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Recent Population Dynamics and Habitat Use of Barnacle Geese and Dark-bellied Brent Geese in the Wadden Sea

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Contents

Summaries 151
Summary 151
Sammenfatning 151
Zusammenfassung 152
Samenvatting 153

1. Introduction 154

2. Data and Methods 155

3. Results 155
3.1 Numbers and trends 155
3.1.1 Barnacle Goose 155
3.1.2 Dark-bellied Brent Goose 156
3.2 Phenology 157
3.2.1 Barnacle Goose 157
3.2.2 Dark-bellied Brent Goose 158
3.3 Habitat use 159
3.3.1 Barnacle Goose 159
3.3.2 Dark-bellied Brent Goose 160

4. Discussion 162
4.1 Expansion of Barnacle Goose 162
4.2 Declining numbers of Dark-bellied Brent Goose 163
4.3 Increased competition? 164
4.4 Feeding on salt marshes and agricultural sites 164
4.5 Feeding on mainland versus islands 165

5. Conclusions and Implications for Management 166

6. References 168

Summaries

Summary

The Wadden Sea is an important staging area for the Russian-Baltic population of Barnacle Geese (*Branta leucopsis*) and the West-Siberian population of Dark-bellied Brent Geese (*Branta b. bernicla*). Both species use the Wadden Sea mainly in spring and autumn as a staging area to accumulate body reserves for migration and breeding. Smaller numbers stay during winter. Data from trilateral goose counts and regular census data was used to review the current status of both species, especially with regard to numbers, phenology and habitat.

In the 1990s, up to 85% of the Russian-Baltic flyway population of Barnacle Geese concentrated in the area in March. Moreover, as a result of the ongoing population increase, numbers and feeding range in the Wadden Sea have expanded considerably, especially in spring and mainly along the mainland coast. This coincided with a delay in spring departure of 4-6 weeks; the last birds leave the area around Mid-May, and probably head directly for their breeding areas from the White Sea and further east. Compared to the 1980s and earlier, the Wadden Sea has grown in importance as a pre-migration area, where body reserves are stored for spring migration and breeding.

In Dark-bellied Brent Goose on the other hand, numbers have declined since the mid-1990s. The decline in the Wadden Sea runs parallel to an overall population decrease, which has been caused by lower reproduction rates at the breeding areas. However, in spring about 85% of the population is still found in the Wadden Sea, whereas in winter only 10% of the population is present. As a result of the lower population level, Dark-bellied Brent Geese have contracted their main feeding sites to the barrier islands.

For both species, the overall changes in numbers, distribution and habitat utilization in the Wadden Sea seem to be mainly related to changes at population level. No evidence has been found that changes in feeding and staging conditions in the Wadden Sea have contributed to the decline and increase in either species. However, further research, such as analysis of movements of color-marked birds could help to understand some of the observed changes in distribution and phenology. In the coming years, further expansion of feeding areas in the Wadden Sea and its immediate surroundings, *i.e.* agricultural areas along the mainland coast, polders on the islands and other sites outside the Wadden Sea is likely for Barnacle Geese, and potential conflicts with farmers might increase.

Sammenfatning

Vadehavet er et vigtigt rasteområde for den russisk-baltiske bestand af Bramgås (Branta leucopsis) og den Vestsiberiske bestand af Mørkbuget Knortegås (Branta b. bernicla). Begge arter bruger især Vadehavet om foråret og efteråret som rasteområde til pålejring af fedtreserver til deres træk- og yngleaktivitet. Et mindre antal

fugle bliver i Vadehavet om vinteren. Data fra de trilaterale gåsetællinger og regelmæssige optællinger er brugt til at revidere arternes nuværende status, især med hensyn til antal, fænologi og habitat.

I 1990erne var op mod 85% af den russisk-baltiske bestand af Bramgæs koncentreret i Vadehavet i marts måned. Desuden, som et resultat af den stigende bestand, er antal og fødesøgningsområde i Vadehavet udvidet betydeligt, specielt om foråret og især langs fastlandskysten. Dette falder sammen med en udsættelse af forårstrækket til yngleområderne med 4-6 uger; de sidste fugle forlader nu området omkring midten af maj, disse fugle flyver sandsynligvis direkte til yngleområderne ved Hvidehavet og længere østpå. Sammenlignet med 1980erne og tidligere, er Vadehavets betydning steget betydeligt som et før-træk område, hvor krops-reserverne bliver fyldt til forårstrækket og yngleaktiviterne.

Antallet af Mørkbuget Knortegås er faldet i antal siden midten af 90erne. Nedgangen i antallet i Vadehavet løber parallelt med en overordnet bestands nedgang, som skyldes lav ynglesucces. På den anden side er 85% af bestanden stadig i Vadehavet, hvorimod kun 10% er tilstede om vinteren. Som et resultat af det lave bestandsniveau, har Mørkbuget Knortegås koncentreret deres fødesøgningsområder på øerne i Vadehavet.

For begge arter er den overordnede ændring i antal, fordeling og habitatudnyttelse i Vadehavet især relateret til ændringen på bestandsniveau. Der er ikke fundet evidens for at der er ændringer i føde- eller rastebetingelserne i Vadehavet, som har bidraget til faldende eller stigende antal for nogle af arterne. Imidlertid kan øget forskning i form af analyser af fuglenes bevægelser ved farvemærkning af individerne kunne hjælpe med til at forstå nogle af de observerede ændringer i fordeling og fænologi. I de kommende år er det sandsynligt at der for Bramgæs vil ske en yderligere ekspansion i fødesøgningsområderne i Vadehavet og i dets umiddelbare omgivelser, f.eks. i landbrugsområder langs fastlandskysten, marskområder på øerne og i andre områder udenfor Vadehavet. Dette kan medføre stigende konflikter med landmænd.

Zusammenfassung

Das Wattenmeer ist ein bedeutendes Rastgebiet für die russisch-baltische Population der Nonnengans (*Branta leucopsis*) und der Dunkelbäuchigen Ringelgans (*Branta b. bernicla*). Beide Arten nutzen das Wattenmeer vor allem im Frühjahr und Herbst, um sich Fettreserven für die weiten Zugstrecken und die Brutzeit anzufressen und zu einem geringeren Anteil auch als Überwinterungsgebiet. Zähldaten der wattenmeerweiten Gänse-Synchronzählungen und der anderen regelmäßigen Zählungen wurden ausgewertet, um einen aktuellen Überblick über den Status beider Arten im Hinblick auf die Bestandsgrößen, die jahreszeitliche Verteilung und die Habitatnutzung zu geben.

In den 1990er Jahren rasteten im März bis zu 85% der russisch-baltischen Nonnengans-Population im Wattenmeergebiet. Als Folge des anhaltenden Populationswachstums, vergrößerte sich sowohl die Zahl der im Wattenmeer rastenden Gänse deutlich, als auch die von ihnen genutzte Fläche, vor allem im Frühjahr entlang der Festlandsküste. Dies wird auch durch einen nun um 4-6 Wochen späteren Abzug deutlich – die letzten Vögel verlassen das Wattenmeergebiet Mitte Mai und ziehen wahrscheinlich direkt in ihre Brutgebiete am Weißen Meer und weiter östlich. Verglichen mit der Zeit vor den 90er Jahren hat die Bedeutung des Wattenmeeres für die Nonnengänse als vorbrutzeitliches Rastgebiet zur Anlage von Fettreserven für Zug und Brut zugenommen.

Bei der Dunkelbäuchigen Ringelgans dagegen haben die Bestände seit Mitte der 1990er Jahre nicht nur im Wattenmeer, sondern in der gesamten Population deutlich abgenommen, was wahrscheinlich vor allem an dem schlechten Bruterfolg der letzten Jahre liegt. Weiterhin rasten aber im Frühjahr etwa 85% der Population im Wattenmeer, während es im Winter nur 10% sind. Als Folge der geringeren Populationsgröße haben sich die Ringelgänse wieder auf die Salzwiesen der Halligen und Inseln als ihre Hauptnahrungshabitate konzentriert.

Für beide Arten gilt wohl, dass die Veränderungen der Anzahl, der Verteilung und Habitatnutzung im Wattenmeer vor allem mit den Bestandsveränderungen der Populationen zusammenhängt. Es gibt keine Anzeichen, dass Veränderungen der Ernährungs- und Rastbedingungen im Wattenmeer auf die Zu- oder Abnahme der Populationsgröße der beiden Arten einen Einfluss gehabt hätten. Weitere Untersuchungen, wie die Beobachtung der Raumnutzung farbmarkierter Vögel könnten helfen, einige der beobachteten Veränderungen in der räumlichen und jahreszeitlichen Verteilung besser zu verstehen. In den kommenden Jahren könnte es bei den Nonnengänsen möglicherweise zu einer Ausweitung der Nahrungsgebiete im Wattenmeer und in angrenzenden Gebieten entlang der Festlandsküste und auf Inseln kommen, was Konflikte mit der Landwirtschaft vergrößern könnte.

Samenvatting

De Waddenzee is van groot belang voor doortrekkende en overwinterende Brandganzen (*Branta leucopsis*) uit het Oostzeegebied en de Russische Arctis en de West-Siberische populatie Rotganzen (*Branta bernicla)*. Beide soorten gebruiken het gebied vooral als tussenstation (opvetgebied) tijdens de voorjaarstrek; kleinere aantallen brengen ook de winter door in het Waddengebied. Dit hoofdstuk beschrijft het voorkomen van beide soorten aan de hand van de speciale ganzentellingen en reguliere hoogwatertellingen van alle soorten die plaatsvinden in het kader van het Trilateral Monitoring and Assessment Program (TMAP). Aan de orde komen aantallen, seizoensvoorkomen en habitat en de ontwikkelingen daarin in de afgelopen decennia.

In de jaren negentig verbleef tot 85% van de Russisch-Baltische populatie in de Waddenzee bij aanvang van de voorjaarstrek in maart. Door de aanhoudende populatiegroei breidde tegelijkertijd het aantal pleisterplaatsen zich steeds verder uit, zowel in de Waddenzee zelf als ook in gebieden in het binnenland. Tevens schoof de vertrekdatum steeds verder naar eind april; tegenwoordig vertrekken Brandganzen maar liefst 4-6 weken later uit de Waddenzee als eind jaren tachtig. Ze vliegen dan vermoedelijk direct naar de Russische Arctis. Voorheen maakten deze vogels nog een tussenstop in het Baltisch gebied. Net als voor de Rotgans, speelt de Waddenzee tegenwoordig dus ook voor Brandganzen een prominente rol als opvetgebied voor de voorjaarstrek en het broedproces.

Tegelijk met de groei van het aantal Brandganzen, nam het aantal Rotganzen in de Waddenzee af. Deze afname bleef niet beperkt tot het Waddengebied, maar is een gevolg van een algehele afname van de populatie. Deze ontwikkeling wordt ingegeven door een lange reeks van jaren met slechte broedresultaten waarvan de oorzaak (nog) niet bekend is. Ondanks de kleinere aantallen wordt in het voorjaar (mei) nog steeds 85% van de rotganzenpopulatie in de Waddenzee aangetroffen. In de winter daarentegen, worden maar weinig vogels waargenomen. Hooguit 10% van de populatie verblijft dan in het Waddengebied, met name in het Nederlandse deel dat klimatologisch gunstiger afsteekt tegen de Duitse en Deense Waddenzee. Door de kleinere aantallen Rotganzen heeft zich een opvallende verschuiving voorgedaan in de verspreiding. Tegenwoordig verblijft een belangrijk deel van de vogels op de eilanden.

De ontwikkelingen in voorkomen en habitatgebruik van beide soorten zijn vooral gevolg van ontwikkelingen die zich op populatieniveau hebben afgespeeld. Er zijn geen aanwijzingen gevonden dat factoren in de Waddenzee zelf mede verantwoordelijk zijn voor de waargenomen trends. Niettemin kunnen verdere analyses licht werpen op achtergronden van verschuivingen in verspreiding en seizoensverloop. In de komende jaren wordt bovendien een verdere toename verwacht van het aantal Brandganzen, waarbij de vogels tegelijk ook hun voedselterreinen zullen uitbreiden. Dit brengt mogelijk nieuwe conflicten met zich mee met de landbouw.

1. Introduction

The Wadden Sea region is an important staging area for Arctic geese. Especially in late winter and spring, a major part of the Russian-Baltic population of Barnacle Geese and the West-Siberian population of Dark-bellied Brent Geese concentrates in the Wadden Sea to accumulate body reserves for spring migration and breeding (Ebbinge and Spaans, 1995; Ebbinge *et al.*, 1999; Ganter *et al.,* 1999). During autumn and winter, the region is used by smaller numbers as a stopover site or wintering area. Both species have benefited from improved protection measures and changes in agricultural practice (Ebbinge, 1991; van Eerden *et al.*, 1996) and have experienced long-term increases since the 1960s. Whilst Barnacle Geese still show an ongoing population growth, the numbers of Dark-bellied Brent Geese have declined recently (Ebbinge *et al.*, 2002). Geese are herbivores and nowadays preferably feed on grass-dominated vegetation. In the Wadden Sea, they are mainly found on the salt marshes. Especially after arrival in autumn, Dark-bellied Brent Geese also feed on eelgrass (*Zostera*) and green algae (*Ulva* and *Enteromorpha*) in the intertidal area. In late autumn and winter, large numbers of Barnacle- and Dark-bellied Brent Geese switch to feed on fertilized pastures at agricultural sites behind the seawall. This occurs mainly in the western part of the Wadden Sea (Niedersachsen and The Netherlands), which supports important wintering concentrations.

Goose grazing has been subject to many controversial discussions. At inland agricultural sites, conflicts with farming are common and various management measures are taken to provide solutions for the co-existence of farmers and geese (van Roomen and Madsen, 1992; Laursen, 2002; Ebbinge *et al.*, 2003). On salt marshes, the role of livestock grazing and the responses of geese to various grazing and management regimes have been studied in detail (*e.g.* van der Wal, 1998; Esselink, 2000; Stock and Kiehl, 2000; Bergmann and Borbach-Jaene, 2001; Stahl, 2001; Bos, 2002; Stock and Hofeditz, 2002; Weigt *et al.*, 2002). Part of these studies have been carried out to detect changes in goose numbers and distribution as a result of the reduction in livestock grazing at salt marshes. In Schleswig-Holstein and Niedersachsen, grazing by sheep and cattle was abandoned in approx. 50% and 60% of the mainland salt marshes respectively, after the establishment of national parks around 1990 (Remmers, 2003; Stock, 2003). In the Dutch Wadden Sea, about 60% of the mainland salt marshes has not been grazed since the 1980s, whereas in Denmark grazing is absent in only 15% of the salt marsh area (Bos *et al.*, in prep.). These management changes have prompted debate with respect to the habitat-conservation of natural salt marshes and species conservation of Barnacle- and Dark-bellied Brent Geese, which are sometimes regarded as contradiction (Bergmann and Borbach-Jaene, 2001; Lutz *et al.*, 2003).

In order to provide a framework for goose management in the Wadden Sea, this chapter aims to present a general review of goose numbers and habitat use of Barnacle Geese and Dark-bellied Brent Geese. In the past decade, numbers, distribution and staging habits of both species have been subject to major changes. Since numbers and trends have been described already in Chapter 7 in Blew *et al.*, 2005 (this volume), this review will focus on the backgrounds of the developments observed and highlight relationships between numbers in the Wadden Sea and trends in the overall population. Furthermore changes in habitat use, phenology and related processes will be discussed and implications for management will be given.

2. Data and Methods

Major parts of the data analyzed in this chapter have been retrieved from the trilateral synchronous goose censuses which are carried out annually in January (both species), March (Barnacle Goose) and early May (Dark-bellied Brent Goose). For phenology, data from spring tide counting sites was also used; these are counted every two weeks during spring tide (see Chapter 6.2.3. in Blew *et al.*, 2005, this volume). Brent Goose numbers always refer to Dark-bellied Brent Geese *Branta b. bernicla.* Light-bellied Brent Geese *Branta b. hrota* occur regularly only in the Danish Wadden Sea (Clausen *et al.*, 1996), and have been left out in this review. Methods and data management of the trilateral counts have been described in detail by Blew *et al.*, 2005 (this volume). Additional data was taken from the national census schemes in The Netherlands (*e.g.* Sovon Ganzen en Zwanenwerkgroep, 2001; van Roomen *et al.*, 2004), Niedersachsen (*e.g.* Krüger, 2001; Kruckenberg and Borbach-Jaene, 2003; Borbach-Jaene *et al.*, 2002; Umland, 2003) and Schleswig-Holstein (*e.g.* Günther and Rösner, 2000; Günther, 2005). These counts were also used to estimate annual population sizes for Barnacle and Dark-bellied Brent Geese, in order to allow a comparison of Wadden Sea numbers and size of the flyway population (see also Günther, 2005). Habitat information was obtained from the recent review of high-tide roosts in the Wadden Sea (Koffijberg *et al.*, 2003).

3. Results

3.1 Numbers and trends

3.1.1 Barnacle Goose

As shown in the species accounts, the occurrence of Barnacle Geese in the Wadden Sea has been subject to a marked increase (Figure 4.4 in chapter 4 in Blew *et al.*, 2005, this volume). There is a strong relationship between the total numbers of geese observed in the Wadden Sea throughout the year and the size of the flyway population (Figure 1), especially in Denmark (total numbers), Schleswig-Holstein (spring and total numbers) and The Netherlands (autumn, spring and total numbers). During winter (December-February), there is no close relationship, probably because wintering numbers in the Wadden Sea are much smaller and primarily determined by winter temperatures and lower food quality and quantity of the salt marsh vegetation compared to the fertilized grasslands at agricultural inland sites (see discussion). At staging sites outside the Wadden Sea numbers have also increased in winter, as expressed, for example, by the counts in the Dutch province of Friesland (Figure 2). In Niedersachsen, the increase of Barnacle Geese was also mainly reported from inland areas, such as the Rheiderland (Dollart), Krummhörn and Westermarsch area (Leybucht), Jadebusen and Lower Elbe estuary (Kruckenberg *et al.*, 1996; Bergmann and Borbach-Jaene, 2001; Krüger, 2001; Kruckenberg and Borbach Jaene, 2003; Borbach-Jaene *et al.*, 2002; Umland, 2003). Although the birds feeding in these areas do roost

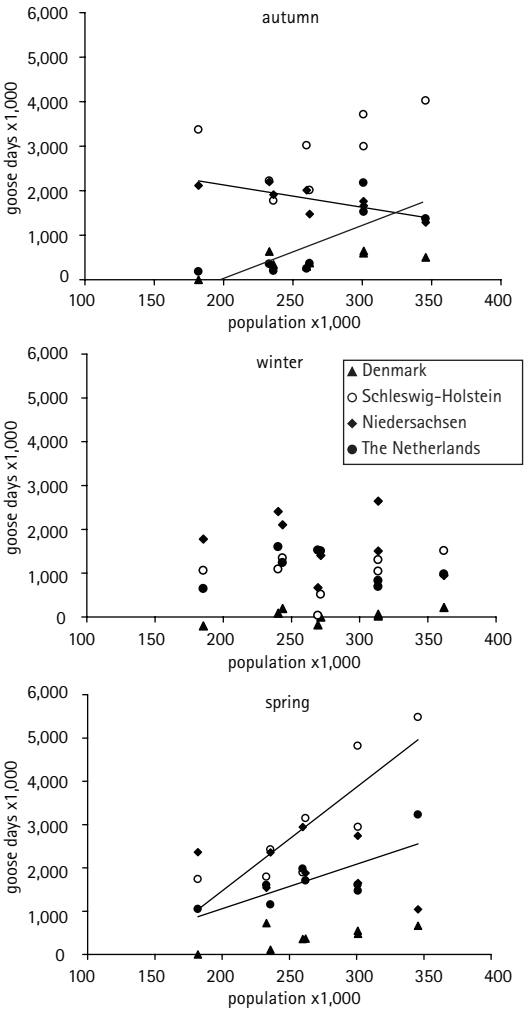


Figure 1: Population trend for Barnacle Geese in the Wadden Sea in relation to size of the flyway population, shown for autumn (September–November), winter (December–February) and spring (March–May). For Denmark data from spring tide counting sites was used, for the other countries data from all (monthly) counts. Regression lines indicate significant relationships, which were found for Schleswig-Holstein in spring ($R^2 = 0.73$, $P = 0.007$) , Niedersachsen in autumn ($R^2 = 0.64$, $P = 0.017$) and The Netherlands in autumn ($R^2 = 0.58$, $P = 0.027$) and spring ($R^2 = 0.59$, $P = 0.027$).

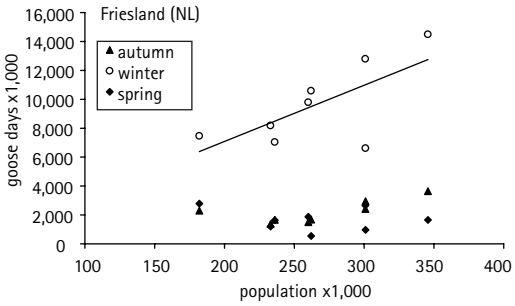


Figure 2: Population trend for Barnacle Goose (goose days from monthly counts) in the Dutch province of Friesland, which is one of the main wintering site in The Netherlands, in relation to size of the flyway population in autumn, winter and spring (see Figure 1 for period). Regression lines indicate significant relationships, which were found only for winter (R^2 = 0.47, P = 0.050).

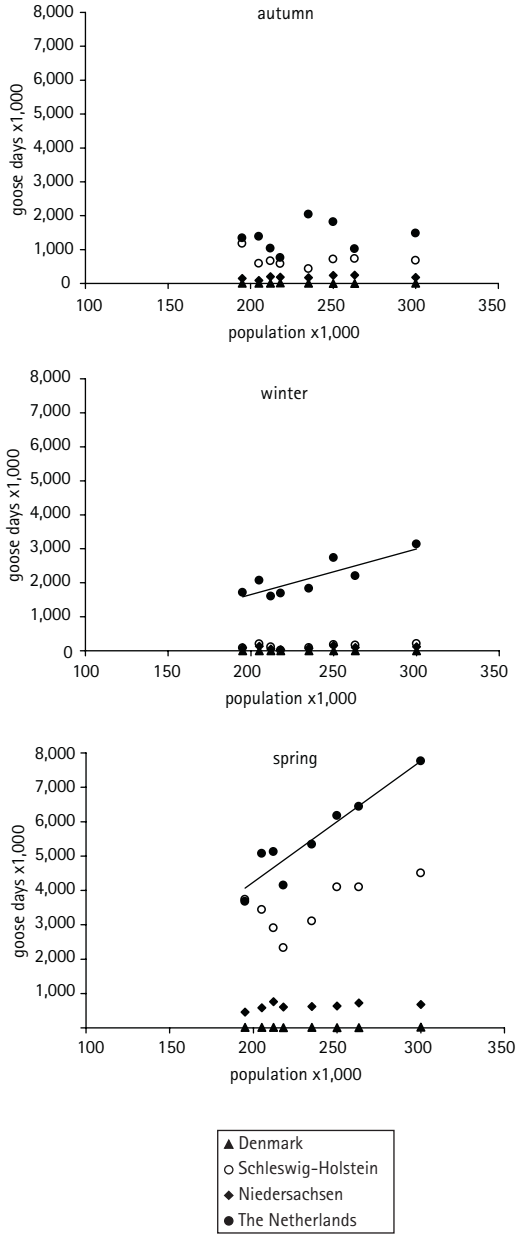


Figure 3: Population trend for Dark-bellied Brent Geese in the Wadden Sea in relation to size of the flyway population, shown for autumn, winter and spring (see Figure 1 for period and data). Regression lines indicate significant relationships, which were found for The Netherlands in winter (R^2 = 0.72, P = 0.001) and spring (R^2 = 0.89, P = 0.001).

in the Wadden Sea, their feeding areas are not part of the Wadden Sea cooperation area, and are not included in the number of goose days in Figure 1. Unlike the three other sections of the Wadden Sea, the numbers on salt marshes in Niedersachsen therefore do not show a clear relationship (or negative relationship, in autumn) with the growth of the flyway population as this development mainly occurs just outside the cooperation area at inland agricultural sites.

3.1.2 Dark-bellied Brent Goose

Traditionally, Dark-bellied Brent Geese especially concentrate in the Wadden Sea during spring migration. Peak numbers in April/May have shown a substantial decline since 1996 (Figure 4.5 in chapter 4 in Blew *et al.*, 2005, this volume) The timing and progress of this development is in line with a reduction of about 30% of the West-Siberian flyway population (Ebbinge *et al.*, 2002). Especially lower spring numbers in Schleswig-Holstein and The Netherlands, which represent the core staging regions in the Wadden Sea, correspond well with the decreased overall population size, although for Schleswig-Holstein no significant relationship could be detected (Figure 3). In winter, only numbers in The Netherlands show a clear trend with the size of the flyway population. In other parts of the Wadden Sea numbers in this time of the year are very small and fluctuate greatly according to winter weather, which makes it difficult to detect any substantial changes. This is similar in autumn, when the geese mainly pass en route to their wintering areas in England and France.

3.2 Phenology

3.2.1 Barnacle Goose

In the past decades, Barnacle Geese occurred in the Wadden Sea mainly in October-November and February-March (Smit and Wolff, 1983; Meltofte *et al.*, 1994). The phenology in the 1990s still shows these two distinct peaks (Figure 4). However, since the 1980s Barnacle Geese have shown a delay in their spring departure from the Wadden Sea of about 4-6 weeks (Koffijberg *et al.*, 1997; Stock and Hofeditz, 2002; Günther, 2005). Data from spring tide counting sites indicates that even during the last ten years, the peak of spring migration shifted from the end of March and beginning of April to the second half of April. The delay in spring departure dates becomes even more pronounced when looking at site level. At Hamburger Hallig and nearby Beltringharder Koog in Schleswig-Holstein for example, departure dates between 1988 and 2003 shifted from about the 1 April to the 15 May, *i.e.* a delay of more than six weeks within 15 years (Figure 5). Currently, the last flocks abandon this area between 15 and 20 May, just before the Dark-bellied Brent Geese start to leave. A similar pattern with nearly synchronous departure dates as observed at Schleswig-Holstein, has recently been reported from the Dollart area at the border of Niedersachsen and The Netherlands (K. Koffijberg, in prep.). Besides the delay in spring departure, Barnacle Geese also arrive earlier in spring in the northern part of the Wadden Sea nowadays, with numbers in Denmark already building up in the second half of February (Figure 4). In autumn, earlier arrival of large numbers has been reported in Schleswig-Holstein

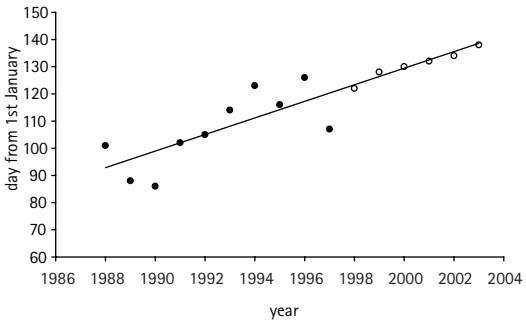


Figure 5 (top): Departure of Barnacle Geese from the Hamburger Hallig, Schleswig-Holstein (redrawn after Stock and Hofeditz, 2002 and updated with unpublished data from K. Günther). Departure was defined as the day 75% of the population had left the area (based on spring tide counts); data from 1998 onwards refers to observed departure dates. The significant relationship is expressed by the regression line ($R^2 = 0.81$, $P < 0.001$).

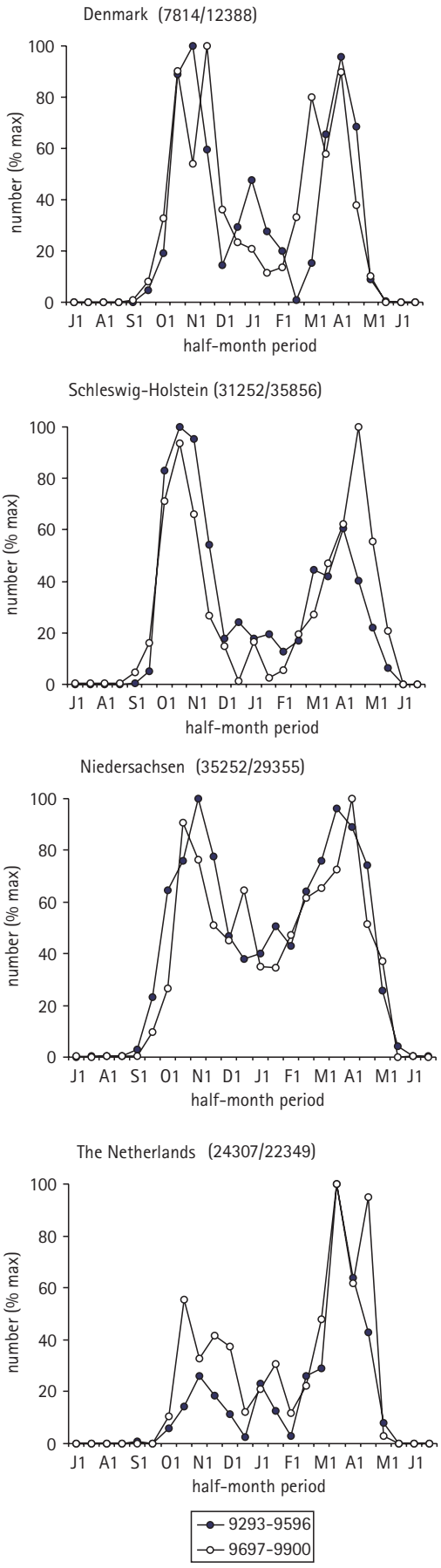


Figure 4: Phenology of Barnacle Geese in the Wadden Sea in 1992/93-1995/96 and 1996/97-1999/2000 (from June to July). Data was derived from spring tide counting sites and numbers shown are relative to the maximum number observed. Data in parentheses after each country shows this maximum in both periods.

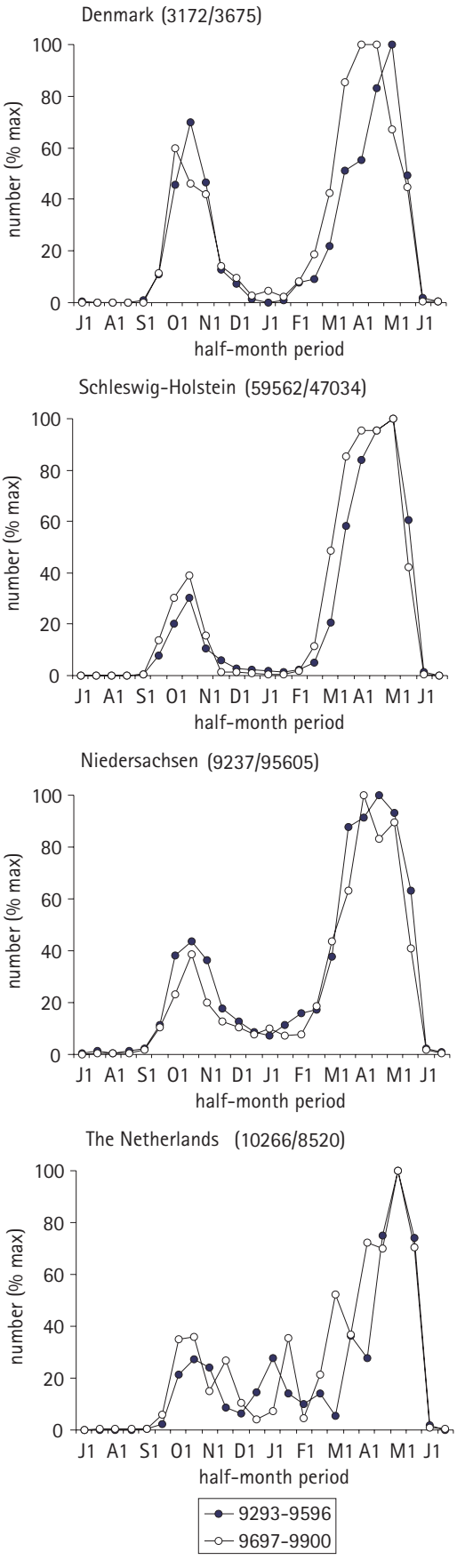


Figure 6:
Phenology of Dark-bellied Brent Geese in the Wadden Sea in 1992/93–1995/96 and 1996/97–1999/2000 (from July to June). Data was derived from spring tide counting sites and numbers shown are relative to the maximum number observed. Data in parentheses after each country shows this maximum in both periods.

(Günther, 2005). Baltic breeding birds (recognizable by individually marked birds) arrive currently around mid-September, whereas Russian breeding birds have shifted their arrival from mid-October to the beginning of October. A similar pattern was observed in The Netherlands in the second half of the 1990s, which has also increased the number of goose days in the Dutch Wadden Sea in autumn (Figure 1).

5.2.2 Dark-bellied Brent Goose

Previous data has shown that Dark-bellied Brent Geese quickly move through the Wadden Sea on their way to wintering sites in southern England and western France. From March to May they return in high numbers to gain body reserves for spring migration to the stop-over sites in the White Sea and breeding at the Taimyr peninsula (Smit and Wolff, 1983; Meltofte *et al.*, 1994; Ebbinge and Spaans, 1995). These movements are still reflected by the current phenology (Figure 6). Apart from Denmark, where autumn and spring numbers are more equal, the seasonal changes in numbers are rather synchronized throughout the Wadden Sea. In Denmark, Schleswig-Holstein and in The Netherlands, the onset of the increase in spring tended to be slightly earlier and shifted from March to the second half of February. Also, peak numbers seem to occur slightly earlier in the second half of the 1990s, with maximum numbers peaking already in April. Previously, largest numbers were always counted in May (*e.g.* Rösner and Stock, 1995). Final departure dates in the second half of May, however, have not changed.

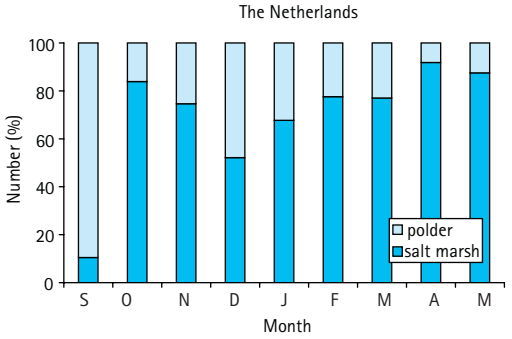
3.3 Habitat use

3.3.1 Barnacle Goose

As shown by data from Schleswig-Holstein and The Netherlands, many Barnacle Geese feed on salt marshes in the Wadden Sea (Figure 7). Here, they prefer *Puccinellia* and *Festuca*-dominated vegetation types (*e.g.* Ydenberg and Prins, 1981; Ebbinge and Boudewijn, 1984). In Schleswig-Holstein, on average 48% of the geese can be found on salt marshes. Just after arrival in September/October and in spring (especially prior to departure in May), many birds also feed on semi-natural grassland in the embanked wetlands, such as Beltringharder Koog and Rickelsbüller Koog. Feeding on fertilized grassland (especially *Lolium* and *Poa* swards) is common in autumn in the Hattstedter Marsch and in autumn, winter and spring also locally on the Eiderstedt peninsula. Feeding on crops (autumn-sown cereals) at coastal sites behind the seawall is less common but is observed in fluctuating numbers and depends on winter weather (increased crop-feeding during cold spells). In the Dutch Wadden Sea, on average 75% of all Barnacle Geese in September-May were observed on salt marshes, the remaining 25% on polders behind the seawall (Figure 7). Despite the population increase, there was only little variation in this pattern between years. However, in the course of winter, there was a tendency towards higher numbers on polders in December and January. This shift in feeding preferences coincides with the departure of large numbers of Barnacle Geese from coastal sites in the Dutch Wadden Sea to the staging sites in e.g. Friesland (Figure 2). The geese observed on polders behind the seawall mainly feed on fertilized grassland and occasionally visit fields with autumn-sown cereals. Recently, increasing numbers have been observed to exploit harvest remains of sugar beet and carrots (K. Koffijberg, in prep.). In Niedersachsen, data from the Rheiderland/Dollart area points to a similar pattern to that found in the Dutch Wadden Sea (Borbach-Jaene *et al.*, 2002; Kruckenberg, in prep.). Here, on average 22% of the Barnacle Geese feed on salt marshes between October-April, whereas 78% of all birds utilize fertilized pastures at sites behind the seawall. From 1996 to 2003, however, the grazing intensity on the salt marsh declined, and dropped from 32% to 19% of the overall number of (increasing) goose days spent in the entire area (Kruckenberg, in prep.). The background to this reduced used of salt marshes is not known, but is not related to changes in grazing management, which did not change during this period.

Compared to Dark-bellied Brent Geese, Barnacle Geese obviously favor feeding sites along the mainland coast, with short flying distances to freshwater sources for drinking (Stahl *et al.*, 2002).

Only minor numbers visit the barrier islands (Figure 8). In The Netherlands, usually 11% of the annual numbers counted are reported from the islands, mainly at Schiermonnikoog. A similar pattern is also found in other parts of the Wadden Sea. In Schleswig-Holstein as many as 99% of all Barnacle Geese are found along the mainland coast (Günther, 2005). The salt marshes and pastures at the Halligen, which are favored by Dark-bellied Brent Geese are hardly visited by Barnacle Geese.



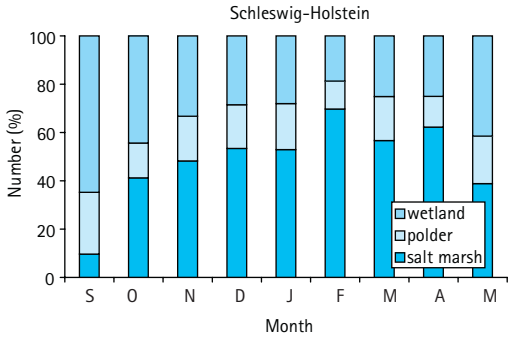


Figure 7: Distribution of Barnacle Geese over salt marshes and inland habitats (polders and embanked coastal wetlands) in The Netherlands and Schleswig-Holstein during winter, expressed in goose days spent in September-May.

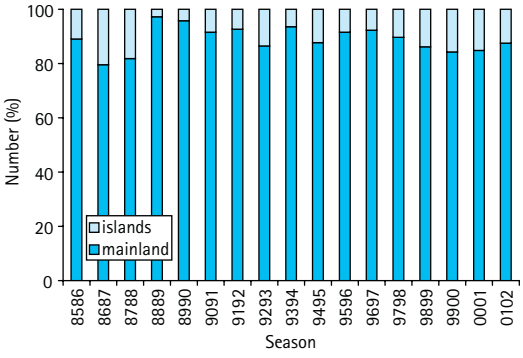


Figure 8: Changes in numbers of Barnacle Geese over feeding sites along the mainland coast and on the barrier islands in the Dutch part of the Wadden Sea, expressed as percentages of the annual number of goose days in September-May.

The overall increase in numbers has not affected the proportion of Barnacle Geese feeding on the islands in the Dutch Wadden Sea so far, although small numbers have expanded to other islands such as Ameland, Terschelling and Texel, and increasing but small numbers have been recorded from some of the islands in Niedersachsen.

3.3.2 Dark-bellied Brent Goose

Dark-bellied Brent Geese in general favor salt marshes as well. During arrival in autumn small numbers also feed in the intertidal area, but these cannot be separated in our data since counts are carried out during high tide, when aquatic feeding birds often gather at the edges of the salt marshes and where they are counted together with salt marsh-feeding birds (Koffijberg *et al.*, 2003). During autumn and winter, they also feed in large numbers in inland polders behind the seawall, as, for example, expressed by the counts in The Netherlands. Overall, on average 59% of the Dutch geese between September and May were observed in this habitat (Figure 9). There were remarkably small fluctuations in this distribution between years. High numbers of Dark-bellied Brent Geese feeding in polders are typical for the Dutch islands in winter, where the large inland polders at Schiermonnikoog, Ameland, Terschelling and Texel provide suitable agricultural areas with fertilized pastures. Along the Dutch mainland coast, where crops dominate and grassland is scarce, inland feeding is observed only occasionally on autumn-sown cereals and oil-seed rape. The shift from coastal feeding sites to inland sites in The Netherlands already starts in October. Towards November-December, most birds have left the Wadden Sea for their wintering areas in England and France. By this time, the majority of the remaining (wintering) birds in The Netherlands have switched to inland feeding sites. With the onset of spring migration, from February onwards, growing numbers are found again on the salt marshes, including the Halligen in Schleswig-Holstein (Günther, 2005). In The Netherlands, however, many Dark-bellied Brent Geese remain to feed on fertilized pastures, which in May still support 37% of the birds (Figure 9). Compared with data from the 1970s (Ebbinge and Boudewijn, 1984), inland feeding in the Dutch Wadden Sea nowadays occurs for a more prolonged period. In the 1970s,

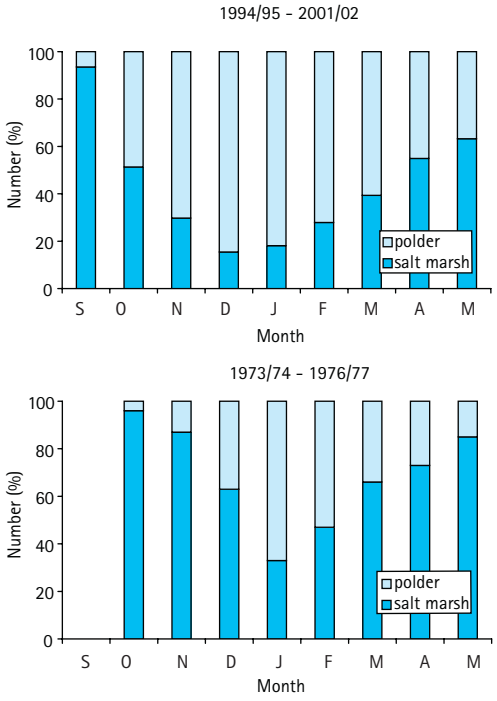


Figure 9: Distribution of Dark-bellied Brent Geese over salt marshes and inland habitats (polders) in the Dutch part of the Wadden Sea, expressed by goose days spent in September-May. Also given is the distribution over these habitats in 1974-77 (Ebbinge and Boudewijn, 1994), which show that nowadays many more Dark-bellied Brent Geese utilize the inland pastures for feeding.

only in January and February did more than 50% of the geese stayed at inland sites. Between 1994-2002 this period lasted from November to March, with high numbers remaining until departure in May (Figure 9).

Contrary to Barnacle Geese, Dark-bellied Brent Geese are especially attracted by feeding sites on the barrier islands. In the Dutch Wadden Sea, 67% of all goose days between 1985 and 2002 were spent on islands. In Schleswig-Holstein (including the Halligen) this even involved 74% of all birds (Figure 10). It is intriguing that the recent decline in numbers coincides with an increasing proportion of Dark-Bellied Brent Geese staying on islands. Especially in Schleswig-Holstein, the distribution over mainland and island-feeding changed considerably in the past decade. During 1997-2002, on average only 11% stayed along the mainland coast, compared to 44% in 1987-1991 (Figure 10; see also Günther, 2005). In The Netherlands, the proportion of birds found along the mainland coast declined from 39% to 20%. Here, numbers visiting the islands remained rather stable, whereas a sharp decrease has been observed along the mainland coast since 1994/1995.

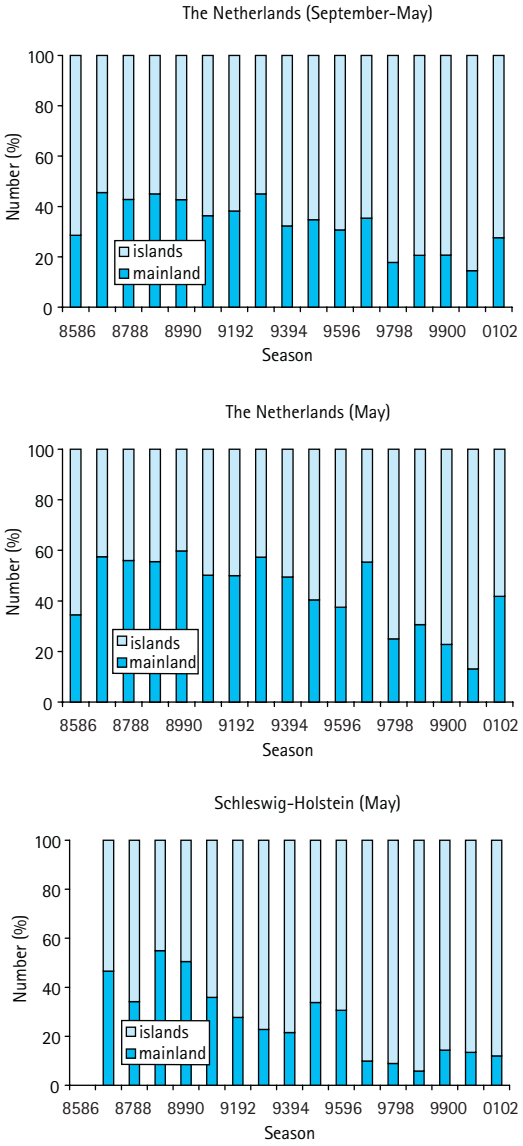


Figure 10:
Changes in numbers of Dark-bellied Brent Geese over feeding sites along the mainland and on the islands in The Netherlands and Schleswig-Holstein, expressed as percentages of the annual number of goose days in September-May (NL) or May (NL and SH).

4. Discussion

4.1 Expansion of Barnacle Geese

The trilateral counts in the Wadden Sea in January 1993-2000 (including inland sites adjacent to the seawall in Niedersachsen) involved on average 60% of the total Russian-Baltic flyway population (Figure 11). During spring migration in March, the average share of the flyway population concentrating in the Wadden Sea is even higher (75%). Low numbers in January (1996 and 1997) are a result of cold spells, which often initiate a shift to inland wintering sites in The Netherlands, such as Friesland or the Delta area in the SW-Netherlands (see section Phenology). In 1996, cold weather lasted until April, and also affected the numbers present in March. Besides these cold rushes, there is a clear trend that a progressively smaller proportion of the Russian-Baltic Barnacle Goose population winters in the Wadden Sea. With the ongoing growth of the flyway population, increasing numbers of Barnacle Geese have expanded their wintering range to inland feeding areas outside the Wadden Sea, especially in The Netherlands and Niedersachsen (Figure 2). In The Netherlands, at eight out of 21 important inland staging sites for Barnacle Geese outside the Wadden Sea, the number of goose days doubled in the 1990s (van Roomen *et al.*, 2004). Increases were also reported in the western part of Niedersachsen, where Barnacle Geese show upward trends in, for example, all staging areas in Ostfriesland (Kruckenberg and Borbach-Jaene, 2003; Borbach-Jaene *et al.*, 2002). In Denmark, increasing numbers of Barnacle Geese are counted along the west coast, north of the Wadden Sea (Amstrup *et al.*, 2004). Apparently, the strong population increase has forced many geese to explore new feeding sites. Parallel to the increased numbers, Barnacle Geese have also prolonged their stay in the Wadden Sea in spring. Data from counts in May indicates that recently up to 115,000 Barnacle Geese are present in the Wadden Sea in the first half of this month (see Chapter 7 in Blew *et al.*, 2005, this volume).

The overall increase of Barnacle Geese in the Wadden Sea is mainly the result of the increased population size and a westward expansion of the breeding areas. In the 1970s and 1980s, these were confined to the islands Novaya Zemlya and Vaygach in the Russian arctic (Ganter *et al.*, 1999).

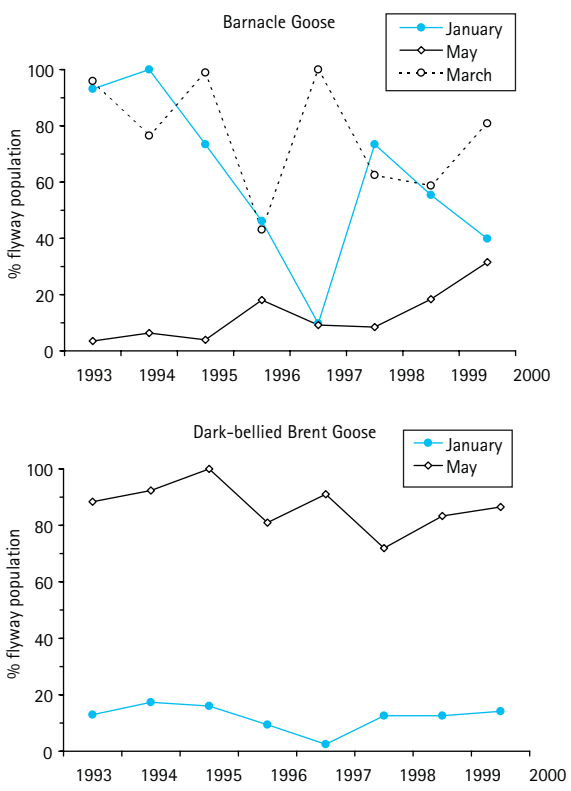


Figure 11: Numbers of Barnacle Geese and Dark-bellied Brent Geese expressed as a percentage of the Russian-Baltic and West-Siberian flyway populations respectively. Population sizes were extracted from Wetlands International (goose database) and Günther (2005).

In the 1980s, a rapid increase was reported from the Baltic (Larsson *et al.* 1988), and growing numbers of Barnacle Geese started to breed along the Russian Barents Sea coast, as far west as the Kola Peninsula (Ganter *et al.*, 1999). Although the breeding population in the Baltic area increased to 17,000 individuals in 1997 (Larsson and van der Jeugd, 1998), they still comprise a minority (6%) of the entire Russian-Baltic flyway population. Therefore, we assume that the majority of the birds in the Wadden Sea will be of Russian origin. Prior to departure in May, nearly all Barnacle Geese in the Wadden Sea will probably involve Russian breeders, since numbers present by that time include 30% of the flyway population (Figure 11). Sightings of color-ringed birds confirm this assumption (Günther, 2005). We hypothesize that the delay in spring departure is mainly caused by an alternative migration strategy of these birds. Instead of stopping-over at traditional spring staging sites in the Baltic, they are probably able to reach the western edge of their arctic breeding area in one direct flight from the Wadden Sea (similar to Dark-bellied Brent Geese flying from the Wadden Sea to the stop-over site in the White Sea, which is about the same distance Barnacle Geese have to cover; Green *et al.*, 2002). Spring staging in the Wadden Sea has therefore become increasingly important for these birds, since they will accumulate body reserves for breeding mainly here, and not at stop-over sites in the Baltic. To what extent an increase in breeding birds in the Baltic (which might compete with migrants stopping-over) is part of this re-distribution process remains unknown.

4.2 Declining numbers of Dark-bellied Brent Geese

Contrary to the upward trend in Barnacle Geese, the West-Siberian flyway population of Dark-bellied Brent Geese has experienced a considerable decline since 1996 (Ebbinge *et al.,* 2002). As a result, numbers in the Wadden Sea are much smaller now compared to the 1990s, especially during the annual peak of spring migration. Despite the reduction in overall population size, the proportion of geese utilizing the Wadden Sea has hardly changed. In January, usually 10% of the population winters in the Wadden Sea (Figure 11), mainly at sites in The Netherlands. Peak numbers during spring migration in May involved on average 85% of the flyway population between 1993-2000. Phenology changed a little during the past decade. Throughout the Wadden Sea, there has been a tendency for an earlier onset of spring migration recently, starting as early as in February and peaking from the beginning of April onwards. The background for this process is unknown. Since Barnacle Geese also show an earlier accumulation of spring numbers in the northern part of the Wadden Sea (Denmark, Figure 3), this trend might be a result of an increased tendency for mild winters, which might affect vegetation growth in the northern parts of the Wadden Sea and thus expand feeding opportunities in early spring.

The main explanation for the overall decline in numbers of Dark-bellied Brent Geese is the increased number of years in which the birds fail to raise offspring (Ebbinge *et al.*, 2002). As a result, annual mortality exceeds reproductive output and has reduced population size in the past decade. The factors which have contributed to the reduced breeding success are not clear yet. Ebbinge (2003) suggested the conditions in the Siberian breeding area as the main reason, expressed, for example, by less pronounced lemming-cycles (which regulate predation pressure by Polar Foxes *Alopex lagopus, for example,* on goose nests) and a more constant moderate to high predation pressure. According to Ebbinge (2003), condition during spring migration, as assessed annually by cannon-net catches in the Dutch Wadden Sea, has not changed during the past decade. This would imply that the opportunities to accumulate body reserves, which have shown to be an important prerequisite for successful breeding (Ebbinge and Spaans, 1995) have not changed in the Wadden Sea. However, this data only refers to a few sites and does not necessarily exclude factors in the Wadden Sea (or in the wintering areas) being responsible for recent changes in survival and/or reproduction rates. Günther (2005) has also pointed to the possible impact of the cold spring in 1996, which marks the start of the population decline. During this spring season, cold weather and a prolonged dry period in March and April prevented the vegetation in the salt marshes from developing. As a result, feeding opportunities for the geese were poor, and this might have caused higher mortality of adult birds during spring migration and during the breeding season. Surprisingly, however, it did not affect the reproductive output in the breeding areas, as in autumn 1996 many birds did return with offspring. Therefore, this hypothesis remains speculative, but it deserves further investigation as to whether changes in the wintering areas, or in the Wadden Sea, play a part in the process of the population decline of Dark-bellied Brent Geese.

4.3 Increased competition?

Since the downward trend for Dark-bellied Brent Geese coincided with a strong increase and prolonged spring staging for Barnacle Geese, competition between both species has also been put forward as a cause for the population decline in Dark-bellied Brent Geese (Engelmoer *et al.,* 2001). Especially at feeding sites along the mainland coast, both species often share the same food resources and often occur in mixed flocks on salt marshes. Behavioral studies in the Leybucht area in Niedersachsen showed that the larger-sized Barnacle Geese are clearly dominant over Dark-bellied Brent Geese in direct conflicts (Rothgänger, 2001). In the Leybucht area as well as at the Hamburger Hallig in Schleswig-Holstein, it has been observed that Dark-bellied Brent Geese changed their feeding sites as soon as Barnacle Geese had left the area (Stock and Hofeditz, 2000; Rothgänger, 2001; Weigt *et al*., 2002). Such changes might point to competition, but could also reflect a facilitative effect, *i.e.* previous grazing by Barnacle Geese improves feeding opportunities for Dark-bellied Brent Geese (Stock and Hofeditz, 2000; Rothgänger, 2001; Stahl, 2001). In addition, declines in numbers of Dark-bellied Brent Geese have been found in areas with and without grazing of Barnacle Geese. If competition between both species occurs, it probably mainly operates at a local site-level, but does not account for the overall population decline in Dark-bellied Brent Geese. Bos and Stahl (2003) came to similar conclusions in a study covering the spring distribution of both species in the Wadden Sea. With the reduced population size and an increased proportion of Dark-bellied Brent Geese feeding at the barrier islands and the Halligen (where Barnacle Geese are often scarce or absent, see section on mainland and islands below), further competition between the two species will probably remain at a local scale. Regarding the continuous expansion of feeding areas by Barnacle Geese, however, further studies should be initiated to assess the interactions between both species and to reveal possible facilitative processes affecting food availability. This also applies to stop-over sites along the Barents Sea coast, where migrating Dark-bellied Brent Geese may compete with breeding Barnacle Geese (Ebbinge, 2004).

4.4 Feeding on salt marshes and at agricultural sites

A large proportion of Barnacle Geese and Dark-bellied Brent Geese preferably feed on the salt marshes (Figure 7, 9). However, feeding habits change during winter and differ within the Wadden Sea. Data from Schleswig-Holstein shows that many Barnacle Geese also use the embanked wetland areas to feed, especially after arrival in autumn and before departure in May. Moreover, both in Schleswig-Holstein and The Netherlands, Barnacle Geese can be found at agricultural feeding sites behind the seawall, where they feed on fertilized pastures and crops. Extensive inland feeding has also been observed in coastal areas in Niedersachsen and Denmark. Dark-bellied Brent Geese show a similar pattern, but exploit a wider range of habitats as they also feed on the intertidal flats.

For both species, it has been suggested that the shift between salt marsh and inland agricultural feeding sites is triggered by the difference in food quality and quantity, which is low on salt marshes during late autumn, winter and early spring, but increases gradually in the course of spring (Boudewijn, 1984; Prins and Ydenberg, 1985; Vickery *et al*., 1995; Bos and Stahl, 2003). This explains why large numbers of geese mainly feed at coastal agricultural sites from November till March or move to agricultural feeding areas further inland (Figure 2, 7, 9). The fluctuations in the observed numbers of Barnacle Geese in the Wadden Sea in March are probably a result of between-year differences in the onset of vegetation growth in the salt marshes. As well as differences in food availability, there is also evidence that higher disturbance levels at agricultural sites prevent the geese from adopting an efficient foraging strategy and force birds to move to the less disturbed salt marshes (Prins and Ydenberg, 1985). This was confirmed in an 'accidental' experiment at Schiermonnikoog, which showed that a ban on scaring activities by farmers (as part of a special goose management scheme) attracted larger numbers of geese to the agricultural area and initiated a prolonged stay of the geese towards spring (Bos and Stahl, 2003).

In addition, the use of salt marshes will also be affected by overall population numbers and adopted traditions in use of feeding sites. Ebbinge (1992) showed that feeding on polders by Dark-bellied Brent Geese became increasingly important in the 1970s and 1980s, when the flyway population started to grow and the traditional feeding sites on the salt marshes became saturated. The expansion of the feeding range of Barnacle Geese described in this chapter, and the exploitation of new food resources such as harvest remains, which has been observed recently for this species, are

probably part of a similar process. The fact that, despite the population decline since 1996, Dark-bellied Brent Geese continue to visit agricultural sites in high numbers (at least in The Netherlands; Figure 9) show, however, that the birds are also very well able to maintain changed traditions.

4.5 Feeding on mainland versus islands

One of the most striking differences in the feeding habits of Barnacle Geese and Dark-bellied Brent Geese in the Wadden Sea is the distribution over the barrier islands/Halligen and the mainland coast. Dark-bellied Brent Geese are found in much larger numbers at the islands and Halligen, whereas Barnacle Geese concentrate along the mainland coast (Figure 8, 10). As shown by Stahl *et al.* (2002), Barnacle Geese are physiologically constrained in their choice of feeding sites in saline habitats like the Wadden Sea. They prefer the less inundated sites with a higher elevation and avoid vegetation with a high salt load, unless fresh water for drinking is available nearby. Dark-bellied Brent Geese are adapted to cope with saline conditions, and are, for example, able to feed on green algae on the intertidal mudflats or at the lower fringes of the salt marshes which are inundated regularly. It is striking that both in Schleswig-Holstein and in The Netherlands, the recent decline in Dark-bellied Brent Goose numbers has caused a change in distribution over the mainland coast and the islands. Following the reduction in overall numbers, an increased proportion of the geese have contracted their feeding range to the islands (Figure 10).

In Schleswig-Holstein, the current distribution of Dark-bellied Brent Geese over mainland and island feeding sites resembles the situation in 1977-79, when about 75% of the geese were found on the islands and 25% staged along the mainland coast (Prokosch, 1991). By that time, the overall population size was only slightly smaller than it is now.

This process of re-distribution probably reflects the same kind of density-dependent regulation that was described by Ebbinge (1992) for the utilization of salt marshes and fertilized grassland behind the seawall (see previous section). During the period in which Dark-bellied Brent Geese showed a strong upward trend (until 1995), a marked expansion of feeding sites was reported on the salt marshes along the mainland coast (*e.g.* Engelmoer *et al.*, 2001), which might indicate that 'preferred' feeding sites at the barrier islands became saturated. According to this hypothesis, the current decline leads to a 'retreat' to the favored feeding sites on the islands. To what extent other factors contribute to this development has to be clarified. As mentioned before, competition with the increased population of Barnacle Geese at mainland staging sites might occur, but probably only at local site level. Furthermore, the sharp decline of numbers of Dark-bellied Brent Geese along the mainland coast in Schleswig-Holstein (when compared to The Netherlands) might also be accelerated by the abandoned livestock grazing in the 1990s, which has occurred on a much smaller scale in The Netherlands.

5. Conclusions / Implications for Management

Data from the trilateral goose counts in the Wadden Sea shows that the population of Barnacle Geese and Dark-bellied Brent Geese in the past decade have experienced some major changes:

Barnacle Geese

- Due to the increase of the Baltic-Russian flyway population, the numbers and feeding range in the Wadden Sea have expanded considerably in the past decades, especially in spring and mainly along the mainland coast and at sites outside the Wadden Sea;
- In the 1990s, up to 85% of the flyway population concentrated in the Wadden Sea (March), however, the Wadden Sea has become less important for wintering birds, since largest numbers in winter are found outside the Wadden Sea, in The Netherlands;
- Along with the increase in numbers and feeding sites, Barnacle Geese have prolonged their stay in spring by four to six weeks and leave the area around mid-May. Recent counts show that up to 30% of the flyway population (mainly assumed Russian breeders) is still present in the Wadden Sea in the first half of May;
- As a result of the delayed spring departure, the Wadden Sea has become increasingly important for Russian Barnacle Geese in particular to accumulate body reserves for breeding.

Dark-bellied Brent Goose

- Lower reproduction rates have initiated a decline in the West-Siberian population of Dark-bellied Brent Geese around 1995. As a result, lower numbers are found in the Wadden Sea;
- Despite the downward trend, the spring staging sites in the Wadden Sea still support about 85% of the flyway population, whereas in winter only a minor share of the flyway population (10%) winters in the area;
- Following the population decline in the Wadden Sea, an increased proportion of the geese are found at the barrier islands and Halligen, especially in the core staging areas in The Netherlands and Schleswig-Holstein.

For both Barnacle Geese and Dark-bellied Brent Geese, the overall changes which have occurred in numbers, distribution and habitat utilization in the Wadden Sea are mainly related to changes at population level of both species. So far, no evidence has been found that management changes and changes in feeding and staging conditions for the geese in the Wadden Sea have contributed to the decline and increase in Dark-bellied Brent Goose and Barnacle Goose respectively (but see re-distribution of Dark-bellied Brent Geese, below). Feeding opportunities for geese have experienced changes in the Wadden Sea in the 1990s with the abandonment of livestock grazing in large parts of the mainland salt marshes of Schleswig-Holstein and Niedersachsen. Several studies have shown that livestock grazing increases the feeding opportunities for geese. Bos *et al.* (in prep.) analyzed vegetation types and the spring distribution of Dark-bellied Brent Geese in the Wadden Sea, and concluded that a situation in which all salt marshes were livestock-grazed, the number of geese supported could be four times higher than in a situation with no livestock grazing at all. Furthermore, they showed that many suitable sites were used less than expected from their vegetation composition, thus being available as alternative or additional feeding sites when conditions elsewhere deteriorated. Similar findings have been produced from a monitoring program in Schleswig-Holstein, which investigated changes in vegetation after the abandonment of livestock grazing and the response of geese to the changed management. Although the geese re-distributed themselves over the area, the maximum numbers and duration of staging did not differ before and after the management changes (Stock and Hofeditz, 2000; 2002). The sharp decrease in numbers of Dark-bellied Brent Geese along the mainland coast of Schleswig-Holstein, and the earlier arrival of large numbers of Barnacle Geese in the Dutch Wadden Sea (see sections Phenology – Barnacle Goose, Feeding on mainland versus islands), however, might also be considered a similar re-distribution process. Here, analysis of movements by sightings of color-marked birds could underpin further evidence.

It will be difficult to predict how the flyway population of Barnacle Geese and Dark-bellied Brent Geese will develop in the years to come. Although the reproductive output of Barnacle Geese seems to have leveled off in recent years (Sovon Ganzen- en Zwanenwerkgroep, 2001; Günther, 2005), the population has continued to increase since 2000. For Dark-bellied Brent Geese, signs of a population recovery have not yet become visible. If the numbers of Barnacle Geese continue to rise, we assume a further expansion of feeding areas in the Wadden Sea (especially in spring) and its immediate surroundings, *i.e.* agricultural areas along the mainland coast (especially in autumn and winter), and to a lesser extent probably also

the polders at the islands. However, the largest increases will probably be noted at sites outside the Wadden Sea (Figure 2). Here, potential conflicts with farmers will increase. Also, as shown earlier in discussions about management of the salt marshes in the Leybucht area in Niedersachsen (Bergmann and Borbach-Jaene, 2001; Lutz *et al.*, 2003) debate will arise as to whether the geese should be accommodated in the Wadden Sea and the salt marshes should be managed in such a way that they can support maximum numbers of geese. Concerning the high number of Barnacle Geese, and the low food quality and quantity at salt marshes in autumn and winter (when compared to fertilized grassland), such a management scenario would not be very successful, since the higher profitability of feeding on fertilized pastures in autumn and winter will always attract large goose numbers. Moreover, the trilateral targets concerning salt marsh management do not include such a species-specific management (de Jong *et al.*, 1999). These aim at natural salt marshes, as well as providing favorable conditions for all migratory and breeding bird species, including species such as Redshank, which prefer tall vegetation for breeding. These targets are in line with the European Habitat Directive, which does not include specific management policies for species-groups such as geese (Lutz *et al.*, 2003).

Moreover, since Barnacle and Dark-bellied Brent Geese depend on the Wadden Sea for only a part of their annual life-cycle, goose management should preferably be achieved at flyway level, with inclusion of all countries within the flyway. Only in this way can a proper management and monitoring of populations and a prevention of actions which would lead to a bottleneck-situation in the Wadden Sea be achieved. Such a flyway management plan has been put forward recently for Dark-bellied Brent Geese by the African Eurasian Waterbird Agreement (AEWA) (van Nugteren, 1997), but this plan had not yet been endorsed by the governments involved.

Solutions for the co-existence of farmers and geese should be found preferably through agri-environmental management schemes in the agricultural feeding areas of the geese. Currently, several of such schemes are running in all Wadden Sea countries (Laursen, 2002). They include management of special reserves (*e.g.* Zeeburg on Texel), agri-environmental schemes (*e.g.* in The Netherlands, Niedersachsen and Schleswig-Holstein), compensation payment for damage (The Netherlands, earlier in Schleswig-Holstein) and active scaring management (The Netherlands, Denmark). In Schleswig-Holstein, there is also an open season for shooting Barnacle Geese at inland sites along the Wadden Sea coast on arable fields, in case damage to crops occurs. As shown by Bos and Stahl (2003), agri-environmental schemes which include a ban on scaring and limit disturbance can be successful to accommodate many extra geese, although similar studies on the Dutch mainland have shown that not all staging areas are suitable to receive 'extra' geese that are actively scared away from surrounding areas (Ebbinge *et al.*, 2000; van Roomen *et al.*, 2004). Designation of staging sites where such schemes should operate must be chosen carefully according to the expected capacity to accommodate extra geese and experiences with grazing damage in the past. As shown by the 'agri-goose' schemes in The Netherlands, farmers tended to accept a higher level of grazing damage and at some sites they started to initiate information centers to increase public awareness of the Nordic geese staying on their fields (Ebbinge *et al.,* 2003).

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