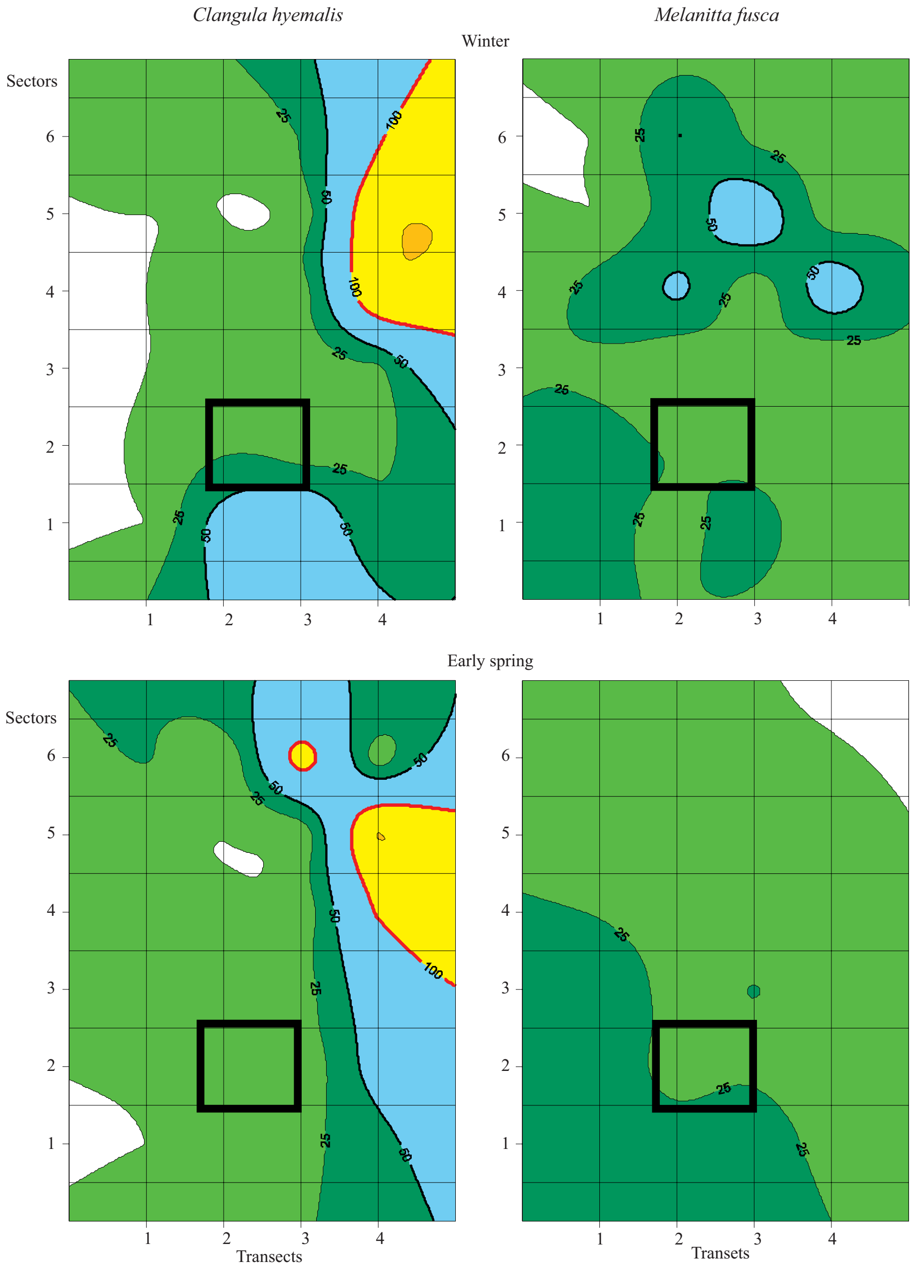


Fig. 8. Distribution of the two commonest species in winter and early spring (late spring not shown due to low numbers of birds) – period averages. Explanations as for Fig. 7.

Estimation of the average distribution of birds for all seasons (Fig. 9) shows two distinct concentrations of birds in the study area, both of which are outside the planned location of the wind farm. One of these is on very shallow waters bordering on the shore, especially in the central and eastern parts of the area. The other is situated in the eastern part, far from the shore, where the average water depth is about 25 m.

The wind farm was planned in an area with relatively low bird densities (under 50 ind./km², in some places even below 25 ind./km²), and only about 30% of the wind farm territory is located within the area of moderate densities.

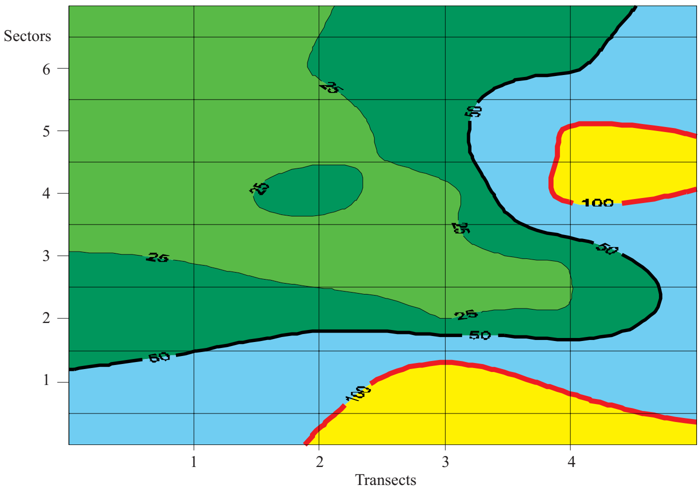


Fig. 9. Distribution of all species – weighted average for all seasons (explanation in the text – p. XX) – shown on a real map of the area (Fig. 1). Other explanations as for Fig. 6.

## Observations of flying birds during ship cruises

As in the case of observations on surface densities (see Fig. 2), flying birds were observed in highly variable numbers (Fig. 10). Single days with high numbers had a strong influence on average values. For all species together the standard deviation was 34.1 while the average was 64.9 ind./km² (so that the coefficient of variation was as high as 52.5%).

The tables in the Appendix (II and III) contain lists of the bird species observed in flight during observations from the ship. The species composition and number relations are similar to that listed for birds observed on the water surface (Table 7). It must be stressed here that the numbers of birds observed flying in winter are not lower than in the migration seasons. This could mean that they are mainly individuals moving between feeding areas and not actively migrating. If this hypothesis is correct, the study area lies outside the main migration routes of waterfowl between north-eastern parts of the Baltic and wintering grounds in the west. In autumn Herring Gulls were quite frequently observed. They were most numerous in November. However, at least some of them did not migrate but were local birds accompanying fishing ships. The numbers of flying birds observed, especially sea ducks, were low in comparison to those observed on the eastern coasts of the Baltic. For example, on the Estonian coast Kontkanen (1996) observed 1,000 flying birds per hour on average during 11 days of

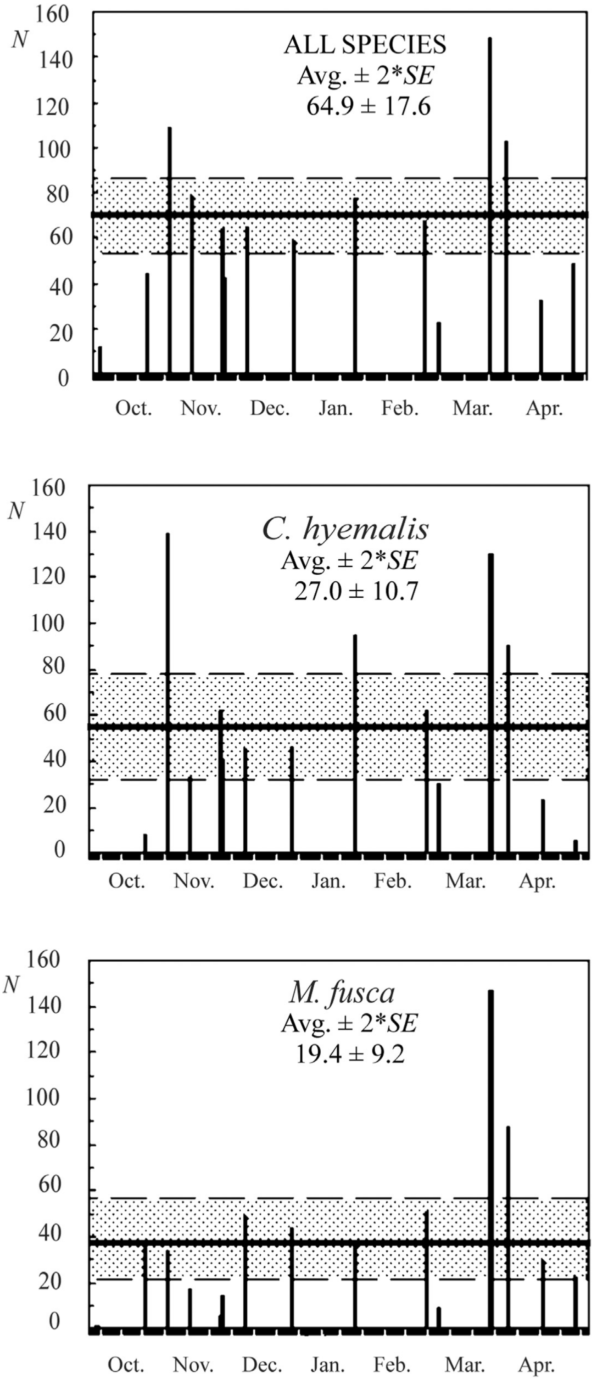


Fig. 10. Densities of birds observed flying (N/h) in each control – for all species together (TOTAL) and for the two most common species. Averages (m) are shown as a line and a 0.05 confidence interval (± 2*SE) as a dotted area.

observations. The distribution of flying birds at different distances from the shore (in successive sectors) is presented in Appendix Tables VI-VIII. The highest number was observed in the sector closest to the shore. Seasonal distributions were very similar (Fig. 11) and the same for all species. In the case of the Velvet Scoter, the numbers observed were especially low, which may confirm the earlier suggestion that the area is outside of the main migration route of waterfowl.

Table 7
Comparison of flights and densities of birds in the area studied

| | | Density | Flights |
|---|---|---|---|
| | | Ind./km$^2$ | Ind./h |
| Total | Autumn | 42.9 | 54.8 |
| | Winter | 54.4 | 58.9 |
| | Spring | 54.3 | 66.8 |
| *C. hyemalis* | Autumn | 24.4 | 23.6 |
| | Winter | 31.2 | 32.3 |
| | Spring | 34.0 | 25.9 |
| *M. fusca* | Autumn | 14.2 | 9.0 |
| | Winter | 20.4 | 22.1 |
| | Spring | 17.8 | 27.3 |

## Coastal observations of flying birds

Summer observations of flying birds performed from the coastal point were complementary to the observations from ships. They covered a coastal strip 2 km wide (Table 8, details in Appendix Table IX).

The average flight intensity observed from the Rozewie post was 22.6 ind./hour (*SD* = 17.3). The highest numbers were observed at the end of July and beginning of August (e.g. on 2$^{nd}$ August 267 flying birds were counted within four hours of observation) and on 20$^{th}$ August (Fig. 12). Once again it must be stressed that the variability of daily counts was very high (e.g. on 16$^{th}$ August not one bird was seen for 3 hours). The migration of waterfowl depends greatly on weather conditions (Alerstam 1979, Camphuysen and Dijk 1983, Meissner 2003), but this was not the reason for the variability of the results, as the weather conditions were quite stable during the entire period of observations.

The numbers of flying birds observed were surprisingly low in comparison with the literature data. In Holland and Finland observed numbers (for single species) ranged from 100 ind./h to 300 per hour and more (Camphuysen and Dijk 1983, Buzun 1998). On the German coast the number of passing waterfowl reaches several thousand per day, and in the north-eastern part of the Baltic Sea more than 100,000 individuals can pass an observation post in one day (Moritz 1983, Nehls and Zöllick 1990, Kontkanen 1996).

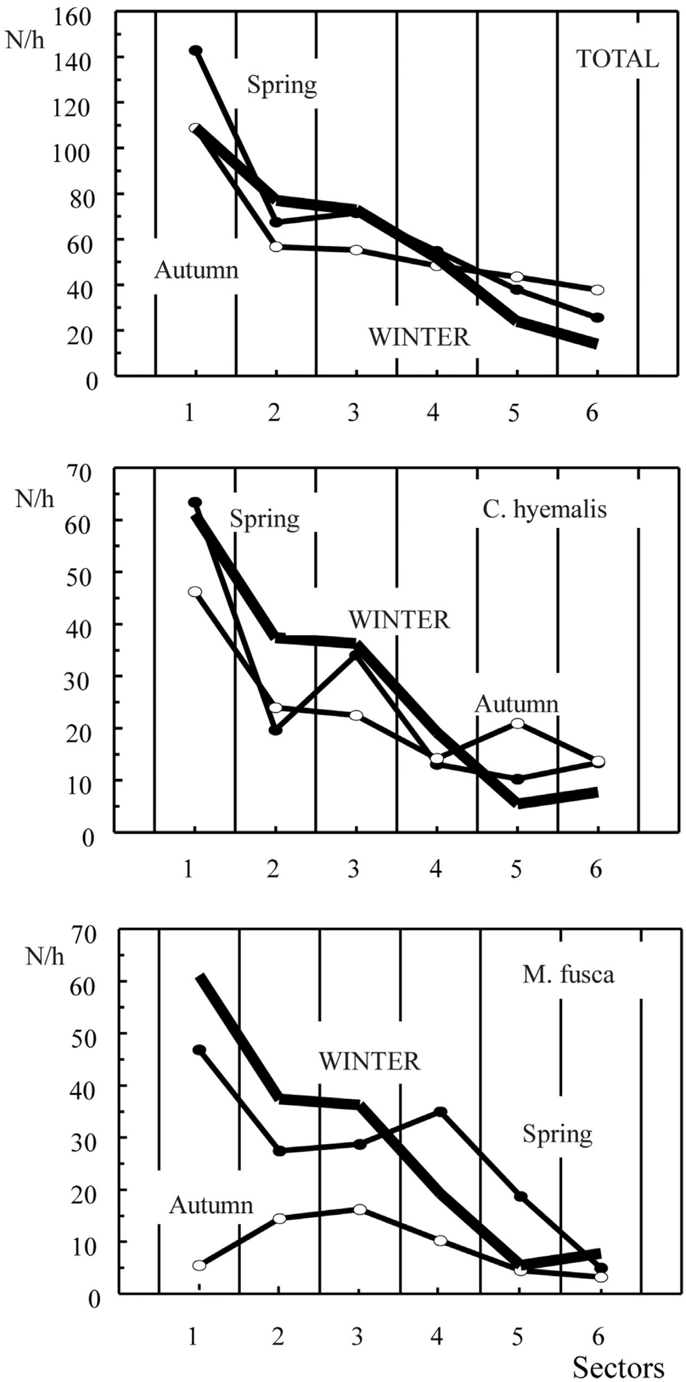


Fig. 11. Distribution of birds observed flying in successive sectors (1-6) in different seasons

Table 8
Numbers and percentage shares of bird species passing the observation point at Rozewie in 2002

| | No. of individuals | [%] |
|---|---|---|
| **Diving benthophages** | | |
| Velvet Scoter *Melanitta fusca* | 11 | 1.2 |
| Common Scoter *Melanitta nigra* | 179 | 19.0 |
| Common Eider *Somateria mollissima* | 170 | 18.0 |
| **Diving ichthyophages** | | |
| Black-throated Diver *Gavia arctica* | 1 | 0.1 |
| Divers *indet. Gavia sp.* | 1 | 0.1 |
| Great Crested Grebe *Podiceps cristatus* | 7 | 0.7 |
| Goosander *Mergus merganser* | 155 | 16.4 |
| Cormorant *Phalacrocorax carbo* | 364 | 38.6 |
| **Others** | | |
| Skuas *indet. Stercorarius sp.* | 3 | 0.3 |
| Mute Swan *Cygnus olor* | 14 | 1.5 |
| Mallard *Anas platyrhynchos* | 6 | 0.6 |
| Tufted Duck *Aythya fuligula* | 30 | 3.2 |
| Marsh Harrier *Circus aeruginosus* | 2 | 0.2 |
| Grey Heron *Ardea cinerea* | 1 | 0.1 |
| **Total** | **944** | **100** |

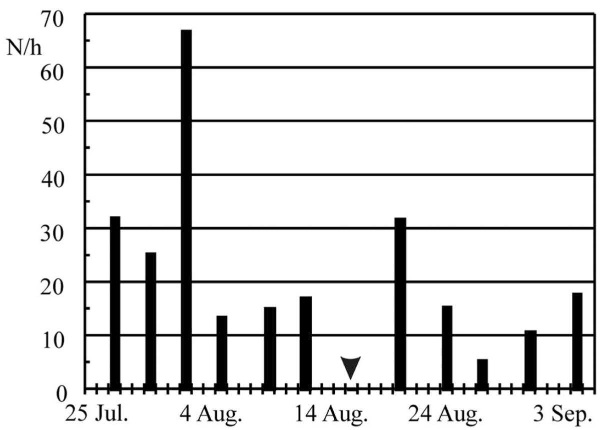


Fig. 12. Numbers of birds (N/h) observed during summer observations from the observation point at Jastrzebia Gora

The spatial distribution of flying birds is presented in Table 9. Most of the birds (95%) were observed near the beach. In the farthermost strip the average movement was only 1 ind./h. In this strip the most common were sea ducks, and it cannot be ruled out that they occurred at distances of more than 2 km from the coast. Comparison with the results obtained during ship cruises, however, suggests that the number of birds flying there is still very low. It is possible that the Polish coast is not visited frequently by migrating ducks which can migrate directly from high-concentration localities in Finland, Estonia and Latvia to moulting grounds in the south-western Baltic (Fig. 13).

Table 9
Number of waterfowl flying at different distances from the shore at the Rozewie observation point

| | to 0.5 km | 0.5 - 1 km | 1 – ca 2 km | **Total** |
|---|---|---|---|---|
| **Diving benthophages** | | | | |
| Velvet Scoter *Melanitta fusca* | 4 | 6 | 1 | **11** |
| Common Scoter *Melanitta nigra* | 40 | 132 | 7 | **179** |
| Common Eider *Somateria mollissima* | 34 | 123 | 13 | **170** |
| **Diving ichthyophages** | | | | |
| Black-throated Diver *Gavia arctica* | | | 1 | **1** |
| Divers indet. *Gavia sp.* | | | 1 | **1** |
| Great Crested Grebe *Podiceps cristatus* | | 5 | 2 | **7** |
| Goosanger *Mergus merganser* | 67 | 86 | 2 | **155** |
| Cormorant *Phalacrocorax carbo* | 261 | 100 | 3 | **364** |
| **Others** | | | | |
| Skuas *indet. Stercorarius sp.* | | 2 | 1 | **3** |
| Mute Swan *Cygnus olor* | | 6 | 8 | **14** |
| Mallard *Anas platyrhynchos* | 6 | | | **6** |
| Tufted Duck *Aythya fuligula* | 30 | | | **30** |
| Marsh Harrier *Circus aeruginosus* | 1 | 1 | | **2** |
| Grey Heron *Ardea cinerea* | 1 | | | **1** |
| **Total** | **444** | **461** | **39** | **944** |
| [%] | 47.0 | 48.8 | 4.1 | 100.0 |
| **Individuals/hour** | **10.6** | **11.0** | **1.0** | **22.6** |

The passage of birds was observed mainly in the morning and at midday. In these periods 94% of flying birds were observed (Table 10). In the afternoon the most common were sea ducks, but in very low numbers (avg. 3.3 ind./h). Summer migration flights of the Common Scoter on the eastern part of the German coast occur mainly in the afternoon (Nehls and Zöllick 1990). Assuming that the migration speed of this species is around 80 km/h, these birds should pass Rozewie shortly after noon, but this was not the case in our observations. This is another argument supporting the hypothesis about the migration pattern of waterfowl over the Baltic.

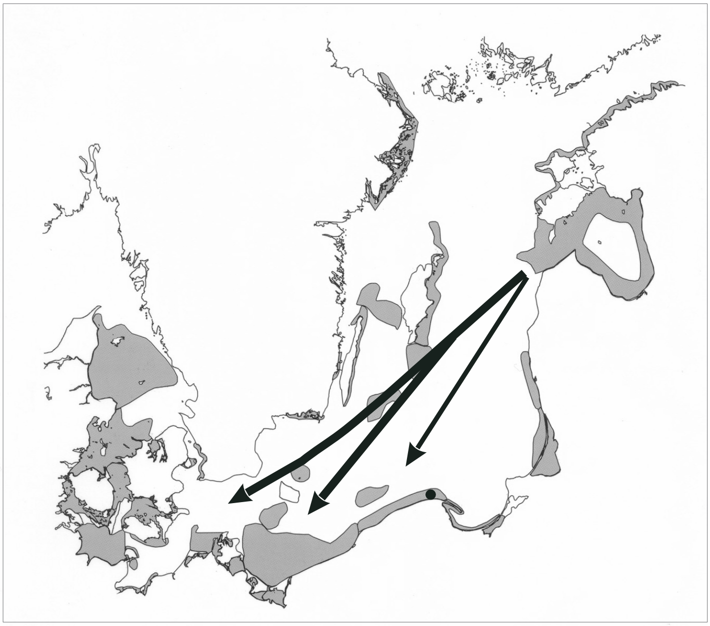

Fig. 13. Hypothetical migration flyways of waterfowl in the region

Table 10
Number of waterfowl passing the Rozewie observation point at different times of day

| | Morning | Midday | Afternoon | Total |
|---|---|---|---|---|
| **Benthophages** | | | | |
| Velvet Scoter *Melanitta fusca* | 7 | 3 | 1 | 11 |
| Common Scoter *Melanitta nigra* | 92 | 58 | 29 | 179 |
| Common Eider *Somateria mollissima* | 47 | 112 | 11 | 170 |
| **Ichthyophages** | | | | |
| Black-throated Diver *Gavia arctica* | 1 | | | 1 |
| Divers *indet. Gavia sp.* | 1 | | | 1 |
| Great Crested Grebe *Podiceps cristatus* | 4 | 3 | | 7 |
| Goosanger *Mergus merganser* | 22 | 133 | | 155 |
| Cormorant *Phalacrocorax carbo* | 245 | 110 | 9 | 364 |
| **Others** | | | | |
| Skuas *indet*. *Stercorarius sp.* | | 3 | | 3 |
| Mute Swan *Cygnus olor* | | 14 | | 14 |
| Mallard *Anas platyrhynchos* | | | 6 | 6 |
| Tufted Duck *Aythya fuligula* | 30 | | | 30 |
| Marsh Harrier *Circus aeruginosus* | 1 | | 1 | 2 |
| Grey Heron *Ardea cinerea* | 1 | | | 1 |
| **Total** | **451** | **436** | **57** | **944** |
| [%] | 47.8 | 46.2 | 6.0 | 100.0 |
| **Individuals/hour** | **29.6** | **31.1** | **4.6** | **22.6** |

## DISCUSSION

### The study area as part of the Baltic Sea winter-quarters of waterfowl

Before evaluating a defined location from the point of view of its suitability for wind farm investments, first the larger area surrounding it should be studied with respect to the migration and wintering system, and only later should local peculiarities be considered. Reliable evaluation of different parts of the Baltic Sea is difficult because of the very different coverage of the area by investigations. For example, Danish and German waters have been thoroughly studied using coast observations, ship surveys and aerial monitoring, while some other areas have been under-studied.
Among waters with the poorest coverage is the central Polish coast, where our study area was located. The only available prior data come from a single ship cruise and are undoubtedly imprecise and unreliable. This wholly insufficient data set was the basis for estimations made by Durinck *et al*. (1994) and given in *NATURA 2000* (PLB990002) project documentation. Estimations in these sources are sometimes highly varied, e.g. Durinck *et al*. (*op. cit*.) estimated density of the Velvet Scoter at 42.9 ind./km$^2$, while the *NATURA 2000* estimate was 12.5 ind./km$^2$, i.e. four times less. The average density of this species within the study area was 23.0 ind./km$^2$. For another species, the Long-tailed Duck, estimations by these authors differ by only 10%, but the density of the species in the present study is four times lower. These differences may be due to an insufficient basis for estimations, different areas taken under consideration, and local variation that cannot be shown in large-scale estimations. This strongly underscores the absolute necessity of intensive evaluation of the entire area that can be designated for use for wind energy projects. Only detailed research can indicate which areas are safe enough for birds when used for investments, and such studies are in fact being conducted.

In the general classification by Durinck *et al.* (*op. cit*.), the Polish Baltic coast was ranked 12$^{th}$ among 39 listed, within a numerous group (ranks 6-16) having moderately high scores (15.57 pts., compared to 101.23 pts. for the 5$^{th}$ rank). At the same time, another Polish maritime area (the Pomeranian Bay) is ranked second.

Despite problems with reliable comparisons, published numbers seem to be overestimated. However, it cannot be ruled out that the area studied was an especially ‘empty’ location; within this area the average density is only 30.9% of the values given in the *NATURA 2000* project (Table 11). Many observations suggest that the central and eastern parts of the Polish Baltic coast are missed by waterfowl migrating from the north-eastern parts of the Baltic to western and south-western parts of the sea (Fig. 13). However, this is still a hypothesis that should be tested by more extensive and detailed studies.

Table 11
Comparison of the wind farm area with important bird areas on the Baltic Sea

| | Area km$^2$ | Total | Ind./km$^2$ | *C. hyemalis* | Ind./km$^2$ | *M. fusca* | Ind./km$^2$ |
|---|---|---|---|---|---|---|---|
| Hoburgs Bank* | 1 645 | 925 770 | 562.8 | 925 120 | 562.4 | – | – |
| Pomeranian Bay* | 8 800 | 1 722 150 | 195.7 | 803 000 | 91.3 | 357 210 | 40.6 |
| Kiel Bay* | 3 130 | 449 540 | 143.6 | 90 000 | 28.8 | – | – |
| Szczecin* | 3 000 | 411 140 | 137.0 | – | – | 41 300 | 13.8 |
| Gulf of Riga* | 12 000 | 1 503 440 | 125.3 | 1 095 000 | 91.3 | 336 000 | 28.0 |
| Northern Kattegat* | 10 500 | 1 242 120 | 118.3 | – | 0.0 | 82 000 | 7.8 |
| Gotland* | 2 575 | 262 400 | 101.9 | 236 500 | 91.8 | – | – |
| Polish coast* | | | | | 89.9 | | 49.2 |
| Natura 2000** | **2 116** | 247 000 | **116.7** | 217 000 | **102.6** | 26 500 | **12.5** |
| STUDY AREA | 16.2 | | 52.0 | | 29.1 | | 23.0 |
| **FARM AREA** | **4.5** | | **36.1** | | **12.6** | | **21.3** |
| in relation to NATURA | 0.21% | | 30.9% | | | | |

* after Durinck *et al.* 1994; ** after NATURA 2000 PLB990002

## Local distribution patterns

In addition to the characteristics of the larger region, it is essential to know the local peculiarities of the distribution of birds. Even in a region generally important for birds, local conditions (e.g. water depth, geology, or feeding conditions) may make a particular location designated for a wind farm sufficiently safe for the bird population. Conversely, an area that is generally not of great importance for birds may contain special sites where high concentrations of birds can be found. Such situations cannot be predicted with high probability without first conducting special research at the site. The present evaluation is an excellent example, as within the study area there are places where bird concentrations are quite high and others with permanently low densities. Similar were conclusions by Meissner (2010), although documented using different presentation method.

The species composition found in the area is consistent with accidental observations done here at of the end of the 1960s and beginning of the 1970s and again at the end of the 1980s and beginning of the 1990s, and is associated with patterns in feeding conditions. More than 93% of the birds observed were of only two species: Long-tailed Duck and Velvet Scoter. The Common Scoter and Herring Gull had shares of more than 1%. The first of these species was associated with the shallowest waters, while Herring Gulls were associated with fishing activity.

The average densities in the study area can be described as moderate. The highest concentrations of waterfowl were near the coast and to the east of the planned wind farm location. However, sometimes larger flocks of Velvet Scoter visited the area.

Comparison of the same season in two subsequent years shows a considerable fluctuation in densities from year to year, but it is still unknown whether this reflects actual changes in numbers (e.g. caused by feeding conditions – Kube and Skov 1996) or weakness of the sampling, i.e. too few cruises in relation to the very dynamic process of bird migration. This aspect is still not well understood and requires further study.

The results of the observations show that the waterfowl migration is not too intensive here, especially in comparison with the data from the eastern Baltic. All gulls and terns migrate along the seashore. Here too intensive migration of waterfowl was not very intensive – it seems that they miss the area and shorten their way from the north-eastern Baltic to western and south-western parts of the sea by flying directly over the open sea. According to Kontkanen (1996), the Long-tailed Duck can migrate during the night, but such migration should be accompanied by diurnal migration as well. This was not found during the observations, at least in the area studied.

The relatively small differences in the numbers of birds observed in flight in winter and during migration periods suggest that actual migration is weak here and most of the birds seen were making local feeding movements.

The results of the research show that the location studied is relatively unattractive to waterfowl (about 31% of the average density estimated in the *NATURA 2000* project) and lies adjacent to areas that are more attractive (around 70% of the average), but still not very important for birds.

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APPENDIX Table I

Distribution of Long-tailed Ducks in the study area in successive seasons. Densities in sectors are given as numbers of individuals per km²

| Early autumn | | Transects | | | |
|---|---|---|---|---|---|
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 0.0 | 3.0 | 0.0 | 0.0 |
| | 5 | 0.7 | 1.5 | 0.0 | 0.0 |
| | 4 | 0.0 | 0.7 | 0.0 | 0.0 |
| | 3 | 0.0 | 0.0 | 0.0 | 3.7 |
| South | 2 | 0.0 | 0.0 | 1.5 | 2.2 |
| | 1 | 0.0 | 59.3 | 75.6 | 117.0 |
| Late autumn | | Transects | | | |
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 0.0 | 0.0 | 1.5 | 0.4 |
| | 5 | 1.1 | 0.0 | 0.4 | 27.0 |
| | 4 | 0.0 | 0.4 | 1.1 | 8.5 |
| | 3 | 0.0 | 0.0 | 0.0 | 16.3 |
| South | 2 | 0.0 | 0.4 | 1.9 | 5.9 |
| | 1 | 1.1 | 125.2 | 412.2 | 305.6 |
| Winter | | Transects | | | |
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 10.4 | 6.9 | 26.7 | 95.9 |
| | 5 | 0.0 | 0.0 | 5.2 | 142.2 |
| | 4 | 0.0 | 11.1 | 12.6 | 148.1 |
| | 3 | 0.0 | 2.2 | 5.6 | 19.3 |
| South | 2 | 4.4 | 20.0 | 5.2 | 20.4 |
| | 1 | 0.0 | 64.4 | 89.3 | 24.8 |
| Early spring | | Transects | | | |
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 27.2 | 4.1 | 120.4 | 9.3 |
| | 5 | 4.9 | 0.4 | 4.1 | 155.2 |
| | 4 | 5.4 | 8.1 | 7.4 | 104.4 |
| | 3 | 6.9 | 13.0 | 14.8 | 73.3 |
| South | 2 | 2.0 | 3.7 | 7.0 | 64.8 |
| | 1 | 0.0 | 8.5 | 18.1 | 41.9 |

Table II cont.

| Late spring | | Transects | | | |
|---|---|---|---|---|---|
| | | West | | East | |
| | Sectors | 1<br>18°00’ | 2<br>18°06’ | 3<br>18°12’ | 4<br>18°18’ |
| North | 6 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 5 | 0.0 | 0.0 | 0.0 | 1.0 |
| | 4 | 0.0 | 0.0 | 0.0 | 4.4 |
| | 3 | 1.0 | 1.0 | 1.0 | 3.0 |
| South | 2 | 2.0 | 0.0 | 2.0 | 0.0 |
| | 1 | 5.9 | 1.0 | 1.0 | 26.2 |

APPENDIX Table II

Distribution of Velvet Scoters in the study area in successive seasons. Densities in sectors are given as numbers of individuals per km$^2$

| Early autumn | | Transects | | | |
|---|---|---|---|---|---|
| | | West | | East | |
| | Sectors | 1<br>18°00’ | 2<br>18°06’ | 3<br>18°12’ | 4<br>18°18’ |
| North | 6 | 0.0 | 0.0 | 2.2 | 0.0 |
| | 5 | 0.0 | 1.5 | 15.6 | 0.0 |
| | 4 | 0.0 | 5.2 | 0.0 | 0.0 |
| | 3 | 16.3 | 3.7 | 0.0 | 0.0 |
| South | 2 | 71.1 | 56.3 | 0.0 | 0.0 |
| | 1 | 14.1 | 7.4 | 0.0 | 0.0 |
| Late autumn | | Transects | | | |
| | | West | | East | |
| | Sectors | 1<br>18°00’ | 2<br>18°06’ | 3<br>18°12’ | 4<br>18°18’ |
| North | 6 | 3.7 | 0.0 | 0.0 | 0.0 |
| | 5 | 0.7 | 0.0 | 1.5 | 5.2 |
| | 4 | 7.8 | 2.6 | 21.1 | 11.9 |
| | 3 | 28.5 | 11.5 | 9.3 | 19.6 |
| South | 2 | 31.1 | 67.8 | 32.6 | 23.3 |
| | 1 | 175.6 | 25.2 | 3.0 | 8.1 |
| Winter | | Transects | | | |
| | | West | | East | |
| | Sectors | 1<br>18°00’ | 2<br>18°06’ | 3<br>18°12’ | 4<br>18°18’ |
| North | 6 | 1.5 | 51.1 | 18.1 | 5.9 |
| | 5 | 0.0 | 32.6 | 75.6 | 9.3 |
| | 4 | 34.1 | 57.0 | 5.9 | 73.3 |
| | 3 | 20.7 | 4.4 | 23.7 | 1.1 |
| South | 2 | 34.1 | 23.7 | 18.9 | 0.7 |
| | 1 | 28.9 | 19.3 | 34.8 | 7.4 |

Table II cont.

| Early spring | | Transects | | | |
|---|---|---|---|---|---|
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 2.5 | 6.3 | 1.5 | 0.7 |
| | 5 | 2.5 | 7.8 | 6.7 | 3.3 |
| | 4 | 23.2 | 8.5 | 6.3 | 5.9 |
| | 3 | 49.9 | 14.8 | 26.7 | 6.7 |
| South | 2 | 38.0 | 15.9 | 21.9 | 3.0 |
| | 1 | 42.5 | 31.9 | 43.3 | 14.1 |
| **Early autumn** | | **Transects** | | | |
| | | West | | East | |
| | Sectors | 1<br>18°00′ | 2<br>18°06′ | 3<br>18°12′ | 4<br>18°18′ |
| North | 6 | 0.0 | 4.0 | 0.0 | 0.0 |
| | 5 | 4.0 | 3.0 | 0.0 | 0.0 |
| | 4 | 0.0 | 1.0 | 0.0 | 0.0 |
| | 3 | 2.0 | 20.7 | 4.0 | 0.0 |
| South | 2 | 6.4 | 5.9 | 10.9 | 0.0 |
| | 1 | 3.5 | 4.4 | 3.0 | 0.0 |

APPENDIX Table III
Species composition and numbers of birds observed flying in the Dębki area in autumn of 2003 and 2004

| | October | | November | | | | **Total** |
|---|---|---|---|---|---|---|---|
| | 4 Oct. 2004 | 25 Oct. 2004 | 4 Nov. 2004 | 14 Nov. 2003 | 28 Nov. 2003 | 29 Nov. 2004 | |
| **Diving benthophages** | | | | | | | |
| Long-tailed Duck *Clangula hyemalis* | | 16 | 278 | 66 | 124 | 83 | **567** |
| Velvet Scoter *Melanitta fusca* | 2 | 73 | 68 | 34 | 11 | 29 | **217** |
| Common Scoter *Melanitta nigra* | 8 | 13 | | 2 | | | **23** |
| Common Eider *Somateria mollissima* | | | 2 | 151 | 2 | 2 | **157** |
| **Diving ichthyophages** | | | | | | | |
| Black-throated Diver *Gavia arctica* | 1 | 1 | 1 | | | | **3** |
| Red-throated Diver *Gavia stellata* | | | | 3 | | 1 | **4** |
| Divers *indet. Gavia sp.* | | 2 | 5 | 1 | 4 | 2 | **14** |
| Goosanger *Mergus merganser* | | | | | 25 | | **25** |
| Red-breasted Merganser *Mergus serrator* | | | | 2 | 4 | | **6** |
| Cormorant *Phalacrocorax carbo* | 2 | | | | | | **2** |
| **Others** | | | | | | | |
| Herring Gull *Larus argentatus* | 19 | 36 | 77 | 46 | 82 | 50 | **310** |
| Common Gull *Larus canus* | 1 | 2 | 1 | 4 | 3 | 2 | **13** |
| Great Black-backed Gull *Larus marinus* | | 2 | 2 | 2 | 2 | 1 | **9** |
| Little Gull *Larus minutus* | | 1 | | | | | **1** |
| Kittiwake *Rissa tridactyla* | | | | 1 | | | **1** |
| Black Tern *Chlidonias niger* | 1 | | | | | | **1** |
| Swans *indet. Cygnus sp.* | | | | 3 | | | **3** |
| Widgeon *Anas penelope* | | 30 | | | | | **30** |
| Mallard *Anas platyrhynchos* | 15 | | | | | | **15** |
| Tufted Duck *Aythya fuligula* | | | 1 | | | | **1** |
| **Total** | **49** | **176** | **435** | **315** | **257** | **170** | **1402** |
| **Individuals/hour** | **12.3** | **44.0** | **108.8** | **78.8** | **64.3** | **42.5** | **58.4** |

APPENDIX Table IV
Species composition and numbers of birds observed flying in the Dębki area in winter 2003/2004

| | December | | January | February | **Total** |
|---|---|---|---|---|---|
| | 9 Dec. 2003 | 30 Dec. 2003 | 27 Jan. 2004 | 27 Feb. 2004 | |
| **Diving benthophages** | | | | | |
| Long-tailed Duck *Clangula hyemalis* | 45 | 93 | 190 | 124 | **452** |
| Velvet Scoter *Melanitta fusca* | 49 | 87 | 72 | 102 | **310** |
| Common Scoter *Melanitta nigra* | 12 | 3 | 5 | 8 | **28** |
| Common Eider *Somateria mollissima* | | | | 17 | **17** |
| **Diving ichthyophages** | | | | | |
| Black-throated Diver *Gavia stellata* | 2 | 1 | | | **3** |
| Divers *indet. Gavia sp.* | | 1 | 4 | | **5** |
| Cormorant *Phalacrocorax carbo* | | | | 1 | **1** |
| **Others** | | | | | |
| Great Black-backed Gull *Larus marinus* | | 2 | | | **2** |
| Herring Gull *Larus argentatus* | 19 | 38 | 34 | 17 | **108** |
| Common Gull *Larus canus* | 2 | 2 | 4 | | **8** |
| Whooper Swan *Cygnus cygnus* | | 6 | | | **6** |
| Swans *indet. Cygnus sp.* | | 2 | | | **2** |
| **Total** | **129** | **235** | **309** | **269** | **942** |
| **Individuals/hour** | **64.5** | **58.8** | **77.3** | **67.3** | **58.9** |

APPENDIX Table V
Species composition and numbers of birds observed flying in the Dębki area in spring 2004

| | 5 March | 28 March | 5 April | 20 April | 5 May | **Total** |
|---|---|---|---|---|---|---|
| **Diving benthophages** | | | | | | |
| Long-tailed Duck *Clangula hyemalis* | 60 | 195 | 180 | 46 | 12 | **493** |
| Velvet Scoter *Melanitta fusca* | 18 | 220 | 176 | 59 | 45 | **518** |
| Common Scoter *Melanitta nigra* | | 2 | 3 | 5 | 80 | **90** |
| **Diving ichthyophages** | | | | | | |
| Black-throated Diver *Gavia arctica* | 1 | | 3 | 5 | 3 | **12** |
| Red-throated Diver *Gavia stellata* | | | 3 | | | **3** |
| Divers *indet. Gavia sp.* | 2 | 1 | 7 | | 8 | **18** |
| Cormorant *Phalacrocorax carbo* | | | | | 1 | **1** |
| **Others** | | | | | | |
| Great Black-backed Gull *Larus marinus* | | 1 | | | | **1** |
| Herring Gull *Larus argentatus* | 9 | 25 | 20 | 14 | 14 | **82** |
| Common Gull *Larus canus* | 1 | | 11 | | | **12** |
| Black-headed Gull *Larus ridibundus* | | | 1 | | | **1** |
| Little Gull *Larus minutus* | | | 6 | 1 | 18 | **25** |
| Kittiwake *Rissa tridactyla* | | | | | 2 | **2** |
| Black Tern *Chlidonias niger* | | | | | 11 | **11** |
| **Total** | **91** | **444** | **410** | **130** | **194** | **1269** |
| **Ind./hour** | **22.8** | **148.0** | **102.5** | **32.5** | **48.5** | **66.8** |

APPENDIX Table VI
Species composition and numbers of birds observed flying in the Dębki area in winter within subsequent sectors

| | Distance from the shore [km] | | | | | | **Total** |
|---|---|---|---|---|---|---|---|
| | 1.5-3.8 | 3.8-5.1 | 5.1-7.4 | 7.4-9.7 | 9.7-12.0 | 12.0-14.3 | |
| Sectors: | 1 | 2 | 3 | 4 | 5 | 6 | |
| **Diving benthophages** | | | | | | | |
| Long-tailed Duck *Clangula hyemalis* | 165 | 101 | 98 | 52 | 15 | 21 | **452** |
| Velvet Scoter *Melanitta fusca* | 62 | 82 | 75 | 66 | 20 | 5 | **310** |
| Common Scoter *Melanitta nigra* | 28 | | | | | | **28** |
| Common Eider *Somateria mollissima* | 7 | 10 | | | | | **17** |
| **Diving ichthyophages** | | | | | | | |
| Black-throated Diver *Gavia stellata* | | 1 | | 2 | | | **3** |
| Divers *indet. Gavia sp.* | 1 | 1 | 3 | | | | **5** |
| Cormorant *Phalacrocorax carbo* | 1 | | | | | | **1** |
| **Others** | | | | | | | |
| Great Black-backed Gull *Larus marinus* | 1 | | 1 | | | | **2** |
| Herring Gull *Larus argentatus* | 21 | 12 | 18 | 19 | 26 | 12 | **108** |
| Common Gull *Larus canus* | | 1 | 2 | 1 | 4 | | **8** |
| Whooper Swan *Cygnus cygnus* | 6 | | | | | | **6** |
| Swans *indet. Cygnus sp* | 2 | | | | | | **2** |
| **Total** | **294** | **208** | **197** | **140** | **65** | **38** | **942** |
| **Individuals/hour** | **108.9** | **77.0** | **73.0** | **51.9** | **24.1** | **14.1** | **58.9** |

APPENDIX Table VII
Species composition and numbers of birds observed flying in the Dębki area in autumn within successive sectors

| | Distance from the shore [km] | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | 1.5-3.8 | 3.8-5.1 | 5.1-7.4 | 7.4-9.7 | 9.7-12.0 | 12.0-14.3 | |
| Sectors: | 1 | 2 | 3 | 4 | 5 | 6 | |
| **Diving benthophages** | | | | | | | |
| Long-tailed Duck *Clangula hyemalis* | 185 | 96 | 90 | 57 | 84 | 55 | **567** |
| Velvet Scoter *Melanitta fusca* | 22 | 58 | 65 | 41 | 18 | 13 | **217** |
| Common Scoter *Melanitta nigra* | 15 | 3 | | | | 5 | **23** |
| Common Eider *Somateria mollissima* | 155 | 2 | | | | | **157** |
| **Diving ichthyophages** | | | | | | | |
| Black-breasted Diver *Gavia arctica* | | 3 | | | | | **3** |
| Red-breasted Diver *Gavia stellata* | | 4 | | | | | **4** |
| Divers *indet. Gavia sp.* | 1 | | 2 | 5 | 1 | 5 | **14** |
| Goosanger *Mergus merganser* | | | | | | 25 | **25** |
| Red-breasted Merganser *Mergus serrator* | | 5 | 1 | | | | **6** |
| Cormorant *Phalacrocorax carbo* | | 1 | | | | 1 | **2** |
| **Others** | | | | | | | |
| Great Black-backed Gull *Larus marinus* | | 3 | 2 | 1 | 3 | | **9** |
| Herring Gull *Larus argentatus* | 54 | 47 | 57 | 58 | 61 | 33 | **310** |
| Common Gull *Larus canus* | 3 | 2 | 1 | 2 | 4 | 1 | **13** |
| Little Gull *Larus minutus* | | | | | | 1 | **1** |
| Kittiwake *Rissa tridactyla* | | 1 | | | | | **1** |
| Black Tern *Chlidonias niger* | | 1 | | | | | **1** |
| Swans *indet. Cygnus sp.* | | | 3 | | | | **3** |
| Widgeon *Anas penelope* | | | | 30 | | | **30** |
| Mallard *Anas platyrhynchos* | | | | | 3 | 12 | **15** |
| Tufted Duck *Aythya fuligula* | | 1 | | | | | **1** |
| **Total** | **435** | **227** | **221** | **194** | **174** | **151** | **1402** |
| **Individuals/hour** | **108.8** | **56.8** | **55.3** | **48.5** | **43.5** | **37.8** | **58.4** |

APPENDIX Table VIII
Species composition and numbers of birds observed flying in the Dębki area in spring within subsequent sectors

| Sectors: | Distance from the shore [km] | | | | | | **Total** |
|---|---|---|---|---|---|---|---|
| | 1.5-3.8 | 3.8-5.1 | 5.1-7.4 | 7.4-9.7 | 9.7-12.0 | 12.0-14.3 | |
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| **Diving benthophages** | | | | | | | |
| Long-tailed Duck *Clangula hyemalis* | 203 | 63 | 109 | 42 | 33 | 43 | **493** |
| Velvet Scoter *Melanitta fusca* | 150 | 88 | 92 | 112 | 60 | 16 | **518** |
| Common Scoter *Melanitta nigra* | 55 | 35 | | | | | **90** |
| **Diving ichthyophages** | | | | | | | |
| Black-breasted Diver *Gavia arctica* | 8 | | 1 | 1 | | 2 | **12** |
| Red-breasted Diver *Gavia stellata* | 1 | | 1 | 1 | | | **3** |
| Divers *indet. Gavia sp.* | | 9 | 3 | 3 | 2 | 1 | **18** |
| Cormorant *Phalacrocorax carbo* | 1 | | | | | | **1** |
| **Others** | | | | | | | |
| Great Black-backed Gull *Larus marinus* | | | | | | 1 | **1** |
| Herring Gull *Larus argentatus* | 23 | 16 | 15 | 10 | 6 | 12 | **82** |
| Common Gull *Larus canus* | 1 | 3 | 4 | 1 | 3 | | **12** |
| Black-headed Gull *Larus ridibundus* | | | | 1 | | | **1** |
| Little Gull *Larus minutus* | | | 2 | 3 | 14 | 6 | **25** |
| Kittiwake *Rissa tridactyla* | | | | | 2 | | **2** |
| Black Tern *Chlidonias niger* | 11 | | | | | | **11** |
| **Total** | **453** | **214** | **227** | **174** | **120** | **81** | **1269** |
| **Individuals/hour** | **142.9** | **67.5** | **71.6** | **54.9** | **37.9** | **25.6** | **66.8** |

APPENDIX Table IX

Details of observations made in summer 2002 at the Rozewie observation point

| | 27 Jul. | 30 Jul. | 2 Aug. | 5 Aug. | 9 Aug. | 12 Aug. | 16 Aug. | 20 Aug. | 24 Aug. | 27 Aug. | 31 Aug. | 4 Sep. | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Benthophages** | | | | | | | | | | | | | |
| Velvet Scoter *Melanitta fusca* | 2 | | | 2 | 1 | | | | | | 1 | 5 | **11** |
| Common Scoter *Melanitta nigra* | 15 | 7 | 36 | 23 | | 11 | | 25 | 12 | | 1 | 49 | **179** |
| Common Eider *Somateria mollissima* | | 75 | 51 | 3 | 20 | 6 | | 1 | 12 | 2 | | | **170** |
| **Ichthyophages** | | | | | | | | | | | | | |
| Black-throated Diver *Gavia arctica* | | | | | | | | | 1 | | | | **1** |
| Divers indet. *Gavia sp.* | | | | | | 1 | | | | | | | **1** |
| Great Crested Grebe *Podiceps cristatus* | 2 | | 3 | 2 | | | | | | | | | **7** |
| Goosander *Mergus merganser* | 13 | 11 | 90 | | 5 | 6 | | 1 | 6 | 4 | 19 | | **155** |
| Cormorant *Phalacrocorax carbo* | 114 | 14 | 86 | 6 | 16 | 21 | | 67 | 15 | 7 | 11 | 7 | **364** |
| **Others** | | | | | | | | | | | | | |
| Skuas indet. *Stercorarius sp.* | | | | | | | | | | 3 | | | **3** |
| Mute Swan *Cygnus olor* | 14 | | | | | | | | | | | | **14** |
| Mallard *Anas platyrhynchos* | | | | | | 6 | | | | | | | **6** |
| Tufted Duck *Aythya fuligula* | 16 | | | 11 | 3 | | | | | | | | **30** |
| Marsh Harrier *Circus aeruginosus* | | | | | | | | 1 | | | | 1 | **2** |
| Grey Heron *Ardea cinerea* | | | 1 | | | | | | | | | | **1** |
| **Total** | **176** | **107** | **267** | **47** | **45** | **51** | **0** | **95** | **46** | **16** | **32** | **62** | **944** |
| Number of observation hours per day | 5:30 | 4:15 | 4:00 | 3:30 | 3:00 | 3:00 | 3:00 | 3:00 | 3:00 | 3:00 | 3:00 | 3:30 | **41:45** |
| **Individuals/hour** | **32.0** | **25.2** | **66.8** | **13.4** | **15.0** | **17.0** | **0.0** | **31.7** | **15.3** | **5.3** | **10.7** | **17.7** | **22.6** |