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Ministry of the Environment · Denmark

Construction of a fixed link across Fehmarnbelt: preliminary risk assessment on birds

Commissioned by The Danish Ministry of Transport and Energy, and the German Federal Ministry of Transport, Building and Housing

Institut für Vogelforschung "Vogelwarte Helgoland", Inselstation

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Data sheet

Title:	Construction of a fixed link across Fehmarnbelt: preliminary risk assessment on birds
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Publisher:	National Environmental Research Institute © Ministry of the Environment
Year of publication:	June 2005
Commissioned by:	The Danish Ministry of Transport and Energy, and the German Federal Ministry of Transport, Building and Housing©
Financial support:	The European Commission
Editor:	Tommy Asferg
Referee:	Henning Noer
Layout:	Karin Balle Madsen
Proofreading:	Else-Marie Nielsen
Drawings:	Grafisk Værksted, Silkeborg
Number of pages:	86

Contents

Summary

In this report surveys and literature on bird occurrences, which could potentially be affected by the construction and operation of a fixed link across Fehmarnbelt, have been compiled. Both the Danish and German part of Fehmarnbelt hold several breeding, moulting, staging and wintering waterbird species, which occur in internationally, nationally and regionally important numbers. In addition, the entire Fehmarnbelt is placed on a main migration route of mainly waterbirds, raptors and passerines. Denmark and Germany have obligations to protect these species according to international conventions, the Wild Birds Directive and national red lists.

A cable-stayed bridge with two connecting low bridges or an immersed tunnel could be feasible solutions for a fixed link. In a preliminary risk assessment these two alternatives are considered in the report.

An immersed tunnel will not be associated with collision risk for birds, whereas collisions with the super-structures are expected to occur as a permanent effect of a cable-stayed bridge. The annual migrations during spring and autumn are predicted to be the most prominent source of collisions both in the Danish and German parts of Fehmarnbelt, although local movements between foraging areas and/or roosting sites must also be considered in a future Environmental Impact Assessment (EIA). The experience from different kinds of man-made structures in coastal and offshore environments suggests that mainly passerines suffer from collisions although these may also involve waterbirds and raptors. Although birds are likely to show avoidance responses as they approach a structure, periods of poor visibility (at night and in foggy conditions) could in particular constitute situations of enhanced collision risk.

Habitat modifications of feeding or nursery grounds, which mainly refer to wintering, staging, moulting and breeding waterbirds, could occur. In a bridge or tunnel solution, temporal and local effects on bird occurrences caused by disturbance, the removal of food resources and sediment spill are possible effect scenarios during the construction phase. Sediment spill effects associated with the construction of a bridge is expected to be restricted to areas extending from bridge piers, and thus these effects are likely to be smaller than the local effects caused by an immersed tunnel.

In a technical solution involving a cable-stayed bridge or a tunnel, benthic habitats and thus potential food resources for birds may recover after the construction period. Hence, effects of food reductions during the construction phase is likely to be temporary. However, firm predictions of effects of habitat modification must await a decision on the exact alignment of the fixed link and scenarios of dredging, sediment spill and sedimentation. The most important areas with respect to occurrences of moulting, staging, wintering and breeding birds are assessed to be Albue Bank, the Rødsand Inlet and offshore areas, Flüggesand, Hohwachter Bucht and Sagas Bank.

Many of the bird species which occur in Fehmarnbelt are subject to other man-induced mortality or habitat changes. The preliminary risk assessement suggests that a future impact from a fixed link could be relatively low compared to other man-induced impact, although this conclusion needs to be supported by further insight into bird occurrences in Fehmarnbelt and thorough analyses of the nature of the population dynamics and the status of conservation of individual species at risk of impact.

A priori, mitigating actions to reduce a potential impact on bird population are possible. At least during specific weather conditions with high migration intensity and low visibility, it is recommended to use a minimum of flood-light on the fixed link within the standards defined by authorities in order to reduce the risk of collisions both during construction and operation. If possible, flood-lights should point away from the approach direction of migratory birds. Flash-lights presumably cause fewer collisions than continuous lights. Wire markers mounted on the cables of a bridge may also reduce collision risk for birds at least during daytime. Markers which may potentially be effective at night includes lights, reflectors and acoustic signals. With respect to habitat modification, thorough control of sediment spill would lower the risk of effects on food resources of birds.

1 Introduction

On 23 June 2004, the Ministers of Transport in Denmark and Germany signed a joint declaration, in which they agreed that a fixed link across Fehmarnbelt would create considerable improvement of transportation of goods and people between Denmark/Scandinavia and Germany/the European Continent. A cable-stayed bridge with a four lane motorway and two railway tracks could be a feasible solution, although an immersed tunnel is an alternative. The Ministers agreed to carry out comprehensive studies of the environment before the start of the project. In this respect, the first step involves that the ministries of Transport with significant contributions from the ministries of environment in Denmark and Germany provide a public consultation process, in which environmental aspects relevant to the fixed link construction are dealt with. Eventually, an environmental impact assessment must be carried out to conform to EU-legislation.

During the mid-1990's a feasibility study was carried out to provide the first assessment of a fixed link across Fehmarnbelt (see summary report, Danish Ministry of Transport 1999). The background for the summary report was provided by several technical reports, which dealt with specific issues of the technical, economic and environmental aspects. The environmental investigations involved birds.

In the technical report concerning birds, new and existing data were compiled to describe abundance and distribution of birds during the period 1987-1997 (Skov *et al.* 1998). This study confirmed Fehmarnbelt as an important area for breeding, staging, wintering and moulting waterbirds. It was also confirmed that Fehmarnbelt is situated on a main migration route of waterbirds, which migrate between their breeding and wintering areas. In addition, Fehmarnbelt is traversed by substantial numbers of migrating birds coming from the direction of the mainland areas. According to its high importance for bird migration, the existing bridge/ferry-link between central Europe and Scandinavia is popularly called 'Vogelfluglinie' and 'Fugleflugtslinien ' in Germany and Denmark, respectively. After the feasibility study was carried out, comprehensive bird studies have been undertaken in both the Danish and German part of Fehmarnbelt.

In the light of the presence of substantial amounts of new relevant data, the forthcoming public consultation process and an extensive environmental impact assessment, the purposes of this report are:

- To make a compilation of surveys and literature of the most important occurrences of breeding, moulting, staging, wintering and migrating birds to assign species into categories of international, national and regional importance within the German and Danish part of Fehmarnbelt, which could potentially be affected by the construction and operation of a fixed link.

- To make a preliminary assessment of the risk of impacts posed by the proposed fixed link on bird species, based on relevant existing knowledge
- To make a preliminary assessment of the contribution of impacts on relevant species posed by the proposed fixed link relative to impacts from other sources (cumulative impacts)
- To make a preliminary assessment of potential mitigating actions
- To present the findings in a report supported by the European Commission and requisitioned by the Ministry of Transport and Energy in Denmark together with the German Federal Ministry of Transport, Building and Housing, providing: a) an initial knowledge base to facilitate decision making in relation to the link, and b) a starting point for a future EIA

After the introduction (chapter 1) and a presentation of the data and rationale behind this preliminary risk assessment (chapter 2), the structure of this report largely follows the first 4 items presented above (chapters 3-7).

Although the final technical solution has not been decided upon yet, an immersed tunnel and a cable-stayed bridge combined with two connecting low bridges were suggested as two viable alternatives to which the preliminary risk assessment in this report has been considered. No decision has been made concerning the exact alignment of the fixed link. County authorities in Denmark (Storstrøms Amt) have reserved a corridor in their regional planning for a fixed link east of Rødbyhavn near the existing motorway termination. A potential solution of a cable-stayed bridge extending from Rødbyhavn to Puttgarden across the shipping lane of Fehmarnbelt (T-route) has previously been investigated in the feasibility study. This included a main bridge of 3.2 km with towers combined with two connecting low bridges of 6.0 km (southern bridge to Germany) and 9.3 km (northern bridge to Denmark). Hence, in a solution with a cable-stayed bridge, the low bridge parts are expected to constitute the majority of the alignment.

2 Methods

2.1 Selection of area and species

The Danish part of Fehmarnbelt covered in the present description of bird occurrences largely follows the area defined by Skov *et al.* (1998), *i.e.* the marine areas south of Lolland and Falster from Albue Bank to Gedser Odde (Fig. 1). On Danish territory, the Hyllekrog-Rødsand area comprises the only marine area, in which birds are protected according to international conventions or EU-directives (Appendix 1): part of Special Protection Area (SPA) no. 83, Special Area of Conservation (SAC) no. 152 and Ramsar area no. 25 and (Fig. 1). In addition, three areas in the Rødsand Inlet were designated as wildlife reserves according to national Danish government order: Hyllekrog, Nysted Nor and Rødsand.

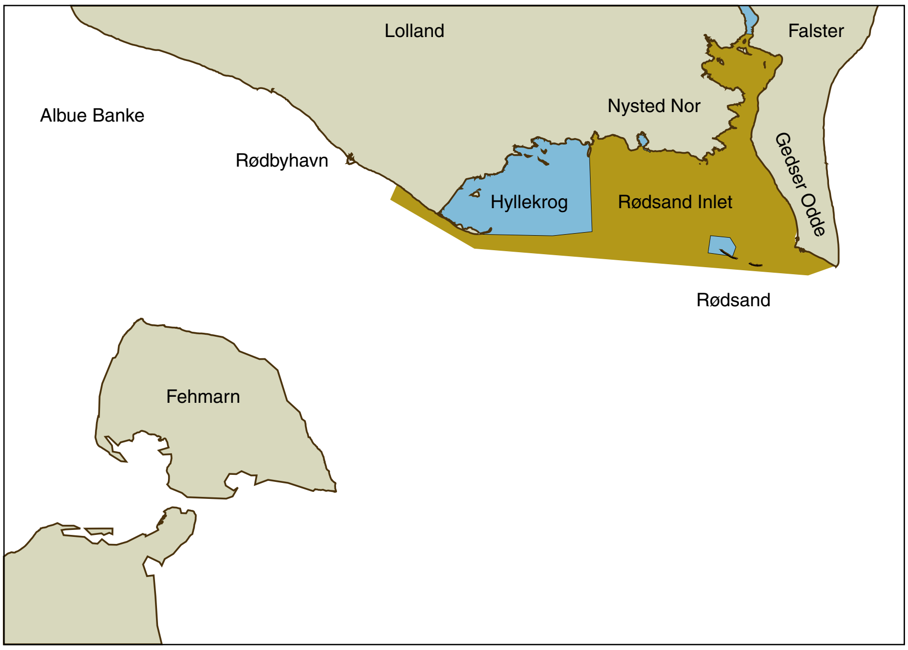

Figure 1. Map of Fehmarnbelt with names of Danish locations referred to in the text. The yellow signature shows the marine part of Special Protection Area (SPA) no. 83, Special Area of Conservation (SAC) no. 152, and Ramsar Area no. 25 and the dark blue signature delineates the same protection categories, which in addition are designated as wildlife reserves (Hyllekrog, Nysted Nor and Rødsand).

The German part of the Fehmarnbelt area is here defined as the Fehmarn/Heiligenhafen area, including the island of Fehmarn, the surrounding offshore areas as visible from the shore (unless mentioned otherwise), the shores and interior lakes and ponds (Fig. 2). The island of Fehmarn is almost totally enclosed by existing and suggested Special Protection Areas (SPA) under the Wild Birds Directive (Appendix 1).

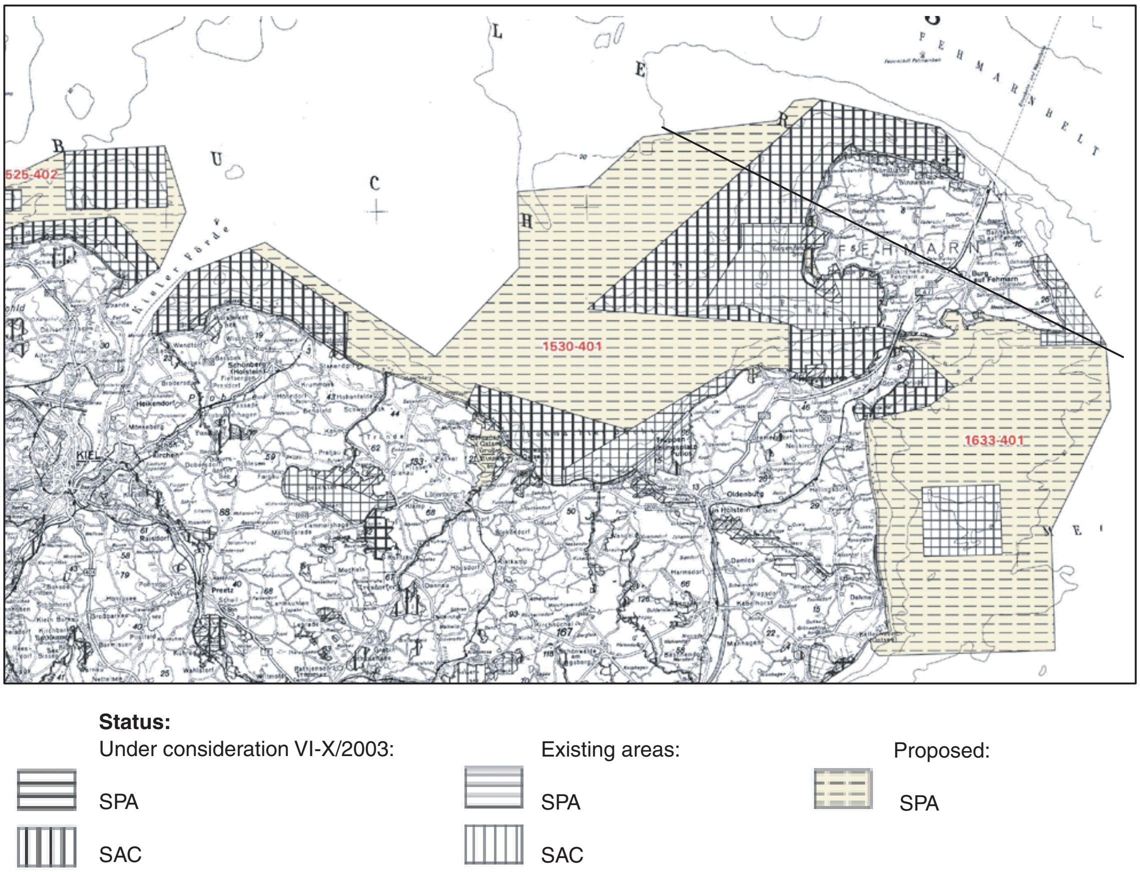

Figure 2. Existing and proposed Special Protected Areas (SPA, 'Europäische Vogelschutzgebiete') and Special Areas of Conservation (SAC, 'FFH-Gebiete') in the German Fehmarn area. The line denotes the separation of northern and southern Fehmarn used in the present report (see chapter 5), (map: Ministerium für Umwelt, Naturschutz und Landwirtschaft des Landes Schleswig-Holstein)

The two SPAs east of Kieler Förde proposed by the government of Schleswig-Holstein include already existing SPAs (Fig. 2). Since the EU-Commission reminded Germany to designate additional SPAs in March 2002, the two proposed SPAs in the study area may be designated in the near future. The proposed SPA "Östliche Kieler Bucht" (37,122 ha) encloses the already designated SPAs "Bottsand and Kolberger Heide" (5,584 ha), "Hohwachter Bucht" (7,901 ha), "West- und Nordküste Fehmarns" (23,690 ha) and the Nature Conservancy Area ("Naturschutzgebiet") "Kleiner, Großer und Sehlendorfer Binnensee" (486 ha). In total, the area of a new SPA will be 74,783 ha (http://natura2000.eformation.de/de/nps/pdf/vogelschutz/1530_401.pdf). The proposed SPA "Fehmarnsund/Ostküste Oldenburgs" (32,820 ha) will comprise the existing SPAs "Küste vor Staberhuk" (1,562 ha), "Ostbucht des Fehmarnsundes" (1,679 ha) and "Sagasbank" (3,238 ha) in total 39,299 ha (http://natura2000-.eformation.de/de/nps/pdf/vogelschutz/1633_401.pdf). Both proposed SPAs fulfil the Ramsar criteria (Appendix 1).

Within the study area, three sites were selected as Important Bird Areas (IBAs) by Sudfeldt *et al.* (2002): "East- and south-east coast of Fehmarn" (IBA SH017, 2,700 ha), "Eastern bight of the Fehmarn Sund" (IBA SH018, 2,930 ha) and "Eastern part of Kiel Bight" (IBA SH035, 59,800 ha). All these areas have partially been notified as SPAs (see above) and fulfil several criteria for their selection as IBAs (Doer *et al.* 2002).

The selection of species for description of offshore and coastal bird occurrences was extended compared to the feasibility study of birds (Skov *et al.* 1998). In particular, species that occur in protected areas were addressed in the present report. Furthermore, species were considered, for which SPA no. 83 was designated in the Danish part of Fehmarnbelt. This also included a proposal for future designation (Appendices 2 and 3). Finally, new important bird occurrences have been acknowledged since the feasibility study. For example, a monitoring programme in relation to the Nysted windfarm has shown that substantial numbers of cormorants and dark-bellied brent geese *Branta bernicla bernicla* occur in the Danish part of Fehmarnbelt during part of their annual life cycle (Desholm *et al.* 2003). For this reason these species are considered in the present report.

2.2 Data

The descriptions of bird occurrences and preliminary risk assessments are based on data and information compiled and published in technical reports and peer-review scientific papers. In addition, data were extracted from the survey databases at the National Environmental Research Institute in Denmark (NERI). Generally, counts based on visual observations of migrating birds may have been carried out less systematically than surveys of moulting, staging, wintering and breeding birds. The available information on visual observations of migrating birds may therefore rely on only partly coverage during migration periods. Hence, numbers may not reflect total occurrences of birds or precise phenology, although, presented as daily or seasonal maxima.

For Danish waters, surveys which were not available at the time of the feasibility study have been compiled by NERI, The Forest and Nature Agency and Storstrøms Amt (county authority). This includes an ongoing intensive monitoring programme of moulting, staging, wintering and migrating birds in relation to the Nysted offshore windfarm commissioned by the Danish production and energy trading company Energi E2 A/S (Kahlert *et al.* 2004b), a national survey of wintering waterbirds (Pihl *et al.* 2001), national surveys in the hunting free reserves (Clausen *et al.* 2004) and local annual counts of breeding waterbirds in coastal areas (Woolhead 2002).

For migratory birds, two published studies contributed mainly to the description of occurrences and distribution of birds. Christensen & Grell (1989) is the most thorough study with respect to absolute numbers of bird occurrences in autumn, since almost daily counts were carried out from 1 August - 31 October. The studies associated with the construction of the Nysted windfarm include both spring and autumn observations but only estimated numbers for selected species. In addition, due to use of radar, the Nysted wind farm studies comprise very detailed descriptions of flight trajectories of birds throughout the daily 24-hour period.

For moulting, staging and wintering birds, the initial feasibility study of a fixed link covered the entire Fehmarnbelt based on a review of existing data and a compilation of newly acquired data mainly based on counts from ships (Skov *et al.* 1998). Total numbers and densities were presented based on count surveys and attempts were made to correct for missed birds during the surveys. The other more recent studies presented count data from mainly the eastern part of the Danish Fehmarnbelt. Counts relied on a combination of land-based counts and aerial surveys mainly on inshore species (Pihl *et al.* 2001, Clausen *et al.* 2004).

Data on moulting, staging and wintering birds from Kahlert *et al.* (2004b) were entirely based on line transect aerial surveys. So far, no attempts have been made to correct for missed birds during these surveys due to the complex statistical implications associated with the line transect approach (see *e.g.* Hedley *et al.* 1999). Therefore, the numbers should be multiplied by an unknown factor (most likely 5 or less in the presented species) to obtain the order of magnitude in numbers. For Danish aerial surveys, which were not corrected for partial coverage, maximum numbers were used in the assessment of international or national importance. For other counts, mean values were used.

In the German part of the Fehmarnbelt comprehensive data were published recently: Numbers and species of migrants based on visual observations from the last decades were compiled by Koop (2004), whereas Hüppop *et al.* (2004) presented data on radar observations carried out only a few kilometres west of the harbour of Puttgarden in 2001. These observations using vertically and horizontally rotating ship radars were part of a project on behalf of The Federal Environmental Agency (Umweltbundesamt) to study potential effects of offshore windfarms on birds. Measurements were carried out around the clock during four periods: 23-31 March, 7-19 May, 27 August – 7 September and 8-15 October.

Numbers of moulting, staging and wintering birds were derived from Struwe-Juhl (2000) who compiled international waterbird counts during the years 1966/67 to 1995/96. Here, we only used the data for the period 1986/87 to 1995/96. Little information was available on numbers of waders. However, Kube & Struwe (1994) compiled data for simultaneous wader counts along the German Baltic coast in 1991.

Bird occurrences in the German part were assigned to two sub-areas: 1) A Belt part (N = north of the line Bojendorf-Staberhuk, see Fig. 2) and 2) A Sund part (S = south of this line). Recent numbers of breeding pairs in Nature Conservancy Areas were available for the years 1997 to 1999 (Knief *et al.* 2000, 2001). Additional data, including birds breeding outside these areas, were found in the breeding bird atlas for Schleswig-Holstein (Berndt *et al.* 2002). The data for this atlas were collected during the years 1985 to 1999, depending on the species. To derive numbers from the maps, the geometric means of the range categories were calculated. Further references for single species are given in the text.

To assess the importance of both the Danish and the German parts of Fehmarnbelt, a well-recognised criterion under the Ramsar convention has been adopted (Appendix 1). Thus, a site is recognised as internationally important for a species, if it occurs regularly at the site in a number, which exceeds 1% of the biogeographic population. Alternatively, a site could be of general international importance for waterbirds, if more than 20,000 individuals occur regularly (Delaney & Scott 2002).

This categorisation is usually used for wintering, staging and moulting birds. However, in this report the abundance of migratory birds was also compared with the biogeographic population estimates to make an assessment of the importance of the Danish and German part of Fehmarnbelt for migratory birds. The background information concerning population estimates for the biogeographic population of each selected species, which occurs in Fehmarnbelt, is presented in Appendix 4. Estimates and names of biogeographic populations were based on Wetlands International's latest update from 2002, in which further details of the distribution pattern of each species can be found (Delaney & Scott 2002).

If a species did not occur in internationally important numbers, it was explored whether it occurred in nationally important numbers. Criteria of national importance have not been defined, neither in Denmark nor in Germany. However, a 1% criterion was used in this report as a provisional definition of nationally important Danish bird occurrences. Danish national estimates for staging migrants are given Appendix 2.

A slightly different approach was used for the German part of Fehmarnbelt. Recent estimates of waterbirds and waders wintering in Germany (1990-2000) were presented by Wahl *et al.* (2003). However, we decided to relate the respective totals presented here to the German part of the Baltic as compiled by Garthe *et al.* (2003), since a geographical context should be preferred to a political one. Hence, ”regional importance” was fulfilled if a species in the study area reached at least 1% of the German Baltic total.

It is unknown how many birds of each species occur on migration on a national or regional scale. Therefore the national or regional importance of migratory occurrences could not be determined.

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3 General aspects of bird occurrences in Fehmarnbelt

Descriptions of bird occurrences have been assigned to two discrete chapters (4 and 5), which consider the Danish and German part of Fehmarnbelt, respectively, since these are the two relevant administrative units. However, some general aspects for both the Danish and German should be addressed. Thus, both Denmark and Germany have obligations to protect bird species according to international conventions, the Wild Birds Directive and national red lists. All species occurring in the Danish and German part of Fehmarnbelt are on global scale (IUCN-list) categorised as species of least concern, except white-tailed eagle *Haliaeetus albicilla*, which is assigned to the category 'Near Threatened'. Several species, which occur in Fehmarnbelt, are also listed on the annexes of the Wild Birds Directive. Annex 1 includes those species that are rare as breeding birds within EU member states, and thus necessitate special protection of these species or their habitats (see Appendix 4). The national red lists are catalogues of species which are rare, vulnerable, threatened or are considered as extinct in Denmark and Germany, respectively (NTCB 2005, Bauer *et al.* 2002). In Germany regional red lists also exist for the state of Schleswig-Holstein (Knief *et al.* 1995) and the German Baltic marine and shore region (Brenning *et al.* 1996).

In the present report bird occurrences in Fehmarnbelt have been divided into three categories: 1) migrating birds, 2) moulting, staging and wintering birds and 3) breeding birds, as these categories represent three useful units with respect to potential effects from a fixed link.

With respect to migrating birds both the Danish and German parts of Fehmarnbelt are situated on the important African-Eurasian migration route. The Fehmarnbelt is a bottleneck for bird migration in two ways. First, it is by far the closest connection for terrestrial birds crossing the Baltic Sea in spring and autumn, heading to their breeding sites in Fenno-Scandia and western Russia or to their wintering sites in west, south and central Europe as well as Africa. Second, the open Baltic Sea narrows in Fehmarnbelt. This leads to high concentrations of waterbirds on their migrations from the Fenno-Scandian and Russian breeding areas to mainly the westernmost Baltic Sea or the North Sea in autumn and vice versa during spring.

Studies in the German part suggested that mainly during daytime, migrating birds coming from the direction of the mainland areas (presumably terrestrial birds) tended to follow guiding lines ("Leitlinien") and tried to avoid crossing large water stretches. By contrast, there was a much higher tendency towards a broad-fronted migration pattern during the night (Fig. 3). The German term 'Vogelfluglinie' is elucidated by Figure 3, which shows four 'snapshots' of bird migration over a part of the western Baltic including Fehmarn and Lolland. While these snapshots may repre-

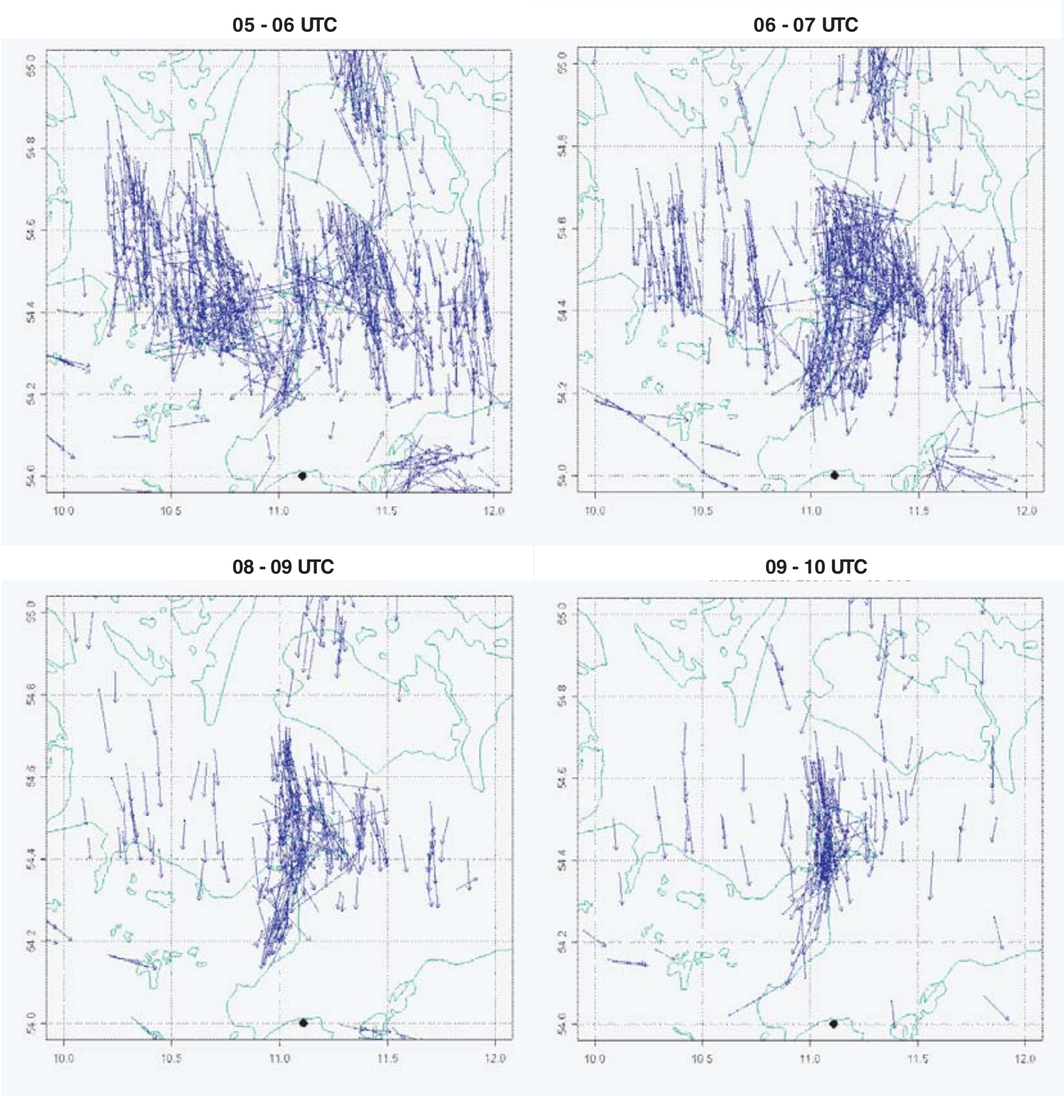

Figure 3. Transition from nocturnal broad-fronted migration to daytime guiding line migration as shown by analysis of data from a large scale military surveillance radar in Mecklenburg-Vorpommern (black dot) during the autumn. This kind of data is not appropriate for regional comparisons, *e.g.* birds migrating west of Fehmarn are to some extent shielded by the Bungsberg area. From Hill & Hüppop (2004). Time refers to Universal Time Coordinated (UTC).

sent a general pattern, it is important to stress that migration routes are highly dependent on weather conditions and show great variability. Thus, the guiding line effect on birds passing over land and having the choice of crossing a stretch of water is also likely to be affected by wind direction and speed (Alerstam 1978) as well as visibility conditions.

Flight directions of migration in Fehmarnbelt have been studied in both Denmark and Germany. At Danish Rødsand (see Fig. 1) waterbirds were generally orientated in westerly directions in autumn and easterly during spring (Fig. 4). Birds coming from the direction of the mainland areas migrated primarily in southerly directions in autumn, although the exact orientation is dependent on wind direction (see Skov *et al.* 1998).

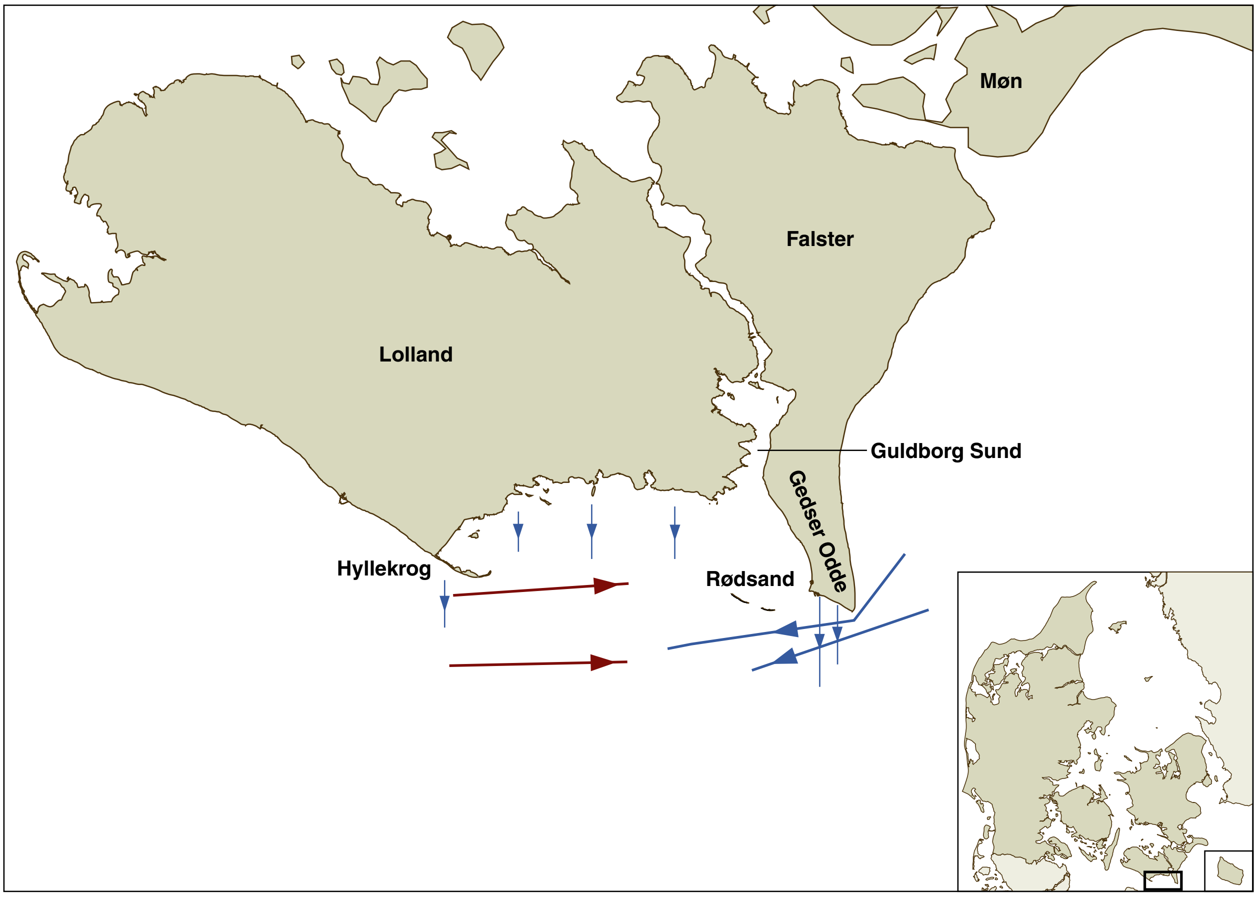

Figure 4. Schematic direction of terrestrial birds (thin arrows) and waterbirds (thick arrows) in the eastern part of Danish Fehmarnbelt. Blue arrows indicate autumn migration and red arrows spring migration. Modified from Kahlert *et al.* (2004b).

Comparable patterns were found close to Puttgarden (Hüppop *et al.* 2004, Fig. 5). Thus, in autumn the orientation of birds over the German part of Fehmarnbelt was mainly to the southwest (presumably terrestrial birds) and northwest (presumably waterbirds, Fig. 5). Moreover in spring, birds were orientated towards the northeast (presumably terrestrial birds) and to east and southeast (presumably waterbirds). Both in spring and autumn, there was considerable migration in other directions in the Danish and German part, indicating local movements, *e.g.* between feeding grounds (Fig. 5, Kahlert *et al.* 2000b).

Flight altitudes recorded with vertically rotating ship radar (for method see Hüppop *et al.* 2002) showed that migratory intensity at Fehmarn was highest within the lower 200 m above sea level throughout the daily 24 hour period and both during spring and autumn (Fig. 6). During spring migration many birds also used the range from 1,400 to 1,800 m above sea level (Fig. 6). Birds flying even higher could not be detected with sufficient accuracy using this type of radar. Generally, birds undertake migration at higher altitudes during the night compared to daytime (Eastwood 1965, Alerstam 1977). In several studies the influence of wind direction has been confirmed, *i.e.* in tailwind migration altitude is increased compared to periods of headwind (*e.g.* Eastwood 1965).

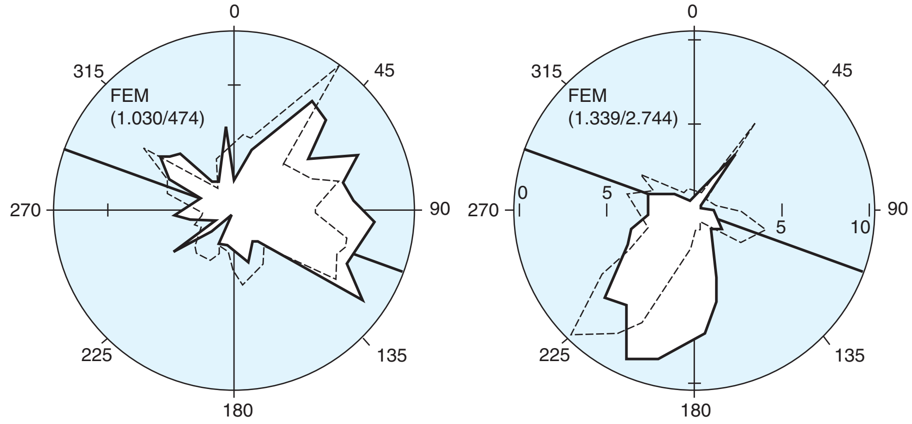

Figure 5. Orientation of bird migration at Fehmarn presented for day and night in spring (left) and autumn (right). Percentages of radar echoes are depicted for every 10°-interval. Night: solid line, day: broken line. The straight solid line for the location shows the coastline. From Hüppop *et al.* (2004).

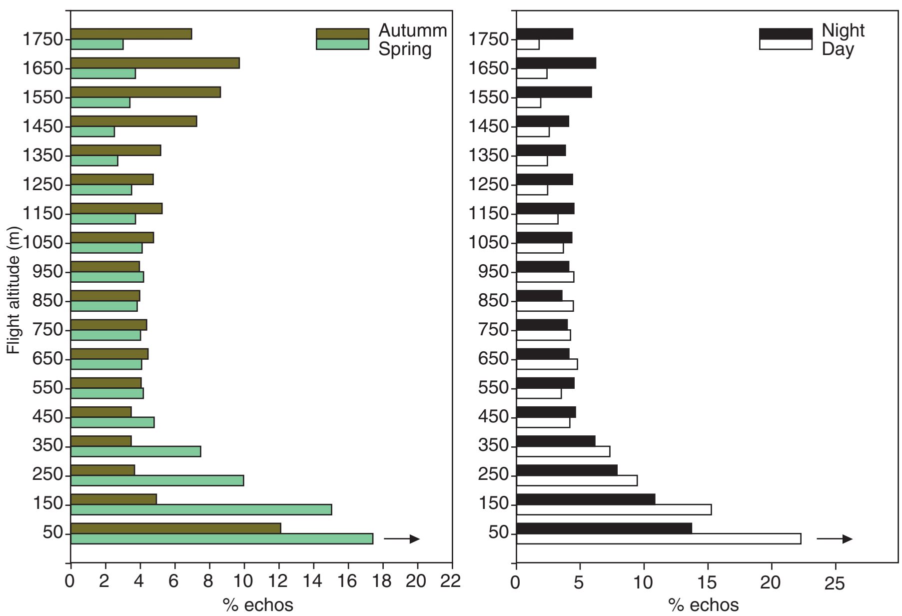

Figure 6. Flight altitudes (% echoes measured with a vertical radar) at Fehmarn, comparing spring and autumn (left) and comparing day and night (right). The arrows denote an underestimation of the lowest altitude level, since birds flying at low altitude cannot be separated from sea-surface radar reflections. From Hüppop *et al.* (2004).

During spring and autumn, migratory intensities in Fehmarnbelt varied considerably throughout the daily 24 hour period (Fig. 7). Daily maxima were recorded after sunset and after midnight. Moreover, a minimum of activity was observed in the early afternoon. Weather conditions determine migration intensity to a large extent. Tailwind has long been known as a main factor, which increases migration intensity (*e.g.* Green 2003). Furthermore, positive correlations between migration intensity and barometric pressure together with visibility have also been found, whereas precipitation, cloud cover and strong winds may reduce migration intensity (Geil *et al.* 1974, Alerstam 1978).

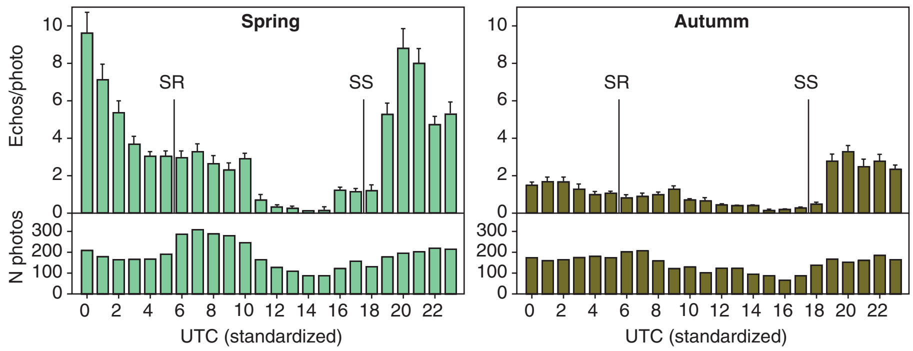

Figure 5. Migratory intensity based on measurements with a vertically rotating ship radar (number of echoes per photo; mean, SE) as a function of daytime (Universal Time Coordinated, UTC) during spring and autumn at the north coast of Fehmarn. The number of photos per hourly interval is shown below the graphs. The time represents the following periods: Example: UTC 8 = 08:00 to 08:59. SR = sunrise; SS = sunset. From Hüppop *et al.* (2004).

In Fehmarnbelt most radar echoes (equiv. to single birds or bird flocks) were found at night (Fig. 7). During spring and autumn, Rabøl *et al.* (1971) also found more intense migration activity at night compared to daytime. Typical nocturnal migrants are found amongst passerines (*e.g.* thrushes *Turdidae* and warblers *Sylviidae*), whereas *e.g.* swallows *Hirundinidae*, swifts *Apodidae*, larks *Alaudidae*, pipits and wagtails *Motacillidae* together with finches *Fringillidae* mainly or exclusively migrate during daytime. Amongst waterbirds, many waders and diving ducks (such as common scoter *Melanitta nigra*, long-tailed duck *Clangula hyemalis* and eider *Somateria mollissima*) are mainly daytime migrants but may also migrate in substantial numbers at night (*e.g.* Bauer & Glutz v. Blotzheim 1969, Alerstam *et al.* 1974, Glutz v. Blotzheim *et al.* 1977). Doves *Columbidae* and raptors *Falconiformes* are exclusively daytime migrants.

Compared to migrating birds, the behaviour of moulting, staging, wintering and breeding birds is different. Although these birds may also undertake local movements in Fehmarnbelt, they mostly stay in the area for a longer period (up to several months) to feed, rest or breed. Individual species amongst the moulting, staging and wintering birds have different preferences for specific food resources, which could potentially be affected by the construction of a fixed link across Fehmarnbelt (see chapter 6). Hence, in the appraisal of birds, which make stop-overs in the Danish or German part, the various species have been grouped according to their food preferences (chapters 4 and 5).

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4 The Danish part

4.1 Migrating birds

4.1.1 Waterbirds

During autumn, the migration route of waterbirds is well-described from land-based visual observations at Gedser Odde and in recent years also from an observation tower at Rødsand. Approximately 300,000 waterbirds were estimated to pass Gedser Odde and Rødsand during daytime in autumn (Christensen & Grell 1989, Kahlert *et al.* 2000b). Autumn migration of waterbirds is dominated by eider. In a recent review, the entire day- and nighttime migration of eider was estimated at 345,000 individuals each autumn in the Danish part of Fehmarnbelt (Desholm 2005). This is about one third of the entire Baltic-Wadden Sea population (Table 1, Appendix 4). The eider breeds in temperate, boreal and arctic regions in northern and western Europe down to the English Channel. Intensive migration occurs from the northern part of the breeding range to the wintering areas in southern Scandinavia and western Europe. In the area of concern the eider heads through the Fehmarnbelt from northeast to southwest during autumn. Eiders, which pass Gedser Odde and Rødsand are orientated in westerly directions and a portion of the eiders is therefore expected to pass south of Hyllekrog and further along the south coast of Lolland. Flight altitude of eider over the open North Sea is generally low with a median between 0 and 5 m (Garthe & Hüppop 2004). The low flight altitude was confirmed in the Baltic Sea, where only ca. 10-20% of the eiders occurred at altitudes higher than 30 m, however, dependent on wind conditions (Kahlert *et al.* 2000b). Similarly, at Helgoland only 3% of all eiders flew higher than 50 m, again depending on wind speed and direction (Dierschke & Daniels 2003).

Table 1. Estimated maximum numbers of seasonal totals of selected species passing Gedser Odde or Rødsand during autumn (A) and spring (S) migration and the proportional significance compared to the biogeographic population. *) Desholm 2005, **) Desholm *et al.* 2003, ***) Christensen & Grell 1989). For biogeographic populations - see Appendix 4.

Species	Estimated maximum number	Percentage of biogeographic population
Eider *Somateria mollissima* (A)	345,000*	29-41
Dark-bellied brent goose *Branta bernicla bernicla* (S)	9,000**	4.2
Wigeon *Anas penelope* (A)	21,057***	1.4
Pintail *Anas acuta* (A)	1,663***	2.8
Scaup *Aythya marila* (A)	7,763***	2.5
Little gull *Larus minutus* (A)	3,652***	3.6-5.5

Other duck species, such as wigeon *Anas penelope*, pintail *Anas acuta*, scaup *Aythya marila*, and little gull *Larus minutus* may also occur in significant numbers on autumn migration (Table 1). In addition, visual and radar studies have suggested that migration of geese (greylag geese *Anser anser*, dark-bellied brent geese and barnacle geese *Branta leucopsis*) occurs from the direction of Lolland and Falster or follow the conventional waterbird westbound migration route along the coast (*e.g.* Desholm *et al.* 2001).

Recent crude estimates suggested that the eider spring migration at Rødsand may potentially amount to the same order of magnitude as during autumn (Kahlert *et al.* 2004a). During spring, a significant eastbound migration of dark-bellied brent geese (Table 1) was described for the Rødsand Inlet. General knowledge of flight behaviour and winter occurrences suggested that these birds would pass through a wide stretch of the Danish part of Fehmarnbelt.

The presented occurrences of migrating waterbirds were based on visual observations from coastal areas. Observers are unlikely to detect most species beyond a range of 4-5 km. Radar studies at Rødsand showed that intense migration occurred beyond this range (*e.g.* Desholm *et al.* 2001). Some species such as divers and common scoters are typical offshore marine species, which in particular may undertake migration beyond the visual range of a land-based observer. Numbers derived from coastal observations could therefore be minimum estimates. A survey during 1988 suggested that migration of divers may occur in significant numbers at Gedser Odde (ca. 1,100 during the period 1 August to 31 October, Christensen & Grell 1989).

4.1.2 Terrestrial birds

During autumn, the southern shores of Lolland and Falster are passed by numbers of raptors, wood pigeons *Columba palumbus* and passerines. Many of the soaring raptors such as buzzards (*Buteo sp./Pernis apivorus*) that need the land-depending thermals for their migration are consequently funnelled into places that give them the shortest route across the Fehmarnbelt. For this reason many of these birds are migrating from the southernmost tips of Lolland and Falster during their southbound movements in the autumn. Therefore, Hyllekrog and Gedser Odde have long been known as the major sites of raptor migration (see Table 2 for occurrences at Hyllekrog). Soaring raptors typically start at high altitude (several hundred metres) before crossing stretches of water, and flight altitude gradually decreases as they glide.

At the west coast of Falster up to 48,000 wood pigeons were estimated in one day (Kahlert *et al.* 2002), and also at Hyllekrog several thousand individuals have been recorded during autumn migration (Table 2). Visible migration of wood pigeons over sea occurs mainly at altitudes > 50 m (83% in spring, 60% in autumn), and never below 10 m (Hüppop *et al.* 2004).

Table 2. Maximum number of autumn totals of raptors and wood pigeon recorded during the period 1984-1992 and 1994-1997 at Hyllekrog, after Skov *et al.* (1998) and Kahlert *et al.* (2000b).

Species	Maximum numbers
Honey buzzard *Pernis apivorus*	2,178
Red kite *Milvus milvus*	30
Marsh harrier *Circus aeruginosus*	52
Hen harrier *Circus cyaneus*	26
Goshawk *Accipiter gentilis*	3
Sparrowhawk *Accipiter nisus*	826
Buzzard *Buteo buteo*	2,452
Rough-legged buzzard *Buteo lagopus*	191
Osprey *Pandion haliaetus*	25
Kestrel *Falco tinnunculus*	27
Merlin *Falco columbarius*	29
Wood pigeon *Columba palumbus*	23,670

Passerines constitute a heterogeneous group of birds, which includes a number of species (probably more than 100), that could occur regularly on migration in Fehmarnbelt. The exact number of passerines migrating from the southern shores of Lolland and Falster is unknown. Christensen & Grell (1989) showed that a minimum of 200,000 passerines would pass Gedser Odde during daytime in the autumn. About half of the passerines were chaffinches *Fringilla coelebs* or bramblings *Fringilla montifringilla*. Skov *et al.* (1998) calculated a crude estimate, which suggested that up to 1.5 millions of birds may pass a sector, which is 5 km wide at Rødbyhavn. This estimate should be considered with caution, as the wind direction can change the migration routes and concentrate migration at various sites along the coastline of Lolland and Falster (see examples in Skov *et al.* 1998).

4.2 Moulting, staging and wintering birds

4.2.1 Birds feeding on bivalves

Amongst the offshore bird species, which mainly feed on bivalves, eider and long-tailed duck occur in numbers of national or international importance (Table 3). Main areas of eider are Albue Bank (Fig. 8) and the offshore areas south of the Rødsand Inlet (Fig. 9). According to Skov *et al.* (1998), eiders tended to abandon Albue Bank in January. This may explain why a recent survey in late January 2004 only revealed 640 individuals (NERI database) in contrast to an estimated 100,000 individuals in early winter in the 1990s (Table 3). Hence, during early winter eiders may occur in internationally important numbers at Albue Bank. However, this needs to be confirmed by additional counts. Long-tailed ducks are mainly distributed southeast of the Rødsand Inlet at Gedser Rev (Skov et *al.* 1998, Kahlert 2004b). The national total is probably an

Table 3. Numbers and relative importance of occurrences (I: international, N: national) for three waterbird species in the Danish part of Fehmarnbelt. Data used to assess the relative importance are bold. Percentages give the proportional significance of the occurrences compared to the national estimates. For international and national estimates - see Appendices 2 and 4. Sources: *) Pihl *et al.* 2001, Clausen *et al.* 2004 and NERI-database, **) NERI database, ***) Skov *et al.* 1998, ****) Kahlert *et al.* 2004b.

Species	Period	Albue Bank Mean	Rødsand (inlet/offshore) Max.	Mean	N	Importance	
Tufted duck *Aythya fuligula* *)	Winter	-	6,900	**3,617**	6	N	2.4%
Eider *Somateria mollissima* **)	Late Jan.	**640**	-	-	1	-	0.1%
Eider *S. mollissima* ***)	Early winter	**100,000**	-	-	-	I	18.2%
Eider *S. mollissima* ****)	Oct.April	-	**8,700**	1,638	20	N	1.6%
Long-tailed duck *Clangula hyemalis* ****)	Feb.March	-	**3,053**	954	10	N	(100%)

underestimate as a comparison with numbers at Rødsand suggested that all Danish birds may be found in this particular area.

n the Danish part of Fehmarnbelt common scoter does not occur numerously. Skov *et al.* (1998) did not report scoters from Albue Bank. In the Rødsand offshore parts between Hyllekrog and Gedser Rev, up to 400 individuals have been counted occasionally, and less than 150 birds regularly (Kahlert *et al.* 2004b).

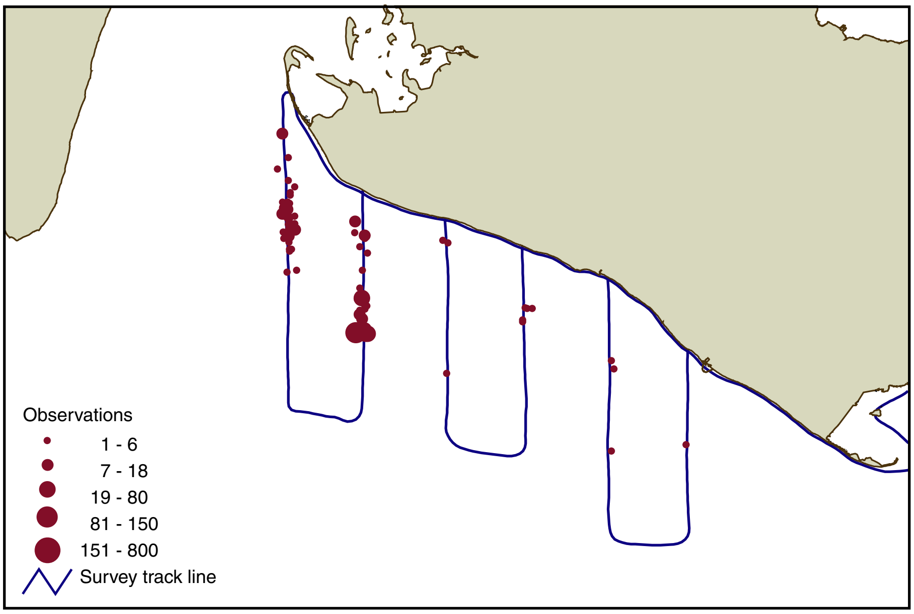

Figure 6. Distribution map of 640 eiders *Somateria mollissima* at Albue Banke in the western part of Danish Fehmarnbelt based on an aerial survey 26 January, 2004 (NERI database).

Wintering tufted ducks *Aythya fuligula*, which loaf on the lakes of interior Lolland during the day, also occur in Fehmarnbelt, primarily in the Rødsand Inlet, on their nocturnal foraging flights (Skov *et al.* 1998). Local movements between feeding and roosting areas occur at dusk or during the night (Berndt & Busche 1993). These movements mainly take place at altitudes less than 75 m, occasionally higher (Dirksen *et al.* 1998). Numbers may vary considerably, but surveys

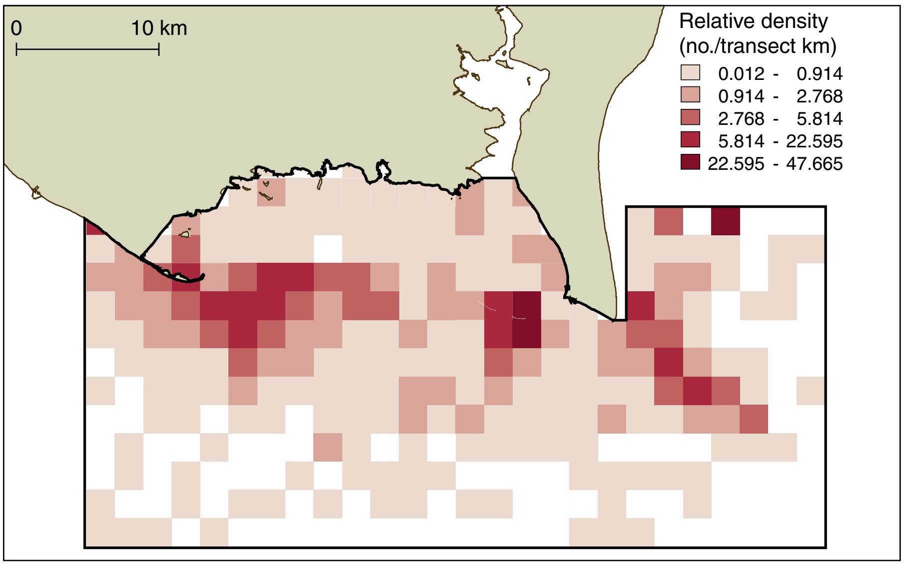

Figure 7. Cumulative distribution map of eider *Somateria mollissima* observations in the eastern part of Danish Fehmarnbelt based on 21 aerial surveys between August 1999 and August 2002. Data are expressed as relative densities measured as observations per kilometre of flown transect coverage for each survey in each 2 x 2 km grid square. Modified from Kahlert *et al.* (2004b).

during the period 1994-2001 showed that approximately 20,000 individuals occurred in the Maribo lakes on the average (Clausen *et al.* 2004). The proportion of these birds, which actually forage in the Rødsand Inlet, is presently unknown. Daytime counts in the Rødsand Inlet showed an average of ca. 3,600 individuals, which qualified the area to be of national importance for tufted duck. During cold spells associated with ice on the lakes, considerable numbers may occur in the Rødsand Inlet, *e.g.* 12,025 in January 2003. This suggested that the Rødsand Inlet could be of international importance for tufted duck during severe winters.

4.2.2 Birds feeding on invertebrates and plant material

This group of birds has a diverse diet of animal and plant food, although goldeneye *Bucephala clangula* may preferably feed on benthic invertebrates, shoveler *Anas clypeata* on non-benthic submerged invertebrates and pochard *Aythya ferina* on plant material. Goldeneye, shoveler and pochard are almost exclusively distributed in the Rødsand Inlet (Skov *et al.* 1998, Kahlert *et al.* 2004b), and all occur in nationally important numbers either during autumn or winter (Table 4).

Table 4. Numbers and relative importance of occurrences (I: international, N: national) for three waterbird species in the Danish part of Fehmarnbelt. Data used to assess the relative importance are bold. Percentages give the proportional significance of the occurrences compared to the national estimates. For international and national estimates - see Appendices 2 and 4. Sources: *) Pihl *et al.* 2001, Clausen *et al.* 2004 and NERI-database, **) Kahlert *et al.* 2004b.

Species	Period	Rødsand Inlet Max.	Rødsand Inlet Mean	N	Importance	
Shoveler *Anas clypeata*[*)]	Autumn	260	**94**	4	N	1.1%
Pochard *Aythya ferina*[*)]	Autumn	950	**599**	6	N	2.5%
Goldeneye *Bucephala clangula*[*)]	Late autumn	745	**352**	6	-	0.5%
Goldeneye *B. clangula*[**)]	Dec.-Feb.	**2,291**	934	9	N	3,5%

4.2.3 Birds feeding on submerged vegetation

Birds, which feed on submerged vegetation, are mainly found in the shallows of the Rødsand Inlet (Skov *et al.* 1998, Kahlert *et al.* 2004b), where extensive stands of preferred food items such as eelgrass *Zostera marina* and seagrass *Ruppia sp.* are found (Danish Ministry of Transport 1999).

Mute swan *Cygnus olor*, the most significant species in the Rødsand Inlet (Fig. 10), occurs in numbers of international importance. Dark-bellied brent goose occurs in nationally important numbers and coot *Fulica atra* may also be categorised as such (Table 5). Thus, the Rødsand Inlet holds numbers of the latter species, which was close to 1% of the national estimate. In addition, the Rødsand Inlet held on an average 3,234 individuals during the period 1992-1997, which would definitely qualify the numbers of coot to be nationally important (Pihl *et al.* 1997, Pihl *et al.* 2001, Clausen *et al.* 2004, NERI-database).

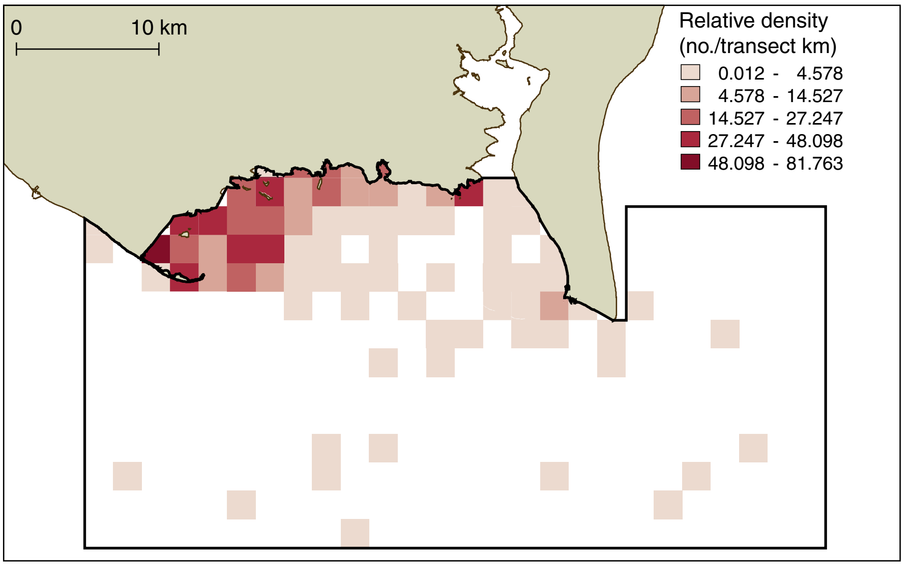

Figure 8. Cumulative distribution map of mute swan *Cygnus olor* observations in the eastern part of Danish Fehmarnbelt based on 21 aerial surveys between August 1999 and August 2002. Data are expressed as relative densities measured as observations per kilometre of flown transect coverage for each survey in each 2 x 2 km grid square. Modified from Kahlert *et al.* (2004b).

Table 5. Numbers and relative importance of occurrences (I: international, N: national) for three waterbird species in the Danish part of Fehmarnbelt. Data used to assess the relative importance are bold. Percentages give the proportional significance of the occurrences compared to the national estimates. For international and national estimates - see Appendices 2 and 4. Sources: *) Kahlert *et al.* 2004b , **) Pihl *et al.* 2001, Clausen *et al.* 2004 and NERI-database.

Species	Period	Rødsand Inlet Max.	Rødsand Inlet Mean	N	Importance	
Mute Swan *Cygnus olor**)*	Aug.	**9,529**	7,543	4	I	16.4%
Mute Swan *C. olor***)*	Aug.-Sept.	12,454	**10,482**	4	I	18.1%
Dark-bellied brent goose *Branta b. bernicla***)*	Spring	911	**218**	6	N	1.6%
Coot *Fulica atra***)*	Late autumn	2750	**1,757**	8	(N)	0.9%

At the southern coastline of Lolland west of Hyllekrog, the submerged vegetation is dominated by a red algae community (Danish Ministry of Transport 1999) not relevant to foraging birds and water depth quickly reaches more than 1 m in this area.

4.2.4 Birds feeding on fish

Amongst the fish eating species cormorant *Phalacrocorax carbo* occurs in internationally important numbers at a roost on the shoals of Rødsand (Table 6, Fig. 11). This substantial occurrence is most likely of recent origin, *e.g.* Skov *et al.* (1998) did not mention cormorant occurrences. The cormorants undertake social foraging bouts from the roost on Rødsand and Hyllekrog to the waters south of Lolland in flocks of up to several thousand individuals (Desholm *et al.* 2003). The extent of social foraging amongst cormorants is presently unknown west of Hyllekrog, but they may travel considerable distances (up to 50 km) to feed.

Table 6. Numbers and relative importance of occurrences (I: international, N: national) for three waterbird species in the Danish part of Fehmarnbelt. Data used to assess the relative importance are bold. Percentages give the proportional significance of the occurrences compared to the national estimates. For international and national estimates - see Appendices 2 and 4. Sources: *) Skov *et al.* 1998, **) Kahlert *et al.* 2004b, ***) Skov *et al.* 2000, ****) Kahlert *et al.* 2000b, Desholm *et al.* 2001, Kahlert *et al.* 2002, Kahlert *et al.* 2004b) *****) Pihl *et al.* 2001, Clausen *et al.* 2004 and NERI-database.

Species	Period	Entire Fehmarn-belt Mean	Rødsand offshore/inlet Max.	Rødsand offshore/inlet Mean	N	Importance	
Divers *Gavia sp.**)*	?	**2,250**	-	-	?	(N)	
Divers *Gavia sp.***)*	Jan.-Feb.	-	**52**	26	7	-	
Red-necked grebe *Podiceps grisegena****)*	Winter	-	**200**	-	?	N	5.6%
Red-necked grebe *P. grisegena**)*	Dec.-Jan.	-	**65**	15	10	N	1.8%
Cormorant *Phalacrocorax carbo*****)*	Sept.	-	5,170	**4,718**	4	I	10.9%
Red-breasted merganser *Mergus serrator******)*	Autumn	-	1,210	**500**	5	N	1.7%
Red-breasted merganser *M. serrator***)*	Nov.-March	-	**1,685**	267	15	N	5,6%

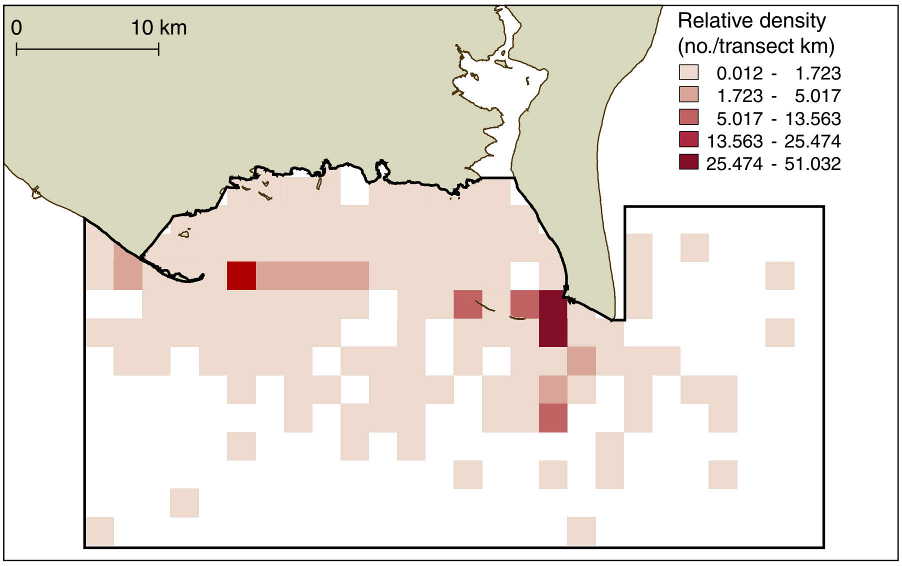

Figure 9. Cumulative distribution map of cormorant *Phalacrocorax carbo* observations in the eastern part of Danish Fehmarnbelt based on 21 aerial surveys between August 1999 and August 2002. Data are expressed as relative densities measured as observations per kilometre of flown transect coverage for each survey in each 2 x 2 km grid square. Modified from Kahlert *et al.* (2004b).

Skov *et al.* (1998) ranked the Rødsand Inlet and the adjacent offshore area as the most important staging and wintering area for red-breasted merganser *Mergus serrator* in the Baltic Sea, holding 8,000 and 4,000 individuals, respectively, during winter and spring. In recent years (1999-2003), internationally important numbers (1,700 individuals) only occurred on one occasion. Regular occurrences comprised numbers up to 300 individuals (Kahlert *et al.* 2004b). Hence, the Rødsand area is probably no longer of international importance for red-breasted merganser, but definitely of national importance. Due to lack of surveys it is unknown whether a redistribution occurred to other sites in the Danish part of Fehmarnbelt.

Up to 2,250 individuals of divers *Gavia sp.* were estimated for the entire Fehmarnbelt in the feasibility study (Skov *et al.* 1998). Specific estimates for the Danish part were not available. However, densities west of Hyllekrog were low (< 1 bird/km^2, Skov *et al.* 1998). At least two studies confirmed that parts of the Rødsand offshore areas were most important with densities generally up to 5 birds per km^2 (Durinck *et al.* 1994, Skov *et al.* 1998). Aerial transect counts carried out in relation to the Nysted offshore windfarm confirmed the presence of divers in the Rødsand offshore area. However, only up to 52 birds have been counted. Present knowledge therefore suggested that the Danish part of Fehmarnbelt is not of international importance, but could potentially be of national importance (Table 6). Median flight altitude for divers was estimated to 5-10 m (Garthe & Hüppop 2004).

Red-necked grebe *Podiceps grisegena* has by various surveys occurred in small, but nationally important numbers in the Rødsand area (Table 6).

Little is known of the food of little gulls during winter time, but besides fish they probably feed on marine invertebrates (Durinck *et al.* 1994). In Fehmarnbelt, they may feed while migrating through the area and have occasionally occurred in considerable numbers (up to 259 individuals) during surveys in the offshore parts (Kahlert *et al.* 2004b).

4.2.5 Birds feeding in terrestrial habitats

Amongst the bird species, which mainly feed on grass and agricultural crop in terrestrial habitats, SPA no. 83 (Rødsand Inlet) was originally designated as such based on the occurrences of whooper swan *Cygnus cygnus* and bean goose *Anser fabalis* (Appendix 2). Furthermore, the Danish Forest & Nature Agency proposed to include greylag goose on the list of species on which designation of SPA no. 83 should be based in the future.

Whooper swans occur in nationally important numbers in SPA no. 83 (Table 7). In addition, substantial numbers of geese feed in agricultural areas on Lolland and Falster. Many goose species are highly gregarious during the non-breeding season and occur in large flocks from a few dozens to several thousands on migration and in terrestrial feeding and roosting habitats. In staging and wintering areas, they feed in agricultural areas, saltmarshes and permanent grassland, but may also occur in shallow water, feeding on submerged vegetation. Movements of large flocks from one foraging area to another at low altitude can be observed. This may involve greylag geese (5,000-13,000 counted at the roost and moult site in Maribo Lakes, Clausen *et al.* 2004) and bean geese. Numbers of bean geese are highly variable but increase dramatically during severe winters and the species may occur in nationally important numbers (Jørgensen *et al.* 1994). Part of the goose occurrences on Lolland and Falster use the shoals of Rødsand as a roost (Skov *et al.* 1998) or may feed in terrestrial habitats of SPA no. 83.

Table 7. Numbers and relative importance of occurrences (N: national) of whooper swan in the Danish part of Fehmarnbelt. Data used to assess the relative importance are bold. Percentages give the proportional significance of the occurrences compared to the national estimates. For international and national estimates - see Appendices 2 and 4. Sources: Pihl *et al.* 2001, Clausen *et al.* 2004 and NERI-database.

Species	Period	Rødsand inlet/inland habitats Max.	Mean	N	Importance	
Whooper swan *Cygnus cygnus*	Winter	569	**231**	6	N	1.3%

4.3 Breeding birds

The most important breeding occurrences of waterbirds in the Danish part of Fehmarnbelt are found in the Rødsand Inlet (SPA no. 83). On Hyllekrog and the islets in the Rødsand Inlet, the breeding bird occurrences are dominated by herring gull *Larus argentatus*, arctic tern *Sterna paradisaea*, mute swan and eider (Table 8). All species except pintail are species of least concern according to the Danish red list (Table 8). Amongst the regularly occurring species herring gull and

Table 8. Selected breeding birds at Hyllekrog and the islets of Rødsand (SPA no. 83), which are omnivorous, feed on bivalves, submerged vegetation, invertebrates, plant material or fish in shallow or offshore water (Woolhead 2002), and their importance relative to national occurrences (% NO, Appendix 3, only calculated for regular occurrences). Moreover, the status of the selected species on the Danish Red List (LC = Least concern, NT = Near Threatened, NTCB 2005). Asterisk denotes species for which SPA no. 83 was designated (see Appendix 3).

Species	2000 (pairs)	2001 (pairs)	2002 (pairs)	% NO	Red List
Red-necked grebe *Podiceps grisegena*	3	0	2	-	LC
Mute swan *Cygnus olor*	88-93	95	66	1-2	LC
Greylag goose *Anser anser*	9-10	18-19	5-6	<1	LC
Mallard *Anas plathyrhynchus*	13-18	10-12	17-19	<1	LC
Garganey *Anas querquedula*	0	1	0	-	LC
Gadwall *Anas strepera*	2-4	5	4	1-2	LC
Pintail *Anas acuta*	1-3	0	0	-	NT
Shoveler *Anas clypeata*	9	5-6	5-6	<1	LC
Tufted duck *Aythya fuligula*	0	1	1	-	LC
Eider *Somateria mollissima*	699-723	438-453	566-583	2-3	LC
Red-breasted merganser *Mergus serrator*	6-10	10-12	2-4	<1	LC
Coot *Fulica atra*	3	3	7	<1	LC
Moorhen *Gallinula chloropus*	2-4	0	0	-	LC
Avocet *Recurvirostra avosetta**)	123-124	41	42-43	<1-2	LC
Great black-backed gull *Larus marinus*	11-12	14-16	19-20	1-2	LC
Lesser black-backed gull *Larus fuscus*	0-1	0	0	-	LC
Herring gull *Larus argentatus*	1360-1402	1994-1999	1925-1937	3-4	LC
Common gull *Larus canus*	40	14-18	8	<1	LC
Black-headed gull *Larus ridibundus*	15	0	1	-	LC
Arctic tern *Sterna paradisaea**)	64-65	44	69	<1	LC
Little tern *Sterna albifrons**)	0	2	0	-	LC

eider are the most important species as more than 2% of the national occurrences breed on the islets of the Rødsand Inlet.

Amongst the species mainly associated with habitats on the mainland, white-tailed eagle, marsh harrier *Circus aeruginosus*, bittern *Botaurus stellaris* and short-eared owl *Asio flammeus* were proposed to be included on the species list on which the designation of SPA no. 83 should be based. White-tailed eagle breeds on Lolland with at least 3 pairs (Grell *et al.* 2004) and occurs regularly in the Rødsand Inlet. Marsh harrier and bittern breed locally. Most likely short-eared owl does not breed annually in the area. On the Danish red list, all these species are categorised as species of least concern, except short-eared owl, which is assessed to be vulnerable (NTCB 2005).

5 The German part

5.1 Migrating birds

5.1.1 Waterbirds

Visual observations on the numbers of migratory waterbird species have been summarised by Koop (2004), (Table 9). The most abundant species at Fehmarn during migration is the eider with daily maxima of more than 100,000 individuals and an estimated annual total of 300,000 individuals, which constitute a large proportion of the Baltic-Wadden Sea population. Also barnacle goose *Branta leucopsis* and dark-bellied brent goose occur in numbers that exceed 1% of the populations. Other numerically important species comprise other ducks such as wigeon and common scoter. In addition, several species of gulls such as the black-headed *gull Larus ridibundus* pass the German part of the Fehmarnbelt during migration (Table 9). Since the daily maxima at Fehmarn always refer to one location at the island only, they are minimum numbers, which show a fraction of the entire migration over Fehmarn only. Under the assumption that slightly lower numbers will pass on other days, the seasonal totals can be expected to exceed the 1% level in several other species.

5.1.2 Terrestrial birds

Observations on the numbers of migratory terrestrial bird species, passing Fehmarn from northeast to southwest during autumn and vice versa during spring, have been summarised by Koop (2004), (Table 10). The terrestrial migrants comprise mainly passerines. Particularly high daily maxima of chaffinch and brambling have been recorded. Also based on daily maxima, the most abundant terrestrial species excluding passerines are wood pigeon, buzzard *Buteo buteo* and honey-buzzard *Pernis apivorus*.

Table 9. Maximum counts of selected migrating coastal waterbird species at Fehmarn (Koop 2004) and the proportional significance compared to the biogeographic population. The daily maxima at Fehmarn always refer to one location at the island only. Thus they are minimum numbers, which show a fraction of the entire migration over Fehmarn only. * = calculated from migratory intensity.

Species	Date	Daily max.	Annual total	Percentage of biogeographic population (daily max /annual total)
Red-throated diver *Gavia stellata*	11.02.1956	1,000		
Black-throated diver *Gavia arctica*	15.10.1985	9		
Bewick's swan *Cygnus columbianus*	11.04.1960	92		
White-fronted goose *Anser albifrons*	24.10.1981	990		
Greylag goose *Anser anser*	08.10.1991	1,400		
Barnacle goose *Branta leucopsis*	15.10.1993	12,068	50,000	3.4 / 13.9
Dark-bellied brent goose *Branta b. bernicla*	11.10.1974	10,710	50,000	5.0 / 23.3
Wigeon *Anas penelope*	18.09.1981	3,600		
Pintail *Anas acuta*	13.09.1987	200		
Eider *Somateria mollissima*	09.10.1975	158,000	300,000 *	13.2-18.6 / 25.0-35.3
Common scoter *Melanitta nigra*	05.08.1960	4,000		
Red-breasted merganser *Mergus serrator*	24.09.1983	110		
Dunlin *Calidris alpina*	29.08.2001	130		
Bar-tailed godwit *Limosa lapponica*	01.06.1987	110		
Little gull *Larus minutus*	02.05.2004	191		
Black-headed gull *Larus ridibundus*	04.05.1978	1,200		
Common gull *Larus canus*	25.03.2002	137		
Sandwich tern *Sterna sandvicensis*	27.07.2002	144		
Common tern *Sterna hirundo*	26.08.2003	270	800 (2003)	

Table 10. Maximum numbers of selected terrestrial migrating bird species at Fehmarn (Koop 2004). The daily maxima at Fehmarn always refer to one location at the island only. Thus they are minimum numbers, which show a fraction of the whole migration over Fehmarn only. * = calculated from migratory intensity.

Species	Date	Daily max.	Annual total
Honey buzzard Pernis apivorus	24.-28.08.1990	5,068	5,000
Red kite Milvus milvus	31.03.2001	20	
White-tailed eagle Haliaeetus albicilla	05.04.2003	2	6 (2003)
Marsh harrier Circus aeruginosus	31.08.1994	40	
Hen harrier Circus cyaneus	13.10.1985	6	
Sparrowhawk Accipiter nisus	27.08.1990	440	10,300 *
Buzzard Buteo buteo	02.10.1954	7,000	
Rough-legged buzzard Buteo lagopus	09.10.1975	18	
Osprey Pandion haliaetus	11.09.1975	18	54 (2002)
Kestrel Falco tinnunculus	17.09.1977	34	
Merlin Falco columbarius	12.10.2001	13	
Hobby Falco subbuteo	17.09.1977	34	50
Peregrine falcon Falco peregrinus	11.09.2002	5	12 (2003)
Crane Grus grus	02.04.2003	32	
Stock pigeon Columba oenas	02.10.1955	250	
Wood pigeon Columba palumbus	15.10.1999	21,680	
Swift Apus apus	27.08.2000	450	
Wood lark Lullula arborea	21.03.1999	11	
Sky lark Alauda arvensis	14.03.1981	3,000	
Sand martin Riparia riparia	22.08.2001	5,500	70,000 *
Barn swallow Hirundo rustica	28.08.2000	1,600	
House martin Delichon urbica	29.08.2001	450	
Tree pipit Anthus trivialis	28.08.2000	600	
Meadow pipit Anthus pratensis	20.04.1998	2,730	27,800 *
Yellow wagtail Motacilla flava	21.05.1975	5,000	
White/Pied wagtail Motacilla alba	08.04.1971	200	6,400 *
Fieldfare Turdus pilaris	11.04.1952	375	15,000-20,000
Redwing Turdus iliacus	24.10.1971	3,000	
Blue tit Parus caeruleus	15.10.1975	500	
Great tit Parus major	17.10.2003	601	
Jay Garrulus glandarius	02.10.1955	1,200	
Jackdaw Corvus monedula	21.11.1976	600	
Rook Corvus frugilegus	21.11.1976	2,000	
Carrion/Hooded crow Corvus corone	26.10.1955	245	
Common starling Sturnus vulgaris	11.04.1960	4,372	
Chaffinch Fringilla coelebs	10.10.1999	90,000	300,000 *
Brambling Fringilla montifringilla	23.04.2001	23,065	
Greenfinch Carduelis chloris	09.10.1955	1,000	
Goldfinch Carduelis carduelis	25.04.1998	380	
Siskin Carduelis spinus	23.04.2001	6,580	
Linnet Carduelis cannabina	02.10.1961	1,138	
Common crossbill Loxia curvirostra	28.09.1990	300	
Reed bunting Emberiza schoeniclus	29.08.1981	200	

5.2 Moulting, staging and wintering birds

On the average, a total of about 62,000 individuals of 37 coastal waterbird species, feeding on bivalves, invertebrates, plant material, submerged vegetation or fish, stay during winter in the area of Fehmarn/Heiligenhafen in the German part of Fehmarnbelt. In general, the number of wintering birds is much higher in the Sund part (the southwestern shore from Staberhuk to Bojendorf, see Figure 2 and interior ponds like, *e.g.* Wallnau, Flügger Teiche and fish ponds in the southwest) than in the Belt part (the northeastern shore from Bojendorf to Staberhuk and shore lakes such as Nördlicher Binnensee, Grüner Brink and Fastensee). The Sund part also connects with Flüggesand, Hohwachter Bucht and Sagas Bank, which the feasibility study suggested to be the most important areas for seaducks (Skov *et al.* 1998).

5.2.1 Birds feeding on bivalves

Numbers of wintering tufted duck and scaup reach regional importance in the Fehmarn/Heiligenhafen area. Wintering eider even classifies this area as internationally important (Table 11), which on a regional scale holds 12% of all German Baltic wintering eiders. The maximum wintering numbers of the three mentioned species correspond to 38%, 44% und 58% of the German Baltic wintering occurrences. In total, a mean number of 40,000 individuals of six coastal waterbird species, feeding on bivalves, is found in the German part of Fehmarnbelt during winter.

Table 11. Maximum and mean numbers of three bivalve-feeding wintering coastal waterbird species of international and regional importance (I, R) and the total of six coastal waterbird species feeding on bivalves as counted at the German part of Fehmarnbelt. Count data (rounded) are from the period 1986/87 to 1995/96 (Struwe-Juhl 2000). R-percentages give the proportional significance of the total Fehmarn mean compared to the regional population (German Baltic) according to count data of Garthe *et al.* (2003).

	N Fehmarn		S Fehmarn		Total Fehmarn			
Species	Max.	Mean	Max.	Mean	Max.	Mean	Importance	
Tufted Duck *Aythya fuligula*	8,900	760	51,400	5,600	60,300	6,360	R	4.0%
Scaup *Aythya marila*	11,000	360	38,000	2,150	49,000	2,510	R	2.3%
Eider *Somateria mollissima*	68,600	8,940	71,000	20,400	139,600	29,340	I	2.9%
Total of 6 species		10,000		30,000		40,000		

All species which feed on bivalves, invertebrates and plant material are ducks (this chapter and 5.2.2). Most ducks are active in the area during the day as well as during the night. As in the Danish part of Fehmarnbelt, tufted ducks have a reverse diurnal rhythm during ice-free periods, as they would feed during the night in the Belt and roost during daytime in sheltered areas. Only when these areas are covered with ice, would tufted ducks mainly stay in open coastal areas of the Baltic Sea day and night. In the entire Fehmarnbelt tufted ducks would be expected to feed at water depths of 0 to 5 m, whereas scaup and eider would also feed in deeper waters of 8 to 9 m or occasionally 15 to 20 m (Berndt & Busche 1993). Concerning the species mentioned here, wintering numbers of tufted duck and scaup in Germany showed a decreasing trend during the last decade of the 20th century, whereas numbers of eider were fluctuating (Wahl *et al.* 2003).

5.2.2 Birds feeding on invertebrates and plant material

Numbers of wintering shelduck *Tadorna tadorna* and teal *Anas crecca* correspond on an average to 19% and 37% of the German Baltic wintering stock. This classifies the Fehmarn/Heiligenhafen area to be of high regional importance (Table 12). Four more species of regional importance occur regularly in the coastal area of German Fehmarnbelt during winter. The number of mallards amounts on an average to 4,100 birds, and a maximum of 18,600 individuals. This is about 19% of the German Baltic wintering stock. In total, an average number of 6,600 individuals of eight waterbird species, feeding on plant material and invertebrates other than bivalves, stay in the German part of Fehmarnbelt during winter.

Table 10. Maximum and mean numbers of six wintering coastal waterbird species of regional importance (R) and the total of eight coastal waterbird species feeding on other invertebrates than bivalves as counted at the German part of Fehmarnbelt. Count data (rounded) are from the period 1986/87 to 1995/96 (Struwe-Juhl 2000). Percentages give the proportional significance of the total Fehmarn mean compared to the regional population (German Baltic) according to count data of Garthe *et al.* (2003).

	N Fehmarn		S Fehmarn		Total Fehmarn			
Species	Max.	Mean	Max.	Mean	Max.	Mean	Importance	
Shelduck *Tadorna tadorna*	230	30	960	190	1,190	220	R	18.8%
Teal *Anas crecca*	620	90	2,230	340	2,850	430	R	36.0%
Mallard *Anas platyrhynchos*	6,600	1,100	12,000	3,000	18,600	4,100	R	4.1%
Pintail *Anas acuta*	420	20	520	70	940	90	R	6.7%
Pochard *Aythya ferina*	350	50	2,770	440	3,120	490	R	1.5%
Goldeneye *Bucephala clangula*	2,200	350	5,000	700	7,200	1,050	R	2.7%
Total of 8 species		1,600		5,000		6,600		

Wintering numbers of teal, mallard, pintail and pochard in Germany showed a decreasing trend during the last decade of the 20th century, whereas numbers of shelduck were fluctuating and numbers of goldeneye were stable (Wahl *et al.* 2003).

At the Baltic coast, staging waders concentrate in a few areas, mostly in salt marshes, coastal lagoons, wind flats, landfills or fish ponds. Most of these habitats are abundant at the island of Fehmarn. Waders are of numerical importance during the migration seasons only. Adult individuals of arctic wader species use the German Baltic coast as stop-over site to a small extent only. However, the region is an important stop-over site for juvenile individuals on their route to the wintering areas, although for Fehmarn, published data are poor. A few hundred individuals of ruff (*Philomachus pugnax*) were counted at the nature conservancy areas at Fehmarn during autumn migration in 1990 and 1991 (Kube & Struwe 1994).

5.2.3 Birds feeding on submerged vegetation

Numbers of mute swan, whooper swan and coot, feeding on submerged vegetation, reach regional importance in the Fehmarn/Heiligenhafen area (Table 13). Their maximum wintering numbers in this area correspond to 7%, 16% and 13%, respectively, of the German Baltic wintering stock. In total, a mean number of almost 5,000 individuals of seven coastal waterbird species, feeding on submerged vegetation, stays in the German part of the Fehmarnbelt area during winter.

Table 13. Maximum and mean numbers of three wintering coastal waterbird species of regional importance (R) and the total of seven coastal waterbird species feeding on submerged vegetation as counted at the German part of Fehmarnbelt. Count data (rounded) are from the period 1986/87 to 1995/96 (Struwe-Juhl 2000). Percentages give the proportional significance of the total Fehmarn mean compared to the regional population (German Baltic) according to count data of Garthe *et al.* (2003).

	N Fehmarn		S Fehmarn		Total Fehmarn		
Species	Max.	Mean	Max.	Mean	Max.	Mean	Importance
Mute swan *Cygnus olor*	600	70	2,400	720	3,000	790	R 1.8%
Whooper swan *Cygnus cygnus*	460	30	1,020	110	1,480	140	R 1.5%
Coot *Fulica atra*	3,130	420	12,860	3,450	15,990	3,870	R 3.0%
Total of 7 species		550		4,400		4,900	

Amongst the species mentioned here, wintering numbers of mute swan and coot showed a decreasing trend during the last decade of the 20th century in Germany, whereas numbers of whooper swan were fluctuating (Wahl *et al.* 2003).

Mute swan, whooper swan and coot occurring in marine areas at Fehmarn feed in shallow water and do not occur offshore. They often occur in the same areas, although they have different abilities to feed on submerged vegetation. Thus, coot is able to dive down to 5 m, whereas a mute swan can reach ca. 1 m below the water surface, when feeding.

5.2.4 Birds feeding on fish

Four coastal waterbird species, feeding on fish and wintering in the German Fehmarnbelt area, occur in numbers of regional importance (Table 14). Little grebe *Tachybaptus ruficollis*, red-necked grebe, cormorant and red-breasted merganser wintering here reach a maximum of 10%, 50%, 82% and 16%, respectively, of all individuals of these species of the German Baltic region.

In the species mentioned here, only wintering numbers of red-breasted merganser in Germany showed a decreasing trend during the last decade of the 20th century, whereas numbers of little grebe were stable and numbers of cormorant showed an increasing trend (Wahl *et al.* 2003).

Table 14. Maximum and mean numbers of four wintering coastal waterbird species of regional importance (R) and the total of 10 coastal waterbird species feeding on fish as counted at the German part of Fehmarnbelt. Count data (rounded) are from the period 1986/87 to 1995/96 (Struwe-Juhl 2000). Percentages give the proportional significance of the total Fehmarn mean compared to the regional population (German Baltic) according to count data of Garthe *et al.* (2003)

	N Fehmarn		S Fehmarn		Total Fehmarn		
Species	Max.	Mean	Max.	Mean	Max.	Mean	Importance
Little grebe *Tachyb. ruficollis*	7	0	34	4	41	4	R 1.0%
Red-necked grebe *Podiceps grisegena*	310	20	170	20	480	40	R 4.5%
Cormorant *Phalacrocorax carbo*	750	120	3,600	350	4,350	470	R 8.8%
Red-breasted merganser *Mergus serrator*	920	130	1,280	270	2,200	400	R 2.9%
Total of 10 species		300		800		1,100	

The total mean number of the waterbird species feeding on fish appears not very high. However, up to now *e.g.* numbers of resting and wintering gulls have not been published for the German Baltic coast. The recently published recordings of "seabird at sea" ship counts showed that mainly little gulls, common gulls and herring gulls occur in the Fehmarnbelt offshore area in large numbers (Garthe *et al.* 2003). In addition, a single observation of a large flock of great black-backed gulls *Larus marinus* (350) in September 2000 at sand-banks northeast of Fehmarn in the Belt part should be noticed (Berndt *et al.* 2004).

5.2.5 Birds feeding in terrestrial habitats

The terrestrial habitats of the Fehmarn/Heiligenhafen area are of high regional importance: wintering greylag goose and wigeon occur in numbers greater than 20% of the German Baltic wintering stock (Table 15). Maximum numbers of 156% and 161% of the German Baltic wintering stock in this area suggest a high turn-over of wintering birds within the entire Baltic area. Even the numbers of canada geese *Branta canadensis* may correspond to a maximum of 42%. In total, an average number of 9,400 individuals of six coastal waterbird species stays in terrestrial habitats at Fehmarnbelt during winter.

Table 15. Maximum and mean numbers of three wintering coastal waterbird species of regional importance (R) and the total of six coastal waterbird species mainly feeding in terrestrial habitats as counted in the German part of Fehmarnbelt. Count data (rounded) are from the period 1986/87 to 1995/96 (Struwe-Juhl 2000). Percentages give the proportional significance of the total Fehmarn mean compared to the regional population (German Baltic) according to count data of Garthe *et al.* (2003).

	N Fehmarn		S Fehmarn		Total Fehmarn		
Species	Max.	Mean	Max.	Mean	Max.	Mean	Importance
Greylag goose Anser anser	2,690	200	4,820	870	7,510	1,070	R 22.3%
Canada goose Branta canadensis	4,060	190	4,440	250	8,500	440	R 2.2%
Wigeon Anas penelope	15,320	1,920	27,600	5,590	42,920	7,510	R 28.1%
Total of 6 species		2,400		7,000		9,400	

Amongst the species mentioned here wintering numbers of wigeon and of canada goose were fluctuating during the last decade of the 20th century in Germany. Numbers of greylag geese showed an increasing trend (Wahl *et al.* 2003).

5.3 Breeding birds

The German Baltic Sea coast is an important breeding area for several bird species. Some species are exclusively coastal but most species are dispersed over a wide range. The coastal areas offer important refuges, and the birds mainly use the Baltic Sea as foraging area (Brenning *et al.* 1996). The most common breeding bird species at the German Baltic Sea coast are gulls with about 2/3 of all breeding birds. Black-headed gull is the most abundant one. Terns and waders are represented with about 6% and 5%, respectively. Most species at the German Baltic Sea coast are in decline, some at an alarming rate. Only numbers of cormorant and herring gull have definitely increased. Especially at the German Baltic coast anthropogenic impact is high and has increased within the last decades, mainly due to tourism and agriculture.

In the area of Fehmarn/Heiligenhafen common gull and herring gull were the most abundant coastal waterbird species in 1999 according to atlas data (Appendix 5). Some other species reached numbers of several hundred breeding pairs in the 1990s. According to the German red list (Bauer *et al.* 2002), six species of category 1 (CR = critical), ten species of category 2 (EN = endangered) and ten species with lower classification in the German red list breed in the area of Fehmarn/Heiligenhafen. In the red list of the German Baltic marine and shore region (Brenning *et al.* 1996) seven breeding species were assigned to category 1. The total of all mentioned species in Appendix 5 (coastal waterbird species and selected terrestrial species with a classification according to the national and regional red lists) shows that at least 9,000 pairs breed in the Fehmarn/Heiligenhafen area. This number is less than the total of all species, since species with no classification were excluded.

In total, among 22 species breeding in the area of Fehmarn/Heiligenhafen the number of breeding pairs reached at least 1% of the national German occurrence and by this they are of national importance. Eighteen of all 37 breeding coastal waterbird species are of national importance. Red-necked grebe, bittern, greylag goose, eider, red-breasted merganser, common gull *Larus canus* and great black-backed gull reached even more than 3% of the national German occurrences.

Species of conservation concern on a European scale (SPEC) have been identified by BirdLife International (Tucker & Heath 1994, Heath *et al.* 2000). These birds are divided into four categories depending on their global conservation status, their European threat status and the proportion of their world population in Europe. In total, 27 species breeding in the area and 15 of 37 coastal waterbird species of are of European concern in the Fehmarn/Heiligenhafen area.

In the four Nature Conservancy Sites in the area Fehmarn/Heiligenhafen (NSG Graswarder, NSG Krummsteert und Sulsdorfer Wiek, NSG Wallnau and NSG Grüner Brink) the most abundant breeding coastal waterbird species were common gull and black-headed gull. Both show a decreasing trend (Table 16). The substantial breeding numbers of terns also decrease, although the breeding numbers of the highly endangered little Tern *Sterna albifrons* remain constant. Amongst the regularly occurring species shelduck, red-breasted merganser, ringed plover *Charadrius hiaticula*, common gull, great black-backed gull and little tern are nationally important species as at least 1% of their national occurrence breeds in these Nature Conservancy Sites. Red-breasted merganser and common gull even reach a much higher percentage.

Table 16. Number of breeding pairs of coastal waterbird species and selected terrestrial species in Nature Conservancy Sites in the Fehmarn/Heiligenhafen area from 1997 to 1999 (data after Knief *et al.* 2000 and Knief *et al.* 2001). Percentage of national occurrence (% NO) in the 1990's and species of European concern (SPEC) after Heath *et al.* (2000), red list status in Germany (RL-G) after Bauer *et al.* (2002), red list status of the German Baltic region (RL-BR) after Brenning *et al.* (1996). B = brood, W = winter, I = increasing guest, NT = near-threatened, R = rare, resp. = special responsibility.

	Breeding pairs						
Species	1997	1998	1999	% NO	SPEC	RL-G	RL-BR
Mute swan *Cygnus olor*	19	39	36	0,5			resp.
Shelduck *Tadorna tadorna*	30	63	53	1,1			
Eider *Somateria mollissima*	9			0,8		NT	NT, resp.
Red-breasted merganser *Mergus serrator*	58	28	27	4,9		2	3
Oystercatcher *Haematopus ostralegus*	37	55	38	0,1			3, resp.
Avocet *Recurvirostra avosetta*	76	47	54	0,9	4B, 3W		3, resp.
Ringed plover *Charadrius hiaticula*	37	44	42	1,8		2	3, resp.
Lapwing *Vanellus vanellus*	34	56	48	0,0		2	3
Common snipe *Gallinago gallinago*	2	1	5	0,0		1	1
Black-tailed godwit *Limosa limosa*	8	9	6	0,1	2	1	1
Curlew *Numenius arquata*	1	0	0	0,0	3W	2	2
Redshank *Tringa totanus*	29	27	18	0,1	2	2	3
Black-headed gull *Larus ridibundus*	208	125	20	0,0			
Common gull *Larus canus*	1568	973	728	5,6		2	
Herring gull *Larus argentatus*	97	54	44	0,1			
Great black-backed gull *Larus marinus*	1	0	0	2,0		R	I
Common tern *Sterna hirundo*	66	61	39	0,6		NT	3
Arctic tern *Sterna paradisaea*	60	53	27	0,8			2
Little tern *Sterna albifron*s	16	17	17	1,8		2	1
Sky lark *Alauda arvensis*	101	133	109	0,0		NT	
Meadow pipit *Anthus pratensis*	60	108	51	0,0			

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6 Preliminary risk assessment

6.1 Collision risk

While a tunnel will not be associated with collision risk for birds, collisions are expected to occur as a permanent effect of a cable-stayed bridge. According to Kahlert *et al.* (2000b), collisions with man-made structures could potentially occur by:

- annual migrations between breeding and wintering areas (including some reverse migration due to sudden changes in weather)
- local (often daily) flights between roost and feeding areas (mainly waterbirds)
- birds that are disturbed by human activity
- birds (*e.g.* gulls, raptors, cormorants) that are attracted by the structure
- foraging birds that undertake aerial pursuit of prey (*e.g.* sparrowhawks, skuas, gulls).

In a bridge solution the annual migrations are predicted to be the most prominent source of collisions both in the Danish and German part of Fehmarnbelt. However, local movements should also be considered. Especially in the German part flights between foraging areas in the Belt and roosting areas in calm interior lakes or ponds on the Island of Fehmarn (Schlenker 1972) have to be considered with regard to potential impact. In the Danish part present knowledge suggests that local movements between inland and marine habitats mainly relate to the Rødsand Inlet (*e.g.* geese and tufted ducks). It is considered unlikely that the alignment of the fixed link will be placed in this area, and hence at the present stage local movements between inland and marine habitats in the Danish part is assessed not to be associated with a major risk of collisions for these birds. Descriptions of local foraging movements between marine habitats exclusively have not been found, except for the social foraging events in the Rødsand area (*e.g.* Desholm *et al.* 2003). Such foraging movements may also be undertaken amongst seaducks, but this has probably never been investigated in the Fehmarnbelt.

An assessment of collision risk with man-made structures allowed the collection of bird carcasses at the offshore research platform "FINO-1" in the North Sea 45 km north of the island of Borkum (http://www.fino-offshore.de) at 25 visits from 1.10.2003 to 6.10.2004 (Fig. 12A). Almost all of the 227 collected individuals were in good condition and showed external injuries, indicating collisions rather than emergency landings of emaciated individuals (Hüppop *et al.*, in prep.). Most of the birds were nocturnal migrants, in particular thrushes, which constituted 84% of all casualties (see Appendix 6 for species list). The number of birds collected was a large underesti-

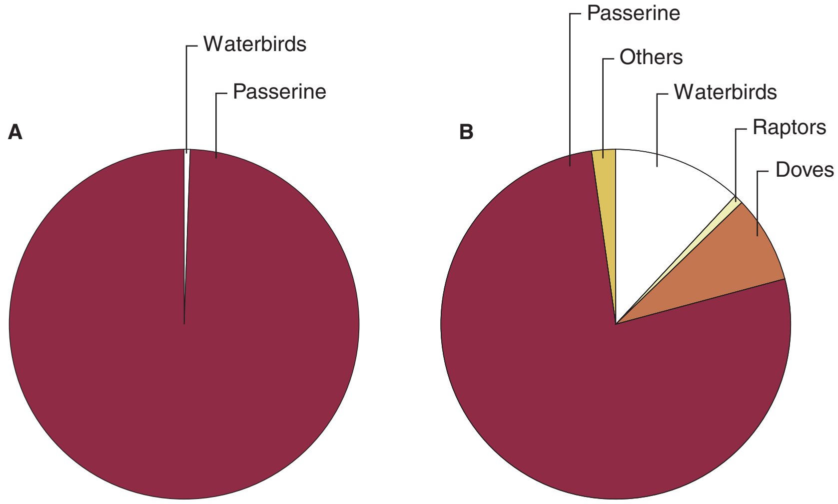

Figure 12. Proportions of dead birds amongst different groups collected at the "FINO-1" offshore research platform, the North Sea (A, N = 227, Hüppop *et al.*, in prep.) and on the Øresund Bridge (B, N=459, Nilsson & Green 2002, Nilsson 2003, Nilsson 2004). For species see Appendices 6 and 7.

mation, since most of the colliding birds would fall into the water or were eaten by scavenging gulls.

Experience from the Øresund Bridge also suggested that mainly passerines suffer from collisions, although casualties also occurred amongst waterbirds and raptors (Fig.12B). There was much greater species diversity amongst the casualties at the Øresund Bridge, probably due to a different and more intense data collection and the position relative to the main migration routes. Furthermore, dead birds compiled on the bridge would also include birds hit by cars. However, undetected casualties are also likely to contribute to a substantial underestimation of the number of casualties at the Øresund Bridge.

Nevertheless, thrushes were the most numerously occurring species group amongst the passerines at the "FINO-1" research platform in the North Sea (85%, song thrush *Turdus philomelos* most abundant) and at the Øresund Bridge (49%, robin *Erithacus rubecula* most abundant), (see Appendices 6 and 7). Next to thrushes, starlings *Sturnus vulgaris* constituted the most abundant species in the North Sea (8% of all passerines). This species was also found in substantial numbers on the Øresund Bridge (5%). Warblers (22% of all passerines, willow warbler *Phylloscopus trochilus* most abundant) and finches (7%, chaffinch most abundant) contributed significantly to the casualties at the Øresund Bridge. Presently, it cannot be judged whether the mentioned species groups are at particular risk or whether their frequency of casualties simply reflects that these species occur in very high numbers.

The risk of collision with suspension cables of a large bridge is comparable to the risk of collision at large power-lines, although the risk depends on the construction characters and the surrounding habitat structure. Due to adaptation to their traditional habitat with natural obstacles, birds are not always able to realise the risk constituted by cables with a more or less horizontal orientation and may not avoid them or react too late (Hoerschelmann *et al.* 1988).

In The Netherlands, Buurma & van Gasteren (1989, in Bruderer & Liechti 2004) estimated that at least 1-2% of all birds passing the netto-risk-area at power-lines actually collided. In Germany, an estimated minimum of 30 million birds per year died due to power-lines (Hoerschelmann *et al.* 1988). At a large 380 kV-power-line crossing the lower river Elbe in northern Germany, which is an important migration corridor for birds (Hüppop & Dien 1984), a minimum of 400 birds were killed per year and km as a result of collisions with the power-lines, mainly during the migration seasons (Hoerschelmann *et al.* 1988), (Fig. 13).

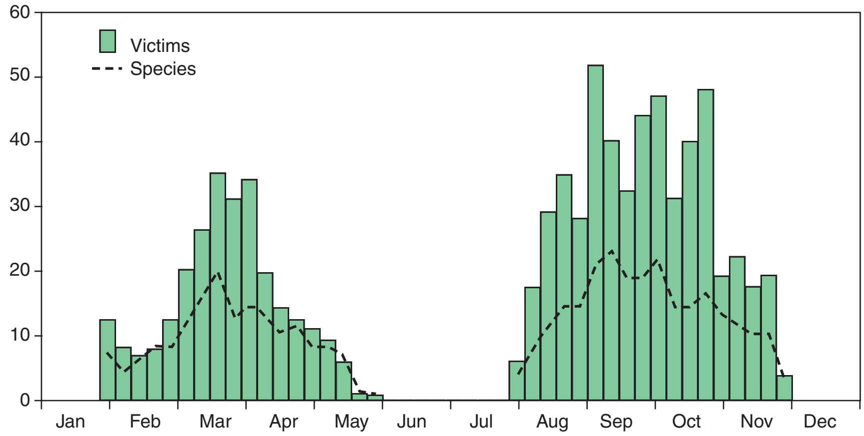

Figure 13. Seasonal distribution of the numbers of bird victims and species found under the power-line near the river lower Elbe throughout the year (from Hoerschelmann *et al.* 1988).

Among the species affected, the majority were nocturnal migrants. However, also species resting or feeding in the vicinity of the pylons suffered from high losses during daylight. Furthermore, the results suggested that birds may be able to detect cables close to the pylons better than at larger distances (Fig. 14), although the pattern of recorded casualties may also reflect that birds simply avoid the pylons, which are likely to be more conspicuous than the cables.

It is well-known that sources of light on technical installations (*e.g.* oil- and gas rigs, lighthouses, telecommunication towers, bridges etc.) affect the behaviour of migratory birds. This may include time-consuming circle flights around such installations (Bourne 1979, Larkin & Frase 1988) and mortality as a result of collisions with structures, because birds are attracted by lights in poor visibility (*e.g.* Weigold 1924, Verheijen 1981, Wiese *et al.* 2001, Nilsson & Green 2002). The motivation behind this behaviour is still largely unknown. Presumably, nocturnal migrants typically navigate using the stars, but rely on the Earth's magnetic field on overcast nights. However, light can cause birds to become disoriented. Red wavelengths, in particular, may interfere with vision-related pigments that also play a role in magnetic orientation. This may explain why towers with red lights seem to be a greater problem than other sources of lights (Wiltschko & Wiltschko 2001, Malakoff 2002).

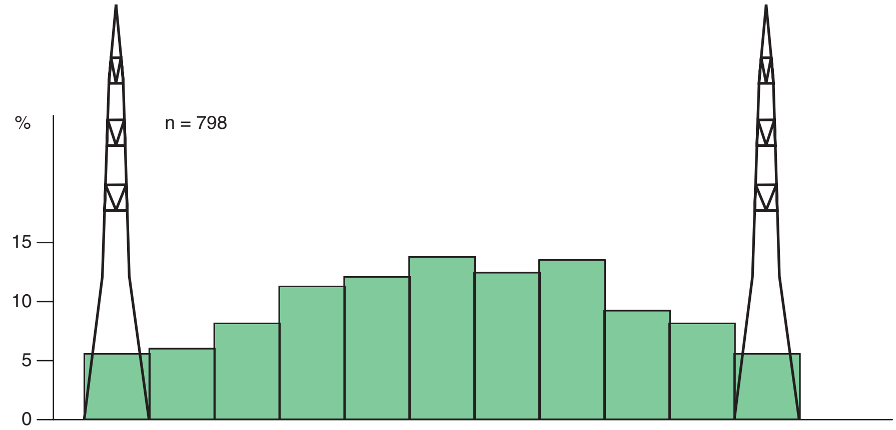

Figure 14. Distribution of victims found under the power-line near the river lower Elbe as dependent on the distance to the pylons (from Hoerschelmann *et al.* 1988).

In conclusion, collisions are discrete events of low frequency compared to the amount of birds passing. However, bird strikes with lighthouses, wind turbines, platforms or bridges would depend heavily on environmental conditions, such as weather and light (both natural and artificial). Mass mortalities with several hundreds to a few thousand victims caused by collisions with a single man-made structure mainly occur in moonless nights with fog or drizzle and not in clear nights with moonshine. Numbers of victims are especially high when the birds under these conditions are attracted by warning lights for navigation of aircraft or ships (Richarz *et al.* 2001, Malakoff 2002, Hüppop 2004).

A preliminary assessment of collision risk suggests that many species amongst migrating waterbirds, raptors and passerines are potentially at risk of colliding with the super-structures or the traffic on a Fehmarnbelt fixed link. Based on count surveys of bird occurrences (chapters 4 and 5) and the experience with collisions from a research platform in the North Sea and the Øresund Bridge (this chapter), this may for example include dark-bellied brent goose, barnacle goose, wigeon, tufted duck, scaup, longtailed duck, eider, little gull, common gull and herring gull amongst the waterbirds, sparrowhawk and buzzards amongst the raptors and swallows, skylarks, starlings, thrushes, warblers and finches amongst the passerines. Presumably, more species are relevant to consider not the least because the experience from the North Sea and Øresund has shown that a great variety of species can be expected to collide, especially amongst the nocturnal migrating passerines. In addition, there is a general lack of knowledge with respect to the species composition and abundance in some parts of Fehmarnbelt, *e.g.* in offshore areas, which will necessitate further bird investigations to be included in a future EIA. Thus, both in the Danish and German part of Fehmarnbelt information about the species composition during migration is mainly limited to near shore daytime migration (Kahlert *et al.* 2000b, Hüppop *et al.* 2004).

6.2 Changes of migration routes

Birds normally elude tall man-made structures at large distances, either vertically or horizontally at least in good visibility (Hoerschelmann *et al.* 1988, Richarz *et al.* 2001, Hicklin & Bunker-Popma 2001, Schmiedel 2001), but also during the night (Kahlert *et al.* 2004b). Hötker *et al.* (2004) mentioned avoidance flights at wind turbines for 81 bird species, namely geese, ducks, cranes, waders and small passerines. Most birds will avoid a large bridge as well. At the Øresund Bridge the majority of individuals amongst waterbirds, raptors and passerines seemed to pass over the bridge, although substantial numbers also passed under the bridge or crossed the alignment over land (Bengtsson 2002, Nilsson & Green 2002). Avoidance responses most certainly reduce the collision risk, however, do not eliminate it. Periods of poor visibility (at night and in foggy conditions) could in particular constitute situations of enhanced collision risk.

In a bridge solution, changes of migration routes may also include that terrestrial species such as raptors and passerines, which are hesitant to cross large water stretches, would follow the fixed link alignment on their migration across the Baltic Sea. However, although single individuals or flocks may be attracted by the superstructures of a fixed link on their migration, no examples have been found of any major change in the migration route amongst a substantial proportion of a bird population at existing bridges. In addition, energetic effects caused by avoidance responses and circular flights at a single bridge would be difficult to discriminate from situations occurring naturally with enhanced energetic costs during migration (*e.g.* caused by tailwind and drift), although theoretically persistent circular flights at obstructions may ultimately affect the survival of the individual.

6.3 Habitat modification

Habitat modifications at a fixed link across Fehmarnbelt can be divided into 1) physical loss of food resources, 2) displacement effects and 3) creation of new habitats. The effects concerning aspects of habitat modification are related to birds, which use Fehmarnbelt as a foraging area, except for the potential blocking effects on migrating birds (see chapter 6.3.2). The issues therefore mainly refer to wintering, staging or moulting birds. In addition, many of the birds, which breed in coastal areas along the Fehmarnbelt, use the Belt as a feeding area (*e.g.* gulls and terns) or to raise their young (*e.g.* eider).

6.3.1 Habitat loss

Physical habitat loss may potentially be caused by:

- A temporary reduction in food availability during construction of the fixed link caused by sediment spill and suspension of material.

- Removal of soil or benthic sediment (placement of fixed link structures, reclamation, compensatory dredging), which can be temporal or permanent.

All these activities can result in losses of substrates for food items used by benthic feeding, herbivorous and piscivorous birds (see chapters 4 and 5).

Sediment spill and suspension of material caused by construction work may increase the turbidity of the water and by this reduce the hunting success of fish eating diving birds (*e.g.* Cezilly 1992). Eventually, suspended material is prone to sedimentation. However, extensive investigations during construction of the Øresund Bridge and assessment during the feasibility study in Fehmarnbelt suggested that effects on food items caused by dredging and sedimentation will be local and temporary (Danish Ministry of Transport 1999, Øresundskonsortiet 2000). Depending on the order of magnitude of sediment spill, effects associated with a bridge are expected to be restricted to areas extending from bridge piers and thus these effects are likely to be smaller than the local ones caused by a tunnel. Furthermore, benthic habitats have the potential to recover after a removal of biomass, although changes in species composition could occur (de Groot 1979).

Both in the case of a cable-stayed bridge and an immersed tunnel dredged material will be deposited elsewhere and cause reclamation of seabed. In the construction scenarios, reclamation areas of 0.9 km^2 and 2 km^2 east of the harbours of Rødbyhavn and Puttgarden have been proposed. Permanent displacement effects on waterbirds feeding or resting in these areas cannot be excluded. However, the feasibility study showed that bird occurrences east of Rødbyhavn were of minor importance as densities did not exceed 25 individuals per km^2 of any species (Skov et al. 1998). Wintering eiders occurred east of Puttgarden in densities up to approximately 50 individuals per km^2. Larger densities (up to approximately 250 eiders per km^2) may occur at the edge of the reclamation area.

Technical solutions involving artificial islands, which occupy feeding areas with benthic fauna or submerged vegetation, would also displace birds permanently as these food items cannot be re-established (see example in Christensen & Noer 2001).

Important bird occurrences in agricultural fields (*e.g.* geese and swans) may theoretically suffer from a permanent habitat loss due to an up-grading of the infra-structure on the mainland. However, this potential loss is considered negligible given the large availability of this particular habitat.

6.3.2 Displacement effects

Displacement effects can occur as:

- A temporary displacement effect caused by disturbance during the construction of the fixed link.

- A permanent displacement effect caused by the structure of the fixed link (including roads).
- A permanent avoidance response amongst migrating birds towards a bridge, which prevent them from using traditional wintering, foraging areas etc. (blocking effect).

At the Øresund Fixed Link a redistribution of eiders, mute swans, brent geese and coots suggested that a disturbance effect may have occurred close to the construction site (Fox *et al.* 1999, Kahlert *et al.* 2000a). After the construction work has ceased eiders were feeding in previously abandoned areas, which supported the hypothesis that a disturbance effect had been present during the construction phase (Christensen & Noer 2001). A comprehensive disturbance study on wing moulting greylag geese confirmed that these birds were extremely sensitive to anthropogenic activity, but showed little change in behaviour and virtually no redistribution in time and space at a distance of 1 km from the artificial island of the Øresund Fixed Link (Kahlert & Nilsson 2000). Since bird occurrences at the Øresund Fixed Link mainly occurred close to the artificial island, the relative importance of disturbance effects due to the construction of the more distant high bridge and tunnel could not be assessed.

Wild birds would to some extent avoid artificial and unusual structures. Displacement effects may therefore result in a reduction of the space effectively available. In recent years it has been discussed whether the construction of offshore wind farms would lead to the exclusion of birds inside the wind farm area. Waterbirds were observed between turbines suggesting that at least some individuals can habituate to the presence of noisy turbines (Christensen *et al.* 2004). However, a significant decline in numbers of long-tailed duck inside the Nysted offshore wind farm may suggest a displacement effect (Kahlert *et al.* 2004b). In marine areas with patchy food resources there is a risk that permanent displacements may lead to a redistribution of birds, which involve areas several kilometres from a fixed link alignment. At the Øresund Bridge the displacement of eiders caused by the presence of an artificial island lead to an increase in numbers at other sites more than 7 km from the alignment, possibly because profitable feeding areas were not present in the vicinity of the fixed link (Noer & Christensen 1997).

Similarly, a displacement effect on birds caused by roads in terrestrial habitats has been demonstrated. For example, grazing wintering pink-footed geese *Anser brachyrhynchus* and greylag geese in north-east Scotland tended to avoid the proximity of roads up to 100 m, and fields with centres closer than 100 m from a road were not visited (Keller 1991). In Germany the intensity of grazing of foraging white-fronted geese *Anser albifrons* was less within the first 80 m along an embankment road compared to more distant areas (Ballasus 2002). Breeding birds as well avoid areas close to even small roads. Depending on the species, a strip of 40 m (oystercatcher *Haematopus ostralegus*) and up to more than 100 m (herring gull) remained very scarcely populated or even unpopulated on the small saltmarsh island Nordstrandischmoor in the German Wadden Sea. The intensity of road use influenced nest distances from the road, especially for colony breeders (Hüppop & Hüppop 1995).

Blocking effects on migrating birds may potentially restrict or even prevent the use of areas by birds for breeding, wintering, staging, moulting, or just for foraging. However, evidence of such blocking effects has not been found elsewhere. In Kalmarsund between the Swedish mainland and the island of Öland the migration of several hundred thousands of eiders has apparently not been constrained by the construction of a bridge.

6.3.3 Creation of new habitats

- A permanent increase in food supply could be provided by new substrates at foundations of a bridge (artificial reefs).

Underwater structures of a bridge will act as artificial reefs offering additional habitats for rock dwelling benthic organisms and fish (*e.g.* Bohnsack *et al.* 1991). Benthos feeding birds such as eiders may profit from these. However, it has to be kept in mind that new artificial reefs would favour benthos species which do not necessarily occur in the area at present.

6.3.4 Concluding remarks

Habitat losses or disturbance effects regarding foraging habitats can eventually result in food shortages for birds. However, a prediction of the possible consequences is extremely difficult. For example, in long-lived species that feed on food items in competition to man, apparently small reductions in food availability may lead to increased mortality, *e.g.* in eiders and oystercatchers. In years when shellfish stocks were low, a switch to alternative prey items could not maintain bird fitness, *i.e.* the production of self-reproducing offspring (Camphuysen *et al.* 2002, Goss-Custard *et al.* 2002). By contrast, the reduction in availability of food resources caused by the temporal and permanent displacement of eiders at the Øresund Fixed Link was not associated with changes in survival and reproductive output, which could be attributed to the construction of the fixed link (Christensen & Noer 2001).

Regarding habitat modification, an EIA must consider the moulting, staging, wintering and breeding birds in and at Fehmarnbelt. This includes as a minimum mute swan and coot in relation to submerged vegetation, wigeon and greylag goose in relation to terrestrial habitats, shelduck, teal, eider, long-tailed duck, goldeneye and tufted duck in relation to benthic fauna and divers, red-necked grebe, cormorant, red-breasted merganser, little gull and common gull in relation to fish as potential food items. Depending on the exact alignment, several breeding colonies of coastal birds may also be appropriate to consider.

In the Danish part of Fehmarnbelt the most sensitive areas with respect to this suite of moulting, staging, wintering and breeding species, are assessed to be Albue Bank, the Rødsand Inlet and the

Rødsand offshore areas between Hyllekrog and Gedser Odde. In the German part, the waters south and southwest of Fehmarn including Flüggesand, Hohwachter Bucht and Sagas Bank are considered more important with respect to bird occurrences than the coastal and offshore areas north of Fehmarn.

6.4 Effects, impact and cumulative impact

From the outset, it is important to discriminate between the local effects and impacts that a fixed link can potentially impose on birds and bird populations. In the present context, effects can be defined as the immediate factors caused by visual stimuli, habitat modification or collisions encountered by the birds, as described in the previous chapters. Effects are usually easier to determine than impacts and can for example be measured in terms of the number of casualties or of local changes in abundance and distribution of birds in the presence or absence of the fixed link. As a consequence of physical or ecological effects, impacts at the population level may occur, which both could be negative and positive.

Thus, impacts can be defined as changes to demographic processes, *i.e.* birth rate or death rate at the population level caused by the effects. The determination of impacts necessitates a population approach and some consideration of the overall cumulative impact of development, such as the added effects from other human activity encountered during the entire annual life cycle of birds, *e.g.* other fixed links, wind farms, fast ferries, fishing activities, recreational activities, ship traffic, oil investigations and sand/gravel dredging.

While it is important to establish global and local impacts upon populations, this does require an understanding of additive/compensatory mortality and the strength of density dependence within those populations. Annual adult survival (0-1) and reproductive output (clutch size), in combination, are good indicators of the potential susceptibility to the extra mortality, that a species may incur by potential impact from the fixed link and how fast it is capable of recovering from a population decline. Generally, high annual adult survival rate (> 0.7 on a scale from 0 to 1) is associated with low reproductive output (clutch size 1-4). Many waterbirds such as divers, swans and eiders, as well as many waders and birds of prey have these population characteristics and are usually most susceptible to extra mortality and have the slowest recovery rate. By contrast, most passerine species have low annual adult survival but high reproductive output. Thus, this group of birds is potentially less susceptible to extra mortality and has the potential of recovery from population declines at a relatively fast rate (*e.g.* Dierschke *et al.* 2003).

The assessment of the potential contribution of impact from the fixed link is extremely difficult and necessitates a modelling approach. A general three-dimensional model description of flight corridors in Fehmarnbelt, which could provide a more fine-grained assessment of collision risk at the fixed link is presently lacking. In addition, information on the exact trajectory of the fixed link and dredging scenarios is important for the ultimate assessment of effects on staging, wintering and moulting birds, but presently not available. Nevertheless, for various groups of birds there are data, which describe other human induced mortality, which could contribute directly to the overall impact on populations and to which a potential additional impact from a fixed link across Fehmarnbelt must be considered.

6.4.1 Waterbirds

Many duck species are subject to hunting (Table 17). Several thousand individuals of various species are bagged every year. However, even if large numbers are bagged annually, populations may still increase or be stable, which sugggest that the harvest is sustainable (Madsen *et al.* 1996). This may also be the case for the eider population, although it presently shows a decreasing trend and is theoretically a very sensitive species to extra mortality (Noer *et al.* 1996). Nevertheless, the eider population has increased or been stable during the last part of last century, when eiders were subject to a hunting bag comparable to the present level (Madsen *et al.* 1996, Rose & Scott 1997, Desholm *et al.* 2002).

Table 17. Estimated annual European hunting bag for eight selected dabbling (DAB) and diving (DIV) duck species (from Bregnballe 2003) and the recent population trends (from Delaney & Scott 2002).

Species	Annual bag (individuals)	Population trend
Wigeon *Anas penelope* (DAB)	200,000	Increase
Tufted duck *Aythya fuligula* (DIV)	100,000	Increase
Scaup *Aythya marila* (DIV)	probably < 1,000	Stable
Eider *Somateria mollissima* (DIV)	100,000	Decrease
Long-tailed duck *Clangula hyemalis* (DIV)	30,000	Stable
Common scoter *Melanitta nigra* (DIV)	10,000	Stable
Goldeneye *Bucephala clangula* (DIV)	130,000	Increase
Red-breasted merganser *Mergus serrator* (DIV)	30,000	Increase

In addition, the diving duck populations are subject to mortality caused by by-catch in fishermen's net. For example, in Dutch Ijsselmeer, an annual by-catch of 50,000 waterbirds was estimated (van Eerden *et al.* 1999, Anon. 2002). Also in the Baltic Sea drowning of waterbirds in setnets is considered a major conservation problem (Garthe *et al.* 2003). Kirchhoff (1982) estimated a total by-catch of 15,800 individuals for the Schleswig-Holstein Baltic coast (mainly eider, common scoter, tufted duck and long-tailed duck). Although data were compiled in areas of intensive fisheries, annual by-catch is assessed to be in the order of magnitude of several thousand diving ducks, even if numbers are virtually unknown over a wide range of the staging areas of birds.

Oil spills from ships occur regularly (see review in Anon. 2001) and at least in Danish waters eider, common scoter and long-tailed duck are amongst the most commonly reported species concerning oil spill, which may occasionally involve thousands of casualties (Information Danish Environmental Protection Agency).

Offshore windfarms constitute a potential mortality factor for waterbirds. Even though the collision risk may be assessed to be negligible at individual turbines or wind farms, the erection of several windfarms in the future along a species' flyway, collisions at low frequency at individual turbines may potentially add up to considerable numbers when waterbirds in the future are predicted to encounter several thousand wind turbines during the annual migration (Kahlert *et al.* 2000b, Hüppop *et al.* 2004).

On top of these direct mortality factors, there is a potential for negative impact on waterbird populations, acting through habitat modification and disturbance, which lead to displacement. This may include all offshore and coastal activity in which areas are reclaimed for man-made structures (*e.g.* wind farms and fixed links). In addition, gravel dredging, ship traffic including fast ferries and disturbant recreational activity (*e.g.* wind- and kite surfing) may lead to displacements.

In the overall assessment of cumulative impact, the potential positive impact caused by the creation of new habitat at man-made structures in the marine environment must be "subtracted" from the total displacement effects. Cause and effect concerning displacement and attraction have been investigated in detail for many species (see literature review in Dahlgren & Korschgen 1992, Wiese *et al.* 2001). However, the link between effect and impact can be extremely difficult to derive, and hence the impact on the population level from these factors is virtually unknown. However, both at the National Environmental Research Institute in Denmark and at the Institute of Avian Research "Vogelwarte Helgoland" population models for selected species are developed within current studies.

Finally, it can be concluded that waterbirds and in particular diving ducks are already subject to considerable annual human-induced mortality of many thousand individuals, and for many species without detectable declines in population size. The same potential to sustain without detectable negative impact on the populations also exists with respect to impact from the fixed link across Fehmarnbelt, although the level of sustainable extra mortality is unknown.

The study at the Øresund Bridge showed that the number of waterbird casualties constituted a fraction of *e.g.* hunting (compare Appendix 7 with Table 17). This suggests a low risk of additional impact on waterbird populations caused by a bridge across Fehmarnbelt. However, it must be emphasized that this *a priori* assessment is based on an underestimation of the number of casualties amongst waterbirds as a substantial proportion is likely to drop into the water after collision with the Øresund Bridge and thus is not reported. Furthermore, the intensity of waterbird migration in Øresund is much lower than in Fehmarnbelt.

6.4.2 Birds of prey

This group of birds is well protected from hunting in northern Europe, although license to bag is given in individual cases where raptors are considered as pest species. Furthermore, the annual bag is unknown in Russia. Amongst other direct mortality factors, collisions at wind turbines have been reported (Tucker 1996, Barrios & Rodriguez 2004) and this could constitute an effect, which may increase in the future given the plans of erecting thousands of wind turbines across Europe. The impact on populations from this source of man-made structures is however unknown. Incidents of poisoning within the breeding or wintering range of raptors may also occur. However, the previous negative impact on reproduction from chemical pollution has declined. Possibly for this reason many of the raptor species showed an increasing or stable population during the 1970s and 1980s (see examples in Hagemeijer & Blair 1997). More recent counts in the 1990s on the migration route further north of Fehmarnbelt at Falsterbo again suggested declines in raptor populations, *i.e.* in more than half of the species (Kjellén & Roos 2000, Table 18). Habitat loss in old deciduous forest and grazed meadows was proposed as the main reason for the declines. Other potential impacts imposed on waterbirds, such as by-catch, oil-spill and other activities in marine areas, are not relevant for birds of prey.

Table 18. Population trends based on migration counts at Falsterbo, Sweden during the 1990s (Kjellén & Roos 2000).

Species	Population trend
Honey buzzard *Pernis apivorus*	Decrease
Buzzard *Buteo buteo*	Decrease
Rough-legged buzzard *Buteo lagopus*	Decrease
Sparrowhawk *Accipiter nisus*	Decrease
Marsh harrier *Circus aeruginosus*	Stable

The number of casualties at the Øresund Bridge showed the same low order of magnitude in raptors as in waterbirds (see Appendix 7). With the reservation that migration patterns and intensity will be different in Fehmarnbelt, the data from Øresund suggested that the contribution from the fixed link to the overall human-induced impact on populations would be very low. However, it must be noted that some of the species (*e.g.* white-tailed eagle and buzzard) could be sensitive to extra mortality due to their demographic features, and that the breeding populations in Sweden, one of the main recruitment areas for several species, mainly show declining numbers (Table 18).

6.4.3 Passerines

Passerines are killed by road traffic each year even on a small part of the flyways of the populations. For example in Germany an estimated 9.4 million birds are killed annually (Fuellhaas *et al.* 1989), in Sweden 10 millions (Svensson 1998) and in Denmark 1.1-3.2 millions (Hansen 1982, Bruun-Schmidt 1994). A Danish study suggested that ca 85% of all bird-traffic casualties were passerines (Bruun-Schmidt 1994).

Comprehensive Dutch studies concluded that roads in general lead to negative impact on the reproduction, population size and densities (Reijnen & Foppen 1994, 1995, Reijnen *et al.* 1995a, 1995b). However, several examples of passerine species can also be found, which are subject to traffic casualties, but show increasing population trends (*e.g.* Hagemeijer & Blair 1997).

Other potential impact on passerine populations may derive from collisions at man-made structures both on land (towers, buildings, power cables, wind turbines etc.) and at sea (oil and gas rigs, wind turbines etc.); (see literature review in Avery *et al.* 1980). Finally, there is a long tradition in southern Europe of catching passerines as an edible delicacy (*e.g.* thrushes).

Passerines occurred most numerously in the casualty record at the Øresund Fixed Link (See figure 12). However, this group of birds also holds the largest populations. In the main recruitment area in Sweden, *e.g.* robin (3-6 million pairs), song thrush (1.5-3 million pairs) and goldcrest (2-5 million pairs, Svensson *et al.* 1999). The Øresund study showed that only abundant species were found dead on the bridge, except one little bunting *Emberiza pusilla*, which occurred outside the usual breeding and wintering range. Under the assumption that the number of casualties at a Fehmarnbelt fixed link will occur at the same low frequency as in Øresund, it is assessed that the contribution in terms of direct mortality from a Fehmarnbelt fixed link would constitute an extremely small fraction of the overall number of casualties caused by other anthropogenic activities along the flyways of various species and a small fraction of the numbers held by the populations (Nilsson & Green 2002). Finally, it should also be noted that passerines, although a diverse group of birds, are quite resilient to extra mortality given the nature of their demographic features.

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7 Mitigating actions

7.1 Outline of the fixed link

A cable-stayed bridge is associated with collision risk for birds and there will be an increased risk of collisions at the link during specific weather conditions, which coincide with intense migration (Avery *et al.* 1980, Nilsson & Green 2002). It is therefore evident that at least a minimum of cables and pylons associated with the structures will reduce the risk. In addition, collision risk associated with the superstructures and possibly the traffic can be reduced by minimizing the illumination of the fixed link as much as possible (see chapter 6.1 for description of attraction effects caused by light). Illumination of man-made super-structures is defined by the maritime and aviation authorities. However, in order to reduce the risk of mass casualties, a minimum of flood-light only for the safety of ships, aircraft and car traffic should be mounted on the fixed link. In case it is decided to mount lights on the fixed link that is not associated with safety aspects (which should be avoided), then it should be ensured that these lights can be switched off independently of safety lights, if weather conditions dictate an elevated risk of collisions.

It is also recommended to explore the possibilities of various illumination alternatives within the standards set by authorities. Flash-lights are assumed to be less harzarduous to birds than continuous lights. The U.S. Fish and Wildlife Service recommends that white or red strobe flashing lights are used at towers (USFWS 2000). In addition, the recommendation suggests use of a minimum number of lights with lowest possible intensity and longest duration between flashes. Solid red or pulsating light may disrupt flight patterns of migrating birds at night to a much larger extent than white strobe light, causing circle flights (Chapter 6.1, Gauthreaux & Belser 1999) and collisions (Malakoff 2002).

Generally, the risk of collision with other horizontal linear structures like power cables or suspension cables of bridges can potentially be reduced by wire markers fixed to the cables, at least during daylight (Koops & de Jong 1982, Hoerschelmann *et al.* 1988). Thus, a high density of markers could possibly make the cable structures of a bridge more conspicuous to birds and thereby help to reduce the risk of collision. Markers, suggested to be effective during the night, include lights, reflectors or acoustic signals (Hoerschelmann *et al.* 1988).

7.2 Restrictions on the construction work

Collision risk is also a potential issue during the construction phase when super-structures such as cranes, towers etc. would be present. Economic cost-benefit analysis is likely to dictate that construction work is also undertaken during nighttime. This will necessitate flood-lights, which could cause the same change in flight behaviour by birds during specific weather conditions associated with a collision risk as described above.

In this respect it may be useful if the direction of the flood-light necessary to undertake construction during night is pointed in the opposite direction of the approaching migratory birds, so that the source of light is not fully visible before they have passed the construction site. However, it would not be possible to reduce collision risk for all bird species in this manner. For example, during autumn nocturnal waterbird migrants are orientated in westerly directions whereas nocturnal passerines are generally southbound. In this respect, either a flexible flood-light system must be mounted or a choice between waterbirds and passerines must be taken. In this context waterbirds are likely to be more sensitive to extra mortality at the population level.

The potential habitat loss for waterbirds as a result of sediment spill could be mitigated by defining criteria of acceptable spill, which secure no adverse effect on benthic fauna and submerged vegetation in marine areas. This could be based on thorough control of the spill and best practise developed during construction of the Øresund Fixed Link.

7.3 Other measures

If some unexpected and unacceptable mortality caused by the fixed link should occur and compensatory measures provided at the fixed link may eventually fail, other mitigating measures may be considered. This involves that human impact on bird populations are taken into account during the entire annual life cycle of different species.

For many waterbird species the major anthropogenic source of direct mortality is hunting, which causes the death of several thousand individuals, annually. Some waterbird species (*e.g.* eiders, common scoter) are also subject to by-catch in fishermen's net. Although this factor has been difficult to quantify, it involves most certainly several thousand individuals, annually (see Kirchhoff 1982, van Eerden *et al.* 1999, Anon. 2002).

Therefore, changes in hunting practise or measures to reduce by-catch could in this case be a solution to mitigate the overall human impact on waterbird populations. This should not be a general ban of activities, but an action which is targeted in time and space considering the specific issue and species (see example in Noer *et al.* 1994), or ideally as preparations of international management plans.

Habitat loss would be difficult to compensate for by general management actions, although it was proposed that artificial mussel farms could compensate for the potential habitat loss at the fixed link across Øresund, at least for the breeding birds, which sustained themselves on bivalves (Noer *et al.* 1996). Moreover, there is probably little experience, if any at all, of farming of submerged vegetation in case of unexpected irreversible habitat loss for species such as mute swan, dark-bellied brent goose and coot.

However, there could be alternative sites from which birds are presently excluded because of certain human activities. Provided that adequate food resources are present such alternative sites could be made attractive to birds by restricting human activity. The implementation of hunting free reserves in Denmark is one example of how a change in management with respect to human activity has created sites, which became more attractive to waterbirds after the implementation of this novel management action (Madsen 1998a, 1998b, Clausen *et al.* 2004). In a fixed link context this approach does not entail that further restrictions on hunting should be implemented, but should be considered as a general tool, which could involve any source of disturbing human activity in specific areas. After a severe oil spill in North America, attempts have been undertaken to quantify the necessary level of breeding habitat protection in order to recover populations of marine birds (Sperduto *et al.* 2003). Prior to such management action in a fixed link context, it must be thoroughly assessed, whether such an action could be implemented on a realistic scale to obtain the adequate effects.

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8 Specifications for a forthcoming Environmental Impact Assessment

8.1 Background

On 23 June 2004, the Ministers of Transport in Germany and Denmark signed the Joint Declaration regarding the realisation of a fixed link across the Fehmarnbelt. It was stated clearly that comprehensive environmental investigations must be carried out prior to the initiation of the project. As part of the planning approval procedures defined by authorities, it would also be compulsory, that an Environmental Impact Assessment (EIA) is elaborated according to EU-directive no. 85/337/EEC

In other words, although the existing environmental information regarding birds in the Fehmarnbelt region is comprehensive and sufficient for the present preliminary risk assessment and sufficient as a basis for a decision in principle to realise the project, a future programme for in-depth investigations of the bird issues is required.

In the following a proposal for a future investigation and monitoring programme is described.

8.2 Identification of topics

Given that several bird species occur in Fehmarnbelt in internationally and nationally important numbers, which Denmark and Germany have obligations to protect according to international conventions, the Wild Birds Directive and national red lists, an EIA and environmental investigations must comprise aspects of birds. Evidently, most attention should be given to bird occurrences in the marine environment (migratory, moulting, wintering, staging and breeding birds). Terrestrial habitats should be addressed in the case that breeding sites of coastal birds and feeding areas of swans and geese are included in a further up-grading of the infrastructure on the mainlands as a result of the construction of the fixed link across Fehmarnbelt.

The preliminary risk assessment has shown that collisions of birds are expected to occur in the case that the fixed link involves a solution with above surface structures. Collision frequency cannot be measured directly before the fixed link has been established. However, *a priori* assessments can be developed based on knowledge of species, numbers, diurnal flight behaviour, lateral and vertical flight corridors, manoeuvrability and response to barriers. Although collision risk may primarily be an issue for migratory birds, which pass the fixed link trajectory once every spring and autumn, collision risk during local movements of wintering and staging birds must also be addressed in an EIA.

In chapter 6.1 a list of species was proposed, which must be considered as minimum with respect to potential collisions at a Fehmarnbelt fixed link. It must be emphasised that the list is not exhaustive due to insufficient knowledge of occurrences and individual risk of collisions specifically in Fehmarnbelt. Furthermore, even if a substantial number of an abundant species should collide, this species is not necessarily the most vulnerable one at the population level. Hence, the list may be modified as more fine-grained information are generated either through monitoring programmes associated with the construction of the fixed link or through other of the existing monitoring programmes undertaken in the region.

The ability amongst birds to undertake an avoidance response as they approach the fixed link across Fehmarnbelt is an important determinant of the resulting collision risk. Alternatively terrestrial birds in particular may be attracted by the link. Therefore an EIA must comprise an update of knowledge on changes of migration routes at man-made structures and especially put emphasis on quantitative studies.

Finally, in the EIA, habitat modification should also address the underlying aspects: sediment spill (caused by dredging), removal of benthic sediment (placement of fixed link structures, compensatory dredging and sedimentation), and displacement caused by disturbance and blocking effects preventing use of habitats.

For each of the main topics, collision risk, changes of migration routes and habitat modification, the potential of mitigating impact must be addressed. This report has presented some preliminary proposals for mitigating measures which may be undertaken before, during and post construction. In the planning of offshore wind farms analogue considerations of mitigating actions are undertaken in these years. The planning and construction of offshore wind farms is a growing business and further proposals for mitigating actions will most likely develop. A future EIA for the Fehmarnbelt fixed link should therefore comprise an update on experience and best practise concerning mitigating actions in other offshore industries.

8.3 Monitoring programmes

A bird monitoring programme is recommended in order to strengthen the knowledge of bird occurrences on a temporal and spatial scale in Fehmarnbelt to support the EIA. Furthermore, a monitoring programme must aim at detecting possible effects and impact caused by the fixed link at a quantitative level.

In this respect attention should be drawn to the current environmental impact assessment procedures followed during the construction of the Danish Nysted offshore windfarm. Under the conditions established for the construction of this windfarm, bird distribution and abundance were explicitly put forward as a major issue, which needed to be investigated before, during and post-construction of the windfarm. The nature of the issues at the proposed fixed link across Fehmarnbelt is comparable and also necessitates before, during and post-construction studies. Further recommendations for EIA´s and supplementary studies for offshore windfarms were also proposed in Germany (Hüppop et al. 2002) and these could also support the EIA of a fixed link across Fehmarnbelt.

8.3.1 Collision risk and changes of migration routes

Evidently, collision is an important issue as it imposes a direct mortality factor on populations. In the Fehmarnbelt feasibility study, Skov et al. (1998) flagged up the need for a description of bird movements in three dimensions to refine the assessment of any impact on migratory birds. However, existing studies are currently insufficient to describe the relative importance of different flight corridors especially in the western part of Fehmarnbelt (Kahlert et al. 2004b, Hill & Hüppop 2004), where a fixed link could potentially be placed.

It is also recommended that a multi-species approach is applied in order to identify the most relevant species, eventually to be considered at the alignment of the fixed link. The methods to be applied (se below) are suitable for such a multi-species approach.

As a minimum requirement, the study of collision risk within the EIA must comprise for relevant species and periods:

1. A base-line description of species, abundance and flight trajectories of migratory birds (by night and day, under a range of different weather conditions and at different stages in their annual cycle), covering the relevant sectors of Fehmarnbelt
2. A base-line model prediction of collision risk based on the description of species, abundance and flight trajectories
3. A base-line assessment*) or theoretical model prediction of the potential impact (i.e. direct changes in abundance as a result of changes in survival) on a species at the population level, based on base-line predictions of collision risk
4. During construction of the fixed link, a description of bird species, abundance and flight trajectories during nighttime to compare with base-line results to detect potential attraction effects and circling flights as a result of flood-lighting and eventually to refine base-line predictions of collision risk
5. During operation of the fixed link, a description of species, abundance and flight trajectories to compare with base-line results to detect potential blocking effects, attraction effects, circling flights or changes of migration routes and eventually to refine base-line predictions of collision risk. All studies regarding migration have in particular to consider the strong day to day variation in migration intensity, species composition, and presumably altitude distribution
6. During operation of the fixed link, validation of collision model predictions by direct measurement of collision frequency

7. During operation of the fixed link, assessment*) or model predictions of potential impact on species' population level based on refined predictions of collision risk and measurements of collision frequency

*) For many species sufficient input to population modelling is presently not available.

A preliminary study at existing fixed links is an option. Such information could give some information on the avoidance responses, blocking effects and mortality of migratory birds caused by fixed links for a range of species, which in some circumstances could be extrapolated with reasonable confidence to Fehmarnbelt. However, not all significantly occurring species in Fehmarnbelt will occur in comparable numbers at other potential study sites to ensure sufficient compilation of data (e.g. wigeon and dark-bellied brent geese). In addition, patterns of migration are site specific both with respect to species composition, abundance and spatial distribution (including altitude). Therefore, a risk assessment that defines important flight corridors of birds must primarily be based on an *in situ* study in Fehmarnbelt.

Data for incorporation into collision models, and data for model validation could be obtained by a combination of conventional visual (day) and acoustic (night) observations and collection of casualties during operation. However, given the restrictions of the human eye to discern birds over longer distances and during periods of restricted visibility, remote sensing technologies such as radar and a thermal animal detection system (TADS) based on infra-red technology will be necessary to achieve the adequate data. Previous and on-going studies could provide a template for future modelling of collision risk at the fixed link across Fehmarnbelt (Tucker 1996, Hüppop et al. 2004, Desholm 2005).

Such investigations must cover the entire trajectory projected for the fixed link. Given the restricted range of visual observers and even of the remote sensing technologies, the nature of the study area will necessitate that data compilation is undertaken in both countries and possibly from offshore platforms or ships. It is essential that these investigations are carried using the same methods collected to the same standards along the entire fixed link trajectory.

8.3.2 Habitat modification

For wintering, staging, moulting and breeding birds, the feasibility study described bird abundance and distribution during the period 1987-1997 (Skov et al. 1998). In the Danish part of Fehmarnbelt, the area east of Hyllekrog has been surveyed intensively since 1999 in relation to the Nysted Offshore Wind Farm. These surveys are expected to continue in 2005. West of Hyllekrog recent surveys are limited and restricted to the coastline of Lolland (see Pihl et al. 2001, NERI database). It is well known that offshore wintering marine species may redistribute over time even on a large scale (e.g. the scaup in the Baltic Sea). In Germany, waterbird and mid-winter bird counts have been carried out for many years as well as breeding bird counts in the nature reserves. These programs will certainly continue.

Here, only published data were used so far. Therefore, hitherto unpublished and new data must be compiled to provide an updated input for the EIA.

As a minimum requirement, a future study of habitat loss within the EIA must comprise for relevant species and periods:

1. A base-line description of species, abundance and distribution of wintering, moulting and staging birds to provide assessment and predictions*) of habitat loss
2. During construction of the fixed link, a description of species, abundance and distribution of wintering, moulting and staging bird to compare with base-line results to detect potential habitat loss

*) Modelling of densities and absolute number of bird occurrences based on line transect surveys has been dealt with by several authors (e.g. Burnham et al. 1980, Buckland et al. 2001) and may in the future involve an approach based on general additive modelling approach (Hedley et al. 1999).

8.4 Areas of construction, impact and control

In relation to the construction of the fixed link across Øresund a socalled BACI-design (before-after-control-impact) was suggested as an overall feasible design of environmental studies (Øresundskonsortiet 1995). A conventional BACI-design would include pre-defined impact and control areas to compare with before, during and post-construction. This approach would not be appropriate to follow in bird issues. For example with respect to migratory birds, overall migration routes are unique. On autumn migration, recruitment areas include mainly Siberia, the European part of Russia and Fenno-Scandia, from which areas birds are funnelled into various corridors over southern Scandinavia for example through the Fehmarnbelt. It is evident that a control area would be impossible to define in this case.

In a lateral and vertical description of migration routes, which should feed into a model of collision risk, changes as a result of avoidance (or attraction) responses towards barriers would be quite conspicuous, if data are compiled by remote sensing technologies such as radar. Hence, the orientation of migratory birds is quite consistent in Fehmarnbelt during a base-line situation, i.e. westerly and southerly during the autumn as well as easterly and northerly during spring. Given the consistency of the orientation of migratory birds, even fine-grained responses to a potential barrier of a few degrees would appear conspicuously and as significant deviations from existing migration routes (Kahlert et al. 2004b). The response distance and nature of the response (lateral or vertical) will be difficult to predict in advance. However, since a radar will usually cover an area of roughly hundred square kilometres or more, a zone of undisturbed flight behaviour and a response zone of birds approaching the fixed link can easily be discerned.

With respect to habitat loss, a control area, which is comparable to a potential impact zone, would also be difficult to predefine for surveys of wintering, staging, moulting and breeding birds (see discussion in Noer et al. 1996, Guillemette et al. 1998). Therefore, changes in numbers and distribution must be associated with an explanation of the causal relationship to discern effects and impact from natural variation. This would at the first instance involve that declines in bird numbers are associated with reductions in food resources or disturbance and secondly that this has been caused by activities at the fixed link. Such causal relationship would be extremely difficult to derive for piscivorous bird species, whereas the possibility exists for birds, which sustain themselves on benthic fauna and submerged vegetation.

Environmental programmes must be dynamic. A base-line period must be long enough to discern natural variation at some level before the construction of the fixed link. In the construction of the Øresund Fixed Link and Nysted Offshore Wind Farm three years defined the current practise in Danish bird studies (Noer et al. 1996, Kahlert et al. 2004b). In relation to the erection of offshore wind farms in Germany two years were proposed as a minimum duration of a base-line study (Hüppop et al. 2002). In addition, the construction phase of the Fehmarnbelt fixed link must be covered and a period during operation relevant for specific issues. In general, studies during the operation period at German offshore wind farms were suggested to comprise 3-5 years (Hüppop et al. 2002) and 2-3 years in environmental studies at Danish offshore wind farm studies. The bird collision study at the Øresund Fixed Link has so far lasted for three years during operation (Nilsson 2004).

8.5 Criteria

Prior to the construction of the fixed link across Øresund, the Danish Environmental Protection Agency adopted environmental criteria, which defined unacceptable impact. If criteria were transgressed mitigating actions had to be undertaken. This also involved birds. The criteria were mainly related to population size, occurrences and numbers of specific species (Danish Ministry of Transport 1995). A similar approach is possible with respect to the construction and operation of the fixed link across Fehmarnbelt. However, criteria may not only be associated with the population level but also with geographic entities.

Although collision risk may be related to local movements of birds, the predominant concern is the movements of dedicated migratory birds through the Fehmarnbelt area. The occurrences of migratory birds are of relative short duration in the area unless they decide to make a stop-over and become staging migrants (see below). Hence, migratory birds are not associated with a particular habitat or a well-defined area, and therefore criteria with respect to collision risk must be related to the number of collisions and ideally to their potential impact at the population level. The criteria for birds in Øresund involved to a large extent well-defined populations with known occurrences throughout the annual life cycle (e.g. the eider). The origin of birds, which occur in Fehmarnbelt, is not described in such fine-grained detail as the recruitment area comprises vast areas east and north of Fehmarnbelt. Hence, it must be emphasized that calculations of impacts on the population in case of adverse effects at the Fehmarnbelt fixed link cannot be carried out with the same accurracy as for example in the Øresund breeding eiders. For a number of species, it may even be impossible to undertake reliable calculations on impacts. It may therefore be appropriate to select a limited number of suitable key species and to define criteria for those species, only, which are assessed to be most sensitive to impacts and for which potential impacts can be detected with reasonable confidence.

Criteria of unacceptable impact on breeding, wintering, staging and moulting birds could also be defined based on population aspects. However, since this group of birds is associated with specific habitats or areas for a longer period (weeks or months) during their annual life cycle, a graded criterion, which relates to certain areas but not to others, is a feasible option. In this respect, the areas with substantial bird occurrences presented in chapter 4 and 5 are the potential important bird areas in Fehmarnbelt to which criteria could be associated.

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Appendix 1

International conventions and directives in relation to birds

Denmark and Germany are obliged to protect and maintain large and healthy bird populations, having ratified international conventions and under various EU-directives. These instruments are summarised below:

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

An area is identified as being of international importance if:

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

Wild Birds Directive
The Directive commits Member States to protect wild birds and for particular threatened species also designate suitable areas for conservation.

EU Habitats Directive
The Directive commits Member States to protect wild species and the habitats of the groups: plants, mammals, reptiles, amphibians, fish, and invertebrates; and to conserve threatened types of habitats. The areas designated in relation to the Ramsar Convention, the EU Birds Directive, and the EU Habitats Directive are in many cases the same.

Bonn Convention
The aim of the convention is conservation of those species of wild animals (including birds) that migrate across or outside national jurisdictional boundaries. Conservation may be exercised through protection of species and habitats and through agreement of management. Germany is a signatory to the African-Eurasian Migratory Waterbird Agreement (AEWA) under the Bonn Convention since 1998, Denmark since 1999.

Bern Convention
The aim of the convention is the conservation of wild European plants and animals and their habitats.

Appendix 2

The national occurrences of 21 waterbird species in Denmark, which occur regularly as staging migrants in the Danish part of Fehmarnbelt, and an appraisal of the species on which the original designation of SPA no. 83 is based and the proposal for future designation (from the public inquiry of Danish SPAs, the Forest & Nature Agency, http://www2.skovognatur.dk/natura2000/fuglebe-kyttelse/plysninger/opdatering_udpegningsgrundlag/udpegningsgrundlag_udkast.pdf)

Species	National occurrence	Original designation in SPA no. 83	Proposed designation in SPA no. 83
Red-throated diver *Gavia stellata*	27,000		
Black-throated diver *Gavia arctica*	Not determined		
Red-necked grebe *Podiceps grisegena*	3,600		
Cormorant *Phalacrocorax carbo*	43,300		
Mute swan *Cygnus olor*	58,000	Yes	Yes
Bewick's swan *Cygnus bewickii*	4,000		
Whooper swan *Cygnus cygnus*	18,000	Yes	Yes
Bean goose *Anser fabalis*	9,900	Yes	Yes
Greylag goose *Anser anser*	100,000		Yes
Canada goose *Anser canadensis*	Not determined		
Barnacle goose *Branta leucopsis*	83,000		
Dark-bellied brent goose *Branta bernicla*	14,000	Yes	Yes
Wigeon *Anas penelope*	170,000		
Shoveler *Anas clypeata*	8,600		
Pochard *Aythya ferina*	24,000		
Tufted duck *Aythya fuligula*	150,000		
Scaup *Aythya marila*	19,000		
Eider *Somateria mollissima*	550,000		
Long-tailed duck *Clangula hyemalis*	3,000		
Common scoter *Melanitta nigra*	595,000		
Goldeneye *Bucephala clangula*	65,000	Yes	Yes
Red-breasted merganser *Mergus serrator*	30,000		Yes
Coot *Fulica atra*	194,000	Yes	Yes

Appendix 3

The national occurrences of 27 waterbird species in Denmark (based on Grell 1998, Grell *et al.* 2004), which could potentially occur as breeding birds in the Danish part of Fehmarnbelt, and an appraisal of the species on which the original designation of SPA no. 83 is based and the proposal for future designation (from the public inquiry of Danish SPAs, the Forest & Nature Agency, http://www2.skovog-natur.dk/natura2000/fuglebeskyttelse/oplysninger/opdatering_udpegningsgrundlag/udpegningsgrundlag_udkast.pdf)

Species	National occurrences (pairs)	Original designation in SPA no. 83	Proposed designation in SPA no. 83
Red-necked grebe *Podiceps grisegena*	1.500-2.000		
Bittern *Botaurus stellaris*	150-200		Yes
Mute swan *Cygnus olor*	5.000		
Greylag goose *Anser anser*	3.500-4.000		
Gadwall *Anas strepera*	250-300		
Mallard *Anas plathyrhynchos*	20.000		
Pintail *Anas acuta*	150-175		
Garganey *Anas querquedula*	250-300		
Shoveler *Anas clypeata*	800-1.000		
Tufted duck *Aythya fuligula*	800-1.000		
Eider *Somateria mollissima*	20.000-24.000		
Red-breasted merganser *Mergus serrator*	2.000-3.000		
White-tailed eagle *Haliaeetus albicilla*	10		Yes
Marsh harrier *Circus aeruginosus*	650	Yes	Yes
Coot *Fulica atra*	20.000		
Moorhen *Gallinula chloropus*	(50.000?)		
Avocet *Recurvirostra avosetta*	5,000	Yes	Yes
Black-headed gull *Larus ridibundus*	150.000		
Common gull *Larus canus*	25.000-30.000		
Lesser black-backed gull *Larus fuscus*	4.400		
Herring gull *Larus argentatus*	55.000-58.000		
Great black-backed gull *Larus marinus*	1.500-1.600		
Sandwich tern *Sterna sandvicensis*	4,500	Yes	Yes
Common tern *Sterna hirundo*	1,000	Yes	Yes
Arctic tern *Sterna paradisaea*	8.000-9.000	Yes	Yes
Little tern *Sterna albifrons*	381-500	Yes	Yes
Short-eared owl *Asio flammeus*	3-11		Yes

Appendix 4

Annotated list of origin, population size and level of international importance for waterbird species (Delaney & Scott 2002) and their conservation status in EU member states (annexes).

Species	Population	Population size (no. individuals)	International importance (no. individuals)	Annex
Red-throated diver *Gavia stellata*	European	183,000-420,000	10,000	I
Black throated diver *Gavia arctica*	European	360,000-690,000	10,000	I
Little grebe *Tachybaptus ruficollis*	*ruficollis*/European	230,000-450,000	3,400	-
Red-necked grebe *Podiceps grisegena*	NW Europe	90,000-420,000	1,000	-
Cormorant *Phalacrocorax carbo sinensis*	N and C Europe	275,000-340,000	3,100	-
Whooper swan *Cygnus cygnus*	N mainland Europe	59,000	590	I
Mute swan *Cygnus olor*	NW and C Europe	250,000	2,500	II
Greylag goose *Anser anser*	NW Europe	400,000	4,000	II/III
White-fronted goose *Anser albifrons*	Baltic-North Sea	1 mill.	10,000	II/III
Bean goose *Anser fabalis*	*fabalis*	100,000	1,000	II
	rossicus	600,000	6,000	II
Barnacle goose *Branta leucopsis*	N Russia / E Baltic	360,000	3,600	I
Dark-bellied brent goose *Branta bernicla bernicla*	W Siberia	215,000	2,200	II
Shelduck *Tadorna tadorna*	NW Europe	300,000	3,000	-
Wigeon *Anas penelope*	NW Europe	1.5 mill.	15,000	II/III
Teal *Anas crecca*	NW Europe	400,000	4,000	II/III
Mallard *Anas plathyrhynchos*	NW Europe	4.5 mill.	20,000	II/III
Pintail *Anas acuta*	NW Europe	60,000	600	II/III
Shoveler *Anas clypeata*	NW and C Europe	40,000	400	II/III
Pochard *Aythya ferina*	NE and NW Europe	350,000	3,500	II/III
Tufted duck *Aythya fuligula*	NW Europe	1.2 mill.	12,000	II/III
Scaup *Aythya marila*	W Europe	310,000	3,100	II/III
Eider *Somateria mollissima*	Baltic-Wadden Sea	850,000-1.2 mill.	10,300	II/III
Longtailed duck *Clangula hyemalis*	W Siberia / N Europe	4.6 mill.	20,000	II
Common scoter *Melanitta nigra*	W Siberia / N Europe	1.6 mill.	16,000	II/III
Goldeneye *Bucephala clangula*	NW and C Europe	400,000	4,000	II
Red-breasted merganser *Mergus serrator*	NW and C Europe	170,000	1,700	II
Coot *Fulica atra*	NW Europe	1.75 mill.	17,500	II/III
Common gull, mew gull *Larus canus*	*canus*	1.3-2.1 mill.	17,000	II
Great black-backed gull *Larus marinus*	NW Atlantic	180,000	1,800	II
Herring gull *Larus argentatus*	*argentatus*	1.1-1.5 mill.	13,000	II
Black-headed gull *Larus ridibundus*	N and C Europe	5.6-7.3 mill.	20,000	II
Little gull *Larus minutus*	N, C and E Europe	66,000-102,000	840	I
Sandwich tern *Sterna sandvicensis*	W Europe	159,000-171,000	1,700	I
Common tern *Sterna hirundo*	S and W Europe	170,000-200,000	1,900	I
	N and E Europe	460,000-820,000	6,400	I
Arctic tern *Sterna paradisaea*	N Eurasia (Europe)	1.32-2.28 mill.	-	I
Little tern *Sterna albifrons*	W Europe	31,000-37,500	340	I

Appendix 5

Number of breeding pairs (BP) of all coastal waterbird species and of selected terrestrial bird species (with a classification in the red lists) in the area of Fehmarn/Heiligenhafen according to atlas data (Berndt *et al.* 2002) and to Berndt *et al.* (2004). Percentage of national occurrence (% NO) in the 1990's and species of European concern (SPEC) after Heath *et al.* (2000), red list status in Germany (RL-G) after Bauer *et al.* (2002), red list status of the German Baltic region (RL-BR) after Brenning *et al.* (1996). Rec. year = year of record, B = brood, W = winter, I = reproduction guest, NT = near-threatened, R = rare, resp. = special responsibility.

Species	BP	Rec. year	% NO	SPEC	RL-G	RL-BR
Little grebe *Tachybaptus ruficollis*	5	1985-1994	0,1		NT	
Great crested grebe *Podiceps cristatus*	71	1985-1994	0,3			resp.
Red-necked grebe *Podiceps grisegena*	119	1997	**6,7**		NT	NT
Bittern *Botaurus stellaris*	18	1985-1994	**5,3**	3	1	2
Mute Swan *Cygnus olor*	73	1985-1994	**1,1**			resp.
Greylag goose *Anser anser*	358	1999	**4,0**			resp.
Canada goose *Branta canadensis*	1	1999				resp.
Common shelduck *Tadorna tadorna*	83	1985-1994	**1,9**			
Gadwall *Anas strepera*	52	1985-1994	**1,8**	3		resp.
Teal *Anas crecca*	8	1985-1994	0,1			2
Mallard *Anas platyrhynchos*	299	1985-1994	0,1			
Garganey *Anas querquedula*	7	1985-1994	0,3	3	2	2
Shoveler *Anas clypeata*	36	1985-1994	0,9			3
Red-crested pochard *Netta rufina*	8	1999	**1,8**	3	2	2
Pochard *Aythya ferina*	172	1985-1994	**1,9**	4		resp.
Tufted Duck *Aythya fuligula*	68	1985-1994	0,6			resp.
Eider *Somateria mollissima*	45	1999	**3,9**			NT, resp.
Red-breasted merganser *Mergus serrator*	72	1999	**9,3**		2	3
Goosander *Mergus merganser*	2	1985-1994	0,4		3	2, resp.
Marsh harrier *Circus aeruginosus*	62	1985-1994	**1,2**			3
Kestrel *Falco tinnunculus*	26	1985-1994	0,0	3		
Grey partridge *Perdix perdix*	43	1985-1994	0,1	3	2	
Quail *Coturnix coturnix*	1	1985-1994	0,0	3		
Spotted crake *Porzana porzana*	2	1985-1994	0,3	4		2
Coot *Fulica atra*	416	1985-1994	0,3			resp.
Oystercatcher *Haematopus ostralegus*	61	1985-1994	0,2			3, resp.
Avocet *Recurvirostra avosetta*	58	1999	0,8	4B, 3W		3, resp.
Ringed plover *Charadrius hiaticula*	59	1999	**2,7**		2	3, resp.

Species	BP	Rec. year	% NO	SPEC	RL-G	RL-BR
Lapwing *Vanellus vanellus*	282	1985-1994	0,3		2	3
Dunlin *Calidris alpina*	1	1985-1994	**1,9**	3W	1	1, resp.
Common Snipe *Gallinago gallinago*	28	1985-1994	0,2		1	1
Black-tailed Godwit *Limosa limosa*	15	1985-1994	0,2	2	1	1
Curlew *Numenius arquata*	1	1985-1994	0,0	3W	2	1
Redshank *Tringa totanus*	101	1985-1994	0,4	2	2	2
Mediterranean gull *Larus melanocephalus*	1	1999	**2,1**	4		NT
Black-headed gull *Larus ridibundus*	18	1999	0,0			
Common gull *Larus canus*	676	1999	**3,5**	2		
Herring gull *Larus argentatus*	1000	1999	**2,1**			
Gr. black-backed gull *Larus marinus*	7	2000	**41**[*)]	4	R	I
Common tern *Sterna hirundo*	62	1999	0,7		NT	3
Arctic tern *Sterna paradisaea*	36	1999	0,6			2
Little tern *Sterna albifrons*	21	1999	**2,3**	3	2	1
Black tern *Chlidonias niger*	11 - 12	2000	**1,2**	3	1	1
Wood pigeon *Columba palumbus*	908	1985-1994	0,0	4		
Collared dove *Streptopelia decaocto*	106	1985-1994	0,0		NT	
Cuckoo *Cuculus canorus*	68	1985-1994	0,1		NT	
Short-eared owl *Asio flammeus*	2	1985-1994	**2,0**	3	1	1
Sky lark *Alauda arvensis*	517	1985-1994	0,0	3		
Sand martin *Riparia riparia*	>1500	1985-1994	**>1,9**	3	NT	
Barn swallow *Hirundo rustica*	682	1985-1994	0,0	3	NT	
House martin *Delichon urbica*	1392	1985-1994	0,1		NT	
Meadow pipit *Anthus pratensis*	177	1985-1994	0,1	4		
Sedge warbler *Acroc. schoenobaenus*	153	1985-1994	**1,0**	4	2	2
Red-backed shrike *Lanius collurio*	1	1985-1994	0,0	3		

[*)] German total only 17 pairs in 1999

Appendix 6

Number of bird carcasses collected at the "FINO-1" offshore research platform (southern North Sea) from 1.10.2003 to 6.10.2004 (Hüppop *et al.* in prep.).

Species	No. of carcasses
Waterbirds	
Dunlin *Calidris alpina*	1
Passerines	
Sky lark *Alauda arvensis*	5
Barn swallow *Hirundo rustica*	1
Meadow pipit *Anthus pratensis*	1
Wheatear *Oenanthe oenanthe*	1
Blackbird *Turdus merula*	12
Fieldfare *Turdus pilaris*	28
Redwing *Turdus iliacus*	43
Song thrush *Turdus philomelos*	98
Mistle thrush *Turdus viscivorus*	1
Thrushes indet. *Turdidae*	8
Willow warbler *Phylloscopus trochilus*	2
Chiffchaff *Phylloscopus collybita*	2
Starling *Sturnus vulgaris*	19
Brambling *Fringilla montifringilla*	2
Twite *Carduelis flavirostris*	1
Reed bunting *Emberiza schoeniclus*	1
Passerines indet. *Passeres spp.*	1
Total	227

Appendix 7

Number of dead birds collected on the Øresund Bridge, September-December 2001, 2002 and 2003 (Nilsson & Green 2002, Nilsson 2003, Nilsson 2004).

Species	Sep.-Dec. 2001	2002	2003
Cormorant *Phalacrocorax carbo*			1
Mute swan *Cygnus olor*			2
Shelduck *Tadorna tadorna*			1
Mallard *Anas plathyrhynchos*		2	1
Tufted duck *Aythya fuligula*			1
Buzzard *Buteo buteo*			1
Sparrow hawk *Accipiter nisus*		2	
Merlin *Falco columbarius*	1		
Coot *Fulica atra*			1
Moorhen *Gallinula chloropus*	1		
Woodcock *Scolopax rusticola*	1		
Common gull *Larus canus*		2	1
Herring gull *Larus argentatus*	4	12	8
Lesser black-backed gull *Larus fuscus*			1
Great black-backed gull *Larus marinus*	1	8	7
Feral rock dove *Columba livia domestica*	1	2	
Carrier pigeon		7	19
Wood pigeon *Columba palumbus*			7
Short-eared owl *Asio flammeus*	4		1
Long-eared owl *Asio otus*	1	1	
Great spotted woodpecker *Dendrocopus major*	3		
Wood-lark *Lullula arborea*	1		
Skylark *Alauda arvensis*	17	2	
Pied wagtail *Motacilla alba*		2	1
Meadow pipit *Anthus pratensis*	10		2
Wren *Troglodytes troglodytes*	3		
Robin *Erithacus rubecula*	125		1
Redstart *Phoenicurus phoenicurus*		1	
Blackbird *Turdus merula*	1	1	1
Fieldfare *Turdus pilaris*	1		
Redwing *Turdus iliacus*	4		
Song thrush *Turdus philomelos*	37	1	1
Reed warbler *Acrocephalus scirpaceus*		1	1

Species	Sep.-Dec. 2001	2002	2003
Icterine warbler *Hippolais icterina*		1	
Lesser whitethroat *Sylvia curucca*		1	
Garden warbler *Sylvia borin*	1		
Blackcap *Sylvia atricapilla*	2		
Willow warbler *Phylloscopus trochilus*	2	39	
Chiffchaff *Phylloscopus collybita*	2		
Pied flycatcher *Ficedula hypoleuca*		1	
Goldcrest *Regulus regulus*	28		
Blue tit *Parus caeruleus*	13		
Magpie *Pica pica*	1		
Crow *Corvus corone*	1	1	
Starling *Sturnus vulgaris*		5	11
Chaffinch *Fringilla coelebs*	10		
Brambling *Fringilla montifringilla*	3	2	
Siskin *Carduelis spinus*	1		
Redpoll *Carduelis flammea*	1		
Yellowhammer *Emberiza citrinella*	2		
Little bunting *Emberiza pusilla*	1		
Reed bunting *Emberiza schoeniclus*	5		
Undetermined passerine *Passeres spp.*	6		
Total	295	94	70

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preliminary risk assessment on birds

National Environmental Research Institute
Ministry of the Environment