Chapter 13

Identification of areas of seabird concentrations in the German North Sea and Baltic Sea using aerial and ship-based surveys

Stefan Garthe

Research and Technology Centre Westcoast (FTZ), Büsum

Abstract

This paper gives a brief overview of the field methods used to study the distribution of seabirds at sea in the German parts of the North and Baltic Seas. It demonstrates how the data were analysed, how seabird concentrations may be delineated, and how suggestions for protected areas were derived from the data.

Seabird distribution was studied by transect counts from ships and aircraft. Species distribution maps produced from these data are based on densities. The distribution of widely dispersed species, e.g., lesser black-backed gull (*Larus fuscus*) and northern fulmar (*Fulmarus glacialis*), were analysed using grid maps. For species occurring in concentrations, a spatial interpolation procedure using ordinary kriging[1] was adopted. Examples of distributions and maps are given for long-tailed duck (*Clangula hyemalis*; Baltic Sea), common eider (*Somateria mollissima*; Baltic Sea) and red-throated and black-throated divers (*Gavia stellata* and *G. arctica*; North Sea). For all specially important species (i.e., species listed in Annex I of the EU Birds Directive that should be the subject of special conservation measures, e.g., red-throated diver and sandwich tern *Sterna paradisaea*), concentration areas were identified and subsequently combined so that a set of potential areas for conservation could be determined. From this map, potential Special Protection Areas (SPAs) were established.

Finally, this paper briefly discusses field methods and methods of analysis and gives further recommendations.

---

[1] Kriging: a form of statistical modelling that interpolates data from a known set of sample points to a continuous surface.

1 Introduction

Marine protected areas (MPAs) for seabirds are currently being established under various international instruments and marine conventions (e.g., OSPAR Convention, Helsinki Convention) and also under the main nature conservation directives of the European Commission. When Germany adopted its Federal Nature Conservation Act in April 2002 in order to select NATURA 2000 sites (including SPAs for birds) also within the Exclusive Economic Zone (EEZ), the need arose to get an up-to-date overview of the distribution and status of seabirds in the German North and Baltic Sea waters. This paper briefly describes the field methods used in studying the distribution of seabirds at sea, how the data were analysed, how seabird concentrations may be identified, and how suggestions for protected areas were derived from the data. The main emphasis is on methods rather than on results. The latter is presented in much more detail in Garthe (2003), Garthe et al. (2003), and Garthe and Skov (in preparation).

2 Materials and methods

2.1 Field methods

Seabird distribution in the southeastern North Sea and the southwestern Baltic Sea was studied by transect counts from ships and aircraft. These methods basically aim at assessing distribution patterns and numbers of seabirds at sea, but they are each differently suited for these purposes (see Camphuysen et al. 2004, and Garthe et al. 2004 for recent reviews). Aerial surveys are able to cover much larger areas in much shorter times at lower per-kilometre price. However, they are only feasible at low-wind situations and there are restrictions on species identification from aerial surveys (e.g., groups such as grebes, gulls, terns, and auks usually cannot be identified up to species level). Ship-based surveys enable collecting additional information on the behaviour of the birds and usually allow for sampling environmental data such as hydrography, which proves very useful for understanding species distribution patterns.

For counts from ships, the methodology has been largely standardised internationally and was first described by Tasker et al. (1984). Due to the presence of high densities of birds that quite often fled away from approaching ships, it proved necessary to regularly or continuously search for birds using binoculars and to deploy at least two observers, as suggested by Webb and Durinck (1992) and Garthe et al. (2002). Birds were counted from either the top deck or the bridge-wing, usually on 300-metre wide transects set to one or both sides of the vessel. Counting intervals during the surveys were initially set at 10 minutes, as suggested by Tasker et al. (1984), but 1- or 2-minute intervals were increasingly used to enable higher resolution for mapping and analysis of seabird distribution, particularly in relation to water depth and hydrography. Flying birds were counted employing the *snapshot* method (Tasker et al. 1984, Garthe et al. 2002). Positions of the survey vessel were recorded automatically by onboard or portable GPS instruments.

Seabirds were also counted from aircraft using a transect methodology recently described by Diederichs et al. (2002). Flights were conducted from double-engine planes (e.g., Partenavia P-68) flying over German waters, from the coast to the outer limit of the EEZ. Transects were usually set perpendicular to the coast to obtain variation over major habitat features such as water depth, distance to coast, and frontal systems. Transects were separated in the North Sea by 10 km (20 km in areas far from the coast) and in the Baltic Sea mostly by 8 km. Flights were conducted at an altitude of 250 feet (78 metres) and a speed of 100 knots (185 km/hour). Transect bands were set for each observer by inclinometers (devices measuring angles) on the side of the aircraft since there was no possibility of looking at the sea surface directly under the plane. Transect widths were either 122 metres (one band only) or 397 metres (two bands) depending on viewing conditions. During the counts, all bird observations were recorded on a portable voice recorder; data recorded include: time (to the nearest second), species, number, general behaviour (five categories) and also, if possible, age and sex. Geographic position was recorded every 5 seconds on-board the plane.

2.2 Data bases

The data bases for the work described in this paper are current versions of the European Seabirds-at-Sea (ESAS) Database, the German Seabirds-at-Sea Database, and the BALTSAS-Database (DHI Water & Environment, Hørsholm, Denmark, c/o H. Skov) (see e.g., Durinck et al. 1994, Stone et al. 1995, Garthe and Hüppop 2000). In Germany, most data were collected by the Research and Technology Centre (FTZ) in Büsum (an external station of the University of Kiel) and the Institute of Avian Research; in Denmark, by Ornis Consult Ltd; in the UK, by the Joint Nature Conservation Committee (JNCC); and in the Netherlands, by the Royal Netherlands Institute for Sea Research (RNIOZ), Camphuysen Seabird Research (CSR), and ALTERRA.

In total, the following distances were covered: in the southeastern North Sea, 103,000 km by ship from 1990 to June 2004, and 28,000 km by plane from 2002 to June 2004; in the southwestern Baltic Sea, 19,000 km each by ship from 1986 to June 2004, and by plane from 2002 to June 2004. The effort at sea varied substantially over the years and seasons.

2.3 Selection of species for SPA delineation

Gellermann et al. (2003) catalogued those species whose occurrence in German waters needed to be considered for the selection of SPAs. They distinguished three different levels of species importance. For the selection of SPAs, only those species that were categorised in their list as of high or medium importance were used. Three groups of bird species comprised this category.

Firstly, the species that are currently listed in Annex I of the EU Birds Directive (species that shall be the subject of special conservation measures) and that occur regularly in the offshore waters of the German parts of the Baltic Sea. These are the red-throated diver (*Gavia stellata*), black-throated diver (*Gavia arctica*), slavonian grebe (*Podiceps auritus*), and four species of terns. (Please note that grebes and terns are much more restricted to the coast in the North Sea than they are in the Baltic Sea).

Secondly, migratory species which regularly occur in offshore areas were included. The EU Birds Directive does not define "migratory species", and the definition used in practice is the one provided by the Bonn Convention. This convention defines migratory species as species where a significant proportion of the population cyclically and predictably crosses one or more national jurisdictional boundaries. For both study areas, this includes all seabird species. Then, for these bird species, especially those that occur in major concentrations, the most important areas (or a few of the most important areas) were recommended to be selected as SPAs. The identification of SPAs focused on the German EEZ, and preferably, on areas derived from more than one species.

The third group or category refers to rare offshore species and species occurring along the coast only (e.g., diving ducks, geese, swans). Analysis of data was equal for the first two groups, i.e., the Annex I-bird species and migratory species. However, concentrations of Annex I-bird species were considered to be much more important and were thus more decisive for the designation of SPAs than areas with only migratory bird species. The third group (i.e., rare offshore and along-the-coast-only species) was not at all relevant for the SPA selection process in the EEZ due to their virtual absence in that area.

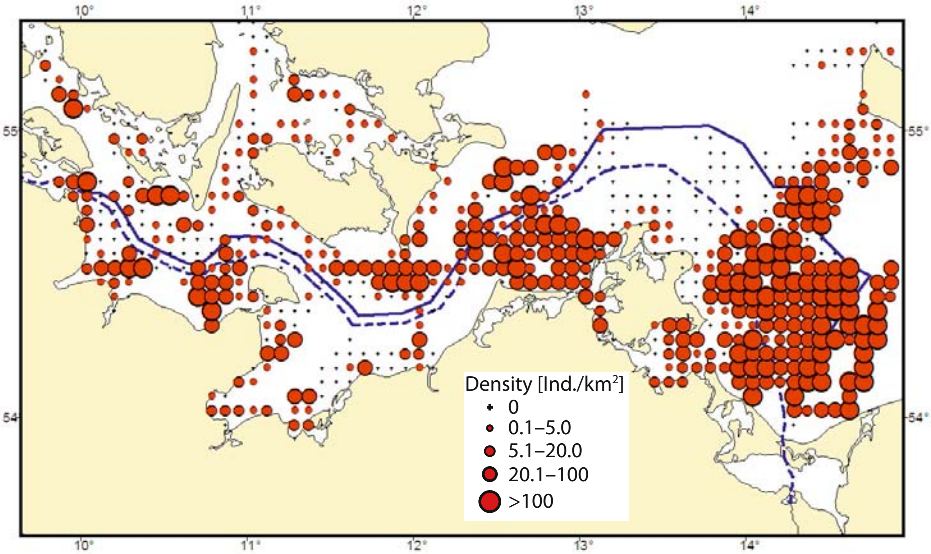
2.4 Species distribution maps

All species distribution maps are based on densities, that is, the number of individuals per unit area. Principally, two types of seabird distribution patterns may be distinguished. Some species are distributed over large areas and exhibit usually only short-term aggregations (e.g., gulls), while other species are often heavily concentrated and are reliably predictable in their distribution (e.g., sea ducks). Although there are intermediate patterns, different approaches were adapted to map and they delineate the major distribution areas. For widely distributed species, distributions were analysed by grid maps with grid cells by either 3′ latitude x 5′ longitude (grid cell size: ca. 30 km^2) or 6′ latitude x 10′ longitude (grid cell size: ca. 120 km^2). Species with wide-ranging distributions were visualised by the larger grid cells, and species with a more restricted distribution by the smaller grid cells. For each grid cell, the overall density was calculated, obtained from the sum of all birds recorded in transect divided by the total area mapped. This way, the data was corrected for effort. Major areas for widely distributed species were difficult to determine precisely.

All species that occur in concentrations aggregated in areas that were far too large to allow total counts of all the birds. For these species, therefore, a spatial interpolation procedure based on ordinary kriging (Kitadinidis 1997, and used by Skov et al. 2000) was adopted and further developed (Garthe 2003, Garthe and Skov in preparation). With this procedure, distributional data were interpolated and smoothed between survey lines on the basis of the species-specific spatial abundance structure (which is measured by the software used).

2.5 Seabird concentrations

Boundaries of concentration areas were determined by an analysis investigating the gradient of density change over space. In order to do that, the modelled distributional data were projected into a two-dimensional map. In each of such cases, the modelled isoline of bird density (i.e., the line drawn through the same level of bird density) located just outside the strongest gradient in spatial density was chosen as the border of a concentration. In this way, the major part of the concentration is included in the selected area. The density value of the borderline was noted and used as the species- and season-specific minimum density defining a seabird concentration. This value was then taken for plotting the contour line showing the spatial extent of the respective concentration.



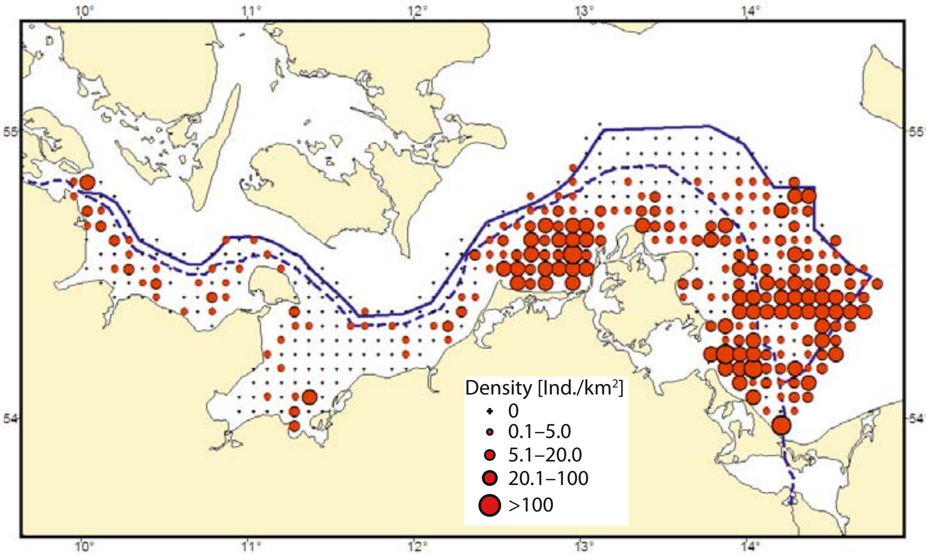


Figure 1. Distribution of long-tailed ducks in the southwestern Baltic Sea in winter as assessed by two different methods. The dashed line indicates the 12-mile zone, the continuous line the EEZ border. (Top) Ship-based data for November–February 1987–2003, (bottom) aerial survey data for February 2003

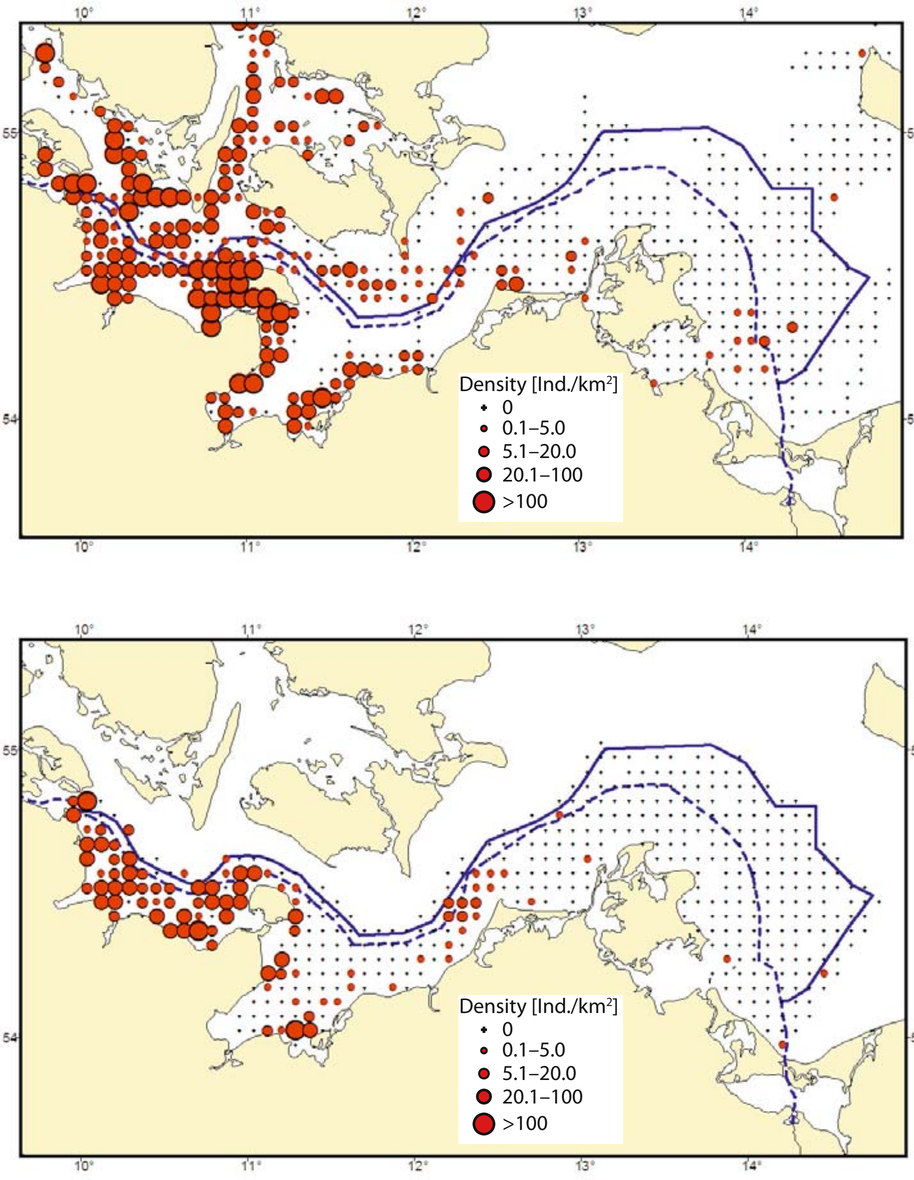


Figure 2. Distribution of common eiders in the southwestern Baltic Sea in winter as assessed by two different methods. The dashed line indicates the 12-mile zone, the continuous line the EEZ border. (Top) Ship-based data for November–February 1987–2003, (bottom) aerial survey data for February 2003

2.6 Combining single-species data into multi-species data

For each of the species of interest derived from the list of Annex I and migratory bird species, concentration areas were retained for analysis. These respective areas and contour lines were then combined so that a set of areas for potential conservation was identified. From this map, potential SPAs were derived.

3 Results

From a total of 25 seabird species that occur regularly in German North and Baltic Sea offshore waters, the distributions of two species of seaduck and two species of divers are shown as examples. The long-tailed duck (*Clangula hyemalis*) is a fairly widespread species in the German Baltic Sea in winter (figure 1), with major concentrations in the *Pommeranian Bay* (*Pommersche Bucht*; the large area in the east of the map) and to the west of Rügen (located towards the centre of the map). There are a few more but less obvious concentration areas. In contrast, the common eider (*Somateria mollissima*) is restricted in its distribution to the western part of the German Baltic Sea (figure 2), with the largest concentration in the *Kiel Bight* (*Kieler Bucht*) (southwestern part of the study area).There were very few sightings of this species east of the Darss peninsula in winter. For both species, the results are quite similar as derived from a multiple year data set covering waters to different extents (top figures 1 and 2) as well as by a single three-day aerial survey (bottom figures 1 and 2). The aerial survey took place at a time when there was no ship survey so that the data sets are temporally independent in that sense.

Red-throated and black-throated divers are important species in the southeastern North Sea. They are shown in joint maps, but around 95% of the individuals identified were red-throated divers. In winter, their distribution is mainly restricted to a relatively small zone near mainland coasts and islands; this is most obvious for the East Friesian Islands (located in the southeastern part of the study area; see top left figure 3). In spring, the centre of the distribution moves further north and further away from the coast and is located west of the North Friesian Islands in the EEZ (top right and bottom figure 3).

Figure 4 shows the concentration areas of all relevant seabird species in the southwestern Baltic Sea following the methodology described in sections 2.3, 2.5 and 2.6. These species are red-throated diver, black-throated diver, great crested grebe (*Podiceps cristatus*), red-necked grebe (*Podiceps grisegena*), slavonian grebe, common eider, long-tailed

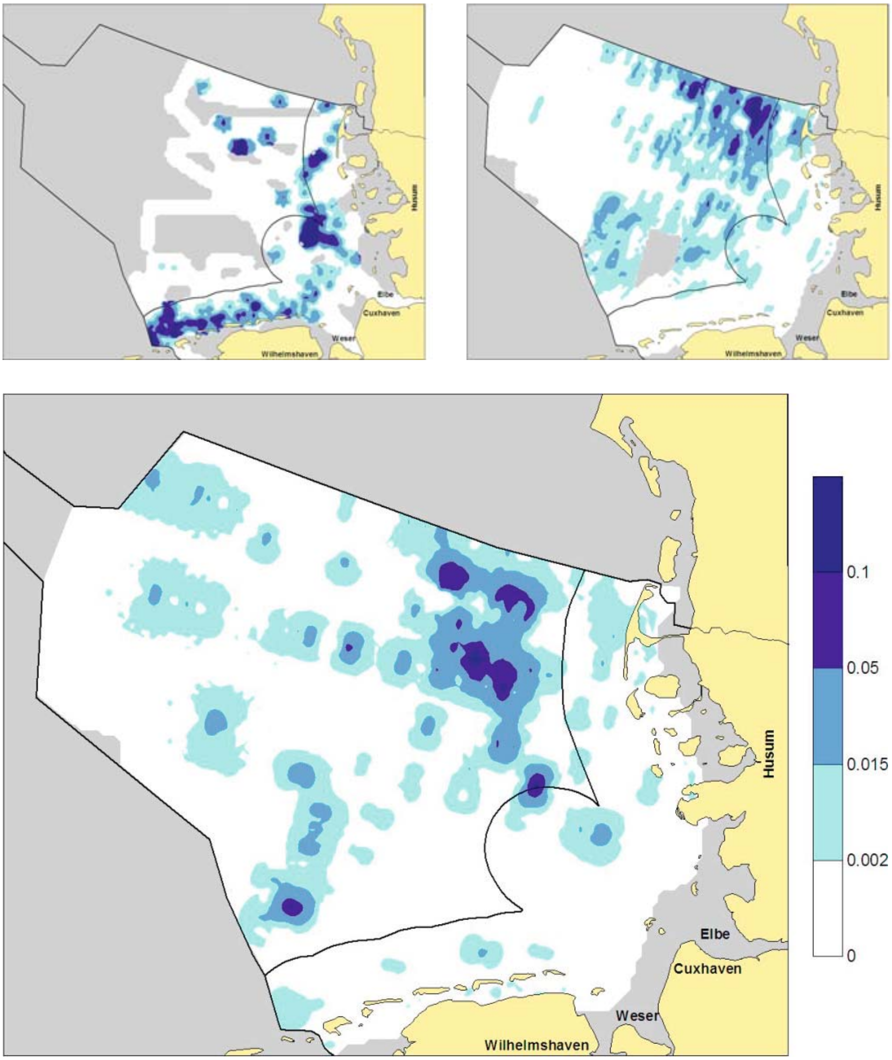


Figure 3. Distribution of red-throated and black-throated divers in the south-eastern North Sea. Data originated from two different methods. The maps have been produced by spatial interpolation; for details see text. Light grey colour indicates areas that were not studied sufficiently during the respective survey periods and/or were outside of the scope (e.g., areas in countries other than Germany). The line more or less parallel to the coast indicates the 12-mile zone, the other line the EEZ border. The *x*-axis gives a total distance of 290 km, the *y*-axis 245 km. The colour scale gives the abundance of the birds on a logarithmic scale (log (birds*km^{-2}+1). (Top left) November–February 2000–2003, ship data; (top right) March 2003, aerial survey data; (bottom) April 2003, aerial survey data

duck, common scoter (*Melanitta nigra*), velvet scoter (*Melanitta fusca*), red-breasted merganser (*Mergus serrator*) and black guillemot (*Cepphus grylle*). The most important areas are situated in the *Pommeranian Bay*, west of Rügen, and in the *Kiel Bight*.

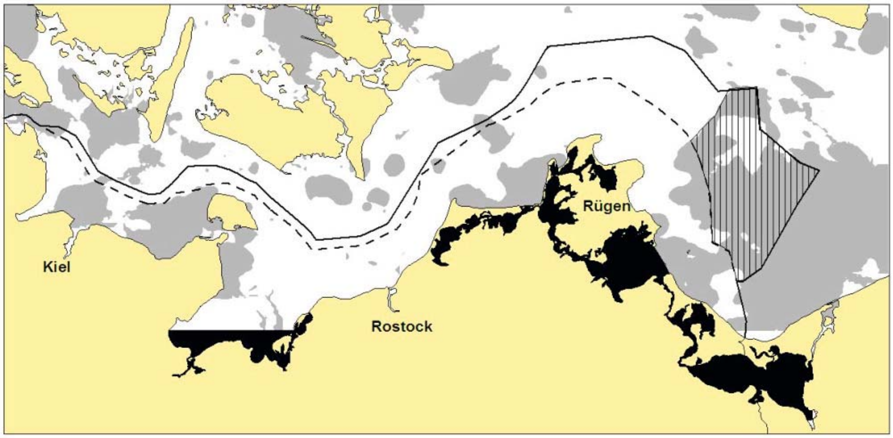


Figure 4. Overlay of all areas exhibiting concentrations of the species of interest in the southwestern Baltic Sea (grey). Black colour indicates areas that were not studied sufficiently and/or were outside the scope. The dashed line indicates the 12-mile zone, the continuous line the EEZ border. Vertical hatches: the offshore Special Protection Area (SPA) for birds

4 Discussion

The data collected by ship-based and aerial surveys have been extremely useful for describing the current distribution patterns of all seabird species in the two study areas. Both field methods have their advantages and disadvantages because of their different characteristics (see section 2.1). A combination of both is ideal for most purposes, including the ones discussed in this paper. It is important to carefully select these field methods with respect to the spatio-temporal scale envisaged for such a study, and to the species under consideration.

The robustness of the results has been the focus of considerable attention by different groups in light of proposals for two large SPAs within the German EEZs of the Baltic and North Seas (Garthe 2003). Most promising was the finding that all surveys carried out after finalisation of the SPA proposals (i.e., all surveys in 2003 and 2004) could prove the same major concentration areas as in the years before (e.g., top right and bottom figure 3 for the North Sea). This shows that even if borderlines of concentration areas may shift slightly, as to be expected by seabirds living in a dynamic environment, the major results are stable and reproducible. However, on a larger time-scale, especially if environmental conditions change, it is possible that the distribution of seabird species may alter. In the Baltic Sea, this could be the case, for instance, with regard to winter ice distribution since nearly all data collected for this study were from mild and normal winters only. In the North Sea, recent evidence of major changes in food availability (which have led to breeding failures in the northwestern North Sea) may influence distribution patterns in the *German Bight* (*Deutscher Bucht*), too, at least of those species ranging over wide areas of the North Sea (northern fulmar, northern gannet *Morus bassanus*).

The analytical methods outlined in this paper are still at an early stage of being adopted as standard procedures for designating SPAs since most Member States of the European Union have not yet delineated such protected sites in offshore areas. However, these methods have been very useful for selecting concentration areas of seabirds and SPAs. More recent works by British colleagues highlight the way forward (e.g., McSorley et al. 2004, Webb et al. in preparation). For species exhibiting widely dispersed distributions, the procedure for identifying concentration areas is much more difficult than for aggregated species. Up to now, no attempt has been shown on how to deal with sea areas where only species that are rather evenly or at least widely distributed occur. In such cases, vast areas would need to be designated to capture a given percentage of bird numbers. This is often politically impossible and might also be scientifically less evident. This problem needs further consideration. For modelling purposes, e.g., future site selections, co-variates (e.g., water depth) should be included. Also, attention may be paid to the reliability of the data by calculating (statistically) the spatial variation of the boundary lines describing concentrations. If such boundary lines vary substantially over space within e.g., standard deviation, then the data basis and/or the aggregation character of the bird species may be less evident than when the boundaries are more stable over space.

Figure 5. Northern Gannet (*Morus bassanus* (L))

Acknowledgements

This work is based on several projects that have been conducted in recent years. Funding has been received primarily by Bundesamt für Naturschutz, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Freunde und Förderer der Inselstation der Vogelwarte Helgoland e.V., Ornithologische Arbeitsgemeinschaft für Schleswig-Holstein & Hamburg e.V. and Forschungs- und Technologiezentrum Westküste (FTZ) der Universität Kiel. Field observations were carried out by many observers over the years. Many private and governmental institutions permitted work on their boats. Furthermore, many people have contributed to this work by collecting, summarising and analysing data, by helping shape the procedures for SPA designations and through general comments. From these, at least the following need to be mentioned: C.J. Camphuysen, V. Dierschke, O. Engelhard, N. Guse, O. Hüppop, J. Kotzerka, J. Krause, U. Kubetzki, K. Ludynia, N. Markones, T. Merck, M. Scheidat, P. Schwemmer, H. Skov, N. Sonntag, A. Webb, and T. Weichler.

References

Camphuysen CJ, Fox AD, Leopold MF, Petersen IK (2004) Towards standardised seabirds at sea techniques in connection with environmental impact assessments for offshore wind farms in the U.K. Final report to COWRIE, COWRIE-BAM-02-2002

Diederichs A, Nehls G, Petersen IK (2002) Flugzeugzählungen zur großflächigen Erfassung von Seevögeln und marinen Säugern als Grundlage für Umweltverträglichkeitsstudien im Offshorebereich. Seevögel 23:38–46

Durinck J, Skov H, Jensen FP, Pihl S (1994) Important marine areas for wintering birds in the Baltic Sea. Ornis Consult report, Kopenhagen

Garthe S (2003) Verteilungsmuster und Bestände von Seevögeln in der Ausschließ-lichen Wirtschaftszone (AWZ) der deutschen Nord- und Ostsee und Fach-vorschläge für EU-Vogelschutzgebiete. Berichte zum Vogelschutz 40:15–56

Garthe S, Hüppop O (2000) Aktuelle Entwicklungen beim "Seabirds-at-Sea"-Programm in Deutschland. Vogelwelt 121:301-305

Garthe S, Skov H (in preparation) Selection of suitable sites for marine protected areas for seabirds: a case study of an EU Special Protection Area in the Baltic Sea

Garthe S, Hüppop O, Weichler T (2002) Anleitung zur Erfassung von Seevögeln auf See von Schiffen. Seevögel 23:47–55

Garthe S, Ullrich N, Weichler T, Dierschke V, Kubetzki U, Kotzerka J, Krüger T, Sonntag N, Helbig AJ (2003) See- und Wasservögel der deutschen Ostsee – Verbreitung, Gefährdung und Schutz. Federal Agency for Nature Conservation, Bonn

Garthe S, Dierschke V, Weichler T, Schwemmer P (2004) Rastvogelvorkommen und Offshore-Windkraftnutzung: Analyse des Konfliktpotenzials für die deutsche Nord- und Ostsee. Unpublished final report of sub-project 5 of the project MINOS to the Federal Environmental Ministry, Berlin

Gellermann M, Melter J, Schreiber M (2003) Ableitung fachlicher Kriterien für die Identifizierung und Abgrenzung von marinen Besonderen Schutzgebieten (BSG) nach Art. 4 Abs. 1 und 2 der Vogelschutzrichtlinie bzw. Vorschlagsgebieten gemäß Art. 4 Abs. 1 der FFH-Richtlinie für die deutsche ausschließliche Wirtschaftszone. Unpublished Report to the Federal Environ-mental Ministry, Berlin

Kitanidis P, (1997) Introduction to geostatistics – Applications in hydrogeology. Cambridge University Press, New York

McSorley CA, Webb A, Dean BJ, Reid JB (2004) Inshore marine Special Protection Areas: a methodological evaluation of site selection and boundary determination. JNCC Report 344. Joint Nature Conservation Committee, Peterborough

Skov H, Vaitkus G, Flensted KN, Grishanov G, Kalamees A, Kondratyev A, Leivo M, Luigojoe L, Mayr C, Rasmussen JF, Raudonikis L, Scheller W, Sidlo PO, Stipniece A, Struwe-Juhl B, Welander B (2000) Inventory of coastal and marine important bird areas in the Baltic Sea. BirdLife International, Cambridge

Stone CJ, Webb A, Barton C, Ratcliffe N, Reed TC, Tasker ML, Camphuysen CJ, Pienkowski MW (1995) An atlas of seabird distribution in north-west European waters. Joint Nature Conservation Committee, Peterborough

Tasker ML, Jones PH, Dixon TJ, Blake BF (1984) Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardized approach. Auk 101:567–577

Webb A, Durinck J (1992) Counting birds from ships. In: Komdeur J, Bertelsen J, Cracknell G (eds) Manual for aeroplane and ship surveys of waterfowl and seabirds. IWRB Special Publication, Slimbridge, UK 19:24–37

Webb A, McSorley CA, Dean BJ, Reid JB, Cranswick PA, Smith L, Hall C (in preparation) An assessment of the numbers and distributions of inshore aggregations of waterbirds using Liverpool Bay during the non-breeding season in support of possible SPA identification. JNCC Report. Joint Nature Conservation Committee, Peterborough