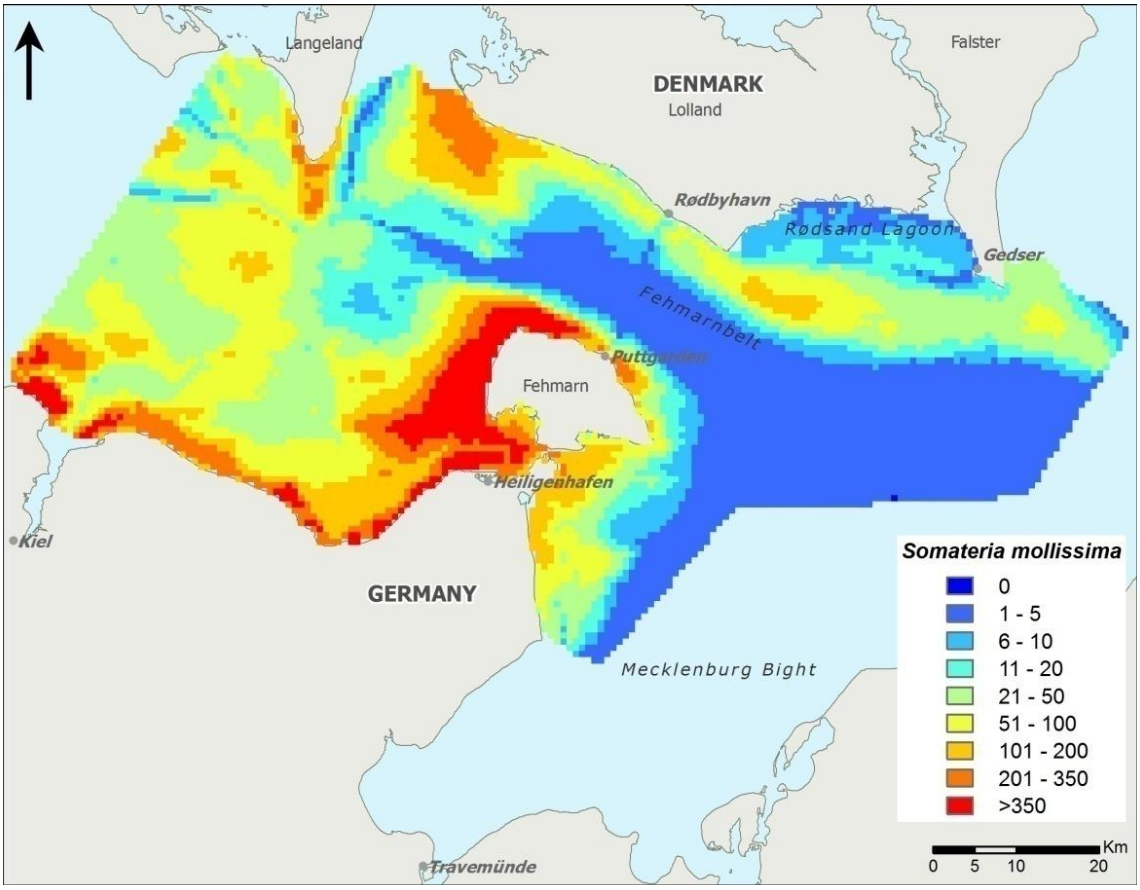
Final Report

FEHMARNBELT FIXED LINK
BIRD SERVICES (FEBI)

Bird Investigations in Fehmarnbelt - Baseline

Waterbirds in Fehmarnbelt

E3TR0011 Volume II



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LIST OF CONTENTS

Lists of figures and tables are included as the final pages

Note to the reader:
In this report the time for start of construction is artificially set to 1 October 2014 for the tunnel and 1 January 2015 for the bridge alternative. In the Danish EIA (VVM) and the German EIA (UVS/LBP) absolute year references are not used. Instead the time references are relative to start of construction works. In the VVM the same time reference is used for tunnel and bridge, i.e. year 0 corresponds to 2014/start of tunnel construction; year 1 corresponds to 2015/start of bridge construction etc. In the UVS/LBP individual time references are used for tunnel and bridge, i.e. for tunnel construction year 1 is equivalent to 2014 (construction starts 1 October in year 1) and for bridge construction year 1 is equivalent to 2015 (construction starts 1st January).

1 INTRODUCTION

The marine and coastal areas of the Fehmarnbelt offer a wide range of habitats for breeding and non-breeding waterbirds. In this volume numbers and distribution of waterbirds in the Fehmarnbelt are presented based on different data sources and investigations. Describing occurrence, habitat utilisation and for some species behaviour and food choice, the volume sets the baseline on waterbirds which are resident in the Fehmarnbelt during at least a part of their annual cycle. The report is structured along three main chapters providing information on breeding waterbirds in the Natura 2000 areas in the Fehmarnbelt area (chapter 3), numbers and distribution of non-breeding waterbirds (chapter 4) and feeding ecology of selected waterbird species (chapter 5).

All information on breeding birds was taken from literature and public sources such as regular reports on Natura 2000 monitoring. Suitable habitats for breeding waterbirds in the Fehmarnbelt area are almost completely included in the Natura 2000 network in Germany and Denmark and as most other areas are either intensively used for recreation or agriculture, there are no relevant numbers of breeding waterbirds outside protected areas.

The chapter on non-breeding waterbirds mainly presents the results of the baseline investigations on numbers and distributions of waterbirds. The main objective of this work has been to provide detailed documentation of the spatio-temporal variation in the waterbirds' use of different parts of the Fehmarnbelt area. The Fehmarnbelt area is of high importance for staging waterbirds during the winter months, and the offshore shallows east and west of Fehmarn and Albue Bank as well as Rødsand Lagoon are classified as areas of international importance to waterbirds (Skov et al. 1998). This status is reflected in the protected area networks of both Germany and Denmark, which together represent 30 % of the marine area in the Fehmarnbelt. In addition, the protected coastal areas, lagoons and lakes in the coastal environment of the region hold relatively important breeding and staging grounds for a range of waterbirds. Waterbirds breeding in the coastal habitats also regularly feed in the offshore parts of the Fehmarnbelt. As the coastal habitats on both the German and the Danish side are subject of national and regional monitoring activities, the baseline investigations were designed to obtain data on numbers and distribution of birds in the marine parts of the Belt.

Aerial surveys were used to map the distribution of staging and wintering waterbirds with the focus on seaducks, and to calculate their numbers. The flights were conducted by standard line transect methods as described in the 'standards for environmental impact assessment' StUK (BSH 2007) for offshore wind farms in Germany. The surveys sampled densities at a relatively high resolution required for analysis and modelling of habitat utilisation. The survey area was slightly smaller than during the feasibility study, but fully covered all SPAs adjacent to the Fehmarnbelt as well as all possibly affected areas.

Additional ship-based surveys focused on the alignment of the fixed link and the coastal areas with occurrence of divers and grebes, and used a transect design with parallel lines near the alignment, and a zig-zag design in the coastal waters around Fehmarn and Lolland. The methods followed the standards of the European Seabirds at Sea database (ESAS, Camphuysen et al. 2004) and the StUK (BSH 2007). Analyses of the ship-based investigations are not yet completed and will be presented in detail in an update of this report.

The baseline investigations of waterbird distribution and abundance were supplemented with investigations on waterbird feeding ecology to increase the knowledge about the waterbirds' use of the region and identify relationships between birds and their habitats. The most abundant and – based on their consumption – ecologically most important species in the Fehmarnbelt are the molluscivorous seaducks Common Eider, Common Scoter and Long-tailed Duck. Seaducks mainly prey on bivalves and other molluscs and are known to be able to substantially deplete the food resources on their wintering grounds and their numbers may be related to the carrying capacity of the wintering areas (Guillemette et al. 1992; Lewis et al. 2007). Habitat changes resulting from sediment spills or hydrological changes from construction or operation of a fixed link across the Fehmarnbelt are thus regarded as relevant impact factors which need to be addressed in the Environmental Impact Studies.

The feeding ecology chapter analyses species-habitat relationships based on feeding ecology and local movements of selected species in order to build a basis for modelling impacts of habitat changes on their populations.

The objectives of this chapter are the following:

- To assess the feeding ecology of important waterbird species wintering or moulting in the Fehmarnbelt and to evaluate the carrying capacity of their habitats. This objective is related to the assessment of potential habitat loss (habitat change, destruction or bird relocation due to disturbance) related to the fixed link construction scenarios.
- Assess local movements of wintering birds. This objective aims at evaluating potential barrier effects to wintering waterbirds if the bridge solution was chosen.

The following species groups have been studies:

- The Common Eider, Common Scoter and Long-tailed Duck as being the most numerous seaduck species in the area;
- The Tufted Duck as the most abundant coastal diving duck species in the area;
- The Mute Swan as a herbivorous waterfowl species, which moults in internationally important numbers in the Rødsand lagoon;
- The Cormorant as the most abundant piscivorous waterbird species in the area.

2 METHODS

2.1 Breeding waterbirds in the Fehmarnbelt

Assessment of breeding waterbirds in the Special Protection Areas in the Fehmarnbelt was based on a review of available literature sources.

2.2 Non-breeding waterbirds in the Fehmarnbelt

2.2.1 Aerial surveys

Baseline aerial surveys were conducted using the German "Standards for the Environmental Impact Assessment" for offshore wind farms (BSH 2007) as guidance. The survey methodology closely followed the modified line transect survey technique with four perpendicular distance bands applied elsewhere during several EIA studies and monitoring programmes (e.g. Diederichs et al. 2002, Noer et al. 2000, Piper et al. 2007, Petersen and Fox 2007).

Survey planes

For safety reasons only twin-engine high-wing planes with professional pilots were used. Plane types used were Partenavia P-68 (FLM-Aviation, Kiel; Sylt-Air, Sylt), Partenavia P-68 Observer (bioflight AS, Holte) and Britten-Norman Islander BN-2 (Air-Hamburg, Hamburg). Seating varied between the planes, with the third observer sitting two rows in front of the main observers in BN-2, or directly behind the main observers in Partenavia (Figure 2.1).

Figure 2.1 Survey plane Partenavia P68.

Aerial survey design

The study area of the aerial surveys for staging birds comprised 4,875 km^2. In the north it follows the coastlines of Langeland, Lolland and Falster; while in the south it extends along the German coast from Kiel in the West to offshore-areas north of Warnemünde. Maximum distance to the alignment is approximately 70 km. Water depth varies up to a maximum of 39 m (Figure 2.2).

Line transect methodology was used for counting the staging birds following the Distance sampling approach of Buckland et al. (2001). A total of 32 parallel transects were used with a 3 km distance between transects. The transects were divided into 2 flight schemes to be covered by two planes in one day, or one plane in two days. Note that some sections of the transect lines cross the land at Fehmarn; these sections were discarded in the analyses. Survey flights targeted birds as well as marine mammals (flight altitude of 250 ft/76 m).

The Rødsand 2 offshore wind farm has been erected during the period of investigations. Consequently, the flight schemes were adjusted for the construction of the Rødsand 2 by adding new waypoints and modifying the transect route, so it passed between the windmill lines. Lengths of individual transects ranged from 24 to 64 km. The total transect length was approximately 1,600 km. Due to several reasons (including flight paths over land or active military areas, high sea state, sun glare, technical problems) the achieved survey effort varied amongst surveys completed in different months.

The transect design is shown in Figure 2.2, which also shows the military area where conducting of surveys was restricted. When there were military activities in those areas, survey flights were not possible for the part of transects that fell within either zone. Some areas within the Kiel Bight were only occasionally restricted; whereas others (e.g. "Todendorf/Putlos" in the Hohwacht Bay) were accessible only on weekends.

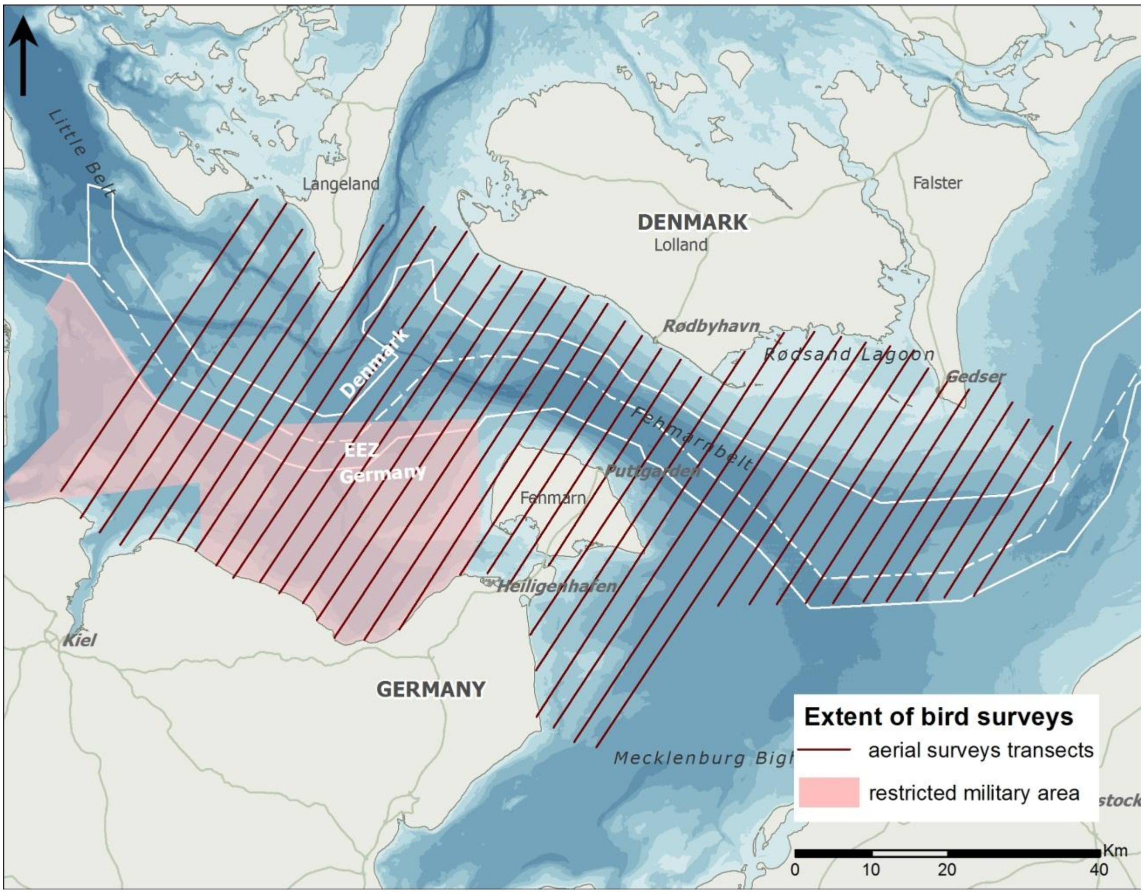


Figure 2.2 Position of the aerial survey transect lines in the Fehmarnbelt. Military areas, where survey flights were frequently restricted are shown in pink.

Recording techniques

Three experienced observers were used during the surveys: two principal observers were placed at the 'bubble' windows (which provide visibility directly below the plane; search angle = 0° - <60°; where 0° is directly below the plane) at each side of a plane. One control observer was placed at a flat window behind or in front of the principal observers (search angle = 20° - < 60°). The control observer switched sides on each transect, depending on sighting conditions. Observers used ear plugs and headphones and therefore were acoustically isolated from each other. From the onset of the survey, the observers searched continuously for birds and marine mammals. For each sighting, the exact time was noted (UTC, synchronised with an on-board GPS) and recorded by speaking into a dictaphone. Following the recommendations for sampling of densities in distance intervals (Buckland et al. 2001), survey transects were subdivided into perpendicular bands to allow calculations of detection probabilities. Four standard bands were used: 0-45 m, 45-167 m, 168-442 m and 442-1,500 m, which corresponded to inclinations in degrees from horizon of 90-60°, 60-25°, 25-11° and <10°. This number of bands is assumed to be the best compromise between obtaining accurate density data and the short period of time available for cognitive processing and recording the information. In periods or areas of low bird densities, clinometers (Suunto PM 5 / 360 PC) were used to measure the sighting angles to birds (Figure 2.3) while in high density areas allocation of observations to transect bands was estimated by the observers.

Figure 2.3 Aerial survey: if possible, measuring the angle to the birds has been done with a clinometer.

From the declination angle and the aircraft altitude the perpendicular distance to the sighting was calculated (Figure 2.4). Additionally, data on group size and composition, travel direction and the behaviour of the animals were recorded. The flight-track was logged and stored continuously in 3 sec intervals by two GPS-units. Further details of the aerial survey techniques used can be found in Diederichs et al. (2002), Christensen et al. (2006), and Piper et al. (2007).

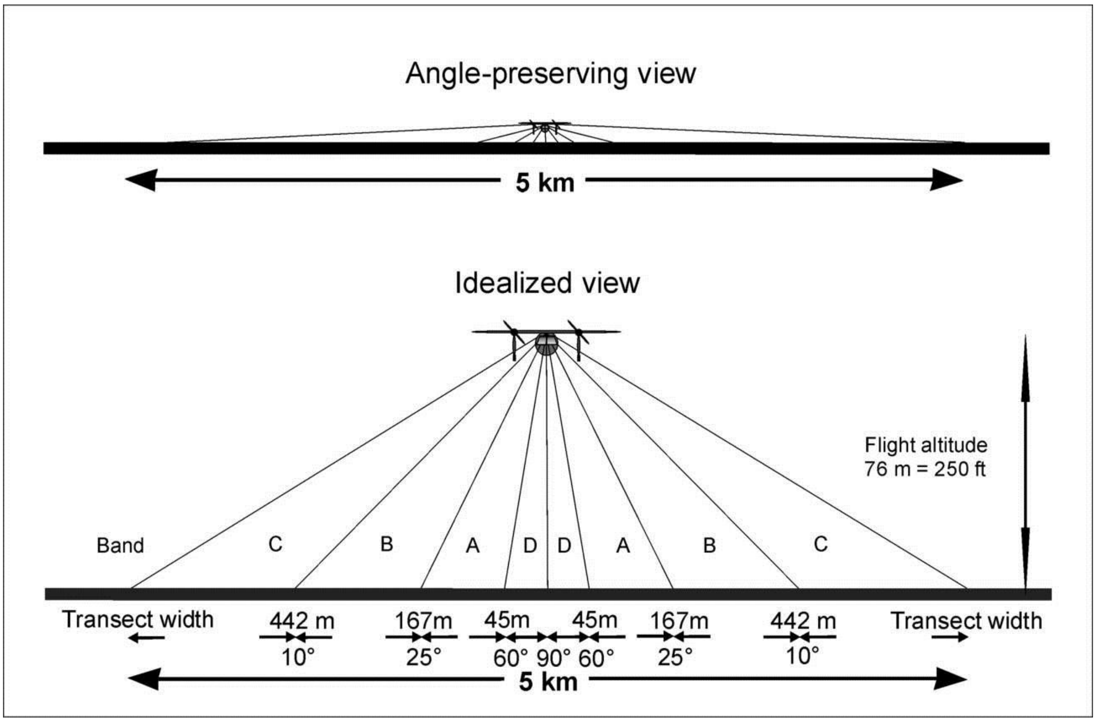


Figure 2.4 Standardised aerial survey method for counting staging birds.

Weather conditions (sea state, glare, cloud reflections, cloud coverage, precipitation and water turbidity) were recorded at the start of each transect and whenever conditions changed. All vessels sighted (including type, distance to transect and heading) and fishing gillnets were also recorded.

Data were only collected in good survey conditions (Douglas sea states below Beaufort 3, visibility more than 5 km) during the combined seabird/marine mammal surveys. Survey speed was approximately 100 knots (185 km/h, 115 mph).

Aerial survey effort

Aerial survey effort (two-sided valid effort in km) varied between different surveys (Table 2.1). The aerial surveys were carried out every month as scheduled except in December 2009 when only a half of one scheme was completed due to bad weather conditions. In July 2010 the survey one cancelled in agreement with Femern A/S.

Table 2.1 Aerial survey effort (two-sided valid effort in km) from November 2008 to December 2009.

Year	Month	Effort (km)
2008	Nov	1,189
2008	Dec	1,202
2009	Jan	1,217
2009	Feb	1,470
2009	Mar	1,140
2009	Apr	1,276
2009	May	1,137
2009	Jun	1,190
2009	Jul	1,274
2009	Aug	1,358
2009	Sep	1,163
2009	Oct	1,175
2009	Nov	1,211
2009	Dec	364
2010	Mar A	1,001
2010	Mar B	1,180
2010	Apr	1,563
2010	May	1,439
2010	Jun	1,105
2010	Aug	1,181
2010	Sep A	701
2010	Sep B	764
2010	Oct	1,249
2010	Nov	1,096
Total		**27,645**

2.2.2 Ship-based surveys

Ship-based surveys were carried out applying the standard method used in Denmark and Germany. The ESAS strip-transect method (Tasker et al. 1984, Webb and Durinck 1992, Camphuysen et al. 2004), slightly revised to a line-transect technique, is still the backbone of modern ship-based surveys of seabirds at sea in northwest European waters (Camphuysen et al. 2004).

Survey ships

From November 2008 to December 2010 three vessels were used for ship-based transect surveys (Table 2.2; Figure 2.5). The survey ships were equipped with a stable observer platform (usually a box, in which the observers are sitting, sheltered against the wind), and were cruising at the speed of ca. 10 knots (ca. 18.5 km/h). Height of the observation platform ranged from 6.2 to 10.3 metres above sea-level.

Table 2.2 Specifications of survey vessels used from November 2008 to November 2010.

Specifications	MV Arne Tiselius	MV Arnar	MV Miljø
Gross tonnage (t)	237	265	122
Length (m)	31	29	29.16
Breadth (m)	7.08	9	7.01
Draft (m)	2.85	2.5	3.1
Height above sea (m)	10.3	6.2	7
Number of cruises	8	10	1

Figure 2.5 MV "Arne Tiselius".

Ship-based survey design
The ship-based surveys covered the area around Fehmarn (incl. the western part of Mecklenburg Bight and eastern part of Hohwacht Bay), the Lolland coast from Langø to Gedser, the Fehmarnbelt offshore sites of community importance (SCI) and the planned fixed link. Geographical position of transects is visualised in Figure 2.6.

Two survey designs were implemented. The coastal surveys have been conducted using zig-zag lines crossing the same depth gradient from 7 to 18 m. The surveys in the SCI areas and along the fixed link were conducted using parallel transect lines with a line spacing of ca. 3 km (according to StUK 2007). The design has been adapted to carry out the full survey in three days during most of the year.

Due to weather conditions and military activities, it often took more than three days to achieve the full survey coverage. Due to the water depth and the draught of the ships used the planned transect lines could not be carried out to their full extent close to the coastlines.

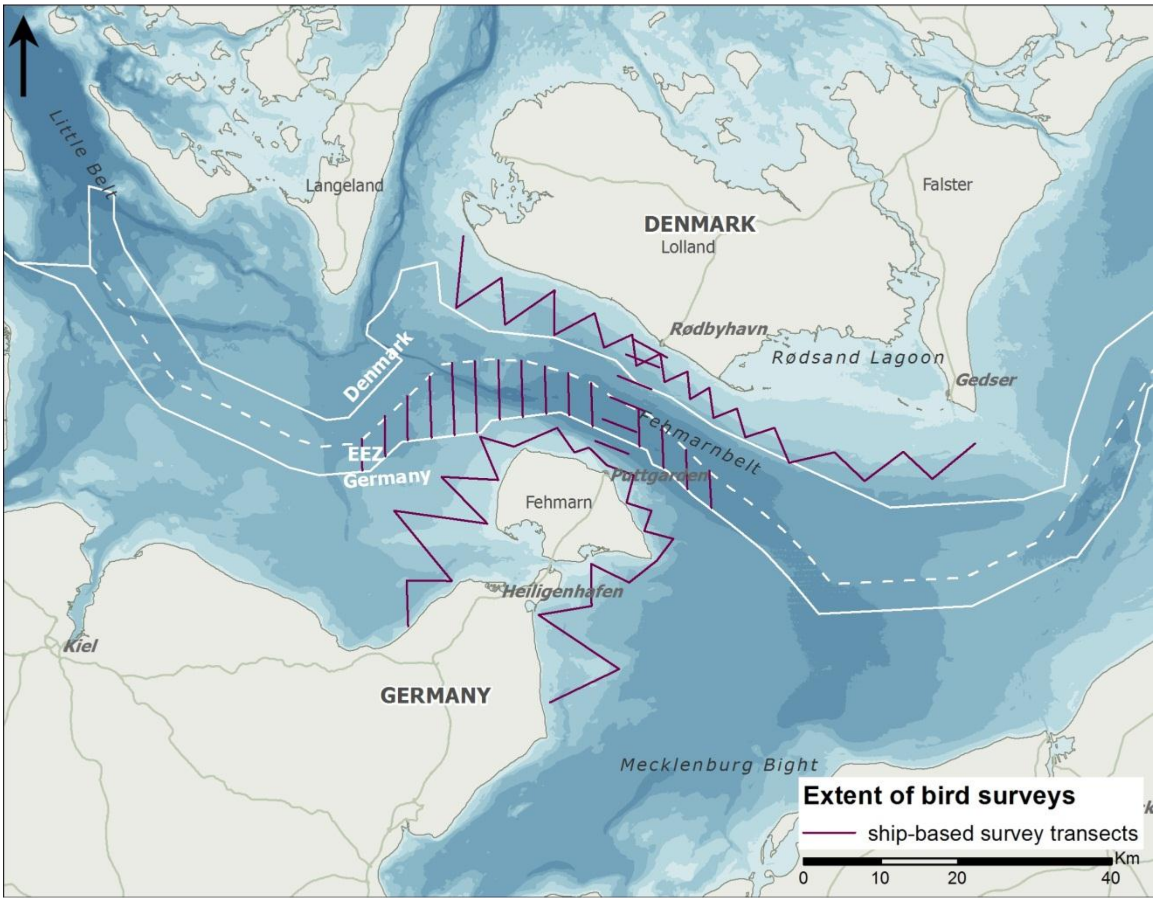


Figure 2.6 Position of the transect lines for the Fehmarnbelt ship-based transect surveys.

Recording techniques

During the ship-based surveys birds were recorded using line transect methods in which densities were sampled in distance intervals (Buckland et al. 2001) within a 300 m wide transect on each side and ahead of the ship. Counts were subdivided into short time intervals (1 min) in a continuous series aiming to sample short stretches of water with a known surface area, a known location and any other biological, geographical, or physical factors that could be associated by that area. The transect was subdivided into narrower distance strata: A = 0-50 m distance to the ship, B = 50-100 m, C = 100-200 m, D = 200-300 m, and E > 300 m (Figure 2.7; Camphuysen et al. 2004). All birds on water within a 300 m perpendicular distance to the track line of the ship were counted as 'in transect'. To avoid an overestimate of flying bird numbers, a regular snapshot of flying birds over the transect and within 300 m ahead of the ship was performed at intervals of 1 min (Tasker et al. 1984; Figure 2.7). As the waterbirds in the study area are dominated by species which react strongly on approaching ships (e.g. Common Eider, Common Scoter) the transect area in front of the ship was scanned continuously using binoculars. An angle-distance corrector (Durinck et al. 1993) was used to enable correct allocation of observations of birds ahead of the ship into the perpendicular distance bands (Figure 2.8).

Birds outside a transect were recorded in 180° scan ahead of the ship. Birds recorded in the scan were not used to calculate densities, and recording them therefore had a lower priority than recording birds in transect since abundance estimates were the main objective of our surveys. Scan results may enhance assessments of age and sex composition or directions of flight by migrants and birds travelling to and from colonies simply by enlarging sample sizes. Also scans accommodate sightings of rarer, highly mobile seabirds such as shearwaters, skuas, terns and migratory birds that would otherwise remain unrecorded or flushed birds, e.g. divers and scoters.

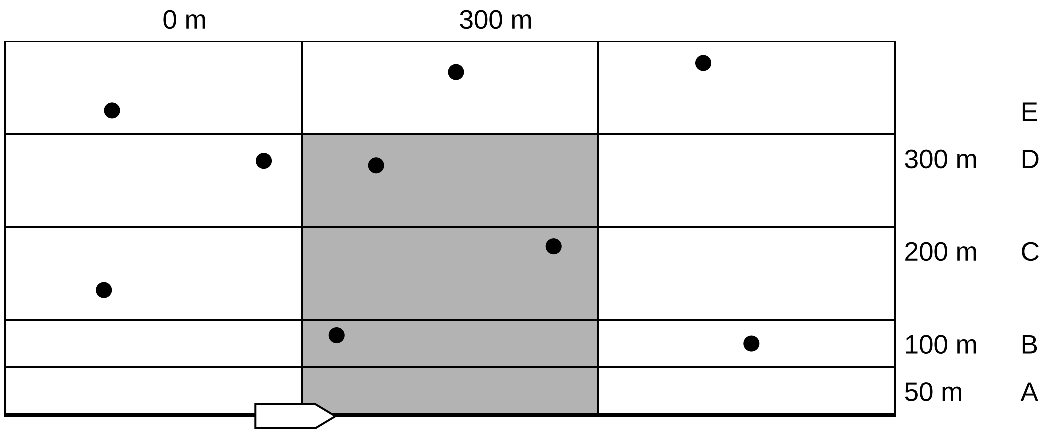


Figure 2.7 *Schematic representation of a strip transect survey by a ship cruising at the speed of 10 kn (flying birds in grey areas at the time of the snapshot are counted as 'in transect', all other flying birds are counted as 'not in transect').*

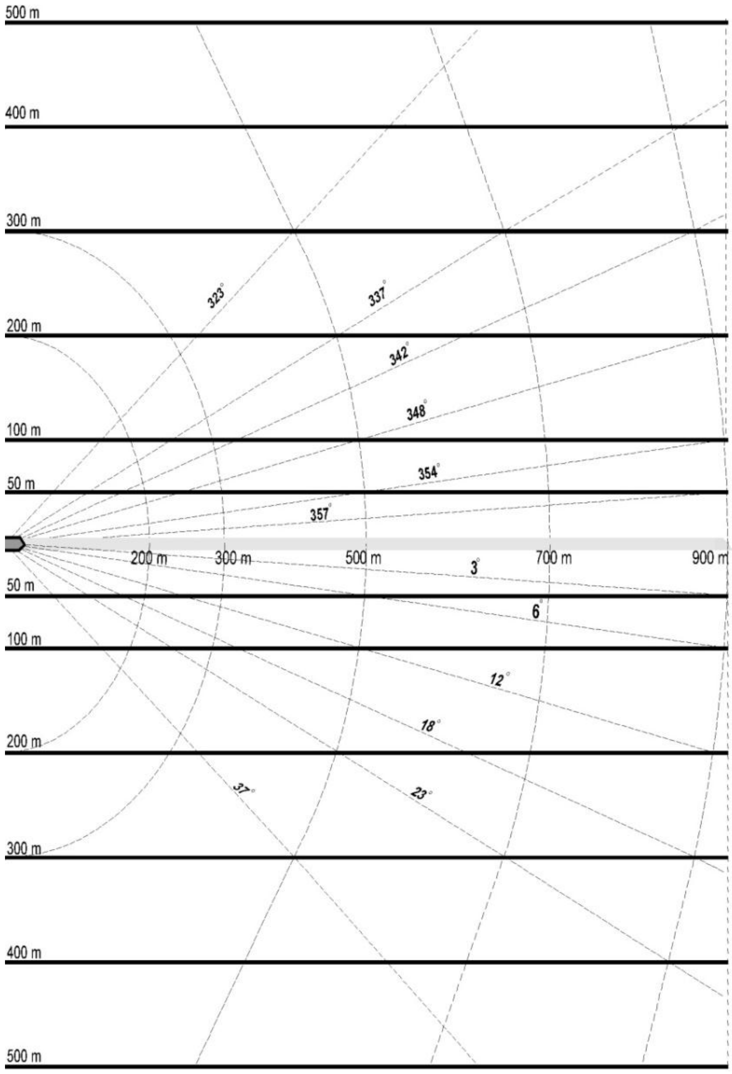


Figure 2.8 Angle-distance corrector used to allocate observations of birds ahead of the ship into the perpendicular distance bands (Durinck et al. 1993).

Data were collected only during good or moderate survey conditions (sea state not higher than Beaufort 4, visibility > 3 km, moderate glare). From the onset of a survey, the observers searched continuously for birds. Bird detections were done by the naked eye and scanning ahead with binoculars by the second observer. Identification of species, recording of behaviour and registration of numbers were done following a modified ESAS-standard (Camphuysen et al. 2004).

Sightings were noted in 1 min intervals on special paper forms (in UTC, watches synchronised with an on-board GPS). The ship-track was logged continuously in 10 sec intervals by a GPS (Garmin GPS 48 with external antenna) connected to a notebook. Simultaneously the track was also logged and stored on the connected notebook by FUGAWI™ software.

Ship-based survey effort

The valid effort of ship-based surveys was rather consistent from November 2008 to November 2010 (Table 2.3). To collect more information on the abundance and distribution of waterbirds during the cold winter 2009/2010 two surveys were made in February 2010. On request by Femern A/S no surveys were undertaken in July and August 2010.

Table 2.3 Ship-based survey effort (two-sided valid effort in km) from November 2008 to November 2010.

Year	Month	Full survey, km	Danish coast, km	SCI/Fixed link, km	German coast, km
2008	Nov/Dec	343.9	107.7	127.4	108.8
2008	Dec	290.7	63.5	113.9	113.4
2009	Jan	392.4	124.4	131.2	136.8
2009	Feb	395.3	120.2	133.3	141.7
2009	Mar	388.8	120.8	129.9	138.1
2009	Apr	395.4	122.0	135.3	138.2
2009	Jun	388.6	121.7	131.4	135.6
2009	Jul A	376.5	110.1	131.5	134.8
2009	Jul B	344.9	118.3	130.5	96.0
2009	Aug	387.6	118.5	131.6	137.5
2009	Sep	383.0	118.7	130.2	134.1
2009	Oct	331.7	118.6	79.3	133.8
2009	Nov	372.5	118.8	131.6	122.1
2009	Dec	385.4	115.4	132.0	138.0
2010	Jan	392.4	117.5	131.3	138.0
2010	Feb A	395.3	117.7	131.1	132.6
2010	Feb B	388.8	117.2	131.4	139.4
2010	Mar	395.4	116.2	123.0	138.0
2010	Apr	388.6	119.3	126.2	139.4
2010	May	376.5	115.7	129.1	133.1
2010	Aug	344.9	114.9	130.9	135.4
2010	Sep	387.6	118.3	126.9	134.9
2010	Oct	383.0	115.4	125.2	137.0
2010	Nov	331.7	118.8	131.4	141.9

2.2.3 *Other data sources*

The surveys undertaken by FEBI have been supplemented by data sources from national, regional and local monitoring activities (Table 2.4).

Table 2.4 Supplementary data sources.

Data source	Method	Area covered	Time period
OAG	Land-based counts	German mainland coast	2008-2010
AKVSW	Land-based counts	Fehmarn coast	1990-2010
NERI	Land-based counts	Hyllekrog-Rødsand	2000-2008
NERI	Aerial line transect and total counts	Sea SE of Lolland	2000-2005
NERI	Aerial line transect and total counts	Danish part of Fehmarnbelt	2004 and 2008
DOF	Non-systematic land-based observations by birdwatchers	Hyllekrog-Rødsand Maribo Lakes Nakskov Fjord and Inderfjord Gedser Odde Guldborgsund	2000-2010
DOF	Non-systematic land-based observations by birdwatchers	Rødbyhavn by og Færgeleje	2000-2011

Waterbirds are counted regularly along the Baltic coast of Schleswig-Holstein by voluntary ornithologists. These counts are coordinated by the OAG/DDA (Jan Kieckbusch) for German Baltic mainland coast and inland lakes and 'Arbeitskreis an der Staatlichen Vogelschutzwarte Hamburg/Naturschutzbund Deutschland e.V., Landesverband Hamburg' (AKVSW; Jens Hartmann, Axel Dien) for Fehmarn. Counts along the German Baltic mainland coast and inland lakes have been conducted monthly from September to April for more than forty years. On Fehmarn the coastline and all inshore waters are surveyed once a year in January since 1972.

In Germany these surveys are embedded into the German-wide waterbird monitoring. The January surveys are also part of the 'International Waterbird Census' (IWC); therefore the dates for the surveys are synchronised German- and Europe-wide and take place in mid-month.

The coastal area is divided into many different count sections and most of the sections have been counted by the same ornithologists for many years. The ornithologists count birds from land with spotting scopes and binoculars.

The land-based counts by OAG are part of the national monitoring of Natura 2000 areas in Schleswig-Holstein and data are analysed and published at regular intervals (e.g., Kieckbusch 2010). A full method description is provided in these publications.

Data from winter seasons 2008/2009 and 2009/2010 were purchased from OAG, and mid-winter data of 1990-2010 for Fehmarn from AKVSW and were analysed for this report. The data gives a sum per species and counting sections, which are shown in Figure 2.9 and listed in Table 2.5.

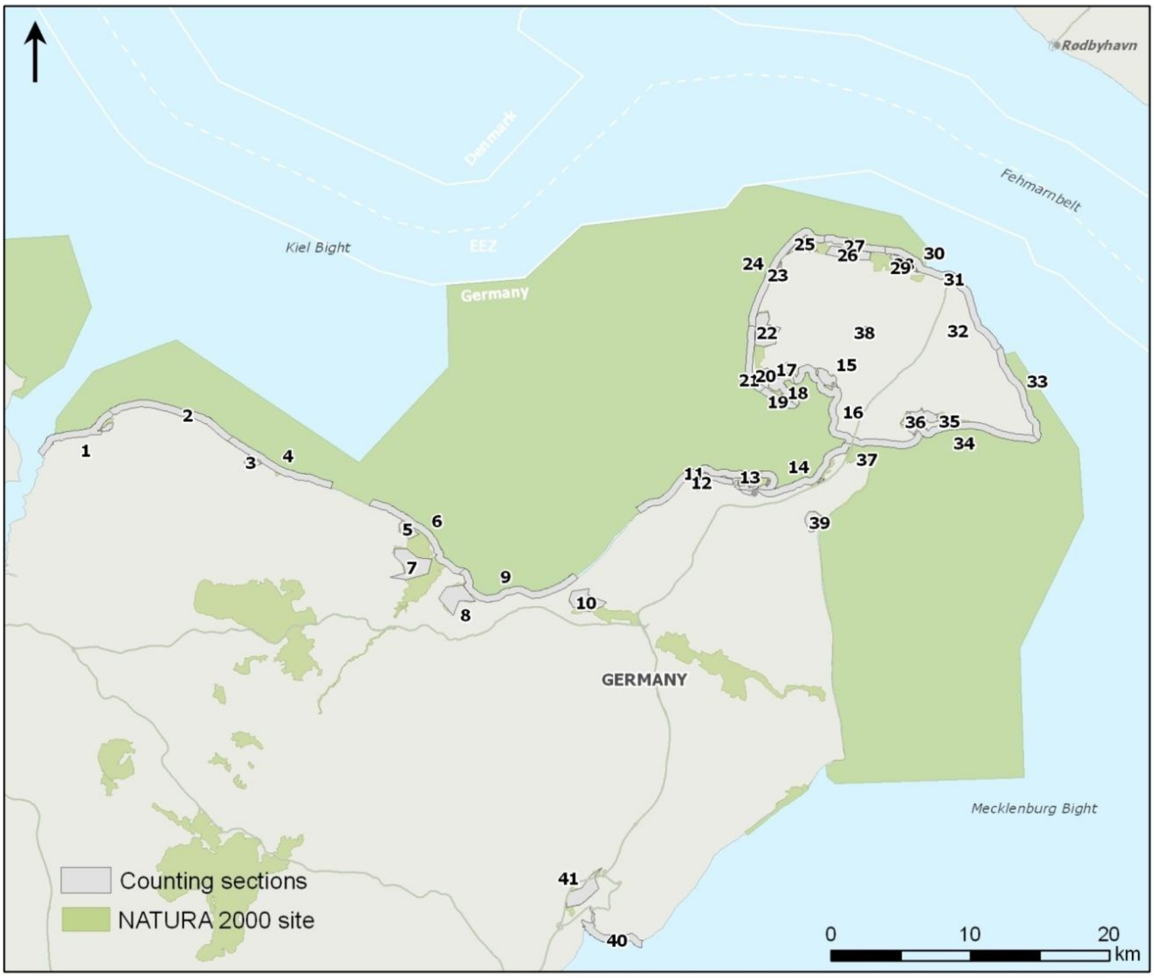


Figure 2.9 Sections of OAG and AKVSW land-based surveys along the German coastline. The dots represent the central coordinate of each coastal segment.

Table 2.5 Site names of OAG and AKVSW land-based survey sections along the German coastline.

ID	Site name
1	Laboe – Bottsand
2	Bottsand – Schönberger Strand
3	Strandlagune Schmoel
4	Schönberger Strand – Hubertsberg
5	Kleiner Binnensee
6	Neuland – Hohwacht
7	Großer Binnensee
8	Sehlendorfer Binnensee
9	Hohwacht – Weißenhäuser Strand
10	Wesseker See
11	Neuteschendorf – Heiligenhafen
12	Heiligenhafen Binnensee
13	Graswarder
14	Heiligenhafen – Sundbrücke
15	Albertsdorfer Niederung
16	Sundbrücke – Orth
17	Sulsdorfer Wiek
18	Orther Reede
19	Krummsteert außen – Flügger Leuchtturm
20	Flügger Teiche
21	Flügger Leuchtturm – Wallnau Nord
22	Wallnau
23	Fastensee
24	Wallnau Nord – Altenteil
25	Salzensee
26	Binnenseen von Altenteil – Niobe Denkmal
27	Ostteil Altenteiler Wald – Niobe Denkmal
28	Grüner Brink (Teiche vordeichs)
29	Grüner Brink (binnendeichs)
30	Niobe Denkmal – Puttgarden
31	Fährhafen Puttgarden
32	Puttgarden (östl. Fährhafen) – Campingplatz Klausdorf
33	Campingplatz Klausdorf – Staberhuk
34	Staberhuk – Burgtiefe
35	Sahrensdorfer Binnensee
36	Burger Binnensee
37	Wulfener Hals – Sundbrücke
38	Fehmarn Binnenland
39	Großenbroder Binnenwasser
40	Pelzerhaken Neustadt
41	Neustädter Binnenwasser

The survey data made available by NERI cover both aerial line transect data collected in the Danish part of the Fehmarnbelt and in Rødsand Lagoon during national-wide (NOVANA) monitoring surveys of waterbirds in January 2004, 2006 and 2008, as well as aerial line transect data collected in relation to the investigations for the Nysted offshore wind farm. Details of the NOVANA monitoring surveys can be found in Petersen et al (2006, 2010), while the results of the bird investigations for the Nysted offshore wind farm have been published Petersen et al. (2006b).

2.2.4 *Handling of survey data*

Data collected during FEBI aerial and ship-based surveys were stored and processed following unified principles. The GPS-tracks (Positions and UTC time/date) exported from the FUGAWI™ software were imported into a specifically designed SQL-Database (called FULMAR) which has a connection to ArcGIS software (ESRI 2009). During import, tracks were cut down in ArcGIS to transect lines and lines were ascribed unique identifiers. At this stage gaps and errors (track points out of area) were corrected. The finalised transect lines were subsequently imported into FULMAR. All information recorded to the dictaphones were entered into the same database and connected transect position using time stamps. All entered information was double-checked twice by experienced persons. In case of gaps or potential misunderstandings dictaphone records were re-analysed or observers contacted. After clarification the effort and observations (e.g., possible double sightings of main observers during aerial surveys) were assigned 'valid' or 'invalid' flags for each of the observers. For all observations by the third observers potential double sightings with the main observers were defined.

A query in FULMAR produces Microsoft Access files or txt-files that contain data records with space, time, species composition and type of information. Different types of data (Distance-import-files, GIS-compatible datasets, Microsoft Access files with standardised queries for effort, observations, densities etc.) were produced in this way. Data exported from FULMAR were further compiled into five sets of geo-databases:

1. Observed densities of species for intervals of 5 seconds for aerial surveys and 10 seconds for ship-based surveys;

2. Records of all bird observations including notes about behaviour, flock size, perpendicular distance and survey conditions;

3. Corrected densities of species for survey time units;

4. Corrected densities of species integrated with static and dynamic habitat variables;

5. Integrated densities of key species and environmental co-variables aggregated into grid cells measuring 750 x 750 m;

6. Predicted continuous densities of key species for the study area at resolution of 750 x 750 m.

Database-1 represented a direct export from FULMAR and contained observed densities of the species at equal time intervals. This database was used as an interim step towards creating input data for statistical analyses.

Database-2 also represented a direct export from FULMAR, but differently from database-1, it contained bird observations and associated parameters (flock size, behaviour, transect strata, survey conditions). This database provided input for Distance analysis (described further in the text) aimed to calculate detection functions and obtain total estimates during each survey.

Database-3 was a product of the previous two databases and associated analyses: observed densities from the database-1 were re-calculated applying distance detection functions obtained from Distance analysis on the database-2. Species-, sea state-, behaviour-, and association-specific correction factors were considered.

Database-4 was a product of database-3 after appending values of static and dynamic environmental variables to each record. A specifically developed (by DHI) data integration tool was used to associate the closest match in time and space between the survey data and the variable data (see more details about the data integration tool below).

Database-5 was produced by aggregating values of the database-4 to a coarser spatial resolution of 750 x 750 m. This database was used as an input for spatial distribution modelling (described further below).

Database-6 contained modelled continuous species distributions at 750 x 750 m resolution. This was achieved by deploying fitted spatial distribution models for waterbird species for different seasons (described further below).

The data integration tool, which was used to create the database-4, has been specifically designed for extracting the data from numerical model files of DHI's MIKE software to data records with spatial and temporal attributes. The integration tool takes care of transformations between the coordinate systems of the extraction points and the raster files, when necessary. Concerning numerical modelling results, the data integration tool can read hydraulic model time series and raster series. From time series, data are extracted for each point in the input tables based on their timestamp. It is possible to choose if values are linearly interpolated between the previous and the next step in the time series file, or if daily means are assigned. In the same way, spatiotemporal data are extracted from raster series, but the extracted values depend on both the location of the extraction points and their timestamp. For some tasks, data were to be extracted from more than 20 input files and for more than one million of extraction points. The data integration tool is thus designed that all files to be processed are chosen and all settings made, before the data extraction and integration starts. The output tables contain all original data from the input tables, and have additional columns with the values extracted from rasters and model results (one for each integrated variable, e.g. water depth, surface temperature).

2.2.5 Data Analyses

Distance analysis

The term 'Distance analysis' used in this report refers to analyses conducted using Distance software (Distance v.6. r2, http://www.ruwpa.st-and.ac.uk, Thomas et al. 2010). These analyses were conducted with two principal objectives: (1) calculation of distance detection functions for data collected during aerial and ship-based transect surveys, and (2) estimation of the total abundance of waterbird species during each of the transect surveys (Buckland et al. 1993, 2001).

The detection of waterbirds along a line transect declines with perpendicular distance from the line. The decline is typically non-linear with a high detection from the line to a deflection point in the transect from where the detection gradually drops to low values in the more distant parts of the transect (Buckland et al. 2001). This effect of distance can be taken into account and even with relatively low sample sizes estimates of densities can be obtained (Buckland et al. 2001).

Estimation of density was achieved for the surveyed area by integration of the sources of variance for three parameters: encounter rate, detection probability, and cluster size. By dividing the detection probability function by the integral of the function over the survey area a probability density function was estimated. Key parametric functions were evaluated with cosines and simple polynomials for adjustment terms: uniform, half-normal and hazard rate, and the best fitting function was chosen on the basis of the smallest Akaike Information Criterion (AIC) values (Burnham and Anderson 2002). Parameter estimates were obtained by maximum likelihood methods. The aerial data were analysed based on a transect width of 1,500 m, and the ship-based data based on a transect width of 300 m. As detection probabilities for waterbirds varies depending on bird behaviour, weather conditions, observer platform and observer skills, estimation of densities can be done by stratifying data into subsets showing different detection functions (Buckland et al. 1993).

However, sample size limits the degree of stratification which can be applied to survey data (Buckland et al. 2001). Distance analysis was conducted separately for each survey platform. Global detection functions were calculated for the entire dataset for each species with sufficient number of observations, assuming that detectability of bird species was similar among surveys. Estimated global detection functions were used to estimate species-specific densities for each survey. A possibility to stratify observations by bird behaviour (swimming or flying) and sea state was considered by attempting to account for these strata using them as covariates with multiple covariate distance sampling (MCDS) engine in Distance software. This approach, however, appeared to be very computationally demanding and also failed for many species due to insufficient sample sizes. Therefore, aiming to obtain as many density estimates as possible, this approach has been abandoned and more simplified method used. Stratum describing the sea state was not further considered.

For aerial surveys detection functions were estimated separately for swimming and flying birds using conventional distance sampling (CDS) engine. Further, estimates and confidence intervals for swimming and flying birds were summed to obtain a single density and associated variability metric to represent each survey.

For ship-based surveys, estimating detection probability was only possible for swimming birds, as no transect bands were associated with flying bird following the standard survey protocol (Camphuysen et al. 2004). As ship-based surveys were designed to cover coastal and offshore waters, densities of swimming birds were estimated separately for these strata using the CDS engine. Then, densities and associated confidence intervals of these two strata were integrated accounting for survey effort in order to obtain an overall density per species for each survey. Finally, counted flying birds were converted into densities assuming 100 % detection in a transect line, and were added to estimated densities of swimming birds.

Total estimates of bird numbers were calculated on the basis of the area actually covered during each survey: 100 % coverage by aerial surveys encompassed an area of 4,875 km^2, and 100 % coverage by ship-based surveys encompassed an area of 2,340 km^2 (presented further in the text, see Figure 2.19, Figure 2.20). For aerial surveys this resulted in estimates for some months, which should be regarded as minimum numbers due to incomplete coverage of the survey area. Highly variable survey effort between aerial surveys was mostly due to limited access to military areas within the study area.

Distance analysis approach for estimating bird densities was compared with bird densities observed in band-A of aerial surveys for Common Eider and Herring Gull, the two most consistently observed species in the Fehmarnbelt. As described above, band-A is part of a transect that is the most proximate to an observer, therefore the best detection of birds would be expected. The results of such a comparison indicated high correlation between densities recorded in band-A and densities estimated using Distance analysis: $r = 0.95$ ($p < 0.05$) for Common Eider and $r = 0.94$ ($p < 0.05$) for Herring Gull (Appendix V).

Environmental variables used in distribution modelling
Environmental variables used were chosen considering their capacity to characterise and predict the distribution of two groups of waterbirds: benthic carnivores and pelagic carnivores. Assigned to the group of benthic carnivores are Common Eider, Long-tailed Duck, Common Scoter, and Goldeneye, while the group of pelagic carnivores consists of Red-throated/Black-throated Divers, Red-necked Grebe, Great Crested Grebe, Red-breasted Merganser, Common Guillemot, Razorbill and Black Guillemot.

Important predictor variables for benthic carnivores (seaducks) have previously been shown to be food resources, water depth, bottom slope and anthropogenic disturbance (e.g. Skov et al. 2006, Kaiser et al. 2006, Žydelis et al. 2006, Kirk et al. 2008, Skov et al. 2008, Zipkin et al. 2010). Tremblay et al. (2009) provides a review of the variables that have been explored in the literature for describing the distribution patterns of pelagic seabirds. The authors argue that factors affecting pelagic carnivore distributions are those describing water masses, food resources and hydraulic structures that are likely to concentrate prey for foraging seabirds (see also Wakefield et al. 2009). Water masses and their hydrodynamic structures are described by depth and strength of the pycnocline, current gradient, horizontal current velocity and vertical current velocity (upwelling/downwelling), vorticity, water temperature and salinity.

The static topographic (depth, bottom slope and substrate type) and anthropogenic pressure variables (distance to land, wind farms and shipping lanes) are used both for pelagic and benthic carnivores (Figure 2.10).

Coordinates (X and Y) were included as variables (as an interaction term) as the aim of this study is to produce as accurate predictions of bird densities as possible. Inclusion of geographic variables has previously shown to improve model accuracy (Miller et al. 2007). The coordinates can explain some of the variance and spatial structure that cannot be explained by only using environmental variables.

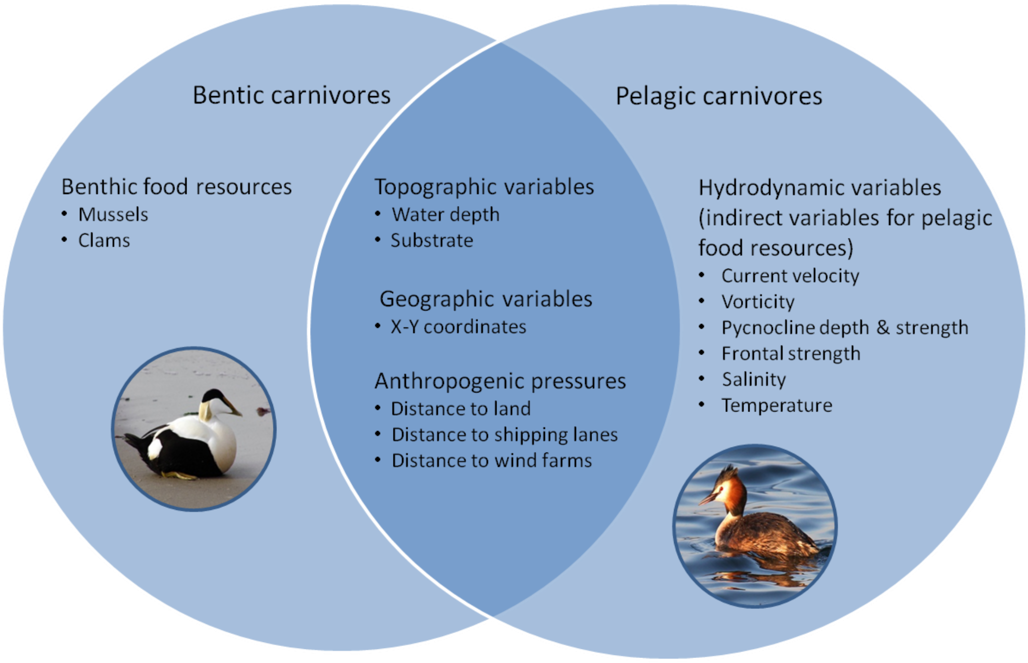


Figure 2.10 Schematic illustration showing the variables used in the models to describe the distribution of waterbird species.

Hydrodynamic variables

Oceanographic variables were extracted from the hydrodynamic simulation model provided by Fehmarnbelt Fixed Link baseline investigations on hydrography (FEHY), which has been run for the period 1 November 2008 – 1 June 2010 (Run No. 9.15 and 11.20) and Femern Water Forecast Model for the period 1 June 2010 – 1 January 2011 (Runs V06 and V07), FEHY's topographic and geological data layers, or developed through post-processing of combinations of model simulation results (Table 2.6). Details of the processing of oceanographic variables used in the distribution models are given in Appendix I.

Table 2.6 List of variables, which were considered as a potential predictor in waterbird distribution models.

Parameter name	Parameter type	Description	Source	Carnivore group(s)	Rationale for inclusion
Biomass of mussels	Dynamic	Dynamic mussel biomass (AFDW) and distribution model for the study area	FEMA	Benthic	Food resource
Eelgrass cover	Static	% eelgrass cover	FEMA	Herbivors	Food resource
Depth	Static	Water depth (m)	FEHY	Benthic/ Pelagic	Diving depth, Pelagic food resource
Proportion of hard substrate	Static	Proportion of hard substrate	FEMA	Benthic/ Pelagic	Related to food resource
Bottom slope	Static	Bottom inclination in degrees calculated on Depth raster	DHI	Benthic/ Pelagic	Topographic feature affecting prey distribution
Distance to land	Static	Euclidian distance (m) to shore (small islands excluded)	DHI	Benthic/ Pelagic	Disturbance
Distance to wind farms	Static	Euclidian distance (m) to Nysted and Rødsand 2 wind farms	DHI	Benthic/ Pelagic	Disturbance
Number of ships	Semi-static	Number of ships that passed a grid cell per month	Ramboll (AIS data)	Benthic/ Pelagic	Disturbance
Pycnocline depth	Dynamic	Local depth (m) of maximum vertical Brunt–Väisälä frequency squared, N^2	FEHY hydro-dynamic model	Pelagic	Hydrodynamic structure concentrating prey
Current gradient*	Dynamic	Local horizontal gradient of currents (m/s/m)	FEHY hydro-dynamic model	Pelagic	Hydrodynamic structure concentrating prey
Salinity*	Dynamic	Local salinity (PSU)	FEHY hydro-dynamic model	Pelagic	Water mass characteristics
Water temperature *	Dynamic	Local seawater temperature (˚C)	FEHY hydro-dynamic model	Pelagic	Water mass characteristics
Current U*	Dynamic	Local E-W current velocity composant (m/s)	FEHY hydro-dynamic model	Pelagic	Water mass characteristics
Current V*	Dynamic	Local N-S current velocity composant (m/s)	FEHY hydro-dynamic model	Pelagic	Water mass characteristics
Current W*	Dynamic	Local vertical current velocity composant (m/s)	FEHY hydro-dynamic model	Pelagic	Water mass characteristics
Vorticity*	Dynamic	Eddy activity measured as the local vorticity (m/s/m) of the flow	FEHY hydro-dynamic model	Pelagic	Water mass characteristics
Current speed*	Dynamic	Local magnitude of horizontal current (m/s)	FEHY hydro-dynamic model		Integration of U velocity and V velocity

** Both surface (at 1 m) and bottom (3 m above bottom) values have been considered*

Topographic variables

The water depth layer was developed by Fehmarnbelt Fixed Link baseline investigations on hydrography by gridding all available depth measurements in the Fehmarnbelt region at a resolution of 50 m. Bottom slope was calculated applying the standard *slope* function available in ArcGIS on the bathymetry raster (Figure 2.11).

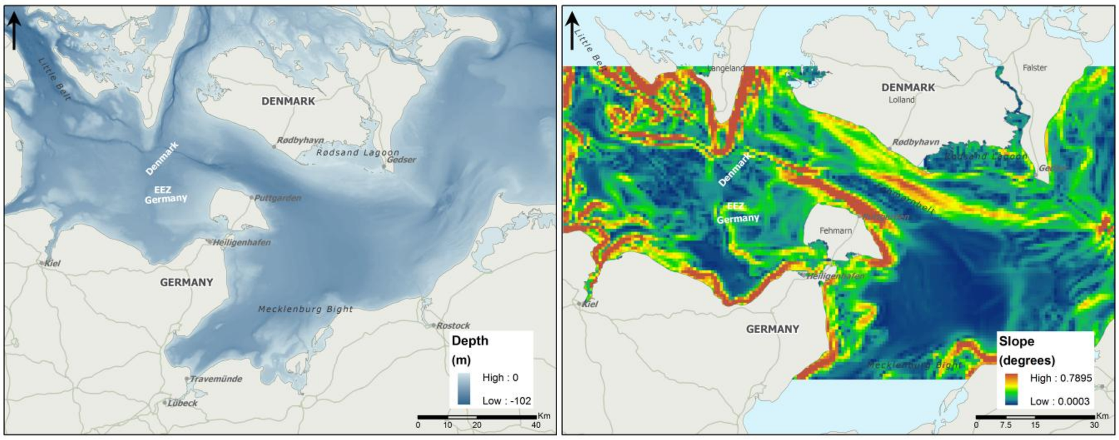


Figure 2.11 Maps representing bathymetry (left) and bottom slope (right), which were used as potential predictor variables in waterbird distribution models.

Bottom sediments were represented as a hard sediment cover map created by the Fehmarnbelt Fixed Link baseline investigations on marine biology (FEMA), which described the hard substrate coverage in percent (Figure 2.12). The map was composed by combining various data sources: FEMA substrate map, GEUS map of the seabed, FEMA diver estimates, Reimers map of sea bottom sediment map, FEMA habitat maps of reefs, and NOVANA monitoring data from NERI.

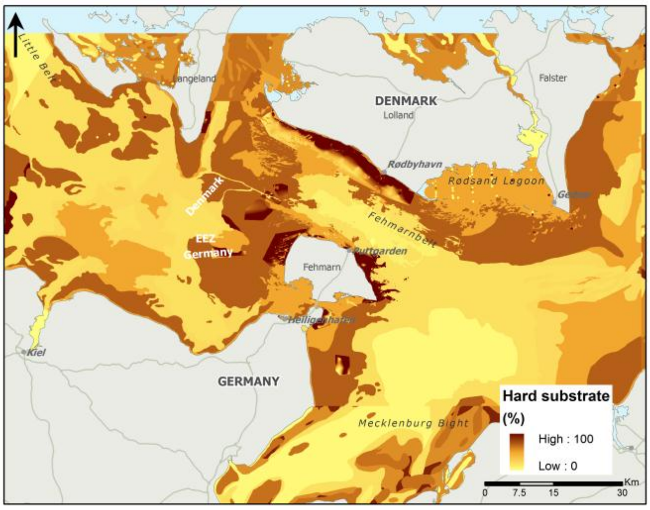


Figure 2.12 Map representing percent cover of hard substrate, which was used as a potential predictor variable in waterbird distribution models.

Variables representing anthropogenic pressures
Three anthropogenic pressures, which can affect bird distribution, were considered as potential predictors: distance to land, distance to wind farms and shipping intensity.

Distance to land was created by calculating the shortest distance to the coast for each pixel of 50x50 m grid (Figure 2.13). Distance to wind farms indicated the shortest distance wind farms Nysted and Rødsand II up to 4,000 meters and was calculated for each pixel of 50x50 m grid (Figure 2.13). A constant value of 4,001 meter was used farther away than 4,000 meters from the nearest turbine, assuming that bird distribution is not influenced beyond that distance (Petersen and Fox 2007). The standard ArcGIS tool 'Path Distance' was used to generate rasters of the shortest distances. Values of distance to land were further averaged for grid of 750 × 750 m resolution in order match scale of response variables.

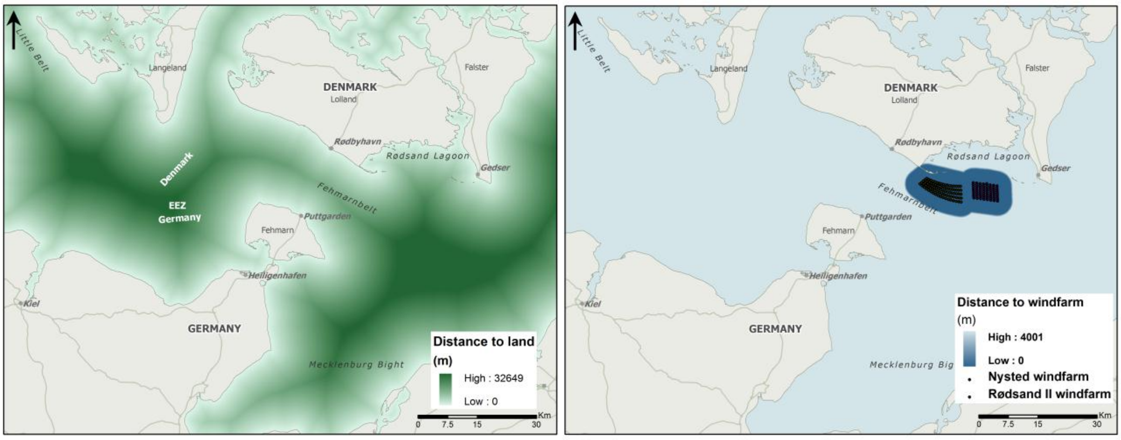


Figure 2.13 Maps representing pressure variables: distance to land (left) and distance to wind farms (right), which were used as potential predictors in waterbird distribution models.

Information about shipping intensity in the Fehmarnbelt area was received from Ramboll as monthly composites of ship traffic at 750 × 750 m grid resolution for the period between November 2008 and November 2010. The shipping data were compiled using ship automatic identification system (AIS, Ramboll 2011). Seasonal averages of shipping intensity were calculated before associating the data with bird observations for distribution modelling (Figure 2.14). (Season duration was species-specific and is identified when presenting results for each waterbird species.)

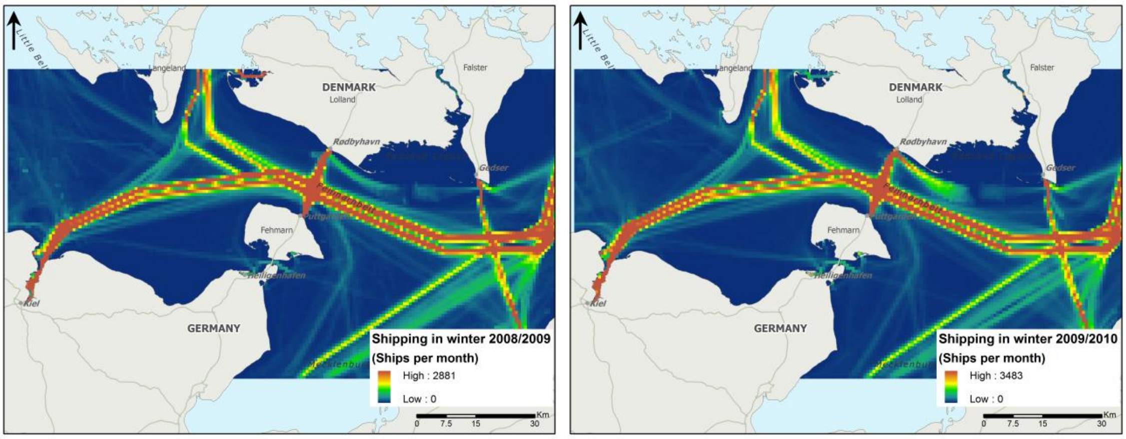


Figure 2.14 Examples of maps representing pressure variables describing shipping intensity in winter 2008/2009 (left) and winter 2009/2010 (right). Note difference in shipping intensity from Rødbyhavn to Rødsand II wind farm.

Variables representing potential food resources

Blue Mussel is a key stone species shaping benthic communities in the Fehmarnbelt and represents a staple food for several waterbird species in the area. Biomass of Blue Mussels was prepared by the Fehmarnbelt Fixed Link baseline investigations on marine biology based on the Fehmarnbelt mussel model (FEMA 2013a; Figure 2.15). This model describes the biomass available to waterbirds dynamically during the entire baseline period. For modelling the distribution of waterbird species, only the biomass of mussels falling within the size range consumed by a particular species was used.

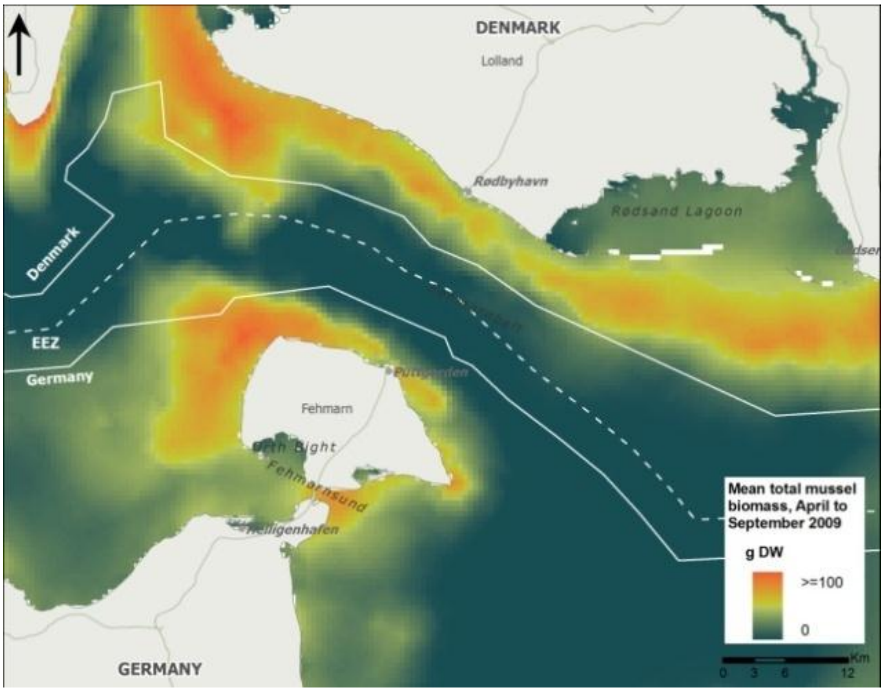


Figure 2.15 Map representing the total modelled biomass of Blue Mussels in the Fehmarnbelt. This dataset was used as a potential predictor variable in waterbird distribution models.

Eelgrass (*Zostera spp*.) cover was used as a predictor variable in models of Mute Swan distribution (the only modelled herbivorous species, Figure 2.16). Predictions of *Zostera* cover exceeding 10 % (proportion, 0.1-1) was based on a generalised additive modelling and was prepared by the Fehmarnbelt Fixed Link baseline investigations on marine biology group (FEMA 2013a). The predicted values in the data set were obtained by fitting the model on 5,582 observed coverage values (samples) and using bathymetry, bed shear stress currents max, current speed bottom annual max 2009, slope, and coordinates as predictor variables. Input of response variable consisted of coverage values assessed by diver transects in winter 2008, and winter and summer 2009, and video transects. As the model was "under predicting" the predictions were multiplied by 2 (based on the calibration curve, predicted against observed values) to increase the coverage values. The model explained 63.1% of the deviance. Areas with no vegetation on the aerial photo were deleted. Areas with predicted *Zostera* cover of less than 10% were also deleted from the predictions.

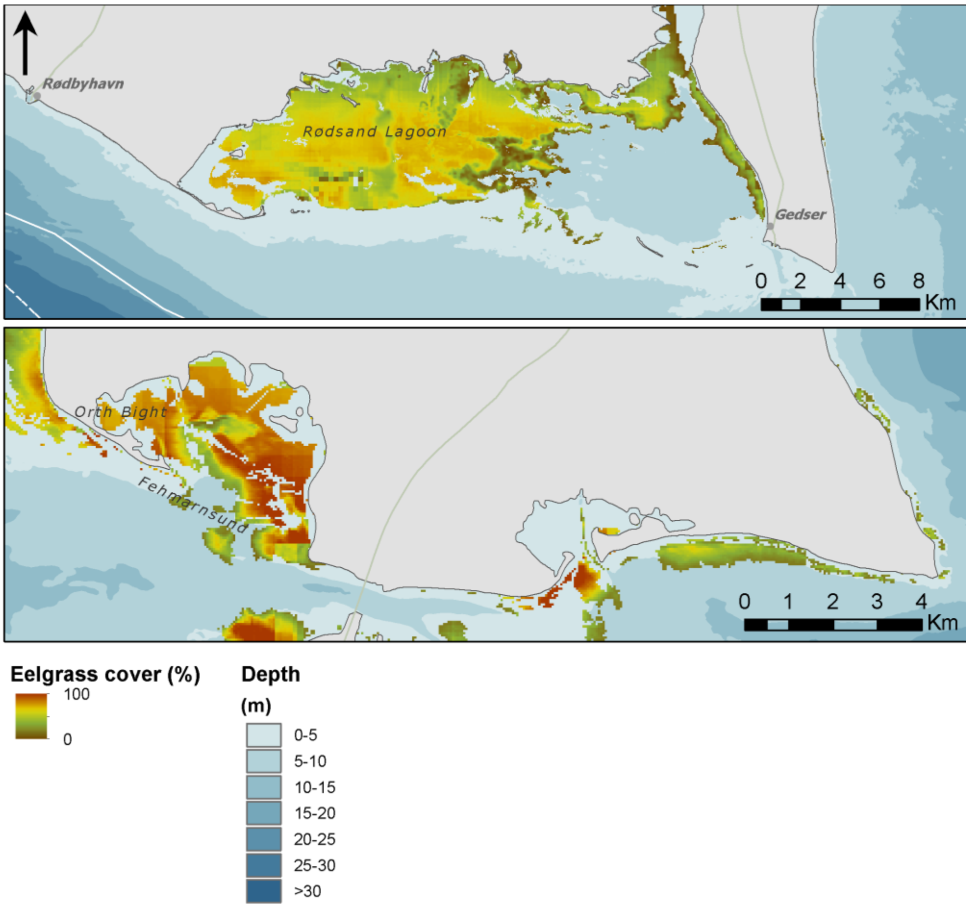


Figure 2.16 Map representing the eelgrass (Zostera spp.) cover in the Fehmarnbelt. This dataset was used as a potential predictor variable in modelling distribution of moulting Mute Swans.

Distribution Modelling

Species distribution modelling (Guisan and Zimmerman 2000, Elith and Leathwick 2009, Franklin 2009) was used to describe the spatial and temporal distribution of waterbirds, relating observed species distribution to a set of predictor variables (Trembley et al. 2009, Sonntag et al. 2009, Zipkin et al. 2010). This approach was used to overcome uneven sampling and undersampling, and to generate a description of the occurrence of waterbirds at a fine scale using transect survey data, and to predict the distribution of waterbirds in the entire study area.

Since the processes shaping the distribution of waterbirds are complex and typically include a non-linear relationship of environmental parameters with waterbird distribution data, generalised additive models (GAMs) were used (Wood 2006). GAMs are widely used (e.g. Guisan et al. 2002) and have been shown to perform well in comparisons with other methods (e.g. Moisen and Frescino 2002, Elith et al. 2006). The method has previously been successfully applied for estimation of waterbird densities based on data from transect surveys, see for example Clark et al. (2003), Kissling et al. (2007), and in Danish waters e.g. Petersen et al. (2006) and Skov et al. (2009). GAMs are data driven and can be fitted using several different error family distributions as for example Gaussian, binomial, Poisson, gamma and Tweedie. An overview of the model development process is shown in Figure 2.17.

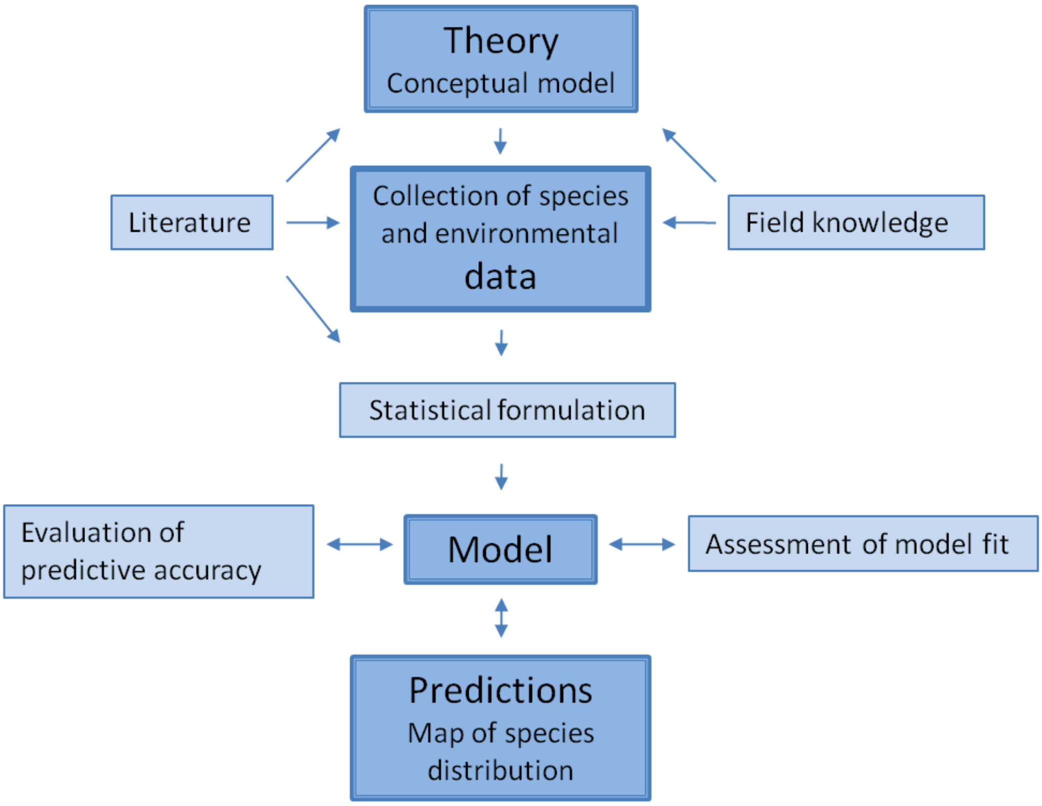


Figure 2.17 Overview of the model development process, from theory to a final species distribution map. The dark blue boxes illustrate the main steps of the process, while the light blue boxes display important input or intermediate steps. Modified from Guisan and Zimmerman (2000) and Franklin (2009).

Model fitting

Observational data collected at short time intervals during FEBI transect surveys resulted in datasets, which could be characterised as having excessive zero values. Because of zero inflation, an excess of zeros in the dataset (Barry and Welsh 2002, Potts and Elith 2006), the GAM models were fitted using a two-step approach (Stefánsson 1996, Ortiz and Arocha 2004), in literature also referred to as a delta model or a hurdle model. The first step in the delta model consists of a presence-absence part, fitted with a binomial distribution (with a logit link), and the second step consists of a positive part, where all the zero records are excluded (Barry and Welsh 2002, Le Pape et al. 2004, Potts and Elith 2006). The positive (density) part the model was fitted using a gamma distribution with a log link (see Stefánson 1996). Different distributions were tested (e.g. log-normal and Tweedie) but the gamma distribution resulted in the best fit (see below for how the fit was assessed). The gamma distribution has also been used by other authors, e.g. Stefánsson (1996) and Andrade (2009). The two model parts (binomial and gamma) were combined by multiplying the predictions of both model parts. The associated standard error was calculated by using the formula for the variance of the product of two random variables (Goodman 1960), which has also been commonly used by others (e.g. Clark et al. 2009, Webley et al. 2011).

The models were fitted in R version 2.9.0 (R Development Core Team, 2004) using the R package "mgcv" (Wood 2006). The GAM models were fitted using thin plate regression splines (which is the default in the "mgcv" package). In 'mgcv' the degree of smoothing (how closely the model follows the data) is chosen based on generalised cross validation (Wood 2006). The default dimension (k = maximum degrees of freedom for each smooth function) is 10 for single covariate smooth functions. To reduce potential overfitting of the GAM models, smooth functions for each of the variables were limited to 5 (k=5). If k=5 was not sufficient (i.e. if the response curves still followed the data too closely based on visual assessment), the limit was set to k=3. Granadeiro et al. (2004), for example, used a maximum of 4 degrees of freedom. The degree of smoothing was not limited for the interaction term of X and Y coordinates.

Strong correlation between variables (collinearity) can result in exclusion of important variables, inaccurate model parameterisation and decreased predictive accuracy (Graham 2003; Heikkinen et al. 2006). It is therefore common practice to leave out one of a pair of highly correlated variables prior to model fitting (Franklin 2009; Guisan and Thuiller 2005). The Pearson's correlation between the environmental variables was checked. For pairs of variables with a correlation coefficient higher than 0.80 the variable having the highest correlation with bird densities was chosen for inclusion in the model (Franklin 2009). The correlation acceptance criteria is a matter of choice and do vary in earlier studies. Wintle et al. (2005) for example accepted correlations of 0.6 at the most.

Variables considered for inclusion in the models were chosen prior to the modelling based on literature and expert opinion (see above, Figure 2.10). To be able to choose between surface or bottom hydrodynamic variables (Table 2.6) an individual GAM model was developed for each hydrodynamic variable. The surface or bottom variable, explaining most of the variance (deviance explained) was chosen. Season was included as a factor variable in the model, defining differences during different periods of the year. Because season was used as a predictor variable it was possible to generate different predictions for the different periods of the year. The models were further refined by excluding variables based on the following questions (Wood and Augustin 2002):

1. Is the estimated degree of freedom for the variable close to 1?
2. Does the plotted confidence band for the variable include zeros everywhere?
3. Does the UBRE/GCV score drop when the variable is dropped?

A variable was excluded from a model if the answer to each of the question was "yes" (Wood and Augustin 2002). Variables contributing very little to the model fit (contributes with a very little change in UBRE/GCV; Wood and Augustin 2002), and variables displaying ecologically meaningless responses (based on expert judgement) were also removed (Austin 2002, Wintle et al. 2005).

Assessing the fit of the models

The fit of the GAM models was assessed based on deviance explained. Diagnostic plots of the positive part, normality and homogeneity of variance (homoscedasticity) of the residuals as well as observed against fitted values were checked (Zuur et al. 2009).

Model residuals were tested for spatial autocorrelation using Moran's I, as spatial autocorrelation in the residuals can inflate the statistical significance, increasing the risk of Type 1 errors (false positives, Segurado et al. 2006). For the calculations of Moran's I the nearest neighbourhood was defined as 1,500 m. To assess the spatial autocorrelation over longer distances a Moran's I correlogram was inspected showing 10 lags where one lag was the defined nearest neighbourhood (1,500 m). For the calculations of the spatial statistics the R package "spdep" was used (Bivand 2009).

Evaluation of predictive accuracy of the models

The predictive accuracy of the models was assessed by randomly splitting the data into a calibration set (70 %) and an evaluation set (30%) (Marini et al. 2010), a commonly used approach (Guisan and Zimmermann 2000; Araújo et al. 2005; Heikkinen et al. 2006). Usage of independent data not used in the model development is essential when evaluating the predictive performance (Fielding and Bell 1997; Guisan and Zimmermann 2000; Pearce and Ferrier 2000).

The final combined model, fitted on the calibration dataset, was assessed against the observed values using Spearman's rank correlation (Potts and Elith 2006). The presence-absence part of the two-part model was also assessed using the area under the receiver operating characteristic curve (AUC) (Pearce and Ferrier 2000). AUC is a threshold independent measure. A value of 0.9 means the model is capable of distinguishing between occupied and unoccupied cells 90% of the time, whereas a value of 0.5 indicates that the model is no better than random (Fielding and Bell 1997).

Predictions

The models were used to depict the distribution of waterbirds in the whole study area for each selected species. As the models were used for mapping the distribution of birds during different seasons of the year, different prediction dataset for each season was made. As the period was built into the model, it was possible to create season-specific predictions, based on the same model.

Because the evaluation statistics of the models were non-spatial, it was important to also assess the modelled distributions in addition to predictive accuracy as described above (Ferrier et al. 2002; Wintle et al. 2005). The spatial structure of the modelled distributions was assessed visually by comparing observed values to model predictions. Unrealistic patterns would suggest that there is something wrong with the model, e.g. that important variables are missing or the model was over-fitted, which might require that the model is rejected (Franklin 2009). The modelling framework is schematically presented in Figure 2.18.

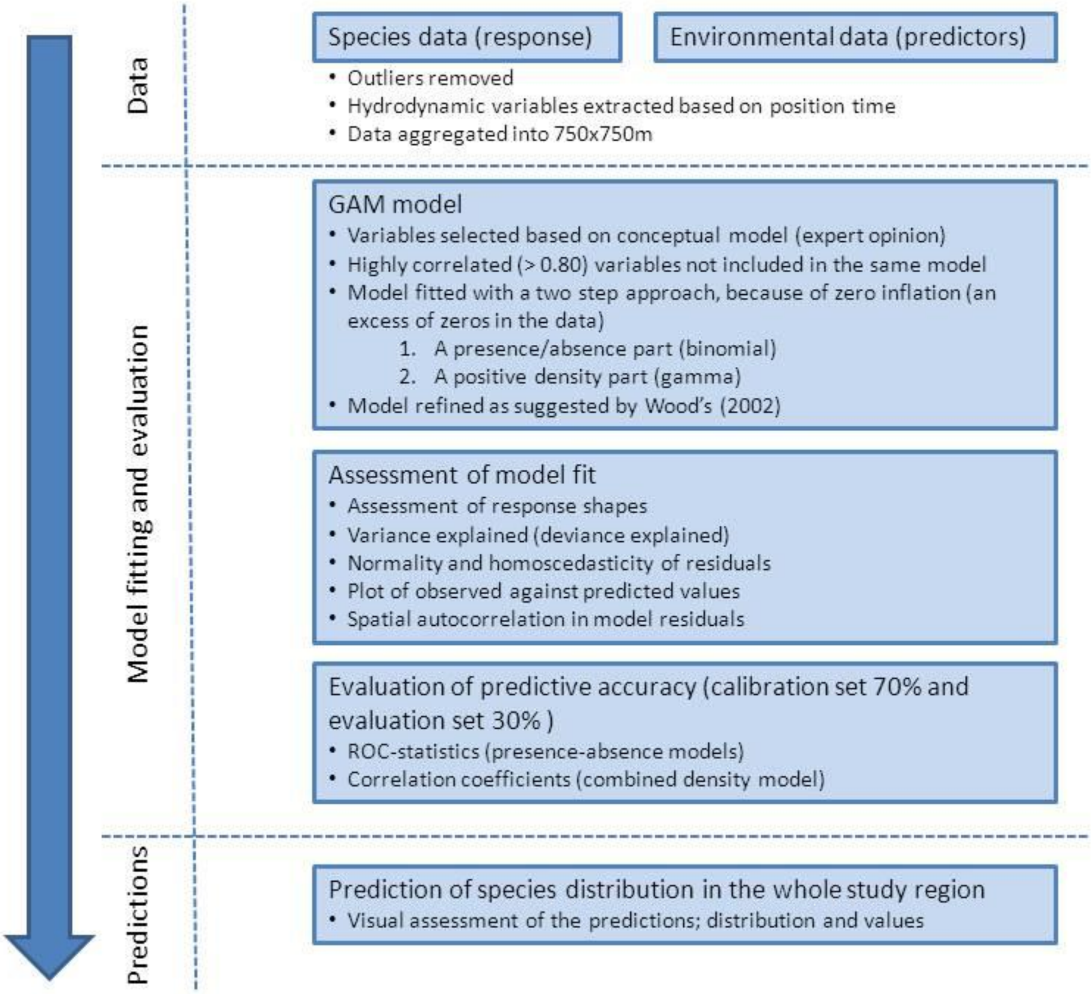


Figure 2.18 Detailed description of the modelling framework used; data handling, model fitting and diagnostics, evaluation and subsequent predictions.

Estimation of Local Abundance

Waterbirds total abundance and densities in protected areas in the Fehmarnbelt were obtained by overlaying polygons representing protected area over prediction rasters of species distribution in ArcMap 9.3 (ESRI 2009). This procedure allowed extracting average densities and associated variance, and total estimates for each protected area. Predictions maps created using models based on aerial data have covered marine SPA in full (Figure 2.19). Area coverage by ship surveys, however, was smaller and therefore bird densities and estimates were provided only for the part of each SPA that overlapped with area surveyed by ships (Figure 2.20).

In addition to species densities and estimates in marine SPAs, average densities and total numbers were estimated for the remaining non-SPA area and area in the 'immediate vicinity' of the planned fixed link across the Fehmarnbelt. The area of the 'immediate vicinity' was arbitrarily set by confining it within 5 km buffer around the easternmost and westernmost candidate solutions of the fixed link (Figure 2.21). The area covered by the immediate vicinity zone is 210 km^2.

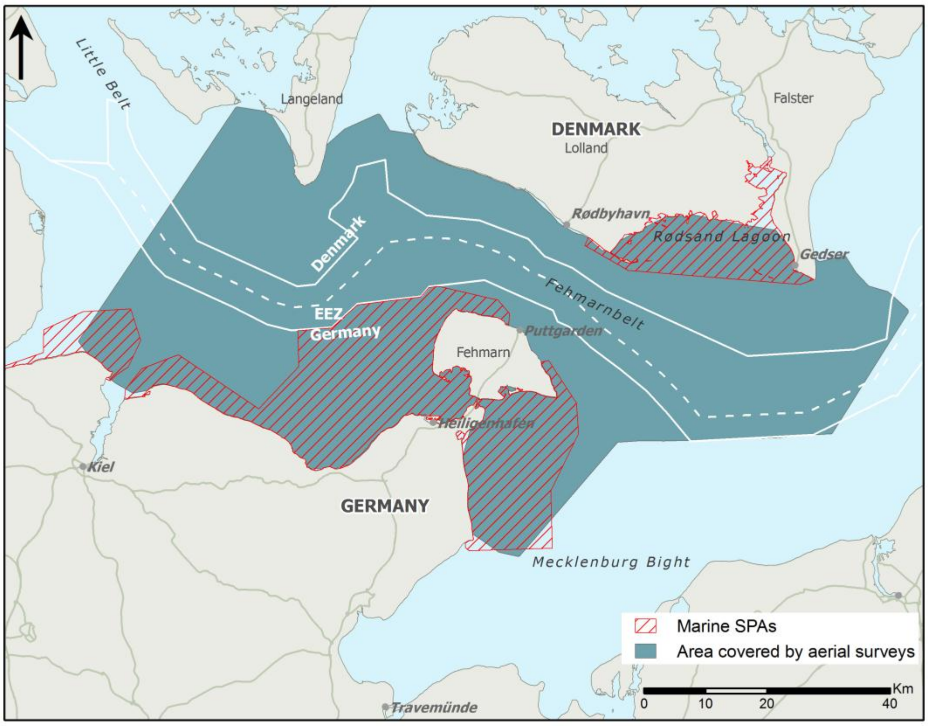


Figure 2.19 Map representing overlap between aerial-based bird survey coverage and marine SPAs in the Fehmarnbelt.

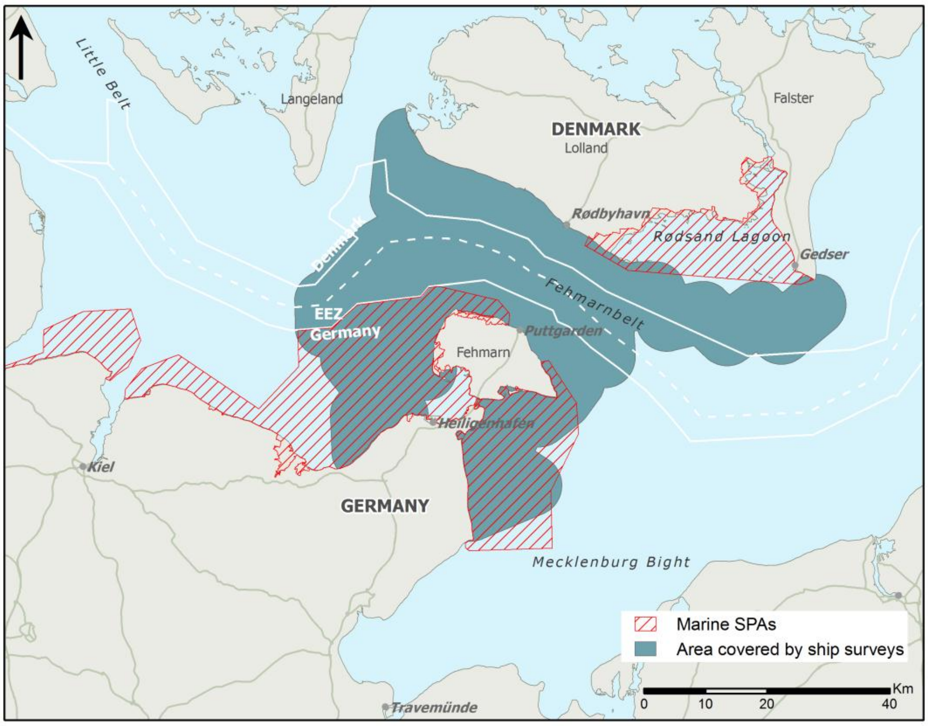


Figure 2.20 Map representing overlap between ship-based bird survey coverage and marine SPAs in the Fehmarnbelt.

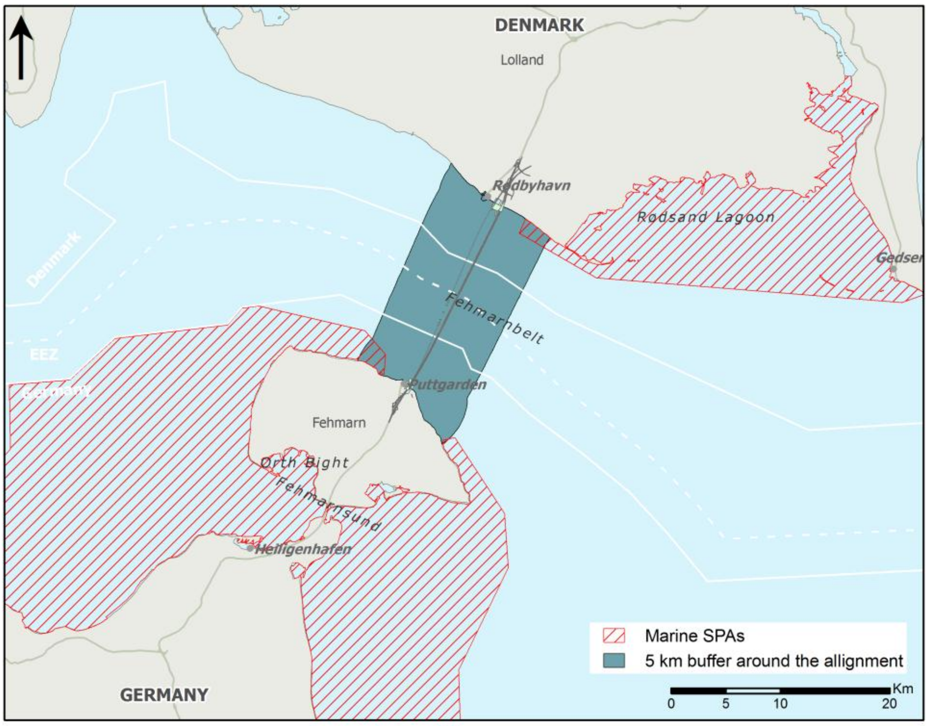


Figure 2.21 Map showing the arbitrarily set 'immediate vicinity' zone surrounding the easternmost and westernmost candidate solutions of the fixed link by 5 km. Densities and total numbers of wintering birds were estimated for this area.

Distribution modelling of moulting Mute Swans

Mute Swan distribution and habitat use were evaluated using GPS-telemetry data (described further in chapter 2.3). An equal number (n=220) of GPS positions was randomly selected from each of 6 birds tracked in summer 2010, aiming to ensure equal representation of each individual and reduce probability of serial correlation. Because telemetry fixes represent only positions of bird presence, pseudo-absence locations were obtained by randomly generating 2,000 points over the entire Rødsand Lagoon (Figure 2.22). Using pseudo-absences is a standard procedure when modelling presence-only data (Guisan et al. 2002, Brotons et al. 2004).

Water depth and *Zostera* coverage values were sampled for each bird presence and pseudo-absence location. Further, generalized additive model (GAM) with binomial distribution was fitted to predict swan habitat suitability using telemetry fixes as presence and random points as pseudo-absence locations (Guissan et al. 2002; Brotons et al. 2004).

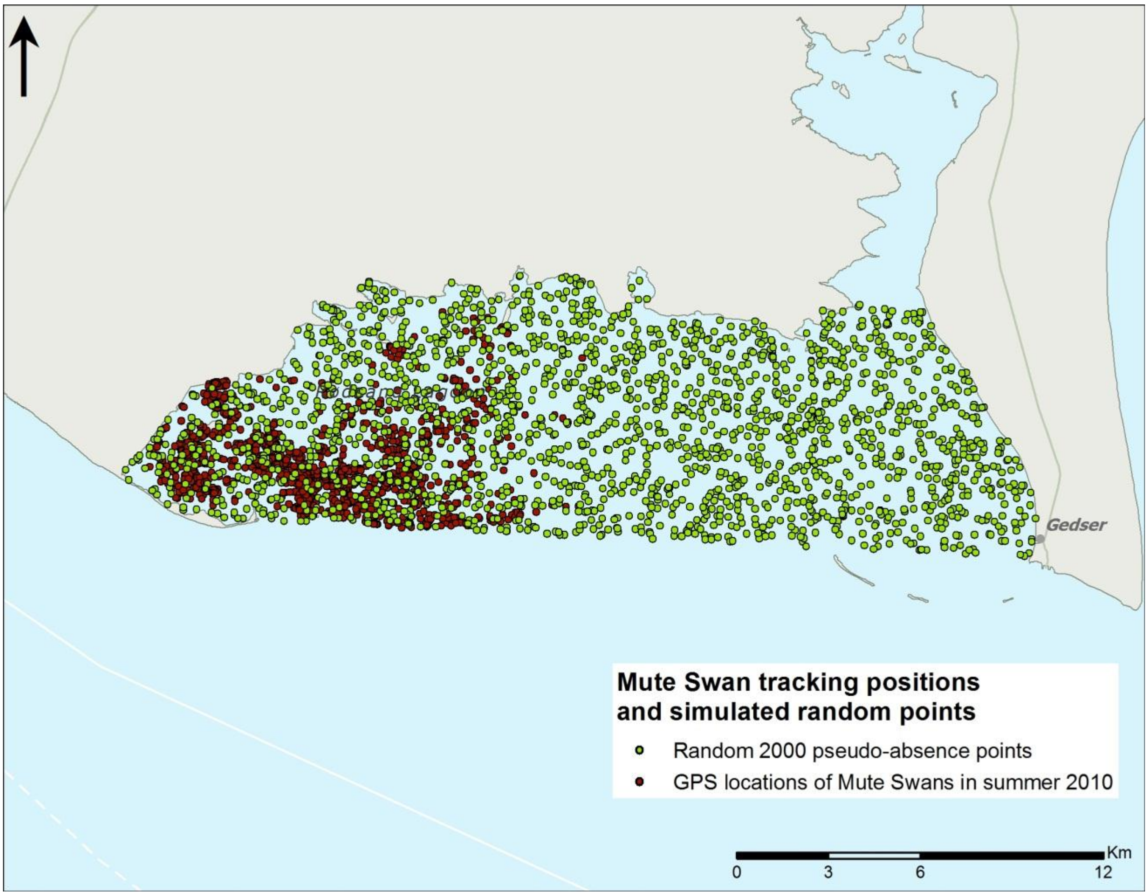


Figure 2.22 A map illustrating locations of GPS-tracked Mute Swan positions and randomly generated pseudo-absence points, which were used in habitat choice analysis.

2.2.6 Structure of species description

Each waterbird species is described in the report follows the same general structure as outlined in this chapter.

Species description starts with a fact box, which provides concise general information about a species (Table 2.7).

Table 2.7 General format of the species fact box used to provide concise information on each species described in this report.

English name – *Latin name*	
Biogeographic population:	
Breeding range:	
Wintering / core non-breeding range:	
Population size:	
1 % value:	
Conservation status:	EU Birds Directive, Annex I: EU SPEC Category: EU Threat Status:
Target species in SPAs:	
Key food:	
Period of presence in Fehmarnbelt:	

The fact box starts with providing English and Latin names of a species (Table 2.7).

Biogeographic population of a species, which occurs in the Fehmarnbelt area was identified following distinction of waterbird populations by Wetlands International (2006). Relevant populations from classification of Wetlands International (2006) were selected following Wahl et al. (2007). If another source was used to identify biogeographic population, it is indicated with the footnote.

Breeding range, *Wintering / core non-breeding range*, *Population size*, and *1% value* were also adapted from Wetlands International (2006) unless indicated otherwise.

Conservation status of each species provided as three different types of conservation categories. First, it is noted whether species is listed on Annex I of the EU Birds Directive 2009/147/EC. BirdLife International (2004) suggested European threat and conservation classification for all bird species, namely the category of Species of European Conservation Concern (SPEC) and the European threat status. Both of these categories are also listed in the species fact box as *EU SPEC Category* and *EU Threat Status*, respectively. Categories of Species of European Conservation Concern (SPEC) identifies whether species are of conservation concern (SPEC) or not (non-SPEC). Further species of conservation concern are categorised into 3 categories: SPEC 1, SPEC 2, and SPEC 3, which respectively refer to globally threatened species; species with unfavourable conservation status in Europe and their global population concentrated in Europe; and species with unfavourable conservation status in Europe but whose global populations are not concentrated in Europe (BirdLife International 2004). European threat status refers to the articles in the Birds Directive: Endangered corresponds with article 4(1)a, Vulnerable with article 4(1)b, and Rare and Localised with article 4(1)c, while Declining refer to articles 2 and 4(1)d. Species classified as Secure had favourable conservation status, and species with unfavourable conservation status were treated as Species of European Conservation Concern (SPEC) as described above (BirdLife International 2004).

Line *Target species in SPAs* lists Special Protection Areas (SPAs) in which standard forms or conservation targets (standard data form paragraphs 3.2.A. and 3.2.B.) a particular species is listed. There are five Special Protection Areas (SPA) located in the Fehmarnbelt area: DK006X083 Hyllekrog-Rødsand; DK006X087 Maribo Lakes; DK006X088 Nakskov Fjord and Inderfjord; DE1530-491 Eastern Kiel Bight; and DE1633-491 Baltic Sea east of Wagrien.

Line *Key food* indicates primary types of food resources used by a species. This information was gleaned from primary literature on general ecology of birds (Cramp and Simmons 1977-1983, Cramp 1985, Bauer et al. 2005).

Finally, species fact box finishes with *Period of presence in Fehmarnbelt*, which indicates period of a year when a species is present or occurs in highest numbers in the Fehmarnbelt. Periods of presence were identified following Wahl et al. (in press) and FEBI baseline investigations.

The species fact box is further followed by species baseline description organised in standard chapters as identified bellow.

1. Origin of [species] in the Fehmarnbelt

FEBI results of ring-recovery analysis.

Results of satellite telemetry.

Literature information about breeding areas of a species, if such data are not available from FEBI ring-recovery analysis and satellite telemetry.

2. Data sources on [species] in the Fehmarnbelt

Listing and briefly over viewing data available on the species from:

- Aerial surveys
- Ship-based surveys
- German land-based counts (OAG)
- NOVANA
- DOF

Identifying and justifying primary and secondary (supporting) datasets.

3. Abundance of [species] in the Fehmarnbelt

3.1. [species] abundance estimates based on Distance analysis

OR (depending on species that is being reported)

[species] abundance estimates according to dedicated search flights

Species abundance estimates for the Fehmarnbelt using Distance-corrected aerial survey data.

Monthly variation in species abundance estimates using Distance-corrected ship-based survey data.

Abundance estimates for each SPA (if obtained from Distance-corrected aerial survey data).

Results of dedicated search flights were used to estimate abundance of highly gregarious coastal species (herbivorous waterfowl), for which transect surveys are not representative and subsequently estimates based on Distance analysis not possible.

3.2. [species] abundance estimates according to supplementary datasets

LLUR flights

German coastal counts

NOVANA and/or DOF data

(No subchapters if information on numbers is coming from only one type of source: FEBI or others)

Chapter ends with a brief literature overview and discussion.

4. Distribution and habitat use of [species] in the Fehmarnbelt

4.1. [species] distribution and habitat use according to spatial modelling

Species distribution and habitat use patterns based on spatial modelling results of aerial or ship-based survey data (maps, GAM response curves, tables with parameter values and interpretation).

Model-based abundance estimates and comparison with estimates obtained using Distance analysis.

OR (depending on species that is being reported)

[species] distribution and habitat use according to survey data

Description of bird distribution and habitat use, if no spatial modelling is used.

Plotting interpolated maps OR maps of species observations during aerial and/or ship-based surveys.

4.2. [species] habitat preferences according to telemetry data

Species habitat preferences based on telemetry data (maps, GAM response curves, tables with parameter values and interpretation).

4.3. [species] distribution according to supplementary datasets

Mapping of LLUR flight survey results

Mapping of German coastal counts

NOVANA and/or DOF data

(No subchapters if information on numbers is coming from only one type of source: FEBI or others)

Chapter ends with a brief literature overview and discussion.

5. [Species] abundance estimates for SPAs

Abundance estimates for each SPA (if obtained by spatial modelling).

6. [Species] trends

Trend of biogeographic population, trend of stock in the Fehmarnbelt and pressure evaluation based on literature and external data sources (Skov et al. 1998; BIOLA 2009, AKVSW 2010, etc.).

7. Importance of the Fehmarnbelt to [species]

Concluding paragraph discussing importance of the Fehmarnbelt to a species with reference to the results presented in chapters above (abundance, proportion of biogeographic population, occurrence in SPAs, etc.).

Finally, each species chapter is closed with a ‘summary box’ in grey presenting summary information for environmental impact assessment (Table 2.8). Maximum abundance estimate presents the highest number of a species as identified (estimated) during the FEBI baseline investigations or supplementary datasets. Maximum abundance in the alignment area refers to the highest number of birds estimated for the area of the immediate vicinity to the alignment (as defined in Figure 2.21). Period of maximum abundance indicates months or a season when highest numbers of a particular species are typically present in the Fehmarnbelt. Line ‘Areas of maximum abundance’ gives a reference to a figure best representing species distribution during periods of the highest abundance. The ‘summary box’ is finished with explanations, which very briefly refer to sources of information provided on other lines of the ‘summary box’.

Table 2.8 General template of the species summary box used at the end of each non-breeding waterbird species description to provide summary information for environmental impact assessment.

[species] – summary of information for EIA
Max. abundance estimate in Fehmarnbelt:
Max. abundance estimate in the alignment area:
Period of max. abundance in Fehmarnbelt:
Areas of max. abundance in Fehmarnbelt:
Explanations:

2.3 Foraging Ecology and local movements of waterbirds in the Fehmarnbelt

2.3.1 Foraging ecology: diet composition

Benthivorous birds: seaducks

The diet composition of benthivorous seaducks was evaluated by examining stomach contents of ducks collected from fishermen, sport hunters and dedicated hunting in the Fehmarnbelt area (Table 2.9). The combined sample consisted of individuals collected from natural foraging grounds across several locations in the Fehmarnbelt and during different periods of the bird wintering season. 19% of the birds collected were obtained from fishermen while others were shot. Male/female and adult/juvenile ratios of collected birds were similar during two winter seasons (Table 2.9). Considering heterogeneity of the sample, it was assumed that birds collected represent overall feeding habits of seaducks wintering in the Fehmarnbelt.

Seaduck hunting season is open in Denmark until February 15. Special permits were obtained from The Danish Forest and Nature Agency (Skov- og Naturstyrelsen, Miljøministeriet) to hunt ducks after this date (ref no: SNS-342-00049). A special permit was received from the German Ministry of Agriculture, Environment and Rural Areas of Schleswig-Holstein (Ministerium für Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein) to collect birds by hunting on the German side of the Fehmarnbelt (ref no: V 5410-7462.3-6).

The diet composition of seaducks has been assessed in terms of the total numeric composition of prey items, and estimated composition of prey weight and energetic value averaged per individual of each species. While dissecting birds, the body condition of all individuals was assessed by deriving an index of fat deposits. Fat deposits in 3 places were inspected and given a score from 0-3 (Jones et al. 1982). Added together into one combined score these values provide an index of the overall condition of the bird together with body weight measurements.

Table 2.9 List of birds collected for diet analysis in the Fehmarnbelt area during two winter seasons.

Species	Number of birds	Sex (m/f)	Age (ad/juv)	Source (shot/nets)
Winter 2008/2009				
Common Eider	35	25 / 10	32 / 3	32 / 3
Long-tailed Duck	16	12 / 4	13 / 3	15 / 1
Common Scoter	4	3 / 1	3 / 1	2 / 2
Red-breasted Merganser	2	0 / 2	0 / 2	0 / 2
Tufted Duck	1	1 / 0	0 / 1	0 / 1
Great Crested Grebe	1	0 / 1	0 / 1	0 / 1
Winter 2009/2010				
Common Eider	100	71 / 29	88 / 12	78 / 22
Long-tailed Duck	59	42 / 17	52 / 7	58 / 1
Common Scoter	57	48 / 9	53 / 4	41 / 16
Tufted Duck	1	1 / 0	0 / 1	0 / 1
Great Crested Grebe	1	1 / 0	0 / 1	0 / 1
Razorbill	1	0 / 1	0 / 1	0 / 1
Sum winter 2008/2009	59	41 / 18	48 / 11	49 / 10
Sum winter 2009/2010	219	163 / 56	193 / 26	177 / 42
Total of both winters	278	204 / 74	241 / 37	226 / 52

Birds collected were dissected in a laboratory and prey items from oesophagus, stomach and intestines were analysed. During dissection all prey items were carefully removed from oesophagus, gizzard and intestine from all birds, and placed in 70% ethanol. Subsequently food items were identified to the lowest possible taxon and measured under a microscope. Bivalves were identified using Bondesen (1984), Christensen et al. (1978); snails were identified using Bondesen (1994); fish remains were identified using Härkönen (1986), Leopold et al. (2001); and crustaceans were identified using Enckell (1980).

A lot of bivalves were crushed in bird gizzards, so the number of bivalves ingested was determined by counting shell hinges. Hinges were measured and these measurements were subsequently used to reconstruct mollusc sizes. Of complete shells, their length, width and hinge thickness were measured to establish allometric equations for calculating length of different bivalve species using fragments of broken shells (Table 2.10). Bivalve weights were estimated from bivalve lengths using allometric equations derived from bivalve measurements conducted by FEMA (Table 2.11).

Table 2.10 Allometric equations used for calculation of bivalve length (Mytilus edulis) or width (clams) (y, mm) from hinge thickness (x, mm).

Species	Equation	Sample size
Mytilus edulis	$y = -9.1967\ x^2 + 36.174\ x + 0.8335$	243
Astarte sp.	$y = 0.9213\ x^2 + 2.6887\ x + 2.5027$	23
Cerastoderma sp.	$y = 21.802\ x^2 - 6.5475\ x + 4.5089$	49
Macoma sp.	$y = -29.548\ x^2 - 46.402\ x - 9.9833$	4
Mya sp.	$y = 16.5\ x - 1.35$	4

Table 2.11 Allometric equations used for estimation of ash free dry weight (AFDW, g) and wet weight (WW, g) of Blue Mussels and clams from mussel length and clam width (mm).

Species	AFDW	WW	Sample size
Mytilus edulis ≤ 20mm	$y = 0.00002*x^{2.4011}$	WW = AFDW/0.0427	66
Mytilus edulis > 20mm	$y = 0.00001*x^{2.5121}$	WW = AFDW/0.0427	133
Clams	$y = 0.00004\ x^{2.175}$	$y = 0.0009\ x^{2.2827}$	779

Fish otoliths were the most common remain of fish prey. Otoliths were measured under a stereo-microscope and fish size was reconstructed using allometric equations provided by Härkönen (1986; used for gobies and sandeels) and Svetocheva (2007; used for sticklebacks). Weight of sticklebacks was assumed as the mean value of stickleback weight as obtained by FEBEC investigations. Energy content of fish was assumed as 4 kJ g^{-1} wet weight (Barrett et al. 2002).

Polychaetes were found in bird diet as fragments of undigested worms or mandibulae jaws. Identified polychaetes belonged to *Nereis sp*. and it was assumed that the mean length of ingested worms was 50 mm.

Crab claws were the most frequent remnant of crabs, when no complete individuals were found. Size (carapax width) of *Carcinus* crabs was estimated from claw size according to an equation for right-handed *Carcinus maenas* males provided by Juanes et al. (2008). Wet weight of crabs was estimated from carapax width using an equation for male *Carcinus aestuarii* in winter (Can et al. 2007).

Weight of *Buccinum* snails was calculated using measured length according to Ilano et al. (2004). The energy content of prey invertebrates was calculated from weight according to allometric equations provided by Rumohr et al. (1987).

Diet composition was summarised as percent composition of prey fresh weight and energy contents per individual bird, and then average values of different prey types were calculated for each species using individual birds as a sampling unit. Similarly, sizes of prey items were averaged for each individual and then the average of individuals was used to represent size measurements of typical prey.

Additional information about diet composition of Tufted Ducks was obtained by analysing droppings of birds that were captured for telemetry investigations. Dropping samples were collected at 3 different occasions: birds were twice caught on freshwater lakes early in the morning when they returned from nocturnal foraging sites for daytime roosting; and once several birds were caught at night when they were foraging. Collected dropping samples were stored frozen and were diluted with 70% ethanol prior to examination in a laboratory. Each sample was thoroughly mixed and sub-sampled 5 times by spreading approximately 2 ml of the contents into a Petri dish. Identifiable fragments of prey were described qualitatively.

Piscivorous birds: Great Cormorants

The diet of Great Cormorants, which is the most abundant piscivorous bird species in the study area, was studied by analysing contents of pellets that birds regurgitate while on roosting sites. Cormorant pellets contain fish remains (otoliths, bones), which allow species identification and reconstructing size of consumed fish. Regurgitated pellets were collected at the breeding colony of Wallnau on the island of Fehmarn, roosting sites on the jetty of Puttgarden harbour, a pier near Dahme, near Großenbroderfähre and from sandbanks of Rødsand Lagoon (Figure 2.23).

Pellets were collected at 13 occasions between May 2009 and June 2010 (Table 2.12). Between 3 and 60 pellets were collected each time totalling 386. Collected pellets were frozen and later analysed in the laboratory identifying fish remains (otoliths, pharyngeal bones and vertebrae) according to Härkönen (1986), Watt et al. (1997) and Leopold et al. (2001) in combination with a reference collection at the Zoological Institute, Christian-Albrechts-University of Kiel. Each fish has two otoliths but no attempt was made to pair up otoliths. Instead the otolith number of each prey species found was counted and divided by two (Johnstone et al. 1990). If bones and otoliths within one pellet were found to originate from the same species, this was only counted as one prey item. Otoliths were measured to the nearest 0.05 mm using a dissecting stereomicroscope. Fish lengths (FL) and fish mass (FM) were then back-calculated from the otolith length (OL), according to regression equation (Härkönen 1986, Leopold et al. 2001). Since partial or even complete digestion may cause fish remains to wear and disappear respectively, estimated numbers of fish per pellet, fish length and fish mass were considered minimum values (Marteijn and Dirksen 1991, Zijlstra and Van Eerden 1995). No attemps were made to account for otolith erosion or possible expulsion from digestive tract; because there are no methods to reliably do so. It was also considered that cormorant diet examination methods used in this study are sufficient to represent general diet composition of cormorants for the purposes of this study.

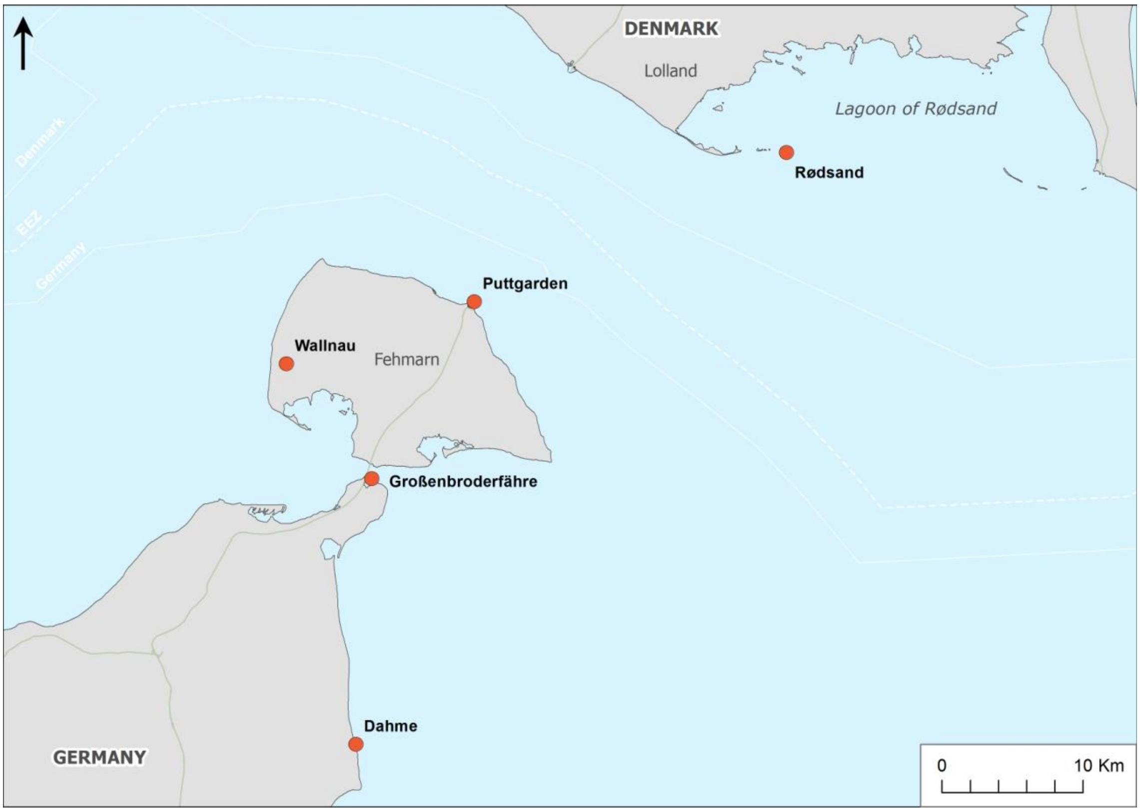


Figure 2.23 Sampling locations of Great Cormorant pellets in the Fehmarnbelt area during May 2009 – June 2010.

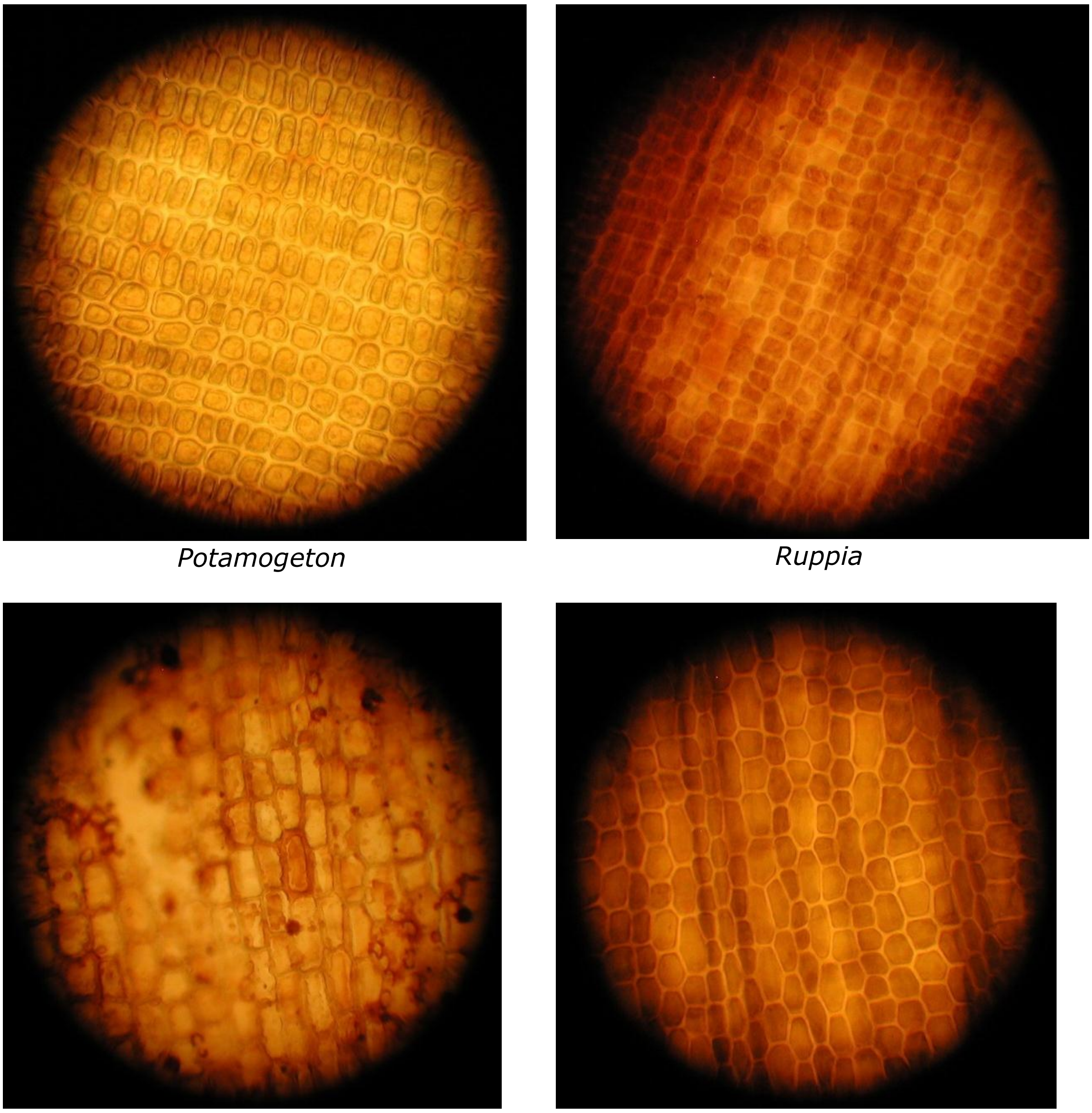
Table 2.12 Great Cormorant pellet sampling dates, locations and number of pellets collected and analysed.

Month	Location	Number of pellets collected	Number of pellets analysed
May 2009	Wallnau	20	10
Jun 2009	Wallnau	20	11
Aug 2009	Rødsand	56	11
Oct 2009	Rødsand	41	12
	Puttgarden	numerous non-separated pellets	
Nov 2009	Puttgarden	20	12
Dec 2009	Großenbroderfähre	40	13
Mar 2010	Dahme	30	5
	Puttgarden	6	6
	Großenbroderfähre	30	5
Apr 2010	Großenbroderfähre	3	2
May 2010	Wallnau	60	13
Jun 2010	Wallnau	60	10
TOTAL		386	110

Herbivorous birds: Mute Swans

Of herbivorous birds, the diet composition of Mute Swans, moulting in Rødsand Lagoon in July and August, was studied. Samples of swan droppings were collected from shorelines or emerged rocks in shallow parts of the lagoon on 9 and 6 different occasions in 2009 and 2010, respectively. During each sampling event approximately an equal amount of dropping material was collected from 2-15 different dropping piles (average 10, SD=2.99), presumably representing different birds. Droppings collected on the same day were placed together into a zip-lock back and stored frozen. In the laboratory the material was thawed, diluted with 70% ethanol and mixed using electric blender to achieve homogenous mix of one sampling day. This homogenised mix was sub-sampled and analysed under stereo microscope using 200x magnification (10x20). Each sample (homogenised mix representing droppings collected on a single day) was sub-sampled 10 times by taking a drop of the mix and placing this on a microscope glass. Further, 5 positions were examined on each of the prepared microscope glass by identifying proportions of different plant matter in the field of view. These 5 positions were conducted in a zig-zag pattern, ensuring that minimal distance of 5 mm was maintained between the steps. The microscope field of view was equipped with 10x10 grid, which helped to determine proportions of observed plant matter. In total, each sample (representing one sampling event) consisted of 50 sub-samples, values of which were averaged for representation.

Different species of submerged vegetation, which the swans were foraging on, have species-specific patterns of epidermis cells, which were used to identify plants in bird diets (Figure 2.24). This method provided qualitative assessment of aquatic plants that were important in swan diets. There was also other plant matter in the samples, such as fibres and presumably rhizome material, which had no distinct features useful for identification and therefore was categorised as 'unidentified material'.



Potamogeton | Ruppia | Zannichelia | Zostera

Figure 2.24 An example of epidermis cells of common aquatic plant species (magnified 200 times), which were consumed by Mute Swans in Rødsand Lagoon.

2.3.2 Foraging ecology: stable isotope analysis

In addition to conventional examination of bird stomach content, diets of studied seaduck species were also assessed applying stable isotope analysis of bird blood composition. The conventional stomach analysis allows precise and specific identification and quantification of foods found in birds. The limitation of the stomach analysis is that it represents only the most recent meal of a bird. Stable isotope analysis allows evaluation of longer-term intake of general prey types.

Stable isotope analysis has already become established as a standard technique of studying seabird diet and trophic ecology (Bond and Jones 2009). Carbon and nitrogen, which are the most commonly used elements in seabird diet analyses were used. These elements consist of stable isotopes varying in mass, which occur in different abundances and could be measured using mass spectrometer (Stable isotopes differ from radiogenic isotopes in that they do not decay over time.) Mass spectrometer measurements are typically expressed as the ratio of heavy to light isotope and are reported as parts per thousand (‰): 13C to 12C is expressed as δ13C; and 15N to 14N is expressed as δ15N. Stable isotope ratios change in a predictable way as heavy isotopes are being concentrated when moving up the food chain. δ15N shows a stepwise increase of 2.5-5‰ between one trophic level to the next. δ13C also increases with trophic level, but to a lesser degree and changes 0-1‰ between diet and consumer; δ13C is also used to indicate the source of carbon in a consumer (De Niro and Epstein 1981; Hobson and Clark 1992). Isotopic composition of bird blood represents the composition of assimilated foods during 2-3 recent weeks (Bearshop et al. 2002).

Sample collection and preparation for measuring stable isotope composition

For stable isotope analysis, blood samples (1 ml) were collected from all birds that were caught alive for telemetry studies (presented further in the text) and also from birds collected for stomach analysis (Table 2.9).

Initially collected blood samples were stored in cryogenic vials and frozen at -18°C. Then, the samples were freeze-dried and powderised. Approximately 1.2 mg of each sample was weighted into special tin capsules, which were finally combusted in a mass spectrometer. The measurements of stable isotope composition were done using a CE 1110 elemental analyser (Thermo Scientific , Milan, Italy) coupled in continuous flow mode to an isotope ratio mass spectrometer (Delta V Advantage, Thermo Scientific, Bremen, Germany) by Risø National Laboratory for sustainable Energy, Technical University of Denmark.

For reference, the stable isotope composition was also measured for potential prey types. Samples of different prey types were collected, freeze-dried, homogenized and processed following the same procedures as for bird blood samples described above. Additionally, prey samples were treated to remove lipids, a procedure which is unnecessary for blood samples (Bond and Jones 2009). Lipids were removed by applying 2:1 chloroform:methanol solution on powderised tissues, which were well mixed, left undisturbed for 30 minutes and then centrifuged. The supernatant containing solvent and lipids was discarded and the procedure was repeated at least 3 times or more until the supernatant was clear following the centrifugation (Logan et al. 2008). Samples were then rinsed with distilled water and re-dried.

In total 428 samples have been measured to determine stable isotope composition, 397 of them representing individual birds and 31 prey items (Table 2.13).

Table 2.13 Sample sizes of measured stable isotope composition in birds and their potential prey.

Species	No in 2008/2009	No in 2009/2010
BIRDS		
Common Eider	62	154
Long-tailed Duck	13	82
Common Scoter	4	59
Tufted Duck	2	16
Red-breasted Merganser	2	
Great Crested Grebe	1	1
Razorbill		1
PREY		
Amphipoda		6
Arctica islandica		2
Asterias rubens		2
Buccinum sp.		3
Carcinus maenas		3
Isopoda		2
Littorina sp.		3
Mytilus edulis		4
Fish		6

Analysis of stable isotope data

Results of stable isotope measurements were represented as mean values and associated variation (95% confidence intervals) of δ13C and δ15N for different groups of study objects – bird species in different seasons. Multiple samples were compared applying one-way ANOVA, and if significant differences were detected, further pair wise comparisons were done using t-test for independent samples (Zar 1998).

2.3.3 *Foraging ecology: daily activities and energy budgets*

Foraging activities of three ducks species: Common Eider, Tufted Duck and Long-tailed Duck have been studied using VHF radio telemetry. During two winter seasons (2008/2009 and 2009/2010) a total of 75 individuals were equipped with external radio transmitters on the Danish and German side of the Fehmarnbelt.

Bird captures and transmitter deployment

Two methods were used to capture live birds for telemetry studies: night lighting and using mist-nets. Both techniques are very safe, cause little disturbance and typically do not result in any bird injuries. With night lighting technique birds were approached by boat on their night roosting sites and caught with a dip net using a bright light. The light disorients birds and they often do not try to escape from the approaching boat. This method was successful in catching ducks at sea and therefore the majority of birds tagged with different types of transmitters (VHF, satellite, GPS loggers) were caught using this technique. The other capture method is setting mist-nets in the areas favoured by waterbirds and catching birds as they entangle in the net stretched over the water between the poles set on the floating platforms (Kaiser et al. 1995; Lewis et al. 2005). This method was used for catching Tufted ducks on their fresh water resting ponds.

Once captured, ducks were placed into dark but well ventilated cages. A clean and dry towel was put into each cage, so ducks stayed dry and clean. Transmitter deployment took place near bird capture locations shortly (within 1-4 hours) after birds had been captured. Birds were released as soon as they were measured, ringed and fitted with a transmitter.

The majority of the transmitters used in this study were 13 gram external radio tags equipped with 1 or 2 subcutaneous anchors, which were attached on bird's back following the procedures described in Iverson et al. (2006) and Lewis and Flint (2008). The type and attachment method of these transmitters has a low burden on birds and they typically shed these transmitters several months after the deployment (Wheeler 1991, Pietz et al. 1995, Lewis and Flint 2008). It was therefore expected that the radio transmitters did not have a significant impact on bird distribution or behaviour, and therefore radio-tagged individuals were considered as a representative sample of birds wintering in the Fehmarnbelt. Radio-transmitters used in this study emitted signals detectable up to a tested distance of 8 km, but the signal strength varied depending on environmental conditions (air humidity, wave height) and positioning of receiving equipment (height of antennas).

Tracking radio-tagged birds

In total 75 five birds were equipped with VHF radio transmitters during the two seasons of the study (Table 2.14). All tagged birds were released near their capture places, which included different locations along the German and Danish costs and offshore areas of the Fehmarnbelt (see map in Figure 5.11). Released radio-tagged birds were subsequently searched from different access points along the shore and from a ship. Directional Yagi antennas and radio receivers (R2000, Advanced Telemetry Systems, Isanti, USA) scanning all radio-frequencies of tagged birds were used to locate birds. Once found, the bird position was determined by measuring bearing angles to the direction of the strongest signal. Measuring bearings to the same individual from 2 or more different positions allowed using triangulation to determine bird location. Bird positions were calculated using LOAS (4.0.2.2 Beta) software. After birds with sufficiently strong signals were positioned (signal strength criteria are described further in the text), pole-mount dipole omnidirectional antennas were used in combination with data logging receivers for recording bird foraging behaviours. Data logging receivers (R4500S, Advanced Telemetry Systems, Isanti, USA) recorded signal presence and signal strength every second. Duck diving caused interruptions in signal records (i.e., no radio signals while bird was underwater) resulting in discrete gaps in the data stream, which later could be interpreted as bird foraging behaviour. If sufficiently strong signals from more than one tagged bird were detected from the same location, simultaneous recording of foraging behaviour of two individuals was possible. Receiving data loggers were always placed in waterproof, locked aluminium boxes, so that data sampling could be conducted independently from observer presence (e.g. during night) and rough weather conditions.

Table 2.14 List of radio-tagged and tracked birds during two winter seasons (2008/2009 and 2009/2010).

Species	Number of tagged birds (1st/2nd winter)	Sex (m/f)	Age (ad/juv)	Number of tracked birds (% of tagged)
Common Eider	52 (16 / 36)	40 / 12	48 / 4	32 (62%)
Long-tailed Duck	12 (0 / 12)	9 / 3	12 / 0	11 (92%)
Tufted Duck	11 (1 / 10)	5 / 6	4 / 7	7 (64%)

During the second field season two omnidirectional antennas were permanently mounted on high structures on Fehmarn Island close to frequently used sea duck resting and feeding grounds. One was placed on the lighthouse of Westermarkelsdorf (antenna height above sea level 16.5 m) and one on a tower next to Staberhuk lighthouse (antenna height above sea level 15 m; Figure 2.25).

During ship-based tracking an omnidirectional antenna was mounted as high as possible on a ship (approximate antenna height was 8-11 m above the sea level depending on the ship). Ships were mainly used to search for tagged birds further offshore and collect diving data of individuals, which were out of the receiving range of shore-based stations. Also, monthly bird counting surveys from ships have regularly been used for screening the entire study area for tagged birds using receivers.

In addition to the permanently mounted antennas on lighthouses, a mobile base with omnidirectional antennas mounted on 8 m telescope pole was also used. This setting has been used at various locations along the shore where transmitting birds have been detected. Together with data-logging receivers, such mobile systems were successfully used at several locations on Fehmarn Island (Germany), the coast of Lolland (Denmark) and the German mainland coast. Because sea state has strong effect on transmitter signal strength and especially on regularity of received pulses, observation were not conducted when wave conditions exceeded stage 3 on the Beaufort scale while tracking from a ship, and 5 Beaufort while tracking from shore.

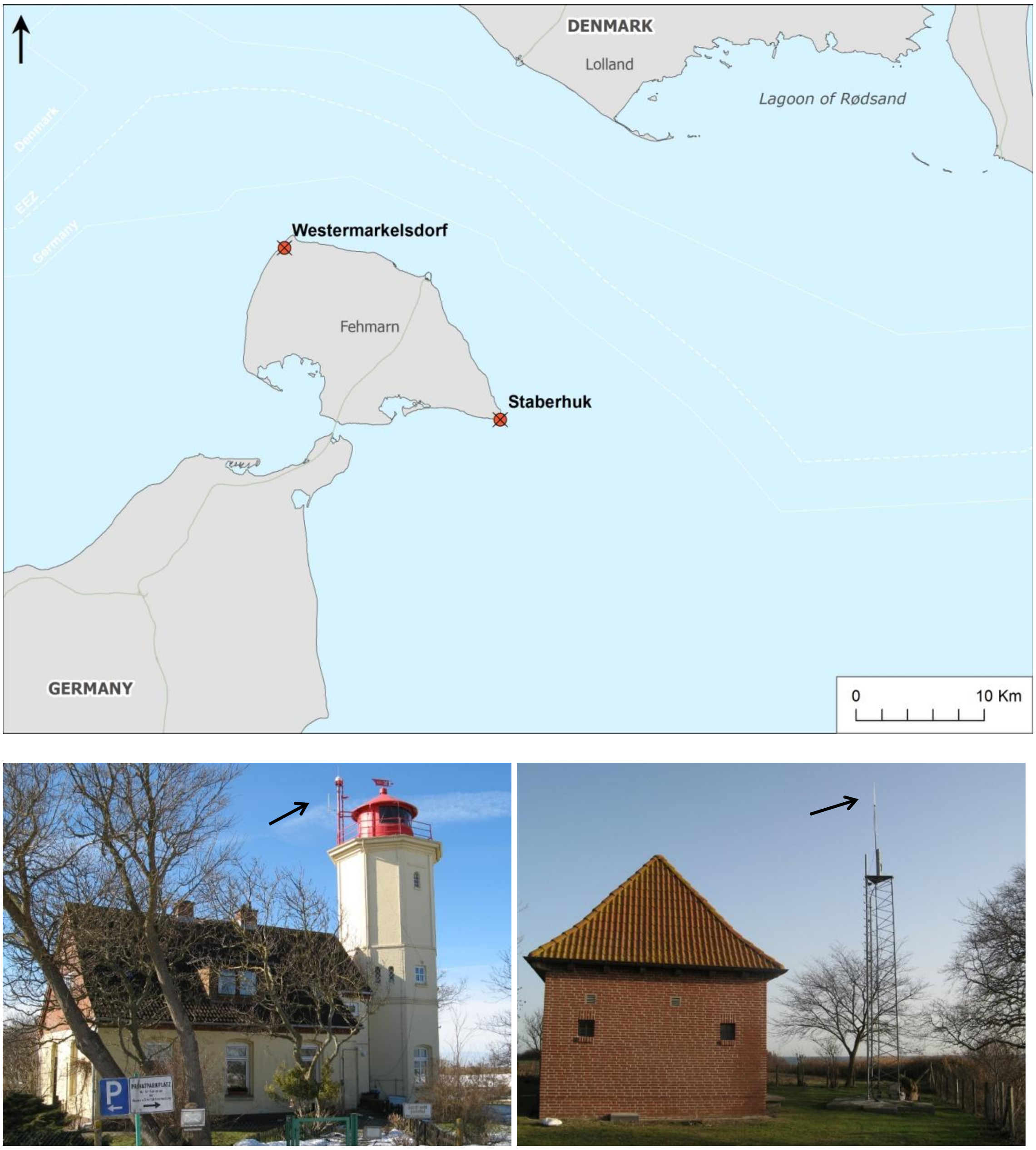


Figure 2.25 Permanently mounted omnidirectional antennas on Fehmarn Island: Westermarkeldorf lighthouse (left) and a tower in Staberhuk (right).

Equipment calibration and processing of VHF radio telemetry data

For documenting diving behaviour of radio-tagged ducks an automatic data logging receiver (R4500S, Advanced Telemetry Systems, Isanti, USA) was used. The signal of a preselected transmitter identity, defined by a specific frequency and a pulse rate, were received and recorded automatically by choosing 'aerial mode' on the device menu. While signals of a selected transmitter identity were present, the following information was recorded at time intervals of one second: date, UTC time (with seconds precision), transmitter frequency, signal strength and pulse rate of the signal. The internal memory of the data logger allowed storage of approximately 14 hours of continuous records. Absence of signals while focus birds were diving extended recording capacity slightly, but nevertheless data were downloaded from receivers at maximum intervals of 14 hours in order to prevent reaching capacity limit of the storage memory, which would result in overwriting of stored data.

Four automatic data loggers were used during the project and all 4 devices were tested and compared with each other by simultaneously logging foraging activities of the same bird from the same location. No differences in performance or signal detection sensitivity were found.

Furthermore, the performance of radio receivers had to be calibrated in the field using simultaneous visual observations of bird activities, as technical receiver characteristics suggest that the equipment needs more than one positive signal at predetermined time intervals to initiate a new burst of recording (Figure 2.26). Diving activities of a tagged bird were recorded by an observer using binoculars a stopwatch and by the automatic data logger. This material was used to assess radio signal strength and related reliability of automatically recorded data, and calculate dive length as measured by signal absence.

As Tufted Duck is the only target species wintering near shores, visual observations were conducted on a radio-tagged Tufted Duck in coastal waters. Foraging behaviour of one individual was visually observed for 2 hours in the harbour of Burgstaaken (Fehmarn Island) on March 12, 2010 while an automatic data logger was recording the signals of this bird (antenna distance to the diving individual was 1.3 km). During the observation period, 18 dives were recorded visually noting precise start and end time.

By comparing visual observations with automatically recorded data it was determined that the start time of a dive was recorded identically using both methods. As expected according to technical characteristics of automatic data loggers, dive end time differed on average by 4.9 seconds (SD ± 1.27 sec) between the logger and visual observations (Figure 2.26). It was therefore concluded that automatically recorded dive lengths would have to be corrected by subtracting 5 seconds for transmitters with pulse rates of 55 and 56 ppm (pulses per minute), and by 7 seconds for transmitters with pulse rate of 40 ppm.

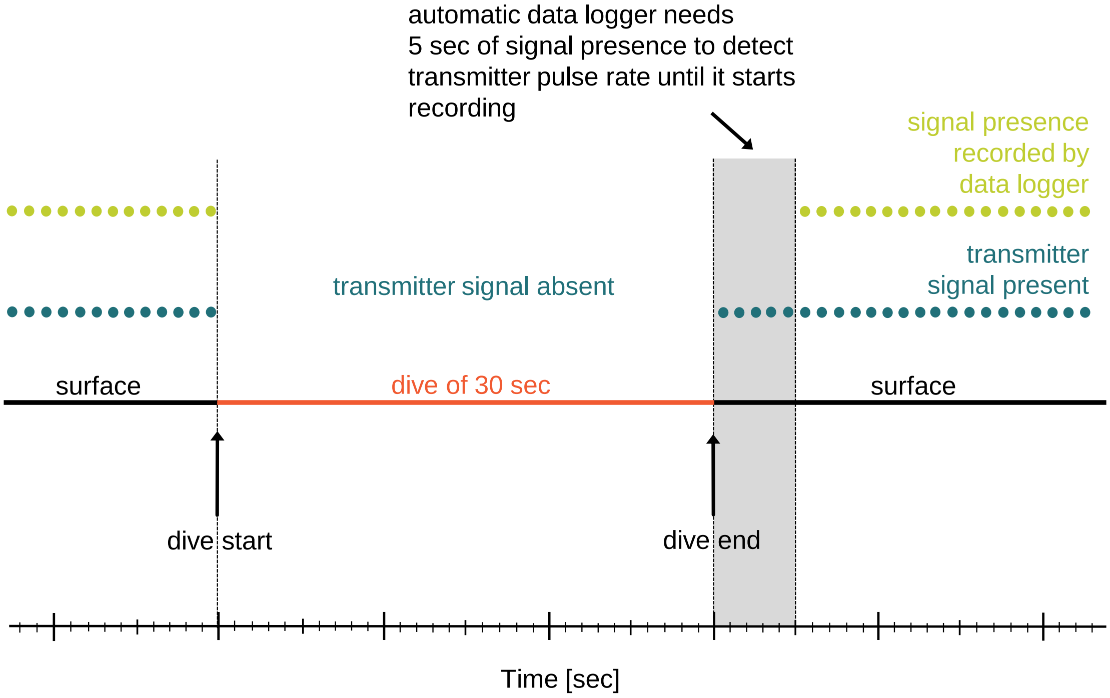


Figure 2.26 Schematic illustration of transmitter signal presence and absence during bird diving event, and response of automatic data-logger.

Acoustic and visual observations verified that the data logger system was working reliably when measuring diving activity of radio-tagged ducks. It is possible that the records of foraging behaviour of Tufted Ducks in very shallow waters were close to the detection limit of the automatic logging system if birds dove and/or made surface pauses for just a few seconds, as surface pauses shorter than 5 seconds cannot be detected. However, we assumed that if very short dives or inter-dive pauses were used, they comprised little proportion of the overall foraging effort. Foraging Common Eiders and Long-tailed Ducks dive in deeper waters, therefore non-detection of dives or pauses were considered very unlikely.

Automatic data loggers ascribe signal strength value ranging between 80 to 150 to every record. By comparing acoustic observations and automatic data records, it was established that only signals with strength levels exceeding 100 could be used to characterise duck diving behaviour.

In total 2,189 hours of bird foraging activities were recorded and, after applying the quality filter, 1,590 hours (or 76% of all collected data) representing 59 individuals were used in further analyses (Table 2.15).

Table 2.15 Volume of data collected on bird foraging behaviour using VHF-radio telemetry in the Fehmarnbelt during the two winter seasons (2008/2009 and 2009/2010).

	Number of hours logged in winter 2008/09		Number of hours logged in winter 2009/10	
Species	**all**	**filtered**	**all**	**filtered**
Common Eider	142.3	142.3	1,380.0	993.5
Long-tailed Duck	–	–	482.9	335.4
Tufted Duck	–	–	183.8	119.1

Analysis of VHF radio telemetry data

To analyse bird foraging activity throughout the day, diving was related to one of four light categories: dawn, day, dusk and night. Dawn and dusk times were categorised using nautical twilight times for Fehmarnbelt. As there have been no visual observations carried out to differentiate surface time by specific behaviour of ducks in more detailed categories (e.g. preening, sleeping, swimming), the analyses only distinguished between diving (i.e. foraging) and surface behaviour. However, short inter-dive surface pauses within a foraging bout and longer surface resting periods in-between (components of a foraging cycle defined according to Heath et al. 2008) were differentiated. In most instances the structure of foraging behaviour data was rather clear allowing for differentiation of these two types of pauses (Figure 2.27).

ID	Sampling_ID	date	start_dive	end_dive	dive_sec	interdive_sec	signal	light	interdive/dive	dive cycle_sec	behaviour
13157	CH150133_20100325_1	20100325	10:34:15	10:34:43	28	13	108	day	0,46	41	foraging
13158	CH150133_20100325_1	20100325	10:34:56	10:35:25	29	40	109	day	1,38	69	foraging
13159	CH150133_20100325_1	20100325	10:36:05	10:36:18	13	1980	108	day	152,31		**resting**
13160	CH150133_20100325_1	20100325	11:09:18	11:09:52	34	14	109	day	0,41	48	foraging
13161	CH150133_20100325_1	20100325	11:10:06	11:10:38	32	19	108	day	0,59	51	foraging
13162	CH150133_20100325_1	20100325	11:10:57	11:11:28	31	14	108	day	0,45	45	foraging
13163	CH150133_20100325_1	20100325	11:11:42	11:12:14	32	14	110	day	0,44	46	foraging
13164	CH150133_20100325_1	20100325	11:12:28	11:12:56	28	24	107	day	0,86	52	foraging
13165	CH150133_20100325_1	20100325	11:13:20	11:13:48	28	14	108	day	0,50	42	foraging
13166	CH150133_20100325_1	20100325	11:14:02	11:14:31	29	21	111	day	0,72	50	foraging
13167	CH150133_20100325_1	20100325	11:14:52	11:15:18	26	37	105	day	1,42	63	foraging
13168	CH150133_20100325_1	20100325	11:15:55	11:16:23	28	15	108	day	0,54	43	foraging
13169	CH150133_20100325_1	20100325	11:16:38	11:17:07	29	16	107	day	0,55	45	foraging
13170	CH150133_20100325_1	20100325	11:17:23	11:17:50	27	974	106	day	36,07		**resting**
13171	CH150133_20100325_1	20100325	11:34:04	11:34:36	32	19	106	day	0,59	51	foraging
13172	CH150133_20100325_1	20100325	11:34:55	11:35:24	29	19	105	day	0,66	48	foraging
13173	CH150133_20100325_1	20100325	11:35:43	11:36:11	28	15	108	day	0,54	43	foraging
13174	CH150133_20100325_1	20100325	11:36:26	11:36:55	29	14	106	day	0,48	43	foraging
13175	CH150133_20100325_1	20100325	11:37:09	11:37:38	29	17	106	day	0,59	46	foraging
13176	CH150133_20100325_1	20100325	11:37:55	11:38:25	30	16	108	day	0,53	46	foraging
13177	CH150133_20100325_1	20100325	11:38:41	11:39:09	28	77	108	day	2,75	105	foraging
13178	CH150133_20100325_1	20100325	11:40:26	11:40:53	27	23	108	day	0,85	50	foraging
13179	CH150133_20100325_1	20100325	11:41:16	11:41:44	28	18	106	day	0,64	46	foraging
13180	CH150133_20100325_1	20100325	11:42:02	11:42:31	29	17	104	day	0,59	46	foraging
13181	CH150133_20100325_1	20100325	11:42:48	11:43:16	28	21	109	day	0,75	49	foraging
13182	CH150133_20100325_1	20100325	11:43:37	11:44:05	28	18	107	day	0,64	46	foraging
13183	CH150133_20100325_1	20100325	11:44:23	11:44:51	28	21	106	day	0,75	49	foraging
13184	CH150133_20100325_1	20100325	11:45:12	11:45:42	30	22	104	day	0,73	52	foraging
13185	CH150133_20100325_1	20100325	11:46:04	11:46:33	29	15	105	day	0,52	44	foraging
13186	CH150133_20100325_1	20100325	11:46:48	11:47:17	29	17	102	day	0,59	46	foraging
13187	CH150133_20100325_1	20100325	11:47:34	11:48:02	28	15	104	day	0,54	43	foraging
13188	CH150133_20100325_1	20100325	11:48:17	11:48:45	28	22	106	day	0,79	50	foraging
13189	CH150133_20100325_1	20100325	11:49:07	11:49:39	32	35	104	day	1,09	67	foraging
13190	CH150133_20100325_1	20100325	11:50:14	11:50:44	30	18	102	day	0,60	48	foraging
13191	CH150133_20100325_1	20100325	11:51:02	11:51:31	29	19	106	day	0,66	48	foraging
13192	CH150133_20100325_1	20100325	11:51:50	11:52:18	28	1578	107	day	56,36		**resting**
13193	CH150133_20100325_1	20100325	12:18:36	12:19:03	27	11	112	day	0,41	38	foraging

Figure 2.27 Excerpt of processed raw data table classified into 'foraging' or 'resting' surface times of a radio-tagged Long-tailed Duck. The interval between two 'resting' phases marks one foraging bout with several consecutive dives.

Short surface pauses between dives within a foraging bout (foraging) were defined as part of foraging behaviour. For Common Eiders the period between two dives was defined as foraging if the surface time was shorter than 150 seconds and the proportion of 'inter-dive time/dive time' was <2.5. For Long-tailed ducks foraging was defined as the surface time between two dives shorter than 120 seconds, for Tufted ducks <90 seconds.

Continuous behaviour recording of a single individual was considered as a sampling unit, with a minimum threshold of observation length being 1 hour. For each sampling unit recorded, the number of dives was converted into number of dives per hour separately for each period of a day (night, dawn, day, dusk). In this way samples of different duration were standardised. Further, monthly values of dives and foraging time for each light condition were calculated by averaging standardised values of dives or foraging time across all samples in a particular month and extrapolating for each period of a day. Records of Tufted ducks were insufficient for calculating monthly means; therefore data were processed considering only a single time period (Dec-Mar 2010).

Aiming to assess the relative importance of different parameters on foraging effort, multiple regression models were used for each studied species considering effects of water depth, sea surface temperature (SST), day length, and bird age and sex on diving intensity using number of dives per hour as a response variable. Models with all possible combinations of input variables were fitted and the most plausible models for each species were selected based on lowest values of Akaike Information Criterion corrected for small samples (AICc, Burnham and Anderson 2002). Additionally, weighted parameter estimates and unconditional standard errors were calculated and parameter importance using AICc weights was assessed (Burnham and Anderson 2002). This exercise allowed camparison of the relative importance of predictor variables.

Constructing Common Eider energy budgets

Common Eider is the most abundant seaduck species wintering in the Fehmarnbelt and consuming a substantial amount of bivalves, chiefly Blue Mussels, during the wintering period. To quantify mussel consumption of eiders wintering in the area, daily energy demand and corresponding mussel intake for this species were estimated based on activity budgets obtained from radio telemetry in winter 2009/2010 and literature data (Table 2.16). Due to the small sample size in radio telemetry data for October and January, the diving activity pattern of November was applied for October calculation, mean values of December and February were used for January. A detailed description of variables used in Common Eider energy budget calculation and literature references are listed in Table 2.16.

The different phases of a foraging cycle were defined following Heath et al. (2008): one foraging cycle consists of a dive bout and a subsequent resting bout; a dive bout consists of one to many (foraging) dives, each followed by a subsequent surface pause. One foraging bout is expected to provide the bird with a ‘meal’, which gets further processed in the gizzard within the following resting bout (Guillemette 1994).

Table 2.16 Description of variables used in calculation of Common Eider energy budget. All variables were calculated on a monthly basis for the period from October 2009 to March 2010.

Variable	Value	Variable description
Environmental factors		
Water temperature	Mean sea surface temperature of duck diving locations	FEHY dataset; for October a value of 12 °C was assumed
Water depth	Mean water depth of duck foraging positions	Duck positions located by triangulation; water depth: FEHY bathymetry data
Time budget		
Number of dives per day	n dives day^{-1} (**1**)	Mean value estimated based on radio telemetry data
Dive length	Mean dive duration [sec] (**2**)	Mean dive length based on radio telemetry data
Descend time	= water depth / 1.15 [sec]	Descend speed according to Heath et al. (2006)
Bottom time	= dive duration – descend time – ascend time [sec]	Total dive duration minus travelling time
Ascend time	= water depth / 1.4 [sec]	Ascend speed according to Heath et al. (2006)
Flight time	9.6 min day^{-1}	Assumption according to Pelletier et al. (2008)
Surface time	= 24 h – (**1**)*(**2**) – Flight time	All non-diving and non-flying behaviour consisting of swimming, comfort/social behaviour and resting (non-active) time

Variable	Value	Variable description
Swimming time	= 0.4*Surface time	Assumed that birds face a mean drift of 0.2 m s^{-1} due to currents and wind. Assumption of a moderate swim speed of 0.5 m s^{-1} (Lovvorn et al. 2009) was used to calculate necessary time spent swimming to hold position during surface time, corresponding to 40 % of surface time
Comfort /social behaviour time	= 0.08*Surface time	According to Systad et al. (2000) and Lovvorn et al. (2009) 8 % of non-diving and non-flying time of eiders
Resting time	= Surface time – Swimming – Comfort/social behaviour time	Remaining surface time after subtraction of swimming and comfort/social behaviour time
Food /energy intake		
Prey	*Mytilus edulis*	Assuming eiders fed exclusively on Blue Mussel which was the most common prey identified
Mussel size	14.0 mm	Mean mussel size found during diet studies in eiders in winter 2009/2010
Mussel wet weight	0.3132 g	Calculated mean wet weight per mussel found during diet studies in eiders in winter 2009/2010; wet weight = AFDW/0.0472 (FEMA data)
Mussel energy content	0.3320 kJ	Calculated mean energy content per mussel found during diet studies in eiders in winter 2009/2010; 1.06 kJ g^{-1} wet weight (FEMA data); 22.46 kJ g^{-1} AFDW (Rumohr et al. 1987)
Intake rate	14.5 g $dive^{-1}$	Assuming a mean intake rate of 14.5 g fresh mussel mass per dive (in accordance with meal size published by Guillemette 1994, and similar to intake rates suggested by Heath and Gilchrist (2010)
Assimilation efficiency	0.73	Kaseloo and Lovvorn (2006)
Energy expenditure		
RMR	RMR = (5.48 - 0.09*T_{water})*2.29 W	Resting metabolic rate (RMR) while the bird is resting on water surface depending on water temperature (T_{water}); RMR = (5.48 - 0.09*T_{water}) [W kg^{-1}] (Jenssen et al. 1989)
Descend (dive)	36.64 W	16 W kg^{-1} (Heath and Gilchrist 2010); mean eider body mass 2,290 g
Bottom (dive)	25.19 W	11 W kg^{-1} (Heath and Gilchrist 2010)
Ascend (dive)	= mean surface costs [W]	During passive ascend assumed that energetic costs are the same as during surface behaviour (Heath and Gilchrist 2010)
DRC	= 0.27*total dive costs	Dive recovery costs (DRC): assumed to be 27 % of total dive costs as measured for White-winged Scoters diving by wing and foot propulsion (Richman and Lovvorn (2008)
Flight	212.97 W	93 W kg^{-1} (Pennycuick (1989) in Lovvorn et al. (2009))
Surface time		Sum of costs of the different behavioural pattern: swimming, comfort/social behaviour and resting

Variable	Value	Variable description
Swimming	= 0.7*12.2 W kg^{-1} -> = 0.7*27.9 W	70 % of costs measured by Hawkins et al. (2000) for eiders swimming with 1.0 m s^{-1} assumed for eiders swimming with 0.5 m s^{-1} (according to Lovvorn et al. (2009))
Comfort/social behavior	= 0.7*12.2 W kg^{-1} -> = 0.7*27.9 W	same energetic costs as for swimming assumed (preening and swimming were measured to lead to similar energy expenditure in seaducks by Kaseloo and Lovvorn (2005, 2006) and Richman and Lovvorn (2008))
Resting	= (5.48 – 0.09*T_{water}) W kg^{-1}	Jenssen et al. (1989)
Heating prey	= 2.43 J g^{-1} °C^{-1}	Costs per gram mussel wet mass per °C temperature difference between water and eider body temperature (40.4°C; Jenssen et al. 1989) (Kaseloo and Lovvorn 2003); assumed to represent all digestion and food processing related costs

2.3.4 *Bird movements*

Satellite telemetry was used to assess (a) local movements of ducks in the Fehmarnbelt, specifically connectivity among discrete wintering sites and wintering site fidelity, and (b) identify bird breeding sites (populations of origin), migration routes and schedules of the annual cycle. Tracking birds over long distances provide information about other potential threats that these populations are facing while outside of the Fehmarnbelt area.

Additionally, GPS telemetry was used to track local movements of Common Eiders.

Satellite telemetry: technology characteristics and transmitter deployment

Satellite telemetry of animals was conducted using the Argos-system, which is a global satellite-based location and data collection system. Platform transmitter terminals (PTTs) send signals at periodic intervals, which are picked up by polar orbiting satellites. The satellites then transfer the messages to ground receiving stations, which automatically pass them to Argos Processing Centres. The Processing Centres calculate the position of the transmitters and process the data measured by the sensors (installed on PTTs). Finally, the Processing Centres automatically deliver the results to the users (CLS 2008). Received positions are classified into one of six quality classes, with accuracy ranging from < 250 m to > 1500 m, and there are also location classes with unavailable accuracy information. Location classes are allocated depending on the number of messages received from the transmitter per satellite pass. Four messages or more allow estimation of location error (classes 0-3), while two or three messages do not allow estimating the error and provide less accurate positions (classes A and B; CLS 2008). In addition to information about the location and time of the transmission, the Argos-system provides auxiliary information originating from additional sensors installed on transmitter terminals.

Argos platforms (PTTs) refer to transmitters that are certified by the Argos system. Transmitters manufactured by Microwave Telemetry, Inc. were used (http://www.microwavetelemetry.com) Along with mplantable PTTs-100, weighing 26 grams or 38 grams (Figure 2.28). The larger units were intended to use for tracking of Common Eiders and the smaller for Long-tailed Ducks, Common Scoters and Tufted Ducks. All transmitters were equipped with a battery voltage meter, activity and temperature sensors, information from which is being sent with each transmission. Battery voltage allows monitoring of the battery power of the transmitter, activity sensor measures relative movement of a study object, and temperature sensor measures ambient temperature (relative to a transmitter) indicating whether the bird is alive. Microwave Telemetry transmitters are also equipped with multi-season timers allowing to set a few transmission regimes in this way extending transmitter operation by saving battery power. The total battery life of a 38 g implantable transmitter is estimated at about 750 hours; a 26 g unit is estimated to last for about 400 active transmission hours. It is possible to extend transmitter life-time up to a year or longer by setting ON and OFF transmission periods and different cycles. Duty cycles set for transmitters in this study have been programmed to transmit for 8 hours and stop for 18-72 hours before transmitting again while birds were expected to be in the Fehmarnbelt during wintering period; and transmit for 8 hours and stop for 144-200 hours before the next transmission during breeding seasons, when birds were expected to be far away from the Fehmarnbelt.

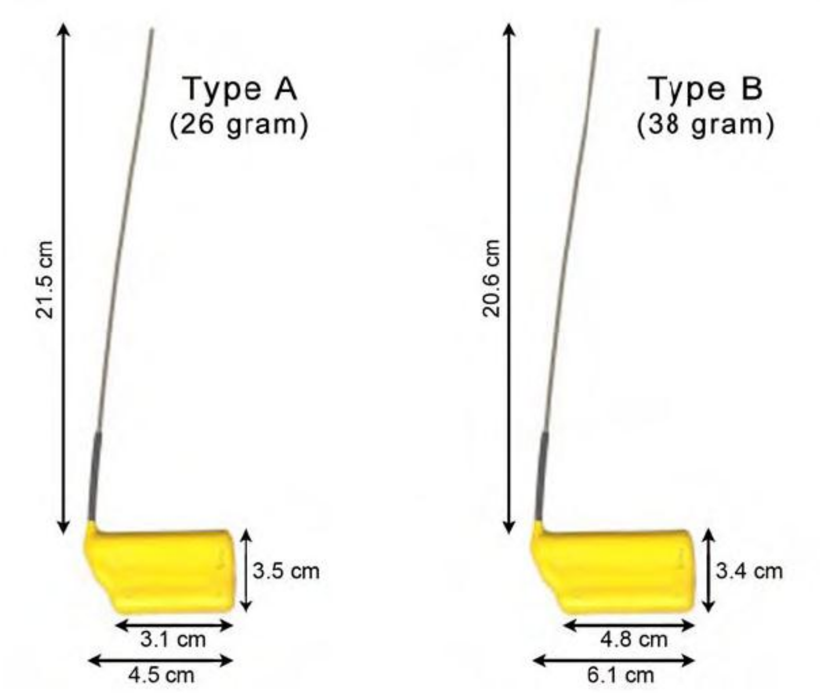


Figure 2.28 Implantable satellite transmitters PTT-100 of two sizes that were used to study waterbird movements in the Fehmarnbelt (picture from Microwave Telemetry, Inc.).

Birds were caught using the night lighting technique as described above in order to equip them with transmitters. Once captured, ducks were placed into dark but well ventilated cages and transported to surgery facilities on land.

Satellite transmitters were implanted in birds by wildlife veterinarians following standard and well-established procedures (Mulcahy and Esler 1999). After the surgery, birds were kept and monitored for 6-24 hours. Once birds were assessed as being in fully alert condition for a few hours, they were released as close to their capture locations as possible. This transmitter implantation method has been shown to perform well for seaducks as compared to other attachment methods (Iverson et al. 2006). Despite the rather intrusive nature, most ducks prove able to withstand the impacts of the implanted transmitters quite well. They conduct long-distance migrations, breed, and their behaviour, activities and survival do not differ from unequipped birds (e.g., Korschgen et al. 1984, Mulcahy and Esler 1999, Esler et al. 2000). Internally implanted transmitters remain in the birds’ bodies for the rest of their life and get encapsulated into connective tissue (Mulcahy et al. 2007).

During two winter seasons 40 ducks were equipped with satellite transmitters (Table 2.14). All birds were captured on key wintering areas in the Fehmarnbelt area: Flüggesand (west of the Fehmarn Island), Sagasbank (SE from the Fehmarn Island) and Fehmarn Sund. Only few ducks experienced early mortality, which could be associated with surgery and transmitter deployment (Table 2.14). Unfortunately, even later in the season Tufted Duck survival was low and by the end of winter 2010, 5 individuals out of 6 tagged birds had died or the transmitters stopped transmitting. The high mortality of this species was likely an effect of severe winter conditions, however a delayed effect of the surgical intrusion cannot be ruled out.

Table 2.17 Birds equipped with satellite transmitters in 2009-2010.

Species	No of ind	Place	Date	Initial mortality*	Comment
Common Eider	10	Flüggesand	March 2009	1	'mortality' signal
Common Eider	10	Flüggesand	Oct 2009	0	
Tufted Duck	1	Rødbyhavn	Oct 2009	1	Shot by a hunter
Long-tailed Duck	2	Sagasbank	Nov 2009	0	
Long-tailed Duck	10	Sagasbank	Jan 2010	1	'mortality' signal
Common Scoter	2	Sagasbank	Jan 2010	0	
Tufted Duck	5	Fehmarnsund	Jan 2010	2	1 'mortality' signal, 1 no signals at all
TOTAL	40		2009-2010	5	

*- initial bird mortality or presumed mortality recorded during the first two weeks after the release.

The weight of the implanted satellite transmitters comprised 1.2-2.3% of Common Eider body mass, 2.3 and 2.5% of Common Scoter body mass, 3.3-3.9% of Long-tailed Duck body mass, and 3.1-3.8% of Tufted Duck body mass. It is generally considered that transmitter weight should not exceed 5 % of bird body mass; however such figure lacks empirical support and remains merely as a recommendation (Caccamise and Hedin 1985).

Performance of satellite transmitters

Although all satellite transmitters have been purchased from the same manufacturer and deployed using the same procedures, the amount of received transmissions varied considerably in terms of number of positions received, location precision and longevity of the transmitter (Table 2.18). Excluding one individual, which experienced initial mortality (occurred during the first 2 weeks), all tagged Common Eiders provided numerous location fixes (Table 2.18). Two Long-tailed Ducks, which were tagged in November 2009, transmitted very few signals, which indicated that birds were alive; however the amount of received Argos messages was insufficient for calculating bird positions. Therefore, these two birds were excluded from all further summaries and analyses. Further, transmissions of Long-tailed Ducks, Common Scoters and Tufted Ducks were variable: some transmitted numerous locations, others relatively few (Table 2.18).

Table 2.18 Average numbers of unique location fixes obtained from birds equipped with satellite transmitters in 2009-2010.

Species	No of ind	Average no of unique locations (range)	No of high quality fixes, classes 1-3 (range)	Duration of transmission, days (range)
Common Eider (March 2009)	9	489 (259-923)	164 (73-380)	256 (80-376)
Common Eider (Oct 2009)	10	546 (164-940)	214 (34-459)	364 (199-432)
Tufted Duck (Oct 2009)	1	21	5	10
Long-tailed Duck (Jan 2010)	9	379 (9-955)	130 (0-437)	214 (88-296)
Common Scoter (Jan 2010)	2	342 (154-529)	99 (17-180)	346 (345-348)
Tufted Duck (Jan 2010)	3	78 (50-120)	20 (15-28)	87 (24-181)

Analysis of satellite telemetry data

Satellite telemetry data files received from the Argos system were first filtered to remove duplicates and merged into a single data frame. Animal satellite telemetry data typically requires filtering to reduce noise produced by location fixes with low or unknown accuracy. A Freitas filter was applied to eliminate unlikely locations on the basis of location quality class, calculated bird moving speed, distance between successive locations, and turning angles (Freitas et al. 2008). Freitas filter outperforms other filters of satellite telemetry data by retaining higher percentages of good-quality positions (Freitas et al. 2008). When applying Freitas algorithm for seaduck telemetry data, bird maximum moving speed was set at 20 m/s and other parameters were kept on default settings. Package 'argosfilter' (Freitas et al. 2008) in R statistical environment (R-Development-Core-Team 2008) was used to apply the filtering algorithm. In practice, applied settings of the Freitas filter eliminated the majority of highly unlikely locations outside of animal presence area and removed 'spikes' along bird tracks (Figure 2.29).

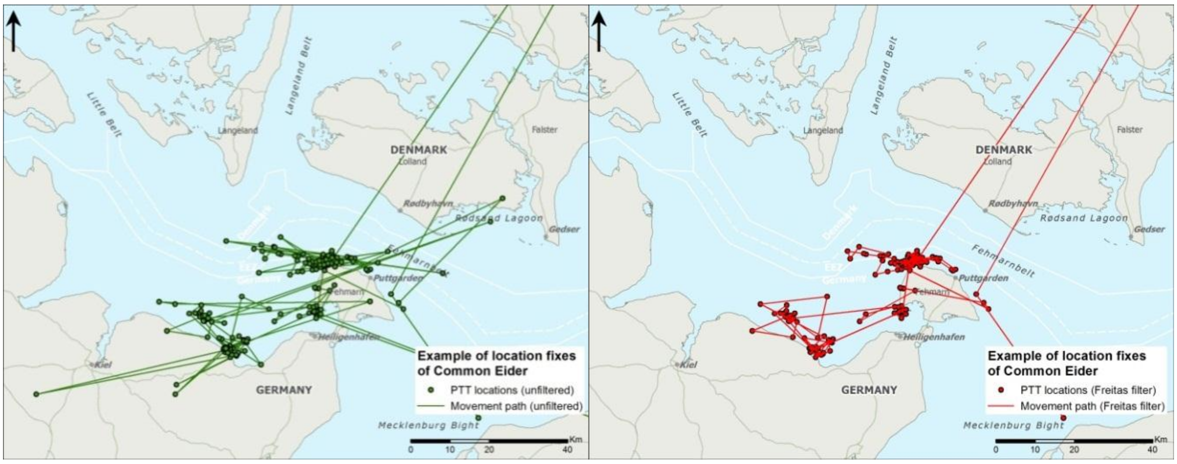


Figure 2.29 Illustration of the performance of Freitas filter, which was used to eliminate unlikely satellite telemetry locations: left map shows unfiltered positions of one bird and right map represents the same dataset after applying Freitas filter.

Local movements of satellite-tagged ducks were assessed by calculating wintering home ranges of studied species, number of discrete wintering sites used by individual birds, and evaluating site fidelity.

95% minimum convex polygons (MCP) were used to identify home ranges of birds in the Fehmarnbelt during the wintering season. All bird positions, which passed Freitas filter, were used for identifying MCPs. However, hundreds of valid telemetry locations remained for every individual, therefore further filtering or sub-sampling was required. The MCP area depends on the number of locations used (Kirk et al. 2008). In order to ensure equal representation of each individual when delineating wintering home ranges, the same number of telemetry fixes from each bird was picked at equal time intervals during the wintering period starting from the beginning of November until the first week of March. The winter period was stratified into weekly intervals and one bird position was randomly drawn from each week. The same procedure of random selection of weekly locations was applied 100 times for each individual and subsequently 100 home range areas were calculated (Figure 2.30). Finally, all home range sizes were averaged to obtain the most plausible figure for each bird. This iterative sub-sampling procedure was applied aiming to reduce bias in otherwise arbitrary selection of several satellite telemetry locations. One hundred sampling iterations were deemed as a sufficient number based on inspection of plots of mean value and variability relative to the number of iterations used: MCP areas and standard deviations stabilised at 50 iterations or less per individual bird (Figure 2.31).

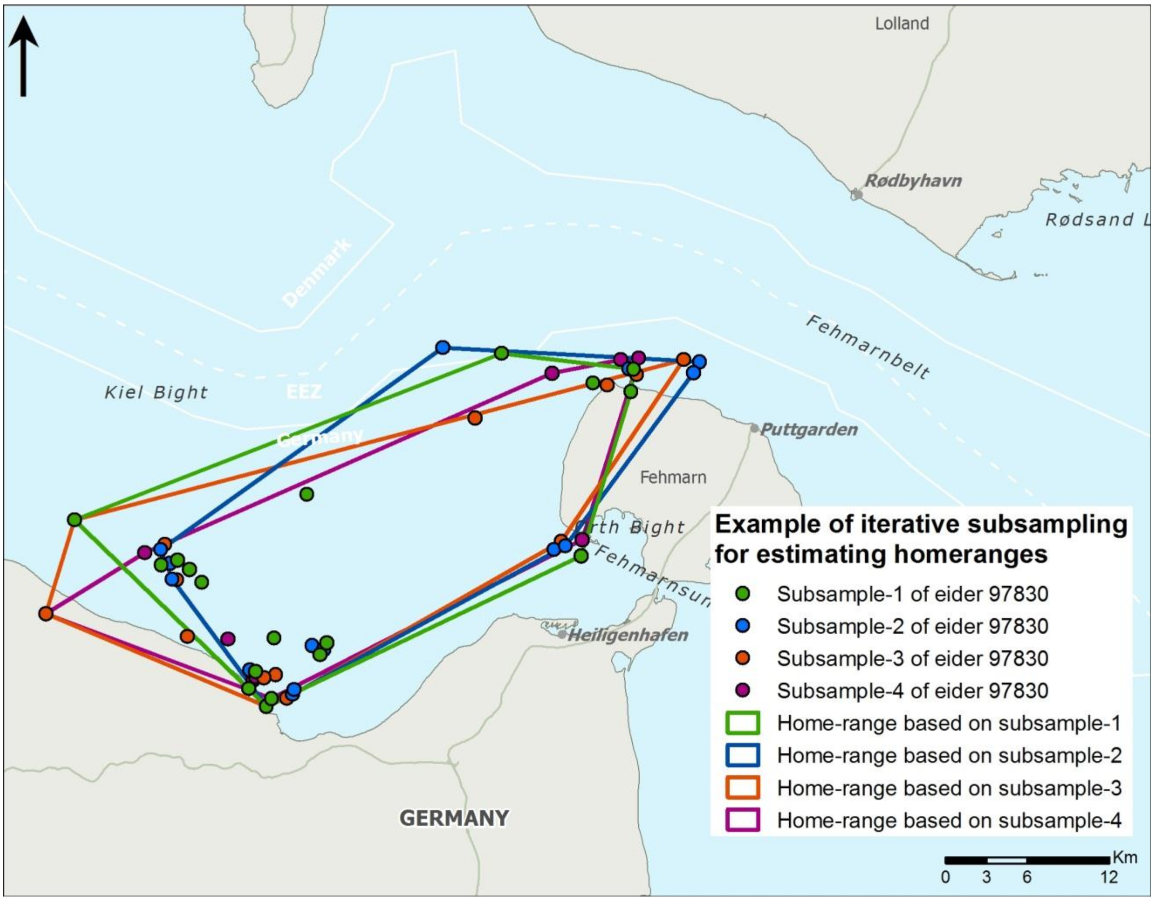


Figure 2.30 An example illustrating generation of home ranges of satellite tagged birds using iterative sub-sampling: results of 4 subsamples are potted on the map, whereas 100 of such iterations were run to obtain average home range of each bird.

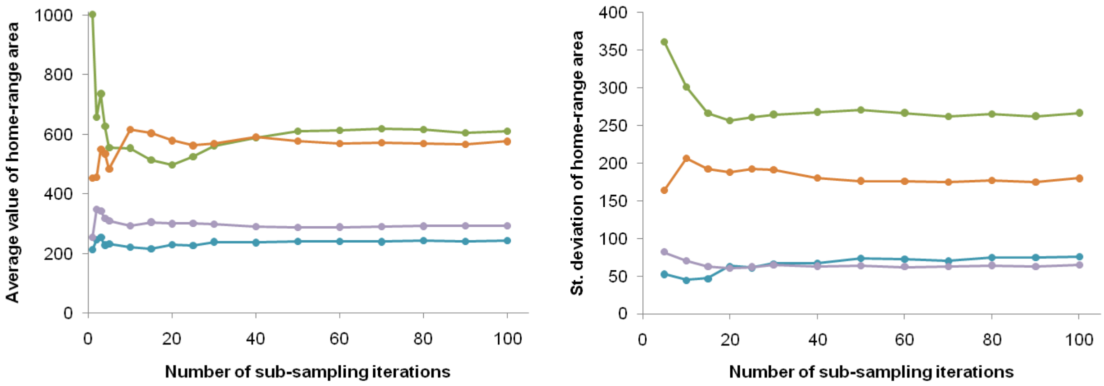


Figure 2.31 An example illustrating influence of different number of sub-sampling iterations of satellite telemetry data of 4 Common Eiders on home range estimates: mean and standard deviation values stabilised at 50 iterations or less.

It was not assume that the 95% minimum convex polygon represented equal usage of the area within it, but rather that it indicated bird movement ranges on wintering quarters.

Bird mobility during the wintering season was evaluated by measuring distances that individual birds moved at equal periods during the wintering season. The winter season was stratified into weekly intervals, the same as for home range estimates described above. Further, an analogous iterative sub-sampling procedure was applied: one bird position from each weekly period was randomly picked using all locations that passed Freitas filter, and distances between these positions were measured. The re-sampling procedure was repeated 100 times for each individual, and weekly relocation distances were finally obtained by averaging all 100 measurements for every weekly relocation of each bird.

In addition to home range analysis, an additional metric was applied to assess site fidelity of wintering Common Eiders – probability of emigration from a wintering site. A modified Kaplan-Meier procedure was used to calculate the probability that individual eiders would remain site faithful during the winter period (Iverson and Esler 2006). Typically the Kaplan-Meier estimator is used to calculate survival probability of an animal from the beginning of the study to a specified time. In a site fidelity analysis, survival function is replaced with a fidelity function using location assignments to infer movement probabilities (Iverson and Esler 2006). The wintering site definition used was also applied as a geographic stratum in site fidelity analysis. By this definition it was considered an emigration event if a bird moved more than 35 km from the previous location to a new wintering site. Emigration events could be detected only at discrete points in time, and we therefore analysed data in 1 week time steps. As a rule only one emigration event per individual was allowed for each winter season.

Home ranges and weekly moving distances of Common Eiders tagged in October 2009 (captured on Oct-23, released on Oct-25 and Oct-26) were analysed starting from the first week of November 2009 until the first week of March 2010. Eiders, which were tagged in March 2009 and continued transmitting in the wintering season 2009/2010 were only considered for assessment of moving distances but not estimates of home ranges, because transmissions from these birds ended before the end of wintering season.

Home ranges and weekly relocation distances of Long-tailed Ducks and Common Scoters have been analysed using the same approach as for Common Eiders.

Definitions

Since bird seasons and movements are not necessary intuitive and match those following human perception, the main terms used to describe the bird telemetry results were defined as follows:

Beginning of wintering period was considered from a start of a series of locations separated by less than 35 km on presumed wintering grounds.

End of wintering period and initiation of spring migration we considered as the first unreversed long distance movement in N-NW direction at a rate of >50 km per day (Oppel et al. 2008).

Wintering site of each bird: we considered an area with more than three consecutive locations <35 km apart from each other during the winter period as a wintering site. This definition was based on the accuracy of satellite transmitters, inspection of winter movements of eiders from satellite and GPS telemetry. In all instances, relocation by greater distance than 35 km indicated bird movement to a new wintering site, separated from the previous one by areas that could not be considered as seaduck habitats (e.g., too deep or separated by land).

GPS telemetry: technology, data logger deployment and tracking

GPS-activity loggers were used to record movements and behaviour of Common Eiders and movements of Mute Swans at fine scale. GPS-activity loggers include 3 electronic units in one device: GPS position logger, activity logger based on acceleration measurements along 3 axes, and radio transmitter for transferring GPS and accelerometer data to a receiving station. The advantages of such data loggers are multiple. GPS logger provides location fixes of an accuracy of a few meters; accelerometer measurements offer opportunities to simultaneously record bird activities, and finally recorded data can be transferred remotely via radio link, therefore eliminating the need to recapture tagged birds in order to recover the data.

Collected GPS fixes and accelerometer records are stored on the internal memory of the device. A radio pinger integrated in the device is continuously sending signals, and if a purpose-built base-station is detected within its range, both devices start automatic communication and data download occurs. Effective distance of data download in the marine environment in winter conditions was up to 2 km only, although producers of these devices achieved downloading distance of 15 km under 'ideal' conditions. The radio signal, however, could be picked up with conventional VHF-receivers at much greater distance of several kilometres. Therefore, we used a conventional VHF-receiver with a directional antenna to find the birds with GPS loggers and approached them to within a distance that was sufficient for downloading the data.

For Common Eider, GPS-activity data loggers were programmed to record a GPS position once every two hours, to measure 3D acceleration for 15 seconds every minute, and to transmit audible radio signals for 3 hours per day.

For Mute Swans, data loggers were programmed to record GPS positions every 20 minutes in summer 2009, and every 15 minutes in summer 2010. No acceleration data were collected for Mute Swans. Audible radio signals were also programmed to transmit 3 hours per day.

Common Eiders were captured at sea using the same technique as described above. GPS-activity loggers weighting 35 grams were deployed on Common Eiders by attaching them externally on back feathers with or without subcutaneous anchor. Loggers were attached mid-dorsally between the scapulae (shoulder feathers). When used, subcutaneous anchors were inserted following Lewis and Flint (2008), and further, a data logger was attached to back feathers using Tesa tape #4651 and cyanoacrylate glue following the deployment procedures described in Wilson et al. (1997). Deployment and carrying GPS-data logers externally is expected to have low burden on eiders, as these devices are shed within several weeks to months after the deployment (Wilson et al. 1997) and comprise just 1.6 % of bird body mass. Two individuals were equipped with such data loggers in March 2009 and 9 in February 2010.

GPS loggers were also deployed on Mute Swans moulting in Rødsand Lagoon during summer months. When moulting during summer, swans shed their wing feathers and thus are flightless for a period of several weeks. Flightless birds were caught by approaching them by boat. Feet and wings of caught swans were restrained by tying with a cord in order to prevent birds struggling or even injuring themselves. Once restrained, swans were measured, ringed and equipped with GPS-loggers. Tags were attached to neck collars using Tesa tape #4651, and were expected to fall off the collars within weeks to months after the deployment. Eight Mute Swans were equipped with such data loggers in July 2009 and 10 in July 2010.

Tracking of GPS-tagged birds in order to download the data required similar procedures as described above for VHF-radio telemetry. In principal, tracking consisted of two stages: finding tagged birds by searching for audible radio signals and then approaching them as close as possible aiming to establish a link between data loggers and base-stations. Because it was often problematic to approach tagged individuals close enough for data downloading, ship and airplane platforms were also used. Additionally, autonomous data downloading stations were set up on the shore and islands in Rødsand Lagoon.

GPS telemetry: transmitter performance

Data downloads were successful from 7 out of 11 deployed data loggers on Common Eiders. The amount of the recovered data varied between birds averaging 13 days (Table 2.19). Recovery of more data was affected by technical data logger characteristics (effective downloading distance was shorter than anticipated; data logger battery life was negatively affected by cold ambient temperatures), and bird inaccessibility if they moved far offshore or outside of the survey area.

The number of GPS fixes per data logger varied despite identical setup (Table 2.19). This was likely determined by bird behaviour or covering of GPS antenna with feathers. The data loggers were programmed to attempt obtaining GPS positions at predetermined intervals, each attempt lasting for 1 minute. If a GPS position was not obtained during that interval, a data logger went dormant until the next recording time.

Table 2.19 Common Eiders equipped with GPS data loggers in 2009-2010 and data logger performance.

Species	Place	Date	Number of tracking days	Number of GPS fixes
Common Eider	Flüggesand	Mar 7, 2009	15	74
Common Eider	NW off Fehmarn	Feb 2, 2010	11	92
Common Eider	NW off Fehmarn	Feb 2, 2010	20	245
Common Eider	Flüggesand	Feb 20, 2010	11	93
Common Eider	Flüggesand	Feb 20, 2010	10	131
Common Eider	NE off Fehmarn	Mar 7, 2010	4	100
Common Eider	NE off Fehmarn	Mar 7, 2010	23	232

Downloading data from Mute Swans appeared to be complicated: moulting Mute Swans were very sensitive to disturbance and kept distance of at least 2-3 kilometres from people walking on the shore or approaching by boats. During the summer of 2009 we succeeded downloading partial tracks of 3 individuals, and 6 tracks have been downloaded in the summer of 2010 (Table 2.20). The manufacturer had improved the GPS data-loggers in 2010 enabling longer downloading distances. This yielded more successful data downloads in 2010.

Table 2.20 Mute Swans equipped with GPS data loggers in summers 2009 and 2010 and data logger performance.

Species	Place	Date	Number of tracking days	Number of GPS fixes
Mute Swan (728)	Rødsand	Aug 8, 2009	6	60
Mute Swan (730)	Rødsand	Aug 8, 2009	8	202
Mute Swan (1098)	Rødsand	Aug 8, 2009	3	80
Mute Swan (1354)	Rødsand	July 22, 2010	16	1,117
Mute Swan (1355)	Rødsand	July 22, 2010	32	2,148
Mute Swan (1360)	Rødsand	July 22, 2010	17	1,268
Mute Swan (1361)	Rødsand	July 22, 2010	17	1,439
Mute Swan (1362)	Rødsand	July 22, 2010	17	1,205
Mute Swan (1363)	Rødsand	July 22, 2010	34	2,477

2.3.5 *Assessment of habitat carrying capacity*

Moulting Mute Swans in Rødsand Lagoon

Habitat carrying capacity of Mute Swan was assessed by evaluating habitat choice and assessing food resource availability depending on changing environmental conditions. Food requirements by moulting Mute Swans were estimated by calculating the number of bird-days in the study area for each study season and multiplying it with daily food intake.

Information about available food resources (*Zostera* biomass for summer 2009) was obtained from Fehmarnbelt Fixed Link baseline investigations on marine biology. Biomass available to swans was estimated for different water level situations, as depth is a limiting factor determining submerged vegetation availability for Mute Swans (Clausen et al. 1995, 1996). Biomass availability to birds was contrasted against their total seasonal food demands.

Individual-based modelling of Common Eiders wintering in the Fehmarnbelt

In this chapter, an approach to assess the relationships between Common Eiders wintering in the Fehmarnbelt and their food resources is described. The aim of this part of the study is to form a base to investigate possible indirect impacts of changing food resources caused by construction or operation of a fixed link across the Fehmarnbelt.

An individual-based model (IBM) developed for Common Eider is presented following a standard protocol for describing individual-based and agent-based models as recommended by Grimm et al. (2006). Specific terms and expressions are defined in the model description when the terminology of different IBM protocol parts is not self-explanatory.

In addition to the description of the IBM design following the protocol by Grimm et al. (2006), sensitivity testing of the calibrated model has been implemented, which is described and presented in the Appendix VI.

Purpose

The overall purpose of the individual-based model is to predict how environmental change related to the construction of a fixed link across the Fehmarnbelt might affect the survival and body condition of wintering Common Eiders.

The specific objectives of applying the IBM were to:

- assess Common Eider habitat carrying capacity in the Fehmarnbelt; and
- predict effects of different impact scenarios, e.g. decreased habitat availability or reduced bivalve biomass, on fitness of wintering Common Eiders (survival, body condition).

The first of these specific objectives is implemented in this report of FEBI Baseline Investigations, whereas prediction of effects of different impact scenarios will take place in the Environmental Impact Assessment, which will follow the Baseline.

The IBM relates individual behaviours such as feeding activity, rate of food intake or inter-specific competition to environmental factors and food availability and provides detailed insight into aspects which constrain species fitness and numbers of birds using certain resources. The model itself was made as simple as possible and contains only the most general aspects of foraging ecology of Common Eiders, which have been measured in the Fehmarnbelt or extracted from literature.

State variables and scales

The Fehmarnbelt eider model runs at discrete time steps of a fixed duration (1 hour). Space is represented by discrete patches with fixed location. In our model patches are defined as a grid with cells of 2 x 2 km. The model was constructed using package MORPH as a platform (Stillman 2008) and has the following predefined 5 entities.

- *Global environment* - State variables which apply throughout the modelled system.
- *Patches* – Locations, which are characterised by local patch variables and containing resources and foragers.

- *Resources* - The food consumed by foragers. Collections of several resources are termed diets.

- *Components* - Elements within resources which foragers assimilate into their bodies.

- *Foragers* - Animals which move within the system attempting to maximise their survival and body condition.

The global state variables are the major driving forces in the model system (e.g., time step, day length, temperature, etc.). Patches are smaller entities, they depend on global variables, and are characterised by patch variables (e.g., patch coordinates, area, depth, etc.). Patches contain resources (e.g., bivalves), which consist of one or more types of components (e.g., bivalve meat contents, amount of shell). Foragers, which in our case are birds, consume resources in combinations called diets. From diets foragers assimilate components and metabolise them. Foragers can make choices and, attempting to maximise their fitness, move between patches, consume diets or emigrate from the model system. Consequences of forager decisions are expressed as fitness (e.g., probability of survival, body condition). State variables are summarised in Table 2.21.

Table 2.21 State variables used to describe the individual based model when using MORPH package (the table adapted from Appendix of Grimm et al. 2006).

Entity	**State variable**	**State variable description**
Global		
	• Global variables	Environmental variables which apply throughout the modelled system
Patches		
	• Location	Central coordinates
	• Size	Patch surface area
	• Patch variables	Zero or more patch-specific environmental variables
Resources		
	• Density on patch	Density of each resource on each patch
Components		
	• Density in resource	Density of each component within each resource on each patch
Foragers		
	• Morph / species	Species that is being modelled
	• Forager constants	Zero or more forager-specific constants which remain constant throughout a simulation
	• Forager variables	Zero or more forager-specific variables which can change throughout a simulation
	• Location	Coordinates of foragers location
	• Patch	Patch number being occupied by forager during current time step
	• Diet	Diet number being consumed by forager during current time step (zero if no diet is being consumed)
	• Proportion of time moving	Proportion of time moving during current time step and averaged over previous time steps

Entity	State variable	State variable description
	• Proportion of time feeding	Proportion of time feeding during current time step and averaged over previous time steps
	• Diet consumption rate	Rate at which diet is being consumed during current time step and averaged over previous time steps
	• Component consumption rate	Rate at which a component is being consumed during current time step and averaged over previous time steps
	• Component assimilation rate	Rate at which a component is assimilated into the body during current time step and averaged over previous time steps
	• Component metabolic rate	Rate at which a component is metabolised / excreted from the body during current time step and averaged over previous time steps
	• Component reserve size	Amount of a component within the body's reserves during current time step and averaged over previous time steps
	• Perceived survival probability	Perceived survival probability associated with current state, location and diet during current time step and averaged over previous time steps

Process overview and scheduling

Process overview and scheduling define environmental and individual processes that are built into the model.

The IBM constructed in MORPH defines the following processes (Grimm et al. 2006, Stillman 2008).

- *Change in resource density*. Changes in the density of a resource on a patch caused by consumption by the foragers and / or other factors.
- *Change in component density*. Changes in the density of a component in a resource.
- *Forager immigration*. The movement of foragers into the system.
- *Forager decision making*. The optimal patch and diet selection of foragers and decisions to emigrate from the system.
- *Forager emigration*. The movement of foragers from the model system.
- *Forager movement between patches*. Movement of foragers between patches. Movement may have associated costs and may take more than one time step.
- *Forager diet consumption*. The transfer of resource components into foragers when diets are consumed.
- *Forager physiology*. Change in the size of a forager's component reserve due to the balance of consumption and metabolism.
- *Forager mortality*. Death of foragers.

In the IBM design time is represented using discrete time steps of constant duration. During each time step global events are processed first, followed by patch events and then forager events (Figure 2.32). Finally, results are displayed and saved.

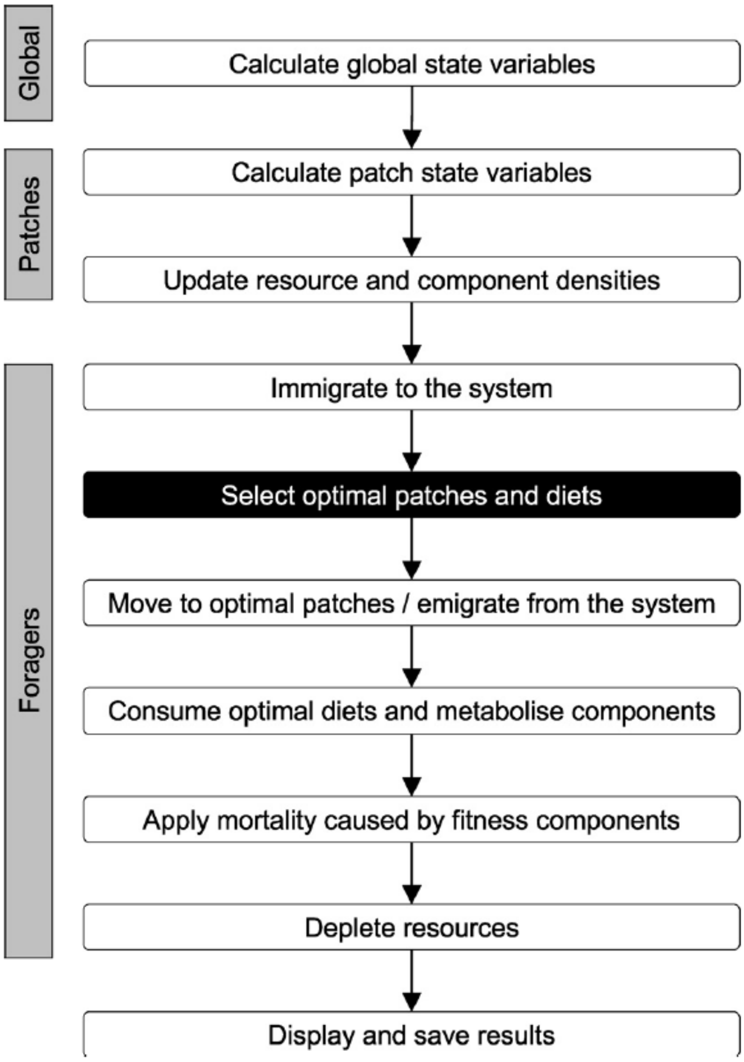


Figure 2.32 The sequence of events during each time step when processing individual-based model. This conceptual figure describing MORPH design adapted from Stillman (2008).

Design concepts
The design concepts provide a common framework for designing and communicating IBMs.

Emergence

Emergence defines which system-level phenomena emerge from individual traits, and which phenomena are imposed.

In MORPH models the following phenomena emerge from the interaction between individual forager traits and global and patch variables, resource and component densities, and forager constants and variables.

- *Resource depletion*. The amount of each resource consumed by foragers from each patch during each time step.

- *Forager distribution and diet selection*. The location of each forager and its diet during each time step.

- *Proportion of time foragers spend feeding*. Proportion of each time step each forager spends feeding.

- *Forager component reserve size*. The amount of each component within each forager's reserves during each time step.

- *Forager mortality and emigration*. The number of foragers remaining in the system after a given number of time steps.

Adaptation

Adaptation described whether the model individuals have adaptive traits which directly or indirectly can improve their potential fitness, in response to changes in themselves or their environment.

In MORPH, foragers' adaptive traits are their location and diet selection. During each time step, foragers select the patch / diet combination which maximises their perceived fitness.

Fitness

This concept defines whether fitness-seeking is modelled explicitly or implicitly. If explicitly, what is the fitness measure of modelled individuals?

In MORPH model design fitness is assumed to equal the probability of surviving to the end of a time step. Survival probability is influenced by a number of mortality sources (causes of death). The forager selects the patch and diet combination (including no diet) which maximises its perceived survival. Once the forager has selected a patch and diet, the consequences of this decision are determined by true probability of survival.

Prediction

Prediction defines how individuals predict the future conditions they will experience and whether this influences their decisions.

In MORPH models foragers remember their foraging success during a given (defined) number of previous time steps. This memory is used to calculate average state variables over previous time steps (see Table 2.21 for a list of these variables). The model does not allow foragers to know the future values of any state variables, instead these must be predicted.

Sensing

Sensing describes the internal and environmental state variables, which model individuals are assumed to "know" and consider in their adaptive decisions.

The amount of knowledge foragers have can be varied in MORPH models. This can range from perfect knowledge of the complete system during the current time step, through complete knowledge of local patches, to no knowledge at all. Similarly, the amount of knowledge a forager has of its own state, both during the current time step and previous time steps, can be varied. Foragers base their decisions on the perceived survival probability associated with different patches and diets (or no diet). The perceived survival probability may or may not be equal to the true probability. Foragers will tend to avoid patches and diets with low perceived survival probabilities. The model does not explicitly represent any sensing mechanisms.

Interaction

This concept identifies interactions among individuals in the model system.

In MORPH model design foragers interact within patches through the consumption of a shared resource (depletion competition). The number of other foragers within a patch can also affect any of a forager's state variables, and hence perceived and true survival probabilities. These effects can be either positive or negative, depending on the submodels used. Foragers can only interact within patches.

Stochasticity

Stochasticity can be part of the model constructed in MORPH and the amount of stochasticity can be varied. Any of state variables, except for patch size and location, and forager species can be stochastic. The probability of a forager dying during a time step is a stochastic event unless the probability is zero or one.

Collectives

Collectives describe whether individuals are grouped into some kind of collective, e.g. a social group.

Collectives are included as part of the model design in MORPH. These are represented by the number and / or density of foragers on each patch, and arise from the patch and diet selection of foragers. Collectives are not represented as social groups, instead each individual behaves independently albeit with its behaviour influenced the number and / or density of competitors on different patches. Super-individuals can also be incorporated, with each forager (super-individual) representing more than one individual. The number of individuals within a forager is set at the start of a simulation, but can decrease through time as some individuals within the forager die. In contrast, all individuals within a forager simultaneous immigrate to or emigrate from the system.

Observation

Observation describes how data are collected from the IBM for testing, understanding, and analysing it.

In MORPH design, the results used to test the model depend on the particular system for which it is parameterised. All state variables can be displayed and saved during each time step. Omniscient results are calculated.

Initialisation

Initialisation deals with questions as: How are the environment and the individuals created at the start of a simulation run? Is initialisation always the same, or was it varied among simulations? Were the initial values chosen arbitrarily or based on data?

In IBMs created using MORPH platform, the initial values of state variables are either read from a parameter file, created using random numbers, or calculated from state variables defined earlier in the parameter file. The sequence of random numbers is itself randomised at the start of each simulation so that replicate simulations using the same set of parameters will produce slightly different predictions. All global and patch variables are initialised at the start of the simulation. Forager state variables are initialised once the forager has immigrated into the system.

Input

The particular data used to parameterise the model depend on the particular system to which it is applied. Table 2.22 lists parameters, which were used to parameterise the Fehmarnbelt Common Eider IBM. Parameters are either single values, values for each time step read in from a file, or an equation (sub-model) to calculate values during each time step. More detailed description of parameter values and sub-models follow in the subsequent chapter.

Table 2.22 Description and values of the baseline individual-based model parameter file developed for Common Eider in the Fehmarnbelt.

Entity/ State variable	Value	Variable description
Global environment		
Day	Day 1 = October 1, Day 182 = March 31	Represents duration of bird wintering season
Time	01 – 24 hours per day	Simulation is conducted at 1 h time steps
Day length	Daily day length	Downloaded from US Navy website
Daylight	0 or 1 depending upon above	Based on sunset and sunrise times
Water temperature	Mean daily water surface temperature	FEHY hydrodynamic model (Run No. 9.15 and 11.20)
Patches		
Number	964	The number of grid cells (2x2 km). Each grid cell represents a discrete patch.
Location	Central coordinates of each patch	Measured in UTM32N
Size	4,000,000 m^2 or less if patch includes land	Size of each patch measured in GIS. If a grid cell (patch) includes both marine and land areas, then land area was excluded.
Patch variable1: Water depth	Mean water depth of a patch	Calculated in GIS using DHI bathymetry raster of 50 m resolution
PV2: Land	Distance to land	Calculated mean value for each patch using 'path distance' to land (50 m resolution)
PV3: Shipping	Shipping intensity	Calculated mean number of ships passing through each cell (patch) per month. AIS data used to describe shipping (Ramboll 2011).
PV4: Wind farm	Distance to wind farms	Calculated mean distance for each patch using custom made raster of distance to Nysted and Rødsand II wind farms.
PV5: Included	0 or 1	Used to include/exclude patches from different model runs.
Resources		
Number	1 – number of resources	A simplified model constructed using a single resource – Blue Mussels
Name	Resource name: MusselsAll	Principal prey type
Initial density	Initial density of mussels on each patch, numbers/m^2	Resources density obtained using mussel biomass modelled for the Fehmarnbelt using data collected from sampling stations during the baseline investigations (FEMA 2013a) and accepting a simplified assumption that mussels of all sizes are available to birds and converting total biomass into a number of 14 mm long mussels
Change in density	Change in resource density in time considering all other factors except bird consumption: MusselsAllDens*POWER(0.9982,(1/24))	Proportional daily decline in numerical abundance of mussels due to natural mortality and predations by other predators (crabs, sea stars)
Components		

Entity/ State variable	Value	Variable description
Number	1	Number of resource components
Name	Flesh dry mass	0.01478 g AFDW
Component density	Grams of flesh dry mass per prey item Grams of shell dry mass per prey item	Values calculated using allometric equations for 14 mm size Blue Mussels in the Fehmarnbelt
Foragers		
Number of forager types	Number of forager types: 1	Common Eider
Number of foragers	250 300 350 400 450 500	This is a number of super-individuals, where each consists of 1,000 individuals resulting in a population of 250,000 (or more) Common Eiders. Super-individuals are used to reduce noise between replicates and ensure faster model processing
Individuals per forager	1,000	Number of individuals per forager (super-individual)
Forager constants	C1: Foraging efficiency normal(1,0.125,0,1000)	A value drawn at random from a normal distribution with mean of 1, standard deviation of 0.125, and max of 1000.
	C2: Dominance uniform(0,1)	A value drawn at random from a uniform distribution with a min of 0 and max of 1
	C3: Arrival day int(uniform(1,30))	A value drawn at random from a uniform distribution starting from day 1 until day 30 (throughout October)
	C4: Departure day int(uniform(153,182))	A value drawn at random from a uniform distribution starting from day 153 until day 182 (throughout March)
	C5: Maximum common eider density: 0.005	A rule was set that maximum Common Eider density shall not exceed 5,000 birds/km^2
Forager variables	Underwater time per dive (hours): (-0.1406*WaterDepth^2 + 6.1077*WaterDepth + 4.4332)/3600	Basic relationship between water depth and diving activity: empirically developed sub-model. See chapter 2.3.3 for details.
	Travel time per dive (hours): ((WaterDepth/1.15)+(WaterDepth/1.4))/3600	Travel time calculated according to: speed of descent 1.15 m/s, speed of ascent 1.4 m/s , (Heath et al. 2006, 2007)
	Surface time per dive (hours): (0.0082*WaterDepth^3 - 0.4874*WaterDepth^2 + 9.6211*WaterDepth + 36.604)/3600	Basic relationship between water depth and diving activity: empirically developed sub-model.
	Forage (bottom) time per dive (hours): if((UWTPDive-TravTPDive)>0, UWTPDive-TravTPDive,0)	Value derived by subtraction of time spent travelling to and from bottom from total time spent underwater
	Disturbance by wind farms: if(WindFarm>1000,1,0)	A simplistic assumption was made that all eiders are excluded from within wind farms and 1 km around them.
	Disturbance from shipping: if(Shipping>1000,0,if(Shipping>500,0.5,1))	It was assumed was that all eiders are excluded from pathes where shipping intensity exceeds 1,000 ships per month, and their foraging efficiency is halved when shipping intensity ranges between 500 and 1,000 ships per month (also see below)
Diet consumption rate	Bivalves eaten per second of the bottom time, as a function of numerical abundance of prey (mussels/m^2): if((CountEider / PatchSize<=MaxEiderDens),Daylight*Eff*3600*(ForTPDive/(UWTPDive+SurfTPDive))*((0.7	Functional response of seaduck intake rate of benthic bivalves, modified equation provided by Richman and Lovvorn (2003). See chapter 2.3.3 for details.

Entity/ State variable	Value	Variable description
	483*MusselDietDensity/(591+MusselDietDensity))*3*DisturbWindF*DisturbShip),0)	
Maximum diet consumption rate	Maximum number of bivalves that can be eaten per second of the bottom time: (ForTPDive/(UWTPDive+SurfTPDive))*2*3600	Set rule that eider cannot eat more than 2 mussels per second of bottom time.
Component assimilation rate	Flesh dry mass: 0.73*(22.46/33.4)	Derived from literature: energy assimilation rate from flesh was assumed to be 0.73 (Hockey 1984); 1 g of mussel ash free dry weight contains 22.46 kJ (Rumohr et al. 1987); energy density of body reserves 33.4 kJ/g (Kersten & Piersma 1987)
Component metabolic rate while feeding	((((16*2.29*(TravTPDive/2)+11*2.29*ForTPDive+15.4*(TravTPDive/2))+(16*2.29*(TravTPDive/2)+11*2.29*ForTPDive+15.4*(TravTPDive/2))*0.27)+((((16*2.29*(TravTPDive/2)+11*2.29*ForTPDive+15.4*(TravTPDive/2))+(16*2.29*(TravTPDive/2)+11*2.29*ForTPDive+15.4*(TravTPDive/2))*0.27))*0.97)+((((5.48-0.09*WaterTemp)*2.29*0.52)+((0.7*12.2*2.29)*0.48))*SurfTPDive)+((93*2.29)*(9.6*60/24/3600)))*3600/1000)/33.4/0.6	Sub-model compiled using literature data about energetic cost of different eider activities while foraging. See chapter 2.3.3 for details.
Component metabolic rate while resting	((((5.48-0.09*WaterTemp)*2.29*0.52)+((0.7*12.2*2.29)*0.48)+((93*2.29)*(9.6*60/24/3600)))*3600/1000)/33.4/0.6	Sub-model compiled using literature data about energetic cost of different eider activities while resting. See chapter 2.3.3 for details.
Component metabolic rate while moving	((93*2.29)*3600/1000/33.4/0.6)*(9.6*60/24/3600)	Equally distributed flights cost per day, assuming that eider flies 9.6 minutes per day (Pelletier et al. 2008), and flight costs 93 W/kg (Lovvorn et al. 2009)
Initial size of reserve store	1476+659	1,476 g is the average published starvation mass for Common Eider (Camphuysen et al. 2002); 659 g is the mass of body reserves measured to be carried by an average Common Eider in the Fehmarnbelt (mean of 19 birds weighted in October 2009)
Target size of reserve store	1476+(659+1.57*Day)	Mean weight of Common Eiders in the Fehmarnbelt in March was measured as 2,371 g; to reach that body weight birds need to gain 1.57 g per day during wintering season.
Fitness components	Starvation	
Survival probability	if(FleshDryMassFinalStore>1476,1,0)	Bird dies if body weight falls below the starvation weight
Emigration probability	if(Day=DepartureDay,1,0)	Birds are not allowed to leave the model system, until the departure day as identified above

Sub-models and values

State variable values and sub-models are read directly from the parameter file while running the Fehmarnbelt IBM. State variable values and sub-models listed in theTable 2.22 Table 2.22 are further explained in the section below.

Global environment: Day

Characterisation of the model system starts by identifying overall duration of the simulation, which starts on October 1 and runs for 182 until March 31. Based on empirical observations, this period represents the core wintering season of Common Eiders in the Fehmarnbelt.

Global environment: Time

Simulation is conducted in 1 hour time steps, values ranging from 1-24 each day, representing the finest temporal unit in the model system.

Global environment: Day length

Daily day length is read from an external file. Day length was downloaded from the US Naval Observatory website (http://www.usno.navy.mil/USNO/astronomical-applications/data-services) for the Fehmarnbelt (11°10′ E, 54°35′ N; Figure 2.33).

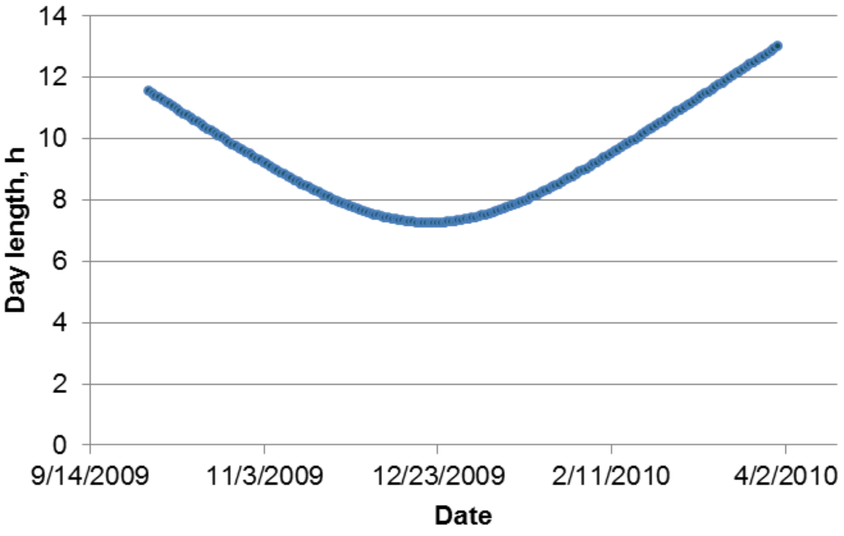


Figure 2.33 Day length in the Fehmarnbelt area, as used in the IBM.

Global environment: Daylight

Based on daily length, daylight was calculated for each time step using the following equation:

if((Time>=(12-(DayLength/2))) and (Time<=(12+(DayLength/2))),1,0)

Global environment: Water temperature

Water temperature is read from an external file. Mean daily water surface temperature extracted from FEHY hydrodynamic model (Run No. 9.15 and 11.20; Figure 2.34).

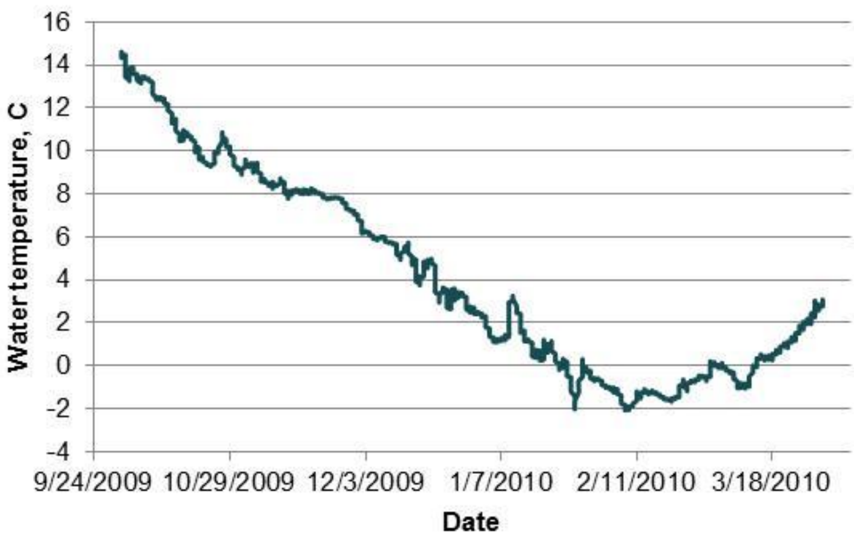


Figure 2.34 Water temperature in the Fehmarnbelt, which was used in the simulation of Common Eider IBM.

Patches

A grid of 2 x 2 km cells, covering an area which approaches that of aerial surveys and includes key habitats of wintering Common Eider, has been generated (Figure 2.35). The grid was clipped with land polygon retaining only aquatic part. The model grid consisted of 964 cells covering the total area of 3,645 km^2.

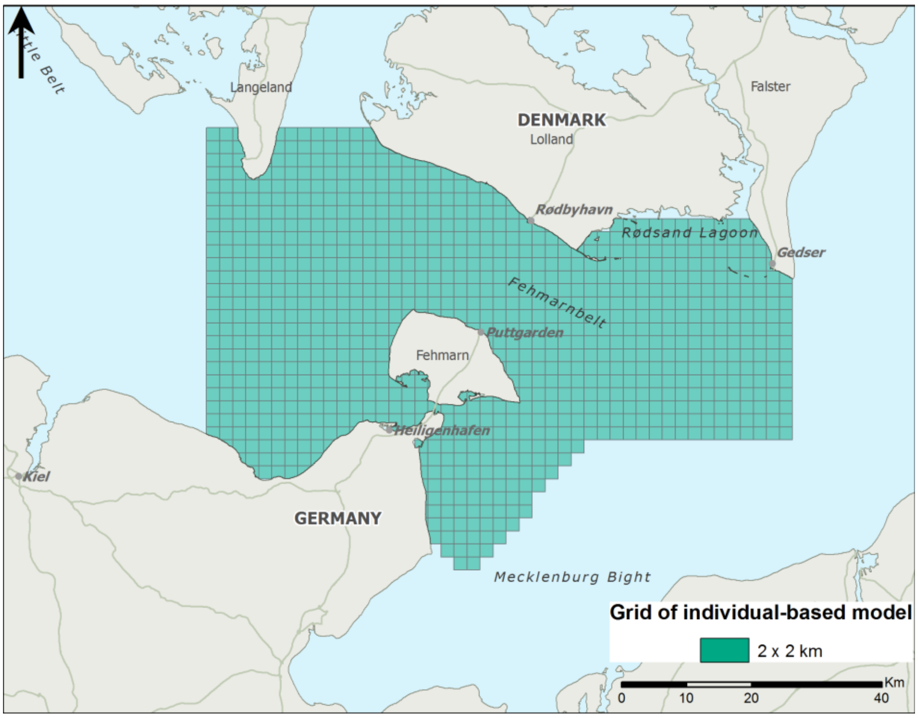


Figure 2.35 Map representing the area covered by the individual-based model for Common Eider in the Fehmarnbelt.

Patch variable 1: Water depth

Mean water depth was calculated for each grid cell using DHI bathymetry raster of 50 m resolution.

Patch variable 2: Distance to land

Mean distance to land was calculated mean for each grid cell (patch) using path distance to land (the same GIS layer as described in chapter 2.2.5).

Patch variable 3: Shipping

Calculated mean number of ships passing through each cell (patch) per month. AIS data used to describe shipping (Ramboll 2011; the same GIS layer as described in chapter 2.2.5).

Patch variable 4: Wind farm

Calculated mean distance for each grid cell (patch) using custom made raster of distance to Nysted and Rødsand II wind farms (the same GIS layer as described in chapter 2.2.5).

Patch variable 5: Included

Patch variable designed for including (value = 1) or excluding (value = 0) patches from different model runs. All patches were 'included' in the baseline IBM.

Resources: Number

Fehmarnbelt Common Eider IBM is a simplified model constructed using a single, but the most important food resource for these birds – Blue Mussels (see chapter 5.1.1 on eider diet composition).

Resources: Initial density

Initial density of mussels on each patch was set as a number of Blue Musells per square meter. Mussel density was calculated from the mussel biomass model developed for the Fehmarnbelt based on empirical data collected in sampling stations during the Fehmarnbelt marine biology baseline investigations (Figure 2.36, FEMA 2013a). A simplified assumption was accepted assuming that mussels of all sizes are available to Common Eiders in the Fehmarnbelt. This assumption was based on the notion that mussels of all sizes as found in the Fehmarnbelt (FEMA 2013a) could potentially be consumed by Common Eiders. Literature suggests that Common Eiders can feed on mussels up to 66 mm long (Nehls 1995, Scheiffarth and Frank 2006). We further simplified resource availability by converting the total mussel biomass into a number of 14 mm long mussels, which were identified as the most common size of these bivalves ingested by Common Eiders in the Fehmarnbelt (see chapter 5.1.1 for diet composition). When converting, we considered that one 14 mm mussel contains 0.01478 g of ash free dry weight (AFDW; see chapter 2.3.1 for empirically developed allometric equations).

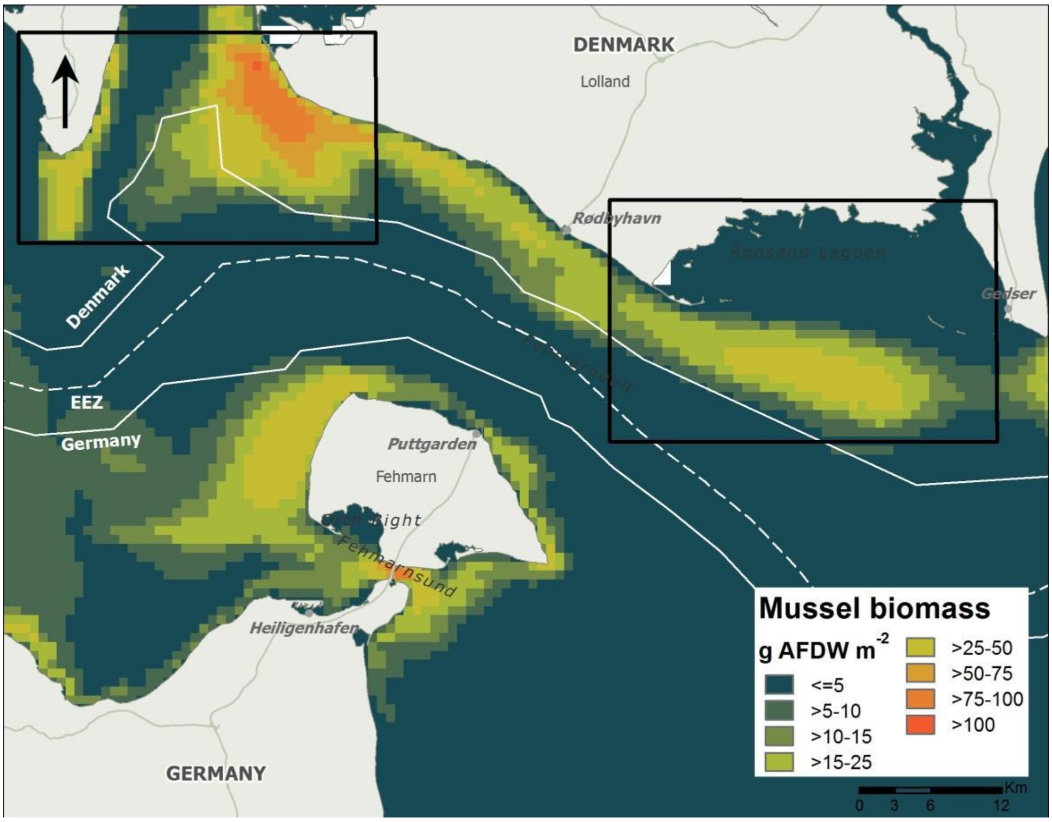


Figure 2.36 Map representing biomass of Blue Mussels, which was used as input to the individual-based model for Common Eider in the Fehmarnbelt (map adapted from the baseline report by FEMA (2013a)).

Resources: Change in density

Because, in addition to bird predation, mussels also suffer natural mortality and are consumed by other predators (crabs, sea stars), we assumed that mussel resources decline at a constant daily rate of 0.18% (Figure 2.37), which was calculated at each time step using the following equation:

MusselsDensity*POWER(0.9982,(1/24))

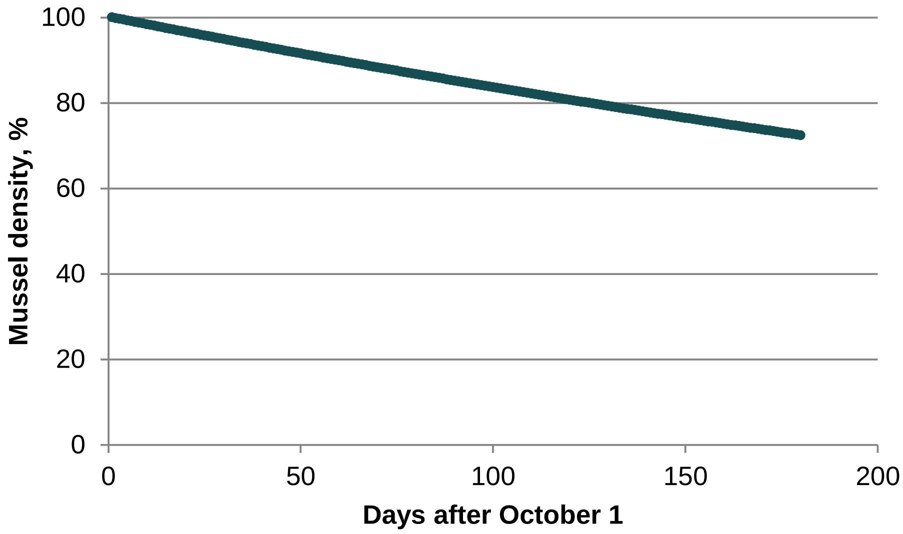


Figure 2.37 Assumed rate of decline of Blue Mussel density due to other causes than bird predation.

Components

Only one type of resource components was considered in the model: ash free dry mass of flesh. As all resources were assumed to be of constant size (14 mm mussels), the amount of components was constant: 0.01478 g of flesh AFDW (see chapter 2.3.1 for empirically developed allometric equations).

Foragers: Number of forager types

One forager type was considered in this IBM - the Common Eider, which is the most numerous benthivorous seaduck species in the Fehmarnbelt.

Foragers: Number of foragers

Number of foragers was set to 250 representing a number of super-individuals, where each consists of 1,000 individuals resulting in a population of 250,000 (or more, see below) Common Eiders. Super-individuals are used to reduce noise between replicates and ensure faster model processing.

Further, aiming to evaluate habitat carrying capacity IBM simulations were run when the number of superindividuals was increased by increments of 50 until it reached 500. Such an approach allows assessing whether the model system can support higher number of wintering Common Eiders compared to actual estimated abundance.

Foragers: Individuals per forager

This parameter defines number of individuals per forager (super-individual as defined above), which was set to 1,000 resulting in a total population of 250,000 Common Eiders wintering in the Fehmarnbelt (see chapter 4.1.22).

Further, aiming to evaluate habitat carrying capacity IBM simulations were run when the number of superindividuals was increasd (see above), however number of individuals per forager was kept constant at 1,000.

Forager constants: Foraging efficiency

Not all individuals are equally efficient in foraging. There are no studies, to our knowledge, reporting seaduck individual variability in foraging efficiency. We therefore accepted an assumption, also used by Kaiser et al. (2005), that individual variation observed in Oystercatchers *Haematopus ostralegus* (Stillman et al. 2000) is comparable to that in seaducks. In the Oystercatcher case, the standard deviation in feeding efficiency around the population mean value was around 12.5%. Thus, the foraging efficiency of Common Eider in the Fehmarnbelt IBM was obtained by drawing a value at random from a normal distribution with mean of 1, standard deviation of 0.125, and maximum value of 1,000:

normal(1,0.125,0,1000)

Forager constants: Dominance

There is likely an effect of interference within groups of wintering Common Eiders, which is a form of intraspecific competition when more dominant individuals exclude others from accessing the resources and cause intraspecific segregation. Such phenomenon is best noticeable in Common Eiders as age-segregation – immature individuals can be forced out from optimal habitats (Nehls and Ketzenberg 2002).

However, as there are no studies allowing to assess interference in Common Eiders in a measurable way, we chose to set individual dominance and maximum individual density per area unit (see below), as mechanisms accounting for individual variability. Dominance value was drawn at random from a uniform distribution with a minimum value of 0 and maximum value of 1: uniform(0,1). This value was used to determine the order in which individuals were processed in each time step.

Forager constants: Arrival Day

All model individuals were allowed to 'immigrate' into the model system during the first 30 days of simulation (throughout October). This coincides with the main period of wintering Common Eider arrival to the Fehmarnbelt (see chapter 4.1.22). To determine a day of immigration for each forager a value was drawn at random from a uniform distribution: int(uniform(1,30)).

Forager constants: Departure Day

All model individuals were allowed to 'emigrate' from the model system during the last 30 days of simulation (throughout March). This represents the period departure of wintering Common Eider from the Fehmarnbelt (see chapter 4.1.22). To determine a day of immigration for each forager a value was drawn at random from a uniform distribution: int(uniform(153,182)).

Forager constants: Maximum density

Maximum density is another tool in the IBM to deal with effects of interference between individuals. Maximum density sets a ceiling of how many birds can use a particular patch at the same time. Based on FEBI aerial and ship-based surveys, it was assumed that 5,000 birds/km^2 could be a reasonable maximum density of Common Eiders.

Forager variables: Underwater time per dive

As air breathing animals, seaducks are limited in their ability to hold breath while diving. While there could be a lot of different factors determining dive duration, in the IBM model we considered only the basic relationship between water depth and diving length. Sub-model was developed to describe this interaction using empirical observations of radio-tagged Common Eiders in the Fehmarnbelt (Figure 2.38; see chapter 5.2.1 for details):

Underwater time per dive = -0.1406*WaterDepth^2 + 6.1077*WaterDepth + 4.4332

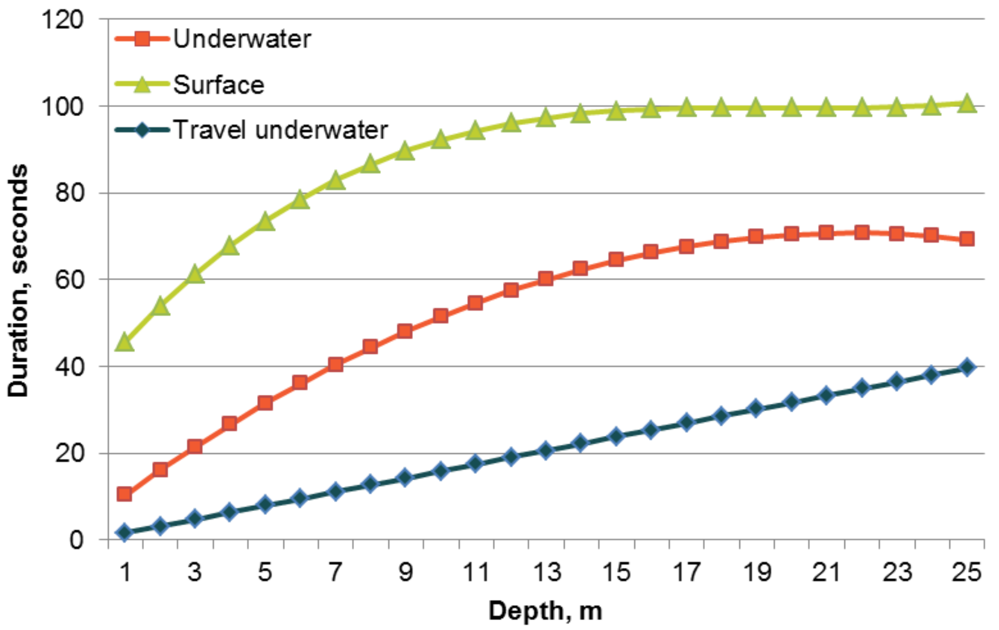


Figure 2.38 Duration of different parts of the Common Eider diving cycle depending on water depth.

Forager variables: Travel time per dive

Travel time per dive was calculated using values of Common Eider descent speed (1.15 m/s) and ascent speed (1.4 m/s) as suggested by Heath et al. (2006, 2007). Travel time was linearly increasing with increasing water depth (Figure 2.38):

Travel time per dive = (WaterDepth/1.15) + (WaterDepth/1.4)

Forager variables: Surface time per dive

When a bird is foraging, pauses between dives are closely related to dive duration as birds need to replenish oxygen reserves. Basic relationship between water depth and pauses between dives was empirically developed from observations of radio-tagged Common Eiders in the Fehmarnbelt (Figure 2.38; See chapter 5.2.1 for details):

Surface time per dive = 0.0082*WaterDepth^3 - 0.4874*WaterDepth^2 + 9.6211*WaterDepth + 36.604

Forager variables: Forage (bottom) time per dive

Bottom time per dive determines the duration when a bird can actually forage, i.e. collect prey. Value of bottom time was obtained by simple subtraction of time spent travelling to and from bottom from total time spent underwater:

Bottom time per dive = if((UWTPDive-TravTPDive)>0, UWTPDive-TravTPDive,0)

Forager variables: Disturbance by wind farms

Offshore wind farms represent a source of disturbance for Common Eiders, responding to which birds may avoid using otherwise suitable habitats within or in close proximity to a wind farm. Although no significant interaction was found between Common Eider distribution and wind farms in the Fehmarnbelt (see chapter 4.1.22), it was precautionary assumed that all birds would be displaced from the area within a wind farm and 1 km buffer around it:

Disturbance by wind farms = if(WindFarm>1000,1,0)

Forager variables: Disturbance by shipping

Ship traffic represents another source of disturbance for Common Eiders (Schwemmer et al. 2011), which might displace birds from suitable habitats. Analysing Common Eider distribution in the Fehmarnbelt it was found that shipping intensity is an important factor determining species distribution and that probability of eiders using an area particularly declined once ship traffic exceeded 1,000 ship passages per month (see chapter 4.1.22). Based on this, it was assumed that all birds would be displaced from patches where shipping intensity exceeds 1,000 ships passing per month, and that shipping intensity between 500 and 1,000 ships would have half of such an impact:

Disturbance by shipping = if(Shipping>1000,0,if(Shipping>500,0.5,1))

Diet consumption rate

Diet consumption rate defines rate at which Common Eiders ingest Blue Mussels per second of the bottom time, as a function of numerical abundance of prey (mussels/m^2).

There are no studies reporting functional response of seaduck intake rate of Blue Mussels. The closest was experimental measurement of intake rates of clams buried in the sediment by White-winged Scoters *Melanitta fusca* (Figure 2.39; Richman and Lovvorn 2003). However, intake rate of infauna (clams) and epifauna (mussels) might be different due to different exposure of bivalves; and different seaduck species might also have different ability to consume prey. Moreover, daily energy budget and foraging activities Common Eiders in the Fehmarnbelt (presented in chapter 5.2.2) suggest intake rate approximately 3 times higher than that for White-winged Scoters foraging on small clams buried in shallow sediment (Figure 2.39). Based on anticipated mussel intake rates by Common Eider in the Fehmarnbelt, an equation, describing intake rates of 18-24 mm clams buried at 4 cm depth of sediment by Velvet Scoters (Richman and Lovvorn 2003) has been modified by increasing intake rate 3 times (Figure 2.39).

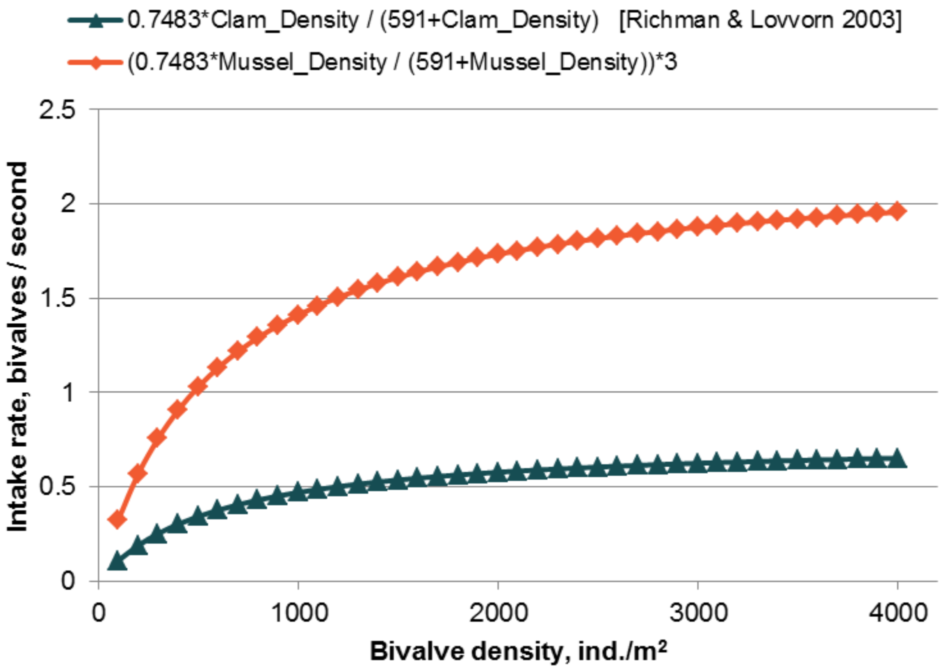


Figure 2.39 Curves representing bivalve intake rates by seaducks: blue line represents White-winged Scoters feeding on 18-24 mm clams buried in 4 cm sediment (adapted from Richman and Lovvorn 2003); orange line represents assumed mussel intake rate by Common Eiders in the Fehmarnbelt, which was obtained by tripling values of Velvet Scoter intake rate.

The following equation was used to calculate intake rate in the IBM, which additionally controls for bird density (intake rate is zero if maximum density on a patch is exceeded), daylight (birds feed only during the daylight hours), accounts for dominance and considers disturbance effects from wind farms and shipping:

Intake rate = if((CountEider/PatchSize<=MaxEiderDens), Daylight*Eff*3600*(ForTPDive/(UWTPDive+SurfTPDive))*((0.7483*MusselDietDensity/(591+MusselDietDensity))*3*DisturbWindF*DisturbShip),0)

Maximum diet consumption rate

Maximum number of bivalves that can be eaten per second of the bottom time was arbitrarily set to 2 indicating that eiders cannot eat more than 2 mussels per second of bottom time. The following equation was used to calculate that in the model:

Maximum intake rate = (ForTPDive/(UWTPDive+SurfTPDive))*2*3600

Component assimilation rate

This parameter defines the proportion of the total amount of resource component (bivalve flesh dry weigh) consumed that is assimilated into the forager's system (eider body reserves). Literature sources suggest that energy assimilation rate from flesh is 0.73 (Hockey 1984); 1 g of Blue Mussel ash free dry weight in the Baltic contains 22.46 kJ of energy (Rumohr et al. 1987); and energy density of bird body reserves is 33.4 kJ/g (Kersten & Piersma 1987). These values result in the following equation for component assimilation rate:

Assimilation of Flesh dry mass = 0.73*(22.46/33.4)

Component metabolic rate while feeding

This parameter requires formula to calculate the amount of a resource component that is lost from the forager's body per unit time while feeding.

Sub-model defining eider metabolic rate while foraging was compiled referring to the Common Eider energy budget constructed using empirical observations in the Fehmarnbelt and literature data (see chapter 5.2.2 for details). Common Eider metabolism while foraging could be broken down into the following parts:

> Diving costs + Dive recovery costs+ Prey heating costs + Resting (between dives) costs

Diving costs consist of energy expenditures incurred during descent, bottom foraging and ascent. According to Heath and Gilchrist (2010) descent costs are 16 W kg^{-1}. Average weight of Common Eider in the Fehmarnbelt was 2.29 kg. The same authors suggest that bottom metabolism is 11 W kg^{-1} and that ascent costs are the same as surface resting metabolism. Average surface costs were calculated in Common Eider budget for the Fehmarnbelt as 15.4 W*Ascent Time (see chapter x). Following Richman and Lovvorn (2008) who measured dive recovery costs being about 27 % of overall diving metabolism for White-winged Scoter, the same value was assumed for Common Eider in the Fehmarnbelt and was therefore added to our estimates.

> Diving costs = (16*2.29*(TravelTimePerDive/2) + 11*2.29*
> ForagingTimePerDive+15.4*(TravelTimePerDive/2)) +
> (16*2.29*(TravelTimePerDive/2) + 11*2.29* ForagingTimePerDive +
> 15.4*(TravelTimePerDive /2))*0.27

Because the current design of MORPH package does not allow using the amount of consumed diet in calculating metabolic costs, energetic expenses of prey heating were taken from Common Eider energy budget compiled in chapter 5.2.2. The estimates suggest that on average prey heating equals to about 97 % of all diving costs, which was subsequently used in calculating prey heating part in the overall budget of metabolic rate while feeding:

> Prey heating = ((((16*2.29*(TravelTimePerDive/2) + 11*2.29*
> ForagingTimePerDive+15.4*(TravelTimePerDive/2)) +
> (16*2.29*(TravelTimePerDive/2) + 11*2.29* ForagingTimePerDive +
> 15.4*(TravelTimePerDive /2))*0.27))*0.97)

Resting between dives was assumed to have the same metabolic costs as described for resting metabolism below.

Component metabolic rate while resting

This sub-model defines equation to calculate the amount of a resource component that is lost from the forager's body per unit time while resting. In our model design 'resting' was assumed to include all surface activities except flying. Main activity types considered were passive resting (floating), swimming (used to compensate for current and wind drift) and comfort/social behaviour. It was assumed that swimming takes up 40% of all surface time, comfort/social behaviour 8% (Systad et al. 2000, Lovvorn et al. 2009), and the remaining 52% was attributed to passive resting (see also chapter 2.3.3). Metabolism of passive resting was calculated by Jensen et al. (1989) for Common Eider as (5.48 – 0.09*WaterTemp) W kg^{-1}. Swimming costs were calculated as 70% of costs measured by Hawkins et al. (2000) for eiders swimming with 1.0 m/s assumed for eiders swimming at the speed of 0.5 m/s in the Fehmarnbelt (also used by Lovvorn et al. 2009): 0.7*12.2 W kg^{-1}. Comfort/social behaviour metabolism was assumed to be the same as swimming (Kaseloo and Lovvorn 2005, 2006; Richman and Lovvorn 2008). Merging these metrics and considering conversion efficiency of energy from body lipid as 0.6 (Lovvorn et al. 2009), the following equation was used to describe average metabolism of Common Eider while resting:

Resting metabolism = ((((5.48-0.09*WaterTemp)*2.29*0.52) + ((0.7*12.2*2.29)*0.48) + ((93*2.29)*(9.6*60/24/3600))) * 3600/1000)/33.4/0.6

Component metabolic rate while moving

This parameter requires formula to calculate the amount of a resource component that is lost from the forager's body per unit time while moving. Flying costs according to Pennycuick (1989) quoted in Lovvorn et al. (2009) are 93 W kg^{-1}. Mean body mass of Common Eiders wintering in the Fehmarnbelt is 2.29 kg. According to Pelletier et al. (2008), Common Eider wintering in Denmark spends approximately 9.8 minutes flying per day. Conversion efficiency of energy from body lipid was assumed to be 0.6 (Lovvorn et al. 2009). Merging these metrics, the following equation was used to describe average metabolism of Common Eider per hour, assuming that flight time is equally distributed:

moving metabolism = ((93*2.29)*3600/1000/33.4/0.6)*(9.6*60/24/3600)

Initial size of reserve store

Mean body weight of 19 Common Eiders captured in the Fehmarnbelt in October 2009 was 2,135 g (mean female body mass 2,035 g (n=6), male 2,235 g (n=13)). According to Camphuysen et al. (2002) mean body weight of lean Common Eider is 1,476 g, which results in 659 g of body reserves in average Common Eider in the Fehmarnbelt at the beginning of wintering season.

Initial reserve store in grams = 1,476 + 659

Target size of reserve store

Mean body weight of Common Eiders in the Fehmarnbelt in March 2009 and March 2010 was measured as 2,371 g (mean female body mass 2,385 g (n=3), male 2,356 g (n=16)). To reach that body weight from measured initial weight in October birds need to gain 1.57 g per day during the wintering season assuming constant rate of reserve accumulation.

Target size of reserve store in grams = 1476+(659+1.57*Day)

Fitness components

Starvation is the only fitness component considered in the model.

Survival probability

Bird dies if body weight falls below the starvation weight:

if(FleshDryMassFinalStore>1476,1,0)

Emigration probability

Common Eiders were not allowed to leave the model system until the departure day (as identified above):

if(Day=DepartureDay,1,0)

Each IBM scenario, assuming different number of birds in the model system, was simulated 5 times, and the final result was obtained by averaging results of each simulation. There are elements of stochasticity in each model run (e.g., randomly assigned individual dominance and efficiency), therefore it was considered that average results of several simulations are more informative about the model predictions than drawing conclusions from a single simulation run.

3 BREEDING WATERBIRDS AT SPECIAL PROTECTION AREAS IN THE FEHMARNBELT

3.1 General overview

The Fehmarnbelt area offers a variety of habitats on Lolland, Fehmarn and along the mainland coast of Germany which are suitable as breeding areas for different bird species. The coastal area has been transformed by coastal protection and land reclamation. Today, many coastal stretches serve important functions as recreational areas restricting the suitability as breeding areas. On the other hand, large nature reserves have been established which partly provide undisturbed areas and protect important areas for colonial breeding waterbirds. Hälterlein (1986) pointed out that numbers of breeding pairs are mostly stable in protected areas, whereas recreational use of beaches and drainage of near shore meadows causes severe problems for breeding birds along the Baltic Sea coastline.

The following chapter summarises breeding bird data from four NATURA 2000 areas lying close to the planned fixed link (Table 3.1). Data from NATURA 2000 monitoring programmes in Germany (Koop 2008, Koop and Struwe-Juhl 2008) and Denmark (Miljøcenter F., Denmark (unpublished), Storstrøms Amt – Teknik- og Miljøforvaltningen (2005), Storstrøms Amt – Teknik- og Miljøforvaltningen (2006)) were used. Table 3.2 lists the number of all breeding pairs from all species in the Special Protection Areas (SPAs).

Table 3.1 List of examined NATURA 2000 areas.

Germany	Denmark
DE 1530-491 Eastern Kiel Bight	DK 006X083 Hyllekrog-Rødsand
DE 1633-491 Baltic Sea east of Wagrien	DK 006X087 Maribo Lakes

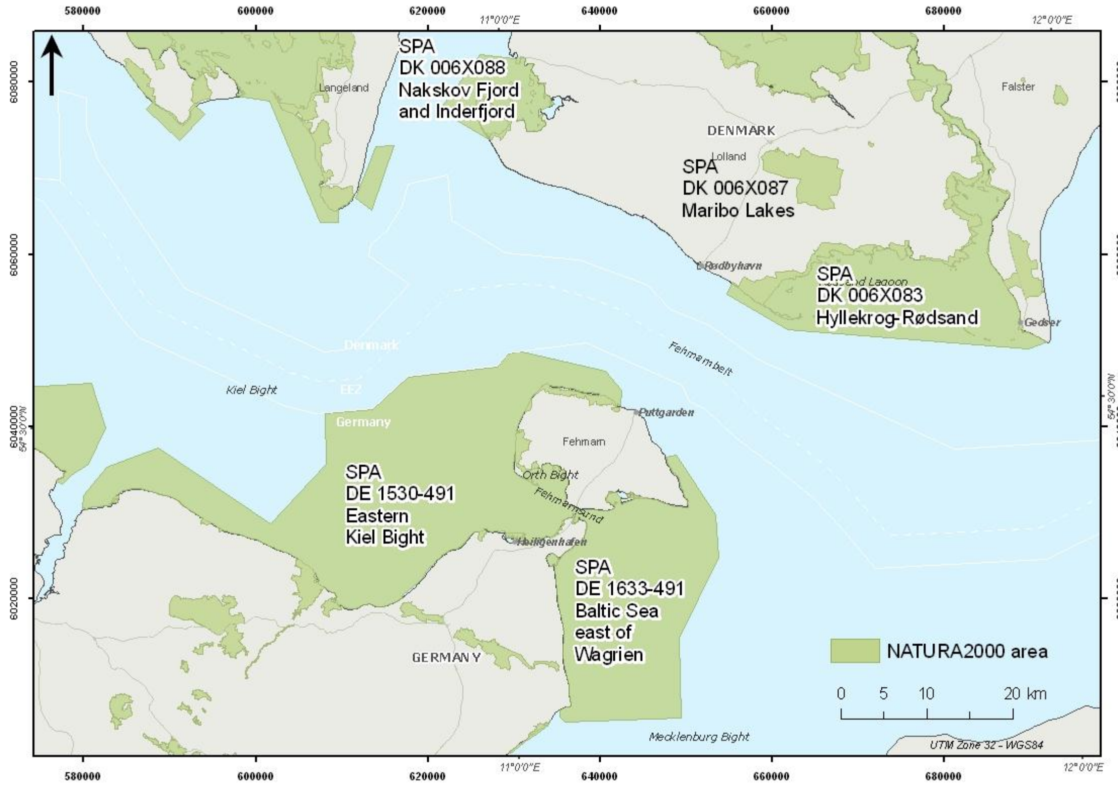


Figure 3.1 Overview map of the Fehmarnbelt area with SPAs.

Table 3.2 Estimated numbers of breeding bird pairs in four NATURA 2000 areas. Data sources for Germany: Koop (2008), Koop and Struwe-Juhl (2008), data sources for Denmark: Miljøcenter F., Denmark (unpublished), Storstrøms Amt – Teknik- og Miljøforvaltningen (2005), Storstrøms Amt – Teknik- og Miljøforvaltningen (2006).

Species name	**Scientific name**	**Annex I Birds Directive**	**SPA (DE 1530-491) Eastern Kiel Bight**	**SPA (DE 1633-491) Baltic Sea east of Wagrien**	**SPA (DK 006X083) Hyllekrog-Rødsand**	**SPA (DK 006X087) Maribo Lakes**
Little Grebe	*Tachybaptus ruficollis*		36			105
Great Crested Grebe	*Podiceps cristatus*		24			387
Red-necked Grebe	*Podiceps grisegena*		84			62
Black-necked Grebe	*Podiceps nigricollis*					7
Great Cormorant	*Phalacrocorax carbo*		120			1806
Eurasian Bittern	*Botaurus stellaris*	X	30	1		35
Common Heron	*Ardea cinerea*		14	12		124
Mute Swan	*Cygnus olor*		43	4	89	28
Greylag Goose	*Anser anser*		444	45	61	550
Canada Goose	*Branta canadensis*		17	1		
Shelduck	*Tadorna tadorna*		168	15	14	23
Gadwall	*Anas strepera*		68	10	15	65
Common Teal	*Anas crecca*		1			6
Mallard	*Anas platyrhynchos*				33	305

Species name	Scientific name	Annex I Birds Directive	SPA (DE 1530-491) Eastern Kiel Bight	SPA (DE 1633-491) Baltic Sea east of Wagrien	SPA (DK 006X083) Hyllekrog-Rødsand	SPA (DK 006X087) Maribo Lakes
Eurasian Wigeon	*Anas penelope*		1			
Garganey	*Anas querquedula*		17			5
Northern Shoveler	*Anas clypeata*		14		10	64
Red-crested Pochard	*Netta rufina*		9			12
Common Pochard	*Aythya ferina*		13			254
Tufted Duck	*Aythya fuligula*		43		1	276
Common Eider	*Somateria mollissima*		56	8	398	
Red-breasted Merganser	*Mergus serrator*		116	28	9	
Goosander	*Mergus merganser*		10			
White-tailed Eagle	*Haliaeetus albicilla*	X	2		2	1
Marsh Harrier	*Circus aeruginosus*	X	30	3		34
Eurasian Kestrel	*Falco tinnunculus*				1	
Hobby	*Falco subbuteo*		2			
Quail	*Coturnix coturnix*		1			
Water Rail	*Rallus aquaticus*		190	10		145
Spotted Crake	*Porzana porzana*	X	10			
Corncrake	*Crex crex*	X	2			
Moorhen	*Gallinula chloropus*		45			210
Common Coot	*Fulica atra*		86			1,255
Crane	*Grus grus*	X	2			
Oystercatcher	*Haematopus ostralegus*		76	7	31	
Avocet	*Recurvirostra avosetta*	X	62	6	41	
Little Ringed Plover	*Charadrius dubius*		5			
Ringed Plover	*Charadrius hiaticula*		114	9	15	
Lapwing	*Vanellus vanellus*		146	12	8	
Dunlin	*Calidris alpina schinzii*	X			2	
Snipe	*Gallinago gallinago*		12	2		
Redshank	*Tringa totanus*		102	10	19	
Mediterranean Gull	*Larus melanocephalus*	X	2			
Black-headed Gull	*Larus ridibundus*		60			215
Common Gull	*Larus canus*		1,251	44	35	
Herring Gull	*Larus argentatus*		771	2	1,066	
Greater Black-backed Gull	*Larus marinus*		8		59	
Sandwich Tern	*Sterna sandvicensis*	X			2	
Common Tern	*Sterna hirundo*	X	84	1		30
Arctic Tern	*Sterna paradisaea*	X	36		14	
Little Tern	*Sterna albifrons*	X	56	44	14	
Black Tern	*Clidonias niger*	X	2			
Stock Dove	*Columba oenas*		3			
Woodpigeon	*Columba palumbus*				3	
Cuckoo	*Cuculus canorus*		19	3		
Eagle Owl	*Bubo bubo*	X	1			
Long-eared Owl	*Asio otus*		6			
Short-eared Owl	*Asio flammeus*	X	1			
Kingfisher	*Alcedo atthis*		3			

Species name	Scientific name	Annex I Birds Directive	SPA (DE 1530-491) Eastern Kiel Bight	SPA (DE 1633-491) Baltic Sea east of Wagrien	SPA (DK 006X083) Hyllekrog-Rødsand	SPA (DK 006X087) Maribo Lakes
Black Woodpecker	*Dryocopus martius*	X	1			
Middle Spotted Woodpecker	*Dryocopus medius*		2			
Skylark	*Alauda arvensis*		278	10	1	
Sand Martin	*Riparia riparia*		230			
Swallow	*Hirundo rustica*				13	
Meadow Pipit	*Anthus pratensis*		231	17	6	
Yellow Wagtail	*Motacilla flava*		48	4	1	
Trush Nightingale	*Luscinia luscinia*		9			
Bluethroat	*Luscinia svecica*	X	25			
Whinchat	*Saxicola rubetra*		13			
Stonechat	*Saxicola torquata*		4			
Grasshopper Warbler	*Locustella naevia*		58	1		
Savi's Warbler	*Locustella luscinoides*		21			
Sedge Warbler	*Acrocephalus schoenobaenus*		446	23		
Marsh Warbler	*Acrocephalus palustris*		24	4		
Reed Warbler	*Acrocephalus scirpaceus*		811	53		
Whitethroat	*Sylvia communis*		145	14		
Bearded Tit	*Panurus biarmicus*		120	8		
Penduline Tit	*Remiz pendulinus*		2	1		
Golden Oriole	*Oriolus oriolus*		2			
Red-backed Shrike	*Lanius collurio*	X	11	1		
Hooded Crow	*Corvus corone cornix*				3	
Common Raven	*Corvus corax*		5			
Siskin	*Carduelis spinus*		3			
Linnet	*Carduelis cannabina*		48			
Common Rosefinch	*Carpodacus erythrinus*		10	7		
Reed Bunting	*Emberiza schoeniclus*		1,043	105	3	
Corn Bunting	*Miliaria calandra*		2			

In total 87 species of breeding birds were recorded in the investigated SPAs with a total estimate of 16,608 breeding pairs during the analysed period. Nineteen of these species are listed in the Annex I of the EU Birds Directive.

3.2 Species relevant for the EIA of a fixed link

Breeding birds which utilise the marine habitats might be affected by habitat changes from constructing and operating a fixed link across the Fehmarnbelt. In most cases utilisation of marine habitats is based on feeding behaviour of the birds, for example terns or gulls flying to the sea to catch prey. Some waterbird species are also raising their chicks in shallow coastal waters. In the following part the breeding bird species of relevance for the EIA of a fixed link utilising marine habitats in the Fehmarnbelt investigation area are described in more detail.

3.2.1 Great Cormorant

There are two colonies of Great Cormorants in the investigated area: one is located on Fehmarn, the other at Maribo lakes. The colony on Fehmarn comprised 120 breeding pairs in 2008, whereas the colony at Maribo Lakes is much larger with more than 1,800 breeding pairs counted in 2005 (Figure 3.2).

The colony on Fehmarn is located in the western part of the island; the one at Maribo lakes is distributed over four small islands. Great Cormorants are known to travel up to 35 km from the breeding colony to feed (Gremillet 1997); therefore birds from both colonies may forage in the marine habitats of the Fehmarnbelt. For the colony of Wallnau (Fehmarn), this has been proven by diet analysis, which indicated that birds foraged exclusively on marine fish (chapter 5).

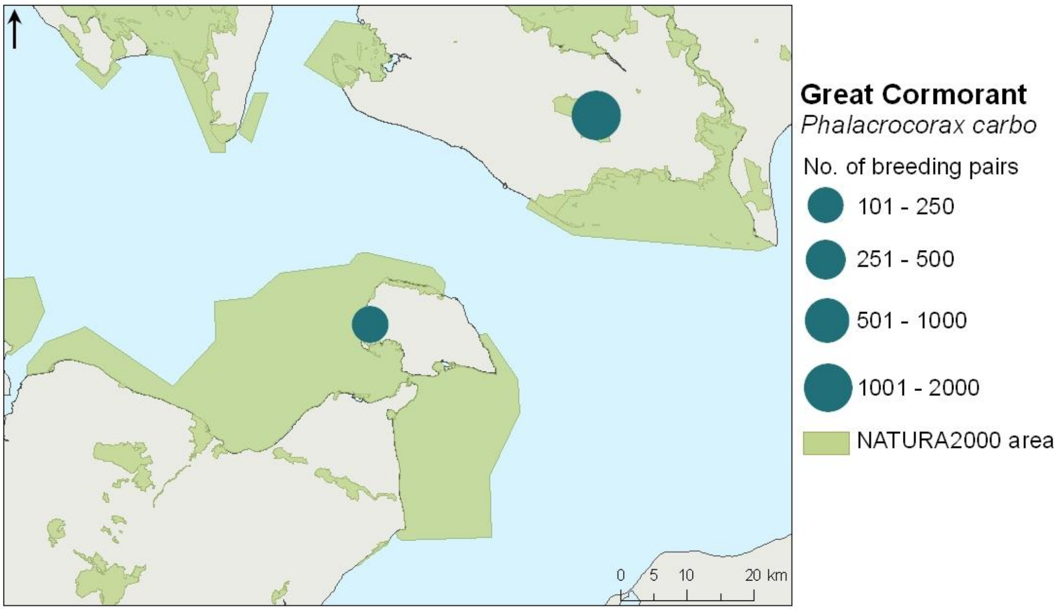


Figure 3.2 Locations of Great Cormorant Phalacrocorax carbo colonies and numbers of breeding pairs *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

3.2.2 Common Eider

Common Eiders breed along the coasts of the Fehmarnbelt area. In total 398 pairs bred on small islands and sands in the SPA Hyllekrog-Rødsand in 2009. Fifty-six breeding pairs were recorded in the SPA Eastern Kiel Bight, and 8 breeding pairs were observed in the SPA Baltic Sea east of Wagrien in 2008 (Figure 3.3).

Common Eiders broods leave their nests soon after hatching and spend their time in shallow coastal waters often several kilometres away from the breeding site until fledging of the chicks. It has been documented that broods from Fehmarnsund area stay mostly in the same area until fledging (Berndt et al. 2002).

Telemetry studies showed that at least some of locally breeding birds spend the winter in the Fehmarnbelt (chapter 5).

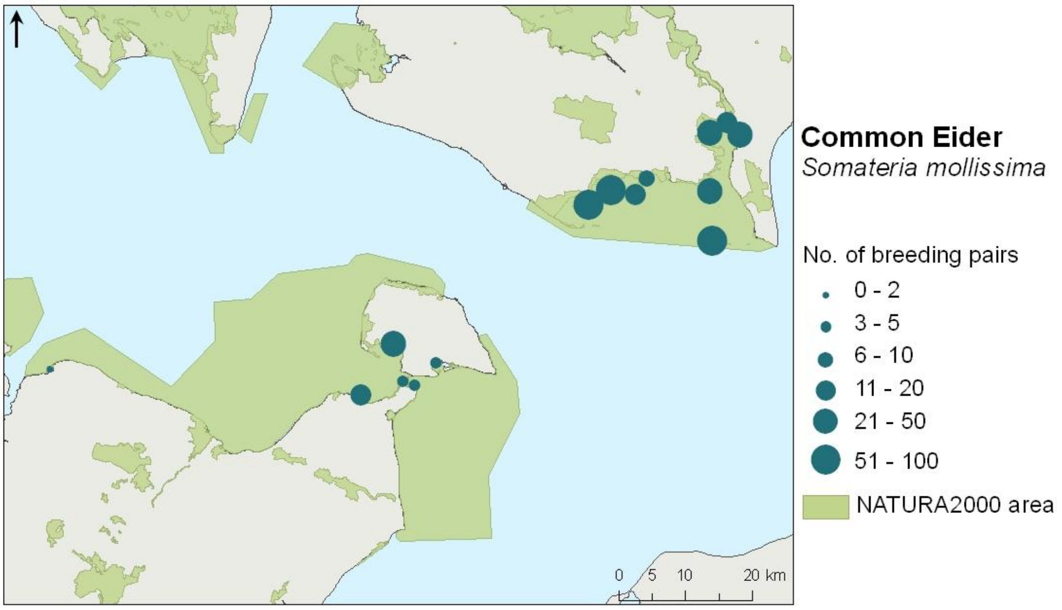


Figure 3.3 Distribution of breeding pairs of Common Eider Somateria mollissima *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

3.2.3 Red-breasted Merganser

Red-breasted Mergansers breed regularly along the German coastline, both on the mainland and on the island of Fehmarn. In the Danish part of the investigated area only a few broods (nine in total) were counted (Figure 3.4). On Fehmarn 77 breeding pairs were found breeding in 2008, thereof 26 in the north of the island. Other sites with larger numbers of breeding pairs are located in the Fehmarnsund region. In the SPA Eastern Kiel Bight 116 breeding pairs of Red-breasted Merganser were found.

Red-breasted Mergansers are quite sensitive to disturbances during the breeding season, especially from recreational activities, and therefore they tend to concentrate in nature reserves (Berndt et al. 2002). After hatching, the adults take their chicks to the sea and stay in shallow water. Sometimes chicks from different broods are tended by one female.

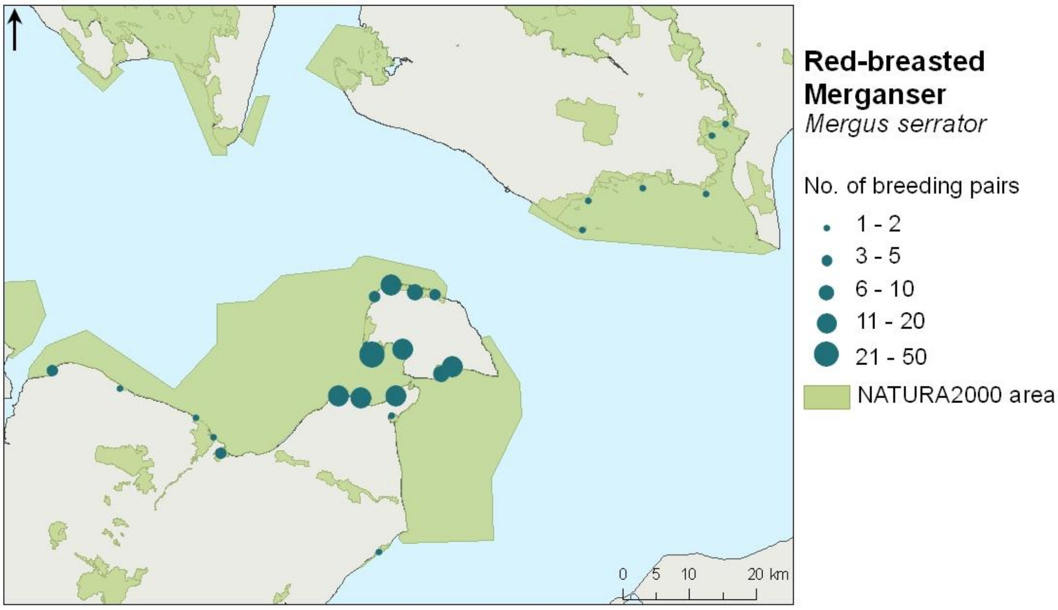


Figure 3.4 Distribution of breeding pairs of Red-breasted Merganser Mergus serrator *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

3.2.4 Goosander

Goosanders bred in 2008 scattered in the investigation area. However, only one pair was detected on Fehmarn (Figure 3.5). In the SPAs Baltic Sea east of Wagrien, Hyllekrog-Rødsand and Maribo Lakes no breeding Goosanders were detected.

Like Red-breasted Mergansers Goosanders are sensitive to disturbance during the breeding period. However, disturbance is mostly not the limiting factor of breeding population but rather the lack of suitable habitats in dead wood (Berndt et al. 2002).

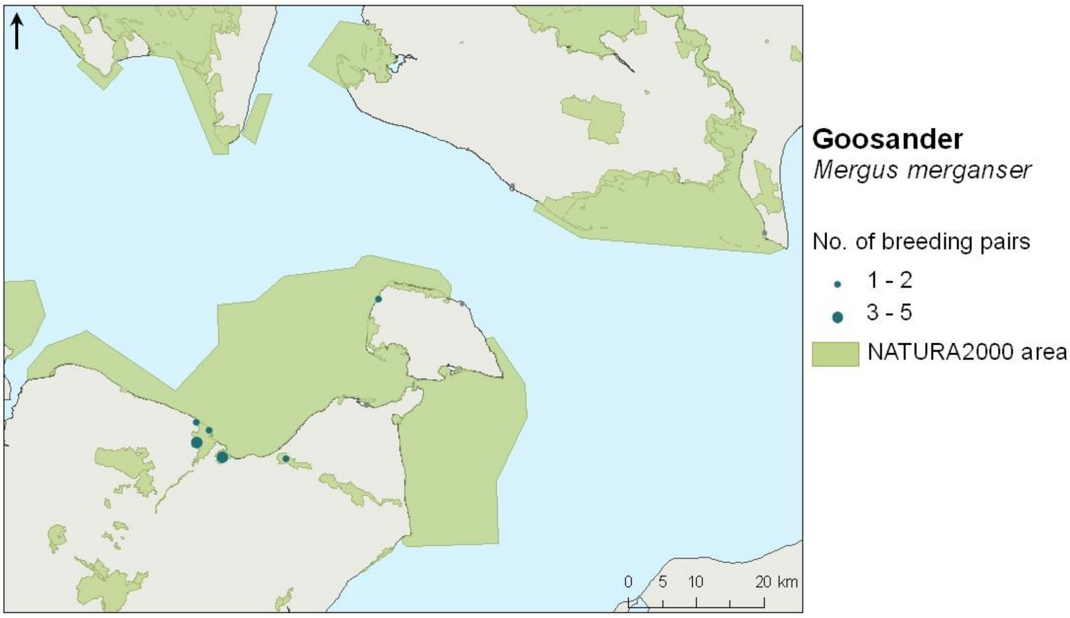


Figure 3.5 Distribution of breeding pairs of Goosander Mergus merganser *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

3.2.5 *White-tailed Eagle*

Five aeries of White-tailed Eagle are located in the investigated area (data from 2008 and 2009). One pair breeds quite near to the planned fixed link on Fehmarn, two pairs breed in the SPA Hyllekrog-Rødsand and one in the SPA Maribo Lakes (Figure 3.6). As White-tailed Eagles have large home ranges (Struwe-Juhl and Grünkorn 2007), it is likely that the breeding pairs from Fehmarn and the Rødsand area use Fehmarnbelt as feeding habitat.

Figure 3.6 Distribution of breeding pairs of White-tailed Eagle Haliaeetus albicilla *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

3.2.6 *Avocet*

Small colonies and single pairs of Avocets were found breeding in the SPAs Eastern Kiel Bight, Baltic Sea east of Wagrien and Hyllekrog-Rødsand (Figure 3.7). In the nature reserve Graswarder the breeding colony consisted of 34 breeding pairs in 2008, and at Rødsand the colony consisted of 40 breeding pairs in 2009.

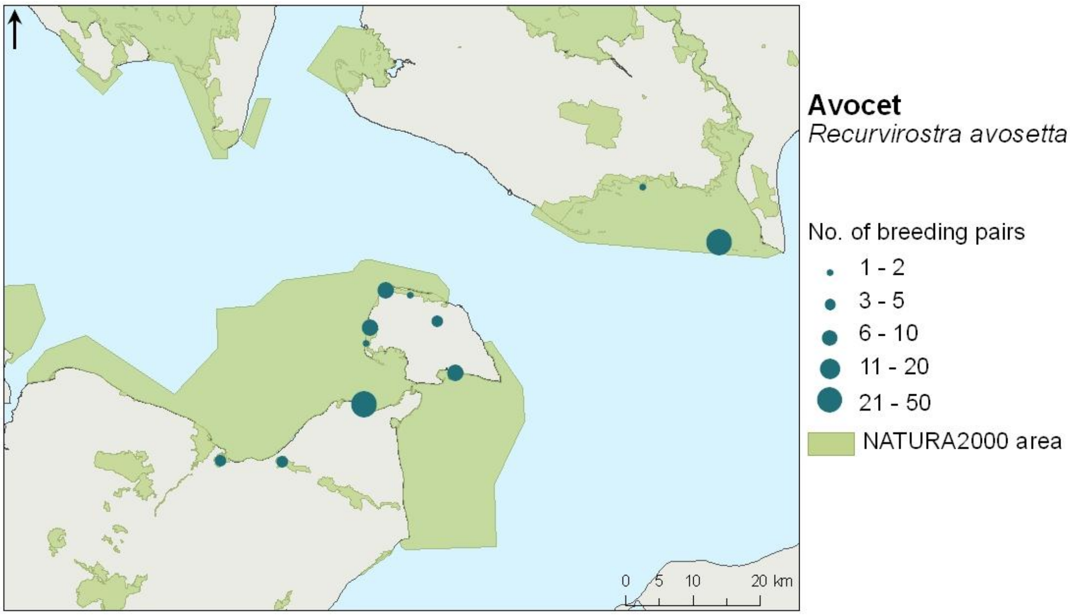


Figure 3.7 *Distribution of breeding pairs of Avocet* Recurvirostra avosetta *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

Hälterlein (1986) gives a total number of 169 breeding pairs for the Baltic Sea coast of Schleswig-Holstein in 1984. In 2008 only 68 breeding pairs were found within the two SPAs along the Baltic Sea coast of Schleswig-Holstein (Table 3.2). Long-term data from the SPA Hyllekrog-Rødsand show large inter-annual-variation in breeding pair numbers ranging from just a few to 150 breeding pairs (Figure 3.8). No trend could be detected in breeding Avocet numbers in Hyllekrog-Rødsand SPA from 1996 to 2009.

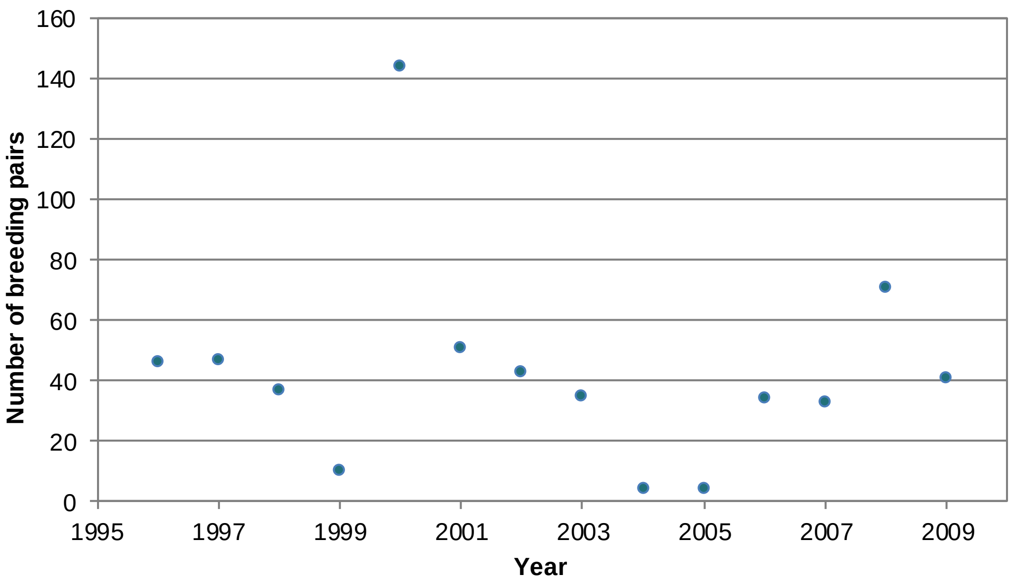


Figure 3.8 *Numbers of breeding pairs of Avocet* Recurvirostra avosetta *in the SPA Hyllekrog-Rødsand from 1996-2009.*

3.2.7 Black-headed Gull

Three colonies of Black-headed Gulls are situated within the investigation area (Figure 3.9). On Fehmarn two small colonies of Black-headed Gulls were recorded in 2008. The colony in the west of Fehmarn (nature reserve Wallnau) consisted of 45 breeding pairs and in the colony in the northern part of the island 15 breeding pairs were recorded. In the Danish part of the area there was one colony at Maribo lakes in 2005 with 215 breeding pairs. No Black-headed Gull colonies were detected in the SPA Hyllekrog-Rødsand.

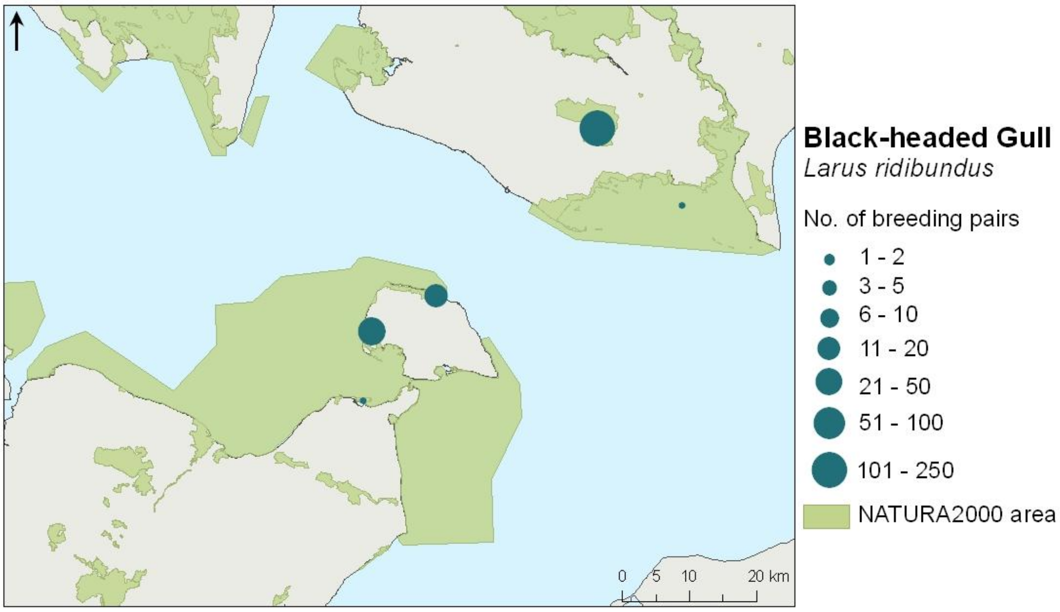


Figure 3.9 Distribution of breeding pairs of Black-headed Gull Larus ridibundus *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

Even though there were no breeding Black-headed Gulls found in the SPA Hyllekrog-Rødsand in 2009, long-term data indicates that the species was regularly breeding in the area until 2003. Since then only few breeding pairs were recorded in 2006 and 2008 (Figure 3.10), in other years no breeding pairs were recorded at all. The number of breeding Black-headed Gulls is declining significantly. Hälterlein (1986) describes increasing numbers of Black-headed Gulls at the Baltic Sea coast of Schleswig-Holstein between 1969/70 and 1984. Since 1990-ies, the species is decreasing in northern and central Europe, particularly in countries bordering the Baltic Sea (BirdLife International 2004, Wetlands International 2006).

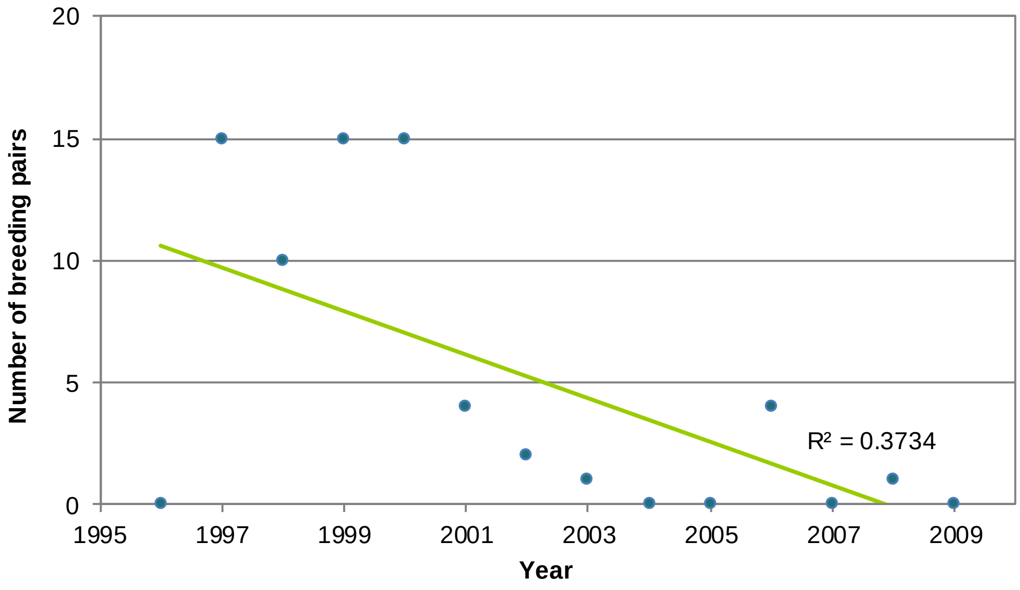


Figure 3.10 Numbers and trend (P = 0.02) of breeding pairs of Black-headed Gull Larus ridibundus *in the SPA Hyllekrog-Rødsand from 1996-2009.*

3.2.8 Mediterranean Gull

Only two pairs of Mediterranean Gulls bred in the German part of the investigated area in 2008. They were located on the mainland in the nature reserve Graswarder. According to Berndt et al. (2002) Mediterranean Gulls fly inland to feed (even to SPA Oldenburger Graben). Accordingly, Fehmarnbelt is not expected to be used by this species.

3.2.9 Common Gull

Common Gulls breed regularly and in larger numbers in the investigated area: 1,251 pairs in the SPA Eastern Kiel Bight, 44 were counted in the SPA Baltic Sea east of Wagrien in 2008, and 35 breeding pairs were recorded in the SPA Hyllekrog-Rødsand in 2009 (Figure 3.11). A large colony consisting of 1,200 Common Gulls pairs bred in the nature reserve Graswarder on the German mainland in 2008. Birds from this colony feed mostly on terrestrial food (e.g. earthworms, arthropods), but marine invertebrates (bivalves, polychaets) also make up small fraction of the diet (Kubetzki 2001). There were also few other colonies located in the study area with fewer than 40 breeding pairs counted during the study period.

Numbers of breeding pairs in the SPA Hyllekrog-Rødsand fluctuated from 8 to 70 between 1996 and 2009 (Figure 3.12).

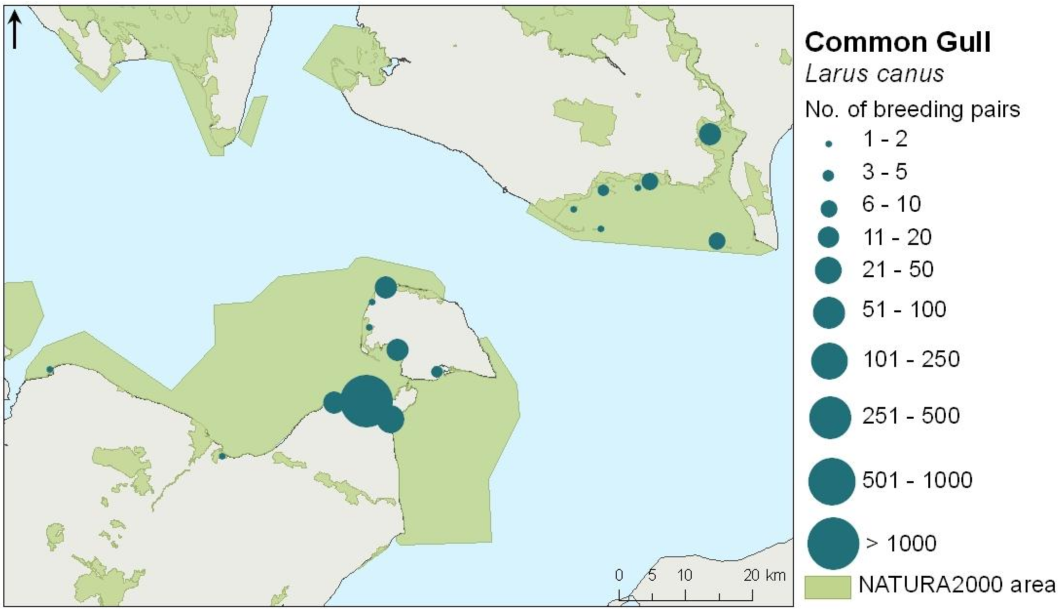


Figure 3.11 *Distribution of breeding pairs of Common Gull* Larus canus *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

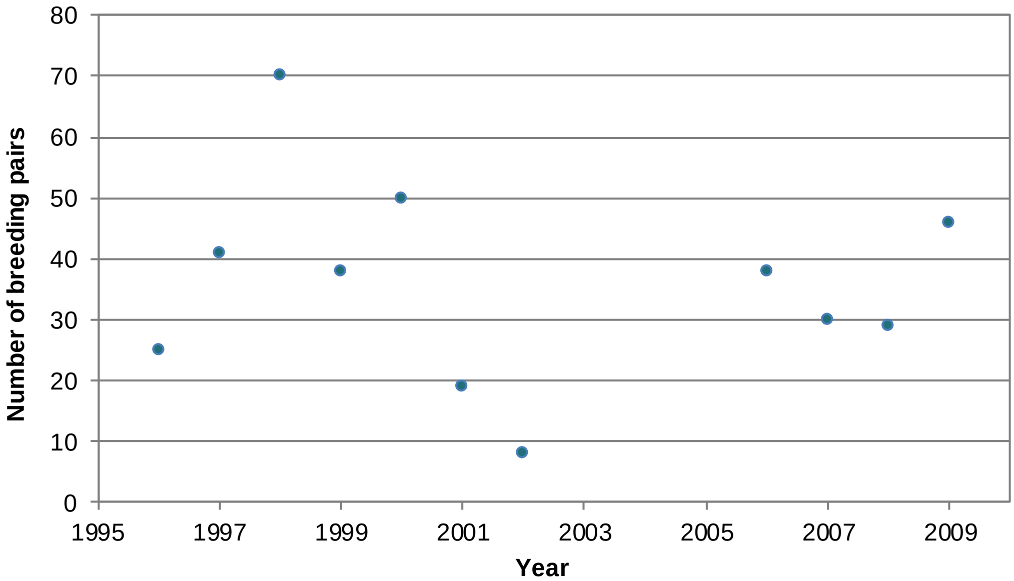


Figure 3.12 *Number of breeding pairs of Common Gull* Larus canus *in the SPA Hyllekrog-Rødsand from 1996-2009. In 2003, 2004 and 2005 not all main breeding sites were covered. Consequently, data for these years are not plotted.*

The colony at the Graswarder site reached the highest recorded numbers in 1970 with 6,000 breeding pairs and declined rapidly between 1970 and 1977 (Kubetzki 2001). After a slight increase 1980 and 1985 another decline has followed (Figure 3.13, Kubetzki 2001).

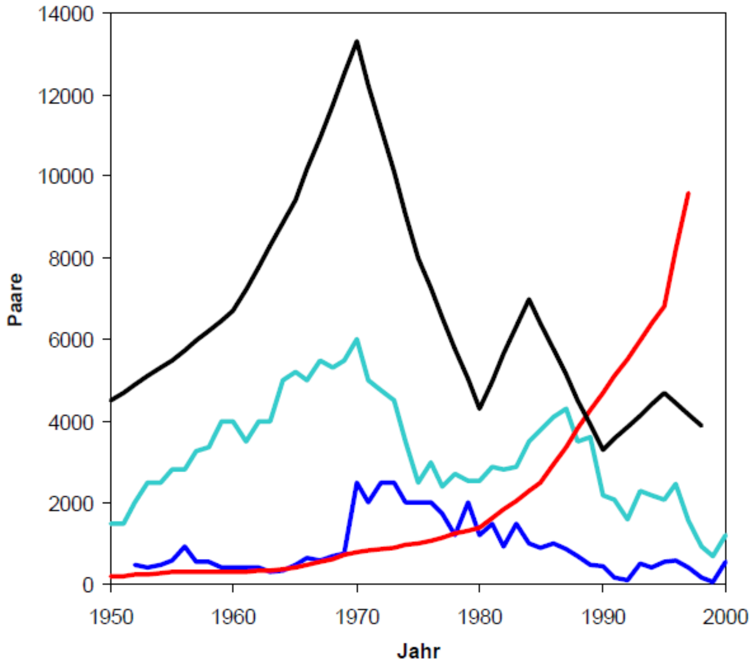


Figure 3.13 Numbers of breeding pairs of Common Gull Larus canus *in four different German sites from 1950-2000. Blue: Oehe/Schleimünde, turquoise: Graswarder, red: German North Sea coast, black: Baltic Sea coast of Mecklenburg-West Pomerania. Figure from Kubetzki (2001).*

3.2.10 Great Black-backed Gull

Great Black-backed Gulls breed at two sites within the study area: in the Fehmarnsund region (SPA Eastern Kiel Bight) and scattered over the small islands in the SPA Hyllekrog-Rødsand. Only one breeding pair was observed in the nature reserve Graswarder, and another 7 pairs bred in the southern part of Fehmarn in 2008. Great Black-backed Gulls bred on several islands in the Rødsand Lagoon in 2009 (Figure 3.14). The biggest colony consisting of 29 breeding pairs was located on Rødsand Island.

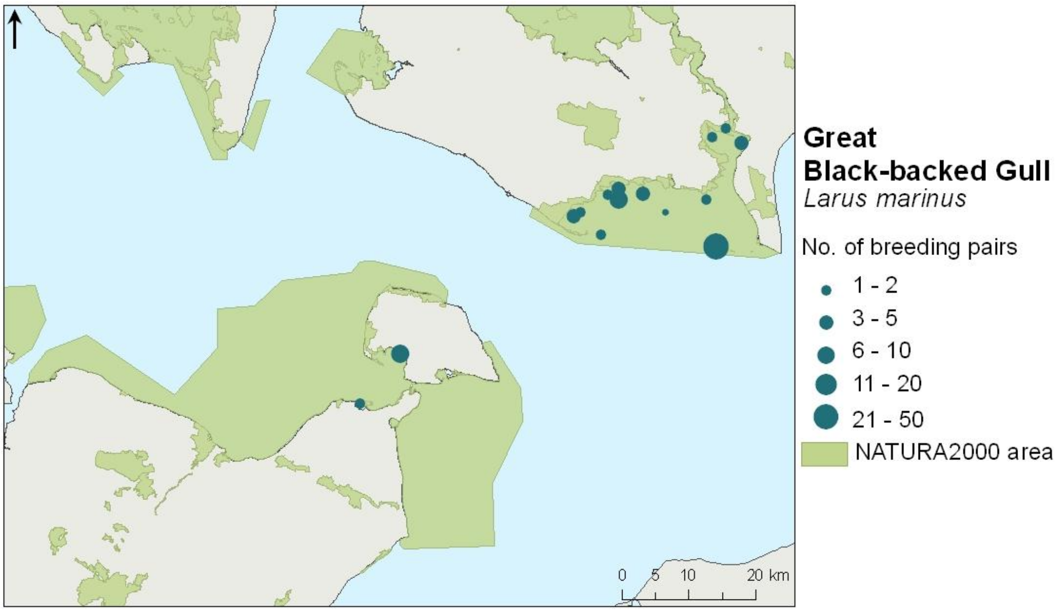


Figure 3.14 Distribution of breeding pairs of Great Black-backed Gull Larus marinus *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

Long-term data show a significant increase in breeding pairs of Great Black-backed Gulls in the Hyllekrog-Rødsand area (Figure 3.15). The total number of 59 breeding pairs recorded in 2009 represents the highest abundance of Great Black-backed Gulls for the period from 1996 until 2009. Records from 2003, 2004 and 2005 are incomplete, because not all breeding sites were covered in these years, and were therefore excluded from the analysis.

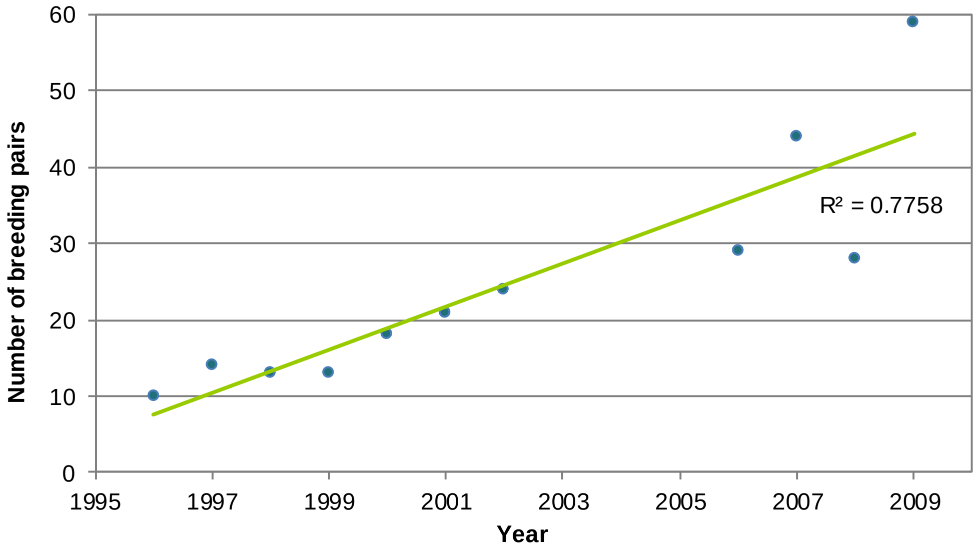


Figure 3.15 Numbers and trend (P =0.001) of breeding pairs of Great Black-backed Gull Larus marinus *in the SPA Hyllekrog-Rødsand from 1996-2009. In 2003, 2004 and 2005 not all main breeding sites were covered. Consequently data for these years have been discarded in the regression analysis.*

3.2.11 Herring Gull

Herring Gulls breed mainly in the SPAs Eastern Kiel Bight and Hyllekrog-Rødsand. In the German part of the investigated area most Herring Gulls breed in the Fehmarnsund area (Figure 3.16). In 2008, there was one large colony in the south of Fehmarn with more than five-hundred breeding pairs. Two other smaller colonies were located in the nature reserves Graswarder and Wallnau. In the Rødsand area more than a thousand Herring Gulls bred in 2009 scattered over the small islands. The largest colony was situated on Rødsand Island with 216 breeding pairs (Figure 3.16).

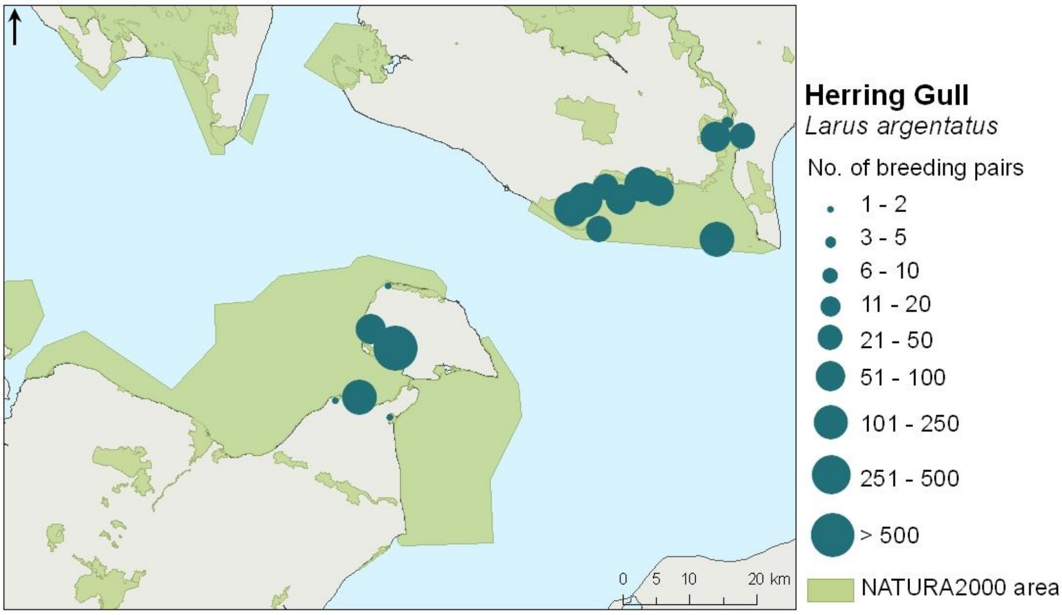


Figure 3.16 Distribution of breeding pairs of Herring Gull Larus argentatus *in the NATURA 2000 areas along the Fehmarnbelt. Data: see Table 3.2.*

Herring Gull numbers have declined significantly in the SPA Hyllekrog-Rødsand (Figure 3.17). As for other species, the data from 2003, 2004 and 2005 are not displayed, because areas were not surveyed completely in these years.

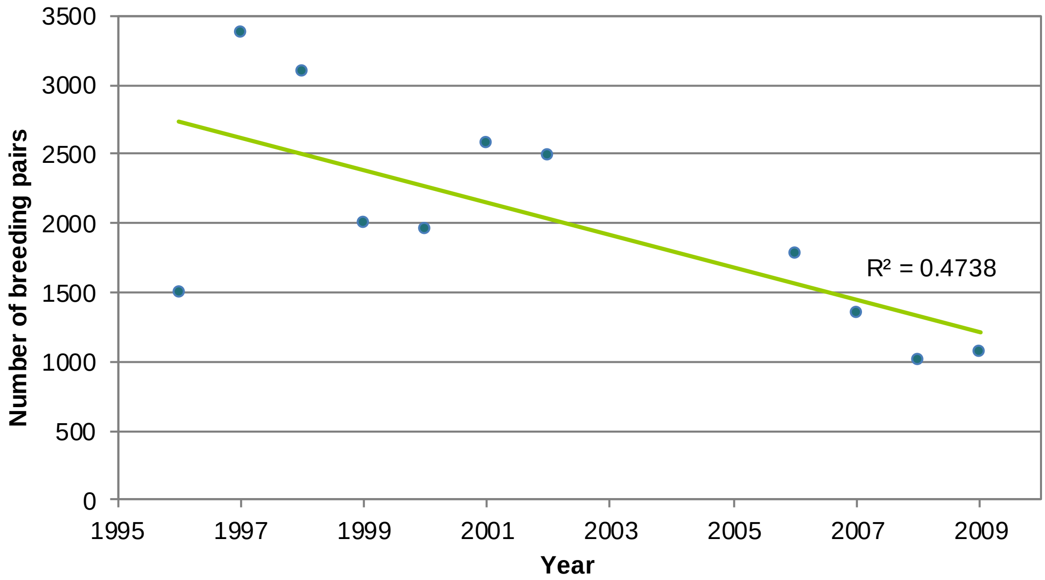


Figure 3.17 Numbers and trend (P = 0.001) of breeding pairs of Herring Gull Larus argentatus *in the SPA Hyllekrog-Rødsand from 1996-2009. In 2003, 2004 and 2005 not all main breeding sites were covered. Consequently data for these years are discarded in the regression analysis.*

3.2.12 Common Tern

There are several small breeding colonies of Common Terns in the study area (Figure 3.18). The largest breeding colony was within the SPA Maribo Lakes with 30 breeding pairs recorded in 2005, but in most other colonies fewer than 20 pairs were observed. No breeding pairs were detected in the SPA Hyllekrog-Rødsand since 1996. Common Terns breeding on Fehmarn are expected to feed mostly in marine areas.

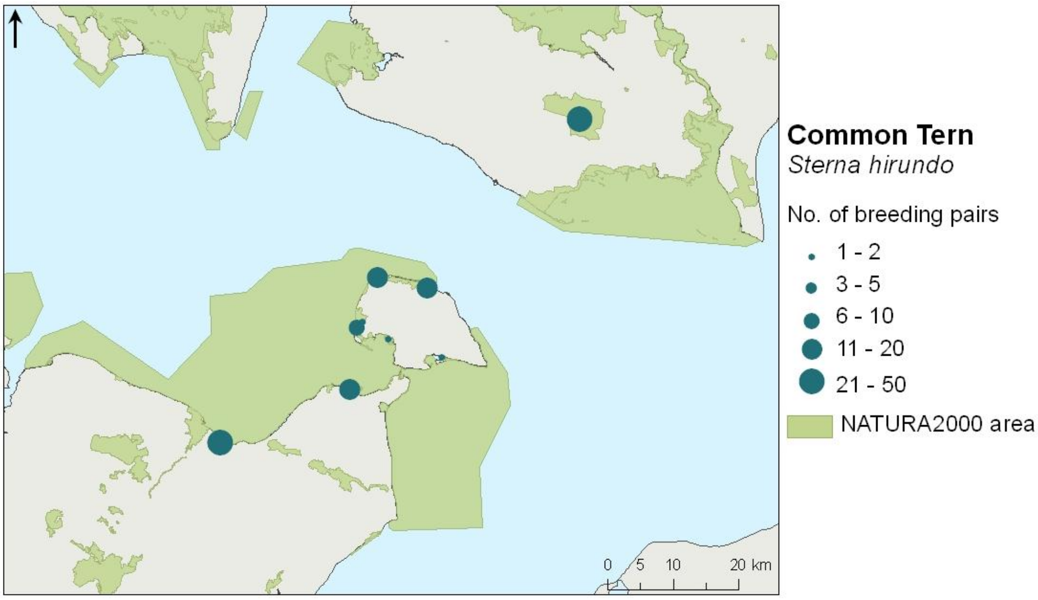


Figure 3.18 Distribution of breeding pairs of Common Tern Sterna hirundo *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

Historical data from the Baltic Sea coast of Schleswig-Holstein from 1984 show 66 breeding pairs in the area, which is now part of the SPA Eastern Kiel Bight and Baltic Sea east of Wagrien (Hälterlein 1986). Eighty-five breeding pairs were counted within this area in 2008. The locations of the breeding sites are similar to those in 1984.

3.2.13 *Arctic Tern*

One relatively large colony of Arctic Terns is located in the nature reserve Graswarder and consisted of 55 breeding pairs in 2008 (Figure 3.19). Several small colonies were recorded in the SPA Hyllekrog-Rødsand in 2009.

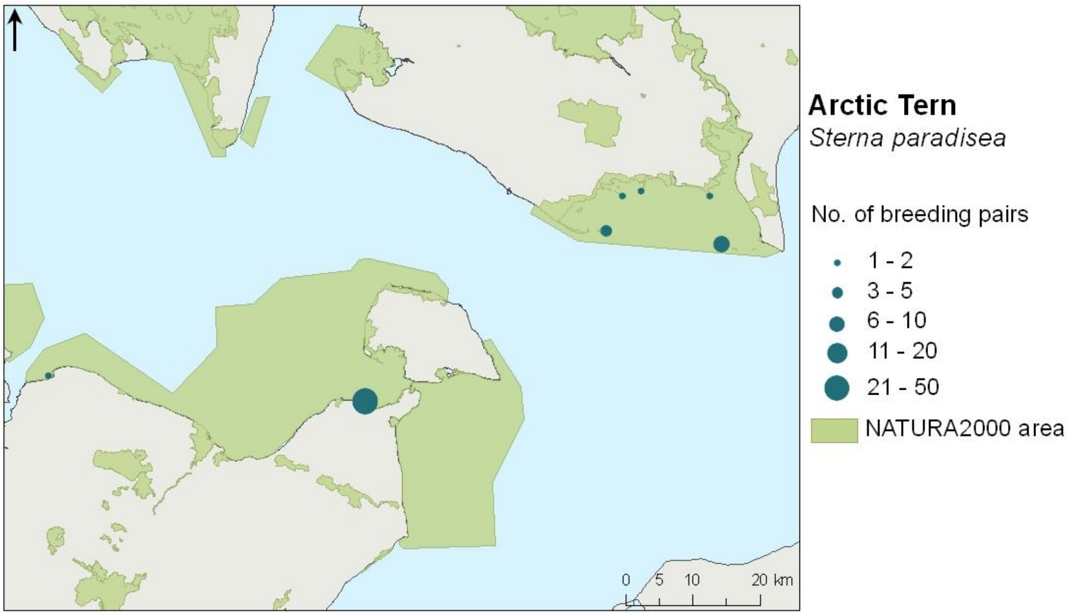


Figure 3.19 Distribution of breeding pairs of Arctic Tern Sterna paradisaea *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

Long-term data for Arctic Terns from SPA Hyllekrog-Rødsand show no significant trend in numbers of breeding pairs (Figure 3.20). The highest abundance was found in 1997 when 128 breeding pairs were recorded. In 2008 still 83 breeding pairs were detected whilst only 13 pairs were counted in 2009. Surveys of 2003, 2004 and 2005 were incomplete. The nature reserve Graswarder supported 180 breeding pairs of Arctic Tern in 1984 (Hälterlein 1986), whereas only 55 breeding pairs were counted in 2008.

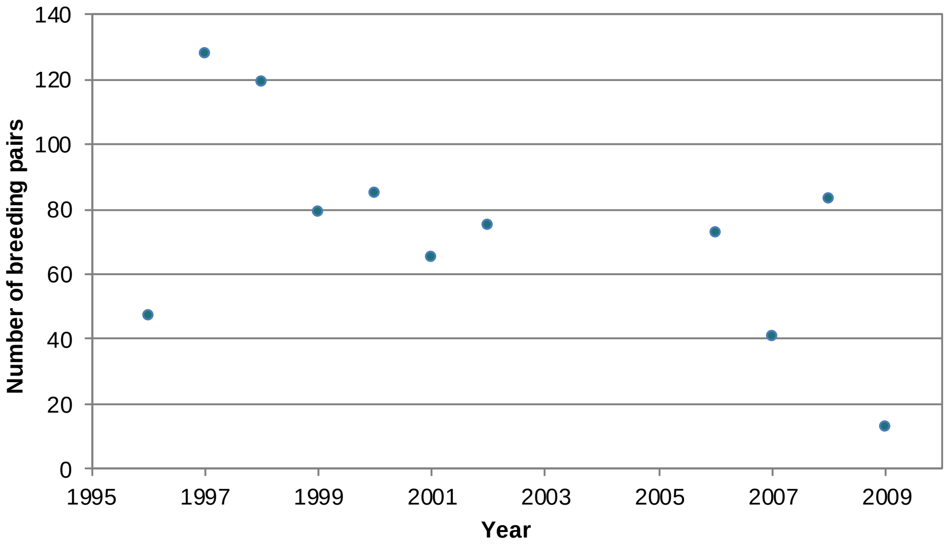


Figure 3.20 Numbers of breeding pairs of Arctic Tern Sterna paradisaea *in the SPA Hyllekrog-Rødsand from 1996-2009. In 2003, 2004 and 2005 not all main breeding sites were covered. Consequently data for these years are not presented.*

3.2.14 Little Tern

Little Terns breed regularly in small colonies along the coasts of the study area (Figure 3.21). The largest colony was located south of the SPA Baltic Sea east of Wagrien with 44 breeding pairs recorded in 2008. Five small colonies were recorded on Fehmarn, one of them in the nature reserve Grüner Brink, close to the planned fixed link, where eight breeding pairs were found in 2008. Fourteen pairs of Little Terns were found in the SPA Hyllekrog-Rødsand. Little Terns are expected to use the Fehmarnbelt area as feeding ground.

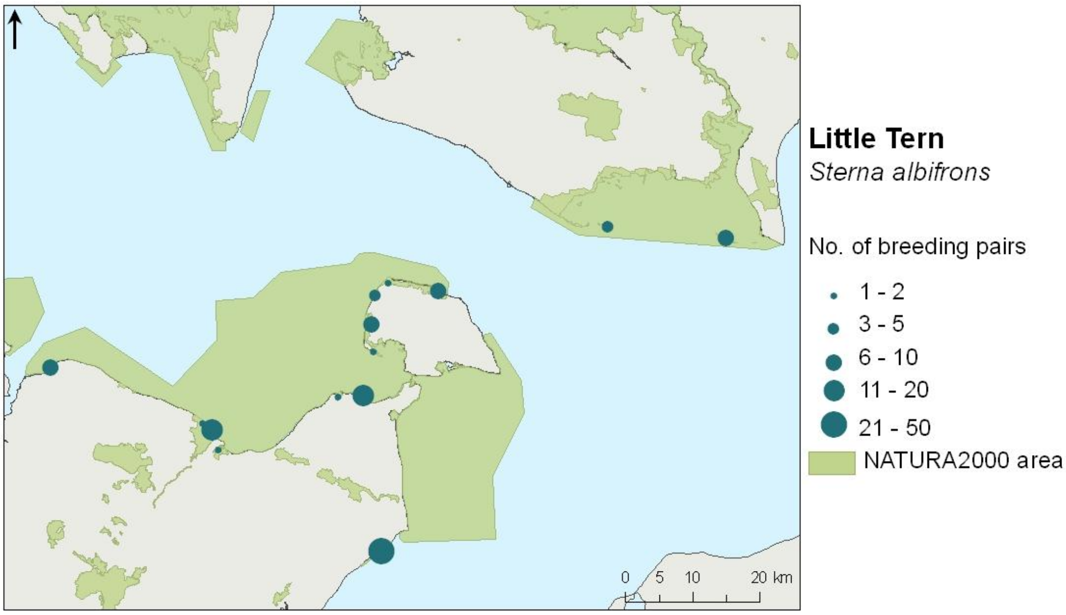


Figure 3.21 Distribution of breeding pairs of Little Tern Sterna albifrons *in the NATURA 2000 areas in the Fehmarnbelt. Data: see Table 3.2.*

4 NON-BREEDING WATERBIRDS IN THE FEHMARNBELT

4.1 Abundance and distribution

In this chapter all waterbird species are described which were considered as relevant for the Environmental Impact Assessment on marine areas of Fehmarnbelt. Species were selected based on their conservation status and the conservation targets of Natura 2000 sites in the Fehmarnbelt area. A complete list of bird species and numbers observed during FEBI baseline investigations (aerial and ship-based surveys) is given in Appendix V.

4.1.1 Red-throated Diver/Black-throated Diver – *Gavia stellata/Gavia arctica*

Red-throated Diver – *Gavia stellata*

Biogeographic population: NW Europe (non-br)

Breeding range: Arctic and boreal W Eurasia, Greenland

Wintering / core non-breeding range: NW Europe

Population size: 150,000 – 450,000

1 % value: 3,000

Conservation status: EU Birds Directive, Annex I: listed
EU SPEC Category: SPEC 3
EU Threat Status: (depleted)

Target species in SPAs: -

Key food: fish

Period of presence in Fehmarnbelt: Wintering / migrations: mid-September – mid-May

Black-throated Diver – *Gavia arctica*

Biogeographic population: *G. a. arctica*

Breeding range: N Europe and W Siberia

Wintering / core non-breeding range: Coastal NW Europe, Mediterranean, Black and Caspian Seas

Population size: 250,000 – 500,000

1 % value: 3,750

Conservation status: EU Birds Directive, Annex I: listed
EU SPEC Category: SPEC 3
EU Threat Status: (vulnerable)

Target species in SPAs: -

Key food: fish

Period of presence in Fehmarnbelt: Wintering / migrations: mid-September – mid-May

Origin of divers in the Fehmarnbelt

The Red-throated Diver winters in high numbers in the Baltic Sea and the few ring recoveries from Danish waters indicate that these birds originate from breeding areas in Sweden and Finland (Bønløkke et al. 2006). This is also confirmed by Fransson and Pettersson (2001).

Danish and German waters are important moulting and wintering areas for Black-throated Diver. However, few birds have been ringed and hence, very little information is available. Fransson and Pettersson (2001) show that Swedish breeders move further south to the wintering areas in the Black Sea and the Atlantic Ocean. The only Danish ring recovery is from Siberia, indicating that Black-throated Divers wintering in the Fehmarnbelt at least partly originate from further north and east compared to the Red-throated Diver (Bønløkke et al. 2006).

Data sources on divers in the Fehmarnbelt

The two diver species are treated together, as only a small proportion of diver observations from airplane and ship can be determined to species level. Numbers and distribution of divers are well reflected in FEBI aerial and ship-based survey data, but aerial surveys were chosen as the primary data source for representing the species due to broader spatial coverage of the study region (Table 4.1). Other datasets were used as supporting data sources to characterise diver densities, distribution and habitat use (Table 4.1).

Table 4.1 List of datasets and their use in baseline assessment of Red-throated and Black-throated Divers in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for evaluating species distribution, abundance, and habitat use
FEBI ship transect surveys	Supporting dataset for evaluating species distribution, abundance and habitat use, and primary for assessing seasonal variability in abundance
OAG land-based counts	Supporting dataset representing species distribution along the German mainland coast
AKVSW land-based counts	Supporting dataset representing species distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for densities and distribution of the species in the Danish part of the Fehmarnbelt
DOF database	Supporting dataset representing species abundance in the Danish part of the Fehmarnbelt

Abundance of divers in the Fehmarnbelt

Red-throated and Black-throated Diver abundance estimates based on Distance analysis

The abundance of divers in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Red-throated and Black-throated Diver during aerial surveys, calculated using the entire dataset, were 189 m for swimming birds and 246 m for flying birds. The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of divers have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.2, Appendix V). Often partial coverage most likely resulted in minimum estimates for this species. The highest estimates of 1,400 and more than 1,500 birds were obtained for the two surveys conducted in early and late March 2010 (Table 4.2).

Month-to-month comparison of density estimates show the species occurring in the Fehmarnbelt area mostly during transitional and wintering periods between October and April. During summer period the species is rarely spotted in the area (Table 4.2). Survey-specific estimates suggest differing diver numbers wintering in the study area between the two years of baseline investigations (Table 4.2). Higher abundance of divers in the second winter could have been influenced by the severe winter conditions and extensive ice cover over large areas of the Baltic Sea.

Table 4.2 Numbers of observed Red-throated Divers / Black-throated Divers during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	5	6	0.01	0.00	0.05	54
Dec-08	81.7	5	6	0.01	0.00	0.04	51
Jan-09	82.8	37	49	0.10	0.07	0.15	406
Feb-09	100	31	52	0.09	0.05	0.17	445
Mar-09	77.5	67	122	0.25	0.15	0.43	950
Apr-09	86.8	10	12	0.02	0.01	0.05	106
May-09	77.3	0	0	0	0	0	0
Jun-09	80.9	0	0	0	0	0	0
Jul-09	86.6	0	0	0	0	0	0
Aug-09	92.3	2	2	0.00	0.00	0.01	15
Sep-09	79.1	0	0	0.00	0.00	0.00	0
Oct-09	79.9	9	14	0.03	0.02	0.06	121
Nov-09	82.4	16	29	0.06	0.03	0.14	256
Dec-09	24.7	38	64	0.49	0.23	1.07	595
Mar-10 A	64.1	98	192	0.48	0.27	0.86	1,513
Mar-10 B	75.6	86	215	0.38	0.25	0.60	1,402
Apr-10	100	36	101	0.17	0.09	0.33	833
May-10	92.1	4	5	0.01	0.00	0.05	39
Jun-10	70.8	0	0	0	0	0	0
Aug-10	75.6	0	0	0	0	0	0
Sep-10 A	44.9	0	0	0	0	0	0
Sep-10 B	48.9	4	7	0.02	0.01	0.07	56
Oct-10	80.0	12	30	0.06	0.02	0.21	238
Nov-10	70.1	22	28	NA	NA	NA	NA

The ESW for Red-throated and Black-throated Divers during ship-based surveys, estimated for the entire dataset, was 193 m. Estimated diver densities were low and ranged between 0 and 0.07 birds/km^2 during wintering period (Table 4.3). Reflecting estimated densities, the highest number in the area covered by ship-based surveys was 163 birds. However, due to low sample size estimated densities and numbers should be interpreted with caution because of broad confidence intervals.

Estimates for divers from ship-based surveys indicate lower densities and total numbers than obtained for aerial surveys (Table 4.2). This may be explained by the high sensitivity of divers towards ships and therefore decreased probability to record birds taking off far in front of the ship (Schwemmer et al. 2011). Although during ship-based surveys one observer has always used binoculars aiming to detect divers flushing in front of the ship (as suggested e.g. by Garthe et al. 2002, Hüppop et al. 2002), it is still possible that a substantial number of divers remained undetected. For this reason surveys from the faster-moving observation platform (plane) were regarded as delivering more reliable results for these species.

Table 4.3 *Numbers of observed Red-throated Divers and Black-throated Divers during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km² covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed. *** indicates that coefficient of variation could not be calculated (typically due to small sample size).*

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	**Stratum**	**N obs**	**N birds**	**D**	**%CV**	**LCI**	**UCI**	**D**	**LCI**	**UCI**	**N flying**	**D**	**Total number**
Nov-08	coastal	20	23	0.22	46	0.09	0.53	-	-	-	17	-	-
	offshore	3	4	-	918	-	-				3		
Dec-08	coastal	4	6	-	***	-	-	-	-	-	5	-	-
	offshore	0	0	0	0	0	0				7		
Jan-09	coastal	7	8	-	***	-	-	-	-	-	3	-	-
	offshore	0	0	0	0	0	0				1		
Feb-09	coastal	1	1	0.01	114	0.00	0.05	0.01	0.00	0.03	9	0.05	111
	offshore	0	0	0	0	0	0				1		
Mar-09	coastal	7	13	-	***	-	-	-	-	-	1	-	-
	offshore	1	3	0.05	108	0.01	0.31				2		
Apr-09	coastal	3	5	-	***	-	-	-	-	-	9	-	-
	offshore	1	1	0.02	116	0.00	0.10				9		
May-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jul-09A	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jul-09B	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Aug-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Oct-09	coastal	2	2	0.02	81	0.00	0.07	0.01	0.00	0.05	0	0.01	30
	offshore	0	0	0	0	0	0				0		

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-09	coastal	3	4	-	***	-	-	-	-	-	6	-	-
	offshore	0	0	0	0	0	0				1		
Dec-09	coastal	2	2	0.02	90	0.00	0.09	0.02	0.00	0.12	1	0.07	163
	offshore	1	2	0.03	114	0.00	0.20				10		
Jan-10	coastal	3	3	0.02	68	0.01	0.09	-	-	-	3	-	-
	offshore	4	9	-	***	-	-				0		
Feb-10A	coastal	5	5	0.04	57	0.01	0.12	0.03	0.01	0.12	2	0.04	100
	offshore	1	1	0.02	115	0.00	0.11				0		
Feb-10B	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Mar-10	coastal	0	0	0	0	0	0	0	0	0	6	0.02	58
	offshore	0	0	0	0	0	0				0		
Apr-10	coastal	0	0	0	0	0	0	0.01	0.00	0.05	2	0.03	76
	offshore	2	2	0.03	81	0.01	0.14				3		
May-10	coastal	0	0		0	0	0	0	0	0	2	0.01	31
	offshore	0	0	0	0	0	0				1		
Jun-10	coastal	1	3	0.03	111	0.00	0.15	0.02	0.00	0.10	0	0.02	39
	offshore	0	0	0	0	0	0				0		
Sep-10	coastal	0	0	0	0	0	0	0	0	0	1	0.00	10
	offshore	0	0	0	0	0	0				0		
Oct-10	coastal	2	2	0.02	84	0.00	0.07	0.01	0.00	0.05	0	0.01	27
	offshore	0	0	0	0	0	0				0		
Nov-10	coastal	1	1	0.01	113	0.00	0.05	0.01	0.00	0.03	0	0.01	13
	offshore	0	0	0	0	0	0				0		

Month-to-month variation in diver occurrence in the Fehmarnbelt was assessed by comparing mean densities of swimming birds recorded during ship-based surveys (and corrected for distance detection bias), as rather consistent spatial coverage has been achieved during these counts. The species were present in the area during the wintering period and transitional months (November – April), and were rarely recorded between May and October (Table 4.3, Figure 4.1).

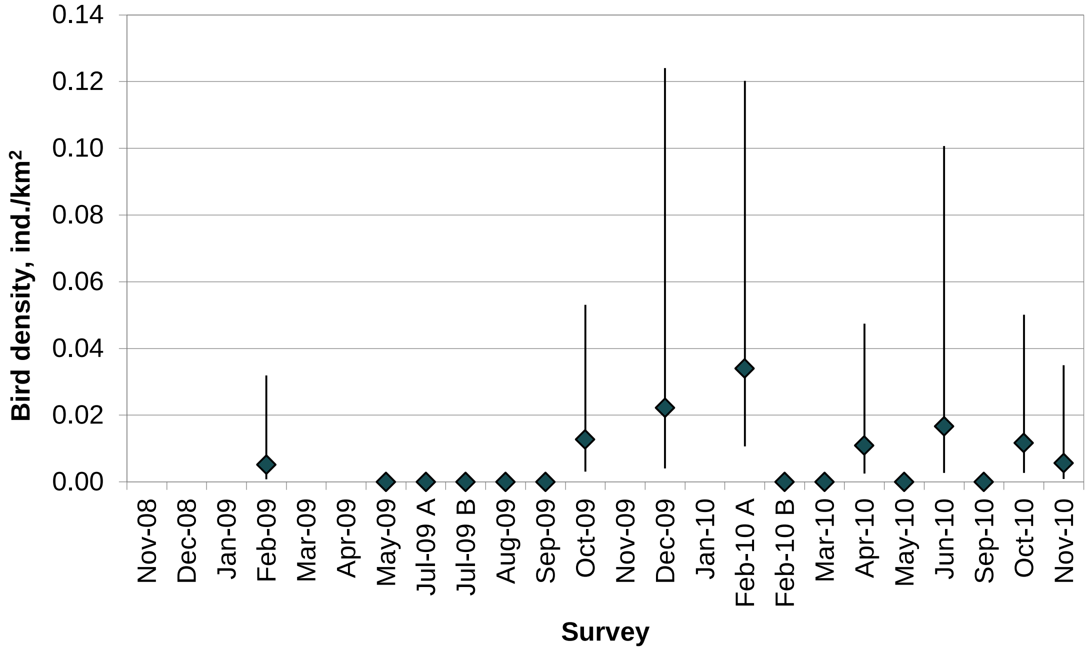


Figure 4.1 *Mean density estimates and 95 % confidence intervals of swimming Red-throated Divers and Black-throated Divers estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150 % were not included into the chart (see Table 4.3 for specific values).*

Diver abundance estimates according to supplementary datasets

Reports from the German aerial waterbird monitoring do not provide total estimates of divers, but present densities for survey bands A and A+D (which are the most proximate to an observer and therefore least biased due to distance detection), which were 0.09 birds/km^2 in winter 2008 and 0.38 birds/km^2 in winter 2009 (BIOLA 2009). These densities of independent surveys fall with the range of diver densities recorded during FEBI baseline investigations (Table 4.2).

The data of the coastal mid-winter waterbird counts on Fehmarn show very few divers: 6 individuals in winter 2008 and 6 in winter 2009 (AKVSW 2010). Coastal counts on German mainland coast also revealed very few diver sightings with a maximum count of 15 Red-throated Divers in November 2009 (OAG 2010).

The aerial surveys of the waterbird monitoring in Denmark report very few diver observations in the Fehmarnbelt area and no density estimates are reported (Petersen et al. 2006, 2010).

Entries in DOF database mainly refer to migrating divers. For marine areas of Hyllekrog and Gedser Odde, reports provide observations of mostly single resting birds. A maximum number of 82 resting divers was reported for Gedser Odde on December 26, 2004 (DOF 2010). The DOF database also indicates that single birds sometimes spend summer in the Fehmarnbelt region.

Distribution and habitat use of divers in the Fehmarnbelt

The FEBI aerial and ship-based surveys showed diver distribution being highly variable among surveys with birds occurring within the entire Fehmarnbelt area. However, the German part of the study area seems to support higher numbers of wintering divers (Appendix II).

Diver distribution and habitat use according to spatial modelling

Distribution models were fitted for the 'winter' period when the divers are present in the Fehmarnbelt region. The 'winter' period was further categorised into four seasons: season 1 (December 2008 – February 2009), season 2 (March – April 2009), season 3 (November 2009 – early March 2010), and season 4 (March – April 2010).

The interaction term XY, representing easting and northing was the most important predictor in the binomial part of the model, indicating that a large part of the variance could not be explained by the environmental variables used in the model (Table 4.4). Several dynamic variables appeared to be significant in determining diver occurrence: water temperature, pycnocline depth, salinity, current speed and northward current speed (current V). Bottom slope was an important predictor of topographic variables, and number of ships was the most important of the variables describing disturbance sources (Table 4.4). Response curves of predictor variables indicated that divers were more likely to occur over steep bottom slopes, increased current speeds and areas of lower salinity. Birds avoided areas close to shipping lanes. Optimum of water temperature of 4 °C most likely is related to the seasonal change in abundance (Figure 4.2A). The categorical variable representing seasons showed that divers were distributed over fewer locations during the winter 2008/2009 (season 1) compared to other seasons (Figure 4.2A).

In the positive part of the model water currents were the most important predictors characterising diver densities (Table 4.4). According to the shapes of variable response curves, diver density was negatively related with an overall current speed, but birds preferred areas of high upwelling activity (current W) and bottom fronts (increasing current gradient, Figure 4.2B). Seasonal patterns indicate that diver densities were higher during the second year of investigations (seasons 3 and 4) compared to the first winter (season 1, Figure 4.2).

The 'winter' distribution model had a relatively poor fit, indicating that other factors than those considered in our models determine bird distribution or perhaps the sample size was insufficient. Deviance explained in the binomial part was 7.2 % and 35.9 % in the positive part (Table 4.4). Diagnostic plots of the positive part can be seen in Appendix III. The accuracy of the predictions of the binomial part according to the AUC equalled 0.73, and the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.12 ($p = 6.3e\text{-}12$). According to Moran's I no significant ($p < 0.01$) spatial autocorrelation was found in the residuals of the presence/absence part nor in the positive part of the model (Appendix III).

The deployed models indicate that wintering divers were widely distributed within the Fehmarnbelt with highest densities occurring in Hohwacht Bay, Mecklenburg Bight, and south of Rødsand Lagoon – Gedser (Figure 4.3, Figure 4.4). It is likely that distribution modelling over-predicted localised diver densities close to the Fehmarnsund Bridge. Comparison between observed and predicted values is presented in Appendix III. The model predicts reduced densities close to the shipping lanes which is in line with previous findings that divers respond at high distance to approaching ships (Bellebaum et al. 2006, Schwemmer et al. 2011). The Fehmarnbelt investigations are, however, the first to show a significant effect on the spatial distribution which indicates an equivalent habitat loss of these species.

Table 4.4 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the 'winter' period for divers in the Fehmarnbelt. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	**Presence/absence**			**Positive part**		
	Z	**X^2**	**P**	**t**	**F**	**P**
Season 2	9.06		<0.01	1.58		0.12
Season 3	14.06		<0.01	4.69		<0.01
Season 4	7.06		<0.01	5.27		<0.01
Depth		-	-		-	-
Proportion hard substrate		-	-		-	-
Bottom slope		36.35	<0.01		-	-
Distance to land		-	-		-	-
Distance to wind farms		-	-		-	-
Number of ships		36.30	<0.01		-	-
Pycnocline depth		122.99	<0.01		-	-
Current gradient (Bottom)		-	-		3.10	0.04
Salinity (Bottom)		69.85	<0.01		-	-
Temperature (Surface)		163.15	<0.01		-	-
Current U (Bottom)		-	-		-	-
Current V (Surface)		31.90	<0.01		-	-
Current W (Surface)		-	-		9.57	<0.01
Vorticity (Surface)		-	-		-	-
Current speed (Surface)		48.34	<0.01		11.12	<0.01
XY		201.17	<0.01		4.24	<0.01
Model performance						
AUC		0.73				
Deviance explained		7.21 %			35.9 %	
Combined correlation (P)			0.12 (p = 6.3e-12)			

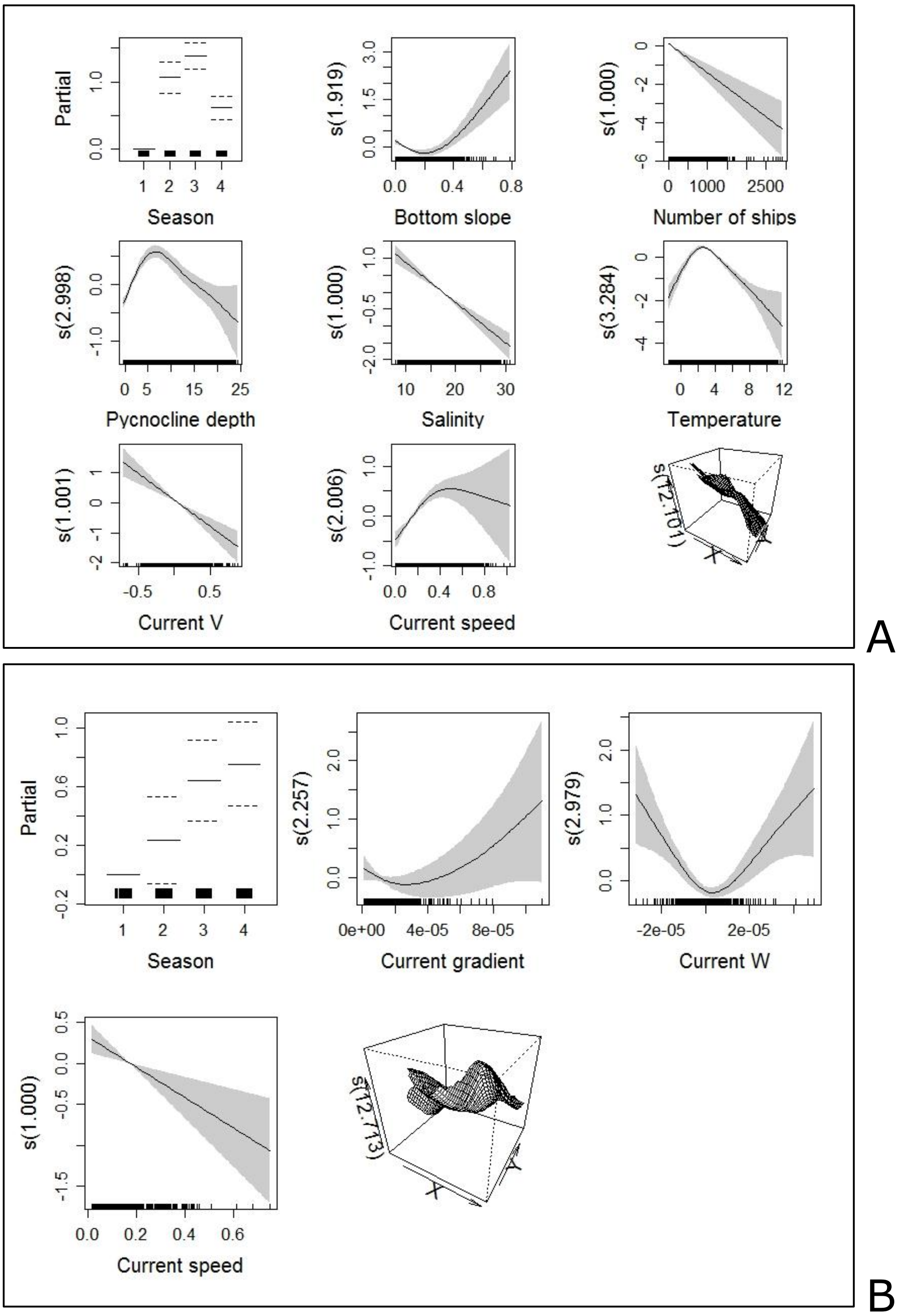


Figure 4.2 *Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of divers (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the winter season. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.*

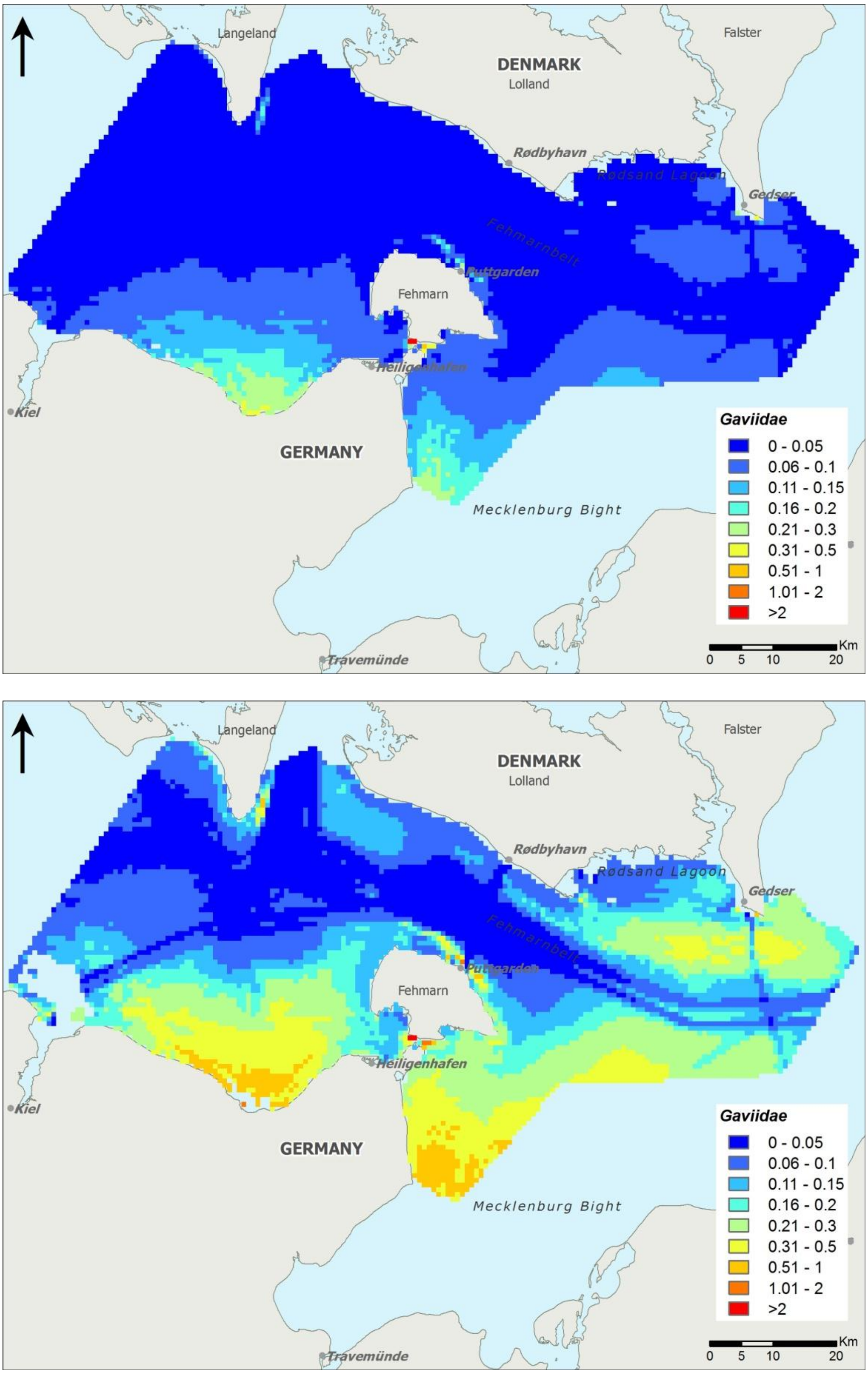


Figure 4.3 *Modelled spatial distribution (numbers per km²) of divers in the Fehmarnbelt based on baseline aerial surveys undertaken between December 2008 and February 2009 (upper map) and March – April 2009 (lower map).*

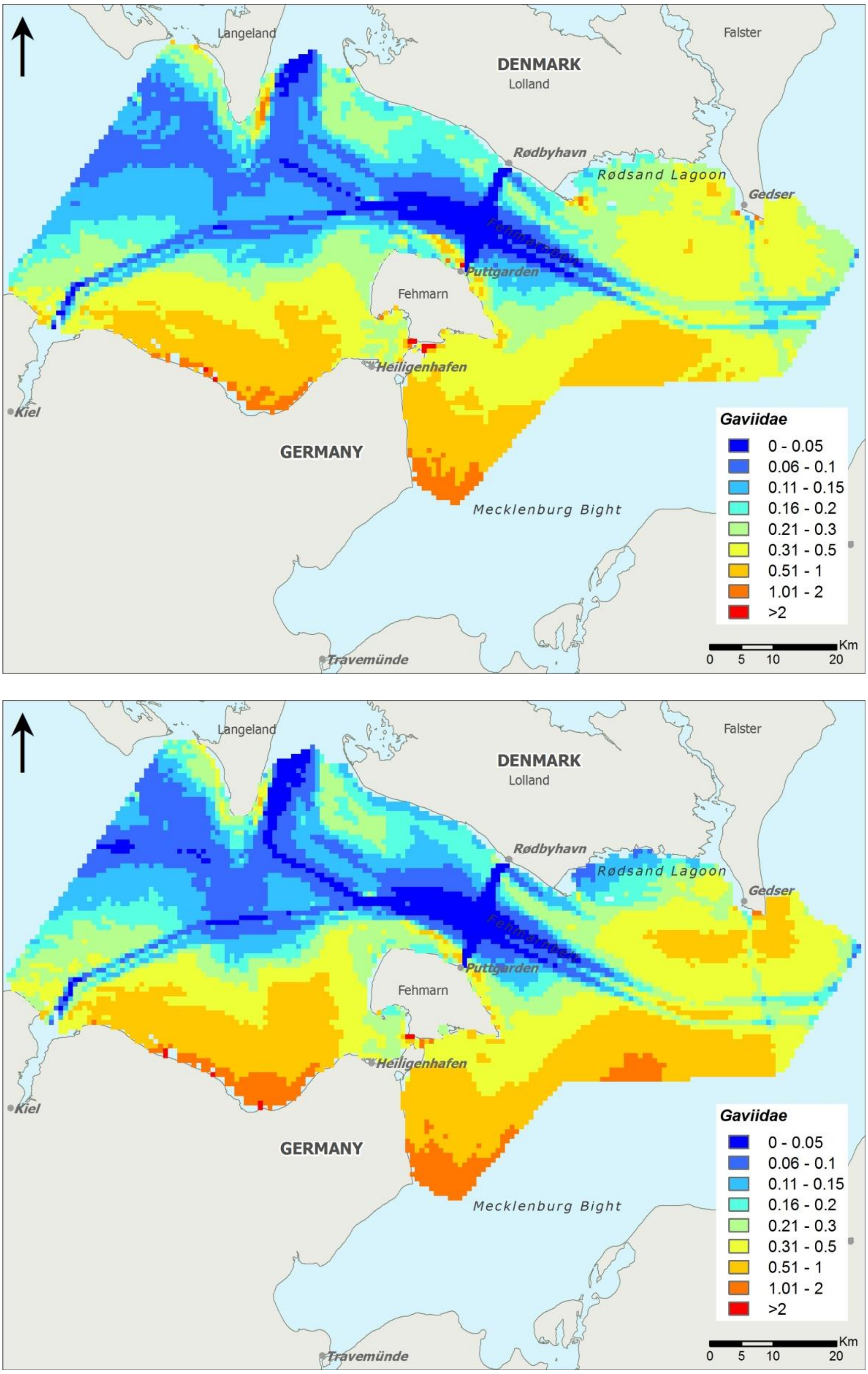


Figure 4.4 *Modelled spatial distribution (numbers per km^2) of divers in the Fehmarnbelt based on baseline aerial surveys undertaken between November 2009 and early March 2010 (upper map) and March – April 2010 (lower map).*

Diver distribution according to supplementary datasets

Although records of divers during the aerial monitoring data from Denmark are scarce, the reports indicated that most of the diver observations occurred in and near Rødsand Lagoon and on Gedser Rev (Petersen et al. 2006, 2010), generally the same areas which FEBI distribution modelling identified as supporting higher concentrations. No diver distribution is presented in the German aerial waterbird monitoring results (BIOLA 2009).

Diver abundance estimates for SPAs

On the basis of the spatial distribution models, the estimates of Red- and Black-throated Diver numbers in the SPA Eastern Kiel Bight ranged between 71 and 374 during winter and spring seasons during the study period (Table 4.5). Estimates ranged between 21 and 257 in the SPA Baltic Sea east of Wagrien, and between 6 and 65 in the SPA Hyllekrog-Rødsand during the same period (Table 4.5).

Further, between 88 and 957 divers have been estimated to occur in the non-SPA area of the Fehmarnbelt. Among these, 6-29 birds were estimated for the area of the immediate vicinity to the planned fixed link (Table 4.5).

The highest estimate of Red- and Black-throated Divers wintering in the entire Fehmarnbelt area reach 1,700 individuals (Table 4.5). It is known that Red-throated Diver is more frequent than Black-throated Diver in the region during wintering period (Mendel et al. 2008; Petersen et al. 2010). FEBI ship-based surveys also indicated that Red-throated Divers comprised 71 % of all identified divers. Therefore assuming that Red-throated Diver dominates the diver numbers in the Fehmarnbelt, it is possible that the area supports up to 0.5 % of the biogeographic population of this species (1 % = 3,000 birds). Because divers are widely dispersed within the area, no particular SPA alone supports numbers of international importance.

The total numbers obtained by the distribution model agree well with estimates of Distance analysis (Table 4.2).

Table 4.5 Seasonal estimates of Red-throated and Black-throated Diver abundance in the SPAs: Eastern Kiel Bight, Baltic Sea east of Wagrien, and Hyllekrog-Rødsand based on the spatial distribution models for the baseline aerial surveys from December 2008 to April 2010. Estimates for the alignment area, total non-SPA area, and total prediction area are also given.

SPA / area	Period	Density	Estimate
Eastern Kiel Bight	Dec 2008 – Feb 2009	0.10	71
(DE1530-491)	Mar – Apr 2009	0.28	191
	Nov 2009 – Mar 2010	0.52	361
	Mar – Apr 2010	0.59	374
Baltic Sea east of Wagrien	Dec 2008 – Feb 2009	0.06	21
(DE1633-491)	Mar – Apr 2009	0.35	130
	Nov 2009 – Mar 2010	0.65	237
	Mar – Apr 2010	0.72	257
Hyllekrog-Rødsand	Dec 2008 – Feb 2009	0.02	6
(DK006X087)	Mar – Apr 2009	0.11	23
	Nov 2009 – Mar 2010	0.30	65
	Mar – Apr 2010	0.23	45
Alignment area	Dec 2008 – Feb 2009	0.03	6
	Mar – Apr 2009	0.08	15
	Nov 2009 – Mar 2010	0.14	29
	Mar – Apr 2010	0.13	26
Non-SPA area (including	Dec 2008 – Feb 2009	0.03	88
the alignment area)	Mar – Apr 2009	0.12	407
	Nov 2009 – Mar 2010	0.24	801
	Mar – Apr 2010	0.28	957
TOTAL	Dec 2008 – Feb 2009	0.05	242
	Mar – Apr 2009	0.16	768
	Nov 2009 – Mar 2010	0.31	1,506
	Mar – Apr 2010	0.36	1,711

Red-throated and Black-throated Diver trends

The biogeographic population of Red-throated Diver was identified as declining and the population of Black-throated Diver as stable by Wetlands International (Wetlands International 2006). European populations of both species are considered as stable by BirdLife International (2004). However, one should consider that a high degree of uncertainty is associated with the population estimates of both species, which would render that changes in population shifts would be very difficult to detect (Wetlands International 2006).

A recent overview of waterbird populations wintering in the Baltic Sea has revealed a substantial decline of divers since 1993 (Skov et al. 2011). However, judged from the baseline estimate for the Fehmarnbelt of up to 1,700 divers (Table 4.5) and the estimates of the historic population size (Durinck et al. 1994), there is no evidence of major changes in the number of divers wintering in the Fehmarnbelt.

Importance of the Fehmarnbelt to Red-throated and Black-throated Divers

Following estimates of FEBI baseline investigations and assuming that the majority of divers wintering in the Fehmarnbelt are Red-throated Divers, wintering numbers would comprise up to 0.5 % of the biogeographic population of the Red-throated Diver. For the Black-throated Diver results of FEBI surveys indicate that wintering numbers in the Fehmarnbelt may exceed 0.1 % of the biogeographic population of the species (1% = 3,750 birds) in some years.

Red-throated Diver / Black-throated Diver – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	1,711
Max. abundance estimate in the alignment area:	29
Period of max. abundance in Fehmarnbelt:	November – April
Areas of max. abundance in Fehmarnbelt:	see Figure 4.3, Figure 4.4
Explanations:	Maximum abundance and distribution obtained from spatial modelling of aerial survey data.

4.1.2 Great Crested Grebe – *Podiceps cristatus*

Great Crested Grebe – *Podiceps cristatus*

Biogeographic population: *P. c. cristatus*, N and W Europe (non-br)

Breeding range: N and W Europe

Wintering / core non-breeding range: inland an coastal in C, W and S Europe (Cramp and Simmons 1977)

Population size: 290,000 – 420,000

1 % value: 3,600

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: non-SPEC
EU Threat Status: secure

Target species in SPAs: -

Key food: fish

Period of presence in Fehmarnbelt: Wintering, migrations: August – mid-April
Breeding: mid-April – July

Origin of Great Crested Grebe in the Fehmarnbelt

The Great Crested Grebe is not a long-distance migrant. The origin of birds wintering in the Fehmarnbelt has not been documented as there are no recoveries of birds ringed abroad. It is assumed that Great Crested Grebes breeding in northern and Eastern Europe spend the non-breeding period in Danish waters (Bønløkke et al. 2006).

Data sources on Great Crested Grebes in the Fehmarnbelt

Numbers and distribution of Great Crested Grebes are best reflected in FEBI ship-based survey data. The species is often misidentified or overlooked during the aerial surveys; therefore this dataset was not used in the analyses (Table 4.6).

Table 4.6 List of datasets and their use in baseline assessment of Great Crested Grebe in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Not used in analyses of this species
FEBI ship transect surveys	Primary dataset for evaluating species distribution, abundance, seasonal variability in abundance, and habitat use.
AKVSW land-based counts	Supporting dataset representing species distribution along the Fehmarn coast.
OAG land-based counts	Supporting dataset representing species distribution along the German mainland coast.
NOVANA surveys	Supporting dataset for densities and distribution of the species in the Danish part of the Fehmarnbelt
DOF database	Supporting dataset representing species abundance in the Danish part of the Fehmarnbelt

Abundance of Great Crested Grebes in the Fehmarnbelt

Great Crested Grebe abundance estimates based on Distance analysis

The abundance of Great Crested Grebe in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly ship-based survey data. The ESW for Great Crested Grebe during ship-based surveys, estimated for the entire dataset, was 204 m. Estimated densities for wintering Great Crested Grebes ranged between 0.2 and 0.7 birds/km² (Table 4.7). Total numbers in the area covered by ship-based surveys ranged from about 600 to over 1,500 individuals during winter months (Table 4.7).

Table 4.7 Numbers of observed Great Crested Grebes during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km^2 covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	31	39	0.40	33	0.21	0.76	0.25	0.13	0.48	1	0.26	611
	offshore	0	0	0	0	0	0				1		
Dec-08	coastal	18	26	0.30	36	0.15	0.60	0.20	0.09	0.47	9	0.26	601
	offshore	2	2	0.04	101	0.01	0.26				1		
Jan-09	coastal	39	52	0.55	30	0.31	1.01	0.40	0.21	0.79	8	0.44	1,030
	offshore	5	6	0.10	68	0.03	0.35				1		
Feb-09	coastal	4	5	-	***	-	-	-	-	-	2	-	-
	offshore	10	16	-	918	-	-				0		
Mar-09	coastal	43	59	0.54	35	0.27	1.05	-	-	-	0	-	-
	offshore	6	7	-	***	-	-				2		
Apr-09	coastal	5	7	0.07	53	0.03	0.20	0.06	0.02	0.20	1	0.06	150
	offshore	2	2	0.04	103	0.01	0.22				0		
May-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jul-09A	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jul-09B	coastal	1	1	0.01	102	0.00	0.06	0.01	0.00	0.04	0	0.01	16
	offshore	0	0	0	0	0	0				0		
Aug-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Oct-09	coastal	7	9	-	597	-	-	-	-	-	1	-	-
	offshore	0	0	0	0	0	0				0		
Nov-09	coastal	1	1	0.01	102	0.00	0.06	0.01	0.00	0.07	0	0.01	31
	offshore	1	1	0.02	95	0.00	0.10				0		

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	**Stratum**	**N obs**	**N birds**	**D**	**%CV**	**LCI**	**UCI**	**D**	**LCI**	**UCI**	**N flying**	**D**	**Total number**
Dec-09	coastal	1	1	0.01	103	0.00	0.06	0.02	0.00	0.11	0	0.02	45
	offshore	2	2	0.04	100	0.01	0.20				0		
Jan-10	coastal	23	29	0.30	45	0.13	0.72	0.35	0.16	0.76	0	0.35	821
	offshore	22	25	0.44	32	0.23	0.83				0		
Feb-10A	coastal	56	69	0.63	23	0.40	0.99	0.52	0.32	0.86	4	0.54	1,271
	offshore	15	16	0.32	30	0.17	0.59				1		
Feb-10B	coastal	37	67	0.59	38	0.28	1.21	0.59	0.31	1.16	12	0.66	1,536
	offshore	28	33	0.60	27	0.35	1.05				3		
Mar-10	coastal	44	49	0.44	30	0.24	0.80	0.40	0.20	0.80	6	0.43	997
	offshore	15	19	0.30	50	0.12	0.80				1		
Apr-10	coastal	3	5	-	***	-	-	-	-	-	0	-	-
	offshore	0	0	0	0	0	0				0		
May-10	coastal	1	2	0.02	106	0.00	0.11	0.01	0.00	0.08	1	0.02	41
	offshore	0	0	0	0	0	0				0		
Jun-10	coastal	1	1	0.01	102	0.00	0.05	0.02	0.00	0.11	0	0.02	45
	offshore	1	2	0.04	100	0.01	0.21				0		
Sep-10	coastal	1	1	0.01	104	0.00	0.05	0.01	0.00	0.04	0	0.01	15
	offshore	0	0	0	0	0	0				0		
Oct-10	coastal	2	2	0.02	69	0.01	0.07	0.03	0.01	0.12	0	0.03	62
	offshore	1	2	0.04	103	0.01	0.22				0		
Nov-10	coastal	9	17	-	***	-	-	-	-	-	2	-	-
	offshore	0	0	0	0	0	0				0		

Month-to-month variation in Great Crested Grebe occurrence in the Fehmarnbelt was assessed by comparing mean densities of swimming birds recorded during ship-based surveys (and corrected for distance detection bias), as rather consistent spatial coverage has been achieved during these counts. The species was present in the area all year, but highest densities were observed during the bird wintering period (October – April). Densities between May and October were very low (Table 4.7, Figure 4.5).

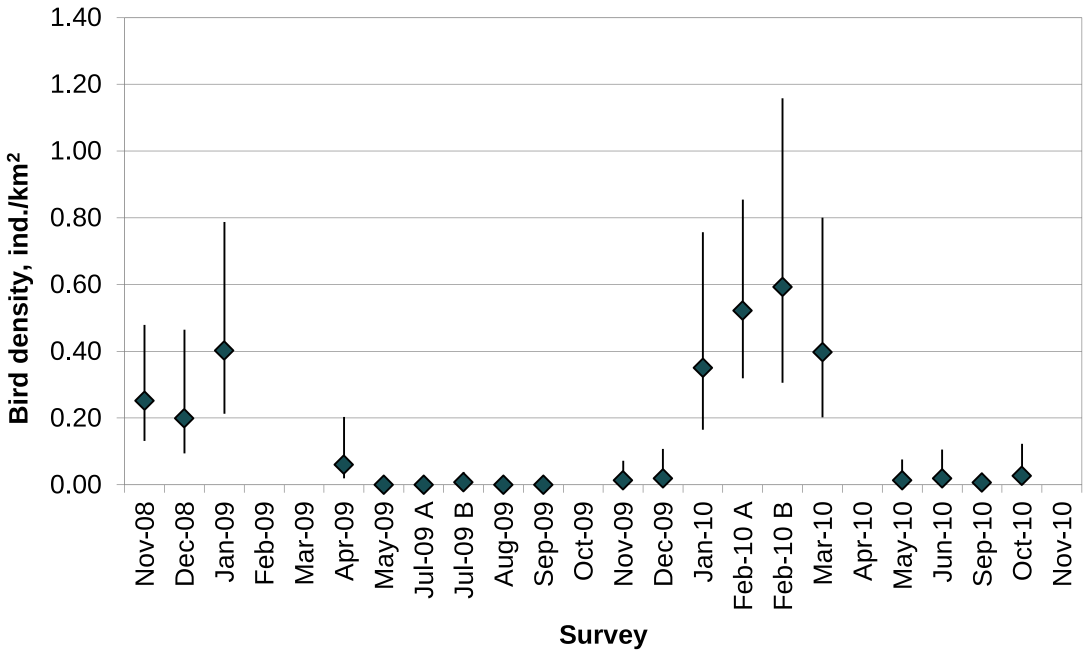


Figure 4.5 Mean density estimates and 95 % confidence intervals of swimming Great Crested Grebes estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 200 were not included into the chart (see Table 4.7 for specific values).

Great Crested Grebe abundance estimates according to supplementary datasets

Aerial surveys often do not allow identifying grebes to a species level. The German aerial waterbird monitoring surveys, however, provide results for the Great Crested Grebe (BIOLA 2009). The authors of the report (BIOLA 2009) present densities for survey bands A and A+D (which are the most proximate to an observer and therefore least biased due to distance detection), which were 0.39 birds/km^2 in winter 2008 and 0.75 birds/km^2 in winter 2009 (BIOLA 2009). These densities fall within the range of Great Crested Grebe densities recorded during FEBI baseline investigations (Table 4.7).

The dataset of land-based surveys along the German mainland coast indicates that the highest numbers of Great Crested Grebes occur in the study area in autumn (Figure 4.6; OAG 2010). This is in accordance with Great Crested Grebe phenology described for Fehmarn and the western German Baltic Sea, respectively (Berndt et al. 2005, Mendel et al. 2008).

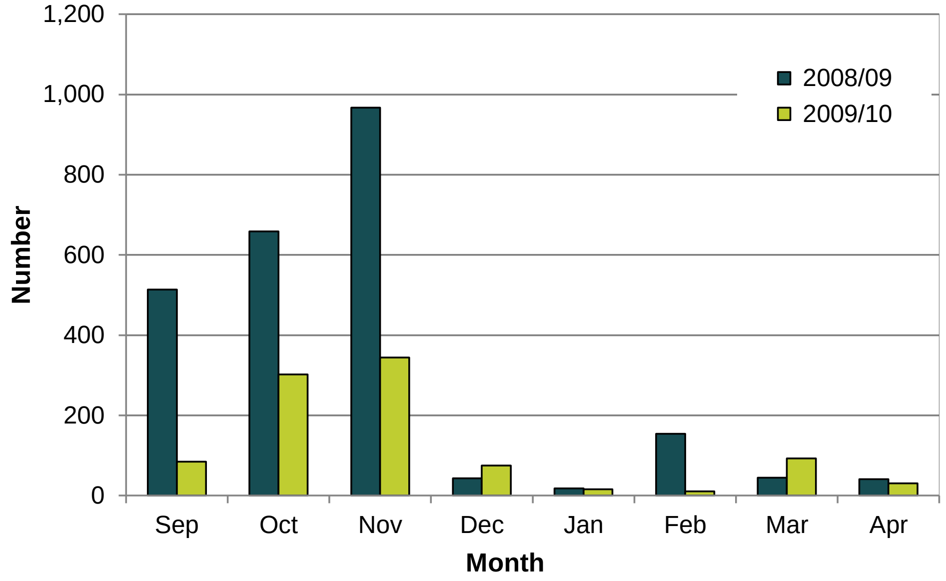


Figure 4.6 Number of Great Crested Grebes recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

The coastal mid-winter waterbird count on Fehmarn and the German mainland coast report 297 Great Crested Grebes in January 2009 (AKVSW 2010, OAG 2010), among which the majority of birds was observed in coastal waters north of Fehmarn. High numbers of Great Crested Grebes were recorded during some periods of monthly German mainland coastal counts, e.g. 1,075 birds were counted in October 2008 (of which 800 were counted resting on the inland lake Großer Binnensee; OAG 2010). The largest aggregation of Great Crested Grebes in marine waters consisted of 570 birds recorded in Hohwacht Bay in October 2007 (OAG 2010).

Very few Great Crested Grebes were recorded in the Fehmarnbelt during aerial surveys of waterbird monitoring in Denmark, and estimates are not available (Petersen et al. 2006, 2010).

According to DOF database, numbers of this species rarely exceed 100 birds in Rødsand Lagoon (DOF 2010).

Distribution and habitat use of Great Crested Grebes in the Fehmarnbelt

Great Crested Grebe distribution and habitat use according to spatial modelling

Inspection of Great Crested Grebe observations (Appendix II) has led to *a priori* conclusion that this species exhibited different distribution patterns during the two wintering seasons included in this study. Therefore a decision was made to model species distribution separately for both seasons rather than in one model like for the majority of other species. Distribution models were fitted for the wintering period when Great Crested Grebes are most numerous in the Fehmarnbelt region.

Great Crested Grebe distribution model for winter 2008/2009

The interaction term XY, representing easting and northing was the most important predictor in the binomial part of the model for the first winter season, indicating that a large part of the variance could not be explained by the environmental variables used in the model (Table 4.8). Water temperature, bottom slope and eddy activity (vorticity) were also significant in the binomial part. The response curves indicate that the Great Crested Grebes were more likely to occur in areas with bottom temperature between 3-6°C, at steeper bottom slopes and in areas of positive vorticity (Table 4.8, Figure 4.7A).

The positive part of the first winter model further explained the relationships of bird densities to the environmental variables. Hydrodynamic variables characterising currents were important and indicated higher densities at areas of upwelling (positive current W) and generally lower current speeds (Table 4.8, Figure 4.7B). Relationship to depth indicated that bird densities were decreasing rapidly with increasing water depth. Great Crested Grebes also showed preference to waters of lower salinity. Variables representing shipping traffic and water temperature were of low significance (Table 4.8, Figure 4.7B).

The distribution model for the winter season of 2008/2009 had generally a good fit: deviance explained in the binomial part was 33.5 % and 28 % in the positive part (Table 4.8), the area under receiver operator curve (AUC) equalled 0.83, the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.37. According to Moran's I significant ($p < 0.01$) spatial autocorrelation was found only in the first lag of the residuals of the presence/absence part of the model and no significant autocorrelation was detected in the positive part of the model (Appendix III).

The model deployed shows that wintering Great Crested Grebes occurred in highest densities along the northern and eastern coasts of Fehmarn, Fehmarnsund and Sagasbank (Figure 4.9). Along the Danish coast higher densities of this species only occurred in a discrete area along the south-western coast of Lolland (Figure 4.9). Further, there were noticeable Great Crested Grebe aggregations along zones with steep bottom slope. The estimated zones of higher densities (> 1 bird/km^2) along the north coast of Fehmarn extended to a distance of 1 km from Puttgarden.

Great Crested Grebe distribution model for winter 2009/2010

Similar to the model for the first wintering season, the interaction term XY representing easting and northing was the most important predictor in the binomial part of the model suggesting that a large part of the variance could not be explained by the environmental variables used in the model (Table 4.8). Depth, water temperature, distance to land and current speed were other variables that were significant in the binomial part. The response curves indicate that the Great Crested Grebes were more likely to occur in areas with deep waters of 15-25 meters, higher water temperature, farther away from land and in slack currents (Table 4.9, Figure 4.8A).

The positive part of the second winter model suggested that Great Crested Grebe densities were dependent upon water temperature, salinity, pycnocline depth, current U, current V, and the current speed (Table 4.9). Grebe densities were increasing with declining temperature, increasing salinity, increasing pycnocline depth, and slower current speeds (Table 4.9, Figure 4.8B).

The distribution model for the winter season of 2009/2010 had a moderate fit: deviance explained in the binomial part was 17 % and 41.9 % in the positive part (Table 4.8), the area under receiver operator curve (AUC) equalled 0.71, the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.34. According to Moran's I no significant ($p < 0.01$) spatial autocorrelation was found in the presence/absence nor the positive part of the model (Appendix III).

The model deployed shows that Great Crested Grebe distribution in winter 2009/2010 was substantially different compared to the previous winter. The majority of birds occurred offshore and in the western part of the Fehmarnbelt (Figure 4.10). Higher densities were not estimated for the areas in the vicinity of the planned alignment. Such distribution was most likely shaped by sea ice formation in the severe winter of 2009/2010, when ice locked all coastal areas and also offshore waters east of Fehmarn. Similar dislocation of Great Crested Grebes during cold winter conditions were recorded in 1986/87 (Laursen et al. 1997).

Table 4.8 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the first 'winter' period (2008/2009) for Great Crested Grebe in the Fehmarnbelt. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	Presence/absence			Positive part		
	Z	X^2	P	t	F	P
Depth		-	-		5.61	<0.01
Proportion hard substrate		-	-		-	-
Bottom slope		25.86	<0.01		-	-
Distance to land		-	-		-	-
Distance to wind farms		-	-		-	-
Number of ships		-	-		2.82	0.10
Pycnocline depth		-	-		-	-
Current gradient (Surface)		-	-		-	-
Salinity (Bottom)		-	-		4.34	0.02
Temperature (Bottom)		43.79	<0.01		2.88	0.09
Current U (Bottom)		-	-		-	-
Current V (Bottom)		-	-		-	-
Current W (Bottom)		-	-		5.13	0.03
Vorticity (Bottom)		17.65	<0.01		-	-
Current speed (Surface)		-	-		3.29	0.07
XY		95.60	<0.01		-	-
Model performance						
AUC	0.83					
Deviance explained	33.5 %				28.0 %	
Correlation (combined)			0.37			

Table 4.9 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the second 'winter' period (2009/2010) for Great Crested Grebe in the Fehmarnbelt. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	**Presence/absence**			**Positive part**		
	Z	**X^2**	**P**	**t**	**F**	**P**
Depth		32.42	<0.01		-	-
Proportion hard substrate		-	-		-	-
Bottom slope		-	-		-	-
Distance to land		7.61	0.08		-	-
Distance to wind farms		-	-		-	-
Number of ships		-	-		-	-
Pycnocline depth		-	-		8.44	<0.01
Current gradient (Surface)		-	-		-	-
Salinity (Surface)		-	-		11.31	<0.01
Temperature (Bottom)		12.87	<0.01		15.12	<0.01
Current U (Surface)		-	-		19.49	<0.01
Current V (Surface)		-	-		6.90	<0.01
Current W (Surface)		-	-		-	-
Vorticity (Surface)		-	-		-	-
Current speed (Surface)		10.60	<0.01		4.65	<0.01
XY		44.23	<0.01		-	-
Model performance						
AUC	0.71					
Deviance explained	17 %			41.9 %		
Correlation (combined)			0.34			

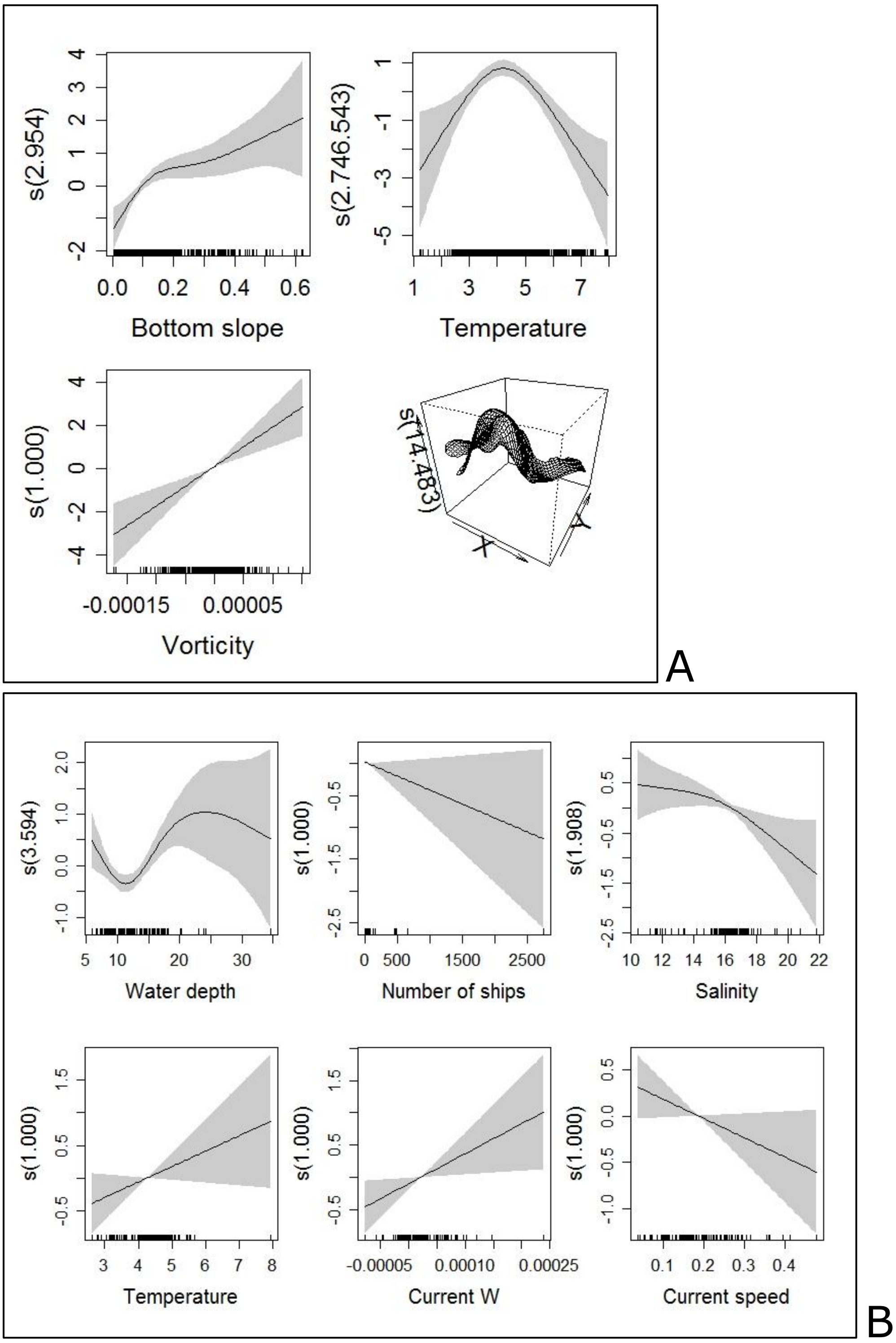


Figure 4.7 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Great Crested Grebe (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the first winter season (2008/2009). The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.

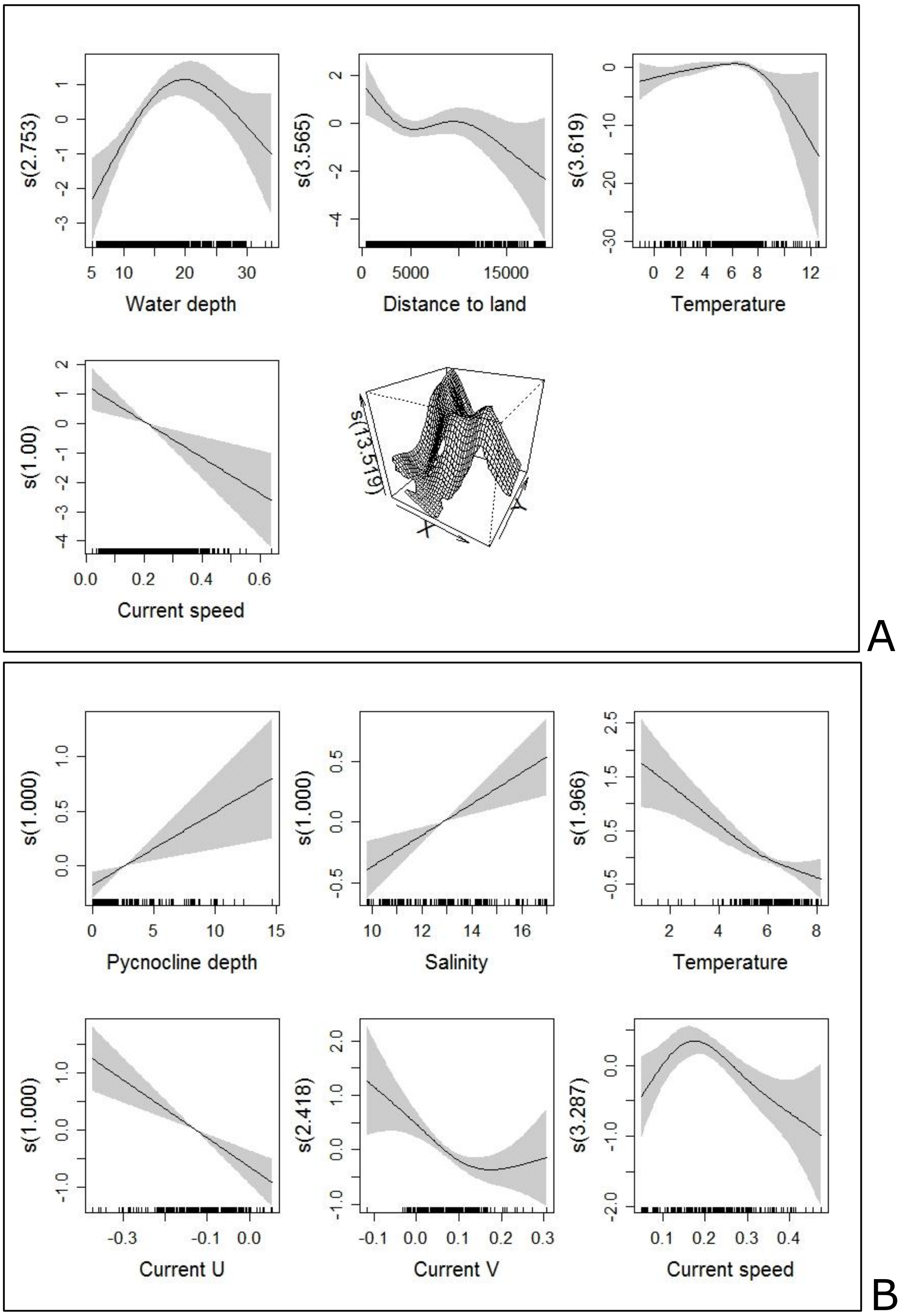


Figure 4.8 *Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Great Crested Grebe (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the second winter season (2009/2010). The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.*

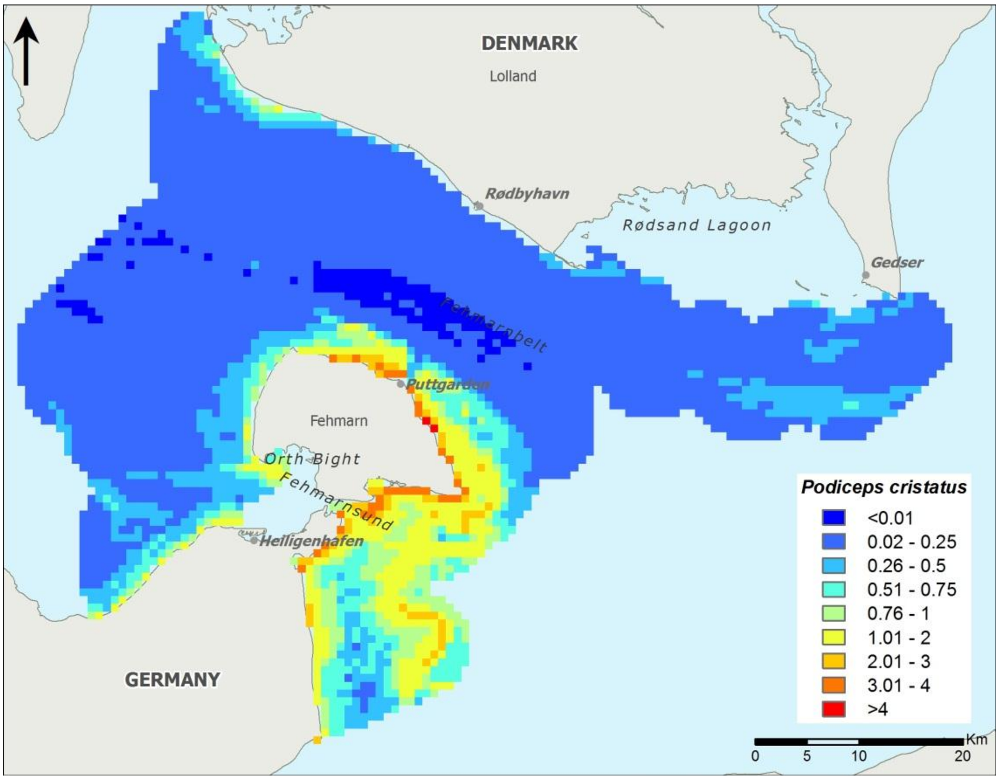


Figure 4.9 *Modelled spatial distribution (numbers per km^2) of Great Crested Grebe* Podiceps cristatus *in the Fehmarnbelt based on baseline ship-based surveys undertaken between November 2008 and March 2009.*

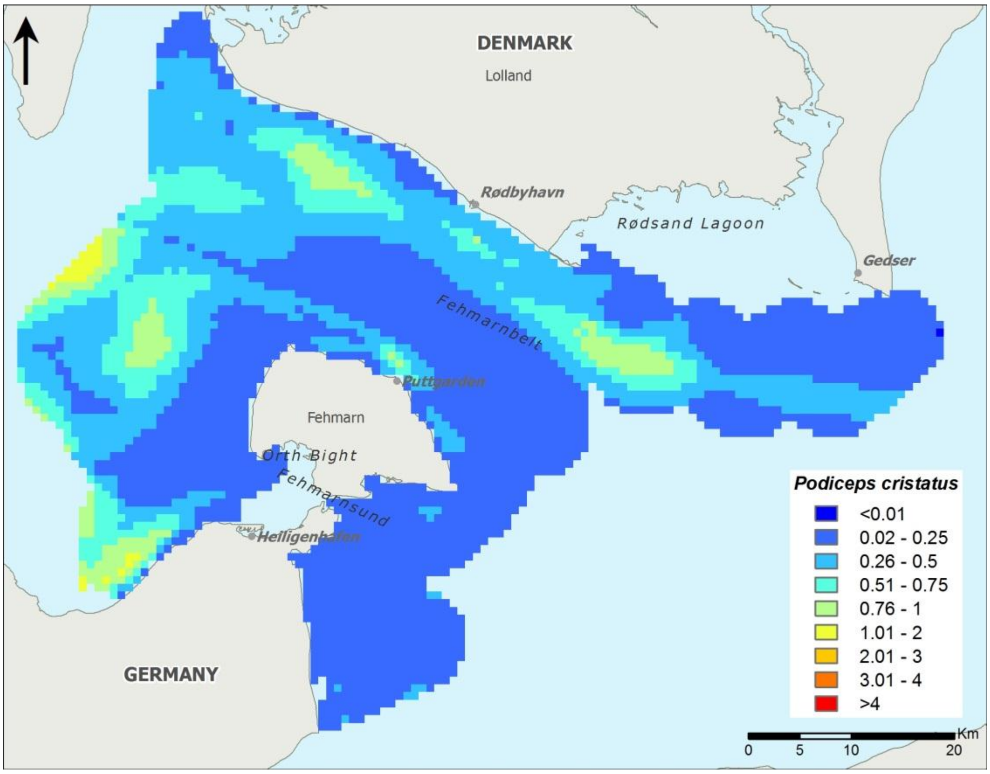


Figure 4.10 *Modelled spatial distribution (numbers per km^2) of Great Crested Grebe* Podiceps cristatus *in the Fehmarnbelt based on baseline ship-based surveys undertaken between October 2009 and March 2010.*

Great Crested Grebe distribution according to supplementary datasets
Because separation of grebe species is generally difficult from aerial surveys, the aerial monitoring data from Germany and Denmark provide only limited information about the distribution and numbers of Great Crested Grebes in the Fehmarnbelt (Petersen et al. 2006, 2010, BIOLA 2009). Results from coastal counts in Germany revealed highest aggregations along the northern coast of Fehmarn (Figure 4.11; AKVSW 2010, OAG 2010).

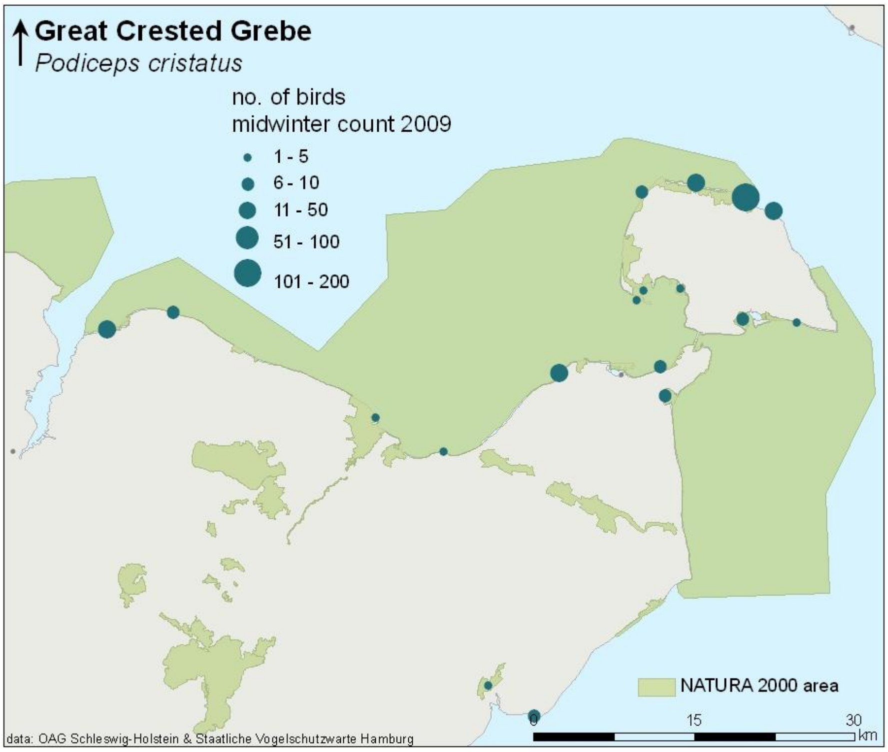


Figure 4.11 Distribution of Great Crested Grebe during winter coastal survey in January 2009 between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt; data: OAG Schleswig-Holstein and AKVSW Hamburg.

Great Crested Grebe abundance estimates for SPAs
On the basis of the spatial distribution models, the numbers of Great Crested Grebes were estimated for ship-covered areas of the two SPAs: Eastern Kiel Bight and Baltic Sea east of Wagrien (Table 4.10). Only a small fraction of SPA Hyllekrog-Rødsand was covered by ship-based surveys. Therefore abundance estimates for this SPA were not possible. The estimate of wintering numbers in the SPA Eastern Kiel Bight was 144 and 142 birds, and 361 and 39 for the SPA Baltic Sea east of Wagrien in winters 2008/2009 and 2009/2010 respectively. These should be considered as minimum estimates of wintering grebes, as ship-based surveys did not cover the SPA areas in full and the estimate is provided only for areas covered.

The total estimate of the number of Great Crested Grebes wintering in the Fehmarnbelt area covered by ship-based surveys was 756 for winter 2008/2009 and 662 for the winter 2009/2010 (Table 4.10, Appendix III). Thus the modelled densities during the second winter seem to be slightly underestimated as compared to the figures obtained for separate surveys using Distance analysis (Table 4.7).

Table 4.10. Seasonal estimates of Great Crested Grebe abundance in the SPAs: Eastern Kiel Bight and Baltic Sea east of Wagrien based on the spatial distribution models for the baseline ship-based surveys in winters 2008/2009 and 2009/2010. Residual and total estimates based on the spatial distribution models are also given.

SPA / area	Period	Density	Estimate
Eastern Kiel Bight	Nov 2008 – Mar 2009	0.32	144
(DE1530-491)	Nov 2009 – Mar 2010	0.30	142
Baltic Sea east of Wagrien	Nov 2008 – Mar 2009	1.12	361
(DE1633-491)	Nov 2009 – Mar 2010	0.04	39
Alignment area	Nov 2008 – Mar 2009	0.35	75
	Nov 2009 – Mar 2010	0.18	51
Non-SPA area (including	Nov 2008 – Mar 2009	0.16	251
the alignment area)	Nov 2009 – Mar 2010	0.37	481
TOTAL	Nov 2008 – Mar 2009	0.33	756
	Nov 2009 – Mar 2010	0.31	662

The external datasets indicate that peak numbers occurring in the area exceed model based estimates presented in Table 4.10. Land-based counts along the mainland coast of the Kiel Bight by OAG Schleswig-Holstein suggest that for the SPA Eastern Kiel Bight (including inland freshwater habitats of the SPA) numbers exceeding 1,000 birds occur in coastal areas alone (OAG 2010).

Great Crested Grebe trends

The biogeographic population of Great Crested Grebe was identified as declining by Wetlands International (2006). BirdLife International suggested that the European breeding population was moderately declining and the wintering population was moderately increasing (BirdLife International 2004).

Durinck et al. (1994) reported an estimated 970 Great Crested Grebes for the Fehmarnbelt area which is in line with FEBI baseline estimates. Fehmarn Belt Feasibility Study suggests an average estimate of 400 Great Crested Grebes wintering during 1987-1995, with numbers peaking up to 1,830 in December 1996 (Skov et al. 1998). Therefore, there is no evidence of major changes in abundance of Great Crested Grebes wintering in the Fehmarnbelt over the last decades.

Importance of the Fehmarnbelt to Great Crested Grebe

Following estimates of FEBI baseline investigations, about 0.3 % of the biogeographic population of Great Crested Grebe winters in the Fehmarnbelt, although this proportion may be slightly higher during cold winters. Supplementary datasets indicate that during autumn migration higher numbers occur in coastal areas, especially of Hohwacht Bay (SPA Eastern Kiel Bight). However, there is no indication that internationally important concentrations of this species use the Fehmarnbelt area on a regular basis.

Great Crested Grebe – summary of information for EIA

Max. abundance estimate in Fehmarnbelt:	1,540
Max. abundance estimate in the alignment area:	225
Period of max. abundance in Fehmarnbelt:	October – April
Areas of max. abundance in Fehmarnbelt:	see Figure 4.9, Figure 4.10
Explanations:	Maximum abundance represents Distance analysis estimate for ship-based survey of January 2009. Maximum abundance in the alignment area represents number of individuals actually counted in the German part of this area during land-based mid-winter survey of 2009.

4.1.3 Red-necked Grebe – *Podiceps grisegena*

Red-necked Grebe – *Podiceps grisegena*

Biogeographic population: *P. g. grisegena*, NW Europe (non-br)

Breeding range: E Europe

Wintering / core non-breeding range: Coastal NW Europe

Population size: 42,000 – 60,000

1 % value: 510

Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC EU Threat Status: secure
Target species in SPAs:	-

Key food: invertebrates, also fish

Period of presence in Fehmarnbelt:	Wintering, migrations: August – April Breeding: May – July

Origin of Red-necked Grebe in the Fehmarnbelt

The main wintering area of the Nordic populations is located along the southern coast of the Baltic Sea (in mild winters), making the Fehmarnbelt a potentially important area for these populations. Ring recoveries in Danish waters during winter origin from Finland and Germany, and indicate that populations from a wide area use this area during the non-breeding periods (Bønløkke et al. 2006).

Data sources on Red-necked Grebe in the Fehmarnbelt

Numbers and distributions of Red-necked Grebes are best reflected in the ship-based survey data. The species is difficult to distinguish from other grebe species and can be overlooked during aerial surveys, therefore this dataset was not considered in the analyses (Table 4.11). Danish and German mid-winter surveys as well as land-based survey datasets were used as supplementary information sources in the assessment (Table 4.11).

Table 4.11 List of datasets and their use in baseline assessment of Red-necked Grebe in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Not used in analyses of this species
FEBI ship transect surveys	Primary dataset for evaluating species distribution, abundance, seasonal variability in abundance, and habitat use.
AKVSW land-based counts	Supporting dataset representing species distribution along the Fehmarn coast
OAG land-based counts	Supporting dataset representing species distribution along the German mainland coast.
NOVANA aerial surveys	Supporting dataset for densities and distribution of the species in the Danish part of the Fehmarnbelt
DOF database	Supporting dataset representing species abundance in the Danish part of the Fehmarnbelt

Abundance of Red-necked Grebe in the Fehmarnbelt

Red-necked Grebe abundance estimates based on Distance analysis

The abundance of Red-necked Grebe in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly ship-based survey data. The ESW for Red-necked Grebe during ship-based surveys, estimated for the entire dataset, was 190 m and thus slightly lower than the ESW for the Great Crested Grebe. Estimated densities for wintering Red-necked Grebes were highly variable and ranged between 0 and almost 0.5 birds/km² (Table 4.12). Reflecting estimated densities, total numbers in the area covered by ship-based surveys ranged from no birds to almost 1,100 individuals during winter months (Table 4.12).

Table 4.12 Numbers of observed Red-necked Grebes during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km² covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	42	56	0.68	32	0.36	1.28	0.43	0.23	0.85	5	0.46	1,070
	offshore	1	1	0.02	102	0.00	0.11				0		
Dec-08	coastal	31	48	0.72	43	0.32	1.65	0.44	0.19	1.01	5	0.47	1,095
	offshore	0	0	0	0	0	0				0		
Jan-09	coastal	39	43	0.42	25	0.26	0.69	0.29	0.17	0.50	0	0.30	695
	offshore	1	1	0.02	104	0.00	0.11				2		
Feb-09	coastal	44	56	0.46	21	0.30	0.69	0.33	0.21	0.53	0	0.33	782
	offshore	5	5	0.10	45	0.04	0.23				0		
Mar-09	coastal	31	35	0.35	31	0.19	0.64	0.24	0.13	0.46	1	0.25	581
	offshore	1	1	0.02	97	0.00	0.11				1		
Apr-09	coastal	32	41	0.38	28	0.22	0.66	0.25	0.14	0.44	5	0.27	633
	offshore	0	0	0	0	0	0				0		
May-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jul-09A	coastal	3	7	0.06	77	0.00	3.65	0.05	0.00	2.45	0	0.05	127
	offshore	1	2	0.04	101	0.01	0.22				0		
Jul-09B	coastal	1	1	0.01	99	0.00	0.07	0.01	0.00	0.04	0	0.01	29
	offshore	0	0	0	0	0	0				1		
Aug-09	coastal	12	18	0.13	54	0.05	0.35	0.08	0.03	0.23	0	0.08	198
	offshore	0	0	0	0	0	0				0		
Sep-09	coastal	7	8	0.07	46	0.03	0.17	0.05	0.02	0.11	1	0.05	121
	offshore	0	0	0	0	0	0				0		
Oct-09	coastal	11	14	0.15	65	0.05	0.49	0.11	0.03	0.37	2	0.12	290
	offshore	0	0	0	0	0	0				0		
Nov-09	coastal	28	38	0.46	32	0.25	0.86	0.31	0.16	0.60	10	0.35	821
	offshore	1	1	0.02	97	0.00	0.11				0		

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Dec-09	coastal	10	12	0.10	38	0.05	0.21	0.07	0.03	0.14	1	0.07	164
	offshore	0	0	0	0	0	0				0		
Jan-10	coastal	3	4	0.03	81	0.01	0.14	0.04	0.01	0.15	0	0.04	96
	offshore	3	3	0.06	55	0.02	0.16				0		
Feb-10A	coastal	16	20	0.19	41	0.09	0.42	0.13	0.06	0.31	0	0.13	305
	offshore	1	1	0.02	101	0.00	0.10				0		
Feb-10B	coastal	3	3	0.03	54	0.01	0.08	0.03	0.01	0.09	0	0.03	61
	offshore	1	1	0.02	98	0.00	0.11				0		
Mar-10	coastal	38	46	0.41	28	0.23	0.71	-	-	-	1	-	-
	offshore	6	7	-	***	-	-				3		
Apr-10	coastal	5	7	-	504	-	-	-	-	-	1	-	-
	offshore	0	0	0	0	0	0				0		
May-10	coastal	2	4	0.04	70	0.01	0.14	0.03	0.01	0.09	0	0.03	62
	offshore	0	0	0	0	0	0				0		
Jun-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-10	coastal	2	2	0.02	72	0.01	0.08	0.01	0.00	0.05	0	0.01	32
	offshore	0	0	0	0	0	0				0		
Oct-10	coastal	7	12	0.09	49	0.03	0.22	0.06	0.02	0.15	0	0.06	136
	offshore	0	0	0	0	0	0				0		
Nov-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		

Month-to-month variation in Red-necked Grebe occurrence in the Fehmarnbelt was assessed by plotting mean densities of swimming birds recorded during ship-based surveys (and corrected for distance detection bias. The species was present in the area all year, but highest densities were observed during the wintering period (October – April). Densities between May and October were very low (Table 4.12, Figure 4.12).

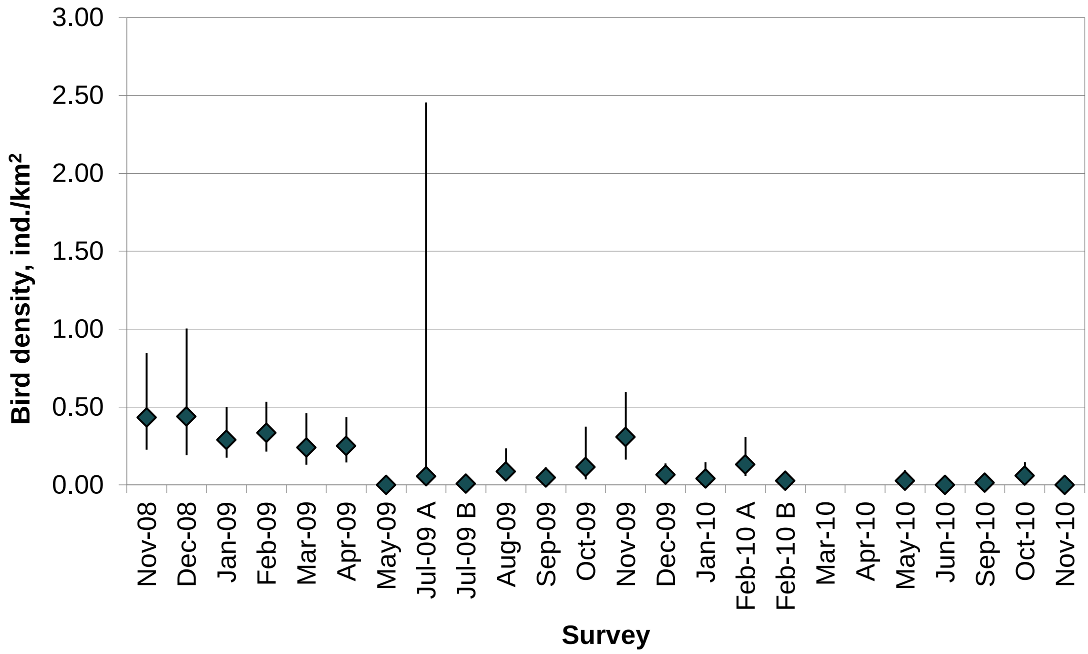


Figure 4.12 Mean density estimates and 95 % confidence intervals of swimming Red-necked Grebes estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation substantially exceeded 200 were not included into the chart (see Table 4.12 for specific values).

Red-necked Grebe abundance estimates according to supplementary datasets

The coastal mid-winter waterbird counts on Fehmarn report very few Red-necked Grebes in the study area with 14 birds in January 2008, and 11 in January 2009 (AKVSW 2010). Similar low numbers are reported by German mainland coastal counts (OAG 2010). Comparably low sighting rates of this species from land could be explained by its preference of offshore habitats (Berndt et al. 2005).

Very few Red-necked Grebes were recorded in the Fehmarnbelt during aerial surveys of waterbird monitoring in Denmark, and estimates are not available (Petersen et al. 2006, 2010).

The DOF database does not indicate greater Red-necked Grebe aggregations occurring in the coastal areas of the Danish Fehmarnbelt (DOF 2010). Numbers up to 30 birds were reported mainly for Rødsand Lagoon during summer period (DOF 2010), and only single birds were observed in winter period (DOF 2010).

Distribution and habitat use of Red-necked Grebes in the Fehmarnbelt

Red-necked Grebe distribution and habitat use according to spatial modelling

Distribution modelling was applied for wintering and moulting periods. The model contained 3 categories representing different seasons: season 1 (November 2008 – April 2009), season 2 (August – September 2009), and season 3 (October 2009 – April 2010).

The interaction term XY, representing easting and northing was the most important predictor in the binomial part of the distribution model indicating that a large part of the variance could not be explained by the environmental variables used in the model (Table 4.13). Other significant variables were salinity, water temperature and current. The response curves indicate that occurrence of Red-necked Grebes was more likely in areas of lower salinity, higher temperatures and low current speeds (Table 4.13, Figure 4.13A). The categorical variable representing seasons indicated that birds occurred over broader areas during both winter seasons (season 1 and season 3) compared to occurrence during the transitional period (season 2, Table 4.13, Figure 4.13A).

The positive part of the distribution model further explained relationships of bird densities to the environmental variables. Hydrodynamic variables were important and indicated higher densities at upwelling areas (elevated vertical current) and northward currents (current V). Relationship to depth indicated that bird densities were decreasing with increasing water depth (Table 4.13, Figure 4.13B). Also grebe densities were higher at gentle slopes. Further, grebe densities were decreasing with increasing number of ships. Seasonal patterns, when considering both model parts, indicate that while Red-necked Grebes occurrence was similar during the two winter seasons (Figure 4.13A), densities were significantly lower during the second winter (season 3, Figure 4.13B), and whereas occurrence was more restricted during the transitional periods (season 2), the densities were higher compared to the winters (Table 4.13, Figure 4.13).

The distribution model had a reasonably good fit. Deviance explained in the binomial part was 23.1% and 44.7% in the positive part (Table 4.13). Diagnostic plots of the positive part can be seen in the Appendix III. The accuracy of the predictions of the binomial part was good and AUC equalled 0.82, and the Spearman’s Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.32.

According to Moran’s I no spatial autocorrelation was found in the residuals of the presence/absence part, and small significant correlation was detected for the first lag in the positive part of the model (Appendix III).

The models deployed show that wintering Red-necked Grebes occurred in highest densities along the Danish coast of Lolland, reaching the highest values in the south-western part and at the interface to the Rødsand Lagoon. Further, higher densities were predicted west of the Fehmarn Island, along its northern coast and in the Fehmarnsund (Figure 4.14, Figure 4.15, Figure 4.16). During the moulting period, Red-necked Grebes were estimated for the same area, yet in much lower densities (Figure 4.15).

Table 4.13 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for Red-necked Grebe in the Fehmarnbelt. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	**Presence/absence**			**Positive part**		
	Z	**X^2**	**P**	**t**	**F**	**P**
Season 2	-1.18		0.24	1.25		0.21
Season 3	-2.09		0.04	-7.47		<0.01
Depth		-	-		6.61	<0.01
Proportion hard substrate		-	-		-	-
Bottom slope		-	-		7.89	<0.01
Distance to land		-	-		-	-
Distance to wind farms		-	-		-	-
Number of ships		-	-		9.07	<0.01
Pycnocline depth		-	-		-	-
Current gradient (Bottom)		-	-		-	-
Salinity (Bottom)		20.68	<0.01		-	-
Temperature (Bottom)		14.95	<0.01		-	-
Current U (Surface)		-	-		-	-
Current V (Surface)		12.86	<0.01		3.14	0.02
Current W (Surface)		-	-		10.22	<0.01
Vorticity (Surface)		-	-		-	-
Current speed (Surface)		8.40	0.05		-	-
XY		127.55	<0.01		-	-
Model performance						
AUC	0.82					
Deviance explained	23.1 %			44.7 %		
Correlation (combined)	0.32					

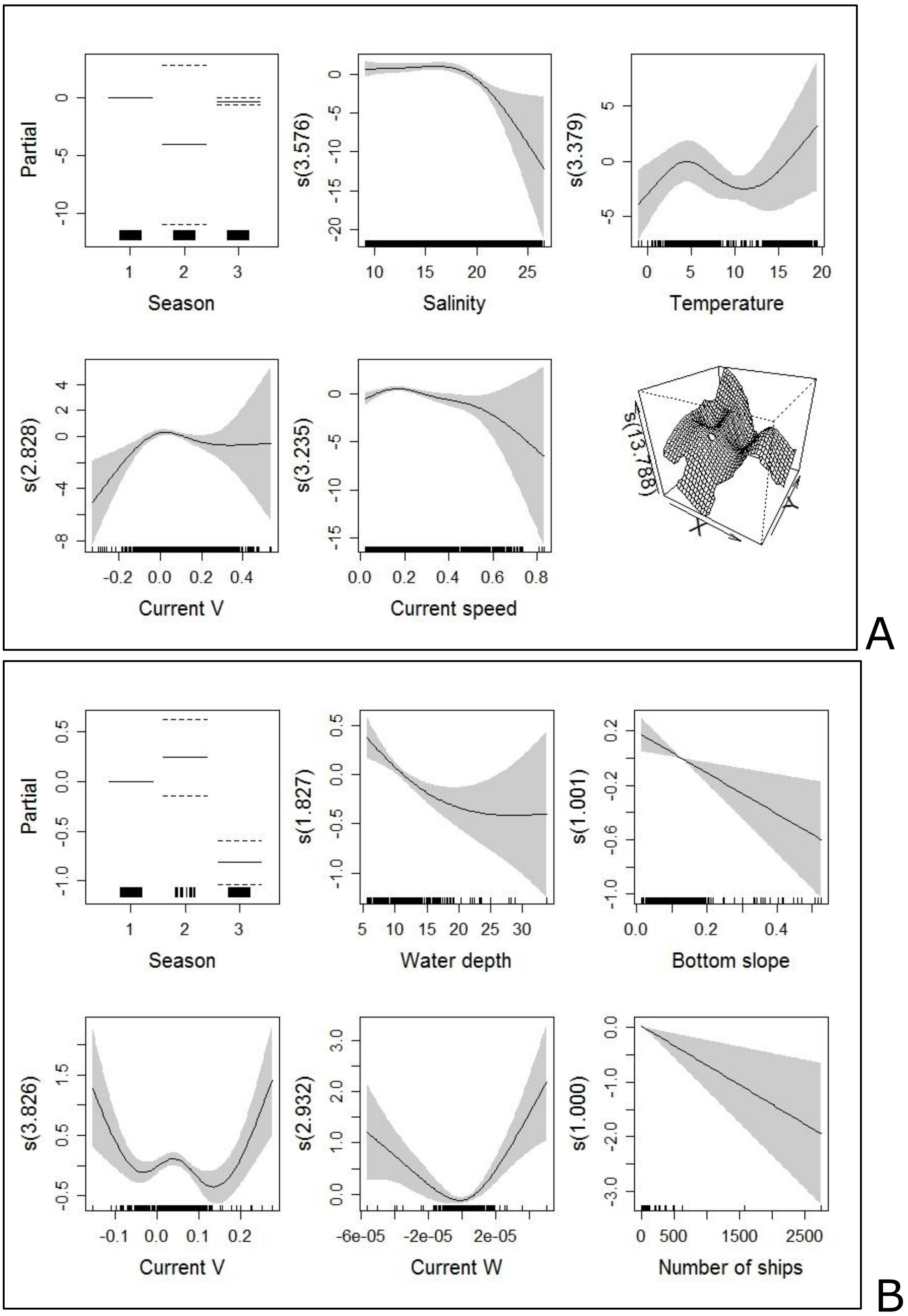


Figure 4.13 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Red-necked Grebe (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.

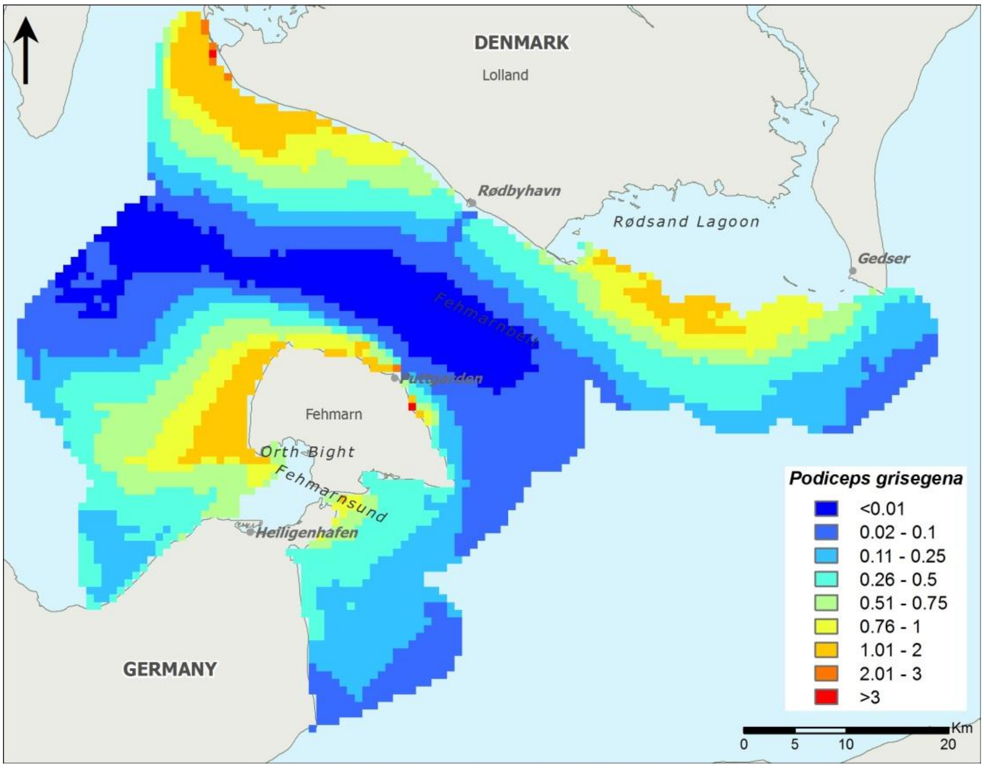


Figure 4.14 *Modelled spatial distribution (numbers per km²) of Red-necked Grebe* Podiceps grisegena *in the Fehmarnbelt based on baseline ship-based surveys undertaken between November 2008 and April 2009.*

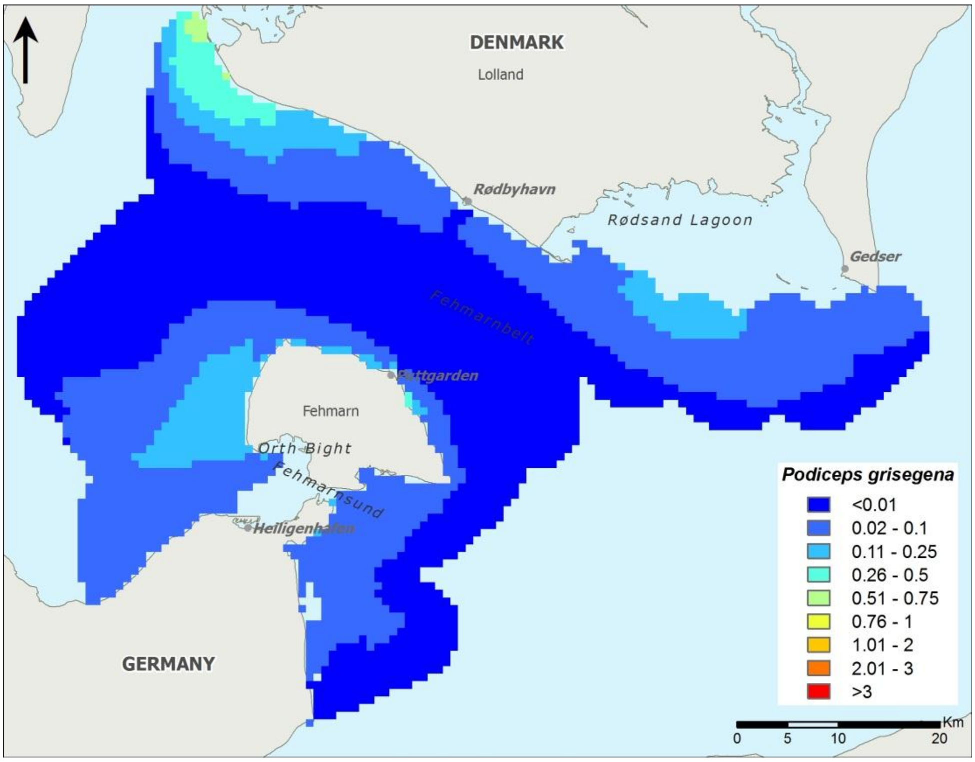


Figure 4.15 *Modelled spatial distribution (numbers per km²) of Red-necked Grebe* Podiceps grisegena *in the Fehmarnbelt based on baseline ship-based surveys undertaken between August 2009 and September 2009.*

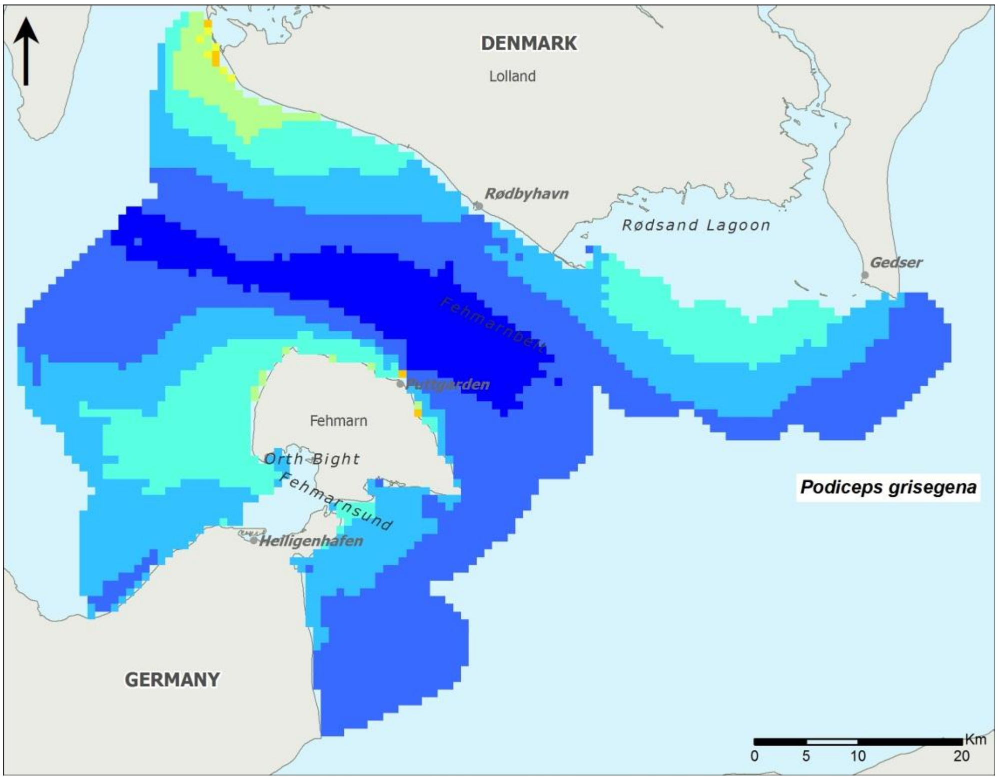


Figure 4.16 *Modelled spatial distribution (numbers per km²) of Red-necked Grebe* Podiceps grisegena *in the Fehmarnbelt based on baseline ship-based surveys undertaken between October 2009 and April 2010.*

Red-necked Grebe distribution according to supplementary datasets

Because separation of grebe species is generally difficult from aerial surveys and species often get misidentified, the monitoring data from Germany and Denmark provide only limited information about the distribution and numbers of Red-necked Grebes in the Fehmarnbelt (Petersen et al. 2006, 2010, BIOLA 2009). Results from coastal counts in Germany revealed only very low numbers in the inshore zone (Figure 4.17; AKVSW 2010, OAG 2010).

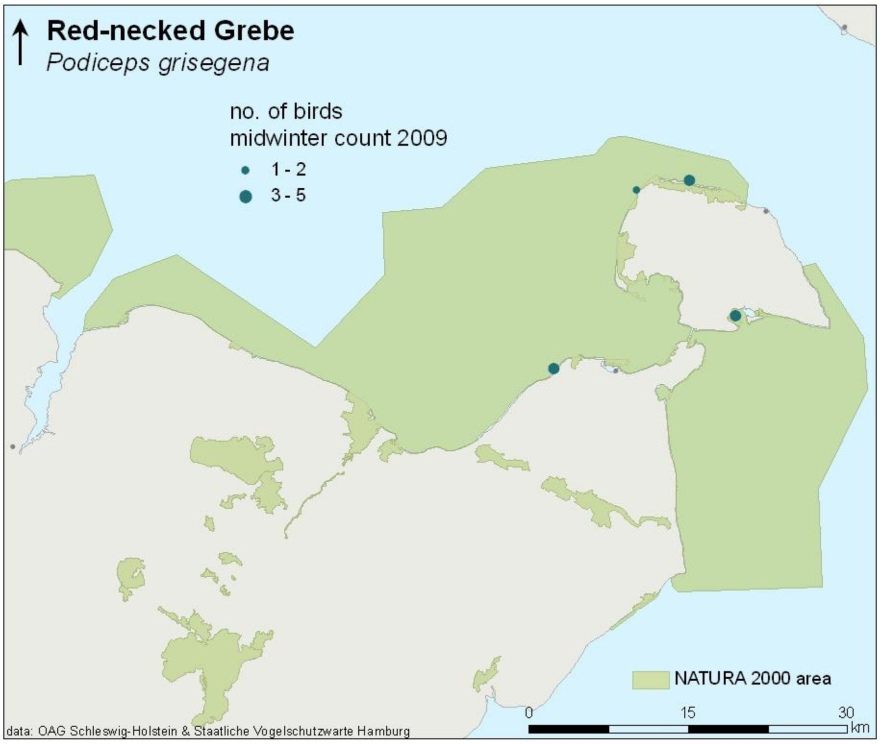


Figure 4.17 Distribution of Red-necked Grebe during winter coastal survey in January 2009 between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt; data: OAG Schleswig-Holstein and AKVSW Hamburg.

Red-necked Grebe abundance estimates for SPAs

On the basis of the spatial distribution models, the numbers of Red-necked Grebes were estimated for the two SPAs: Eastern Kiel Bight and Baltic Sea east of Wagrien (Table 4.14). Only a small fraction of the SPA Hyllekrog-Rødsand was covered by ship-based surveys, therefore abundance estimates for this SPA were not possible. The estimate of wintering numbers in the surveyed part of the Eastern Kiel Bight was 248 birds in winter 2008/2009 and 104 in winter 2009/2010, and 69 and 26 birds in the SPA Baltic Sea east of Wagrien (Table 4.14), respectively. These should be considered as minimum estimates of wintering grebes, as ship-based surveys did not cover the SPA areas in full and the estimates are provided only for areas covered.

Further, 445 Red-necked Grebes were estimated to occur in the non-SPA area surveyed from ship in winter 2008/2009 and 178 in winter 2009/2010. Within this non-SPA area, 13-36 birds were estimated to winter in the area of the immediate vicinity to the planned alignment (Table 4.14).

The total estimate of numbers of Red-necked Grebes occurring in the Fehmarnbelt obtained using the distribution modelling was 762 ± 168 (±SE) for winter 2008/2009 (Appendix III), 81 for August – September 2009, and 308 for winter 2009/2010 (Table 4.14).

Estimates by spatial modelling fall within the range of Distance analysis, but results of Distance analysis suggest slightly higher values for separate ship-based surveys (Table 4.12).

Table 4.14 Seasonal estimates of Red-necked Grebe abundance in the SPAs: Eastern Kiel Bight and Baltic Sea east of Wagrien based on the spatial distribution models for the baseline ship-based surveys from November 2008 to April 2010. Estimates for the alignment area, total non-SPA area, and total prediction area are also given.

SPA / area	Period	Density	Estimate
Eastern Kiel Bight	Nov 2008 – Apr 2009	0.56	248
(DE1530-491)	Aug – Sep 2009	0.06	26
	Oct 2009 – Apr 2010	0.24	104
Baltic Sea east of Wagrien	Nov 2008 – Apr 2009	0.22	69
(DE1633-491)	Aug – Sep 2009	0.02	6
	Oct 2009 – Apr 2010	0.08	26
Alignment area	Nov 2008 – Apr 2009	0.18	36
	Aug – Sep 2009	0.01	3
	Oct 2009 – Apr 2010	0.06	13
Non-SPA area (including	Nov 2008 – Apr 2009	0.29	445
the alignment area)	Aug – Sep 2009	0.03	48
	Oct 2009 – Apr 2010	0.12	178
TOTAL	Nov 2008 – Apr 2009	0.34	762
	Aug – Sep 2009	0.04	81
	Oct 2009 – Apr 2010	0.14	308

Red-necked Grebe trends

The biogeographic population of Red-necked Grebe is rather small and was identified as declining by Wetlands International (2006). BirdLife International concluded that the European breeding population is Stable (BirdLife International 2004).

In general, records about the occurrence of Red-necked Grebes are scarce from the Fehmarnbelt area, compared to the relatively high estimates obtained by the baseline investigations.

Importance of the Fehmarnbelt to Red-necked Grebe

Following the estimates of the FEBI baseline investigations, up to 2 % of the biogeographic population of Red-necked Grebe winters in the area of Fehmarnbelt covered by ship-based surveys. The SPA Eastern Kiel Bight is the most important among protected areas, which supports up to 0.5 % of the biogeographic population during the wintering period (Table 4.14).

Red-necked Grebe – summary of information for EIA

Max. abundance estimate in Fehmarnbelt:	1,100
Max. abundance estimate in the alignment area:	36
Period of max. abundance in Fehmarnbelt:	October – April
Areas of max. abundance in Fehmarnbelt:	See Figure 3.16, Figure 3.18

Explanations: Maximum abundance represents Distance analysis estimate for ship-based survey of December 2008.

Maximum abundance in the alignment and distribution obtained from spatial modelling on ship-based surveys.

4.1.4 Slavonian Grebe – *Podiceps auritus*

Slavonian Grebe – *Podiceps auritus*

Biogeographic population: *P. a. auritus*, NE Europe (small billed)

Breeding range: NE Europe

Wintering / core non-breeding range: Baltic Sea, Mediterranean, Black Sea

Population size: 14,200 – 26,000

1 % value: 200

Conservation status: EU Birds Directive, Annex I: listed
EU SPEC Category: SPEC 3
EU Threat Status: declining

Target species in SPAs: -

Key food: invertebrates, fish

Period of presence in Fehmarnbelt: Wintering, migrations: September – mid-May

Origin of Slavonian Grebe in the Fehmarnbelt
Slavonian Grebe is a circumpolar breeder (except in Greenland). The Western Palaearctic wintering areas are found along coastal regions of Iceland, Scandinavia (excluding the Eastern Baltic Sea), around the United Kingdom and the Channel area, the Central Mediterranean and the Black Sea (Cramp and Simmons 1977).

Data sources on Slavonian Grebe in the Fehmarnbelt
Table 4.15 provides an overview of available datasets and their use in the baseline assessment of Slavonian Grebe in the Fehmarnbelt area. Data on Slavonian Grebes wintering in the Fehmarnbelt are scarce with few or no sightings obtained by different methods. The FEBI ship-based surveys yielded the highest number of observations of the species, thus, this method was chosen as primary dataset for description of species abundance and distribution. The FEBI aerial surveys and supplementary datasets of Danish and German coastal counts provided supporting information on the species in the study area.

Table 4.15 List of datasets and their use in baseline assessment of Slavonian Grebe in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset representing species abundance and distribution
FEBI ship transect surveys	Primary dataset for estimating abundance and distribution
AKVSW land-based counts	Supporting dataset representing species winter abundance and distribution along the Fehmarn coast
OAG land-based counts	Supporting dataset representing species abundance and distribution along the German mainland coast
NOVANA aerial surveys	Dataset not used due to absence of sightings of the species
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Slavonian Grebe in the Fehmarnbelt
In total 20 Slavonian Grebes were recorded during the FEBI ship-based surveys between November 2008 and November 2010 (max. count: 4 birds in November 2008); 6 birds during aerial surveys (max. count: 4 birds in March 2010). Most of the birds were recorded during transitional periods in autumn and spring. These findings agree with literature records. Slavonian Grebes utilise the German Baltic Sea during migration and wintering period with highest densities occurring in Mecklenburg-Western Pomerania (Mendel et al. 2008). According to Berndt et al. (2005) the species is a regular, but very rare wintering guest around Fehmarn Island. Slavonian Grebe more frequently occurs in the area during migration periods (Berndt et al. 2005, Sonntag et al. 2009).

During the past 20 years a maximum of 3 individuals were recorded on Fehmarn during a single mid-winter coastal survey (in 2000 and 2010; AKVSW 2010). For the German mainland coast only single birds are typically reported with a maximum of 4 individuals observed in Hohwacht Bay in March 2009 (OAG 2010).

The DOF database indicates Slavonian Grebes occurring sporadically in Rødsand Lagoon with up to 10 birds reported for this area in autumn 2007 (DOF 2010).

Distribution and habitat use of Slavonian Grebe in the Fehmarnbelt
Slavonian Grebes use coastal and open sea areas as well as large inland lakes. Mendel et al. (2008) describe that wintering Slavonian Grebes prefer shallow waters and sandy sediments in the eastern part of the German Baltic Sea (Pomeranian Bight). Additionally, Sonntag et al. (2009) suggest that competition with other grebe species and human activities (especially shipping) influence Slavonian Grebe distribution at sea. Distribution maps of this species in the German Baltic Sea suggest that higher densities occur in the Hohwacht Bay within the Fehmarnbelt region, areas southwest of Lolland and east of Wagrien. However, densities in the Fehmarnbelt are much lower compared to those in the Pomeranian Bight (Sonntag et al. 2009).

Slavonian Grebe records of FEBI aerial and ship-based transect surveys indicated no major aggregations. Birds were observed in Hohwacht Bay, along the coastline south of Lolland and Rødsand Lagoon, and also east of Fehmarn.

Slavonian Grebe abundance estimates for SPAs
Because of a scarcity of information about this species and generally low numbers of Slavonian Grebes observed in the study area, no abundance estimates for particular SPAs were possible. Slavonian Grebes observed during FEBI baseline investigations were recorded within all three marine SPAs: Eastern Kiel Bight, Baltic Sea east of Wagrien and Hyllekrog-Rødsand. DOF database reports numbers of up to 10 individuals in the SPA Hyllekrog-Rødsand (DOF 2010).

Slavonian Grebe trends
The European breeding population of Slavonian Grebe is small (14,200 – 26,000) and was described to be stable between 1970 and 1990. In the following decade the species underwent a moderate decline due to declining numbers in important breeding areas in Finland and Sweden (BirdLife International 2004). Slavonian Grebes are sensitive to some human activities, particularly ship traffic and show strong fleeing reactions towards approaching ships (Garthe et al. 2004, Sonntag et al. 2009).

Importance of the Fehmarnbelt to Slavonian Grebe

The Slavonian Grebe is a rare wintering guest in the study area. All available data sources indicate that this species regularly occurs in the Fehmarnbelt during migration and winter periods, but usually only single birds are recorded. Available data sources suggest that the abundance of Slavonian Grebe is unlikely to exceed 0.1% of the biogeographic population (20 birds) in the Fehmarnbelt.

Slavonian Grebe – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	single birds (max. count: 10 birds)
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	November – March
Areas of max. abundance in Fehmarnbelt:	no aggregation areas identified
Explanations: –	

4.1.5 Great Cormorant – *Phalacrocorax carbo*

Great Cormorant – *Phalacrocorax carbo*	
Biogeographic population: *P. c. sinensis*, N and C Europe	
Breeding range: N and C Europe	
Wintering / core non-breeding range: N and C Europe to the Mediterranean	
Population size: 380,000 – 405,000	
1 % value: 3,900	
Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC EU Threat Status: secure
Target species in SPAs:	Hyllekrog-Rødsand (DK006X083)
Key food: various fish species	
Period of presence in Fehmarnbelt:	Wintering, migrations: August – March Breeding: April – July

Origin of Great Cormorant in the Fehmarnbelt

The Great Cormorant is migratory within the region. According to the FEBI ring recovery analysis (Appendix IV) the Fehmarnbelt area is visited by birds breeding in Scandinavia during the non-breeding period, and there are also indications that birds originating from NW Europe. Birds breeding in the Fehmarnbelt region leave the area for wintering further south, such as northern Italy or Switzerland (Appendix IV; Fransson and Pettersson 2001, Bønløkke et al. 2006).

Data sources on Great Cormorant in the Fehmarnbelt

Numbers and distribution of Great Cormorants are well reflected in the FEBI aerial and ship-based survey data, but aerial surveys were chosen as the primary data source for representing the species due to broader spatial coverage of the study region (Table 4.16). The seasonal variation in abundance of cormorants in the Fehmarnbelt area was analysed both using aerial and ship-based survey data. As aerial surveys also cover resting sites, this dataset was chosen as the primary source to represent seasonal variation. Other datasets were used as supporting data sources to characterise Great Cormorant distribution and habitat use (Table 4.16).

Table 4.16 List of datasets and their use in baseline assessment of Great Cormorant in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating species densities, abundance, habitat use and seasonal variation
FEBI ship transect surveys	Supporting dataset for species densities and distribution
	Supporting dataset for representing within and between seasonal variation in bird numbers
OAG land-based counts	Supporting dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Supporting dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for winter abundance and distribution of the species in the Danish part of the Fehmarnbelt
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Great Cormorant in the Fehmarnbelt

Great Cormorant abundance estimates based on Distance analysis

The abundance of Great Cormorant in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Great Cormorants during aerial surveys, calculated using the entire dataset, were 202 m for swimming birds and 246 m for flying birds. The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of Great Cormorants have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.17, Appendix V). Often partial coverage likely resulted in minimum estimates for this species. However, highest numbers of cormorants can be recorded when surveying their roosts. Thus, the highest estimate of 3,580 birds from aerial transect survey in later September 2010 (Table 4.17) is almost certainly an underestimate of actual numbers of cormorants using the Fehmarnbelt area.

Aerial survey results indicate that the highest densities of Great Cormorant occur in autumn months September and October (Table 4.17). The observed seasonal pattern agrees with Mendel et al. (2008), who also report maximum resting numbers of Great Cormorant in northern Germany for September/October.

Table 4.17 Numbers of observed Great Cormorants during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	34	209	0.38	0.15	0.95	1,505
Dec-08	81.7	47	388	0.45	0.10	2.33	1,794
Jan-09	82.8	36	81	0.14	0.06	0.30	552
Feb-09	100	62	115	0.17	0.10	0.29	830
Mar-09	77.5	47	142	0.27	0.09	0.96	1,012
Apr-09	86.8	34	138	0.25	0.06	1.17	1,062
May-09	77.3	19	62	0.15	0.03	0.72	550
Jun-09	80.9	39	187	-	-	-	-
Jul-09	86.6	84	487	0.58	0.24	1.39	2,429
Aug-09	92.3	56	609	0.57	0.21	1.55	2,554
Sep-09	79.1	38	179	0.38	0.16	0.87	1,451
Oct-09	79.9	49	1,067	-	-	-	-
Nov-09	82.4	70	401	0.42	0.20	0.93	1,701
Dec-09	24.7	10	11	0.06	0.02	0.20	75
Mar-10 A	64.1	29	46	0.09	0.04	0.18	267
Mar-10 B	75.6	26	198	0.37	0.07	2.14	1,365
Apr-10	100	33	57	0.06	0.03	0.13	316
May-10	92.1	24	30	0.04	0.02	0.08	197
Jun-10	70.8	27	61	0.12	0.04	0.41	406
Aug-10	75.6	73	130	0.21	0.12	0.38	767
Sep-10 A	44.9	35	126	0.21	0.08	0.51	454
Sep-10 B	48.9	97	968	1.50	0.38	6.16	3,579
Oct-10	80.0	37	429	-	-	-	-
Nov-10	70.1	36	251	0.45	0.09	2.29	1,529

Additional information on Great Cormorant abundance in Rødsand Lagoon was obtained during dedicated aerial swan surveys in this area. About 2,000 Great Cormorants were recorded resting on Rødsand during swan count of October 30, 2009.

The ESW for Great Cormorant during ship-based surveys, estimated for the entire dataset, was 185 m. Great Cormorant densities were typically higher in coastal areas than offshore areas. Only in February 2010, when coastal areas were mostly ice covered, offshore areas were more frequently used (Table 4.18). A maximum number of 4,200 Great Cormorants was estimated for the ship-based survey area in November 2009 (Table 4.18).

Table 4.18 Numbers of observed Great Cormorants during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km^2 covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	64	101	1.01	28	0.58	1.77	0.77	0.43	1.39	23	0.93	2,181
	offshore	18	19	0.36	36	0.18	0.75				10		
Dec-08	coastal	63	226	2.99	47	1.23	7.30	-	-	-	39	-	-
	offshore	14	23	-	***	-	-				5		
Jan-09	coastal	85	111	1.18	26	0.71	1.96	0.92	0.54	1.58	20	1.05	2,467
	offshore	20	21	0.40	36	0.20	0.83				12		
Feb-09	coastal	74	136	0.85	18	0.60	1.21	0.67	0.45	1.02	19	0.76	1,789
	offshore	16	19	0.32	35	0.16	0.65				3		
Mar-09	coastal	42	53	0.61	30	0.34	1.11	0.51	0.27	0.97	27	0.80	1,861
	offshore	15	15	0.31	41	0.14	0.70				39		
Apr-09	coastal	33	58	0.44	30	0.24	0.80	0.42	0.21	0.89	15	0.73	1,698
	offshore	19	21	0.37	54	0.13	1.06				58		
May-09	coastal	25	31	0.33	29	0.19	0.58	-	-	-	27	-	-
	offshore	7	11	-	***	-	-				4		
Jul-09A	coastal	56	71	0.86	30	0.47	1.56	0.63	0.32	1.36	26	0.75	1,746
	offshore	7	11	0.21	87	0.04	0.98				0		
Jul-09B	coastal	21	23	0.25	24	0.16	0.41	-	-	-	21	-	-
	offshore	3	6	-	923	-	-				1		
Aug-09	coastal	92	102	1.00	15	0.75	1.34	0.73	0.51	1.12	15	0.80	1,872
	offshore	7	13	0.19	69	0.05	0.69				2		
Sep-09	coastal	44	47	0.48	29	0.27	0.84	0.42	0.21	0.91	14	0.51	1,200
	offshore	13	19	0.30	67	0.08	1.05				8		
Oct-09	coastal	59	160	1.67	54	0.61	4.58	-	-	-	23	-	-
	offshore	8	13	-	***	-	-				3		
Nov-09	coastal	51	56	0.64	25	0.39	1.06	0.47	0.27	0.85	293	1.80	4,213
	offshore	7	7	0.14	63	0.04	0.47				5		
Dec-09	coastal	66	120	1.19	37	0.58	2.41	0.88	0.43	1.80	7	0.93	2,174
	offshore	15	16	0.30	38	0.14	0.63				4		
Jan-10	coastal	96	122	1.28	16	0.94	1.75	-	-	-	12	-	-
	offshore	21	26	-	***	-	-				2		
Feb-10A	coastal	71	171	1.10	26	0.66	1.83	1.04	0.56	1.98	19	1.17	2,748
	offshore	37	46	0.92	46	0.37	2.27				12		
Feb-10B	coastal	67	112	0.93	29	0.53	1.62	0.96	0.42	2.79	9	1.01	2,369
	offshore	21	33	1.02	92	0.20	5.10				4		
Mar-10	coastal	58	97	0.93	26	0.55	1.56	-	-	-	17	-	-
	offshore	14	18	-	***	-	-				4		
Apr-10	coastal	27	31	0.29	31	0.16	0.54	0.22	0.11	0.43	7	0.26	613
	offshore	3	3	0.06	57	0.02	0.19				3		

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
May-10	coastal	16	18	0.24	37	0.12	0.51	0.22	0.10	0.53	6	0.25	587
	offshore	6	9	0.19	60	0.06	0.58				0		
Jun-10	coastal	35	36	0.39	21	0.26	0.60	0.26	0.17	0.40	13	0.33	779
	offshore	0	0	0	0	0	0				4		
Sep-10	coastal	50	52	0.53	19	0.36	0.77	0.40	0.25	0.71	12	0.46	1,068
	offshore	6	6	0.13	86	0.03	0.59				2		
Oct-10	coastal	61	304	0.94	33	0.50	1.76	0.72	0.36	1.48	26	0.83	1,943
	offshore	12	13	0.27	65	0.08	0.92						
Nov-10	coastal	40	56	0.56	28	0.33	0.98	0.47	0.25	0.92	23	0.57	1,332
	offshore	13	14	0.27	56	0.09	0.81				1		

As for aerial surveys, the ship-based surveys showed Great Cormorants being present in the area covered by ship-based surveys all the year, with no clear seasonal pattern (Table 4.18, Figure 4.18).

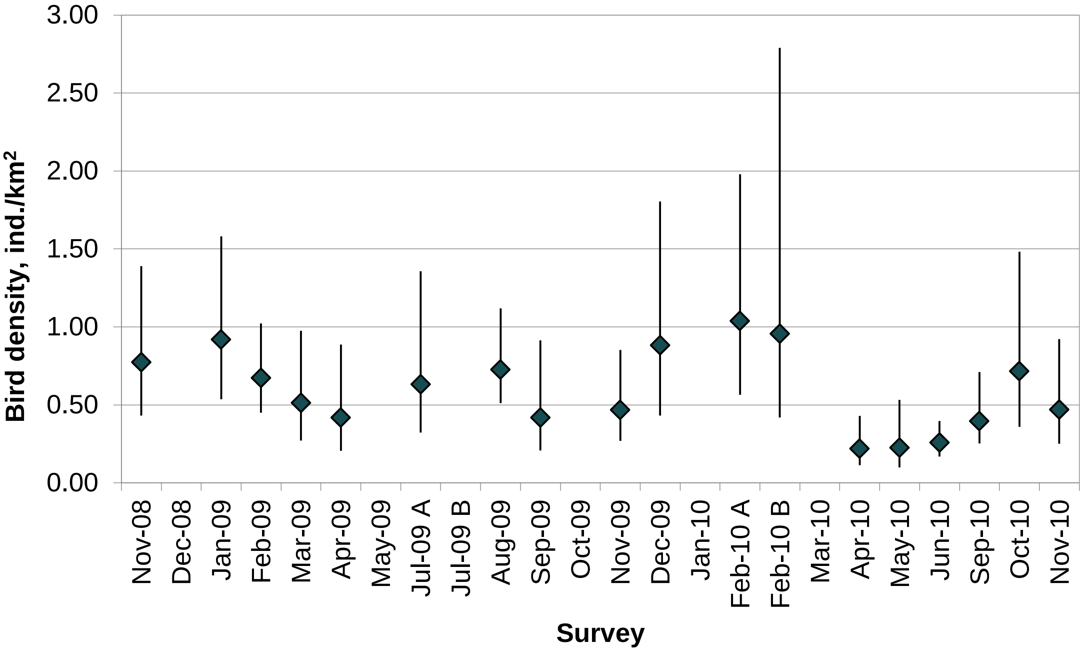


Figure 4.18 Mean density estimates and 95 % confidence intervals of swimming Great Cormorants estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150 % were not included into the chart (see Table 4.18 for specific values).

Great Cormorant abundance according to supplementary datasets

The land-based mid-winter survey in 2009 led to a total number of 1,143 Great Cormorants along the German coast of the study area (OAG 2010, AKVSW 2010). Figure 4.19 shows the seasonal variation of Great Cormorant numbers as recorded in selected (consistently covered) survey sections along the German mainland coast in two sequent winter seasons (OAG 2010). These data indicate peak numbers occurring in September and October, which coincides with findings of the FEBI aerial surveys and literature (Berndt et al. 2005, Mendel et al. 2008). The maximum count of 3,813 Great Cormorants was obtained along the incompletely covered shoreline of the eastern Kiel Bight in September 2009. This indicates that FEBI aerial surveys represent minimum estimates for the entire Fehmarnbelt area. OAG data show major Great Cormorant resting sites being located inland (e.g. Großer and Kleiner Binnensee) or within restricted military areas of Hohwacht Bay, which therefore might have been missed during aerial surveys.

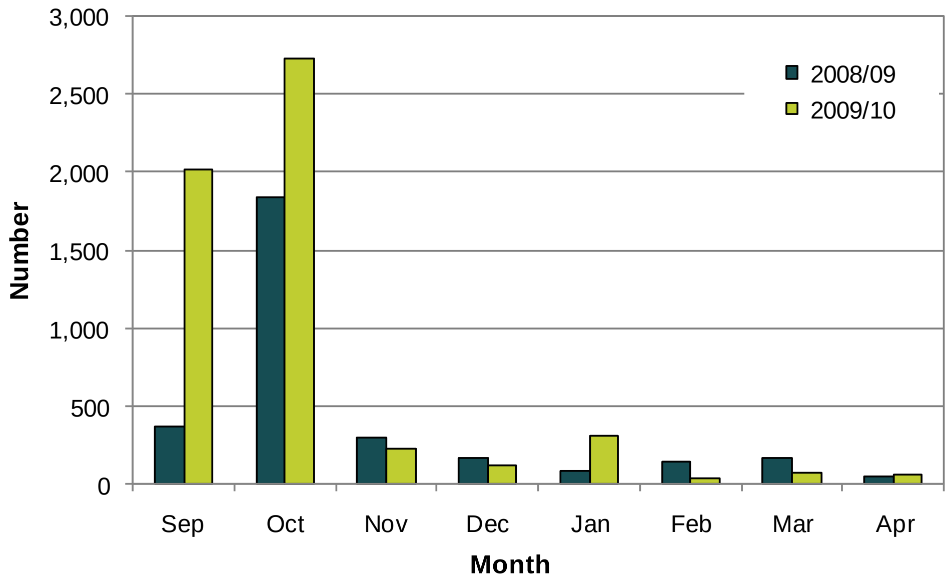


Figure 4.19 Numbers of Great Cormorants recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

For the Danish part of the study area, the DOF database confirms that Rødsand Lagoon supports high numbers of Great Cormorants There are regularly more than 2,000 birds reported in autumn months (DOF 2010). A maximum of 6,500 Great Cormorants was recorded on October 7, 2009 (DOF 2010), indicating that internationally important aggregations occur in this site. For the Danish alignment area up to 500 birds are reported to rest at the harbour breakwaters of Rødbyhavn (DOF 2011).

The Danish mid-winter survey of 2008 revealed comparably low numbers of Great Cormorant within the Danish part of the study area, a total count being 268 birds (Petersen et al. 2010).

Distribution and habitat use of Great Cormorant in the Fehmarnbelt

Great Cormorant distribution according to FEBI survey data

During aerial and ship-based surveys Great Cormorants were observed throughout the Fehmarnbelt with higher densities recorded in the near-shore areas (Figure 4.20 – Figure 4.22; Appendix II). Highest concentrations were recorded when encountering birds at their resting sites, primarily sand banks and harbour structures on both sides of the Fehmarnbelt. Most important resting sites observed during aerial surveys were Krummsteert (southwest of Fehmarn Island) and sand banks of Rødsand Lagoon with several hundreds to 2,000 birds being recorded on each site.

Although cormorants are known to sometimes forage in large flocks consisting of several hundred individuals (e.g., van Eerden and Voslamber 1995, DOF 2010), and foraging flocks of several thousand birds have been recorded previously within the wind farm Rødsand I area (Blew et al. 2008), only single individuals or groups of less than 10 birds were observed offshore during the FEBI surveys. This mostly individual foraging behaviour can indicate that birds were mostly foraging on benthic fish but not on pelagic schooling fish (e.g., herring; see chapter 5.1.9 for cormorant diet composition in the Fehmarnbelt). A maximum size of a feeding flock consisting of 179 individuals was recorded during a ship-based survey west of Fehmarn in November 2009. Cormorants were observed dispersed throughout the study area and no outstanding foraging grounds could be identified during the baseline investigations. However, Great Cormorants seem to frequently use areas close to known resting and breeding sites, such as jetties of ferry harbours in Puttgarden and Rødby or breeding colony of Wallnau reserve on Fehmarn Island and appear to use coastal areas more frequently than offshore areas (Figure 4.20 – Figure 4.22).

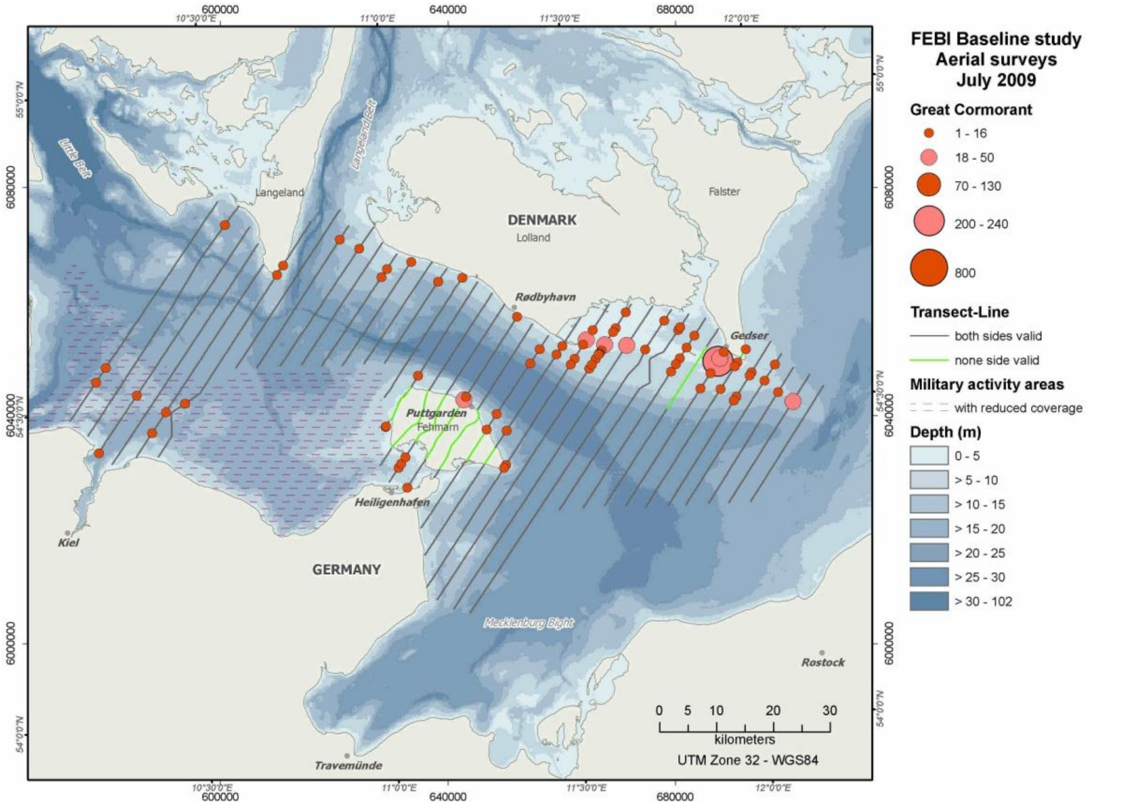


Figure 4.20 Example of the observed Great Cormorant distribution in the study area during aerial surveys (July 2009).

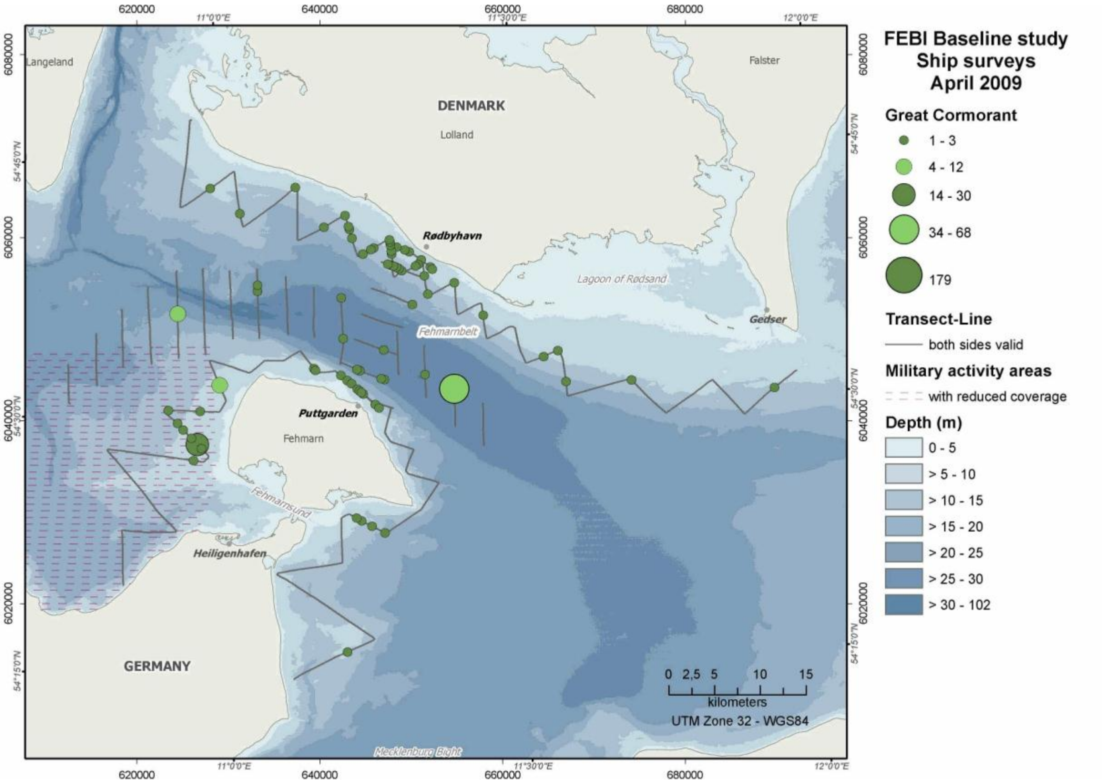


Figure 4.21 Examples of the observed Great Cormorant distribution in the study area during ship-based surveys (April 2009).

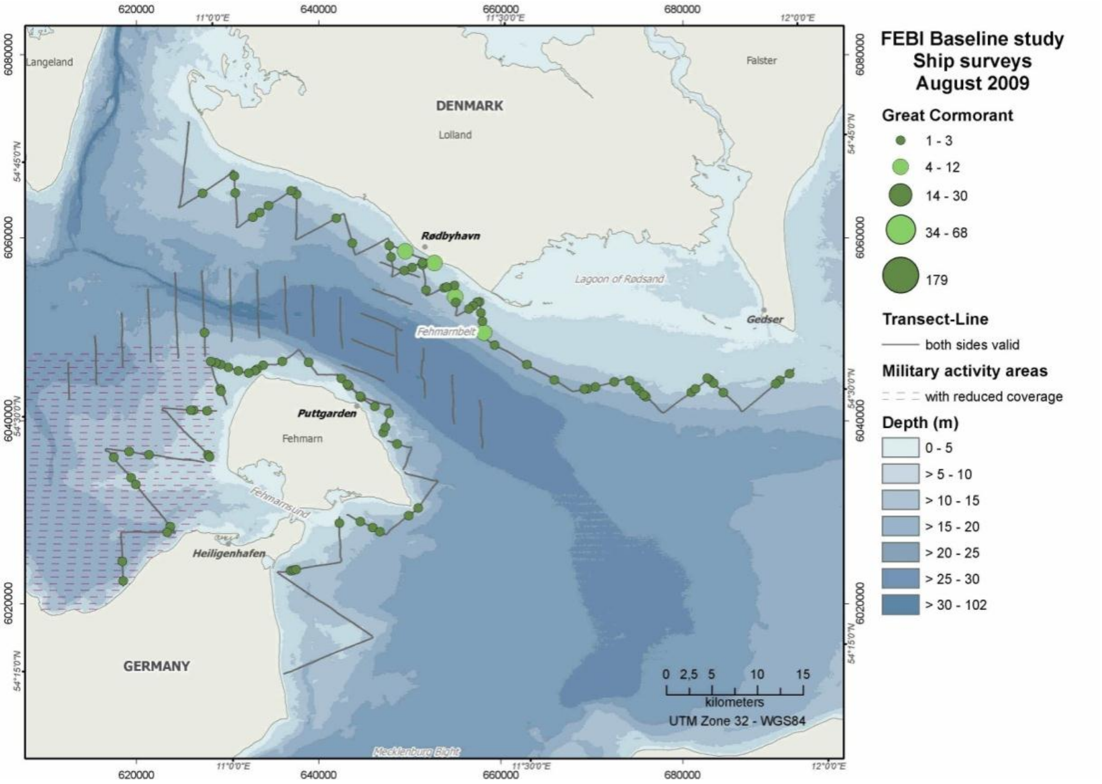


Figure 4.22 Examples of the observed Great Cormorant distribution in the study area during ship-based surveys (August 2009).

FEBI aerial records of this species aggregated into seasonal composite maps show variable distribution patterns in different seasons, but indicate coastal areas of Fehmarn and Rødsand Lagoon holding higher cormorant densities than offshore areas (Figure 4.23, Figure 4.24, Appendix II).

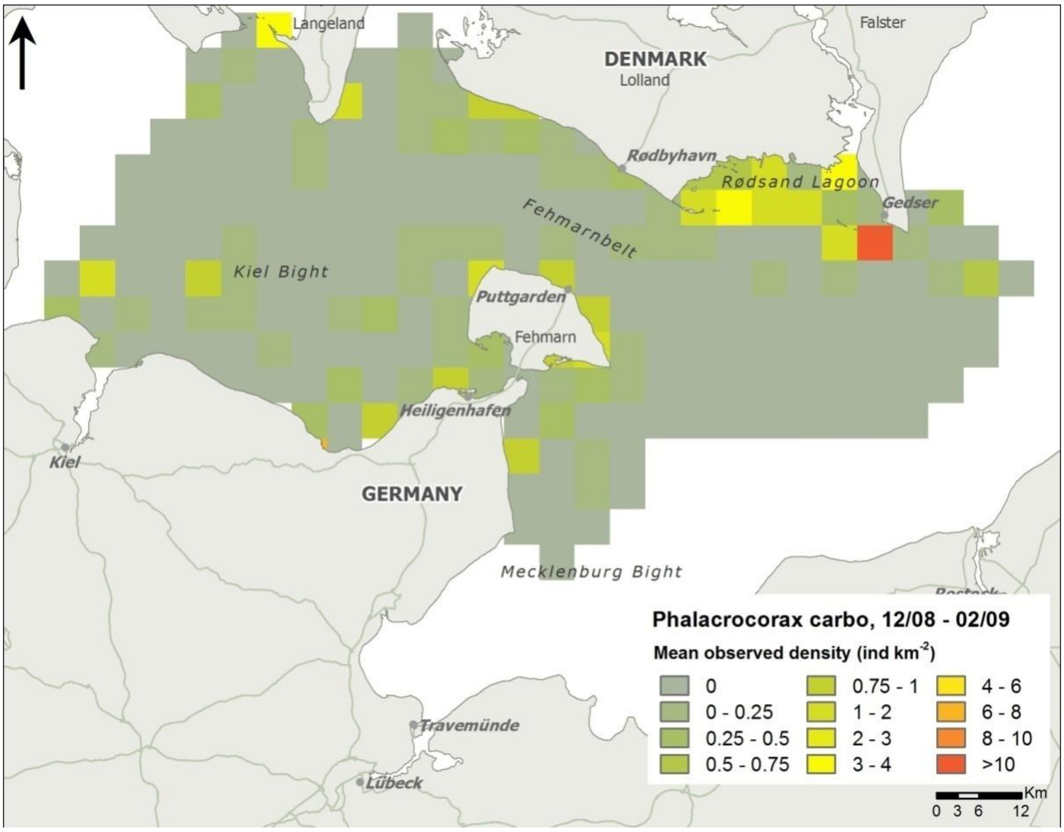


Figure 4.23 Exemplary map showing mean densities of Great Cormorant Phalacrocorax carbo *recorded during aerial surveys in December 2008 – February 2009. The densities are shown in 5 km squares. See all composite distribution maps of Great Cormorant in Appendix II.*

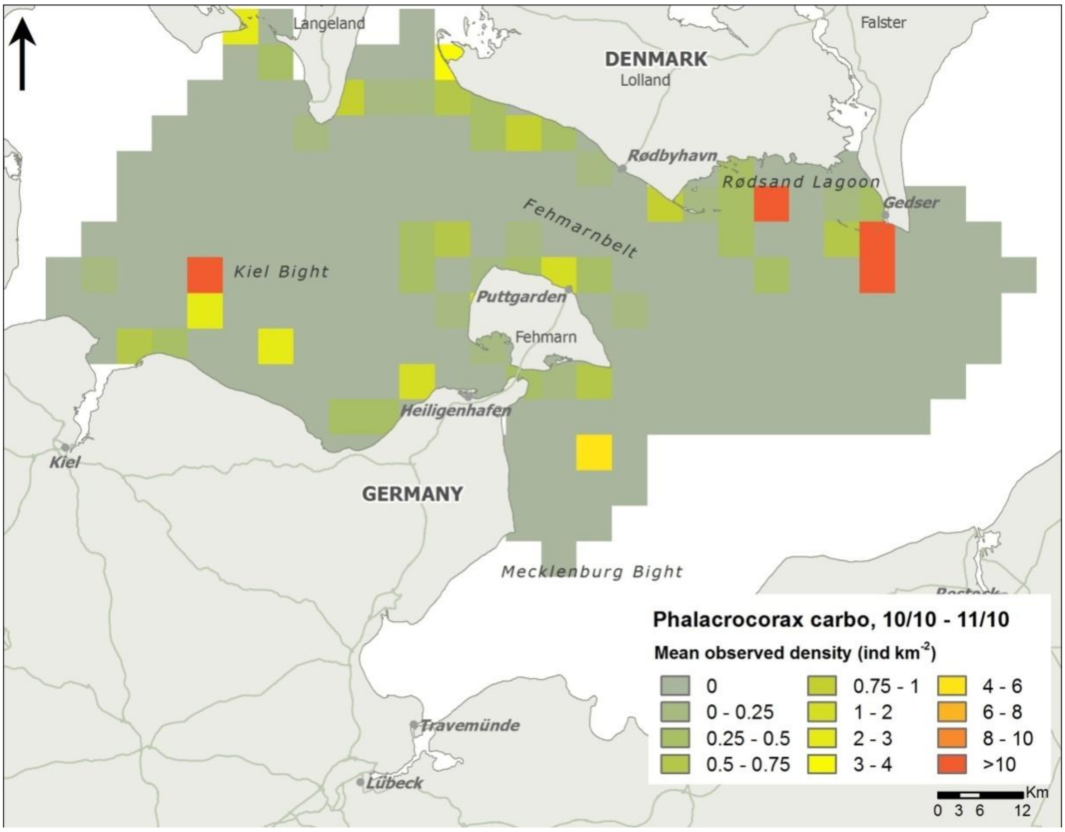


Figure 4.24 Exemplary map showing mean densities of Great Cormorant Phalacrocorax carbo *recorded during aerial surveys in October – November 2010. The densities are shown in 5 km squares. See all composite distribution maps of Great Cormorant in Appendix II.*

Great Cormorant distribution according to supplementary datasets

The distribution of Great Cormorant recorded during the German mid-winter coastal count of 2009 corroborates the results of the FEBI surveys and shows that this species is widely distributed in coastal waters of the study area (Figure 4.25; AKVSW 2010, OAG 2010). A similar pattern is shown by the results of the Danish mid-winter survey 2008. (Figure 4.25; Petersen et al. 2010).

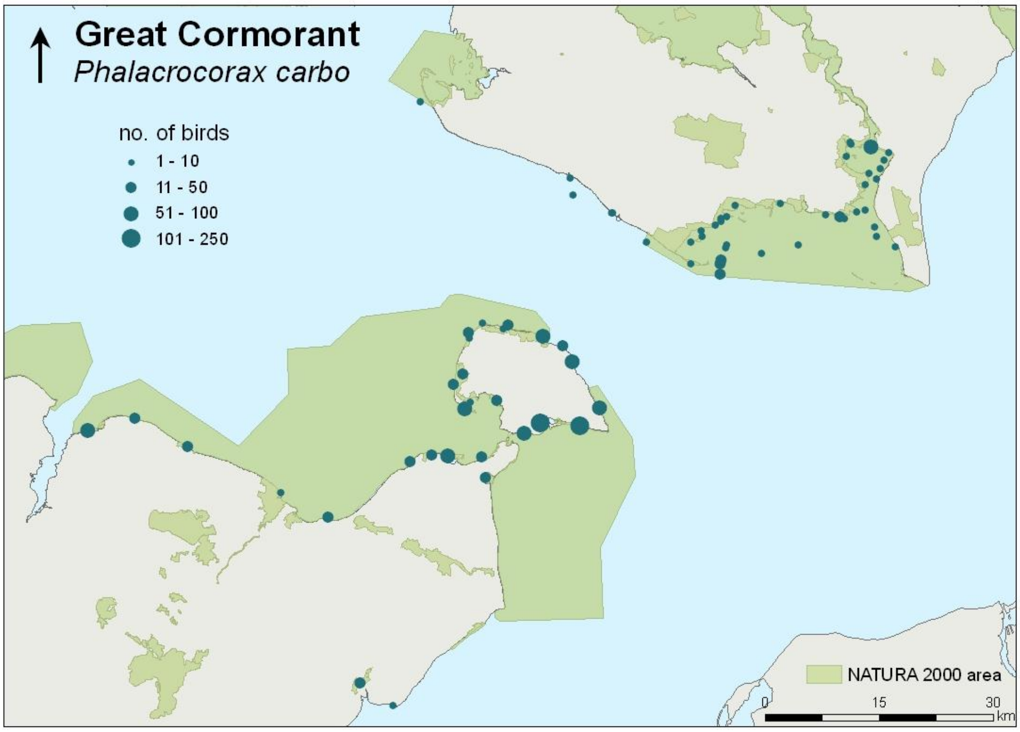


Figure 4.25 Distribution of Great Cormorant during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Great Cormorant abundance estimates for SPAs

Based on FEBI survey data no estimates for particular SPAs were possible. According to supplementary datasets, the SPA Hyllekrog-Rødsand regularly supports high numbers of Great Cormorants, especially during autumn months. Sand banks of this area are an important resting site for Great Cormorants in the Fehmarnbelt area with regularly numbers observed of about 2,000 birds. The DOF database reports an observation of 6,500 Great Cormorants for this area, indicating this SPA supporting internationally important numbers of the species (DOF 2010).

The German mainland coastal counts indicate high numbers occurring in the SPA Eastern Kiel Bight (OAG 2010). More than 3,800 cormorants were reported for mainland sections of this area alone in September 2009 (OAG 2010). Taking incomplete coverage during this survey into account, internationally important numbers exceeding 1 % of the biogeographic population (3,900 birds) are expected to occur in this SPA in autumn.

For the SPA Baltic Sea east of Wagrien only data of mid-winter count 2009 with incomplete coverage of the mainland coastal area is available. Thus, recorded 463 birds have to be considered as a minimum estimate for this SPA.

Great Cormorant trends

After a critical decline of Great Cormorants in the 20th century due to intense hunting, populations in Europe have recovered since the late 1970s and are considered as increasing or stable (BirdLife International 2004, Wetlands International 2006, Mendel et al. 2008). Long-term data of annual mid-winter land-based counts from the island of Fehmarn indicates a similar pattern in numbers for Great Cormorants wintering in the study area (Figure 4.26; AKVSW 2010). Mid-winter counts in Denmark suggest increasing numbers of Great Cormorants for entire Denmark (Petersen et al. 2010), whereas the breeding population in Denmark is described as stagnant or slightly declining (Bregnballe and Eskildsen 2009). Kieckbusch et al. (2010) describe a similar pattern for German and particularly Schleswig-Holstein Great Cormorant breeding population.

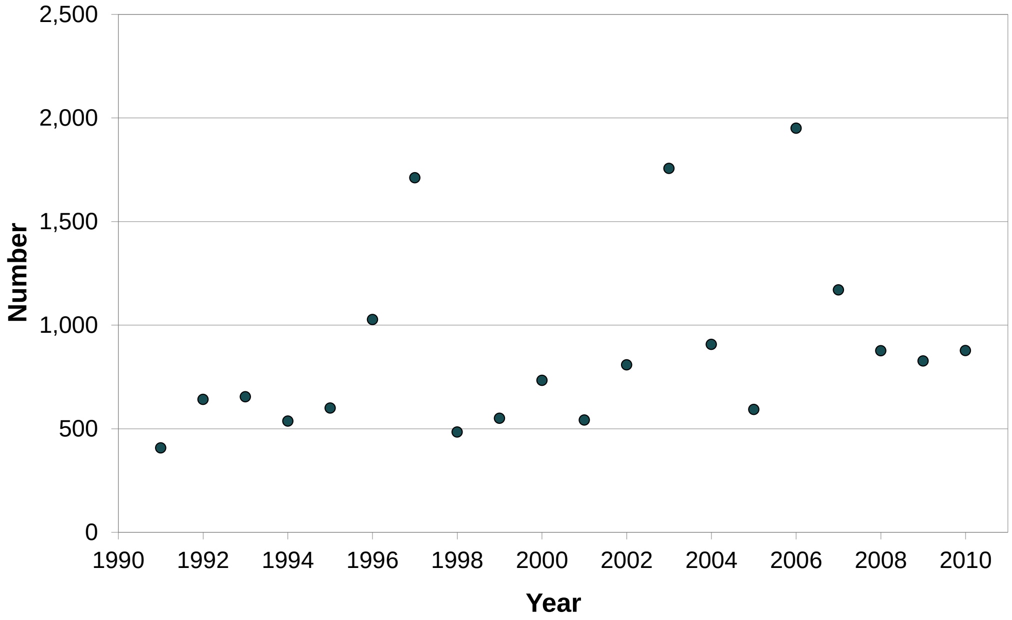


Figure 4.26 Numbers of Great Cormorants recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010. Data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Great Cormorant

The NW European breeding population of *P. c. sinensis* comprises 380,000 to 405,000 birds (Wetlands International 2006). As the 1 % value for this biogeographic population is 3,900 individuals, the results of FEBI baseline investigations and supplementary data indicate that more than 1 % of the population presently uses the Fehmarnbelt area in the course of the year. Available datasets indicate that numbers of international importance occur in the SPAs Hyllekrog-Rødsand (maximum 6,500 birds) and Eastern Kiel Bight (more than 3,900 birds expected).

Great Cormorant – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	6,500 + 3,900
Max. abundance estimate in the alignment area:	500 + 150
Period of max. abundance in Fehmarnbelt:	September – November
Areas of max. abundance in Fehmarnbelt:	See Figure 4.23, Figure 4.24
Explanations:	Maximum abundance estimate represents sum of maximum counts in the SPAs Hyllekrog-Rødsand (6,500 birds) and Eastern Kiel Bight (3,900 birds) from supplementary datasets. Maximum abundance in the alignment area was obtained from supplementary datasets for Rødbyhavn (500 birds) and land-based mid-winter survey of 2009 for the German part of this area (150 birds).

4.1.6 Mute Swan – *Cygnus olor*

Mute Swan – *Cygnus olor*

Biogeographic population: NW and C Europe

Breeding range: NW mainland and C Europe

Wintering / core non-breeding range: W and S Baltic Sea, few inland (Cramp and Simmons 1977)

Population size: 250,000

1 % value: 2,500

Conservation status: EU Birds Directive, Annex I: -

EU SPEC Category: non-SPEC^{E}

EU Threat Status: secure

Target species in SPAs: Hyllekrog-Rødsand (DK006X083)

Key food: water and swamp plants, grass, in winter also arable crops

Period of presence in Fehmarnbelt: Breeding, moulting: April – August

Wintering, migrations: September – March

Origin of Mute Swan in the Fehmarnbelt

The Mute Swan is a resident or partly migratory species in the region. The species is a common breeding bird in north-western Europe. Wintering birds in the Fehmarnbelt region are described as originating from Germany, Poland, the Baltic countries and Sweden, and there are also a few records from the Netherlands and England (Fransson and Petterson 2001, Bønløkke et al. 2006). FEBI ring recovery analysis could not find indications for a seasonal pattern of movements (Appendix IV).

Data sources on Mute Swan in the Fehmarnbelt

Table 4.19 shows a list of available datasets and their use for the baseline assessment of the species. Numbers and distribution of Mute Swans are best represented in FEBI dedicated search flights over Rødsand Lagoon and Orther Reede. Due to ship's draught, ship-based surveys are not suitable for surveying swans as these birds are confined to shallow waters. Therefore ship-based data were not used in swan baseline assessment. Additional information about Mute Swan abundance and distribution was provided by FEBI aerial transect surveys and supplementary datasets of Danish and German land-based counts (AKVSW 2010, DOF 2010, OAG 2010) and Danish mid-winter aerial surveys (NOVANA, Petersen et al. 2006, 2010) (Table 4.19).

Table 4.19 List of datasets and their use in baseline assessment of Mute Swan in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species distribution
FEBI dedicated search flights	Primary dataset for estimating species abundance in Rødsand Lagoon and Orther Reede
FEBI ship transect surveys	Dataset not used due to non-covered shallow water areas
FEBI GPS telemetry	Primary dataset for assessing species habitat use in Rødsand Lagoon
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Mute Swan in the Fehmarnbelt

According to Berndt and Busche (1991) Mute Swans are very abundant along the German Baltic Sea coast. The species is present in the region all year and maximum numbers are reached in winter (January/February; Berndt and Busche 1991).

Mute Swan abundance estimates based on dedicated search flights

Monthly search flights were conducted in Rødsand Lagoon (including its northern part Guldborg Bredning) between January 2009 and October 2010 in order to count resting swans in the area (Figure 4.27). Because this method did not allow a reliable differentiation between different swan species due to flight altitude and speed, swans were not identified to species level. Thus, winter numbers displayed in Figure 4.27 include Mute Swans, Whooper Swans, which also winter in the area, and possibly Bewick’s Swans. Summer numbers presented are expected to consist only of Mute Swans.

High numbers exceeding 1,000 swans were present in Rødsand Lagoon all year round with the highest concentrations occurring between July and September (Figure 4.27). During this period Mute Swans gather in the area for moulting their feathers and are flightless for approximately 6 weeks (Bauer et al. 2005). A maximum number of 10,401 Mute Swans was recorded during the survey flight on August 1, 2009 (Figure 4.27; equalling to 4.2 % of the biogeographic population).

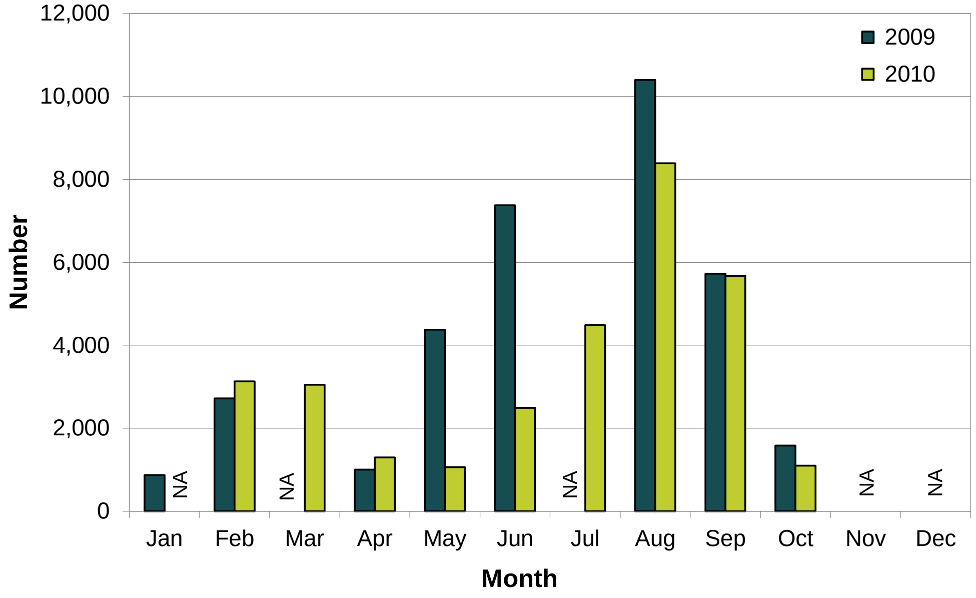


Figure 4.27 *Numbers of swans counted during dedicated search flights in Rødsand Lagoon between January 2009 and September 2010. Swans of genus* Cygnus *were not identified to species level; NA = no data available.*

Between August 2009 and October 2010 monthly search flights for census of herbivorous waterbirds were conducted in Orther Reede (southwest of Fehmarn Island). Number of swans recorded fluctuated between 0 and 476 birds (Figure 4.28). In contrast to the seasonal pattern observed in Rødsand Lagoon (Figure 4.27), the highest numbers in this area were observed during transitional and winter periods (Figure 4.28). A maximum of 476 swans was recorded during the search flight in October 2010.

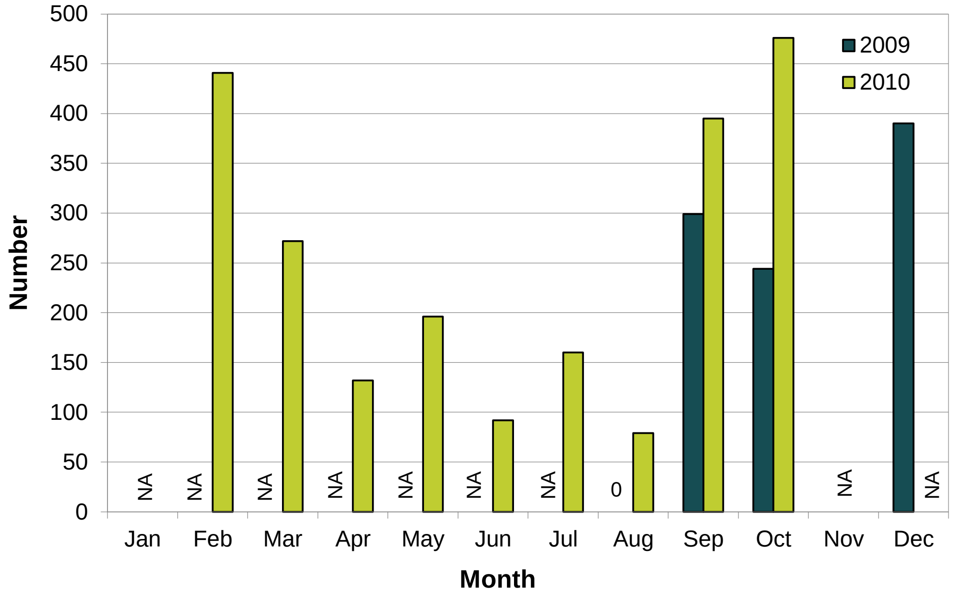


Figure 4.28 *Numbers of swans counted during dedicated search flights in Orther Reede between August 2009 and October 2010. Swans of genus* Cygnus *were not identified to species level; NA = no data available.*

Mute Swan abundance according to supplementary datasets
Coastal counts in selected (consistently covered) survey sections along the German mainland coast between September and April 2008/2009 and 2009/2010 show consistent presence of Mute Swans in the survey area (Figure 4.29; OAG 2010). Mainland counts agree well with the seasonal pattern recorded during search flights in Orther Reede (Figure 4.28) with highest numbers occurring in transitional and winter periods.

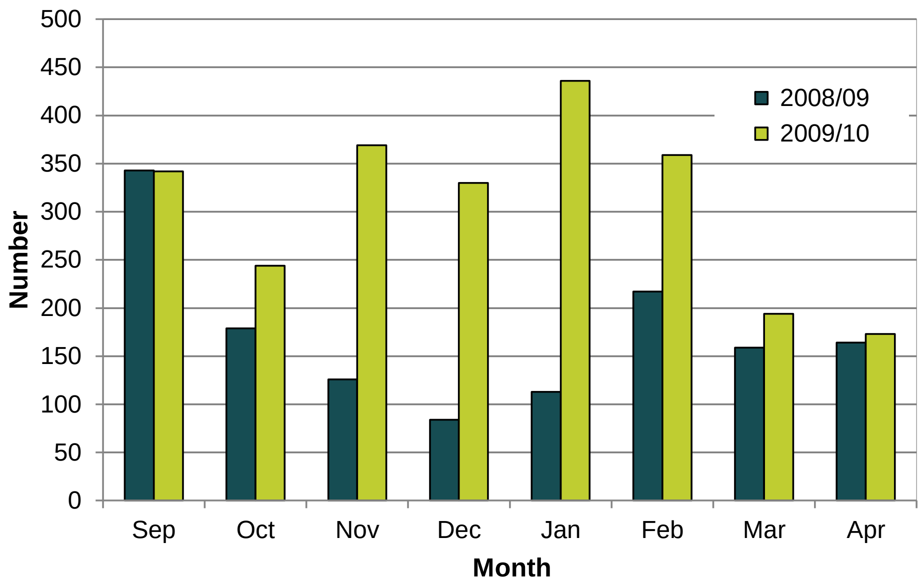


Figure 4.29 Numbers of Mute Swans recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

In a total 1,819 Mute Swans were counted in the German part of the study area during the German mid-winter land-based survey of 2009 (AKVSW 2010, OAG 2010). Monthly surveys by OAG Schleswig-Holstein indicated that highest numbers occur in autumn and winter (Figure 4.29; OAG 2010), therefore mid-winter survey could be assumed to represent a reliable estimate of Mute Swan abundance in the German part of the Fehmarnbelt.

The Danish mid-winter waterbird census of 2008 (NOVANA, Petersen et al. 2010) reported 1,138 Mute Swans in the Danish part of the study area (birds observed during search and transect aerial surveys). The majority of these birds (1,064) were observed in the Rødsand Lagoon. For the Danish alignment area a maximum number of 100 Mute Swans is reported for the area of Rødbyhavn (DOF 2011).

The data from the DOF database confirm that Rødsand Lagoon supports high numbers of Mute Swans all year with numbers peaking in July-August (DOF 2010). Mid-winter numbers regularly exceed 1,000 birds and maximum reported summer estimate is 16,200 (August 1, 2009; DOF 2010).

Distribution and habitat use of Mute Swan in the Fehmarnbelt
The Mute Swan is widely distributed in freshwater habitats and sheltered coastal areas of the Baltic Sea (Berndt and Busche 1991). The species is confined to shallow water areas where it mainly feeds on submerged vegetation (Berndt and Busche 1991).

Mute Swan distribution and habitat use according to GPS telemetry

GPS telemetry of swans in Rødsand Lagoon revealed that tagged birds moved relatively extensively within the lagoon, but were always restricted to its western part (Figure 4.30). A habitat model considering only two predictor variables: average water level and *Zostera* coverage, suggested that key habitats of moulting Mute Swans are mainly distributed in the western half of the lagoon (Figure 4.31) and that habitat suitability is primarily driven by water depth and only partly by coverage of *Zostera* beds (Figure 4.32).

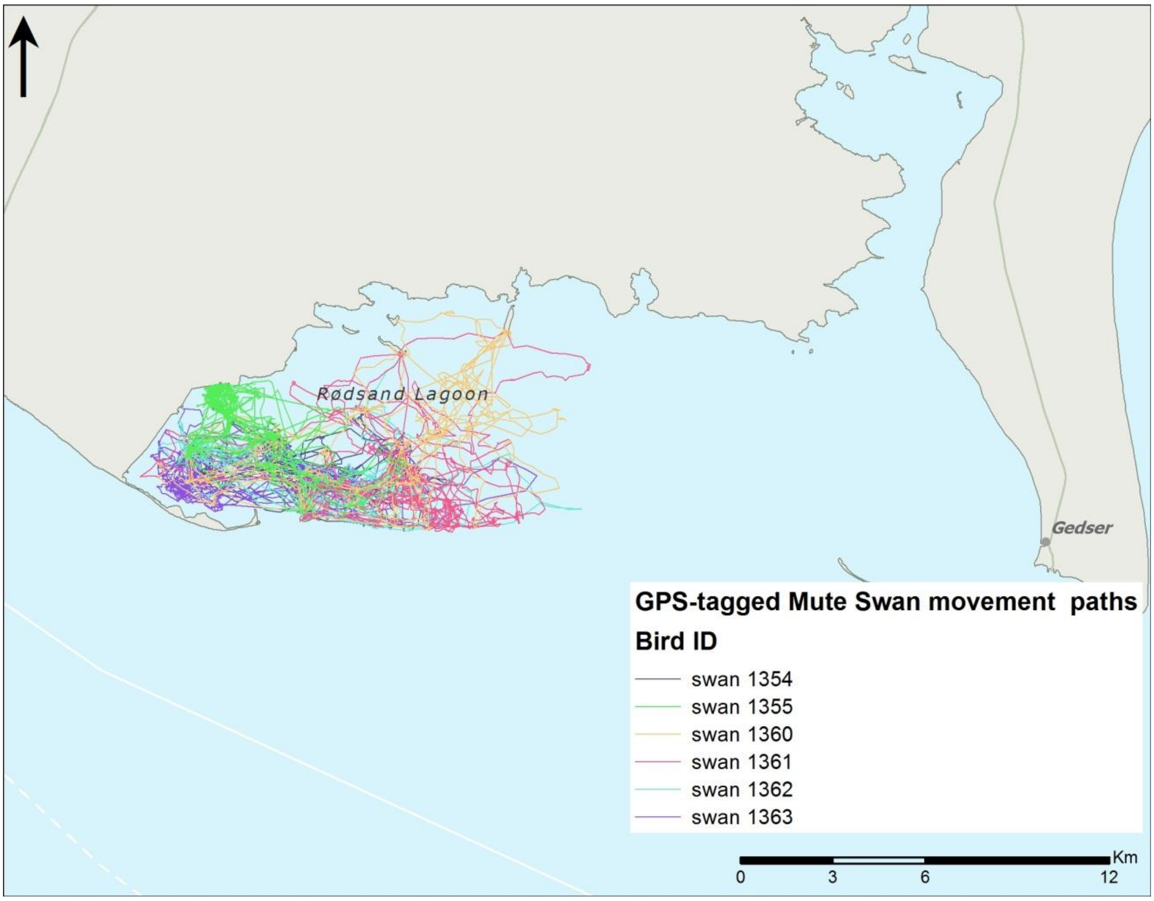


Figure 4.30 Movement paths of Mute Swans, tracked using GPS telemetry in July – August 2010.

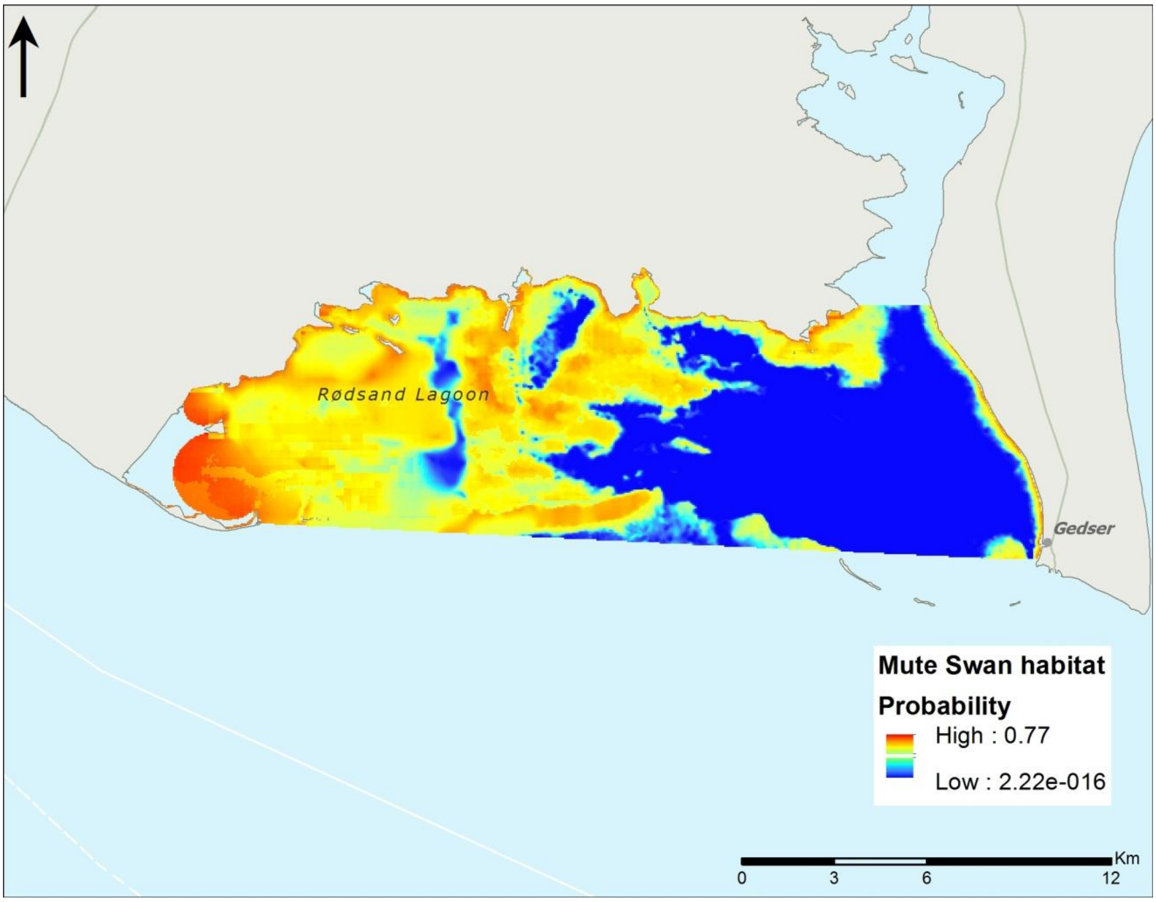


Figure 4.31 Modelled habitat suitability of moulting Mute Swans in Rødsand Lagoon indicates that key habitats are mainly distributed in the western half of the area.

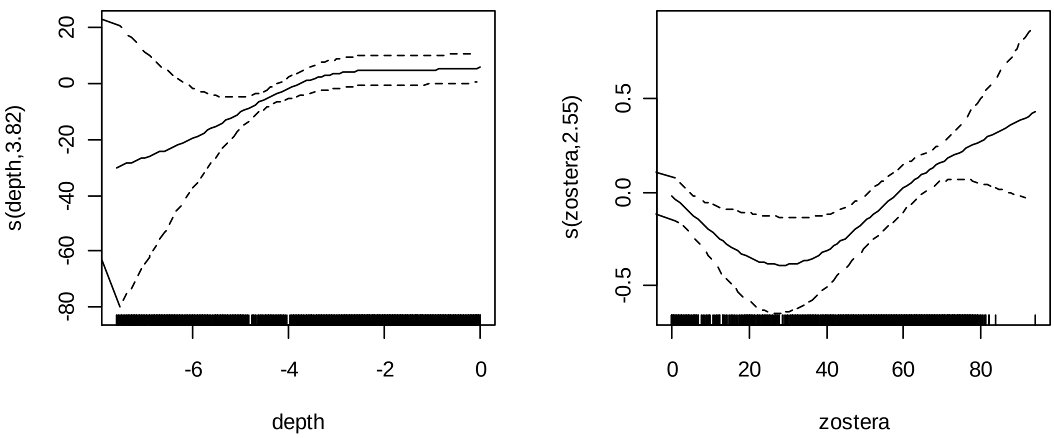


Figure 4.32 Spline curves of Mute Swan habitat suitability model for Rødsand Lagoon illustrating modelled habitat dependence on water depth (χ^2=101.5, P<0.01) and Zostera coverage (χ^2=15, P<0.01).

Mute Swan distribution according to FEBI survey data

During aerial transect surveys swans often could not be identified to species level. Therefore, beside Mute and Whooper Swans a third category of unidentified swans was added in the distribution maps (Figure 4.33, Figure 4.34). Based on known species biology and land-based observations it can be assumed that a majority of unidentified swans were Mute Swans during summer surveys.

The results from the aerial surveys identified the southern coast of Fehmarn (Orther Reede and Burger Binnensee) and the inner part of Rødsand Lagoon as areas of main Mute Swan concentrations in winter (Figure 4.33). This agrees with earlier findings reported in the Fehmarnbelt feasibility study (Skov et al. 1998). The aerial transect survey of July 2009 (Figure 4.34; Appendix II) illustrates a typical Mute Swan distribution in summer, when the majority of birds aggregate in the western part of Rødsand Lagoon. This coincides with findings about Mute Swans habitat use according to GPS telemetry presented above (Figure 4.30).

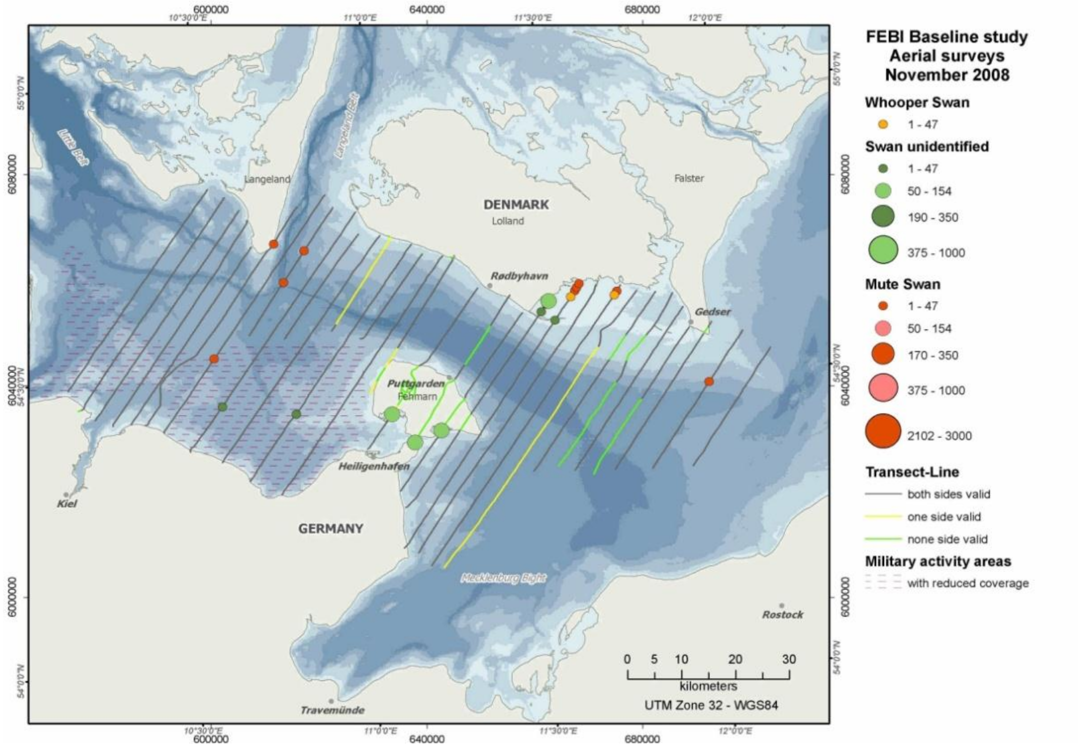


Figure 4.33 Example of the observed swan distribution in the study area during aerial transect surveys in winter period (November 2008).

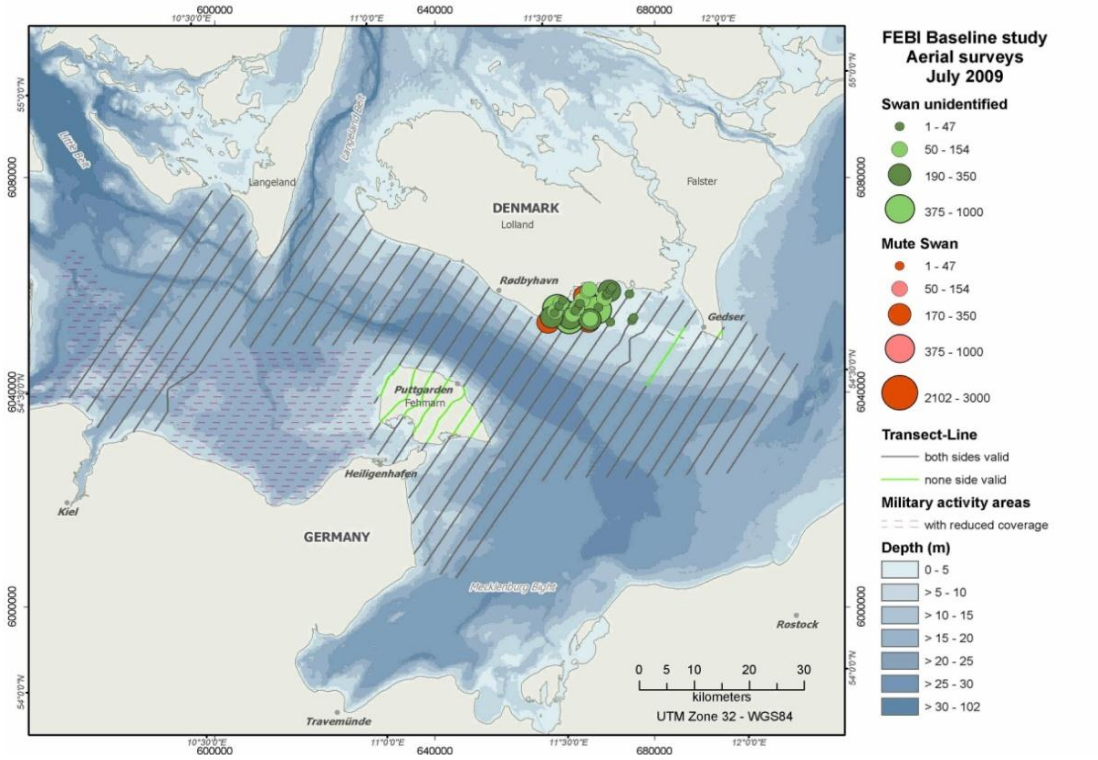


Figure 4.34 Example of the observed Mute Swan distribution in the study area during aerial transect surveys in summer period (July 2009).

The results of dedicated search flights for counting swans in Rødsand Lagoon (Figure 4.35, Figure 4.36; Appendix II) confirm the swans are concentrating in the western part of the lagoon during the moulting season in summer (Figure 4.36). Besides, the results also indicate that the northern part of the lagoon (Guldborg Bredning) is frequently used by swans, also (Figure 4.36). The swan distribution recorded during winter surveys differed from the summer distribution as wintering birds were distributed along the entire coastline of the lagoon (Figure 4.35).

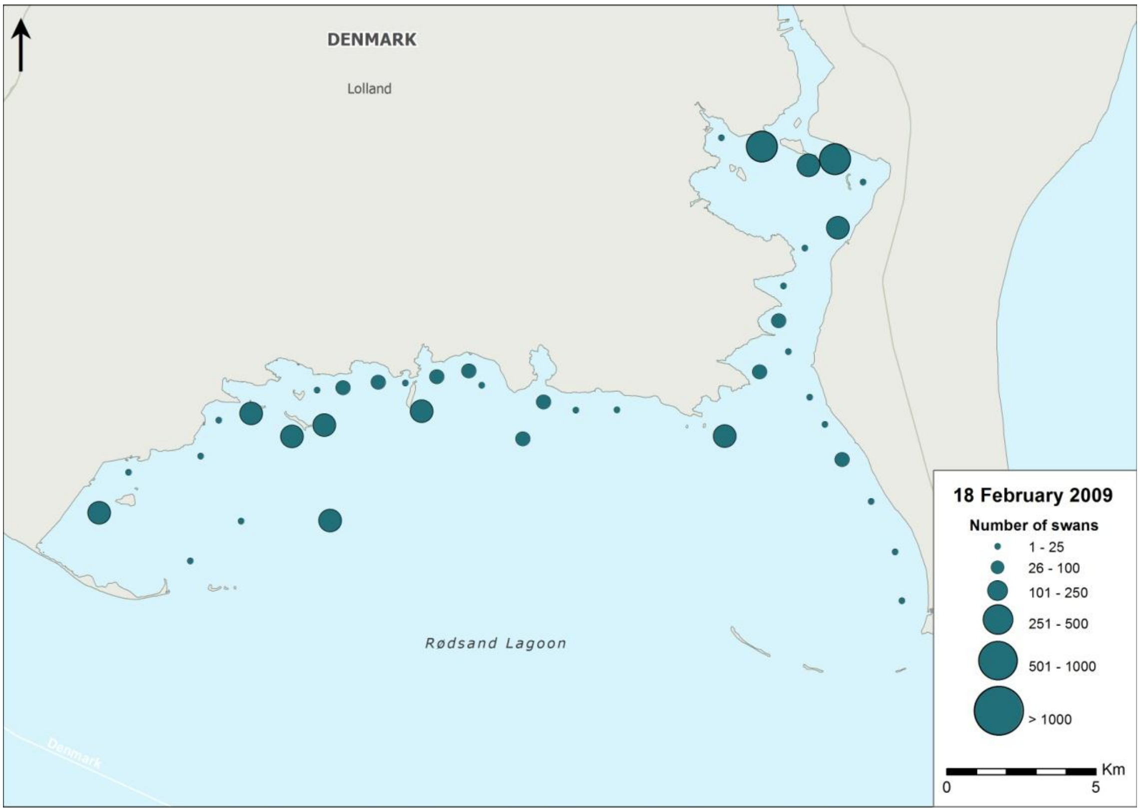


Figure 4.35 *Example of observed swan distribution in Rødsand Lagoon during dedicated search flight in February 2009. Swans of genus* Cygnus *were not identified to species level.*

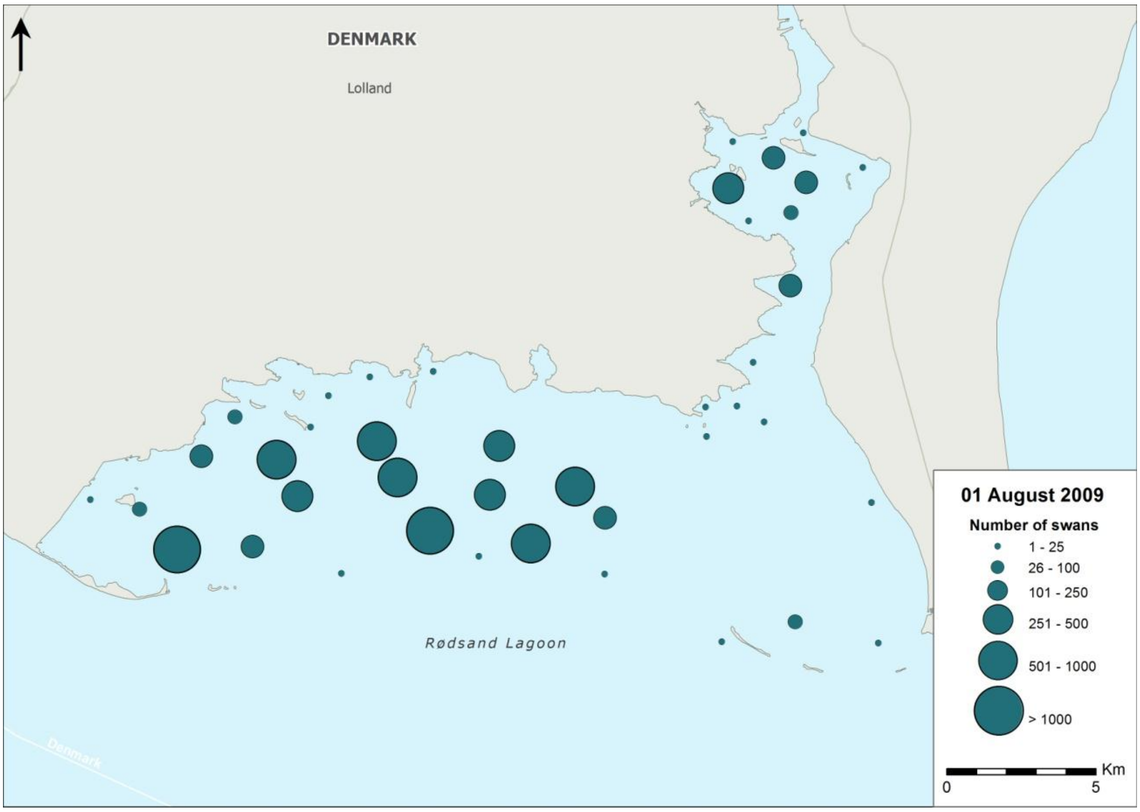


Figure 4.36 *Example of observed swan distribution in Rødsand Lagoon during dedicated search flight in August 2009. Swans of genus* Cygnus *were not identified to species level.*

Mute Swan distribution according to supplementary datasets

The Danish mid-winter survey of 2008 confirms the pattern of winter swan distribution as recorded during the FEBI surveys in Rødsand Lagoon: birds were mainly observed in the coastal areas of the lagoon (Figure 4.37; Petersen et al. 2010). The German mid-winter land-based count of 2009 indicated that Mute Swans occur in different parts of the surveyed coastline with highest aggregations recorded within two areas in the south of Fehmarn: Orther Reede and Burger Binnensee (Figure 4.37; AKVSW 2010, OAG 2010).

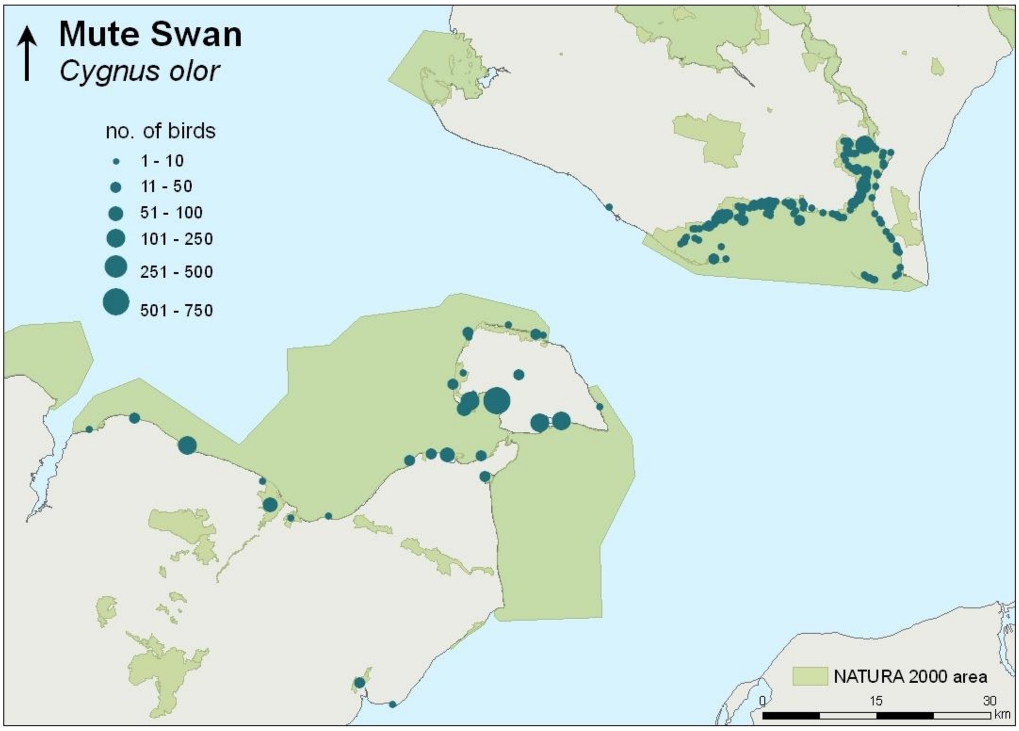


Figure 4.37 Distribution of Mute Swan during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Mute Swan abundance estimates for SPAs

The majority of Mute Swans counted during the German mid-winter land-based count of 2009 were recorded within the SPA Eastern Kiel Bight (1,414 birds, corresponding to 0.6 % of the biogeographic population; AKVSW 2010, OAG 2010). Burger Binnensee in the southeast of the island of Fehmarn within the SPA Baltic Sea east of Wagrien also regularly supports aggregations of up to a few hundred of Mute Swans, but in general recorded swan numbers were not very high within this SPA (381 swans in January 2009; AKVSW 2010, OAG 2010).

The FEBI dedicated search flights and supporting information of DOF database (DOF 2010) indicated that between 10,000 and 16,000 Mute Swans use the SPA Hyllekrog-Rødsand during summer months, corresponding to 4.0-6.5 % of the biogeographic population.

Mute Swan trends

The trend in the population of Mute Swans in Europe has been described as increasing for many years, although there are indications that the Baltic wintering population has declined since 1990 (Wetlands International 2006). Land-based mid-winter counts on the island of Fehmarn show no significant trend over the past 20 years (Figure 4.38; AKVSW 2010). According to numbers presented in Petersen et al. (2006, 2010) the overall Danish wintering Mute Swan population appears to be stable or slightly decreasing.

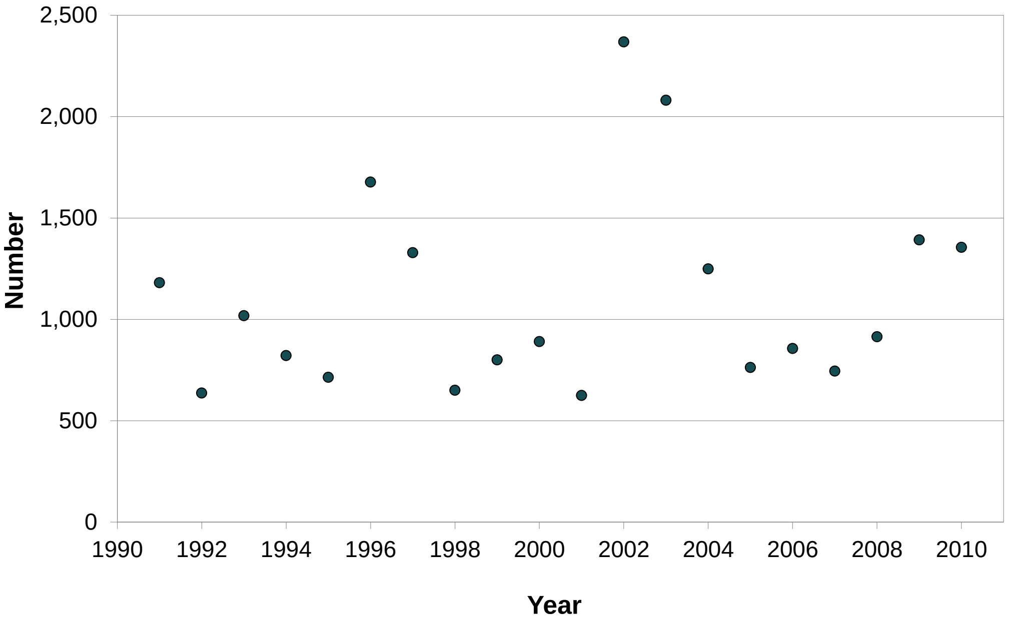


Figure 4.38 *Number of Mute Swans recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.*

Importance of the Fehmarnbelt to Mute Swan

Mute Swans are present in high numbers in the study area throughout the year. Within the study area Rødsand Lagoon is an internationally important site since the area regularly supports more than 10,000 moulting Mute Swans during summer months (4.2% of the biogeographic population). We used our own count of 10,400 as the highest estimate recorded in Rødsand Lagoon, as we consider this being a more reliable figure compared to a report of 16,200 (DOF 2010) dated on the same day as our dedicated aerial survey. German coastal areas, especially sheltered bays in the south of Fehmarn Island, regularly hold more than 0.5% of the European Mute Swan population in winter as well (AKVSW 2010, OAG 2010).

Mute Swan – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	10,400
Max. abundance estimate in the alignment area:	100 + 16
Period of max. abundance in Fehmarnbelt:	July – September
Areas of max. abundance in Fehmarnbelt:	Rødsand Lagoon, Figure 4.36
Explanations:	Maximum abundance obtained from FEBI aerial surveys in Rødsand Lagoon. Maximum abundance in the alignment area was obtained from supplementary datasets for Rødbyhavn (100 birds) and 16 individuals reported for the German part of this area during land-based mid-winter survey of 2009. Distribution obtained from FEBI swan search flights.

4.1.7 Whooper Swan – *Cygnus cygnus*

Whooper Swan – *Cygnus cygnus*

Biogeographic population: N mainland Europe (br)

Breeding range: Scandinavia, N European Russia

Wintering / core non-breeding range: NW and C mainland Europe

Population size: 59,000

1 % value: 590

Conservation status:	EU Birds Directive, Annex I: listed
	EU SPEC Category: non-SPEC^{E}W
	EU Threat Status: secure
Target species in SPAs:	Hyllekrog-Rødsand (DK006X083)
	Eastern Kiel Bight (DE1530-491)
	Baltic Sea east of Wagrien (DE1633-491)

Key food: water plants, weeds, and arable crops in winter

Period of presence in Fehmarnbelt: Wintering, migrations: October – April

Origin of Whooper Swan in the Fehmarnbelt

The Whooper Swan breeds from the western to the easternmost edge of the Palaearctic. The Western Palaearctic breeding population winters in northern parts of Western and Central Europe and in Scandinavia (Cramp and Simmons 1977). Whooper Swans wintering in Denmark mainly originate from breeding areas in Finland and Russia. Birds wintering in the southern part of the country are from mid- to southern Finland as opposed to the population in the north of Finland (Bønløkke et al. 2006).

Data sources on Whooper Swan in the Fehmarnbelt

Table 4.20 provides an overview of available datasets and their use in the baseline assessment of Whooper Swans in the Fehmarnbelt area. As the FEBI aerial and ship-based surveys did not cover inland areas often used by staging Whooper Swans, the baseline assessment of this species was mainly based on supplementary datasets providing information from land-based counts in Germany and Denmark (Table 4.20).

Table 4.20 List of datasets and their use in baseline assessment of Whooper Swan in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used due to non-covered inland areas
FEBI dedicated search flights	Dataset not used as swans could not be identified to species level
FEBI ship transect surveys	Dataset not used due to non-covered shallow water areas
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the coast of Fehmarn
NOVANA aerial surveys	Supporting dataset for species abundance and distribution in Danish part of the Fehmarnbelt in winter
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Whooper Swan in the Fehmarnbelt

Denmark and Germany represent the most important wintering areas for the north European population of Whooper Swan with approximately two thirds of the entire population wintering in the two countries (Wahl and Degen 2009). In Germany the species is most abundant on the inland areas of Schleswig-Holstein and further east along the Baltic Sea coast of Mecklenburg-Western Pomerania (Wismar Bay, Rügen, Darß and Usedom; Wahl and Degen 2009). According to the swan census of 2005, the north European mainland population of Whooper Swans was estimated at 90,000 birds (Wahl and Degen 2009) compared to an earlier estimate of 59,000 (Wetlands International 2006). This would correspond to a 1% value of 900 birds. However, as these results have not been formally published and agreed on for updating the 1% criterion, a lower conservative value of 590 birds as listed in Wetlands International (2006) is applied in this assessment.

The Whooper Swan is a typical wintering species in Schleswig-Holstein with the highest numbers usually observed in January (Berndt and Busche 1991, Berndt et al. 2005). On Fehmarn Island, maximum numbers were frequently observed in March as the island appears to serve as a stop-over site for birds during spring migration (Berndt et al. 2005). This pattern is confirmed by monthly surveys conducted along the German mainland coast between September and April 2008/2009 and 2009/2010 (Figure 4.39; only selected, consistently covered areas displayed; OAG 2010). In both analysed datasets highest numbers of Whooper Swans were recorded during transitional periods in November and March (Figure 4.39).

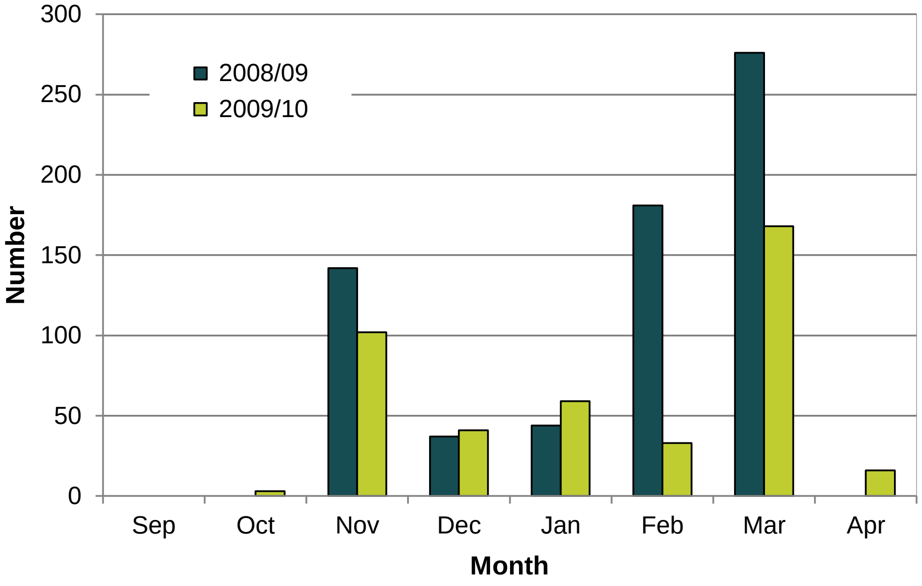


Figure 4.39 Numbers of Whooper Swans recorded during the land-based surveys between September and April 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

The mid-winter coastal count in January 2009 reported a total number of 379 Whooper Swans observed in the German part of study area (AKVSW 2010, OAG 2010). As Figure 4.39 indicates, January numbers might not represent the peak numbers occurring in the area. The Danish mid-winter census of waterbirds in 2008 recorded a total of 886 Whooper Swans within Rødsand Lagoon (Petersen et al. 2010) equal to 1.6 % of the biogeographic population, out of which 276 birds were registered inland. The DOF database mentions a maximum number of 335 Whooper Swans in Rødsand Lagoon (March 10, 2006).

Distribution and habitat use of Whooper Swan in the Fehmarnbelt

During the mid-winter coastal count of 2009 in Germany, the majority of Whooper Swans were recorded inland (the highest numbers recorded on Fehmarn and on Großer Binnensee close to Hohwacht Bay, Figure 4.40; AKVSW 2010, OAG 2010). This information agrees well with general habitat preferences of the species in mid-winter as presented in Wahl and Degen (2009). The authors report that in contrast to Mute Swan wintering in shallow coastal areas close to Rügen (Mecklenburg-Western Pomerania, Germany), Whooper Swan is almost exclusively found inland further west in Schleswig-Holstein (Wahl and Degen 2009). A similar pattern of habitat use is described by Berndt et al. (2005) for Fehmarn with most swans being inland in January, although the authors also mention that a higher proportion of Whooper Swans uses coastal waters earlier in the winter. Sheltered coastal areas of Orther Reede, Fehmarnsund and Burger Binnensee south of the island are mentioned as sites used by the species (Berndt et al. 2005).

In Germany the near-shore lake Großer Binnensee and agricultural areas of Fehmarn supported most of the Whooper Swans recorded in January 2009 (Figure 4.40; AKVSW 2010, OAG 2010). On the Danish side, a mid-winter survey of 2008 indicated high numbers of this species in Rødsand Lagoon (Figure 4.40; Petersen et al. 2010).

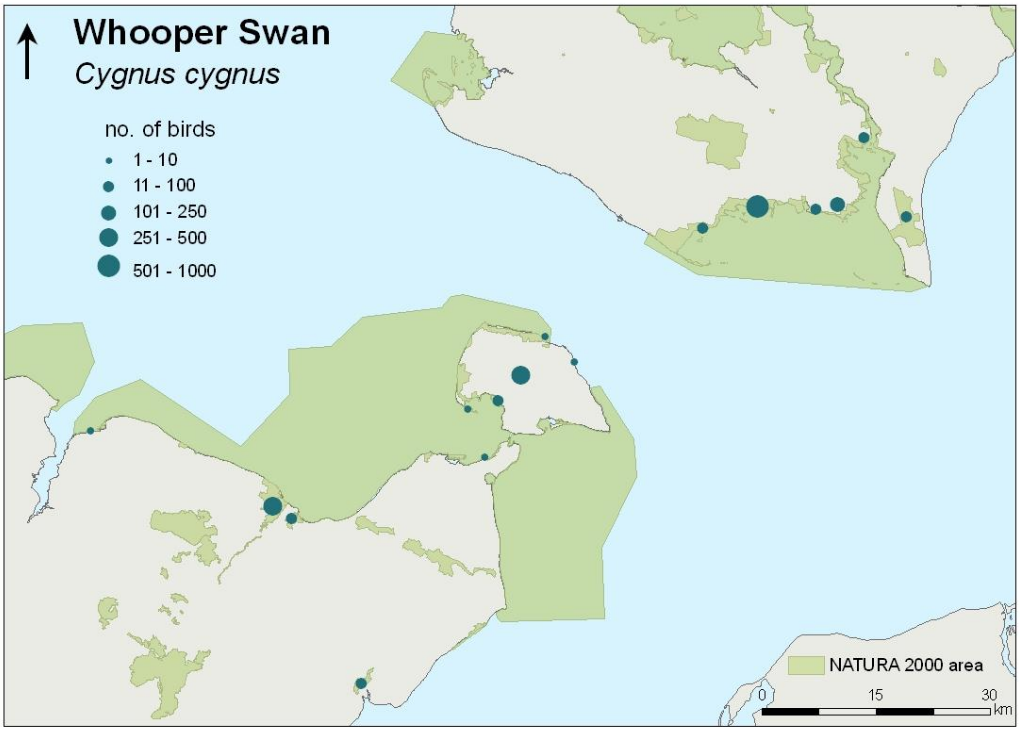


Figure 4.40 Distribution of Whooper Swan during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Whooper Swan abundance estimates for SPAs

Out of 379 Whooper Swans observed in the German part of the study area during mid-winter coastal counts (AKVSW 2010, OAG 2010), the majority of birds (261) were recorded within the SPA Eastern Kiel Bight and no swans in the SPA Baltic Sea east of Wagrien. Monthly land-based surveys along the mainland coast of the SPA Eastern Kiel Bight suggest that higher numbers are present in the area during migration periods (OAG 2010): 555 Whooper Swans were counted in mainland sections of the SPA Eastern Kiel Bight in February 2010. Taking into account the survey sections not covered on Fehmarn, the total number (590 birds) is expected to exceed 1% of the biogeographic population in the SPA Eastern Kiel Bight during transitional periods. The SPA Baltic Sea east of Wagrien includes three sheltered areas which regularly support Whooper Swans: Burger Binnensee, Sahrendorfer Binnensee and Großenbroder Binnenwasser. Available datasets do not indicate that internationally important numbers occur in these areas. These conclusions also agree with numbers published in Kieckbusch (2010).

A total of 886 Whooper Swans equal to 1.6% of the biogeographic population have been recorded within the SPA Hyllekrog-Rødsand during the mid-winter waterbird census in Denmark in February 2008 (Petersen et al. 2010).

Whooper Swan trends

The north European breeding population of Whooper Swan is described as increasing since the 1990s (BirdLife International 2004, Wetlands International 2006). Especially, increasing numbers of Whooper Swans were reported for Germany and Denmark during the most recent years (Wahl and Degen 2009, Petersen et al. 2010). However, the pattern of an increasing population is not reflected in the long-term mid-winter data of Fehmarn, where survey results show no significant trend in Whooper Swan numbers on the island over the past 20 years (Figure 4.41, AKVSW 2010).

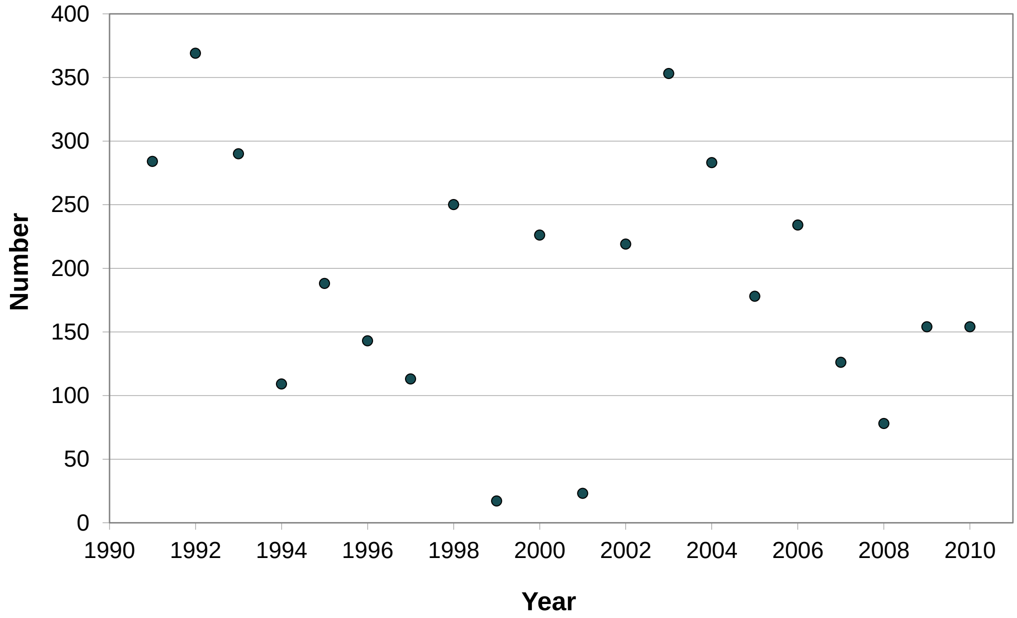


Figure 4.41 Numbers of Whooper Swans recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW 2010.

Importance of the Fehmarnbelt to Whooper Swan

The Whooper Swan occurs mainly during transitional periods and winter time in the study area. Internationally important numbers were observed in both Danish and German parts of the Fehmarnbelt. In Denmark the SPA Hyllekrog-Rødsand (886 birds; 1.6% of the biogeographic population; Petersen et al. 2010) supports internationally important numbers. In Germany the SPA Eastern Kiel Bight likely meets the 1 % criterion in late winter (555 birds counted in February 2010, without Fehmarn being included in the survey; OAG 2010).

The majority of Whooper Swans counted in Germany were observed inland (89% of the birds recorded during the mid-winter survey of 2009; AKVSW 2010, OAG 2010). In Denmark a high proportion of Whooper Swans was recorded using marine or brackish habitats such as Rødsand Lagoon.

Whooper Swan – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	890 + 590
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	November, Februray/March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.40
Explanations:	Maximum abundance obtained from supplementary datasets for the SPAs Hyllekrog-Rødsand (890 birds, partly inland) and Eastern Kiel Bight (590 birds, mostly inland). Maximum abundance in the alignment area estimated based on 2 individuals reported for the German part of this area during land-based mid-winter survey of 2009. Distribution obtained from supplementary datasets representing mid-winter survey.

4.1.8 *Bewick's Swan – Cygnus (columbianus) bewickii*

Bewick's Swan – *Cygnus (columbianus) bewickii*

Biogeographic population: *C. c. bewickii*, NW Europe (non-br)

Breeding range: Arctic N Russia

Wintering / core non-breeding range: NW Europe

Population size: 20,000

1 % value: 200

Conservation status: EU Birds Directive, Annex I: listed
EU SPEC Category: SPEC 3W
EU Threat Status: vulnerable

Target species in SPAs: -

Key food: grass, arable crops

Period of presence in Fehmarnbelt: Wintering, migrations: October – April

Origin of Bewick's Swan in the Fehmarnbelt

In the Western Palaearctic the Bewick's Swan breeds in the Russian tundra all the way to the eastern Siberia. The western Siberian populations are migratory and winter in Western Europe (Cramp and Simmons 1977). Denmark is one of the key staging areas of the Bewick's Swan, but the most important sites are located in western and northern Jutland (Petersen et al. 2006, 2010).

Data sources on Bewick's Swan in the Fehmarnbelt

Bewick's Swan is a rare species in the study area and has not been registered during the FEBI investigations. Therefore, supporting datasets were used for assessing abundance and distribution of the species in the Fehmarnbelt area (Table 4.21).

Table 4.21 List of datasets and their use in baseline assessment of Bewick's Swan in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used due to no sightings of the species
FEBI dedicated search flights	Dataset not used due to no sightings of the species
FEBI ship transect surveys	Dataset not used due to no sightings of the species
OAG land-based counts	Primary dataset representing species winter abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset representing species winter abundance and distribution along the coast of Fehmarn
NOVANA aerial surveys	Primary dataset for species wintering abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Bewick's Swan in the Fehmarnbelt

In Germany the lowlands of rivers Ems and Elbe are important wintering areas for Bewick's Swans from November to March (Wahl and Degen 2009). Highest numbers occur during spring migration in March, as shown by census of 2005, when almost 35 % (6,882 swans) of the biogeographic population were counted mainly in the eastern part of Schleswig-Holstein, outside the Fehmarnbelt study area (Wahl and Degen 2009). In Denmark northern and western Jutland support highest numbers of wintering birds, with a total count of 554 Bewick's Swans in the entire country in 2008 (Petersen et al. 2010).

In the Fehmarnbelt Bewick's Swans are recorded only irregularly as staging birds and in low numbers. Berndt et al. (2005) describe this species as a rare wintering species on Fehmarn Island. There are historical records of flocks bigger than 100 birds using inland areas of the island, but no aggregations exceeding 25 birds have been recorded in recent years. This pattern is confirmed by the mid-winter counts on the island of Fehmarn by AKVSW Hamburg, when only three times 1-14 Bewick's Swans were recorded during the past 20 years (AKVSW 2010). Only a few sightings of Bewick's Swans were recorded along the mainland coast of the German study area during the monthly counts by OAG Schleswig-Holstein within the past two years. The highest count consisted of 61 bird observed on the inland lake Kleiner Binnensee in November 2008, and 15 birds were recorded on the inland lake Sehlendorfer Binnensee in December 2009 (OAG 2010).

The DOF database confirms Bewick's Swan being a rare staging species in the study area. A maximum number of 138 resting Bewick's Swans were recorded on March 27, 2008 within SPA Hyllekrog-Rødsand (DOF 2010). Apart from this exceptionally high number, only single birds have been recorded during the recent years.

Distribution and habitat use of Bewick's Swan in the Fehmarnbelt
Bewick's Swans have only been recorded in the study area during land-based counts and only in low numbers. All observations recorded during German land-based surveys have been located inland (AKVSW 2010, OAG 2010). For the Danish coast the highest number of 138 resting Bewick's Swans close to the Fehmarnbelt was recorded in Saksfjed Inddæmning (DOF 2010), an inland area west of Rødsand Lagoon.

The observed inland habitat use of this species agrees with literature sources suggesting that Bewick's Swans rely exclusively on grasslands with no indication of aquatic feeding in Schleswig-Holstein during the census of 2005 (Wahl and Degen 2009).

Bewick's Swan abundance estimates for SPAs
No Bewick's Swans were recorded during the FEBI surveys. There is only indication of Bewick's Swans occurring in inland parts of the SPAs within the study area with one flock of 138 resting birds counted in the SPA Hyllekrog-Rødsand in March 2008 and a maximum of 61 birds recorded within the SPA Eastern Kiel Bight in November 2008.

No sightings of Bewick's Swan were reported in the available datasets for the SPA Baltic Sea east of Wagrien.

Bewick's Swan trends
The northwest European biogeographic population of Bewick's Swans is described as declining since the 1990s (Beekman 1997, Wetlands International 2006) and, based on international census of 2005, was estimated to consist of 20,000 birds compared to almost 30,000 individuals recorded in 1995 (Wetlands International 2006, Wahl and Degen 2009). Due to changes in winter distribution, numbers of Bewick's Swans wintering in Germany have increased during the same period, and inland areas of Lower Saxony and Schleswig-Holstein become of increasing international importance for this species (Wahl and Degen 2009).

Importance of the Fehmarnbelt to Bewick's Swan

Bewick's Swan is a rare wintering species in the Fehmarnbelt area and is mainly confined to inland habitats. The maximum available number recorded in the study area is one sighting of 138 birds (equalling to 0.7 % of the biogeographic population) on inland areas of the SPA Hyllekrog-Rødsand in 2008 (DOF 2010). At the German side the maximum of 61 birds (0.3 % of the biogeographic population) were recorded in inland areas of the SPA Eastern Kiel Bight (OAG 2010).

Bewick's Swan – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	138 + 61
Max. abundance estimate in the alignment area:	no records
Period of max. abundance in Fehmarnbelt:	November, February/March
Areas of max. abundance in Fehmarnbelt:	inland areas of SPA Hyllekrog-Rødsand and SPA Eastern Kiel Bight
Explanations:	Maximum abundance obtained from supplementary dataset for the SPAs Hyllekrog-Rødsand (138 birds, all inland) and Eastern Kiel Bight (61 birds, all inland). Distribution obtained from supplementary datasets.

4.1.9 Bean Goose – Anser fabalis

Bean Goose – *Anser fabalis*

Biogeographic population: A. f. rossicus (‘Tundra Bean Goose’)*

Breeding range: tundra from Kola Peninsula eastwards to Taymyr

Wintering / core non-breeding range: C and SW Europe

Population size: 600,000

1 % value: 6,000

Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC^{E}W EU Threat Status: secure
Target species in SPAs:	Hyllekrog-Rødsand (DK006X083)

Key food: herbs, grass, berries, outside breeding season mainly arable crops

Period of presence in Fehmarnbelt: Wintering, migrations: October – April

* Population *A. f. fabalis* (‘Taiga Bean Goose’), NW Europe (non-br) occurs, too. However, following Meininger et al. (1995) and Wahl et al. (2007) numbers of the larger population (*A. f. rossicus*) apply.

Origin of Bean Goose in the Fehmarnbelt

The Bean Goose breeds from the western to the easternmost parts of the Palaearctic. The entire Western Palaearctic population is migratory and winters in Europe (Cramp and Simmons 1977). Ring recoveries in Denmark originate mainly from Bean Geese breeding in Sweden and Finland. Especially Finish birds are recovered in Smålandsfarvandet (Appendix IV). In Denmark the first wintering Bean Geese arrive in October but leave the area again shortly after arrival. Other birds, mostly from Sweden, arrive in December when the weather is getting colder. As soon as the weather turns mild again, the wintering birds return to Sweden (Pihl et al. 2005). Berndt et al. (2005) also suggest that birds wintering on Fehmarn belong to the Swedish breeding population.

Data sources on Bean Goose in the Fehmarnbelt

During the FEBI baseline investigations no Bean Geese were recorded except for one sighting of 3 birds during the aerial survey in April 2010. Thus, supplementary datasets of land-based counts were used to evaluate species abundance and distribution in the Fehmarnbelt area (Table 4.22).

Table 4.22 List of datasets and their use in baseline assessment of Bean Goose in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used due to only one sighting of the species
FEBI dedicated search flights	Dataset not used due to no sightings of the species
FEBI ship transect surveys	Dataset not used due to no sightings of the species
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Bean Goose in the Fehmarnbelt
Bean Geese occur in the study area only during the winter period. The first individual birds can be observed in September, but the species becomes more frequent in the Fehmarnbelt area in mid- and late winter. In April most of the birds have already left the area, and only individual Bean Geese can be observed (Berndt et al. 2005, DOF 2010).

No Bean Geese were recorded along the German mainland coast during the mid-winter land-based survey in 2009 (OAG 2010). On Fehmarn 102 birds were observed inland near Wallnau, Salzensee and Grüner Brink (AKVSW 2010). Monthly waterbird counts along the German mainland coast between September and April (2008/2009 and 2009/2010; OAG 2010) report only two records of 5 and 20 birds on the coastal freshwater lakes Großer and Kleiner Binnensee.

Higher numbers of Bean Geese were reported for the Danish side of the study area. During NOVANA mid-winter survey 2008, 447 Bean Geese were counted in the area northwest of Guldborg Bredning, Rødsand Lagoon (Petersen et al. 2010). Further 380 individuals were counted inland east of Rødsand Lagoon on inland areas of southern Falster (2,981 birds in 2004; Petersen et al. 2006). The DOF database confirms that more than 100 Bean Geese regularly occur inland in the vicinity of Rødsand Lagoon (maximum 2,100 birds in March 2006; DOF 2010). For the Danish alignment area occasioanal records of single birds were documented in the marine areas at Rødbyhavn (DOF 2011).

Distribution and habitat use of Bean Goose in the Fehmarnbelt
During the Danish mid-winter survey of 2008 Bean Geese have been recorded aggregating on inland areas close to Rødsand Lagoon (Figure 4.42; Petersen et al. 2010). This distribution pattern was confirmed by observations reported in the DOF database (DOF 2010).

During the German mid-winter survey of 2009 birds were recorded on Fehmarn with small flocks resting inland at Grüner Brink, Salzensee and Wallnau (Figure 4.42; AKVSW 2010). No Bean Geese were observed along the German mainland coast counting sections during the mid-winter survey in 2009 (Figure 4.42; OAG 2010).

Usually Bean Geese feed on arable crops and grass. As observed during the land-based counts, this species is confined to inland areas during the daytime, but lakes and lagoons may be used as resting or retreat areas (Berndt et al. 2005; DOF 2010).

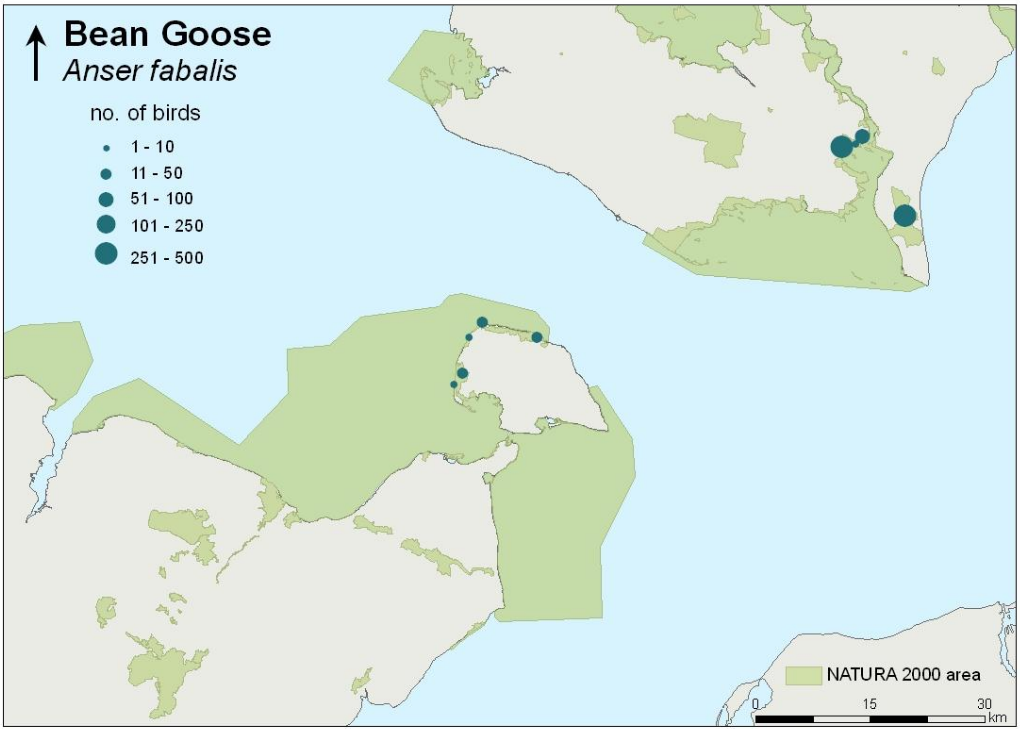


Figure 4.42 Distribution of Bean Goose during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of the aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Bean Goose abundance estimates for SPAs

All Bean Geese recorded along the German coastline of the study area were observed within the SPA Eastern Kiel Bight with the highest number of 102 individuals counted on inland freshwater habitats of Fehmarn Island. Bean Geese are rarely observed along the mainland coast. During the monthly surveys of the past two years Bean Geese were recorded only twice (5 and 20 birds) on inland lakes along the mainland coast (Großer und Kleiner Binnensee; OAG 2010). Thus, only low numbers use the inland areas of the SPA Eastern Kiel Bight.

No records were available about Bean Geese in the SPA Baltic Sea east of Wagrien. According to Kieckbusch (2010) there is no indication for larger Bean Goose aggregations using this SPA.

Higher numbers of Bean Geese were reported for the Danish part of the study area compared to numbers on the German side. Over 100 Bean Geese are regularly reported for inland areas of the SPA Hyllekrog-Rødsand (DOF 2010, Petersen et al. 2010). A maximum number of 2,100 birds was reported for this area on March 3, 2006 (DOF 2010).

Bean Goose trends

The European population of Bean Goose has increased substantially between 1970 and 1990 and the trend stabilised between 1990 and 2000. Thus, the European population is considered as being Secure (BirdLife International 2004).

Numbers of Bean Geese observed on the island of Fehmarn during the mid-winter land-based counts vary between years, but the long-term dataset shows that a few tens of Bean Geese regularly winter in the study area (AKVSW 2010, Figure 4.43). According to Berndt et al. (2005) the wintering numbers on Fehmarn vary depending on winter severity , with the highest numbers being observed in cold winters. A maximum number of 700 birds was recorded in winter 1978/79 (Berndt et al. 2005), but since the late 1980s no similar high numbers have been observed on the island (Figure 4.43; AKVSW 2010).

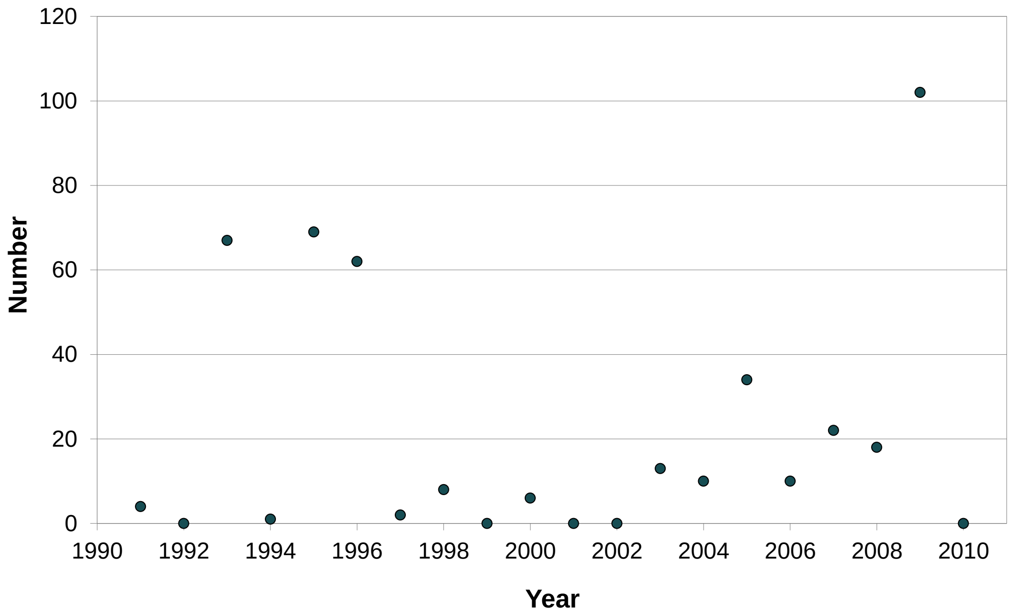


Figure 4.43 Numbers of Bean Geese recorded during the annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW 2010.

Importance of the Fehmarnbelt to Bean Goose

Bean Geese regularly winter in the Fehmarnbelt area, but the species is mostly confined to inland areas. Numbers recorded on the German side are low (maximum count - 102 birds) and all birds were observed inland. Within the Danish study area several hundred birds, occasionally up to 3,000 (equalling up to 0.5 % of the biogeographic population) winter inland near Rødsand Lagoon.

Bean Goose – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	2,100 + 102
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	November – March
Areas of max. abundance in Fehmarnbelt:	inland areas of SPA Rødsand Lagoon and SPA Eastern Kiel Bight
Explanations:	Maximum abundance obtained from supplementary datasets for the SPAs Hyllekrog-Rødsand (2,100 birds, all inland) and Eastern Kiel Bight (102 birds, all inland). Distribution obtained from supplementary datasets.

4.1.10 Greater White-fronted Goose – Anser albifrons

Greater White-fronted Goose – *Anser albifrons*

Biogeographic population: *A. a. albifrons*, Baltic and North Sea

Breeding range: European arctic Russia and NW Siberia

Wintering / core non-breeding range: NW Europe

Population size: 1,000,000

1 % value: 10,000

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: non-SPEC
EU Threat Status: secure

Target species in SPAs: Eastern Kiel Bight (DE1530-491)

Key food: herbivorous; mainly grass, in winter also arable crops

Period of presence in Fehmarnbelt: Wintering, migrations: October – April

Origin of Greater White-fronted Goose in the Fehmarnbelt

The Greater White-fronted Goose has a circumpolar breeding range. Breeding birds of western Greenland (*A. a. flavirostris*) winter mainly on the British Isles. The west Russian breeding population, breeding at latitudes between 66 and 75° N, winters in continental northern Europe, south-eastern Europe, Iraq and Caucasus (Cramp and Simmons 1977). The autumn migration of the Siberian subspecies (*A. a. albifrons*) goes along the south coast of the Baltic Sea and across the Fehmarnbelt area into the wintering grounds in the Netherlands, Belgium and northern Germany (Bønløkke et al. 2006, citing Mooij et al. 1999). A single recovery in the Fehmarnbelt region of the *A. a. flavirostris* subspecies ringed in western Greenland, documents that this subspecies also sometimes occurs in the area (Appendix IV).

Data sources on Greater White-fronted Goose in the Fehmarnbelt

Only a few Greater White-fronted Goose individuals were recorded during the FEBI baseline surveys. Thus, supplementary datasets of land-based counts, which also cover inland areas, were used as a primary source to assess species abundance and distribution in the Fehmarnbelt area (Table 4.23).

Table 4.23 List of datasets and their use in baseline assessment of Greater White-fronted Goose in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used due to non-covered inland areas
FEBI dedicated search flights	Dataset not used due to no sightings of the species
FEBI ship transect surveys	Dataset not used due to non-covered shallow water areas
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA surveys	Supporting dataset for species wintering abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance and distribution in the Danish part of the Fehmarnbelt

Abundance of Greater White-fronted Goose in the Fehmarnbelt

The Greater White-fronted Goose occurs in the Fehmarnbelt area mainly during autumn and spring migrations, but is also a regular winter visitor. On Fehmarn peak numbers are typically recorded in November and March (Berndt et al. 2005). Numbers counted in selected (consistently covered) survey sections along the German mainland coast also show two peaks during the course of the winter season, with maximum numbers being reached in December (Figure 4.44; OAG 2010). This coincides with the phenology pattern of Greater White-fronted Geese in Schleswig-Holstein as described by Berndt and Busche (1991).

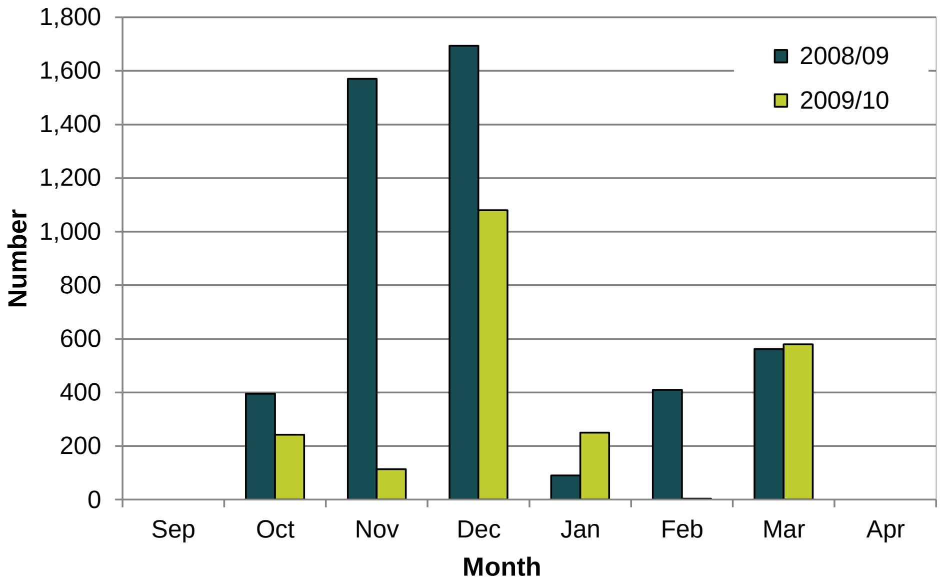


Figure 4.44 Number of Greater White-fronted Geese recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

In total 957 Greater White-fronted Geese were counted along the German mainland coast and on Fehmarn during the mid-winter waterbird survey in 2009 (OAG 2010, AKVSW 2010). Among these, 856 birds were observed on inland areas of Fehmarn

(600 on Grüner Brink and 230 on lake Salzensee; AKVSW 2010). Only 90 birds have been counted on the inland lake Sehlendorfer Binnensee along the mainland coast (OAG 2010). As highest numbers of Greater White-fronted Goose occur during migration periods but not in mid-winter, considerably higher numbers of resting birds are expected to use the area during these months. A maximum number of 1,595 Greater White-fronted Geese was counted on the lake Kleiner Binnensee alone in December 2009. Other areas supporting aggregations of this species during migration periods are: Schönberger Strand – Hubertusberg (max. 800; November 2009), Großer Binnensee (max. 492; March 2009), Wesseker See (max. 400; November 2009) and Sehlendorfer Binnensee (max. 180; February 2009) (OAG 2010).

During the NOVANA mid-winter survey in 2008, 91 Greater White-fronted Geese were observed within the Rødsand Lagoon area (Petersen et al. 2010). The DOF database contains observations of regularly occurring aggregations in the SPA Bøtø Nor (east of Rødsand Lagoon, outside the Fehmarnbelt investigation area) with a maximum count of 3,120 birds in November 2008 (DOF 2010). Only low numbers of a few tens of Greater White-fronted Geese are usually reported for the Rødsand Lagoon area (maximum 200 birds counted inland in January 2010; DOF 2010).

Distribution and habitat use of Greater White-fronted Goose in the Fehmarnbelt

Greater White-fronted Geese feed on arable crops and various grasses and use lakes and lagoons as resting or retreat areas. Typical retreat areas on Fehmarn are Wallnau and Wenkendorfer See (Berndt et al. 2005). Only inland sightings of Greater White-fronted Goose were reported in the Danish part of the study area (DOF 2010, Petersen et al. 2010).

This distributional pattern was confirmed by the Danish and German mid-winter surveys of 2008 and 2009, when most of the birds have been located in protected areas inland, such as freshwater areas of Grüner Brink on Fehmarn and the SPA Bøtø Nor, a protected area east of Rødsand Lagoon (Figure 4.45; AKVSW 2010, DOF 2010, OAG 2010).

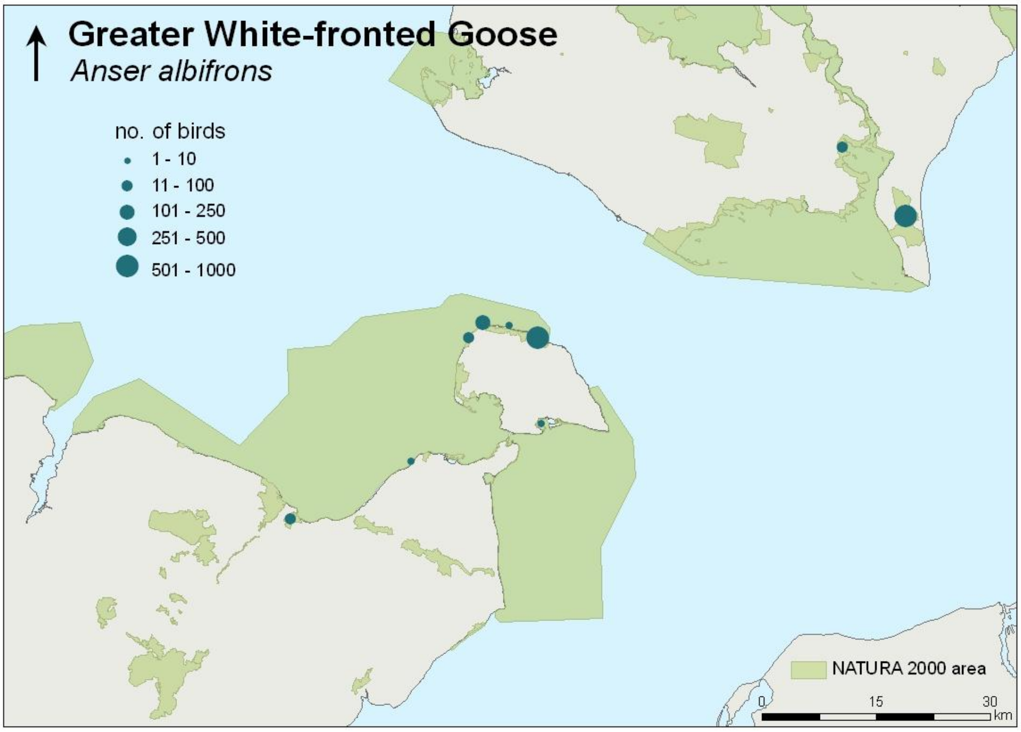


Figure 4.45 Distribution of Greater White-fronted Goose during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Greater White-fronted Goose abundance estimates for SPAs

Almost all birds of 957 Greater White-fronted Geese counted during the mid-winter coastal count 2009 in Germany were recorded within inland areas of the SPA Eastern Kiel Bight. However, this January count does not represent the maximum number of birds in the area as peaks are usually reached during autumn and spring migration periods (Figure 4.44). This statement could be supported by 1,674 birds counted in three inland survey sections along the mainland coast of the SPA Eastern Kiel Bight alone: Kleiner Binnensee (1,595 birds), Sehlendorfer Binnensee (55 birds) and Großer Binnensee (24 birds) in December 2008 (OAG 2010). Due to incomplete coverage of the mainland survey sections and absence of data for Fehmarn during autumn and spring periods, no total estimate is available for Greater White-fronted Goose abundance in this SPA during migration periods.

Only one sighting of 8 birds is available for the SPA Baltic Sea east of Wagrien in mid-winter (Burger Binnensee, January 2009; AKVSW 2010). This SPA was not sufficiently surveyed during migration periods; therefore no abundance estimates are available, but according to Kieckbusch (2010) there is no indication of larger Greater White-fronted Goose aggregations occurring in this SPA.

The SPA Hyllekrog-Rødsand typically supports only low numbers up to a few tens of Greater White-fronted Geese. A maximum of 200 inland resting birds were observed in January 2010 (DOF 2010).

Greater White-fronted Goose trends

The European population of Greater White-fronted Goose species was described as stable between 1970 and 1990. From 1990 to 2000 the numbers increased, although the population of Greenland declined during the same period. Thus, the European population was evaluated as Secure (BirdLife International 2004).

The long-term dataset of annual mid-winter land-based counts on the island of Fehmarn indicates no trend in numbers of wintering Greater White-fronted Geese (Figure 4.46; AKVSW 2010).

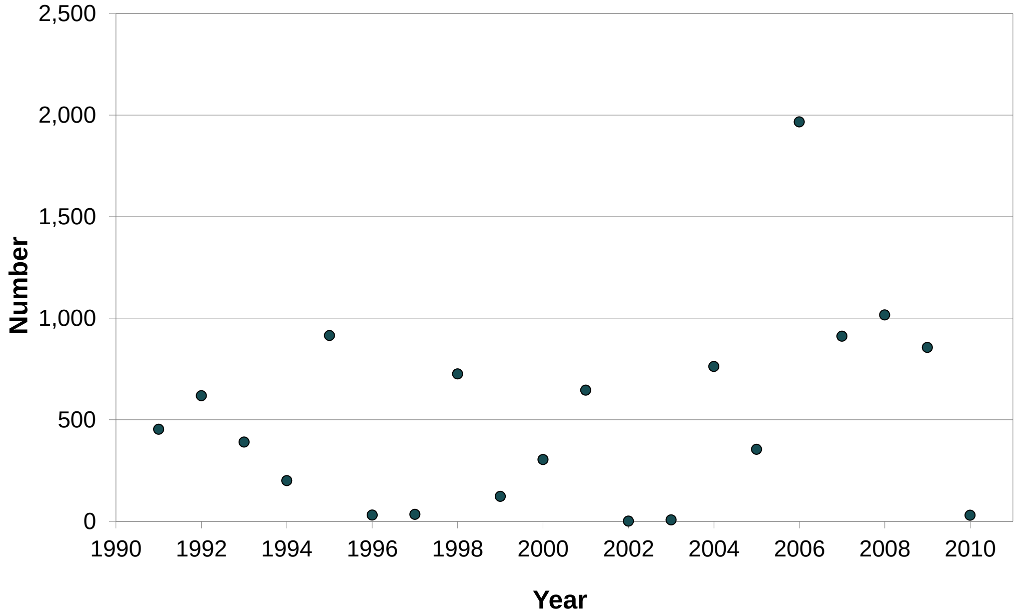


Figure 4.46 Numbers of Greater White-fronted Geese recorded during annual mid-winter coastal counts on the island of Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Greater White-fronted Goose

The highest numbers of Greater White-fronted Geese within the Fehmarnbelt area were recorded in the SPA Eastern Kiel Bight. Available datasets indicate that more than 1,700 birds (> 0.2 % of the biogeographic population) utilise this SPA during spring and autumn migration periods (OAG 2010), but there is no indication that numbers exceed 4,500 birds (equalling 0.45 % of the biogeographic population) as reported in the Standard Data Form.

In the Danish part of the Fehmarnbelt area the maximum reported number was 200 birds in the SPAs Hyllekrog-Rødsand (DOF 2010).

Greater White-fronted Geese were reported using mostly inland habitats. Marine areas like sheltered lagoons or fjords are only used as resting but not as foraging sites. The Danish coastal areas usually support less than 0.1 % and the German part of the Fehmarnbelt less than 0.5 % of the biogeographic population of the Greater White-fronted Goose.

Greater White-fronted Goose – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	1,700 + 200
Max. abundance estimate in the alignment area:	no records
Period of max. abundance in Fehmarnbelt:	November – March
Areas of max. abundance in Fehmarnbelt:	inland areas of SPA Eastern Kiel Bight and SPA Hyllekrog-Rødsand
Explanations:	Maximum abundance obtained from supplementary datasets for the SPAs Eastern Kiel Bight (1,700 birds, all inland) and Hyllekrog-Rødsand (200 birds, all inland). Distribution obtained from supplementary datasets.

4.1.11 *Greylag Goose – Anser anser*

Greylag Goose – *Anser anser*

Biogeographic population: *A. a. anser*, NW Europe (br)

Breeding range: NW Europe

Wintering / core non-breeding range: NW and SW Europe

Population size: 500,000

1 % value: 5,000

Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC EU Threat Status: secure
Target species in SPAs:	Hyllekrog-Rødsand (DK006X083) Eastern Kiel Bight (DE1530-491)

Key food: a wide range of plants including arable crops

Period of presence in Fehmarnbelt:	Wintering, migrations: September – March Breeding, moulting: April – August

Origin of Greylag Goose in the Fehmarnbelt

The Greylag Goose is a migratory species within the region although the migration distances vary from north to south with northern-breeding birds generally moving longer distances (Cramp and Simmons 1977). The FEBI ring recovery analysis (Appendix IV) show that wintering birds in the Fehmarnbelt region originate from Denmark, Sweden, Norway and Germany, with a few additional records from north-western and central Europe. Birds ringed during the breeding season in the Fehmarnbelt region have been recovered in France, southern Spain and Tunisia, indicating that locally breeding birds travel there to winter. Wintering areas have most likely moved towards northeast in accordance with continuously milder winter conditions (Bønløkke et al. 2006). Patterns are in agreement with the Scandinavian ringing atlases (Fransson and Pettersson 2001; Bakken et al. 2003; Bønløkke et al. 2006).

Data sources on Greylag Goose in the Fehmarnbelt

The FEBI baseline surveys only partly covered main resting sites of Greylag Geese in the study area as these birds are often found on inland freshwater habitats. Thus, supplementary datasets of land-based counts were chosen as primary source to assess species abundance and distribution in the Fehmarnbelt area (Table 4.24).

Table 4.24 List of datasets and their use in baseline assessment of Greylag Goose in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI dedicated search flights	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Dataset not used due to non-covered shallow water areas
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Greylag Goose in the Fehmarnbelt

Greylag Geese are found in the study area all year. On Fehmarn maximum numbers occur during summer months (July/August; Berndt et al. 2005). In mainland Schleswig-Holstein the highest numbers occur in autumn, peaking in September/October (Berndt and Busche 1991).

Greylag Goose abundance according to FEBI survey data

Monthly search flights to survey herbivorous waterfowl were conducted in Orther Reede, a shallow bay in the southwest of Fehmarn Island, between August 2009 and October 2010. The highest number of Greylag Geese was counted in this area in autumn: 855 birds in September 2010 (Figure 4.47).

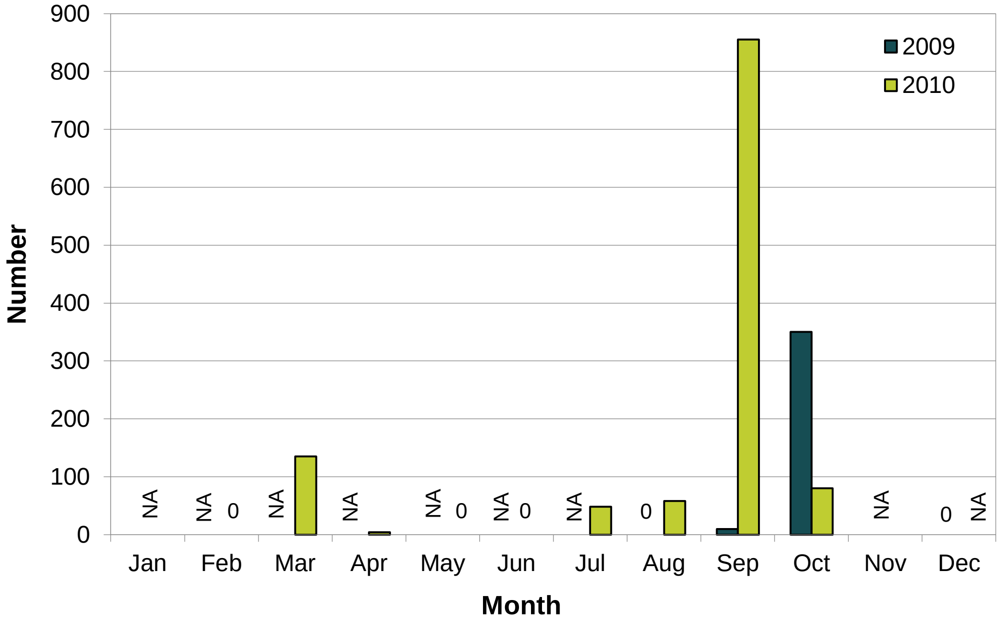


Figure 4.47 Numbers of Greylag Geese counted during dedicated search flights in Orther Reede in August 2009 – October 2010.

Because inland areas were not covered by the FEBI aerial and ship-based surveys, no abundance estimates based on these surveys were possible. Within the area covered by the aerial transects, the highest concentrations of Greylag Geese were recorded in the western part of Rødsand Lagoon. Maximum number of 2,234 birds was observed during the survey in October 2009 (Table 4.25). Due to the clustered distribution of Greylag Geese no Distance analysis was possible. A high number of 2,425 Greylag Geese was counted during the FEBI dedicated swan search flight in Rødsand Lagoon in September 2009.

Table 4.25 Results of monthly aerial surveys for Greylag Goose between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects; Coverage % is percentage of survey area covered in valid conditions.

Survey	Number of birds observed	Coverage %
Nov-08	0	80.9
Dec-08	110	81.7
Jan-09	216	82.8
Feb-09	73	100.0
Mar-09	30	77.5
Apr-09	73	86.8
May-09	42	77.3
Jun-09	24	80.9
Jul-09	71	86.6
Aug-09	701	92.3
Sep-09	1,196	79.1
Oct-09	2,234	79.9
Nov-09	120	82.4
Dec-09	0	24.7
Mar-10 A	286	64.1
Mar-10 B	82	75.6
Apr-10	48	100.0
May-10	15	92.1
Jun-10	7	70.8
Aug-10	213	75.6
Sep-10 A	795	44.9
Sep-10 B	505	48.9
Oct-10	613	80.0
Nov-10	385	70.1

Greylag Goose abundance according to supplementary datasets

The seasonal pattern of Greylag Goose abundance recorded during the coastal counts in the selected (consistently covered) survey sections along the German mainland coast (Figure 4.48; OAG 2010) coincides with the pattern described in Berndt and Busche (1991): the highest numbers of Greylag Goose were observed in autumn (October) in both study seasons 2008/2009 and 2009/2010.

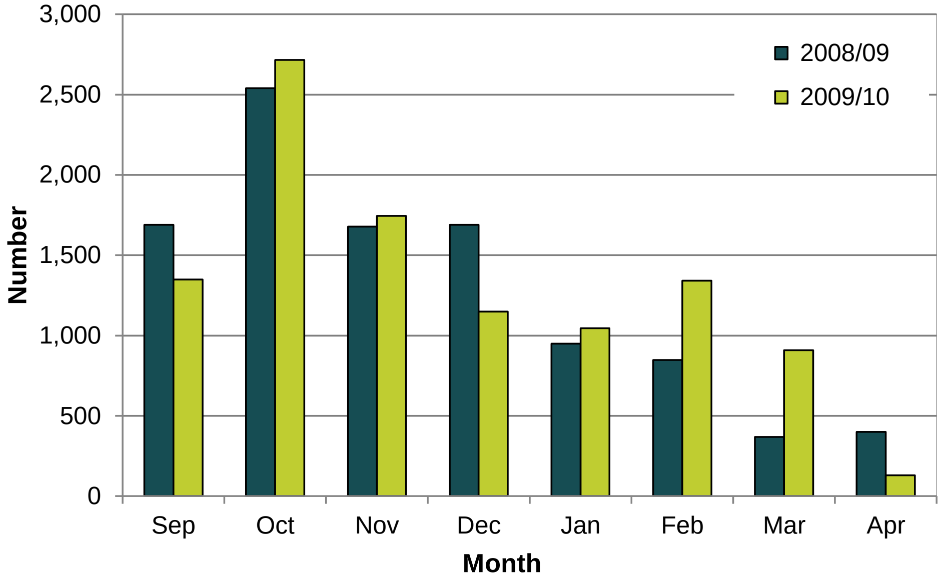


Figure 4.48 Numbers of Greylag Geese recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

Supplementary datasets of land-based surveys also cover adjacent inland areas with major resting sites of Greylag Geese. In total 4,865 Greylag Geese were recorded along the German coast of the study area during the mid-winter coastal survey in January 2009 (AKVSW 2010, OAG 2010). The majority of these birds were counted on the island of Fehmarn (3,016 geese) and most of Greylag Geese were observed inland (3,141 geese). Results of monthly counts along the German mainland coast indicate several areas, which regularly support high numbers of this species in autumn: Graswarder (max. 3,300 in September 2007), Sehlendorfer Binnensee (max. 1,820 in October 2009) and Großer and Kleiner Binnensee with maximum numbers in each exceeding 800 birds (OAG 2010). Berndt et al. (2005) report maximum numbers of 3,000 birds being present on the island of Fehmarn during summer and autumn months. In summary, more than 1 % of the Greylag Goose biogeographic population (5,000 birds) is wintering in the German part of the study area, most of them on inland habitats.

In total 1,728 Greylag Geese were recorded in Rødsand Lagoon during the mid-winter survey in February 2008 (only search flight data, Petersen et al. 2010). The DOF database indicates that the highest numbers of geese use this area in late summer and autumn with a maximum count of 2,700 birds in August 2009 (DOF 2010). For the Danish alignment area a maxiumum of 240 Greylag Geese was reported for the marine areas at Rødbyhavn (in December 2009, DOF 2011).

Distribution and habitat use of Greylag Goose in the Fehmarnbelt

Greylag Geese are described as feeding mainly on arable crops and various grasses. Lakes and lagoons are used as resting or retreat areas (Berndt et al. 2005). During the NOVANA mid-winter survey 2008, 29 % of recorded Greylag Geese were observed inland (Petersen et al. 2010); thus, this species uses marine habitats more extensively compared to the other geese of *Anser* genus.

Greylag Goose distribution according to FEBI survey data

FEBI aerial transect surveys recorded concentrations of Greylag Geese mainly in the shallow western part of Rødsand Lagoon and coastal areas south of Nakskov Fjord (southwest Lolland; Figure 4.49). In the German part of the study area FEBI transect and search flights identified Orther Reede as the area supporting larger aggregations of Greylag Geese (Figure 4.49; Figure 4.47).

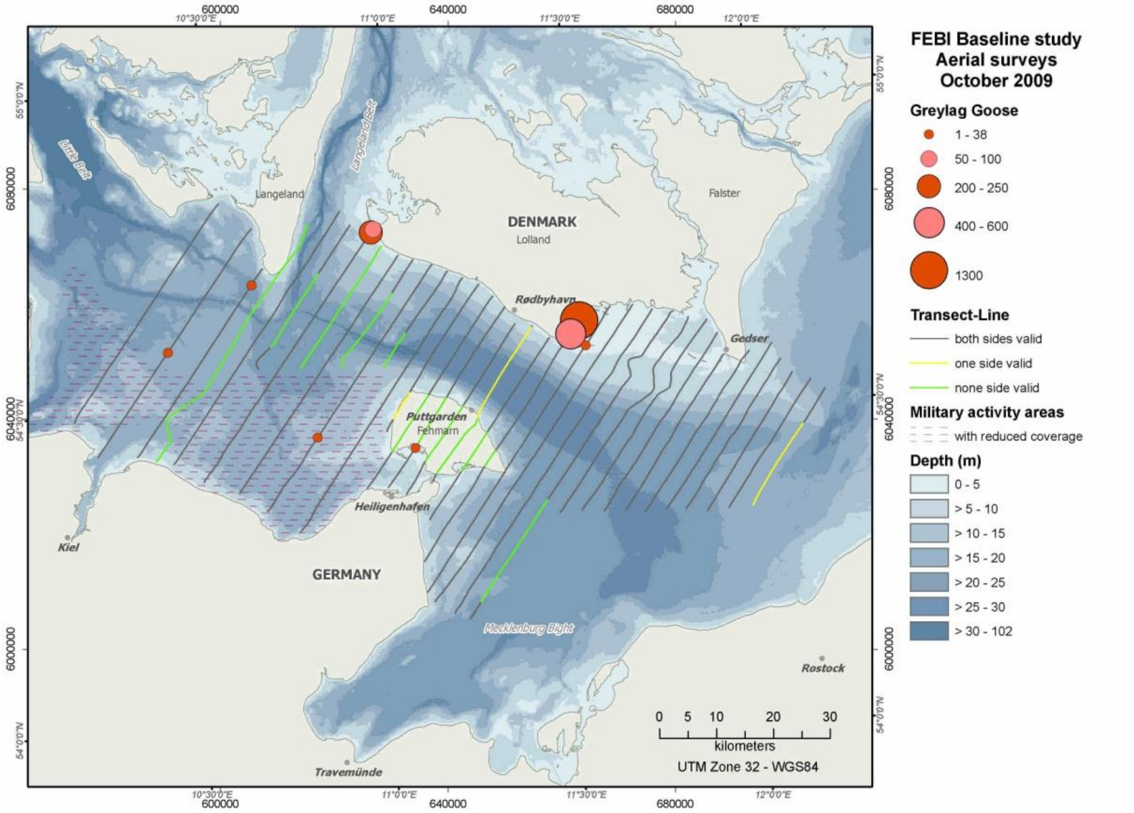


Figure 4.49 Example of the observed Greylag Goose distribution in the study area during FEBI aerial surveys (October 2009).

Greylag Goose distribution according to supplementary datasets

Danish and German mid-winter surveys of 2008 and 2009 suggest that Greylag Geese are widely distributed in coastal areas of the Fehmarnbelt region with high concentrations also found inland, especially on Fehmarn (Figure 4.50; AKVSW 2010, OAG 2010, Petersen et al. 2010). Within the Danish survey area these results confirm that Greylag Geese aggregate in the sheltered parts of Rødsand Lagoon (Figure 4.50; Petersen et al. 2010).

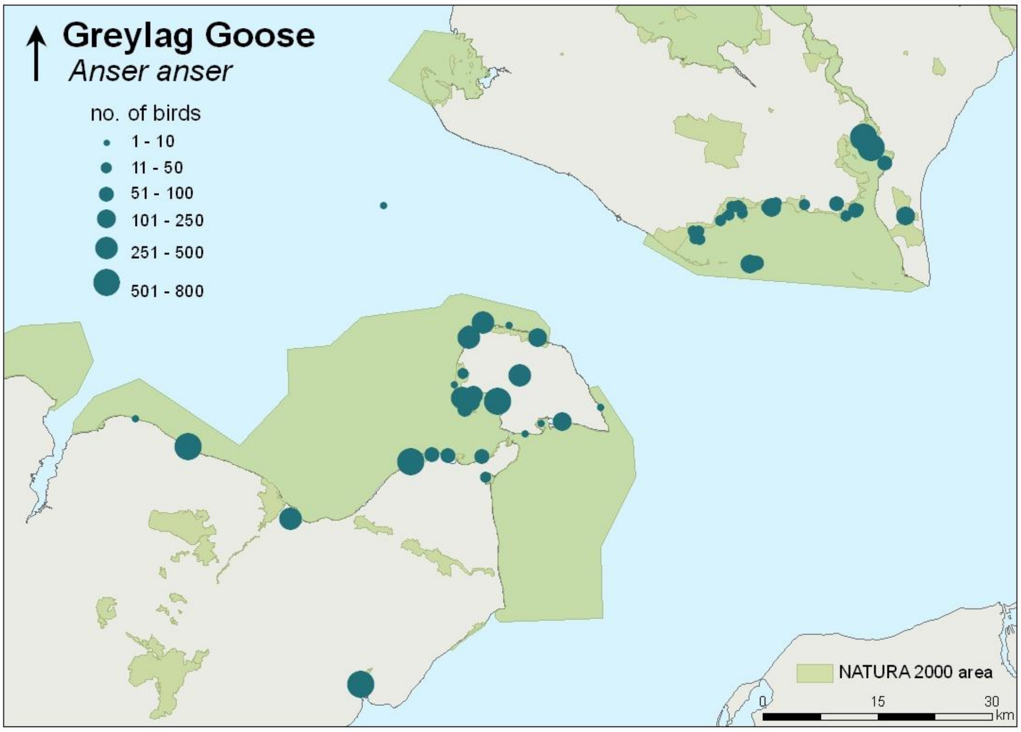


Figure 4.50 Distribution of Greylag Goose during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Greylag Goose abundance estimates for SPAs

In total 4,185 Greylag Geese were counted within the SPA Eastern Kiel Bight during the mid-winter count of 2009 (AKVSW 2010, OAG 2010). The majority of these birds (2,349) were counted on Fehmarn Island. No Fehmarn data are available for autumn months, when the highest numbers of Greylag Geese occur in the study area. Monthly surveys by OAG along the mainland coast of this SPA indicate high numbers of up to 3,300 birds (in Graswarder in September 2007; OAG 2010). Based on this information no total estimate for the SPA Eastern Kiel Bight can be given for migration periods, but available data and literature information suggest that the 1 % criterion of 5,000 birds could be reached on Fehmarn during late summer and autumn months (Berndt et al. 2005).

In the SPA Baltic Sea east of Wagrien Greylag Geese occur in much lower numbers: 280 birds were recorded within this SPA during mid-winter survey of 2009 (of these 250 on Sahrensdorfer Binnensee, Fehmarn). Although the coastal areas of this SPA have not been fully covered, according to Kieckbusch (2010) there is no indication that major Greylag Goose aggregations occur there.

Data available for the SPA Hyllekrog-Rødsand suggest maximum numbers of 2,700 Greylag Geese (equals 0.54 % of the biogeographic population) using this area in late summer (August 27, 2009, DOF 2010). A similar number of 2,425 birds was recorded during the FEBI dedicated swan search flight in September 2009. A lower number of 1,728 Greylag Geese was recorded within this SPA during the search flight for mid-winter census of waterbirds in Denmark in February 2008 (Petersen et al. 2010).

Greylag Goose trends
From 1970 to 1990 the European population has increased substantially. Also from 1990 to 2000 the increase continued across Europe. Thus, the European population was evaluated as being Secure (BirdLife International 2004).

The long-term dataset of annual mid-winter land-based bird counts on the island of Fehmarn indicates a constant increase of wintering Greylag Goose numbers in the study area (Figure 4.51; AKVSW 2010). This coincides with the general trend of Greylag Geese wintering in Denmark, where a constant increase was recorded since the mid-1990s (Petersen et al. 2010). Berndt et al. (2005) explain this pattern suggesting that an increasing number of local birds wintering in the area is the result of recent mild winters.

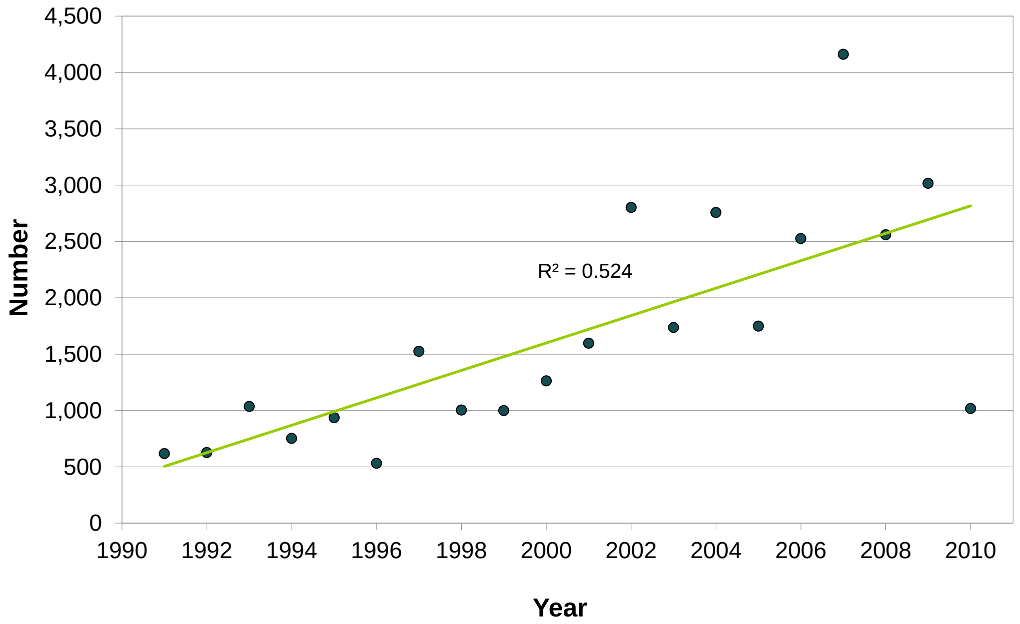


Figure 4.51 Numbers of Greylag Goose recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg; $p < 0.001$.

Importance of the Fehmarnbelt to Greylag Goose
Coastal waters and adjacent inland freshwater habitats in the Fehmarnbelt area support high numbers of resting Greylag Geese especially during autumn migration. Available datasets indicate that the 1 % level (5,000 birds) is being reached in the SPA Eastern Kiel Bight. FEBI baseline investigations and supplementary datasets suggest that SPA Hyllekrog-Rødsand supports more than 0.5 % of the biogeographic population (> 2,500 birds) in autumn.

According to the Danish mid-winter survey of 2008 (Petersen et al. 2010), 29 % of Greylag Geese were observed inland. According to German mid-winter coastal counts in 2009, 61 % of Greylag Geese were recorded inland (AKVSW 2010, OAG 2010). Although a substantial proportion of Greylag Geese use marine habitats as resting and retreat areas, the key feeding grounds are located inland (Berndt et al. 2005).

Greylag Goose – summary of information for EIA		
Max. abundance estimate in Fehmarnbelt:		5000 + 2,700
Max. abundance estimate in the alignment area:		240 + 9
Period of max. abundance in Fehmarnbelt:		September – March
Areas of max. abundance in Fehmarnbelt:		see Figure 4.50
Explanations:	Maximum abundance obtained from supplementary datasets for the SPAs Eastern Kiel Bight (5,000 birds, partly inland) and Hyllekrog-Rødsand (2,700 birds, partly inland). Maximum abundance in the alignment area obtained from supplementary datasets for Rødbyhavn (240 birds) and 9 individuals reported for the German part of this area during the land-based mid-winter survey of 2009. Distribution obtained from supplementary datasets.	

4.1.12 Barnacle Goose – *Branta leucopsis*

Barnacle Goose – *Branta leucopsis*

Biogeographic population: N Russia, E Baltic Sea (br)

Breeding range: N Russia, E Baltic Sea, S North Sea

Wintering / core non-breeding range: N Germany, Netherlands

Population size: 420,000

1 % value: 4,200

Conservation status: EU Birds Directive, Annex I: listed
EU SPEC Category: non-SPEC^{E}
EU Threat Status: secure

Target species in SPAs: Eastern Kiel Bight (DE1530-491)

Key food: tundra plants (breeding), salt marsh vegetation, arable crops (migration and wintering), grass

Period of presence in Fehmarnbelt: Wintering, migrations: September – May

Origin of Barnacle Goose in the Fehmarnbelt

The Fehmarnbelt area is on the main passage route of Barnacle Geese migrating from the Siberian breeding grounds to the staging and wintering areas in the Wadden Sea. The breeding population of Barnacle Goose has increased and the range has expanded dramatically during the last three decades, and the species is now also breeding in north-western Europe (Van der Jeugd et al. 2009).

Data sources on Barnacle Goose in the Fehmarnbelt

Barnacle Geese are known to use the Fehmarnbelt area mainly as short-term stop-over site during migration periods (Berndt et al. 2005). Because flocks of Barnacle Geese are present in the area only for a short period, it is possible that the highest numbers were missed during monthly aerial surveys. Ship-based surveys do not enter resting habitats of Barnacle Goose, so ship-based surveys were not considered for assessing abundance and distribution of this species. Supplementary datasets of land-based counts (AKVSW 2010, OAG 2010) and database of non-systematic observations in Denmark (DOF 2010) were assumed to deliver the best available information, as also inland resting areas are covered by these schemes (Table 4.26).

Table 4.26 List of datasets and their use in baseline assessment of Barnacle Goose in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI dedicated search flights	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Dataset not used due to non-covered shallow water areas
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Barnacle Goose in the Fehmarnbelt

Barnacle Geese pass the Fehmarnbelt area in high numbers mainly during autumn and spring migrations, but only a small proportion of birds stop in the coastal areas of the Fehmarnbelt for resting (Berndt et al. 2005). Abundance of resting Barnacle Geese coincides with the main migration periods with highest numbers being observed during the second decade of October (Berndt et al. 2005). Over the past 30 years there was a tendency of more birds staying for wintering compared to former times (Berndt et al. 2005, Petersen et al. 2010). These authors explain this being possible because of better food availability (winter grain) on Fehmarn (Berndt et al. 2005) and mild winters (Petersen et al. 2010).

Barnacle Goose abundance according to FEBI survey data

Barnacle Geese were only rarely recorded during the FEBI aerial transect surveys. Apart from single birds, all observed in Rødsand Lagoon area, only one bigger flock of 80 birds was recorded on Rødsand on June 1, 2009 (no total estimate, only birds recorded in transect). Another flock of 90 geese flying east of Fehmarn, presumably migrating birds, was encountered during the FEBI aerial surveys on October 13, 2010.

Four hundred Barnacle Geese were recorded on one occasion (October 30, 2009) during the dedicated search flights in Orther Reede (southwest of Fehmarn) between August 2009 and October 2010.

Barnacle Goose abundance according to supplementary datasets

Supplementary datasets confirm FEBI aerial survey results and literature information suggesting that resting Barnacle Geese mainly occur in the study area in October (Figure 4.52, OAG 2010).

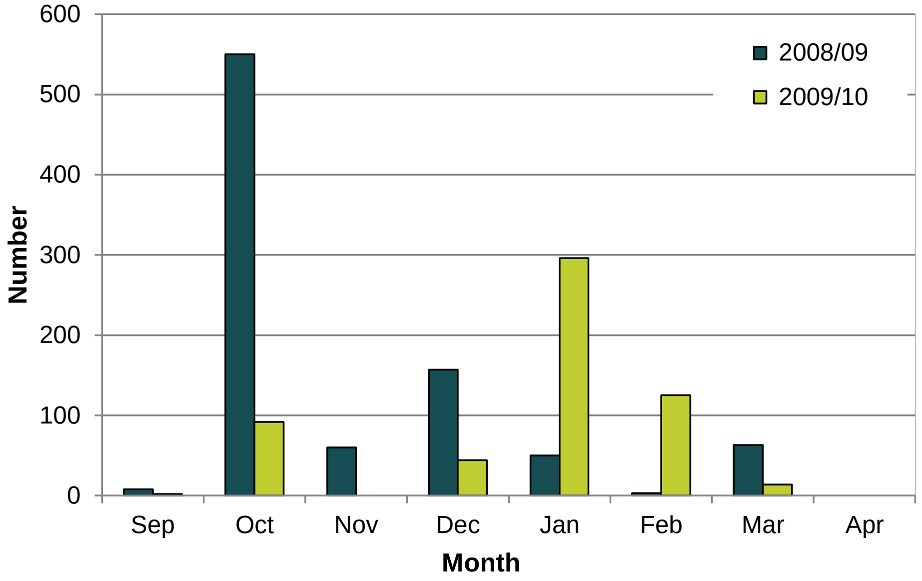


Figure 4.52 Numbers of Barnacle Geese recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

The supplementary datasets of land-based surveys cover marine and adjacent inland areas with major resting sites of Barnacle Geese. In total 315 Barnacle Geese were recorded during the mid-winter coastal count in Germany in January 2009 (AKVSW 2010, OAG 2010). Of these, the majority was counted on the island of Fehmarn (185 geese) and a high proportion of the observed Barnacle Geese were inland (145 birds). Results of monthly counts along the German mainland coast show substantially higher numbers occurring in these areas in autumn. During October survey in 2008, 2,987 Barnacle Geese were recorded along the mainland survey sections alone (OAG 2010). Flock sizes varied between 10 and 850 individuals (OAG 2010). Berndt et al. (2005) report 910 birds counted on the island of Fehmarn in November 1987 as the highest number of staging Barnacle Geese on the island. Thus, it is unlikely that numbers of resting Barnacle Geese reach the 1% level (4,200 birds) in the German part of the study area.

During the NERI mid-winter survey in January 2008, 300 Barnacle Geese were observed within the SPA Hyllekrog-Rødsand (Petersen et al. 2010). The DOF database indicates the highest numbers using this area for short periods between mid and end of October with a maximum of 5,350 Barnacle Geese (1.3% of the biogeographic population) counted in autumn 2007 (October 22, 2007; DOF 2010). Also, single birds were occasionally recorded in the alignment area at Rødbyhavn (DOF 2011).

Distribution and habitat use of Barnacle Goose in the Fehmarnbelt

Barnacle Geese usually forage on salt marsh and meadow grasses, but also feed on winter grain (Berndt et al. 2005, Pihl et al. 2006, DOF 2010).

Barnacle Goose distribution according to FEBI survey data

The few observations of Barnacle Geese during the FEBI aerial surveys indicated Rødsand Lagoon and Orther Reede being used as resting areas within the Fehmarnbelt.

Barnacle Goose distribution according to supplementary datasets

During the German mid-winter count of 2009 Barnacle Geese were located both inland (Sehlendorfer Binnensee and Grüner Brink) and at outer dike areas along the mainland coast and in the north of the island of Fehmarn (Figure 4.53; AKVSW 2010, OAG 2010). On the Danish side, inland areas to the northwest and east of Rødsand Lagoon supported flocks of wintering Barnacle Geese (NOVANA survey 2008; Petersen et al. 2010).

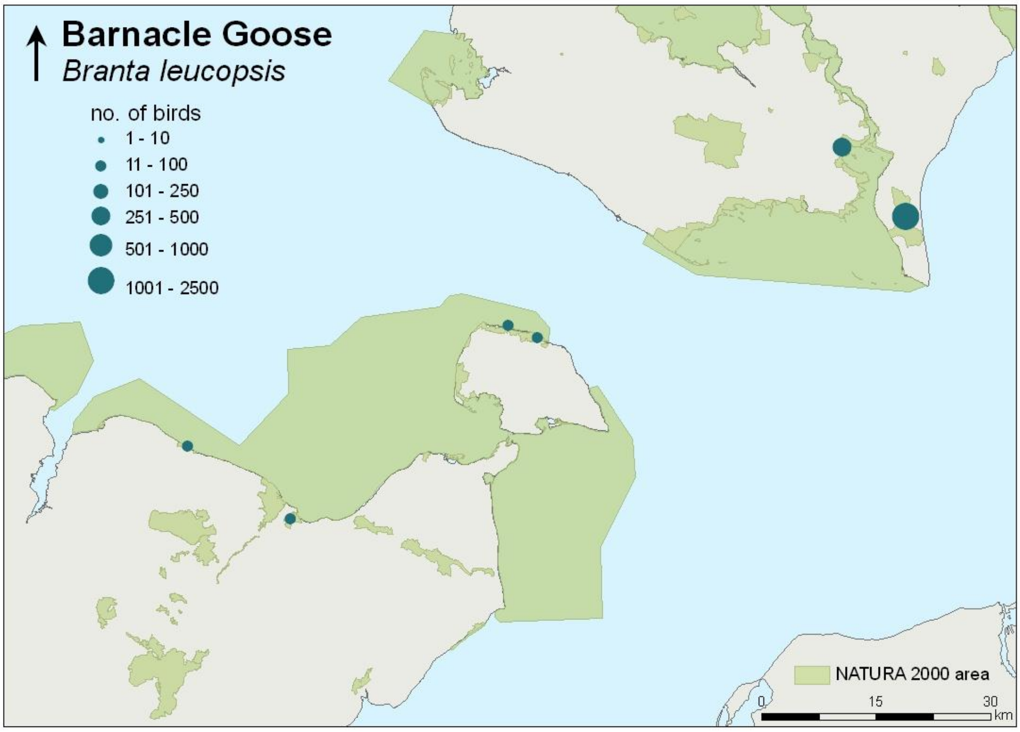


Figure 4.53 Distribution of Barnacle Goose during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Barnacle Goose abundance estimates for SPAs

In total 315 Barnacle Geese were recorded within the SPA Eastern Kiel Bight during mid-winter count 2009 (AKVSW 2010, OAG 2010), of which 185 birds were counted on Fehmarn Island. No observations are available for the island of Fehmarn during autumn migration period, when high numbers of Barnacle Goose occur elsewhere in the study area. Monthly surveys along the mainland coast of this SPA indicate that almost 3,000 birds occur along the mainland areas of this SPA in October (on October 18/19, 2008; OAG 2010). Based on this information no final estimate for the full area of the SPA Eastern Kiel Bight can be given, but available data and literature on Fehmarn numbers (Berndt et al. 2005) indicate that this SPA holds more than 0.5% (2,100 birds), but probably less than 1% (4,200 birds) of the biogeographic population during a short period in October/November.

No records of Barnacle Goose were found in available datasets for the SPA Baltic Sea east of Wagrien. Kieckbusch (2010) also reports no major Barnacle Goose aggregations occurring within this SPA.

During the NOVANA mid-winter survey in January 2008, 300 Barnacle Geese were observed within the SPA Hyllekrog-Rødsand (Petersen et al. 2010). The DOF database indicates the highest numbers of this species being observed during a short period between mid and end of October. A maximum count of 5,350 Barnacle Geese was reported in autumn 2007 (October 22, 2007; DOF 2010). This was the only entry in DOF database for this SPA since the year 2000 when numbers of Barnacle Geese exceeded the 1% threshold of international importance (4,200 birds, DOF 2010).

Barnacle Goose trends

The European wintering and also breeding populations have been steadily increasing during the recent 40 years. Consequently the population is considered as Secure (BirdLife International 2004).

The long-term dataset of annual mid-winter land-based bird counts on Fehmarn indicates a significantly increasing trend for wintering Barnacle Goose (AKVSW 2010, Figure 4.54). Also, Berndt et al. (2005) describe an increase in numbers of staging birds on Fehmarn since 1980. According to Petersen et al. (2010) Barnacle Goose wintering numbers vary with winter severity.

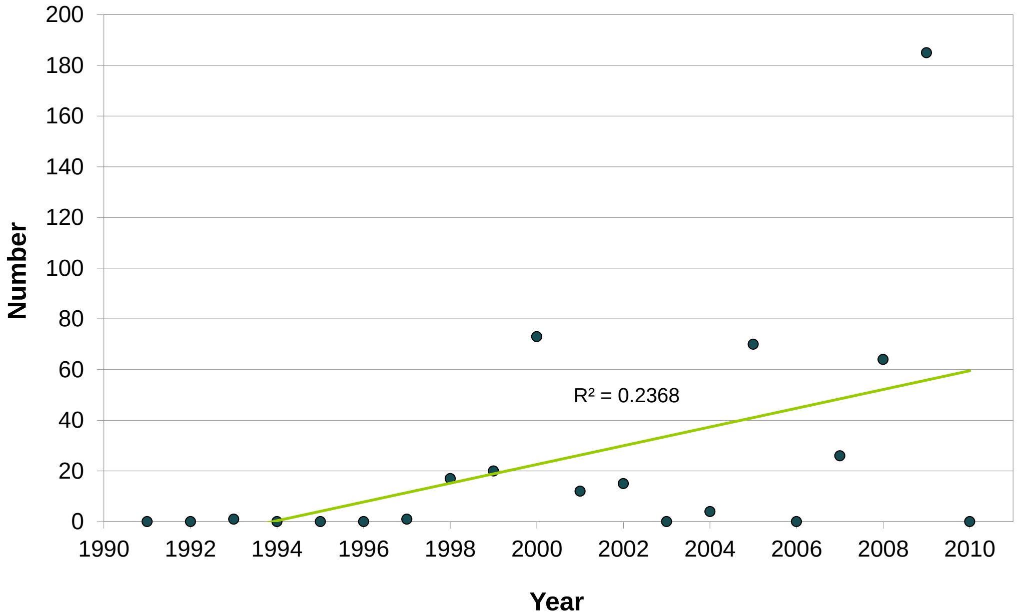


Figure 4.54 Numbers of Barnacle Goose recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg; p = 0.03.

Importance of the Fehmarnbelt to Barnacle Goose

Barnacle Geese can be observed in the study area mainly during the migration periods in autumn and spring, but there is also an increasing trend of birds which stay in the area for the wintering period (Berndt et al. 2005, Petersen et al. 2010). Most Barnacle Geese only pass the Fehmarnbelt area during migration periods, but high numbers of resting birds have been recorded in the area for short periods in autumn.

More than 0.5% of the biogeographic Barnacle Goose population use the SPA Eastern Kiel Bight in autumn, but numbers reaching the 1% level (4,200 birds) are not expected within the German part of the study area.

In Denmark, the SPA Hyllekrog-Rødsand usually supports between 0.5 and 1.0 % of the biogeographic population. Within the recent ten years the 1% criterion of international importance was only met once with 5,350 Barnacle Geese (1.3% of the biogeographic population) resting in the area in October 2007 (DOF 2010).

Barnacle Goose – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	5,350 + 3,000
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	October, March – May
Areas of max. abundance in Fehmarnbelt:	inland areas of the SPAs Eastern Kiel Bight and Hyllekrog-Rødsand
Explanations:	Maximum abundance obtained from supplementary datasets for the SPAs Hyllekrog-Rødsand (5,350 birds) and Eastern Kiel Bight (3,000 birds, partly inland). Distribution obtained from supplementary datasets.

4.1.13 Brent Goose – Branta bernicla

Brent Goose – *Branta bernicla*

Biogeographic population: *B. b. bernicla* (‘Dark-bellied Brent Goose’)

Breeding range: W Siberia

Wintering / core non-breeding range: Coastal W Europe

Population size: 200,000

1 % value: 2,000

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: SPEC 3W
EU Threat Status: vulnerable

Target species in SPAs: Hyllekrog-Rødsand (DK006X083)

Key food: tundra plants (breeding), marine shallow water plants (eelgrass, *Salicornia*, algae) and salt marsh vegetation (migration and wintering); also agricultural grassland

Period of presence in Fehmarnbelt: Wintering, migrations: September – May

Origin of Brent Goose in the Fehmarnbelt

The Fehmarnbelt area is on the major passage route of the Siberian Brent Goose population during autumn and spring migration. The Brent Goose breeds circumpolarly in the high Arctic, in the Western Palaearctic on Svalbard and Russian Arctic islands up to 80° N (Cramp and Simmons 1977). The Russian *B. b. bernicla* population winters in north-western Europe (Denmark, north-western Germany, The Netherlands, southeast England and west France; Cramp and Simmons 1977).

Data sources on Brent Goose in the Fehmarnbelt

Brent Geese were regularly observed during FEBI aerial surveys during transitional periods. However, as coastal areas were better covered by the supplementary land-based surveys and Distance analysis was not possible using FEBI aerial survey data, the land-based datasets were used as primary data sources for assessing abundance and distribution of the species (Table 4.27). FEBI aerial surveys were used as a supporting dataset in the assessment.

Table 4.27 List of datasets and their use in baseline assessment of Brent Goose in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI dedicated search flights	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Dataset not used due to non-covered shallow water areas
OAG land-based counts	Primary dataset for estimating species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset for estimating species winter abundance on Fehmarn
NOVANA aerial surveys	Dataset not used due to no entries for this species
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Brent Goose in the Fehmarnbelt

Brent Geese occur in the study area mainly during transitional periods of the year, but only a small proportion of birds use the study area for stopping-over. The highest numbers of migrating and resting birds along the German coast are usually observed in September/October (Berndt et al. 2005), whereas on the Danish side of the Fehmarnbelt the highest numbers occur in spring (April/May; Berndt et al. 2005, DOF 2010). Winter numbers are generally low in the area (Berndt et al. 2005).

Brent Goose abundance according to FEBI survey data

During the FEBI aerial transect surveys Brent Geese were regularly recorded in low numbers during transitional periods (Table 4.28). The majority of birds were observed in the area of Rødsand Lagoon, where also the highest number of 291 Brent Geese was recorded during the aerial transect survey of October 2009 (Table 4.28).

During dedicated search flights in Orther Reede (southwest of Fehmarn), which were conducted between August 2009 and October 2010, Brent Geese were recorded only once (23 birds on October 30, 2009).

Table 4.28 Results of monthly aerial surveys for Brent Goose between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects; Coverage % is percentage of survey area covered in valid conditions.

Survey	Number of birds observed	Coverage %
Nov-08	0	80.9
Dec-08	0	81.7
Jan-09	0	82.8
Feb-09	0	100.0
Mar-09	24	77.5
Apr-09	0	86.8
May-09	0	77.3
Jun-09	0	80.9
Jul-09	0	86.6
Aug-09	0	92.3
Sep-09	0	79.1
Oct-09	291	79.9
Nov-09	3	82.4
Dec-09	0	24.7
Mar-10 A	7	64.1
Mar-10 B	50	75.6
Apr-10	22	100.0
May-10	117	92.1
Jun-10	0	70.8
Aug-10	0	75.6
Sep-10 A	0	44.9
Sep-10 B	0	48.9
Oct-10	36	80.0
Nov-10	0	70.1

Brent Goose abundance according to supplementary datasets

During monthly surveys along the German mainland coast of the study area (September-April of 2008/2009 and 2009/2010) only low numbers of Brent Geese were recorded. A maximum of 50 birds was counted in October 2008 (OAG 2010). The mid-winter data from Fehmarn confirm that this species winters rarely in the area with a maximum count of 10 birds in January 1997 and no mid-winter records since 2003 (AKVSW 2010).

Data from the DOF database indicate a different Brent Goose abundance pattern on the Danish side. Numbers of more than 100 resting Brent Geese are regularly observed in the Rødsand Lagoon area during spring migration period (April/May). A maximum number of 1,800 birds was reported on May 6, 2007 (DOF 2010). In autumn only few resting Brent Geese were reported for this area (DOF 2010). Single birds occasionally occur in the alignment area at Rødbyhavn (DOF 2011).

Distribution and habitat use of Brent Goose in the Fehmarnbelt

On Fehmarn Brent Geese use shallow coastal inlets and near shore areas of the Baltic Sea as well as beaches. Birds only occasionally feed on arable crops (Berndt et al. 2005).

Brent Goose distribution according to FEBI survey data

During FEBI aerial transect surveys Brent Geese were most frequently observed within the SPA Hyllekrog-Rødsand (Appendix II).

Brent Goose distribution according to supplementary datasets

The German coastal surveys revealed no high concentrations of Brent Geese along the mainland coast of the German part of the study area where recorded flocks rarely exceed 20 individuals (OAG 2010). This is in agreement with Berndt et al. (1991), who describe this species mainly passing the area without stopping-over and only low numbers occurring in different places along the Baltic coast of Schleswig-Holstein.

Confirming FEBI aerial survey data, the DOF database indicates Rødsand Lagoon as the main resting site of Brent Geese within the study area (DOF 2010).

Brent Goose abundance estimates for SPAs

Available datasets do not cover the German part of the study area completely during the main Brent Geese abundance periods in spring and autumn. Thus, there are no abundance estimates for particular German SPAs available. However, literature and available data indicate that less than 0.1 % of the biogeographic population (200 birds) use the German Fehmarnbelt area as stop-over site. Data of ten-year land-based waterbird census confirm few sightings of Brent Geese in the SPA Eastern Kiel Bight. Most birds were recorded in October, but not more than 50 birds were recorded within one survey section (Kieckbusch 2007).

The DOF database contains sightings of up to 1,800 Brent Geese resting in the SPA Hyllekrog-Rødsand (highest record on May 6, 2007; DOF 2010). Usually there are less than 500 birds in this area (< 0.25 % of the biogeographic population), but resting numbers of more than 500 birds have been observed in two spring seasons since the year 2000 (1,800 birds in 2007 and 710 birds in 2010).

Brent Goose trends

After a strong decline in the 1930s the European wintering population has increased between 1970 and 1990 (BirdLife International 2004). Although a few populations increased or were broadly stable during 1990–2000, key wintering populations (of the subspecies *B. b. bernicla*) in the United Kingdom, France and the Netherlands have declined, and the species underwent a large overall decline (>30 %).

Consequently, it was evaluated as Vulnerable (BirdLife International 2004). Correspondingly, more staging Brent Geese were recorded on Fehmarn during the 1980s and 1990s than during 1950s and 1960s, but recent numbers are still lower compared to the beginning of the 20th century (Berndt et al. 2005).

Importance of the Fehmarnbelt to Brent Goose
The majority of Brent Geese pass the Fehmarnbelt during migration without stopping. Birds that were observed resting in the Fehmarnbelt usually use the area only for a short break during migration. In the German part of the study area only low numbers have been recorded and resting flocks rarely exceed 20 individuals. Higher numbers have been recorded in Rødsand Lagoon with a maximum count of 1,800 birds, corresponding to 0.9 % of the biogeographic population.

Brent Goose – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	1,800
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	September - October, March – May
Areas of max. abundance in Fehmarnbelt:	Rødsand Lagoon
Explanations:	Maximum abundance obtained from supplementary datasets for Rødsand Lagoon. Other coastal areas were not completely covered during peak abundance periods, but were assessed to hold only low numbers of Brent Geese. Distribution obtained from supplementary datasets.

4.1.14 Eurasian Wigeon – *Anas penelope*

Eurasian Wigeon – *Anas penelope*

Biogeographic population: NW Europe (non-br)

Breeding range: W Siberia, NW and NE Europe

Wintering / core non-breeding range: NW Europe

Population size: 1,500,000

1 % value: 15,000

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: non-SPEC^{E}W
EU Threat Status: secure

Target species in SPAs: -

Key food: grass, arable crops, aquatic vegetation

Period of presence in Fehmarnbelt: Wintering, migrations: September – April
Breeding, moulting: May – August

Origin of Eurasian Wigeon in the Fehmarnbelt

The southern Baltic Sea is located on the migration route of the Eurasian Wigeon between the northern and eastern breeding areas and the wintering areas in north-western Europe (Fransson and Pettersson 2001; Bønløkke et al. 2006). According to the FEBI ring recovery analysis (Appendix IV) the area is visited by birds breeding in eastern Siberia and Finland (and one summer record from Iceland) during transitional and winter periods. After stopping-over in the Fehmarnbelt region many birds continue to wintering areas in the Netherlands, Great Britain, France and Spain. Birds summering in the region may mainly consist of moulting males.

Data sources on Eurasian Wigeon in the Fehmarnbelt

Numbers and distribution of Eurasian Wigeon are well reflected by Danish and German land-based survey datasets; therefore these datasets (AKVSW 2010, DOF 2010, OAG 2010) were used as primary data sources for Eurasian Wigeon baseline assessment. The FEBI ship-based surveys were not considered as a primary dataset due to scarce sightings of the species and non-covered shallow water areas. Danish mid-winter aerial surveys and FEBI aerial surveys (transect and search flights) were used as supporting datasets in the assessment (Table 4.29).

Table 4.29 List of datasets and their use in baseline assessment of Eurasian Wigeon in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI dedicated search flights	Supporting dataset for estimating species abundance and distribution in Orther Reede
FEBI ship transect surveys	Dataset not used due to non-covered shallow water areas
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Primary dataset for species wintering distribution in the Danish Fehmarnbelt area
	Supporting dataset for species wintering abundance in the Danish Fehmarnbelt area
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Eurasian Wigeon in the Fehmarnbelt

The Eurasian Wigeon can be observed in the study area all year, but only low numbers are present in summer. Numbers increase in autumn, and along the Schleswig-Holstein Baltic Sea coast highest numbers are usually observed in October/November (Berndt et al. 2005). Wigeon numbers usually decline in mid-winter and increase again in February/March (Berndt et al. 2005).

Eurasian Wigeon abundance estimates based on FEBI survey data

The Eurasian Wigeon was regularly observed during the two years of monthly FEBI aerial transect surveys, with all sightings obtained in winter period between September and April (Table 4.30). Highest numbers were recorded during surveys in February 2009 (547 birds) and November 2009 (750 birds; Table 4.30). Due to clustered distribution of the species no Distance analysis could be applied on aerial survey datasets; therefore no Distance-corrected abundance estimates based on this method were possible.

Dedicated monthly search flights in Orther Reede between August 2009 and October 2010 revealed three sightings of Eurasian Wigeon in the area: 265 birds on October 30, 2009; 180 birds on March 5, 2010; and 192 birds on September 22, 2010.

Table 4.30 Results of monthly aerial surveys for Eurasian Wigeon between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects; Coverage % is percentage of survey area covered in valid conditions.

Survey	Number of birds observed	Coverage %
Nov-08	350	80.9
Dec-08	50	81.7
Jan-09	309	82.8
Feb-09	547	100.0
Mar-09	33	77.5
Apr-09	1	86.8
May-09	0	77.3
Jun-09	0	80.9
Jul-09	0	86.6
Aug-09	0	92.3
Sep-09	6	79.1
Oct-09	85	79.9
Nov-09	750	82.4
Dec-09	0	24.7
Mar-10 A	26	64.1
Mar-10 B	7	75.6
Apr-10	0	100.0
May-10	0	92.1
Jun-10	0	70.8
Aug-10	0	75.6
Sep-10 A	0	44.9
Sep-10 B	110	48.9
Oct-10	85	80.0
Nov-10	0	70.1

Eurasian Wigeon abundance estimates based on supplementary datasets

Coastal counts in selected (consistently covered) survey sections along the German mainland coast in winter seasons 2008/2009 and 2009/2010 indicate Eurasian Wigeon occurring mainly in autumn months with exceptionally high numbers observed in October 2008 (Figure 4.55; OAG 2010).

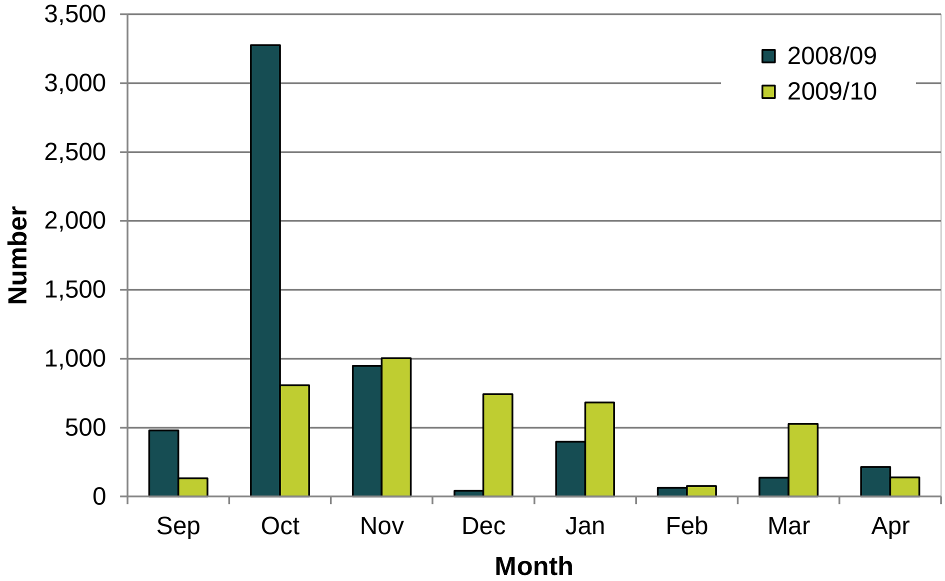


Figure 4.55 Numbers of Eurasian Wigeon recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

The German land-based mid-winter survey of 2009 resulted in a total number of 10,416 of Eurasian Wigeon wintering in the study area (AKVSW 2010, OAG 2010). Due to an incomplete coverage of the coastal areas by this dataset and a seasonal pattern indicating that this species occurs in highest numbers during autumn months (Figure 4.55), the mid-winter count is not expected to represent maximum numbers in the German Fehmarnbelt area.

Monthly land-based count along the mainland coast of the Kiel Bight in October 2008 revealed 6,029 Eurasian Wigeon resting within this incompletely covered mainland part of the SPA Eastern Kiel Bight (OAG 2010). During the mid-winter survey of 2009, only 1,376 birds were recorded in the same area. Assuming that at least similar numbers as observed during mid-winter counts on Fehmarn (9,040 birds in January 2009; AKVSW 2010) also occur in autumn (according to Berndt et al. (2005) Fehmarn numbers also peak in October/November), total numbers exceeding the 1 % criterion of international importance (>15,000 birds) can be expected to occur in the German part of the Fehmarnbelt during peak months.

Compared to the coastal counts on Fehmarn, the Eurasian Wigeon occurs in lower numbers in the Danish part of the Fehmarnbelt area. Petersen et al. (2010) report 1,868 Wigeon in Rødsand Lagoon during mid-winter survey of 2008. Numbers reported in the DOF database show regularly more than 500 Wigeon using the lagoon mainly late in autumn and early spring (DOF 2010). The maximum count listed in the DOF database reports 1,400 Wigeon in November 2009 and is below the number reported by Petersen et al. (2010) for this area.

Distribution and habitat use of Eurasian Wigeon in the Fehmarnbelt
Eurasian Wigeon wintering in Schleswig-Holstein is almost exclusively confined to coastal marine areas and near-shore inland water bodies (Berndt and Busche 1991). The species feeds on aquatic vegetation and is often found associated with swans in the same foraging habitats. In winter the birds are also often observed inland feeding on arable crops, mainly rape (Berndt et al. 2005).

Eurasian Wigeon distribution according to FEBI survey data

The FEBI aerial transect surveys highlighted the coastal areas of Fehmarn as supporting high numbers of Eurasian Wigeon (Figure 4.56). Aerial transect surveys recorded this duck species mostly using sheltered marine areas, such as Orther Reede and Burger Binnensee in the south of Fehmarn, or Rødsand Lagoon in the Danish part of the study area (example in Figure 4.56; Appendix II).

High numbers of Eurasian Wigeon counted during FEBI dedicated search flights in Orther Reede confirm that this shallow bay in the south of Fehmarn is a major resting site for this species, especially during the transitional periods of the year.

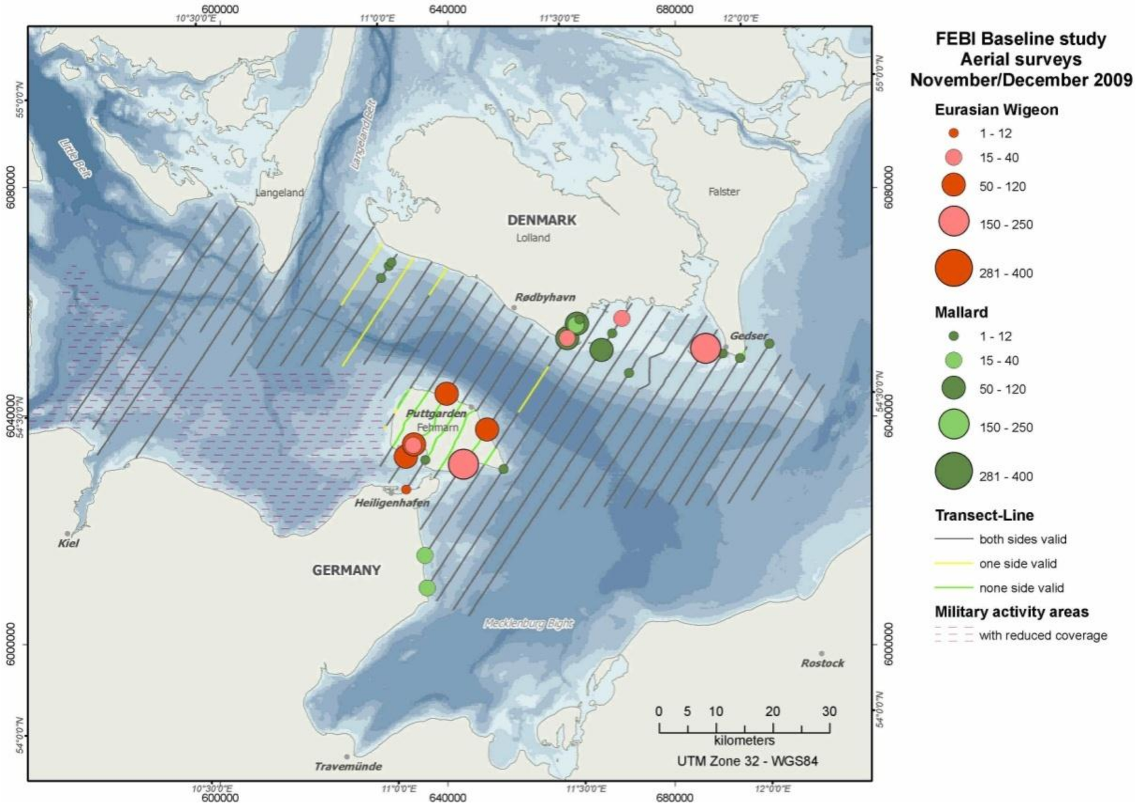


Figure 4.56 Example of observed Eurasian Wigeon (and Mallard) distribution in the study area during aerial baseline surveys (November 2009).

Eurasian Wigeon distribution according to supplementary datasets

An analysis of supplementary datasets confirms the Eurasian Wigeon distribution pattern as recorded by the FEBI aerial transect surveys (Figure 4.57). Mid-winter land-based counts along the German mainland and Fehmarn coast in 2009 revealed Eurasian Wigeon being concentrated in coastal areas of Fehmarn with largest aggregations recorded in the sheltered shallow bays of Orther Reede and Burger Binnensee in the south of the island (Figure 4.57; AKVSW 2010, OAG 2010). Numbers observed along the German mainland coast were comparably low (Figure 4.57).

Petersen et al. (2006, 2010) show Eurasian Wigeon being widely distributed in coastal areas of Denmark. Within the Fehmarnbelt, this duck species concentrates in sheltered areas of Rødsand Lagoon (Figure 4.57; Petersen et al. 2010).

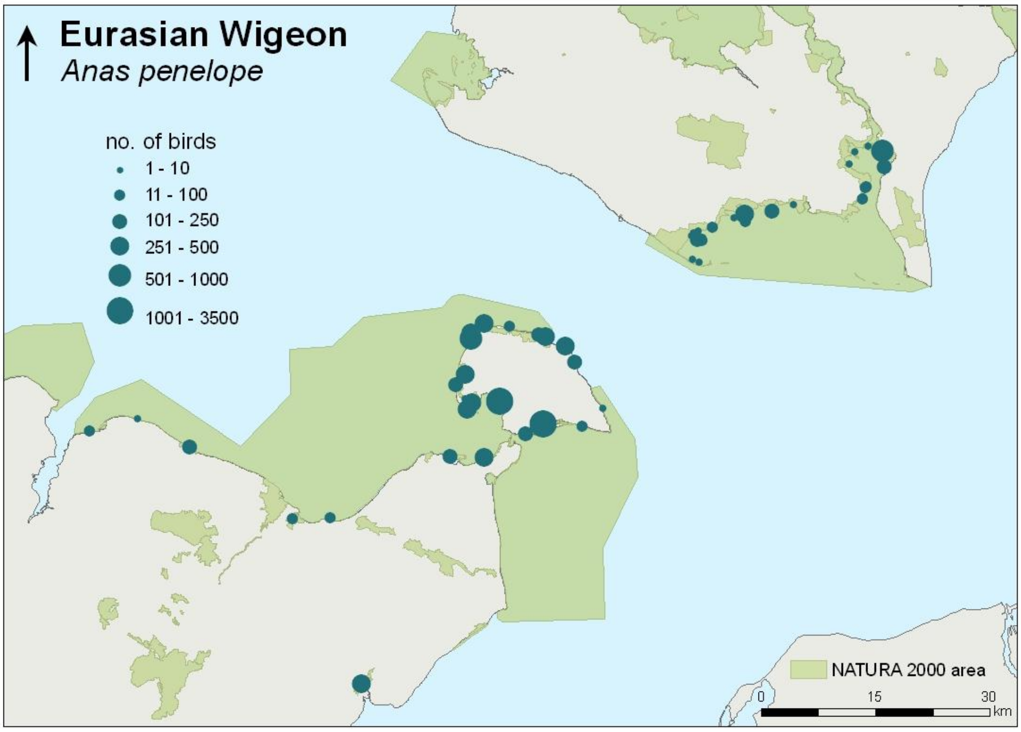


Figure 4.57 Distribution of Eurasian Wigeon during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Eurasian Wigeon abundance estimates for SPAs

The available datasets having incomplete coverage of the German study area during the land-based surveys in autumn months do not allow an accurate abundance estimate for the German SPAs. A maximum count of more than 6,000 Eurasian Wigeon has been obtained within only partly covered SPA Eastern Kiel Bight alone (in October 2008; OAG 2010), without key resting sites on Fehmarn being included during this survey. Assuming that birds have been missed on Fehmarn Island, it is likely that more than 0.5% of the biogeographic population (> 7,500 birds) uses this SPA in autumn and winter.

The SPA Baltic Sea east of Wagrien was also covered incompletely during the land-based surveys (AKVSW 2010, OAG 2010), and only for January numbers are available. Kieckbusch (2010) shows that mainly two areas support high numbers of Eurasian Wigeon within the SPA Baltic Sea east of Wagrien: Burger Binnensee and Großenbroder Binnenwasser. Both areas were covered during the mid-winter survey in 2009 with a total estimate of 1,911 birds (equals to 0.13% of the biogeographic population). Although this number should be considered as a minimum estimate, there is no indication that internationally important concentrations occur in this SPA in the course of the year.

The SPA Hyllekrog-Rødsand has not been reported to support internationally important numbers of Eurasian Wigeon. A maximum 1,868 birds (equals to 0.12% of the biogeographic population) were recorded in January 2008 (Petersen et al. 2010).

Eurasian Wigeon trends

The European wintering population of Eurasian Wigeon is very large and underwent a moderate increase during 1970-1990 (BirdLife International 2004). The overall wintering population is assumed to be stable, thus the species was evaluated as Secure (BirdLife International 2004). Wahl and Sudfeldt (2005) show increasing numbers for Eurasian Wigeon wintering along the German Baltic Sea coast since the early 1980s. This increase is explained by an expansion of wintering areas to the northeast due to mild winters and a shift in foraging habits to winter grain (Brunckhorst and Rösner 1998). Numbers of wintering Wigeon in the coastal areas of Fehmarn appear to be high and stable since 1991 (Figure 4.58).

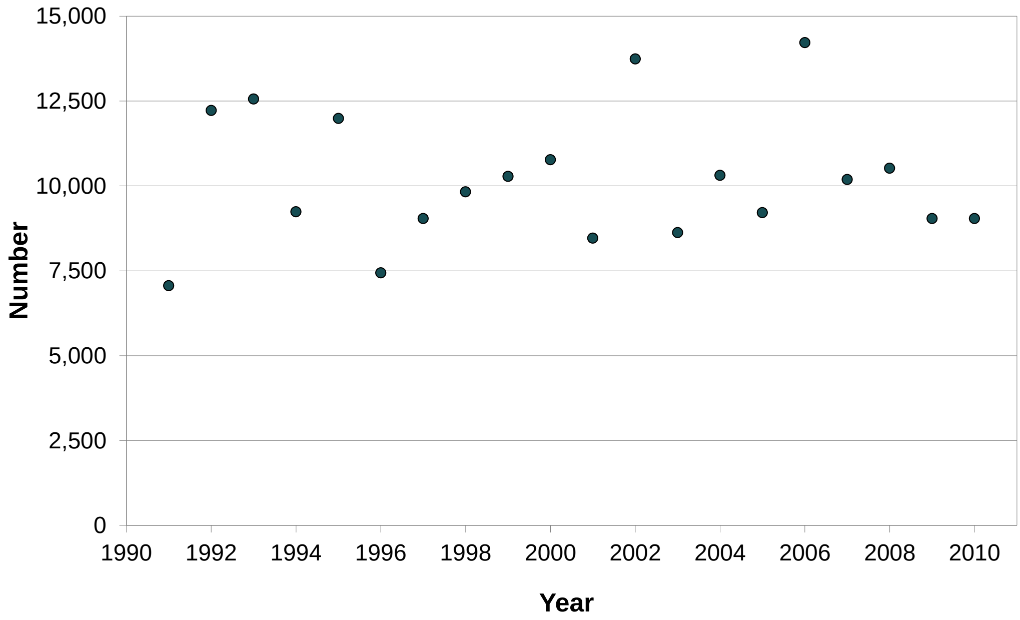


Figure 4.58 Numbers of Eurasian Wigeon recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Eurasian Wigeon

The Eurasian Wigeon is a common species in shallow water areas of the Fehmarnbelt, where the species mainly feeds on aquatic vegetation. In winter the species is also found inland feeding on arable crops. Highest numbers usually occur in the area in late autumn. Analysed datasets and literature indicate that sheltered marine areas of the Fehmarnbelt, especially around Fehmarn Island, are frequently used by this species. A German coastal count in January 2009 indicates more than 0.75 % of the biogeographic population (>10,000 birds) wintering in the area (AKVSW 2010, OAG 2010). As Fehmarn mid-winter counts in some years nearly met the 1 % criterion (Figure 4.58) and autumn numbers are usually higher than numbers in mid-winter (Figure 4.55), it is expected that regularly more than 1 % of the biogeographic population uses the German part of the Fehmarnbelt. The Danish part of the Fehmarnbelt supports comparably low numbers of Eurasian Wigeon with a total numbers rarely exceeding 1,500 birds (0.1 % of the biogeographic population; DOF 2010, Petersen et al. 2010).

Eurasian Wigeon – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	> 15,000 + 1,900
Max. abundance estimate in the alignment area:	> 1,500
Period of max. abundance in Fehmarnbelt:	October – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.57
Explanations:	Maximum abundance estimated from German (10,400 birds) and Danish mid-winter surveys (1,900 birds, Rødsand Lagoon). There is no total count for the entire study area available during maximum abundance periods, but surveys covering parts of the area indicate that total numbers exceed 15,000 birds in German coastal areas during peak abundance period. Maximum abundance in the alignment area estimated based on 1,190 individuals reported for the German part of this area during land-based mid-winter counts. Distribution obtained from supplementary datasets.

4.1.15 *Gadwall – Anas strepera*

Gadwall – *Anas strepera*

Biogeographic population: *A. s. strepera*, NW Europe (br)

Breeding range: NW Europe

Wintering / core non-breeding range: W Europe

Population size: 60,000

1 % value: 600

Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: SPEC 3 EU Threat Status: (depleted)
Target species in SPAs:	Eastern Kiel Bight (DE1530-491)

Key food: mainly water plants

Period of presence in Fehmarnbelt:	Wintering, migrations: September – April Breeding, moulting: May – August

Origin of Gadwall in the Fehmarnbelt

The Gadwall breeds from Western Europe to the easternmost parts of the Palaearctic and further east to North America (Cramp and Simmons 1977). The northern and easternmost populations are migratory, wintering in Western Europe, the Mediterranean, and the Middle East and as far south as areas along the Nile (Cramp and Simmons 1977). The area of Maribo Lakes is an important breeding area for the species in Denmark. No ringed birds have been recovered in the Fehmarnbelt region (Bønløkke et al. 2006, FEBI ring recovery study in Appendix IV). Thus, the origin of staging and wintering birds is unknown.

Data sources on Gadwall in the Fehmarnbelt

Numbers and distribution of Gadwall are well reflected in the Danish and German land-based survey data. Therefore, these datasets (AKVSW 2010, DOF 2010, OAG 2010) were used as primary data sources for Gadwall baseline assessment. FEBI ship-based surveys were not considered due to no sightings of the species and non-covered shallow water areas. Danish mid-winter aerial surveys (NOVANA) and FEBI aerial surveys (transect and search flights) were used as supporting datasets in the assessment (Table 4.31).

Table 4.31 List of datasets and their use in baseline assessment of Gadwall in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI dedicated search flights	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Dataset not used due to no sightings of the species
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for estimating species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish Fehmarnbelt area

Abundance of Gadwall in the Fehmarnbelt

The Gadwall is a common staging bird in Schleswig-Holstein during autumn months (Berndt and Busche 1991), but winter numbers are relatively low (Berndt et al. 2005). More recent studies suggest the species relocating their wintering areas to the north and east, presumably due to milder winters. Consequently higher numbers of wintering Gadwall are recorded in the Baltic region (Wahl and Sudfeldt 2005). On Fehmarn peak numbers of Gadwall are usually recorded during migration period in August (Berndt et al. 2005).

Gadwall abundance estimates based on FEBI survey data

During two years of FEBI baseline investigations Gadwall was recorded only once during aerial transect surveys: 10 birds were observed in the vicinity of Rødsand Lagoon in September 2010. Monthly FEBI dedicated search flights in Orther Reede revealed no sightings of this species.

Gadwall abundance estimates based on supplementary datasets

Coastal counts in selected (consistently covered) survey sections along the German mainland coast indicate Gadwall occurring in highest numbers in autumn and spring, but only few birds were recorded in winter (monthly surveys between September-April 2008/2009 and 2009/2010; Figure 4.59; OAG 2010).

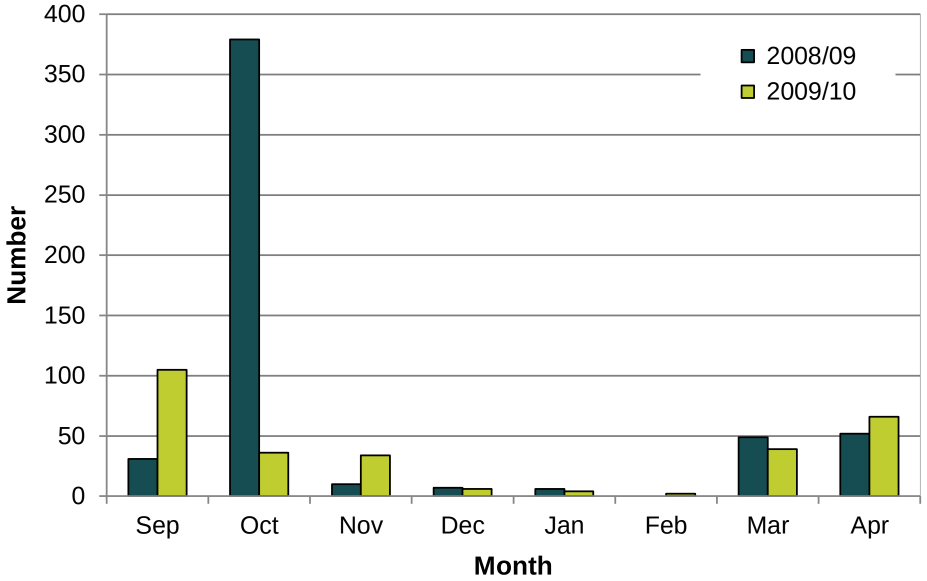


Figure 4.59 Numbers of Gadwall recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

During the mid-winter count in 2009, 273 Gadwall were recorded along the surveyed coastline of Schleswig-Holstein mainland coast and on Fehmarn (AKVSW 2010, OAG 2010). However, as peak numbers occur during migration periods (Figure 4.59), mid-winter surveys do not represent highest abundance of the species.

Monthly land-based counts along the mainland coast of the Kiel Bight revealed 611 resting Gadwall in September 2008 for this incompletely covered coastal sections of the SPA Eastern Kiel Bight (OAG 2010). Thus, this incomplete count has met the 1 % criterion of international importance (600 birds). Based on the OAG data (OAG 2010) and literature information (Berndt et al. 2005) international important numbers are expected to occur regularly in the German Fehmarnbelt area in late summer and autumn.

The Danish mid-winter surveys report very low numbers of Gadwall wintering in Denmark with no sightings within marine habitats of the Fehmarnbelt (Petersen 2006, 2010). The DOF database reports a maximum of 64 Gadwall observed in Rødsand Lagoon (DOF 2010).

Distribution and habitat use of Gadwall in the Fehmarnbelt
The Gadwall uses mainly large near-shore inland lakes and near-shore marine areas along the Baltic coastline. When inland lakes freeze over in winter, Gadwall is described to concentrate in sheltered marine areas (Berndt and Busche 1991).

Gadwall distribution according to FEBI surveys
Gadwall was recorded only once during FEBI aerial surveys: ten birds have been observed in shallow waters of Rødsand Lagoon.

Gadwall distribution according to supplementary datasets
According to a German mid-winter land-based survey in January 2009, Gadwall was observed concentrating in sheltered marine bays and harbours, such as Großenbroder Binnenwasser, which supported the largest flock of 110 individuals during this survey (Figure 4.60, AKVSW 2010, OAG 2010).

Monthly surveys along the German mainland coast indicate the species mainly using inland lakes such as Kleiner Binnensee or Wesseker See in autumn (OAG 2010). This is confirmed by observations described in Berndt et al. (2005) and Kieckbusch (2010).

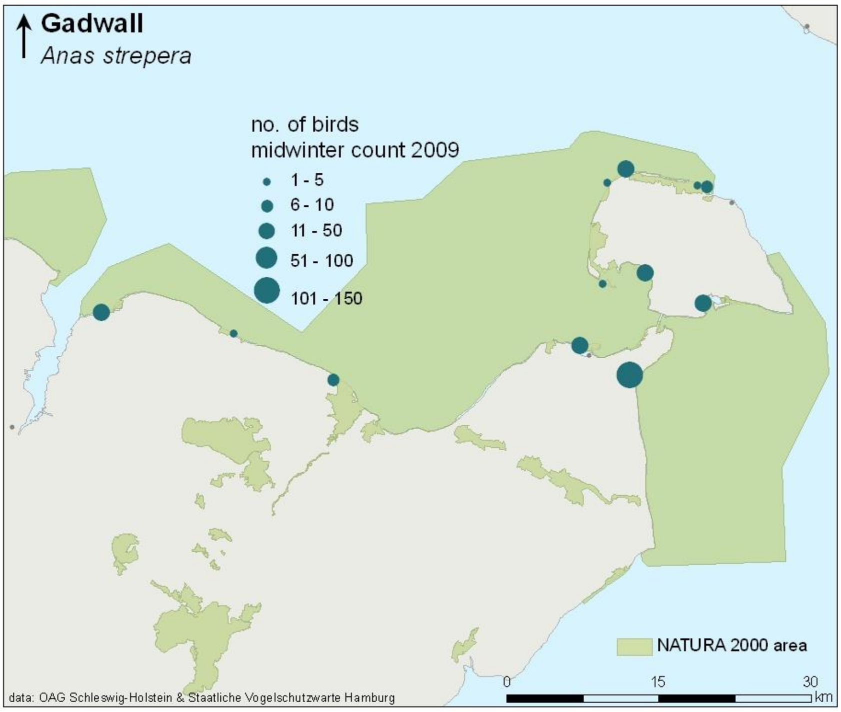


Figure 4.60 Distribution of Gadwall during winter coastal count in January 2009 between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt. Data: OAG Schleswig-Holstein and AKVSW Hamburg.

The DOF database confirms that Gadwall is usually found inland such as Maribo Lakes in the centre of Lolland (DOF 2010). The species was only rarely recorded in the Danish coastal areas (DOF 2010).

Gadwall abundance estimates for SPAs

Monthly surveys along the German mainland coast indicate that aggregation of up to 1 % of the biogeographic population of the species and possibly higher numbers occur in the SPA Eastern Kiel Bight (611 Gadwall recorded in September 2009).

The SPA Baltic Sea east of Wagrien has not been fully covered by the available land-based survey datasets (AKVSW 2010, OAG 2010) and only January numbers were available. However, Kieckbusch (2010) reports no high numbers of Gadwall occurring in this SPA in autumn. Thus, there are no indications that internationally important concentrations of Gadwall occur regularly in this.

The Danish land-based surveys indicate that usually less than 0.1 % of the biogeographic population (60 birds) of Gadwall uses the SPA Hyllekrog-Rødsand. A maximum number of 64 birds was recorded in April 2009 (DOF 2010).

Gadwall trends

The overall European breeding population of Gadwall is rather small and underwent a substantial decline between 1970 and 1990 (BirdLife International 2004). Since 1990 the population appears to be stable, but it is likely that the total population size remains below the level that before the decline. For this reason the species was provisionally evaluated as Depleted (BirdLife International 2004).

A strong increase in Gadwall numbers has been observed in Germany since the late 1960s (Wahl and Sudfeldt 2005); especially a strong increase was noted for the north-western part of the country (Wahl and Sudfeldt 2005, Flade et al. 2008). Wintering numbers of Gadwall are low in Germany, but an increase has been identified as well although winter numbers do vary with winter severity (Wahl and Sudfeldt 2005). Long-term mid-winter survey dataset of Fehmarn indicates an increasing trend (Figure 4.61; AKVSW 2010).

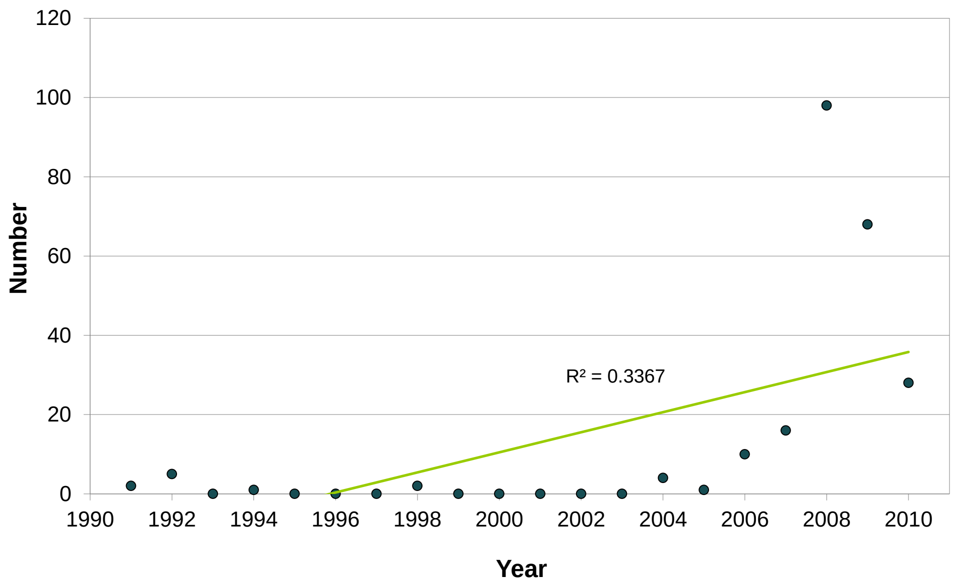


Figure 4.61 Numbers of Gadwall recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; p = 0.007; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Gadwall

The Gadwall is present in the Fehmarnbelt area all year, but highest numbers are usually observed in spring and autumn periods, when birds are mostly recorded on inland freshwater habitats. Wintering numbers are generally low, but an increasing trend of wintering birds has been recorded. Internationally important numbers of Gadwall (> 600 birds) have been recorded in the German study area, where SPA Eastern Kiel Bight is expected to meet the 1% criterion of international importance regularly. Gadwall numbers in the Danish Fehmarnbelt only rarely exceed the 0.1% of the biogeographic population (maximum count 64 birds in Rødsand Lagoon in April 2009, equalling 0.11% of the biogeographic population; DOF 2010).

Gadwall – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	> 610 + 110 + 60
Max. abundance estimate in the alignment area:	a few tens of birds
Period of max. abundance in Fehmarnbelt:	September – November, March/April
Areas of max. abundance in Fehmarnbelt:	inland areas of SPA Eastern Kiel Bight and see Figure 4.60
Explanations:	Maximum abundance estimated based on supplementary data for the SPAs Eastern Kiel Bight (610 birds, partly inland), Baltic Sea east of Wagrien (110 birds) and Hyllekrog-Rødsand (60 birds). There is no total count for the entire study area available during maximum abundance periods, but non-covered marine areas of the Fehmarnbelt were assessed as not holding relevant numbers of Gadwall. Maximum abundance in the alignment area estimated based on 12 individuals reported for the German part of this area during the land-based mid-winter survey of 2009. Distribution obtained from supplementary datasets.

4.1.16 Common Teal – *Anas crecca*

Common Teal – *Anas crecca*

Biogeographic population: *A. c. crecca*, NW Europe (non-br)

Breeding range: N and NW Europe

Wintering / core non-breeding range: NW Europe

Population size: 500,000

1 % value: 5,000

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: non-SPEC
EU Threat Status: (secure)

Target species in SPAs: -

Key food: omnivorous; seeds of aquatic plants predominant (especially in autumn/winter)

Period of presence in Fehmarnbelt: Wintering, migrations: September – April
Breeding, moulting: May – August

Origin of Common Teal in the Fehmarnbelt

According to the FEBI ring recovery analysis the Fehmarnbelt region serves as stop-over area for Common Teal originating from Sweden, Finland, the Baltic countries and western Russia during their migration towards main wintering areas in Great Britain, the Netherlands, France and Spain (Appendix IV).

Data sources on Common Teal in the Fehmarnbelt

Numbers and distribution of Common Teal are well reflected in the Danish and German land-based survey datasets. Therefore these datasets (AKVSW 2010, DOF 2010, OAG 2010) were used as primary data sources. The FEBI ship-based and aerial surveys (transect and search flights) as well as the Danish mid-winter aerial surveys (NOVANA) were used as supporting information sources in the assessment (Table 4.32).

Table 4.32 List of datasets and their use in baseline assessment of Common Teal in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI dedicated search flights	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Supporting dataset for estimating species abundance
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for species wintering abundance and distribution in Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Common Teal in the Fehmarnbelt

The Common Teal is present as breeding and resting bird in Schleswig-Holstein all the year (Berndt and Busche 1991). Peak numbers are typically reached in the period between August and October, when northern breeding birds use the area as a stop-over site on their migration to wintering grounds. Pihl et al. (2006) describe a similar pattern of Common Teal abundance in Denmark with highest numbers of resting birds being recorded between September and November, and again in March/April. Numbers of wintering birds are generally rather low in the region (Berndt and Busche 1991, Berndt et al. 2005, Pihl et al. 2006).

Common Teal abundance estimates based on FEBI survey data

The Common Teal was rarely observed during FEBI aerial surveys. During the two years of baseline investigations the species was observed twice during aerial transect surveys: one flock of 80 birds on October 30, 2009, and 5 birds during survey in April 2010. Dedicated monthly search flights in Orther Reede between August 2009 and October 2010 revealed one sighting of 15 Common Teal resting in the area in October 2010.

During two years of monthly ship-based surveys in the Fehmarnbelt, Common Teal was recorded four times with a maximum count of 35 birds in December 2008.

Common Teal abundance estimates based on supplementary datasets

The seasonal pattern of Common Teal abundance in selected mainland count sections indicates high numbers in the area during the migration periods with peaks in September and April (Figure 4.62, OAG 2010). Comparably low numbers of Common Teal were observed during mid-winter (Figure 4.62).

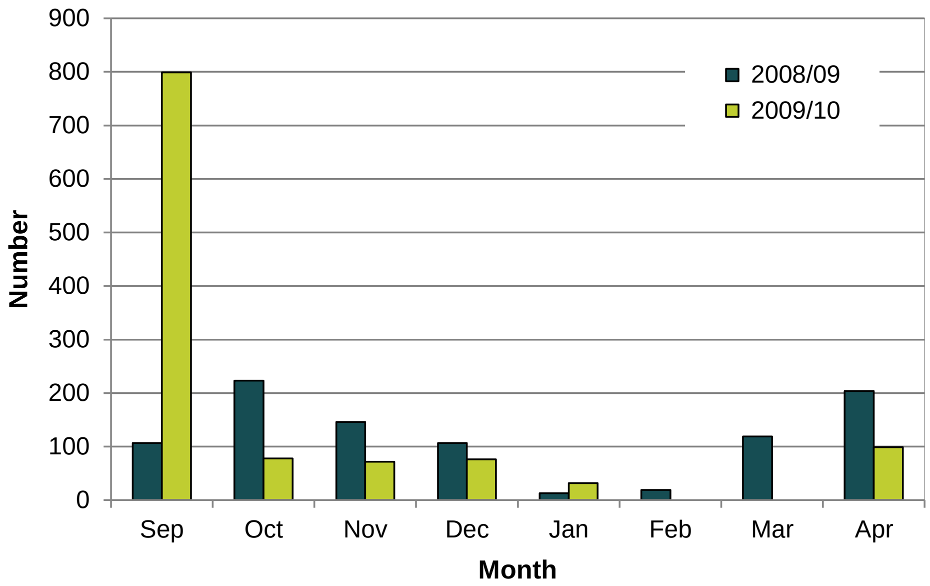


Figure 4.62 Numbers of Common Teal recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

In total 193 Common Teal were recorded along the surveyed coastal sections of the German study area during the mid-winter land-based survey in 2009 (AKVSW 2010, OAG 2010). According to the observed abundance pattern in the study area (Figure 4.62) mid-winter counts represent only a fraction of duck numbers using the area during transitional periods.

Monthly land-based counts along the mainland coast of the Kiel Bight revealed 887 Common Teal resting in this part of the study area in September 2009 (OAG 2010). According to Kieckbusch (2010) main Common Teal resting habitats along the mainland coast were covered by this survey (inland lakes like Kleiner and Großer Binnensee). Freshwater habitats on Fehmarn, such as protected areas of Wallnau and Grüner Brink, regularly support high numbers of Common Teal especially in autumn (Berndt et al. 2005, Kieckbusch 2010). Berndt et al. (2005) report maximum number of 2,000 Common Teal resting on Fehmarn during these peak periods.

The Danish mid-winter aerial survey of 2008 (both, transect survey and total count) revealed only 10-50 Common Teal wintering in Rødsand Lagoon (Petersen et al. 2010). The DOF database reports highest numbers occurring in autumn with regularly more than 100 Common Teal observed in Rødsand Lagoon (maximum 520 birds in October 2009; DOF 2010).

Distribution and habitat use of Common Teal in the Fehmarnbelt

The Common Teal prefers shallow water areas with mudflats and use inlets and bays as well as shallow water bodies close to coastal areas (Berndt and Busche 1991). Agricultural areas with winter grain are used as foraging sites in winter as well.

Common Teal distribution according to FEBI survey data

The Common Teal was recorded twice during FEBI aerial transect surveys. Both records (80 birds in October 2009 and 5 birds in April 2010) are from shallow water areas of Rødsand Lagoon. For the German coast there is one additional record of Common Teal available where fifteen birds were observed during the search flight in Orther Reede on October 15, 2010.

Common Teal distribution according to supplementary datasets

During a German mid-winter land-based survey in January 2009 (AKVSW 2010, OAG 2010) Common Teal was recorded on inland lakes and sheltered marine areas like Burger Binnensee (southeast of Fehmarn), which supported the largest flock of 80 individuals during this survey (Figure 4.63).

Monthly surveys along the German mainland coast indicate the species is predominantly using inland freshwater habitats like Kleiner Binnensee or Wesseker See (OAG 2010). This is confirmed by observations published in Berndt et al. (2005) and Kieckbusch (2010), who also identify areas on Fehmarn (e.g. Wallnau, Grüner Brink) as supporting high numbers of Common Teal especially in autumn.

Petersen et al. (2010) report only low numbers of Common Teal resting in sheltered areas of Rødsand Lagoon during mid-winter (Figure 4.63). The DOF database confirms that Danish coastal areas support rather low numbers of this species (DOF 2010).

Figure 4.63 Distribution of Common Teal during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Common Teal abundance estimates for SPAs

Mid-month survey along the German mainland coast in September 2009 resulted in 887 Common Teal counted within mainland sections of the SPA Eastern Kiel Bight (OAG 2010). According to Berndt et al. (2005) numbers up to 2,000 birds can be observed on Fehmarn in autumn. Thus, as major Teal resting sites on the island are located within the SPA Eastern Kiel Bight (Kieckbusch 2010), numbers of more than 2,500 birds (0.5 % of the biogeographic population) might occur in this SPA during autumn months of some years.

The SPA Baltic Sea east of Wagrien was incompletely covered by the available land-based survey datasets (AKVSW 2010, OAG 2010), and only January numbers are available. Survey sections within this SPA held 42 % of ducks observed during the mid-winter count 2009 (80 birds in Burger Binnensee). However, Kieckbusch (2010) reports no higher numbers occurring within the survey sections of this SPA during autumn months. Thus, internationally important numbers of Common Teal are not expected to occur in the SPA Baltic Sea east of Wagrien.

According to the DOF database (DOF 2010), the SPA Hyllekrog-Rødsand does not support internationally important numbers of Common Teal in the course of the year. Whithin this SPA regularly more than 100 birds are reported in autumn, but maximum numbers rarely exceed 0.1 % of the biogeographic population (500 birds).

Common Teal trends
The Common Teal breeding population was stable between 1970 and 1990 (BirdLife International 2004). After 1990 the numbers declined in some European countries (especially in Finland), but the entire population probably declined only slightly. Hence, the species was provisionally evaluated as Secure (BirdLife International 2004). For Germany Wahl and Sudfeldt (2005) describe a decline in Common Teal numbers since 1990, and explain this pattern with reduced nutrient flow of Elbe river. Local numbers of wintering birds on Fehmarn do not show a significant trend over the past 20 years (Figure 4.64; AKVSW 2010). Variable local numbers can be explained by varying winter conditions (Wahl and Sudfeldt 2005).

According to Pihl et al. (2006) Common Teal is a legal quarry in Denmark. The species is highly gregarious and is sensitive to human disturbances, particularly hunting disturbance (Pihl et al. 2006).

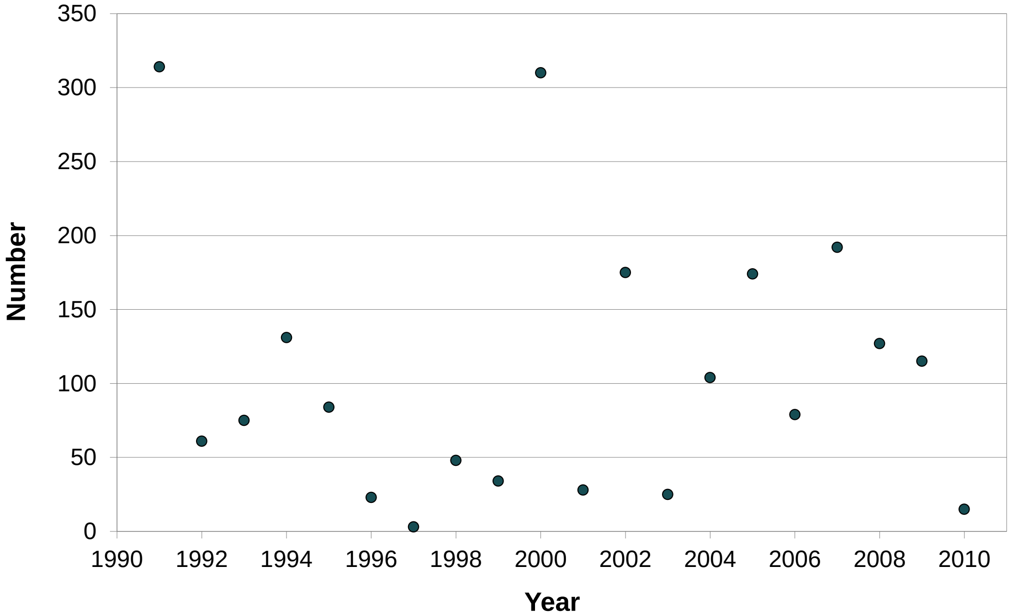


Figure 4.64 Numbers of Common Teal recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Common Teal
The Common Teal is present in the Fehmarnbelt area all year. Highest numbers are typically observed during migration periods, especially in autumn, when birds are mostly recorded using inland freshwater habitats. In winter the numbers of Common Teal drop remarkably in the study area. Supplementary datasets indicate higher numbers of Common Teal occurring along the German coast on inland areas of the SPA Eastern Kiel Bight, where maximum numbers are expected to reach and exceed 0.5 % of the biogeographic population in some years. In Denmark coastal areas of Rødsand Lagoon regularly support more than 100 Common Teal, but internationally important numbers were not reported for this area (DOF 2010).

Common Teal – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	> 2,500 + 520
Max. abundance estimate in the alignment area:	several tens of birds
Period of max. abundance in Fehmarnbelt:	August – October
Areas of max. abundance in Fehmarnbelt:	inland areas of SPA Eastern Kiel Bight, see Figure 4.63

Explanations: Maximum abundance estimated based on supplementary data for the SPAs Eastern Kiel Bight (890 birds, partly inland) and Hyllekrog-Rødsand (520 birds). There is no total count for the entire study area available during maximum abundance periods, but surveys covering parts of the area indicate that total numbers likely exceed 2,500 birds in the German part of the study area during peak abundance periods.

Maximum abundance in the alignment area estimated based on 35 individuals reported for the German part of this area during land-based mid-winter survey 2009.

Distribution obtained from supplementary datasets.

4.1.17 Mallard – Anas platyrhynchos

Mallard – *Anas platyrhynchos*		
Biogeographic population: *A. p. platyrhynchos*, NW Europe (non-br)		
Breeding range: N Europe		
Wintering / core non-breeding range: NW Europe eastwards to the Baltic Sea		
Population size: 4,500,000		
1 % value: 45,000*		
Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC EU Threat Status: (secure)	
Target species in SPAs:	-	
Key food: wide range of vegetable food, invertebrates, also spawn and tadpoles		
Period of presence in Fehmarnbelt:		Wintering, migrations: September – April Breeding, moulting: May – August

* For populations over 2 million birds, Ramsar Convention criterion 5 (20,000 or more waterbirds) applies.

Origin of Mallard in the Fehmarnbelt

The Mallard is mostly resident within the study region (Cramp and Simmons 1977; Bønløkke et al. 2006). However, according to the FEBI ring recovery study a large number of ringed bird recoveries from the Fehmarnbelt region reveal that breeding birds from Sweden, Finland, the Baltic countries, Russia and Poland use the Fehmarnbelt area during winter and as stop-over site on migration towards wintering areas in northern Germany, the Netherlands, Great Britain and France (Appendix IV).

Data sources on Mallard in the Fehmarnbelt

The numbers and distribution of Mallard are well represented in the Danish and German land-based survey datasets. Therefore these datasets (AKVSW 2010, DOF 2010, OAG 2010) were used as primary data sources for the species baseline assessment. FEBI ship-based and aerial surveys (transect and search flights) as well as Danish mid-winter aerial surveys (NOVANA) were used as supporting sources in the assessment (Table 4.33).

Table 4.33 List of datasets and their use in baseline assessment of Mallard in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI dedicated search flights	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Supporting dataset for estimating species abundance
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish Fehmarnbelt area

Abundance of Mallard in the Fehmarnbelt

The Mallard is a very common duck species, which is abundant in the study area as breeding and migratory bird throughout the year. Highest numbers on Fehmarn occur in late autumn and winter when northern-breeding birds arrive to the area in addition to resident birds (Berndt and Busche 1991, Berndt et al. 2005).

Mallard abundance estimates according to FEBI survey data

The Mallard was regularly observed during the two years of monthly FEBI aerial transect surveys, with highest numbers observed in November (Table 4.34). Due to clustered distribution of the species no Distance analysis could be applied on aerial survey datasets. Consequently, no Distance-corrected abundance estimates were possible.

Dedicated monthly search flights in Orther Reede (southwest of Fehmarn) between August 2009 and October 2010 revealed regular records of Mallard in the area (Figure 4.65). During October survey of 2009 a maximum of 140 Mallard was observed in this area (Figure 4.65).

Table 4.34 Results of monthly aerial surveys for Mallard between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects; Coverage % is percentage of survey area covered in valid conditions.

Survey	Number of birds observed	Coverage %
Nov-08	958	80.9
Dec-08	261	81.7
Jan-09	348	82.8
Feb-09	142	100.0
Mar-09	55	77.5
Apr-09	15	86.8
May-09	7	77.3
Jun-09	5	80.9
Jul-09	8	86.6
Aug-09	0	92.3
Sep-09	0	79.1
Oct-09	44	79.9
Nov-09	527	82.4
Dec-09	2	24.7
Mar-10 A	60	64.1
Mar-10 B	36	75.6
Apr-10	27	100.0
May-10	16	92.1
Jun-10	14	70.8
Aug-10	2	75.6
Sep-10 A	3	44.9
Sep-10 B	10	48.9
Oct-10	68	80.0
Nov-10	134	70.1

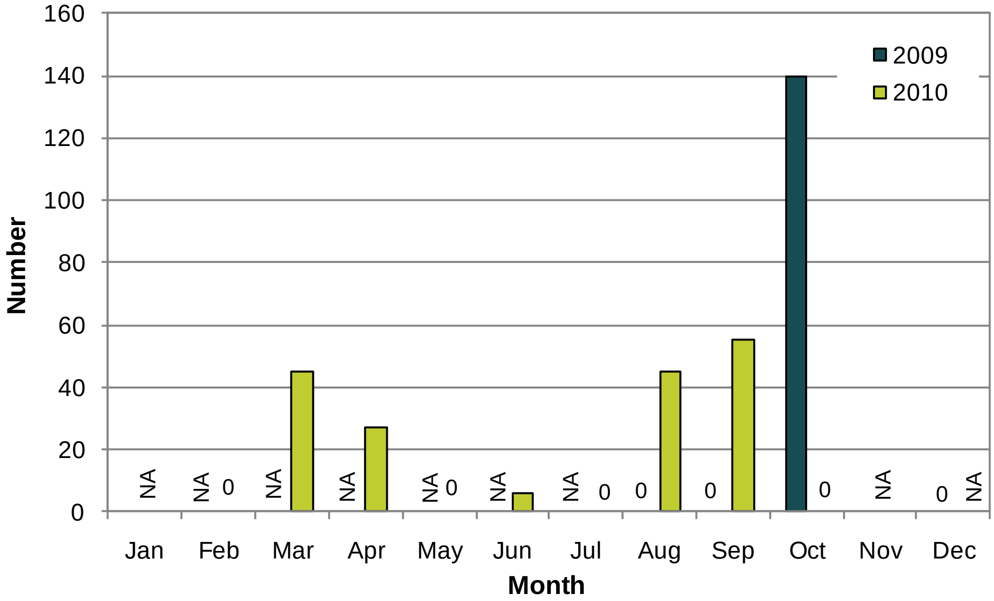


Figure 4.65 Numbers of Mallard counted during dedicated search flights in Orther Reede in August 2009 – October 2010.

Mallard abundance in the Fehmarnbelt offshore areas surveyed by ship was rather low (Table 4.35). During most FEBI ship-based surveys none or single birds were recorded, but a seasonal pattern with highest numbers being observed in winter months was also clearly reflected by this dataset (Table 4.35).

Table 4.35 Results of monthly ship-based surveys for Mallard between November 2008 and November 2010. Number of birds observed represents actual number of birds counted within transects.

Survey	Number of birds observed	Survey	Number of birds observed
Nov-08	0	Nov-09	20
Dec-08	98	Dec-09	24
Jan-09	12	Jan-10	16
Feb-09	6	Feb-10 A	0
Mar-09	1	Feb-10 B	1
Apr-09	2	Mar-10	7
Jun-09	3	Apr-10	0
Jul-09 A	0	May-10	0
Jul-09 B	0	Jun-10	2
Aug-09	0	Sep-10	0
Sep-09	0	Oct-10	3
Oct-09	0	Nov-10	6

Mallard abundance estimates according to supplementary datasets
Surveys along selected sections of the German mainland coast indicate peak numbers of Mallard occurring in mid-winter (Figure 4.66; OAG 2010).

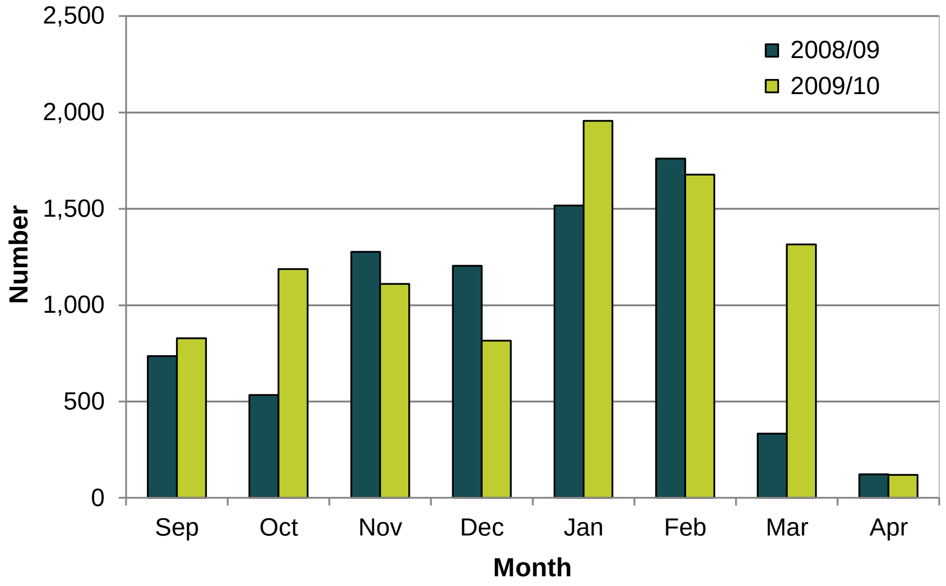


Figure 4.66 Numbers of Mallard recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

The German land-based mid-winter survey of 2009 revealed a total number of 7,390 Mallard wintering in the German study area (AKVSW 2010, OAG 2010).

The Danish mid-winter survey of 2008 resulted in 3,246 Mallard observed in the Danish part of the Fehmarnbelt, of which the majority (3,184) was recorded in sheltered areas of the Rødsand Lagoon (Petersen et al. 2010). Records in the DOF database provide similar maximum number for this area: 2,900 Mallard were reported in the Rødsand Lagoon on October 23, 2005 (DOF 2010). A maximum of 600 birds was reported to occur in the alignment area at Rødbyhavn (in December 2010, DOF 2011).

Distribution and habitat use of Mallard in the Fehmarnbelt
Mallards are very common in the near-shore inland lakes and Baltic coastal waters. When inland lakes freeze in winter, Mallards concentrate in sheltered marine areas (Berndt and Busche 1991).

Mallard distribution according to FEBI survey data
During the FEBI aerial surveys Mallards were mostly recorded in sheltered coastal areas, such as Rødsand Lagoon, Burger Binnensee or Orther Reede. Birds were also regularly recorded in shallow water areas of the Kiel Bight mainland coast. Dedicated search flights in Orther Reede confirmed that this area regularly support the species.

Mallard distribution according to supplementary datasets
The md-winter land-based count along the German mainland and Fehmarn coast in 2009 revealed Mallard being widely distributed in coastal areas (Figure 4.67; AKVSW 2010, OAG 2010). Flocks of more than 500 birds were observed within survey sections Laboe-Bottsand, Sehlendorfer Binnensee, Graswarder and Orther Reede. Kieckbusch (2010) also reports this species being widely distributed along

the German coast and describes high numbers of Mallard occurring in various sections of the study area.

The Danish mid-winter survey in 2008 identified the Rødsand Lagoon as a major resting site for Mallard within the Danish part of the study area (Figure 4.67; Petersen et al. 2010).

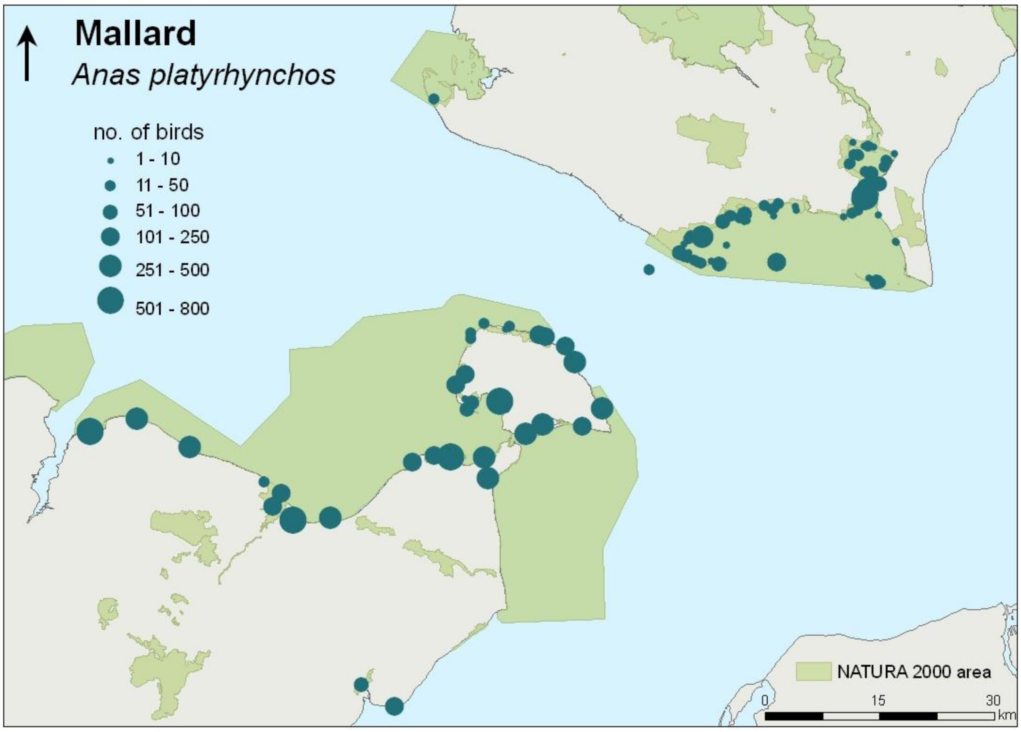


Figure 4.67 Distribution of Mallard during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Mallard abundance estimates for SPAs

The land-based mid-winter counts could be considered as delivering reliable abundance estimates for the Mallard, because of the coastal distribution of this species. During the German mid-winter survey in 2009, 5,409 Mallard were recorded within the SPA Eastern Kiel Bight, and 1,389 birds within the SPA Baltic Sea east of Wagrien. Hence, none of the two German SPAs in the study area supports internationally important numbers of this species according to the Ramsar Convention Criterion 5 (20,000 or more waterbirds).

Similar numbers of Mallard have been reported in the Danish part of the study area: a mid-winter count of 2008 revealed 3,184 Mallard wintering in the SPA Hyllekrog-Rødsand (Petersen et al. 2010). The DOF database reports a similar maximum number of Mallards using this SPA (2,860 birds in October 2005; DOF 2010). Thus, the SPA Hyllekrog-Rødsand does not hold internationally important numbers of this species.

Mallard trends

The European breeding population of Mallard is very large and was described as stable between 1970 and 1990 (BirdLife International 2004). Between 1990 and 2000 the species declined in some countries, but this probably resulted in only a slight overall decline. Thus, the species was evaluated as Secure (BirdLife International 2004). For Germany Wahl and Sudfeldt (2005) describe a decreasing trend for Mallard wintering in the country. This decline could be explained by an extension of the general wintering area to the north and east due to recent mild winters (Flade et al. 2008). Petersen et al. (2010) report almost constant numbers of about 135,000 Mallard wintering in Denmark between 1989 and 2008. Mid-winter surveys on Fehmarn between 1991 and 2010 show no significant trend of birds wintering in the area (Figure 4.68).

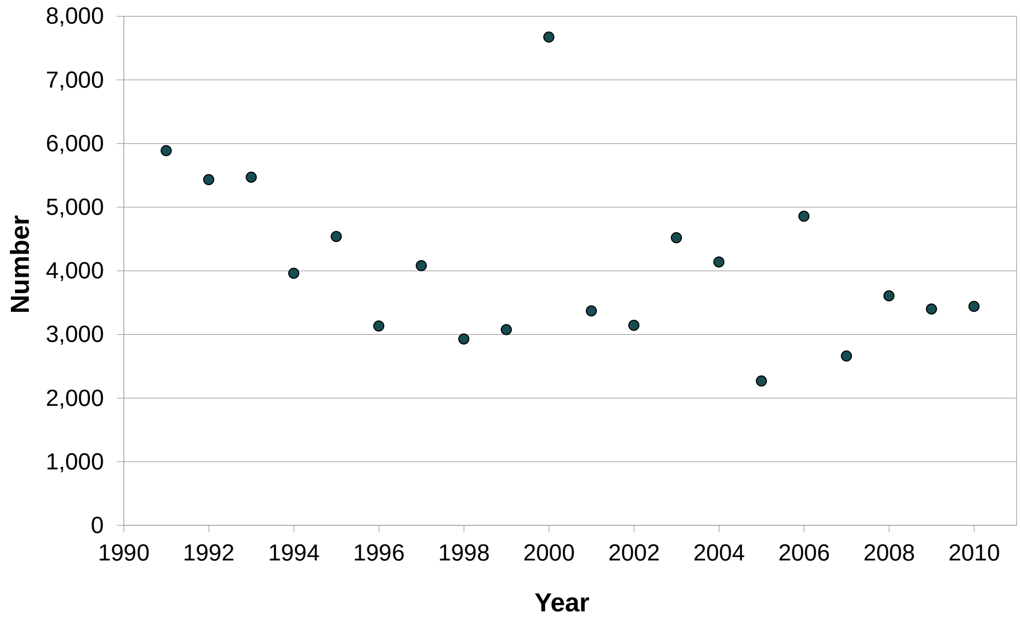


Figure 4.68 Numbers of Mallard recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Mallard

The Mallard is a very common species in Europe and occurs in high numbers in coastal areas of the Danish and German parts of the Fehmarnbelt area. The species is present in the area all the year with highest numbers being reported during winter months. The species is widely distributed within the study area and occurs in numbers reaching several thousand individuals (7,400 birds for the German part of the study area in January 2009; AKVSW 2010, OAG 2010; 3,250 birds in coastal areas of the Danish Fehmarnbelt in February 2008; Petersen et al. 2010). There were no internationally important numbers of Mallard recorded in the Fehmarnbelt area.

Mallard – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	7,400 + 3,250
Max. abundance estimate in the alignment area:	600 + 1,018
Period of max. abundance in Fehmarnbelt:	October – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.67
Explanations:	Maximum abundance estimated from German (7,400 birds) and Danish mid-winter surveys (3,250 birds). Maximum abundance in the alignment area obtained from supplementary datasets for Rødbyhavn (600 birds) and 1,018 individuals reported for the German part of this area during the land-based mid-winter survey of 2009. In addition, there are usually some Mallards staying in the harbour of Rødbyhavn. Distribution obtained from supplementary datasets.

4.1.18 Shoveler – *Anas clypeata*

Shoveler – *Anas clypeata*

Biogeographic population: NW and C Europe (non-br)

Breeding range: N, NW and C Europe

Wintering / core non-breeding range: NW and C Europe

Population size: 40,000

1 % value: 400

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: SPEC 3
EU Threat Status: (declining)

Target species in SPAs: Eastern Kiel Bight (DE1530-491)

Key food: vegetable and animal water organisms, plankton

Period of presence in Fehmarnbelt: Wintering, migrations: September – April
Breeding, moulting: May – August

Origin of Shoveler in the Fehmarnbelt
The Shoveler is migratory within the region (Cramp and Simmons 1977). According to the FEBI ring recovery study (Appendix IV) birds ringed in the Fehmarnbelt area were recovered along the southern Baltic Sea coast, Denmark and the Benelux countries in summer, indicating that birds using the Fehmarnbelt originate from these areas. Furthermore, breeding birds of the Nordic countries and Russia are reported to stop-over in the southern Baltic (Fransson and Pettersson 2001; Bønløkke et al. 2006). The wintering areas of these birds are located in Great Britain, France and Spain, and there is even a single record from as far south as the Senegal in West Africa.

Data sources on Shoveler in the Fehmarnbelt
Numbers and distribution of Shoveler are best reflected by the Danish and German land-based survey data. Therefore these datasets (AKVSW 2010, DOF 2010, OAG 2010) were used as primary data sources for Shoveler baseline assessment. No Shoveler was recorded during the two years of the FEBI baseline investigations (aerial and ship-based surveys). Danish mid-winter aerial surveys (NOVANA) were used as supporting datasets in the assessment (Table 4.36).

Table 4.36 List of datasets and their use in baseline assessment of Shoveler in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used due to no sightings of the species
FEBI dedicated search flights	Dataset not used due to no sightings of the species
FEBI ship transect surveys	Dataset not used due to no sightings of the species
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Shoveler in the Fehmarnbelt

Coastal counts in selected (consistently covered) survey sections along the German mainland coast indicate that Shoveler occurs in rather low numbers with only one observation of nearly 1,000 birds recorded during the migration period in September (Figure 4.69; OAG 2010). The same is suggested by Wahl and Sudfeldt (2005), who describe maximum numbers occurring during transitional periods and only low numbers of Shoveler wintering in Germany. During severe winters birds are known to leave the area completely (Berndt et al. 2005).

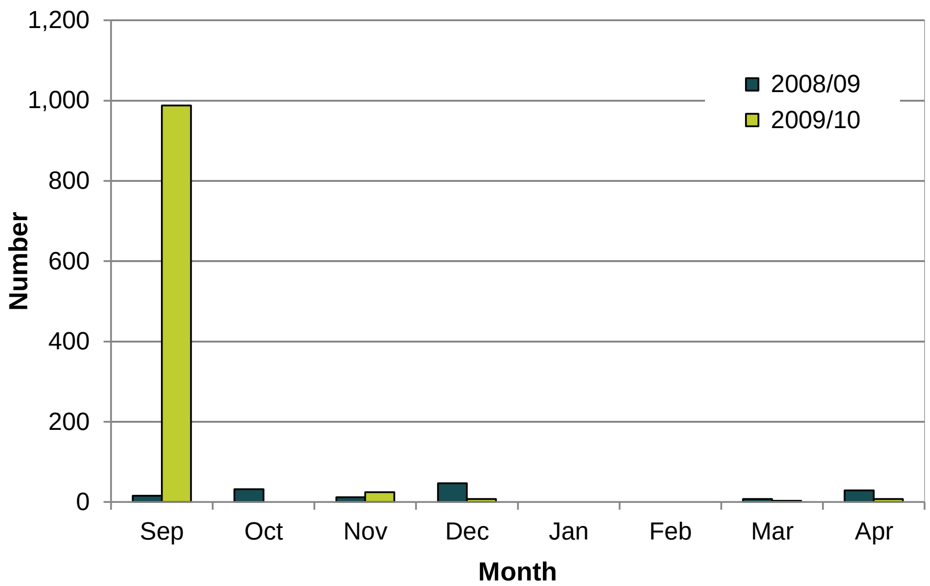


Figure 4.69 Numbers of Shoveler recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

During the mid-winter count of 2009, 5 Shoveler were recorded along the covered coastline of the German study area (AKVSW 2010, OAG 2010). This confirms that only single birds of this species winter in the area. Monthly land-based counts along the mainland coast of the Kiel Bight revealed 989 resting Shoveler in September 2009 (OAG 2010). Almost all of these birds were counted on the inland lake Großer Binnensee (OAG 2010). This count exceeded the 1 % criterion of international importance (400 birds). Based on OAG data (OAG 2010) and literature information (Berndt et al. 2005) internationally important numbers are expected to occur regularly in the German part of the Fehmarnbelt area in late summer and autumn.

Petersen et al. (2010) report 3 Shoveler recorded in Rødsand Lagoon during the mid-winter count of 2008, and confirm that this species winters in very low numbers in the area. The DOF database reports very few winter sightings of this species and generally low numbers of Shoveler using Rødsand Lagoon during other seasons (DOF 2010). Single birds are regularly present in the lagoon during the breeding season and higher numbers occur in transitional periods (maximum 87 birds recorded on October 22, 2008; DOF 2010). Single birds are occasionally reported in the alignment area at Rødbyhavn (DOF 2011).

Distribution and habitat use of Shoveler in the Fehmarnbelt
The Shoveler favours eutrophic shallow water areas abundant with vegetation as resting and foraging sites (Berndt and Busche 1991). The species is mostly confined to inland habitats (Berndt and Busche 1991, Berndt et al. 2005, Kieckbusch 2010).

Monthly surveys along the German mainland coast in 2008/2009 and 2009/2010 (OAG 2010) revealed the species mainly resting on shallow inland lakes (Großer and Kleiner Binnensee, Sehlendorfer Binnensee, Wesseker See), but sheltered coastal areas like Graswarder are also used. The largest aggregation of more than 900 Shoveler was recorded on Großer Binnensee (OAG 2010). On Fehmarn the inland nature reserves Wallnau and Grüner Brink regularly support high numbers of Shoveler in autumn (Berndt et al. 2005, Kieckbusch 2010).

The Danish land-based observations show the Shoveler is mainly using inland areas, such as Maribo Lakes and rarely occurs in coastal areas of the Fehmarnbelt (DOF 2010).

Shoveler abundance estimates for SPAs
A total of 988 Shoveler were counted inland on the Großer Binnensee within the SPA Eastern Kiel Bight in September 2009 (2.5 % of the biogeographic population). There are no survey data available for the island of Fehmarn during the autumn peak months, but according to Berndt et al. (2005) several hundreds of Shoveler are regularly recorded on the island as well. Thus, numbers considerably exceeding the 1 % threshold of international importance occur within the entire SPA in autumn.

There are no records suggesting that internationally important numbers of Shoveler regularly occur in the SPA Baltic Sea east of Wagrien. This is also confirmed by low numbers of Shoveler reported for this SPA by Kieckbusch (2010).

On the Danish side, the SPA Hyllekrog-Rødsand supports comparably low numbers of this species, which only rarely exceed 0.1 % of the biogeographic population (40 birds) in this area (maximum 87 birds in October 2008; DOF 2010).

Shoveler trends
The European breeding population of Shoveler was stable between 1970 and 1990 (BirdLife International 2004). Between 1990 and 2000 the population underwent a moderate decline of more than 10 %. Hence, this previously Secure species was provisionally evaluated as Declining (BirdLife International 2004).

The long-term mid-winter survey dataset of Fehmarn shows no trend in wintering numbers of Shoveler on the island (Figure 4.70; AKVSW 2010). Local winter numbers are generally very low. Berndt et al. (2005) assume no significant trend in numbers of autumn resting Shoveler on Fehmarn, but suggest that exceptionally high numbers occur more frequently in recent years.

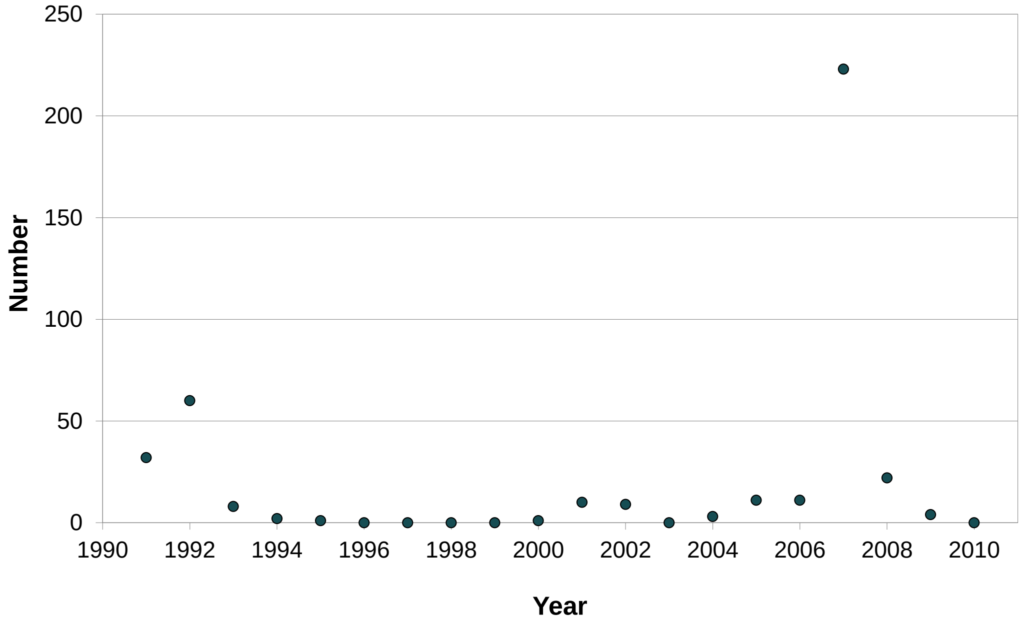


Figure 4.70 *Numbers of Shoveler recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.*

Importance of the Fehmarnbelt to Shoveler

Shoveler is present in the Fehmarnbelt area all year, but wintering numbers are usually very low. Highest numbers are typically observed during migration periods in spring and autumn, when birds are mostly recorded on inland freshwater habitats. In autumn internationally important numbers of Shoveler regularly occur on German side of the Fehmarnbelt, especially within the SPA Eastern Kiel Bight, where e.g. almost 1,000 Shoveler (2.5 % of the biogeographic population) were recorded on the inland lake Großer Binnensee in September 2009 (OAG 2010). Within coastal habitats of the Danish study area Shoveler is rarely recorded and numbers usually do not exceed 0.1 % of the biogeographic population (DOF 2010).

Shoveler – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	990 + 90
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	September/October
Areas of max. abundance in Fehmarnbelt:	inland areas of SPA Eastern Kiel Bight
Explanations:	Maximum abundance estimated from supplementary data for the SPAs Eastern Kiel Bight (990 birds, mostly inland) and Hyllekrog-Rødsand (90 birds). Distribution obtained from supplementary datasets.

4.1.19 Common Pochard – *Aythya ferina*

Common Pochard – *Aythya ferina*		
Biogeographic population: NE and NW Europe (non-br)		
Breeding range: Russia, NE and NW Europe		
Wintering / core non-breeding range: NE and NW Europe		
Population size: 350,000		
1 % value: 3,500		
Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: SPEC 2 EU Threat Status: (declining)	
Target species in SPAs:	Eastern Kiel Bight (DE1530-491)	
Key food: aquatic plants and invertebrates (mainly molluscs)		
Period of presence in Fehmarnbelt:		Wintering, migrations: September – April Breeding, moulting: May – August

Origin of Common Pochard in the Fehmarnbelt

According to the FEBI ring recovery analysis (Appendix IV) birds wintering in the Fehmarnbelt area originate from the Baltic countries, eastern Europe as well as eastern and central Russia. Some birds use the Fehmarnbelt region for stopping-over during migrations, and breeding birds of the area move west and southwest for wintering grounds in north-western Europe, Great Britain, France and the Iberian Peninsula.

Data sources on Common Pochard in the Fehmarnbelt

Numbers and distribution of Common Pochard are well reflected in the Danish and German land-based survey datasets. Therefore these datasets (AKVSW 2010, DOF 2010, OAG 2010) were used as primary data sources for the species baseline assessment. The FEBI ship-based surveys were not considered due to absence of sightings of this species. Danish mid-winter aerial surveys and FEBI aerial surveys (transect and search flights) were used as supporting information in the assessment (Table 4.37).

Table 4.37 List of datasets and their use in baseline assessment of Common Pochard in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI dedicated search flights	Supporting dataset for estimating species abundance and distribution in Orther Reede
FEBI ship transect surveys	Dataset not used due to no sightings of the species
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supplementary dataset for estimating species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Common Pochard in the Fehmarnbelt

The Common Pochard occurs in the study area all year round, but only low numbers are present during summer. Pochard numbers start to increase in September and along the Baltic Sea coast of Schleswig-Holstein the highest numbers are usually recorded in November (Berndt and Busche 1993). Pihl et al. (2006) describe a similar seasonal pattern for Common Pochard in Denmark with the highest numbers recorded between mid-September and November. Most birds leave the area in early winter (Berndt and Busche 1993). Seasonal patterns and wintering numbers of Common Pochard vary depending on winter severity (Berndt and Busche 1993, Berndt et al. 2005).

Common Pochard abundance estimates based on FEBI survey data

The Common Pochard was only rarely observed during the FEBI aerial transect surveys. In the two years of baseline investigations only one observation of 34 individuals was recorded in Orther Reede (southwest Fehmarn) in January 2009. Dedicated monthly search flights in Orther Reede between August 2009 and October 2010 also revealed only one sighting of 30 Common Pochard in April 2010.

Common Pochard abundance estimates based on supplementary datasets

Coastal counts in selected (consistently covered) survey sections along the German mainland coast indicate high numbers of Common Pochard between September and December (Figure 4.71; OAG 2010). However, the displayed phenology pattern is based on relatively few but consistently covered inland survey sections, where Common Pochard numbers peak earlier in winter. Survey results of all coastal sections indicate that the highest number of Common Pochard along the mainland coastline was in January 2009 (OAG 2010). Therefore this survey of 2009 was used for estimating winter abundance of Common Pochard in the German part of the study area.

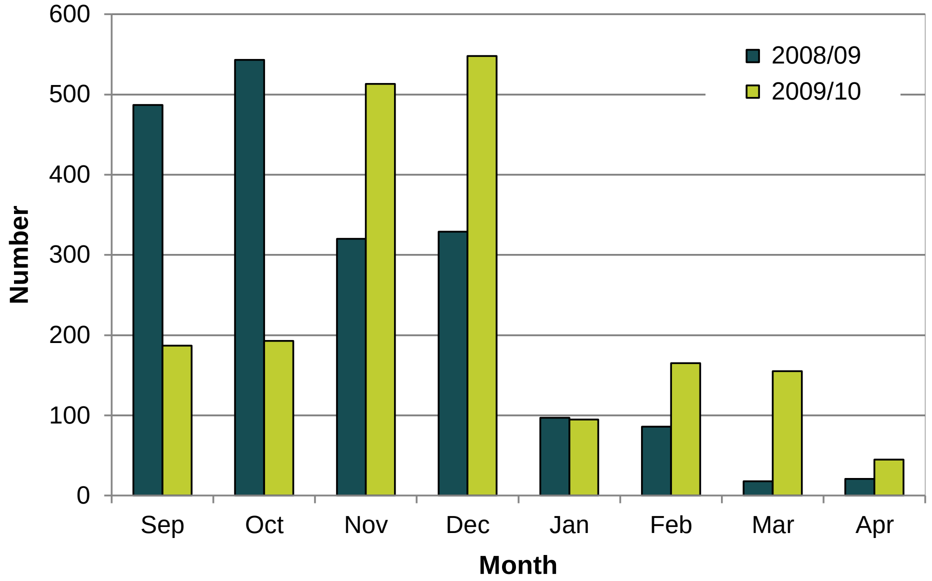


Figure 4.71 *Number of Common Pochard recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein. Note: this phenology chart is based on a limited number of consistently covered inland survey sections. The full coverage of coastal sections indicated the highest number of Common Pochard in January 2009.*

In total 1,723 Common Pochard were recorded along the German mainland and Fehmarn survey sections during the mid-winter count of 2009 (AKVSW 2010, OAG 2010). As the German mainland coastal areas east and southeast of Fehmarnsund Bridge were not fully covered during this survey, this number should be considered as a minimum estimate for this area.

The Danish mid-winter surveys revealed rather low numbers of Common Pochard. 131 birds were recorded in Rødsand Lagoon and coastal waters northwest of Rødbyhavn in 2004, and no Common Pochard were observed in the Danish part of the study area in 2008 (Petersen et al. 2006, 2010).

Records in the DOF database (DOF 2010) show occasionally higher numbers of Common Pochard occurring in the Danish study area in autumn and spring. Rødsand Lagoon regularly supports more than 100 Common Pochard with the highest count of 1,800 birds in March 2006 (DOF 2010). A maximum of 710 Common Pochard was reported in the alignment area at Rødbyhavn (on January 11, 2011, DOF 2011).

The Maribo Lakes in the centre of Lolland support much higher numbers of up to 9,480 Common Pochard (maximum count of October 2008; DOF 2010). Pochard are known to conduct short night-time foraging flights from freshwater (daytime) resting sites to marine (night-time) feeding grounds (Berndt and Busche 1993, see below). However, there is no information indicating that Common Pochard from Maribo Lakes regularly commute to the Fehmarnbelt for foraging.

Distribution and habitat use of Common Pochard in the Fehmarnbelt

In autumn and spring Common Pochard is described to mainly use inland freshwater habitats for daytime resting. Coastal areas are more frequently used in winter due to freezing over of inland habitats. In severe winter conditions the species most often leave the area (Sudfeldt et al. 2000).

Similar to other *Aythya* species in the region, Tufted Duck and Greater Scaup, the Common Pochard conducts night-time foraging flights to feeding grounds in the Baltic Sea (Berndt and Busche 1993, Berndt et al. 2005). Thus, displayed daytime (resting) distribution is expected to differ from night-time (foraging) distribution.

Common Pochard distribution according to FEBI survey data

The Common Pochard was recorded twice during the FEBI aerial transect surveys: 34 birds were observed in Orther Reede in January 2009, and 30 birds were observed in the same area in April 2010.

Common Pochard distribution according to supplementary datasets

During German mid-winter coastal survey 2009 Common Pochard aggregated in sheltered marine areas, such as Graswarder, Heiligenhafener Binnenwaser, Orther Reede, Burger Binnensee, Großenbroder Binnenwasser and the ferry harbour Puttgarden (Figure 4.72; AKVSW 2010, OAG 2010).

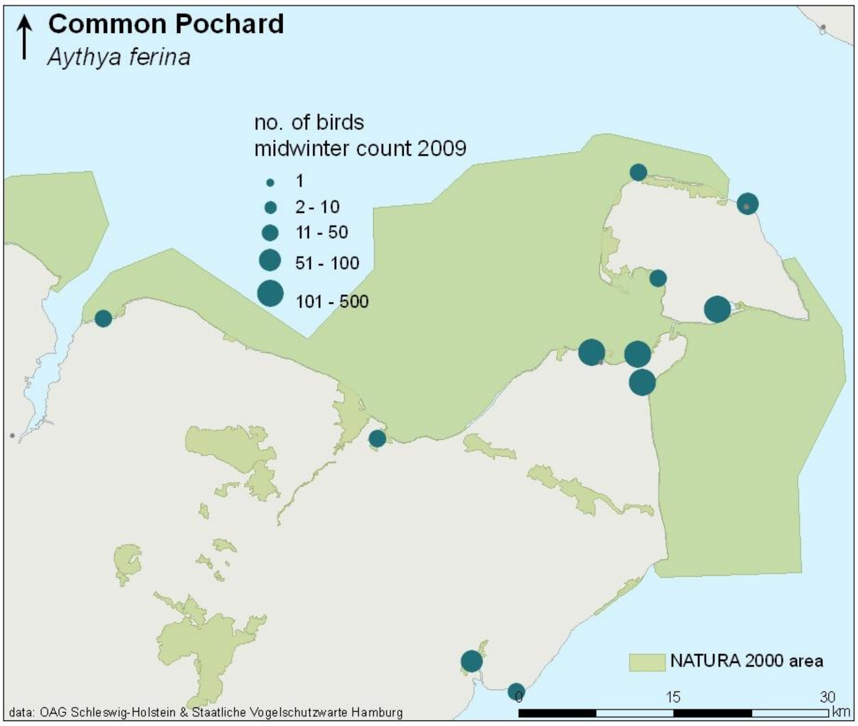


Figure 4.72 Distribution of Common Pochard during the winter coastal count in January 2009 between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt; data: OAG Schleswig-Holstein and AKVSW Hamburg.

The DOF database indicates high aggregations of Common Pochard occurring on inland water bodies such as Maribo Lakes (DOF 2010), but also sheltered marine habitats like Rødsand Lagoon support aggregations of the species (DOF 2010). Petersen et al. (2006) report the species also occurring in low numbers in other coastal areas of the Danish Fehmarnbelt.

Common Pochard abundance estimates for SPAs

The German mid-winter coastal count resulted in 988 Common Pochard recorded within the SPA Eastern Kiel Bight and 665 birds using sheltered bays of the SPA Baltic Sea east of Wagrien, equal to 0.3 % and 0.2 % of the biogeographic population, respectively. Kieckbusch (2010) suggests substantially higher numbers occurring in some survey sections of the SPA Eastern Kiel Bight (Großer and Kleiner Binnensee, Heiligenhafener Binnenwasser) in some years, but mean numbers presented by Kieckbusch (2010) fall within the range of the analysed mid-winter survey of 2009. The same holds for the SPA Baltic Sea east of Wagrien where higher numbers were recorded in some years (Kieckbusch 2010), but mid-winter count of 2009 represents a typical Common Pochard abundance in the area.

The SPA Hyllekrog-Rødsand regularly supports more than 100 Common Pochard in spring and autumn periods. A maximum count of 1,800 birds (0.5 % of the biogeographic population) was reported for this area in March 2006 (DOF 2010).

Common Pochard trends

Long-term data of Fehmarn mid-winter surveys show no significant trend in local numbers of wintering Common Pochard since 1991 (Figure 4.73). Sudfeldt et al. (2003) describe an increase in Common Pochard abundance in Germany between 1968 and 2000. In contrast, a moderate decline is assumed for the entire northeast and northwest European population of Common Pochard (Wetlands International 2006, Flade et al. 2008), thus the population was provisionally evaluated as Declining (BirdLife International 2004).

Figure 4.73 Numbers of Common Pochard recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Common Pochard

Common Pochard is a common species in the Fehmarnbelt area, which is more abundant during the non-breeding period between September and March. Analysed datasets and literature indicate that sheltered marine areas of the Fehmarnbelt are frequently used by this species. German coastal waters support approximately 1,750 Common Pochard counted in the area in January 2009 (AKVSW 2010, OAG 2010), which corresponds to 0.5% of the biogeographic population of the species. Aggregations were found in the two German SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien with main resting areas located along the mainland coast and in the south of Fehmarn Island. Long-term dataset analysed by Kieckbusch (2010) suggest that internationally important numbers of Common Pochard may occur in the German Fehmarnbelt area in some years.

No internationally important numbers of this species were recorded for the Danish part of the study area (DOF 2010). Aggregations were reported in the SPA Hyllekrog-Rødsand, where a maximum of 1,800 Common Pochard (equalling 0.5 % of the biogeographic population) were recorded, but usually numbers are much lower in this area (DOF 2010, Petersen et al. 2006, 2010). High numbers of up to 9,480 Common Pochard occur at Maribo Lakes (DOF 2010).

Common Pochard – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	1,720 + 1,800
Max. abundance estimate in the alignment area:	710 + 70
Period of max. abundance in Fehmarnbelt:	September – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.72
Explanations:	Maximum abundance estimated from German mid-winter survey (1,720 birds) and Danish land-based counts (1,800 birds). Maximum abundance in the alignment area estimated based on 710 indivdiuals reported for the Danish part of this area and 70 individuals reported for the German part of this area during land-based mid-winter counts. Distribution obtained from supplementary datasets.

4.1.20 Tufted Duck – Aythya fuligula

Tufted Duck – *Aythya fuligula*		
Biogeographic population: NW Europe (non-br)		
Breeding range: N and NW Europe		
Wintering / core non-breeding range: NW Europe		
Population size: 1,200,000		
1 % value: 12,000		
Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: SPEC 3 EU Threat Status: (declining)	
Target species in SPAs:	Hyllekrog-Rødsand (DK006X083) Eastern Kiel Bight (DE1530-491) Baltic Sea east of Wagrien (DE1633-491)	
Key food: mainly animal food, in winter mainly mussels		
Period of presence in Fehmarnbelt:		Wintering, migrations: September – April Breeding: May – August

Origin of Tufted Duck in the Fehmarnbelt

The FEBI ring recovery analysis shows this species being a partial migrant, with birds wintering as far south as the Iberian Peninsula as well as birds wintering in the Fehmarnbelt area (Appendix IV). There are indications that Tufted Ducks wintering in the Fehmarnbelt area originate from a large area including inland Sweden, Finland, and also Russia as far as east of the Ural Mountains (Fransson and Pettersson 2001, Bønløkke et al. 2006). This long-distance migration of Tufted Ducks wintering in the study area was also confirmed by a recovery of one bird, which was ringed and radio-tagged during FEBI telemetry investigations, and was eventually shot 3,000 km east-northeast of the Fehmarnbelt in Russia.

One of the Tufted Ducks equipped with satellite transmitters during the FEBI baseline investigations has successfully been tracked to the breeding grounds and back to the Baltic Sea. That individual (adult female) migrated to the southern coast of the White Sea in early May 2010, where it presumably was engaged in breeding as for the next two months the majority of the locations originated from an inland area 6-8 km from the coast (Figure 4.74). The transmissions became scarce since the end of June due to transmitter battery drain. The last locations were transmitted from the east coast of Sweden in December 2010, indicating that the bird returned to the Baltic Sea but stayed at a different wintering site compared to the previous winter (Figure 4.74).

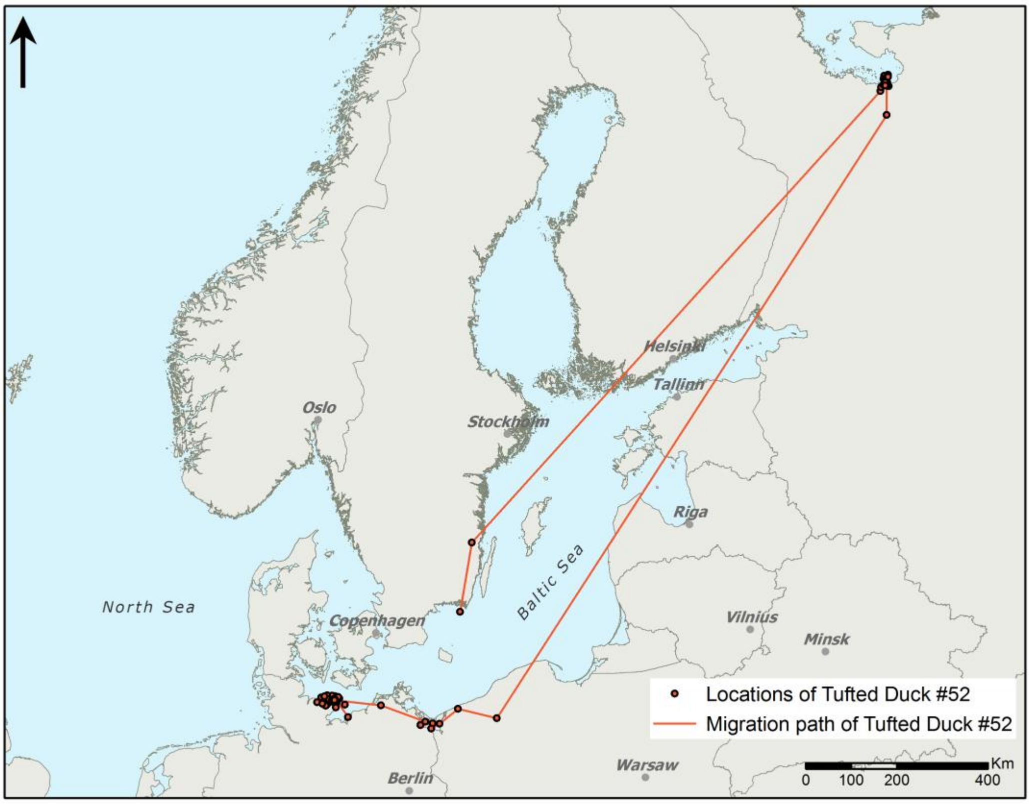


Figure 4.74 Migration path of the Tufted Duck equipped with satellite transmitter during the FEBI baseline investigations.

Data sources on Tufted Duck in the Fehmarnbelt

Table 4.38 provides an overview of available datasets and their use in the assessment of Tufted Duck in the Fehmarnbelt area. As FEBI aerial and ship-based surveys did not cover inland wetlands, where Tufted Ducks usually spent daylight hours, the assessment was mainly based on supplementary datasets, namely land-based counts in Germany (AKVSW 2010, OAG 2010) and Denmark (DOF 2010).

Table 4.38 List of datasets and their use in baseline assessment of Tufted Duck in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Dataset not used due to non-covered shallow water areas
FEBI radar observation	Supporting dataset indicating foraging movements of this species
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Tufted Duck in the Fehmarnbelt

Tufted Ducks are present in the study area all the year, but numbers are relatively low during summer represented by scarce locally breeding birds (Berndt et al. 2005). With beginning of September numbers start to increase and usually reach their maximum in mid-winter.

Tufted Duck abundance estimates based on FEBI survey data

Tufted Ducks were regularly recorded during FEBI aerial surveys in winter months, but numbers observed were rather low (Table 4.39). Due to a clustered distribution of the species and low numbers observed, no Distance analysis was possible for this species. Additionally, Tufted Duck daytime roosts are mainly located on inland freshwater habitats, which were not covered by aerial surveys. Therefore, data recorded during aerial surveys of marine waters were not representative of Tufted Duck abundance in the study area. It is known, however, that Tufted Ducks forage in the study area during the night-time.

Table 4.39 Results of monthly aerial surveys for Tufted Duck between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects; Coverage % is percentage of survey area covered in valid conditions.

Survey	Number of birds observed	Coverage %
Nov-08	51	80.9
Dec-08	0	81.7
Jan-09	154	82.8
Feb-09	199	100.0
Mar-09	96	77.5
Apr-09	0	86.8
May-09	0	77.3
Jun-09	0	80.9
Jul-09	0	86.6
Aug-09	0	92.3
Sep-09	0	79.1
Oct-09	104	79.9
Nov-09	273	82.4
Dec-09	0	24.7
Mar-10 A	34	64.1
Mar-10 B	0	75.6
Apr-10	59	100.0
May-10	0	92.1
Jun-10	1	70.8
Aug-10	0	75.6
Sep-10 A	0	44.9
Sep-10 B	4	48.9
Oct-10	0	80.0
Nov-10	0	70.1

Tufted Duck abundance estimates based on supplementary datasets

Tufted Duck numbers recorded within consistently covered land-based survey sections in Germany indicate that the species is relatively numerous during wintering period with the highest numbers recorded in January and February (Figure 4.75, OAG 2010). This abundance pattern agrees well with the phenology described in Berndt et al. (2005), who suggest the highest Tufted Duck numbers occurring in the Fehmarn area in late winter.

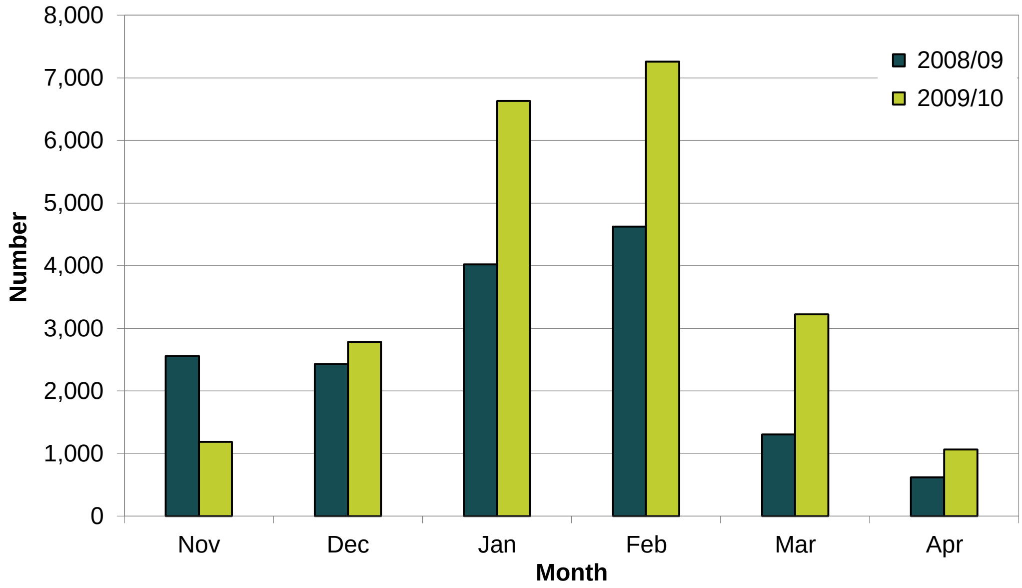


Figure 4.75 Numbers of Tufted Ducks recorded during land-based surveys between November and April in 2008/2009 and 2009/2010; only survey sections 1-2, 5-9, 12-13 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

As highest numbers of Tufted Ducks occur during winter months, land-based mid-winter counts qualify for assessing the importance of the study area to this species. During the mid-winter survey 2009, a total number of 13,918 Tufted Ducks was reported for the German part of the study area. The long-term dataset for the island of Fehmarn indicates that Tufted Duck numbers recorded in 2009 fall within the range of typical observations (Figure 4.79). However, it has to be considered that the eastern Fehmarnsund and the area east of Wagrien were not fully covered by these land-based counts, thus recorded numbers should be considered as minimum values, because some sites known to hold Tufted Ducks (e.g., south-eastern Fehmarnsund) were not covered by this survey. Thus, the German Fehmarnbelt area regularly meets the 1 % criterion of international importance (12,000 birds) to this species. Coastal waters of Fehmarn are known to support up to 60,000 Tufted Ducks during severe winter conditions, when species habitats freeze over farther north and east (in February 1986; Berndt et al. 2005).

Tufted Ducks conduct foraging flights between daytime resting sites on inland freshwater bodies and night-time foraging areas in marine waters (see below and chapter 5). Therefore, Tufted Ducks recorded on inland areas of Lolland are expected to at least partly use the Danish Fehmarnbelt area for foraging and are therefore discussed in the baseline assessment. Tufted Duck numbers reported for different Danish areas vary between surveys and winter seasons. NOVANA mid-winter survey 2008 reports the rather low number of 392 birds wintering in Rødsand Lagoon (Petersen et al. 2010). The DOF database indicates up to 17,500 Tufted Ducks occurring in the same area (maximum count on March 12, 2006; DOF

2010). Maribo Lakes in the centre of Lolland support up to 14,400 Tufted Ducks (in February 2007; DOF 2010), and the Guldborgsund (area between Lolland and Falster) is reported to support maximum 23,500 Tufted Ducks (on March 12, 2006; DOF 2010). These numbers indicate that the Danish Fehmarnbelt area is of international importance to Tufted Ducks with regularly 1-2 % of the biogeographic population wintering there. This agrees with a maximum estimate of 28,380 Tufted Ducks in the study area reported by Skov et al. (1998). A maximum of 7,100 Tufted Ducks was reported in the alignment area at Rødbyhavn (on December 20, 2002, DOF 2011).

Distribution and habitat use of Tufted Duck in the Fehmarnbelt

Tufted Ducks are known to spend their daytime roosting on freshwater ponds and lakes close to shore and forage in shallow coastal waters of the Baltic Sea during the night-time (Nilsson 1970, Kirchhoff 1979, Berndt and Busche 1993, Skov et al. 1998, Berndt et al. 2005). When freshwater habitats freeze in the course of the winter, Tufted Ducks spend all day in marine habitats, usually sheltered bays and fjords. In such instances the birds forage not only at night but also during the daylight hours (Berndt and Busche 1993, Berndt et al. 2005, results of FEBI telemetry study – see chapter 5). Because of the daytime-specific distribution pattern results of aerial and land-based surveys have to be discussed considering that night-time distribution of the species might be different.

Tufted Duck distribution according to FEBI survey data

The FEBI aerial transect surveys provide some information about Tufted Duck distribution in times when this species uses marine areas during the day (mainly during cold winter periods when inland waters were frozen). Exemplary distribution maps of this species in February and November/December 2009 (Figure 4.76, Figure 4.77; Appendix II) show that Tufted Ducks were confined to shallow waters and sheltered bays and lagoons, when resting in marine habitats. The Fehmarnsund with its sheltered bights and harbours, and the Rødsand Lagoon were main areas holding Tufted Duck aggregations in the study area.

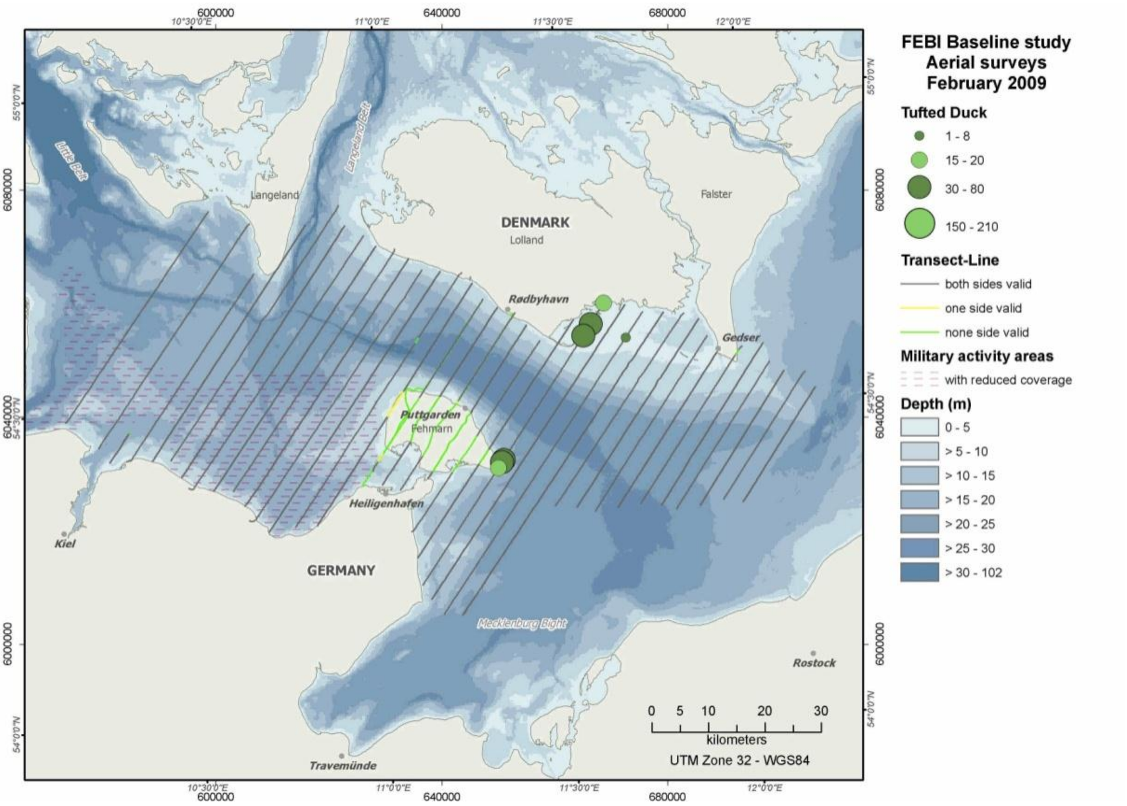


Figure 4.76 Example of the observed Tufted Duck distribution in the study area during aerial survey in February 2009.

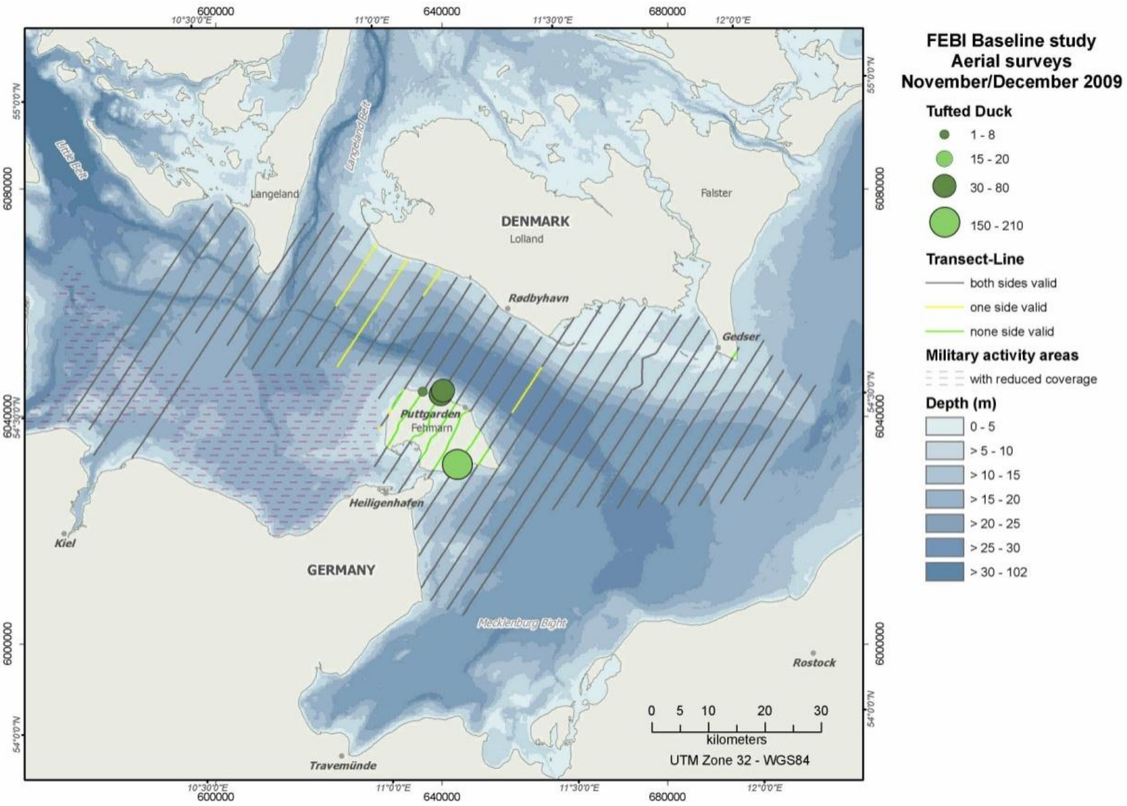


Figure 4.77 Example of the observed Tufted Duck distribution in the study area during aerial survey in November/December 2009.

Tufted Duck distribution according to supplementary datasets

The German land-based surveys focus on near-shore inland waters and coastal marine habitats and therefore represent well the Tufted Duck distribution during the daytime. These surveys suggest that Tufted Ducks were widely distributed along the Fehmarn and Kiel Bight coastlines with major duck concentrations in the Fehmarnsund area and in the west of SPA Eastern Kiel Bight (mid-winter survey 2009; Figure 4.78, AKVSW 2010, OAG 2010).

In the Danish part of the study area, besides small resting flocks in Rødsand Lagoon and nearby inshore waters (Figure 4.78; Petersen et al. 2010), Maribo Lakes in the centre of Lolland represent the prominent daytime resting sites for Tufted Ducks wintering in the area (Petersen et al. 2010).

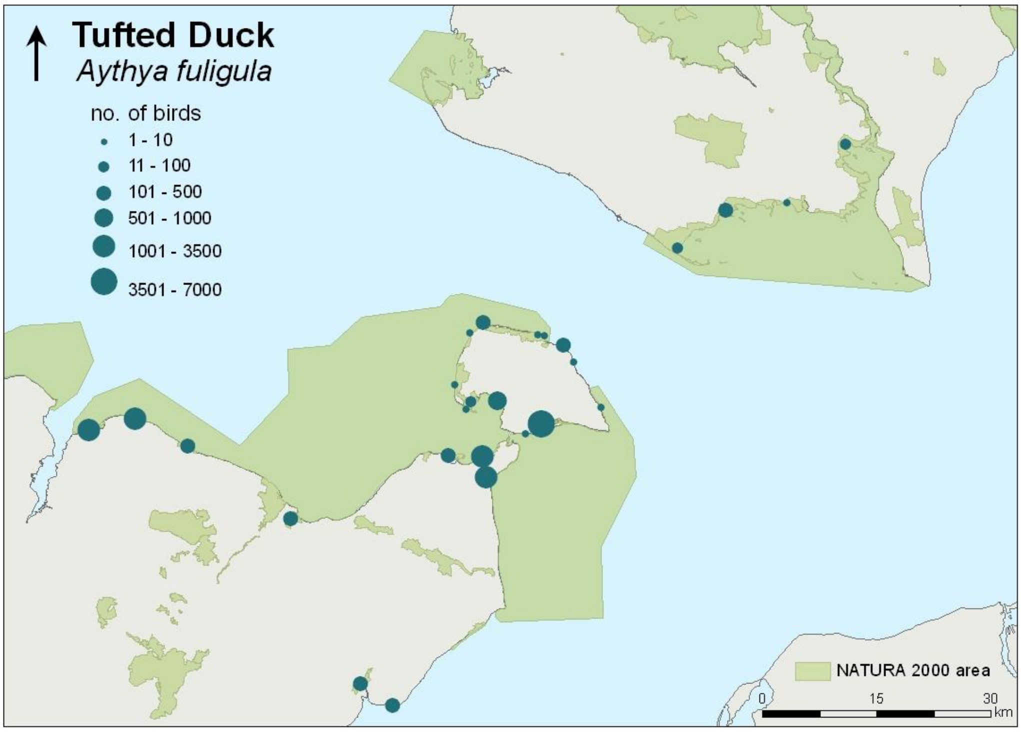


Figure 4.78 Distribution of Tufted Duck during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI; note: Maribo Lakes are not included in the displayed dataset.

Tufted Duck abundance estimates for SPAs

During the mid-winter coastal survey of 2009, 5,650 Tufted Ducks were recorded in the SPA Eastern Kiel Bight and 8,123 birds in the SPA Baltic Sea east of Wagrien (AKVSW 2010, OAG 2010). The actual number of birds in the SPA Baltic Sea east of Wagrien was probably higher, as only a part of the SPA area was covered by these surveys.

The mid-winter survey of 2008 in Denmark resulted in 8,875 Tufted Ducks recorded in the SPA Maribo Lakes and 392 birds in the SPA Hyllekrog-Rødsand (Petersen et al. 2010). The DOF database reports the following maximum values recorded for the SPAs in the vicinity of the Fehmarnbelt since the year 2000: 17,500 birds in Hyllekrog-Rødsand (March 2006); 14,400 birds in Maribo Lakes (February 2007); 8,000 birds in Nakskov Fjord and Inderfjord (February 2006); and 23,500 birds in the SPA Guldborgsund (March 2006; DOF 2010).

Tufted Duck trends

The general population trend of the northwest European Tufted Duck population is described as moderately decreasing after reaching a peak in 1993 (Wetlands International 2006). Due to this decline taking place mainly in north-eastern European countries (Finland and Russia) the status of this species was provisionally changed from Secure to Declining (BirdLife International 2004). Long-term land-based waterbird counts on the island of Fehmarn (AKVSW 2010) display no significant trend in wintering Tufted Duck numbers in the waters around the island (Figure 4.79). Winter numbers of this species are known to vary with weather conditions with especially high numbers of Tufted Ducks wintering in the area during cold winters (Berndt et al. 2005). This may explain the high variability in bird numbers observed around Fehmarn (Figure 4.79).

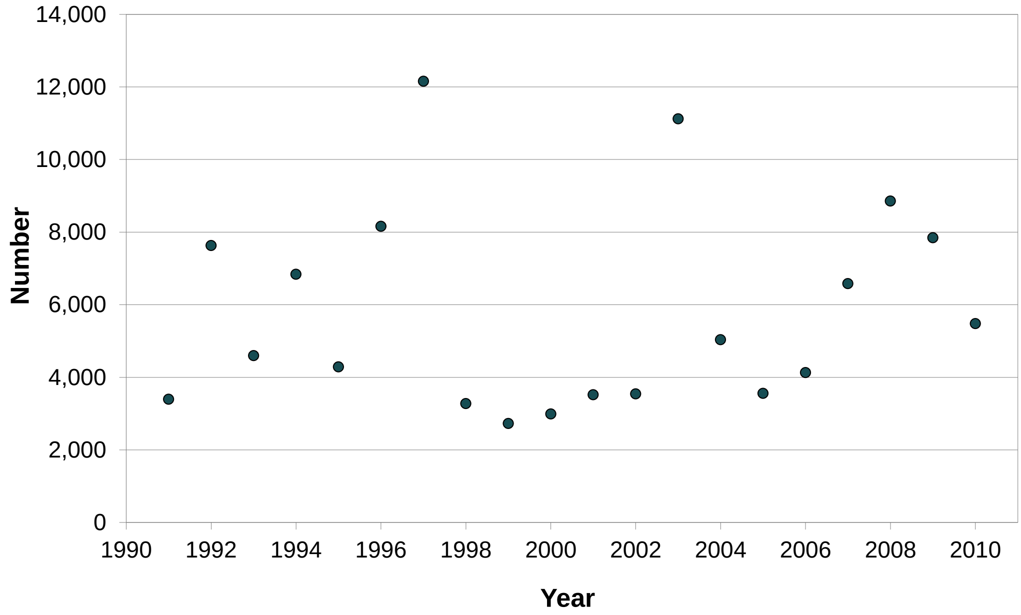


Figure 4.79 Numbers of Tufted Ducks recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Tufted Duck

The shallow coastal waters of the Baltic Sea and adjacent inland lakes in the Fehmarnbelt area represent an internationally important wintering area for Tufted Ducks. Depending on winter conditions up to several 10,000s of individuals can be present in the Fehmarnbelt area. More than 20,000 Tufted Ducks have been reported for the SPA Maribo Lakes (Jørgensen 1990), and at least some of these birds are expected to use Fehmarnbelt for night foraging (Skov et al. 1998, see also chapter 5). Internationally important numbers were also reported for the SPA Hyllekrog-Rødsand (17,500 birds; equals 1.5 % of the biogeographic population) and the SPA Guldborgsund (22,500 birds; equals 1.9 % of the biogeographic population), indicating that 1-2 % of the biogeographic population regularly uses the Danish part of Fehmarnbelt in winter.

Internationally important numbers of 14,000 Tufted Ducks (1.2 % of the biogeographic population; minimum estimate due to incomplete coverage of coastal areas by this survey) also occur in German coastal areas of the Fehmarnbelt (mid-winter survey 2009; AKVSW 2010, OAG 2010), with especially high aggregations being observed in the Fehmarnsund area (Berndt et al. 2005).

Tufted Duck – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	17,500 + 14,000
Max. abundance estimate in the alignment area:	7,100 +153
Period of max. abundance in Fehmarnbelt:	November – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.78 and Rødsand Lagoon, Maribo Lakes
Explanations:	Maximum abundance estimated from German mid-winter survey (14,000 birds) and supplementary dataset representing Danish land-based counts (17,500 birds, Rødsand Lagoon, Maribo Lakes). Maximum abundance in the alignment area was obtained from supplementary datasets with 7,100 individuals reported for the Danish part and 153 individuals reported for the German part of this area during land-based mid-winter survey. Distribution obtained from supplementary datasets.

4.1.21 Greater Scaup – *Aythya marila*

Greater Scaup – *Aythya marila*

Biogeographic population: *A. m. marila*, W Europe (non-br)

Breeding range: W Siberia and N Europe

Wintering / core non-breeding range: W Europe

Population size: 310,000

1 % value: 3,100

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: SPEC 3W
EU Threat Status: endangered

Target species in SPAs: Eastern Kiel Bight (DE1530-491)
Baltic Sea east of Wagrien (DE1633-491)

Key food: molluscs, crustaceans

Period of presence in Fehmarnbelt: Wintering, migrations: September – April

Origin of Greater Scaup in the Fehmarnbelt

The Greater Scaup occurs in the Fehmarnbelt region mainly during winter time. Birds utilising the area originate from breeding areas in Russia, partly from areas as far as east of the Ural Mountains. This pattern found during FEBI ring recovery study (Appendix IV) is in agreement with the Danish and Swedish ringing atlases (Fransson and Pettersson 2001; Bønløkke et al. 2006).

Data sources on Greater Scaup in the Fehmarnbelt

Species abundance and distribution was best reflected by the land-based survey datasets, therefore the assessment was primarily based on the land-based counts along the German and Danish coasts (AKVSW and OAG for German sections and DOF for Danish areas). FEBI aerial and ship-based survey results as well as NOVANA aerial surveys were used as supporting information for describing abundance and distribution of the Greater Scaup in the Fehmarnbelt (Table 4.40).

Table 4.40 List of datasets and their use in baseline assessment of Greater Scaup in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Supporting dataset for estimating species abundance and distribution
OAG land-based counts	Primary dataset representing species winter abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Greater Scaup in the Fehmarnbelt

The Greater Scaup is a regularly wintering species in the Fehmarnbelt area. The core wintering areas of Greater Scaup in the German Baltic Sea are located further east (Greifswalder Bodden, west of Rügen, Wismar Bay and Lower Trave), but high numbers have also been recorded in the Fehmarnbelt, Kiel Fjord and Eckernförde Bight (Mendel et al. 2008).

Greater Scaup abundance estimates based on FEBI survey data

The Greater Scaup was recorded only three times during the monthly FEBI aerial surveys between November 2008 and November 2010. In January 2009 one flock of 300 ducks was observed close to the Kiel Fjord, 8 individuals were counted off the coast of Wagrien in October 2009, and another 16 individuals southeast of Langeland in February 2010.

During ship-based surveys only one Greater Scaup was recorded in winter of 2008/2009 (Table 4.41). Higher numbers have been observed in winter 2010 with more than 100 birds being observed close to the ferry terminal in Puttgarden in January and February 2010, and 75 birds in Hohwacht Bay in March 2010 (Table 4.41). Higher observations could be related to the severe conditions of winter 2009/2010.

Table 4.41 Results of monthly ship-based surveys for Greater Scaup between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects.

Survey	Number of birds observed	Survey	Number of birds observed
Nov-08	0	Nov-09	0
Dec-08	0	Dec-09	0
Jan-09	0	Jan-10	101
Feb-09	0	Feb-10 A	157
Mar-09	1	Feb-10 B	150
Apr-09	0	Mar-10	75
Jun-09	0	Apr-10	0
Jul-09 A	0	May-10	0
Jul-09 B	0	Jun-10	0
Aug-09	0	Sep-10	2
Sep-09	0	Oct-10	0
Oct-09	0	Nov-10	4

Greater Scaup abundance estimates based on supplementary datasets

According to Berndt et al. (2005) the Greater Scaup occurs in highest numbers in the Fehmarn area in late winter. This seasonal pattern is also reflected in the dataset of monthly surveys along the German mainland coast (Figure 4.80; OAG 2010). Observed high variation in Greater Scaup numbers between different winters can be explained by high mobility of the species and distribution dependence on winter severity (Berndt and Busche 1993, Berndt et al. 2005).

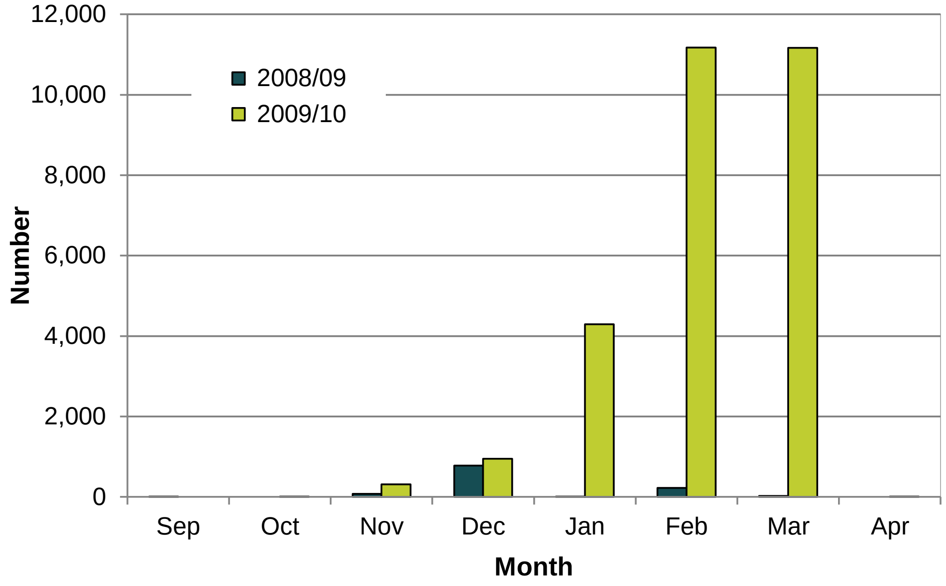


Figure 4.80 Numbers of Greater Scaup recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

The mid-winter coastal survey in January 2009 resulted in a total number of 880 Greater Scaup wintering along the German coastline of the study area (AKVSW 2010, OAG 2010). Monthly land-based counts along the German mainland coast of Schleswig-Holstein showed much higher numbers occurring in the study area in the cold winter 2009/2010 (Figure 4.80; OAG 2010). More than 11,000 Greater Scaup were counted in February and March 2010. Also, between 10,000 and 12,000 individuals were counted in January 2011 (Wilfried Knief pers. comm.).

The main wintering areas of the Greater Scaup in Denmark are located outside of the Fehmarnbelt area (Petersen et al. 2006, 2010). Mid-winter surveys in 2004 and 2008 revealed fewer than 100 Greater Scaup wintering in the Danish part of the study area (Petersen et al. 2006, 2010). Other sources indicate no major numbers occurring in the Danish Fehmarnbelt area as well. The highest numbers of Greater Scaup were reported in Rødsand Lagoon with a maximum of 450 birds recorded on January 6, 2007 (DOF 2010).

Distribution and habitat use of Greater Scaup in the Fehmarnbelt

The Greater Scaup is less confined to inland waters for daytime roosting as compared to the Tufted Duck, but has a similar foraging ecology (Berndt and Busche 1993, Mendel et al. 2008). The Greater Scaup spend their daytime mostly resting and sleeping in sheltered areas close to shore and forage mainly during the night in open waters of the Baltic Sea (Leipe 1986, Berndt and Busche 1993). According to Kirchhoff (1979) Greater Scaup are able to dive for food (mostly small-sized bivalves) to greater depths than Tufted Ducks, but are usually found closer to shore than seaducks such as eiders, scoters or Long-tailed Ducks.

Greater Scaup distribution according to FEBI survey data

The FEBI aerial survey transects often did not cover the complete shoreline of the study area because of restricted access to large parts of the Kiel Bight due to military activities. The sighting of one flock of Greater Scaup close to Kiel Fjord in January 2009 (Figure 4.81) coincides with literature information reporting this area as one of the major resting sites of the species within the Fehmarnbelt (Mendel et al. 2008, OAG 2010).

In winter 2010 ship-based surveys recorded Greater Scaup aggregations at the north coast of Fehmarn (Figure 4.82; more than 100 birds close to ferry harbour Puttgarden in January and February 2010) and Hohwacht Bay (75 birds in March 2010).

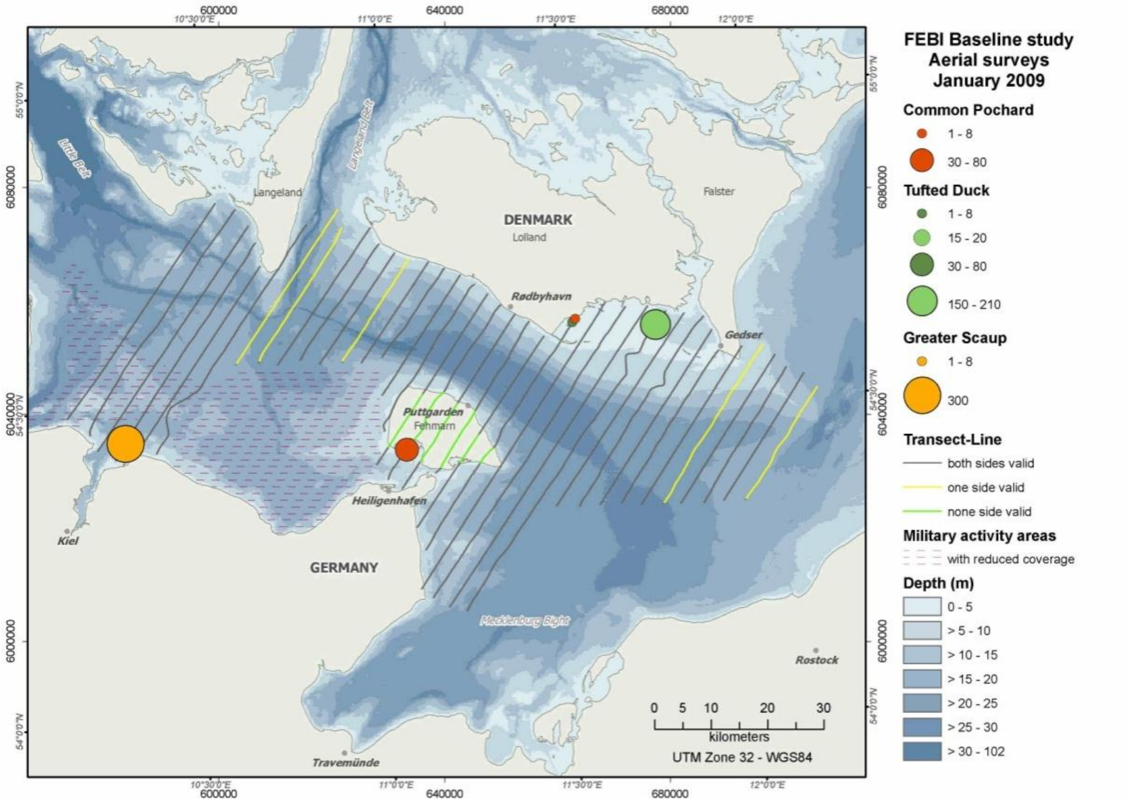


Figure 4.81 Example of the observed duck distribution of the genus Aythya *(Greater Scaup, Tufted Duck and Common Pochard) in the study area during aerial surveys (January 2009).*

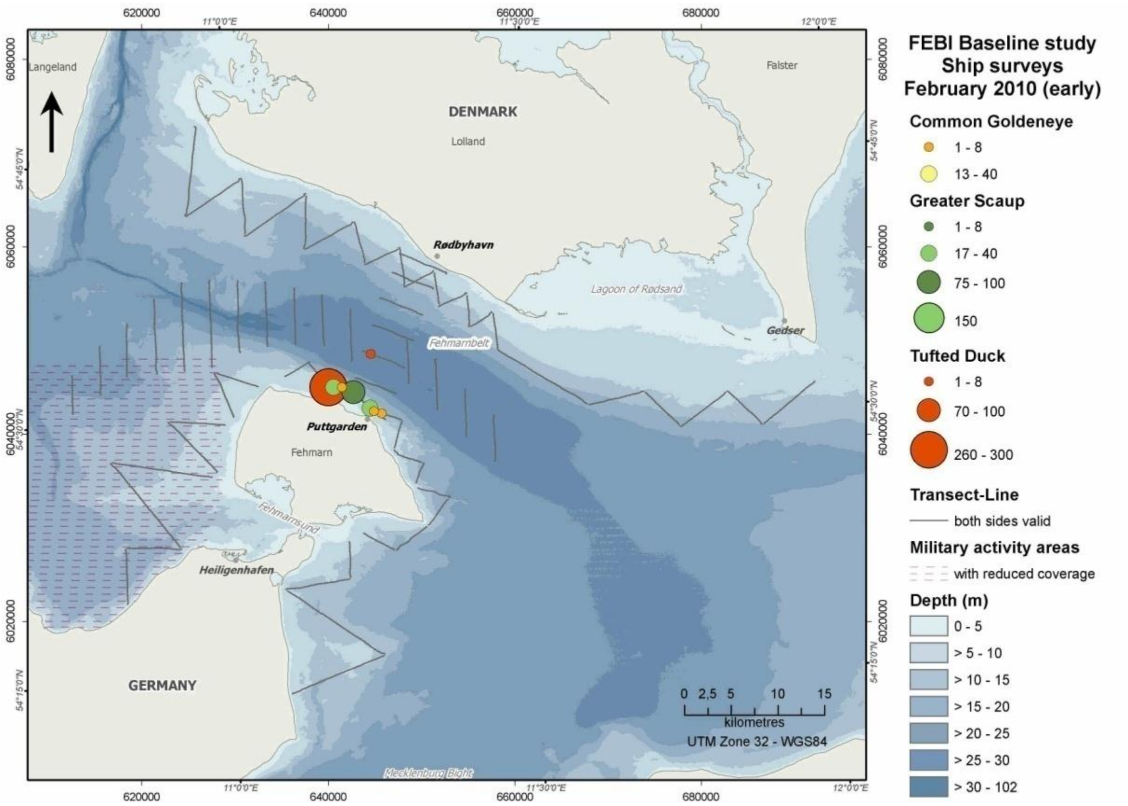


Figure 4.82 Example of the observed Greater Scaup distribution (and Tufted Duck and Goldeneye) in the study area during ship-based survey February 2010.

Greater Scaup distribution according to supplementary datasets

The mid-winter coastal count in Germany in January 2009 showed Greater Scaup being concentrated in a few areas along the surveyed coastline (Figure 4.83, AKVSW 2010, OAG 2010). The highest number was recorded in survey section Laboe-Bottsand close to Kiel Fjord (603 birds). Sheltered areas of Puttgarden harbour and Burger Binnensee (southeast Fehmarn) supported more than 100 Greater Scaup each (Figure 4.83).

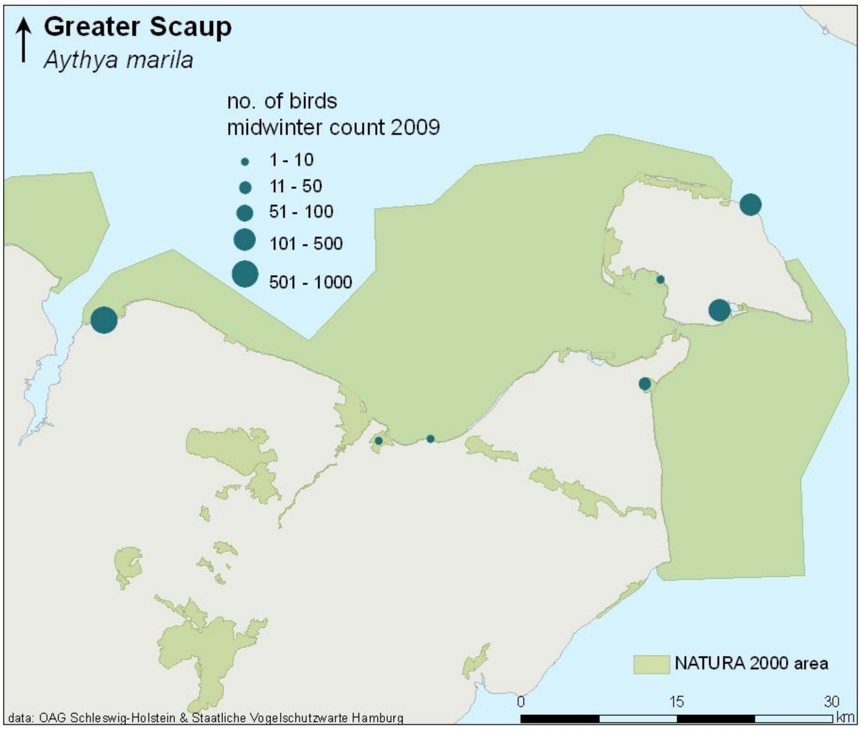


Figure 4.83 Distribution of Greater Scaup during winter coastal count in January 2009 between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt; data: OAG Schleswig-Holstein and AKVSW Hamburg.

The monthly coastal counts by OAG Schleswig-Holstein confirm high concentrations of the species occurring along the Kiel Bight mainland coast with more than 11,000 birds (OAG 2010).

Greater Scaup abundance estimates for SPAs

During the land-based mid-winter count in 2009 there were 622 Greater Scaup recorded in the SPA Eastern Kiel Bight and 128 in the SPA Baltic Sea east of Wagrien. Because of incomplete coverage of the SPA Baltic Sea east of Wagrien, these estimates should be considered as minimum values. OAG monthly surveys along the German mainland coast indicated much higher numbers occurring in the SPA Eastern Kiel Bight in some years (e.g. 11,474 birds in March 2010, OAG 2010; between 10,000 and 12,000 in January 2011, Wilfried Knief pers. comm.), equal to 3.2–3.9% of the biogeographic population. Data presented in Kieckbusch (2010) also indicate internationally important numbers occurring in the SPA Baltic Sea east of Wagrien in some years.

Numbers of Greater Scaup recorded on the Danish side of the Fehmarnbelt were lower than those on the German side. The SPA Hyllekrog-Rødsand supports the highest numbers of Greater Scaup within the Danish part of the Fehmarnbelt with a maximum of 450 birds reported in January 2007 (DOF 2010).

Greater Scaup trends

The European wintering population of Greater Scaup was stable with more than 120,000 birds recorded between 1970 and 1990. Since then bird numbers declined substantially in the north-western Europe, with a likely overall decline exceeding 50% (BirdLife International 2004). Although Skov et al. (2011) describe a northward shift of the Baltic wintering population, these authors also agree with a general decline of Greater Scaup in the Baltic and especially for the German coast. Due to this substantial decline since the 1990s, the 15-year old population estimate of 310,000 birds presented by Wetlands International (2006) is likely an overestimate (Mendel et al. 2008). Considering the substantial declines of the European population during the last 15 years, the threat status of Greater Scaup was changed from Localised to Endangered (BirdLife International 2004).

No significant trend could be detected in numbers of recorded Greater Scaup during mid-winter counts in coastal waters off the island of Fehmarn between 1990 and 2010 (Figure 4.84). Numbers of locally wintering birds fluctuated between years, which has probably been influenced by winter severity. High numbers of the species in the Fehmarn area were described to occur in cold winters (Berndt and Busche 1993, Berndt et al. 2005).

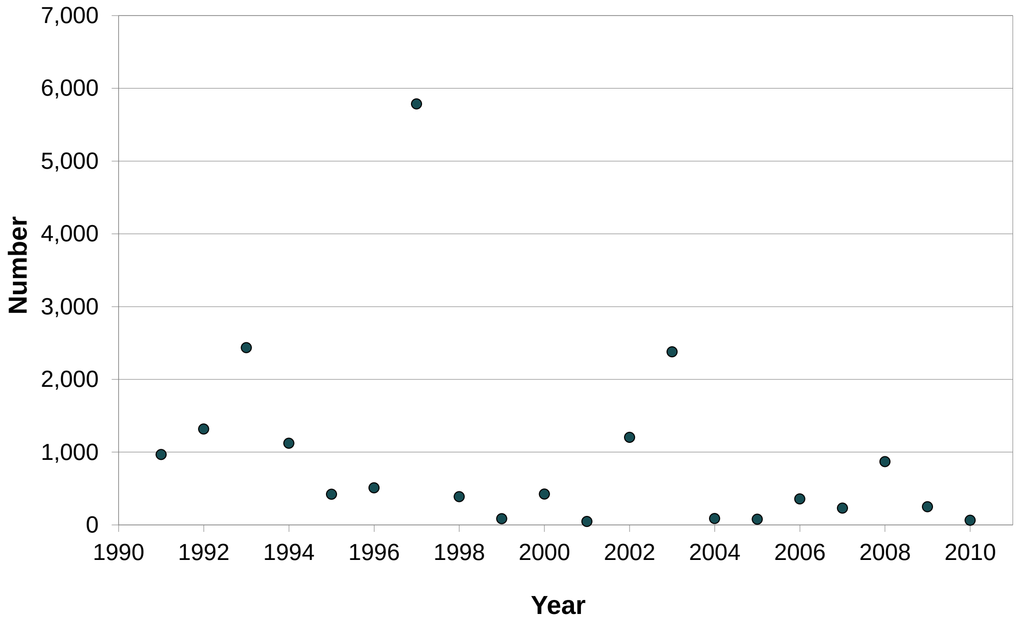


Figure 4.84 Number of Greater Scaup recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Greater Scaup

The numbers of wintering Greater Scaup in the study area are highly variable among years. For the Baltic Sea coast of Schleswig-Holstein numbers are described to vary between 50,000 birds in severe winter conditions to comparably low numbers in mild winters (Berndt and Busche 1993). High variability in winter number was also observed in the analysed datasets of 2009-2011. Whereas 1,716 birds counted along the mainland coast of Kiel Bight were comparably low in winter 2009, more than 10,000 Greater Scaup were recorded in the same area in winters 2010 (OAG 2010) and 2011 (Wilfried Knief pers. comm.). These records show that more than 3% of the biogeographic population of Greater Scaup regularly occur in the SPA Eastern Kiel Bight, indicating this area being of international importance to this species. In some years internationally important numbers are also expected to occur in the SPA Baltic Sea east of Wagrien, especially in the Fehmarnsund area (Kiekbusch 2010).

There is no indication of internationally important concentrations of Greater Scaup wintering in the Danish part of the Fehmarnbelt (< 0.1% of the biogeographic population).

Greater Scaup – summary of information for EIA		
Max. abundance estimate in Fehmarnbelt:		12,000 + 450
Max. abundance estimate in the alignment area:		< 310 expected
Period of max. abundance in Fehmarnbelt:		December – March
Areas of max. abundance in Fehmarnbelt:		SPA Eastern Kiel Bight and see Figure 4.83
Explanations:	Maximum abundance estimated from supplementary data for the SPAs Eastern Kiel Bight (12,000 birds) and Hyllekrog-Rødsand (450 birds). Maximum abundance in the alignment area estimated based on 130 individuals reported for the German part of this area during the land-based mid-winter survey of 2009. The night-time (foraging) numbers in the alignment area are not known, but expected to be higher than daytime numbers. Distribution obtained from supplementary datasets.	

4.1.22 Common Eider – *Somateria mollissima*

Common Eider – *Somateria mollissima*

Biogeographic population: *S. m. mollissima*, Baltic, Wadden Sea

Breeding range: Baltic and Wadden Sea

Wintering / core non-breeding range: Western Baltic, Kattegat, Wadden Sea

Population size: 760,000

1 % value: 7,600

Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC^{E} EU Threat Status: secure
Target species in SPAs:	Eastern Kiel Bight (DE1530-491) Baltic Sea east of Wagrien (DE1633-491)

Key food: molluscs, crustaceans

Period of presence in Fehmarnbelt:	Wintering, migrations: September – April Breeding, moulting: May – August

Origin of Common Eiders in the Fehmarnbelt

Common Eiders utilising the Fehmarnbelt area during the non-breeding season mostly consist of breeding birds from the Baltic Sea with the highest concentration in south-western Finland and around the Åland Islands (Appendix IV). Birds ringed in the Wadden Sea during summer are likewise found in the Fehmarnbelt during the winter. These birds spend the summer and early autumn in the Wadden Sea to moult after which they partly move into the southern Baltic and inner Danish waters including the Fehmarnbelt. This pattern is confirmed by Bønløkke et al. (2006) and Fransson and Pettersson (2001).

The FEBI satellite telemetry study confirms the origin of birds and the general patterns identified from ring recoveries: 17 of 19 successfully tracked Common Eider migrated to the northern Baltic to breed (Figure 4.85) and 2 individuals presumably represented the locally breeding population and spent the nesting period on islands and shallow waters around Lolland (Figure 4.86). Furthermore, 8 individuals (7 males and 1 female) conducted moult migration to the Wadden Sea, where they spent summer and early autumn before returning to the southern Baltic (Figure 4.87). None of the two birds which stayed in the greater Fehmarnbelt area conducted moult migration to the Wadden Sea.

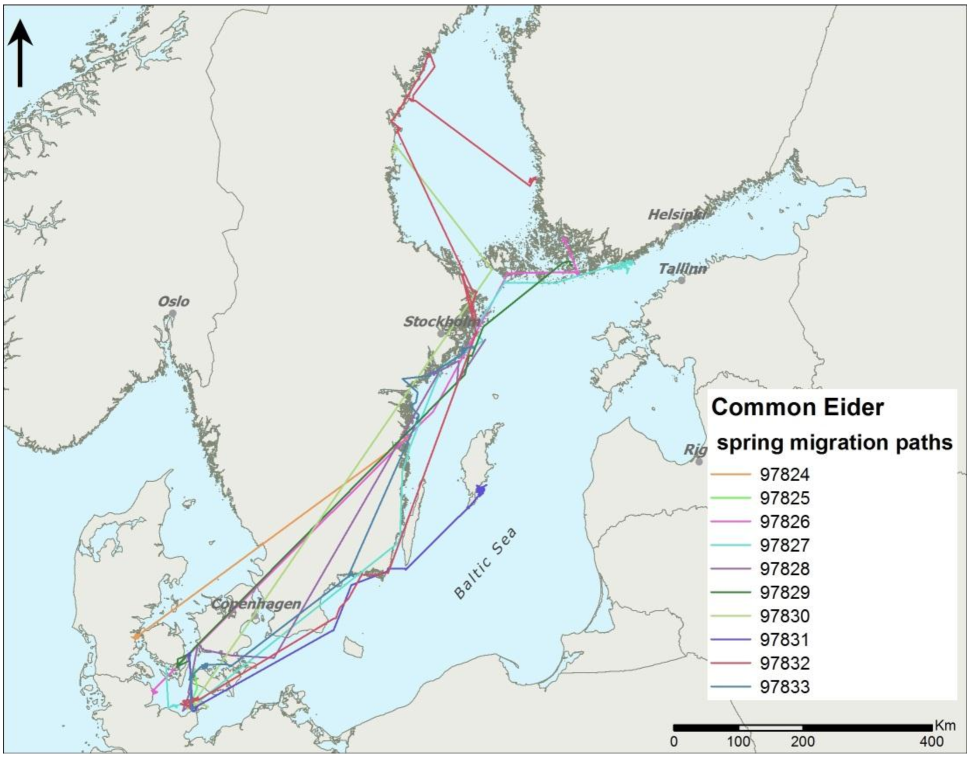


Figure 4.85 *Tracks of 10 Common Eider equipped with satellite transmitters during spring migration to the breeding areas in the northern Baltic region. Representation of bird tracks was restricted to March-May 2010. Trajectories do not necessarily indicate actual flight paths, but connect recorded bird positions.*

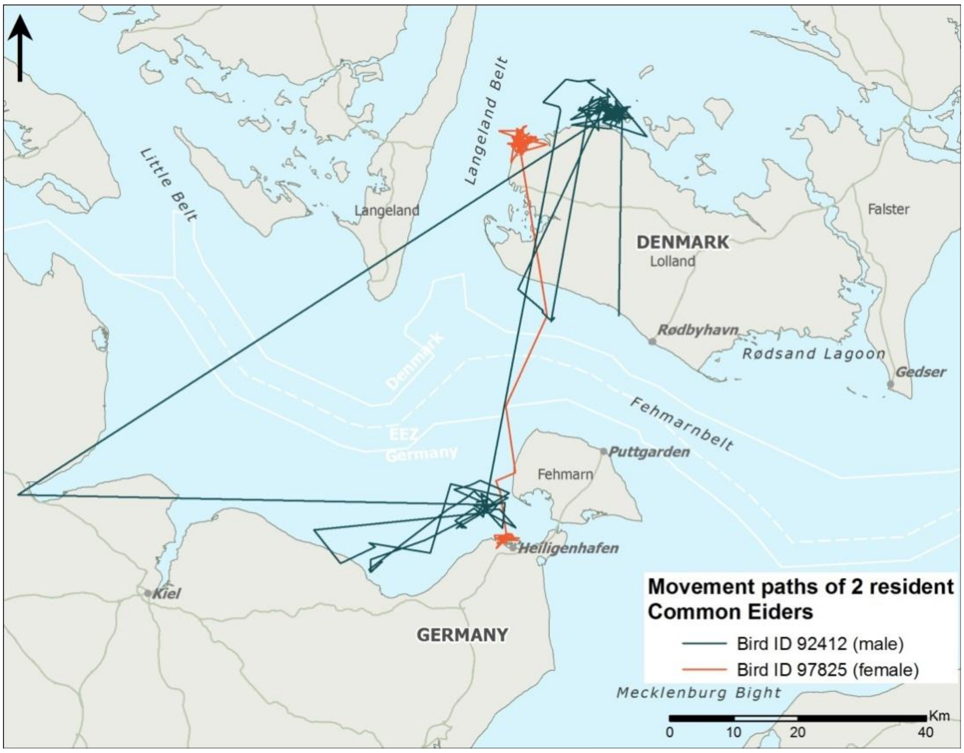


Figure 4.86 *Tracks of 2 Common Eiders equipped with satellite transmitters, resident in Fehmarnbelt. Bird ID 92412 was tracked between March 2009 – March 2010, and bird ID 97825 was tracked between October 2009 – December 2010. Trajectories do not necessarily indicate actual flight paths, but connect recorded bird positions.*

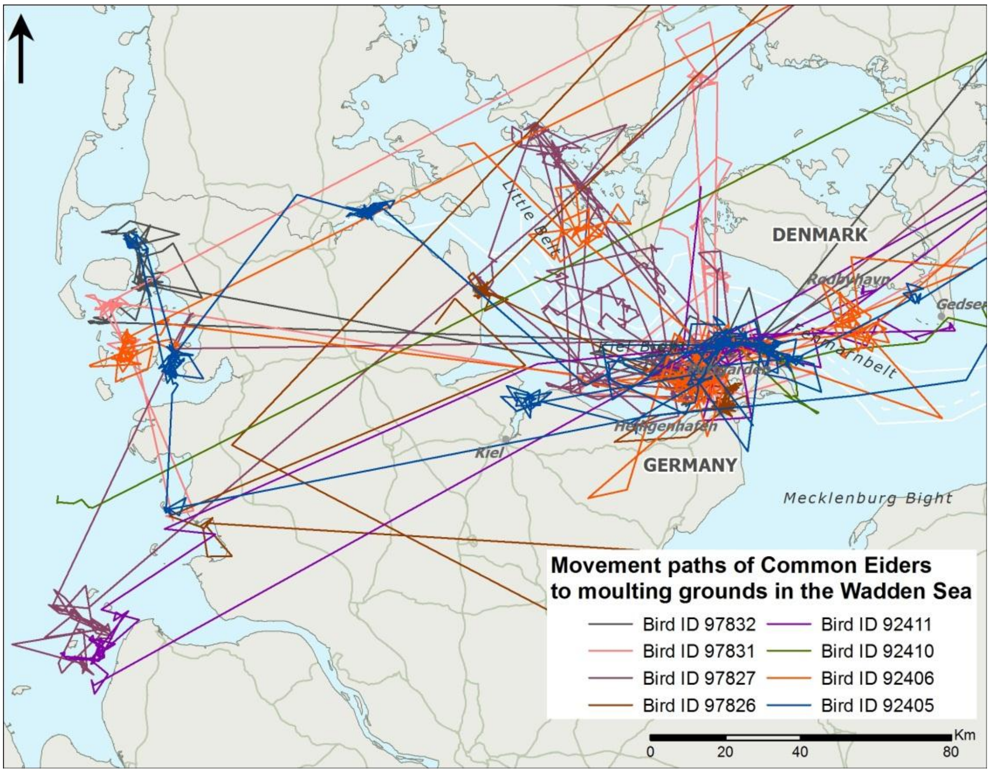


Figure 4.87 Tracks of 8 Common Eiders equipped with satellite transmitters, which migrated to the Wadden Sea for moulting in summer and early autumn of 2009 and 2010. Trajectories do not necessarily indicate actual flight paths, but connect recorded bird positions.

Data sources on Common Eider in the Fehmarnbelt

Numbers and distribution of Common Eiders are well reflected in both FEBI aerial and ship-based survey data. Aerial surveys had broader spatial coverage of the study region and ship-based surveys possibly had higher detectability of the species due to slower speed of survey vessel. Therefore, both survey platforms were considered equally when assessing abundance and distribution of the Common Eider (Table 4.42).

Table 4.42 List of datasets and their use in baseline assessment of Common Eider in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating Common Eider densities, abundance and habitat use
FEBI ship transect surveys	Primary dataset for estimating Common Eider densities, abundance, habitat use and seasonal variation
FEBI satellite telemetry	Supporting dataset in assessing habitat use, and site fidelity
FEBI GPS telemetry	Supporting dataset in assessing habitat use
AKVSW land-based counts	Supporting dataset representing species distribution along the Fehmarn coast
OAG land-based counts	Supporting dataset representing species distribution along the German mainland coast
NOVANA aerial surveys	Supporting dataset for densities and distribution of the species in Danish part of the Fehmarnbelt

Abundance of Common Eider in the Fehmarnbelt

Common Eider abundance estimates based on Distance analysis

The abundance of Common Eider in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Common Eider during aerial surveys, calculated using the entire dataset, were 218 m for swimming birds and 236 m for flying birds. Estimated detection functions and ESWs fall within the same range as found by other authors for seaducks using aerial surveys. ESW varied between 182-287 m for Common Scoters in the Camarthen Bay (Burt et al. 2010). Curves representing detection functions also indicated similar detectability of Common Scoters in the North Sea (Figure 1 in Petersen 2007). Although similar, these detection functions are not directly comparable to ESWs obtained for FEBI aerial surveys due to different width of transects. No information on detection functions specific to Common Eiders counted during aerial surveys was found in the published literature.

The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of eiders have only been estimated for the area that has been actually surveyed, and restricted military areas comprise large parts of an important eider wintering area (Hohwacht Bay), different coverage of separate surveys contributed to a substantial variation in estimated bird numbers. Therefore, most of the total numbers per survey obtained applying Distance analysis are likely underestimates (Table 4.43).

The estimated numbers and densities of Common Eiders for March-April and September-October indicate the transition period between winter and summer seasons, when birds leave and arrive to the Fehmarnbelt. From May to August the total estimates of Common Eiders were low with fewer than 10,000 birds estimated as being present in the study area (Table 4.43). The highest estimate of 256,000 birds was obtained for the complete survey conducted in February 2009. Also more than 244,000 Common Eiders were estimated for incomplete survey of late March 2010 (Table 4.43).

Table 4.43 Numbers of observed Common Eiders during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	672	62,982	51.83	21.05	127.86	204,423
Dec-08	81.7	1,248	35,217	40.24	19.26	84.12	160,252
Jan-09	82.8	1,218	22,476	33.62	21.42	52.86	135,717
Feb-09	100	1,723	39,866	52.54	34.70	79.59	256,154
Mar-09	77.5	1,463	28,200	43.08	28.43	65.36	162,744
Apr-09	86.8	221	2,034	2.45	1.36	4.45	10,379
May-09	77.3	165	1,507	2.32	1.28	4.24	8,758
Jun-09	80.9	138	1,410	1.67	0.87	3.42	6,603

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Jul-09	86.6	94	1,180	1.53	0.89	2.99	6,449
Aug-09	92.3	86	511	0.78	0.51	1.19	3,490
Sep-09	79.1	160	1,335	1.85	0.97	3.75	7,121
Oct-09	79.9	655	15,917	22.26	7.34	68.52	86,696
Nov-09	82.4	1,203	30,066	35.13	21.10	58.49	141,126
Dec-09	24.7	774	18,743	84.65	40.67	176.81	101,933
Mar-10 A	64.1	1,313	27,310	45.50	27.85	74.40	142,188
Mar-10 B	75.6	1,471	40,537	66.39	42.34	104.10	244,686
Apr-10	100	879	11,618	13.81	7.62	25.07	67,348
May-10	92.1	121	1,051	1.37	0.66	2.97	6,146
Jun-10	70.8	157	1,481	2.32	1.16	4.73	8,002
Aug-10	75.6	32	537	0.95	0.33	2.72	3,484
Sep-10 A	44.9	52	323	0.97	0.49	1.91	2,121
Sep-10 B	48.9	45	477	1.72	0.79	3.75	4,103
Oct-10	80.0	741	14,180	19.77	12.03	32.50	77,095
Nov-10	70.1	1,427	23,839	32.15	17.16	60.38	109,877

The ESW for Common Eider during ship-based surveys, estimated for the entire dataset, was 205 m. Estimated Common Eider densities were variable and ranged between 30 to more than 100 birds/km^2 during wintering period (Table 4.44). Reflecting estimated densities, total numbers in the area covered by ship-based surveys ranged from 70,000 to over 200,000 individuals during winter months. Very high estimates were obtained for a few ship-based surveys (December 2008, November 2009, late February 2010 and November 2010; Table 4.44), however, we consider as misleading despite reasonable variability of statistical treatment. Double counting of the same birds during ship-based surveys also cannot be excluded: large flocks of Common Eiders flee at long distance from approaching ships (Schwemmer et al. 2011) and can therefore be encountered more than once during the same survey.

Excluding surveys with these very high estimates, Common Eider densities obtained for aerial and ship-based surveys were comparable, ship-based surveys producing slightly higher densities (Table 4.43, Table 4.44). It is possible that more individuals were detected from slower moving platform. Furthermore, ship-based survey coverage included higher proportion of habitats suitable for seaducks whereas aerial surveys also covered extensive offshore areas with few birds.

Month-to-month variation in Common Eider abundance was assessed by plotting mean densities of birds recorded during ship-based surveys (and corrected for distance detection bias), as rather consistent coverage has been achieved during these counts (Table 4.44, Figure 4.88). Numbers observed and mean densities of the species indicate consistently high abundance during the wintering period and transitional months (October - April), and considerably lower densities between late April-May and September (Table 4.44, Figure 4.88).

Table 4.44 Numbers of observed Common Eiders during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95% confidence interval; Total number represents total estimate for the area of 2,340 km² covered by ship-based surveys. Note: coefficients of variation greater than 50% are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150% no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	**Stratum**	**N obs**	**N birds**	**D**	**%CV**	**LCI**	**UCI**	**D**	**LCI**	**UCI**	**N flying**	**D**	**Total number**
Nov-08	coastal	872	17,012	125.90	35	64.25	246.74	83.55	42.59	163.94	803	87.86	205,596
	offshore	161	653	11.58	35	5.78	23.20				86		
Dec-08	coastal	798	32,866	303.61	37	149.08	618.33	191.84	93.88	392.12	307	194.35	454,771
	offshore	215	1,083	18.29	40	8.18	40.89				131		
Jan-09	coastal	1,257	14,347	119.05	28	68.33	207.43	82.98	47.71	144.31	447	85.46	199,969
	offshore	223	727	11.16	25	6.68	18.65				137		
Feb-09	coastal	1,022	11,640	87.14	22	56.38	134.69	61.68	39.13	97.99	106	62.24	145,636
	offshore	152	783	11.64	40	5.23	25.88				27		
Mar-09	coastal	1,046	10,131	79.78	20	53.82	118.27	55.28	37.05	82.55	236	56.36	131,873
	offshore	113	373	6.42	28	3.63	11.36				16		
Apr-09	coastal	352	2,313	15.68	22	10.15	24.20	11.21	7.00	18.42	237	12.40	29,009
	offshore	33	136	2.62	54	0.94	7.32				45		
May-09	coastal	127	491	4.61	32	2.45	8.66	3.14	1.65	6.05	114	3.67	8,598
	offshore	9	13	0.26	68	0.07	0.92				11		
Jul-09A	coastal	32	111	-	389	-	-	-	-	-	42	-	-
	offshore	9	13	0.27	67	0.08	0.96				2		
Jul-09B	coastal	12	38	-	952	-	-	-	-	-	14	-	-
	offshore	8	19	-	***	-	-				0		
Aug-09	coastal	34	65	0.66	47	0.27	1.63	-	-	-	0	-	-
	offshore	3	25	-	***	-	-				0		
Sep-09	coastal	101	435	3.73	31	2.04	6.81	2.87	1.36	21.28	23	2.97	6,957
	offshore	4	29	1.20	283	0.03	49.39				1		
Oct-09	coastal	587	14,324	101.31	39	48.48	211.69	77.98	37.23	163.41	535	80.70	188,844
	offshore	34	88	3.75	48	1.44	9.79				7		
Nov-09	coastal	716	22,400	203.26	34	104.97	393.61	134.81	69.57	261.25	554	137.74	322,307
	offshore	165	612	9.53	34	4.77	19.01				101		
Dec-09	coastal	577	17,692	75.63	42	33.99	168.29	53.11	23.56	120.14	745	56.50	132,217
	offshore	125	726	9.90	53	3.53	27.76				39		
Jan-10	coastal	579	6,118	42.21	29	24.11	73.89	30.45	16.78	56.58	67	30.74	71,937
	offshore	67	387	7.56	59	2.50	22.88				0		
Feb-10A	coastal	839	10,465	75.94	22	49.43	116.67	54.90	35.00	86.57	53	55.19	129,133
	offshore	182	790	14.71	34	7.45	29.07				12		

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Feb-10B	coastal	699	25,845	167.53	43	74.28	377.85	115.89	51.13	262.88	58	116.19	271,875
	offshore	131	792	13.67	49	5.29	35.30				12		
Mar-10	coastal	1,160	15,747	121.75	24	75.83	195.47	87.15	52.83	147.23	222	88.12	206,192
	offshore	108	965	14.59	61	4.62	46.08				12		
Apr-10	coastal	201	2,175	14.75	54	5.41	40.19	10.41	3.75	29.19	154	11.21	26,221
	offshore	26	91	1.52	82	0.35	6.64				30		
May-10	coastal	10	18	0.16	56	0.06	0.45	0.14	0.04	0.48	2	0.16	372
	offshore	1	5	0.10	97	0.02	0.54				3		
Jun-10	coastal	171	888	9.29	41	4.21	20.48	-	-	-	31	-	-
	offshore	16	59	-	542	-	-				65		
Sep-10	coastal	51	292	2.71	44	1.17	6.29	1.83	0.78	4.39	53	2.11	4,927
	offshore	2	3	0.07	142	0.01	0.58				10		
Oct-10	coastal	347	5,653	56.11	47	22.90	137.46	38.79	15.65	96.76	46	39.02	91,308
	offshore	42	247	3.85	73	1.01	14.68				7		
Nov-10	coastal	646	50,929	362.42	45	154.86	848.21	248.57	106.40	580.86	148	249.51	583,857
	offshore	193	745	14.13	38	6.59	30.28				78		

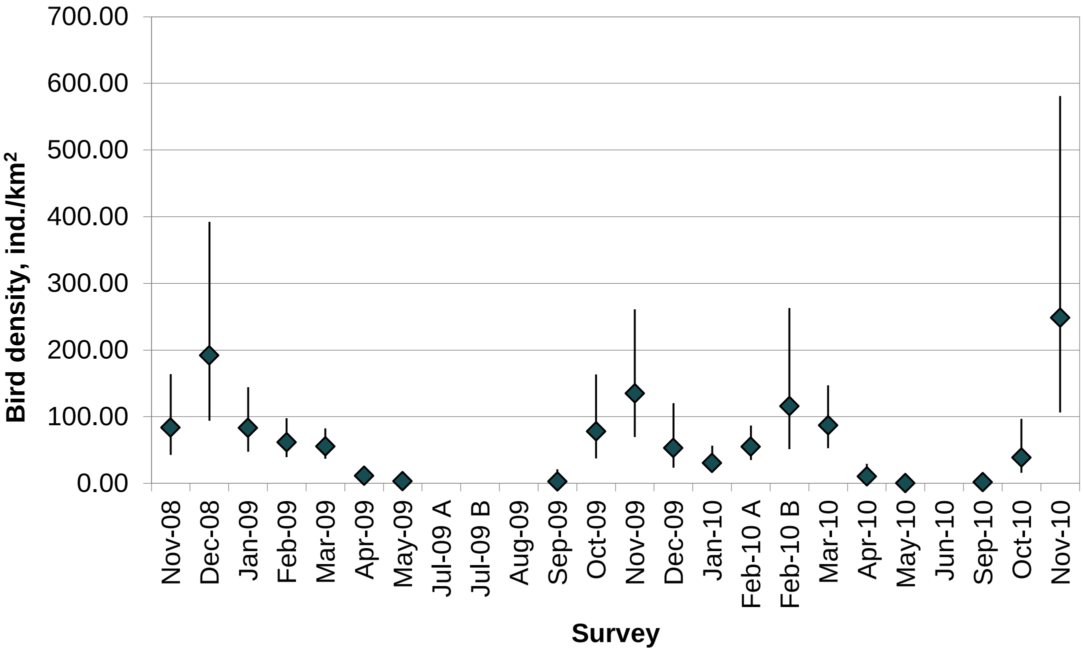


Figure 4.88 Mean density estimates and 95% confidence intervals of swimming Common Eiders estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150 % were not included into the chart (see Table 4.43 for specific values).

Common Eider abundance estimates according to supplementary datasets

The German waterbird monitoring reports 62,000 Common Eiders counted in Schleswig-Holstein in January 2009 (BIOLA 2009). These total numbers are difficult to compare to the results of FEBI baseline investigations due to differences in survey design (total counts *versus* line transect surveys) and coverage (surveying only shallow areas *versus* equal coverage of all depth strata), respectively. Furthermore, detection of seaducks is limited during aerial surveys, as it was demonstrated by the FEBI Distance analysis (see above) and found by others (Burt et al. 2010), but no correction accounting for the distance-detection bias has been applied for the German aerial monitoring counts (BIOLA 2009). In addition to the total counts, aerial transect surveys were also conducted in Baltic waters off Schleswig-Holstein, which covered both shallow and deep areas (BIOLA 2009). Although distance-correction has not been applied on transect data, Common Eider densities are reported for survey bands that are least affected by detection bias (i.e. proximate to an observer): 61.84 ind./km^2 in February 2008 and 80.91 ind./km^2 in February 2009 (BIOLA 2009). These densities are similar to those estimated during FEBI baseline investigations (Table 4.43, Table 4.44).

According to the Danish aerial monitoring of wintering birds, densities lower than 7 individuals/km^2 prevail in the bigger part of the Danish Fehmarnbelt, and higher concentrations of up to 100 birds/km^2 were reported at localised areas southwest of Lolland and south of Langeland (Petersen et al. 2006).

Results from mid-winter coastal counts in Germany in 2009 and 2010 revealed 29,300 and 61,400 Common Eiders resting in the inshore zone, mainly in coastal areas of Hohwacht Bay (AKVSW 2010, OAG 2010).

Distribution and habitat use of Common Eider in the Fehmarnbelt

Both aerial and ship-based surveys were considered for representing Common Eider distribution in the Fehmarnbelt (Appendix II). Spatial modelling was applied on data collected from both survey platforms.

Common Eider distribution and habitat use according to spatial modelling of aerial survey data

Using aerial survey data distribution models were fitted separately for a ‘winter’ period and a ‘summer’ period due to different densities and presumed different habitats occupied by Common Eiders during the two seasons. The ‘winter’ period was further categorised into 5 seasons: season 1 (December 2008 – February 2009), season 2 (March 2009), season 3 (October 2009), season 4 (November 2009 – early March 2010), and season 5 (March – April 2010). The ‘summer’ period was not categorised and included observations between April and September 2009.

Distribution model for the ‘winter’ period

The interaction term XY, representing easting and northing was the most important predictor in the binomial part of the ‘winter’ model, indicating that a large part of the variance could not be explained by the environmental variables used in the model (Table 4.45). Water depth, proportion of hard bottom substrate and mussel biomass were important predictors among the environmental variables, and distance to land and number of ships were important variables describing disturbance (Table 4.45). The response curves of the binomial model indicated that Common Eider occurrence was increasing up to a depth of about 12 m and then declined with increasing depth values, with a peak at about 8-12 m (Figure 4.89A). Bird occurrence increased with increasing hard substrate coverage and increasing mussel biomass. Eiders occurrence gently increased with increasing distance to land, up to a distance of about 5 km and then started to decline. Also, bird occurrence declined with increasing ship number (Figure 4.89A). The categorical variable representing seasons indicated that birds occurred over broader areas during winter (seasons 1 and 4), distribution was more localised in spring (seasons 2 and 5), and it was the most patchy in autumn (season 3, Figure 4.89A).

The positive part of the 'winter' model further explained relationships of bird densities to the environmental variables. Water depth was the most important predictor in the positive part, indicating similar relationship as identified in the binomial part of the model: bird densities were highest at depths of less than 12 m, with a peak at 5-10 m depth zone (Table 4.45, Figure 4.89B). The next variable in terms of importance was 'XY', and was followed by mussel biomass and bottom slope (Table 4.45, Figure 4.89B). Similarly to the binomial part of the model, eider densities increased with increasing mussel biomass. Further, eider densities gently increased with increasing bottom slope and after peaking at about 0.15° declined further at steeper slopes (Table 4.45, Figure 4.89B). Seasonal patterns indicate that Common Eider densities were the highest in spring 2009, and that densities in winter and spring 2010 were higher than those in winter 2009 and autumn 2009 (Figure 4.89B).

The 'winter' distribution model had a reasonably good fit. Deviance explained in the binomial part was 19.9 % and 24.7 % in the positive part (Table 4.45). The accuracy of the predictions in the binomial part according to the AUC equalled 0.79 and the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.42 ($P < 2.2e-16$).

Significant ($P < 0.05$) but low spatial autocorrelation was found in the residuals of both model parts. In the presence/absence part autocorrelation was present in 4 out of 10 lags (1 lag = 1,500 m which was the defined nearest neighbourhood). The Moran's I values were, however, very low ranging from -0.008 to 0.017 (Moran's I range from -1.0 to 1.0). In the positive part significant spatial autocorrelation was found in 7 out of 10 lags, the Moran's I values also being very low and ranging from 0.012 to 0.068 (Appendix III).

Distribution model for the 'summer' period

In the binomial part of the 'summer' model XY was the most important predictor, indicating that there was a lot of variability unexplained by environmental variables (Table 4.46). Mussel biomass and bottom slope were nearly equally important among the environmental predictors, being followed by water depth and distance to land (Table 4.46). The response curves of the binomial model indicated that Common Eiders occurrence increased with increasing mussel biomass, and with increasing bottom slope. Birds mostly occurred at shallow depths in summer and the probability of bird occurrence linearly declined with increasing water depth. Finally, bird occurrence increased with increasing distance from land up to about 5 km off the coast (Figure 4.90A).

The positive part of the 'summer' model provided further details about the relationships of bird densities to the environmental variables. Water depth was the most important predictor in the positive part, indicating similar relationship as identified in the binomial part of the model. Bird densities declined linearly with increasing water depth (Table 4.46, Figure 4.90B). The next variable in terms of importance was proportion of hard substrate and bird densities declined linearly with increasing proportion of hard bottom. Further, distance to land indicated gradually increasing densities with increasing distance from land up to 6-7 km and declining further out (Table 4.46, Figure 4.90B). The significance of XY variable was marginal in the positive part of the 'summer' model (Table 4.46).

The 'summer' distribution model had a reasonably good fit also. Deviance explained in the binomial part was 31.6% and 18.7% in the positive part (Table 4.45). The AUC equalled 0.87 when the model was calibrated on 70% and evaluated on 30%, and the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.38 ($P < 2.2e-16$). The presence/absence part performed better in the 'summer' model compared to the 'winter' model, and *vice-versa* performance of positive part was better in the 'winter' model (Table 4.45, Table 4.46, also see detailed model diagnostics in Appendix III). This could be explained by the fact that eider densities were much higher in 'winter' than in 'summer'.

Significant ($P < 0.01$) but low spatial autocorrelation was found in the residuals of both model parts. In the presence/absence part autocorrelation was present in 3 out of 10 lags (1 lag = 1,500 m which was defined as the nearest neighbourhood). The Moran's I values were, however, very low ranging from -0.010 to 0.099. In the positive part significant spatial autocorrelation was found in only 1 out of 10 lags, the Moran's I values ranging from -0.035 to 0.143 (Appendix III).

Deployment of distribution models

The deployed models show that Common Eiders between December 2008 and February 2009 and again between November 2009 and March 2010 occurred in mean densities exceeding 100 birds/km^2 on the offshore areas of Flüggesand, Sagasbank, Stoller Grund, and Albue Bank (Figure 4.91). Densities off Hyllekrog were higher during the first winter (December 2008 – February 2009) compared to the second winter (November 2009 – March 2010) of the study period (Figure 4.91), a difference which might be attributed to the construction of Rødsand II wind farm and associated ship traffic. Densities of wintering Common Eiders were lower in the immediate area of the planned alignment of a fixed link compared to a broader area of bird distribution (Figure 4.91), indicating a combination of foraging habitat suitability and disturbance from the existing ferry line. The zone of high densities (> 200 birds/km^2) off the north coast of Fehmarn extended as close as 2 km to Puttgarden. On the Danish side the closest high densities of the species to Rødbyhavn were located on the Albue Bank, 20 km to the west. Distribution of Common Eider densities during transitional spring periods was similar to that recorded in winter (Figure 4.92), and autumn (October) densities were slightly lower (Figure 4.93).

Densities of Common Eider during the breeding and moulting period from April to September were low (< 5 birds/km^2) on the offshore banks, but densities above 10 birds/km^2 were estimated for the coastal area southwest of Lolland, Hyllekrog in the Rødsand Lagoon, and around the island of Fehmarn (Figure 4.93). This indicates a shift of aggregation sites from offshore banks in winter to more coastal areas in summer.

Table 4.45 Significance of smooth terms (X2, Z, t and F values) of variables in the spatial distribution model for the 'winter' period for Common Eider in the Fehmarnbelt. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model and the positive part by a gamma model.

Variable	Presence/absence			Positive part		
	Z	X^2	P	t	F	P
Season 2	-16.72		<0.01	6.36		<0.01
Season 3	-19.04		<0.01	0.12		0.90
Season 4	-4.06		<0.01	1.78		0.08
Season 5	-11.78		<0.01	1.82		0.07
Mussel biomass		9.22	0.02		5.82	<0.01
Depth		155.17	<0.01		45.13	<0.01
Proportion hard substrate		13.36	<0.01		-	-
Bottom slope		-	-		4.74	<0.01
Distance to land		51.60	<0.01		-	-
Distance to wind farms		-	-		-	-
Number of ships		45.05	<0.01		-	-
XY		754.79	<0.01		29.16	<0.01
Model performance						
AUC		0.79				
Deviance explained		19.9 %			24.7 %	
Combined correlation (P)			0.42 (P < 2.2e-16)			

Table 4.46 Significance of smooth terms (X^2, and F values) of variables in the spatial distribution model for the 'summer' period for Common Eider in the Fehmarnbelt. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model and the positive part by a gamma model.

Variable	Presence/absence			Positive part		
	Z	X^2	P	t	F	P
Mussel biomass		42.72	<0.01		-	-
Depth		27.57	<0.01		27.33	<0.01
Proportion hard substrate		-	-		12.56	<0.01
Bottom slope		41.13	<0.01		-	-
Distance to land		22.30	<0.01		5.48	<0.01
Distance to wind farms		-	-		-	-
Number of ships		-	-		-	-
XY		162.65	<0.01		1.79	0.04
Model performance						
AUC		0.87				
Deviance explained		31.6 %			18.7 %	
Combined correlation (P)			0.38 (P < 2.2e-16)			

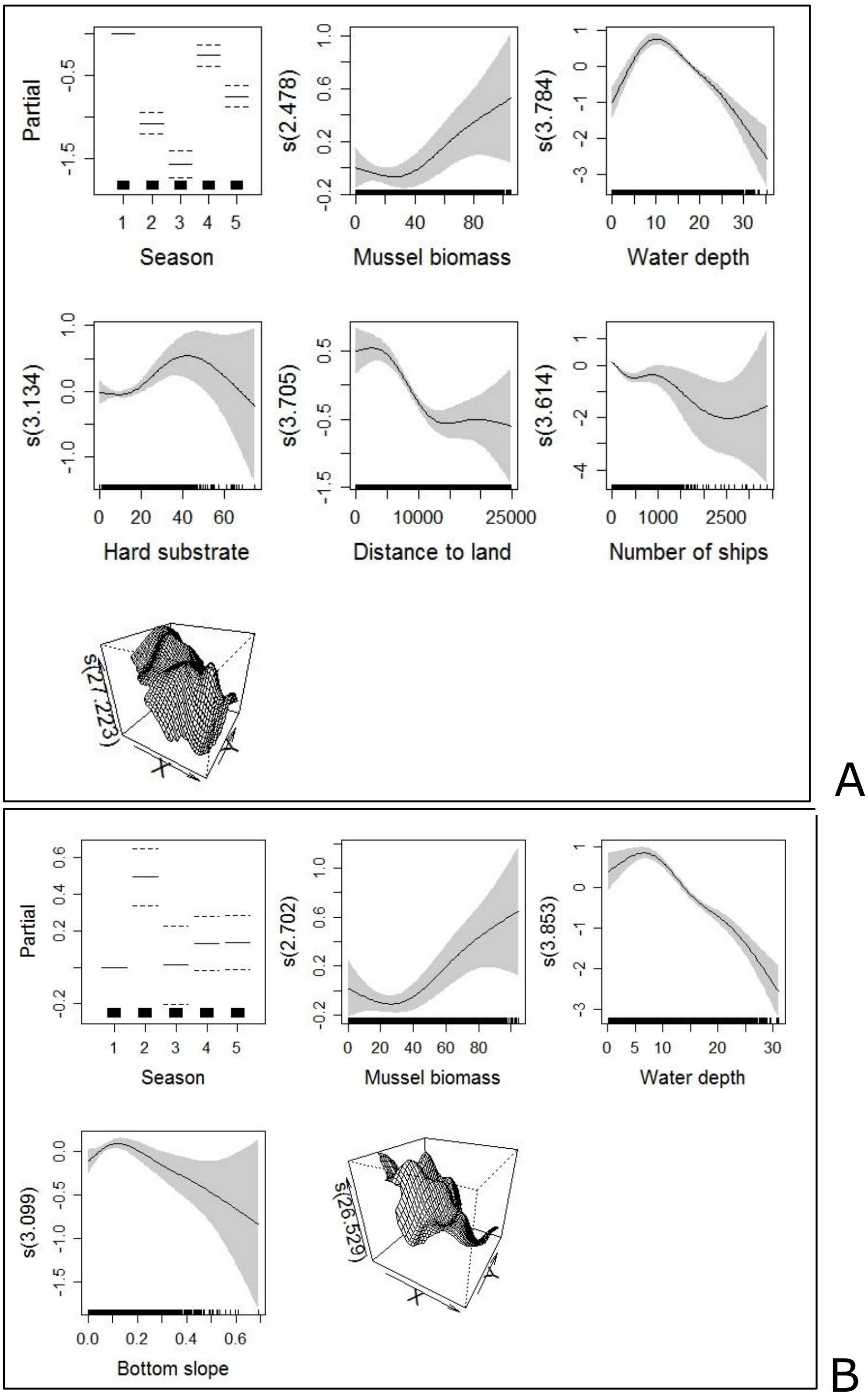


Figure 4.89 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Common Eider (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the 'winter' season. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.

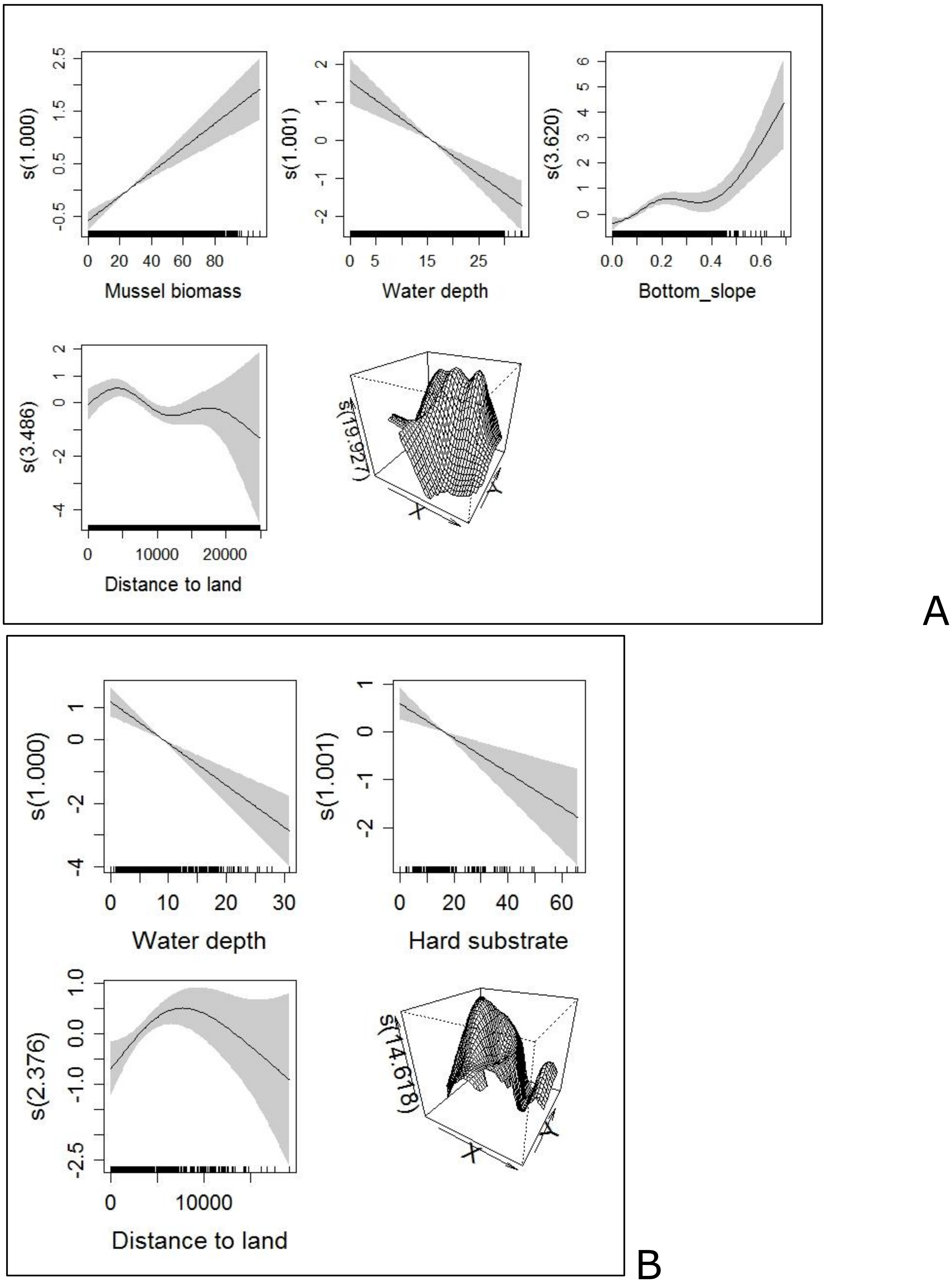


Figure 4.90 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Common Eider (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the summer season. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.

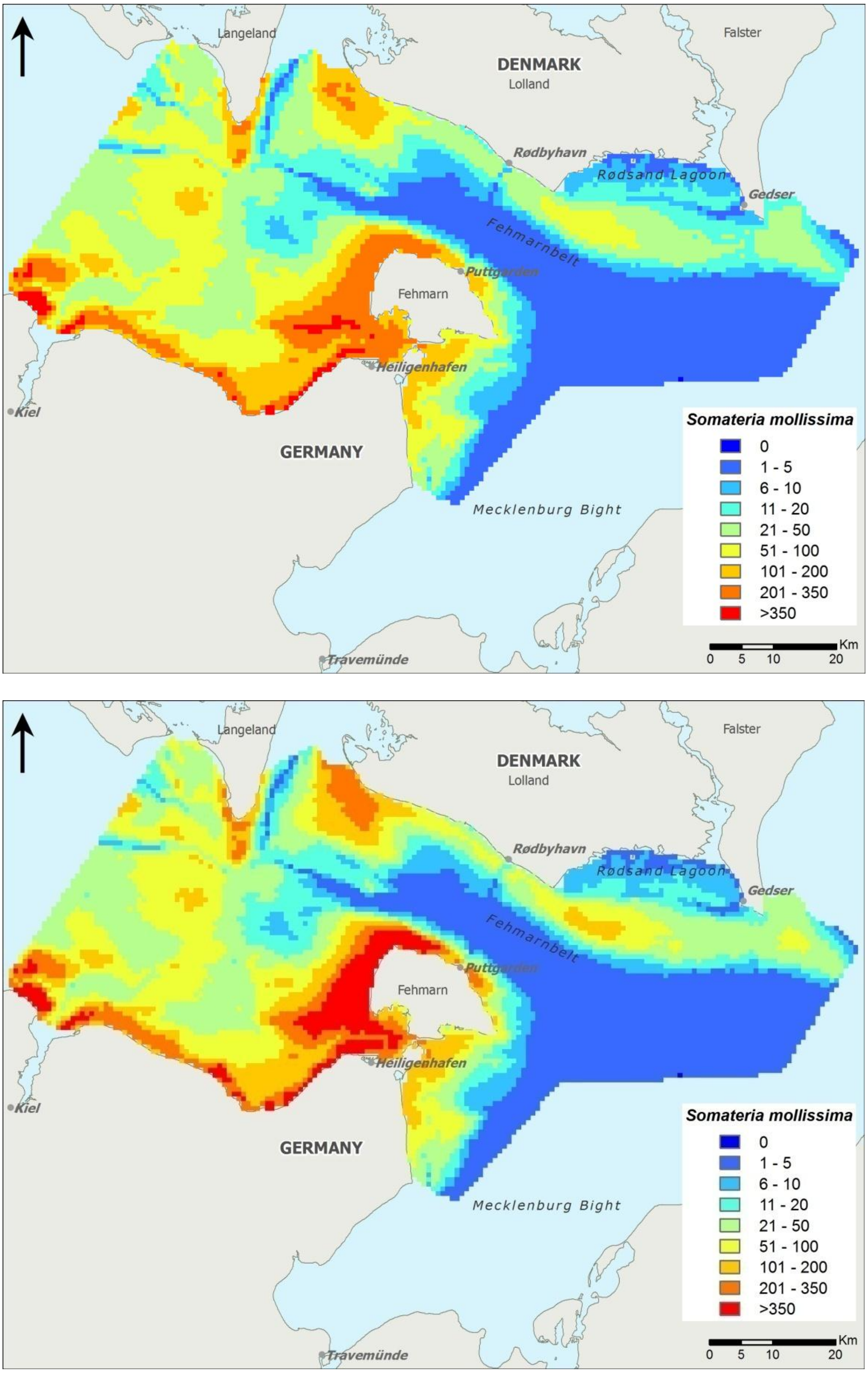
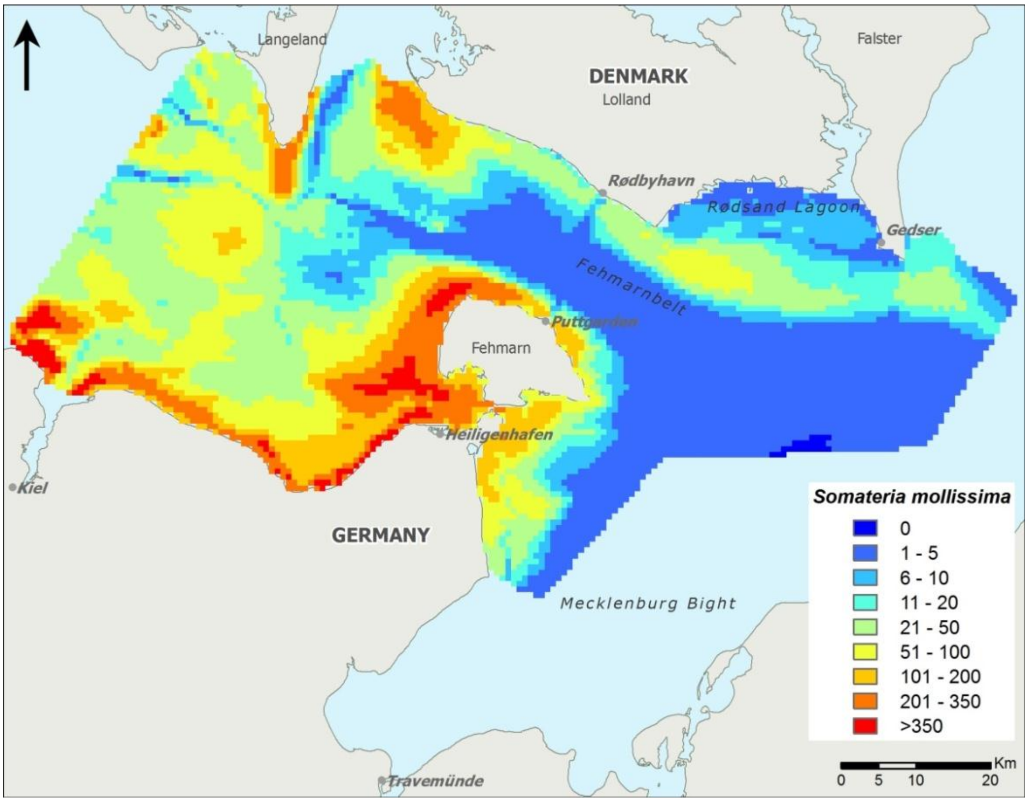


Figure 4.91 Spatial distribution models (numbers per km^2) of Common Eider Somateria mollissima *in the Fehmarnbelt in winter periods based on baseline aerial surveys undertaken between December 2008 – February 2009 (upper map) and November 2009 – early March 2010 (lower map; 'winter' seasons 1 and 4 respectively).*



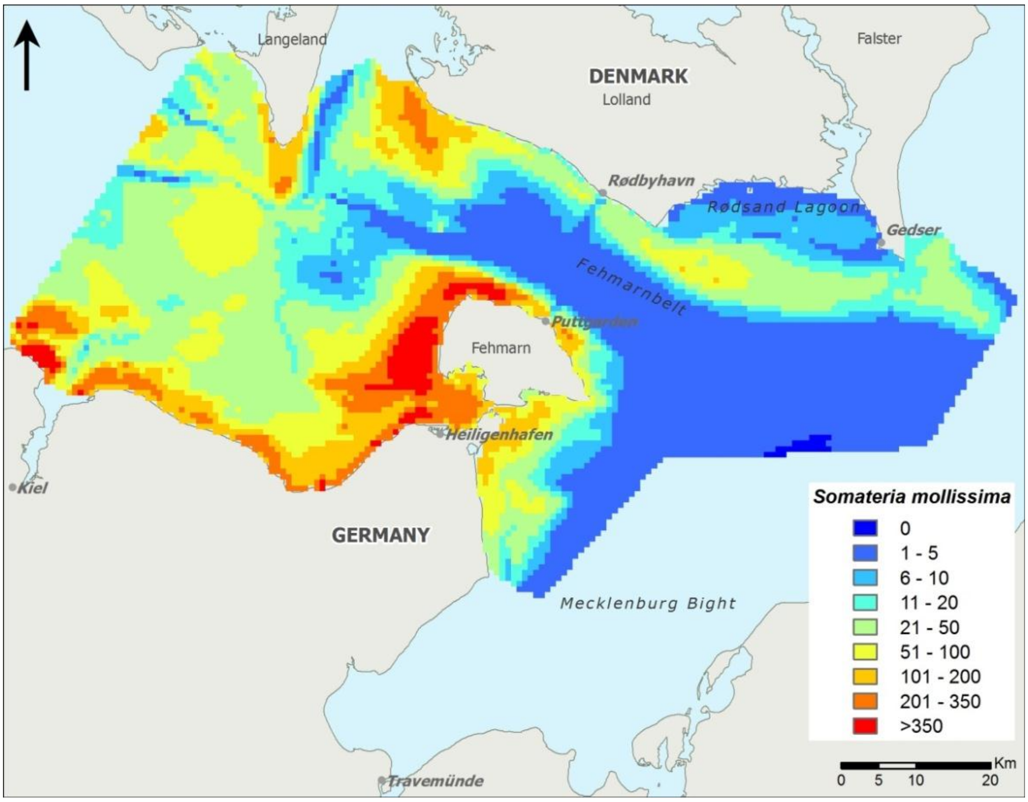
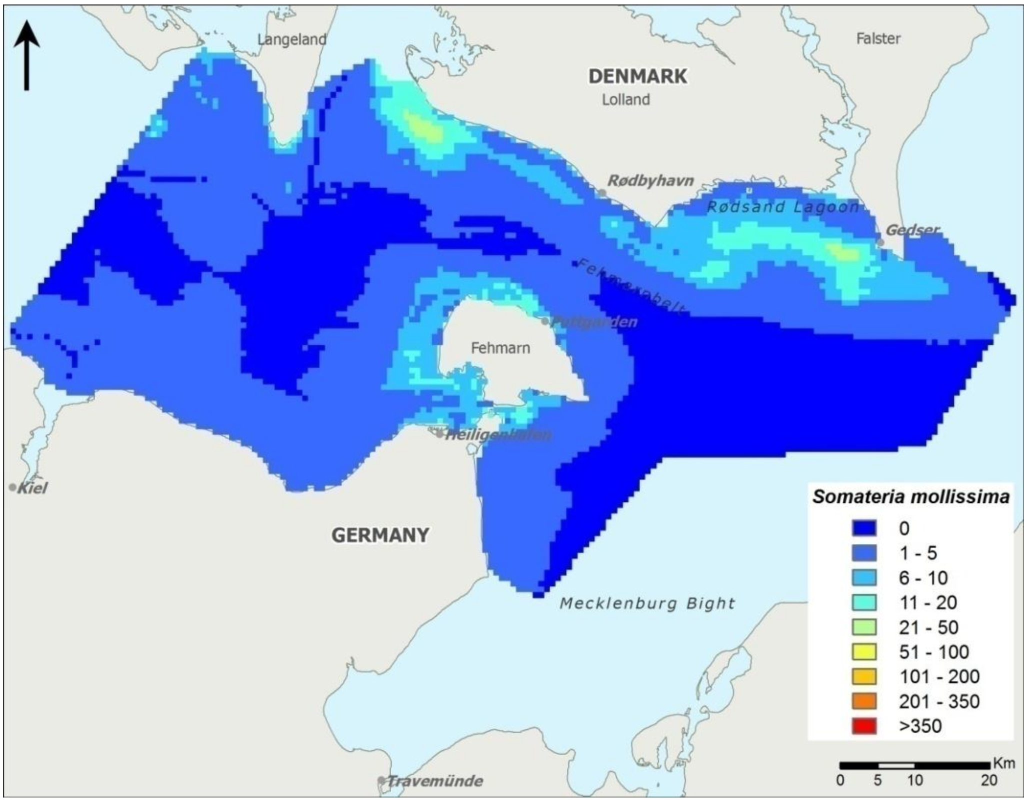


Figure 4.92 *Spatial distribution models (numbers per km²) of Common Eider* Somateria mollissima *in the Fehmarnbelt in spring periods based on baseline aerial surveys undertaken in March 2009 (upper map) and March – April 2010 (lower map; 'winter' seasons 2 and 5 respectively).*



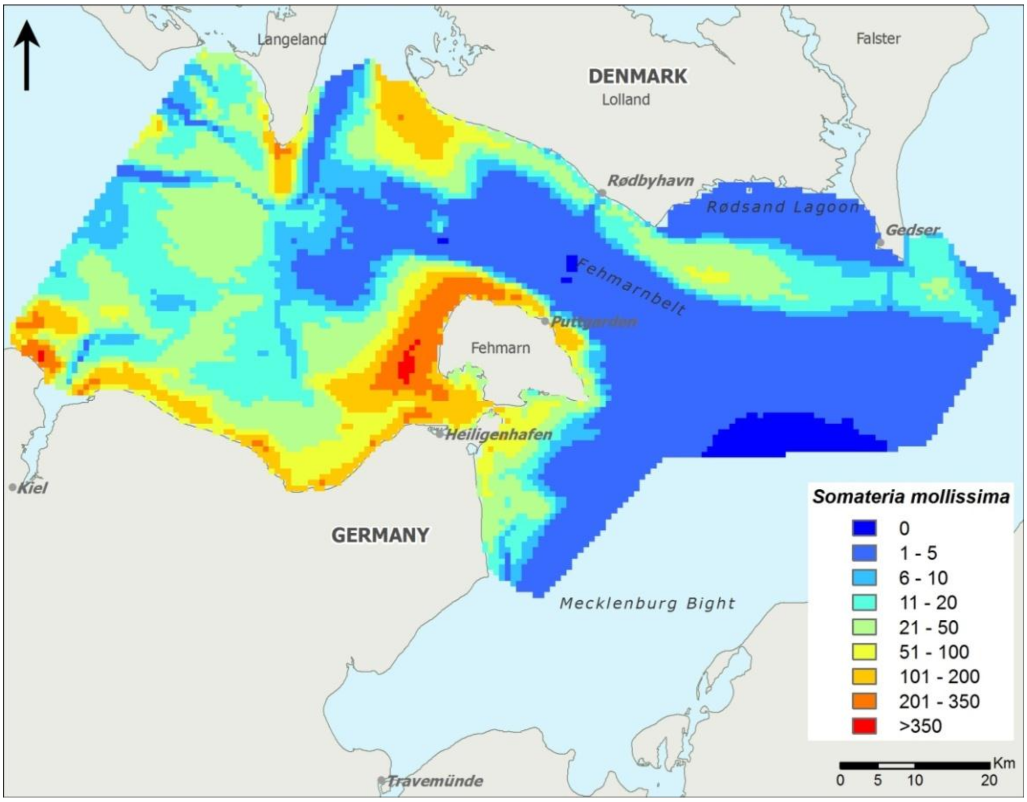


Figure 4.93 Spatial distribution models (numbers per km^2) of Common Eider Somateria mollissima *in the Fehmarnbelt in summer (April – September 2009, upper map) and autumn (October 2009, lower map) periods based on baseline aerial surveys (summer models and 'winter' model seasons 3 respectively).*

Common Eider distribution and habitat use according to spatial modelling of ship-based survey data

Using ship-based survey data distribution models were fitted for a 'winter' period. The 'winter' period was further categorised into five seasons: season 1 (December 2008 – February 2009), season 2 (March 2009), season 3 (October 2009), season 4 (November 2009 – early March 2010), and season 5 (March – April 2010). The 'summer' period was not considered using ship-based surveys, as Common Eiders use coastal habitats in summer (see spatial modelling results based on aerial surveys) and these were only partly covered by ships.

The 'winter' model fitted using data collected from ships turned out to be very similar to the model developed using aerial survey data. The interaction term XY was the most important predictor in the binomial part of the 'winter' model, indicating that a large part of the variance could not be explained by the environmental variables used in the model (Table 4.8). Water depth, mussel biomass and bottom slope were important predictors among the environmental variables, and number of ships was important variable describing disturbance (Table 4.8). The response curves of the binomial model indicated that Common Eider occurrence was increasing up to a depth of about 12 m and then declined with increasing depth values (Figure 4.94A). Bird occurrence increased with increasing mussel biomass, and was dome-shaped in relation to the bottom slope. Eiders occurrence declined with increasing ship number (Figure 4.94A). The categorical variable representing seasons indicated that birds occurred over broader areas during winter (seasons 1 and 4), distribution was more localised in spring (seasons 2 and 5), and it was the most patchy in autumn (season 3, Figure 4.94A).

The positive part of the 'winter' model further explained relationships of bird densities to the environmental variables. Water depth was the most important predictor in the positive part, indicating declining eider densities with increasing depth (Table 4.8, Figure 4.94B). The next variable in terms of importance was 'XY', and was followed by distance to land, mussel biomass and number of ships (Table 4.8, Figure 4.94B). Similarly to the binomial part of the model, eider densities were highest at highest mussel biomass. In relation to distance to land, eider densities peaked at about 5,000 m from the shoreline and declined further out (Table 4.8, Figure 4.94B). Also, bird densities were decreasing with increasing ship traffic. Seasonal patterns suggest higher densities of Common Eiders during transitional periods - spring and autumn (Figure 4.94B).

The 'winter' distribution model according to ship-based survey data had a rather good fit. Deviance explained in the binomial part was 26.2 % and 45.5 % in the positive part (Table 4.8). The accuracy of the predictions in the binomial part according to the AUC equalled 0.80 and the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.55 ($P < 2.2e-16$).

No spatial autocorrelation was found in the residuals of the presence/absence part of the model. In the positive part significant spatial autocorrelation was found in 5 out of 10 lags, however the Moran's I values were very low ranging from 0.020 to 0.053 (Moran's I range from -1.0 to 1.0; Appendix III).

The deployed model from ship-based surveys showed generally the same patterns as obtained by distribution modelling using aerial survey results, and indicated that key concentrations occur on Flüggesand, northwest of Westermarkelsdorf (northwest Fehmarn) and Sagasbank at the German side, and Albue Bank at the Danish side of the Fehmarnbelt (Figure 4.95, Appendix II).

Table 4.47 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the 'winter' period for Common Eider in the Fehmarnbelt according to ship-based surveys. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	Presence/absence			Positive part		
	Z	X^2	P	t	F	P
Season 2	-8.00		<0.01	-2.52		0.01
Season 3	-11.53		<0.01	0.30		0.77
Season 4	0.35		0.73	-3.45		<0.01
Season 5	-8.29		<0.01	0.83		0.41
Mussel biomass		12.47	<0.01		11.59	<0.01
Depth		22.00	<0.01		25.56	<0.01
Proportion hard substrate			-		-	-
Bottom slope		10.03	0.01		-	-
Distance to land		-	-		12.52	<0.01
Distance to wind farms		-	-		-	-
Number of ships		11.32	<0.01		9.30	<0.01
XY		190.91	<0.01		20.57	<0.01
Model performance						
AUC	0.80					
Deviance explained	26.2 %			45.5 %		
Correlation (combined)	0.55 (p < 2.2e-16)					

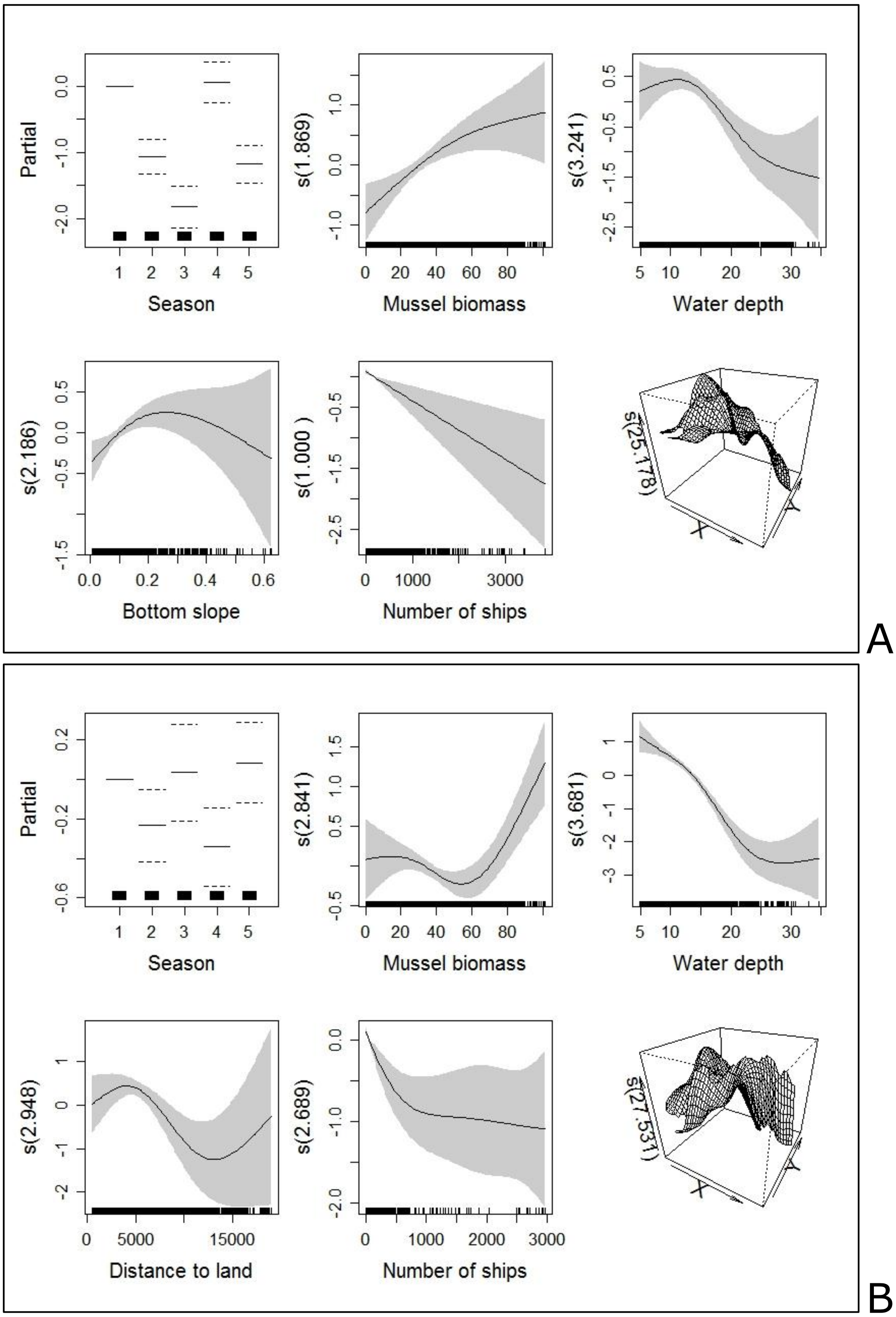
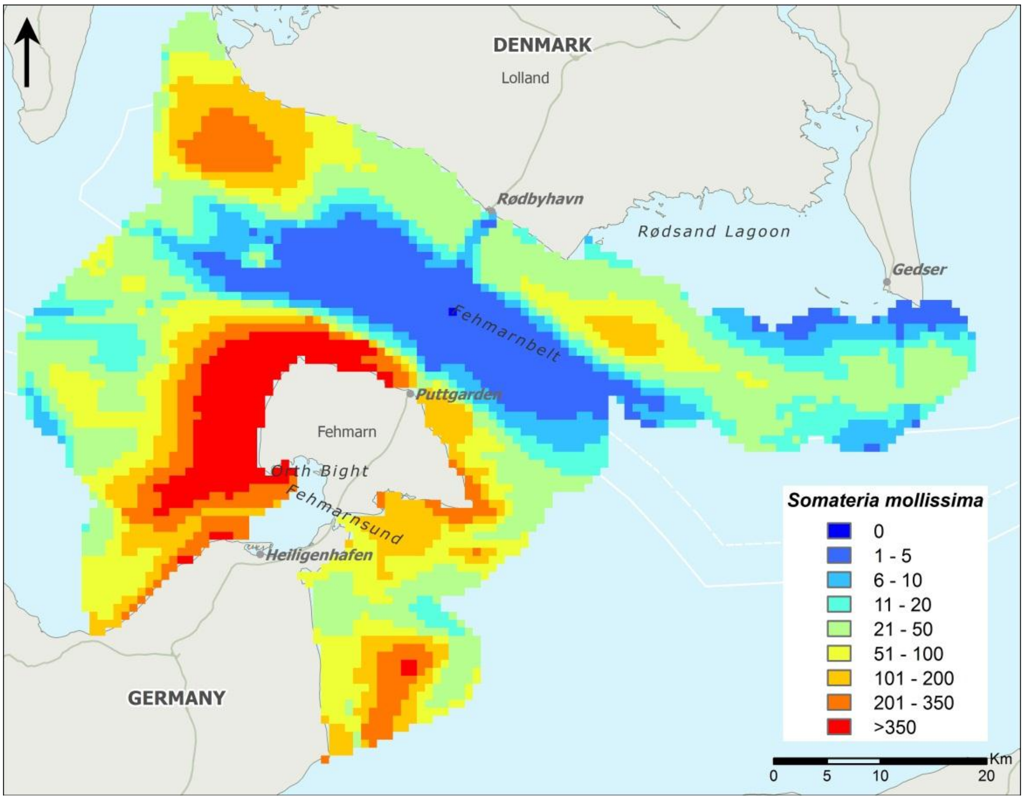


Figure 4.94 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Common Eider (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the winter season according to ship-based survey data. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.



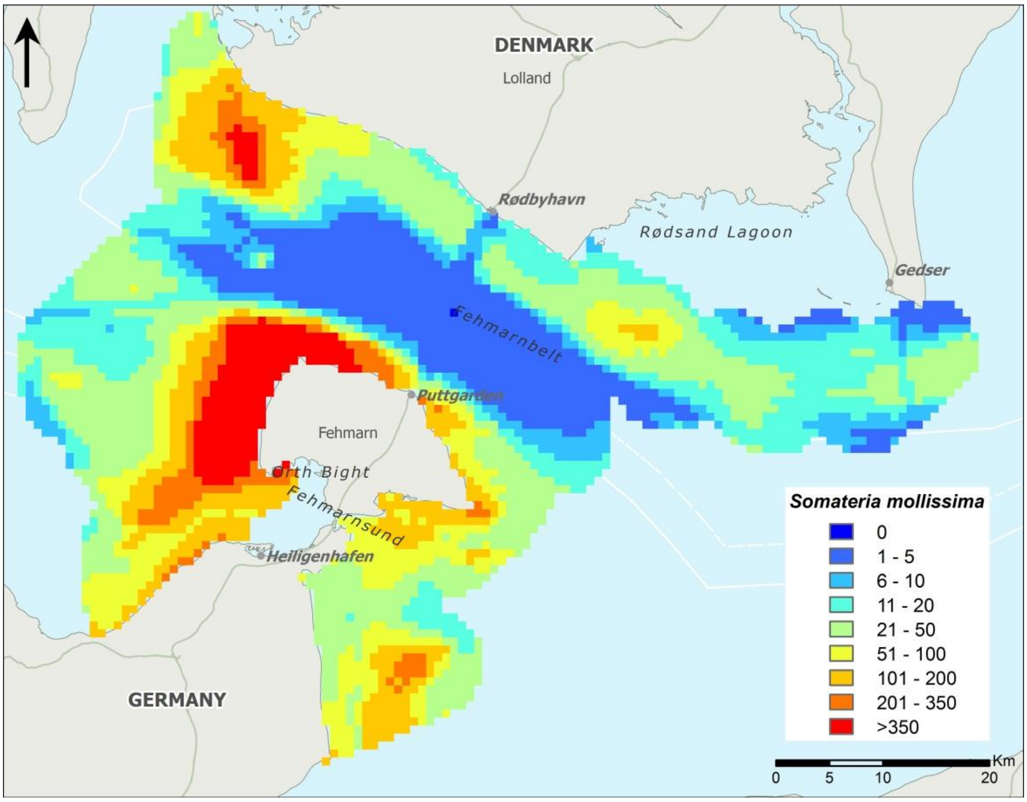


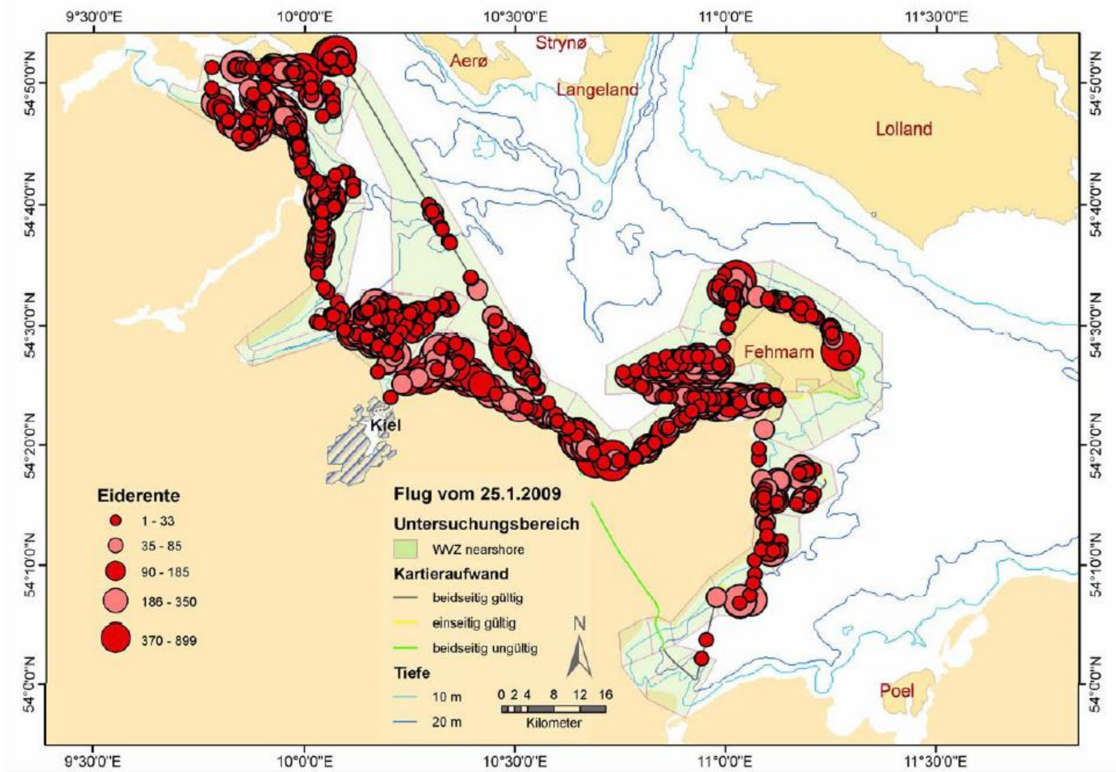
Figure 4.95 Spatial distribution models (numbers per km²) of Common Eider Somateria mollissima *in the Fehmarnbelt based on baseline ship-based surveys undertaken between December 2008 – February 2009 (upper map) and November 2009 – February 2010 (lower map).*

Common Eider distribution according to supplementary datasets

Winter distribution of Common Eiders recorded during waterbird monitoring surveys in the Baltic waters of Schleswig-Holstein resembled closely the results of FEBI baseline investigations. The highest numbers were recorded on Flüggesand, Sagasbank, and in Hohwacht Bay (Figure 4.96; BIOLA 2009).

Mapped results of wintering waterbird monitoring in Denmark indicate the same areas of higher concentrations of Common Eiders as identified during the baseline investigations at Albue Bank, Gulstav Flak and Gedser Rev. However, there were also some differences as Danish monitoring flights suggested concentrations of eiders in Rødsand Lagoon (Petersen et al. 2006, 2010) whereas no high densities were recorded during the FEBI baseline investigations in winter period.

Further evidence of a very stable distribution of Common Eiders in the Fehmarnbelt comes from the Feasibility studies for the Fehmarnbelt Fixed Link construction carried out in the same areas between 1996 and 1998 (Skov et al. 1998).



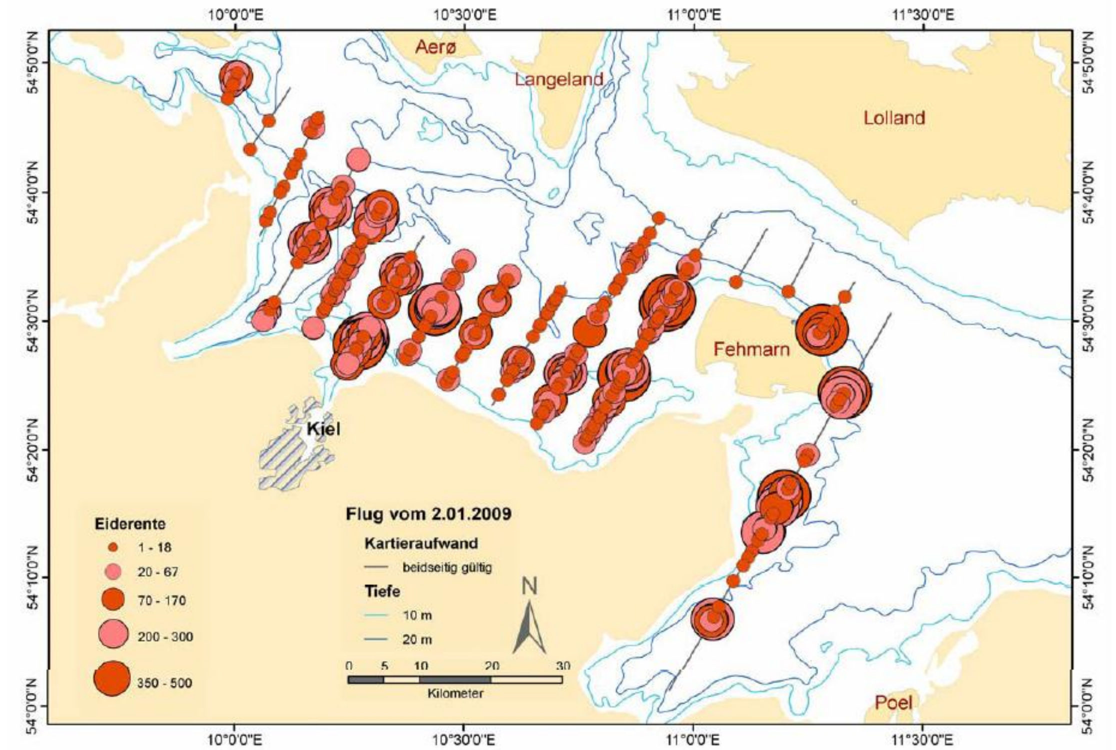


Figure 4.96 Common Eider winter distribution patterns documented during waterbird monitoring surveys in the Baltic waters of Schleswig-Holstein resembled closely the distribution of this species recorded during FEBI baseline investigations. Maps adapted from BIOLA (2009) with permission from the authors.

Common Eider abundance estimates for SPAs

Because estimated densities of aerial and ship-based surveys were similar according to both Distance analysis and spatial modelling, but aerial surveys achieved better spatial coverage of the Fehmarnbelt area, spatial modelling results of these surveys were used to present estimates of Common Eiders in the Fehmarnbelt.

Abundance estimates based on distribution models for the SPA Eastern Kiel Bight ranged from less than 2,000 birds in summer 2009 to about 125,000 in winter 2008/2009, spring 2009 and spring 2010, and 160,000 in winter 2009/2010 (Table 4.48). The estimates for the SPA Baltic Sea east of Wagrien ranged from less than 500 during summer 2009 to between 13,000 and 18,000 birds during winter and spring periods. The SPA Hyllekrog-Rødsand supports between 2,000 and 3,000 birds during winter and spring periods, and about 2,000 in summer (Table 4.48).

Total numbers of Common Eider as modelled from aerial survey data indicate that the greater Fehmarnbelt area hosts up to 43 % of the biogeographic population of the species. Among these 16-21 % of the biogeographic population winter in the SPA Eastern Kiel Bight, 1.0-2.4 % in the SPA Baltic Sea east of Wagrien, and up to 0.5 % in the SPA Hyllekrog-Rødsand. The non-SPA area of the Fehmarnbelt supports further 12-17 %, among that up to 1 % of the biogeographic population winters in the immediate vicinity of the planned alignment (5 km around, see Figure 2.21 in Methods).

Modelled densities of wintering Common Eiders in the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien were substantially higher than those in the remaining non-SPA area. Densities of wintering Common Eiders were the lowest in the SPA Hyllekrog-Rødsand, but the area hosted the highest densities of birds in summer (Table 4.48).

The total estimates obtained from the distribution models are comparable to the estimates of Distance analysis (presented in Table 4.43): 272,000 for winter 2008/2009, 269,000 for spring 2009, 9,390 for summer 2009, 150,000 for autumn 2009, 327,500 for winter 2009/2010 and 253,000 for spring 2010 (Table 4.48, Appendix III).

The very high abundance of 327,505 ± 53,794 (±SE) eiders for winter 2009/2010 was most likely related to severe winter conditions and extensive ice cover in all coastal areas in the region and also offshore areas in the Baltic east from the Fehmarnbelt.

Table 4.48 Seasonal estimates of Common Eider abundance in the SPAs: Eastern Kiel Bight, Baltic Sea east of Wagrien, and Hyllekrog-Rødsand based on the spatial distribution models for the baseline aerial surveys from December 2008 to November 2010. Estimates for the alignment area, total non-SPA area, and total prediction area are also given.

SPA / area	Period	Density	Estimate
Eastern Kiel Bight (DE1530-491)	Dec 2008-Feb 2009	175.5	124,112
	March 2009	178.1	125,906
	Apr-Sep 2009	2.5	1,793
	Oct 2009	105.1	74,343
	Nov 2009-Mar 2010	226.7	160,262
	Mar-Apr 2010	177.2	125,271
Baltic Sea east of Wagrien (DE1633-491)	Dec 2008-Feb 2009	46.8	17,194
	March 2009	44.9	16,488
	Apr-Sep 2009	1.3	485
	Oct 2009	20.8	7.658
	Nov 2009-Mar 2010	48.8	17,908
	Mar-Apr 2010	37.1	13,609
Hyllekrog-Rødsand (DK006X083)	Dec 2008-Feb 2009	11.7	2,882
	March 2009	8.7	2,144
	Apr-Sep 2009	8.0	1,962
	Oct 2009	4.6	1,126
	Nov 2009-Mar 2010	12.8	3,143
	Mar-Apr 2010	8.2	2,016
Alignment area	Dec 2008-Feb 2009	24.8	5,211
	March 2009	23.7	4,976
	Apr-Sep 2009	2.4	503
	Oct 2009	17.6	3,697
	Nov 2009-Mar 2010	35.2	7,395
	Mar-Apr 2010	23.8	4,989
Non-SPA area (including the alignment area)	Dec 2008-Feb 2009	32.3	110,275
	March 2009	30.7	104,829
	Apr-Sep 2009	2.5	1,793
	Oct 2009	17.0	57,870
	Nov 2009-Mar 2010	41.32	146,192
	Mar-Apr 2010	28.2	96,311
TOTAL	Dec 2008-Feb 2009	55.9	272,270
	March 2009	55.3	269,364
	Apr-Sep 2009	1.9	9,386
	Oct 2009	30.9	150,280
	Nov 2009-Mar 2010	67.5	327,505
	Mar-Apr 2010	51.9	252,682

Common Eider trends

Following a steep increase since the 1970-ies, the Baltic population of Common Eider has declined during the 1990-ies from an estimated 1.2 million in 1991 to 760,000 in 2000 (Desholm et al. 2002). A recent overview of seaduck populations wintering in the entire Baltic Sea has revealed similar figures suggesting about 50% in Common Eider population between 1993 and 2009 (Skov et al. 2011). The steepest decline has taken place in the northwest Kattegat, which used to be the most important wintering area of Common Eiders in the Baltic Sea (Durinck et al. 1994). Similarly, the south-western Kattegat now supports considerably fewer birds. The Kiel Bight-Little Belt-South Funen region has maintained its importance for the population of this species. The trend of wintering Common Eider abundance in the German part of the Fehmarnbelt follows this pattern and shows a yearly decline of 2.4 % between 1991 and 2009, the trend being significant (R^2=0.34, P=0.01; Figure 4.97; BIOLA 2009). The aerial monitoring surveys conducted in spring indicate a less pronounced decrease (R^2=0.12, P=0.29; BIOLA 2009, Figure 4.98).

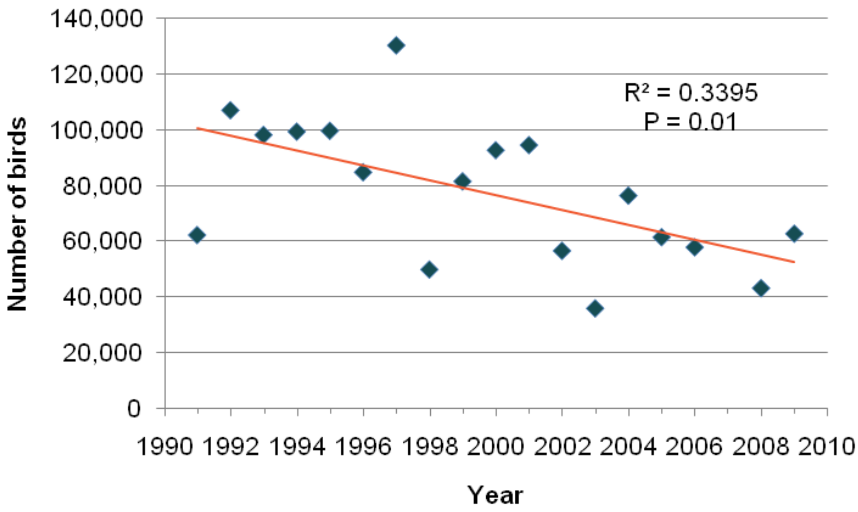


Figure 4.97 Numbers of wintering Common Eiders counted in Kiel Bight and Mecklenburg Bight in winters 1991-2009 show a declining trend. Numbers were obtained from the German aerial monitoring surveys of Schleswig-Holstein (BIOLA 2009).

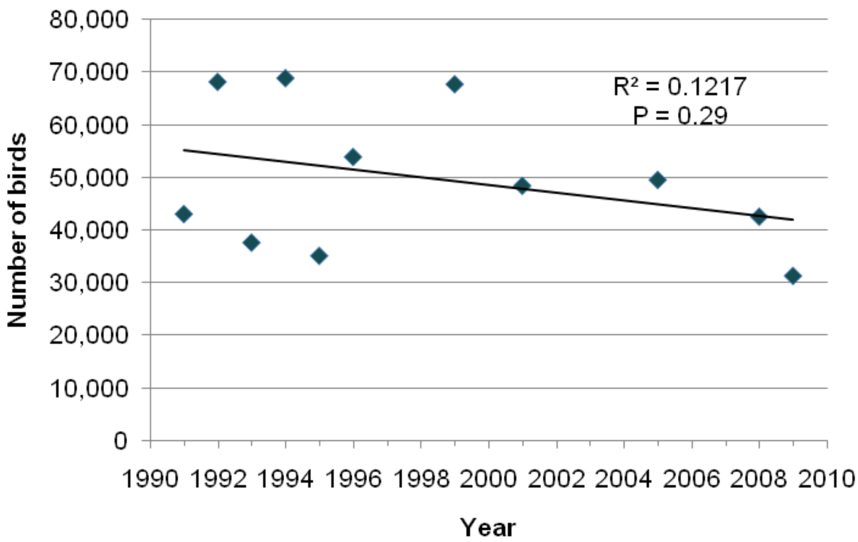


Figure 4.98 Numbers of staging Common Eiders counted in Kiel Bight and Mecklenburg Bight in March 1991-2009 show no significant trend. Numbers were obtained from the German aerial monitoring surveys of Schleswig-Holstein (BIOLA 2009).

The decline in the populations of wintering Common Eiders in the southern Baltic may be related to a wide range of pressures related to conditions on the breeding grounds as well as in the wintering areas (Desholm et al. 2002). To what extent changing conditions in the wintering areas contribute to this decline is not clear.

Importance of the Fehmarnbelt to Common Eider
The total number of Common Eiders in the Western Palearctic has been estimated at between 1.82 and 2.38 million, of which 760,000 comprise the Wadden Sea – Baltic Sea population (Desholm et al. 2002; Wetlands International 2006). The uncertainties regarding the size of the flyway population are mainly due to uncertain estimates of the breeding populations in NW Russia and Iceland (Wetlands International 2006).

The FEBI baseline results suggest that up to 18% of the Western Palearctic winter population or up to 43% of the Wadden Sea – Baltic Sea population winters in the Fehmarnbelt. Numbers of Common Eider in the Fehmarnbelt as estimated from the present study are higher than previous studies and possibly reflect a local increase against the background of a general decrease of the population. The feasibility study, however, reported similar estimates (Skov et al. 1998). This renders the Fehmarnbelt to be probably the most important region for this biogeographic population of Common Eider.

The baseline confirms the results of the feasibility study and monitoring programmes in both countries that Common Eiders aggregate on Flüggesand, Sagasbank, Stoller Grund, Albue Bank, Hyllekrog and Gedser Rev which harbour numbers of international importance. The very high importance of the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien to wintering Common Eiders has also been confirmed.

Common Eider – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	327,505
Max. abundance estimate in the alignment area:	7,395
Period of max. abundance in Fehmarnbelt:	November – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.91
Explanations:	Maximum abundance and distribution obtained from spatial modelling of aerial survey data. Although total numbers for separate ship-based surveys resulted in higher estimates than presented above, these figures were rejected due to either data collection or computational errors.

4.1.23 *Long-tailed Duck – Clangula hyemalis*

Long-tailed Duck – *Clangula hyemalis*

Biogeographic population: *W Siberia, N Europe (br)*

Breeding range: W Siberia, N Europe

Wintering / core non-breeding range: N Atlantic, Baltic, N Seas, C European Lakes

Population size: 4,600,000

1 % value: 46,000*

Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC EU Threat Status: secure
Target species in SPAs:	Eastern Kiel Bight (DE1530-491) Baltic Sea east of Wagrien (DE1633-491)

Key food: bivalves, crustaceans, fish

Period of presence in Fehmarnbelt: Wintering, migrations: October – April

* For populations over 2 million birds, Ramsar Convention criterion 5 (20,000 or more waterbirds) applies.

Origin of Long-tailed Duck in the Fehmarnbelt

The Danish Bird Migration Atlas includes two recoveries of ringed Long-tailed Ducks in Denmark, both from the greater Fehmarnbelt area. One bird ringed as a duckling in Lapland was shot west of Langeland and the other bird ringed as a juvenile in western Greenland was shot at Gedser (Bønløkke et al. 2006).

Six Long-tailed Ducks (5 males and 1 female) have been tracked beyond wintering season while conducting FEBI satellite telemetry studies. All these individuals migrated to the high Arctic and spent the breeding season at the coast of the Kara Sea or inland on Gydan and Yamal Peninsulas (Figure 4.99). On their northward migration, all birds moved to the NW Baltic in a stepwise pattern and spent about a month at the coast of Estonia before crossing to the White Sea and continuing further northeast following the retreating ice in the Arctic Ocean (Figure 4.99).

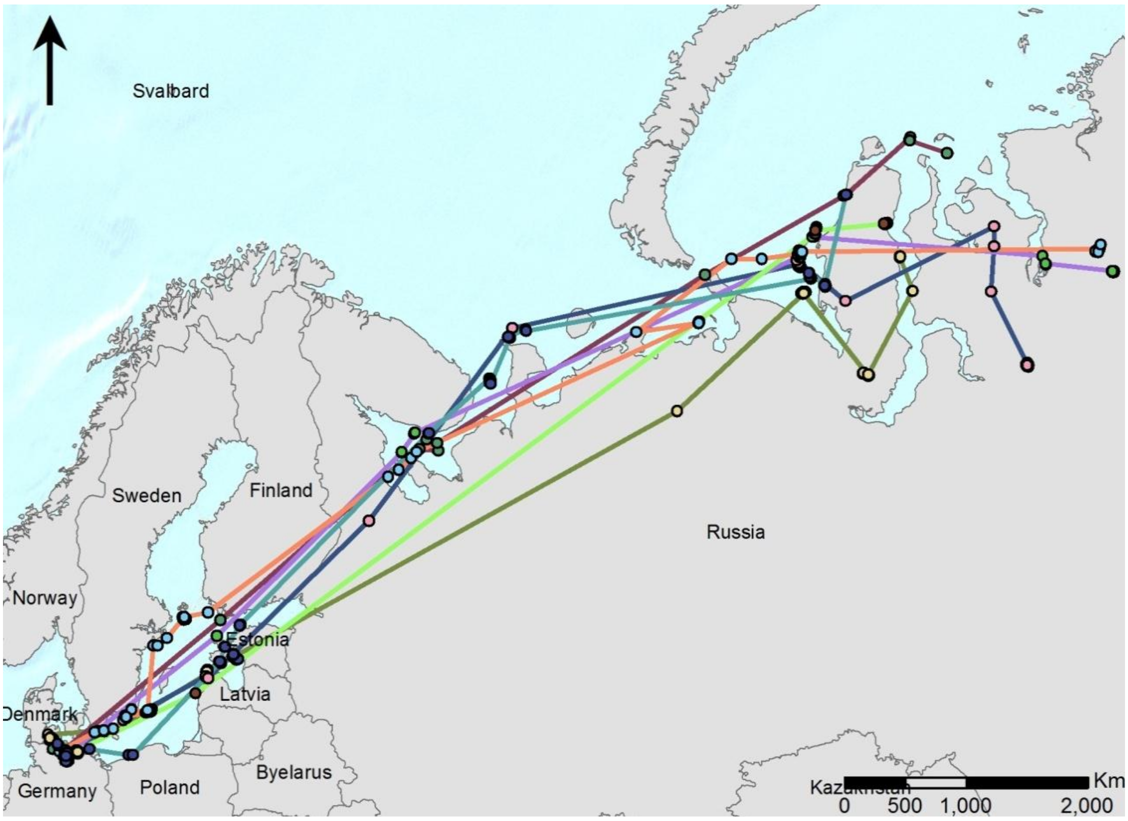


Figure 4.99 *Paths of 6 Long-tailed Ducks equipped with satellite transmitters show spring migration to the breeding grounds in the Kara Sea region. Representation of the tracks was restricted to March-June 2010. The trajectories do not indicate the flight paths, but connect recorded bird positions.*

Data sources on Long-tailed Duck in the Fehmarnbelt

Numbers and distribution of Long-tailed Ducks are well reflected in FEBI aerial and ship-based survey data, but both methods have own advantages and disadvantages. Aerial surveys had broader spatial coverage of the study region but possibly poorer detectability of this species compared to ship-based surveys. Therefore, both survey platforms were considered equally when assessing abundance and distribution of the Long-tailed Duck (Table 4.49).

Table 4.49 *List of datasets and their use in baseline assessment of Long-tailed Duck in the Fehmarnbelt.*

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating Long-tailed Duck densities, abundance and habitat use.
FEBI ship transect surveys	Primary dataset for estimating Long-tailed Duck densities, abundance and habitat use. Also used to represent variability in bird densities in different periods.
FEBI satellite telemetry	Supporting dataset in assessing habitat use, and site fidelity.
OAG land-based counts	Supporting dataset representing species distribution along the German coast.
NOVANA aerial surveys	Supporting dataset for densities and distribution of the species in Danish part of the Fehmarnbelt

Abundance of Long-tailed Duck in the Fehmarnbelt

Long-tailed Duck abundance estimates based on Distance analysis

The abundance of Long-tailed Ducks in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Long-tailed Duck during aerial surveys, calculated using the entire dataset, were 188 m for swimming birds and 204 m for flying birds. These detection functions are slightly lower than those estimated for e.g., Common Eider and Common Scoter. Poorer detection of Long-tailed Ducks can be explained by the smaller size of this duck, light plumage and foraging behaviour when birds spend a substantial proportion of daylight hours foraging underwater (reported further in chapter 5).

The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of Long-tailed Ducks have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.50, Appendix V). Often partial coverage most likely resulted in minimum estimates for this species. The highest reliable estimate of nearly 16,000 birds was obtained for the survey conducted in late March 2010.

Table 4.50 Numbers of observed Long-tailed Ducks during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	79	1,795	3.70	1.64	8.36	14,585
Dec-08	81.7	180	1,457	2.94	1.71	5.08	11,728
Jan-09	82.8	237	1,298	2.58	1.59	4.19	10,399
Feb-09	100	182	1,253	1.76	1.12	2.76	8,575
Mar-09	77.5	254	1,849	3.69	2.53	5.39	13,925
Apr-09	86.8	4	6	0.01	0.00	0.05	52
May-09	77.3	0	0	0	0	0	0
Jun-09	80.9	1	1	0.00	0.00	0.01	10
Jul-09	86.6	1	1	0.00	0.00	0.01	8
Aug-09	92.3	0	0	0	0	0	0
Sep-09	79.1	0	0	0	0	0	0
Oct-09	79.9	15	243	0.89	0.20	4.15	3,475
Nov-09	82.4	147	1,919	3.43	0.80	15.11	13,775
Dec-09	24.7	69	248	1.66	0.80	3.44	1,998
Mar-10 A	64.1	205	1,126	2.61	1.46	4.67	8,160
Mar-10 B	75.6	165	1,945	4.33	2.78	6.77	15,953
Apr-10	100	109	689	1.11	0.66	1.87	5,427
May-10	92.1	3	12	0.03	0.00	0.64	120

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Jun-10	70.8	0	0	0	0	0	0
Aug-10	75.6	0	0	0	0	0	0
Sep-10 A	44.9	0	0	0	0	0	0
Sep-10 B	48.9	0	0	0	0	0	0
Oct-10	80.0	4	8	0.02	0.01	0.06	66
Nov-10	70.1	57	326	0.67	0.20	2.25	2,281

The ESW for Long-tailed Duck during ship-based surveys, estimated for the entire dataset was 162 m, indicating a rather poor detectability of the species. Long-tailed Duck densities typically ranged between 10 and 20 birds/km^2 in coastal areas and never exceeded 1 bird/km^2 in offshore areas during wintering period (Table 4.51). Total numbers in the area covered by ship-based surveys reached 20,000 individuals for several surveys with the highest estimate exceeding 44,000 birds in April 2010, however confidence intervals were usually broad.

Estimates for Long-tailed Duck from ship-based surveys indicate higher densities and total numbers than obtained for aerial surveys (Table 4.51). This can be explained by better detectability of this species from slower-moving observation platform (ship). Long-tailed Ducks spend a substantial proportion of day-time foraging underwater (see chapter 5), and therefore can be easily missed when counting from a plane.

Table 4.51 Numbers of observed Long-tailed Ducks during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km^2 covered by ship-based surveys. <u>Note</u>: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	186	1,442	13.27	41	5.98	29.44	8.40	3.78	18.69	75	8.84	20,686
	offshore	4	6	0.13	52	0.04	0.42				15		
Dec-08	coastal	196	1,459	18.14	38	8.69	37.87	11.04	5.29	23.09	49	11.35	26,564
	offshore	1	1	0.03	94	0.01	0.15				5		
Jan-09	coastal	287	989	12.78	29	7.17	22.76	-	-	-	76	-	-
	offshore	3	11	-	***	-	-				6		
Feb-09	coastal	292	1,071	11.96	22	7.72	18.52	8.01	5.14	12.60	56	8.27	19,353
	offshore	5	9	0.27	67	0.07	0.97				5		
Mar-09	coastal	287	1,288	12.14	26	7.25	20.33	-	-	-	89	-	-
	offshore	5	28	-	208	-	-				2		
Apr-09	coastal	242	1,830	17.08	38	8.14	35.83	-	-	-	28	-	-
	offshore	3	10	-	***	-	-				0		
May-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Jul-09A	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jul-09B	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Aug-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Oct-09	coastal	11	95	0.42	84	0.10	1.84	0.32	0.07	1.40	16	0.40	942
	offshore	0	0	0	0	0	0				0		
Nov-09	coastal	105	866	11.41	51	4.32	30.16	7.43	2.80	19.72	53	7.73	18,083
	offshore	3	4	0.14	84	0.03	0.62				14		
Dec-09	coastal	187	1,122	10.96	39	5.14	23.37	7.27	3.39	15.69	132	7.84	18,339
	offshore	1	8	0.18	95	0.03	0.96				0		
Jan-10	coastal	200	563	5.96	24	3.73	9.50	4.08	2.52	6.67	17	4.16	9,732
	offshore	13	27	0.42	53	0.15	1.15				2		
Feb-10A	coastal	267	1,655	20.13	27	11.92	34.00	-	-	-	60	-	-
	offshore	19	66	-	995	-	-				2		
Feb-10B	coastal	282	2,050	15.37	19	10.50	22.50	-	-	-	33	-	-
	offshore	15	35	-	***	-	-				10		
Mar-10	coastal	346	1,528	14.03	22	9.10	21.62	9.76	6.22	15.82	48	9.97	23,325
	offshore	22	47	0.83	82	0.19	3.66				1		
Apr-10	coastal	173	4,056	27.91	62	9.00	86.56	18.78	6.05	58.31	48	18.99	44,431
	offshore	3	3	0.08	96	0.01	0.41				0		
May-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jun-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Oct-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Nov-10	coastal	37	713	8.88	65	2.72	29.01	6.00	1.83	19.65	51	6.22	14,547
	offshore	1	3	0.07	98	0.01	0.39				1		

Month-to-month variation in Long-tailed Duck occurrence in the Fehmarnbelt was assessed by comparing mean densities of swimming birds recorded during ship-based surveys (and corrected for distance detection bias), as rather consistent spatial coverage has been achieved during these counts. The species was present in the area during the wintering period and transitional months (November – April), and occurred at very low densities or was completely absent between May and October (Table 4.51, Figure 4.100).

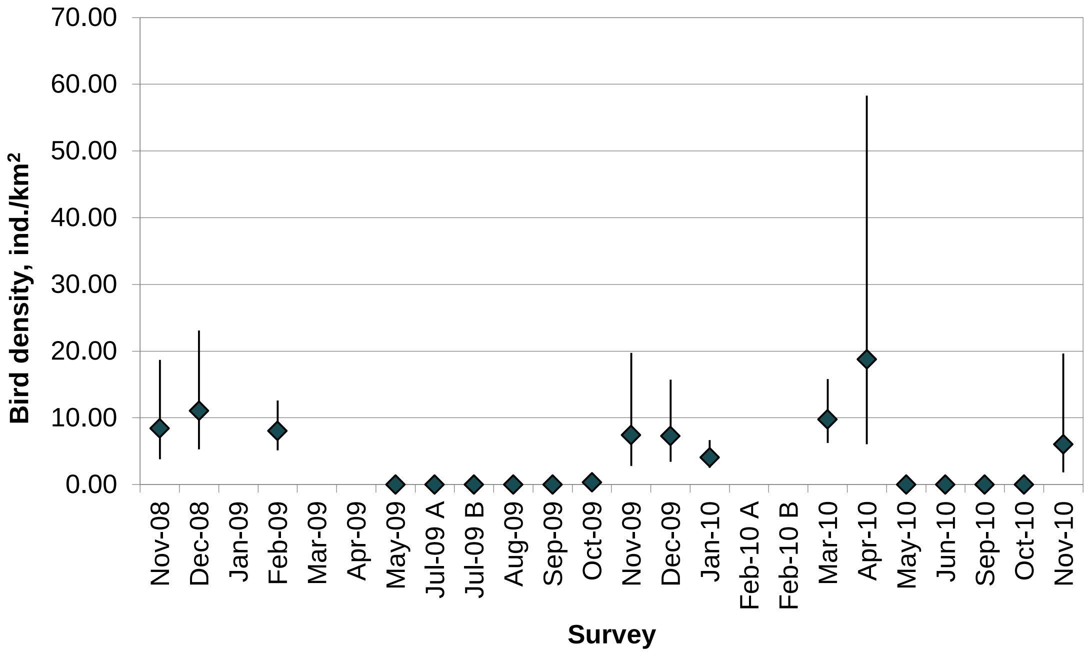


Figure 4.100 Mean density estimates and 95% confidence intervals of swimming Long-tailed Ducks estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150% were not included into the chart (see Table 4.51 for specific values).

Long-tailed Duck abundance estimates according to supplementary datasets

From German waterbird monitoring aerial surveys 1,663 Long-tailed Ducks are reported in Schleswig-Holstein in January 2009 (BIOLA 2009). These total numbers are difficult to compare with the results of FEBI baseline investigations due to differences in survey design (total counts *versus* line transect surveys) and coverage (surveying only shallow areas *versus* equal coverage of all depth strata), respectively. Furthermore, detection of seaducks is limited during aerial surveys, as it was demonstrated during the FEBI Distance analysis (see above) and found by others (Burt et al. 2010), but no correction of the distance-detection bias has been made for the German waterbird monitoring aerial counts (BIOLA 2009). In addition to the total counts, aerial transect surveys were also conducted in Baltic waters off Schleswig-Holstein, which covered both shallow and deep areas (BIOLA 2009). Although distance-correction has not been applied on transect data, Long-tailed Duck densities are reported for survey bands that are least affected by detection bias (i.e. proximate to an observer): 7.46 ind./km^2 in February 2008 and 6.57 ind./km^2 in February 2009 (BIOLA 2009). These densities are actually higher than the mean densities estimated during FEBI baseline aerial surveys (Table 4.50). This could be explained by the fact that German monitoring surveys focus at shallow coastal and offshore waters whereas FEBI baseline investigations cover the entire Fehmarnbelt evenly including extensive offshore areas with few birds.

According to the Danish aerial monitoring of wintering birds, Long-tailed Duck densities of up to 20 birds/km^2 have been recorded in the Danish part of the Fehmarnbelt, particularly in the Hyllekrog – Rødsand – Gedser area (Petersen et al. 2006; 2010).

Results from coastal mid-winter counts in Germany revealed only low numbers (about 160 birds in winter 2009) of Long-tailed Ducks in the inshore zone (AKVSW

2010, OAG 2010), which is not surprising as this species mostly use offshore habitats.

Distribution and habitat use of Long-tailed Duck in the Fehmarnbelt

Both aerial and ship-based surveys were considered for representing Long-tailed Duck distribution in the Fehmarnbelt (Appendix II). Therefore, spatial modelling was applied on data collected from both survey platforms.

Long-tailed Duck distribution and habitat use according to spatial modelling of aerial survey data

Distribution was modelled for the ‘winter’ period when Long-tailed Ducks are present in the Fehmarnbelt region. The ‘winter’ period was further categorised into two seasons: season 1 (December 2008 – March 2009) and season 2 (November 2009 – April 2010).

The most important variable in the presence/absence part of the model was the interaction term XY (easting and northing), which accounts for some of the spatial variance not accounted for by the environmental predictor variables. Water depth was the most important environmental variable according to the chi-square statistics (Table 4.52). The response curve indicates that the Long-tailed Duck prefers shallower waters and bird occurrence starts declining steeply at depths greater than 15 m (Figure 4.101A). Distance to land and number of ships were also included in the binomial part of the model. Presence of Long-tailed Ducks increased with increasing distance from land up until about 6 km and declined farther out. Bird occurrence declined also linearly with increasing number of ships (Figure 4.101A). The categorical variable representing season indicated that birds occurred over broader areas during season 1, than during season 2 (Figure 4.101A).

The positive part of the ‘winter’ model further explained relationships of bird densities to the environmental variables. Water depth was the most important predictor variable in the positive part, indicating a somewhat similar relationship as identified in the binomial part of the model with high duck densities at depths between 0 and 12 m then declining steeply (Table 4.52, Figure 4.101B). Other variables according to importance were distance to land, proportion of hard substrate, the interaction term XY, and the bottom slope (Table 4.52). The probability of increasing bird density increased linearly with distance to land (Figure 4.101B). It seems that Long-tailed Ducks prefer either soft or hard bottom sediments, as their densities decreased with increasing proportion of hard substrate at the beginning of the response curve. Also, the species densities increased with increasing bottom slope (Figure 4.101B). Long-tailed Duck densities appeared to be slightly higher in season 2 compared to season 1, but the difference was not statistically significant (Table 4.52, Figure 4.101B).

The ‘winter’ distribution model had a reasonably good fit. Deviance explained in the binomial part was 18.3% and 25.1% in the positive part (Table 4.52). Diagnostic plots of the positive part can be seen in Appendix III. The accuracy of the predictions in the binomial part of the model based on the AUC equalled 0.79 when the model was calibrated on 70 % and evaluated on 30%, and the Spearman’s Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.36 ($p < 2.2e-16$).

No significant ($p < 0.01$) spatial autocorrelation was found in the residuals of the presence/absence part of the model. In the positive part autocorrelation was present in 3 out of 10 lags (1 lag = 1,500 m which was the defined nearest neighbourhood). The Moran’s I values were, however, quite low ranging from -0.011 to 0.132 (Appendix III).

The models deployed show that Long-tailed Ducks between December 2008 and March 2009 and again in November 2009 and April 2010 occurred in highest densities in the offshore area of Sagasbank (Figure 4.102). Flüggesand, Stoller Grund, east of Fehmarnsund, south of Rødsand Lagoon and Gedser Rev also harboured medium densities (Figure 4.102). Densities of wintering Long-tailed Ducks were low in the immediate and neighbouring areas of the planned alignment of the fixed link.

Table 4.52 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the 'winter' period for Long-tailed Duck in the Fehmarnbelt according to aerial survey data. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	**Presence/absence**			**Positive part**		
	Z	**X^2**	**P**	**t**	**F**	**P**
Season 2	-5.06		<0.01	1.68		0.09
Mussel biomass		-	-		-	-
Depth		228.64	<0.01		21.69	<0.01
Proportion hard substrate		-	-		5.50	<0.01
Bottom slope		-	-		4.73	0.01
Distance to land		27.43	<0.01		6.44	0.01
Distance to wind farms		-	-		-	-
Number of ships		7.11	<0.01		-	-
XY		234.51	<0.01		5.17	<0.01
Model performance						
AUC	0.79					
Deviance explained	18.3 %			25.1 %		
Combined correlation (P)	0.36 (P < 2.2e-16)					

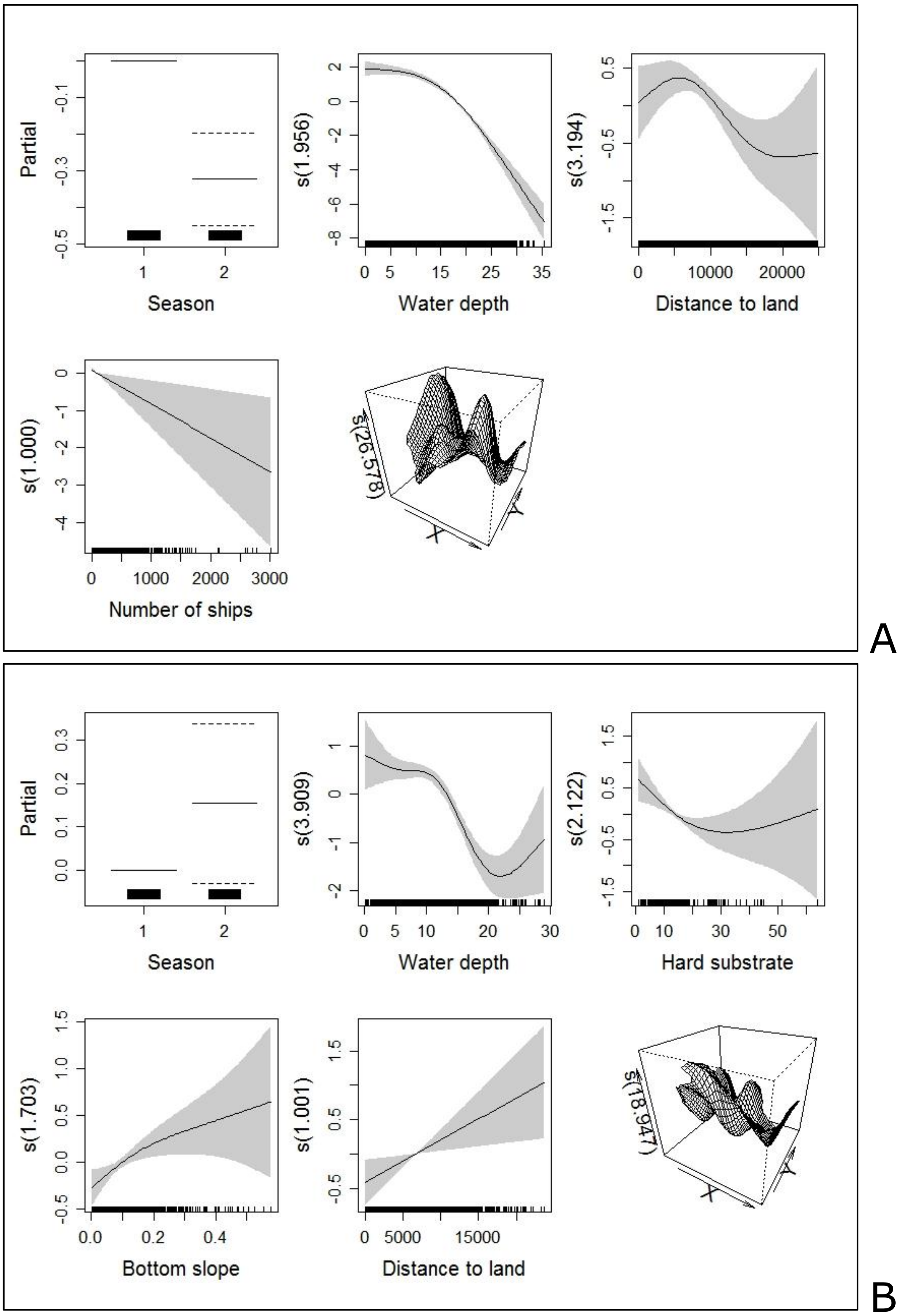
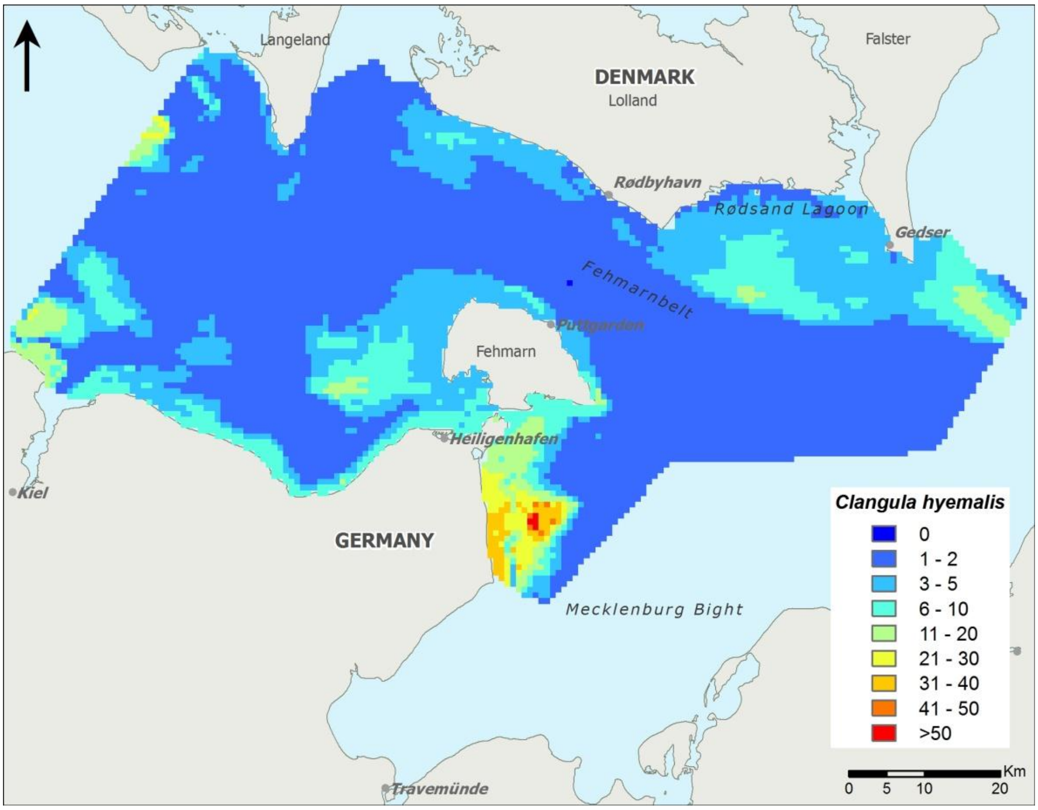


Figure 4.101 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence (A – binomial part of the model) or density (B – positive part of the model) of Long-tailed Duck in the Fehmarnbelt for the winter season according to aerial survey data. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.



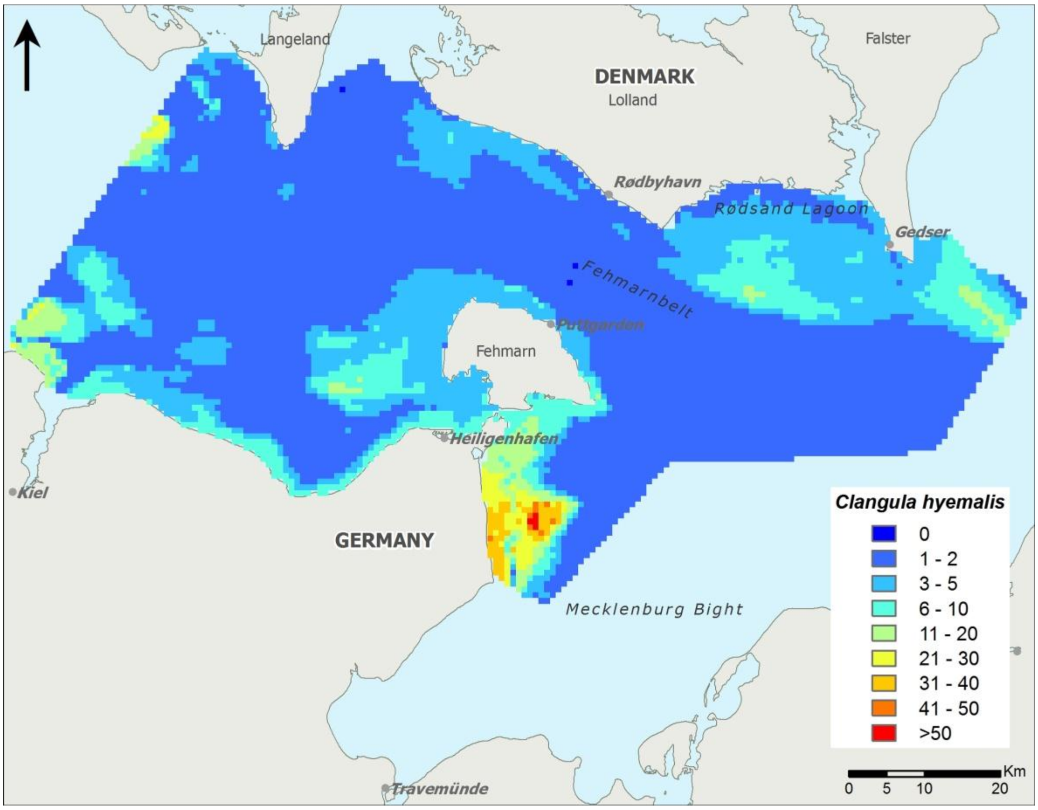


Figure 4.102 Spatial distribution models (numbers per km2) of Long-tailed Duck Clangula hyemalis *in the Fehmarnbelt based on baseline aerial surveys undertaken between December 2008 – March 2009 (upper map) and November 2009 – April 2010 (lower map).*

Long-tailed Duck distribution and habitat use according to spatial modelling of ship-based survey data

Distribution model on ship-based survey data was fitted for the 'winter' period when Long-tailed Ducks are present in the Fehmarnbelt region. The 'winter' period was further categorised into two seasons: season 1 (November 2008 – April 2009) and season 2 (November 2009 – March 2010).

The most important variable in the presence/absence part of the model was the interaction term XY (easting and northing), which accounts for some of the spatial variance not accounted for by the environmental predictor variables. Water depth was the most important environmental variable (Table 4.8). The response curve indicates that Long-tailed Ducks prefer shallower waters and bird occurrence declines at depths over 13 m (Figure 4.94A). Mussel biomass and proportion of hard substrate were also significant in the binomial part of the model. Presence of Long-tailed Ducks increased with increasing mussel biomass and declined with increasing coverage of hard substrate (Figure 4.94A). The categorical variable representing season indicated that birds occurred over broader areas during season 2 than during season 1 (Figure 4.94A).

The positive part of the 'winter' model further explained relationships of bird densities to the environmental variables. The interaction term XY was again the most important variable followed by water depth, which indicated decreasing bird densities with increasing water depth (Table 4.8, Figure 4.94B). Contrary to the presence/absence part of the model, Long-tailed Duck densities were increasing with increasing hard substrate cover. The probability of increasing bird density increased linearly with distance to land (Table 4.8, Figure 4.94B). Long-tailed Duck densities were not significantly different between the two study seasons (Table 4.8, Figure 4.94B).

The 'winter' distribution model according to ship-based surveys had a good fit. Deviance explained in the binomial part was 31.9 % and 45.2 % in the positive part (Table 4.8). Diagnostic plots of the positive part can be seen in Appendix III. The accuracy of the predictions in the binomial part of the model based on the AUC equalled 0.84, and the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.59 ($p < 2.2e-16$). No significant ($p < 0.01$) spatial autocorrelation was found in the residuals of either part of the model (Appendix III).

The deployed models show similar distribution as found according to aerial surveys: wintering Long-tailed Ducks occurred in highest densities in the offshore areas of Sagasbank and Flüggesand, and also east of Fehmarnsund (Figure 4.95). In the Danish side of the study area higher densities occurred off Gedser, Hyllekrog-Rødsand and SW of Lolland (Figure 4.95).

Table 4.53 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the 'winter' period for Long-tailed Duck in the Fehmarnbelt according to ship-based survey data. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	**Presence/absence**			**Positive part**		
	Z	**X^2**	**P**	**t**	**F**	**P**
Season 2	4.49		<0.01	-1.523		0.13
Mussel biomass		13.67	<0.01		-	-
Depth		37.15	<0.01		11.46	<0.01
Proportion hard substrate		5.81	0.02		4.03	<0.01
Bottom slope		-	-		-	-
Distance to land		-	-		3.59	0.06
Distance to wind farms		-	-		-	-
Number of ships		-	-		-	-
XY		166.59	<0.01		14.00	<0.01
Model performance						
AUC	0.84					
Deviance explained	31.9 %			45.2 %		
Correlation (combined)	0.59 (p < 2.2e-16)					

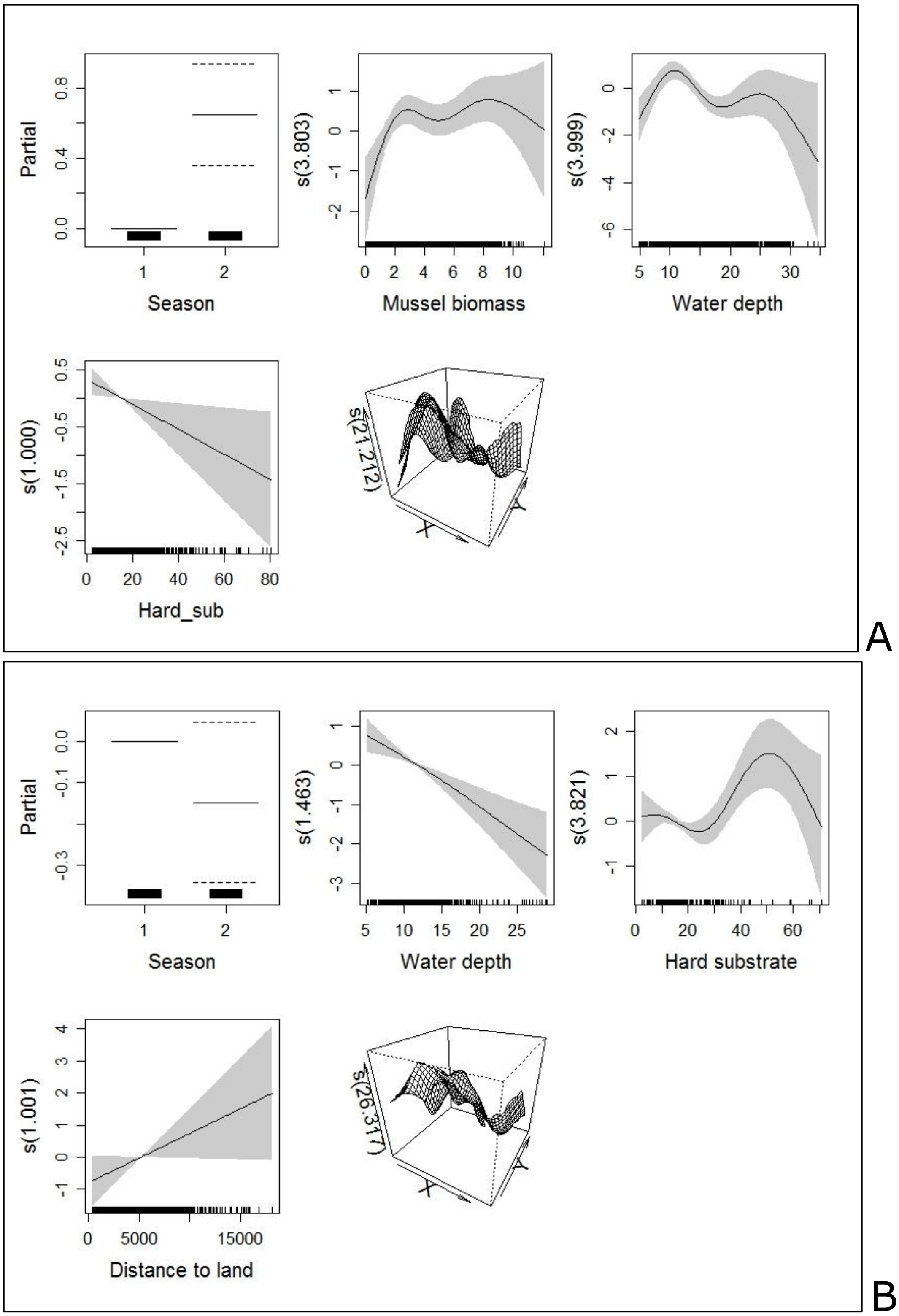
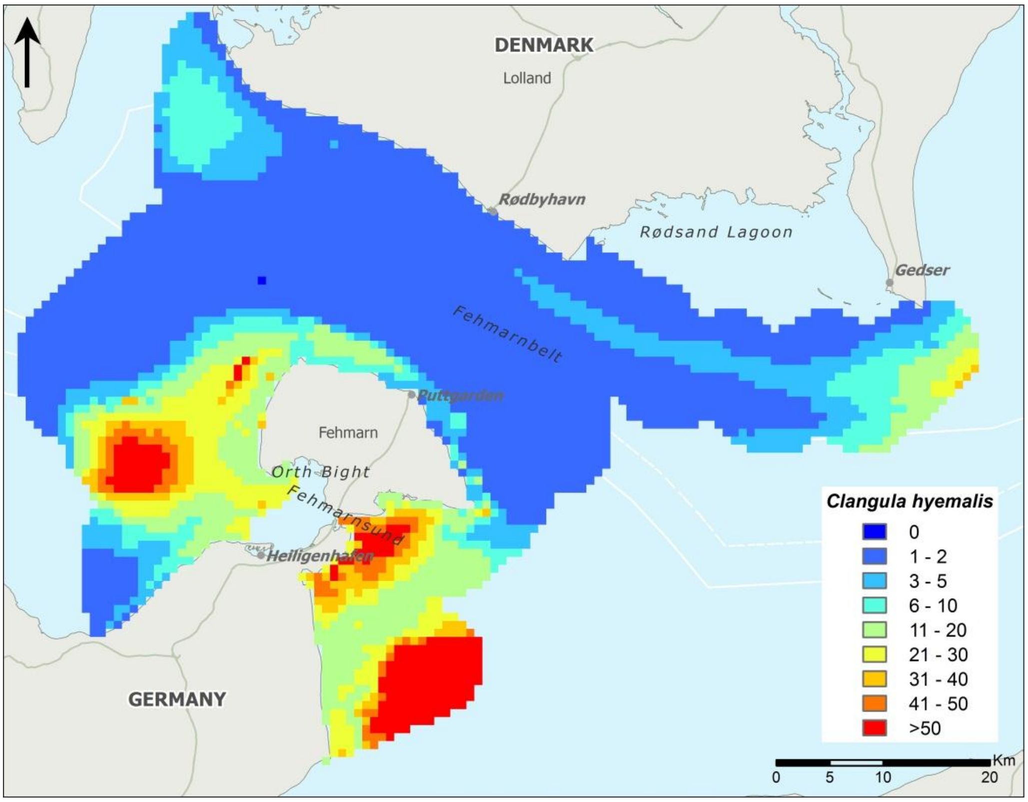


Figure 4.103 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Long-tailed Duck (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the winter season according to ship-based survey data. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.



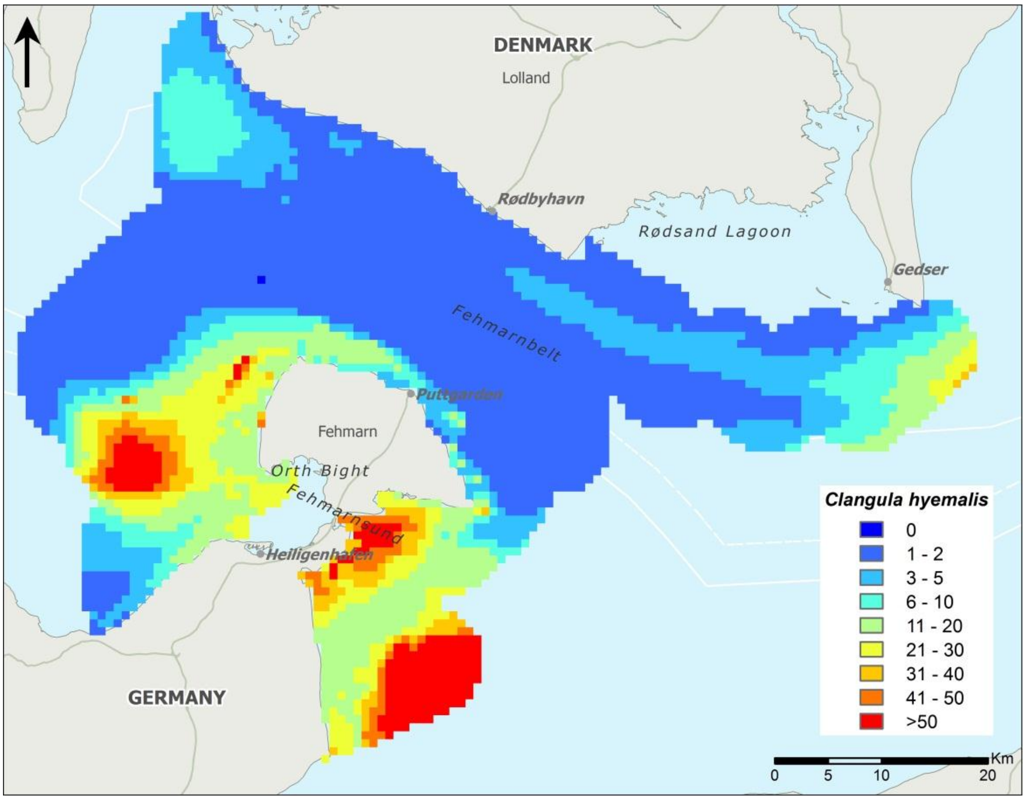
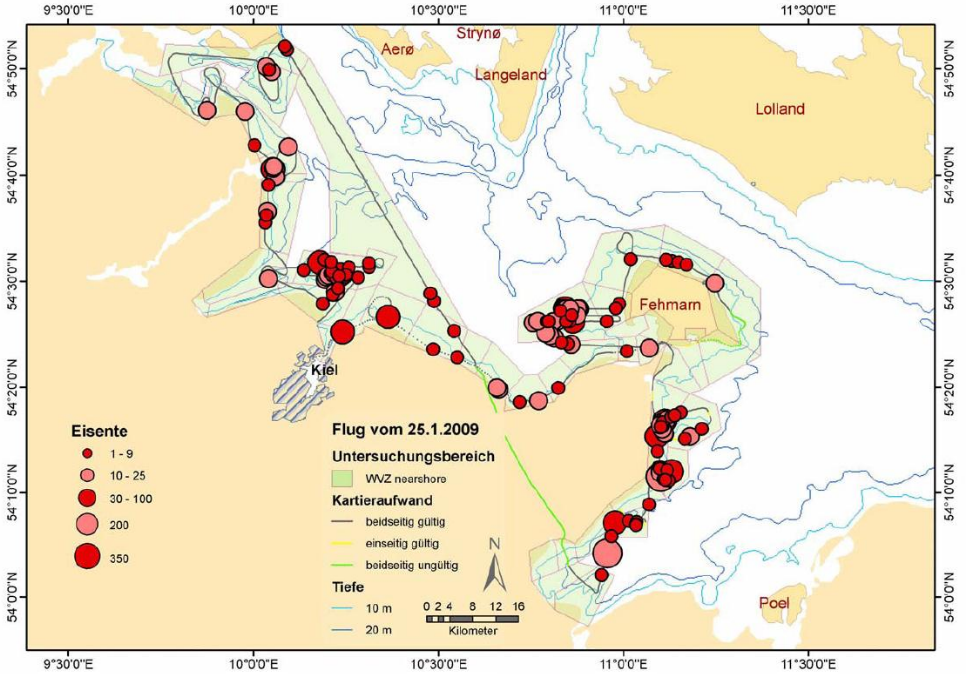


Figure 4.104 Spatial distribution models (numbers per km2) of Long-tailed Duck Clangula hyemalis *in the Fehmarnbelt based on baseline ship-based surveys undertaken between November 2008 – April 2009 (upper map) and November 2009 – March 2010 (lower map).*

Long-tailed Duck distribution according to supplementary datasets

Winter distribution of Long-tailed Ducks recorded during waterbird monitoring surveys in the Baltic waters of Schleswig-Holstein resembled closely the results of FEBI baseline investigations: the highest numbers were recorded on Sagasbank, Flüggesand and SW Kiel Bight (Figure 4.105; BIOLA 2009). Monitoring of wintering waterbirds in Denmark indicate that Long-tailed Ducks aggregate in Hyllekrog – Rødsand – Gedser area (Petersen et al. 2006, 2010), which is in agreement with results of FEBI baseline investigations.



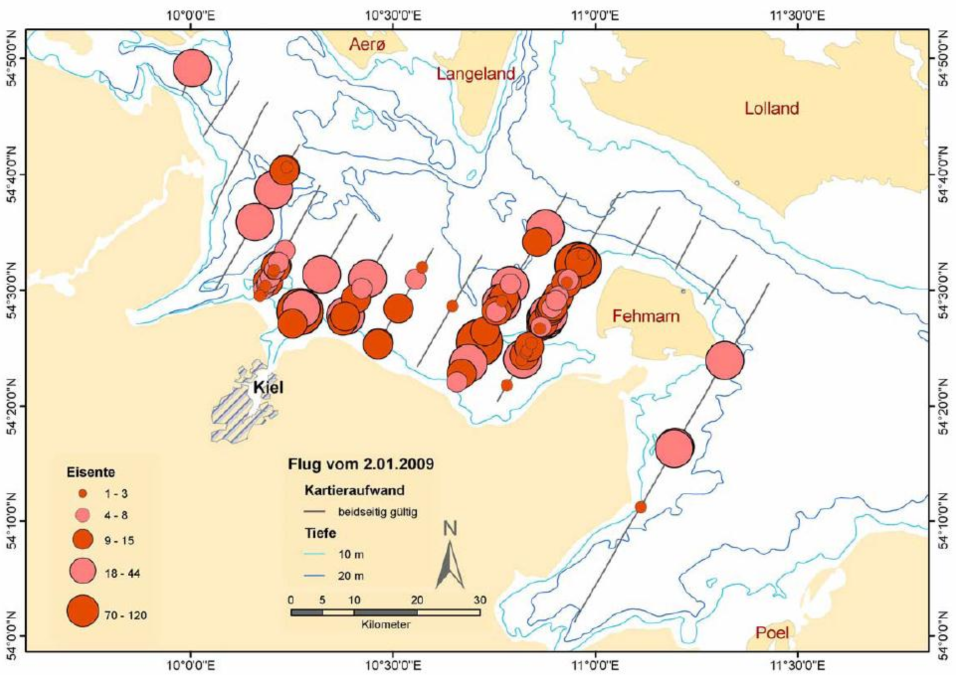


Figure 4.105 Long-tailed Duck winter distribution patterns documented during waterbird monitoring surveys in the Baltic waters of Schleswig-Holstein resembled closely the distribution of this species recorded during FEBI baseline investigations. Maps adapted from BIOLA (2009) with permission from the authors.

Long-tailed Duck abundance estimates for SPAs

Although aerial surveys achieved better spatial coverage of the Fehmarnbelt area, ship-based surveys resulted in higher estimates of Long-tailed Ducks according to both Distance analysis and spatial modelling. Therefore, using the precautionary principle, spatial modelling results of ship-based surveys were used to evaluate total numbers of this species in the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien. Since ship-based surveys did not cover Rødsand Lagoon, abundance assessment in the SPA Hyllekrog-Rødsand was based on spatial model according to aerial surveys.

Results of distribution modelling using ship-based data indicated that the SPA Eastern Kiel Bight hosted about 8,000 wintering Long-tailed Ducks (Table 4.54). The estimates for the SPA Baltic Sea east of Wagrien suggest nearly 11,000 Long-tailed Ducks wintering there during both winters of the study period. Between 700 and 800 birds were estimated to winter in the SPA Hyllekrog-Rødsand according to aerial survey data (Table 4.54).

The non-SPA area of the Fehmarnbelt covered by ship-based surveys supported an additional 3,500–4,000 Long-tailed Ducks during the study period (Table 4.54). Within the non-SPA area, about 220–280 individuals were estimated to winter in the immediate vicinity of the planned alignment (5 km around, see Figure 2.21 in Methods).

Overall FEBI estimates indicate that 0.5 % of the biogeographic population of Long-tailed Ducks winter in the Fehmarnbelt. Modelled densities of wintering birds of this species were substantially higher in the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien compared to those in the remaining area of the Fehmarnbelt (Table 4.54).

The total estimates obtained using the distribution modelling (Table 4.54, Appendix III) are close to the estimates of Distance analysis of ship-based survey data (Table 4.51). The distribution modelling predicted about 23,000 Long-tailed Ducks wintering in the study area and Distance analysis estimates ranged from 9,700 to 44,000, but most often were similar to the model predictions.

Table 4.54 Seasonal estimates of Long-tailed Duck abundance in the SPAs: Eastern Kiel Bight, Baltic Sea east of Wagrien, and Hyllekrog-Rødsand based on the spatial distribution models. Estimates for the alignment area, total non-SPA area, and total prediction area are also given. Note: the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien were not fully covered by ship-based surveys. Estimates were only calculated for the area covered by surveys.

Long-tailed Duck	Period	Density	Estimate
Eastern Kiel Bight*	Nov 2008 – Apr 2009	17.90	7,874
(DE1530-491)	Nov 2009 – Mar 2010	18.28	8,040
Baltic Sea east of Wagrien*	Nov 2008 – Apr 2009	34.64	10,989
(DE1633-491)	Nov 2009 – Mar 2010	34.42	10,919
Hyllekrog-Rødsand**	Dec 2008 – Mar 2009	3.22	791
(DK006X087)	Nov 2009 – Apr 2010	2.93	719
Alignment area*	Nov 2008 – Apr 2009	1.05	221
	Nov 2009 – Mar 2010	1.35	284
Non-SPA area (including*	Nov 2008 – Apr 2009	2.33	3,566
the alignment area)	Nov 2009 – Mar 2010	2.69	4,108
TOTAL	Nov 2008 – Apr 2009	9.61	23,200
	Nov 2009 – Mar 2010	9.89	23,786

** - based on ship-based survey data*
*** - based on aerial survey data*

Long-tailed Duck trends

The biogeographic population of Long-tailed Duck was identified as stable by Wetlands International and BirdLife International (BirdLife International 2004, Wetlands International 2006). However, a recent overview of seaduck populations wintering in the Baltic Sea and other sources suggests large-scale decline of this species (Nilsson 2008; Skov et al. 2011). Estimates of FEBI baseline investigations show that about 23,000 Long-tailed Ducks wintered in the Fehmarnbelt during the period of baseline investigations, which indicates a decline since 1993 when close to 100,000 birds were estimated for the same general area (Durinck et al. 1994). The Fehmarn Belt Feasibility Study provided an average estimate of 50,000 wintering Long-tailed Ducks during 1987-1995 (Skov et al. 1998).

However, results of German waterbird monitoring surveys in Schleswig-Holstein show no trend in numbers of wintering Long-tailed Ducks between 1991 and 2009 according to mid-winter surveys (R^2=0.01, P=0.75; Figure 4.106) and spring surveys in March (R^2=0.00, P=0.99; BIOLA 2009, Figure 4.107).

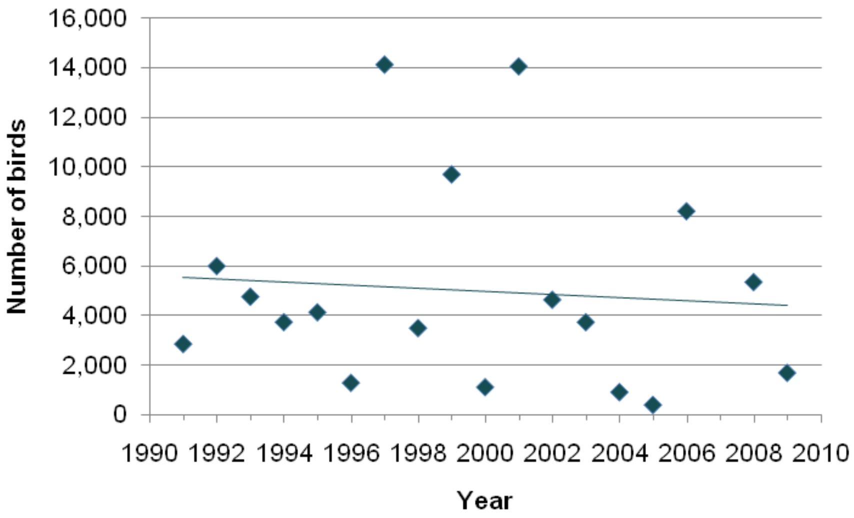


Figure 4.106 Numbers of wintering Long-tailed Ducks counted in Kiel Bight and Mecklenburg Bight in winters 1991-2009 do not show significant trend. Numbers were obtained from the German aerial monitoring surveys of Schleswig-Holstein (BIOLA 2009).

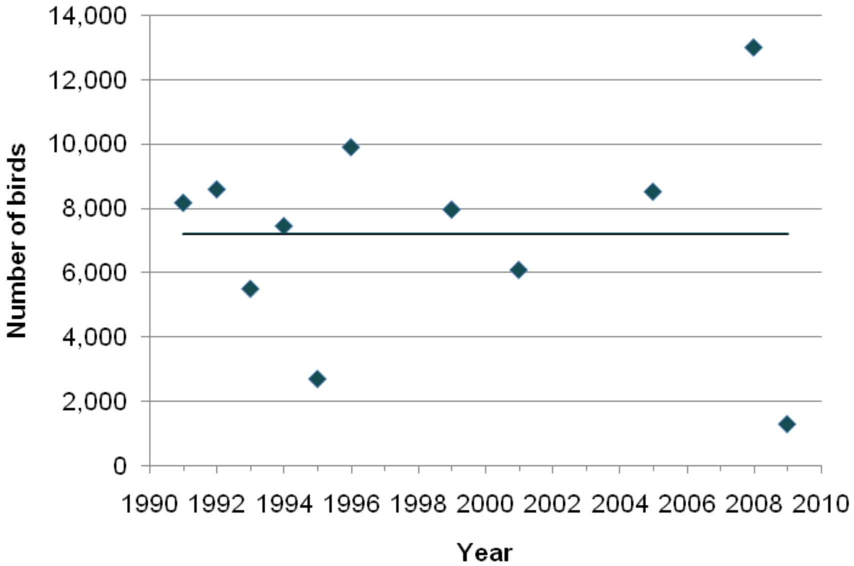


Figure 4.107 Numbers of staging Long-tailed Ducks counted in Kiel Bight and Mecklenburg Bight in March 1991-2009 indicate no trend. Numbers were obtained from the German aerial monitoring surveys of Schleswig-Holstein (BIOLA 2009).

Importance of the Fehmarnbelt to Long-tailed Duck

Considering the population size suggested by Wetlands International (2006), about 0.5 % of the biogeographic population of Long-tailed Duck regularly uses the Fehmarnbelt area. Accounting for the latest population decline by more than 50 % (Skov et al. 2011), Long-tailed Duck numbers would meet the 1 % criterion of international importance. The Southern Baltic, including Fehmarnbelt represents the southernmost end of the distribution range of the Long-tailed Duck (Durinck et al. 1994; Wetlands International 2006).

Long-tailed Duck – summary of information for EIA		
Max. abundance estimate in Fehmarnbelt:		23,800
Max. abundance estimate in the alignment area:		284
Season of max. abundance in Fehmarnbelt:		winter / spring (November – April)
Areas of max. abundance in Fehmarnbelt:		see Figure 4.95
Explanations:	Maximum abundance and distribution obtained from spatial modelling of ship-based survey data. Although total number for one ship-based survey resulted in higher estimate than presented above, that figure was considered of low reliability due to very broad confidence intervals.	

4.1.24 Common Scoter – Melanitta nigra

Common Scoter – *Melanitta nigra*

Biogeographic population: *M. n. nigra*

Breeding range: W Siberia, Scandinavia, Iceland, Scotland, Ireland

Wintering / core non-breeding range: Baltic, E Atlantic S to Mauritania

Population size: 1,600,000

1 % value: 16,000

Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC EU Threat Status: secure
Target species in SPAs:	Eastern Kiel Bight (DE1530-491) Baltic Sea east of Wagrien (DE1633-491)

Key food: molluscs, annelids, crustaceans; in fresh water also insect larvae and plants

Period of presence in Fehmarnbelt: Wintering, migrations: October – May

Origin of Common Scoter in the Fehmarnbelt

It is likely that Common Scoters utilising the Fehmarnbelt area during the non-breeding season represent birds breeding in northern Scandinavia to NW Siberia. The knowledge about origin of Common Scoters in the study area is very scarce due to lack of ring recoveries (Appendix IV). Only one individual that has been ringed in Kandalaksha Bay, White Sea, has been shot in the Little Belt, Denmark (Bønløkke et al. 2006).

Two Common Scoters (a male and a female) have been tracked while conducting FEBI satellite telemetry studies. One of these individuals (female) migrated for the breeding period to Malozemelskaya Tundra, SE of Kanin Peninsula (Figure 4.108), where it presumably nested as the bird spent 30 days inland before returning to marine waters of the Barents Sea. The tagged male did not leave the Baltic during the breeding season (Figure 4.108), which is not unusual for Common Scoters as large numbers of non-breeding birds, mostly males, have been reported to spend summer time in the Baltic and the Wadden Sea (Petersen et al. 2003, Mendel et al. 2008). (Movements of this individual (satellite-tagged male) were incorrectly interpreted as indicating eastward migration in FEBI ring recovery report (Appendix IV), as early conclusions have been made using pre-processed telemetry dataset.)

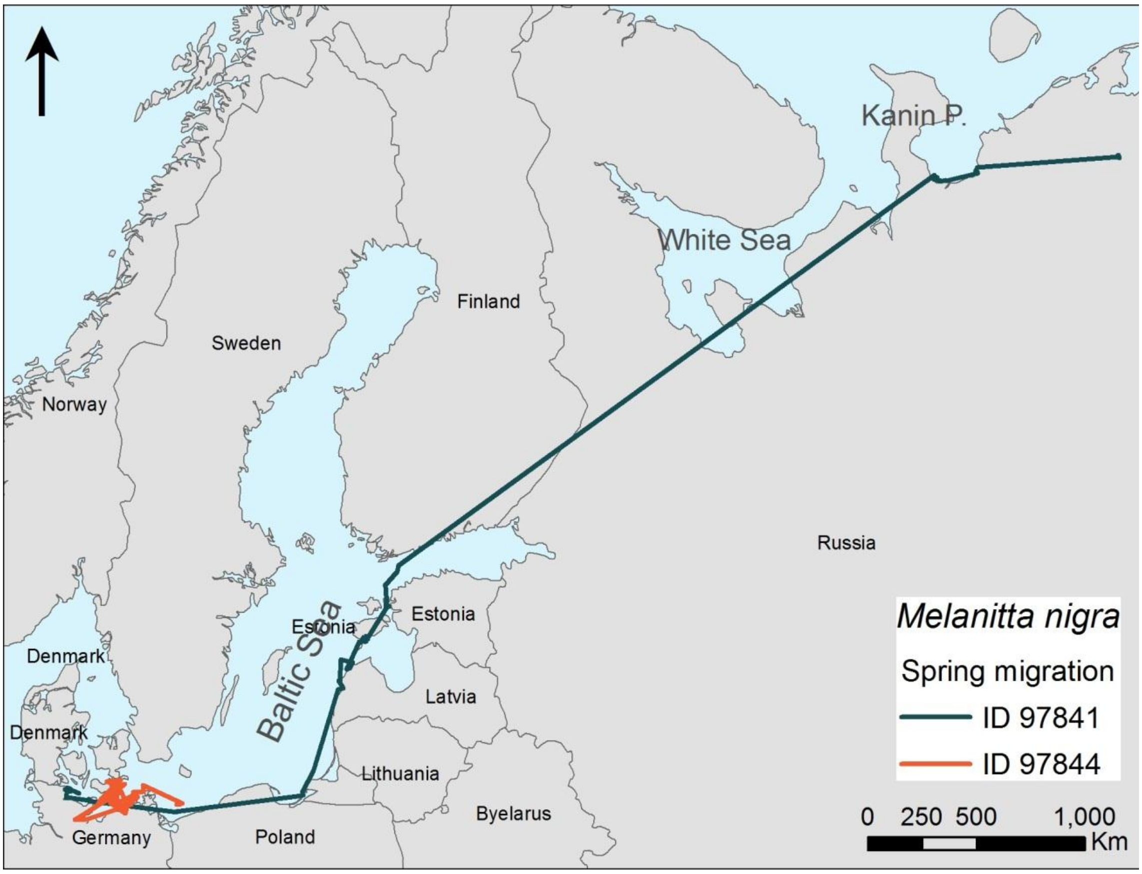


Figure 4.108 Migration paths of Common Scoters equipped with satellite transmitters show spring migration of the female (ID 97841) to the breeding area east of Kanin Peninsula, while the male (ID 97844) did not migrate and remained in the southern Baltic. Representation of the tracks was restricted to March-June 2010. The trajectory does not indicate the flight paths, but connects recorded bird positions.

Data sources on Common Scoter in the Fehmarnbelt

Numbers and distribution of Common Scoters are well reflected in FEBI aerial and ship-based survey data, but both methods have own advantages and disadvantages. Aerial surveys had broader spatial coverage of the study region but possibly poorer detectability of this species compared to ship-based surveys. Therefore, both survey platforms were considered equally when assessing abundance and distribution of the Common Scoter (Table 4.55).

Table 4.55 List of datasets and their use in baseline assessment of Common Scoter in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating Common Scoter densities, abundance habitat use.
FEBI ship transect surveys	Primary dataset for estimating species densities, abundance and habitat use. Also used to represent variability in bird densities in different periods.
FEBI satellite telemetry	Supporting dataset in assessing habitat use, and site fidelity.
OAG land-based counts	Supporting dataset representing species distribution along the German coast.
NOVANA aerial surveys	Supporting dataset for densities and distribution of the species in Danish part of the Fehmarnbelt

Abundance of Common Scoter in the Fehmarnbelt

Common Scoter abundance estimates based on Distance analysis

The abundance of Common Scoter in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Common Scoter during aerial surveys, calculated using the entire dataset, were 283 m for swimming birds and 278 m for flying birds. Estimated detection functions and ESWs fall within similar ranges as found by other authors for Common Scoter using aerial surveys. The ESW varied between 182-287 m for Common Scoter in the Camarthen Bay (Burt et al. 2010). Curves representing detection functions also indicated a similar detectability of Common Scoter in the North Sea (Figure 1 in Petersen 2007). Although similar, these detection functions are not directly comparable to the ESWs obtained for the FEBI aerial surveys due to different width of transects.

The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of Common Scoters have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.56, Appendix V). Often partial coverage most likely resulted in minimum estimates for this species. The highest estimate of nearly 34,500 birds was obtained for the survey conducted in December 2008 and several other surveys also indicated numbers exceeding 30,000 individuals (Table 4.56).

Table 4.56 Numbers of observed Common Scoters during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	73	7,624	6.76	2.23	20.77	26,669
Dec-08	81.7	263	17,655	8.66	3.66	20.49	34,475
Jan-09	82.8	61	675	0.84	0.36	1.97	3,405
Feb-09	100	428	5,682	6.60	3.33	13.11	32,157
Mar-09	77.5	465	8,169	6.33	3.36	12.12	23,898
Apr-09	86.8	6	74	0.12	0.04	0.40	522
May-09	77.3	1	35	0.05	0.01	0.26	172
Jun-09	80.9	1	24	0.04	0.01	0.24	168
Jul-09	86.6	0	0	0	0	0	0
Aug-09	92.3	2	6	0.01	0.00	0.04	39
Sep-09	79.1	3	23	0.04	0.01	0.20	142
Oct-09	79.9	63	581	0.83	0.30	2.32	3,246
Nov-09	82.4	165	5,605	7.61	2.95	19.82	30,585
Dec-09	24.7	62	2,663	3.94	1.45	10.85	4,750
Mar-10 A	64.1	192	3,145	3.64	1.83	7.25	11,375
Mar-10 B	75.6	190	8,513	8.78	2.74	30.08	32,369

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Apr-10	100	288	4,653	3.65	1.50	9.09	17,784
May-10	92.1	2	11	0.01	0.00	0.15	56
Jun-10	70.8	1	1	0.00	0.00	0.01	6
Aug-10	75.6	1	4	0.01	0.00	0.03	21
Sep-10 A	44.9	3	11	0.03	0.01	0.19	72
Sep-10 B	48.9	5	218	0.23	0.07	0.72	541
Oct-10	80.0	18	203	0.28	0.09	0.86	1,094
Nov-10	70.1	70	740	1.18	0.44	3.17	4,048

The ESW for Common Scoter during ship-based surveys, estimated for the entire dataset, was 213 m. Estimated Common Scoter densities were variable and ranged between 10 and 50 birds/km^2 during wintering period (Table 4.57). Reflecting estimated densities, total numbers in the area covered by ship-based surveys ranged from 25,000 to over 100,000 individuals during winter months, however confidence intervals were often broad.

Estimates for Common Scoter from ship-based surveys indicate higher densities and total numbers than obtained for aerial surveys (Table 4.57). This can be explained by better detectability of this species from slower-moving observation platform (ship). Also, similar to other seaducks, Common Scoters presumably spend a substantial proportion of day-time foraging underwater, and therefore can be simply missed when counting from a plane. Furthermore, Common Scoter is one of the most sensitive species to disturbance and flees from approaching survey planes or ships at large distances (Schwemmer et al. 2011). This may not only reduce bird detection, but also have opposite effect and lead to an overestimation of this species due to double counts in neighbouring transects

Table 4.57 Numbers of observed Common Scoters during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km^2 covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	172	3,583	41.44	56	14.56	117.96	26.15	9.18	74.58	98	26.79	62,692
	offshore	4	13	0.15	77	0.03	0.85				35		
Dec-08	coastal	200	3,676	46.18	58	15.52	137.38	28.09	9.44	83.56	88	28.65	67,052
	offshore	0	0	0	0	0	0				11		
Jan-09	coastal	205	2,162	14.99	28	8.64	26.01	9.98	5.75	17.31	195	10.81	25,302
	offshore	0	0	0	0	0	0				2		
Feb-09	coastal	282	2,283	17.10	28	9.88	29.61	-	-	-	86	-	-
	offshore	3	8	-	***	-	-				10		

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Mar-09	coastal	387	6,687	57.38	35	28.95	113.75	38.28	19.30	75.95	326	39.71	92,912
	offshore	3	12	0.21	53	0.08	0.60				6		
Apr-09	coastal	297	2,031	15.48	30	8.59	27.92	10.26	5.66	18.90	169	11.18	26,164
	offshore	2	12	0.21	96	0.03	1.56				50		
May-09	coastal	4	29	0.89	133	0.05	17.13	0.59	0.03	11.34	44	0.78	1,820
	offshore	0	0	0	0	0	0				0		
Jul-09A	coastal	1	1	0.01	102	0.00	0.05	0.01	0.00	0.03	17	0.08	190
	offshore	0	0	0	0	0	0				0		
Jul-09B	coastal	1	9	0.10	94	0.02	0.49	0.06	0.01	0.31	1	0.07	153
	offshore	0	0	0	0	0	0				0		
Aug-09	coastal	3	8	-	***	-	-	-	-	-	7	-	-
	offshore	0	0	0	0	0	0				0		
Sep-09	coastal	2	2	0.02	67	0.01	0.06	0.01	0.00	0.04	1	0.02	38
	offshore	0	0	0	0	0	0				0		
Oct-09	coastal	48	447	2.41	56	0.86	6.79	-	-	-	32	-	-
	offshore	2	5	-	***	-	-				0		
Nov-09	coastal	124	1,897	21.57	45	9.23	50.44	13.98	5.97	32.79	103	14.53	34,007
	offshore	1	5	0.09	101	0.02	0.51				20		
Dec-09	coastal	174	7,038	24.51	45	10.44	57.53	16.32	6.90	38.98	236	17.36	40,627
	offshore	4	66	0.60	101	0.11	3.38				5		
Jan-10	coastal	194	5,366	24.92	40	11.60	53.51	-	-	-	54	-	-
	offshore	16	424	-	***	-	-				0		
Feb-10A	coastal	341	10,844	81.59	39	38.78	171.66	55.30	25.52	158.46	208	-	-
	offshore	24	234	-	342	-	-				1		
Feb-10B	coastal	203	6,499	74.92	56	26.76	209.77	51.07	18.07	145.13	45	51.26	119,942
	offshore	15	131	3.85	85	0.86	17.17				0		
Mar-10	coastal	506	9,226	90.94	35	45.95	180.00	-	-	-	148	-	-
	offshore	8	23	-	***	-	-				17		
Apr-10	coastal	150	5,055	49.72	81	12.07	204.87	-	-	-	104	-	-
	offshore	4	17	-	***	-	-				26		
May-10	coastal	1	2	0.02	98	0.00	0.10	0.01	0.00	0.07	0	0.04	102
	offshore	0	0	0	0	0	0				7		
Jun-10	coastal	2	25	-	***	-	-	-	-	-	0	-	-
	offshore	0	0	0	0	0	0				0		
Sep-10	coastal	8	72	0.44	80	0.10	1.90	0.29	0.07	1.26	23	0.43	1,007
	offshore	0	0	0	0	0	0				8		
Oct-10	coastal	44	356	4.63	78	1.17	18.34	3.11	0.78	12.38	39	3.29	7,699
	offshore	1	3	0.06	102	0.01	0.34				1		
Nov-10	coastal	84	1,713	13.78	81	3.33	57.08	9.28	2.24	38.42	5,197	31.05	72,660
	offshore	0	0	0	0	0	0				55		

Month-to-month variation in Common Scoter occurrence in the Fehmarnbelt was assessed by comparing mean densities of swimming birds recorded during ship-based surveys (and corrected for distance detection bias), as rather consistent spatial coverage has been achieved during these counts. The species was present in the area during the wintering period and transitional months (November – April), and occurred only at very low densities between May and October (Table 4.57, Figure 4.109).

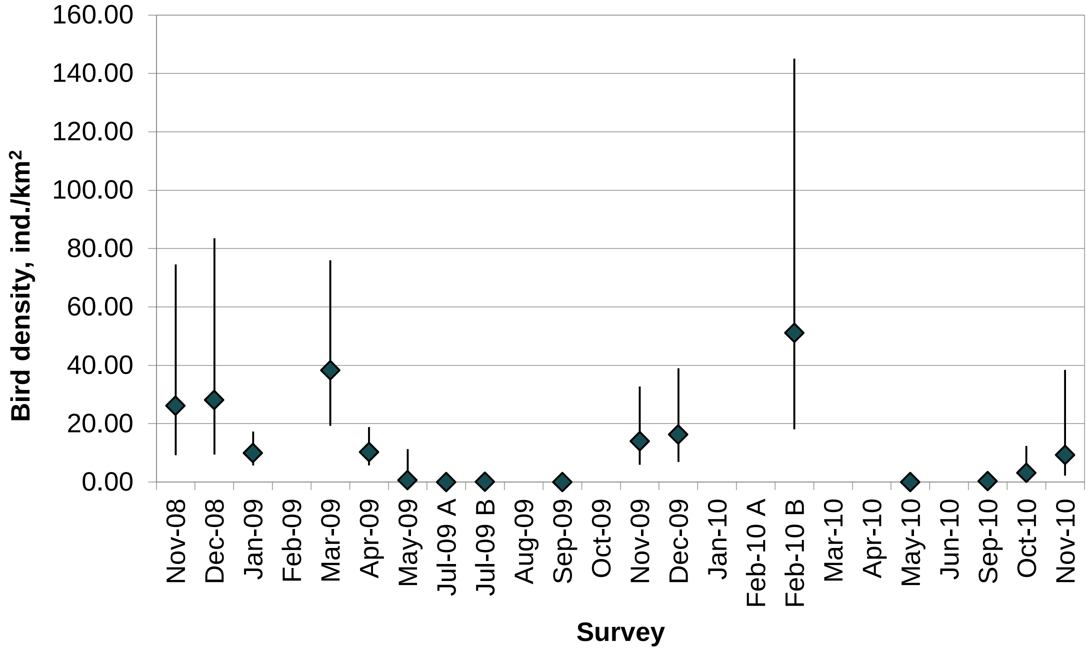


Figure 4.109 Mean density estimates and 95% confidence intervals of swimming Common Scoters estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150% were not included into the chart (see Table 4.57 for specific values).

Common Scoter abundance estimates according to supplementary datasets

The German waterbird monitoring aerial surveys report 10,700 Common Scoters counted in Schleswig-Holstein in January 2009 (BIOLA 2009). These total numbers are difficult to compare to the results of FEBI baseline investigations due to differences in survey design (total counts *versus* line transect surveys) and coverage (surveying only shallow areas *versus* equal coverage of all depth strata), respectively. Furthermore, the detection of seaducks is limited during aerial surveys, as it was demonstrated during the FEBI Distance analysis (see above) and found by others (Burt et al. 2010), but no correction of the distance-detection bias has been made for the German waterbird monitoring aerial counts (BIOLA 2009). In addition to the total counts, aerial transect surveys were also conducted in Baltic waters off Schleswig-Holstein, which covered both shallow and deep water areas (BIOLA 2009). Although distance-correction has not been applied on transect data, Common Scoter densities are reported for survey bands that are least affected by detection bias (i.e. proximate to an observer): 2.22 ind./km^2 in February 2008 and 6.77 ind./km^2 in February 2009 (BIOLA 2009). These densities are in line with those of the FEBI baseline aerial surveys (Table 4.56).

According to the Danish aerial monitoring of wintering birds, very few Common Scoters have been recorded in the Danish part of the Fehmarnbelt (Petersen et al. 2006; 2010).

Results from mid-winter coastal counts in Germany in 2009 revealed only low numbers of Common Scoters in the inshore zone (300 birds), reflecting a poor coverage of this mostly offshore species by coastal counts (AKVSW 2010, OAG 2010). Mid-winter survey in 2010 revealed higher number of 11,500 Common Scoters for the same area (AKVSW 2010, OAG 2010).

Distribution and habitat use of Common Scoter in the Fehmarnbelt

Both aerial and ship-based surveys were considered for representing Common Scoter distribution in the Fehmarnbelt (Appendix II). Therefore, spatial modelling was applied on data collected from both survey platforms.

Common Scoter distribution and habitat use according to spatial modelling of aerial survey data

Distribution model was fitted for the 'winter' period when Common Scoters are most abundant in the Fehmarnbelt region. The 'winter' period was further categorised into 2 seasons: season 1 (December 2008 – March 2009) and season 2 (November 2009 - April 2010).

The interaction term XY was the most important predictor in the binomial part of the model, indicating that a large part of the variance could not be explained by the environmental variables used in the model (Table 4.58). Water depth was the most important predictor among the environmental variables, being followed by number of ships, distance to land, and bottom slope (Table 4.58). The response curves of the binomial model indicated that the probability of presence of Common Scoter increased slightly with increasing water depth up to about 5 m, remained even until about 12 m and started declining further with increasing water depth (Figure 4.110A). The probability of species occurrence was higher at gentle and lower at steeper slopes, respectively. The probability of scoter occurrence was lower at areas of intensive shipping. Further, bird occurrence increased with increasing distance from land up to about 5,000 m and started to decline beyond that distance (Figure 4.110A). The categorical variable representing seasons indicated that birds occurred over broader areas during season 1 than during season 2 (Figure 4.110A).

The positive part of the 'winter' model further explained relationships of bird densities to the environmental variables. Water depth was the most important predictor in the positive part (Table 4.58). The probability of higher densities increased with increasing water depth up to about 7 m and started declining beyond that depth (Figure 4.110B). The interaction term XY was the second-most important predictor in the positive part (Table 4.58, Figure 4.110B). Response variable interaction with the predictor describing the proportion of hard substrate indicated that scoter densities increased with increasing hard substrate cover, but started declining once hard substrate exceeded 30%. Scoters responded negatively to presence of offshore wind farms and bird density increased with increasing distance from wind farms. Interaction with shipping intensity suggested that scoter densities decreased with increasing number of ships (Table 4.58, Figure 4.110B). Seasonal patterns, when considering both model parts, indicate that Common Scoter occurred over broader areas but at lower average densities in season 1, compared to more aggregated distribution and higher densities during season 2 (Figure 4.110B).

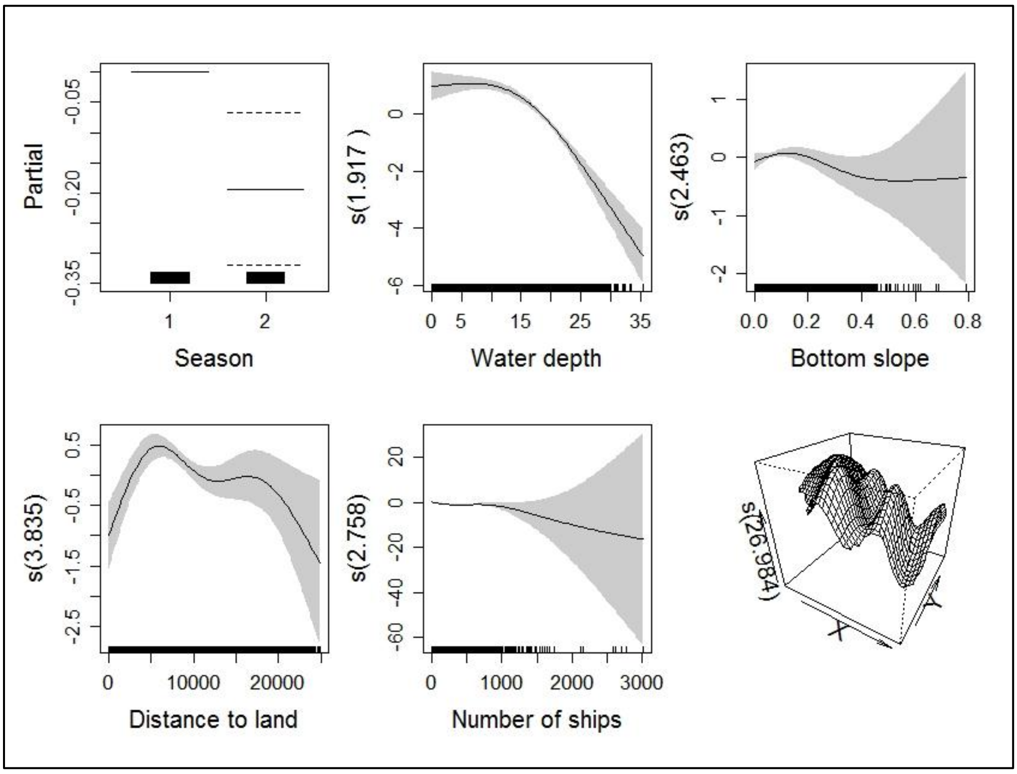
The scoter distribution model had a good fit. Deviance explained in the binomial part was 23.9% and 33.3% in the positive part (Table 4.58). The accuracy of the predictions according to the AUC equalled 0.83 when the model was calibrated on 70% and evaluated on 30 %, and the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.39 ($P < 2.2e-16$).

Significant ($P < 0.01$) but low spatial autocorrelation was found in the residuals of both model parts. In the presence/absence part autocorrelation was present in 1 out of 10 lags (1 lag = 1,500 m which was the defined nearest neighbourhood). The Moran's I values were, however, very low ranging from -0.005 to 0.015 (Moran's I range from -1.0 to 1.0). In the positive part significant spatial autocorrelation was also found only in 1 out of 10 lags, the Moran's I values also being very low and ranging from 0.002 to 0.092 (Appendix III).

The models deployed show that between December 2008 and March 2009 and again between November 2009 and April 2010 Common Scoters occurred in highest densities in the offshore areas of Flüggesand, Sagasbank, and the southern parts of Kiel Bight (Figure 4.111). Common Scoter densities were generally very low in the Danish part of the Fehmarnbelt with small aggregation off the SE coast of Lolland and south of Gedser. Densities of wintering Common Scoter were lower in the immediate area of the planned alignment of the fixed link compared to a broader area of species distribution (Figure 4.111), indicating a combination of foraging habitat suitability and disturbance from the existing ferry line. The zone of higher densities (> 100 birds/km^2) off the northwest coast of Fehmarn did not extend closer than 10 km to Puttgarden.

Table 4.58 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the 'winter' period for Common Scoter in the Fehmarnbelt based on aerial survey data. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	**Presence/absence**			**Positive part**		
	Z	**X^2**	**P**	**t**	**F**	**P**
Season 2	-3.07		<0.01	2.88		<0.01
Mussel biomass		-	-		-	-
Depth		137.09	<0.01		12.24	<0.01
Proportion hard substrate		-	-		5.10	<0.01
Bottom slope		7.40	0.04		-	-
Distance to land		41.18	<0.01		-	-
Distance to wind farms		-	-		5.56	0.02
Number of ships		44.61	<0.01		3.24	0.07
XY		653.21	<0.01		7.94	<0.01
Model performance						
AUC	0.83					
Deviance explained	23.9 %			33.3 %		
Combined correlation (P)	0.39 (P<2.2e-16)					



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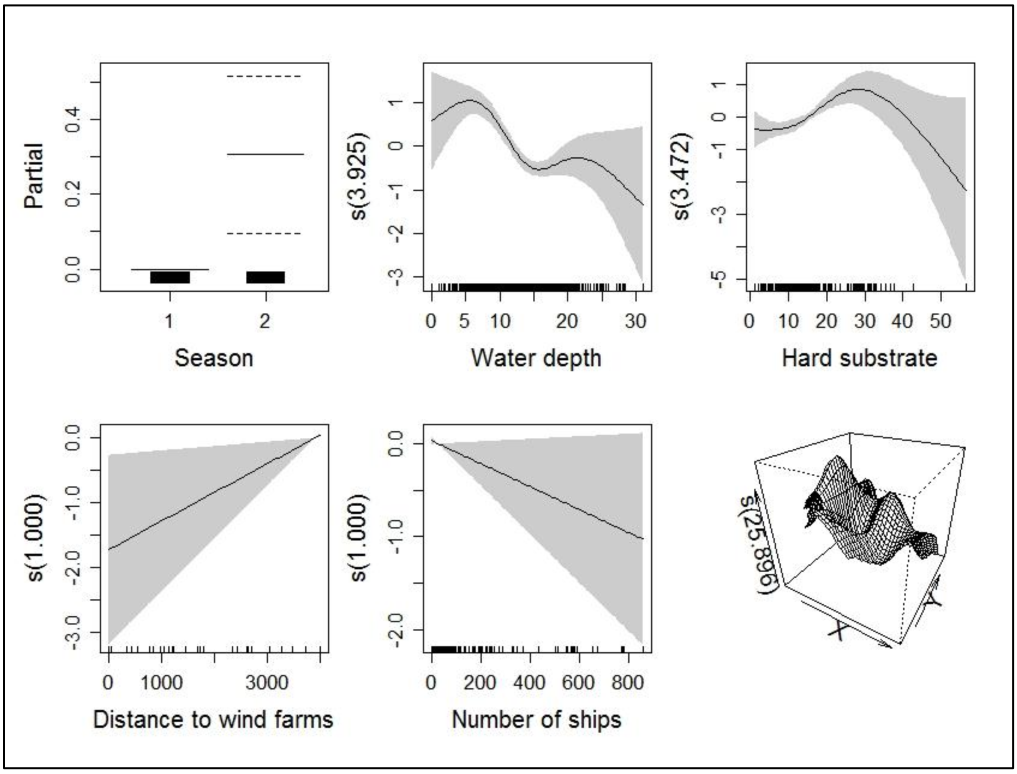
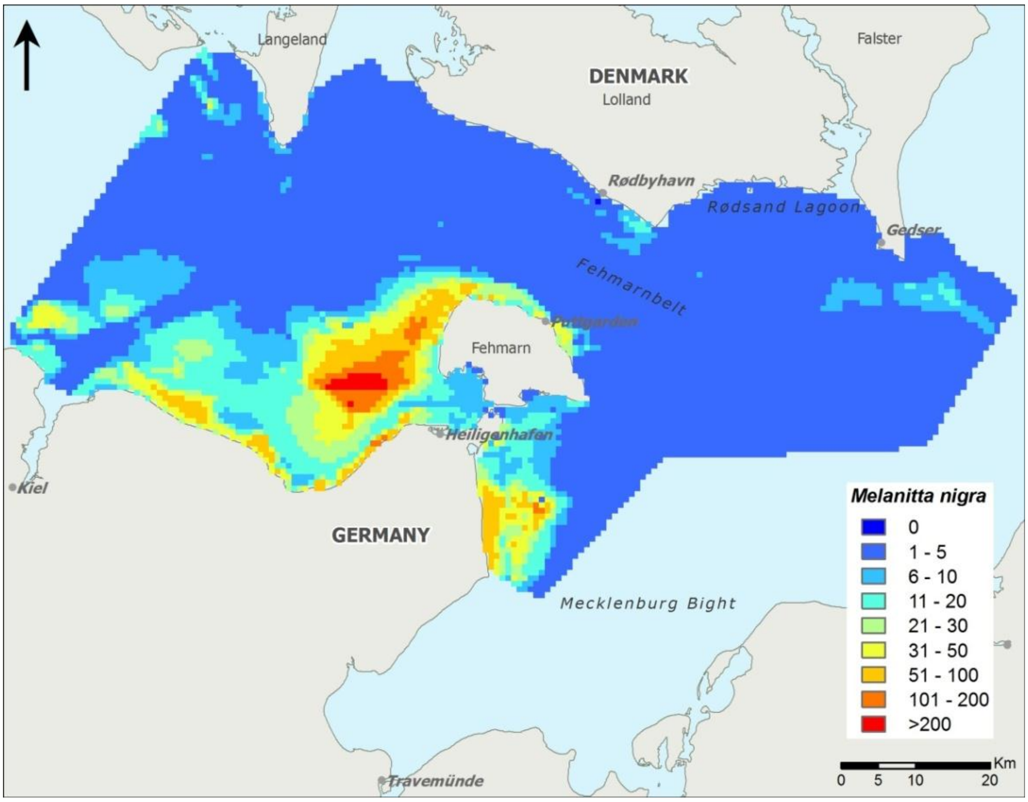


B

Figure 4.110 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence (A – binomial part of the model) or density (B – positive part of the model) of Common Scoter in the Fehmarnbelt for the winter season based on aerial survey data. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.



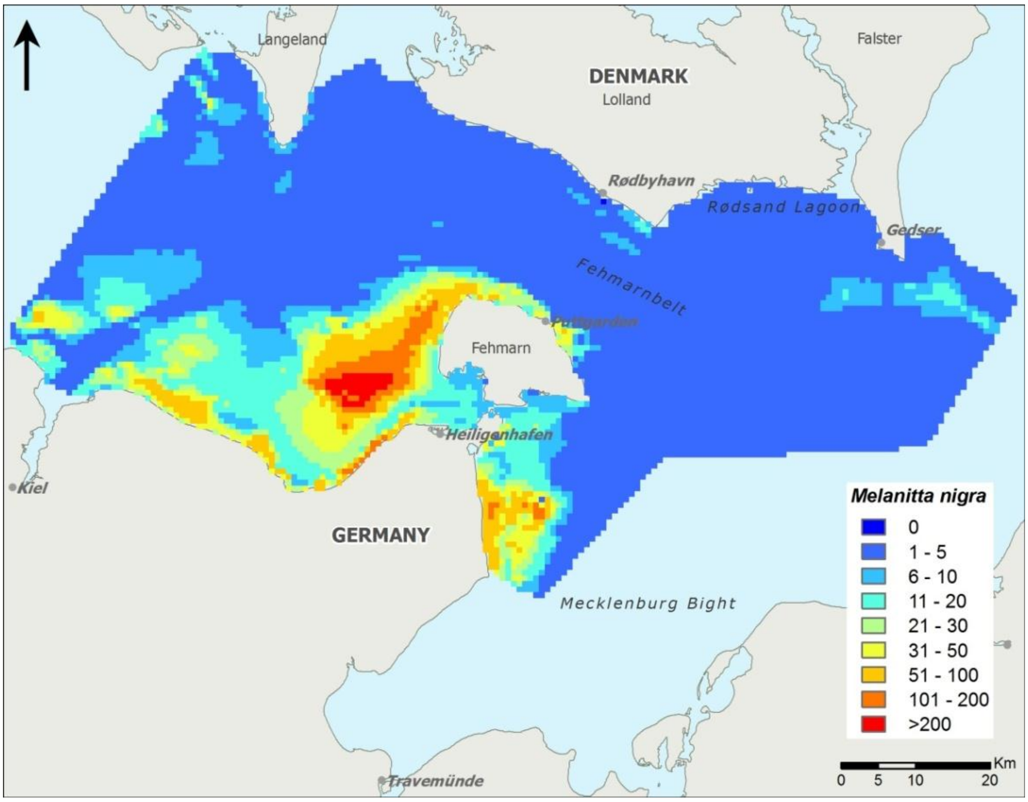


Figure 4.111 Spatial distribution models (numbers per km^2) of Common Scoter Melanitta nigra in the Fehmarnbelt based on baseline aerial surveys undertaken between December 2008 – March 2009 (upper map) and November 2009 – April 2010 (lower map).

Common Scoter distribution and habitat use according to spatial modelling of ship-based survey data

Distribution model on ship-based survey data was fitted for the 'winter' period when Common Scoters are present in the Fehmarnbelt region. The 'winter' period was further categorised into two seasons: season 1 (November 2008 – April 2009) and season 2 (November 2009 – March 2010).

The most important variable in the presence/absence part of the model was the interaction term XY (easting and northing), which accounts for some of the spatial variance not accounted for by the environmental predictor variables. Water depth was the only environmental variable that was important (Table 4.8). The response curve indicates that Common Scoter occurrence peaks at depths of 10-12 m (Figure 4.94A). Presence of Common Scoters showed a tendency to decrease with increasing number of ships (Figure 4.94A). The categorical variable representing season indicated that birds occurred over broader areas during season 2 than during season 1 (Figure 4.94A).

The positive part of the 'winter' model further explained relationships of bird densities to the environmental variables. The interaction term XY was again the most important variable closely followed by water depth, which indicated decreasing bird densities with increasing water depth (Table 4.8, Figure 4.94B). The probability of increasing Common Scoter density increased with increasing distance to land up to about 6,000 m and then declined gradually (Table 4.8, Figure 4.94B). Common Scoter densities were not significantly different between the two study seasons (Table 4.8, Figure 4.94B).

The 'winter' distribution model according to ship-based surveys had a good fit. Deviance explained in the binomial part was 35.3% and 48.6% in the positive part (Table 4.8). Diagnostic plots of the positive part can be seen in Appendix III. The accuracy of the predictions in the binomial part of the model based on the AUC equalled 0.82, and the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.62 ($p < 2.2e\text{-}16$). No significant ($p < 0.01$) spatial autocorrelation was found in the residuals of the binomial part of the model and slight spatial autocorrelation was detected for the first lag in the positive part of the model, Moran's I value being very low (Appendix III).

The deployed models show similar distribution as found according to aerial surveys: wintering Common Scoter were mostly found in the German part of the study area and occurred in highest densities in the offshore areas of Sagasbank and Flüggesand, and the southeastern part of the Kiel Bight (Figure 4.95).

Table 4.59 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the 'winter' period for Common Scoter in the Fehmarnbelt according to ship-based surveys. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	**Presence/absence**			**Positive part**		
	Z	**X^2**	**P**	**t**	**F**	**P**
Season 2	3.85		<0.01	1.83		0.07
Mussel biomass		-	-		-	-
Depth		36.43	<0.01		11.53	<0.01
Proportion hard substrate		-	-		-	-
Bottom slope		-	-		2.25	0.07
Distance to land		-	-		3.11	0.02
Distance to wind farms		-	-		-	-
Number of ships		4.06	0.09		-	-
XY		287.85	<0.01		11.95	<0.01
Model performance						
AUC		0.82				
Deviance explained		35.3 %			48.6 %	
Correlation (combined)			0.62 (p < 2.2e-16)			

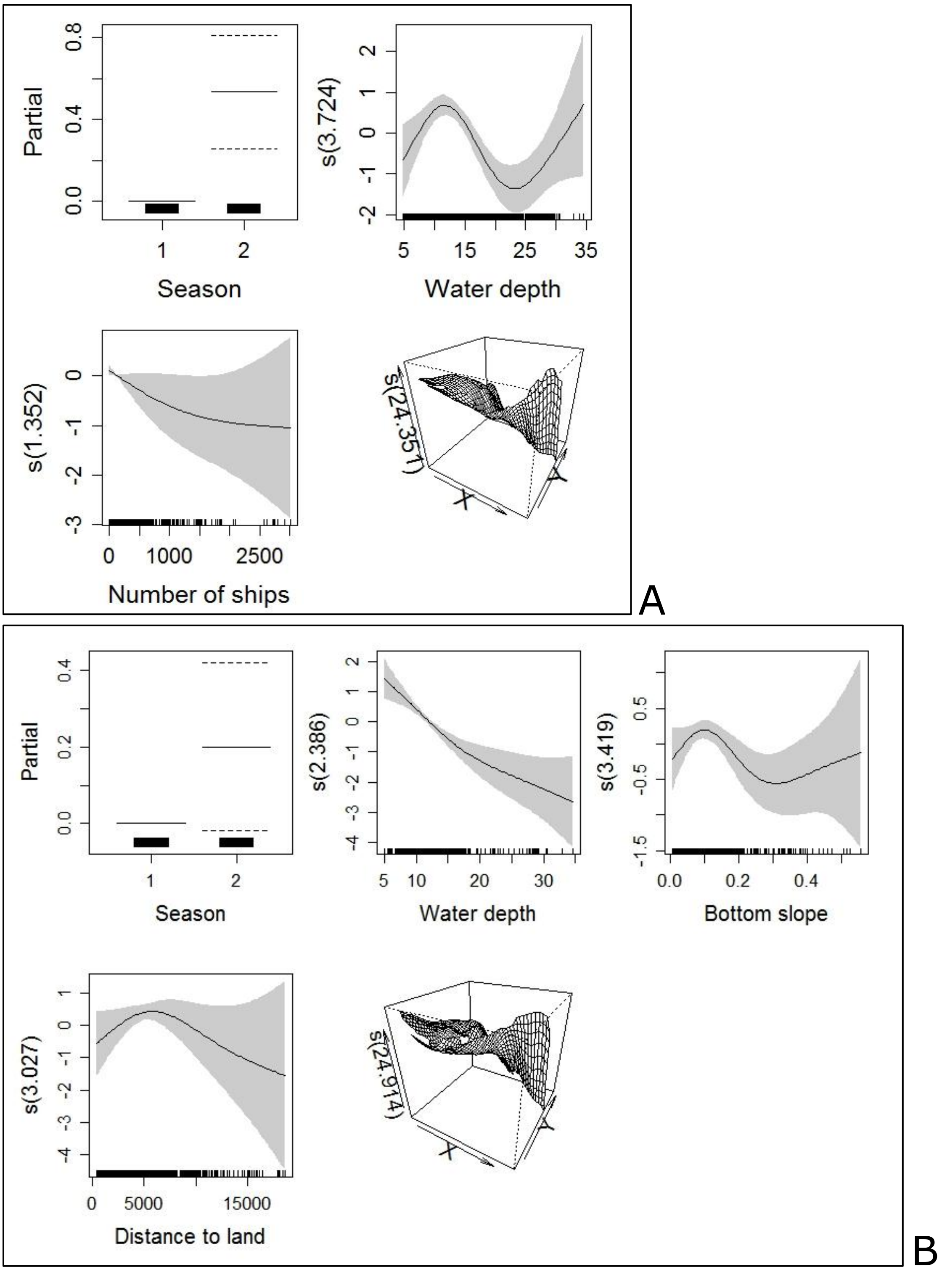
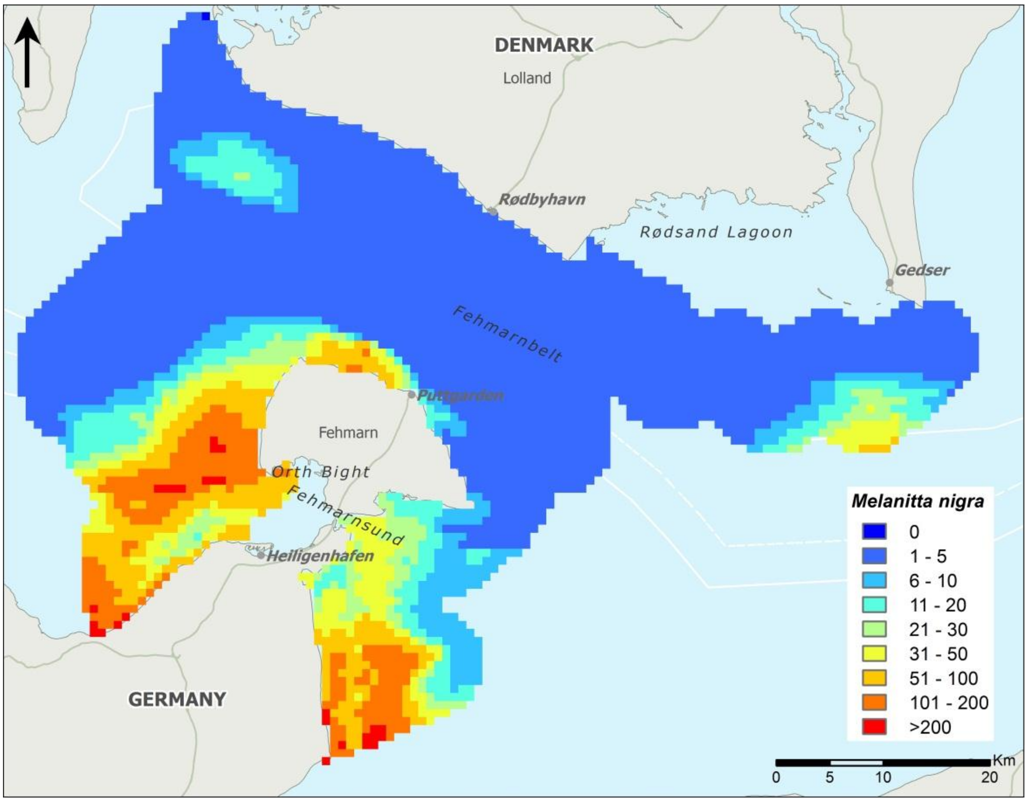


Figure 4.112 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Common Scoter (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the winter season according to ship-based survey data. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.



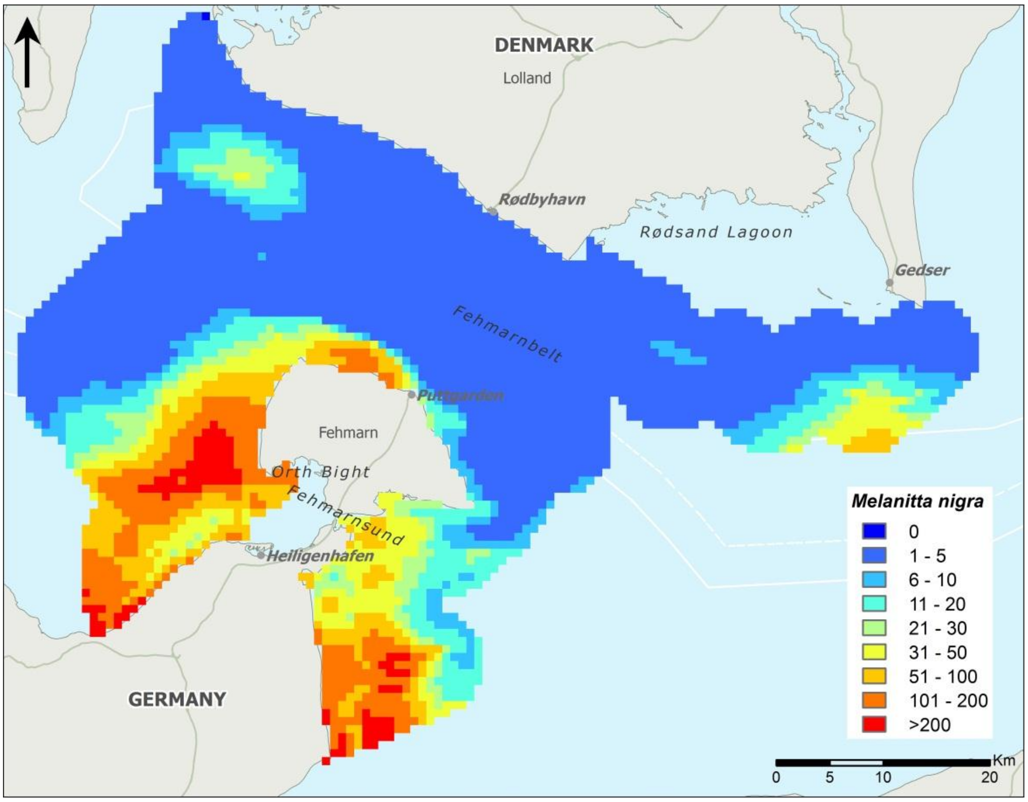


Figure 4.113 Spatial distribution models (numbers per km^2) of Common Scoter Melanitta nigra *in the Fehmarnbelt based on baseline ship-based surveys undertaken between November 2008 – April 2009 (upper map) and November 2009 – March 2010 (lower map).*

Common Scoter distribution according to supplementary datasets

The winter distribution of Common Scoter as recorded during the waterbird monitoring surveys in the Baltic waters of Schleswig-Holstein resembled closely the results of the FEBI baseline investigations with the highest numbers recorded on Sagasbank and Flüggesand (Figure 4.114; BIOLA 2009).

Monitoring of wintering waterbirds in Denmark indicated no areas of higher concentrations of Common Scoters in the Danish part of the Fehmarnbelt (Petersen et al. 2006, 2010), the same as concluded from the FEBI baseline investigations.

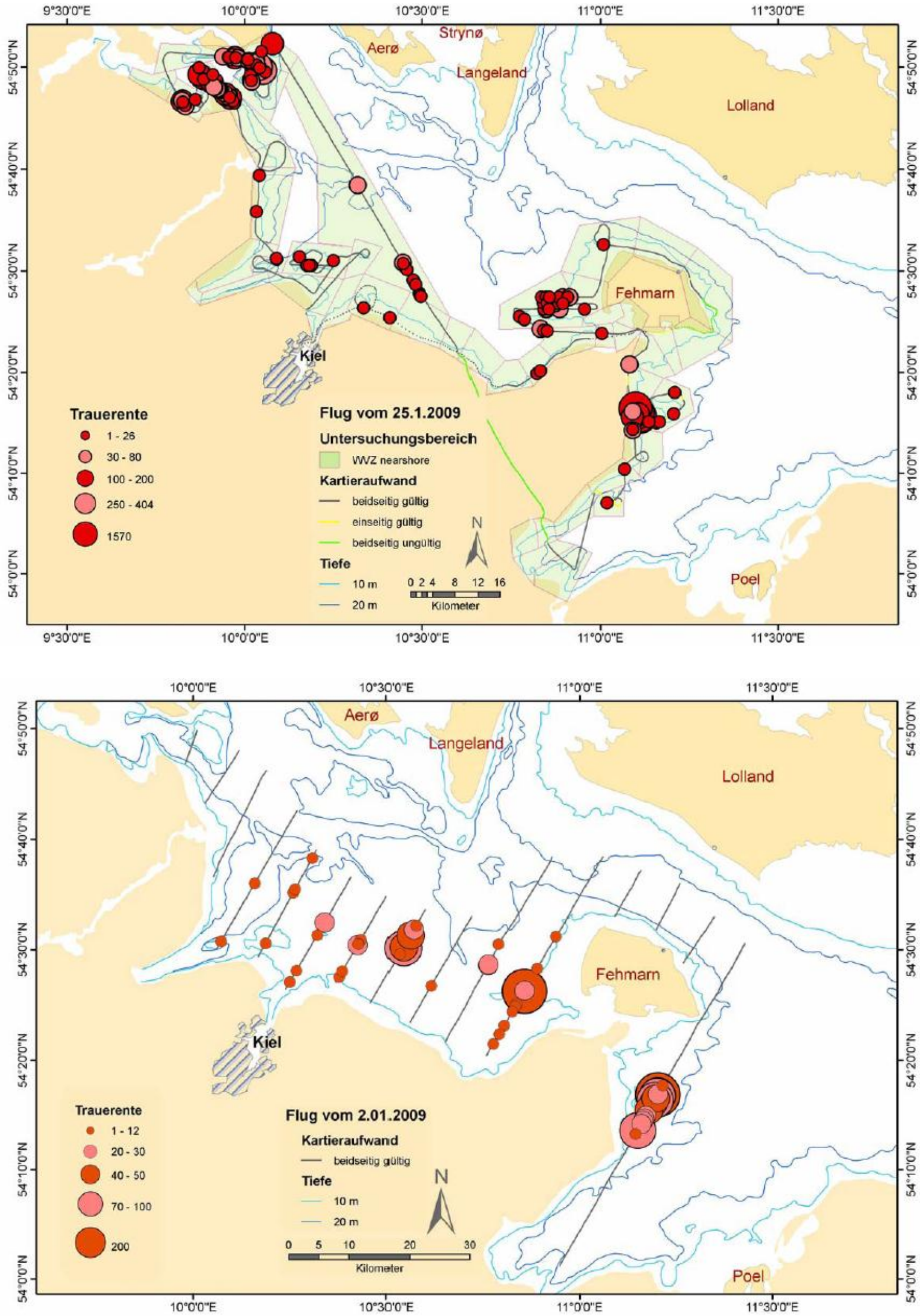


Figure 4.114 Common Scoter winter distribution patterns documented during waterbird monitoring surveys in the Baltic waters of Schleswig-Holstein resembled closely the distribution of this species recorded during FEBI baseline investigations. Maps adapted from BIOLA (2009) with permission from the authors.

Common Scoter abundance estimates for SPAs

Although aerial surveys achieved better spatial coverage of the Fehmarnbelt area, ship-based surveys resulted in higher estimates of Common Scoters in the Fehmarnbelt according to both Distance analysis and spatial modelling. Therefore, using the precautionary principle, spatial modelling results of ship-based surveys were used to evaluate total numbers of this species in the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien. Since ship-based surveys did not cover Rødsand Lagoon, abundance assessment in the SPA Hyllekrog-Rødsand was based on spatial model according to aerial surveys.

Results of distribution modelling using ship-based data indicated that the SPA Eastern Kiel Bight hosted about 30,000 wintering Common Scoters in winter 2008/2009 and 40,000 in winter 2009/2010, corresponding to 1.9 % and 2.5 % of the biogeographic population, respectively (Table 4.54). The estimates for the SPA Baltic Sea east of Wagrien suggest nearly 16,000 and more than 20,000 of Common Scoters wintering there during the two winters of the study period, which corresponds to 1% and 1.25% of the biogeographic population, respectively. Only about 200 Common Scoters were estimated to winter in the SPA Hyllekrog-Rødsand (Table 4.54).

The non-SPA area of the Fehmarnbelt covered by ship-based surveys supported an additional 3,500–6,000 Common Scoters during the study period (Table 4.54). Within the non-SPA area, about 700–1,150 individuals were estimated to winter in the immediate vicinity of the planned alignment (5 km around, see Figure 2.21 in Methods).

The total FEBI estimates indicate that 3.1 - 4.1% of the biogeographic population of Common Scoters winter in the Fehmarnbelt. Modelled densities of wintering birds of this species were substantially higher in the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien compared to those in the remaining area of the Fehmarnbelt (Table 4.54).

The total estimates obtained using the distribution modelling (Table 4.54, Appendix III) fall within a range of the estimates of Distance analysis of ship-based survey data (Table 4.57). Spatial modelling is regarded to provide the best approximation of wintering numbers of Common Scoters as Distance analysis estimates were highly variable among different surveys and had broad confidence intervals. Also, spatial modelling is more reliable tool to extrapolate numbers to areas between ship transects in a heterogenous environment like the Fehmarnbelt.

Table 4.60 Seasonal estimates of Common Scoter abundance in the SPAs: Eastern Kiel Bight, Baltic Sea east of Wagrien, and Hyllekrog-Rødsand based on the spatial distribution models. Estimates for the alignment area, total non-SPA area, and total prediction area are also given. Note: the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien were not fully covered by ship-based surveys. Estimates were only calculated for the area covered by surveys.

Common Scoter	Period	Density	Estimate
Eastern Kiel Bight*	Nov 2008 – Apr 2009	67.05	29,491
(DE1530-491)	Nov 2009 – Mar 2010	89.62	39,420
Baltic Sea east of Wagrien*	Nov 2008 – Apr 2009	49.45	15,687
(DE1633-491)	Nov 2009 – Mar 2010	65.01	20,623
Hyllekrog-Rødsand**	Dec 2008 – Mar 2009	0.85	210
(DK006X087)	Nov 2009 – Apr 2010	0.93	229
Alignment area*	Nov 2008 – Apr 2009	3.35	703
	Nov 2009 – Mar 2010	5.47	1,148
Non-SPA area (including*	Nov 2008 – Apr 2009	2.53	3,566
the alignment area)	Nov 2009 – Mar 2010	3.94	6,018
TOTAL	Nov 2008 – Apr 2009	21.02	49,259
	Nov 2009 – Mar 2010	28.33	66,290

** - based on ship-based survey data*
*** - based on aerial survey data*

Common Scoter trends

The biogeographic population of Common Scoter is identified as stable by Wetlands International and BirdLife International (BirdLife International 2004, Wetlands International 2006). However, a recent overview of seaduck populations suggests a decline of scoters wintering in the Baltic Sea by at least 30 % since 1993 (Skov et al. 2011). Estimates from the FEBI baseline investigations show that 49,000 and 66,000 of Common Scoters wintered in the Fehmarnbelt in 2008/2009 and 2009/2010 respectively, which suggest a decline since 1993 when 97,000 birds were estimated for the same general area (Durinck et al. 1994). The Fehmarn Belt Feasibility Study provided an average estimate of 52,000 wintering Common Scoters during 1987-1995, with numbers peaking up to 92,000 – 151,000 in March (Skov et al. 1998), which indicates similar abundances of wintering birds compared to the estimates obtained from the FEBI baseline investigations.

The results of the German waterbird monitoring surveys in Schleswig-Holstein do not support the declining trend of wintering Common Scoters as identified above and reveal no trend between 1991 and 2009 according to mid-winter surveys (R^2=0.01, P=0.69; Figure 4.115) and increasing tendency but no significant trend according to spring surveys in March (R^2=0.29, P=0.09; BIOLA 2009, Figure 4.116).

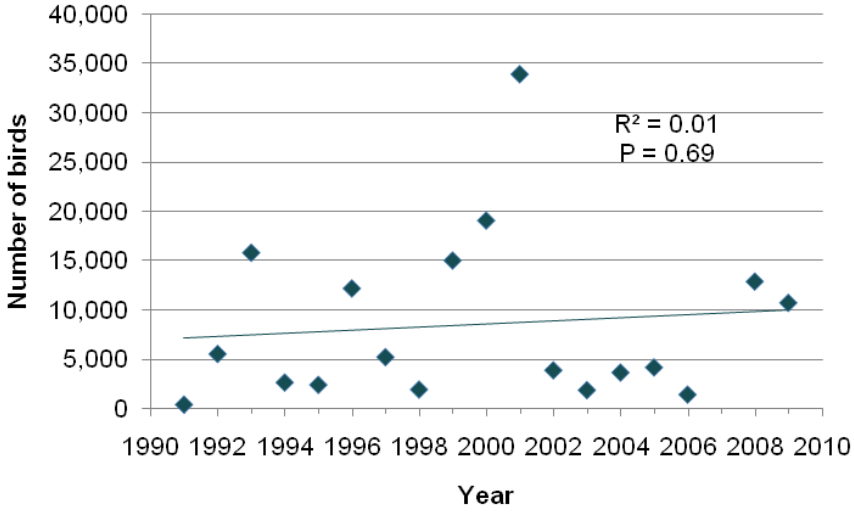


Figure 4.115 Numbers of Common Scoters counted in Kiel Bight and Mecklenburg Bight in winters 1991-2009 do not show any significant trend. Numbers were obtained from the German aerial monitoring surveys of Schleswig-Holstein (BIOLA 2009).

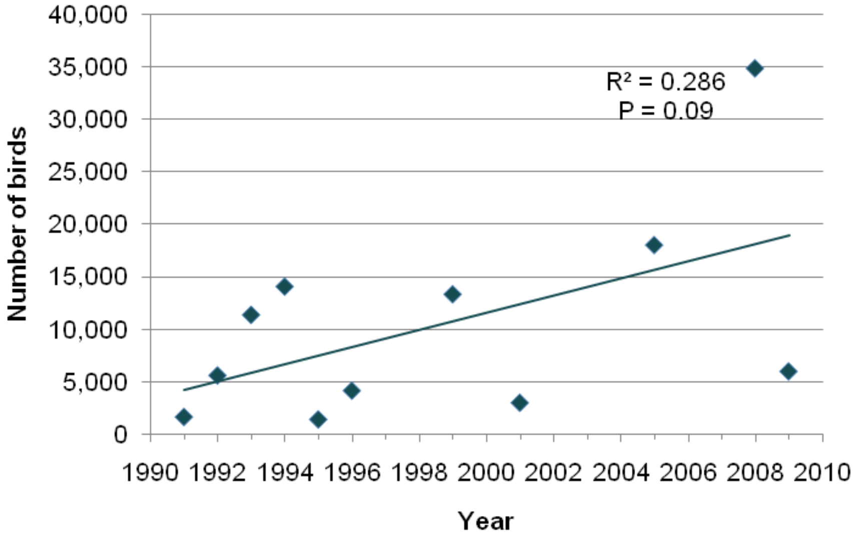


Figure 4.116 Numbers of Common Scoters counted in Kiel Bight and Mecklenburg Bight in March 1991-2009 show an increasing tendency but no significant trend. Numbers were obtained from the German aerial monitoring surveys of Schleswig-Holstein (BIOLA 2009).

Importance of the Fehmarnbelt to Common Scoter

The total number of Common Scoter in the Western Palearctic has been estimated at 1.6 million (Wetlands International 2006). The baseline results for 2008/2009 indicate that about 3-4% of the Western Palearctic population occur in the Fehmarnbelt.

FEBI baseline investigations confirm the results of the feasibility study and waterbird monitoring in Germany that Common Scoters aggregate on Flüggesand and Sagasbank, both sites being of international importance for the species.

Common Scoter – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	66,290
Max. abundance estimate in the alignment area:	1,150
Period of max. abundance in Fehmarnbelt:	November – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.95
Explanations:	Maximum abundance and distribution obtained from spatial modelling of ship-based survey data. Although total numbers for some of ship-based surveys resulted in higher estimates than presented above, these figures were of low reliability due to broad confidence intervals.

4.1.25 Velvet Scoter – *Melanitta fusca*

Velvet Scoter – *Melanitta fusca*

Biogeographic population: *M. f. fusca*, Baltic Sea and W Europe (non-br)

Breeding range: W Siberia and N Europe

Wintering / core non-breeding range: Baltic Sea and W Europe

Population size: 1,000,000

1 % value: 10,000

Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: SPEC 3 EU Threat Status: (declining)
Target species in SPAs:	-

Key food: molluscs, crustaceans

Period of presence in Fehmarnbelt:	Wintering, migrations: September – May Breeding, moulting: June – August

Origin of Velvet Scoter in the Fehmarnbelt

The Velvet Scoter breeds on the continental parts of northern Eurasia and North America. In the Western Palaearctic it breeds in the countries surrounding the northern Baltic Sea (Cramp and Simmons 1977). The species is migratory and winters along the coasts of Norway, southern Sweden, Denmark, in the southern and eastern Baltic Sea, the Wadden Sea, less commonly around the United Kingdom and the coasts of the Channel area (Cramp and Simmons 1977, Durinck et al. 1994). The population wintering in Northern Europe originates from the Baltic Sea and the White Sea (Bønløkke et al. 2006).

Data sources on Velvet Scoter in the Fehmarnbelt

As the Velvet Scoter is a typical offshore species, abundance and distribution were best covered by data of the FEBI baseline investigations. As identification of *Melanitta* species can be more reliably done from ship than from an aircraft, and as also more Velvet Scoters have been identified during ship-based surveys, this dataset was chosen as the primary source in assessing species abundance and distribution in the Fehmarnbelt (Table 4.61). Aerial surveys were used as supporting dataset. The land-based counts from Denmark and Germany were considered as inappropriate to represent this offshore species and were therefore not considered in the assessment (Table 4.61).

Table 4.61 List of datasets and their use in baseline assessment of Velvet Scoter in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Primary dataset for estimating species densities, abundance and habitat use
OAG land-based counts	Dataset not used due to inappropriate method for surveying this offshore species
AKVSW land-based counts	Dataset not used due to inappropriate method for surveying this offshore species
NOVANA aerial surveys	Dataset not used due to no sightings of the species
DOF database	Dataset not used due to inappropriate method for surveying this offshore species

Abundance of Velvet Scoter in the Fehmarnbelt

The Velvet Scoter is a typical but relatively rare wintering species in the Fehmarnbelt area. According to Mendel et al. (2008) the main wintering sites of Velvet Scoters in the German Baltic Sea are located in the very eastern part of the Pomeranian Bight and numbers in the Fehmarnbelt area are generally low (Mendel et al. 2008).

Velvet Scoter abundance estimates based on Distance analysis

More Velvet Scoters were recorded during the FEBI ship-based surveys compared to aerial counts (Table 4.62, Table 4.63). From an aircraft only flying Velvet Scoters can be distinguished from Common Scoters, whereas swimming Velvet Scoters are usually not identified among the more abundant Common Scoters. Thus, numbers obtained by aerial surveys are likely underestimates (Table 4.62).

Table 4.62 Results of monthly aerial surveys for Velvet Scoter between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects; Coverage % is percentage of survey area covered in valid conditions.

Survey	Number of birds observed	Coverage %
Nov-08	0	80.9
Dec-08	10	81.7
Jan-09	13	82.8
Feb-09	31	100.0
Mar-09	19	77.5
Apr-09	0	86.8
May-09	0	77.3
Jun-09	0	80.9
Jul-09	0	86.6
Aug-09	0	92.3
Sep-09	0	79.1
Oct-09	0	79.9
Nov-09	13	82.4
Dec-09	1	24.7
Mar-10 A	53	64.1
Mar-10 B	3	75.6

Survey	Number of birds observed	Coverage %
Apr-10	25	100.0
May-10	0	92.1
Jun-10	0	70.8
Aug-10	0	75.6
Sep-10 A	1	44.9
Sep-10 B	0	48.9
Oct-10	18	80.0
Nov-10	53	70.1

Distance analysis of ship-based survey data revealed higher numbers of Velvet Scoters for the Fehmarnbelt area with a maximum estimate of more than 3,000 birds in late winter 2009/2010 (Table 4.63). The ESW for Velvet Scoter during ship-based surveys, estimated for the entire dataset, was 180 m and therefore slightly lower than the one calculated for Common Scoters and eiders, but higher than for Long-tailed Ducks. The results of the FEBI baseline investigations indicate Velvet Scoter being more abundant in coastal areas than offshore. Abundance also varied between the two investigated winter seasons with higher numbers observed in winter 2009/2010 (Table 4.63). However, the confidence intervals of estimated densities are very broad and calculated total numbers have to be interpreted with caution.

Table 4.63 *Numbers of observed Velvet Scoters during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km² covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.*

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	2	10	-	***	-	-	-	-	-	3	-	-
	offshore	0	0	0	0	0	0				0		
Dec-08	coastal	7	23	-	***	-	-	-	-	-	3	-	-
	offshore	1	1	0.02	101	0.00	0.14				0		
Jan-09	coastal	7	24	-	***	-	-	-	-	-	14	-	-
	offshore	0	0	0	0	0	0				0		
Feb-09	coastal	8	21	-	***	-	-	-	-	-	7	-	-
	offshore	0	0	0	0	0	0				0		
Mar-09	coastal	18	71	-	***	-	-	-	-	-	12	-	-
	offshore	0	0	0	0	0	0				0		
Apr-09	coastal	3	8	0.09	89	0.02	0.40	0.06	0.01	0.27	0	0.06	133
	offshore	0	0	0	0	0	0				0		

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
May-09	coastal	1	5	0.05	102	0.01	0.26	0.03	0.01	0.17	0	0.03	74
	offshore	0	0	0	0	0	0				0		
Jul-09A	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jul-09B	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Aug-09	coastal	3	4	-	***	-	-	-	-	-	0	-	-
	offshore	0	0	0	0	0	0				0		
Sep-09	coastal	1	2	0.02	103	0.00	0.11	0.01	0.00	0.07	0	0.01	31
	offshore	0	0	0	0	0	0				0		
Oct-09	coastal	3	3	0.03	63	0.01	0.09	0.02	0.01	0.07	0	0.02	53
	offshore	0	0	0	0	0	0				0		
Nov-09	coastal	3	4	-	***	-	-	-	-	-	4	-	-
	offshore	0	0	0	0	0	0				4		
Dec-09	coastal	5	11	-	***	-	-	-	-	-	0	-	-
	offshore	0	0	0	0	0	0				6		
Jan-10	coastal	10	27	-	***	-	-	-	-	-	0	-	-
	offshore	0	0	0	0	0	0				0		
Feb-10A	coastal	16	64	0.85	62	0.27	2.66	0.56	0.18	1.74	10	0.61	1,433
	offshore	0	0	0	0	0	0				3		
Feb-10B	coastal	17	81	0.95	54	0.35	2.61	0.63	0.23	1.74	3	0.64	1,507
	offshore	0	0	0	0	0	0				0		
Mar-10	coastal	37	166	1.78	47	0.73	4.35	1.22	0.49	3.02	13	1.30	3,050
	offshore	1	2	0.04	110	0.01	0.24				8		
Apr-10	coastal	43	427	-	***	-	-	-	-	-	6	-	-
	offshore	0	0	0	0	0	0				0		
May-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jun-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-10	coastal	1	2	0.02	103	0.00	0.11	0.01	0.00	0.07	0	0.01	30
	offshore	0	0	0	0	0	0				0		
Oct-10	coastal	2	4	-	422	-	-	-	-	-	0	-	-
	offshore	0	0	0	0	0	0				0		
Nov-10	coastal	1	2	0.02	105	0.00	0.11	0.01	0.00	0.07	1	0.02	50
	offshore	0	0	0	0	0	0				1		

Velvet Scoter occurs in the study area mostly during the wintering season between November and April, but single individuals were also occasionally recorded during the summer months (Figure 4.117, Table 4.63).

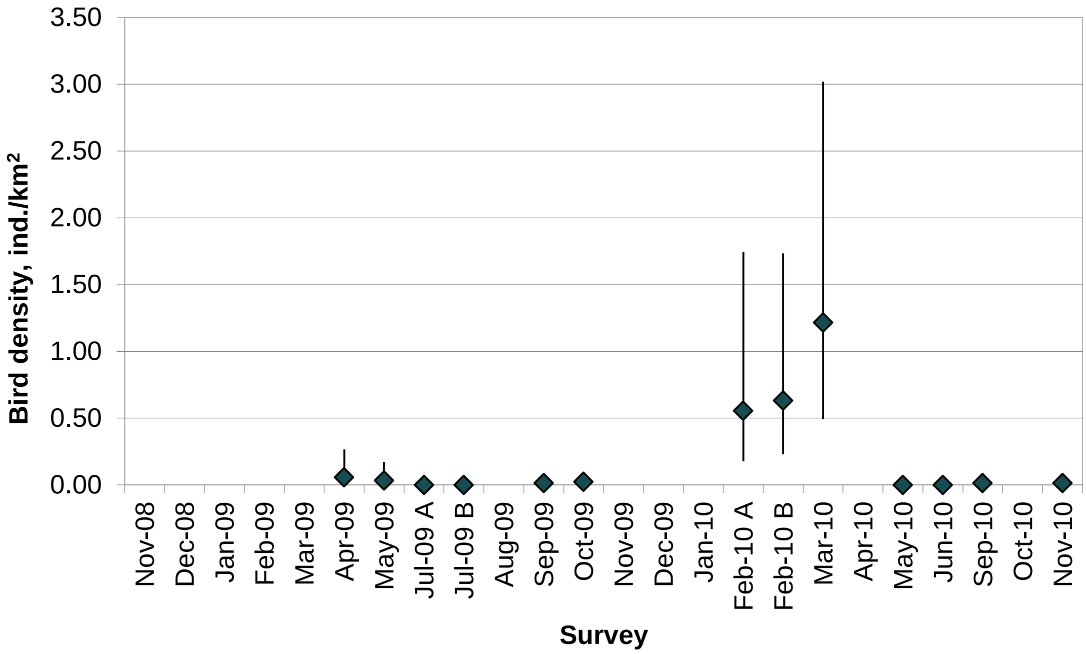


Figure 4.117 Mean density estimates and 95 % confidence intervals of swimming Velvet Scoters estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150 % were not included into the chart (see Table 4.63 for specific values).

Velvet Scoter abundance estimates according to supplementary datasets

The German waterbird monitoring aerial surveys report only low numbers of Velvet Scoters in Schleswig-Holstein in January 2009 (BIOLA 2009). Densities observed in transect bands that are least affected by detection bias (i.e. proximate to an observer) were 0.08 ind./km² in February 2008 and 0.09 ind./km² in January 2009 (BIOLA 2009). There is no total estimate of this species provided in the German waterbird monitoring report (BIOLA 2009). Danish aerial monitoring of wintering birds does report Velvet Scoter in the Fehmarnbelt area (Petersen et al. 2006, 2010).

The results from the coastal counts in Germany revealed only single individuals of Velvet Scoters in the inshore zone (maximum 25 in January 2006; AKVSW 2010). Likewise, only single birds were recorded by volunteer observers contributing to the DOF database in Denmark (maximum 18 Velvet Scoters in Rødsand Lagoon in April 2000; DOF 2010). Berndt and Busche (1993) report a maximum of 3,000 Velvet Scoter being counted in Hohwacht Bay in February 1964.

Distribution and habitat use of Velvet Scoter in the Fehmarnbelt

The Velvet Scoter is a typical seaduck and is usually found offshore at water depths down to 30 m, where birds dive to the bottom to feed on bivalves (Berndt and Busche 1993, Mendel et al. 2008). Velvet Scoters are often found in mixed flocks with Common Scoters (Mendel et al. 2008).

Velvet Scoter distribution according to survey data

During the FEBI ship-based surveys Velvet Scoters were mostly observed associated with Common Scoters (Figure 4.118, Figure 4.119; Appendix II). Highest concentrations of Velvet Scoter were recorded west of Fehmarn on Flüggesand in April 2010, but the species was also found in the Danish part of the Fehmarnbelt on Albue Bank and south of Rødsand Lagoon (Figure 4.119).

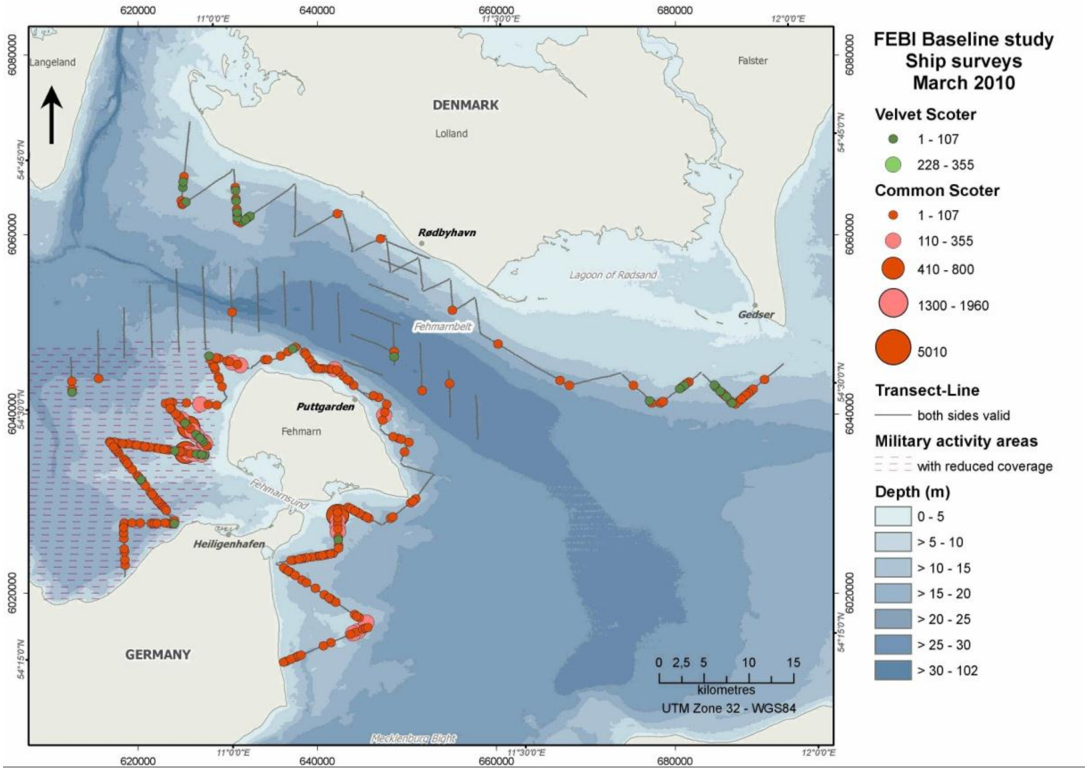


Figure 4.118 Example of the observed Velvet Scoter (and Common Scoter) distribution in the study area during ship-based surveys in March 2010.

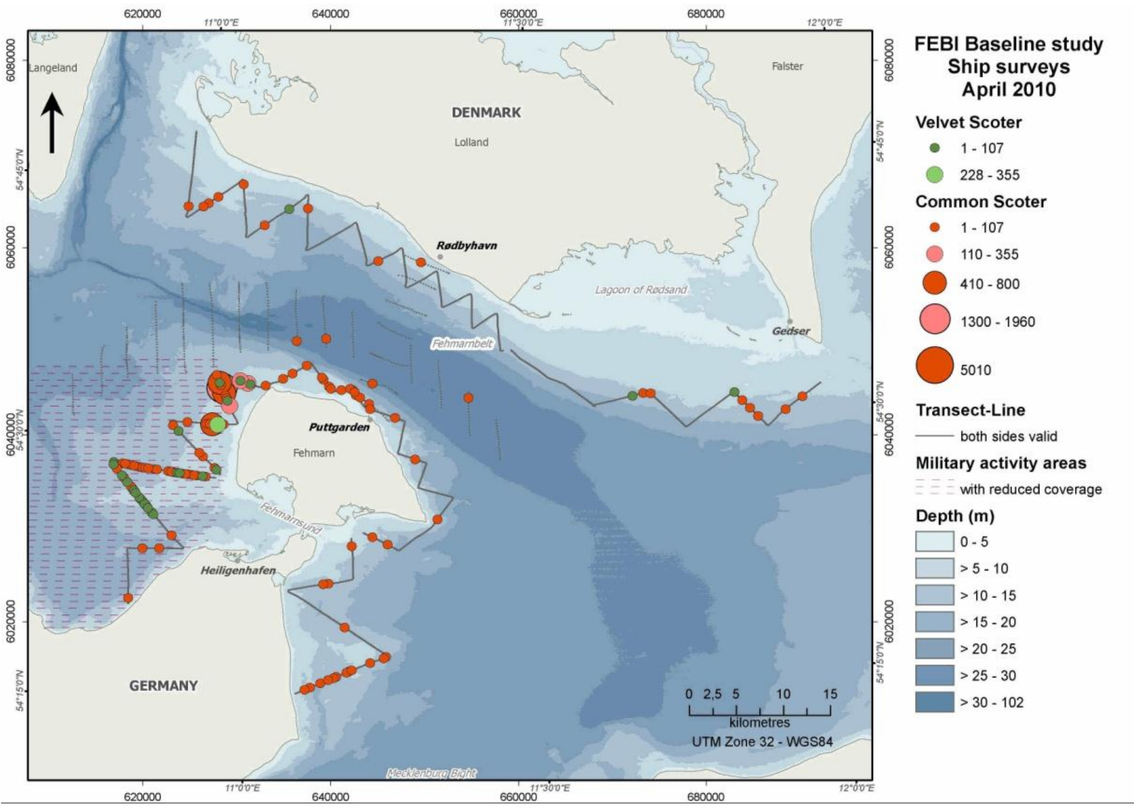


Figure 4.119 Example of the observed Velvet Scoter (and Common Scoter) distribution in the study area during the ship-based surveys in April 2010.

Velvet Scoter abundance estimates for SPAs

Due to generally low abundance of the species no abundance for particular SPAs can be estimated.

Velvet Scoter trends

The European wintering population of Velvet Scoter was stable between 1970 and 1990, but in the following decade a decline of 10 % took place due to decreasing numbers in Russia and Norway. Hence, the species was provisionally evaluated as Declining (BirdLife International 2004). Skov et al. (2011) report further decline of the Baltic wintering population of Velvet Scoter from 1993 to 2008.

Importance of the Fehmarnbelt to Velvet Scoter

The population of Velvet Scoter wintering in the Baltic Sea and Western Europe has been estimated at 1 million (Wetlands International 2006). In the first year (2008/2009) of FEBI baseline investigations only low numbers of Velvet Scoter were observed in the Fehmarnbelt. A maximum of 130 birds was estimated based on the ship-based survey in March 2009. The species was more numerous during the second year of baseline investigations (2009/2010) with estimated numbers regularly exceeding 1,000 birds in late winter (maximum estimate 3,050 birds in March 2010; equals to 0.3 % of the biogeographic population).

Velvet Scoter – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	3,050
Max. abundance estimate in the alignment area:	275
Period of max. abundance in Fehmarnbelt:	November – April
Areas of max. abundance in Fehmarnbelt:	see Figure 4.118, Figure 4.119
Explanations:	Maximum estimate represents Distance result on ship-based survey of March 2010. Maximum possible abundance in the alignment area estimated by applying the density of ship-based survey of March 2010 on the area of the alignment zone. Distribution obtained from ship-based surveys.

4.1.26 Common Goldeneye – Bucephala clangula

Common Goldeneye – *Bucephala clangula*

Biogeographic population: *B. c. clangula*, NW and C Europe (non-br)

Breeding range: N and NW Europe

Wintering / core non-breeding range: NW and C Europe

Population size: 1,000,000 – 1,300,000

1 % value: 11,500

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: Non-SPEC
EU Threat Status: (secure)

Target species in SPAs: Hyllekrog-Rødsand (DK006X083)
Eastern Kiel Bight (DE1530-491)

Key food: water invertebrates, fish, spawn

Period of presence in Fehmarnbelt: Wintering, migrations: September – April

Origin of Common Goldeneye in the Fehmarnbelt

There is no ring recovery available which would provide information about the origin of Common Goldeneye occurring in the Fehmarnbelt (Appendix IV). The majority of individuals recovered in Danish waters originate from Sweden, Finland, Norway, and NW Russia. Also, a few Goldeneye ringed in Germany and the Czech Republic were recovered in Denmark (Bønløkke et al. 2006). Therefore, it is most likely that Common Goldeneye wintering in the Fehmarnbelt belong to birds breeding in northern and to some extent central Europe.

Data sources on Common Goldeneye in the Fehmarnbelt

Numbers and distributions of Common Goldeneye are well reflected in the FEBI aerial survey data and therefore aerial surveys were chosen as the primary data source for representing the species in the study region (Table 4.64). FEBI ship-based surveys resulted in very few records of Common Goldeneye. Consequently this dataset has not been used in the assessment of the species. Other datasets were used as supporting data sources to characterise Common Goldeneye densities, distribution and habitat use (Table 4.64).

Table 4.64 List of datasets and their use in baseline assessment of Common Goldeneye in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating Common Goldeneye densities, abundance, habitat use and seasonal variation
FEBI ship transect surveys	Dataset not used due to few records of the species.
OAG land-based counts	Supporting dataset representing species distribution along the German mainland coast.
AKVSW land-based counts	Primary dataset in trend analysis
	Supporting dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for densities and distribution of the species in Danish part of the Fehmarnbelt
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt area

Abundance of Common Goldeneye in the Fehmarnbelt

Common Goldeneye abundance estimates based on Distance analysis

The abundance of Common Goldeneye in the Fehmarnbelt was estimated by applying Distance analysis (Thomas et al. 2010) on the monthly aerial survey data. The effective strip widths (ESWs) for Common Goldeneye during aerial surveys, calculated using the entire dataset, were 202 m for swimming birds and 214 m for flying birds. These detection functions and ESWs were close to those of other species of similar size estimated in this study.

The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of Common Goldeneye have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.65, Appendix V). Highest numbers of Common Goldeneye have been recorded during bird wintering season between November and April, resulting in the highest estimate of almost 6,400 birds in February 2009, when 100 % of the study area was covered (Table 4.65). However, the confidence intervals of the maximum estimated density are broad and calculated total numbers have to be interpreted with caution.

Month-to-month variation in Common Goldeneye abundance indicate that the species occurs in the study area mainly in transitional and winter periods, while very few birds were recorded in the summer period between May and October (Table 4.65).

Table 4.65 Numbers of observed Common Goldeneye during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	30	362	0.87	0.33	2.28	3,445
Dec-08	81.7	43	283	0.64	0.22	2.49	2,551
Jan-09	82.8	58	443	1.09	0.44	2.81	4,413
Feb-09	100	66	720	1.31	0.47	3.69	6,391
Mar-09	77.5	9	75	0.22	0.02	2.20	827
Apr-09	86.8	2	11	0.02	0.00	0.24	69
May-09	77.3	0	0	0	0	0	0
Jun-09	80.9	1	3	0.01	0.00	0.03	23
Jul-09	86.6	0	0	0	0	0	0
Aug-09	92.3	0	0	0	0	0	0
Sep-09	79.1	1	1	0.00	0.00	0.01	9
Oct-09	79.9	8	16	0.03	0.01	0.08	104
Nov-09	82.4	27	210	0.46	0.14	1.74	1,861
Dec-09	24.7	3	30	0.11	0.01	1.80	135
Mar-10 A	64.1	62	316	0.69	0.32	1.50	2,157
Mar-10 B	75.6	67	511	0.93	0.43	2.02	3,443
Apr-10	100	48	400	0.65	0.21	2.33	3,178
May-10	92.1	5	16	0.03	0.01	0.11	126
Jun-10	70.8	0	0	0	0	0	0
Aug-10	75.6	0	0	0	0	0	0
Sep-10 A	44.9	1	2	0.01	0.00	0.04	17
Sep-10 B	48.9	0	0	0	0	0	0
Oct-10	80.0	0	0	0	0	0	0
Nov-10	70.1	28	112	0.20	0.06	0.66	668

Common Goldeneye abundance estimates according to supplementary datasets

Common Goldeneye is present in the study area all year round, but numbers in summer are comparatively low. By the end of the moulting season in autumn Common Goldeneye numbers increase in the Fehmarnbelt area, and peak in late winter (Berndt et al. 2005). Goldeneye counted within selected (consistently covered) coastal survey sections along the German mainland coast in the two seasons 2008/2009 and 2009/2010 confirm that the highest numbers occur in the study area in January/February (Figure 4.120; OAG 2010).

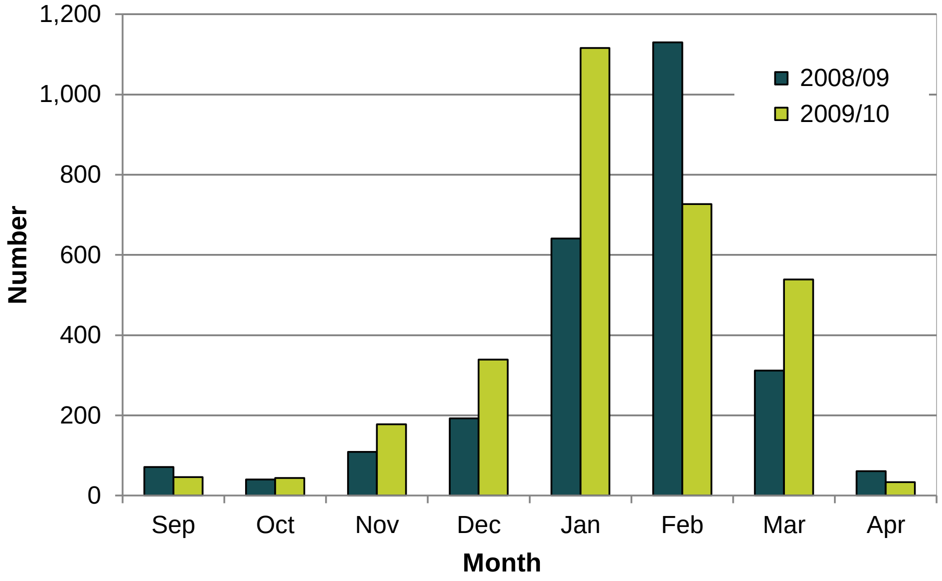


Figure 4.120 Numbers of Common Goldeneye recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

The data from the German mid-winter coastal counts show that 3,443 birds wintered in coastal waters along the Fehmarn and the German mainland coast in 2009 (AKVSW 2010, OAG 2010).

The German waterbird monitoring aerial surveys do not report total estimates of Goldeneye, but densities are reported for survey bands that are least affected by detection bias (i.e. proximate to an observer): 0.61 birds/km^2 in February 2008 and 0.13 ind./km^2 in February 2009 (BIOLA 2009). While the density recorded in 2008 is similar to those of FEBI surveys, the density of 2009 is surprisingly low. According to the Danish aerial monitoring of wintering birds, Goldeneye flocks up to a few hundred birds, with a total exceeding 2,800, have been recorded in the Danish part of the Fehmarnbelt, particularly in the Hyllekrog–Rødsand area in February 2008 (Petersen et al. 2010).

In the DOF database voluntary birdwatchers regularly report several hundred Goldeneye resting in Rødsand Lagoon during winter. The maximum number of 2,410 Goldeneye reported on February 6, 2006 (DOF 2010) is similar to the number obtained from NOVANA mid-winter survey 2008 (2,831 birds; Petersen et al. 2010). According to the DOF database Goldeneye numbers are lower in other parts of the Fehmarnbelt area than those reported for the Rødsand Lagoon (DOF 2010). Low numbers of Goldeneye are regularly reported for the alignment area at Rødbyhavn (maximum 39 birds; DOF 2011).

Distribution and habitat use of Common Goldeneye in the Fehmarnbelt

Common Goldeneye distribution according to survey data

Aerial surveys of FEBI baseline investigations show Common Goldeneye being mainly found close to shore and in sheltered marine areas, especially in Rødsand Lagoon and Orther Reede (southwest Fehmarn). Only a few birds were recorded offshore (Appendix II).

Common Goldeneye distribution and habitat use according to spatial modelling

A distribution model was fitted for the 'winter' period when the Goldeneye is present in highest abundance in the Fehmarnbelt region. The 'winter' period was further categorised into 2 seasons: season 1 (December 2008 – February 2009) and season 2 (November 2009 – April 2010).

Water depth was the most important predictor variable in the presence/absence part of the model according to the chi-square statistics (Table 4.66). The response curve indicates that the Goldeneye prefers shallower waters (Figure 4.121A). The interaction term XY was the second most important variable. Number of ships was also included in the model indicating decreasing occurrence of the species with increasing number of ships. The categorical variable representing seasons indicated that birds occurred over broader areas during the season 2 than during the season 1 (Figure 4.121A).

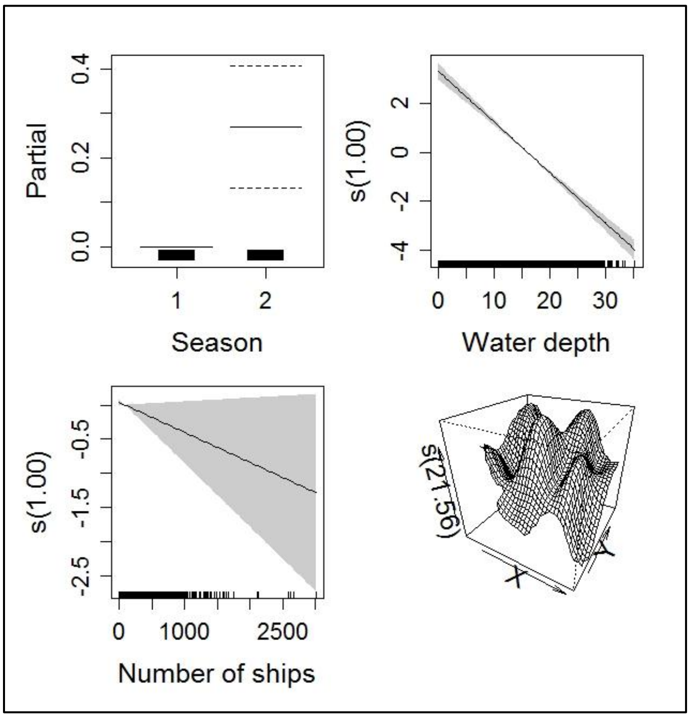
Water depth was also the most important predictor in the positive part of the model, indicating a similar relationship as identified in the binomial part (Table 4.66, Figure 4.121B). The interaction term XY was a significant predictor variable indicating that there was some variance unexplained by environmental variables. The variables describing disturbance, distance to land and distance to wind farms, were both included in the positive part of the model, their estimates were not, however, significant ($P > 0.05$). Seasonal patterns, when considering both model parts, indicate that Goldeneye occurred over broader areas in season 2, compared to the season 1 and that densities were similar during both periods (Figure 4.121B).

Both parts of the distribution model had a good fit when considered separately. Deviance explained in the binomial part was 30.4 % and 35.4 % in the positive part (Table 4.66). Diagnostic plots of the positive part can be seen in Appendix III. The accuracy of the predictions was very good and the AUC equalled 0.90. The Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was highly significant 0.28 ($P < 2.2e-16$). No significant ($p < 0.01$) spatial autocorrelation was found in the residuals of both parts of the model according to the Moran's I (Appendix III).

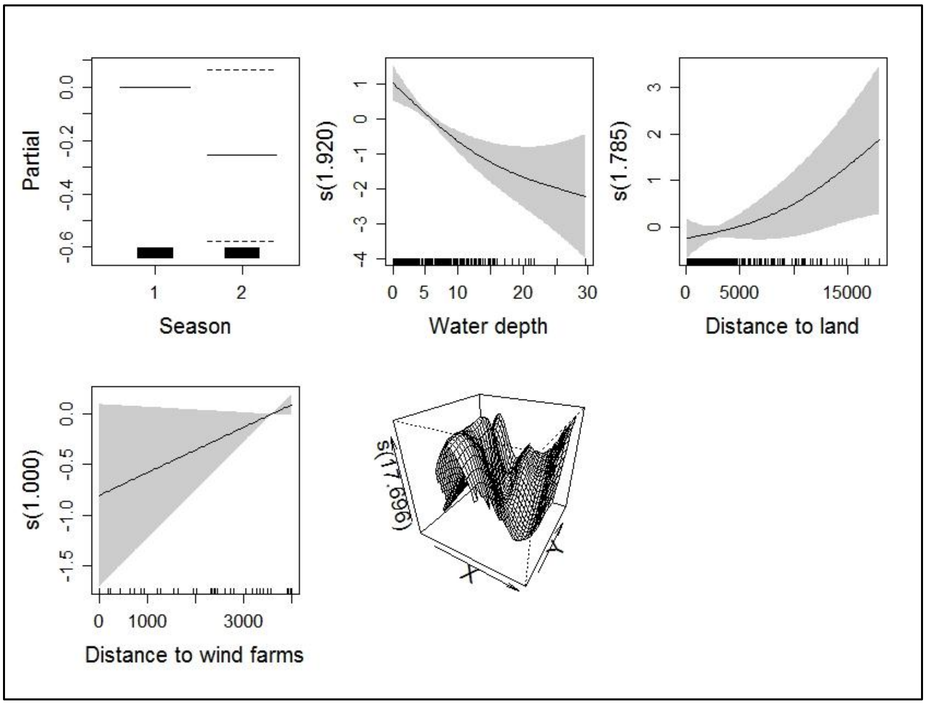
The models deployd show that wintering Goldeneye occurred in highest densities in Rødsand Lagoon and in the Orther Reede area (Figure 4.122).

Table 4.66 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the 'winter' period for Common Goldeneye in the Fehmarnbelt. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	Presence/absence			Positive part		
	Z	X^2	P	t	F	P
Season 2	3.92		<0.01	-1.599		0.11
Mussel biomass		-	-		-	-
Depth		391.28	<0.01		11.183	<0.01
Proportion hard substrate		-	-		-	-
Bottom slope		-	-		-	-
Distance to land		-	-		1.821	0.17
Distance to wind farms		-	-		3.174	0.08
Number of ships		3.17	0.07		-	-
XY		158.87	<0.01		2.802	<0.01
Model performance						
AUC	0.90					
Deviance explained	30.4 %			35.4 %		
Combined correlation (P)	0.28 (P < 2.2e-16)					

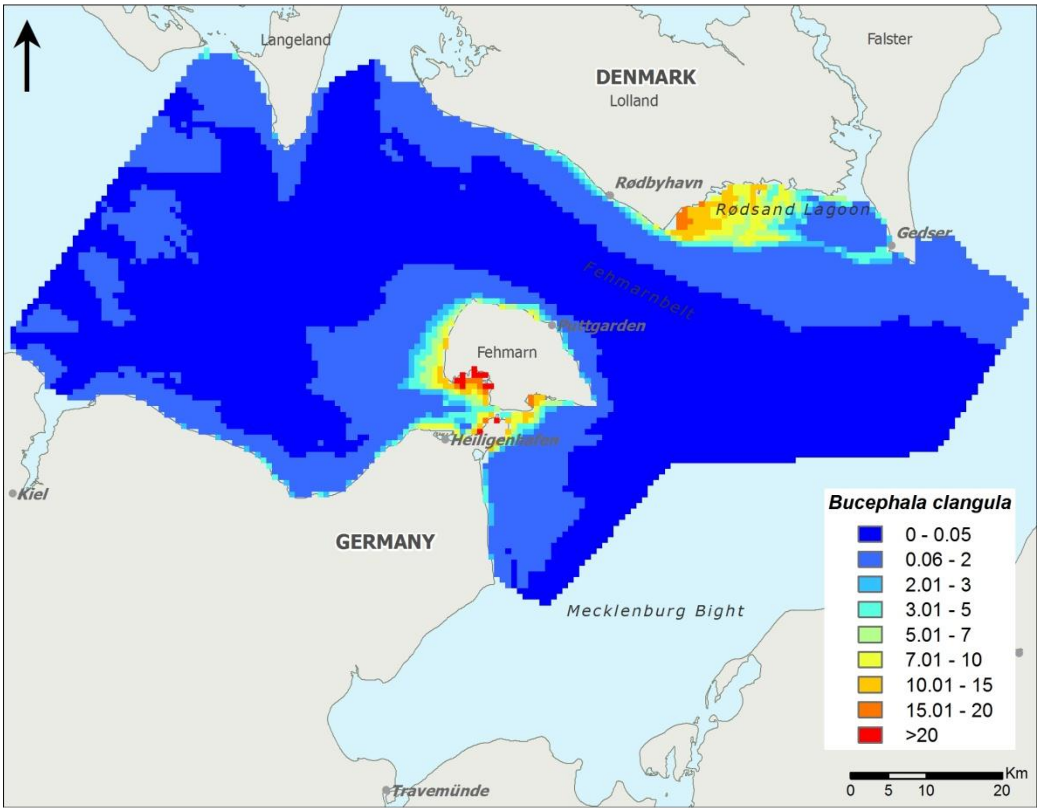


A



B

Figure 4.121 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Common Goldeneye (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the winter season. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.



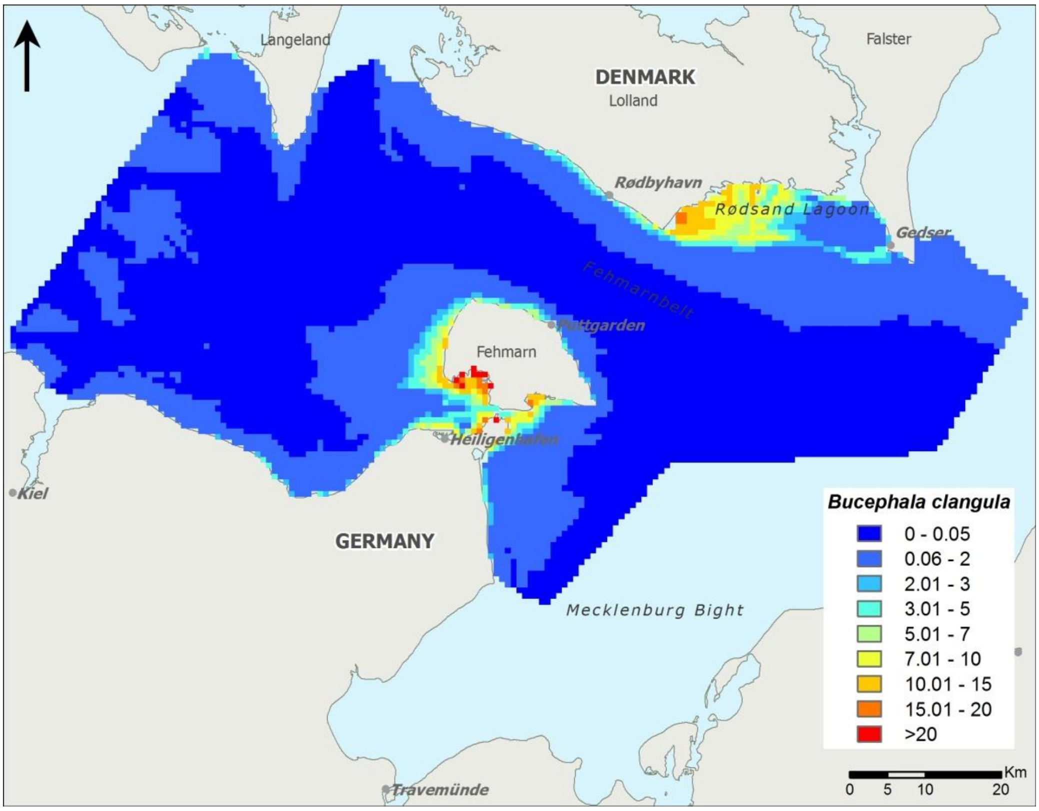


Figure 4.122 Spatial distribution models (numbers per km^2) of Common Goldeneye Bucephala clangula *in the Fehmarnbelt based on baseline aerial surveys undertaken between December 2008 – February 2009 (upper map) and November 2009 – April 2010 (lower map).*

Common Goldeneye distribution according to supplementary datasets
Common Goldeneye is known to use near-shore areas as daytime feeding grounds and is also often recorded on inland freshwater lakes (Berndt et al. 2005).

During the German mid-winter coastal count in 2009 a rather even distribution of Common Goldeneye was observed along the surveyed German mainland and Fehmarn coastline (Figure 4.123; AKVSW 2010, OAG 2010). Danish mid-winter (NOVANA) survey in 2008 showed Goldeneye primarily being found within western and northern parts of Rødsand Lagoon (Figure 4.123; Petersen et al. 2010).

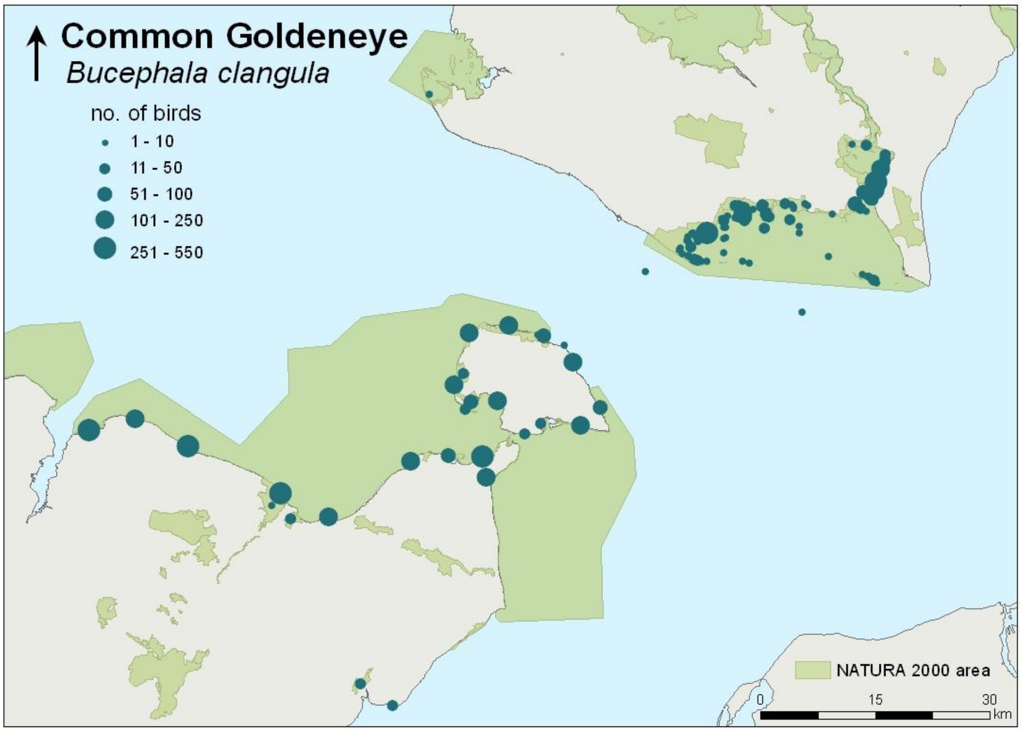


Figure 4.123 Distribution of Common Goldeneye during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Common Goldeneye abundance estimates for SPAs
On the basis of the spatial distribution models, the estimate of wintering Common Goldeneye in the SPA Eastern Kiel Bight was about 900 birds, about 300 for the SPA Baltic Sea east of Wagrien, and 1,100 – 1,200 for the SPA Hyllekrog-Rødsand (Table 4.67). The non-SPA area of the Fehmarnbelt supported additionally about 400 Common Goldeneye during the study period (Table 4.67). Within the non-SPA area, about 100 individuals were estimated to winter in the immediate vicinity of the planned alignment (5 km around, see Figure 2.21 in Methods).

Overall FEBI estimates indicate that about 0.25% of the biogeographic population of Common Goldeneye winters in the Fehmarnbelt. Modelled densities of wintering birds of this species were highest in the SPA Hyllekrog-Rødsand (Table 4.67). The total estimates obtained using the distribution modelling fall within the range of estimates obtained by Distance analysis in most of the cases, but the maximum estimate of 6,400 birds from a single survey, and estimates exceeding 3,000 birds for a few other surveys indicate that the model produced rather low estimates (Table 4.65). The distribution model predicted similar numbers for both winter seasons (Table 4.65), with a slightly higher estimate for winter 2008/2009 with 2,863 ± 984 Common Goldeneyes in the Fehmarn Belt (±SE; Appendix III).

Table 4.67 *Seasonal estimates of Common Goldeneye abundance in the SPAs: Eastern Kiel Bight, Baltic Sea east of Wagrien, and Hyllekrog-Rødsand based on the spatial distribution models for the baseline aerial surveys from December 2008 to April 2010. Estimates for the alignment area, total non-SPA area, and total prediction area are also given.*

SPA / area	Period	Density	Estimate
Eastern Kiel Bight	Dec 2008 – Feb 2009	1.33	941
(DE1530-491)	Nov 2009 – Apr 2010	1.27	895
Baltic Sea east of Wagrien	Dec 2008 – Feb 2009	0.84	307
(DE1633-491)	Nov 2009 – Apr 2010	0.79	292
Hyllekrog-Rødsand	Dec 2008 – Feb 2009	4.87	1,196
(DK006X087)	Nov 2009 – Apr 2010	4.47	1,098
Alignment area	Dec 2008 – Feb 2009	0.51	107
	Nov 2009 – Apr 2010	0.48	100
Non-SPA area (including	Dec 2008 – Feb 2009	0.13	419
the alignment area)	Nov 2009 – Apr 2010	0.12	420
TOTAL	Dec 2008 – Feb 2009	0.60	2,863
	Nov 2009 – Apr 2010	0.57	2,753

Results of supplementary data sources indicate higher numbers occurring in particular SPAs. German land-based mid-winter survey in 2009 resulted in 2,808 Goldeneye utilising coastal and inland waters of the SPA Eastern Kiel Bight, and 449 birds the SPA Baltic Sea east of Wagrien (this SPA was not fully covered by the survey; AKVSW 2010, OAG 2010). Both, Danish mid-winter waterbird census in 2008 (Petersen et al. 2010) and DOF database indicate winter numbers of 2,831 and 2,410 (February 6, 2006; DOF 2010) respectively using the SPA Hyllekrog-Rødsand.

Common Goldeneye trends

The long-term dataset of annual mid-winter land-based bird counts from Fehmarn do not show a significant trend for Common Goldeneye wintering in the study area (AKVSW 2010, Figure 4.124).

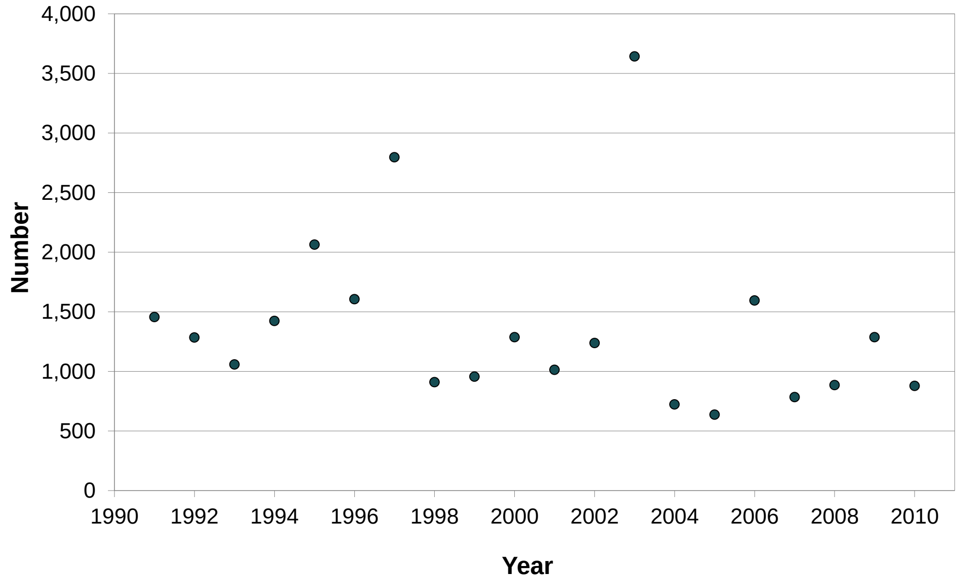


Figure 4.124 Number of Common Goldeneye recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Common Goldeneye

The estimate of the northwest European winter population of Common Goldeneye has been updated to 1.0–1.3 million birds (Wetlands International 2006). As the 1% criterion for this population is 11,500 birds, the FEBI baseline results and supplementary datasets indicate that numbers of wintering Common Goldeneye exceed 0.5% of the biogeographic population (6,400 birds) during the periods of peak abundance. High numbers representing more than 0.1% of the biogeographic population occur in the SPAs Hyllekrog-Rødsand and Eastern Kiel Bight.

Common Goldeneye – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	6,400
Max. abundance estimate in the alignment area:	39 + 160
Period of max. abundance in Fehmarnbelt:	December – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.122, Figure 4.123
Explanations:	Maximum abundance estimated for aerial survey of February 2009. Maximum abundance in the alignment area obtained from supplementary datasets for Rødbyhavn (39 birds) and the German land-based mid-winter survey of 2009 (160 birds). Distribution obtained from spatial modelling on aerial surveys, and from mid-winter surveys from external sources.

4.1.27 Smew – *Mergus albellus*

Smew – *Mergus albellus*	
Biogeographic population: NW and C Europe (non-br)	
Breeding range: N Scandinavia and N Russia	
Wintering / core non-breeding range: NW and C Europe	
Population size: 40,000	
1 % value: 400	
Conservation status:	EU Birds Directive, Annex I: listed EU SPEC Category: SPEC 3 EU Threat Status: (declining)
Target species in SPAs:	Hyllekrog-Rødsand (DK006X083) Eastern Kiel Bight (DE1530-491) Baltic Sea east of Wagrien (DE1633-491)
Key food: fish (winter), insects (summer)	
Period of presence in Fehmarnbelt:	Wintering, migrations: September – April

Origin of Smew in the Fehmarnbelt
The Western Palaearctic breeding range of Smew includes Scandinavia extending east through Finland and Russia (Cramp and Simmons 1977). The species is migratory, but migration routes are poorly known. Breeding birds of Scandinavia and Russia winter around the coasts of Denmark, Germany, Great Britain and the Netherlands (Cramp and Simmons 1977). According to the FEBI ring recovery study there was only one ring recovery of a single bird from northern Sweden in Limfjord, Denmark (Appendix IV).

Data sources on Smew in the Fehmarnbelt
The FEBI baseline surveys covered only partly the main resting sites of Smew in the study area as these birds mostly are confined to inland freshwater habitats or sheltered bays. Thus, supplementary datasets of land-based counts, that cover inland areas also, were used as primary source to assess species abundance and distribution in the Fehmarnbelt area (Table 4.68). Data of FEBI aerial surveys were used as supporting data source for describing species offshore abundance and distribution during severe winter conditions in 2010, when all freshwater habitats were covered with ice.

Table 4.68 List of datasets and their use in baseline assessment of Smew in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Dataset not used due to non-covered shallow water areas
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for species wintering abundance and distribution in Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Smew in the Fehmarnbelt

Smew is a typical wintering species in the Fehmarnbelt region. First individuals arrive in September/October, and the numbers usually peak in winter. Berndt et al. (2005) describe Smew mainly being present at Fehmarn between December and March with a maximum usually observed in January.

Abundance according to FEBI survey data

During FEBI baseline surveys Smew were only rarely observed. In 2009, 8 individuals were recorded in total during aerial transect surveys (6 on November 30, 2009 and 2 on February 7, 2009). During the aerial survey of March 5, 2010 an exceptionally high number of 47 Smew was counted within the transects. The majority of these birds were recorded far offshore in areas of more than 10 m water depth. Because of clustered distribution of these birds no Distance-based abundance estimate was possible. This observation of high number of Smew offshore is very unusual for this species (BirdLife International 2011) and could be explained by extreme winter conditions when inland and also most of coastal marine habitats were covered with ice.

Abundance according to supplementary datasets

Smew numbers recorded within the consistently covered land-based survey sections in Germany indicate higher numbers occurring during transitional periods of the wintering season (OAG 2010; Figure 4.125). Similarly, Berndt et al. (2005) described Smew occurring along the German mainland coast in high numbers already in November and reported birds leaving the area mostly before April. Difference in March numbers between the years 2009 and 2010 might be due to different winter weather conditions.

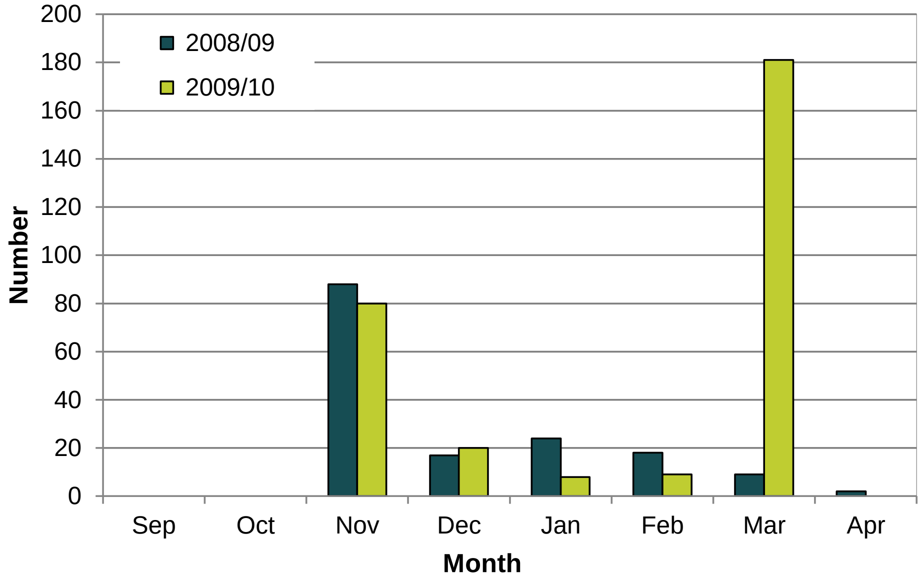


Figure 4.125 Number of Smew recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

Supplementary datasets of land-based surveys also covered adjacent inland areas with important resting sites of Smew. During the mid-winter coastal count of 2008/2009, 163 Smew were recorded along the German coast of the study area (AKVSW 2010, OAG 2010). The majority of these birds were counted in the Fehmarnsund area (92 birds west of the Fehmarnsund Bridge, 23 in Burger Binnensee). Results of monthly counts along the German mainland coast between September and April indicated a similar maximum number of 100 birds in this part of the study area in March 2010 (OAG 2010).

The NOVANA mid-winter surveys of 2004 and 2008 in Denmark reported no Smew for the Danish Fehmarnbelt area (Petersen et al. 2006, 2010). Larger aggregations were recorded on inland lakes of Lolland outside the study area (Petersen et al. 2006, 2010).

The DOF database, however, reports high numbers of Smew occurring in the Rødsand Lagoon. According to this data source the 1% threshold of international importance (400 birds) was exceeded in this area in three winters since 2000 (DOF 2010) with 453 birds on February 19, 2006 (1.1% of the biogeographic population), 1,300 birds on January 21, 2009 (3.3%) and 835 birds on March 7, 2010 (2.1%). Compared to literature data about Smew abundance in Denmark these numbers appear exceptionally high. Pihl et al. (2006) report 660 Smew counted during mid-winter survey of 2000 in the entire Denmark. Petersen et al. (2006) registered 1,447 Smew during the mid-winter survey of 2004 in Denmark. Numbers of wintering Smew are increasing in Denmark (BirdLife International 2004, Petersen et al. 2006, Pihl et al. 2006) and this is also confirmed by observations reported in the DOF database (DOF 2010). Single birds are occasionally reported occurring in the alignment area at Rødbyhavn (DOF 2011).

Distribution and habitat use of Smew in the Fehmarnbelt

According to BirdLife International (2011) wintering Smew are mainly found on large freshwater lakes, ice-free rivers, brackish coastal lagoons, estuaries and sheltered coastal bays (although rarely on the open sea), often resting and feeding on small water bodies or small streams while on passage. Their diet consists mainly of fish in winter and early spring (BirdLife International 2011).

Main wintering areas of Smew in the German Baltic Sea are located further east at Oderhaff and Usedomer Bodden (Sudfeldt et al. 2003).

Smew distribution according to FEBI survey data

During FEBI baseline investigations Smew was only rarely recorded. Aerial survey transects do not include inland areas with numerous freshwater habitats, so this method does not cover the entire possible distribution area of Smew. Although Smew is described as being mostly confined to freshwater and brackish, and sheltered marine habitats (BirdLife International 2011), this species has been recorded offshore in the Fehmarnbelt area during FEBI aerial surveys. During aerial survey in March 2010 a total of 47 Smew were recorded with most of these birds sighted offshore (Figure 4.126). A high proportion of marine habitats in the Fehmarnbelt was covered with ice during this period, therefore this observation does not represent a typical distribution of the species.

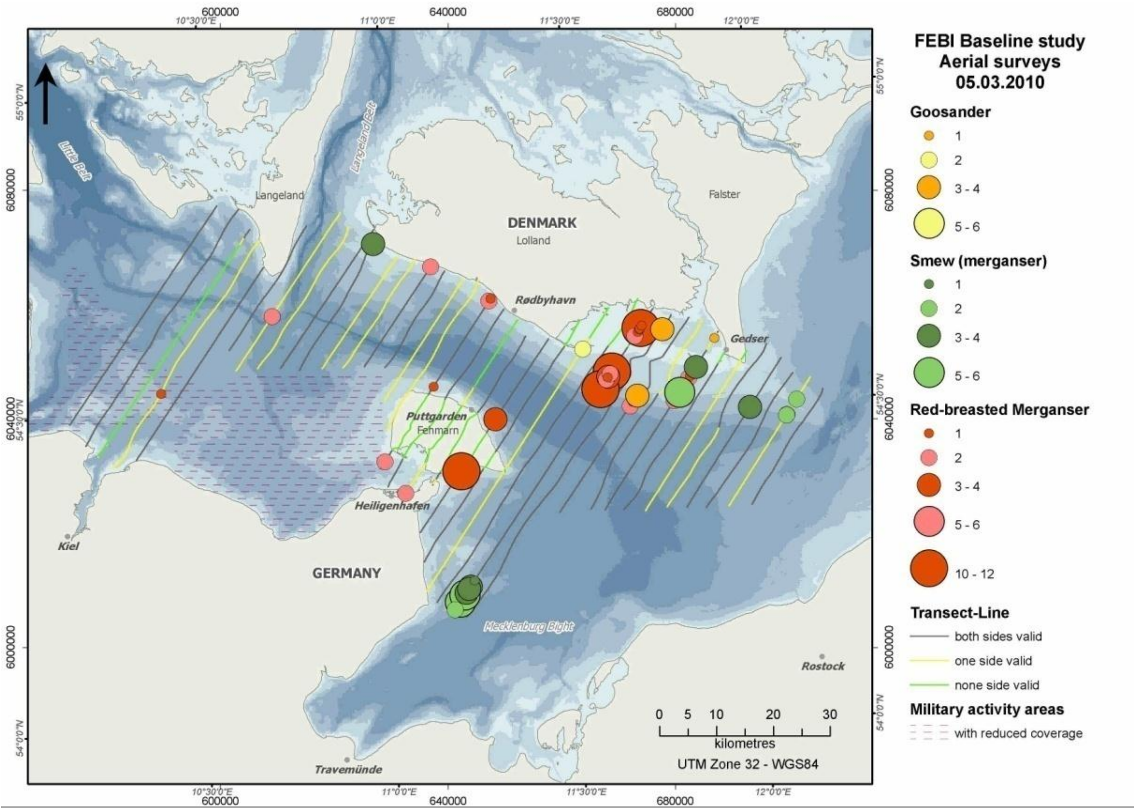


Figure 4.126 Example of the observed Smew (and Red-breasted Merganser, and Goosander) distribution during aerial survey in March 2010.

Smew distribution according to supplementary datasets

The German land-based mid-winter survey of 2009 shows Smew being confined to sheltered bays and lagoons like Orther Reede, Burger Binnensee or Großenbroder Binnenwasser (Figure 4.127; AKVSW 2010, OAG 2010). This pattern was also confirmed by monthly land-based surveys by OAG Schleswig-Holstein along the German mainland coast with 97 % of observed Smew have been recorded inland or in sheltered marine inlets such as Großenbroder Binnenwasser (OAG 2010).

Location descriptions of places where Smew was recorded within Rødsand Lagoon suggest that this species occurred in the northern part of the lagoon (Guldborg Bredning; DOF 2010).

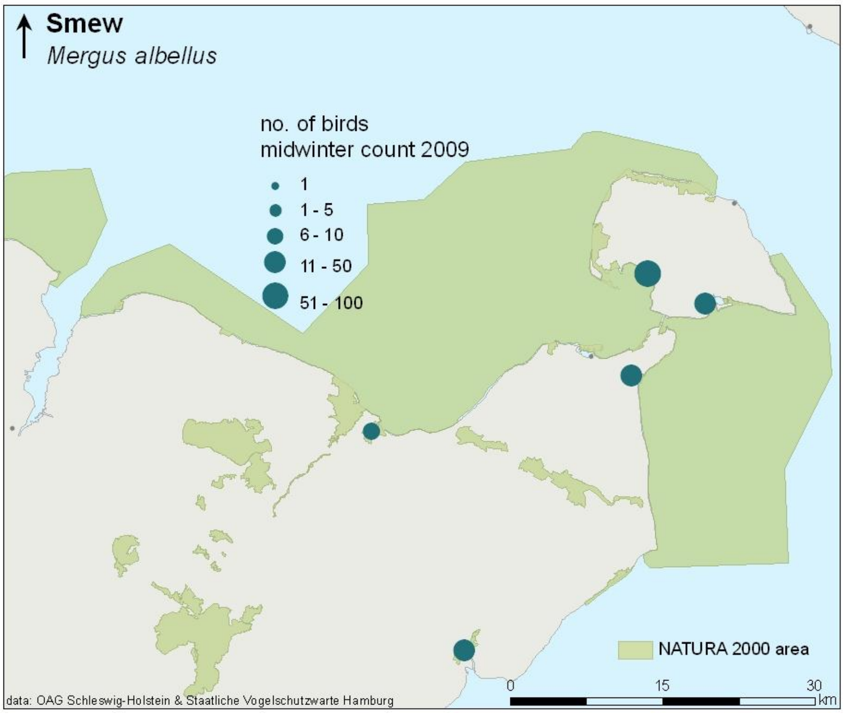


Figure 4.127 Distribution of Smew during winter coastal count in January 2009 between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt. Data: OAG Schleswig-Holstein and AKVSW Hamburg.

Smew abundance estimates for SPAs

In total 163 Smew were counted along the German coast of the study area in mid-winter land-based survey in January 2009, of which 103 were observed within the SPA Eastern Kiel Bight (AKVSW 2010, OAG 2010). Of these, 92 birds were counted in the western Fehmarnsund area. On the mainland survey sections higher numbers were observed in November 2008 (88 Smew) and in March 2010 (100 birds; OAG 2010). Available data indicate that 0.25 % of the biogeographic population use the SPA Eastern Kiel Bight during winter time. It can be expected that even higher numbers were present in the area during the severe winter conditions of February/March 2010, but no data are available for these months.

During the mid-winter survey of 2009, 60 Smew (0.15 % of the biogeographic population) were counted within the SPA Baltic Sea east of Wagrien (37 Großenbroder Binnenwasser, 23 Burger Binnensee; AKVSW 2010, OAG 2010).

High numbers of Smew reported in the DOF database indicate that SPA Hyllekrog-Rødsand is an internationally important site to this species. According to this data source the 1 % threshold of 400 birds was exceeded in three winters since 2000: 453 birds in February 2006 (1.1 % of the biogeographic population), 1,300 birds in January 2009 (3.3 %) and 835 birds in March 2010 (2.1 %; DOF 2010).

Smew trends

European breeding populations of Smew was stable or increasing during 1990-2000 (Sudfeldt et al. 2003, Pihl et al. 2006). But as the large Russian breeding population declined, the species was evaluated as Declining (BirdLife International 2004). For the Baltic Sea Skov et al. (2011) describe a decline in wintering numbers, especially in the southern and western part of the Baltic Sea.

Smew winter distribution and consequently local numbers in particular areas depend on winter severity (Berndt and Busche 1993, Petersen et al. 2006, 2010). On Fehmarn, the highest numbers of Smew occur in cold winters, when birds leave frozen freshwater habitats and aggregate in in coastal areas of the Baltic Sea. In such instances higher numbers are usually recorded in the Fehmarnsund area (Berndt et al. 2005). This could explain fluctuations in Smew numbers recorded during mid-winter coastal counts on Fehmarn between 1991 and 2010 (Figure 4.128; AKVSW 2010).

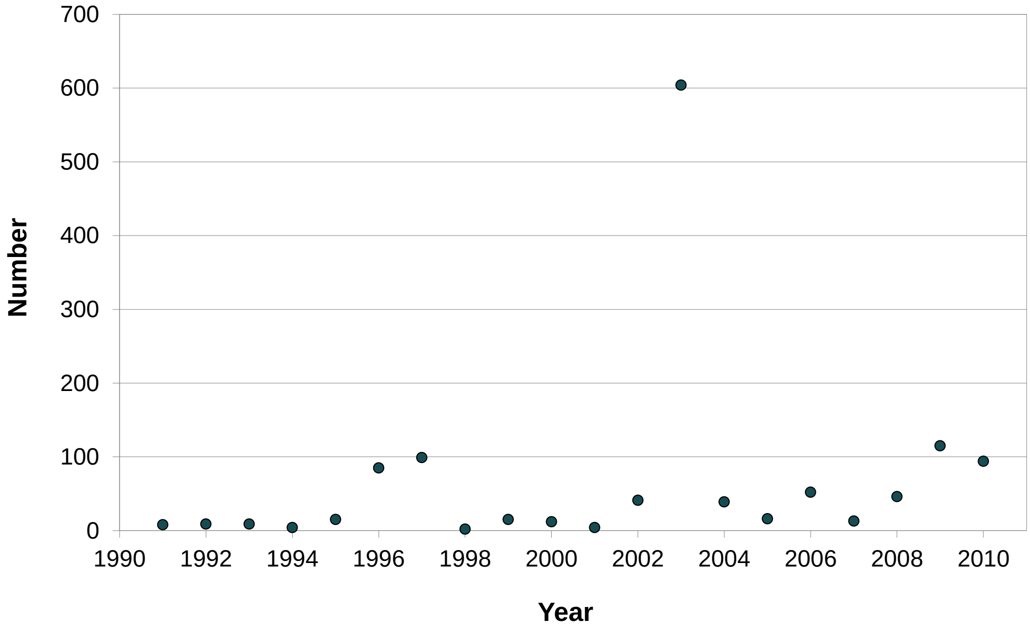


Figure 4.128 Numbers of Smew recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Smew

The Baltic Sea is an important wintering area for the northwest European Smew population (Sudfeldt et al. 2003). The Fehmarnbelt area lies outside of the core wintering range in the Baltic (Sudfeldt et al. 2003). However, internationally important numbers of Smew were observed in the Fehmarnbelt region during wintering period with a peak of 1,300 birds (3.3 % of the biogeographic population) counted in the SPA Hyllekrog-Rødsand alone (January 2009; DOF 2010). Numbers occurring in the study area vary substantially depending on winter conditions; and more birds were recorded during cold winters (Berndt et al. 2005). Smew abundance regularly exceeds the 1 % population threshold in the SPA Hyllekrog-Rødsand (DOF 2010).

The highest number of Smew on the German side of the study area is 163 individuals recorded during the mid-winter land-based count of 2009, but this is rather exceptional occurrence (Figure 4.128; AKVSW 2010, OAG 2010). There is no indication that more than 0.5 % of the biogeographic population would be regularly present in the German part of the Fehmarnbelt. However, exceptionally high number of 604 Smew counted in Fehmarnsund and Burger Binnensee in January 2003 (Figure 4.128) shows that internationally important numbers are occasionally observed in the area.

During the FEBI aerial survey of late winter 2009/2010 relatively high numbers of Smew were recorded in offshore areas of the Fehmarnbelt (47 birds in March

2010). This case, however, represents atypical habitat use of the species when all inland and coastal waters were covered with ice.

Smew – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	1,300 + 160
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	November – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.127 and Rødsand Lagoon
Explanations:	Maximum abundance estimated from Danish land-based counts (1,300 birds in Rødsand Lagoon) and German mid-winter survey of 2009 (160 birds, mostly inland). Distribution obtained from supplementary datasets.

4.1.28 Red-breasted Merganser – *Mergus serrator*

Red-breasted Merganser – *Mergus serrator*	
Biogeographic population: NW and C Europe (non-br)	
Breeding range: N and NW Europe, Iceland, E Greenland	
Wintering / core non-breeding range: N, NW and C Europe, Iceland	
Population size: 170,000	
1 % value: 1,700	
Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: Non-SPEC EU Threat Status: (secure)
Target species in SPAs:	Hyllekrog-Rødsand (DK006X083)
Key food: fish, also crustaceans, annelids, insects	
Period of presence in Fehmarnbelt:	Wintering, migrations: September – April Breeding, moulting: May – August

Origin of Red-breasted Merganser in the Fehmarnbelt

The Red-breasted Merganser is a partial migrant with the majority of local breeding birds staying within the Fehmarnbelt region during the winter (Cramp and Simmons 1977; Bønløkke et al. 2006). Ring recoveries indicate that Red-breasted Merganser recovered during the non-breeding season in the Fehmarnbelt region are ringed throughout the Baltic Sea (Appendix IV). Local breeders seem to remain in southern Baltic waters during winter. These patterns are in agreement with the Danish and Swedish ringing atlases (Fransson and Pettersson 2001; Bønløkke et al. 2006) with some evidence of Norwegian birds moving to the Fehmarnbelt region during the non-breeding season (Bakken et al. 2003).

Data sources on Red-breasted Merganser in the Fehmarnbelt

Red-breasted Mergansers have been recorded during both FEBI aerial and ship-based surveys and both platforms were considered when assessing abundance and distribution of the species (Table 4.69). Other datasets were used as supporting data sources to characterise Red-breasted Merganser densities, distribution and habitat use (Table 4.69).

Table 4.69 List of datasets and their use in baseline assessment of Red-breasted Merganser in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating Red-breasted Merganser densities, abundance and habitat use.
FEBI ship transect surveys	Primary dataset for estimating Red-breasted Merganser densities, abundance and habitat use. Also used to represent variability in bird densities in different periods.
OAG land-based counts	Supporting dataset representing species distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis Supporting dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for densities and distribution of the species in Danish part of the Fehmarnbelt
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt area

Abundance of Red-breasted Merganser in the Fehmarnbelt

Red-breasted Merganser abundance estimates based on Distance analysis

The abundance of Red-breasted Merganser in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Red-breasted Merganser during aerial surveys, calculated using the entire dataset, were 206 m for swimming birds and 217 m for flying birds. These detection functions and ESWs were close to those of other species of similar size estimated in this study.

The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of Red-breasted Merganser have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.70, Appendix V). Peak abundances of Red-breasted Merganser have been recorded either at the end or beginning of wintering season: March 2009 and October 2009 (Table 4.70).

Month-to-month variation in Red-breasted Merganser abundance indicate that the species is present throughout the year, with the highest numbers during wintering period between October and March, while very few birds were recorded during April – September (Table 4.70).

Table 4.70 Numbers of observed Red-breasted Mergansers during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95% confidence interval, UCI – upper 95% confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50% and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	5	12	0.02	0.01	0.07	82
Dec-08	81.7	10	22	0.05	0.02	0.16	197
Jan-09	82.8	10	20	0.04	0.02	0.10	159
Feb-09	100	21	79	0.15	0.04	0.87	755
Mar-09	77.5	60	183	0.37	0.18	0.77	1,406
Apr-09	86.8	2	3	0.01	0.00	0.02	24
May-09	77.3	0	0	0	0	0	0
Jun-09	80.9	1	2	0.00	0.00	0.02	16
Jul-09	86.6	3	3	0.01	0.00	0.02	26
Aug-09	92.3	0	0	0	0	0	0
Sep-09	79.1	1	1	0.00	0.00	0.01	7
Oct-09	79.9	7	69	0.46	0.03	5.95	1,775
Nov-09	82.4	11	118	-	-	-	-
Dec-09	24.7	0	0	0	0	0	0
Mar-10 A	64.1	30	85	0.19	0.06	0.58	596
Mar-10 B	75.6	12	28	0.06	0.02	0.15	207
Apr-10	100	4	6	0.01	0.00	0.04	46
May-10	92.1	2	2	0.00	0.00	0.01	14
Jun-10	70.8	6	10	0.02	0.00	0.06	53
Aug-10	75.6	1	2	0.00	0.00	0.02	17
Sep-10 A	44.9	0	0	0	0	0	0
Sep-10 B	48.9	0	0	0	0	0	0
Oct-10	80.0	4	16	0.03	0.01	0.10	110
Nov-10	70.1	12	20	0.04	0.01	0.13	140

Although ship-based surveys do not cover shallow coastal waters where Red-breasted Mergansers are typically observed, aggregations of this species have also been recorded in deeper water areas, especially during the severe period of winter 2009/2010, when inland and coastal waters became covered with ice (Table 4.71).

The global ESW for Red-breasted Merganser during ship-based surveys was 183 m. Probably due to a more coastal distribution, only few birds have been recorded on some surveys and small sample size made Distance estimates impossible for those surveys. However, in some periods fair numbers of Red-breasted Mergansers have been recorded from ships, which led to relatively high estimates of the total abundance: 2,756 birds in February 2009, 2,481 in November 2009 and 7,802 in February 2010.

Distance results from ship-based surveys confirm the general seasonal pattern of Red-breasted Merganser abundance in Fehmarnbelt with highest numbers being present in the area at beginning and end of winter period and only few birds using the Fehmarnbelt during summer (Table 4.71, Figure 4.129). Very high estimate for February 2010 was most likely influenced by unusually severe winter conditions when extensive ice cover of coastal and some offshore areas caused higher than usual bird aggregations in the Fehmarnbelt.

Table 4.71 Numbers of observed Red-breasted Mergansers during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km^2 covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	**Stratum**	**N obs**	**N birds**	**D**	**%CV**	**LCI**	**UCI**	**D**	**LCI**	**UCI**	**N flying**	**D**	**Total number**
Nov-08	coastal	39	150	-	***	-	-	-	-	-	27	-	-
	offshore	3	6	0.13	73	0.03	0.51				1		
Dec-08	coastal	23	140	-	***	-	-	-	-	-	30	-	-
	offshore	2	6	-	***	-	-						
Jan-09	coastal	28	109	0.93	42	0.42	2.08	-	-	-	47	-	-
	offshore	3	5	-	***	-	-				2		
Feb-09	coastal	43	118	1.39	59	0.46	4.15	1.06	0.33	3.51	22	1.18	2,756
	offshore	9	16	0.43	95	0.08	2.25				5		
Mar-09	coastal	38	80	0.64	38	0.31	1.33	-	-	-	28	-	-
	offshore	3	8	-	541	-	-				4		
Apr-09	coastal	19	44	-	***	-	-	-	-	-	24	-	-
	offshore	1	3	0.06	99	0.01	0.34				2		
May-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jul-09A	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jul-09B	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Aug-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Oct-09	coastal	2	5	0.05	81	0.01	0.32	0.04	0.01	0.24	4	0.06	141
	offshore	0	0	0	0	0	0				0		
Nov-09	coastal	17	55	1.52	60	0.50	4.63	1.01	0.33	3.12	5	1.06	2,481
	offshore	1	3	0.06	103	0.01	0.35				7		
Dec-09	coastal	15	32	-	***	-	-	-	-	-	16	-	-
	offshore	3	7	-	***	-	-				5		
Jan-10	coastal	29	64	0.52	35	0.26	1.01	-	-	-	23	-	-
	offshore	2	90	-	***	-	-				0		
Feb-10A	coastal	83	392	3.39	35	1.73	6.64	-	-	-	32	-	-
	offshore	12	37	-	***	-	-				1		
Feb-10B	coastal	141	555	4.40	24	2.76	7.03	3.23	1.94	5.54	20	3.33	7,802

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
	offshore	12	33	0.90	55	0.31	2.58				5		
Mar-10	coastal	148	435	4.37	41	2.00	9.55	-	-	-	66	-	-
	offshore	7	29	-	887	-	-				1		
Apr-10	coastal	9	32	0.31	81	0.07	1.33	0.22	0.05	0.93	4	0.23	544
	offshore	1	1	0.02	102	0.00	0.13				0		
May-10	coastal	0	0	0	0	0	0	0.02	0.00	0.08	0	0.02	35
	offshore	2	2	0.04	96	0.01	0.24				0		
Jun-10	coastal	5	6	0.09	83	0.02	0.39	0.06	0.01	0.26	0	0.07	162
	offshore	0	0	0	0	0	0				2		
Sep-10	coastal	0	0	0	0	0	0	0	0	0	1	0.00	10
	offshore	0	0	0	0	0	0				0		
Oct-10	coastal	1	2	0.02	100	0.00	0.12	0.02	0.00	0.08	3	0.03	66
	offshore	0	0	0	0	0	0				0		
Nov-10	coastal	3	7	0.11	132	0.01	0.85	0.08	0.01	0.57	11	0.13	302
	offshore	0	0	0	0	0	0				2		

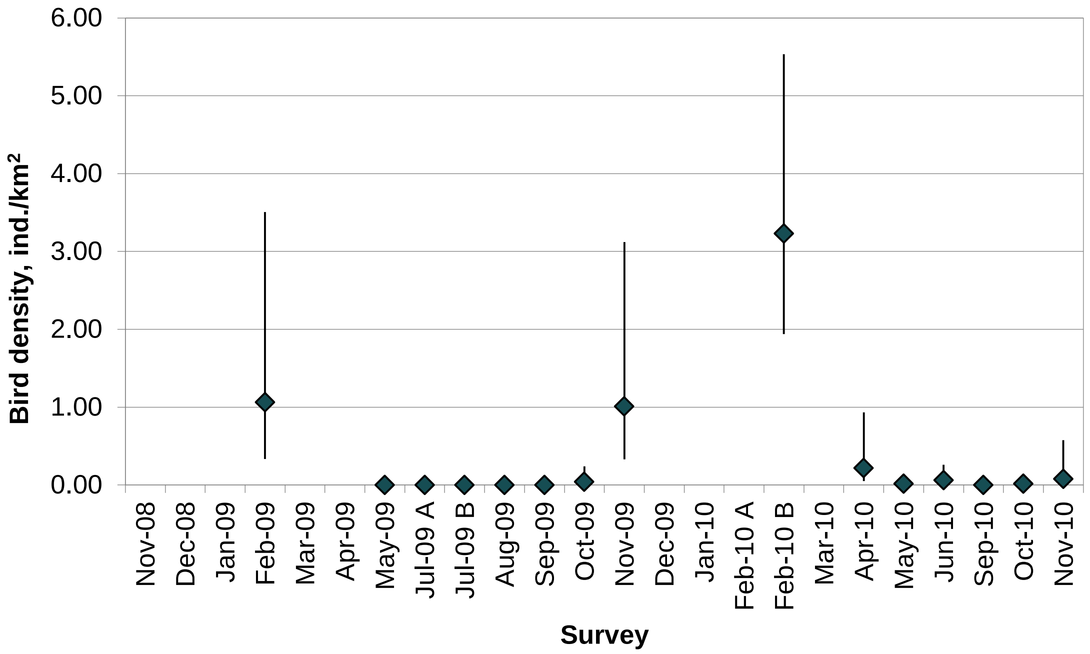


Figure 4.129 Mean density estimates and 95 % confidence intervals of swimming Red-breasted Mergansers estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150 % were not included into the chart (see Table 4.71 for specific values).

Red-breasted Merganser abundance estimates according to supplementary datasets

The German waterbird monitoring aerial surveys report very few observations of Red-breasted Mergansers and provide no total estimates for the species (BIOLA 2009).

Red-breasted Mergansers are regularly recorded in the Fehmarnbelt area during the Danish aerial waterbird monitoring surveys, mostly in Rødsand Lagoon (Petersen et al. 2006, 2010). For example a total of 164 Red-breasted Mergansers were recorded during these surveys (NOVANA) in February 2008 (Petersen et al. 2010).

The data from the German mid-winter coastal counts indicate that about 422 birds wintered in coastal waters along the Fehmarn and the mainland coast in January 2009 (AKVSW 2010, OAG 2010). This mid-winter count should be considered as a minimum estimate for coastal areas of the German part of the study area, as highest numbers of Red-breasted Mergansers occur during autumn and spring migration periods (Berndt et al. 2005; Figure 4.130, OAG 2010).

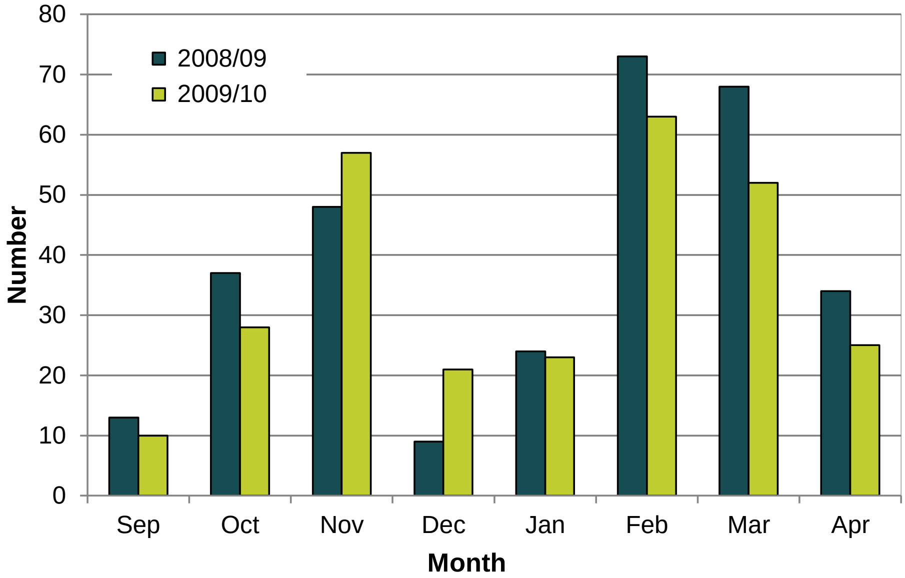


Figure 4.130 Numbers of Red-breasted Mergansers recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

The Danish Ornithological Society (DOF) database reports up to 290 Red-breasted Mergansers occurring in Rødsand Lagoon (December 28, 2009; DOF 2010).

According to Mendel et al. (2008) maximum numbers of Red-breasted Mergansers resting in northern Germany appear in autumn (November). Around the island of Fehmarn maximum numbers were reported in spring. Mendel et al. (2008) estimate the wintering population in the German Baltic Sea at 10,500 birds. Pihl et al. (2006) defined the period from September to November as the period with the largest numbers of migrating Red-breasted Mergansers in Denmark (28,000 birds, mainly concentrated in the Limfjord and Smålandsfarvandet).

Distribution and habitat use of Red-breasted Merganser in the Fehmarnbelt
Aerial surveys of FEBI baseline investigations show Red-breasted Mergansers being usually found close to shore and in sheltered marine areas like Rødsand Lagoon, Schönberger Strand and Fehmarnsund. However occasionally birds were recorded offshore, and this was their regular distribution during cold winter periods when coastal waters were frozen (Appendix II).

Red-breasted Merganser distribution and habitat use according to spatial modelling of aerial survey data

The distribution models were fitted for the 'winter' period when the Red-breasted Merganser is most abundant in the Fehmarnbelt region. The 'winter' period was further categorised into 2 seasons: season 1 (November 2008 – March 2009) and season 2 (October 2009 – March 2010).

Easting and northing 'XY' was the most important predictor variable in the presence/absence part of the model indicating that a part of the variance could not be explained by the environmental variables used in the model (Table 4.72). Water depth was the most important environmental variable and indicated that the Red-breasted Merganser prefers shallow waters (Table 4.72; Figure 4.131A). Other significant variables described currents, indicating that occurrence of the species was more likely in areas of positive eddy activity (vorticity) and slack northward currents (current V; Figure 4.131A). Further, merganser occurrence decreased steeply with water temperature above 8 °C, which probably characterises the seasonal change in abundance. Birds were also more likely to occur in areas with higher salinity and hard bottom substrate (Figure 4.131A). The categorical variable representing seasons indicated that Red-breasted Merganser occurred over broader areas during the season 1 than during the season 2 (Table 4.72).

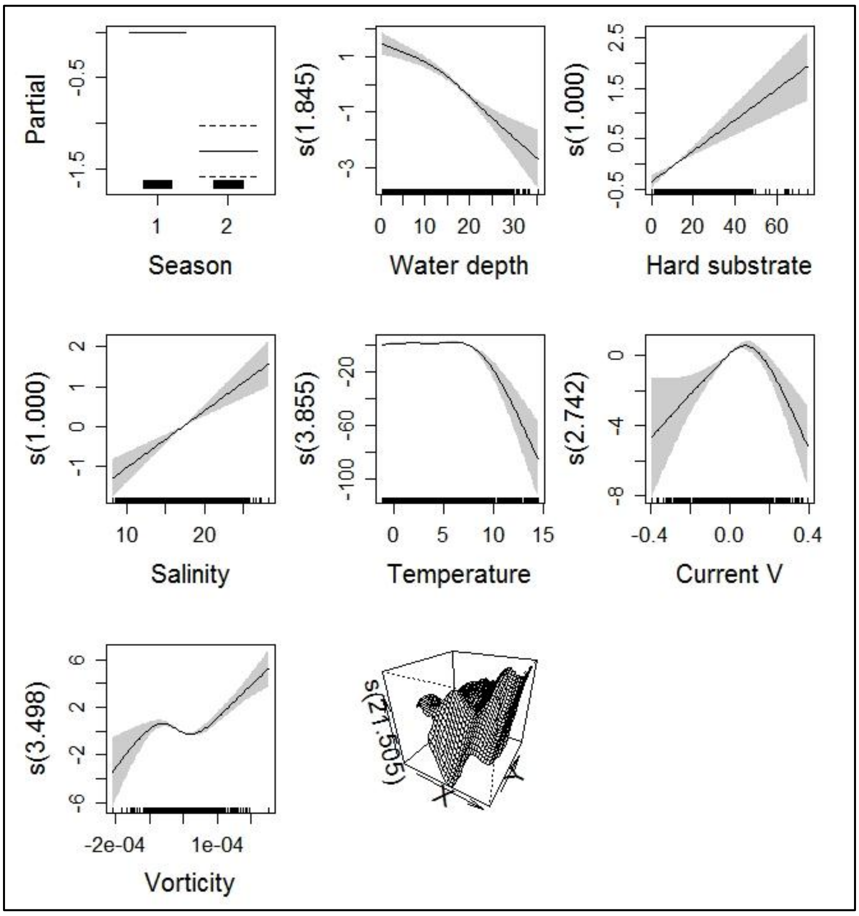
Water depth was the most important predictor in the positive part, indicating a similar relationship as identified in the binomial part of the model (Table 4.72, Figure 4.131B). Merganser densities also increased with increasing upwelling activity (positive current W). Similarly to the binomial part of the model, the relationship with bottom substrate suggested birds preferring hard sediments (Table 4.72, Figure 4.131B). Seasonal patterns, when considering both model parts, indicate that Red-breasted Merganser occurred over broader areas in season 1, compared to season 2, but the densities were higher during the season 2 (Table 4.72, Figure 4.131B).

The distribution model had a moderately good fit. Deviance explained in the binomial part was 25.5 % and 72.3 % in the positive part (Table 4.72). Diagnostic plots of the positive part can be seen in Appendix III. The accuracy of the predictions based on the AUC equalled 0.79 and the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.17 ($P = 2.3e-13$). No significant ($P < 0.01$) spatial autocorrelation was found in residuals of either part of the model (Appendix III).

The models deployed show that wintering Red-breasted Merganser occurred in highest densities in coastal waters of Schönberger Strand, Rødsand Lagoon and western Fehmarnsund with Orther Reede (Figure 4.132).

Table 4.72 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the 'winter' period for Red-breasted Merganser in the Fehmarnbelt according to aerial survey data. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	Presence/absence			Positive part		
	Z	X^2	P	t	F	P
Season 2	-9.44		<0.01	3.28		<0.01
Depth		75.99	<0.01		19.06	<0.01
Proportion hard substrate		32.35	<0.01		2.37	0.07
Bottom slope		-	-		-	-
Distance to land		-	-		-	-
Distance to wind farms		-	-		-	-
Number of ships		-	-		-	-
Pycnocline depth		-	-		-	-
Current gradient (Surface)		-	-		-	-
Salinity (Bottom)		29.89	<0.01		-	-
Temperature (Bottom)		46.05	<0.01		-	-
Current U (Surface)		-	-		-	-
Current V (Bottom)		51.62	<0.01		-	-
Current W (Surface)		-	-		10.29	<0.01
Vorticity (Bottom)		50.07	<0.01		-	-
Current speed (Surface)		-	-		-	-
XY		337.79	<0.01		2.57	<0.01
Model performance						
AUC	0.79					
Deviance explained	25.5 %			72.3 %		
Combined correlation (P)	0.17 (P = 2.3e-13)					



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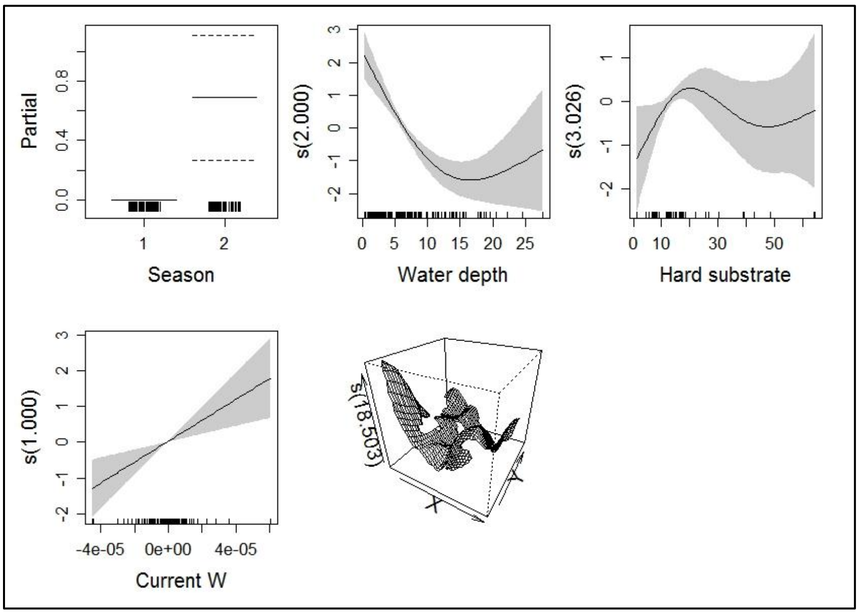
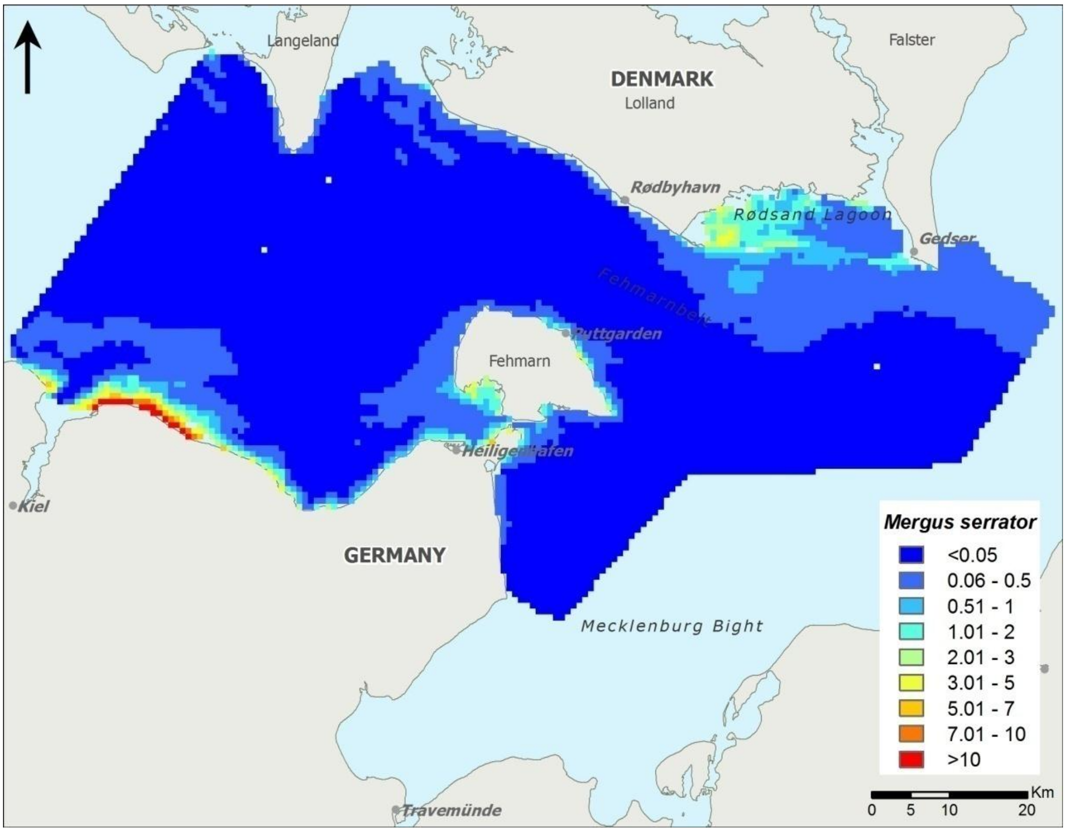


B

Figure 4.131 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence (A – binomial part of the model) or density (B – positive part of the model) of Red-breasted Merganser in the Fehmarnbelt for the winter season according to aerial survey data. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.



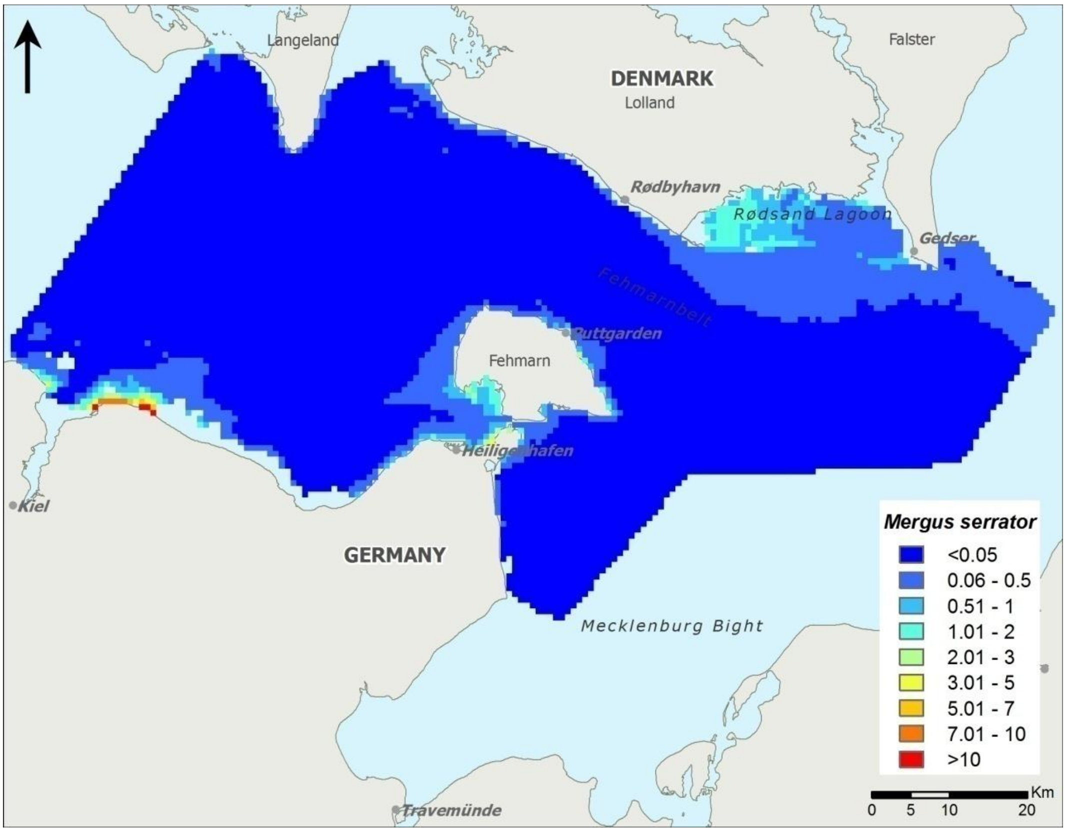


Figure 4.132 Spatial distribution models (numbers per km^2) of Red-breasted Merganser Mergus serrator *in the Fehmarnbelt based on baseline aerial surveys undertaken between Novemberr 2008 – March 2009 (upper map) and October 2009 – March 2010 (lower map).*

Red-breasted Merganser distribution and habitat use according to spatial modelling of ship-based survey data

Distribution model on ship-based survey data was fitted for the 'winter' period when Red-breasted Mergansers are present in the Fehmarnbelt region. The 'winter' period was further categorised into two seasons: season 1 (November 2008 – April 2009) and season 2 (November 2009 – March 2010).

Similar to the model based on aerial surveys, easting and northing 'XY' was the most important predictor variable in the presence/absence part of the model developed using ship-based survey data (Table 4.8). Also, water depth was the most important environmental variable and indicated that the Red-breasted Merganser prefers shallow water areas (Table 4.8; Figure 4.94A). Other significant variables included water temperature and vorticity, indicating that mergansers were most likely to occur in areas with water temperature of about 4°C and negative eddy activity (Figure 4.94A). The categorical variable representing seasons indicated that Red-breasted Merganser occurred over broader areas during the season 2 than during the season 1 (Table 4.8).

Water depth was the most important predictor in the positive part, indicating a similar relationship as identified in the binomial part of the model (Table 4.8, Figure 4.94B). Other significant predictors included current describing variables, which patterns are not very clear. Relationship with distance to land variable suggests that merganser densities were increasing with increasing distance to the shoreline (Table 4.8, Figure 4.94B). Seasonal patterns, when considering both model parts, suggest that Red-breasted Merganser occurred over broader areas in season 2, but densities were not significantly different between the two winters (Table 4.8, Figure 4.94B).

The distribution model had a reasonable fit. Deviance explained in the binomial part was 28.6 % and 46 % in the positive part (Table 4.8). Diagnostic plots of the positive part can be seen in Appendix III. The accuracy of the predictions based on the AUC equalled 0.81 and the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.39 ($P = 2.2e-16$). No significant ($P < 0.01$) spatial autocorrelation was found in residuals of either part of the model (Appendix III).

The deployed models show similar distribution for overlapping area as found according to aerial surveys: wintering Red-breasted Mergansers occurred in highest densities in shallow coastal areas along the coast of Lolland, around Fehmarn and off Rødsand Lagoon (Figure 4.95). Differently from aerial surveys, modelling according to ship-based survey data suggests that this species also occurs in moderate densities in shallow offshore areas such as Sagasbank and Flüggesand and extensive areas along the Lolland coast support high densities of Red-breasted Mergansers (Figure 4.95).

Table 4.73 Significance of smooth terms (X^2, Z, t and F values) of variables in the spatial distribution model for the 'winter' period for Red-breasted Merganser in the Fehmarnbelt according to ship-based survey data. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	Presence/absence			Positive part		
	Z	X^2	P	t	F	P
Season 2	5.10		<0.01	1.01		0.32
Depth		21.05	<0.01		7.18	<0.01
Proportion hard substrate		-	-		-	-
Bottom slope		-	-		-	-
Distance to land		-	-		3.82	<0.01
Distance to wind farms		-	-		-	-
Number of ships		-	-		-	-
Pycnocline depth		-	-		-	-
Current gradient (Bottom)		-	-		-	-
Salinity (Bottom)		-	-		-	-
Temperature (Bottom)		14.93	<0.01		-	-
Current U (Bottom)		-	-		3.62	<0.01
Current V (Surface)		-	-		4.34	<0.01
Current W (Bottom)		-	-		-	-
Vorticity (Surface)		5.95	0.02		-	-
Current speed (Surface)		-	-		3.12	0.01
XY		106.28	<0.01		2.89	<0.01
Model performance						
AUC	0.81					
Deviance explained	28.6 %			46 %		
Correlation (combined)	0.39 (p = <2.2e-16)					

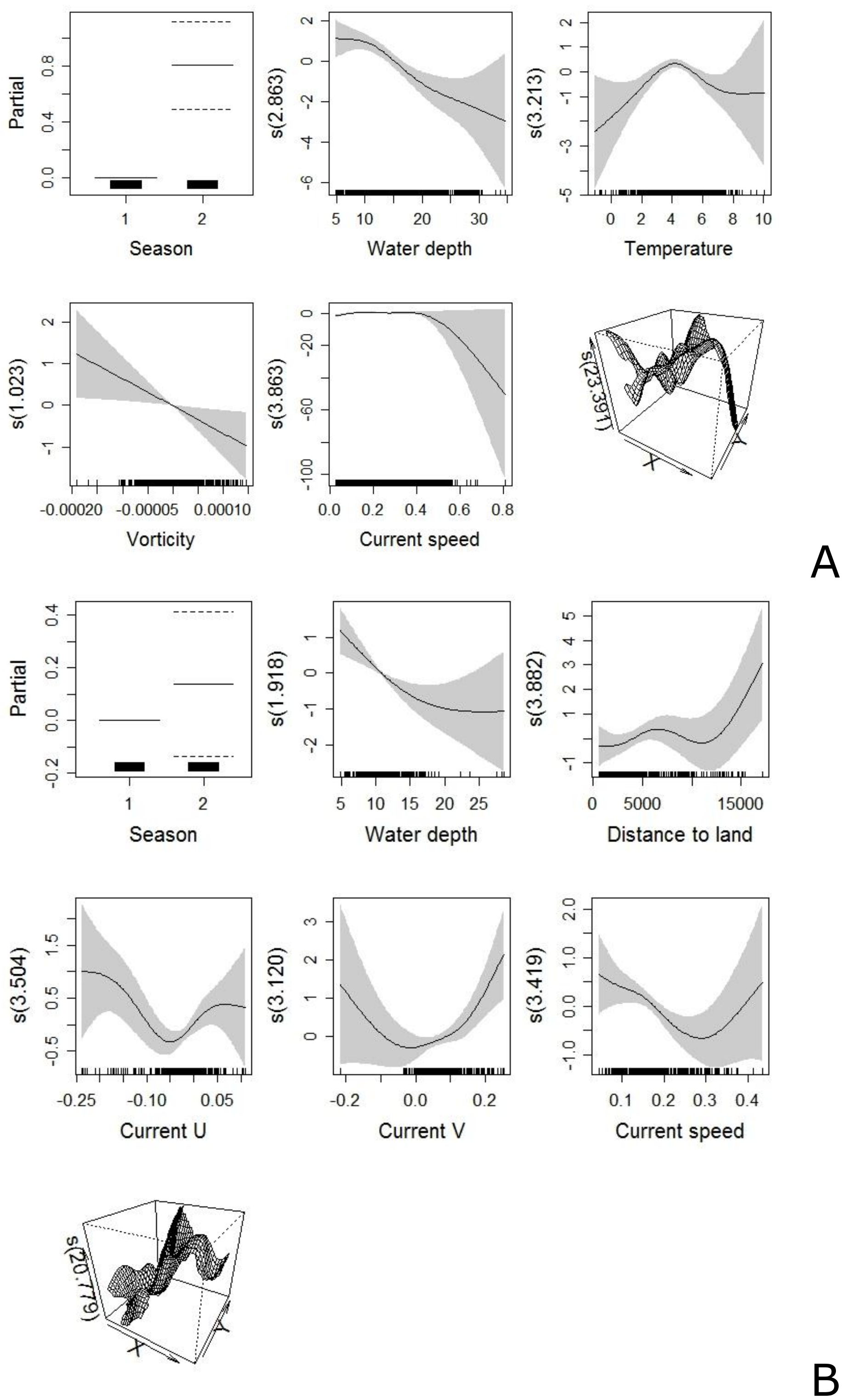
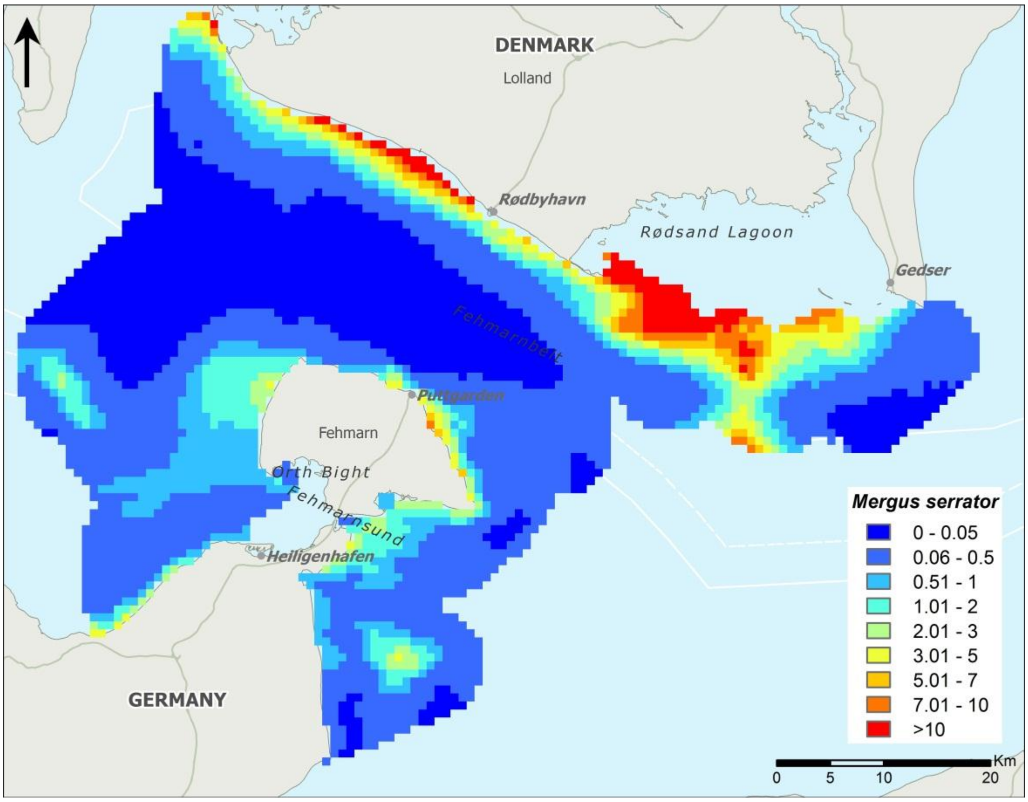


Figure 4.133 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Red-breasted Merganser (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the winter season according to ship-based survey data. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.



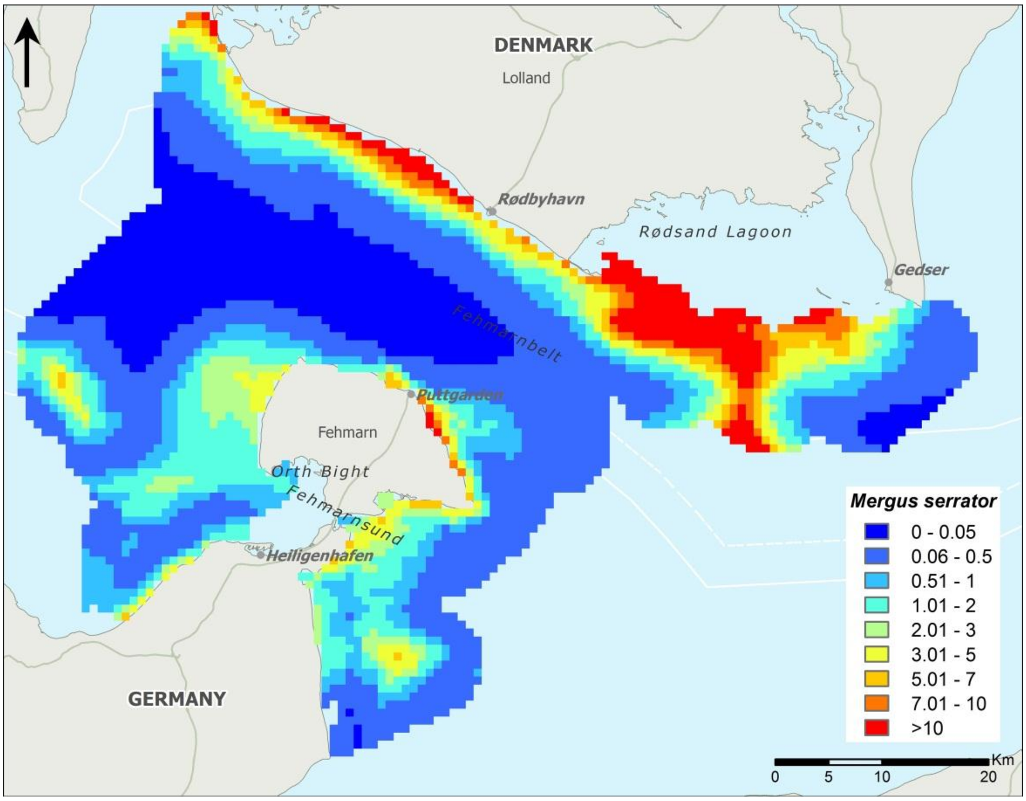


Figure 4.134 Spatial distribution models (numbers per km2) of Red-breasted Merganser Mergus serrator *in the Fehmarnbelt based on baseline ship-based surveys undertaken between November 2008 – April 2009 (upper map) and November 2009 – March 2010 (lower map).*

Red-breasted Merganser distribution according to supplementary datasets

The German land-based mid-winter surveys 2009 show Red-breasted Mergansers being widely distributed in the coastal waters around Fehmarn and along the German mainland coast, with birds preferring sheltered bights and lagoons like Orther Reede, Burger Binnensee or Großenbroder Binnenwasser (AKVSW 2010, OAG 2010). The results of the Danish mid-winter survey 2008 show a similar distribution pattern of Red-breasted Mergansers, as this species mainly has been observed within the sheltered area of the Rødsand Lagoon (Figure 4.135; Petersen et al. 2010).

Red-breasted Mergansers use nearly exclusively near-shore areas along the Baltic coastline as wintering habitat (Mendel et al. 2008).

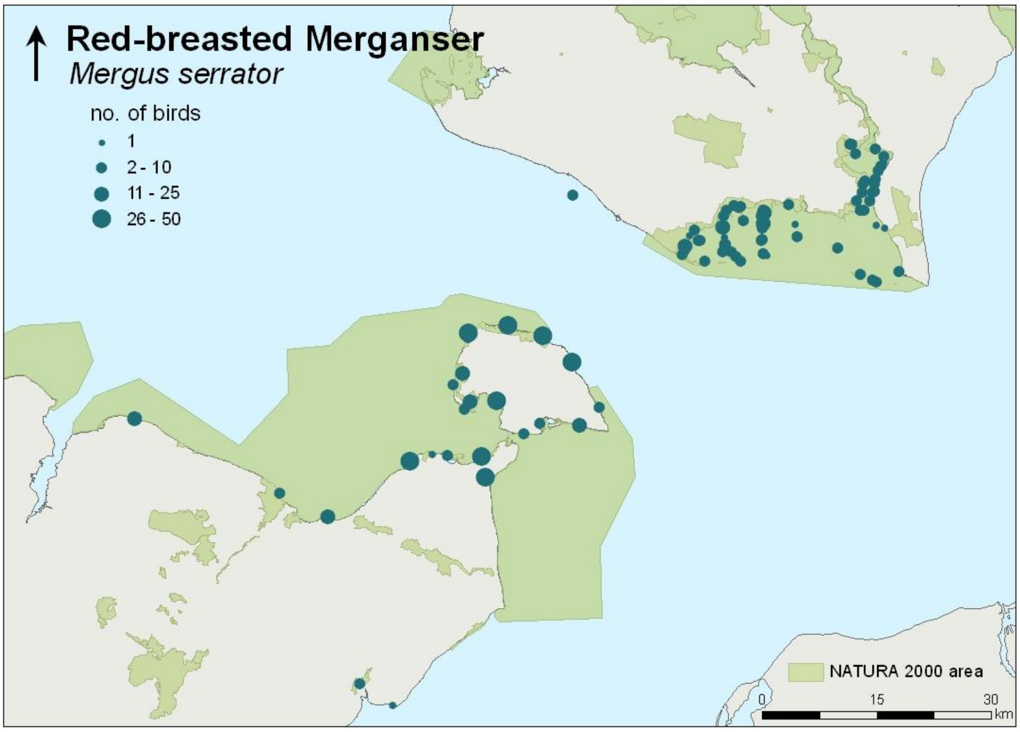


Figure 4.135 Distribution of Red-breasted Mergansers during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Red-breasted Merganser abundance estimates for SPAs

Aerial surveys achieved better spatial coverage of the Fehmarnbelt area, but ship-based surveys resulted in higher estimates of Red-breasted Mergansers according to both Distance analysis and spatial modelling. Therefore, using the precautionary principle, spatial modelling results of ship-based surveys were used to evaluate total numbers of this species in the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien. Since ship-based surveys did not cover Rødsand Lagoon, abundance assessment in the SPA Hyllekrog-Rødsand was based on the spatial model according to aerial surveys.

Results of distribution modelling using ship-based data indicated that the SPA Eastern Kiel Bight supported 234 and 451 wintering Red-breasted Mergansers in winters 2008/2009 and 2010/2011 respectively (Table 4.74). The estimates for the SPA Baltic Sea east of Wagrien were 184 and 363 Red-breasted Mergansers during the two winters. Between 100 and 200 birds were estimated to winter in the SPA Hyllekrog-Rødsand according to aerial survey data (Table 4.74).

The non-SPA area of the Fehmarnbelt supported additionally about 1,700 and nearly 3,000 Red-breasted Mergansers in winters 2008/2009 and 2009/2010 respectively (Table 4.74). Within the non-SPA area, about 150-250 individuals were estimated to winter in the immediate vicinity of the planned alignment (5 km around, see Figure 2.21 in Methods).

The total estimates obtained using the distribution modelling fall within a range of estimates obtained by Distance analysis for winter 2008/2009: distribution models predicted 2,320 birds for winter 2008/2009 and 3,908 for winter 2009/2010 (Table 4.74, Appendix III). Distance analysis estimates of ship-based surveys suggested 2,756 in winter 2008/2009 and from 2,481 to 7,800 in winter 2009/2010 (Table 4.71).

Overall FEBI estimates indicate that 1.4-2.3% of the biogeographic population of Red-breasted Merganser winter in the Fehmarnbelt with possible peaks of up to 4.6%. The highest modelled densities of wintering Red-breasted Mergansers were located outside of the SPAs, and none of the protected areas supported internationally important concentrations of this species (Table 4.74).

Table 4.74. Seasonal estimates of Red-breasted Merganser abundance in the SPAs: Eastern Kiel Bight, Baltic Sea east of Wagrien, and Hyllekrog-Rødsand based on the spatial distribution models. Estimates for the alignment area, total non-SPA area, and total prediction area are also given. Note: the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien were not fully covered by ship-based surveys. Estimates were only calculated for the area covered by surveys.

SPA / area	Period	Density	Estimate
Eastern Kiel Bight*	Nov 2008 – Apr 2009	0.53	234
(DE1530-491)	Nov 2009 – Mar 2010	1.04	451
Baltic Sea east of Wagrien*	Nov 2008 – Apr 2009	0.58	184
(DE1633-491)	Nov 2009 – Mar 2010	1.16	363
Hyllekrog-Rødsand**	Dec 2008 – Mar 2009	0.91	196
(DK006X087)	Nov 2009 – Apr 2010	0.56	123
Alignment area*	Nov 2008 – Apr 2009	0.72	147
	Nov 2009 – Mar 2010	1.23	253
Non-SPA area (including*	Nov 2008 – Apr 2009	1.12	1,705
the alignment area)	Nov 2009 – Mar 2010	1.96	2,971
TOTAL	Nov 2008 – Apr 2009	1.11	2,320
	Nov 2009 – Mar 2010	1.67	3,908

** - based on ship-based survey data*
*** - based on aerial survey data*

Red-breasted Merganser trends

The population of Red-breasted Merganser in Europe was evaluated as being Secure (BirdLife International 2004) and Wetlands International provide no trend for this species (Wetlands International 2006).

From 1968 to 2005 the wintering numbers in Germany increased with about 4.5 % per year (Mendel et al. 2008). Along the German Baltic Sea the numbers of wintering Red-breasted Mergansers have been declining since the mid-1990s (Mendel et al. 2008).

In Denmark, the countrywide surveys in late summer as well as in mid-winter indicate a slight decrease over the latest 30 years (Pihl et al. 2006).

Not only the total population wintering in the Baltic Sea has declined, but the distribution of the species has shifted remarkably from a core wintering area in the southeast, including the Fehmarnbelt, to a more widespread distribution, with higher proportions of the population now occurring in the north and west of the Baltic Sea (Skov et al. 2011). According to this report the shift in the winter distribution of the species has affected the population in the Fehmarnbelt area. Long-term dataset of annual mid-winter land-based surveys from the island of Fehmarn indicate a declining trend for Red-breasted Mergansers wintering in the study area (AKVSW 2010, Figure 4.136).

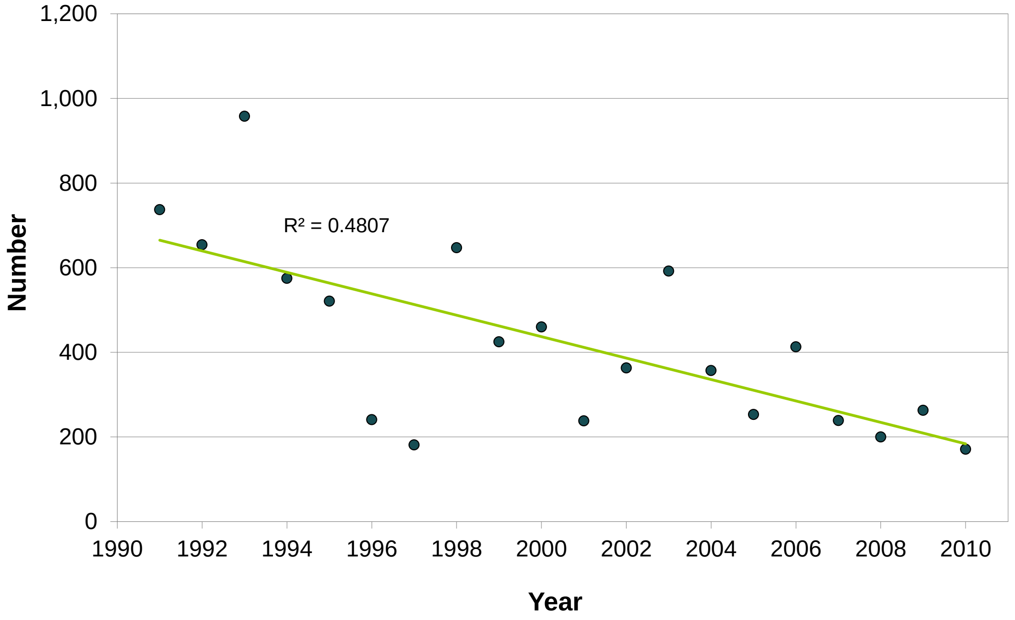


Figure 4.136 Number of Red-breasted Mergansers recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg; p = 0.001.

Importance of the Fehmarnbelt to Red-breasted Merganser

FEBI baseline investigations revealed that up to 7,800 Red-breasted Mergansers may use the Fehmarnbelt area as it occurred in the severe winter of 2010. This number corresponds to 4.6% of the biogeographic population making the Fehmarnbelt of international importance for this species (1% of the population, equals to 1,700 birds). Beside this unusual high estimate spatial modelling and Distance analysis estimates suggested that more than 1% of the Red-breasted Merganser population regularly winters in the Fehmarnbelt. However, none of the SPAs in the Fehmarnbelt was found holding internationally important numbers of this species.

Red-breasted Merganser – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	7,800
Max. abundance estimate in the alignment area:	253
Period of max. abundance in Fehmarnbelt:	November – April
Areas of max. abundance in Fehmarnbelt:	see Figure 4.95
Explanations:	Maximum estimate for Red-breasted Merganser represents ship-based survey of February 2010. High aggregations in the Fehmarnbelt were presumably caused due to extensive ice cover of the Baltic Sea further east. Confidence intervals around this estimate are reasonable, especially for the main component of the survey transects in nearshore waters (Table 4.71).

4.1.29 Goosander – *Mergus merganser*

Goosander – *Mergus merganser*

Biogeographic population: *M. m. merganser*, NW and C Europe (non-br)

Breeding range: Scandinavia, Baltic Sea, W Russia, Britain

Wintering / core non-breeding range: NW and C Europe

Population size: 266,000

1 % value: 2,700

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: Non-SPEC
EU Threat Status: (secure)

Target species in SPAs: –

Key food: fish

Period of presence in Fehmarnbelt: Wintering, migrations: October – April
Breeding, moulting: May – September

Origin of Goosander in the Fehmarnbelt

Goosanders wintering in northern and western Europe originate from the entire Baltic region, and from an area ranging from northern Scandinavia to north-western Russia (Sudfeldt et al. 2003). According to the FEBI ring recovery study there is no further information about the origin of Goosanders wintering in the study area available (Appendix IV).

Data sources on Goosander in the Fehmarnbelt

The FEBI baseline surveys covered only partly the resting sites of Goosander in the Fehmarnbelt as this species is mostly confined to inland freshwater habitats or sheltered bays. Thus, supplementary datasets of land-based counts, which also cover inland areas, were used as primary sources to assess species abundance and distribution in the Fehmarnbelt area (Table 4.75). Data of FEBI aerial surveys were used as supporting data source for describing abundance and distribution of the species.

Table 4.75 List of datasets and their use in the FEBI baseline assessment of Goosander in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Supporting dataset for estimating species abundance
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for winter abundance and distribution species in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Goosander in the Fehmarnbelt

Single individuals are present in the Fehmarnbelt region throughout the year, but higher numbers occur during winter time. Abundance of Goosander on Fehmarn markedly increases in November and reaches its peak in mid-winter (Berndt et al. 2005).

Goosander abundance according to FEBI survey data

During the FEBI baseline surveys low numbers of Goosanders were regularly observed during wintering periods. During the two years of aerial surveys in total 88 and 40 individuals were recorded in 2009 and 2010, respectively (Table 4.76). A maximum number of 59 Goosanders was recorded during the aerial survey of February 2009 (Table 4.76), among which almost all birds (58) were counted in Rødsand Lagoon.

Goosanders were only rarely recorded during the FEBI ship-based surveys with maximum counts of 11 birds in January 2009 and 16 birds in January 2010.

Table 4.76 Results of monthly aerial surveys for Goosander between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects; Coverage % is percentage of survey area covered in valid conditions.

Survey	Number of birds observed	Coverage %
Nov-08	2	80.9
Dec-08	8	81.7
Jan-09	4	82.8
Feb-09	59	100.0
Mar-09	0	77.5
Apr-09	0	86.8
May-09	0	77.3
Jun-09	0	80.9
Jul-09	0	86.6
Aug-09	0	92.3
Sep-09	0	79.1
Oct-09	0	79.9
Nov-09	0	82.4
Dec-09	15	24.7
Mar-10 A	10	64.1
Mar-10 B	25	75.6
Apr-10	1	100.0
May-10	3	92.1
Jun-10	0	70.8
Aug-10	0	75.6
Sep-10 A	0	44.9
Sep-10 B	0	48.9
Oct-10	1	80.0
Nov-10	0	70.1

Goosander abundance according to supplementary datasets
The seasonal pattern of Goosander abundance indicated higher numbers recorded during transitional periods and mid-winter according to coastal counts in the selected (consistently covered) survey sections along the German mainland coast (OAG 2010; Figure 4.137). Similarly, Berndt et al. (2005) described Goosanders occurring in the highest numbers on Fehmarn in January.

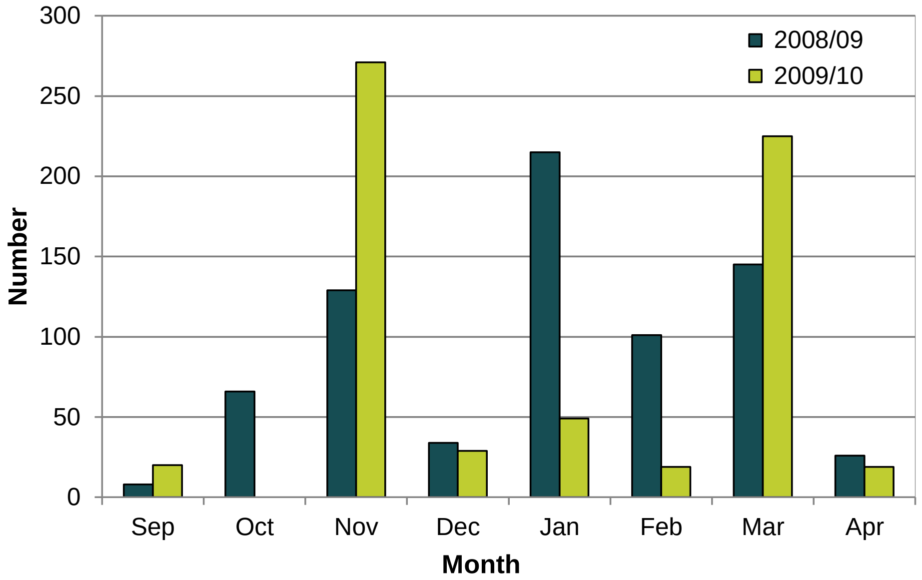


Figure 4.137 Number of Goosanders recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

In total 371 Goosanders were recorded along the Fehmarn and mainland count sections during the German mid-winter land-based surveys in 2009 (AKVSW 2010, OAG 2010). The majority of these birds (175 individuals) were recorded outside the study area in Neustädter Binnenwasser, and 197 birds were observed within the German part of the study area. OAG monthly surveys along the German mainland coast between September and April show a maximum number of 284 Goosanders recorded within the study area in November 2009 (OAG 2010). The majority of these birds were counted on the inland lake Großer Binnensee (265). These data indicate that usually more than 0.1 % of the biogeographic population (270 birds) spend winter in the German part of the Fehmarnbelt.

Similar numbers are reported for the Danish part of the study area. Petersen et al. (2010) report 36 Goosanders for the Danish part of the Fehmarnbelt (mid-winter survey 2008), with all birds counted within Rødsand Lagoon. The DOF database mostly report similar low numbers for this area with maximum counts of few hundred birds wintering in the lagoon (maximum: 325 birds on February 5, 2006; DOF 2010). There is no indication that internationally important numbers of Goosander wintering in the Danish Fehmarnbelt area, usually less than 0.1 % of the biogeographic population (270 birds) are recorded in the area (DOF 2010). Single birds are regularly recorded in the alignment area at Rødbyhavn (maxiumum 161 birds in January 2003; DOF 2011).

Distribution and habitat use of Goosander in the Fehmarnbelt

Goosanders winter on large unfrozen lakes, rivers, lagoons and brackish waters. Generally the species avoids highly saline waters although it may move to estuaries, coastal lagoons and sheltered sea coasts with waters less than 10 m deep in particularly harsh winters (BirdLife International 2011). The species predominantly feed on fish (BirdLife International 2011).

Goosander distribution according to FEBI survey data

During aerial transect surveys the majority of observed Goosanders were recorded in sheltered coastal areas such as the Rødsand Lagoon (Figure 4.138; Appendix II) and only rarely in offshore habitats of the Fehmarnbelt area.

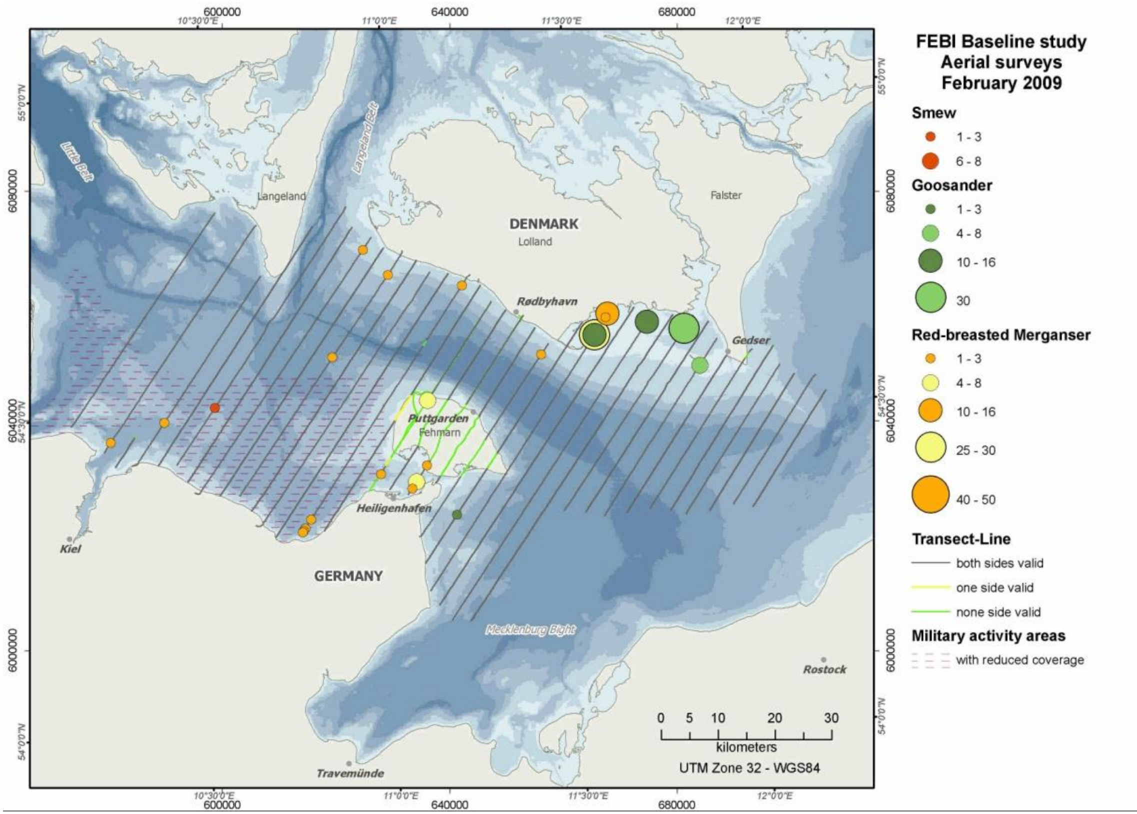


Figure 4.138 Example of observed distribution of merganser species (Goosander: green dots) in the study area during aerial surveys (February 2009).

Goosander distribution according to supplementary datasets

The German land-based mid-winter survey in 2009 shows Goosanders being mainly confined to sheltered inland and coastal habitats like Orther Reede, Burger Binnensee and Großer Binnensee (Figure 4.139; AKVSW 2010, OAG 2010). Danish mid-winter survey 2008 showed Rødsand Lagoon with Guldborg Bredning in the north being a preferred wintering area of Goosanders in the Fehmarnbelt region (Figure 4.139; Petersen et al. 2010).

The German mid-winter coastal survey of 2009 showed 61 % of Goosanders using inland habitats (AKVSW 2010, OAG 2010). Petersen et al. (2010) describe a similar pattern for Denmark with 50 % of Goosanders observed on inland water bodies during mid-winter survey 2008.

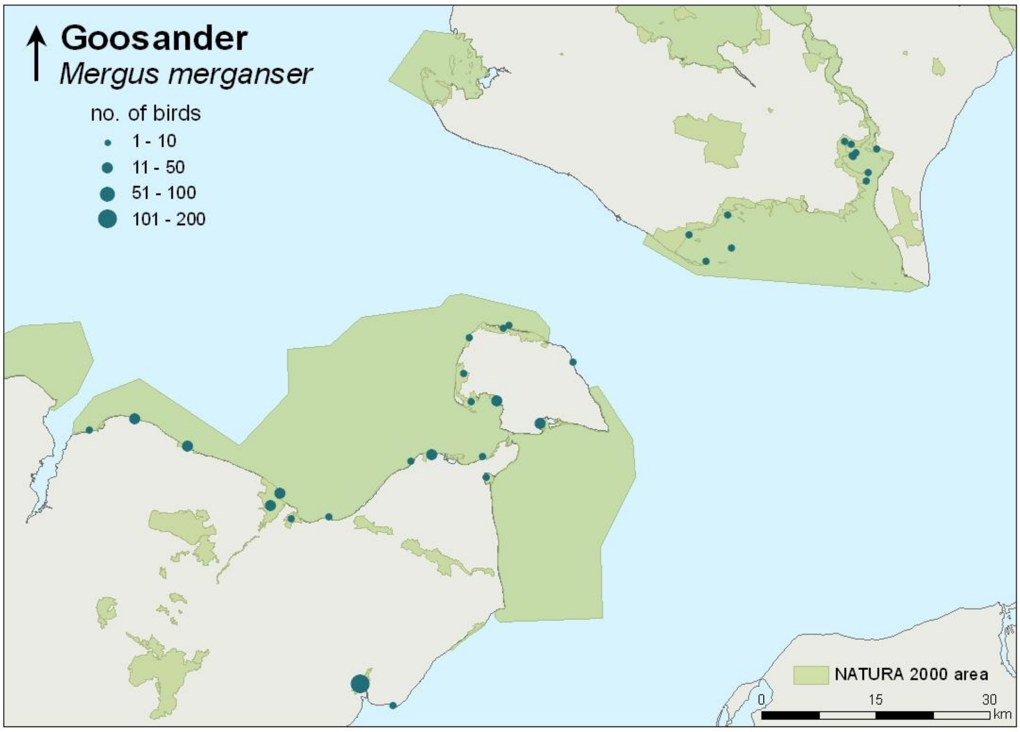


Figure 4.139 Distribution of Goosanders during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Goosander abundance estimates for SPAs

In total 147 Goosanders were counted within the SPA Eastern Kiel Bight during the mid-winter land-based survey in January 2009 (AKVSW 2010, OAG 2010). On the mainland survey sections of the SPA Eastern Kiel Bight higher numbers have been observed in November 2009 (284 Goosanders; OAG 2010). Available data indicate that more than 0.1% of the biogeographic population (270 birds) use the SPA Eastern Kiel Bight in winter.

During the mid-winter survey of 2009, 49 Goosanders were counted within the SPA Baltic Sea east of Wagrien (41 at Burger Binnensee; AKVSW 2010, OAG 2010). Within this SPA, Burger Binnensee is the most important wintering site for Goosanders (Berndt et al. 2005, Kieckbusch 2010). Since 1965 there is only one exceptionally high count of 700 birds reported for this area in January 1997 (Berndt et al. 2005, Kieckbusch 2010), but regularly the SPA Baltic Sea east of Wagrien supports less than 0.1% of the biogeographic population of Goosander.

Numbers of Goosander reported in the DOF database (DOF 2010) indicate that the SPA Hyllekrog-Rødsand does not support internationally important numbers of this species (usually < 0.1% of the biogeographic population). The maximum reported number of 325 Goosanders in February 2006 (DOF 2010) equals to 0.12% of the biogeographic population.

Goosander trends

The European Goosander population is considered as being Secure (BirdLife International 2004). The wintering numbers in Germany were increasing continuously between 1968 and 2000 (Sudfeldt et al. 2003). A similar pattern was described by Petersen et al. (2006, 2010) for Denmark. Wintering numbers of

Goosanders vary with winter severity in the study area, the highest numbers being recorded in cold winters (Berndt et al. 2005, Petersen et al. 2006, 2010). Long-term dataset of the annual mid-winter land-based bird counts on Fehmarn shows variable numbers of this species with no detectable trend (Figure 4.140; AKVSW 2010).

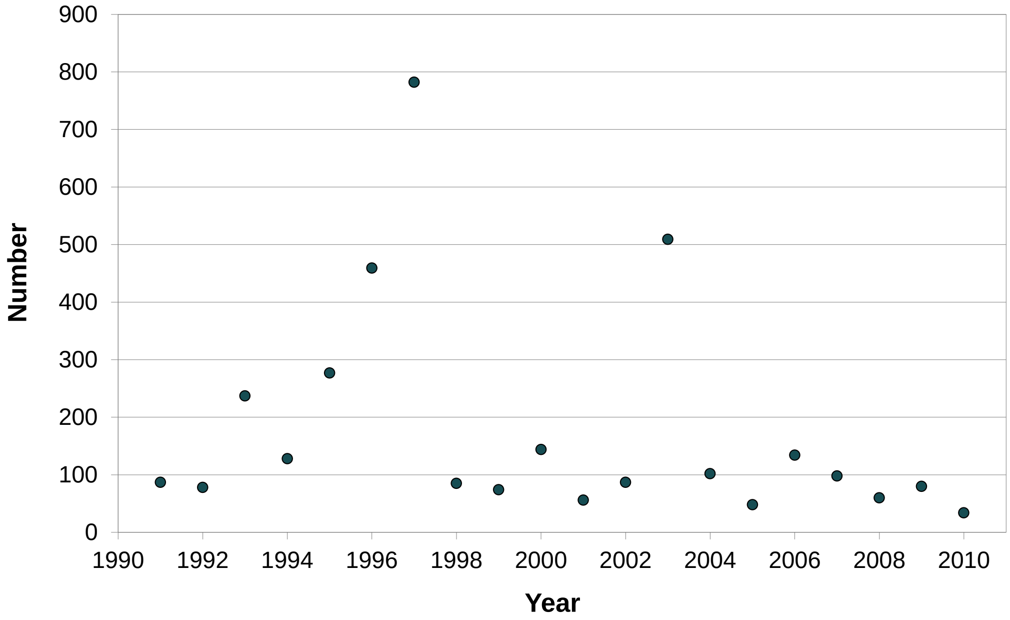


Figure 4.140 Numbers of Goosanders recorded during the annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Goosander

Results of the baseline investigations and supplementary datasets indicate that less than 1% of the biogeographic Goosander population uses the Fehmarnbelt area in the course of the year. Numbers in the SPA Eastern Kiel Bight regularly exceed 0.1% of the biogeographic population (270 birds; OAG 2010), in the SPA Hyllekrog-Rødsand numbers exceeding this level are only exceptionally reported (DOF 2010). Wintering Goosanders use inland freshwater habitats, shallow coastal waters and sheltered bays and lagoons in the study area.

Goosander – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	325 + 284
Max. abundance estimate in the alignment area:	161 + 1
Period of max. abundance in Fehmarnbelt:	November – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.139
Explanations:	Maximum abundance obtained from supplementary data for Rødsand Lagoon (325 birds) and the SPA Eastern Kiel Bight (284 birds, mostly inland). Maximum abundance in the alignment area was obtained from supplementary datasets for the Danish part (161 birds) and 1 individual reported for the German part of this area during the land-based mid-winter survey of 2009. Distribution obtained from supplementary mid-winter datasets.

4.1.30 *White-tailed Eagle – Haliaeetus albicilla*

White-tailed Eagle – *Haliaeetus albicilla*

Biogeographic population: Europe (br)

Breeding range: northern and central Europe

Wintering / core non-breeding range: N and northern C Europe

Population size: 15,000-19,800*

1 % value: 150

Conservation status: EU Birds Directive, Annex I: listed
EU SPEC Category: SPEC 1
EU Threat Status: rare

Target species in SPAs: Hyllekrog-Rødsand (DK006X083)

Key food: birds, fish, mammals up to a considerable size, carrion

Period of presence in Fehmarnbelt: Non-migratory
Breeding: mid-February – July

* BirdLife International (2004)

Origin of White-tailed Eagle in the Fehmarnbelt
According to Struwe-Juhl and Grünkorn (2007) young White-tailed Eagles in Schleswig-Holstein disperse to all directions and partly conduct long-distance movements. Four to five year old birds search for a breeding territory close to their hatching site. Among 29 eagles colour-ringed in Schleswig-Holstein the medium natal dispersal distance was 89 km, the maximum 450 km (Struwe-Juhl and Grünkorn 2007). Adult White-tailed Eagles are mostly resident birds in the area (Mebs and Schmidt 2005). Ring recoveries of this species in Denmark indicate that birds originated from Germany (Schleswig-Holstein) and Sweden (Stockholm area, Bønløkke et al. 2006).

Data sources on White-tailed Eagle in the Fehmarnbelt
During FEBI aerial and ship-based surveys no White-tailed Eagles were recorded. Therefore data from mid-winter coastal counts and DOF database were used as primary data sources for the baseline assessment of this species (Table 4.77).

Table 4.77 List of datasets and their use in baseline assessment of White-tailed Eagle in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used due to no sightings of the species
FEBI ship transect surveys	Dataset not used due to no sightings of the species
OAG land-based counts	Primary dataset representing species winter abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA surveys	Dataset not used due to no entries for this species
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of White-tailed Eagle in the Fehmarnbelt
According to Berndt et al. (2005) White-tailed Eagles are regular, but not numerous wintering species on Fehmarn. As adults White-tailed Eagles are resident birds in the Baltic Sea region, the species might not show high seasonal variation in numbers (Bauer et al. 2005, Struwe-Juhl and Grünkorn 2007). Higher numbers can be observed along the coast in cold winters when inland lakes become ice-covered (Bauer et al. 2005, own observations during the severe winter 2009/2010). As White-tailed Eagles are resident in the area, it can be assumed that the local breeding population (5 pairs; see Chapter 3 'Breeding Waterbirds in the Fehmarnbelt') represents a minimum number of birds utilising the region.

During the German mid-winter coastal count of 2009, 6 White-tailed Eagles were recorded within the surveyed area. At the Danish coast DOF database reports a maximum of 21 individuals occurring in Rødsand Lagoon area (on February 28, 2010; DOF 2010). Similar high numbers have been also recorded at inland lakes of Lolland in previous winters (DOF 2010).

Distribution and habitat use of White-tailed Eagle in the Fehmarnbelt
White-tailed Eagles are confined to habitats close to open waters such as large inland lakes or coasts with a mature tree population in the area (Bauer et al. 2005). For feeding, White-tailed Eagles mostly use eutrophic lakes, which are rich in fish and waterfowl. In winter White-tailed Eagles are frequent along marine coastlines (Bauer et al. 2005).

Available datasets indicate that White-tailed Eagles regularly use German and Danish coastal areas of the Fehmarnbelt with no specific distribution pattern detectable.

White-tailed Eagle abundance estimates for SPAs
During the mid-winter count of 2009, 5 White-tailed Eagles were recorded within the SPA Eastern Kiel Bight and one bird in coastal areas of SPA Baltic Sea east of Wagrien (AKVSW 2010, OAG 2010).

Higher numbers are reported for the Danish SPA Hyllekrog-Rødsand with a maximum of 21 White-tailed Eagles recorded in February 2010 (DOF 2010).

White-tailed Eagle trends
Fehmarn mid-winter counts between 1991 and 2010 reveal fluctuating numbers of up to 10 White-tailed Eagles on the island (Figure 4.141). According to Bauer et al. (2005) White-tailed Eagles used to be widely distributed in Europe until in the beginning of the 20th century, when a dramatic decline took place due to hunting. After a slight increase due to conservation efforts, the numbers plummeted again in the 1950s and 1960s because of DDT impact. Since 1980 numbers of White-tailed Eagles are increasing and the species re-colonised its former range. Nevertheless, the White-tailed Eagles are still threatened due to collision with power lines, traffic and lead contamination from ammunition (Bauer et al. 2005).

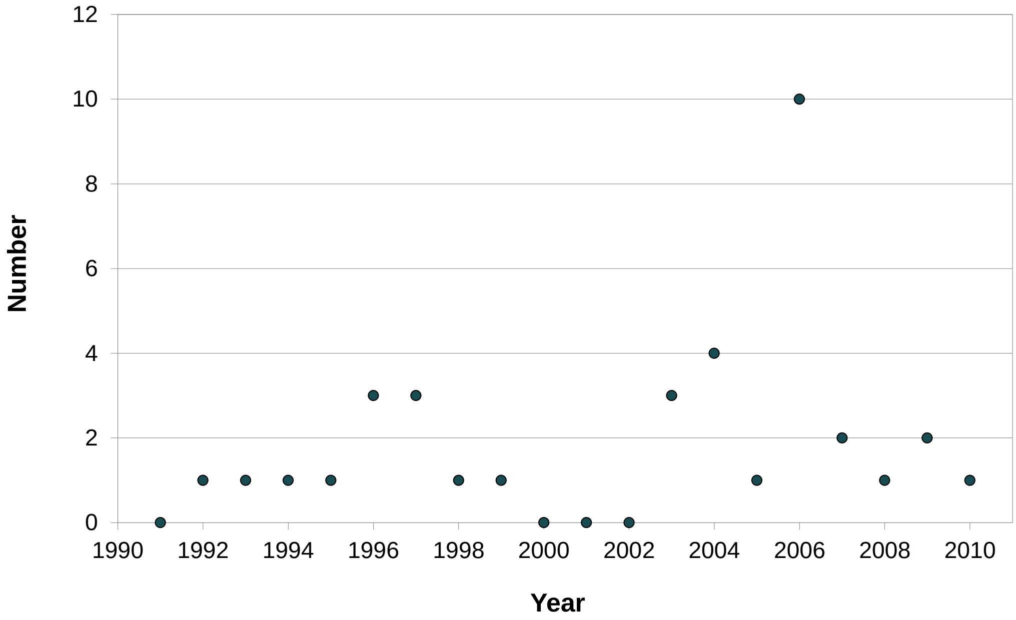


Figure 4.141 Number of White-tailed Eagles recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to White-tailed Eagle

The Fehmarnbelt area is regularly used by staging or wintering White-tailed Eagles. The area is important as a feeding ground for year-round present resident birds, but also juvenile and immature birds are expected to use the Fehmarnbelt. During winter, the numbers of White-tailed Eagles on the Danish side of the Fehmarnbelt can reach 20 individuals and more (> 0.1% of the biogeographic population). However, even the maximum numbers observed in cold winters in the Fehmarnbelt do not represent more than 0.3% of the biogeographic population of the species.

White-tailed Eagle – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	21 + 6
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	all year
Areas of max. abundance in Fehmarnbelt:	all coastal areas within the study area, no aggregation areas identified
Explanations:	Maximum abundance estimated from supplementary datasets for the SPA Hyllekrog-Rødsand (21 birds) and from German mid-winter survey of 2009 (6 birds).

4.1.31 Common Coot – *Fulica atra*

Common Coot – *Fulica atra*

Biogeographic population: *F. a. atra*, NW Europe (non-br)

Breeding range: E, N and W Europe

Wintering / core non-breeding range: NW Europe

Population size: 1,750,000

1 % value: 17,500

Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC EU Threat Status: (secure)
Target species in SPAs:	Hyllekrog-Rødsand (DK006X083)

Key food: very variable; all sorts of water plants and water related plants, detritus, invertebrates

Period of presence in Fehmarnbelt:	Wintering, migrations: September – April Breeding: May – August

Origin of Common Coot in the Fehmarnbelt

The Common Coot is present in the study area all year, but local breeding birds are most likely partial migrants (Cramp and Simmons 1980). According to the FEBI ring recovery study (Appendix IV) different breeding populations of Common Coot visit the Fehmarnbelt region from the east with ringing and recovery localities found in Denmark, Sweden, Finland, the Baltic countries and Poland. There are additional data indicating origins of Common Coot from Ukraine potentially showing that Common Coot from far eastern and south-eastern populations may move northwest to winter in the shallow waters in north-western Europe. Local breeding Common Coot seem to be moving towards southwest and winter in the Benelux countries, France, Germany, and even as far south as northern Italy and Spain. Findings presented in the national ringing atlases largely confirm these patterns (Bønløkke et al. 2006, Fransson et al. 2008).

Data sources on Common Coot in the Fehmarnbelt

The FEBI baseline surveys only partly covered the main resting sites of Common Coot in the study area as these birds are confined to inland freshwater and sheltered marine habitats in winter. Thus, supplementary datasets of land-based counts and dedicated search flights, which cover these areas, were used as primary sources to assess species abundance and distribution in the Fehmarnbelt area (Table 4.78). Data of the FEBI dedicated search flights in Orther Reede were used as supporting data source, the FEBI aerial and ship transect surveys were not considered as the species was rarely recorded during these surveys.

Table 4.78 List of datasets and their use in baseline assessment of Common Coot in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used due to no sightings of the species
FEBI dedicated search flights	Supporting dataset for estimating species abundance and distribution
FEBI ship transect surveys	Dataset not used due to non-covered shallow water areas
OAG land-based counts	Primary dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
	Primary dataset representing winter abundance and distribution of the species along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for winter abundance and distribution of the species in the Danish part of the Fehmarnbelt
DOF database	Primary dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Common Coot in the Fehmarnbelt

The Common Coot is present in the study area all the year with numbers peaking during the moulting time in late summer and especially in winter, when maximum numbers are usually reached in January (Berndt et al. 2005).

Common Coot abundance according to FEBI survey data

Apart from a single sighting of Common Coot during the FEBI ship-based surveys this species was not recorded during FEBI aerial and ship baseline transect surveys. Monthly dedicated search flights in Orther Reede between August 2009 and October 2010 resulted in one record of this species with 150 individuals observed in October 2009.

Common Coot abundance according to supplementary datasets

Seasonal pattern of Common Coot abundance indicates that higher numbers occur during transitional periods and mid-winter according to coastal counts in selected (consistently covered) survey sections along the German mainland coast between September and April (OAG 2010; Figure 4.142). Similarly, Berndt et al. (2005) described Common Coot occurring in highest numbers on Fehmarn in mid-winter.

The German mid-winter land-based survey of 2009 recorded 4,766 Common Coots along the surveyed sections of Fehmarn and German mainland coast (AKVSW 2010, OAG 2010). Among these 4,197 Common Coots were observed within the Fehmarnbelt study area. As Figure 4.142 indicates, higher winter numbers can be observed in the area. In January 2010, 9,421 Common Coots were recorded along the mainland survey sections of OAG coastal counts with the majority of 5,162 birds being observed outside the Fehmarnbelt area in sections of Pelzerhaken-Neustadt and Neustädter Binnenwasser (site IDs 40, 41; OAG 2010). In total more than 6,500 Common Coots (equaling to 0.37% of the biogeographic population) were present within the German part of the study area in January 2010. High numbers observed in 2010 are probably related to severe winter conditions as in the past the highest numbers were also recorded during cold winters (maximum of several 10,000s birds in Fehmarnsund in 1978/79; Berndt et al. 2005).

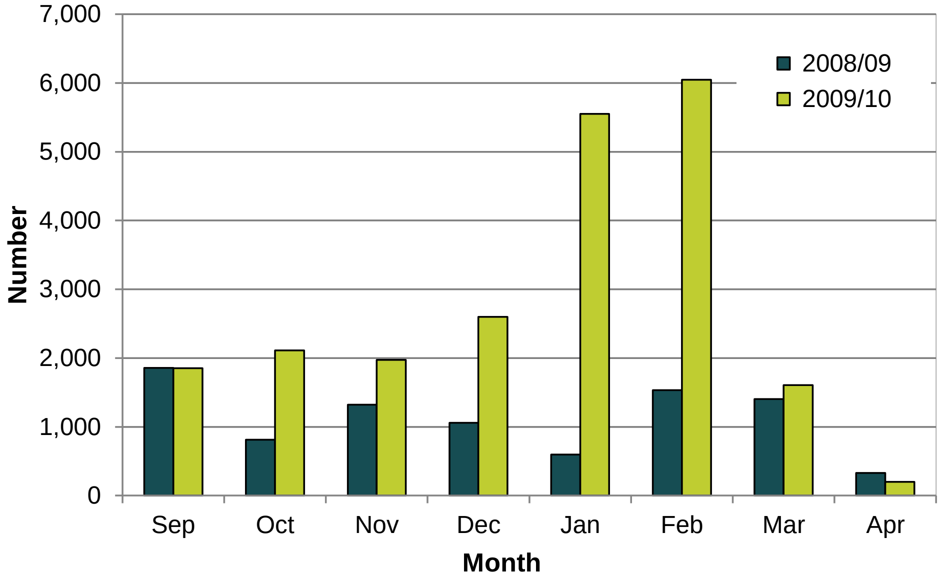


Figure 4.142 Numbers of Common Coot recorded during the land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

The NOVANA mid-winter survey of 2008 in Denmark reported 8,050 Common Coot for the Danish Fehmarnbelt area, all observed in Rødsand Lagoon (Petersen et al. 2010).

The DOF database reports similar high numbers of Common Coot wintering in Rødsand Lagoon, with a maximum number of 8,500 birds (0.49% of the biogeographic population) counted in February 2006 (DOF 2010). Similar high numbers of several thousand birds were also regularly reported for other areas on Lolland such as Maribo Lakes or the Guldborgsund (DOF 2010), but there is no indication that birds from these sites would use coastal areas of the Fehmarnbelt and are therefore not discussed further.

According to available datasets there is no indication that numbers in the German and Danish parts of the Fehmarnbelt meet the 1% criterion of international importance (17,500 birds). Typically, Common Coot numbers do not exceed 0.5% of the biogeographic population at either side of the Fehmarnbelt. Up to 340 birds were reported in the alignment area at Rødbyhavn (DOF 2011).

Distribution and habitat use of Common Coot in the Fehmarnbelt
During the non-breeding season Common Coot is described to utilise sheltered marine habitats, such as lagoons (Pihl et al. 2006). It is a common and numerous species in Denmark, which occurs in coastal areas all over the country (Pihl et al. 2006). The birds are known to forage in lakes and sheltered marine areas mainly on various water plants (Pihl et al. 2006).

During mid-winter coastal count of 2009, 4,298 birds were recorded along the German coastal areas (Figure 4.143). Major concentrations were observed in sheltered areas like Orther Reede, Burger Binnensee and Großenbroder Binnenwasser (AKVSW 2010, OAG 2010). Danish mid-winter survey of 2008 indicated Rødsand Lagoon and especially its northern part of Guldborg Bredning being the major wintering site for Common Coot within the Danish Fehmarnbelt area (Figure 4.143; Petersen et al. 2010).

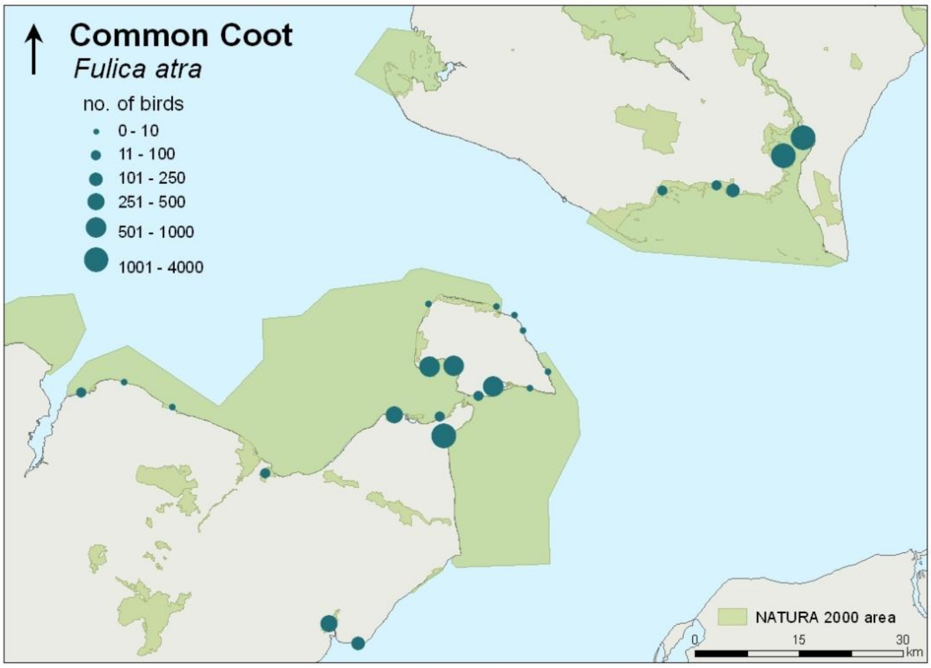


Figure 4.143 Distribution of Common Coot during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Common Coot abundance estimates for SPAs

In total 2,381 Common Coot have been recorded within the SPA Eastern Kiel Bight during the mid-winter land-based survey along the German coast in January 2009 (AKVSW 2010, OAG 2010). Of these, more than 1,200 birds were counted in the western Fehmarnsund and Orther Reede. Mid-winter count in January 2010 resulted in the higher number of 3,281 Common Coot (0.2% of the biogeographic population) in this SPA, among which more than 2,000 birds were observed within the sheltered marine areas of Heiligenhafener Binnenwasser and Graswarder (OAG 2010).

During the mid-winter survey of 2009, 1,812 Common Coots were counted within the SPA Baltic Sea east of Wagrien (1,015 Großenbroder Binnenwasser, 765 Burger Binnensee; AKVSW 2010, OAG 2010). In the subsequent winter of 2010 an even higher number of 3,242 Common Coot (0.2% of the biogeographic population) was observed within this SPA (AKVSW 2010, OAG 2010) with the highest aggregations recorded in the same areas. The coastline of the SPA Baltic Sea east of Wagrien was not completely covered by these land-based surveys, therefore numbers mentioned for this SPA should be considered as a minimum estimate.

Higher numbers of Common Coot were reported for the Danish SPA Hyllekrog-Rødsand, which regularly supports several thousand wintering birds of this species. Both, aerial mid-winter survey in 2008 (8,050 birds; Petersen et al. 2010) and maximum estimate reported in the DOF database (8,500 birds in February 2006; DOF 2010) suggest numbers equalling to approximately 0.5% of the biogeographic population within this SPA.

Common Coot trends

Common Coot populations wintering in the Baltic and northwest Europe were evaluated as marginally decreasing in both long and medium terms (Wetlands International 2006). However, the European breeding population is very large and the recent decline is still assumed to be outweighed by earlier increases. Therefore, the species was provisionally evaluated as Secure (BirdLife International 2004). A declining trend has been suggested for Germany by Wahl et al. (2003). Berndt et al. (2005) confirm this pattern for Fehmarn with a long-term decline in wintering numbers, but also suggests that numbers vary depending on winter severity. Highly fluctuating numbers are also described for Denmark, but overall numbers appear to be stable (Pihl et al. 2006).

According to annual mid-winter land-based bird counts on Fehmarn Island, numbers of Common Coot fluctuate remarkably with no significant trend over the last 20 years. (Figure 4.144, AKVSW 2010)

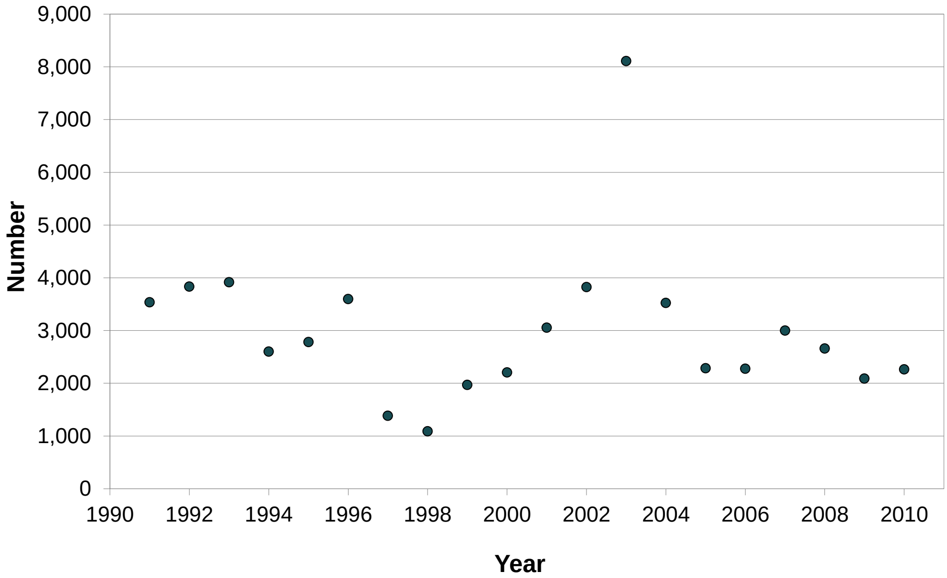


Figure 4.144 Numbers of Common Coot recorded during the annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to Common Coot

Analyses of supplementary datasets suggest that 0.1-0.5% of the Common Coot biogeographic population winters in the coastal areas of the German Fehmarnbelt (maximum count of 6,520 birds recorded in January 2010; AKVSW 2010, OAG 2010). Higher numbers of this species occur in the Danish waters of the Fehmarnbelt with highest aggregations reported for the SPA Hyllekrog-Rødsand (max. 8,500 birds in February 2006; DOF 2010) representing almost 0.5% of the biogeographic population. This indicates that also numbers exceeding 0.5% of the population cannot be excluded to occur in the Danish study area in some years. However, recent data sources do not indicate that the 1% criterion of international importance (17,500 birds) is reached neither in the Danish nor in the German part of the study area at any time of the year.

Common Coot – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	8,500 + 6,520
Max. abundance estimate in the alignment area:	340 + 6
Period of max. abundance in Fehmarnbelt:	September – April
Areas of max. abundance in Fehmarnbelt:	see Figure 4.143
Explanations:	Maximum abundance estimated from supplementary data for Rødsand Lagoon (8,500 birds) and German mid-winter count (6,500 birds). Maximum abundance in the alignment area was obtained from supplementary datasets for the Danish part (340 birds) and 6 individuals reported for the German part of this area during the land-based mid-winter survey of 2009. Distribution obtained from supplementary datasets.

4.1.32 *Little Gull – Larus minutus*

Little Gull – *Larus minutus*

Biogeographic population: N, C and E Europe (br)

Breeding range: N Scandinavia, Baltic States, W Russia, Belarus, Ukraine

Wintering / core non-breeding range: W Europe and NW Africa

Population size: 72,000 – 174,000

1 % value: 1,230

Conservation status: EU Birds Directive, Annex I: listed
EU SPEC Category: SPEC 3
EU Threat Status: (depleted)

Target species in SPAs: -

Key food: insects (breeding, migration); marine invertebrates, fish (wintering)

Period of presence in Fehmarnbelt: Wintering, migrations: mid-July – May

Origin of Little Gull in the Fehmarnbelt

No ring recovery is available which could provide information about the origin of Little Gulls occurring in the Fehmarnbelt area. However, it is known that the vast majority of the flyway population breeds in Belarus (Cramp and Simmons 1977).

Data sources on Little Gull in the Fehmarnbelt

Numbers and distribution of Little Gull are well reflected in FEBI aerial and ship-based survey data, but aerial surveys were chosen as the primary data source for representing the species due to broader spatial coverage of the study region (Table 4.79). Other datasets were used as supporting data sources to characterise Little Gull densities, distribution and habitat use (Table 4.79).

Table 4.79 List of datasets and their use in baseline assessment of Little Gull in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating species abundance and distribution
FEBI ship transect surveys	Supporting dataset for estimating species abundance and distribution
OAG land-based counts	Supporting dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Supporting dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Dataset not used as no information about this species available
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Little Gull in the Fehmarnbelt

Little Gull abundance estimates based on Distance analysis

The abundance of Little Gull in the Fehmarnbelt was estimated by applying Distance analysis (Thomas et al. 2010) on the monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Little Gull during aerial surveys, calculated using the entire dataset, were 236 m for swimming birds and 198 m for flying birds. This detection function for swimming birds is rather high compared to other gull species, detection function for flying birds is lower than for other gull species, which can be explained by the smaller size of this species.

The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of Little Gulls have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.80, Appendix V). Often partial coverage most likely resulted in minimum estimates for this species. The highest estimate of more than 5,700 birds was obtained for the survey conducted during the spring migration period in April 2009 (Table 4.80).

Table 4.80 Numbers of observed Little Gulls during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	16	22	0.04	0.02	0.09	169
Dec-08	81.7	0	0	0	0	0	0
Jan-09	82.8	0	0	0	0	0	0
Feb-09	100	0	0	0	0	0	0
Mar-09	77.5	17	38	0.08	0.03	0.26	291
Apr-09	86.8	189	803	1.35	0.73	2.49	5,719
May-09	77.3	3	12	0.03	0.01	0.11	105
Jun-09	80.9	2	17	0.02	0.00	0.15	93
Jul-09	86.6	8	69	0.14	0.04	0.54	606
Aug-09	92.3	3	4	0.01	0.00	0.04	40
Sep-09	79.1	1	5	0.01	0.00	0.04	34
Oct-09	79.9	62	87	0.18	0.10	0.36	718
Nov-09	82.4	3	5	0.01	0.00	0.04	35
Dec-09	24.7	0	0	0	0	0	0
Mar-10 A	64.1	8	9	0.02	0.01	0.06	58
Mar-10 B	75.6	2	5	0.01	0.00	0.05	37
Apr-10	100	8	9	0.01	0.01	0.04	67
May-10	92.1	5	6	0.01	0.00	0.03	47
Jun-10	70.8	1	1	0.00	0.00	0.01	9
Aug-10	75.6	6	9	0.02	0.01	0.07	73

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Sep-10 A	44.9	0	0	0	0	0	0
Sep-10 B	48.9	0	0	0	0	0	0
Oct-10	80.0	21	26	0.05	0.03	0.10	202
Nov-10	70.1	6	7	0.02	0.01	0.05	63

The ESW for Little Gull during ship-based surveys, estimated for the entire dataset was 156 m, indicating a rather poor detectability of the species. Numbers observed during ship-based surveys were in general lower than during aerial surveys, but results show a similar seasonal pattern with highest abundances of Little Gull occurring during transitional periods in April and September/October (Table 4.81, Figure 4.145).

Table 4.81 Numbers of observed Little Gulls during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km² covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	0	0	0	0	0	0	0	0	0	0	0.00	11
	offshore	0	0	0	0	0	0				1		
Dec-08	coastal	0	0	0	0	0	0	0	0	0	0	0.04	94
	offshore	0	0	0	0	0	0				7		
Jan-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Feb-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Mar-09	coastal	0	0	0	0	0.	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Apr-09	coastal	12	29	-	***	-	-	-	-	-	16	-	-
	offshore	7	24	-	690	-	-				7		
May-09	coastal	0	0	0	0	0	0	0.02	0.00	0.09	0	0.03	67
	offshore	1	2	0.05	105	0.01	0.28				3		
Jul-09A	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jul-09B	coastal	0	0	0	0	0	0	0	0	0	1	0.00	11
	offshore	0	0	0	0	0					0		
Aug-09	coastal	0	0	0	0	0	0	0	0	0	4	0.03	60
	offshore	0	0	0	0	0	0				2		
Sep-09	coastal	1	1	0.01	114	0.00	0.08	0.01	0.00	0.05	0	0.01	19
	offshore	0	0	0	0	0	0				0		
Oct-09	coastal	0	0	0	0	0	0	0	0	0	10	0.05	118
	offshore	0	0	0	0	0	0				0		

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-09	coastal	1	1	0.01	115	0.00	0.09	0.02	0.00	0.11	6	0.07	156
	offshore	1	1	0.02	108	0.00	0.15				5		
Dec-09	coastal	0	0	0	0	0	0	0	0	0	1	0.00	10
	offshore	0	0	0	0	0	0				0		
Jan-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Feb-10A	coastal	0	0	0	0	0	0	0.02	0.00	0.10	1	0.03	71
	offshore	1	2	0.05	102	0.01	0.29				2		
Feb-10B	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Mar-10	coastal	1	1	0.01	107	0.00	0.08	-	-	-	0	-	-
	offshore	2	3	-	***	-	-				0		
Apr-10	coastal	0	0	0	0	0	0	0.01	0.00	0.05	0	0.01	19
	offshore	1	1	0.02	103	0.00	0.15				0		
May-10	coastal	0	0	0	0	0	0	0	0	0	5	0.02	52
	offshore	0	0	0	0	0	0				0		
Jun-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-10	coastal	3	6	0.07	80	0.02	0.31	0.12	0.03	0.60	4	0.14	339
	offshore	1	8	0.22	98	0.04	1.18				1		
Oct-10	coastal	4	5	0.05	59	0.02	0.16	0.08	0.02	0.40	7	0.13	302
	offshore	2	5	0.13	88	0.02	0.88				4		
Nov-10	coastal	1	1	0.01	101	0.00	0.06	0.02	0.00	0.10	0	0.02	48
	offshore	1	1	0.03	111	0.00	0.16				1		

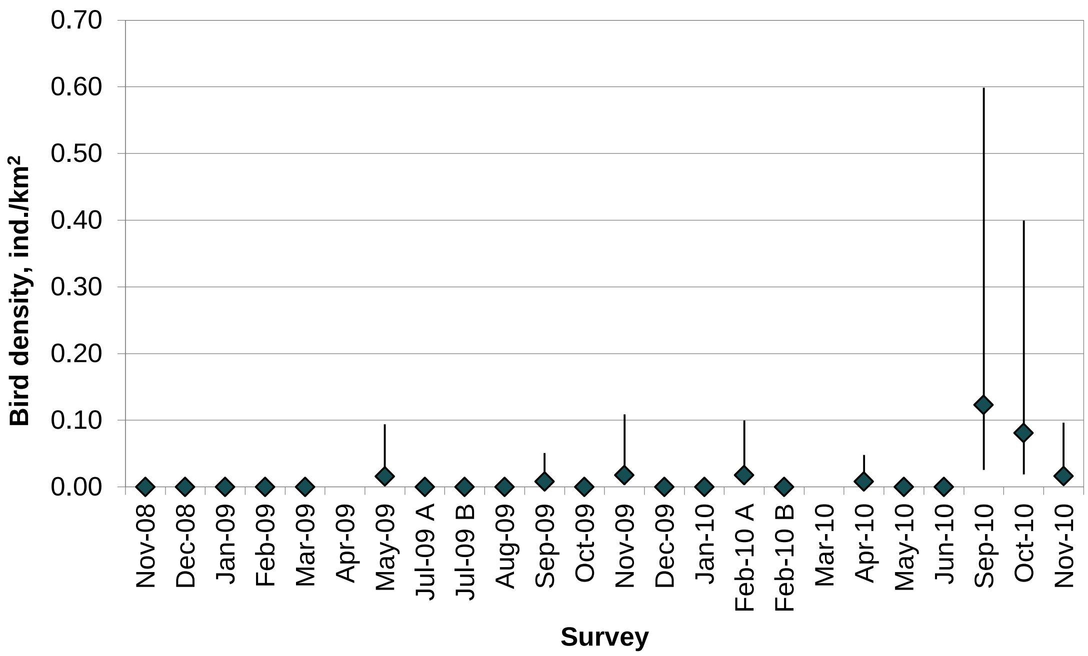


Figure 4.145 Mean density estimates and 95 % confidence intervals of swimming Little Gulls estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). <u>Note</u>: density estimates where the coefficient of variation exceeded 150 % were not included into the chart (see Table 4.81 for specific values).

Little Gull abundance estimates according to supplementary datasets

Supplementary data sources confirm that Little Gull occurs in the Fehmarnbelt region mainly during short periods in spring and autumn, when birds pass the area during migration. Berndt et al. 2005 mention the period between late April and mid-May as the period when Little Gulls are most numerous in the Fehmarnbelt. Monthly counts along mainland coastal areas of the eastern Kiel Bight show high numbers occurring in autumn, and especially in April (Figure 4.146) with a maximum of 3,612 Little Gulls counted on April 11, 2009 (3,550 on lake Großer Binnensee alone; OAG 2010). Similarly, the DOF database reports high numbers of migrating Little Gulls (DOF 2010).

Sightings of this species are very rare in summer and winter (AKVSW 2010, DOF 2010, OAG 2010).

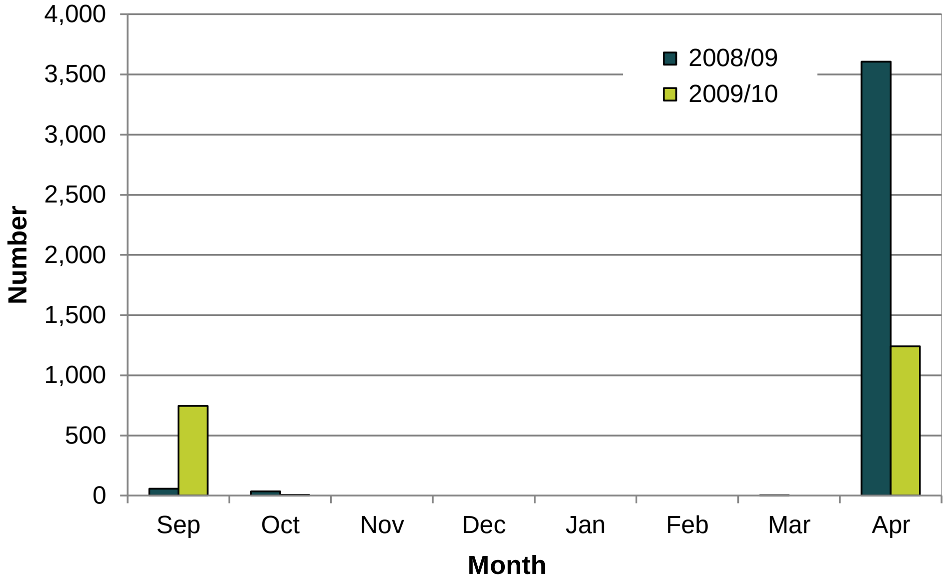
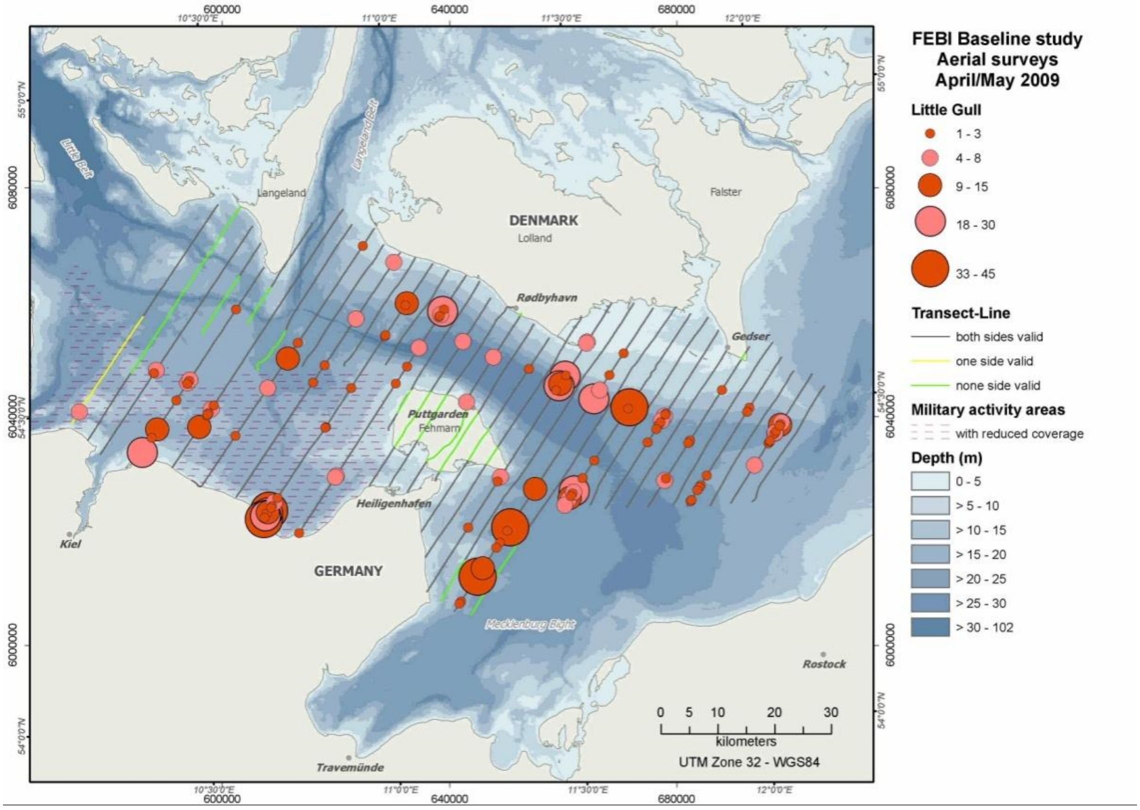


Figure 4.146 Number of Little Gulls recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

Distribution and habitat use of Little Gull in the Fehmarnbelt

During the migration periods in April/May and October birds were distributed all over the Fehmarnbelt (Figure 4.147; Appendix II). Mean seasonal densities sampled during the aerial surveys indicate no preference for particular areas or environmental features, and show a high degree of fluctuations between the two years of baseline surveys (Figure 4.148, Figure 4.149).



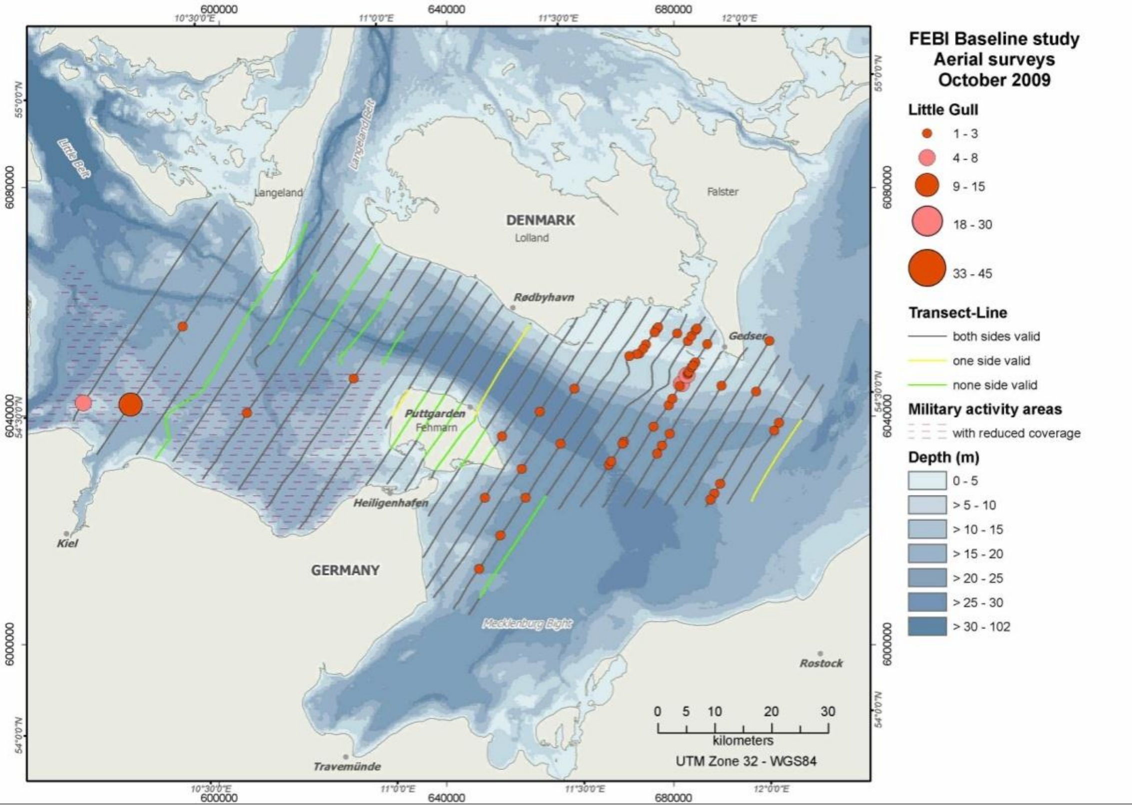
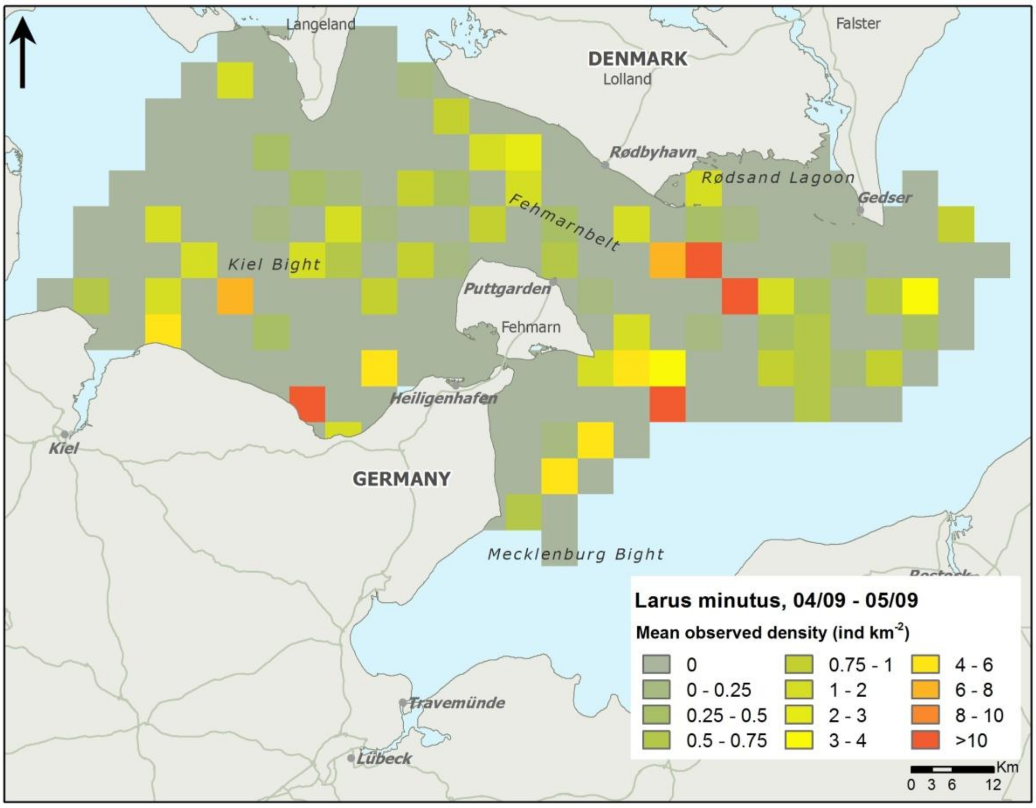


Figure 4.147 Examples of observed Little Gull distribution in the study area during aerial surveys (April/May and October 2009).



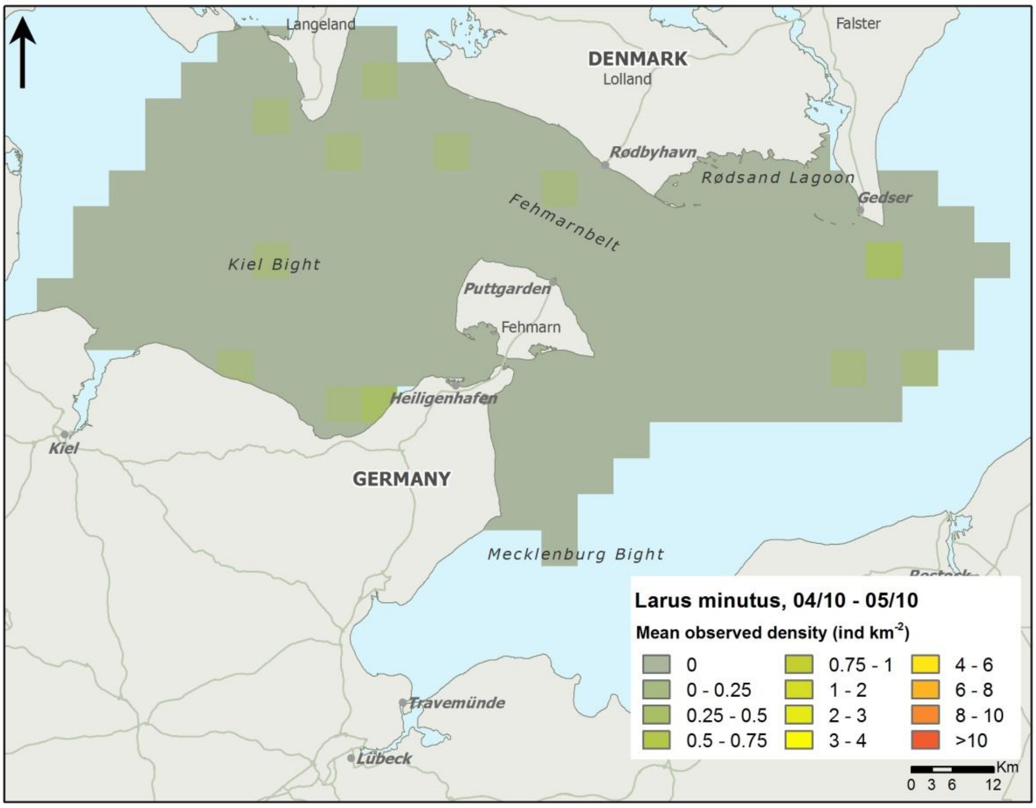
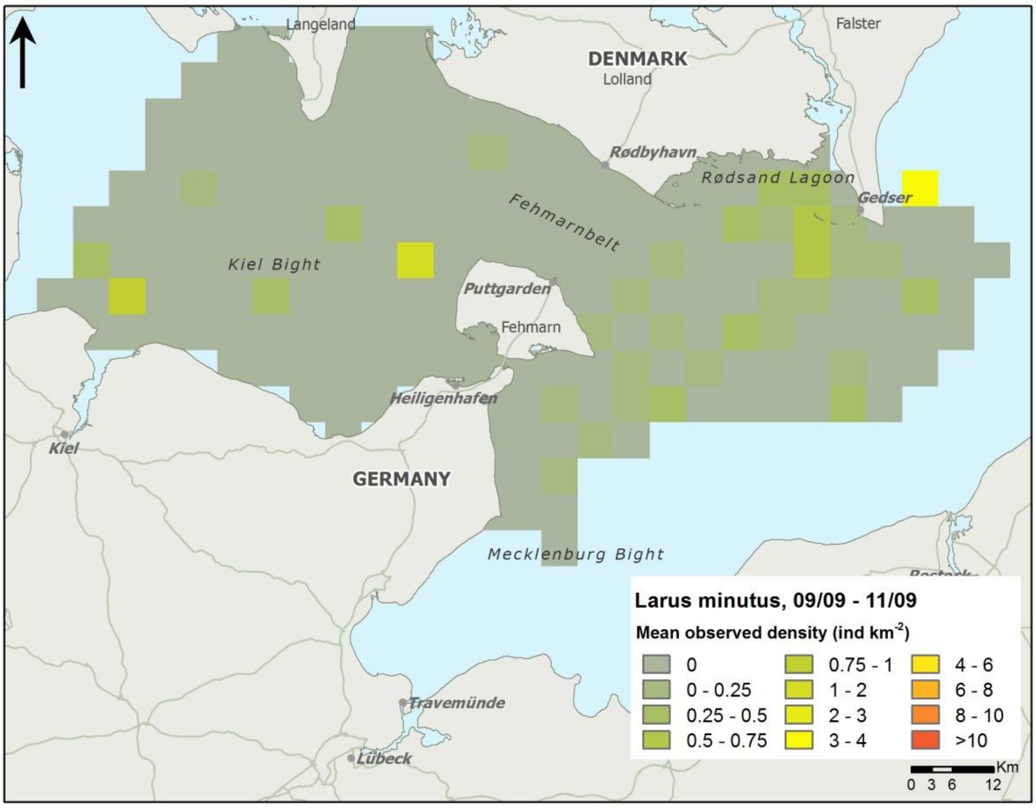


Figure 4.148 Mean densities of Little Gull Larus minutus sampled during April-May by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.



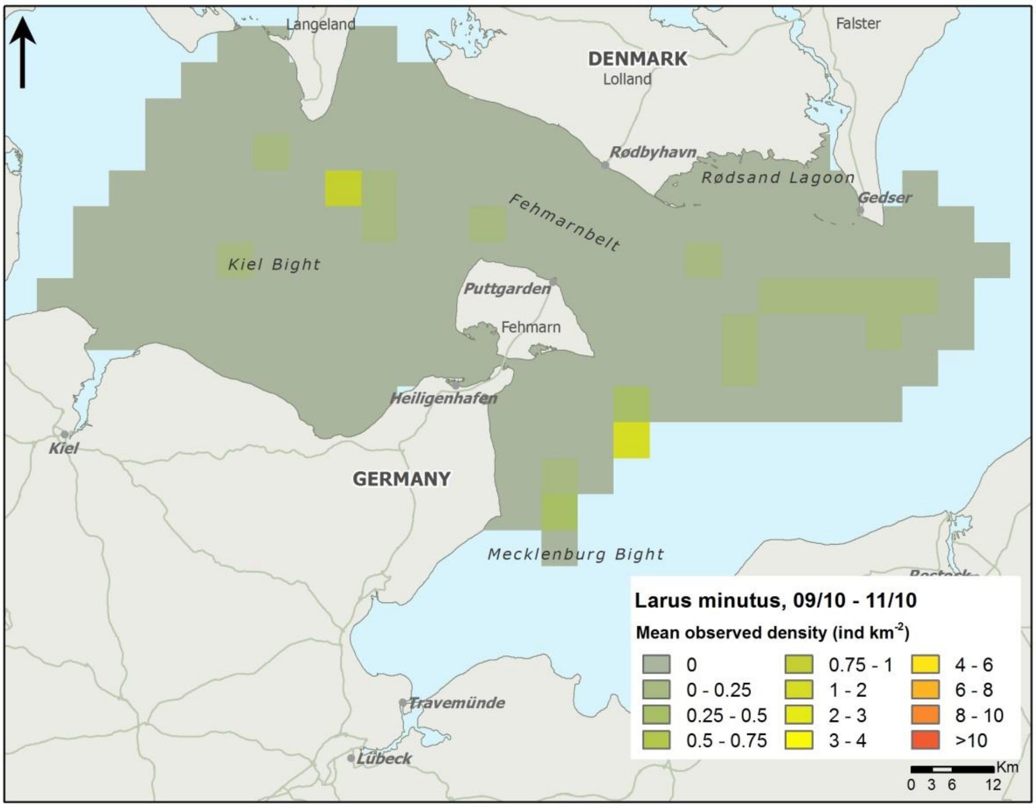


Figure 4.149 Mean densities of Little Gull Larus minutus *sampled during June-March by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.*

Little Gull abundance estimates for SPAs

As no distribution models were developed for the Little Gull, abundance estimates for particular SPAs are not available. Supplementary datasets indicate that at least the SPA Eastern Kiel Bight supports internationally important numbers during transitional periods (3,612 birds in April 2009, equalling 2.9% of the biogeographic population; OAG 2010).

Little Gull trends

No information is available on regional trends in the numbers of Little Gull using the Fehmarnbelt as a migration corridor. The European population underwent a moderate decline from 1970 – 1990. Although the population increased markedly between 1990 and 2000, it did not reach the former level. Thus, the population was provisionally evaluated as Depleted (BirdLife International 2004).

Importance of the Fehmarnbelt to the Little Gull

As the 1% criterion for the Little Gull population is 1,230 individuals, the results of the FEBI baseline investigations indicate that more than 4.5% of the biogeographic population (5,720 birds) use the Fehmarnbelt area at a time during transitional periods.

Little Gull – summary of information for EIA		
Max. abundance estimate in Fehmarnbelt:		5,720
Max. abundance estimate in the alignment area:		285
Period of max. abundance in Fehmarnbelt:		April/May, September/October
Areas of max. abundance in Fehmarnbelt:		see Figure 4.148, Figure 4.149
Explanations:	Maximum abundance represents Distance analysis estimate for the aerial survey of April 2009.	
	Maximum abundance in the alignment estimated by applying the density of the aerial survey of April 2009 on the area of the alignment zone.	
	Distribution pattern obtained from FEBI aerial surveys.	

4.1.33 *Black-headed Gull – Larus ridibundus*

Black-headed Gull – *Larus ridibundus*

Biogeographic population: W and C Europe (br)

Breeding range: N and W Europe, S Greenland

Wintering / core non-breeding range: S and W Europe

Population size: 3,700,000 – 4,800,000

1 % value: 42,000*

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: non-SPEC[E]
EU Threat Status: (secure)

Target species in SPAs: -

Key food: variable; aquatic and terrestrial invertebrates

Period of presence in Fehmarnbelt: Moult, wintering, migrations: July – April
Breeding: May – June

* For populations over 2 million birds, Ramsar Convention criterion 5 (20,000 or more waterbirds) applies.

Origin of Black-headed Gull in the Fehmarnbelt

The species is regarded as migratory within the Western Baltic region. The rather large amount of ring recoveries from Fehmarnbelt (N=716) reveals that the area functions as a wintering area for breeding populations from southern Sweden, Finland, the Baltic countries and Poland (FEBI ring recovery study; Appendix IV).

Data sources on Black-headed Gull in the Fehmarnbelt

Numbers and distributions of Black-headed Gulls are well reflected in FEBI aerial and ship-based survey data, but aerial surveys were chosen as the primary data source for representing the species due to broader spatial coverage of the study region (Table 4.82). Other datasets were used as supporting data sources to characterise Black-headed Gull densities, distribution and habitat use (Table 4.82).

Table 4.82 List of datasets and their use in baseline assessment of Black-headed Gull in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating species abundance and distribution
FEBI ship transect surveys	Supporting dataset for estimating species abundance and distribution
OAG land-based counts	Supporting dataset representing species winter abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Black-headed Gull in the Fehmarnbelt

Black-headed Gull abundance estimates based on Distance analysis

The abundance of Black-headed Gull in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Black-headed Gull during aerial surveys, calculated using the entire dataset, were 198 m for swimming birds and 227 m for flying birds. These detection functions are close to those of the similar sized Common Gull.

The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of Black-headed Gulls have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.83, Appendix V). Often partial coverage most likely resulted in minimum estimates for this species. Black-headed Gulls are present in the Fehmarnbelt throughout the year, but larger numbers were mainly observed during spring, moult and autumn migration periods (Table 4.83). Distance analysis of aerial surveys revealed a maximum estimate of more than 5,000 Black-headed Gulls using the Fehmarnbelt area during the spring migration (March 2010; Table 4.83).

Table 4.83 Numbers of observed Black-headed Gulls during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	7	29	0.03	0.01	0.17	116
Dec-08	81.7	8	47	0.09	0.03	0.33	368
Jan-09	82.8	3	181	-	-	-	-
Feb-09	100	4	31	0.06	0.00	1.02	269
Mar-09	77.5	51	137	0.32	0.13	0.82	1,207
Apr-09	86.8	2	5	0.01	0.00	0.06	34
May-09	77.3	15	51	0.07	0.02	0.35	257
Jun-09	80.9	6	7	0.02	0.01	0.04	61
Jul-09	86.6	46	193	0.28	0.09	0.94	1,180
Aug-09	92.3	18	26	0.05	0.02	0.12	211
Sep-09	79.1	9	11	0.02	0.01	0.06	94
Oct-09	79.9	38	79	0.16	0.07	0.79	619
Nov-09	82.4	13	34	0.07	0.02	0.23	296
Dec-09	24.7	3	15	0.13	0.01	2.43	152
Mar-10 A	64.1	9	16	0.04	0.01	0.15	136
Mar-10 B	75.6	76	709	1.37	0.64	2.97	5,042
Apr-10	100	46	153	0.25	0.08	0.99	1,217
May-10	92.1	1	2	0.00	0.00	0.01	13

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Jun-10	70.8	4	4	0.01	0.00	0.03	28
Aug-10	75.6	48	245	0.31	0.08	1.19	1,125
Sep-10 A	44.9	37	152	0.46	0.15	1.43	999
Sep-10 B	48.9	75	348	0.92	0.30	2.87	2,205
Oct-10	80.0	21	111	0.23	0.09	0.59	880
Nov-10	70.1	10	21	0.05	0.01	0.16	155

The ESW for Black-headed Gull during ship-based surveys, estimated for the entire dataset, was 114 m, indicating a poor detectability of the species. During ship-based surveys Black-headed Gull was observed regularly, but observed densities were in general lower compared to aerial surveys (Table 4.84, Table 4.83). Abundance estimates show a similar seasonal pattern as described based on the results of aerial surveys with higher numbers present in the area between spring and autumn and the species being less abundant in winter.

Displaying a chart representing the seasonal abundance of Black-headed Gull based on swimming bird densities, as was done for other birds, was not possible since the species was mostly recorded flying.

Table 4.84 Numbers of observed Black-headed Gulls during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km² covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	1	20	0.47	121	0.07	3.22	0.30	0.04	2.03	0	0.30	711
	offshore	0	0	0	0	0	0				1		
Dec-08	coastal	0	0	0	0	0	0	0	0	0	5	0.13	309
	offshore	0	0	0	0	0	0				18		
Jan-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Feb-09	coastal	0	0	0	0		0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Mar-09	coastal	0	0	0	0	0	0	0	0	0	6	0.06	130
	offshore	0	0	0	0	0	0				7		
Apr-09	coastal	2	26	0.46	116	0.04	5.06	-	-	-	1	-	-
	offshore	3	6	-	810	-	-				1		
May-09	coastal	0	0	0	0	0	0	0	0	0	0	0.01	20
	offshore	0	0	0	0	0	0				2		
Jul-09A	coastal	2	2	0.03	81	0.01	0.14	0.04	0.01	0.18	22	0.19	435
	offshore	2	2	0.07	74	0.02	0.25				10		

Survey	Stratum	Density estimates for swimming birds per stratum: N obs	N birds	D	%CV	LCI	UCI	Combined density estimates for swimming birds per survey: D	LCI	UCI	Combined estimates including flying birds: N flying	D	Total number
Jul-09B	coastal	0	0	0	0	0	0	0.02	0.00	0.22	8	0.07	156
	offshore	1	2	0.06	150	0.01	0.58				1		
Aug-09	coastal	1	2	0.06	115	0.01	0.35	0.05	0.01	0.33	1	0.05	128
	offshore	1	1	0.04	123	0.01	0.29				0		
Sep-09	coastal	0	0	0	0	0	0	0.08	0.01	0.48	1	0.08	191
	offshore	1	6	0.23	108	0.04	1.40				0		
Oct-09	coastal	0	0	0	0	0	00	0	0	0	5	0.04	94
	offshore	0	0	0	0	0	0				3		
Nov-09	coastal	1	1	0.02	77	0.01	0.08	0.01	0.00	0.05	0	0.03	74
	offshore	0	0	0	0	0	0				4		
Dec-09	coastal	0	0	0	0	0	0	0	0	0	1	0.00	10
	offshore	0	0	0	0	0	0				0		
Jan-10	coastal	2	2	0.04	97	0.01	0.19	0.02	0.00	0.13	4	0.05	118
	offshore	0	0	0	0	0	0				2		
Feb-10A	coastal	7	10	-	1,000	-	-	-	-	-	12	-	-
	offshore	1	1	0.03	143	0.00	0.31				0		
Feb-10B	coastal	0	0	0	0	0	0	0	0	0	1	0.00	10
	offshore	0	0	0	0	0	0				0		
Mar-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Apr-10	coastal	0	0	0	0	0	0	0	0	0	3	0.01	30
	offshore	0	0	0	0	0	0				0		
May-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Jun-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-10	coastal	3	10	0.17	122	0.02	1.44	0.11	0.01	0.96	0	0.12	273
	offshore	0	0	0	0	0	0				1		
Oct-10	coastal	0	0	0	0	0	0	0	0	0	0	0.00	10
	offshore	0	0	0	0	0	0				1		
Nov-10	coastal	0	0	0	0	0	0	0	0	0	5	0.02	58
	offshore	0	0	0	0	0	0				1		

Black-headed Gull abundance estimates based on supplementary datasets

Coastal counts in selected (consistently covered) survey sections along the German mainland coast between September and April 2008/2009 and 2009/2010 indicated that Black-headed Gull was most abundant in early autumn (Figure 4.150, OAG 2010). In contrast to the FEBI survey results, the seasonal pattern recorded during these surveys shows no peak numbers during the spring migration (Figure 4.150). The maximum number was recorded in September 2008 with 8,249 birds within mainland sections of the eastern Kiel Bight (OAG 2010). National mid-winter surveys record fewer birds compared to migration periods (AKVSW 2010, OAG 2010, Petersen et al. 2010).

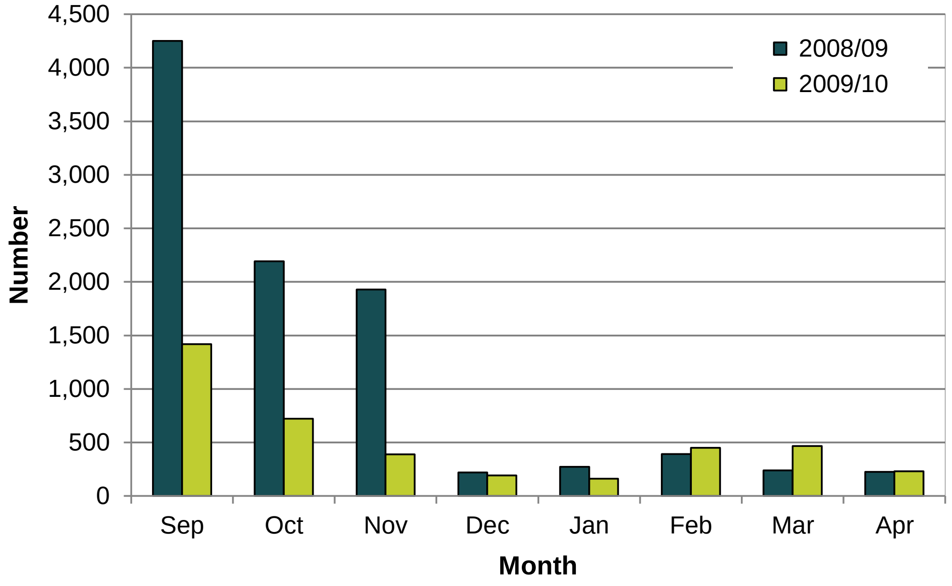


Figure 4.150 Number of Black-headed Gulls recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

The coastal areas of Gedser Odde regularly support more than 100 Black-headed Gulls with numbers peaking in September (DOF 2010). Up to 650 birds were recorded in the alignment area at Rødbyhavn (DOF 2011).

Distribution and habitat use of Black-headed Gull in the Fehmarnbelt

Black-headed Gull distribution according to FEBI survey data

The FEBI ship-based surveys indicate Black-headed Gulls are using coastal areas as well as offshore habitats of the Fehmarnbelt (Figure 4.151). Aerial surveys also show Black-headed Gulls being widely distributed in the study area (Figure 4.152; Appendix II).

Aggregated seasonal maps of Black-headed Gull observations show no clear distribution pattern (Figure 4.153–Figure 4.155). The Black-headed Gulls seems to use all open waters and onshore habitats alike during all seasons. However, the summer distribution in 2010 shows the species occurring more frequently in coastal areas, such as the Rødsand Lagoon or coastal areas of Fehmarn (Figure 4.153, lower map).

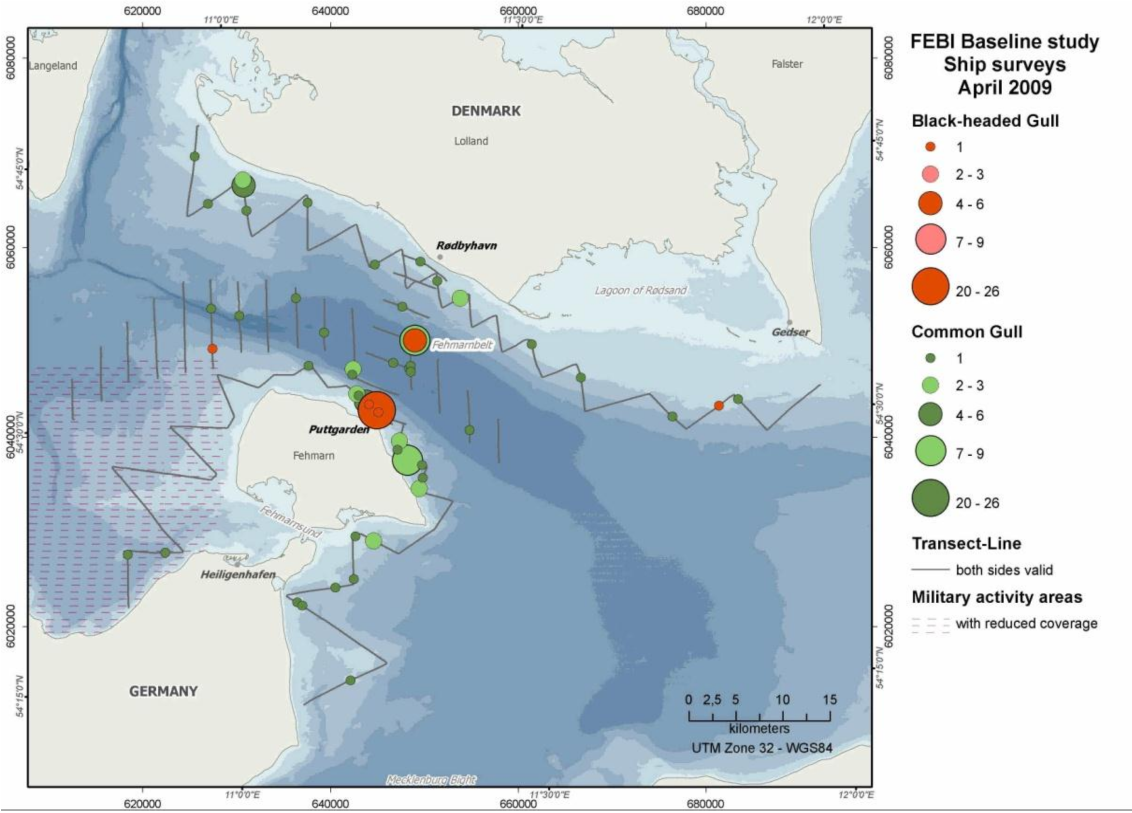


Figure 4.151 Example of observed Black-headed Gull distribution in the study area during ship-based surveys (April 2009).

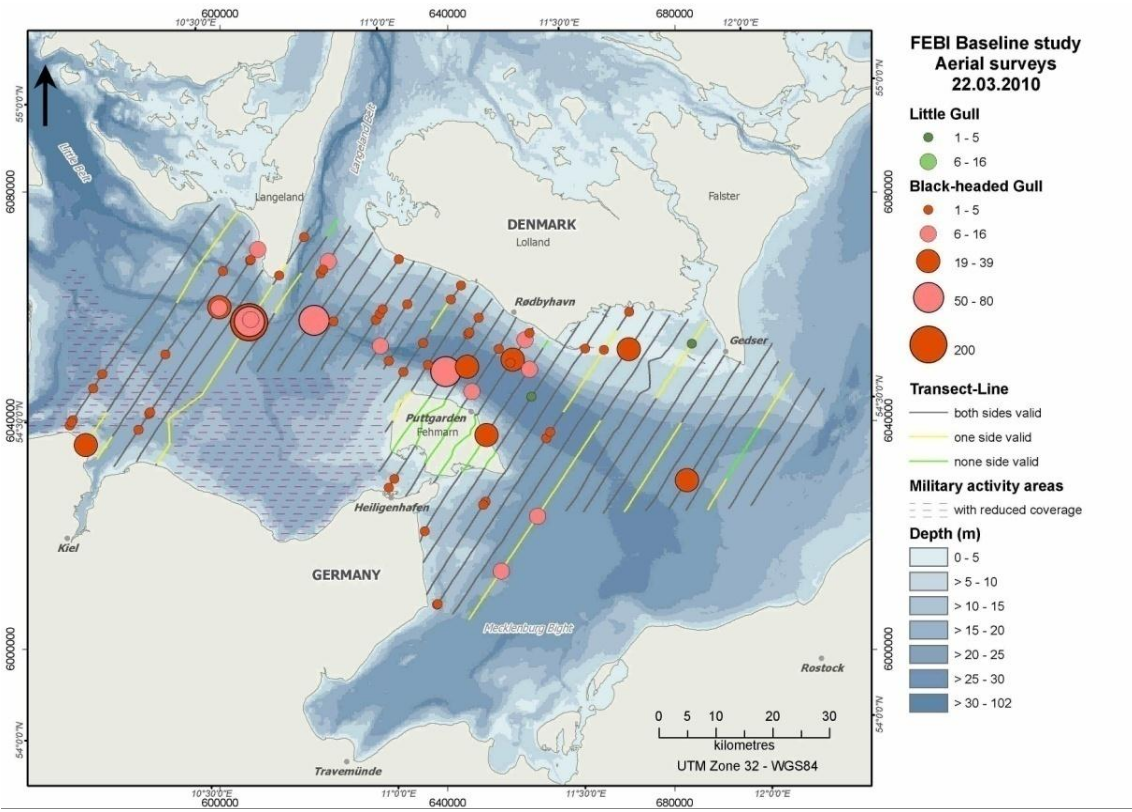
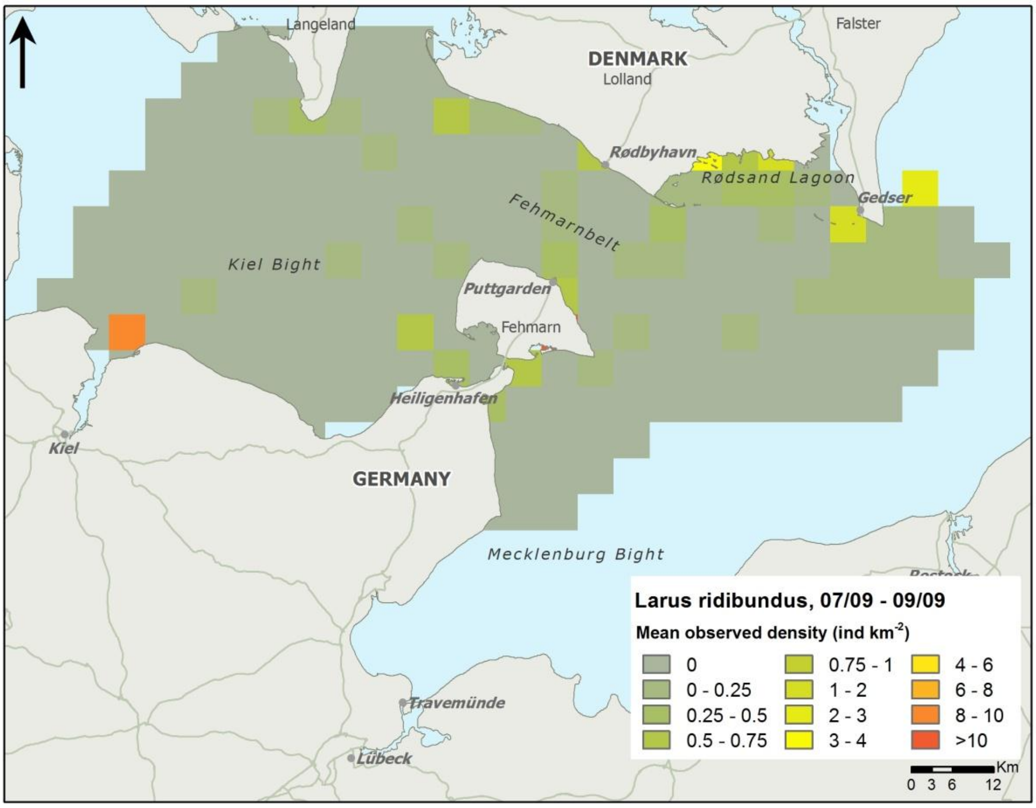


Figure 4.152 Example of observed Black-headed Gull distribution in the study area during aerial surveys (March 2010).



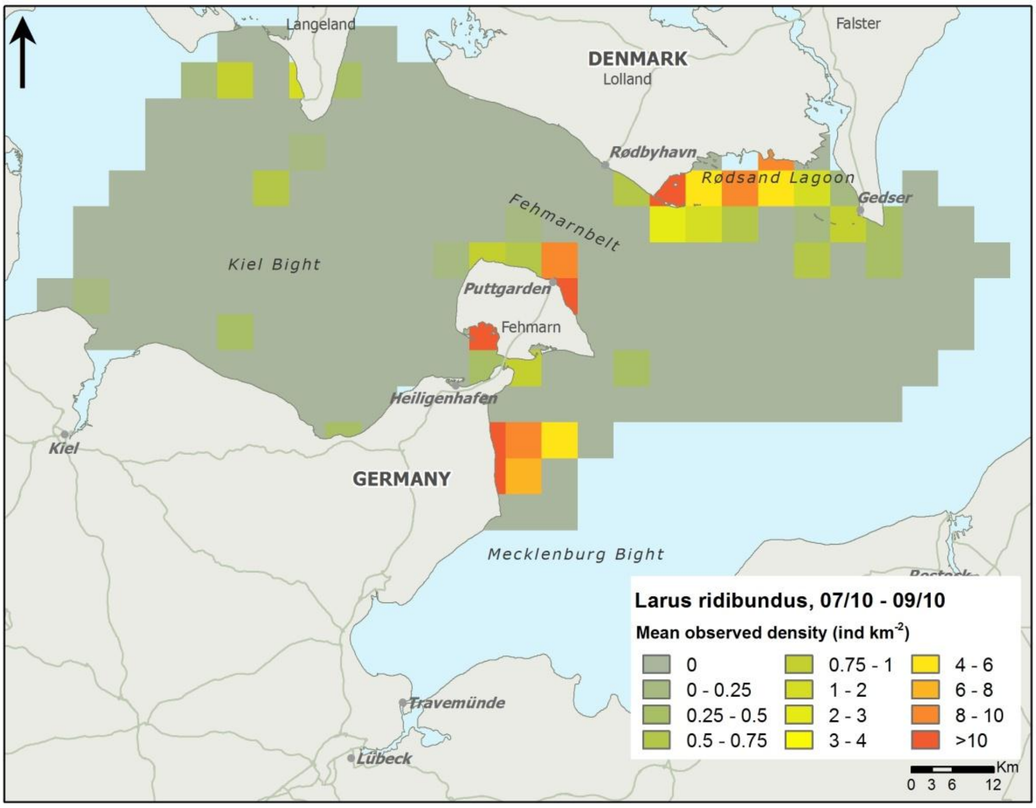
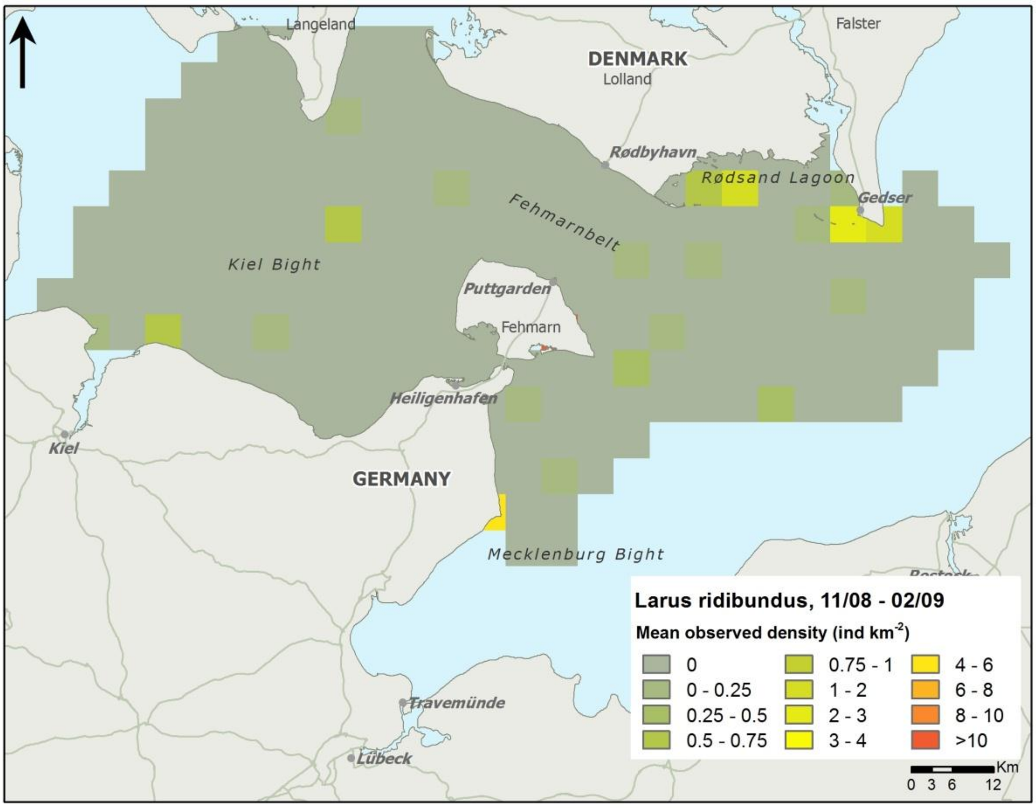


Figure 4.153 Mean densities of Black-headed Gull Larus ridibundus *sampled during July-September by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown in 5 km squares.*



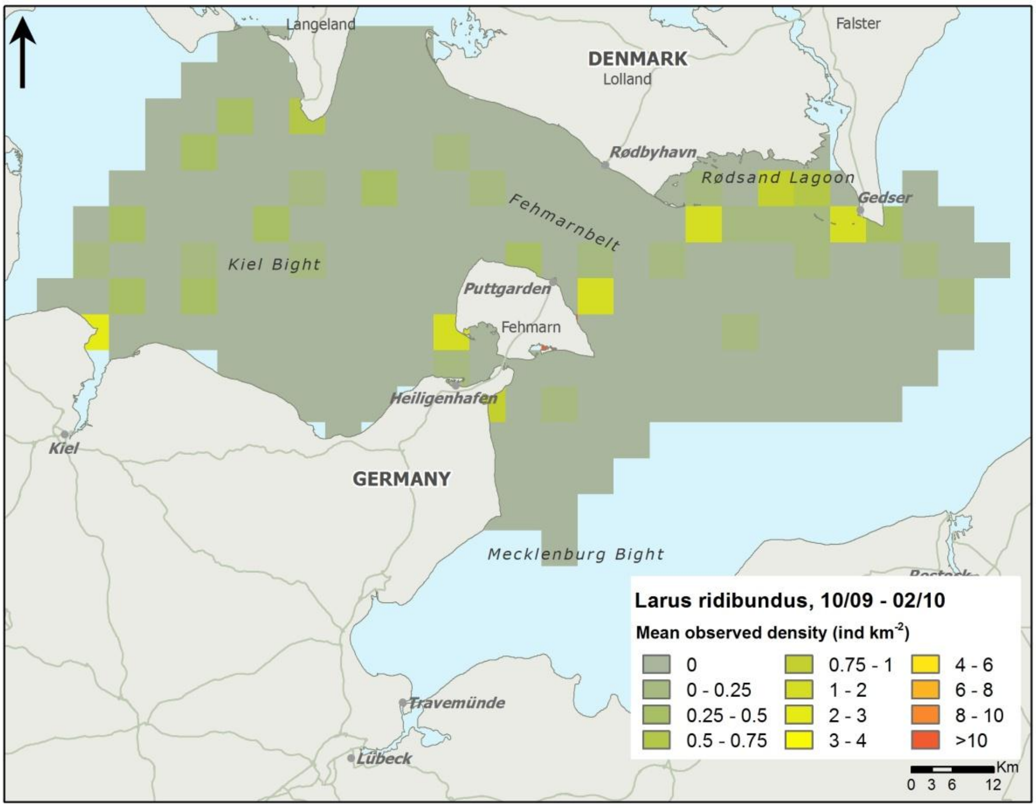
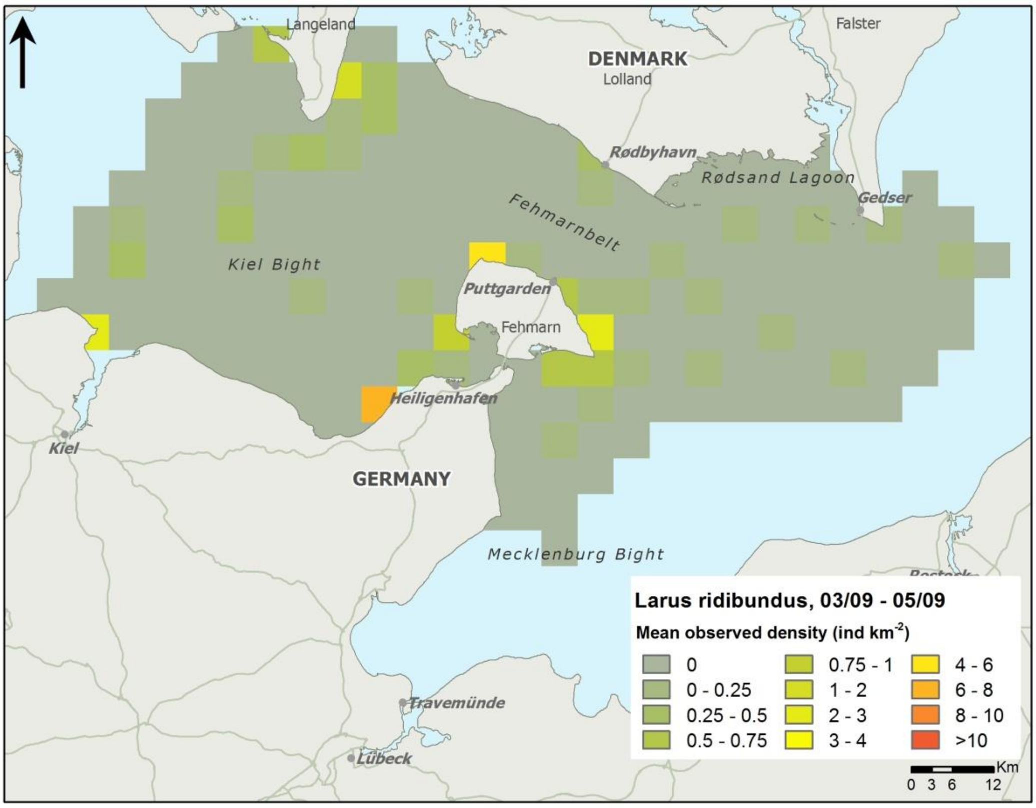


Figure 4.154 Mean densities of Black-headed Gull Larus ridibundus *sampled during October-February by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown in 5 km squares.*



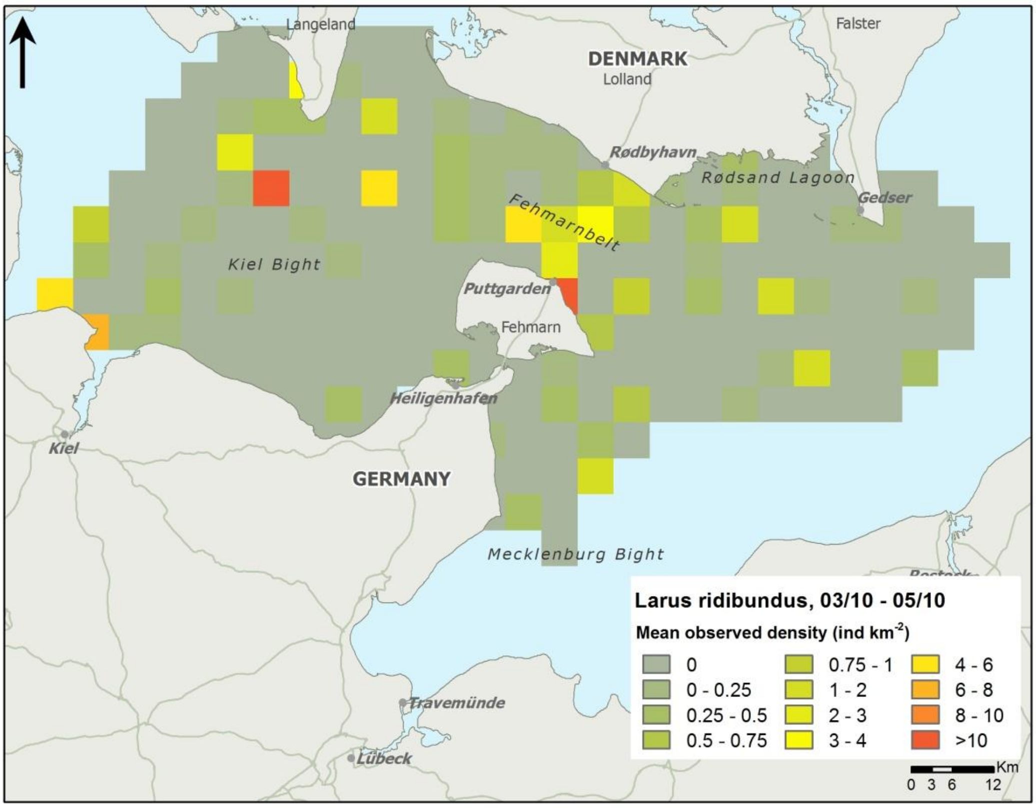


Figure 4.155 Mean densities of Black-headed Gull Larus ridibundus *sampled during March-May aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown in 5 km squares.*

Black-headed Gull distribution according to supplementary datasets

During the German land-based mid-winter count in 2009 Black-headed Gulls were rather evenly distributed along the observed coastline, as indicated in Figure 4.156 (AKVSW 2010, OAG 2010). During Danish mid-winter survey of 2008 Black-headed Gulls were recorded in low numbers and were mainly observed in Rødsand Lagoon (Petersen et al. 2010).

Black-headed Gulls also often use inland freshwater habitats. Among the 8,250 birds recorded along the Kiel Bight mainland coast in September 2008, 40 % (3,260 birds) were recorded on inland areas of the SPA Eastern Kiel Bight (OAG 2010). Also the DOF database indicates that Black-headed Gulls is frequently using inland areas (DOF 2010).

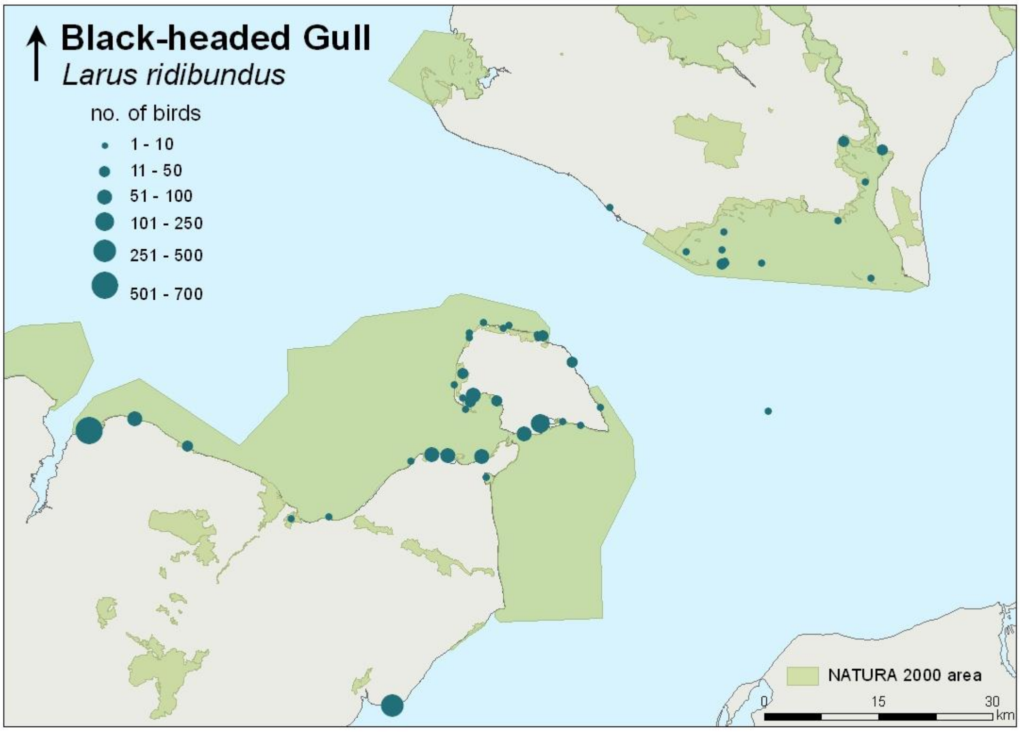


Figure 4.156 Distribution of Black-headed Gull during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish area: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Black-headed Gull abundance estimates for SPAs

As no distribution models were developed for Black-headed Gull, abundance estimates for particular SPAs are not available. Supplementary datasets indicate high numbers of Black-headed Gull occurring in coastal areas of the SPA Eastern Kiel Bight (8,250 birds in mainland coastal sections of the SPA; OAG 2010). There are no records available about abundance of this species in the SPA Baltic Sea east of Wagrien during the periods of peak abundance.

According to supplementary datasets, the SPA Hyllekrog-Rødsand supports comparably low numbers with reported maximum of 500 birds (in September 2008; DOF 2010).

Black-headed Gull trends

The European population of Black-headed Gulls increased between 1970 and 1990. Between 1990 and 2000 the population declined markedly in many regions. However, because of its large population Black-headed Gull status was evaluated as Secure (BirdLife International 2004).

The long-term dataset of annual mid-winter land-based bird counts from the island of Fehmarn shows variable numbers of Black-headed Gull wintering in the study area with no detectable trend (Figure 4.157; AKVSW 2010).

Figure 4.157 Number of Black-headed Gulls recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to the Black-headed Gull

The baseline results and supplementary datasets indicate that numbers of Black-headed Gull using the Fehmarnbelt area do not meet international importance criteria due to the large population size of this species. Between 5,000 and 10,000 birds use the study area. Aggregations of more than 8,000 Black-headed Gulls were reported for the SPA Eastern Kiel Bight, but a high proportion (40 %) of these birds was counted on inland parts of this SPA (OAG 2010).

Black-headed Gull – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	8,250
Max. abundance estimate in the alignment area:	650 + 55
Period of max. abundance in Fehmarnbelt:	March – November
Areas of max. abundance in Fehmarnbelt:	see Figure 4.153, Figure 4.155
Explanations:	Maximum abundance obtained from supplementary data for the SPA Eastern Kiel Bight (8,250 birds, partly inland). The maximum Distance estimate based on FEBI aerial surveys was 5,040 birds. Maximum abundance in the alignment area was obtained from supplementary data from the Danish part of the area (650 birds) and for the German part from mid-winter coastal count in 2009 (55 birds). Distribution pattern obtained from FEBI aerial surveys.

4.1.34 *Common Gull – Larus canus*

Common Gull – *Larus canus*	
Biogeographic population: *L. c. canus*	
Breeding range: Iceland, Ireland, Britain, eastwards to White Sea	
Wintering / core non-breeding range: Europe to N Africa	
Population size: 1,200,000 – 2,250,000	
1 % value: 20,000	
Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: SPEC 2 EU Threat Status: (depleted)
Target species in SPAs:	-
Key food: terrestrial and aquatic invertebrates, fish	
Period of presence in Fehmarnbelt:	Wintering, migrations: mid-July – mid-May Breeding: mid-May – mid-July

Origin of Common Gull in the Fehmarnbelt

The FEBI ring recovery analysis (n=844) indicates that the population wintering in Fehmarnbelt consists of breeding birds from Denmark, southern Sweden, Finland, the Baltic countries and NW Russia (Appendix IV). The NW European populations including the local breeding birds winter inland as well as offshore in W Europe (Appendix IV). Common Gulls ringed in Denmark during the non-breeding season show mean summer (May-August) recovery positions in southern Finland (Bønløkke et al. 2006). The mean winter positions (December-February) of birds ringed in Denmark are the northern part of the English Channel (Bønløkke et al. 2006). The main migration routes are in a southwest-northeast direction. Overall, this indicates that the southern Baltic Sea is a migration corridor for Common Gulls between breeding and wintering areas.

Data sources on Common Gull in the Fehmarnbelt

Numbers and distribution of Common Gulls are well reflected in the FEBI aerial and ship-based survey data, but aerial surveys were chosen as the primary data source for representing the species due to broader spatial coverage of the study region (Table 4.85). Other datasets were used as supporting data sources to characterise Common Gull densities, distribution and habitat use (Table 4.85).

Table 4.85 List of datasets and their use in baseline assessment of Common Gull in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating species abundance and distribution
FEBI ship transect surveys	Supporting dataset for estimating species abundance and distribution
OAG land-based counts	Supporting dataset representing species winter abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Common Gull in the Fehmarnbelt

Common Gull abundance estimates based on Distance analysis

The abundance of Common Gull in the Fehmarnbelt was estimated by applying Distance analysis (Thomas et al. 2010) on the monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Common Gull during aerial surveys, calculated using the entire dataset, were 185 m for swimming birds and 230 m for flying birds. These detection functions are close to those of the similar sized Black-headed Gull.

The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of Common Gulls have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.86, Appendix V). Often partial coverage most likely resulted in minimum estimates for this species. Common Gulls are present in the Fehmarnbelt throughout the year (Table 4.86). Abundance estimates among different months varied considerably, and ranged from several hundreds to nearly 6,700 birds in January 2009 (Table 4.86).

Table 4.86 Numbers of observed Common Gulls during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	20	40	-	-	-	-
Dec-08	81.7	40	128	0.26	0.10	0.68	1,024
Jan-09	82.8	117	1,210	1.66	0.65	4.27	6,684
Feb-09	100	81	339	0.48	0.22	1.04	2,340
Mar-09	77.5	231	348	0.62	0.39	1.02	2,345

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Apr-09	86.8	35	104	0.20	0.06	0.64	854
May-09	77.3	42	602	1.36	0.17	12.91	5,124
Jun-09	80.9	28	36	0.07	0.03	0.18	291
Jul-09	86.6	107	303	0.69	0.33	1.49	2,927
Aug-09	92.3	28	89	0.18	0.05	0.67	831
Sep-09	79.1	7	21	0.05	0.01	0.25	208
Oct-09	79.9	47	57	0.12	0.07	0.22	472
Nov-09	82.4	47	115	0.22	0.09	0.55	880
Dec-09	24.7	5	5	0.03	0.01	0.14	39
Mar-10 A	64.1	91	209	0.41	0.21	0.84	1,290
Mar-10 B	75.6	79	455	0.93	0.50	1.73	3,432
Apr-10	100	102	214	0.28	0.17	0.48	1,349
May-10	92.1	33	40	0.06	0.03	0.12	265
Jun-10	70.8	33	45	0.11	0.05	0.23	377
Aug-10	75.6	45	85	0.15	0.05	0.44	562
Sep-10 A	44.9	7	10	0.04	0.01	0.66	94
Sep-10 B	48.9	33	165	0.57	0.17	1.84	1,349
Oct-10	80.0	153	403	0.56	0.35	0.90	2,187
Nov-10	70.1	33	38	0.08	0.04	0.17	278

The ESW for Common Gull during ship-based surveys, estimated for the entire dataset, was 156 m. During ship-based surveys Common Gulls were regularly observed (Table 4.87). The mean densities and the maximum estimate of 4,430 birds obtained by Distance analysis on ship-based survey data fall within the range obtained from aerial surveys (Table 4.86). Common Gulls were observed in similar densities within coastal and offshore transects (Table 4.87).

Table 4.87 *Numbers of observed Common Gulls during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km^2 covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.*

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	1	1	0.02	99	0.00	0.08	-	-	-	5	-	-
	offshore	5	33	-	***	-	-				15		
Dec-08	coastal	5	12	-	***	-	-	-	-	-	19	-	-
	offshore	1	7	0.19	95	0.04	1.00				17		
Jan-09	coastal	3	3	0.04	57	0.01	0.11	0.05	0.02	0.14	5	0.11	264
	offshore	3	3	0.07	54	0.03	0.21				10		

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Feb-09	coastal	1	1	0.01	101	0.00	0.07	0.03	0.01	0.15	6	0.08	194
	offshore	2	3	0.07	76	0.02	0.30				6		
Mar-09	coastal	4	6	-	***	-	-	-	-	-	8	-	-
	offshore	0	0	0	0	0	0				7		
Apr-09	coastal	15	40	-	920	-	-	-	-	-	23	-	-
	offshore	4	10	0.29	83	0.07	1.32				16		
May-09	coastal	2	2	0.02	71	0.01	0.09	-	-	-	6	-	-
	offshore	2	4	-	448	-	-				1		
Jul-09A	coastal	5	7	-	***	-	-	-	-	-	22	-	-
	offshore	2	10	0.24	71	0.06	0.92				6		
Jul-09B	coastal	0	0	0	0	0	0	0.02	0.00	0.07	6	0.05	110
	offshore	2	2	0.05	72	0.01	0.19				0		
Aug-09	coastal	2	3	-	***	-	-	-	-	-	0	-	-
	offshore	2	5	0.13	95	0.02	0.68				1		
Sep-09	coastal	3	4	0.04	74	0.01	0.20	0.03	0.01	0.13	2	0.05	108
	offshore	0	0	0	0	0	0				2		
Oct-09	coastal	3	3	0.04	55	0.01	0.10	0.03	0.01	0.08	20	0.13	312
	offshore	0	0	0	0	0	0				1		
Nov-09	coastal	0	0	0	0	0	0	0	0	0	1	0.01	21
	offshore	0	0	0	0	0	0				1		
Dec-09	coastal	7	7	0.09	46	0.04	0.21	0.11	0.04	0.32	13	0.21	484
	offshore	4	10	0.16	65	0.05	0.54				9		
Jan-10	coastal	24	26	-	***	-	-	-	-	-	17	-	-
	offshore	15	16	0.38	51	0.14	1.03				16		
Feb-10A	coastal	68	102	1.48	34	0.76	2.88	1.47	0.70	3.09	48	1.89	4,433
	offshore	41	59	1.45	45	0.60	3.48				50		
Feb-10B	coastal	15	23	0.33	65	0.10	1.07	-	-	-	19	-	-
	offshore	13	38	-	***	-	-				7		
Mar-10	coastal	3	3	0.04	75	0.01	0.15	-	-	-	10	-	-
	offshore	37	81	-	160	-	-				5		
Apr-10	coastal	1	1	0.01	102	0.00	0.07	0.01	0.00	0.05	6	0.05	121
	offshore	0	0	0	0	0	0				4		
May-10	coastal	0	0	0	0	0	0	0	0	0	0	0.00	0
	offshore	0	0	0	0	0	0				0		
Jun-10	coastal	0	0	0	0	0	0	0	0	0	3	0.01	31
	offshore	0	0	0	0	0	0				0		
Sep-10	coastal	7	18	-	***	-	-	-	-	-	9	-	-
	offshore	4	4	0.10	59	0.03	0.30				7		
Oct-10	coastal	9	9	0.11	48	0.04	0.28	0.10	0.04	0.32	13	0.21	482
	offshore	3	4	0.09	71	0.02	0.39				10		
Nov-10	coastal	8	16	-	***	-	-	-	-	-	40	-	-
	offshore	2	4	0.10	79	0.02	0.52				6		

Month-to-month variation in Common Gull occurrence in the Fehmarnbelt was assessed by plotting mean densities of swimming birds recorded during ship-based surveys (and corrected for distance detection bias), as rather consistent spatial coverage has been achieved during these counts. The species was present in the area all year with highest densities occurring in winter (Table 4.87, Figure 4.158).

However, a high proportion of Common Gulls was observed flying and sample size of sitting birds was often too small for Distance analysis.

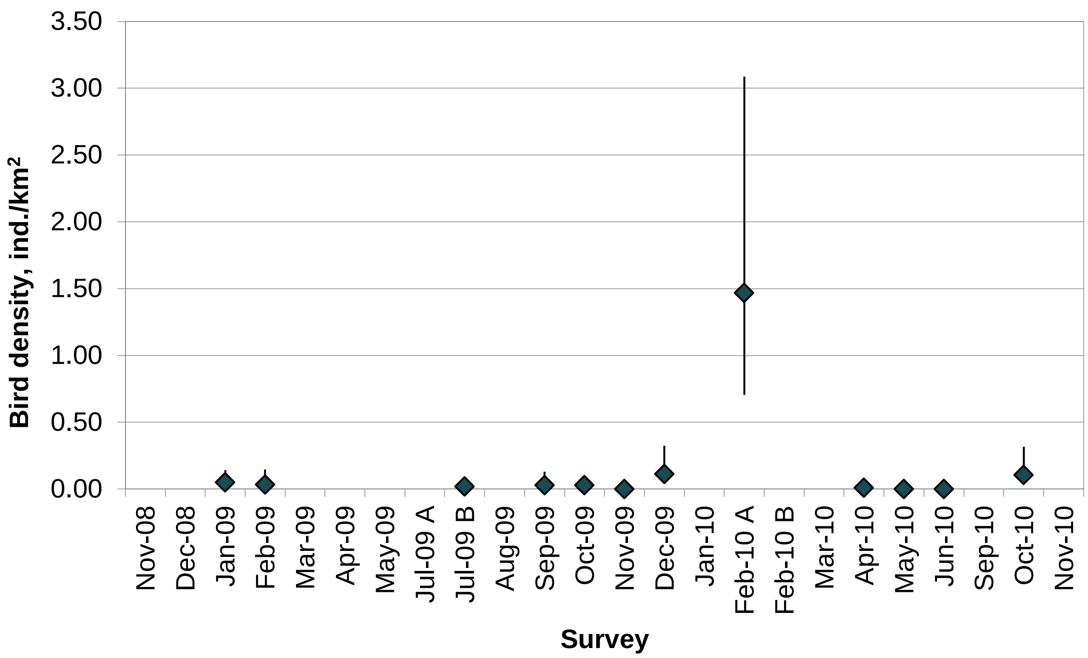


Figure 4.158 Mean density estimates and 95 % confidence intervals of swimming Common Gulls estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150 % were not included into the chart (see Table 4.87 for specific values).

Common Gull abundance estimates based on supplementary datasets

Coastal counts in selected (consistently covered) survey sections along the German mainland coast (September–April 2008/2009 and 2009/2010) show no clear seasonal pattern of Common Gull abundance in the study area (Figure 4.159; OAG 2010). According to Berndt et al. (2005) maximum numbers of Common Gull occur on Fehmarn in September/October.

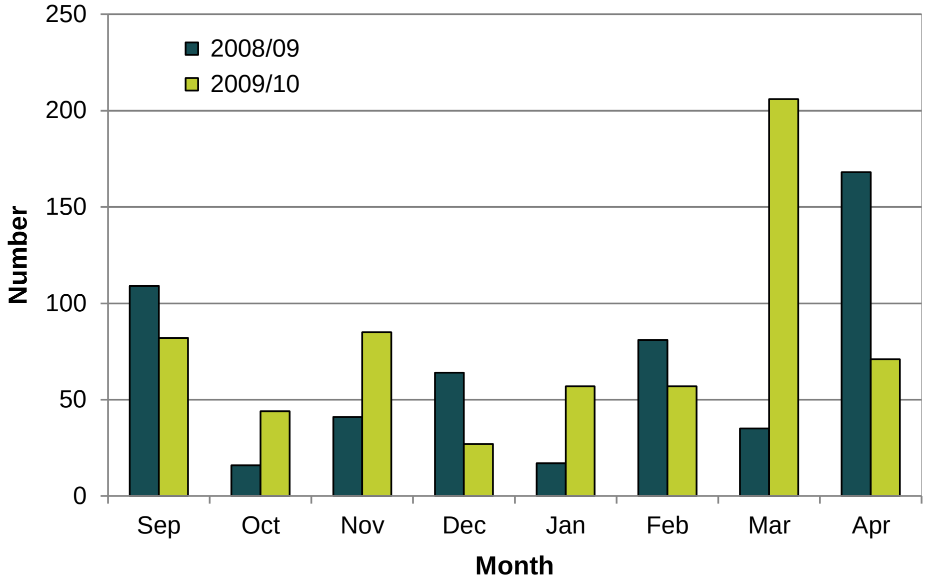


Figure 4.159 Number of Common Gulls recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

During German land-based monthly counts the maximum number of Common Gull was recorded in April 2009 with 2,182 birds recorded within mainland sections of the eastern Kiel Bight (OAG 2010). Another single count reported 2,280 Common Gulls at Graswarder in Hohwacht Bay (in April 2008; OAG 2010). Such records suggest regular presence of high numbers of this species in these coastal areas.

Comparably few Common Gulls have been recorded during German and Danish mid-winter surveys in the Fehmarnbelt. 584 birds were recorded during the German mid-winter survey in 2009, and 78 during the Danish mid-winter survey in 2008 (AKVSW 2010, OAG 2010, Petersen et al. 2010).

According to the DOF database Common Gulls are present in the Rødsand Lagoon in low numbers all the year with the highest numbers reported during transitional periods (maximum 600 birds in April 2010; DOF 2010). In coastal areas of Gedser Odde more than 100 Common Gulls are regularly recorded with the highest number of 1,150 reported in December 2007 (DOF 2010). Up to 469 birds were documented to occur in the alignment area at Rødbyhavn (DOF 2011).

Distribution and habitat use of Common Gull in the Fehmarnbelt

In the Baltic Sea, the distribution of Common Gulls is largely determined by fishing activities (Durinck et al. 1994), and the species is frequently observed scavenging for fish discards (Garthe and Scherp 2003). The species is also described to use inland areas frequently, primarily grasslands and arable land (Berndt et al. 2005, Mendel et al. 2008).

Common Gull distribution according to FEBI survey data

Common Gulls were observed being widely distributed in the Fehmarnbelt area (Figure 4.160, Figure 4.161, Appendix II). Common Gull distribution recorded during the FEBI baseline investigations suggests no habitat associations or preferred areas (Figure 4.160, Figure 4.161). FEBI aerial observations of this species aggregated into seasonal composite maps confirm variable distribution and absence of detectable patterns (Figure 4.162–Figure 4.164).

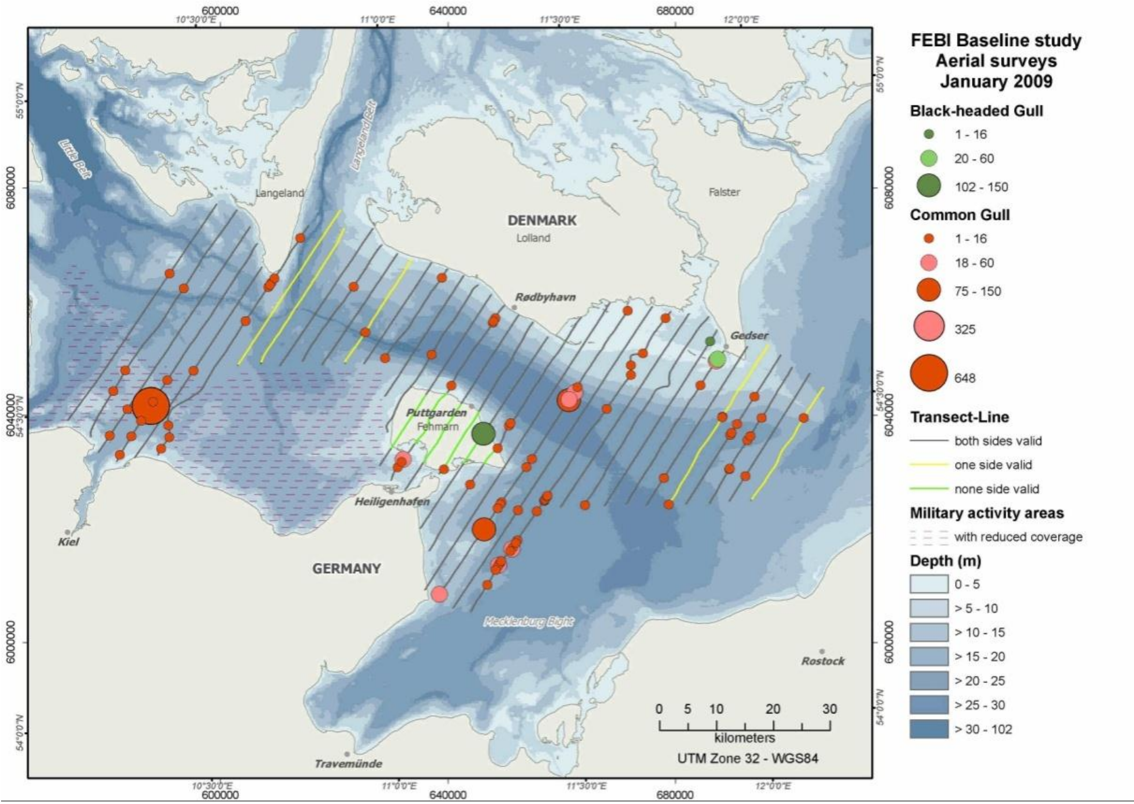


Figure 4.160 *Distribution of Common Gull (and Black-headed Gull) in the study area during the aerial survey in January 2009.*

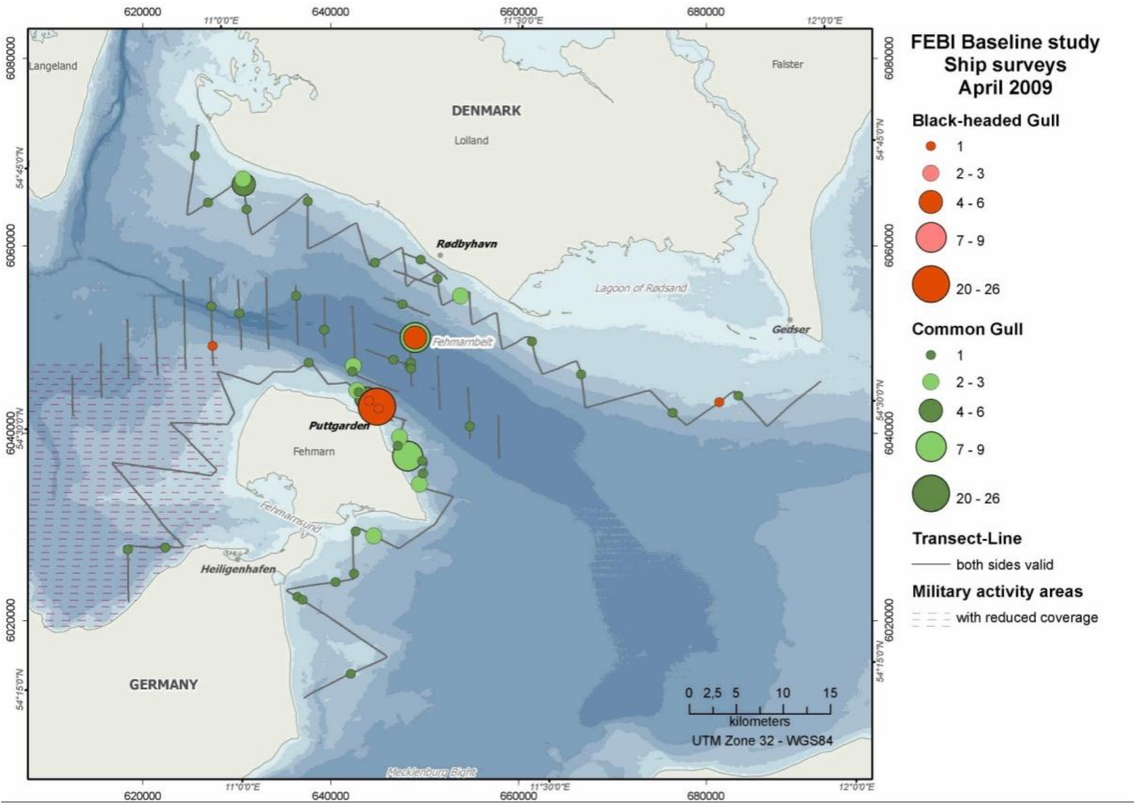
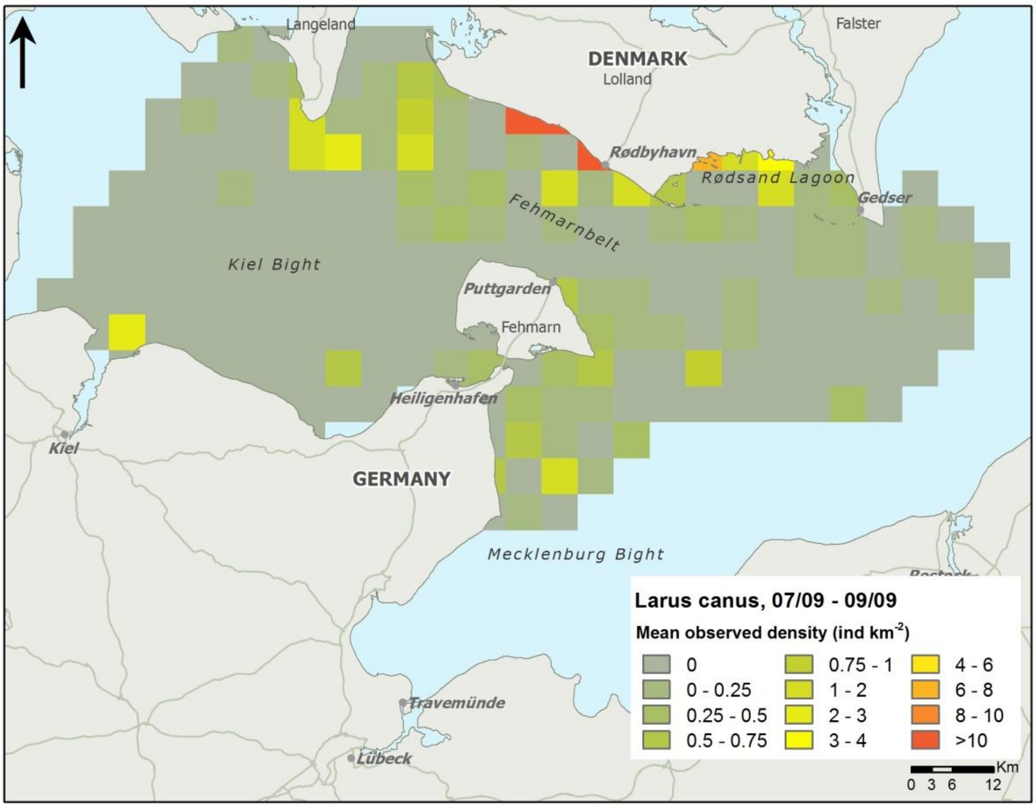


Figure 4.161 *Distribution of Common Gull (and Black-headed Gull) in the study area during the ship-based survey in April 2009.*



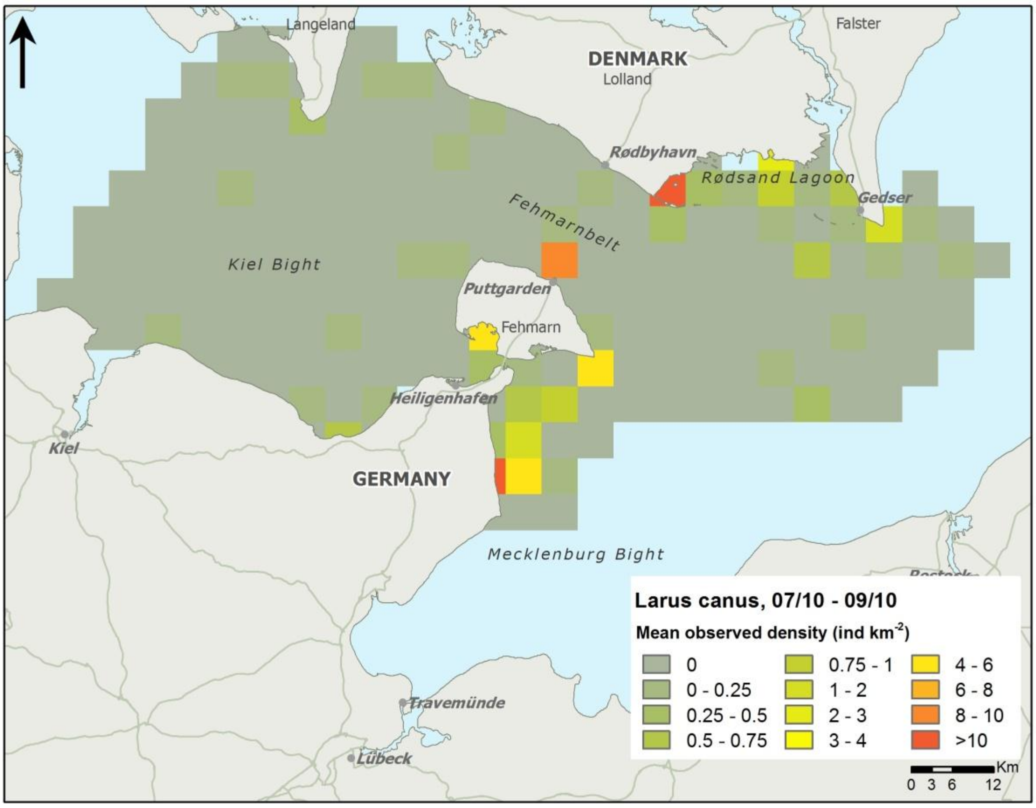
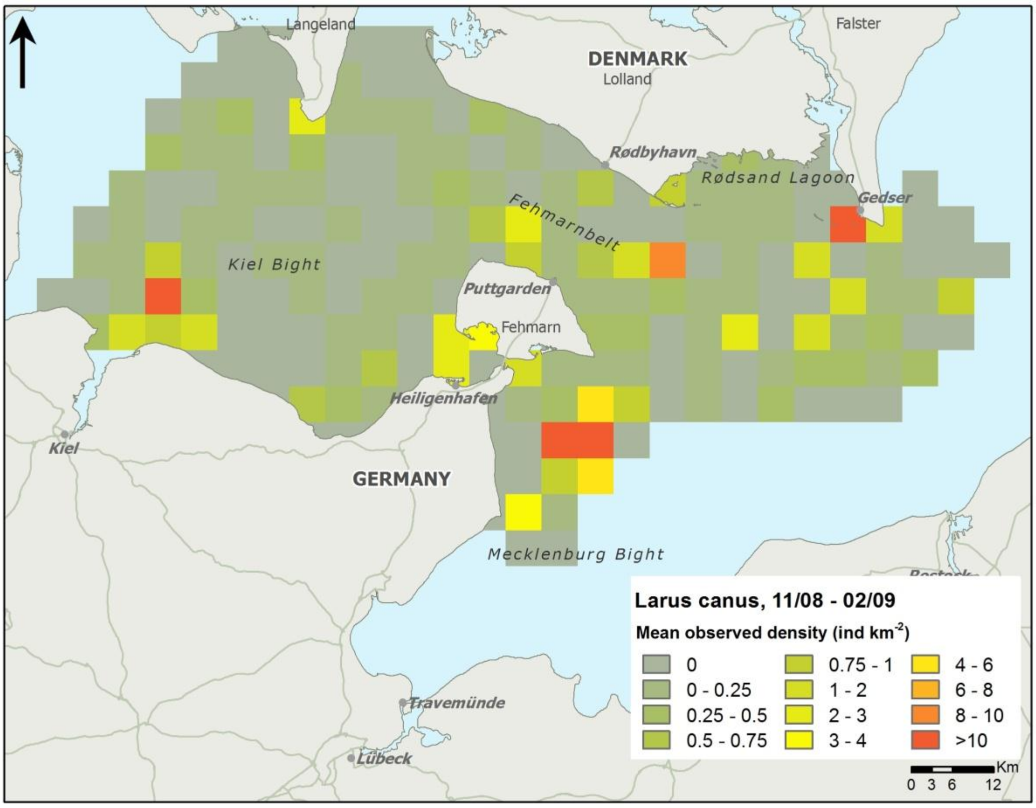


Figure 4.162 Mean densities of Common Gull Larus canus *sampled during July-September by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.*



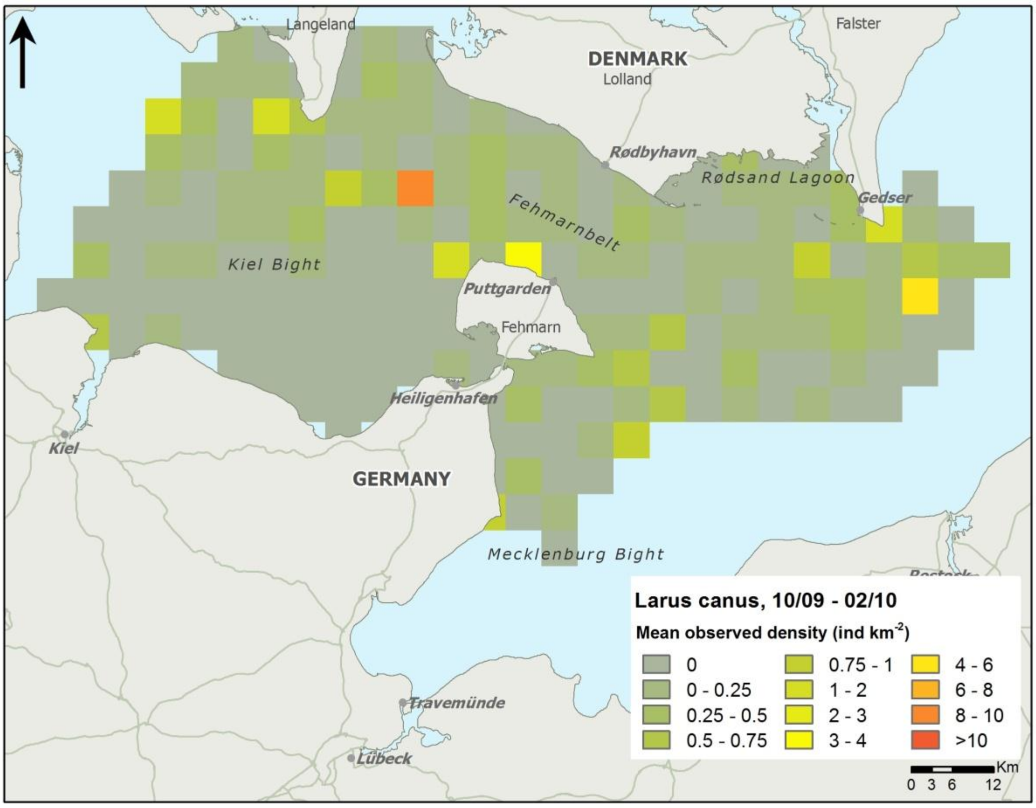


Figure 4.163 Mean densities of Common Gull Larus canus *sampled during October-February by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.*

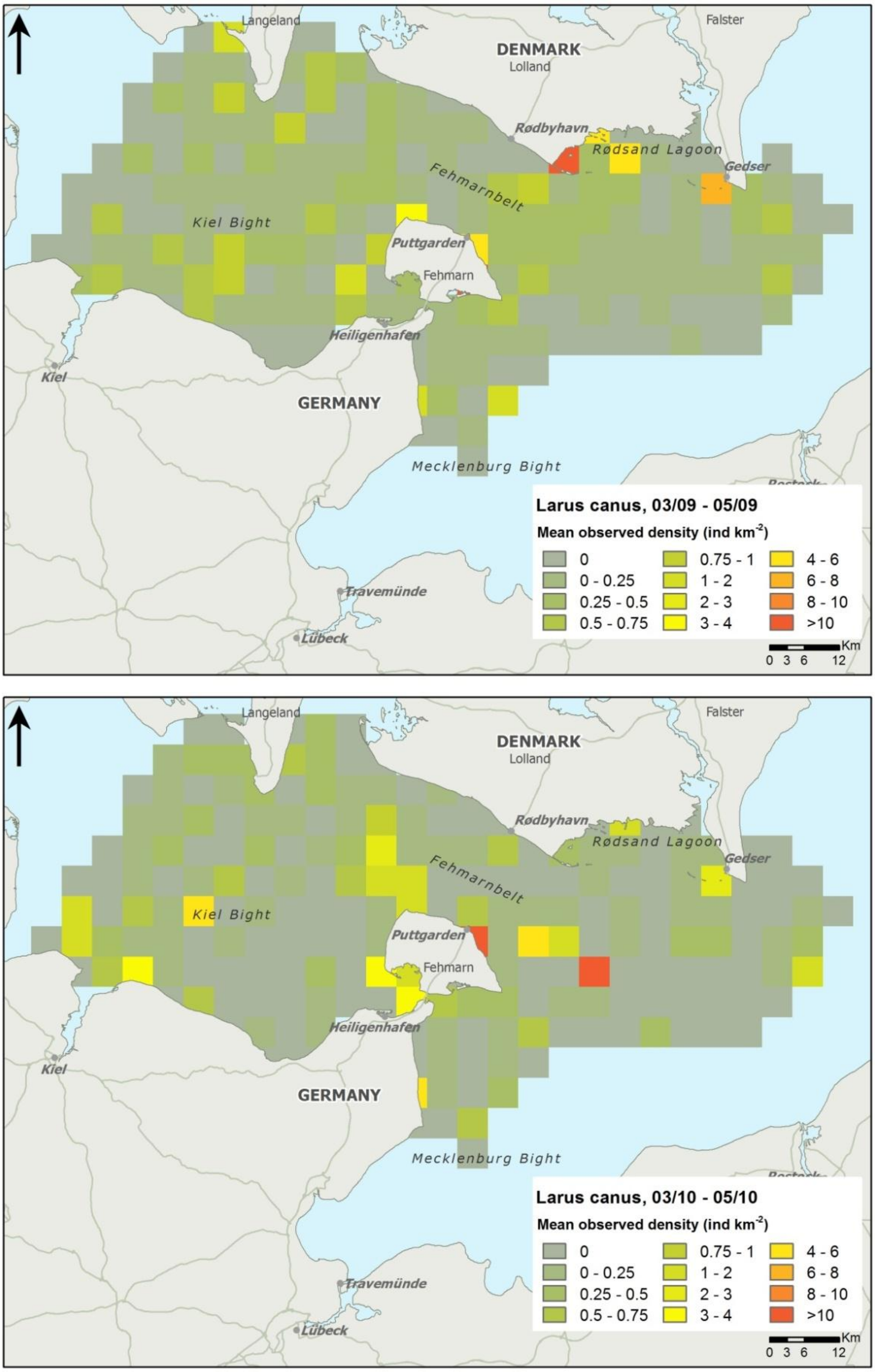


Figure 4.164 Mean densities of Common Gull Larus canus *sampled during March-May by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.*

Common Gull distribution according to supplementary datasets
During German land-based mid-winter count of 2009, Common Gull was recorded quite evenly distributed along the observed coastline (Figure 4.165, AKVSW 2010, OAG 2010). Danish mid-winter survey 2008 reports only low numbers of Common Gull, which were observed mainly offshore (Petersen et al. 2010).

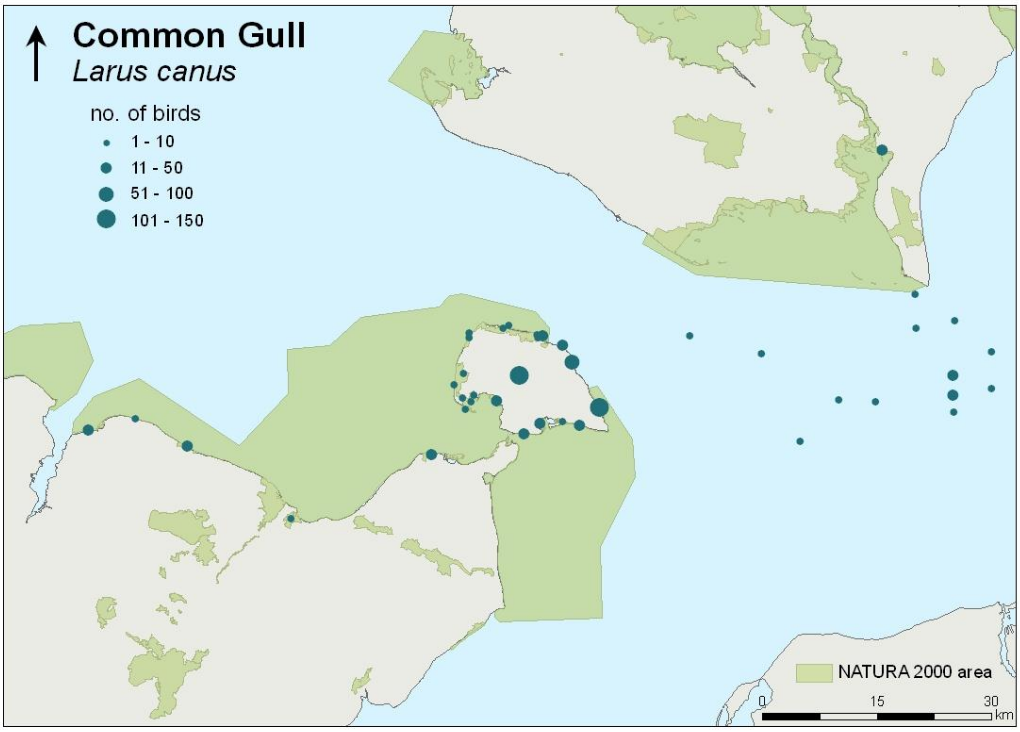


Figure 4.165 Distribution of Common Gull during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

According to the DOF database, the highest numbers of Common Gull occur on inland areas, such as Maribo Lakes in the centre of Lolland (DOF 2010). However, coastal counts along the German mainland coast recorded more than 90 % of Common Gulls using inshore marine areas and the species was less frequently observed in the surveyed inland sections of SPA Eastern Kiel Bight (OAG 2010).

Common Gull abundance estimates for SPAs
As no distribution models were developed for Common Gull, abundance estimates for particular SPAs are not available based on FEBI survey data. Supplementary datasets indicate high numbers of Common Gull occurring in coastal areas of the SPA Eastern Kiel Bight in April (more than 2,000 birds in mainland coastal sections of the SPA; OAG 2010). There are no records about Common Gull abundance in the SPA Baltic Sea east of Wagrien during the peak periods of abundance.

According to the DOF database coastal areas of the SPA Hyllekrog-Rødsand support up to 600 birds (DOF 2010).

Common Gull trends
The European population of Common Gull underwent a moderate decline between 1970 and 1990. Between 1990 and 2000 the population increased markedly, but did not reach previous levels of abundance. Thus, the population was provisionally

evaluated as Depleted (BirdLife International 2004). Long-term dataset of annual mid-winter land-based counts from the island of Fehmarn shows variable numbers of Common Gull wintering in the study area, with no detectable trend during the analysed 20 year period (Figure 4.166; AKVSW 2010).

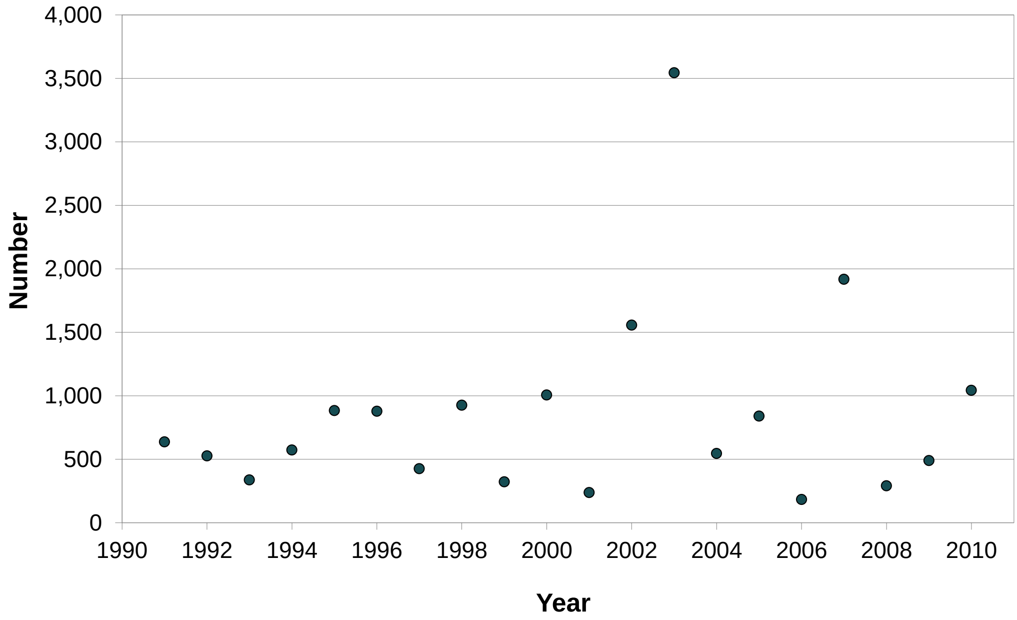


Figure 4.166 Number of Common Gulls recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to the Common Gull

Common Gull is an abundant and common species, and is present in the Fehmarnbelt area all year. The highest numbers typically occur during transitional and winter periods. FEBI baseline investigations and supplementary datasets indicate several thousand birds using the area regularly with the highest estimate of 6,700 birds (0.34 % of the biogeographic population) for the entire Fehmarnbelt area.

Common Gull – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	6,700
Max. abundance estimate in the alignment area:	769 + 98
Period of max. abundance in Fehmarnbelt:	September – April
Areas of max. abundance in Fehmarnbelt:	see Figure 4.163, Figure 4.164
Explanations:	Maximum abundance represents Distance analysis estimate of the aerial survey of January 2009. Maximum abundance in the alignment was obtained from supplementary data on the Danish part (769 birds) and 98 birds reported for the German part of this area during the land-based mid-winter survey of 2009. Distribution pattern obtained from FEBI aerial surveys.

4.1.35 Lesser Black-backed Gull – *Larus fuscus*

Lesser Black-backed Gull – *Larus fuscus*

Biogeographic population: *L. f. fuscus, L. f. intermedius*

Breeding range: *L. f. fuscus* – N Norway, E Sweden, E Denmark, Finland, Estonia, W Russia eastwards to White Sea; *L. f. intermedius* – S Norway, W Sweden, Denmark, Germany, The Netherlands, Ebro Delta, Spain

Wintering / core non-breeding range: *L. f. fuscus* – E Africa southwards to Tanzania (plus few SW Asia); *L. f. intermedius* – W Europe to W Africa

Population size: *L. f. fuscus* – 55,500; *L. f. intermedius* – 325,000 – 440,000

1 % value: *L. f. fuscus* – 555; *L. f. intermedius* – 3,800

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: non-SPEC^{E}
EU Threat Status: secure

Target species in SPAs: -

Key food: omnivorous, offshore mainly fish (also discard)

Period of presence in Fehmarnbelt: Breeding, migrations: mid-March – October

Origin of Lesser Black-backed Gulls in the Fehmarnbelt
FEBI ring recovery analysis (n=9) showed that this long-distance migrant is using Fehmarnbelt as a stop-over site to and from breeding areas along the coast of the Baltic Sea (Appendix IV). There are no ring-recoveries from wintering areas of Lesser Black-backed Gull available (Appendix IV). However, the ringing atlases show wintering areas in the northern Atlantic and sub-Saharan Africa (Bakken et al. 2003; Bønløkke et al. 2006; Fransson et al. 2008).

Data sources on Lesser Black-backed Gulls in the Fehmarnbelt
The numbers and distributions of Lesser Black-backed Gulls are well reflected in FEBI aerial and ship-based survey data, but aerial surveys were chosen as the primary data source for representing the species due to broader spatial coverage of the study region and more sightings of the species (Table 4.88). Other datasets were used as supporting sources to characterise abundance, distribution and habitat use of the species (Table 4.88). Datasets of AKVSW Hamburg (AKVSW 2010) and NOVANA surveys (Petersen et al. 2010) were not used as there were no sightings of Lesser Black-backed Gulls in these datasets (Table 4.88).

Table 4.88 List of datasets and their use in baseline assessment of Lesser Black-backed Gull in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating species abundance and distribution
FEBI ship transect surveys	Supporting dataset for estimating species abundance and distribution
OAG land-based counts	Supporting dataset representing species winter abundance along the German mainland coast
AKVSW land-based counts	Dataset not used due to no records of the species
NOVANA aerial surveys	Dataset not used due to no records of the species
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Lesser Black-backed Gulls in the Fehmarnbelt

Mendel et al. (2008) report very low numbers of Lesser Black-backed Gull occurring in the German Baltic Sea. With estimated 160 birds being present in the entire German Baltic Sea, maximum numbers are reached in summer. Only few individuals spend winter in the region (Mendel et al. 2008). Berndt et al. (2005) report regular observations of single Lesser Black-backed Gulls on Fehmarn between spring and autumn.

Lesser Black-backed Gull abundance according to FEBI survey data

During the FEBI baseline investigations Lesser Black-backed Gulls were observed in low numbers, therefore no Distance analysis could be applied on aerial and ship-based survey datasets due to low sample size. The species was mainly observed in summer period, but there were also single birds recorded during winter surveys in 2009/2010 (Table 4.89).

Two years of FEBI ship-based surveys resulted in only four observations of 1-2 Lesser Black-backed Gulls in summer and autumn months.

Table 4.89 Results of monthly aerial surveys for Lesser Black-backed Gull between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects; Coverage % is percentage of survey area covered in valid conditions.

Survey	Number of birds observed	Coverage %	Survey	Number of birds observed	Coverage %
Nov-08	0	80.9	Nov-09	1	82.4
Dec-08	0	81.7	Dec-09	1	24.7
Jan-09	0	82.8	Mar-10 A	0	64.1
Feb-09	0	100.0	Mar-10 B	7	75.6
Mar-09	0	77.5	Apr-10	2	100.0
Apr-09	1	86.8	May-10	2	92.1
May-09	1	77.3	Jun-10	6	70.8
Jun-09	6	80.9	Aug-10	9	75.6
Jul-09	6	86.6	Sep-10 A	4	44.9
Aug-09	5	92.3	Sep-10 B	0	48.9
Sep-09	8	79.1	Oct-10	4	80.0
Oct-09	3	79.9	Nov-10	0	70.1

Lesser Black-backed Gull abundance according to supplementary datasets

The land-based surveys conducted along the German mainland coast between September and April 2008/2009 and 2009/2010 revealed only two records of Lesser Black-backed Gull with 1 bird in October 2009 and 1 bird April 2010 (OAG 2010). Thus, the German coastal counts confirm that the species is rare in the area in winter (OAG 2010). However, due to absence of surveys during the summer months, German land-based counts provide no information about numbers of Lesser Black-backed Gull during the main period of species presence in the area.

The DOF database indicates the Lesser Black-backed Gull being rare also in the Danish coastal areas (DOF 2010). Lesser Black-backed Gulls were reported only five times for Rødsand Lagoon with a maximum of 3 birds counted in July 2007 (DOF 2010). Single sightings of the species are also reported for Gedser Odde (DOF 2010). Seasonal pattern of the species’ occurrence at the Danish coasts agrees with the FEBI observations.

Distribution and habitat use of Lesser Black-backed Gull in the Fehmarnbelt

The FEBI baseline investigations revealed very few sightings of Lesser Black-backed Gull in the study area. Therefore distribution and habitat use analysis was not possible.

Lesser Black-backed Gulls are described as using offshore habitats when foraging (Kubetzki and Garthe 2003). Like other gull species, Lesser Black-backed Gulls are often observed associated with fishing vessels, where they feed on discards (Schwemmer and Garthe 2005).

Lesser Black-backed Gull abundance estimates for SPAs

As no distribution models were possible for the Lesser Black-backed Gull, abundance estimates for particular SPAs are not available. All available information sources suggest that this species occurs in very low numbers in Fehmarnbelt as a whole.

Lesser Black-backed Gull trends

The European breeding population of Lesser Black-backed Gull was described as increasing between 1970 and 1990 (BirdLife International 2004). In the following decade (1990-2000) this trend continued in most of the countries, but the subspecies L .f. *fuscus* has been declining recently in the Baltic region. Nevertheless, the European breeding population of Lesser Black-backed Gull was evaluated as Secure (BirdLife International 2004). No information is available about trends of the species in the Fehmarbelt region.

Importance of the Fehmarnbelt to the Lesser Black-backed Gull

The FEBI baseline investigations and supplementary data sources indicate Lesser Black-backed Gulls regularly occurring in the Fehmarnbelt area between spring and autumn, but numbers are low with mostly single birds being recorded. It can be concluded that a very low proportion (< 0.1 %) of the biogeographic population uses the Fehmarnbelt area in the course of the year.

Lesser Black-backed Gull – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	single birds (max. count: 9 birds)
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	March – October
Areas of max. abundance in Fehmarnbelt:	no aggregation areas identified
Explanations: –	

4.1.36 Herring Gull – *Larus argentatus*

Herring Gull – *Larus argentatus*

Biogeographic population: *L. a. argentatus*

Breeding range: Denmark and Fennoscandia to E Kola Peninsula

Wintering / core non-breeding range: N and W Europe

Population size: 1,700,000 – 3,600,000

1 % value: 26,500*

Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC[E] EU Threat Status: secure
Target species in SPAs:	-

Key food: omnivorous

Period of presence in Fehmarnbelt:	Wintering, migrations: mid-July – mid-May Breeding: mid-May – mid-July

* For populations over 2 million birds, Ramsar Convention criterion 5 (20,000 or more waterbirds) applies.

Origin of Herring Gull in the Fehmarnbelt

The ring recovery analysis showed that Fehmarnbelt is frequently used by Herring Gull originating from the Netherlands, Scandinavia, Finland and western Russia (Appendix IV). The wintering areas of local breeding Herring Gull or Herring Gull ringed in the Fehmarnbelt during the breeding season are found in the Netherlands, northern Germany and Poland, with the most southern recovery in Belgium.

Data sources on Herring Gull in the Fehmarnbelt

Numbers and distribution of Herring Gull are well reflected in the FEBI aerial and ship-based survey data, but aerial surveys were chosen as the primary data source for representing the species due to broader spatial coverage of the study region (Table 4.90). Other datasets were used as supporting data sources to characterise Herring Gull densities, distribution and habitat use (Table 4.90).

Table 4.90 List of datasets and their use in baseline assessment of Herring Gull in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating species abundance and distribution
FEBI ship transect surveys	Supporting dataset for estimating species abundance and distribution
OAG land-based counts	Supporting dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis Supporting dataset representing species winter abundance and distribution along the Fehmarn coast
NOVANA aerial surveys	Supporting dataset for winter abundance and distribution of the species in the Danish part of the Fehmarnbelt
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Herring Gull in the Fehmarnbelt

Herring Gull abundance estimates based on Distance analysis

The abundance of Herring Gull in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Herring Gull during aerial surveys, calculated using the entire dataset, were 203 m for swimming birds and 230 m for flying birds. Estimated detection functions and ESWs fall within similar ranges as obtained for other gull species.

The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of Herring Gulls have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.91, Appendix V). Often partial coverage most likely resulted in minimum estimates for this species. Herring Gulls are present in the Fehmarnbelt study area all the year. Baseline aerial surveys revealed lowest numbers in late spring and early summer and highest numbers in winter and early spring. Abundance estimates add up to a maximum of 10,600 Herring Gulls in the study area in March 2010 (Table 4.91).

Table 4.91 Numbers of observed Herring Gulls during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	83	249	0.47	0.22	1.07	1,856
Dec-08	81.7	194	568	0.85	0.49	1.53	3,396
Jan-09	82.8	250	705	1.24	0.76	2.01	4,985
Feb-09	100	338	1,066	1.36	0.93	1.98	6,621
Mar-09	77.5	225	358	0.68	0.44	1.06	2,578

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Apr-09	86.8	118	330	0.49	0.23	1.04	2,061
May-09	77.3	78	130	0.26	0.13	0.54	997
Jun-09	80.9	91	139	0.25	0.14	0.44	973
Jul-09	86.6	84	165	0.29	0.18	0.45	1,204
Aug-09	92.3	68	264	0.42	0.19	0.95	1,872
Sep-09	79.1	43	75	0.15	0.07	0.34	582
Oct-09	79.9	99	197	0.33	0.18	0.65	1,304
Nov-09	82.4	166	860	1.49	0.79	2.80	5,970
Dec-09	24.7	86	311	2.02	0.66	6.37	2,437
Mar-10 A	64.1	205	377	0.76	0.49	1.18	2,367
Mar-10 B	75.6	245	1,705	2.88	1.61	5.14	10,596
Apr-10	100	181	495	0.65	0.37	1.17	3,176
May-10	92.1	132	294	0.38	0.21	0.70	1,726
Jun-10	70.8	84	140	0.30	0.16	0.60	1,044
Aug-10	75.6	65	162	0.28	0.12	0.63	1,016
Sep-10 A	44.9	27	89	0.32	0.11	1.00	705
Sep-10 B	48.9	80	620	1.29	0.47	3.53	3,065
Oct-10	80.0	166	661	1.06	0.60	1.89	4,131
Nov-10	70.1	141	358	0.63	0.32	1.26	2,169

The ESW for Herring Gull during ship-based surveys, estimated for the entire dataset, was 155 m, which surprisingly suggests low detectability of the species during ship-based surveys. Distance analysis (Thomas et al. 2010) applied on this dataset revealed similar densities between 0.4-3.1 birds/km² as obtained for aerial transect surveys (Table 4.92). Ship-based surveys indicate Herring Gull being more abundant in coastal areas than offshore (Table 4.92).

Table 4.92 Numbers of observed Herring Gulls during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km^2 covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	93	142	1.80	36	0.90	3.63	-	-	-	40	-	-
	offshore	6	7	-	830	-	-				16		
Dec-08	coastal	101	313	3.87	31	2.09	7.16	-	-	-	17	-	-
	offshore	8	12	-	***	-	-				16		
Jan-09	coastal	175	264	3.01	26	1.80	5.03	2.05	1.21	3.50	30	2.24	5,248
	offshore	6	6	0.15	56	0.05	0.44				15		

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Feb-09	coastal	137	229	2.51	23	1.61	3.93	1.83	1.12	3.09	22	2.04	4,762
	offshore	14	43	0.50	56	0.17	1.46				26		
Mar-09	coastal	51	73	0.90	23	0.57	1.41	-	-	-	53	-	-
	offshore	14	22	-	***	-	-				36		
Apr-09	coastal	32	56	0.44	28	0.25	0.75	0.34	0.18	0.64	15	0.49	1,139
	offshore	3	6	0.14	55	0.05	0.42				21		
May-09	coastal	9	15	-	***	-	-	-	-	-	23	-	-
	offshore	2	2	0.05	72	0.01	0.19				23		
Jul-09A	coastal	14	22	0.36	51	0.14	0.94	0.29	0.09	1.33	15	0.41	971
	offshore	3	5	0.17	76	0.01	2.06				13		
Jul-09B	coastal	2	2	0.03	69	0.01	0.11	-	-	-	12	-	-
	offshore	5	15	-	***	-	-				2		
Aug-09	coastal	17	33	-	***	-	-	-	-	-	6	-	-
	offshore	2	2	0.05	65	0.02	0.18				5		
Sep-09	coastal	12	23	-	***	-	-	-	-	-	6	-	-
	offshore	1	1	0.03	97	0.00	0.14				1		
Oct-09	coastal	84	361	3.84	51	1.48	9.94	2.94	1.13	7.64	23	3.06	7,167
	offshore	2	2	0.08	68	0.02	0.30				1		
Nov-09	coastal	67	163	2.56	38	1.22	5.35	1.78	0.83	3.85	37	1.99	4,656
	offshore	7	9	0.37	58	0.12	1.11				9		
Dec-09	coastal	40	64	0.79	30	0.44	1.42	0.55	0.29	1.08	28	0.72	1,693
	offshore	3	3	0.08	100	0.01	0.42				13		
Jan-10	coastal	107	243	2.18	26	1.30	3.66	2.04	1.13	3.72	17	2.19	5,120
	offshore	43	94	1.76	39	0.81	3.83				18		
Feb-10A	coastal	118	265	2.71	26	1.62	4.54	2.12	1.11	5.21	23	2.28	5,338
	offshore	23	42	1.01	113	0.16	6.50				13		
Feb-10B	coastal	111	289	3.04	31	1.65	5.59	2.30	1.21	4.42	24	2.50	5,851
	offshore	26	41	0.83	48	0.32	2.12				24		
Mar-10	coastal	111	150	1.86	26	1.10	3.14	1.54	0.87	2.73	36	1.74	4,081
	offshore	29	36	0.85	39	0.39	1.87				14		
Apr-10	coastal	12	18	-	***	-	-	-	-	-	12	-	-
	offshore	12	20	-	***	-	-				8		
May-10	coastal	10	28	1.20	109	0.20	7.26	0.79	0.13	4.78	17	0.88	2,059
	offshore			0.00	0	0.00	0.00				4		
Jun-10	coastal	25	72	-	754	-	-	-	-	-	18	-	-
	offshore	4	12	-	732	-	-				5		
Sep-10	coastal	5	11	-	230	-	-	-	-	-	14	-	-
	offshore	3	3	0.08	52	0.03	0.21				3		
Oct-10	coastal	41	46	0.61	34	0.32	1.18	-	-	-	21	-	-
	offshore	6	11	-	***	-	-				6		
Nov-10	coastal	35	52	0.61	33	0.32	1.16	0.43	0.22	0.87	23	0.55	1,295
	offshore	3	4	0.07	69	0.02	0.26				6		

Month-to-month variation in Herring Gull occurrence in the Fehmarnbelt was assessed by comparing mean densities of swimming birds recorded during ship-based surveys (and corrected for distance detection bias). The species was present in the area all year and occurred in highest densities in the winter period between October and March (Table 4.92, Figure 4.167).

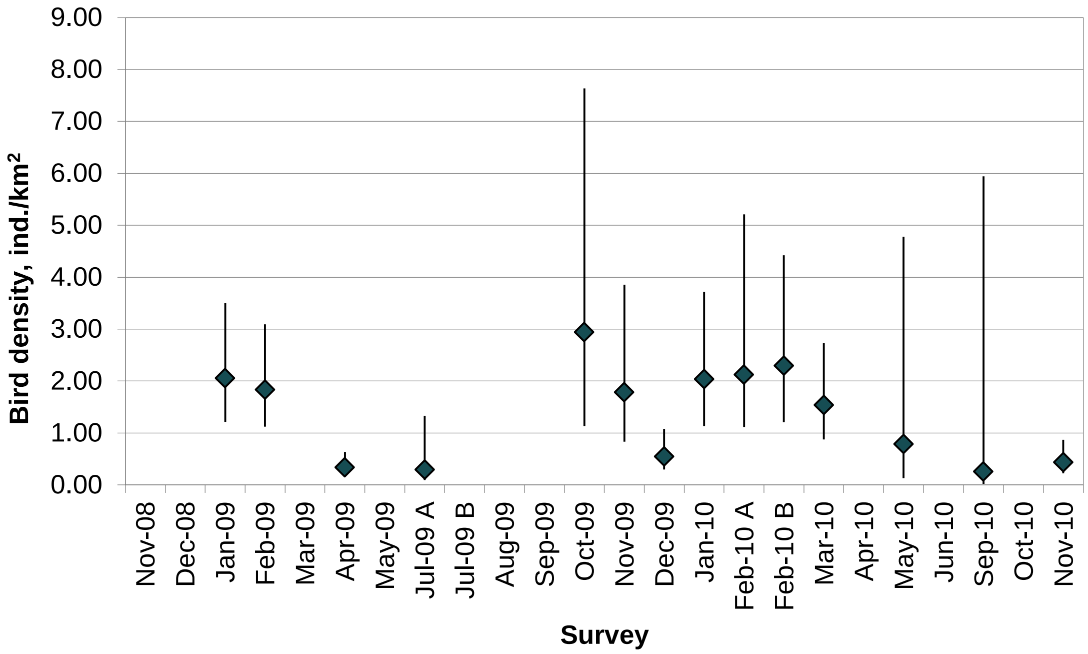


Figure 4.167 Mean density estimates and 95 % confidence intervals of swimming Herring Gulls estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150 % were not included into the chart (see Table 4.92 for specific values).

Herring Gull abundance estimates according to supplementary datasets

The coastal counts in selected (consistently covered) survey sections along the German mainland coast (September–April 2008/2009 and 2009/2010) support the findings of the FEBI surveys with highest numbers of Herring Gull observed in winter months (Figure 4.168, OAG 2010). Especially high numbers of Herring Gull were recorded in January 2010 when almost 9,000 birds were counted along the German mainland and Fehmarn coast (AKVSW 2010, OAG 2010). Data of mid-winter survey in January 2009 resulted in 4,652 Herring Gulls for the same area (AKVSW 2010, OAG 2010).

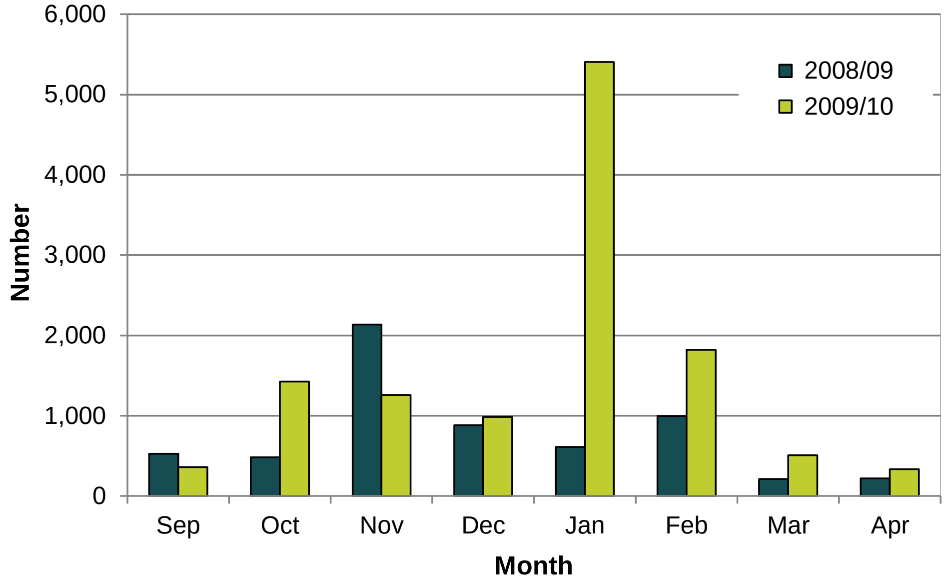


Figure 4.168 Number of Herring Gulls recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

Comparably low numbers of Herring Gulls were reported for the Danish mid-winter survey of 2008 with only 359 birds in the entire Fehmarnbelt study area (Petersen et al. 2010).

According to the DOF database Herring Gulls are regularly reported along the Danish coast. However their numbers are generally lower than those observed on the German side of the Fehmarnbelt. Maximum numbers of more than 1,000 individuals were reported in Rødsand Lagoon (March 2010) and Gedser Odde (September 2010, DOF 2010). Up to 1,170 birds were observed in the alignment area at Rødbyhavn (DOF 2011).

Distribution and habitat use of Herring Gull in the Fehmarnbelt
Herring Gulls are the most commonly birds observed following fishing vessels in the Baltic Sea (Garthe and Scherp 2003), and the distribution of Herring Gulls is largely determined by fishing activities (Durinck et al. 1994).

Herring Gull distribution according to FEBI data
During the FEBI aerial and ship-based surveys Herring Gulls were observed throughout the Fehmarnbelt, but larger numbers were typically seen in the shallower areas, and especially around Fehmarn (Figure 4.169, Figure 4.170; Appendix II).

FEBI aerial records of this species aggregated into seasonal composite maps show variable distribution patterns in different seasons (Figure 4.171–Figure 4.173).

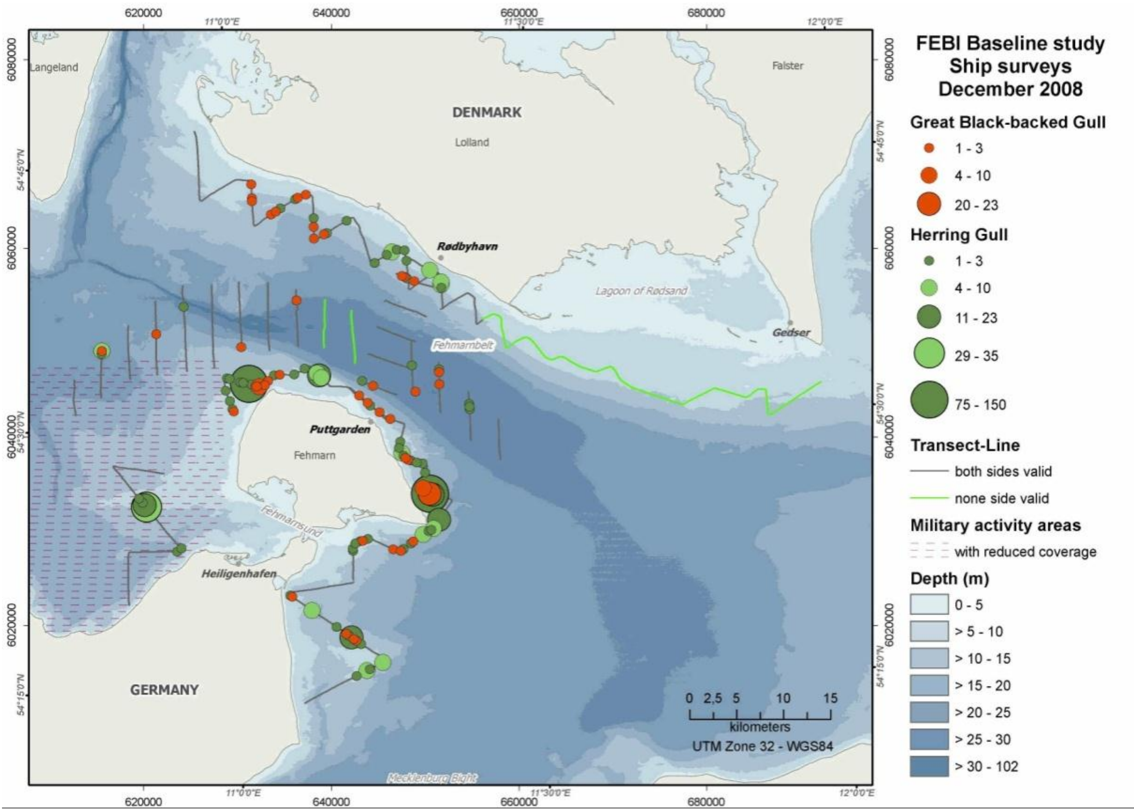


Figure 4.169 Example of observed Herring Gull (and Great Black-backed Gull) distribution in the study area during ship-based surveys (December 2008).

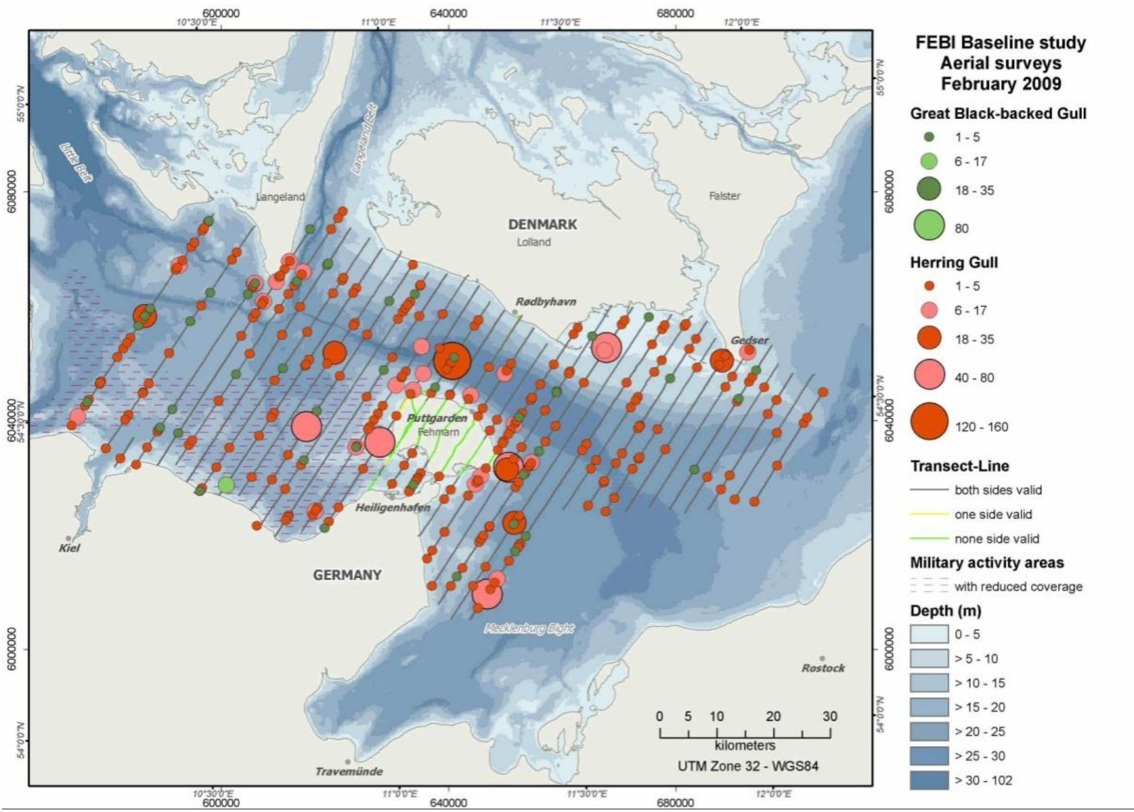
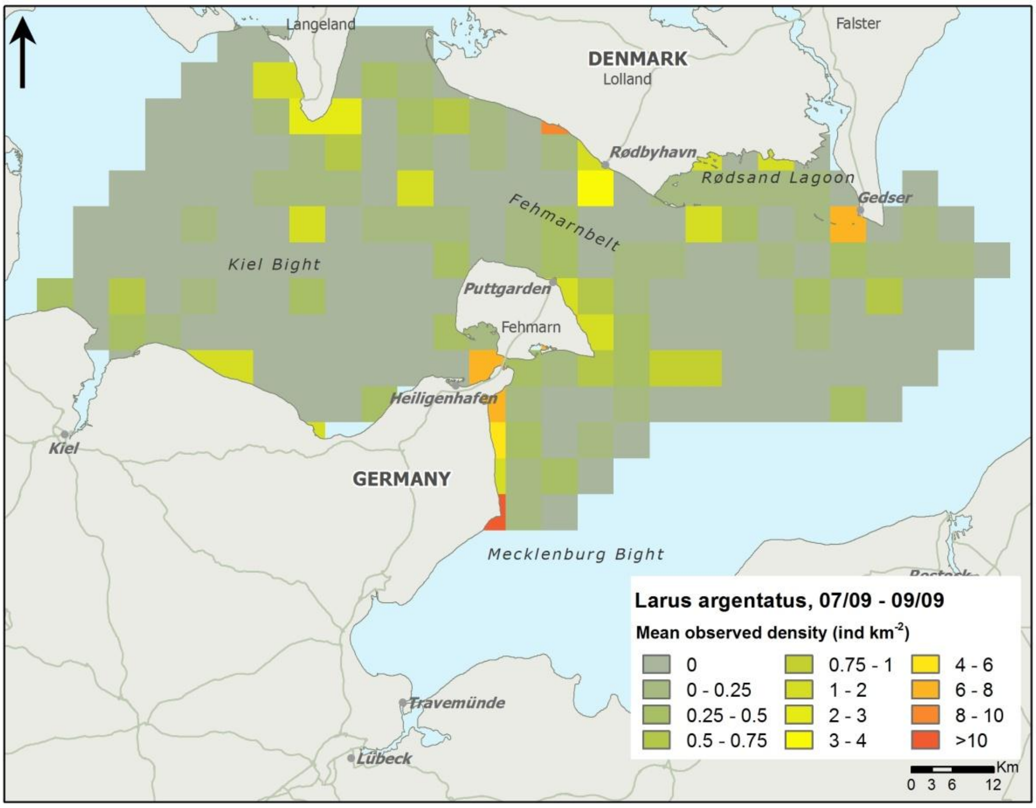


Figure 4.170 Example of observed Herring Gull (and Great Black-backed Gull) distribution in the study area during aerial surveys (February 2009).



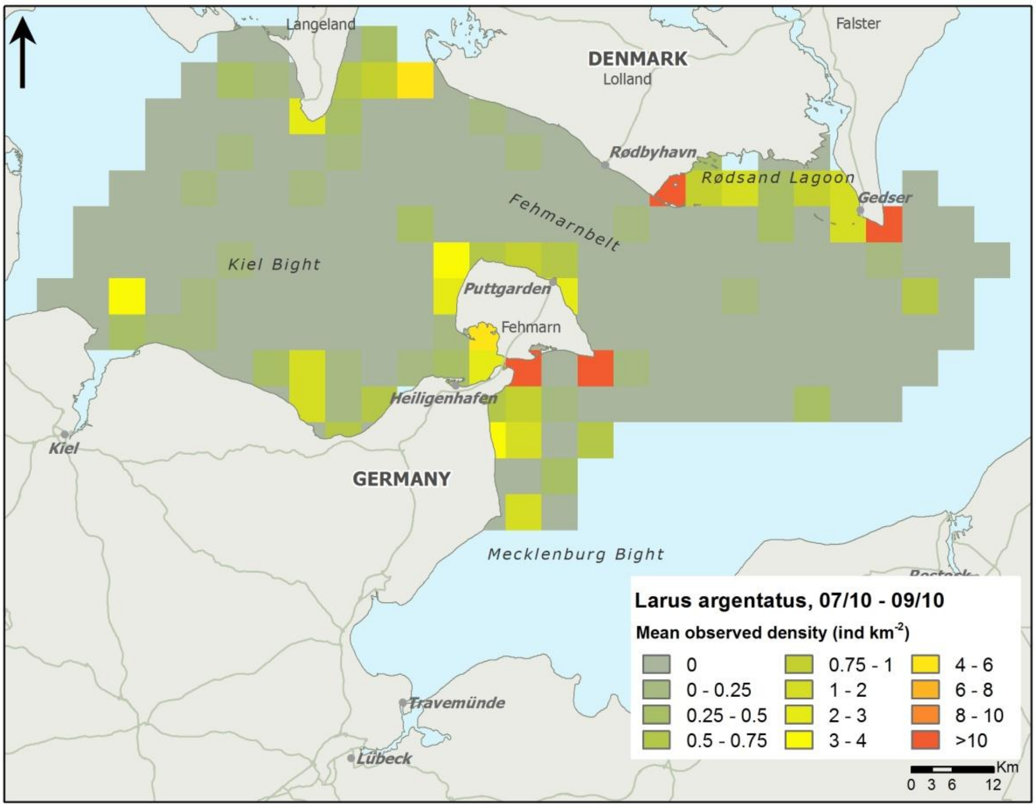
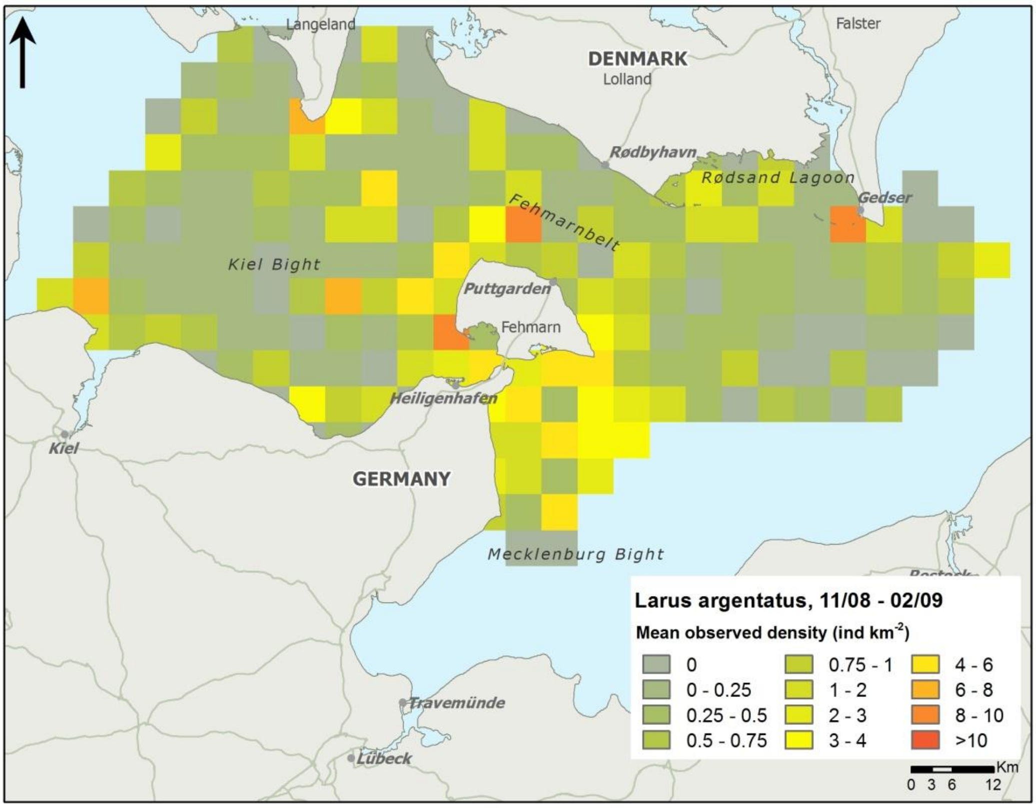


Figure 4.171 Mean densities of Herring Gull Larus argentatus *sampled during July-September by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.*



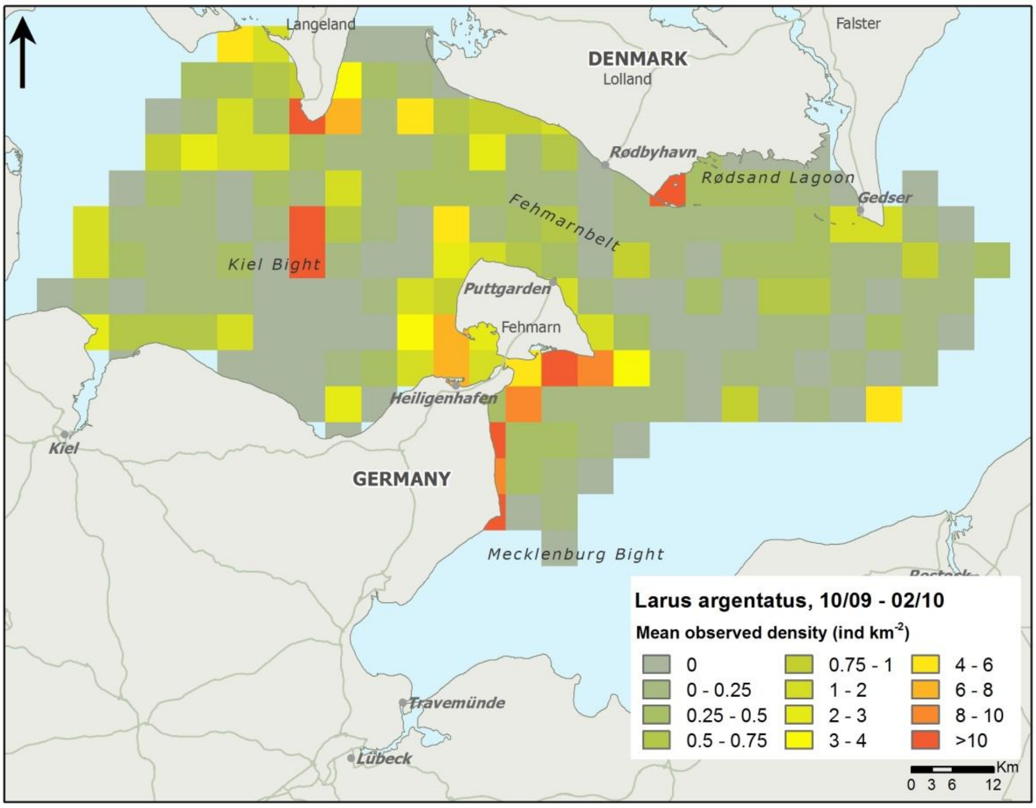
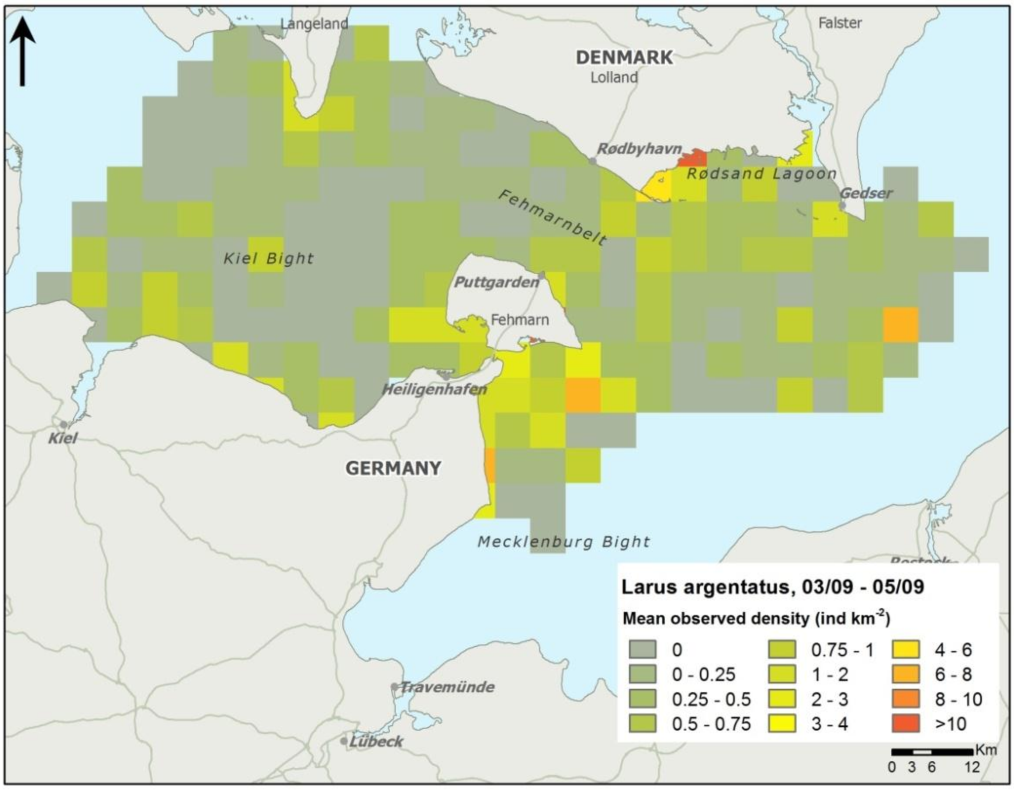


Figure 4.172 Mean densities of Herring Gull Larus argentatus *sampled during October-February by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.*



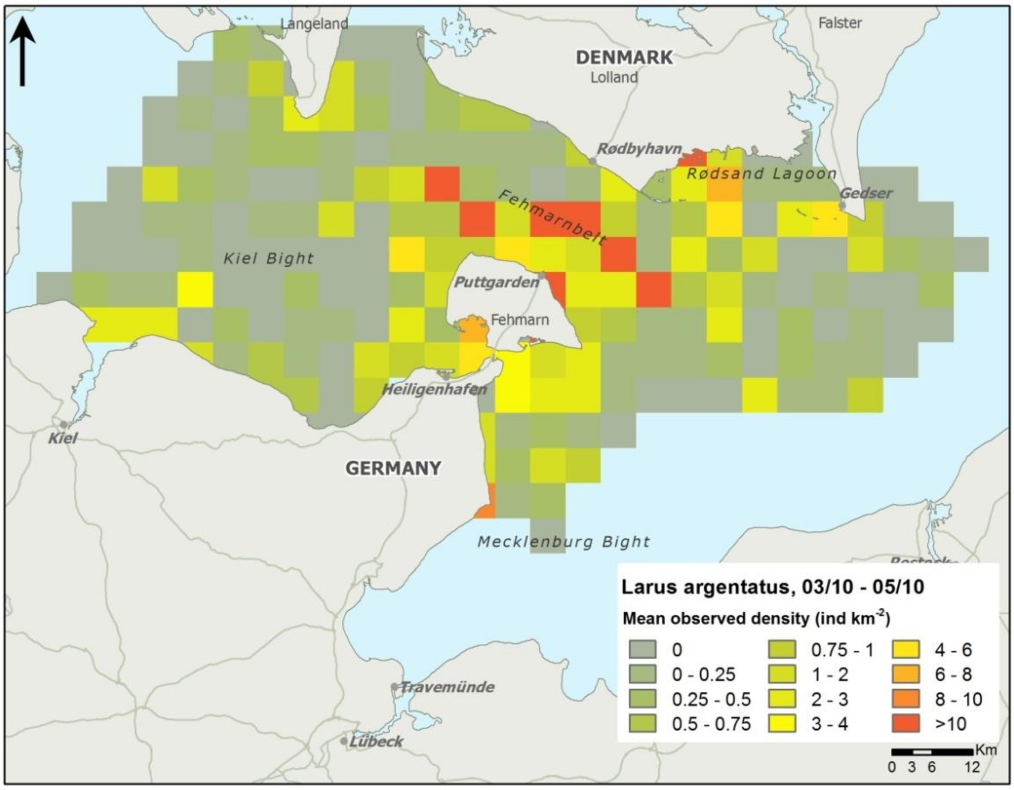


Figure 4.173 Mean densities of Herring Gull Larus argentatus *sampled during March-May by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.*

Herring Gull distribution according to supplementary datasets
During the land-based mid-winter counts by OAG Schleswig-Holstein and AKVSW Hamburg, Herring Gulls were quite evenly distributed along the observed coastline, yet with a tendency to aggregate on the southeast and south coasts of Fehmarn and along the shores of Hohwacht Bay (Figure 4.174; AKVSW 2010, OAG 2010). On the Danish side Herring Gulls were recorded in lower numbers and occurred in both inshore and offshore waters (Petersen et al. 2010).

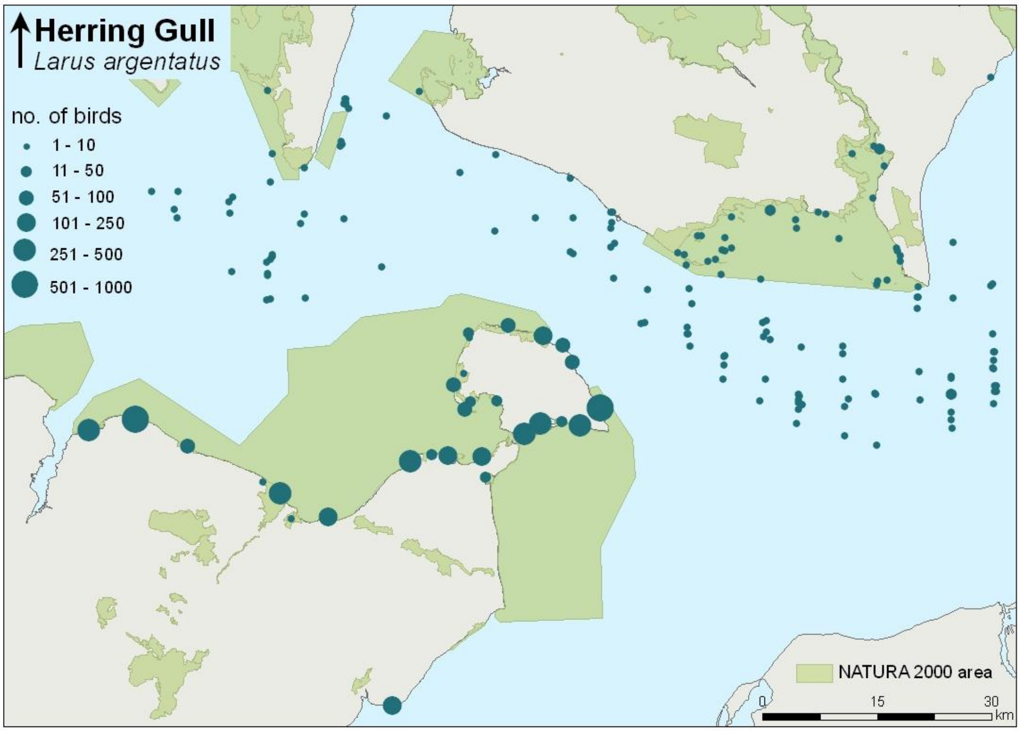


Figure 4.174 Distribution of Herring Gull during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Herring Gull abundance estimates for SPAs

As no distribution models could be developed for Herring Gulls, abundance estimates for particular SPAs are not available. The German land-based mid-winter survey of 2010 indicates more than 7,400 Herring Gulls (0.37 % of the biogeographic population) wintering in the coastal areas of the SPA Eastern Kiel Bight (AKVSW 2010, OAG 2010). About 1,500 Herring Gulls were counted in only partly covered coastal areas of the SPA Baltic Sea east of Wagrien during the same survey (AKVSW 2010, OAG 2010).

The DOF database indicates no internationally important numbers of Herring Gull in the coastal areas of the SPA Hyllekrog-Rødsand: the highest reported number of 1,100 birds represents less than 0.1 % of the biogeographic population (DOF 2010).

Herring Gull trends

The European population increased between 1970 and 1990 (BirdLife International 2004). This trend is also reported for the subsequent decade between 1990 and 2000. Thus, the European population is currently evaluated as Secure (BirdLife International 2004). Although some European countries report declining Herring

Gull numbers (e.g. the Netherlands), the Baltic populations show positive trends (BirdLife International 2004).

The increasing trend of the European population is not reflected in local numbers of wintering Herring Gull on Fehmarn Island. The species declined significantly (p=0.021) in the Fehmarn area between 1991 and 2010 (Figure 4.175, AKVSW 2010).

Figure 4.175 Number of Herring Gulls recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg; p = 0.021.

Importance of the Fehmarnbelt to the Herring Gull

The Herring Gull is an abundant and common species, and is present in the Fehmarnbelt area all the year. Highest numbers occur in winter time, when FEBI baseline investigations and supplementary datasets indicate about 10,600 birds using the area. The species is widely distributed in the Fehmarnbelt area and distribution patterns vary among surveys. The baseline results indicate that 0.4 % of the biogeographic population uses the Fehmarnbelt area in the course of the year.

Herring Gull – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	10,600
Max. abundance estimate in the alignment area:	1,170 + 354
Period of max. abundance in Fehmarnbelt:	October – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.172, Figure 4.173
Explanations:	Maximum estimate represents Distance analysis result for the aerial survey of late March 2010. Maximum abundance in the alignment was obtained from supplementary data on the Danish part (1,170 birds) and 354 birds reported for the German part of this area during the land-based mid-winter survey of 2009. Distribution pattern obtained from FEBI aerial surveys.

4.1.37 Great Black-backed Gull – *Larus marinus*

Great Black-backed Gull – *Larus marinus*

Biogeographic population: NE Atlantic

Breeding range: coasts of NW France, Ireland, Britain, Iceland eastwards to Scandinavia and White Sea

Wintering / core non-breeding range: E Atlantic coast southwards to Iberia

Population size: 330,000 – 540,000

1 % value: 4,400

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: non-SPEC^{E}
EU Threat Status: secure

Target species in SPAs: -

Key food: omnivorous

Period of presence in Fehmarnbelt: Wintering, migrations: August – April
Breeding: May – July

Origin of Great Black-backed Gull in the Fehmarnbelt

The FEBI ring recovery analysis (n=100) showed that the Great Black-backed Gull is a mostly resident species within the Fehmarnbelt (Appendix IV). Fehmarnbelt is visited by breeding birds from Scandinavia, Finland and even western Russia during the non-breeding season. There is no indication that local breeders would move further south (Appendix IV). However, Bønløkke et al. (2006) show evidence of some movements mainly towards the English Channel.

Data sources on Great Black-backed Gull in the Fehmarnbelt

Numbers and distribution of the Great Black-backed Gull are well reflected in the FEBI aerial and ship-based survey data, but aerial surveys were chosen as the primary data source for representing the species due to broader spatial coverage of the study region (Table 4.93). Other datasets were used as supporting data sources to characterise Great Black-backed Gull densities, distribution and habitat use (Table 4.93).

Table 4.93 List of datasets and their use in baseline assessment of Great Black-backed Gull in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Primary dataset for estimating species abundance and distribution
FEBI ship transect surveys	Supporting dataset for estimating species abundance and distribution
OAG land-based counts	Supporting dataset representing species winter abundance and distribution along the German mainland coast
AKVSW land-based counts	Primary dataset in trend analysis
NOVANA aerial surveys	Supporting dataset for species winter abundance and distribution in the Danish part of the Fehmarnbelt
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Great Black-backed Gull in the Fehmarnbelt

Great Black-backed Gull abundance estimates based on Distance analysis

The abundance of Great Black-backed Gull in the Fehmarnbelt was estimated by applying Distance analysis (Thomas et al. 2010) on monthly aerial and ship-based survey data.

The effective strip widths (ESWs) for Great Black-backed Gull during aerial surveys, calculated using the entire dataset, were 201 m for swimming birds and 217 m for flying birds. Estimated detection functions and ESWs fall within similar ranges as obtained for other gull species.

The limited access to military areas prevented a full coverage of the entire study area during several aerial surveys. As numbers of Great Black-backed Gulls have only been estimated for the area actually surveyed, different coverage of separate surveys contributed to a substantial variation in estimated bird numbers (Table 4.94, Appendix V). Often partial coverage most likely resulted in minimum estimates for this species. Great Black-backed Gulls are present in the Fehmarnbelt study area all the year. Baseline aerial surveys revealed lowest numbers during summer period and highest in autumn and early spring. The highest abundance of 1,200 Great Black-backed Gulls was estimated in March 2010 (Table 4.94). However, the confidence intervals of the highest estimated densities are rather broad and calculated total numbers have to be interpreted with caution.

Table 4.94 *Numbers of observed Great Black-backed Gulls during monthly aerial surveys and results of Distance analysis. N-obs represents actual number of observations (bird flocks), N-birds – actual number of birds counted within transects. D represents density, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area surveyed during a particular survey. Note: total numbers in shaded cells represent estimates where coefficients of variation were greater than 50 % and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation exceeding 150 % no estimates are displayed. See Appendix V for details.*

Survey	Effort, %	N-obs	N-birds	D	LCI	UCI	Total number
Nov-08	80.9	10	10	0.02	0.01	0.05	75
Dec-08	81.7	40	46	0.09	0.06	0.14	357
Jan-09	82.8	28	37	0.08	0.03	0.19	312
Feb-09	100	46	60	0.10	0.06	0.16	487
Mar-09	77.5	32	36	0.07	0.05	0.12	282
Apr-09	86.8	0	0	0	0	0	0
May-09	77.3	6	6	0.01	0.00	0.04	48
Jun-09	80.9	6	6	0.01	0.00	0.04	45
Jul-09	86.6	1	1	0.00	0.00	0.01	6
Aug-09	92.3	2	2	0.00	0.00	0.02	16
Sep-09	79.1	5	5	0.01	0.00	0.03	38
Oct-09	79.9	27	43	0.09	0.04	0.24	359
Nov-09	82.4	51	98	0.20	0.11	0.35	802
Dec-09	24.7	16	25	0.16	0.06	0.46	193
Mar-10 A	64.1	43	144	0.28	0.09	0.90	878
Mar-10 B	75.6	38	190	0.33	0.13	0.87	1,204
Apr-10	100	17	21	0.03	0.01	0.08	158
May-10	92.1	2	4	0.01	0.00	0.03	30
Jun-10	70.8	3	3	0.01	0.00	0.03	24
Aug-10	75.6	11	12	0.02	0.01	0.06	86
Sep-10 A	44.9	3	4	0.01	0.01	0.04	33
Sep-10 B	48.9	36	92	0.29	0.15	0.55	687
Oct-10	80.0	54	82	0.15	0.07	0.30	579
Nov-10	70.1	18	19	0.04	0.02	0.08	141

The ESW for Great Black-backed Gull during ship-based surveys, estimated for the entire dataset, was 265 m, which indicates good detectability of the species. Distance analysis (Thomas et al. 2010) applied on this dataset revealed similar densities as obtained for aerial transect surveys (Table 4.94, Table 4.95). Ship-based surveys indicate Black-backed Gull being similarly abundant in coastal and offshore areas (Table 4.95). Due to a relatively low sighting rate of the species results of Distance analysis (Thomas et al. 2010) should be interpreted with caution as confidence intervals of many estimates are broad.

Table 4.95 Numbers of observed Great Black-backed Gulls during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km^2 covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	**Stratum**	**N obs**	**N birds**	**D**	**%CV**	**LCI**	**UCI**	**D**	**LCI**	**UCI**	**N flying**	**D**	**Total number**
Nov-08	coastal	21	21	0.19	49	0.08	0.48	-	-	-	7	-	-
	offshore	8	17	-	471	-	-				11		
Dec-08	coastal	26	57	0.51	90	0.11	2.35	0.36	0.08	1.56	7	0.44	1,023
	offshore	7	7	0.12	53	0.04	0.34				7		
Jan-09	coastal	16	16	0.12	32	0.06	0.22	-	-	-	5	-	-
	offshore	3	4	-	***	-	-				8		
Feb-09	coastal	21	26	0.18	30	0.10	0.33	0.28	0.10	0.94	6	0.33	765
	offshore	15	28	0.49	83	0.11	2.13				4		
Mar-09	coastal	3	3	0.02	56	0.01	0.07	0.02	0.01	0.08	3	0.04	98
	offshore	2	2	0.03	71	0.01	0.11				1		
Apr-09	coastal	1	2	0.01	103	0.00	0.08	0.01	0.00	0.05	3	0.02	53
	offshore	0	0	0	0	0	0				0		
May-09	coastal	0	0	0	0	0	0	0	0	0	0	0.00	10
	offshore	0	0	0	0	0	0				1		
Jul-09A	coastal	5	5	0.04	54	0.01	0.11	0.03	0.01	0.07	1	0.03	71
	offshore	0	0	0	0	0	0				0		
Jul-09B	coastal	1	1	0.01	100	0.00	0.05	0.01	0.00	0.03	4	0.03	70
	offshore	0	0	0	0	0	0				1		
Aug-09	coastal	20	29	0.20	47	0.08	0.48	0.15	0.06	0.38	4	0.18	412
	offshore	5	5	0.07	49	0.03	0.19				1		
Sep-09	coastal	3	3	0.02	63	0.01	0.07	0.04	0.01	0.11	7	0.09	215
	offshore	4	4	0.06	60	0.02	0.19				6		
Oct-09	coastal	16	19	0.13	32	0.07	0.25	0.12	0.06	0.24	4	0.14	329
	offshore	3	3	0.07	55	0.02	0.22				0		
Nov-09	coastal	20	23	0.18	36	0.09	0.35	0.19	0.09	0.40	5	0.26	599
	offshore	13	14	0.22	41	0.10	0.49				9		
Dec-09	coastal	17	17	0.13	30	0.07	0.23	0.10	0.05	0.21	7	0.18	417
	offshore	4	4	0.06	52	0.02	0.16				10		
Jan-10	coastal	15	19	-	572	-	-	-	-	-	2	-	-
	offshore	10	11	-	***	-	-				1		
Feb-10A	coastal	17	19	0.14	35	0.07	0.27	-	-	-	3	-	-
	offshore	10	13	-	***	-	-				1		
Feb-10B	coastal	22	32	0.25	43	0.11	0.56	0.25	0.12	0.53	4	0.28	657
	offshore	15	17	0.24	32	0.13	0.46				4		
Mar-10	coastal	6	8	-	***	-	-	-	-	-	1	-	-
	offshore	8	11	-	***	-	-				5		
Apr-10	coastal	4	5	-	806	-	-	-	-	-	0	-	-
	offshore	2	3	0.04	74	0.01	0.17				0		

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
May-10	coastal	3	3	0.02	57	0.01	0.07	0.02	0.01	0.05	1	0.02	57
	offshore	0	0	0	0	0	0				1		
Jun-10	coastal	3	4	-	***	-	-	-	-	-	0	-	-
	offshore	2	2	0.03	69	0.01	0.11				0		
Sep-10	coastal	12	13	-	175	-	-	-	-	-	0	-	-
	offshore	3	6	-	***	-	-				3		
Oct-10	coastal	22	23	0.18	39	0.09	0.38	0.13	0.06	0.28	5	0.15	347
	offshore	1	1	0.02	96	0.00	0.08				0		
Nov-10	coastal	8	8	0.06	37	0.03	0.12	0.06	0.03	0.13	2	0.07	155
	offshore	4	4	0.06	49	0.02	0.15				0		

Month-to-month variation in Great Black-backed Gull occurrence in the Fehmarnbelt was assessed by comparing mean densities of swimming birds recorded during ship-based surveys (and corrected for distance detection bias), as rather consistent spatial coverage has been achieved during these counts. The species was present in the area all year and occurred in highest densities in the winter period between October and March (Table 4.95, Figure 4.176).

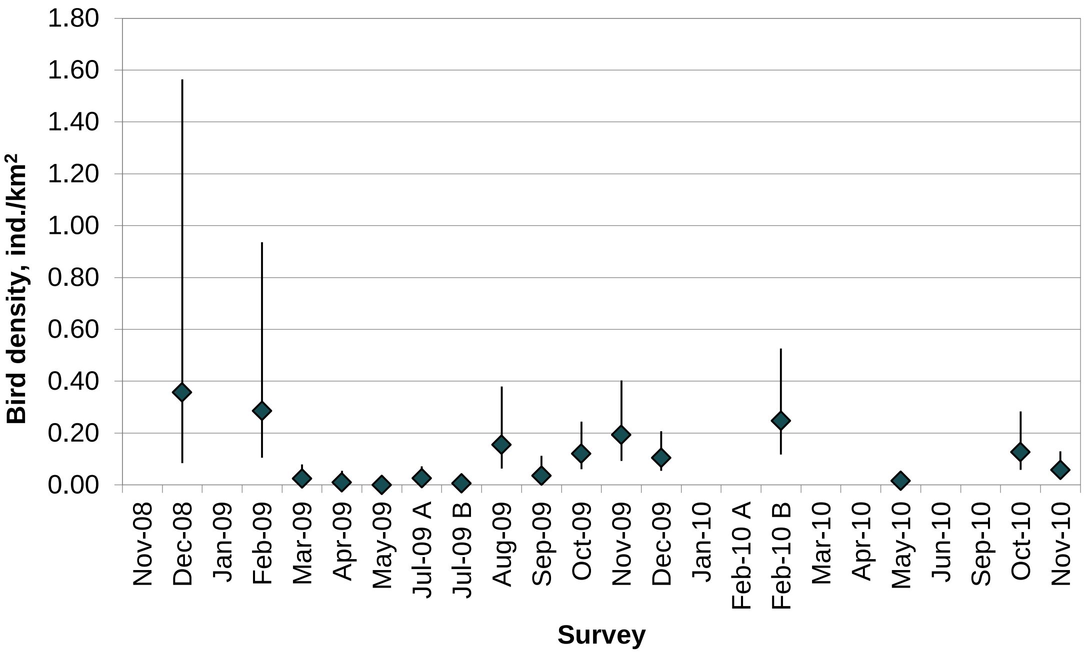


Figure 4.176 Mean density estimates and 95 % confidence intervals of swimming Great Black-backed Gulls estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150 % were not included into the chart (see Table 4.95 for specific values).

Great Black-backed Gull abundance estimates based on supplementary datasets

The coastal counts in selected (consistently covered) survey sections along the German mainland coast (survey conducted between September–April in 2008/2009 and 2009/2010) support the findings of the FEBI surveys that Great Black-backed

Gulls are more numerous in winter months (Figure 4.177; OAG 2010). The highest recorded number of this species along the German coast consists of 419 birds counted on mainland and Fehmarn in January 2010 (AKVSW 2010, OAG 2010).

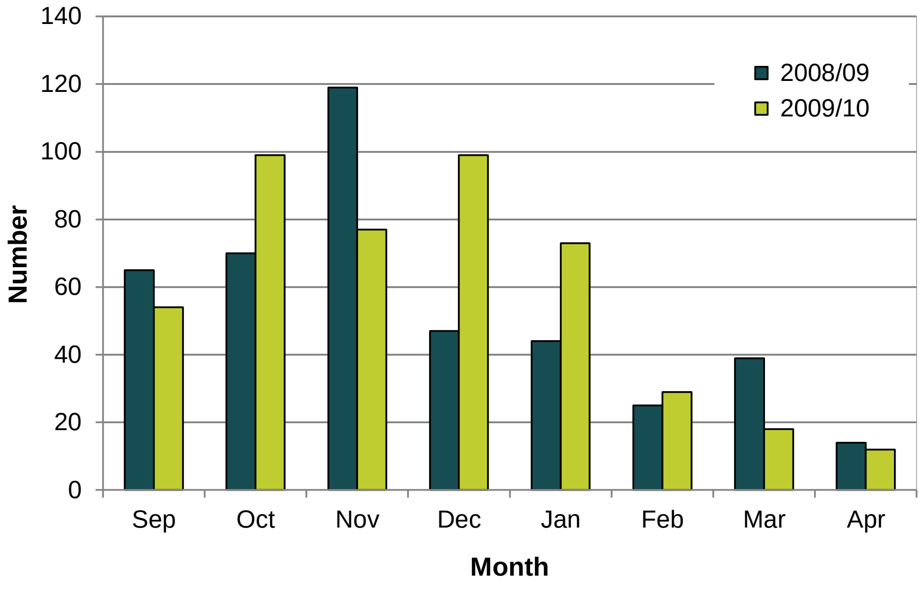


Figure 4.177 Number of Great Black-backed Gulls recorded during land-based surveys between September and April in 2008/2009 and 2009/2010; note: only survey sections 5-9 and 40-41 included (site IDs, for full site names see Table 2.5); data: OAG Schleswig-Holstein.

Reported numbers of Great Black-backed Gulls are generally lower for the Danish study area. For example, only 51 birds were observed in the Danish study area during the mid-winter survey in 2008 (Petersen et al. 2010).

The DOF database also reports mostly single individuals of the species observed along the Danish coast of the Fehmarnbelt with the highest record of 70 birds in Rødsand Lagoon (November 2007; DOF 2010).

Distribution and habitat use of Great Black-backed Gull in the Fehmarnbelt

Great Black-backed Gull distribution according to FEBI data

The FEBI aerial and ship-based surveys revealed the Great Black-backed Gull being widely distributed across the Fehmarnbelt (Figure 4.178, Figure 4.179; Appendix II). The lack of obvious habitat associations could be explained by a strong affinity to fishing activities, as it was observed during the FEBI surveys where 31 % of birds recorded during ship-based surveys were associated with vessels. In the Baltic Sea, the distribution of the species is largely determined by fishing activities (Durinck et al. 1994), and the species is the second most common scavenger at fishing vessels (Garthe and Scherp 2003).

The FEBI aerial observations of Great Black-backed Gulls aggregated into seasonal composite maps confirm a variable distribution and absence of detectable patterns (Figure 4.180 – Figure 4.182).

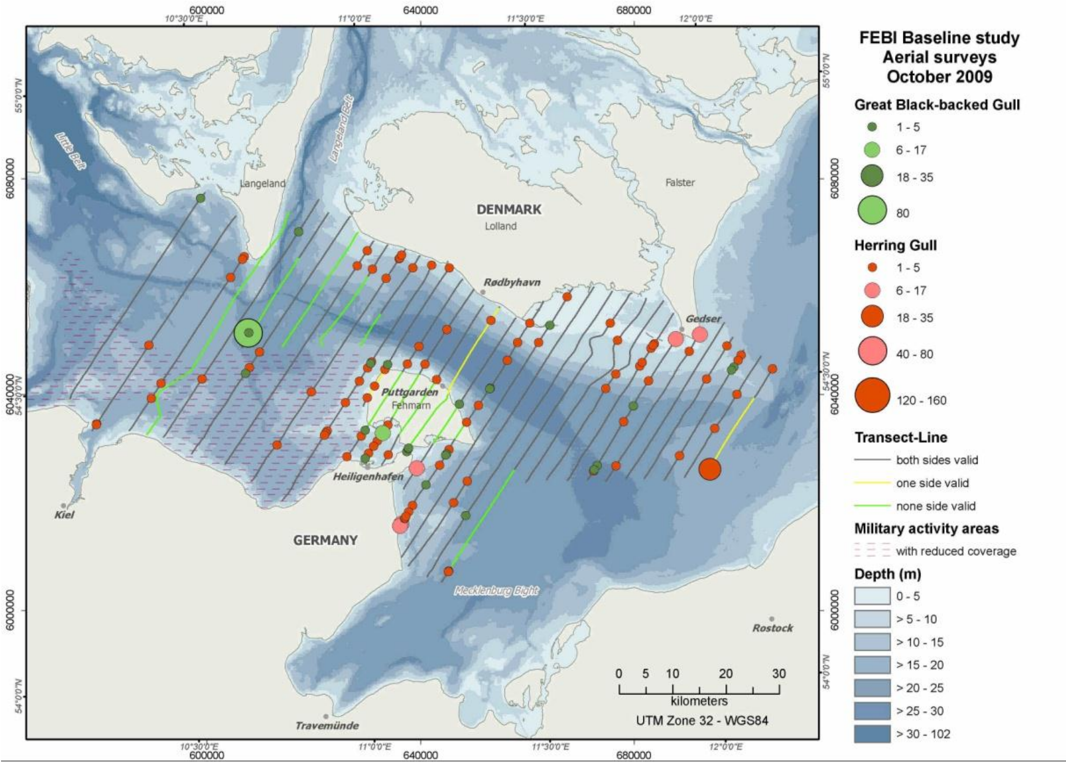


Figure 4.178 Example of observed Great Black-backed Gull (and Herring Gull) distribution in the study area during aerial surveys (October 2009).

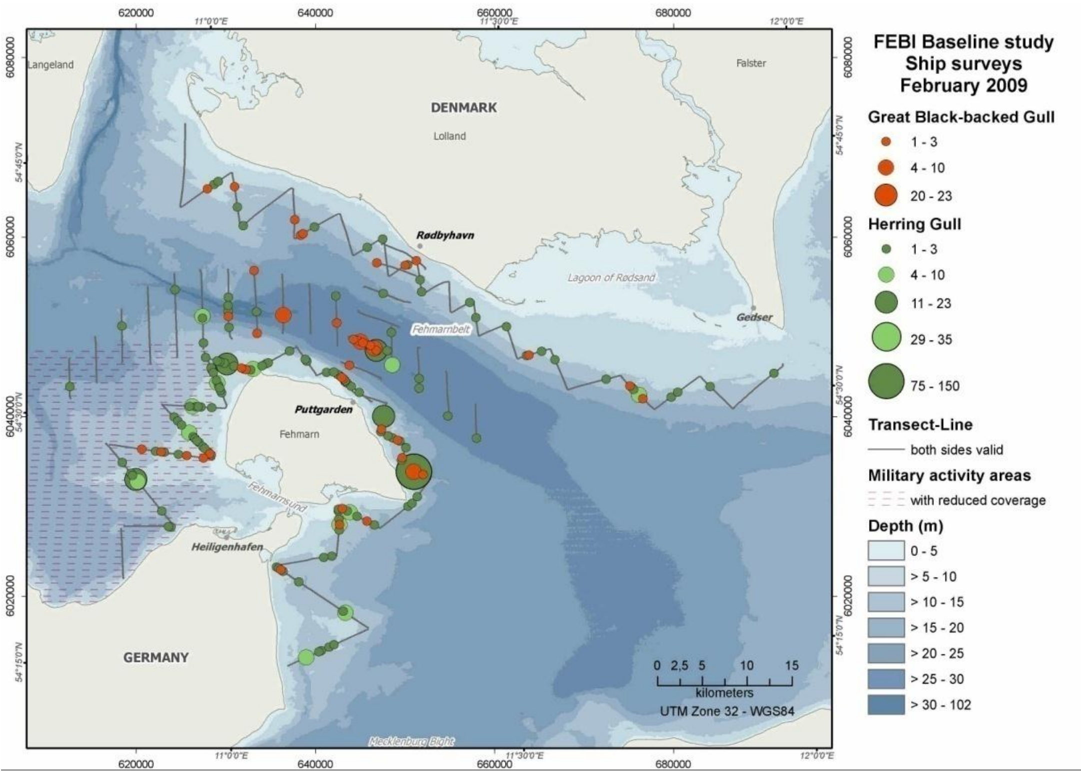
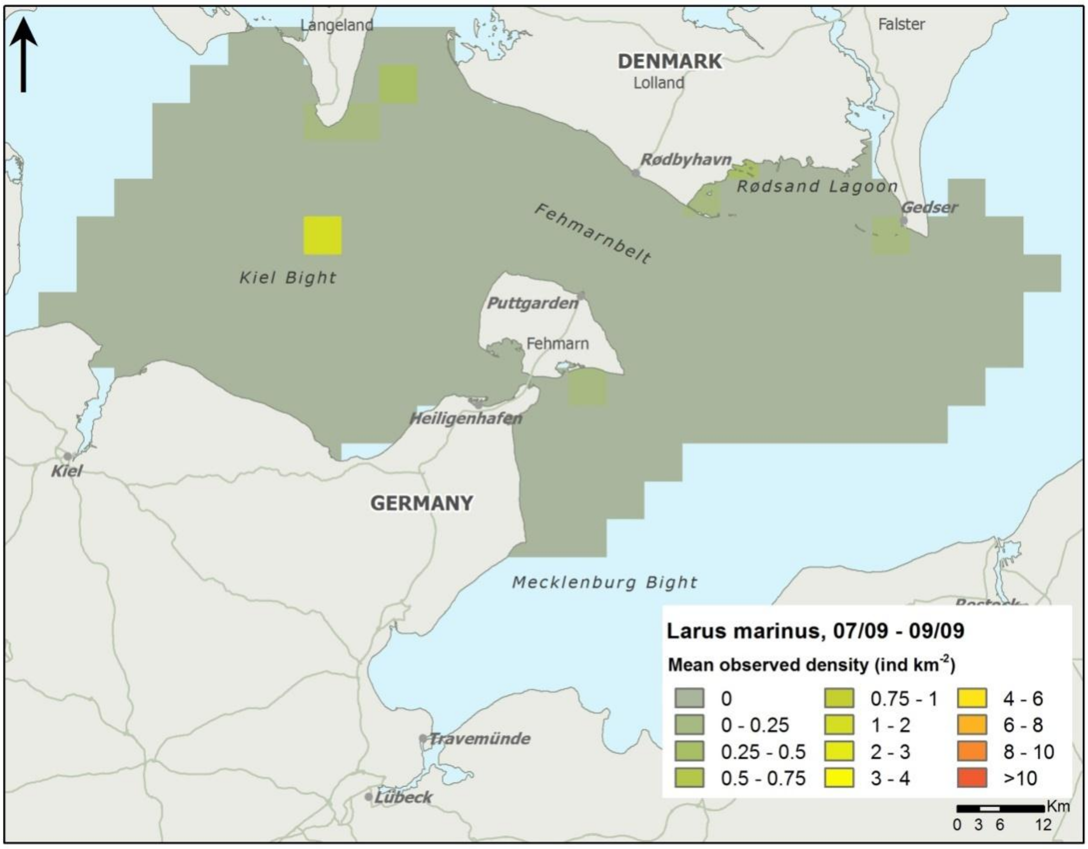


Figure 4.179 Example of observed Great Black-backed Gull (and Herring Gull) distribution in the study area during ship-based surveys (February 2009).



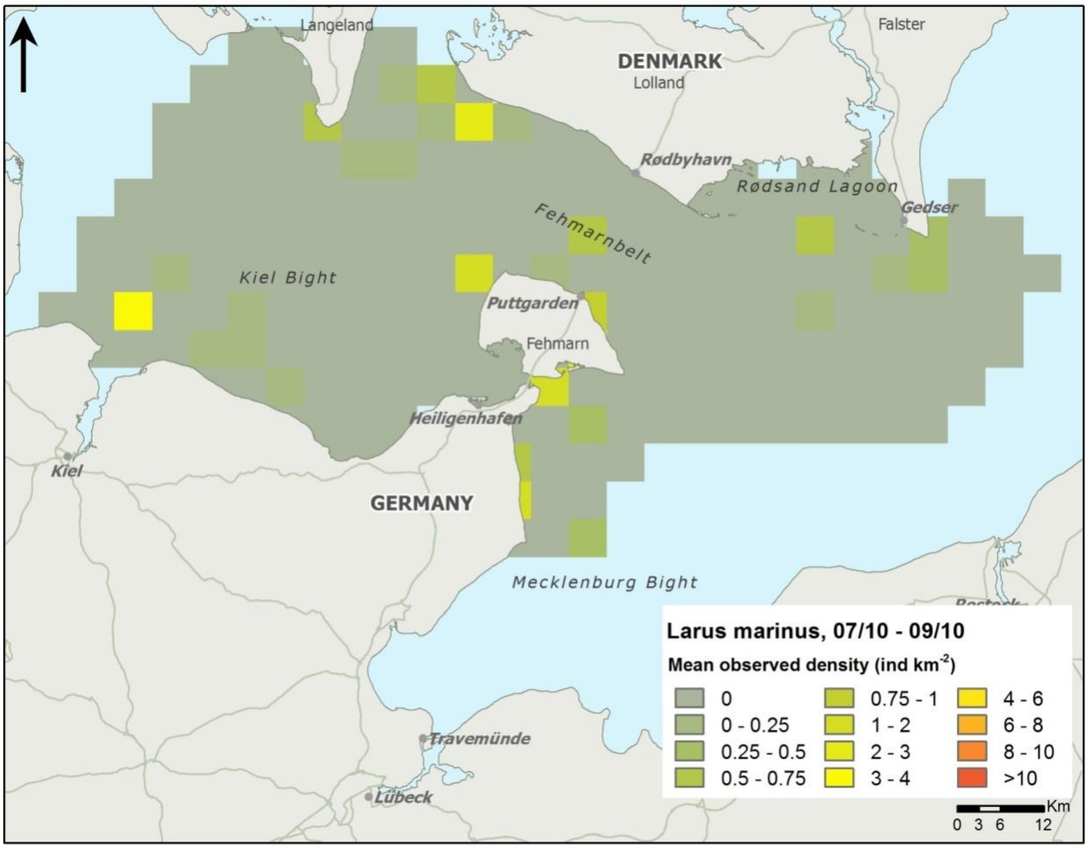
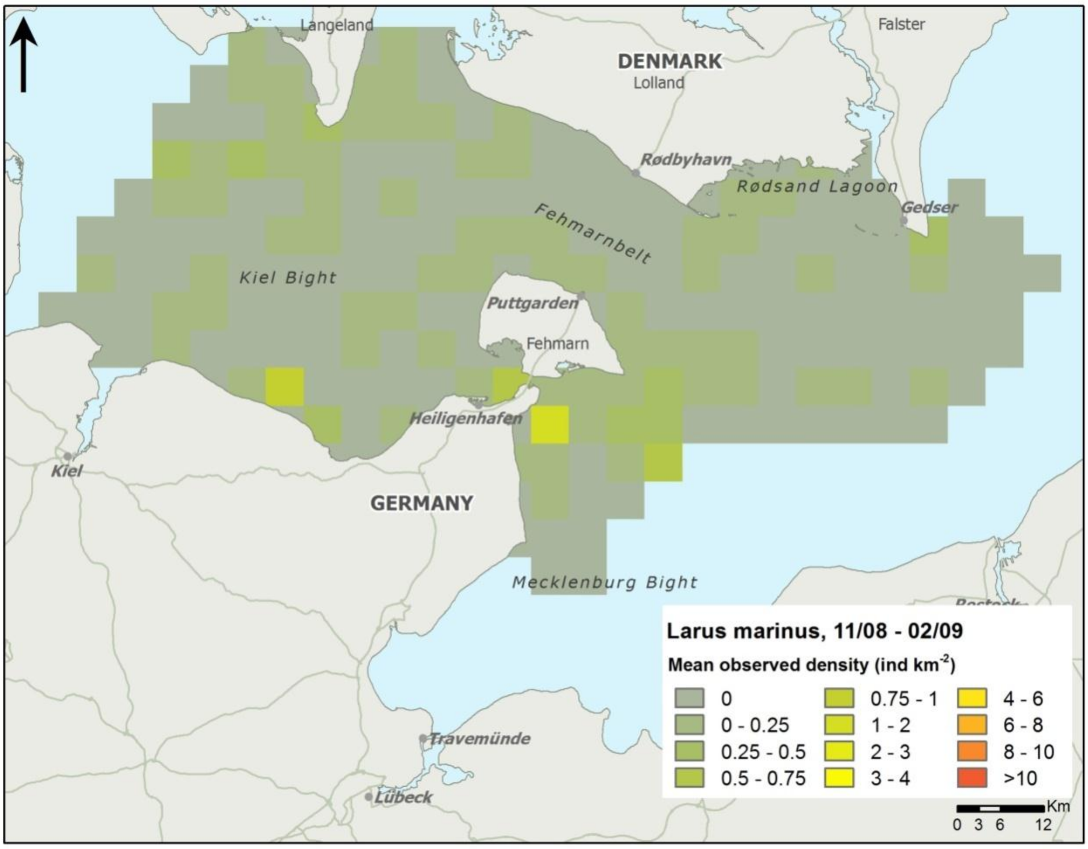


Figure 4.180 Mean densities of Great Black-backed Gull Larus marinus *sampled during July-September by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.*



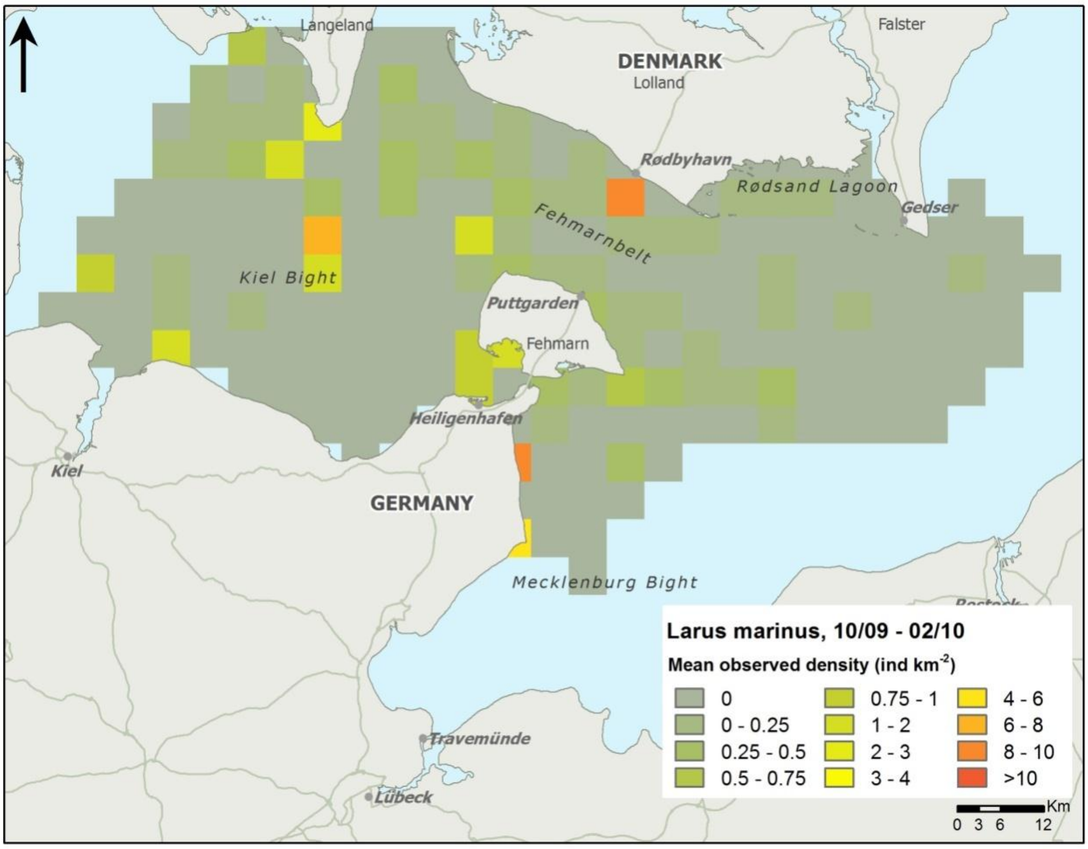
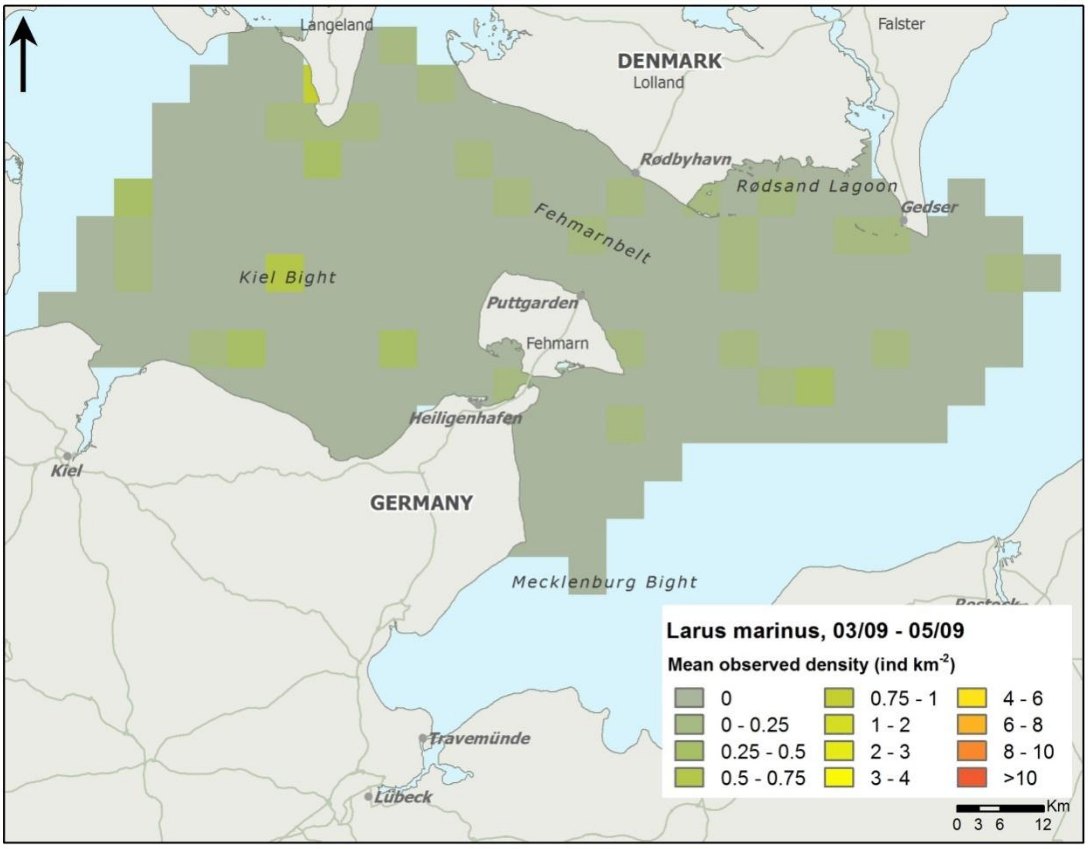


Figure 4.181 Mean densities of Great Black-backed Gull Larus marinus *sampled during November-February by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.*



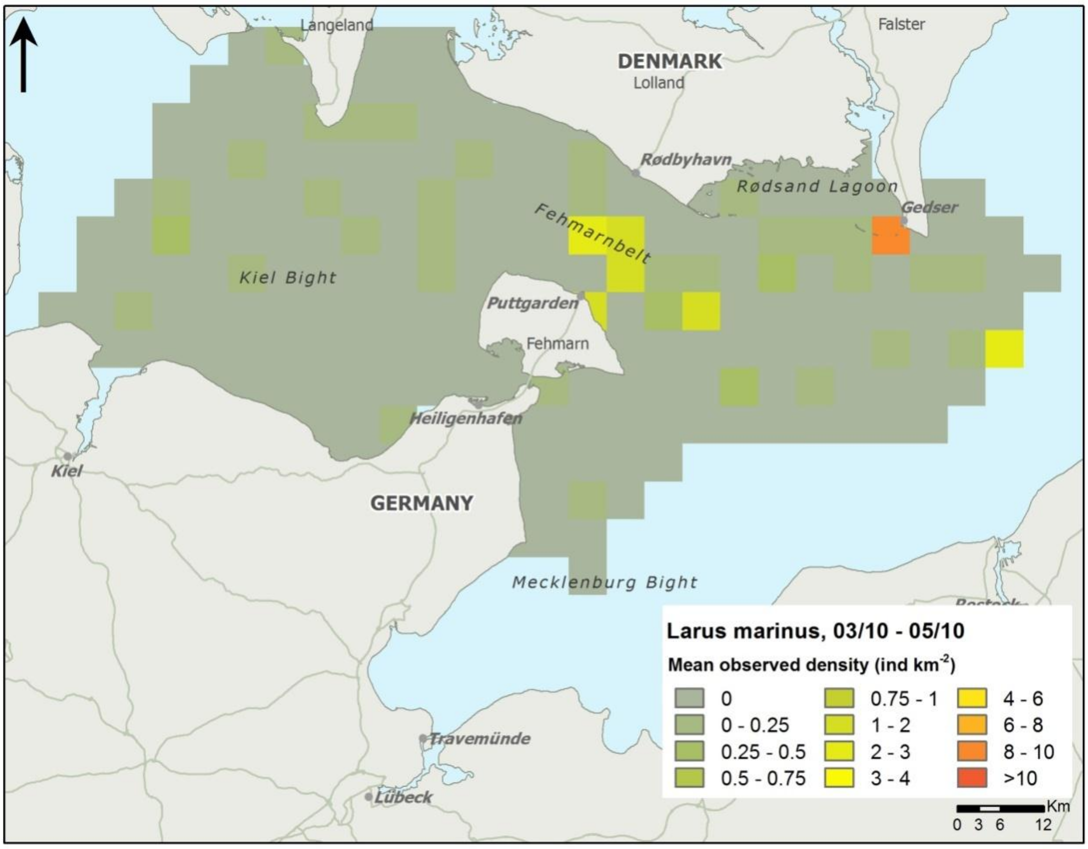


Figure 4.182 Mean densities of Great Black-backed Gull Larus marinus *sampled during March-May by aerial surveys undertaken in 2009 (upper map) and 2010 (lower map). The densities are shown for 5 km squares.*

Great Black-backed Gull distribution according to supplementary datasets

During the German land-based mid-winter survey of 2009 Great Black-backed Gulls were observed rather evenly distributed along the observed coastline (Figure 4.183; AKVSW 2010, OAG 2010). The Danish mid-winter survey of 2008 shows the species using both inshore and offshore waters, with slightly higher numbers observed in the offshore areas of the Fehmarnbelt (Petersen et al. 2010).

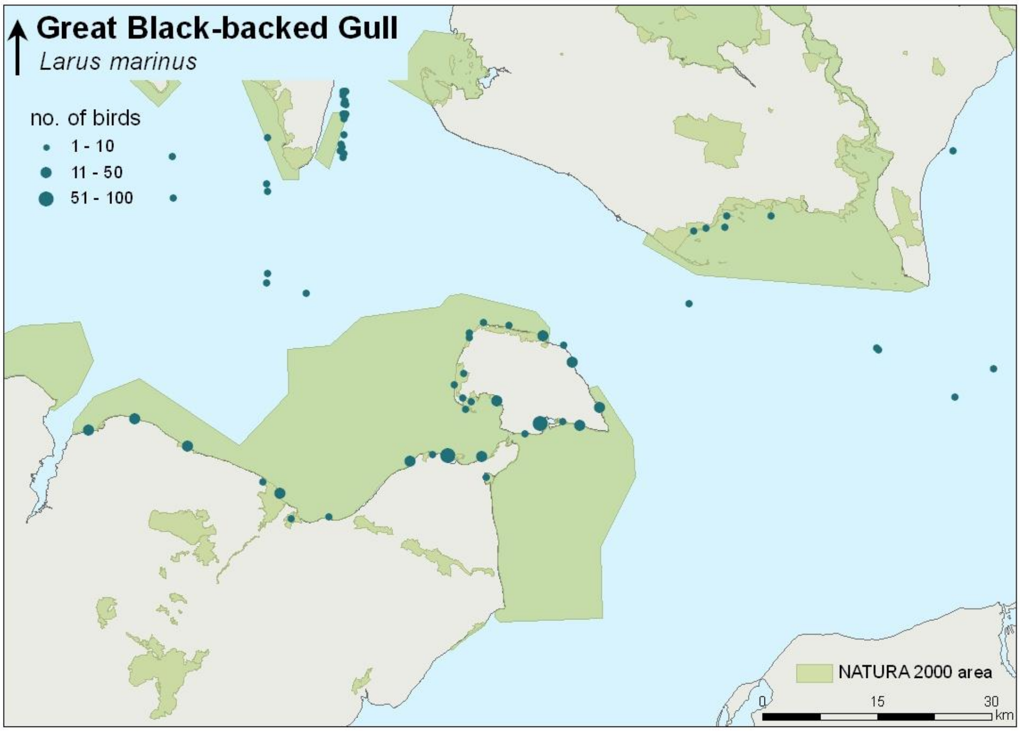


Figure 4.183 Distribution of Great Black-backed Gull during winter counts. German coast: land-based counts between Kiel Fjord and Großenbrode, and Pelzerhaken-Neustadt in January 2009; data: OAG Schleswig-Holstein and AKVSW Hamburg. Danish coast: counts of aerial transect survey, search flights and land-based counts in February 2008; NOVANA survey data provided by NERI.

Great Black-backed Gull abundance estimates for SPAs

As no distribution models were developed for Great Black-backed Gull, abundance estimates for particular SPAs are not available. Supplementary datasets of mainly land-based counts indicate rather low numbers occurring in coastal areas of Danish and German SPAs. The highest number reported for coastal areas of the SPA Eastern Kiel Bight was 289 birds in January 2010 (OAG 2010). The 111 Great Black-backed Gulls counted within coastal areas of SPA Baltic Sea east of Wagrien should be considered as minimum estimate due to incomplete coverage of the area.

The DOF database reports a maximum number of 70 Great Black-backed Gulls resting in the SPA Hyllekrog-Rødsand (DOF 2010).

Great Black-backed Gull trends

The European Great Black-backed Gull population was stable between 1970 and 1990 (BirdLife International 2004). In the following decade (1990–2000) the European breeding population was described as increasing. Thus, the European Great Black-backed Gull population was evaluated as Secure (BirdLife International 2004).

Long-term dataset of annual mid-winter land-based bird counts from Fehmarn show variable numbers of Great black-backed Gull wintering in the area, with no detectable trend between 1991–2010 (Figure 4.184; AKVSW 2010).

Figure 4.184 Number of Great Black-backed Gulls recorded during annual mid-winter coastal counts on Fehmarn from 1991-2010; data: AKVSW Hamburg.

Importance of the Fehmarnbelt to the Great Black-backed Gull

The European breeding population of Great Black-backed Gull comprises of 330,000 to 540,000 birds (Wetlands International 2006). As the 1 % value for this bio-geographic population is 4,400 individuals, the FEBI baseline investigations indicate up to 0.3 % of the biogeographic population (1,200 birds) using the Fehmarnbelt area in the course of the year. The species is widely distributed in coastal and offshore areas of the Fehmarnbelt, and distribution patterns varied among surveys.

Great Black-backed Gull – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	1,200
Max. abundance estimate in the alignment area:	70
Period of max. abundance in Fehmarnbelt:	October – March
Areas of max. abundance in Fehmarnbelt:	see Figure 4.181, Figure 4.182
Explanations:	Maximum abundance represents Distance analysis estimate for the aerial survey of late March 2010. Maximum abundance in the alignment area estimated by applying the mean density of the aerial survey of late March 2010 on the area of the alignment zone. Distribution pattern obtained from FEBI aerial surveys.

4.1.38 *Sandwich Tern – Sterna sandvicensis*

Sandwich Tern – *Sterna sandvicensis*

Biogeographic population: *S. s. sandvicensis*, W Europe (br)

Breeding range: coasts of W and N Europe

Wintering / core non-breeding range: mostly W and NW African coasts southwards to South Africa

Population size: 166,000 – 171,000

1 % value: 1,700

Conservation status: EU Birds Directive, Annex I: listed
EU SPEC Category: SPEC 2
EU Threat Status: depleted

Target species in SPAs: -

Key food: fish

Period of presence in Fehmarnbelt: Breeding, migrations: mid-March – mid-October

Origin of Sandwich Tern in the Fehmarnbelt

The Sandwich Tern is a long-distance migrant and winters along the coast of West Africa. According to Cramp (1985), all western European birds share similar wintering grounds, mainly on the west coast of Africa from Mauritania south to Cape of Good Hope. Birds ringed or recovered in the Fehmarnbelt area show spring, summer and autumn recoveries throughout the inner Danish and southern Baltic waters with few birds recovered further east and west (Appendix IV).

Data sources on Sandwich Tern in the Fehmarnbelt

From the airplane different tern species are difficult to identify to species level, thus the FEBI aerial surveys were not used for evaluation of Sandwich Tern abundance and distribution in the Fehmarnbelt area (Table 4.96). The FEBI ship-based surveys were chosen as the primary dataset for species description; land-based datasets of DOF and OAG (DOF 2010, OAG 2010) provided supporting information. The datasets of the Danish (NOVANA surveys; Petersen et al. 2006, 2010) and German (AKVSW 2010) mid-winter surveys do not provide any data on the Sandwich Tern as the species is not wintering in the study area (Table 4.96).

Table 4.96 List of datasets and their use in baseline assessment Sandwich Tern in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used due to uncertain species identification by this method
FEBI ship transect surveys	Primary dataset for estimating species abundance and distribution
OAG land-based counts	Supporting dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Dataset not used due to no sightings of the species
NOVANA aerial surveys	Dataset not used due to no sightings of the species
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Sandwich Tern in the Fehmarnbelt

The Sandwich Tern is a rare breeding bird in the study area (see Chapter 0), but is described as being regularly present in low numbers in the southern Baltic Sea during summer period (Mendel et al. 2008).

According to Pihl et al. (2006) Sandwich Tern arrives to Denmark in April, and almost all birds have left the area by the end of August. Berndt et al. (2005) describe a similar seasonal pattern of Sandwich Tern abundance for Fehmarn, but mention a later autumn migration period with higher numbers using the area as a stop-over site until late September.

Sandwich Tern abundance according to FEBI survey data

During the two years of monthly FEBI ship-based surveys Sandwich Tern was rarely observed (Table 4.97). A maximum number of 14 birds was observed during the ship-based survey in September 2009 (Table 4.97). Due to the low sighting rates of the species no Distance analysis was possible.

Table 4.97 Results of monthly ship-based surveys for Sandwich Tern between November 2008 and November 2010. Numbers of birds observed represent actual number of birds counted within transects.

Survey	Number of birds observed	Survey	Number of birds observed
Nov-08	0	Nov-09	0
Dec-08	0	Dec-09	0
Jan-09	0	Jan-10	0
Feb-09	0	Feb-10 A	0
Mar-09	0	Feb-10 B	0
Apr-09	1	Mar-10	0
Jun-09	0	Apr-10	0
Jul-09 A	4	May-10	2
Jul-09 B	5	Jun-10	0
Aug-09	8	Sep-10	4
Sep-09	14	Oct-10	1
Oct-09	1	Nov-10	0

Sandwich Tern abundance according to supplementary datasets

The OAG monthly surveys along the German mainland coast report only few sightings of Sandwich Tern for the surveyed winter seasons (between September and April) 2008/2009 and 2009/2010 (OAG 2010). Within this period all birds were observed in April or September with maximum counts of 13 birds in April 2010 and 7 birds in September 2009 (OAG 2010). These surveys miss the main abundance period of terns in the area as surveys are not conducted during summer months. Berndt et al. (2005) report maximum numbers for Fehmarn occurring in the last decade of April and first decade of May (e.g. 54 recorded birds at Grüner Brink on April 21, 1996) and again numbers peaking during autumn transitional period in August/September.

The DOF database reports rather low numbers of Sandwich Tern in the Danish coastal areas of the Fehmarnbelt (DOF 2010). For Rødsand Lagoon numbers exceeding 10 individuals were reported for transitional periods, mainly in April and

August/September (DOF 2010). There are two exceptionally high records for this area with 350 birds counted in August 2005 and 120 birds in August 2008 (DOF 2010). Similar numbers of Sandwich Tern were reported for Gedser Odde with several tens of birds being counted mostly in August and September (maximum 264 birds on August 31, 2009; DOF 2010).

Distribution and habitat use of Sandwich Tern in the Fehmarnbelt

The Sandwich Tern is mostly confined to coastal areas within the Baltic Sea region and is rarely observed offshore (Mendel et al. 2008). The species prefers sandy beaches as resting sites and is rarely observed inland (Mendel et al. 2008).

Sandwich Tern distribution according to FEBI survey data

During the FEBI ship-based surveys Sandwich Terns were rarely observed. All recorded birds occurred in coastal transects, a pattern confirming the species' preference for near-shore habitats (Figure 4.185; Appendix II).

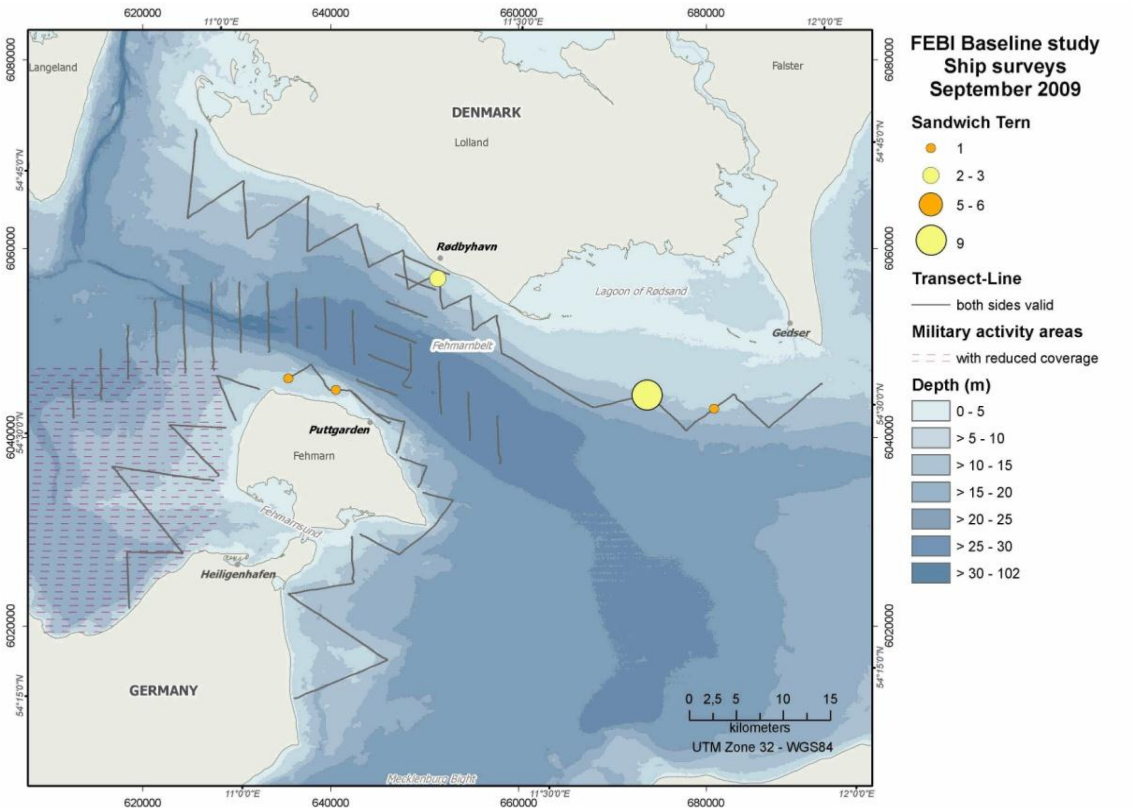


Figure 4.185 Example of observed Sandwich Tern distribution in the study area during ship-based surveys (September 2009).

Sandwich Tern distribution according to supplementary datasets

Supplementary datasets provide only little information on Sandwich Tern distribution and habitat use. Highest numbers of 13 and 7 birds reported for the German coastal count sections between Laboe and Schönberger Strand in the west of the SPA Eastern Kiel Bight indicate coastal areas more frequently used than inland freshwater habitats (OAG 2010). Sandwich Tern records in DOF database indicate that the species is regularly observed in the Rødsand Lagoon and at Gedser Odde (DOF 2010).

Sandwich Tern abundance estimates for SPAs

Based on the available data, no abundance estimates are possible for particular SPAs. The FEBI baseline investigations as well as supplementary datasets indicate Sandwich Tern being regularly present in the study area during the summer season, but no numbers of international importance were reported for any of the SPAs or the entire study area. The FEBI ship-based surveys and supplementary datasets indicate relatively high numbers occurring within the SPA Hyllekrog-Rødsand, however the maximum numbers reported for this area (350 birds in August 2005; DOF 2010) equal to only 0.2 % of the biogeographic population of the species.

Sandwich Tern trends

The European Sandwich Tern population underwent a moderate decline between 1970 and 2000 (BirdLife International 2004). Consequently, the European population of Sandwich Tern was evaluated as Depleted (BirdLife International 2004). Pihl et al. (2006) describe a similar trend of decreasing breeding pair numbers in Denmark. Garthe and Flore (2007) report high fluctuations in the German North Sea coast breeding population over the past 100 years. After numbers had reached a maximum in 1996, breeding numbers have dropped again in recent years (Garthe and Flore 2007).

Importance of the Fehmarnbelt to Sandwich Tern

The Sandwich Tern occurs in the Fehmarnbelt mainly as migratory species. It is present in the study area during the summer season and transitional periods in April/May and August/September. Numbers observed during FEBI baseline investigations as well as reported in supplementary datasets (DOF 2010, OAG 2010) and literature (Mendel et al. 2008) indicate that observations exceeding 100 individuals are rare. The highest count of 350 birds in the SPA Hyllekrog-Rødsand (DOF 2010) accounts for approximately 0.2 % of the biogeographic population of Sandwich Tern.

Sandwich Tern – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	350
Max. abundance estimate in the alignment area:	single to a few tens of birds
Period of max. abundance in Fehmarnbelt:	April/May, August/September
Areas of max. abundance in Fehmarnbelt:	Rødsand Lagoon
Explanations:	Maximum abundance estimated from supplementary data for Rødsand Lagoon (350 birds). This number is expected to represent an exceptionally high abundance as numbers of this species are usually lower. Distribution obtained from supplementary datasets.

4.1.39 Common Tern/Arctic Tern – Sterna hirundo/Sterna paradisaea

Common Tern – *Sterna hirundo*

Biogeographic population: *S. h. hirundo*, N and E Europe (br)

Breeding range: NE Europe, mainly countries around Baltic Sea

Wintering / core non-breeding range: mainly Southern Africa

Population size: 630,000 – 1,500,000

1 % value: 11,000

Conservation status: EU Birds Directive, Annex I: listed
EU SPEC Category: non-SPEC
EU Threat Status: secure

Target species in SPAs: -

Key food: fish, also invertebrates

Period of presence in Fehmarnbelt: Breeding, migrations: April – mid-October

Arctic Tern – *Sterna paradisaea*

Biogeographic population: N Eurasia (br)

Breeding range: Europe N of France, Scandinavia, Russia N of Arctic Circle

Wintering / core non-breeding range: Antarctic Ocean

Population size: > 1,000,000

1 % value: (20,000)*

Conservation status: EU Birds Directive, Annex I: listed
EU SPEC Category: non-SPEC
EU Threat Status: (secure)

Target species in SPAs: -

Key food: fish, also invertebrates

Period of presence in Fehmarnbelt: Breeding, migrations: April – mid-October

* estimate in WPE4 given as > 1,000,000 without 1 % threshold; according to Wahl et al. (2007) leading to the application of the maximum 1 % threshold (cf. criterion 5 Ramsar Convention).

Origin of Common Tern/Arctic Tern in the Fehmarnbelt

Common Tern

There are recoveries of this long-distance migrant reported from the entire North Sea and the Baltic Sea during spring, summer and autumn, indicating that Common Terns use the Fehmarnbelt region during passage to and from their wintering areas (Appendix IV). Breeding birds of the southern Baltic Sea seem to use the Fehmarnbelt during migration. Furthermore, Bønløkke et al. (2006) show that a higher number of breeding birds from western Russia and the Baltic countries are recorded in Danish waters. The wintering areas of local breeding birds are found along the coast of West Africa and as far south as South Africa.

Arctic Tern

Summer and autumn recoveries of ringed Arctic Terns are spread out over most of north-western Europe indicating that birds from a large area utilise the Fehmarnbelt region in the course of the year (Appendix IV). The Arctic Tern is an extreme long-distance migrant, migrating to the southern Atlantic Ocean (Cramp 1985). Birds from the Fehmarnbelt region are recovered throughout the year (summer records probably young non-breeders) along the coast of West and southern Africa. These patterns are confirmed by ringing atlases (e.g. Bønløkke et al. 2006).

Data sources on Common Tern/Arctic Tern in the Fehmarnbelt

From the airplane tern species are difficult to identify, thus FEBI aerial surveys were not used for evaluation of Common and Arctic Tern abundance and distribution in the Fehmarnbelt area (Table 4.98). The FEBI ship-based surveys were chosen as the primary dataset for species description. The land-based datasets of DOF and OAG (DOF 2010, OAG 2010) delivered supporting information. Datasets of the Danish (NOVANA surveys; Petersen et al. 2006, 2010) and German (AKVSW 2010) mid-winter surveys do not provide any data on these species because these terns do not winter in the study area (Table 4.98).

Table 4.98 List of datasets and their use in baseline assessment of Common and Arctic Tern in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used due to uncertain species identification by this method
FEBI ship transect surveys	Primary dataset in the assessment of species abundance and distribution
OAG land-based counts	Supporting dataset representing species abundance and distribution along the German mainland coast
AKVSW land-based counts	Dataset not used due to no sightings of the species
NOVANA aerial surveys	Dataset not used due to no sightings of the species
DOF database	Supporting dataset for species abundance in the Danish part of the Fehmarnbelt

Abundance of Common Tern/Arctic Tern in the Fehmarnbelt

Both species, Common Tern and Arctic Tern, occur in the study area as breeding birds (see chapter 0), and were described to be present in low numbers in the southern Baltic Sea during summer period (Mendel et al. 2008).

According to Pihl et al. (2006) Common Terns arrive in Denmark in late April and leave in August/September. Arctic Terns also arrive in the region in late April, but leave in July/August (Pihl et al. 2006). Berndt et al. (2005) describe a similar seasonal pattern of Common Tern and Arctic Tern abundance for Fehmarn.

Common Tern/Arctic Tern abundance according to FEBI survey data

During the two years of monthly FEBI ship-based surveys Common and Arctic Terns were only rarely recorded during the summer period (Table 4.99). A maximum of 20 terns were observed during the ship-based survey in late July 2009 (Table 4.99). Most of the Common/Arctic Terns identified during the ship-based surveys were Common Terns. Arctic Terns were identified only once with 4 birds recorded during the survey in May 2010 (Table 4.99).

Table 4.99 Results of monthly ship-based surveys for Common Tern/Arctic Tern between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects (in brackets number of identified Common Terns/number of identified Arctic Terns).

Survey	Number of birds observed	Survey	Number of birds observed
Nov-08	0	Nov-09	0
Dec-08	0	Dec-09	0
Jan-09	0	Jan-10	0
Feb-09	0	Feb-10 A	0
Mar-09	0	Feb-10 B	0
Apr-09	0	Mar-10	0
Jun-09	0	Apr-10	0
Jul-09 A	3 (3/0)	May-10	8 (4/4)
Jul-09 B	20 (13/0)	Jun-10	0
Aug-09	4 (3/0)	Sep-10	2
Sep-09	0	Oct-10	0
Oct-09	0	Nov-10	0

Common Tern /Arctic Tern abundance according to supplementary datasets

The OAG monthly surveys along the German mainland coast between September and April in 2008/2009 and 2009/2010 show only a few sightings of Common Tern and no records of Arctic Tern (OAG 2010). Within this period, the highest number of 8 Common Terns was recorded twice at Großer Binnensee, in September 2008 and September 2009 (OAG 2010). However, these surveys miss the main season of tern abundance as summer months are not covered.

Local breeding birds are present in the German SPAs during the summer season with 85 pairs of Common Tern and 36 pairs of Arctic Tern (see chapter 0).

The DOF database regularly reports single Common Tern individuals in Rødsand Lagoon, with the highest count of 18 Common Terns in September 2001 (DOF 2010). Arctic Tern is more abundant in Rødsand Lagoon with regularly 10-30 birds reported (maximum 115 birds in May 2009; DOF 2010). These are presumably locally breeding birds (14 pairs breed in the SPA Hyllekrog-Rødsand, see chapter 0).

Distribution and habitat use of Common Tern/Arctic Tern in the Fehmarnbelt

Common Tern and Arctic Tern are described as mostly confined to coastal areas within the Baltic Sea region. Locally breeding birds mostly forage in coastal waters and inland lakes adjacent to their breeding sites (Mendel et al. 2008).

Common Tern/Arctic Tern distribution according to FEBI survey data

During the FEBI ship-based surveys Common Tern and Arctic Tern were observed within the entire study area with no identified areas of elevated aggregations (Figure 4.186). Individuals were observed close to shore as well as offshore in the Fehmarnbelt (Figure 4.186).

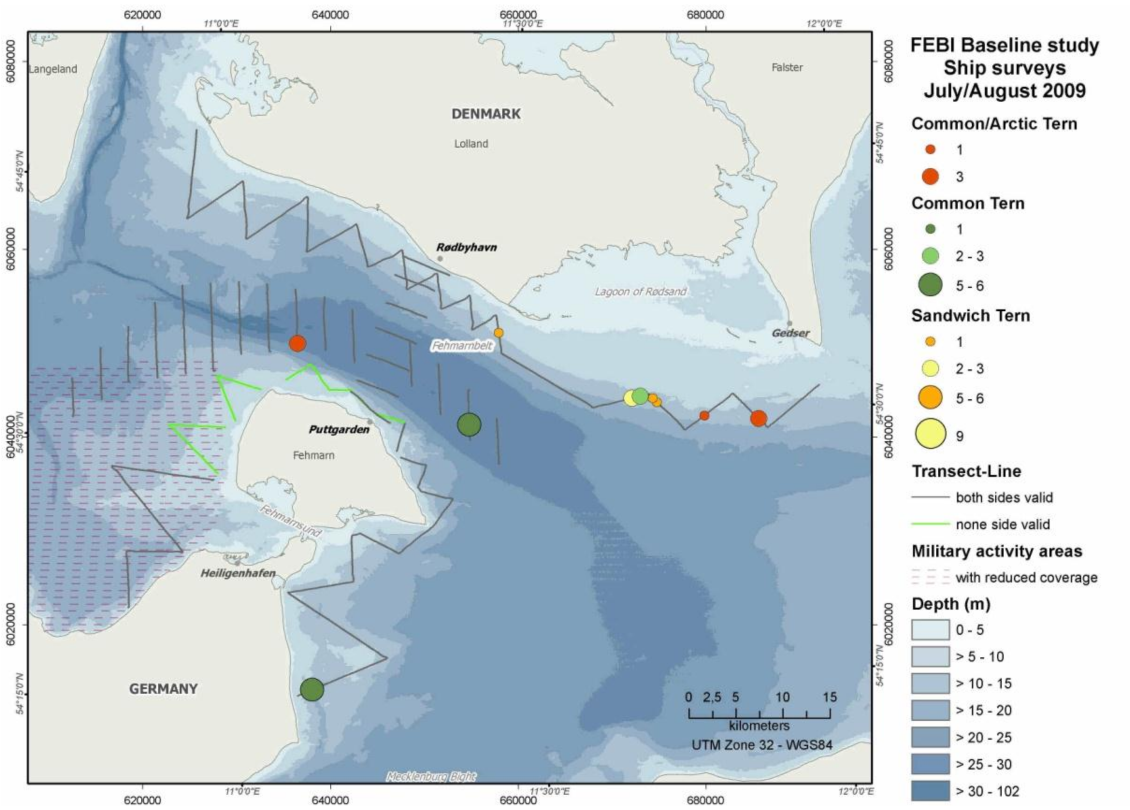


Figure 4.186 Example of observed tern distribution in the study area during the ship-based surveys (July/August 2009; survey 'Jul-09 B').

Common Tern/Arctic Tern distribution according to supplementary datasets

Supplementary datasets provide only little information on the distribution and habitat use of these tern species. Coastal surveys in Germany report the highest number of 8 Common Terns recorded on the inland lake Großer Binnensee (OAG 2010). Common Tern and Arctic Tern records in the DOF database indicate Common Tern frequently occurring inland (e.g., Maribo Lakes) whereas Arctic Tern was only rarely observed away from marine waters (DOF 2010).

Common Tern/Arctic Tern abundance estimates for SPAs

Based on available datasets, no abundance estimates are possible for particular coastal SPAs. FEBI baseline investigations as well as supplementary datasets indicate Common Tern and Arctic Tern regularly being present in the study area in the summer season, but no numbers of international importance were reported for any SPAs, nor for the entire study area. According to the reported breeding pair numbers (see chapter 0), the SPA Eastern Kiel Bight supports the highest abundance of Common and Arctic Tern within the study area, with about 250 Common Terns and about 110 Arctic Terns using the area (number of breeding pairs multiplied by 3). Because of large European population sizes the numbers of both species observed in the different SPAs are well below 0.1 % of the particular biogeographic population.

Common Tern/Arctic Tern trends

The European populations of Common Tern and Arctic Tern were described as stable between 1970 and 1990 (BirdLife International 2004). Between 1990 and 2000 the populations remained stable, even though the numbers of breeding birds have declined in some countries. Consequently the European populations of Common Tern and Arctic Tern were evaluated as Secure (BirdLife International 2004). Breeding population sizes of both species are described as stable in

Denmark (1,000 pairs of Common Tern; 8,000-9,000 pairs of Arctic Tern) and Germany (8,900-9,600 pairs of Common Tern; 6,100-6,700 pairs of Arctic Tern; BirdLife International 2004).

Importance of the Fehmarnbelt to Common Tern/Arctic Tern

Common Tern and Arctic Tern occur in the Fehmarnbelt area as breeding and migratory species. These species are present almost exclusively during the summer season, mostly between April and August/September. No internationally important aggregations were identified within the study area. Numbers observed during the FEBI baseline investigations and those reported in supplementary datasets (DOF 2010, OAG 2010) and literature (Mendel et al. 2008) rarely exceeded 100 individuals. Breeding pair numbers indicate that about 255 Common Terns and 150 Arctic Terns use the German Fehmarnbelt area (mainly SPA Eastern Kiel Bight). In summary, numbers well below 0.1 % of the particular biogeographic populations of Common Tern and Arctic Tern occur in the Fehmarnbelt area.

Common Tern / Arctic Tern – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	255 / 150
Max. abundance estimate in the alignment area:	42 / single birds
Period of max. abundance in Fehmarnbelt:	April – September
Areas of max. abundance in Fehmarnbelt:	see Figure 3.18, Figure 3.19
Explanations:	Maximum abundance and distribution obtained from monitoring of breeding birds in the SPAs (first number: Common Tern, second number: Arctic Tern). Numbers are estimated by multiplying numbers of breeding pairs (see chapter 3.1) by a factor of 3. Maximum abundance in the alignment area was estimated using the size of the Common Tern breeding colony at Grüner Brink on Fehmarn (14 pairs).

4.1.40 Common Guillemot – *Uria aalge*

Common Guillemot – *Uria aalge*	
Biogeographic population: North Sea - Baltic Sea (non-br)	
Breeding range: NE Atlantic	
Wintering / core non-breeding range: North Sea – Kattegat	
Population size: > 4,300,000*	
1 % value: 43,000	
Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: non-SPEC EU Threat Status: (secure)
Target species in SPAs:	-
Key food: fish	
Period of presence in Fehmarnbelt:	Wintering, migrations: July – mid-April

* BirdLife International (2004)

Origin of Common Guillemot in the Fehmarnbelt

The largest part of the NE Atlantic breeding Common Guillemot population breeds in Iceland and the British Isles. The wintering range of Common Guillemot extends to the Skagerrak-Kattegat, and possibly parts of the western Baltic (Lloyd et al. 1991). A small fraction of the population breeds in the Baltic Sea. There is no information from ring recovery available which would provide information about the origin of Common Guillemots occurring in the Fehmarnbelt.

Data sources on Common Guillemot in the Fehmarnbelt

Numbers and distribution of Common Guillemots are best reflected in FEBI ship-based survey data. The species is typically misidentified or overlooked during the aerial surveys, therefore the FEBI and NOVANA (Petersen et al. 2010) aerial surveys were not used in the analyses (Table 4.100). German land-based survey datasets were not used as no recent records of Common Guillemots were identified in the dataset (AKVSW 2010, OAG 2010). Danish land-based observations (DOF 2010) were used as supporting information source for Common Guillemot abundance in Danish coastal areas (Table 4.100).

Table 4.100 List of datasets and their use in baseline assessment of Common Guillemot the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used due to uncertain species identification by this method
FEBI ship transect surveys	Primary dataset for estimating species abundance and distribution
OAG land-based counts	Dataset not used due to no entries for this species
AKVSW land-based counts	Dataset not used due to no recent entries for this species
NOVANA aerial surveys	Dataset not used due to uncertain species identification by this method
DOF database	Supporting dataset for estimating species abundance

Abundance of Common Guillemot in the Fehmarnbelt

The Common Guillemot is present in the German Baltic Sea all year, but between spring and autumn only single birds are present in the area (Mendel et al. 2008). Higher numbers occur in the German Baltic Sea during winter period (Mendel et al. 2008).

Common Guillemot abundance according to FEBI survey data

Very few Common Guillemots were recorded during the FEBI ship-based surveys (Table 4.101), and sample sizes did not allow for estimation of the total abundance in any season. The species was primarily recorded during the winter period (Table 4.101).

Table 4.101 Results of monthly ship-based surveys for Common Guillemot between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects.

Survey	Number of birds observed	Survey	Number of birds observed
Nov-08	3	**Nov-09**	10
Dec-08	5	**Dec-09**	0
Jan-09	1	**Jan-10**	0
Feb-09	1	**Feb-10 A**	2
Mar-09	6	**Feb-10 B**	0
Apr-09	0	**Mar-10**	1
Jun-09	1	**Apr-10**	3
Jul-09 A	0	**May-10**	2
Jul-09 B	0	**Jun-10**	2
Aug-09	1	**Sep-10**	0
Sep-09	0	**Oct-10**	0
Oct-09	6	**Nov-10**	2

Common Guillemot abundance according to supplementary datasets

The Danish land-based bird observation only rarely reported Common Guillemots in coastal areas of the Fehmarnbelt (DOF 2010). Single resting birds were recorded in Rødsand Lagoon and off Gedser Odde in some winters (DOF 2010).

Distribution and habitat use of Common Guillemot in the Fehmarnbelt

In the German Baltic Sea the highest densities of the Common Guillemot occur outside the Fehmarnbelt in offshore areas of the Pomeranian Bight (Mendel et al. 2008). In the Danish Baltic Sea the core wintering area of Common Guillemot is located in the eastern Kattegat (Durinck et al. 1994, Petersen et al. 2006, 2010). In the Baltic Proper, Common Guillemots primarily winter in proximity to their breeding colonies (Durinck et al. 1994).

Common Guillemot distribution according to FEBI data

The few Common Guillemots recorded during the FEBI ship-based surveys were widely distributed in the offshore areas of the Fehmarnbelt (Figure 4.187).

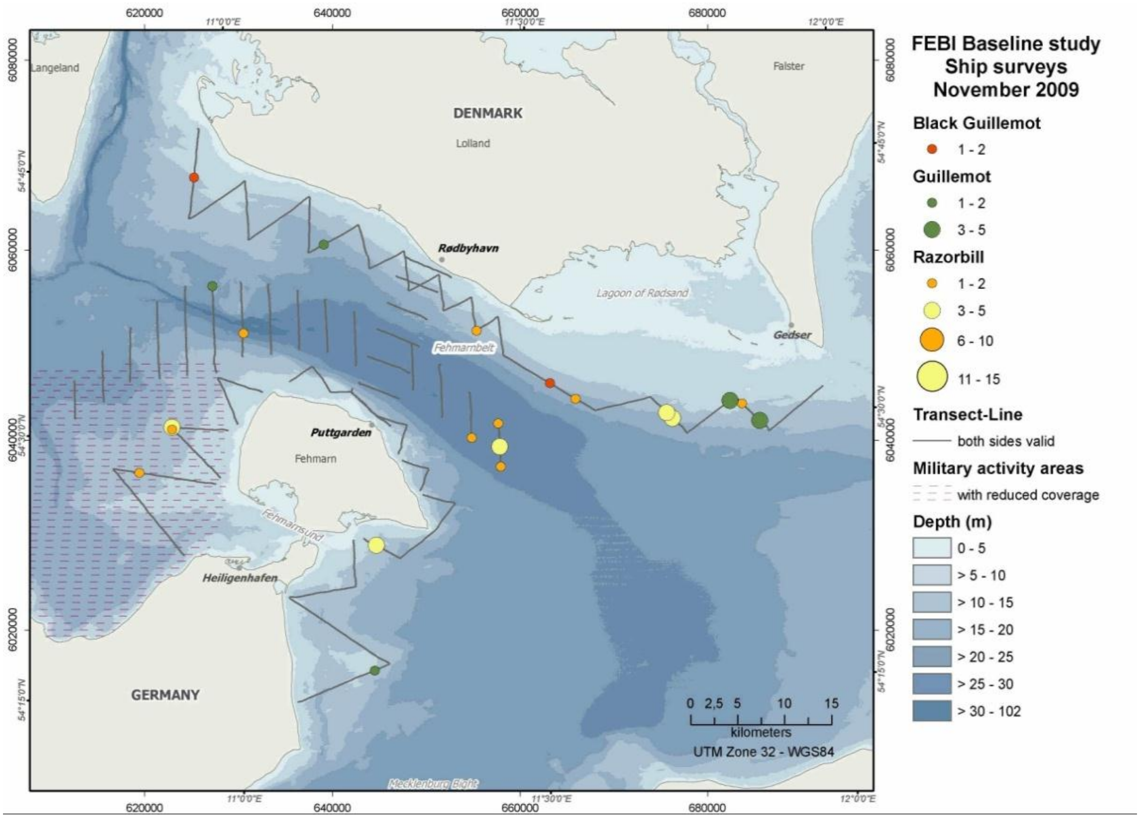


Figure 4.187 Example of observed auk distribution in the study area during ship-based surveys (November 2009).

Common Guillemot distribution according to supplementary datasets

Rare or no sightings of Common Guillemot obtained by land-based surveys confirm the species only occurring infrequently in coastal areas of the Fehmarnbelt (AKVSW 2010, DOF 2010, OAG 2010).

Common Guillemot abundance estimates for SPAs

Based on available data no abundance estimates for distinct SPAs were possible, but available datasets and literature (Mendel et al. 2008) indicate Common Guillemots to be present in low numbers well below international importance occurring in the SPAs within the Fehmarnbelt area.

Common Guillemot trends

From 1970 to 1990 the population was evaluated as stable. Also from 1990 to 2000 the population trend was positive. BirdLife International (2004) evaluated the population as being Secure. However, since the mid-2000s the species has undergone a prominent decline across the entire breeding range, including the Baltic Sea (Nordic Council of Ministers 2010).

Importance of the Fehmarnbelt to the Common Guillemot

The baseline results indicate that a very low (< 0.1 %) proportion of the biogeographic population occurs in the Fehmarnbelt. The species was mainly observed in offshore areas, but no specific aggregation areas were identified in the study area.

Common Guillemot – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	a few tens of birds (max. count: 10 birds)
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	October – March
Areas of max. abundance in Fehmarnbelt:	offshore areas, no aggregations
Explanations: –	

4.1.41 Razorbill – Alca torda

Razorbill – *Alca torda*

Biogeographic population: North Sea – Baltic Sea (non-br)

Breeding range: NE Atlantic

Wintering / core non-breeding range: North Sea - Kattegat

Population size: > 500,000*

1 % value: 5,000

Conservation status: EU Birds Directive, Annex I: -
EU SPEC Category: non-SPEC[E]
EU Threat Status: secure

Target species in SPAs: -

Key food: fish

Period of presence in Fehmarnbelt: Wintering, migrations: July – mid-April

* BirdLife International (2004)

Origin of Razorbill in the Fehmarnbelt

The largest part of the NE Atlantic population breeds in Iceland and the British Isles. The main wintering areas for these populations are found in the Kattegat, and the range may include parts of the western Baltic (Durinck et al. 1994, Skov et al. 1995). A small fraction of the population breeds in the Baltic Sea. There is no ring recovery available, which could provide information about the origin of Razorbills occurring in the Fehmarnbelt (Appendix IV).

Data sources on Razorbill in the Fehmarnbelt

The numbers and distribution of Razorbills are best reflected in the FEBI ship-based survey data. The species is typically misidentified or overlooked during the aerial surveys as Guillemots and Razorbills mostly cannot be differentiated from the air. Therefore this dataset was not used in the analyses (Table 4.102).

Table 4.102 List of datasets and their use in baseline assessment of Razorbill in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Dataset not used for this species
FEBI ship transect surveys	Primary dataset for estimating species abundance and distribution
OAG land-based counts	Dataset not used due to no entries for this species
AKVSW land-based counts	Dataset not used due to no entries for this species
NOVANA aerial surveys	Dataset not used for this species
DOF database	Dataset not used due to inappropriate method for surveying this offshore species

Abundance of Razorbills in the Fehmarnbelt

Razorbill abundance estimates based on Distance analysis

The abundance of Razorbill in the Fehmarnbelt was estimated applying Distance analysis (Thomas et al. 2010) on the monthly ship-based survey data. The ESW for Razorbill during ship-based surveys, estimated for the entire dataset, was 195 m. Razorbill occurs in highest densities in the study area in winter. The species is almost absent from the area between May and September (Table 4.103). Estimated densities of wintering Razorbills were variable and ranged between 0 and 0.5 birds/km² (Table 4.103). Reflecting densities, total estimated numbers in the area covered by ship-based surveys ranged from a few birds to over 1,000 individuals during winter months. However, due to small sample size confidence intervals were often broad and results should be interpreted with caution.

Table 4.103 Numbers of observed Razorbills during monthly ship-based surveys and results of Distance analysis. Results are presented separately for coastal and offshore strata and combined for the entire survey area for swimming birds, and as overall (combined) density with added flying birds. N-obs represents actual number of observations (bird flocks), N-birds – actual number of swimming birds counted within transects, N-flying – number of recorded flying birds within transect. D represents density, %CV – percent coefficient of variation, LCI – lower 95 % confidence interval, UCI – upper 95 % confidence interval; Total number represents total estimate for the area of 2,340 km² covered by ship-based surveys. Note: coefficients of variation greater than 50 % are shaded and respective density estimates should be interpreted with caution as they have very broad confidence intervals and therefore low reliability. For surveys with coefficients of variation greater than 150 % no estimates are displayed.

		Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
Survey	Stratum	N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Nov-08	coastal	4	5	-	***	-	-	-	-	-	0	-	-
	offshore	8	14	-	***	-	-				5		
Dec-08	coastal	1	2	0.02	102	0.00	0.14	0.13	0.03	0.61	0	0.13	304
	offshore	6	16	0.29	85	0.06	1.36				0		
Jan-09	coastal	17	54	0.35	60	0.12	1.06	0.33	0.11	0.96	32	0.51	1,184
	offshore	8	17	0.28	52	0.10	0.77				10		
Feb-09	coastal	5	23	-	***	-	-	-	-	-	12	-	-
	offshore	8	28	-	***	-	-				2		
Mar-09	coastal	3	4	0.03	82	0.01	0.17	0.06	0.01	0.52	4	0.12	277
	offshore	2	7	0.12	98	0.01	1.24				9		
Apr-09	coastal	1	1	0.01	106	0.00	0.05	0.02	0.00	0.10	3	0.03	67
	offshore	1	2	0.03	105	0.01	0.19				0		
May-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0		0	0	0				0		
Jul-09A	coastal	0	0	0	0	0	0	0	0	0	2	0.01	21
	offshore	0	0	0	0	0	0				0		
Jul-09B	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0					0		
Aug-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-09	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		

Survey	Stratum	Density estimates for swimming birds per stratum						Combined density estimates for swimming birds per survey			Combined estimates including flying birds		
		N obs	N birds	D	%CV	LCI	UCI	D	LCI	UCI	N flying	D	Total number
Oct-09	coastal	3	3	0.03	83	0.01	0.11	0.05	0.01	0.23	2	0.06	130
	offshore	2	4	0.11	98	0.02	0.63				0		
Nov-09	coastal	8	22	0.16	39	0.08	0.35	0.13	0.05	0.48	9	0.19	449
	offshore	2	6	0.08	92	0.01	0.71				4		
Dec-09	coastal	6	6	0.05	46	0.02	0.13	0.05	0.02	0.16	3	0.07	169
	offshore	1	2	0.04	104	0.01	0.21				3		
Jan-10	coastal	13	24	0.22	63	0.07	0.72	-	-	-	0	-	-
	offshore	5	9	-	***	-	-				0		
Feb-10A	coastal	43	63	-	32	-	-	-	-	-	1	-	-
	offshore	14	36	-	***	-	-				9		
Feb-10B	coastal	3	8	-	684	-	-	-	-	-	1	-	-
	offshore	3	5	-	192	-	-				1		
Mar-10	coastal	2	2	0.02	103	0.00	0.09	-	-	-	0	-	-
	offshore	2	3	-	***	-	-				2		
Apr-10	coastal	1	2	0.02	102	0.00	0.09	0.01	0.00	0.06	0	0.01	27
	offshore	0	0	0	0	0	0				0		
May-10	coastal	1	1	0.01	102	0.00	0.05	0.01	0.00	0.03	0	0.01	14
	offshore	0	0	0	0	0	0				0		
Jun-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Sep-10	coastal	0	0	0	0	0	0	0	0	0	0	0	0
	offshore	0	0	0	0	0	0				0		
Oct-10	coastal	1	1	0.01	104	0.00	0.05	0.01	0.00	0.03	0	0.01	13
	offshore	0	0	0	0	0	0				0		
Nov-10	coastal	1	2	0.02	97	0.00	0.08	0.02	0.00	0.09	0	0.02	38
	offshore	1	1	0.02	101	0.00	0.09				0		

Month-to-month variation in Razorbill occurrence in the Fehmarnbelt was assessed by plotting mean densities of swimming birds recorded during ship-based surveys (and corrected for distance detection bias). The species was present in the area during the wintering period and transitional months (October – April), and occurred only at very low densities between May and September (Table 4.103, Figure 4.188).

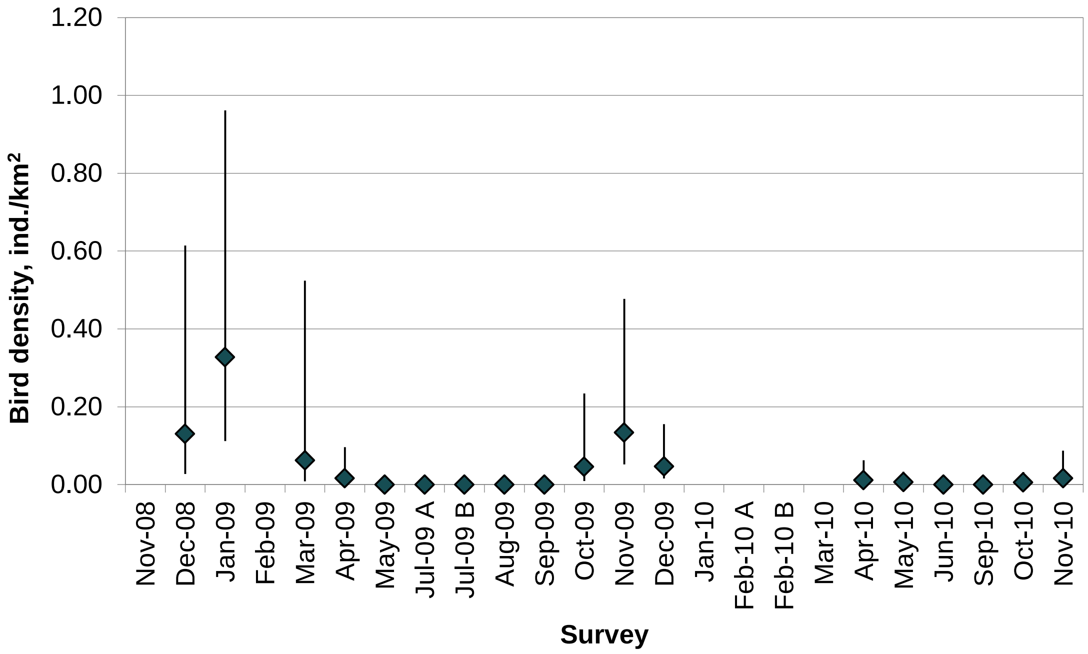


Figure 4.188 Mean density estimates and 95 % confidence intervals of swimming Razorbills estimated for FEBI ship-based surveys between November 2008 and November 2010 (flying birds were not considered). Note: density estimates where the coefficient of variation exceeded 150 % were not included into the chart (see Table 4.103 for specific values).

Distribution and habitat use of Razorbills in the Fehmarnbelt

Razorbill distribution according to FEBI survey data

Ship-based surveys of FEBI baseline investigations show Razorbills being found widely distributed in the Fehmarnbelt with higher densities observed south of Rødsand and northwest of Fehmarn (Appendix II).

Razorbill distribution and habitat use according to spatial modelling

A distribution model was fitted for the 'winter' period covering two seasons: November 2008 – March 2009 and October – March 2010.

The interaction term XY, water depth and bottom salinity were the most important predictors in the binomial part of the model (Table 4.104). Northward (V) current velocities, bottom temperature and slope were also quite important predictors in the binomial part. Bottom temperature was the most important predictor in the positive part, with distance to land, eastward current, upwelling and XY also being significant.

The distribution model had a rather good fit. Deviance explained in the binomial part was 16% and 50.6% in the positive part (Figure 4.189, Table 4.104). The accuracy of the predictions of the binomial part according to AUC equalled 0.74 and the Spearman's Rank correlation coefficient between the observed and predicted densities of the final combined model was 0.14 (P = 0.002).

The models deployed show that Razorbills use the area south of Rødsand and northwest of Fehmarn in winter, where densities above 0.5 birds/km^2 were estimated (Figure 4.190). The densities obtained from the distribution models are similar to those of the Distance analysis. The areas of concentration coincide with the areas characterised by prominent upwelling and downwelling activities in the northern Mecklenburg Bight and Kiel Bight (FEHY 2013).

Table 4.104 Significance of smooth terms (X2 and F values) of variables in the spatial distribution model for the 'winter' period for Razorbill in the Fehmarnbelt. Evaluation results presented as area under receiver operator curve (AUC), deviance explained and Spearman's correlation coefficient. Values for both stages (presence/absence and positive part) of GAM are presented on separate panels. Dashes indicate variables, which have been eliminated during the most plausible model selection procedure. The presence-absence part was fitted by a binomial model, and the positive part by a gamma model.

Variable	**Presence/absence**			**Positive part**		
	Z	**X^2**	**P**	**t**	**F**	**P**
Season 2	2.64		<0.01	-2.38		0.02
Depth		20.35	<0.01	-	-	-
Proportion hard substrate		-	-	-	-	-
Bottom slope		8.97	<0.01	-	-	-
Distance to land		-	-	-	7.28	<0.01
Distance to wind farms		-	-	-	-	-
Number of ships		-	-	-	-	-
Pycnocline depth		-	-	-	-	-
Current gradient (Surface)		-	-	-	-	-
Salinity (Bottom)		18.70	<0.01	-	-	-
Temperature (Bottom)		10.07	<0.01	-	8.09	<0.01
Current U (Surface)		-	-	-	6.39	0.01
Current V (Surface)		11.93	<0.01	-	-	-
Current W (Surface)		-	-	-	4.92	<0.01
Vorticity (Bottom)		-	-	-	-	-
Current speed (Bottom)		5.42	0.04	-	-	-
XY		44.48	<0.01		6.69	<0.01
Model performance						
AUC		0.74				
Deviance explained		16.0 %			50.6 %	
Correlation (combined)			0.14 (P = 0.002)			

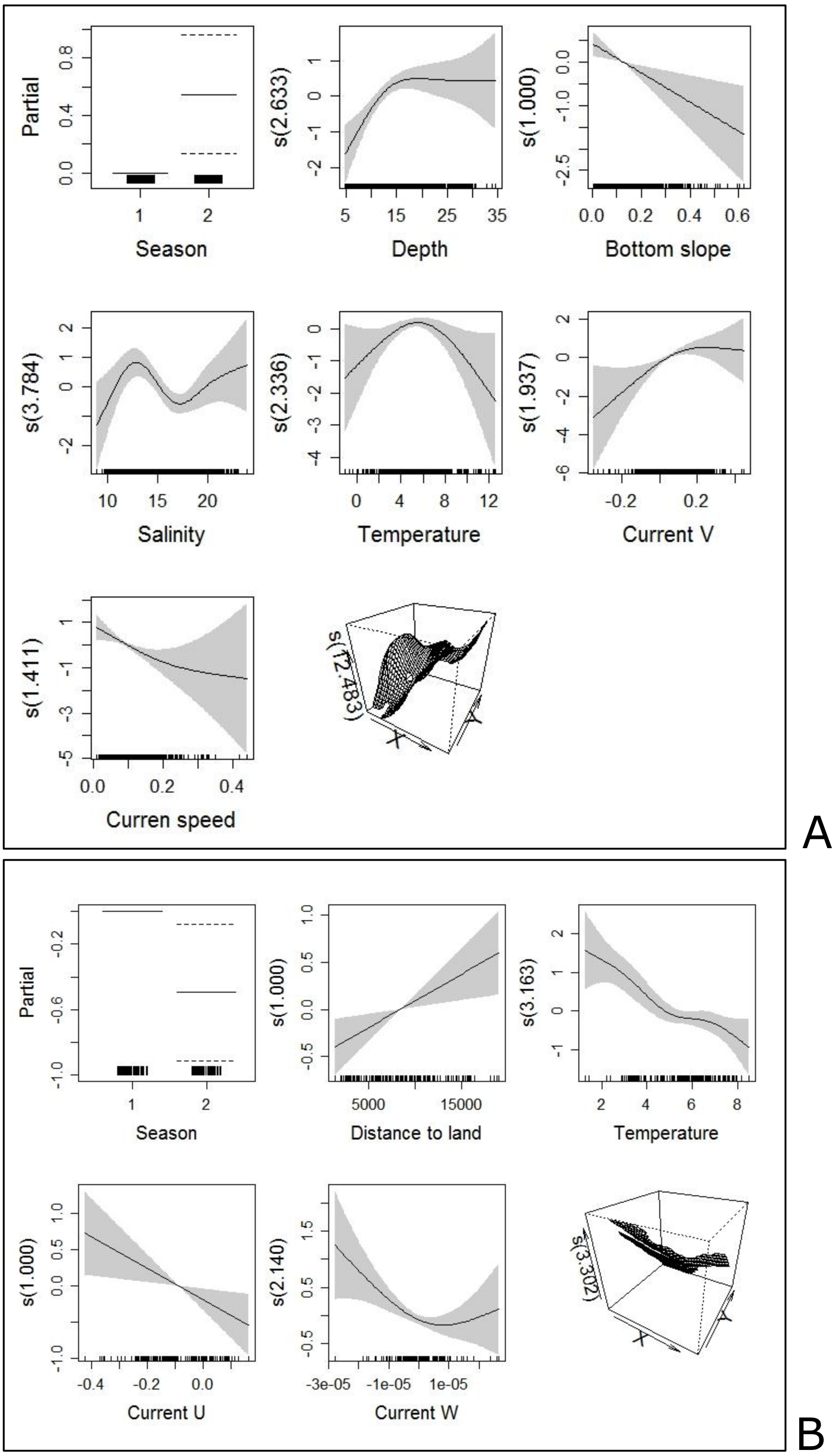
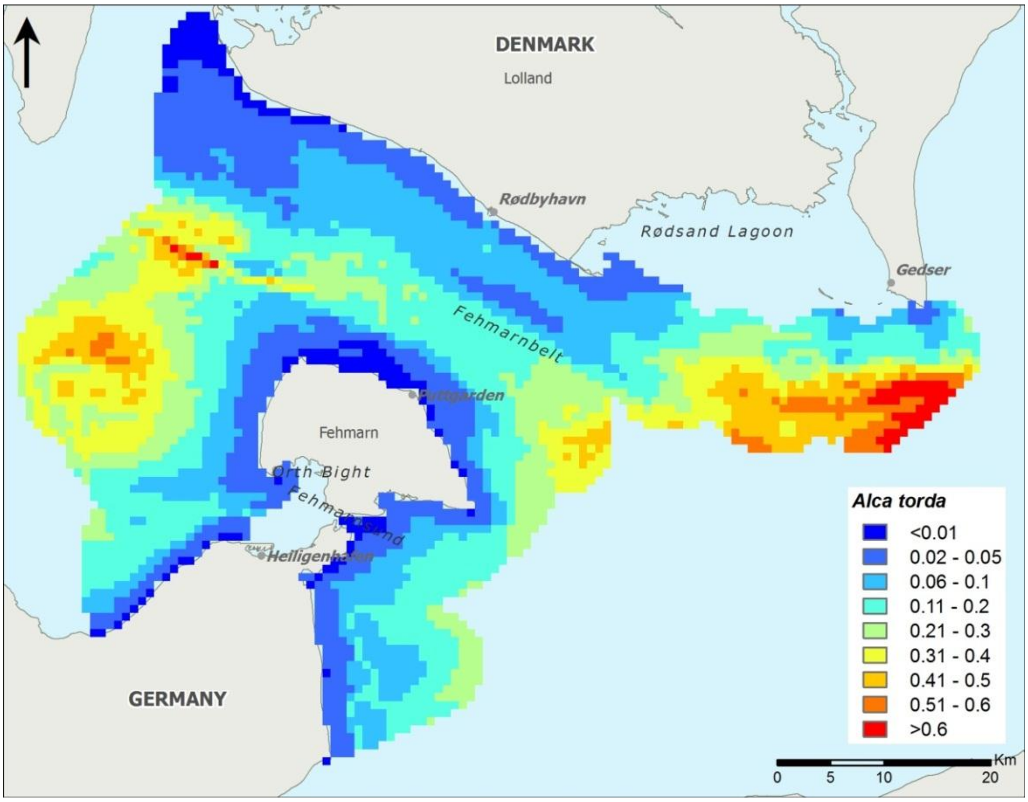


Figure 4.189 Response curves of the two-part GAM representing the relationship between the predictor variables and presence/absence of Razorbill (A – binomial part of the model) or density (B – positive part of the model) in the Fehmarnbelt for the 'winter' season. The values of the environmental predictor are shown on the X-axis and the probability on the Y-axis in logit scale. The degree of smoothing is indicated in the title of the Y-axis. The shaded areas and the dotted lines show ±1 standard errors. For the 2-d term (X,Y) a perspective plot is shown, with the degree of smoothing indicated as a label to the Z-axis.



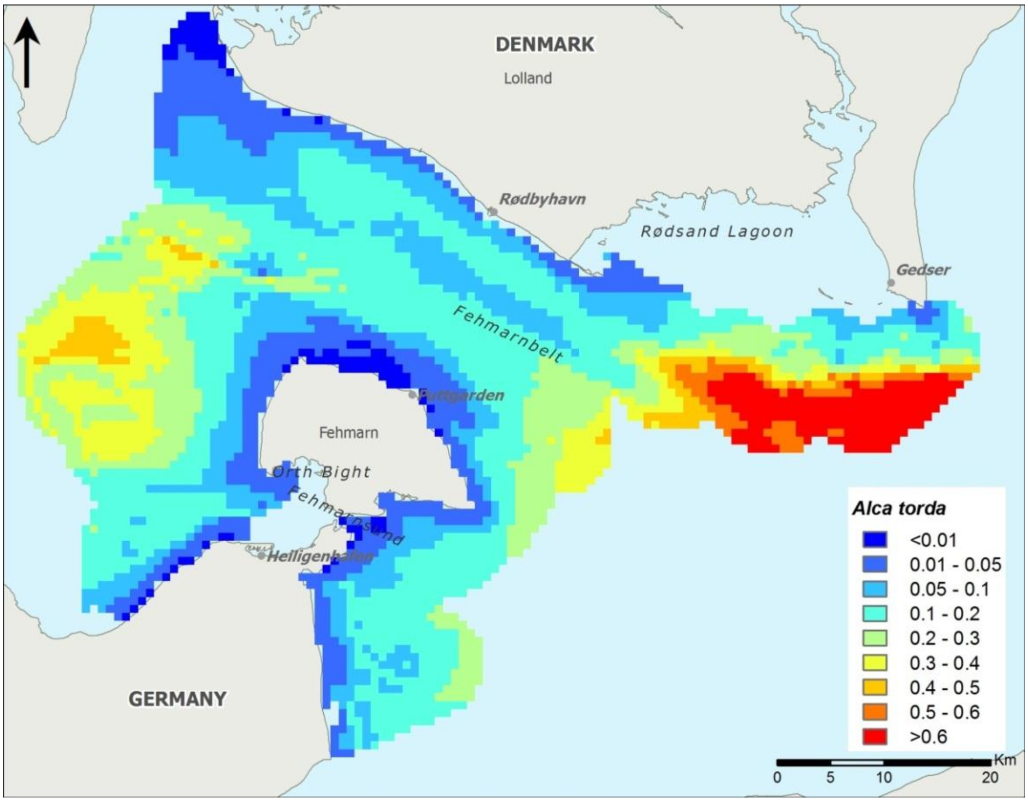


Figure 4.190 Spatial distribution model (numbers per km^2) of Razorbill Alca torda *in the Fehmarnbelt in winter periods based on baseline ship-based surveys undertaken between November 2008 and March 2009 (upper map) and October 2009 and March 2010 (lower map).*

Razorbill abundance estimates for SPAs

On the basis of the spatial distribution models, the numbers of Razorbill were estimated for the ship covered areas of the two SPAs, the Eastern Kiel Bight and Baltic Sea east of Wagrien (Table 4.105). Only a small fraction of the SPA Hyllekrog-Rødsand was covered by ship-based surveys. Therefore abundance estimates for this SPA were not possible. The estimates of Razorbill were similar for both winters. About 65 birds were estimated for the SPA Eastern Kiel Bight and 30 for the SPA Baltic Sea east of Wagrien. These should be considered as incomplete estimates of wintering birds, as ship-based surveys did not fully cover the SPA areas. Further, about 300 birds wintered in the non-SPA area and among these 18 birds were estimated to occur in the immediate vicinity of the planned alignment.

The total estimates of Razorbill wintering in the Fehmarnbelt area covered by ship-based surveys were about 400 birds during both winter seasons of the study period (Table 4.105), which falls within the range of numbers obtained from Distance analysis (Table 4.103). Slightly more birds were estimated for the second winter with a total of 427 ± 174 (± SE, Appendix III). Distance analysis suggested one estimate exceeding 1,000 birds for the study area (January 2009; Table 4.103), which represents unusually high number of this species in the study area.

Table 4.105 Estimates of Razorbill abundance in the SPAs: Eastern Kiel Bight and Baltic Sea east of Wagrien based on the spatial distribution models for the baseline aerial surveys from December 2008 to November 2010. Estimates for the alignment area and total non-SPA area are also given. Note: the SPAs Eastern Kiel Bight and Baltic Sea east of Wagrien were not fully covered by ship-based surveys. Estimates were only calculated for the area covered by surveys.

SPA / area	Period	Density	Estimate
Eastern Kiel Bight	Dec 2008-Feb 2009	0.15	65
(DE1530-491)	Nov 2009-Mar 2010	0.15	64
Baltic Sea east of Wagrien	Dec 2008-Feb 2009	0.09	29
(DE1633-491)	Nov 2009-Mar 2010	0.10	33
Alignment area	Dec 2008-Feb 2009	0.08	17
	Nov 2009-Mar 2010	0.09	19
Non-SPA area (including	Dec 2008-Feb 2009	0.20	298
the alignment area)	Nov 2009-Mar 2010	0.22	330
TOTAL	Dec 2008-Feb 2009	0.33	392
	Nov 2009-Mar 2010	0.31	427

Razorbill trends

From 1970–1990 the Razorbill population increased. Also from 1990–2000 the population trend was positive and the population was evaluated as Secure (BirdLife International 2004). However, since the mid-2000s the trend of the species has been uncertain, and in most countries it is now regarded as probably decreasing (Nordic Council of Ministers 2010).

Importance of the Fehmarnbelt to the Razorbill

The baseline results indicate that on average about 400 Razorbills winter in the Fehmarnbelt area that was covered by ship-based surveys. This constitutes less than 0.1% of the NE Atlantic population. However, some surveys indicated higher numbers,compared to those estimated by distribution modelling, including one of 1,184 birds, therefore numbers exceeding the 0.1% of the biogeographic population are expected to occur in the entire Fehmarnbelt area.

Razorbill – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	1,184
Max. abundance estimate in the alignment area:	18
Period of max. abundance in Fehmarnbelt:	October – April
Areas of max. abundance in Fehmarnbelt:	see Figure 4.190
Explanations:	Maximum abundance was estimated for the ship-based survey of Janury 2009. Although confidence intervals are relatively broad for this estimate, we consider this estimate being robust as actual bird observations were rather numerous and densities were similar for coastal and offshore areas.

4.1.42 Black Guillemot – *Cepphus grylle*

Black Guillemot – *Cepphus grylle*	
Biogeographic population: Baltic Sea	
Breeding range: Scandinavian coast of the Baltic Sea	
Wintering / core non-breeding range: Baltic Sea	
Population size: 8,250–12,750*	
1 % value: 105	
Conservation status:	EU Birds Directive, Annex I: - EU SPEC Category: SPEC 2 EU Threat Status: depleted
Target species in SPAs:	-
Key food: fish	
Period of presence in Fehmarnbelt:	Wintering, migrations: September – April

* BirdLife International (2004)

Origin of Black Guillemot in the Fehmarnbelt
There are no ring recoveries available which would provide information about the origin of Black Guillemots occurring in the Fehmarnbelt.

Data sources on Black Guillemot in the Fehmarnbelt
The numbers and distribution of Black Guillemot is best reflected in FEBI ship-based survey data. Therefore this dataset was used as primary source for assessing abundance and distribution of this species in the Fehmarnbelt area (Table 4.106). Aerial survey data and Danish land-based counts (DOF 2010) were used as supporting datasets. Danish mid-winter surveys (NOVANA) and German land-based surveys (AKVSW 2010, OAG 2010) were not used as there are no recent sightings in the study area (Table 4.106).

Table 4.106 List of datasets and their use in baseline assessment of Black Guillemot in the Fehmarnbelt.

Data source	Comment on use
FEBI aerial transect surveys	Supplementary dataset for estimating species abundance and distribution
FEBI ship transect surveys	Primary dataset for estimating species abundance and distribution
OAG land-based counts	Dataset not used due to no entries for this species
AKVSW land-based counts	Dataset not used due to no recent entries for this species
NOVANA aerial surveys	Dataset not used due to no recent entries for this species
DOF database	Supporting dataset for estimating species abundance

Abundance of Black Guillemot in the Fehmarnbelt
The Black Guillemot occurs in the southern Baltic mainly in winter (Durinck et al. 1994, Mendel et al. 2008). The highest densities within the German and Danish Baltic Sea are reported for offshore areas around Rügen and the north-western

Kattegat. Densities in the Fehmarnbelt area are low (Durinck et al. 1994, Mendel et al. 2008).

Black Guillemot abundance according to FEBI data

The Black Guillemot was only recorded infrequently and in low numbers during the baseline surveys. Thus, abundance estimates based on Distance analysis were not possible. During ship-based surveys the species was only recorded in winter (Table 4.107).

Table 4.107 Results of monthly ship-based surveys for Black Guillemot between November 2008 and November 2010: Number of birds observed represents actual number of birds counted within transects.

Survey	Number of birds observed	Survey	Number of birds observed
Nov-08	3	Nov-09	2
Dec-08	1	Dec-09	1
Jan-09	1	Jan-10	2
Feb-09	5	Feb-10 A	0
Mar-09	2	Feb-10 B	3
Apr-09	1	Mar-10	8
Jun-09	0	Apr-10	1
Jul-09 A	0	May-10	0
Jul-09 B	0	Jun-10	0
Aug-09	0	Sep-10	0
Sep-09	0	Oct-10	0
Oct-09	0	Nov-10	1

During the FEBI aerial transect surveys the Black Guillemot was recorded infrequently with a maximum of 18 birds counted during the survey in March 2009. All Black Guillemots were recorded during aerial surveys between November and April, confirming the seasonal pattern recorded during ship-based surveys.

Black Guillemot abundance according to supplementary datasets

The Danish land-based bird observations rarely report Black Guillemot in the coastal areas of the Fehmarnbelt (DOF 2010). Except for one individual observed in the Rødsand Lagoon in spring 2010 the species was not recorded in this sheltered coastal area. One single Black Guillemot was recorded off Gedser Odde in some winters (DOF 2010).

Distribution and habitat use of Black Guillemot in the Fehmarnbelt

In their Baltic wintering areas Black Guillemots are described as using offshore banks, but also occurring in coastal areas more frequently compared to other auk species (Durinck et al. 1994, Mendel et al. 2008).

Black Guillemot distribution according to FEBI data

The FEBI ship-based and aerial surveys recorded the Black Guillemot widely distributed in the Fehmarnbelt area (Figure 4.191, Figure 4.192), but the sighting rate was too low for detecting habitat preferences. However, the species appears to be more frequent in the eastern part of the study area, such as Sagasbank and Rødsand Lagoon (Figure 4.191, Figure 4.192).

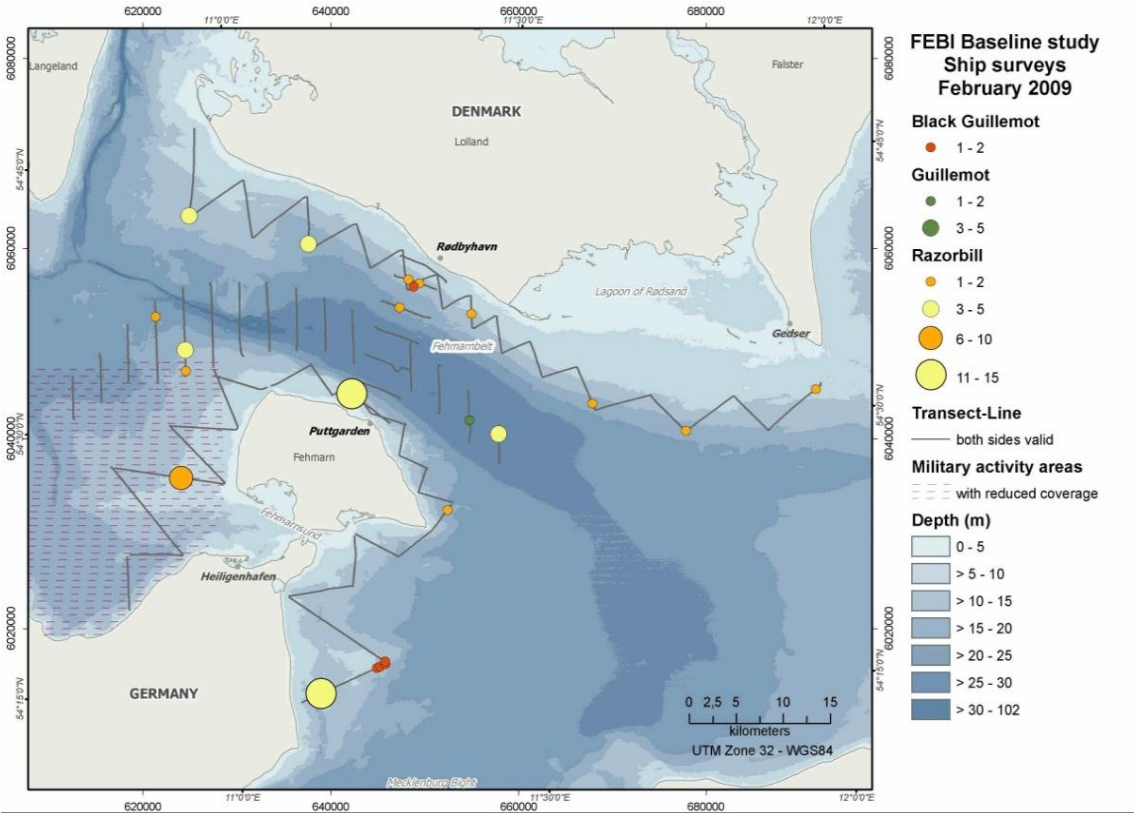


Figure 4.191 Example of observed auk distribution in the study area during the ship-based surveys (February 2009).

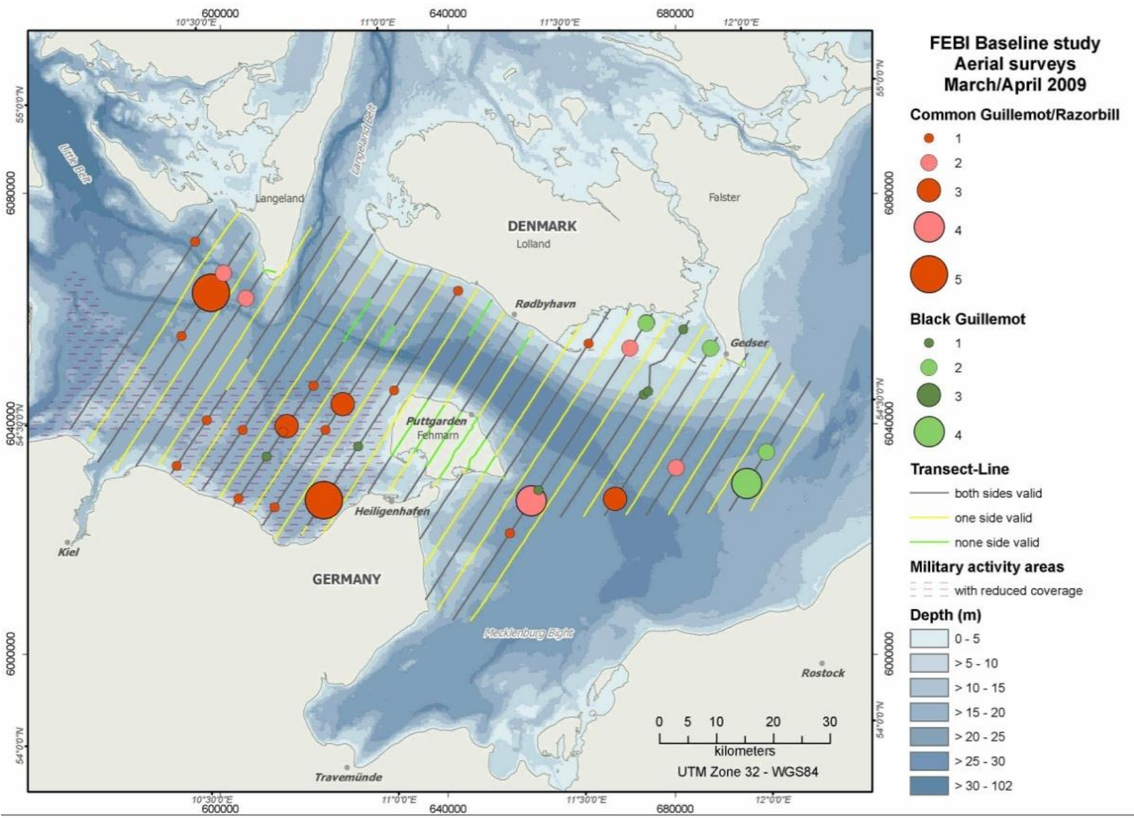


Figure 4.192 Example of observed auk distribution in the study area during aerial surveys (March/April 2009).

Black Guillemot distribution according to supplementary datasets

Rare or no sightings of Black Guillemot obtained by land-based surveys confirm that the species only infrequently occurs in coastal areas of the Fehmarnbelt (AKVSW 2010, DOF 2010, OAG 2010).

Black Guillemot abundance estimates for SPAs

Based on available data no abundance estimates for distinct SPAs were possible. Literature information also does not suggest the presence of internationally important numbers of Black Guillemot in the SPAs within the Fehmarnbelt area (Mendel et al. 2008).

Black Guillemot trends

From 1970 – 1990 the NE Atlantic population declined moderately. However, from 1990 – 2000 the population was stable. Consequently, the European population of Black Guillemot was evaluated as Depleted (BirdLife International 2004). Recent trends in the Baltic breeding population of *C. g. grylle* show steep declines (HELCOM 2009).

Importance of the Fehmarnbelt to the Black Guillemot

The Black Guillemot is a rare wintering bird in the Fehmarnbelt area. However, the Baltic wintering population is small, thus it is assumed that the area is possibly used by 0.1-0.5 % of the biogeographic population (11-53 individuals) during winter.

Black Guillemot – summary of information for EIA	
Max. abundance estimate in Fehmarnbelt:	single birds (max. count: 18 birds)
Max. abundance estimate in the alignment area:	single birds
Period of max. abundance in Fehmarnbelt:	November – March
Areas of max. abundance in Fehmarnbelt:	no aggregation areas identified
Explanations: –	

5 ECOLOGY AND LOCAL MOVEMENTS OF WATERBIRDS IN THE FEHMARNBELT

5.1 Waterbird feeding ecology in the Fehmarnbelt: diet composition

5.1.1 Diet composition of Common Eider

Molluscs dominated the diet of Common Eiders during both study seasons, Blue Mussel being the most common prey item taken by at least 80 % of the dissected birds (Table 5.1, Table 5.2). In terms of wet weight and energetic value of consumed prey, Blue Mussels remained the most important prey type, but other prey also appeared as being important. Crabs contributed 21 % of the total energy intake during the first study season (winter 2008/2009) and, in addition to crabs, gastropods were also important in winter 2009/2010 (Figure 5.1). Blue Mussels ingested by Common Eiders were of similar size during both study seasons, averaging at 14.5±8.4 mm (±SD, N=25 birds, n=2,398 mussels) in winter 2008/2009 and 14.0±7.0 mm (±SD; N=83 birds, n=5,175 mussels) in winter 2009/2010.

Table 5.1 Numeric composition of Common Eider diets in the Fehmarnbelt in winter 2008/2009. Prey individuals represent numbers after accounting for paired structures (e.g. otoliths, jaws). Occurrence identifies number of birds containing certain prey type.

Prey group	Prey species	Prey individuals		Occurrence	
Molluscs	*Mytilus edulis*	2,364	(94.7%)	28	(80.0%)
	Hydrobia ulvae	15	(0.6%)	5	(14.3%)
	Clam unident.	5	(0.2%)	2	(5.7%)
	Cerastoderma edule	4	(0.2%)	2	(5.7%)
	Littorina littorea	2	(0.1%)	2	(5.7%)
Polychaetes	*Nereis diversicolor*	45	(1.8%)	5	(14.3%)
Crustaceans	*Carcinus maenas*	26	(1.1%)	8	(22.9%)
	Balanus sp.	19	(0.8%)	3	(8.6%)
Echinoderms	*Asterias sp.*	8	(0.3%)	3	(8.6%)
Fish	Fish unident.	3	(0.1%)	2	(5.7%)
	Gobius sp.	4	(0.2%)	4	(11.4%)
Algae	Sea weed	1	(0.0%)	1	(2.9%)
TOTAL		2,496	(100%)	35	(100 %)

Table 5.2 Numeric composition of Common Eider diets in the Fehmarnbelt in winter 2009/2010. Prey individuals represent numbers after accounting for paired structures (e.g. otoliths, jaws). Occurrence identifies number of birds containing certain prey type.

Prey group	**Prey species**	**Prey individuals**		**Occurrence**	
Molluscs	*Mytilus edulis*	5,402	(88.7%)	87	(87.0%)
	Hydrobia ulvae	225	(3.7%)	14	(14.0%)
	Littorina sp.	112	(1.8%)	23	(23.0%)
	Buccinum undatum	83	(1.4%)	4	(4.0%)
	Clam unident.	55	(0.9%)	6	(6.0%)
	Astarte sp.	50	(0.8%)	5	(5.0%)
	Mya sp.	20	(0.3%)	4	(4.0%)
	Neptunea sp.	20	(0.3%)	2	(2.0%)
	Cerastoderma sp.	6	(0.1%)	5	(5.0%)
	Modiolus barbatus	5	(0.1%)	1	(1.0%)
	Arctica islandica	3	(0.0%)	1	(1.0%)
	Mussel unident.	1	(0.0%)	1	(1.0%)
Crustaceans	*Carcinus maenas*	38	(0.6%)	12	(12.0%)
	Gammarus sp.	30	(0.5%)	1	(1.0%)
	Idotea baltica	26	(0.4%)	2	(2.0%)
Echinoderms	*Asterias sp.*	5	(0.1%)	3	(3.0%)
Fish	Fish unident.	4	(0.1%)	2	(2.0%)
	Gobius sp.	1	(0.0%)	1	(1.0%)
Polychaetes	Polychaete unident.	2	(0.0%)	2	(2.0%)
TOTAL		6,088	(100%)	100	(100%)

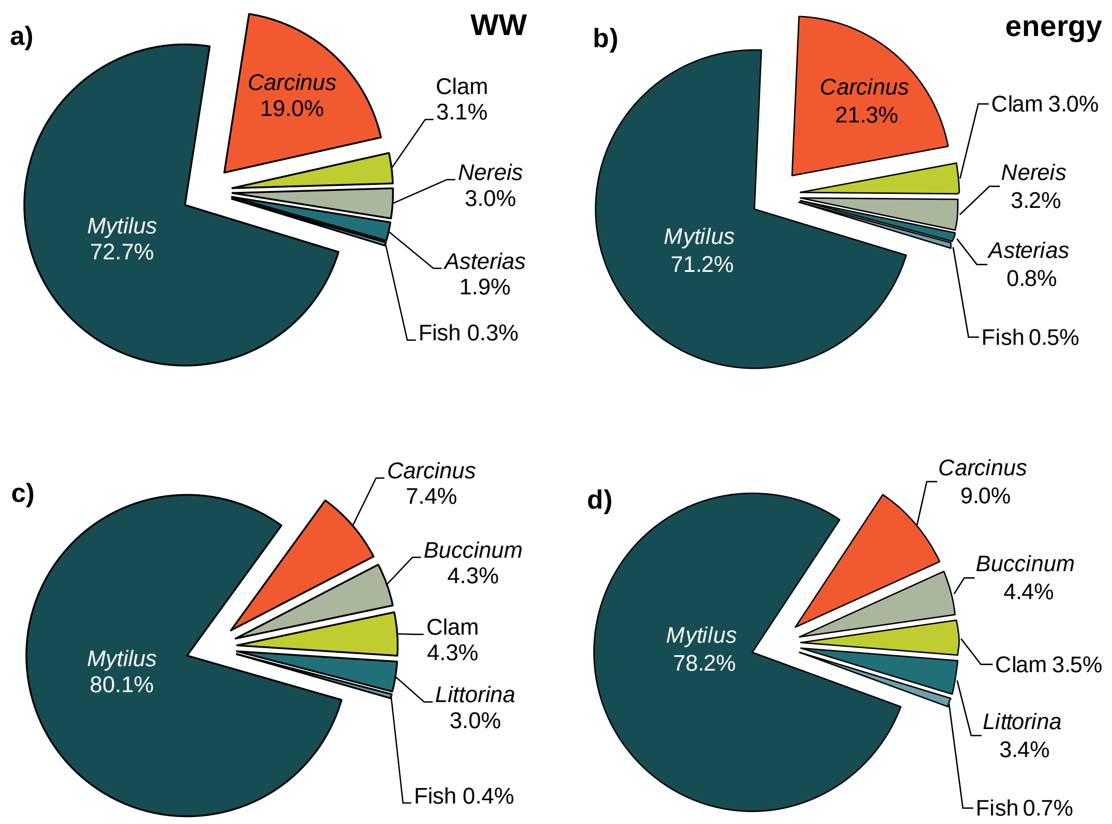


Figure 5.1 Overall diet composition of Common Eiders in the Fehmarnbelt in two subsequent winters (a-b: 2008/2009, c-d: 2009/2010) according to estimated wet weight (WW; charts a, c) and energy content of prey (energy; charts b, d); n=35 (2008/2009), n=100 (2009/2010).

5.1.2 Diet composition of Common Scoter

Only 4 Common Scoters were collected for diet analysis in winter 2008/2009, but with 55 birds the sample size was adequate in the subsequent winter (n=57). The few birds which were examined during the first winter season were eating predominantly Blue Mussels, whereas clams dominated Common Scoter diet numerically in winter 2009/2010 (Table 5.3, Table 5.4). The estimated wet weight of ingested prey and energy value also suggested that clams were more important than Blue Mussels in the diet of Common Scoter in winter 2009/2010 (Figure 5.2). In terms of size of ingested bivalves, birds consumed extremely small clams, which sizes averaged at 5.6±2.3 mm (±SD; N=34 birds, n=10,512 clams). The average size of ingested Blue Mussels was 9.6±2.5 mm (±SD; N=24 birds, n=2,962 mussels).

Table 5.3 Numeric composition of prey items in diets of Common Scoters (n=4) in the Fehmarnbelt in winter 2008/2009. Prey individuals represent numbers after accounting for paired structures (e.g. jaws). Occurrence identifies number of birds containing certain prey type.

Prey group	Prey species	Prey individuals		Occurrence
Molluscs	*Mytilus edulis*	130	(92.2%)	3
	Clam unident.	1	(0.7%)	1
	Macoma baltica	2	(1.4%)	1
Polychaetes	*Nereis sp.*	8	(5.7%)	2
TOTAL		141	(100%)	4

Table 5.4 Numeric composition of prey items in diets of Common Scoters (n=55) in the Fehmarnbelt in winter 2009/2010. Prey individuals represent numbers after accounting for paired structures (e.g. jaws). Occurrence identifies number of birds containing certain prey type.

Prey group	Prey species	Prey individuals		Occurrence	
Molluscs	*Cerastoderma sp.*	9,157	(65.8%)	32	(58.2%)
	Astarte sp.	1,021	(7.3%)	29	(52.7%)
	Macoma baltica	444	(3.2%)	18	(32.7%)
	Mya sp.	17	(0.1%)	2	(3.6%)
	Ensis sp.	3	(0.0%)	3	(5.5%)
	Clam unident.	295	(2.1%)	11	(20.0%)
	Mytilus edulis	2,962	(21.3%)	24	(43.6%)
	Hydrobia sp	8	(0.1%)	5	(9.1%)
	Littorina sp.	5	(0.0%)	5	(9.1%)
	Neptunea sp.	1	(0.0%)	1	(1.8%)
	Snail unident.	2	(0.0%)	2	(3.6%)
Polychaetes	Polychaete unident.	1	(0.0%)	1	(1.8%)
TOTAL		13,916	(100%)	55	(100%)

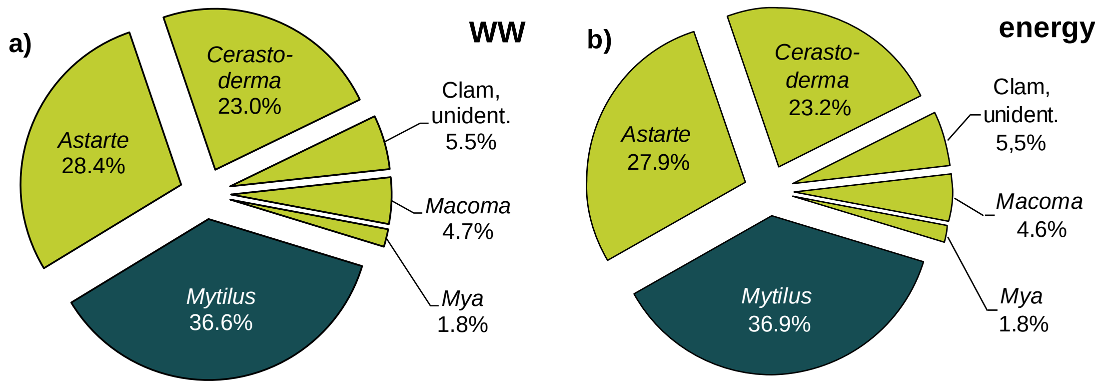


Figure 5.2 Average diet composition of Common Scoters in the Fehmarnbelt in winter 2009/2010 according to estimated prey wet weight (WW; chart a) and energy content (b); n=55.

5.1.3 Diet composition of Long-tailed Duck

The diet composition of Long-tailed Ducks was highly variable and differed between the two study seasons. Blue Mussels were numerically the most common prey species comprising 37 % in 2008/2009 and 76 % in 2009/2010. The second most frequent prey was fish in 2008/2009, and clams in 2009/2010 (Table 5.5, Table 5.6). Bivalves ingested by Long-tailed Ducks were rather small during both winter seasons. The average length of Blue Mussels was 6.7±1.8 (±SD, N=9 birds, n=274 mussels) and 7.5±2.8 mm (±SD, N=42 birds, n=8,206 mussels) and average length of clams was 5.5±1.9 mm (±SD; N=14 birds, n=1,053 mussels) in winter 2009/2010.

Gobies (mean length 51.4±9.2 mm in 2008/2009, 53.6±7.8 mm in 2009/2010) and sandeels (mean length 103.0±25.3 mm; ±SD in 2008/09) made up the biggest part of the fish in the diet of Long-tailed Ducks. According to calculated wet weight and energy contents of prey, the diet composition of Long-tailed Ducks was dominated by fish in winter 2008/2009 and by Blue Mussels in winter 2009/2010 (Figure 5.3).

Table 5.5 Numeric composition of Long-tailed Duck diets in the Fehmarnbelt in winter 2008/2009. Prey individuals represent numbers after accounting for paired structures (e.g. otoliths, jaws). Occurrence identifies number of birds containing certain prey type.

Prey group	Prey species	Prey individuals		Occurrence	
Molluscs	*Mytilus edulis*	275	(37.2%)	10	(62.5%)
	Clam unident.	223	(30.2%)	10	(62.5%)
	Macoma baltica	4	(0.5%)	2	(12.5%)
	Mya sp.	4	(0.5%)	2	(12.5%)
	Hydrobia ulvae	5	(0.7%)	3	(18.8%)
Fish	*Ammodytes tobianus*	57	(7.7%)	6	(37.5%)
	Gobiidae	103	(13.9%)	11	(68.8%)
	Gasterosteus aculeatus	5	(0.7%)	1	(6.3%)
Crustaceans	*Crangon sp.*	22	(3.0%)	7	(43.8%)
	Idotea baltica	3	(0.4%)	1	(6.3%)
Polychaetes	*Nereis sp.*	37	(5.0%)	6	(37.5%)
TOTAL		739	(100%)	16	(100%)

Table 5.6 Numeric composition of Long-tailed Duck diets in the Fehmarnbelt in winter 2009/2010. Prey individuals represent numbers after accounting for paired structures (e.g. otoliths, jaws). Occurrence identifies number of birds containing certain prey type.

Prey group	Prey species	Prey individuals		Occurrence	
Molluscs	*Mytilus edulis*	9,249	(75.7%)	44	(80.0%)
	Cerastoderma	1,768	(14.5%)	12	(21.8%)
	Astarte sp.	611	(5.0%)	13	(23.6%)
	Macoma baltica	122	(1.0%)	3	(5.5%)
	Clam unident.	63	(0.5%)	1	(1.8%)
	Abra alba	24	(0.2%)	2	(3.6%)
	Arctica islandica	6	(0.0%)	2	(3.6%)
	Ensis sp.	2	(0.0%)	1	(1.8%)
	Hydrobia sp.	118	(1.0%)	16	(29.1%)
	Littorina sp.	16	(0.1%)	9	(16.4%)
Crustaceans	*Gammarus sp.*	161	(1.3%)	3	(5.5%)
	Idotea baltica	21	(0.2%)	7	(12.7%)
	Carcinus sp.	5	(0.0%)	2	(3.6%)
Fish	Gobiidae	39	(0.3%)	4	(7.3%)
Polychaetes	*Polychaete* unident.	9	(0.1%)	5	(9.1%)
TOTAL		12,214	(100%)	55	(100%)

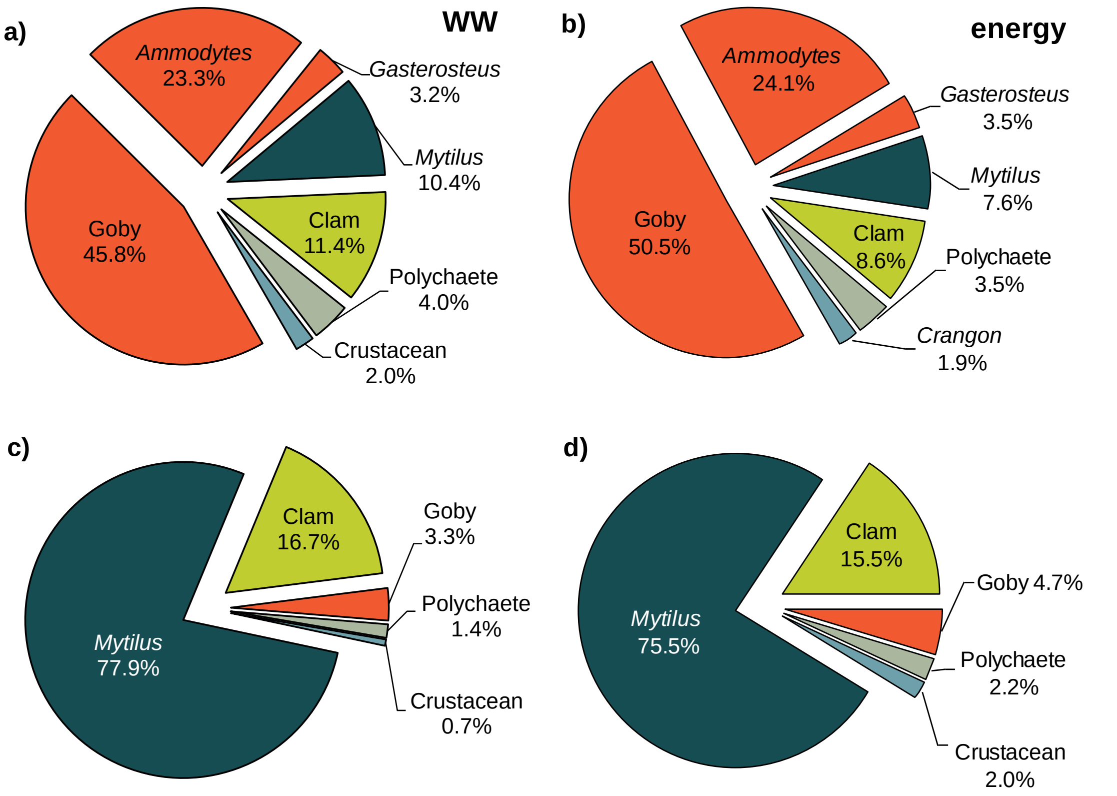


Figure 5.3 Average diet composition of Long-tailed Ducks in the Fehmarnbelt in winters 2008/2009 (a-b) and 2009/2010 (c-d) according to estimated prey wet weight (WW; chart a, c) and energy content (b, d); n=16 (2008/2009), n=54 (2009/2010).

5.1.4 Diet composition of Tufted Duck

Only two Tufted Ducks were obtained for stomach analysis with one bird in the winter 2008/2009 and another in the winter 2009/2010. Both birds drowned in fishing nets. The bird collected during the first winter contained fragments of gastropods and bivalve molluscs were identified in its gizzard: *Hydrobia ulvae* (n=288), *Dreissena polymorpha* (n=25), *Mytilus edulis* (n=3), *Cerastoderma edule* (n=1) and *Littorina sp*. (n=1). The other bird collected in winter 2009/2010 contained fragments only of *Mytilus edulis* (n=6).

Additional information about diet composition of Tufted Duck was obtained by analysing droppings of ducks that were captured for telemetry investigations. Three dropping samples collected at different locations indicated that birds used both marine and freshwater (or brackish) areas for foraging. Small gastropod *Hydrobia* was the most frequent prey item. These samples also contained remains of large molluscs *Mytilus edulis* and *Dreissena polymorpha*, the first being marine bivalve and the second originating from fresh or brackish water (Figure 5.4, Table 5.7). Additionally there were fragments of clams and gastropods larger than *Hydrobia* (most likely *Littorina*). Plant seeds and other plant matter were found in one sample.

Both stomach analysis and droppings revealed the same prey items comprising the diet of Tufted Ducks. It appears that Tufted Ducks forages in marine as well as fresh water habitats, and specialises on small molluscs especially *Hydrobia* snails.

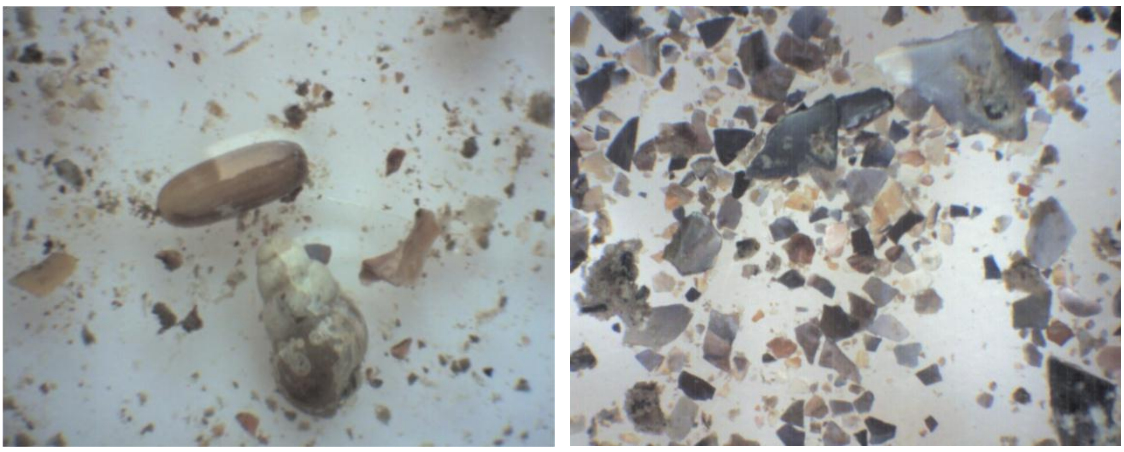


Figure 5.4 Photographs of prey items in Tufted Duck dropping samples taken through a microscope: plant seed (2 mm long) and Hydrobia snail (left picture) and Mytilus edulis shell fragments (right picture).

One Tufted Duck was observed at Burgstaaken (Fehmarn) on March 12, 2010, eating fish that it brought to the surface. This is assumed to be rather unusual foraging behaviour for Tufted Ducks and might be explained by cold water temperatures during that time, enabling Tufted Ducks to catch fish that became slow due to very low ambient temperature.

Table 5.7 Identified prey items in three dropping samples of Tufted Ducks, collected in the Fehmarnbelt area.

Sample No (number of ind)	Location	Identified prey	Comments
#1 (1 individual)	Hirsbosøerne, Rødbyhavn	*Hydrobia sp.*	frequent prey item
		Mytilus edulis	frequent prey item
		Dreissena polymorpha	frequent prey item
		Clams unidentified	few fragments
		Gastropods unidentified	few fragments
		sand	
#2 (7 individuals)	Lake at Strandby	*Hydrobia sp.*	frequent prey item
		Dreissena polymorpha	frequent prey item
		Gastropods unidentified	few fragments
		Plant seeds	frequent item
		Unidentified plant matter	few fragments
		sand	
#3 (7 individuals)	Fehmarnsund	*Mytilus edulis*	frequent prey item
		Hydrobia sp.	few specimens
		Gastropods unidentified	few fragments
		Clams unidentified	few fragments
		sand	

5.1.5 Diet composition of seaducks according to stable isotope analysis

Plotting averaged values of stable isotope measurements provided a rather clear distribution of isotopic signatures of waterbirds and their prey, especially along the $\delta^{15}N$ axis representing the trophic levels (Figure 5.5). Consumers of primary production appeared on the lowest level of $\delta^{15}N$ ranging between 4-7‰ (*Mytilus*, Amphipods, Isopods, *Littorina* snails). Higher up were lower level carnivores 8-10‰ (*Asterias, Carcinus*), followed by seaducks, small fish and carnivorous snails (*Buccinum*) 11-13‰; and fish eating birds were at the highest trophic level as indicated by isotopic signatures of $\delta^{15}N$ ranging between 15-18 ‰ (Figure 5.5). Samples of soft-shell clams (*Macoma* and *Mya*) were not obtained from the Fehmarnbelt, but literature suggests that their $\delta^{15}N$ values are similar to those of Blue Mussels. Nordström et al. (2009) found no significant difference between *Mytilus edulis* and *Macoma baltica*. We therefore assumed close similarity in trophic levels of Blue Mussel and soft-shell clams.

Stable isotope composition did not differ significantly among 4 studied duck species according to $\delta^{15}N$ (one-way ANOVA: $F_{3,388}=0.17$, $P=0.92$), but differences were significant according to $\delta^{13}C$ (one-way ANOVA: $F_{3,388}=15.59$, $P<0.01$; Figure 5.5).

These results suggest that on average all 4 duck species forage at the same trophic level. Seaducks most likely rely primarily on Blue Mussels. Higher carbon enrichment in Common Scoter supports stomach analysis indicating that part of the diet for this species originates from other sources, most likely clams. Neither of the isotopes supported the findings of stomach analysis that fish made up an important part of the nutrient income for Long-tailed Ducks, and snails for Common Eider compared to other duck species. Higher $\delta^{13}C$ enrichment in Tufted Ducks indicates other nutrient sources than Blue Mussels, most likely *Hydrobia* snails and/or *Dreissena* mussels.

Because stomach analysis showed distinct differences in diet composition between the two winter seasons, stable isotope composition was also analysed separately for both periods. In general, $\delta^{15}N$ values indicate that diets of all duck species were more enriched in winter 2008/2009 compared to winter 2009/2010 (Figure 5.6).

Differences were significant according to $\delta^{15}N$ values for Long-tailed Duck (t_{93}=2.95, P<0.01) and Common Eider (t_{214}=3.14, P<0.01), but did not differ for Common Scoter (t_{61}=0.77, P=0.77). Differences were not significant according to $\delta^{13}C$ between the two years for all 3 seaduck species. Sample size of Tufted Ducks was insufficient for comparison between the two seasons.

This slight and for some species significant difference in $\delta^{15}N$ enrichment indicates that bird diets included more items of higher trophic level during the winter 2008/2009 compared to 2009/2010. But nevertheless, the overall trophic level was similar indicating that filter feeding bivalves comprised the staple food for seaducks (excluding the Tufted Duck) during the both study seasons.

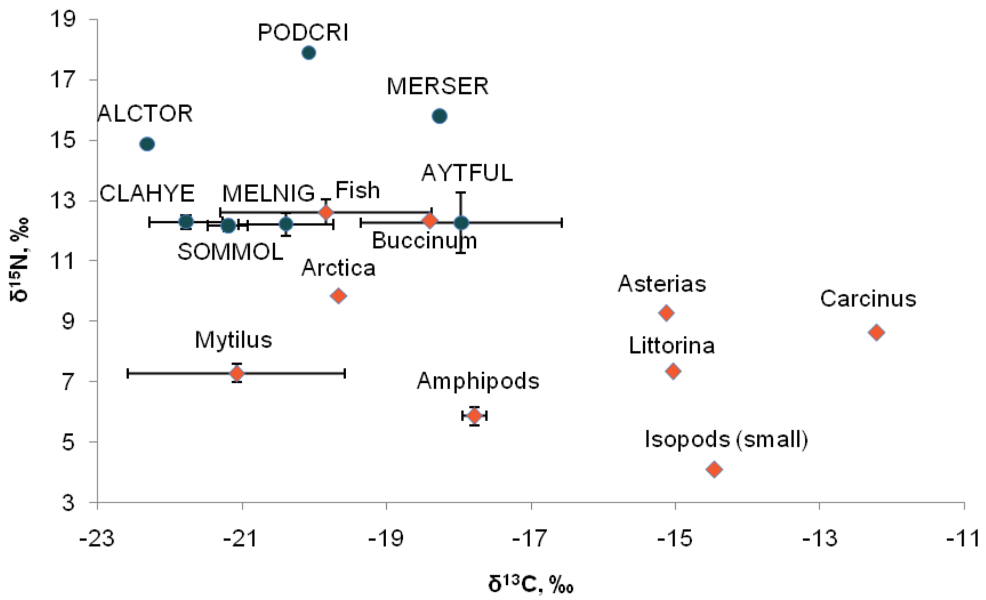


Figure 5.5 *Average values and 95 % confidence intervals of stable isotope $\delta^{15}N$ and $\delta^{13}C$ measurement in waterbird blood samples and potential prey types in the Fehmarnbelt. Birds are represented by blue circles and prey objects by orange diamonds. Abbreviations: ALCTOR – Razorbill* Alca torda*, PODCRI – Great Crested Grebe* Podiceps cristatus*, MERSER – Red-breasted Merganser* Mergus serrator*, CLAHYE – Long-tailed Duck* Clangula hyemalis*, SOMMOL – Common Eider* Somateria mollissima*, MELNIG – Common Scoter* Melanitta nigra*, AYTFUL – Tufted Duck* Aythya fuligula*.*

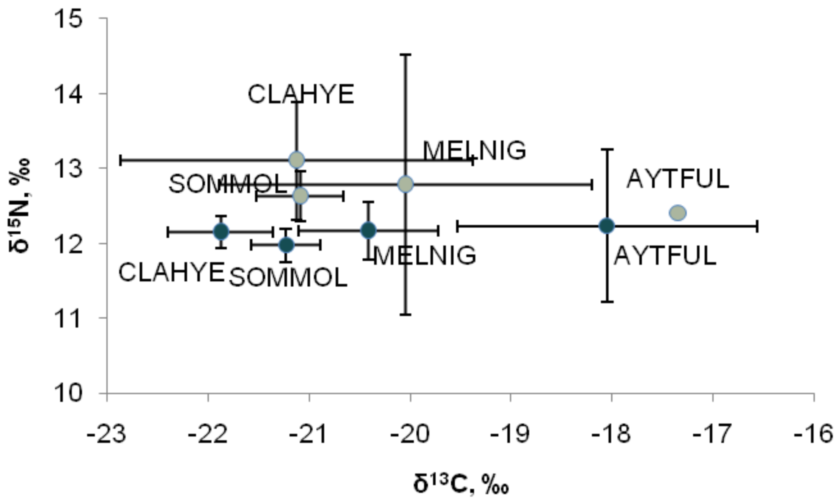


Figure 5.6 *Average values and 95 % confidence intervals of stable isotope δ[15]N and δ[13]C measurements in blood samples of four duck species wintering in the Fehmarnbelt during winters 2008/2009 (grey circles) and 2009/2010 (blue circles). See previous Figure for abbreviations.*

5.1.6 *Body condition of seaducks in two winter seasons*

Aiming to compare foraging conditions during the two wintering seasons, body condition of Common Eider males (the most numerous cohort) was assessed using two independent samples: body weight of birds caught for telemetry study, and fat score assessment (range: 0-9; 0 – no fat, 9 – a lot of fat) of birds collected for stomach analysis.

Neither of these metrics indicated significant differences in body weight (t_{49}=-0.12, P=0.90) or fat score (t_{132}=-0.88, P=0.38) between the two wintering seasons (Figure 5.7).

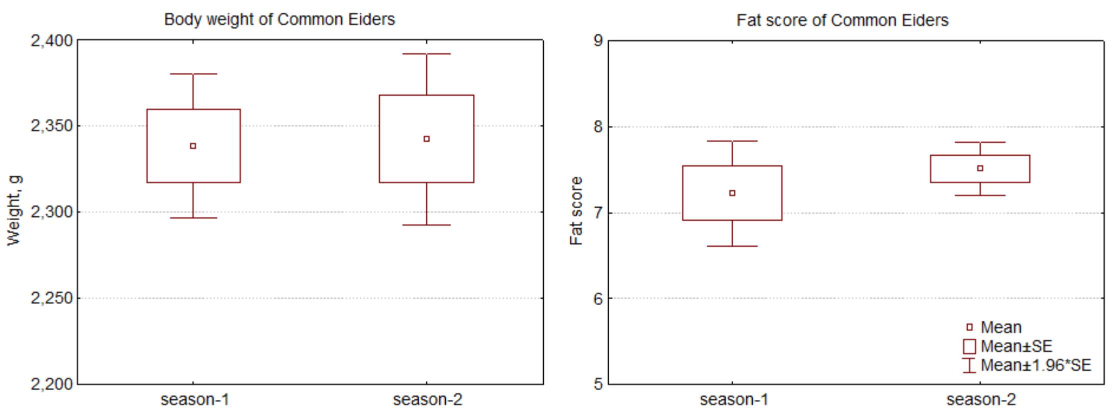


Figure 5.7 *Average body weight and associated variability of captured Common Eider males, and fat score of dissected Common Eider males during the two study seasons (winters 2008/2009 and 2009/2010).*

5.1.7 *Discussion on seaduck diet composition*

The baseline investigations revealed that the Blue Mussel *Mytilus edulis* was the most important prey for Common Eider, Common Scoter and Long-tailed Duck in the Fehmarnbelt. These findings concur with the fact that Blue Mussel is the most abundant and dominant species of benthic macrofauna in the study area (FEMA

2013a) and agree with literature on seaduck diet composition in the western Baltic. Blue Mussel was described as the primary prey of Common Eiders in the Inner Danish waters (Madsen 1954, Asferg 1989, Skov et al. 1998), and the German coast of the Baltic Sea (Kirchhoff 1979, Meissner 1992).

In the Fehmarnbelt Common Eider consistently fed on relatively small mussels of an average size of 14 mm. The literature indicates that bivalve size selected by Common Eiders vary from place to place. The majority of studies report mussel size ranging between 12-25 mm (Kirchhoff 1979, Nyström et al. 1991, Meissner 1992, Kallenborn et al. 1994; Merkel et al. 2007). Guillemette et al. (1992) found that small mussels averaging at 10 mm dominated Common Eider diet in the Gulf of St. Lawrence; and Common Eiders staging in the Wadden Sea were found foraging mostly on large mussels of up to 66 mm (Nehls 1995, Scheiffarth and Frank 2006). Bustnes (1998) suggested that 13 mm mussels selected by Common Eiders in northern Norway represent individuals with the lowest relative shell amount and highest relative energy content. The relatively large proportion of *Carcinus* crabs in Common Eider diet in 2008/2009 may indicate limitations of their primary food resource (Blue Mussel) during that winter. This kind of diet shift has been observed for Common Eiders in other regions and was described as foraging strategy in poor conditions (Guillemette et al. 1992, Systad et al. 2000).

Long-tailed Duck diet composition during the same two winters corroborates the opinion that seaducks experienced limited Blue Mussel availability in winter 2008/2009. While Long-tailed Duck diet consisted primarily of Blue Mussels in 2009/2010; 77 % of the estimated energy uptake came from fish in winter 2008/2009. Long-tailed Ducks are known as being generalist foragers and take a broad range of prey including gastropods (Stott and Olson 1973, Bustnes and Systad 2001), crustaceans (Peterson and Ellarson 1977, Vermeer and Levings 1977, Jamieson et al. 2001, White et al. 2009), and bivalves, which are described as being the main prey type in the Baltic Sea (Madsen 1954, Mathiasson 1970, Nilsson 1972, Kirchhoff 1979, Böhme 1992, Stempniewicz 1995, Kube 1996, Evert 2004, Žydelis and Ruškytė 2005). Fish has also been reported as being an important food item for Long-tailed Ducks (Madsen 1954, Stempniewicz 1995, Skov et al. 1998), but not to such a large degree as observed in the Fehmarnbelt in winter 2008/2009. Many authors agree that Long-tailed Ducks are opportunistic foragers (Peterson and Ellarson 1977, Goudie and Ankney 1986, Bustnes and Systad 2001, Žydelis and Ruškytė 2005), therefore the species is flexible in exploiting the most profitable food resources, as it likely happened in winter 2008/2009 when Long-tailed Ducks fed mainly on gobies and sandeels instead of their usual prey Blue Mussels in the Fehmarnbelt. Size distribution of ingested bivalves in the Fehmarnbelt coincided with observations of other studies in the Baltic Sea (Madsen 1954, Kirchhoff 1979, Böhme 1992, Skov et al. 1998, Žydelis 2002).

Too few Common Scoters have been collected for diet analysis in winter 2008/2009, therefore findings cannot be generalised as representing food choice of the species during that season. It was found that Common Scoters almost exclusively relied on bivalves in the Fehmarnbelt. This agrees with general diet composition of this species reported in literature (Madsen 1954, Stempniewicz 1986, Meissner and Bräger 1990, Meissner 1992, Evert 2004), although Žydelis (2002) documented Common Scoters additionally feeding on polychaetes and large isopods at the Lithuanian coast of the Baltic Sea. In the Fehmarnbelt Common Scoters were found feeding mostly on clams (particularly *Cerastoderma* and *Astarte*) and Blue Mussels in winter 2009/2010. Literature on Common Scoters in the Baltic Sea indicates Common Scoters forages on a wide range of bivalve species, depending on dominant benthic community (Skov et al. 1998, Žydelis 2002). In Hohwacht Bay Kirchhoff (1979) recorded Common Scoters predominately feeding on small sized *Cerastoderma spp*. (year class 0); and Meissner (1992) described the diet composition varying depending on season and location, with *Cerastoderma spp.*, *Mytilus edulis*, *Arctica islandica* and *Mya arenaria* appearing as dominant species. Size distribution of bivalves found in Common Scoter stomachs in the Fehmarnbelt in 2009/2010 follows a similar pattern as described by Kirchhoff (1979) with very small sized specimens dominating the diet. But few samples of winter 2008/2009 and other studies indicate that this species can also feed on larger bivalves (e.g., Meissner 1992, Evert 2004).

The present diet study on these three most abundant seaduck species wintering in the Fehmarnbelt indicated that each species has plasticity to adapt to changing foraging conditions. Benthic communities are dynamic and food limiting conditions can occur naturally, subsequently forcing ducks to shift to an alternative prey. The three seaduck species, Common Eider, Common Scoter and Long-tailed Duck, relied mostly on bivalve diet during the two wintering seasons of the baseline investigations.

Both diet assessment methods, examination of stomach contents and stable isotope analysis, indicated that foraging conditions were different between the two seasons. Although the results of stomach analyses suggested that the diet composition of Long-tailed Duck and Common Eider included substantial proportions of other prey than bivalves during the first study season (winter 2008/2009), stable isotope analysis supported such findings only partly. Reliance of Long-tailed Ducks mostly on fish diet in winter 2008/2009 is unlikely, but higher trophic level foods certainly comprised higher proportion in winter 2008/2009 compared to winter 2009/2010.

Despite the detected differences in diet composition between the two seasons, body condition of male Common Eiders also did not differ between the two wintering seasons.

5.1.8 Diet composition of Mute Swans

Qualitative analysis of Mute Swan diet composition revealed that these birds rely on four species of submerged vegetation in Rødsand Lagoon during the summer moulting period: *Zostera marina*, *Ruppia spp.*, *Potamogeton pectinatus* and *Zannichelia palustris*. The amount of plant epidermis cells identified in swan droppings indicated equal shares of *Zostera* and *Potamogeton* constituting 37 % each in averaged samples of the two study seasons (Figure 5.8). However, diet composition could be varying by year, as substantially more *Ruppia* and less *Potamogeton* were detected in 2010 compared to 2009 (Figure 5.8). It should be stressed, however, that quantification of epidermis cells in bird droppings does not allow evaluating quantities or proportions of different plant species. This is merely a relative index of occurrence, which represents types or species of submerged vegetation which are consumed by birds in substantial quantities.

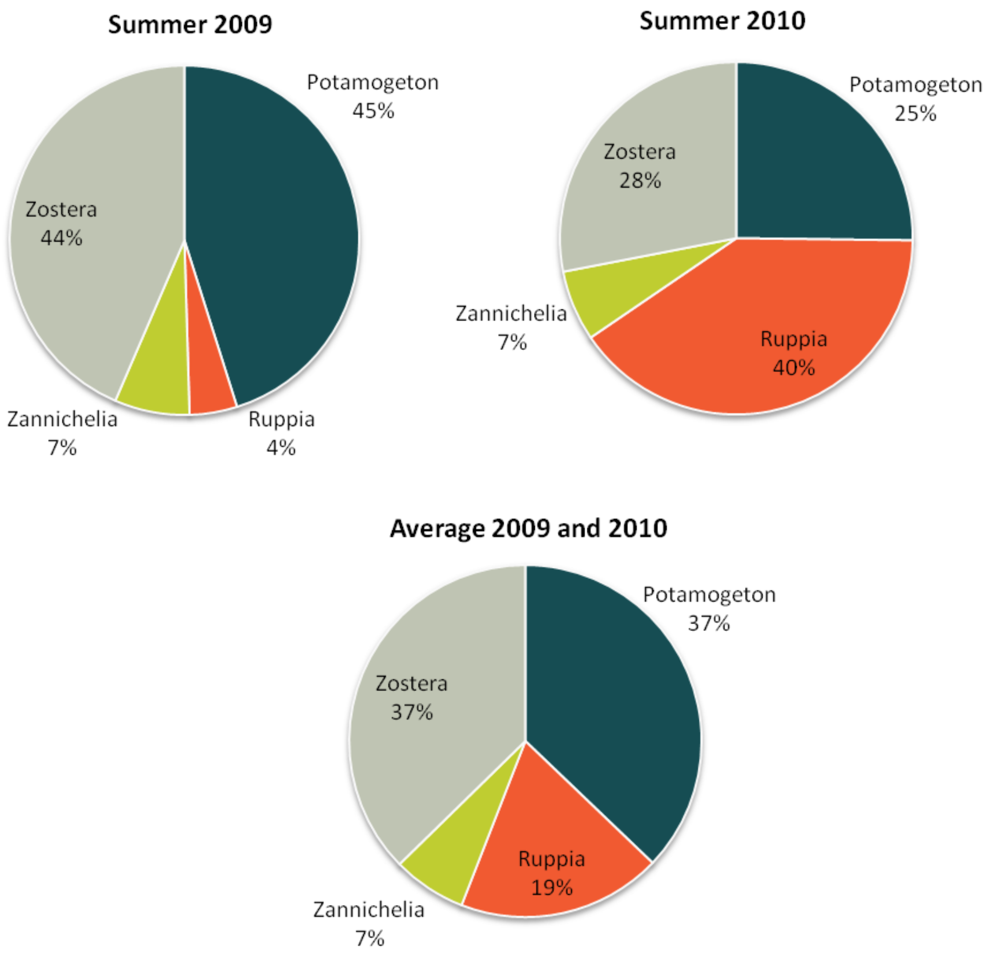


Figure 5.8 *Diet composition of Mute Swans moulting in Rødsand Lagoon according to the area of epidermis cells of different species of aquatic vegetation as identified in bird droppings.*

Moulting mute swans around Saltholm in Øresund were found using habitats with the same species of submerged vegetation (*Zostera*, *Ruppia* and *Potamogeton*) as found in the swan diet in Rødsand Lagoon during this study (Clausen et al. 1995, 1996).

5.1.9 Diet composition of Great Cormorants

A total of 1,015 otoliths were found in a subsample consisting of 110 distinct pellets and 2 samples of a non-separated mix of several pellets. Thirteen fish species of 7 families were identified, which represented marine fish only (Table 5.8). Cod and other species of *Gadidae* family were the most common prey found in Great Cormorants diet in the Fehmarnbelt (61 %). Size distribution of *Gadus morhua* shows that birds fed mainly on small Cod with 50 % of ingested fish being lighter than 100 g (Figure 5.9).

Table 5.8 Fish species, their estimated sizes and abundance as identified in Great Cormorant diet in the Fehmarnbelt during May 2009 – June 2010. Fish size and mass estimated from otolith size found in collected regurgitates. Occurrence identifies number of regurgitates containing certain fish type.

Scientific name	Fish length mean (min-max), cm	Fish mass mean (min-max), g	Fish individuals (%)	Occurrence (%)
Gadidae				
Gadidae unident.			68 (6.7%)	17 (24.1%)
Gadus morhua	22.8 (7.3-39.3)	130.5 (4.9-597.0)	541 (53.3%)	83 (69.6%)
Merlangius merlangus	15.1 (10.8-21.1)	30.4 (9.3-75.4)	11 (1.1%)	4 (3.6%)
Gobiidae				
Gobiidae unident.			16 (1.6%)	11 (9.8%)
Gobius niger	7.9 (3.7-11.5)	7.2 (0.5-21.6)	160 (15.8%)	31 (27.7%)
Pomatoschistus minutus	6.9 (4.7-10.4)	4.1 (1.0-9.9)	6 (0.6%)	5 (4.5%)
Pomatoschistus microps	5.0	1.4	1 (0.1%)	1 (0.9%)
Pleuronectidae				
Pleuronectidae unident.			17 (1.7%)	9 (8.0%)
Pleuronectes platessa	14.3 (7.9-22.2)	32.7 (5.2-109.7)	26 (2.6%)	16 (14.3%)
Limanda limanda	15.0 (7.4-22.6)	37.8 (3.6-121.8)	49 (4.8%)	17 (15.2%)
Platichthys flesus	12.5 (7.9-17.4)	18.8 (5.0-38.4)	6 (0.6%)	2 (1.8%)
Glyptocephalus cynoglossus	18.5 (15.4-21.6)	132.8 (70.1-194.3)	2 (0.2%)	2 (1.8%)
Hippoglossoides platessoides	16.0	28.8	1 (0.1%)	1 (0.9%)
Ammodytidae				
Ammodytidae unident.	14.4 (6.3-19.2)	8.7 (1.0-20.0)	90 (8.9%)	10 (8.9%)
Cottidae				
Myoxocephalus scorpius	14.5 (9.5-18.4)	52.6 (13.6-99.3)	14 (1.4%)	7 (6.3%)
Pholidae				
Pholis gunnellus	19.4 (14.4-24.4)	43.9 (11.6-76.2)	2 (0.2%)	2 (1.8%)
Trachiidae				
Trachinus draco			4 (0.4%)	2 (1.8%)
Fish unidentified			1 (0.1%)	1 (0.9%)
TOTAL			1,015 (100%)	112 (100%)

Typically the recovery rate is the highest for the relatively large, thick and sturdy otoliths from gadoids and the lowest for the smaller, more fragile and thin otoliths from Herring (*Clupea harengus*) and Sprat (*Sprattus sprattus*). In this study no otoliths of the latter two species were found.

Although cormorant diet was relatively diverse in terms of species occurrence, *Gadidae* fish dominated the diet composition in terms of calculated fish mass constituting 92.4 % (Figure 5.10).

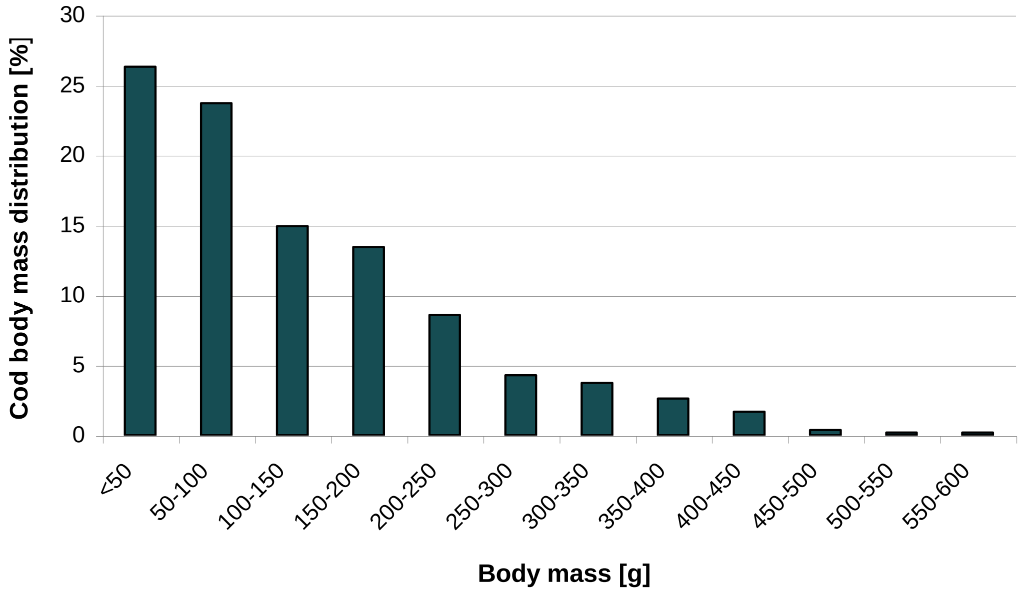


Figure 5.9 Size distribution of Cod Gadus morhua *in the diet of Great Cormorants in the Fehmarnbelt in May 2009 – June 2010. Fish size estimated from otoliths (n=536) found in regurgitated pellets.*

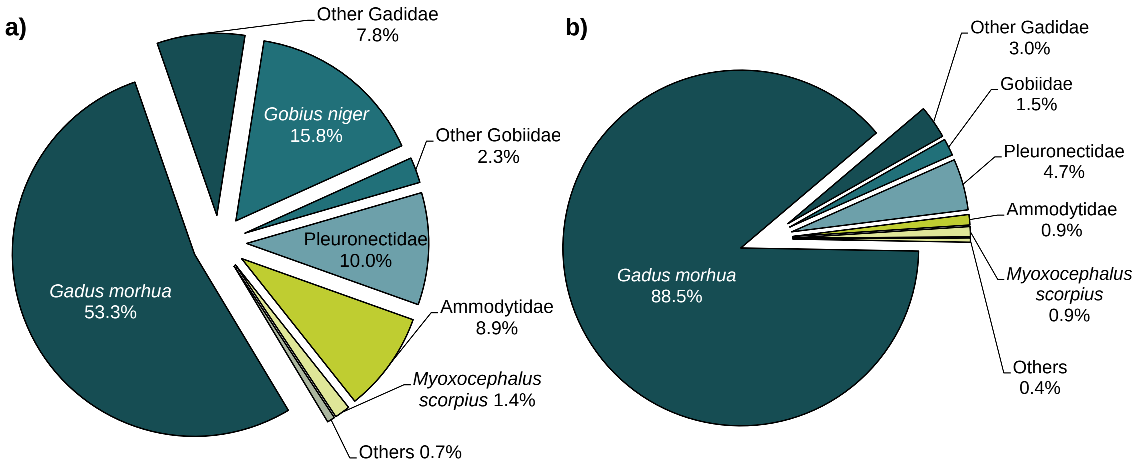


Figure 5.10 Great Cormorant diet composition in the Fehmarnbelt according to numbers of identified fish species (left chart, a) and estimated fish mass (right chart, b).

Cormorants are considered to be opportunistic foragers, meaning that their diet composition is determined by relative availability of fish (Martucci and Consiglio 1991, Keller 1995, Suter 1997). Nearly all fish taken by Great Cormorants in the Fehmarnbelt represent benthic fish species. FeBEC (2013) reported that Cod was one of the dominating fish species in the Fehmarnbelt area in terms of abundance and biomass. Frequency distribution of other prey species taken by cormorants during this study generally matched fish abundance as reported by FeBEC (2013), where Dab (*Limanda limanda*), Whiting (*Merlangius merlangus*) and Flounder (*Platichthys flesus*) were found to be the dominating fish species in the Fehmarnbelt area in addition to Cod (*Gadus morhua*).

Kieckbusch and Koop (1996) analysed pellets of Great Cormorants from different roosts and breeding sites in Schleswig-Holstein, where cormorants fed on inland and marine waters. They found that the diet of cormorants foraging in the Baltic Sea mainly consisted of Cod (*Gadus morhua*), Eelpout (*Zoarces viviparus*), Bull-rout (*Myoxocephalus scorpius*) and Black Goby (*Gobius niger*), which also agrees with findings of our study.

5.1.10 *Diet composition of other species*

In addition to the species presented above there were two Great Crested Grebes, two Red-breasted Mergansers and one Razorbill received from fishermen for diet analysis. These birds drowned in gillnets. One of the Great Crested Grebes, which was received in winter 2008/2009 had an empty stomach with no identifiable diet remains. The other Great Crested Grebe contained remains of polychaetes (jaws) and unidentified fish (fish eyes) (Table 5.9). In 2008/2009 two Red-breasted Mergansers were collected and each of them contained only fish remains. One bird fed on sticklebacks (mean size: 35.4 mm ± 14.20 mm SD), the other bird contained gobies (mean size: 78.5 mm ± 25.22 mm SD; Table 5.9). The Razorbill was filled up with more than 1,000 Two-spotted Gobies *Gobiusculus flavescens* (mean size: 27.4 mm ± 3.65 mm SD), adding up to 111 g fresh mass of fish, which equalled to 10 % of the bird's body weight after subtraction of ingested fish mass (1,113 g) (Table 5.9).

Table 5.9 Numeric composition of Great Crested Grebe, Red-breasted Merganser and Razorbill diets in the Fehmarnbelt in winter 2008/2009 and winter 2009/2010. 'N birds' represents number of birds examined. 'N prey' represents numbers of prey individuals after accounting for paired structures (e.g. otoliths, jaws). Occurrence identifies number of birds containing certain prey type. Dominance describes the proportion of prey type in relation to all prey items per species.

Bird species	N birds	Prey species	N prey	Occurrence	Dominance
Great Crested Grebe (2008/2009)	1	-	-	-	-
Great Crested Grebe (2009/2010)	1	Polychaetes	12	1	63.2%
		Fish unident.	7	1	36.8%
Red-breasted Merganser (2008/2009)	2	*Gasterosteus aculeatus*	19	1	52.8%
		Gobiusculus flavescens	3	1	8.3%
		Gobius niger	14	1	38.9%
Razorbill (2009/2010)	1	*Gobiusculus flavescens*	1,026	1	100%

5.2 Waterbird feeding ecology in the Fehmarnbelt: foraging behaviour

5.2.1 Foraging effort by wintering seaducks

Radio-tracking of ducks took place in different parts of the Fehmarnbelt, around the Fehmarn Island, south-west of Lolland and in the Guldborgsund (Figure 5.11). Radio-tagged Common Eiders and Long-tailed Ducks were recorded foraging at deeper waters compared to Tufted Ducks. Common Eiders were found at an average depth of 7.4±2.7 m (± SD, range 1.5 to 13.3 m), Long-tailed Ducks at 6.3±3.2 m (± SD, range 1.4 to 12.7 m) and Tufted Ducks at 3.4±2.0 m (± SD, range 1.0 to 7.9 m).

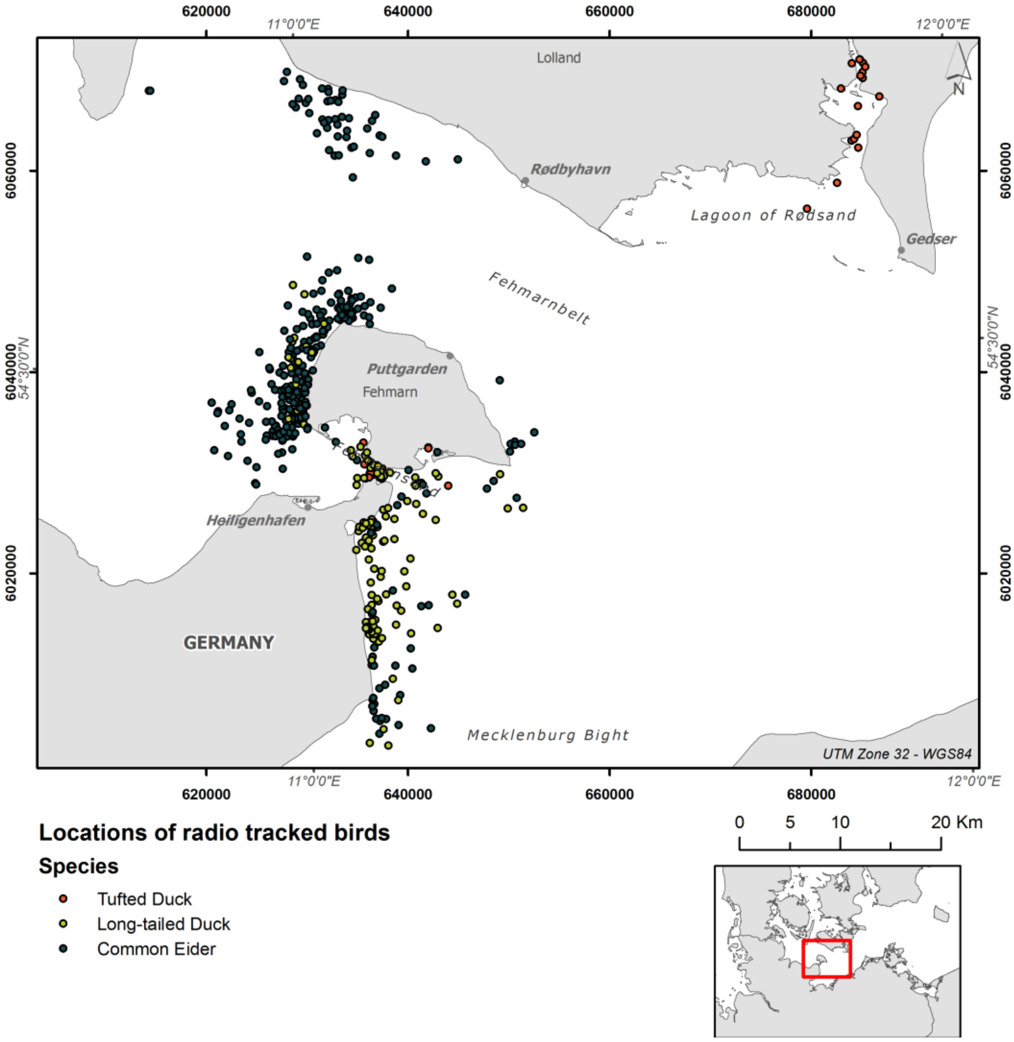


Figure 5.11 Locations of radio-tagged birds when foraging behaviour data have been recorded during winters 2008/2009 and 2009/2010. One location indicates a position of a bird during a tracking event lasting from 1 up to 24 hours.

Common Eider and Long-tailed Duck were almost exclusively diurnal foragers, whereas Tufted Duck foraged either exclusively at night, when birds were resting on freshwater ponds inland during mild winter periods, or during both day and night, when staying in marine waters all the time during cold winter periods (Figure 5.12, Figure 5.13). Whereas it is typical for Tufted Duck to feed at night (Nilsson 1970, Berndt and Busche 1993, de Leeuw 1999), seaducks (eiders, scoters, Long-tailed Ducks) are generally considered as diurnal foragers (Goudie and Ankney

1986, Guillemette et al. 1992, Lewis et al. 2005). However, some authors reported nocturnal foraging of Common Eiders (Swennen 1976, Nehls 1995, Merkel and Mosbech 2008), which suggests that Common Eiders are not obligatory daytime feeders, and can forage at night if for instance there is a need to compensate for digestive constrains or avoid diurnal predators (Guillemette 1998; Merkel and Mosbech 2008). For Long-tailed Ducks, Systad et al. (2000) suggested that they are probably obligatory daytime feeders as they leave their wintering areas in northern Norway in mid-winter because daylight time becomes too short for them to meet energy demands. A small proportion of the nocturnal foraging by Common Eiders in the Fehmarnbelt could be considered as an indication of good foraging conditions for this species and the birds' ability to meet their energy demands during daylight hours. Tufted Ducks in the Fehmarnbelt region have been described to extend their foraging effort into daylight hours, when inland resting ponds freeze during severe winter conditions (Berndt and Busche 1993). Daytime foraging of Tufted Ducks is also known to occur regularly in other regions, such as in the UK (Sutherland 2009).

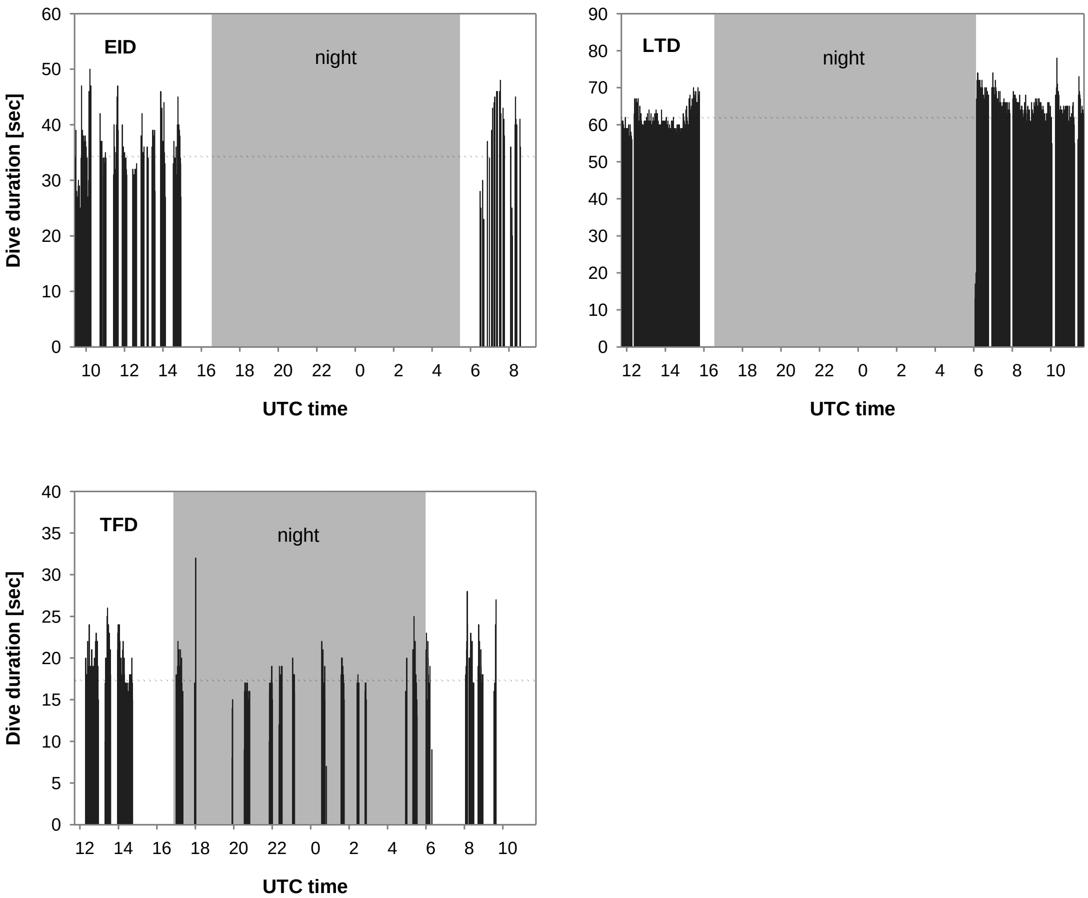


Figure 5.12 Sample plots of typical 24h diving activities of studied duck species: adult male Common Eider (EID) on 19/20 Nov 2009, adult male Long-tailed Duck (LTD) on 4/5 Jan 2010, and immature female Tufted Duck (TFD) on 18/19 Jan 2010. Shaded areas indicate periods of darkness of the particular day. Dotted lines represent the average dive length during the recorded period.

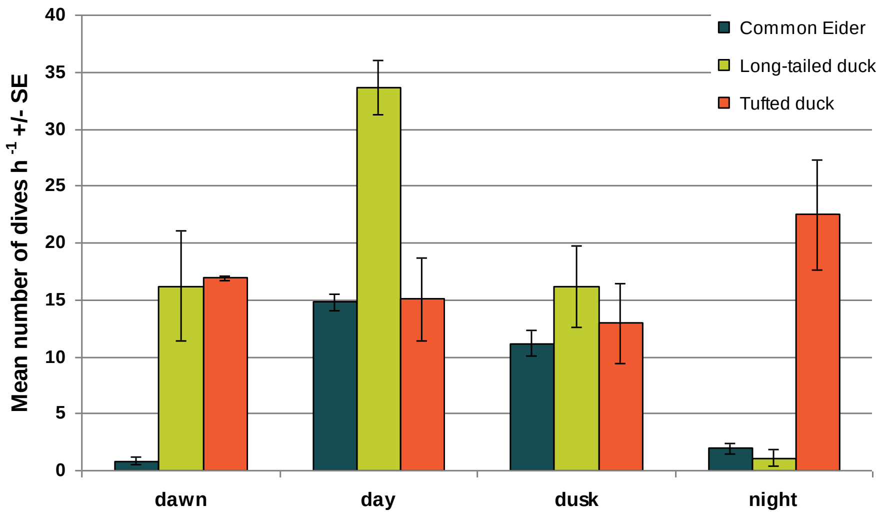


Figure 5.13 Diving activities of three duck species during the daily cycle. Bars represent average number of dives during two winter seasons (Jan-Feb 2009, Oct-Mar 2009/2010).

Foraging intensity varied during the winter period for Common Eiders and Long-tailed Ducks, indicating that birds had to invest more of the daylight time feeding in mid-winter (Figure 5.14). Foraging intensity also differed between species: Common Eiders spent up to 60 % of daylight hours diving, whereas Long-tailed Ducks were engaged into foraging activities for up to 90 % of daylight hours during winter months (Figure 5.12, Figure 5.14). Data collected on foraging activities of Tufted Ducks were not sufficient to depict variation within winter season. However it was obvious that Tufted Ducks spent more time foraging than Common Eiders, but much less than Long-tailed Ducks (Figure 5.12, Table 5.10).

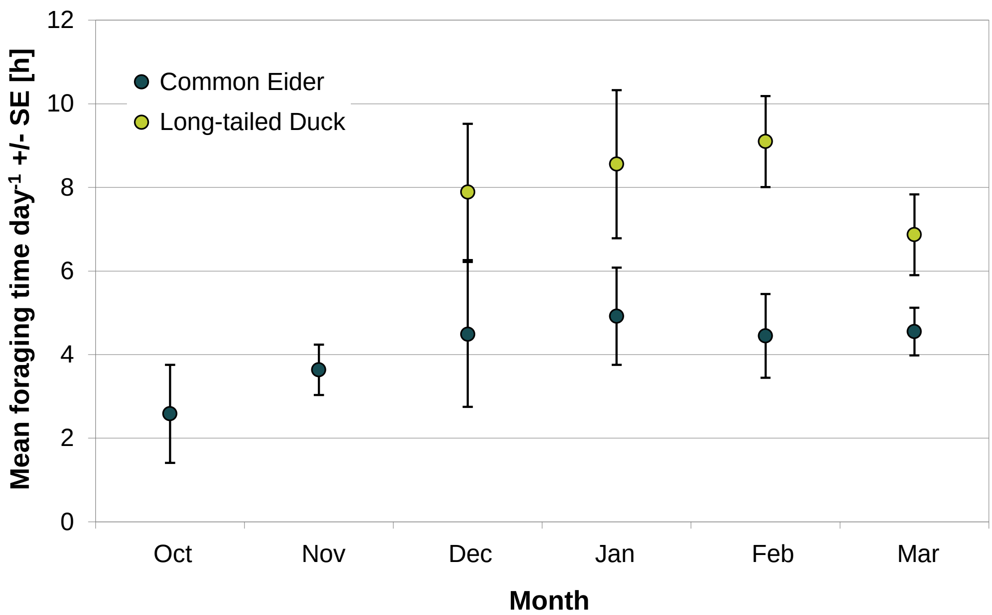


Figure 5.14 Time spent foraging (mean sum of dive cycles) by Common Eiders and Long-tailed Ducks in the Fehmarnbelt in winter 2009/2010.

Table 5.10 Average values (±SE) of foraging parameters of three studied duck species in the Fehmarnbelt in winter 2009/2010.

Month	Dive time, sec	Inter-dive time, sec	Dive cycle length, sec	Number of dives per day	Total time spent foraging per day, min
Common Eider					
Oct	42.6 ± 2.7	56.3 ± 7.1	98.8 ± 9.7	94 ± 41.7	155 ± 70.3
Nov	38.0 ± 1.0	43.7 ± 2.7	81.8 ± 3.2	160 ± 25.8	218 ± 36.2
Dec	41.2 ± 4.1	55.5 ± 5.0	96.7 ± 6.3	167 ± 63.7	269 ± 104.1
Jan	43.3 ± 4.1	44.2 ± 5.4	87.5 ± 7.9	202 ± 44.3	295 ± 69.9
Feb	36.1 ± 1.5	64.8 ± 6.0	95.9 ± 7.9	167 ± 35.0	267 ± 60.1
Mar	35.6 ± 1.3	54.3 ± 4.1	89.8 ± 4.8	183 ± 20.6	273 ± 34.1
Long-tailed Duck					
Dec	61.0 ± 1.0	29.1 ± 1.0	90.1 ± 1.8	315 ± 64.8	473 ± 97.7
Jan	36.7 ± 4.8	28.5 ± 4.8	65.3 ± 7.4	472 ± 82.1	513 ± 106.4
Feb	38.7 ± 1.2	33.5 ± 1.2	72.1± 3.3	454 ± 50.2	546 ± 65.2
Mar	36.7 ± 1.3	33.3 ± 1.3	70.0 ± 2.9	353 ± 47.6	412 ± 58.0
Tufted Duck					
Dec-Mar	18.8 ± 0.9	17.3 ± 1.5	36.1 ± 2.4	466 ± 116.2	280 ± 72.4

To assess the relative importance of different parameters on bird foraging effort, multiple regression models were used for Common Eiders and Long-tailed Ducks considering effects of water depth, sea surface temperature (SST), day length, and bird age and sex on diving intensity using number of dives per hour as a response variable. The most plausible model for Common Eider included only *Bird age* and *Sea surface temperature* as explanatory variables. These two parameters stood out as variables accounting for most of the variance. Immature birds were diving more intensively than adults, and the slope coefficient for sea surface temperature was negative indicating that the diving frequency was decreasing with increasing water temperature (Table 5.11). According to AIC weights, other variables were of little importance and their confidence intervals broadly overlapped zero indicating poor explanatory power.

All tracked Long-tailed Ducks were adults. Therefore *Bird age* was not among potential predictor variables in models for this species. The most plausible model for Long-tailed Ducks included *Day length* and *Sea surface temperature* variables. The slope coefficient with both variables was negative indicating that the diving frequency was decreasing with increasing day length and increasing water temperature. According to AIC weights, *Day length* was the most influential parameter followed by *SST*, while *Bird sex* and *Depth* were poor predictors (Table 5.11).

Table 5.11 Results of explanatory models assessing values of several bird and environmental parameters on diving intensity of Common Eider and Long-tailed Duck in the Fehmarnbelt in winter 2009/2010. Significant values are highlighted in bold font.

	Common Eider			Long-tailed Duck		
Parameter	**Coeff**	**SE**	**AIC weight**	**Coeff**	**SE**	**AIC weight**
Intercept	2.790	0.297		4.880	0.378	
Bird age (imm)	**0.612**	**0.139**	**1.00**			
Bird sex (M)	0.005	0.026	0.18	0.002	0.013	0.09
Day length	-0.014	0.025	0.32	**-0.122**	**0.034**	**1.00**
Depth	-0.002	0.006	0.21	0.0139	0.021	0.40
SST	**-0.037**	**0.018**	**0.95**	**-0.059**	**0.050**	**0.72**

Observations in the Fehmarnbelt indicate that Common Eiders spent from 2.6 to 5.5 hours per day foraging in winter 2009/2010, which comprised 26-60% of the total daylight time. Other authors report comparable foraging intensity of this species, 21-58% of daytime hours in southern Sweden (Nilsson 1970), 55-60 % in Newfoundland (Goudie and Ankney 1986) and 61% in the Gulf of St. Lawrence, Canada (Guillemette et al. 1992). In another study Guillemette (1998) described seasonal variation of Common Eider foraging intensity in the Gulf of St. Lawrence where birds spent 56% of daylight time foraging in mid-winter, 46 % in late winter and 33% in spring, results which are similar to those observed in the Fehmarnbelt (Table 5.10). Using time spent underwater as another metric of foraging effort Systad et al. (2000) reported that Common Eiders dive for 73 to 144 minutes per day in northern Norway, while Rigou and Guillemette (2010) estimated that annual the mean of daily time that female Common Eider spends diving in Danish waters is 91.4 min. These observations fall within the range of Common Eider diving intensity recorded in the Fehmarnbelt: 67–146 minutes during winter season (total time underwater calculated using mean dive length and number of dives per month, Table 5.10). The match between foraging intensity of Common Eiders observed in the Fehmarnbelt and elsewhere is an indication that Fehmarnbelt represents favourable winter habitat for this species, which is of comparable quality with other important wintering areas across the species distribution range.

Similarly to our findings in the Fehmarnbelt, other authors also report Long-tailed Ducks spending a substantial amount of the daylight hours foraging with 59-92% in Øresund and at the coast of southern Sweden (Nilsson 1970), ca. 83% in Newfoundland (Goudie and Ankney 1986), and about 80% in northern Norway (Systad et al. 2000). However, no studies exist about Long-tailed Duck foraging activities in the most important wintering areas where the highest concentrations of this species occur (e.g. Hoburg Banks, Pomeranian Bight and Riga Bay in the Baltic Sea; Durinck et al. 1994). Considering the very high foraging intensity of Long-tailed Ducks observed in the Fehmarnbelt, it is likely that they operate close to their physiological limits, as there is virtually no room for extending the foraging effort if the birds were to encounter reduced conditions of food availability/quality or disturbance.

Diving activity recorded for Tufted Ducks in the Fehmarnbelt is considered to represent a foraging pattern of the species reflecting severe winter conditions. The high observed general mortality of Tufted Ducks in the region during the study period (own observations) and known occurrence of high mortality of the species during adverse winter conditions in former times (Suter and van Erden 1992, Sutherland 2009) suggest this species operated close to its physiological limits during the study period. The recorded dive durations fall within a range of 11-23 sec reported in other studies (de Leeuw et al. 1998, Halsey et al. 2003, Sutherland 2009).

5.2.2 *Energy requirements of wintering Common Eiders*

Recorded daily activity budgets of eiders wintering in the Fehmarnbelt were converted into an overall daily energy balance. Such information allows better understanding of duck winter ecology, and provides background for evaluating food requirements.

The energy demand of wintering Common Eiders varies depending on behavioural activities, ambient temperature and species-specific characteristics. To construct an energy budget of eiders wintering in the Fehmarnbelt, behavioural data and environmental parameters were used. Estimates of energetic requirements of Common Eiders indicate that the daily energy demand increases slightly with progressing wintering season, mainly due to decreasing water temperature, and is the highest in late winter (Table 5.12). The daily energy expenditure was calculated to vary between 1,670 kJ and 1,880 kJ per day, equalling 2.3-2.6 times the basal metabolic rate (BMR) according to Jenssen et al. (1989). Nehls (1995) reports much higher energy expenditures for wintering eiders in the German Wadden Sea of more than 4*BMR, indicating the Fehmarnbelt area as a favourable wintering habitat for Common Eiders.

The daily mussel consumption of 2.1-2.4 kg fresh mass as estimated for Eiders in the Fehmarnbelt (Table 5.12) fall well within the range estimated for Common Eiders during other studies (Swennen 1979, Guillemette et al. 1992, Guillemette 1994, Nehls 1995, Heath and Gilchrist 2010).

Table 5.12 Estimates of Common Eider daily energy budgets and mussel consumption during different months of wintering period in the Fehmarnbelt based on telemetry data of winter 2009/2010. BMR calculated according to Jenssen et al. (1989).

Energy expenditure lines, kJ	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Diving	226	226	238	233	227	241
Flight	123	123	123	123	123	123
Swimming	623	623	621	622	623	620
Comfort/social behaviour	125	125	124	124	125	124
Resting	417	451	474	502	531	510
Digestion (prey heating)	160	182	208	227	245	255
Total daily energy expenditure	1,673	1,729	1,788	1,830	1,873	1,872
Equals to *BMR (BMR = 728 kJ day^{-1})	2.30	2.37	2.46	2.51	2.57	2.57
Total daily gross energy demand (0.73 assimilation efficiency)	2,292	2,368	2,449	2,507	2,565	2,565
Total daily fresh mass demand [g]	2,162	2,234	2,310	2,365	2,420	2,419
Mussel consumption						
Fresh mass intake [g]	2,320	2,320	2,422	2,422	2,422	2,654
Equals gross energy uptake [kJ]	2,459	2,459	2,567	2,567	2,567	2,813

According to Guillemette (1994) a typical eider meal size consists of about 80 g (fresh) mussel mass. Maximum oesophagus content of eiders is 3.5-5.0 % of birds' body mass (Guillemette et al. 1992) corresponding with 80-115 g for Fehmarnbelt eiders (mean weight 2,290 g). According to Guillemette (2004) the working capacity of the gizzard lies between 2.4 g min^{-1} and 6.1 g min^{-1} fresh mass.

The energy budget calculation for Common Eiders wintering in the Fehmarnbelt results in corresponding meal sizes and the necessary gizzard processing rates, which lie well within the range suggested by Guillemette (2004) and Kaiser et al.

(2005) (Table 5.13). There are no functional response measurements available in literature for seaducks foraging on epibenthic mussels, but assuming a similar time effort for ducks finding and digging up buried clams as detachment of mussel byssal threads would take, energy intake rates calculated for Common Eiders in the Fehmarnbelt fall well within the range as measured for scoters feeding on clams (Richman and Lovvorn 2003). Consequently, the energy budgets as presented in Table 5.12 can be considered to reflect the actual energy demand of Common Eiders wintering in the Fehmarnbelt area very well.

Table 5.13 Corresponding mean meal size, intake rates and gizzard process rates in terms of ingested mussel specimens, mussel fresh mass and gross energy intake (based on assumed mussel consumption).

	Nov 2009	**Dec 2009**	**Feb 2010**	**Mar 2010**
Mussel intake [g dive^{-1}] in fresh mass per dive	14.5	14.5	14.5	14.5
Mussel intake [kJ dive^{-1}] in energy per dive	15.4	15.4	15.4	15.4
Mussel intake rate in mean weight (0.3132 g) specimen per dive	46.3	46.3	46.3	46.3
Mussel intake rate in mean weighing (0.3132 g) specimen/sec bottom time	1.7	1.8	1.7	1.9
Mussel intake [g sec^{-1}] in fresh mass/sec bottom time	0.52	0.55	0.53	0.60
Mussel intake [kJ sec^{-1}] in energy/sec bottom time	0.55	0.58	0.56	0.64
Mean meal size [g] ± SD Mussel intake*n dives per Foraging bout	93.1 ± 43.66	78.1 ± 31.69	54.3 ± 36.41	61.7 ± 32.12
Mean gizzard process rate (Mussel intake per dive/foraging intensity) [g min^{-1}] ± SD	3.3 ± 1.02	2.7 ± 0.70	2.9 ± 1.32	2.8 ± 0.96

5.3 Local movements of non-breeding waterbirds in the Fehmarnbelt

5.3.1 Common Eider

Nineteen Common Eiders equipped with satellite transmitters were successfully tracked in the Fehmarnbelt (Figure 5.15). Telemetry studies typically involve relatively few individuals that are tracked and it is therefore frequently questioned whether these birds could be considered as representative of the studied population. To address this question we developed spatial distribution models using telemetry data and compared the results with distribution models obtained using aerial and ship-based survey (i.e. independent) data. The results of such modelling, presented in Appendix VII of this report, revealed close match between the telemetry and observation data, based on which we assume that tracked birds were indeed a representative sample of Common Eiders wintering in the Fehmarnbelt.

According to the results of satellite telemetry, the winter period of Common Eiders lasts from late October (arrival dates October 15 – November 5, n=6) until mid-March – early April (departure dates March 6 – April 14; n=19) in the Fehmarnbelt. Based on the median of these dates, the duration of the wintering period of this species is approximately 152 days.

The size of winter home ranges varied greatly among individuals ranging from 22 to 2,237 km^2, the average being 606±663 km^2 SD (n=10). One bird (id 97825) was extremely sedentary and spent all winter within a restricted area SW of Fehmarn Island (Figure 5.16), whereas the individual with the largest home range (id 97827) moved extensively within greater Fehmarnbelt (Figure 5.16). All other tracked individuals were relatively sedentary and their home ranges were determined by gradual transition from one location to another rather than regular commuting between discrete wintering sites (Figure 5.17).

Distances between Common Eider weekly location fixes were rather small during the wintering season averaging at 13.2±14.3 km (±SD, range 1.0-93.6 km, n=14) (Figure 5.18). Based on inspection of moving trajectories and relocation distances, 11 out of 13 PTT-tagged Common Eiders, which were followed during the entire wintering season, used only one or two discrete wintering sites (as defined in *Methods* above), one bird used three sites, and none of these individuals commuted regularly between these sites (Figure 5.17). However one individual was exceptionally mobile (id 97827), often flying distances exceeding 35 km between subsequent locations, and also returned to previously visited sites situated far apart (Figure 5.16).

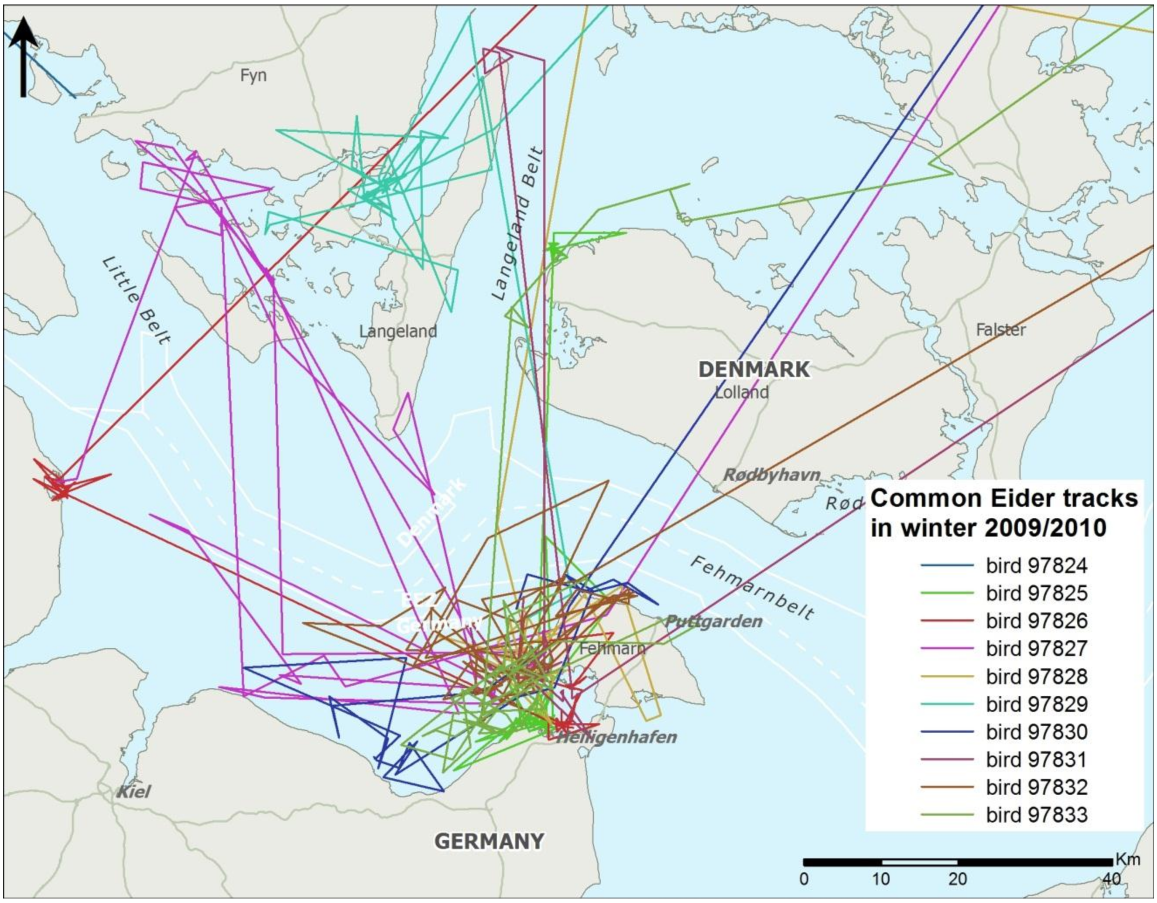


Figure 5.15 Tracks of 10 satellite-tagged Common Eiders in the Fehmarnbelt in winter 2009/2010.

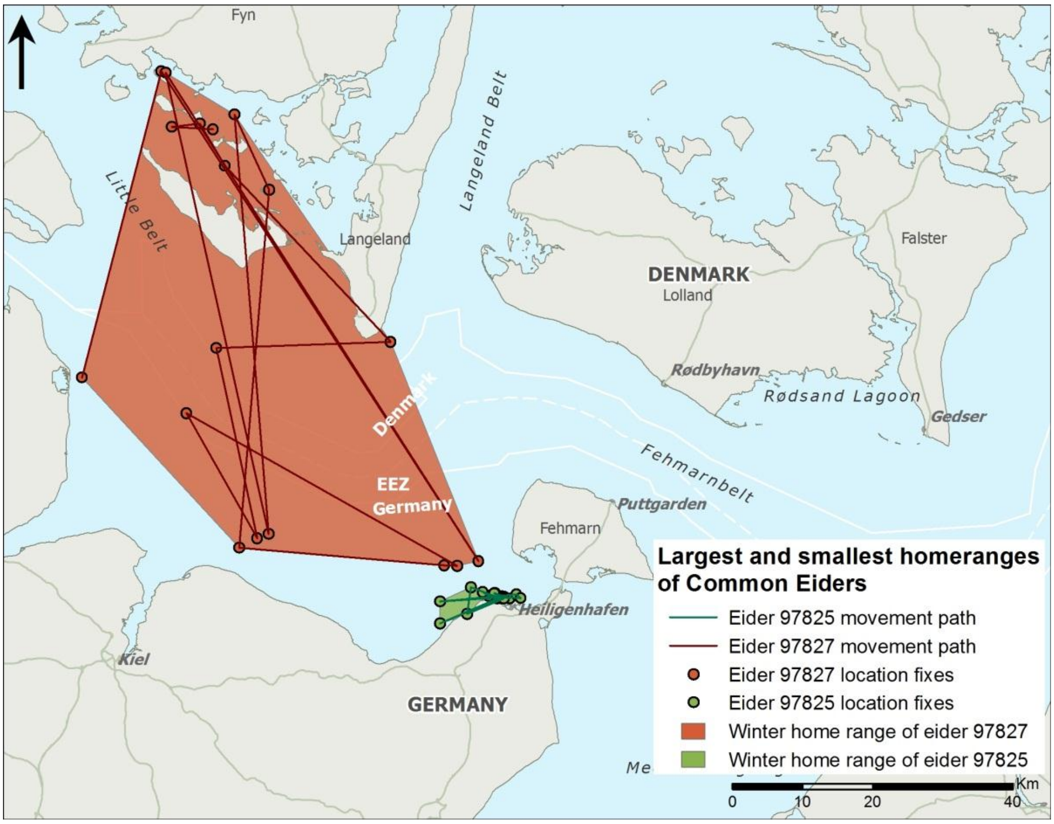


Figure 5.16 Winter movement range of two Common Eiders with the largest and the smallest winter home ranges recorded in winter 2009/2010.

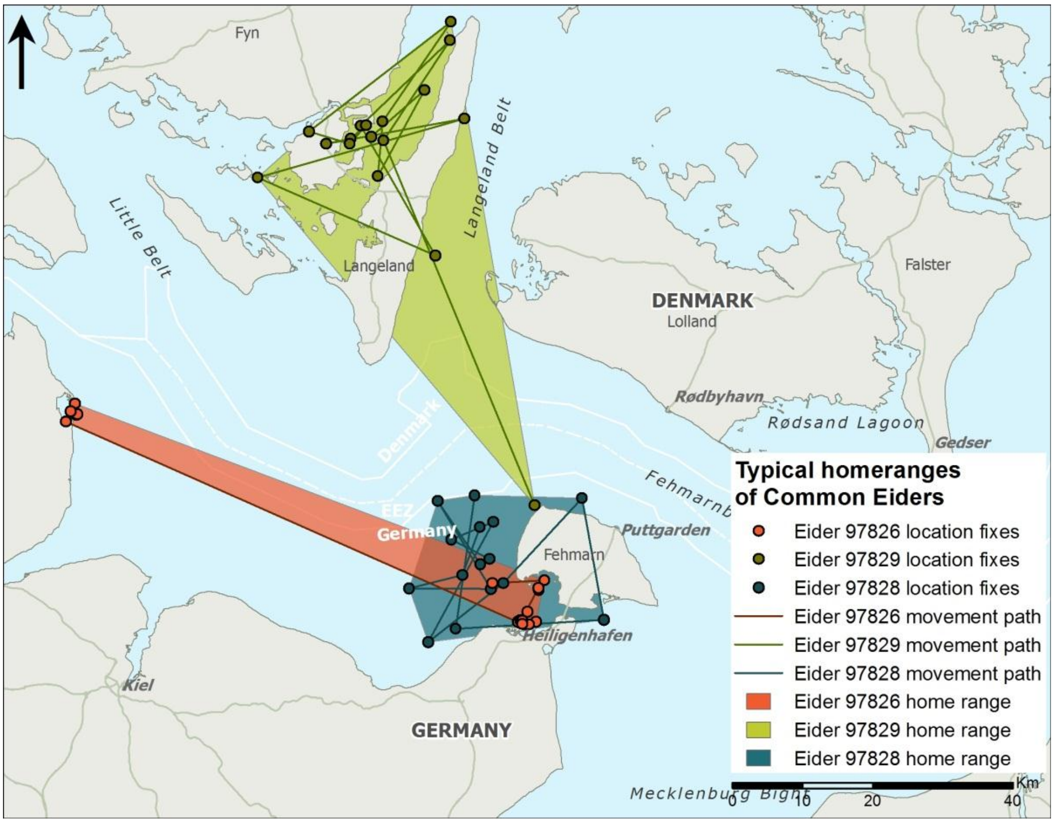


Figure 5.17 An example of typical winter home ranges (defined as minimum convex polygons) of three Common Eiders in winter 2009/2010.

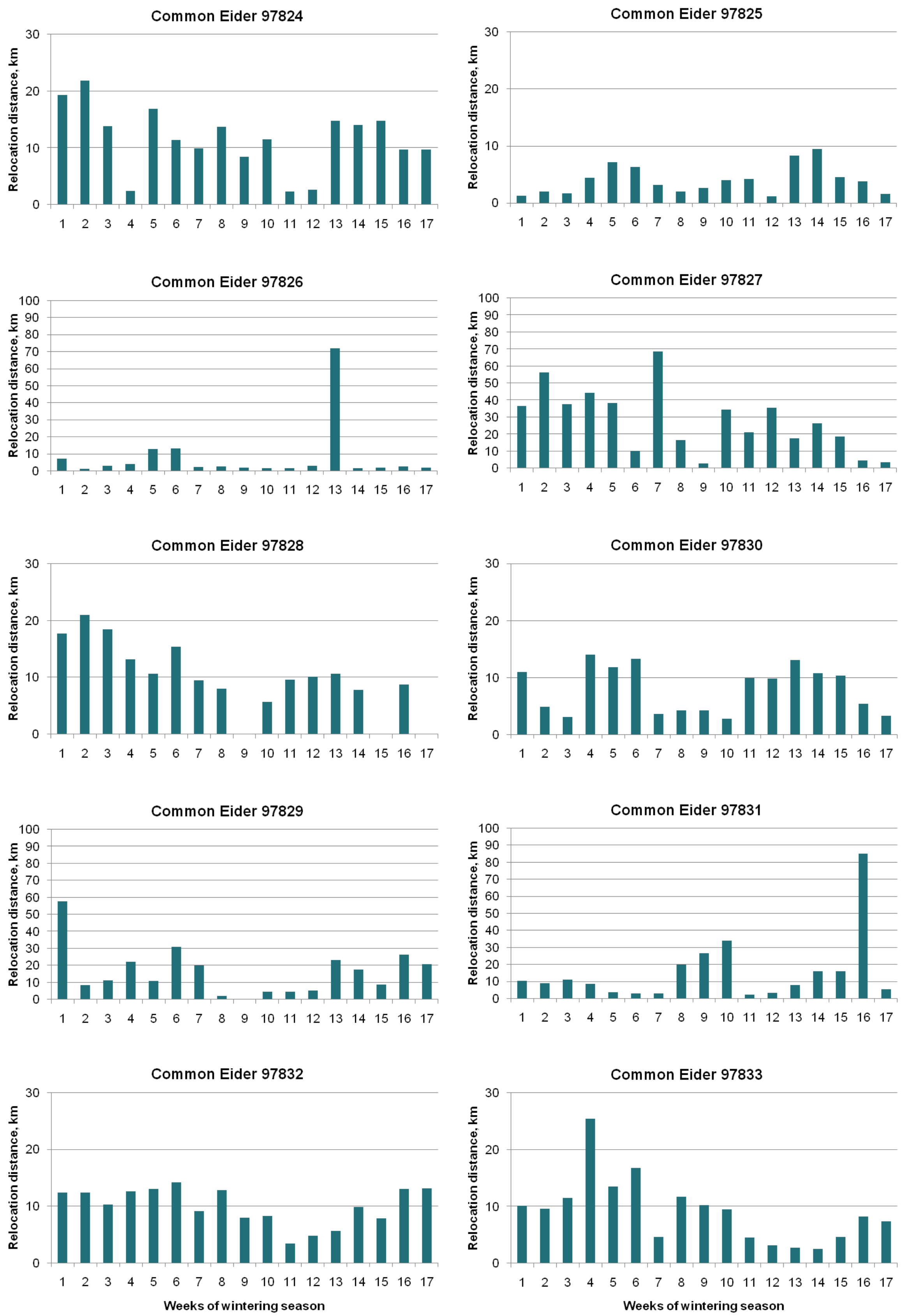


Figure 5.18 Charts presenting moving distances between weekly locations of 10 Common Eiders wintering in the Fehmarnbelt as recorded by satellite telemetry.

In addition to satellite telemetry, 7 Common Eiders were also tracked using GPS data loggers in March 2009 (n=1) and February – March 2010 (n=6). Detailed GPS tracks demonstrated that tagged individuals spent a lot of time close to the coast with short-term swings offshore (Figure 5.19). Daily movement distance (measured at noon of each tracking day) of a Common Eider averaged at 9.7±7.7 km (±SD), and ranged from 0.27 to 33.3 km. Home ranges were not estimated using GPS telemetry data, as these would not be comparable with the material obtained from satellite telemetry due to different spatial and temporal resolutions of these datasets.

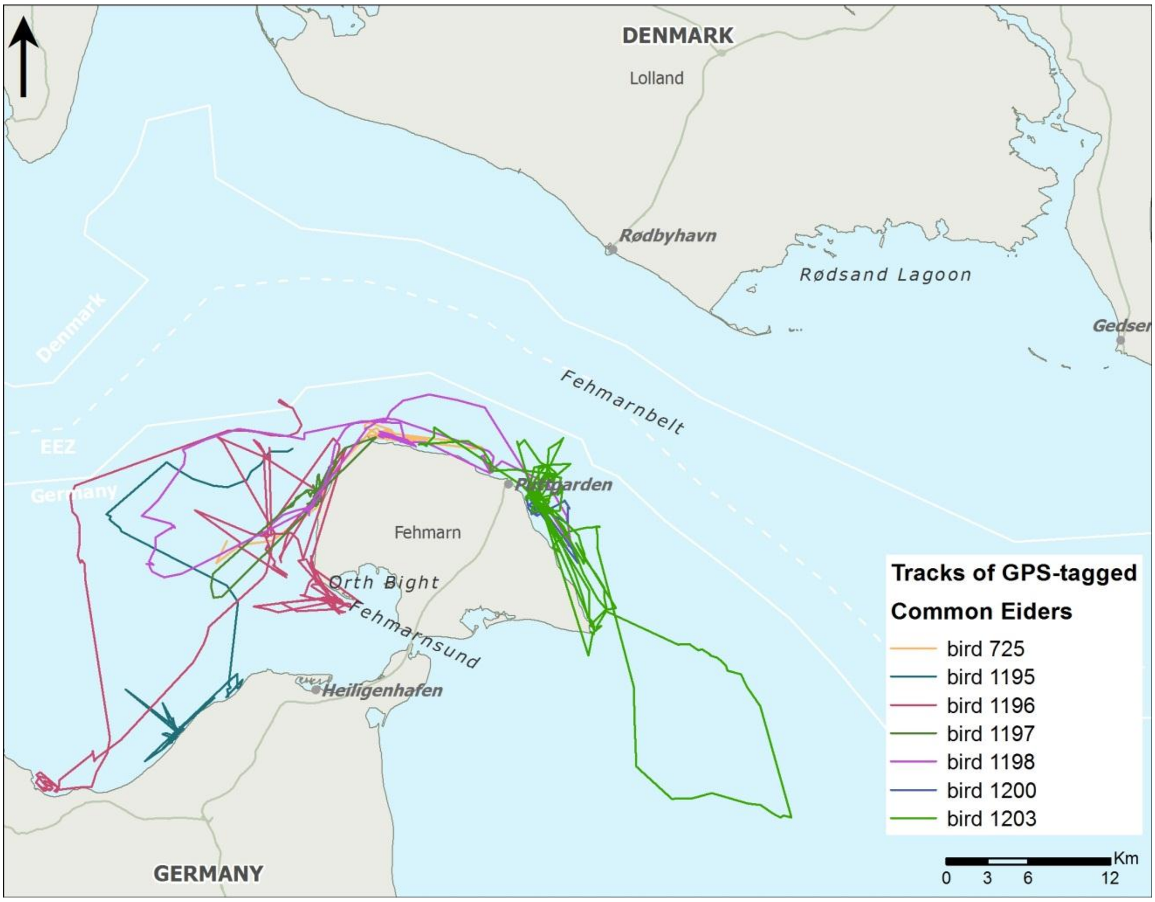


Figure 5.19 Winter movement trajectories of 7 Common Eiders GPS-tagged at the end of bird wintering season.

As an additional metric of home range analysis, the probability of site fidelity was calculated using a modified Kaplan-Meier procedure (Iverson and Esler 2006). At the scale of wintering site (as defined in methods) the probability of site-fidelity at weekly intervals ranged between 0.83 and 1 during the bird wintering season 2009/2010. The cumulative site-fidelity function for the entire winter season was estimated as $F(t)$=0.48 (95 % CI: 0.08-0.88; n=14). The cumulative site-fidelity declined early and late during the wintering period (Figure 5.20). This indicates that about a half of tracked individuals stayed at the same wintering site through the entire winter. Movement patterns could be interpreted assuming that birds were searching for favourable habitats early in the season and settled down during the first half of the winter. In the second half of wintering period eider mobility could have increased due to possible depletion of food resources.

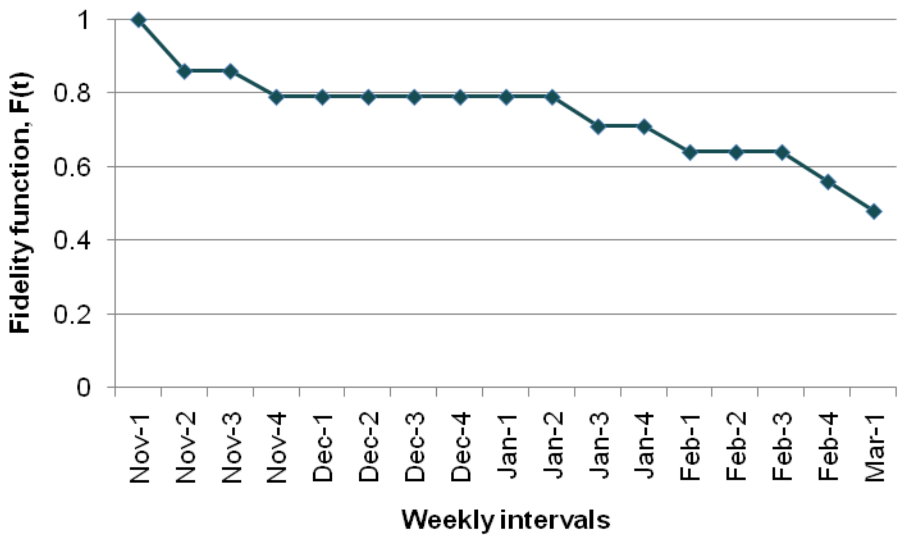


Figure 5.20 Winter site fidelity function of satellite-tagged Common Eiders (N=14) in the Fehmarnbelt during winter season 2009/2010.

Finally, the inter-seasonal wintering area-fidelity was evaluated for individuals, which were tracked over two winter seasons. Tracking of 13 PTT-tagged Common Eiders extended over two winters, and all these birds returned to the greater Fehmarnbelt area (as identified by the extent of FEBI surveys) the following winter. This suggests 100% inter-seasonal wintering area-fidelity.

5.3.2 Long-tailed Duck

Long-tailed Ducks were equipped with satellite transmitters only during the second winter of the study period (2009/2010). Therefore no information was obtained about arrival dates of individual birds to the Fehmarnbelt and the longevity of the wintering period. Median departure date (i.e. end of wintering period) of 6 successfully transmitting individuals was April 16 (range April 4–29).

Four out of six satellite-tracked Long-tailed Ducks stayed within relatively small areas in the Fehmarnbelt during January – March (Figure 5.21). Home range areas of these four birds ranged between 56-1,244 km^2 averaging at 604±631 km^2 (±SD). One individual (id 97837) was more mobile and moved rather extensively within the greater Fehmarnbelt area and beyond (home range area 2,717 km^2; Figure 5.22), and another bird (id 97846) started migration-type movement northwards since late January, stopping for a brief periods at several coastal and offshore sites (home range area 7,833 km^2; Figure 5.22).

Distances between Long-tailed Duck weekly locations were relatively large and averaged at 40.0±66.4 km (±SD, range 2.6–442.4 km), but differences between individuals were also substantial (Figure 5.23).

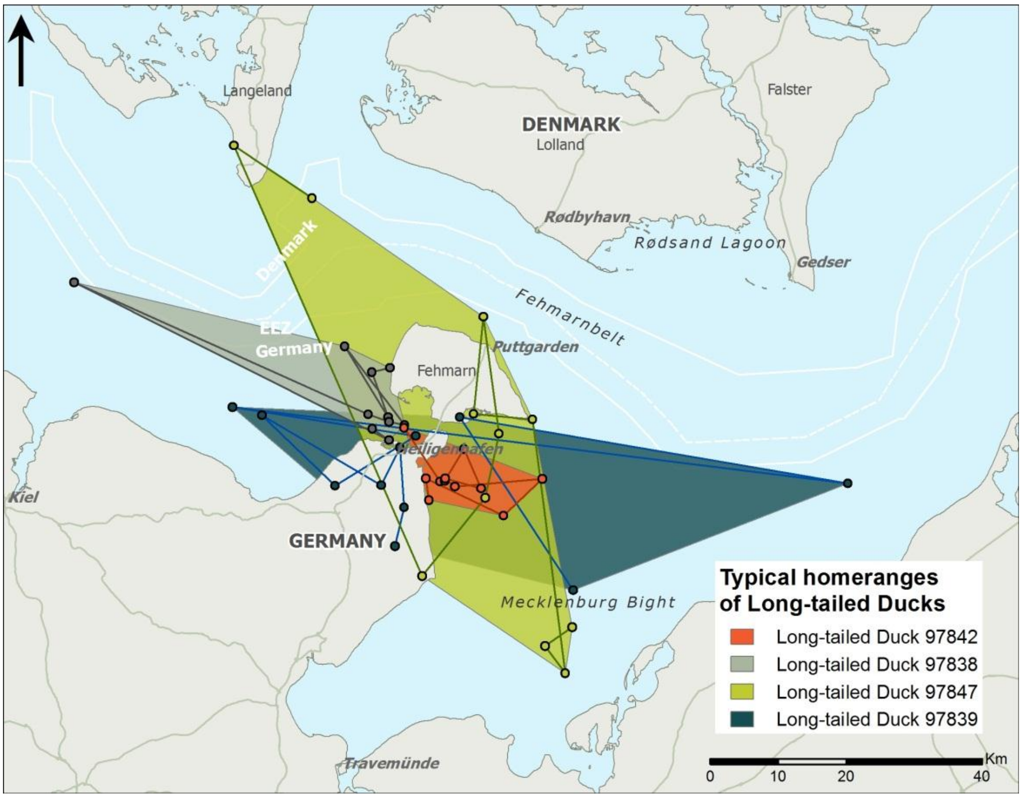


Figure 5.21 Winter home ranges of 4 Long-tailed Ducks in the Fehmarnbelt between mid-January and late March 2010.

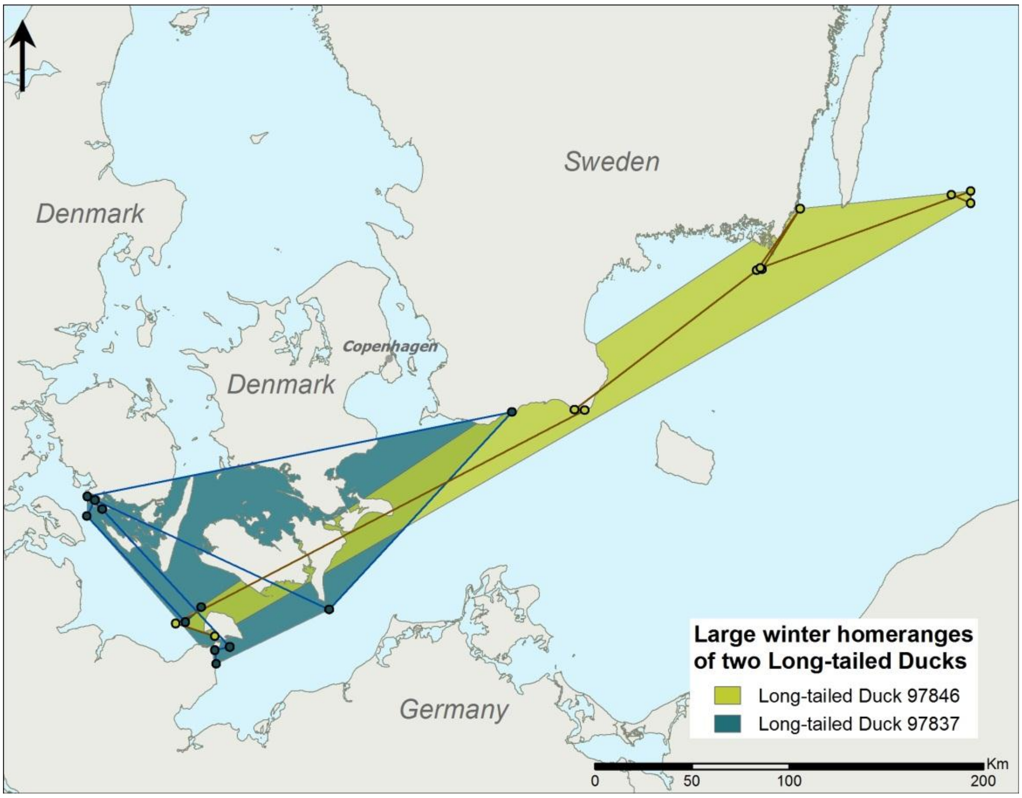


Figure 5.22 Extensive winter movements of 2 Long-tailed Duck individuals recorded between mid-January and late March 2010: bird id 97837 moved extensively with Fehmarnbelt and beyond, whereas bird id 97846 exhibited northward migration-like pattern, which started from late January.

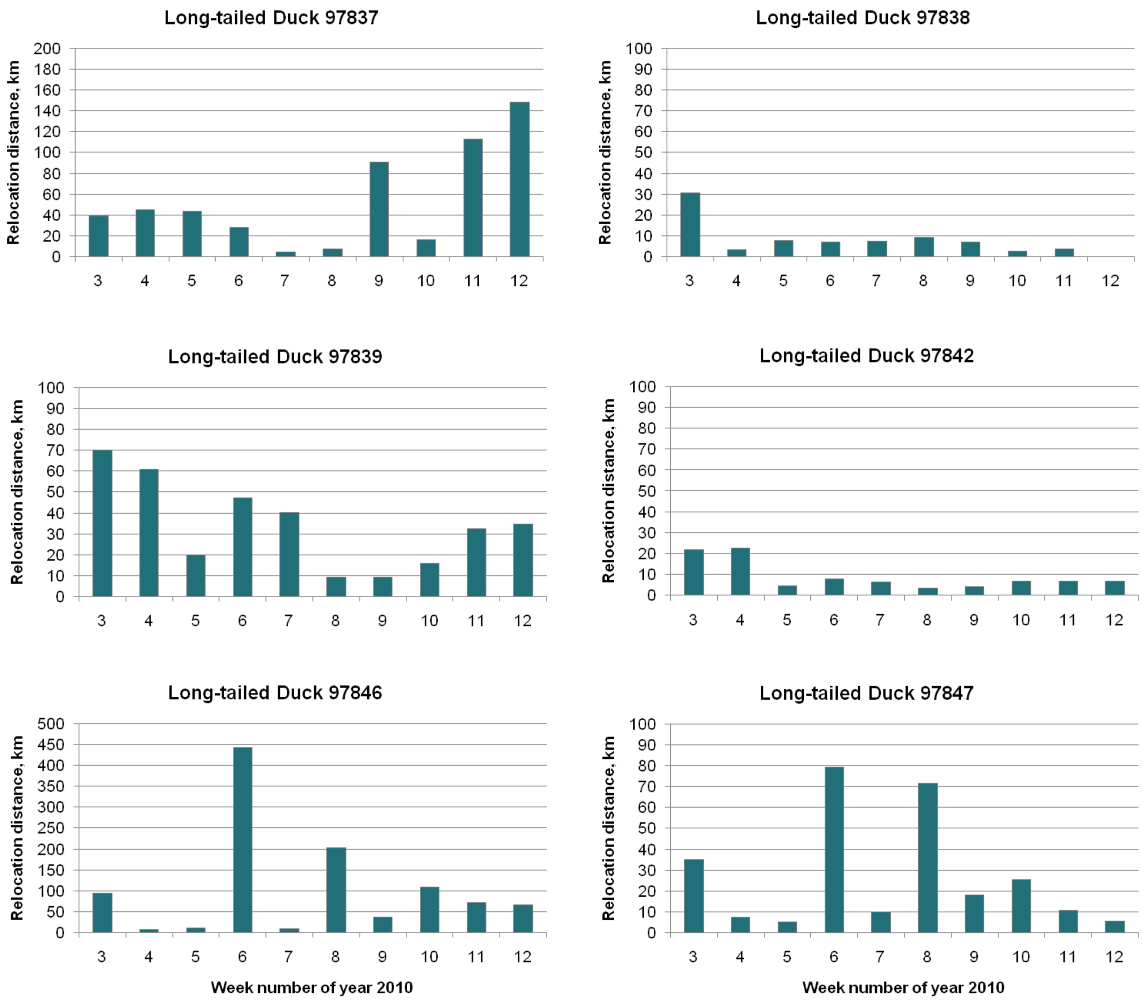


Figure 5.23 Charts presenting moving distances between weekly locations of 6 Long-tailed Ducks equipped with satellite transmitters in the Fehmarnbelt in January 2010. Please note varying scale of Y-axis.

5.3.3 Common Scoter

Since both the studied Common Scoters were satellite-tagged during the second winter season (2009/2010), no information was collected about arrival dates of individual birds to the Fehmarnbelt and the length of their winter period. The tagged female scoter (bird id: 97841) initiated spring migration (i.e. end of wintering season) on April 2, 2010. The other tagged bird (male, bird id: 97844) left the greater Fehmarnbelt area eastbound on May 10, 2010.

Both Common Scoters used two discrete wintering sites during January – March 2010 (Figure 5.24). One individual (bird ID 97844), however, was extremely mobile and frequently commuted long distances within a single wintering site on the eastern part of the greater Fehmarnbelt area (Figure 5.24).

The mean area of the wintering sites used by the two Common Scoters was 1,466±2,497 km^2 (±SD, n=4, range 24–5,202 km^2). Distances between subsequent location fixes (separated by 1-3 days) varied highly averaging at 25.8±26.8 km (±SD, range 0.5-118.4 km).

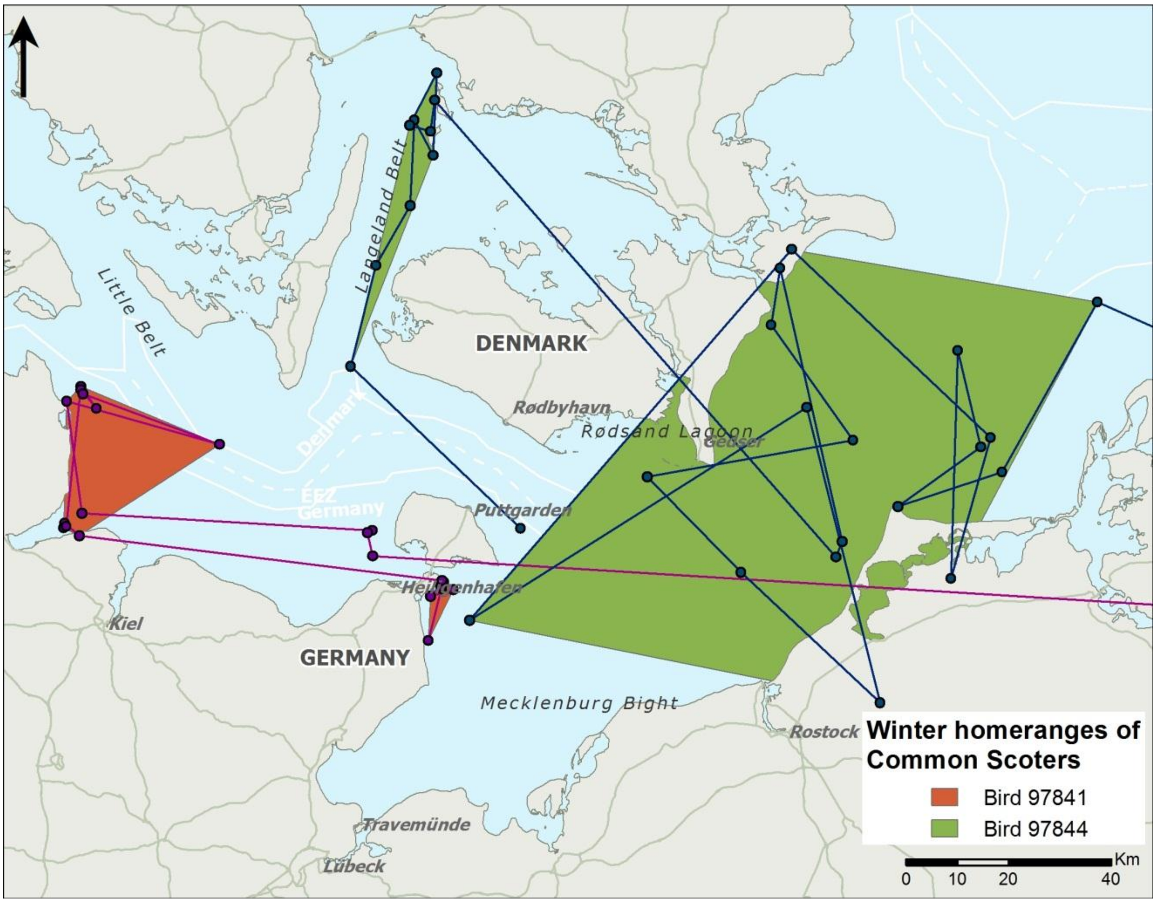


Figure 5.24 Winter home ranges of 2 Common Scoters satellite-tagged in January 2010.

5.3.4 Tufted Duck

Tufted Ducks represent a species with different ecology compared to other studied ducks. Wintering Tufted Ducks do not stay on marine waters all the time and prefer using inland lakes as day roosting sites and move to coastal marine waters at night for feeding. However, during cold winter periods when inland fresh waters freeze over, Tufted Ducks spend all their time in the marine environment. Because of this commuting between freshwater lakes and marine coastal areas, home ranges were not calculated as for seaduck species.

Satellite telemetry indicated, that Tufted Ducks typically move the shortest distance between the daily roosting site and marine coastal waters (Figure 5.25). On a few occasions, one individual (bird id 97852) was recorded moving up to 10 km offshore.

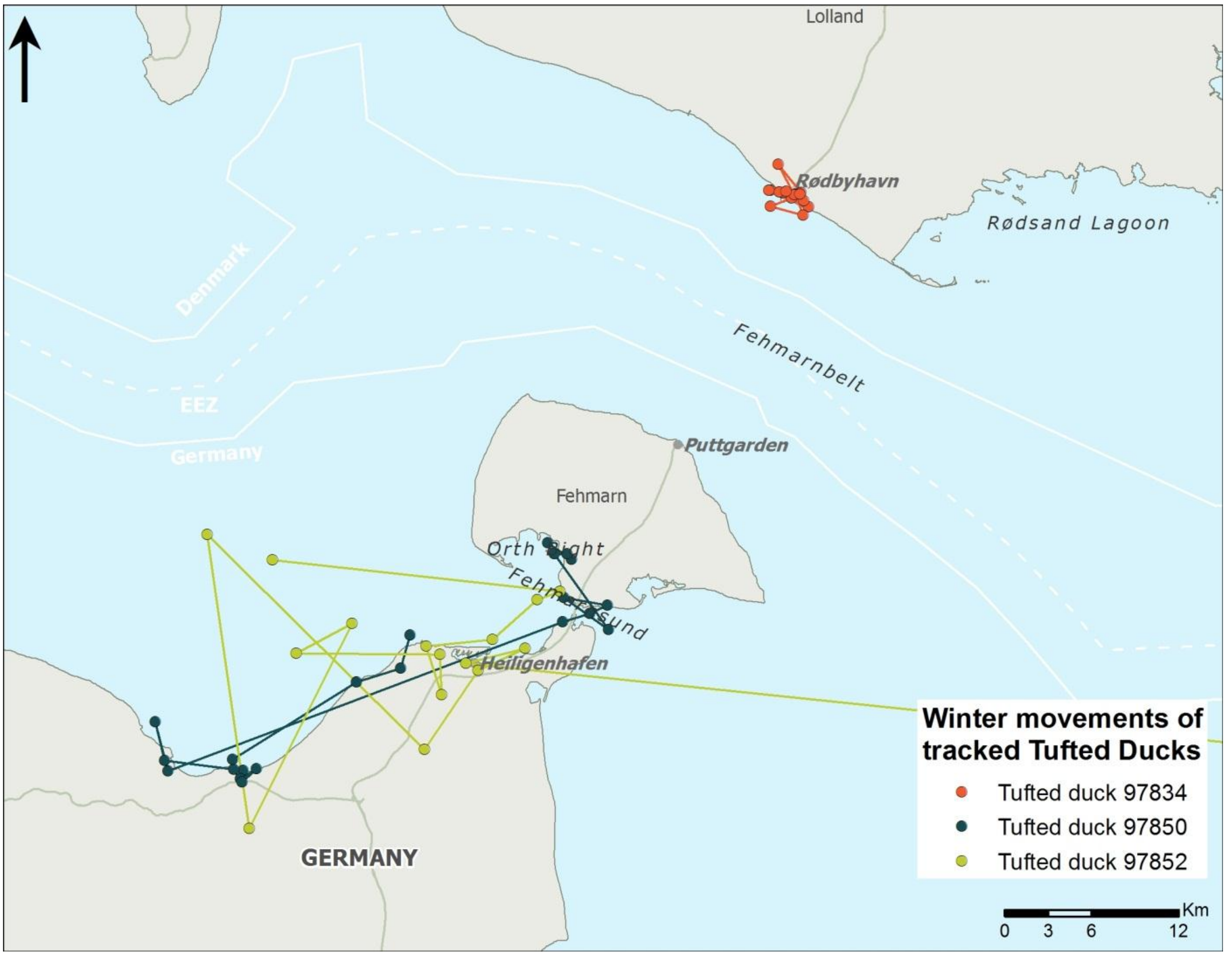


Figure 5.25 Winter movement patterns of 3 satellite-tagged Tufted Ducks.

Tufted Ducks roost not only on fresh water ponds adjacent to the coast, but also on waters located further inland. The Maribo Lakes, located in the central Lolland are known to support thousands of Tufted Ducks every wintering season. Radar observations have been conducted in early April 2010 aiming to record flying directions of Tufted Ducks as they leave Maribo Lakes in the evening. All Tufted Ducks roosting along the southern coast of Søndersø Lake were recorded flying northwards (Figure 5.26). This direction coincides with the direction of the shortest distance to marine waters. A feasibility study conducted in the late 1990s reported Tufted Ducks flying southwards from Maribo Lakes to the Fehmarnbelt, which is opposite to our observations (Skov et al. 1998). This suggests that Tufted Ducks from the same daytime roosting location may use different foraging areas at night.

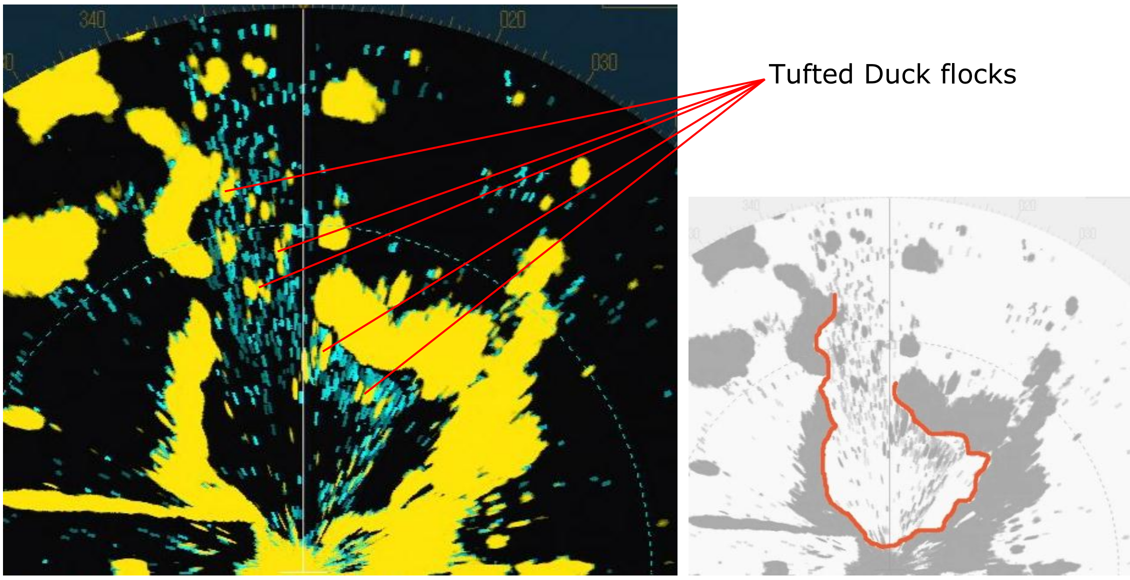


Figure 5.26 Radar screen shot illustrating Tufted Ducks flying north from a bay in the southern part of Søndersø Lake: bird flocks are visible as small yellow patches followed by blue traces indicating previous locations of a flock. The black and white image on the right shows the same radar screen shot, where red line highlights the coastline of surveyed Søndersø bay.

5.4 Mute Swan and seaduck habitat carrying capacity

5.4.1 Food resources and consumption by moulting Mute Swans in Rødsand Lagoon

As reported in the chapter 4, moulting Mute Swans were confined to the western part of Rødsand Lagoon and birds preferred shallow waters where submerged vegetation could be reached (Figure 4.30, Figure 4.35, Figure 4.36).

When foraging, Mute Swans can reach down to 1.05 m underwater (Clausen at al. 1995), therefore depth is a factor limiting food availability for swans. Water level fluctuates regularly within ±0.4 m amplitude from average daily water levels in the Rødsand Lagoon (Figure 5.27), and such fluctuations represent an important factor influencing *Zostera* availability to swans and determining the swans' habitat choice.

Potamogeton and *Ruppia* are found in shallower waters compared to *Zostera* beds (FEMA 2013b) and these species were also identified as being frequently consumed by swans moulting in Rødsand Lagoon. Fluctuations of water level have a less pronounced effect on accessibility of *Potamogeton* and *Ruppia* compared to *Zostera.* However, biomass of the former two species is several times lower per area unit than that of *Zostera* (FEMA 2013b).

Food requirements by Mute Swans have been estimated for summer periods of 2009 and 2010 between May 1 and October 1, when they were most numerous in Rødsand Lagoon (Figure 4.27). Numbers of bird days were estimated for each month by multiplying the total number of birds observed and number of days on a particular month. Mute Swan abundance was substantially higher in the summer of 2009 compared to the summer of 2010, and the total number of bird-days during the first summer of investigations was nearly twice as high as during the second summer season (Table 5.14). A detailed study was conducted about the foraging ecology of moulting Mute Swans during studies related to the construction of a fixed link across Øresund (Clausen et al. 1995, 1996, Noer et al. 1996). This study suggested an intake rate of 487.7 g of dry weight (DW) of submerged vegetation per day (Noer et al. 1996). A combination of estimated numbers of bird-days in Rødsand Lagoon and daily intake leads to estimates of the total consumption of 549.6 tonnes DW in the summer of 2009 and 330.2 tonnes DW in the summer of 2010.

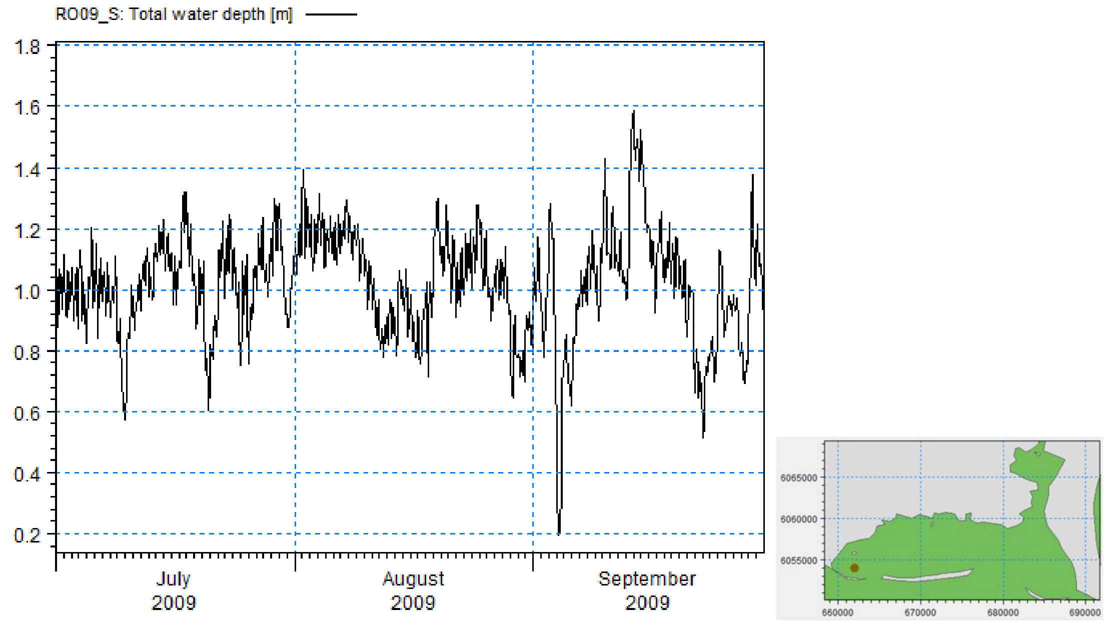


Figure 5.27 An example of water level fluctuation in Rødsand Lagoon between July 1 and October 1, 2009, as extracted for one location (at 1 m depth) within Mute Swan foraging habitat (see index map). Source: Fehmarnbelt Fixed Link baseline investigations on hydrography, model HD9.15.

Table 5.14 Mute Swan numbers recorded on Rødsand Lagoon during dedicated search flights between May and September in 2009 and 2010; and calculated numbers of bird-days during these periods.

Month	2009	2010	bird-days 2009	bird-days 2010
May	4,379	1,059	135,749	32,829
June	7,377	2,493	221,310	74,790
July	8,889*	4,490	275,559	139,190
August	10,401	8,385	322,431	259,935
September	5,729	5,678	171,870	170,340
TOTAL			1,126,919	677,084

* mean value between June and August, as no survey was conducted on July 2009

The standing biomass of *Zostera* in Rødsand Lagoon has been estimated at 6,962 tonnes DW in summer 2009. However, *Zostera* grows at depths down to 4 m, therefore a large part of it is inaccessible to birds. It was assumed that birds can forage on *Zostera* until 1.25 m depths, as birds can reach down to 1.05 m when foraging by up-ending (Clausen et al. 1995) and *Zostera* leaves are available at least 20 cm above the bottom. Considering this depth (1.25 m) as a threshold, available Zostera biomass was calculated for different water level conditions. It appears, that about 2,000 t DW of *Zostera* are available to birds at average water level (Figure 5.28). Depending on water level in the lagoon, this amount could range from 1,000 t to about 3,500 t.

Relating these calculations to swan intake, indicates that birds consumed about 27 % of the average available (at average water level) standing crop between May 1 and October 1, 2009. It has been estimated for the Danish waters that primary production of *Zostera* makes up 2.4-5.9 times the standing crop during a summer period (Noer et al. 1996 and references there in).

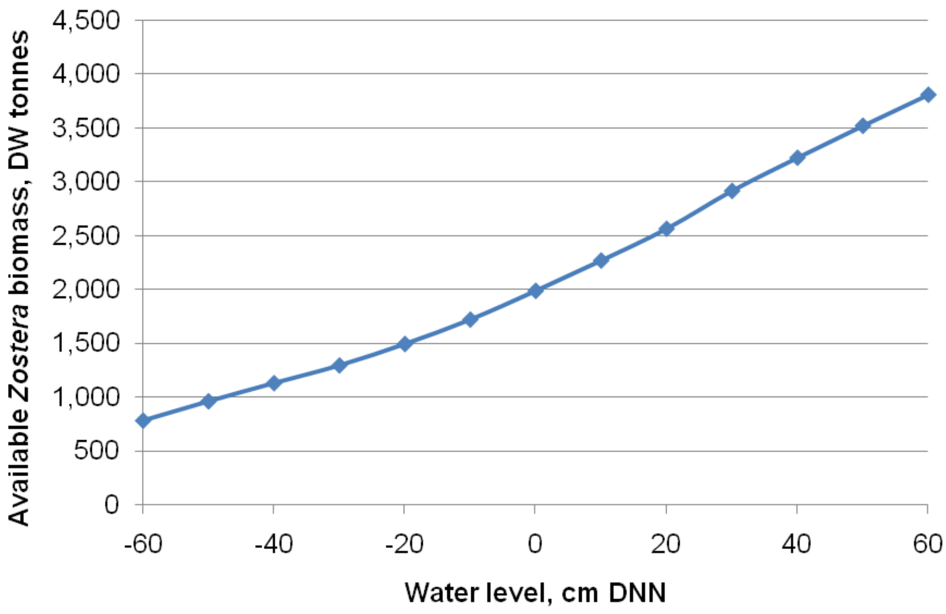


Figure 5.28 Zostera *biomass available to Mute Swans in Rødsand Lagoon depending on water level fluctuations in relation to average daily water levels.* Zostera *biomass estimated for summer 2009 by Fehmarnbelt Fixed Link baseline investigations on marine biology.*

For comparison, a similar study on foraging ecology of moulting Mute Swans around the island of Saltholm in Øresund estimated that birds consume 15–40 % of the available standing crop in different years, or always less than 25 % accounting for the net primary production (Noer et al. 1996).

This assessment of carrying capacity of Rødsand Lagoon to moulting Mute Swans is largely based on a similar and very detailed study on Mute Swans foraging ecology around Saltholm (Clausen et al. 1995, 1996, Noer et al. 1996). Therefore the conclusions were based relative to the 'Saltholm study' and no re-investigation of the established findings was carried out. Considering that the estimates about food demand by Mute Swans in the Rødsand Lagoon fall within the range of available standing crop of Zostera as estimated in the 'Saltholm study', it is provisionally concluded that with the current conditions Mute Swans are not food-limited in Rødsand Lagoon. More specific assessment will be provided during the EIA stage of this study, when concrete figures about *Zostera* production in Rødsand Lagoon are available from FEMA.

5.4.2 *Seaduck habitat carrying capacity in the Fehmarnbelt*

A baseline individual-based model (IBM) for Common Eider has been developed using modelled abundance of Blue Mussels in the Fehmarnbelt and bird foraging behaviour data collected using FEBI diet and telemetry studies. Baseline IBM covers area approaching that of aerial surveys and achieves reasonable correspondence between the virtual ecosystem of IBM and empirical observations. Sensitivity testing of the calibrated baseline model indicated that the model results were most sensitive to parameters describing bird food resources (mussel density, mussel flesh contents), environment (day length), eider foraging behaviour and efficiency, and eider physiology (metabolic rates, component assimilation rate, starvation body mass) (for details see Appendix VI). This indicates that the calibrated IBM is highly sensitive to a series of parameters that are known as being important for seaducks, and therefore the model is considered suited to analyse the carrying capacity of seaduck habitats.

By allowing 250,000 eiders into the IBM system and without forcing bird spatial distribution, the model predicted spatial spreading of model birds resembling closely observed eider distribution in the study area (see chapter 4.1.22): birds were spread out throughout the Fehmarnbelt with core aggregations around the island of Fehmarn (Flüggesand) and off southwest Lolland (Figure 5.29). Eider spatial distribution obtained from aerial surveys (Figure 4.91) correlated highly ($R = 0.77$, $P < 0.01$) with mussel consumption by model birds predicted in the IBM over wintering season (which represents predicted bird habitat use). The IBM slightly under-predicted utilisation of shallow water areas and over-predicted use of deep waters (Figure 5.29). Nevertheless, the majority of observed eiders and IBM birds utilised the depth range with the main biomass of Blue Mussels (Figure 5.29). Good correspondence between the IBM-predicted bird habitat use with the observed bird distribution represents one type of IBM validation with an independent dataset and supports our claim about IBM ability to assess bird-habitat interactions in the Fehmarnbelt.

The IBM results suggest that model eiders consume about 5,000 mussels per day (Figure 5.30), the amount which is about 30% lower than estimates according to eider energy budget (see chapter 5.2.2). However, there is no discrepancy from the actual Blue Mussel intake as these bivalves actually contribute about 70-80 % of the total energy intake for Common Eiders in the Fehmarnbelt, as it was established by the diet analysis.

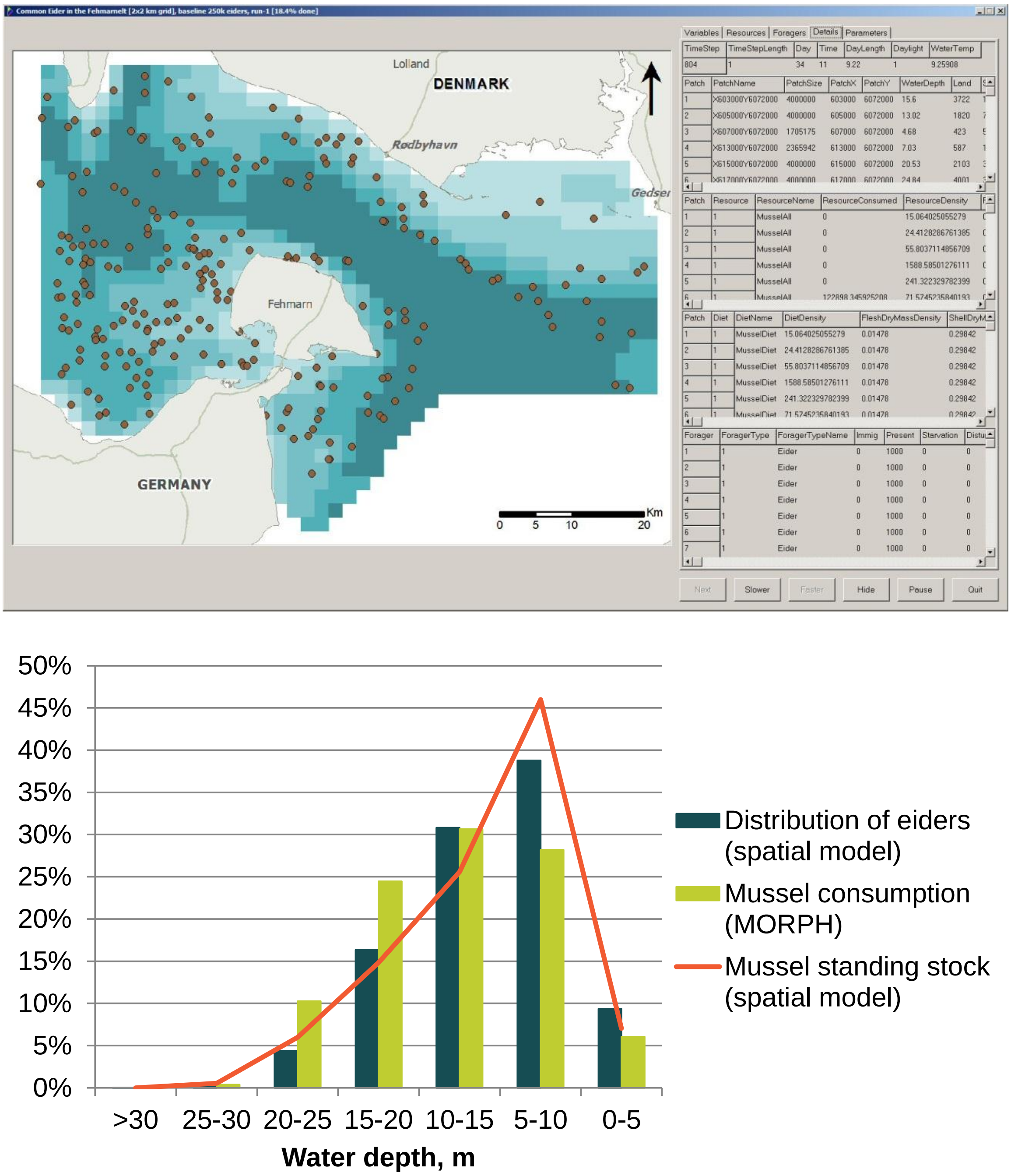


Figure 5.29 *IBM-predicted bird distribution: <u>upper map</u> shows screen shot of MORPH running individual-based model for Common Eiders in the Fehmarnbelt: each dot represents a 'super-individual' consisting of 1000 model birds. Modelled bird distribution closely resembles observed bird distribution patterns in the Fehmarnbelt. <u>Lower chart</u> illustrates correspondence between Common Eider distribution according to spatial modelling and IBM-predicted mussel consumption by birds (representing habitat use).*

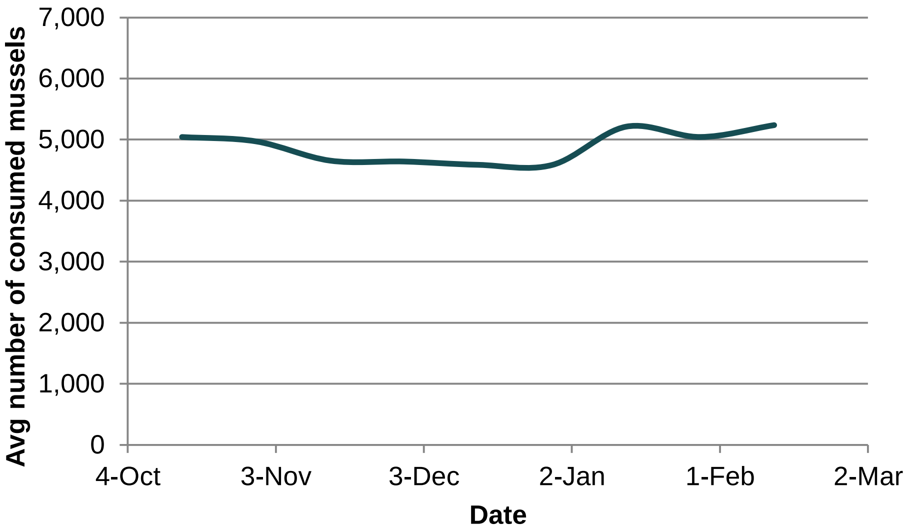


Figure 5.30 IBM-predicted 14 mm mussel consumption by Common Eider per day.

While testing the baseline IBM, the carrying capacity of the model system was assessed by varying a number of birds and measuring predicted bird survival. IBMs were simulated using several scenarios: by allowing 250,000 Common Eiders into the model system, and then by increasing bird numbers by an increment of 50,000 until the total number reached 500,000. Low mortality levels of model birds due to starvation were predicted when number of eider in the model system was 250-350,000 individuals: 400-600 birds were estimated to die during the wintering season (Figure 5.31). Predicted mortality started to increase with number of birds raising further and reached 2,400 when hypothetical population of 500,000 was allowed to winter in the Fehmarnbelt (Figure 5.31). However it was not a mass die off, which could be expected if habitat carrying capacity was exceeded, and proportionally comprised only 0.13-0.48% of all wintering birds. This represents only a fraction of natural mortality, which could be expected to be 2-3% during wintering season lasting 6 months (annual survival of Common Eiders could be as high as 0.936; Balmer and Peach 1997). Slightly increased mortality when number of birds was artificially inflated could indicate not only food limitation, but that factors such as density dependence also play are role.

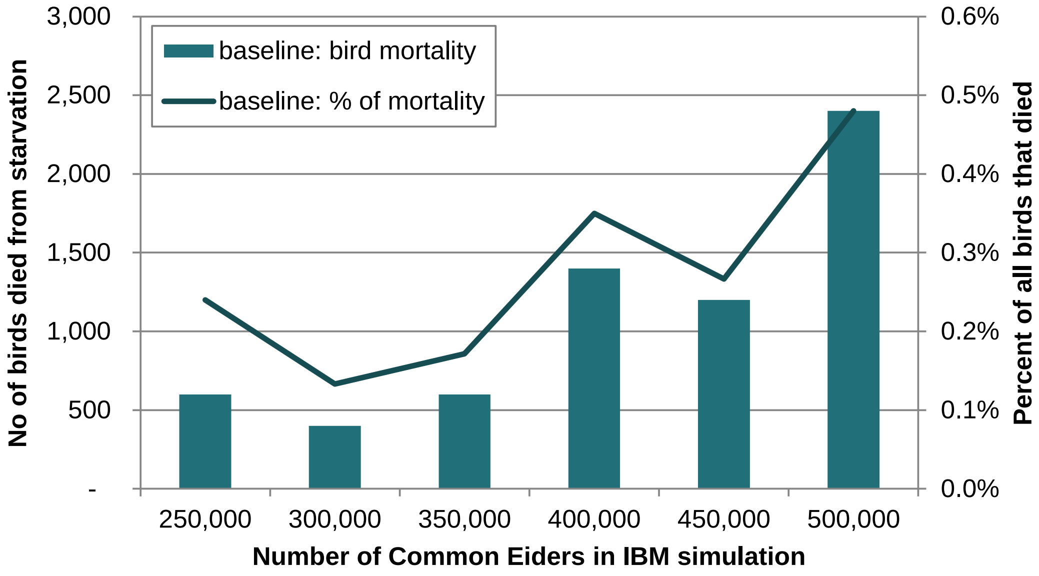


Figure 5.31 IBM-predicted Common Eider mortality due to starvation depending on the number of birds allowed into the model system.

As another test of the IBM performance, we checked dynamics of body mass of model birds. Although it was set in the model parameters that birds should gain mass at a constant rate during the wintering season, the model predicted that mass gain stopped in December, slightly decreased in early January and resumed growth in late January reaching the target level at the end of the wintering season (Figure 5.32). This pattern suggests that months with the shortest daylight could represent a critical period for wintering eiders. Additionally, average body mass variation was checked for simulations with higher number of model birds: the pattern suggested that higher abundance of birds results in slightly lower average body mass for part of the wintering season, but also that birds under all scenarios managed to reach their target body condition by the end of the winter (Figure 5.33).

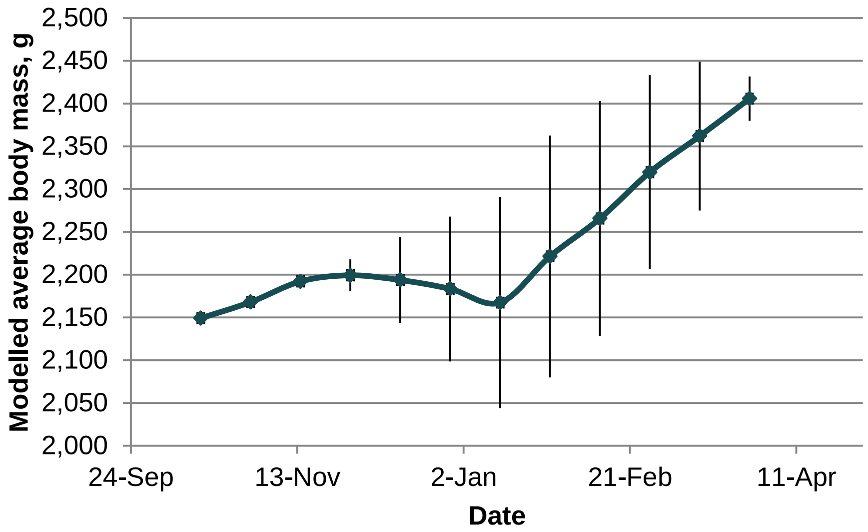


Figure 5.32 Mean body mass of Common Eiders (with bar indicating standard deviation) as predicted by the baseline IBM when 250,000 birds were allowed into the model system.

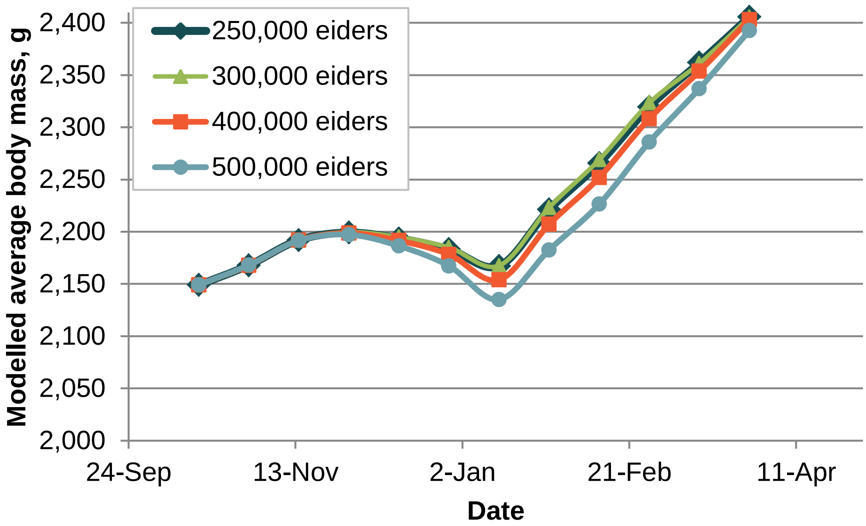


Figure 5.33 Varying number of birds (250 – 500 thousands) in the model system indicated that increasing numbers of birds have led to lower mean body mass. Note: this simulation was performed for testing model performance and does not represent anticipated numbers of birds in the Fehmarnbelt.

The IBM predicted that 250,000 Common Eiders consumed a total of about 3,000 tonnes of AFDW of Blue Mussels per wintering season in order to satisfy their energetic requirements. Initial standing stock of Blue Mussels for the entire model area was estimated at 28,000 tonnes AFDW. This renders that 250,000 Common Eiders consume about 10.7 % of the initial standing stock of Blue Mussels per wintering season.

This modelling exercise suggested that currently estimated food resources are sufficient to support the number of Common Eiders wintering in the Fehmarnbelt, and that population of this size is not even close to the carrying capacity of the ecosystem.

Considering that at some periods there could be more than 250,000 Common Eiders in the Fehmarnbelt, and other seaduck species also consume Blue Mussels, it still could be safely concluded that annual bird consumption does not exceed 20 % of the standing stock of Blue Mussels.

Opinions vary about the amount of food that wintering seaducks need for satisfying their energetic demands. Laursen et al. (2010) suggested that Common Eiders wintering in the Danish Wadden Sea need a standing stock of Blue Mussels that exceed the birds' physiological needs at least 2.5 times. Camphuysen et al. (2002) reported mass mortality of starving Common Eider in the Dutch Wadden Sea even though estimated stock of bivalves 4.7 times exceeded bird physiological demands.

We conclude that the current design of the IBM, although not perfect, represents relationships between wintering Common Eiders and their primary food base reasonably well. Therefore the model might serve as a tool for predicting possible effects of a fixed link construction over the Fehmarnbelt using impact scenarios.

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List of figures

List of tables