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Migratory Birds

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1. Introduction

Photo: Jan van de Kam

For migratory birds using the East Atlantic Flyway the Wadden Sea is of great importance as a staging, wintering and moulting area. At least 52 populations of 41 migratory waterbird species breeding in a large part of the northern hemisphere, from Canada in the west to Siberia in the east, use the Wadden Sea on their movements to the winter areas, that include Western Europe, the Mediterranean, West Africa and as far south as South Africa (Meltofte et al., 1994). Of these 44 populations belonging to 34 species the numbers are of a magnitude that the Wadden Sea can be considered as their most important stop-over site during migration, or their primary wintering or moulting ground (Blew et al., 2005a). When including the turnover rate of the birds, the total number of migrants is estimated at 10-12 million individuals.

The Joint Monitoring of Migratory Birds (JMMB) in the Wadden Sea, carried out in the framework of Trilateral Monitoring and Assessment Program (TMAP), consists of (a) at least two synchronous, complete counts each year, one of them in January, the other one in another month shifting from year to year; (b) frequent (bi-monthly to monthly) spring tide counts at 60 sites; and (c) an additional three counts for geese and aerial counts for shelduck and eider (Rösner, 1993). These surveys allow estimations of numbers, phenology and trends. For a more detailed description see Blew et al. (2005a, 2007) and Laursen et al. (2009a). The trilateral counts were initiated in 1980 and from 1987/1988 a solid counting scheme was established. This paper presents results from 1987/1988-2006/2007, thus covering a period of 20 years.

This chapter is an update of the QSR 2004 (Essink et al., 2005; Blew et al., 2005b) summarizing the results of the latest JMMB report covering the trends of 33 migratory bird species during a 20-year period from 1986/87-2006/07, and the common eider from 1992/93-2006/07 (JMMB 2008, Laursen et al., 2009a); in addition particular assessments are made concerning the ecological targets for migratory waterbirds according to the Wadden Sea Plan (Trilateral Wadden Sea Plan, 1997). The targets for favorable conditions for breeding and migratory birds are:

- Sufficiently large undisturbed roosting and moulting areas
- Favorable food availability
- Natural flight distances
- Natural breeding success*

* only relevant for breeding birds

2. Trend results for 20 years

Considering the results of the trends estimated for the period 1987/1988-2006/2007 for the entire Wadden Sea, eight species show a strong or moderate increase, 12 species are stable and 14 species show decreasing trends (Figure 1). Among the increasing species are the great cormorant *Phalacrocorax carbo*, Eurasian spoonbill *Platalea leucorodia*, barnacle goose *Branta leucopsis*, great ringed plover *Charadrius hiaticula*, grey plover *Pluvialis squatarola* and sanderling *Calidris alba*. Some of the stable species are brent goose *Branta bernicla*, Eurasian wigeon *Anas penelope*, red knot *Calidris canutus*, dunlin *Calidris alpina*, bar-tailed godwit *Limosa lapponica* and Eurasian curlew *Numenius arquata*. Among the decreasing species are common shelduck *Tadorna tadorna*, mallard *Anas platyrhynchos*, Eurasian oystercatcher *Haematopus ostralegus*, Kentish plover *Charadrius alexandrinus*, Eurasian golden plover *Pluvialis apricaria*, ruff *Philomachus pugnax*, whimbrel *Numenius phaeopus* and European herring gull *Larus argentatus*. The trend for common eider *Somateria mollissima* covers only the last 15 years and this is also decreasing.

2.1 Species and trend characteristics

To further study these trends, species have been allocated in relation to population and ecological features by six aspects: total numbers, trend of flyway population, proportion of flyway population migrating through the Wadden Sea, breeding and wintering grounds, and feeding habitat.

2.2 Increasing and stable trends

The three species, which show strong increases during the last 20 years in the entire Wadden Sea, also show increases in their flyway populations (Wetlands International, 2006). Of these, the great cormorant and Eurasian spoonbill are either exclusively or partly fish eaters, while the barnacle goose is an herbivore. In the other four aspects these species differ.

Five species show moderate **increasing trends** in the Wadden Sea, including northern pintail *Anas acuta*, great ringed plover, grey plover, Sanderling and curlew sandpiper *Calidris ferruginea*. All these species winter in tropical Africa while parts of their populations remain in Western Europe and the Mediterranean (Wetlands International, 2006), and all of these species except pintail breed in the Arctic.

Stable numbers were observed in 12 species. More than half of those species also have stable flyway numbers. They also share breeding and wintering grounds in the Arctic, Europe and Africa in similar proportions.

2.3 Declining trends

In total 14 species are in decline in the Wadden Sea. This fraction of species is dominated by species breeding in North, Central and Western Europe, and several of these species also winter there. A large part of the declining species use the polder areas or mussel beds for feeding, and are feeding on terrestrial arthropods, grass, seeds or mussels. However, other species that also feed on grass and seeds, for example the northern pintail and the northern shoveler *Anas clypeata*, are not decreasing, indicating that these food items are probably not the critical factors.

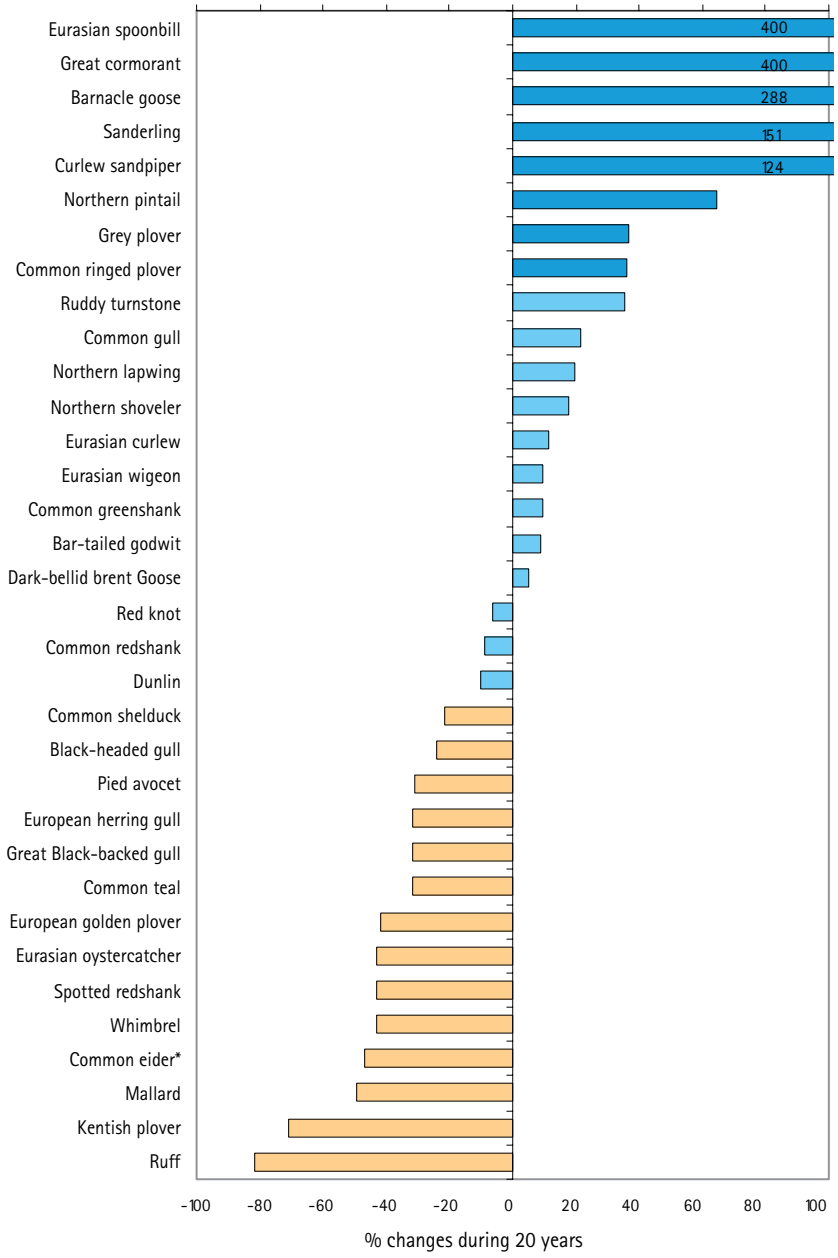

Figure 1:
Changes in numbers of 34 migratory waterbird species in the Wadden Sea during 20 years (1987/88–2006/07). Dark blue columns indicate species with significant, increasing numbers; light blue indicate species with stable numbers and orange columns indicate species with significant, decreasing numbers. * Data for Common eiders are from 1992/93–2006/07.

3. Target evaluation

3.1 Sufficiently large undisturbed roosting area

Waterbirds in the Wadden Sea gather at roosting places during high tide, such as sandbanks, salt marshes or inland polders with wetlands. In most cases they roost near to the high-tide-line, following the tides. The safeguarding of these high tide roosts is an issue of conservation and protection of the waterbirds in the Wadden Sea. To assess the possible conflicts between the birds and human interests, the status has been assessed by Koffijberg *et al.* (2003). The numbers and species using a high tide roost in the Wadden Sea are influenced by many factors, including actual water level, distance to nearest feeding areas, preferred roosting habitat, social status of the birds and disturbance levels, both anthropogenic as well as natural predators. As a result, the species use a network of roosts. The largest roosting sites are located where large intertidal mudflats occur at close range and with low level of human activity (Figure 2). These combinations are found for example on small remote and uninhabited islands such as Keld Sand (Denmark), Süderoogsand and Trischen (Schleswig-Holstein), Scharhörn (Hamburg), Memmert and Mellum (Niedersachsen), Griend and Richel (The Netherlands).

3.2 Protection of roosting sites

Human disturbance is in some areas among the most important factors regulating bird numbers at high tide roosts, and it can put an extra stress on the species' energetic balance and their tight migration schedule. Studies have shown that recreational activities are among the most frequent sources of anthropogenic disturbances, and Koffijberg *et al.* (2003) describe that 29% to 42% of all roosting sites are subjected to moderate to heavy recreational pressure. Moreover, data on phenology show that the seasonal occurrence of some species is affected by recreational pressure where birds tend to avoid roosts visited regularly by people in the summer holiday season. As the summer holiday season recently extends more into spring and autumn, it can be expected that more recreational pressure will arise in the future, especially when regarding the timing of migration

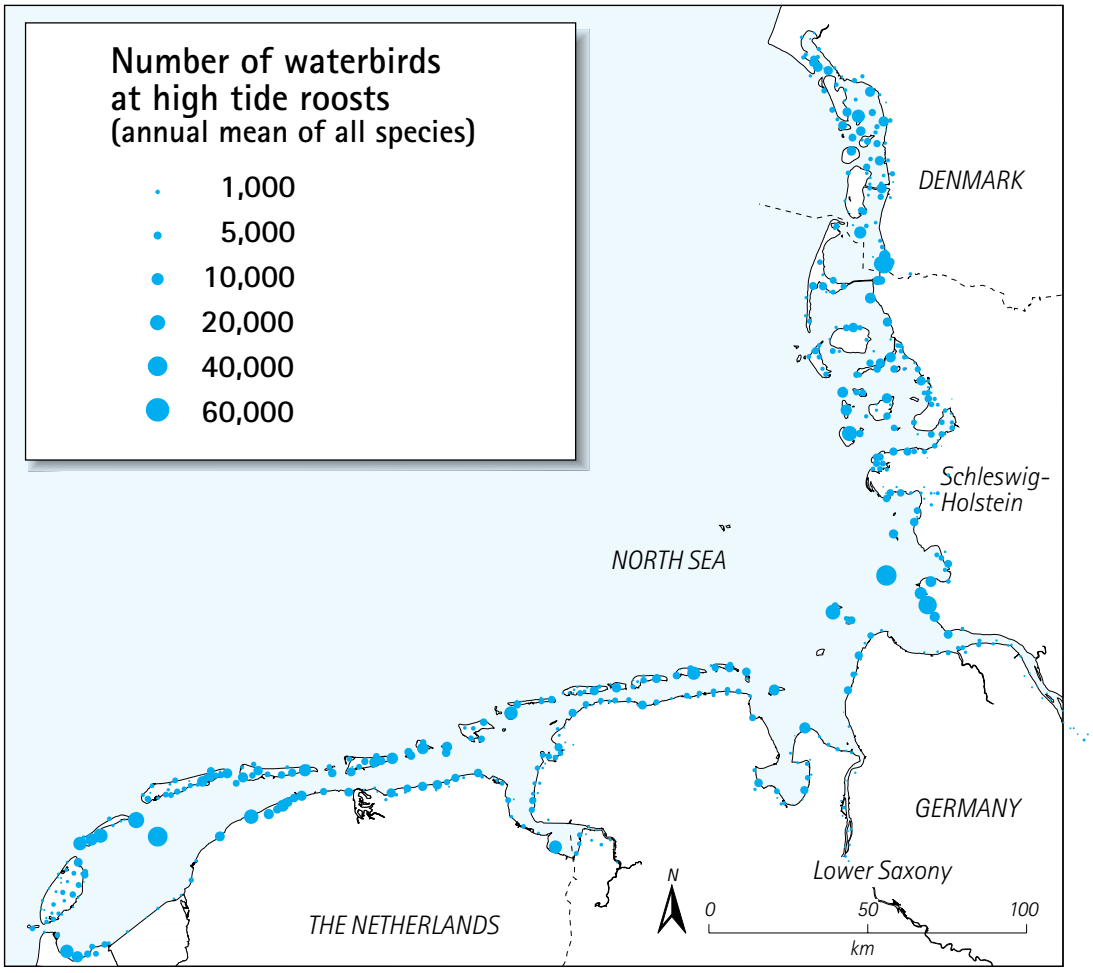

Figure 2: Distribution of high tide roosts in the Wadden Sea expressed by the sum of annual means of all species. After Koffijberg *et al.* (2003).

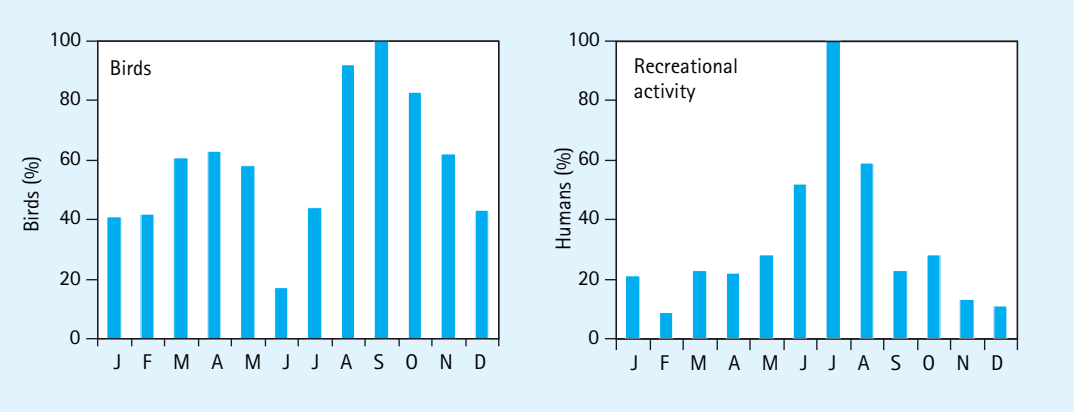

Figure 3: Occurrence (%) of migratory birds and human beings throughout the year in the Danish Wadden Sea. The highest value of both species is set at 100 %. Redrawn after Laursen *et al.* (1997).

of long-distance migrants, for which important numbers use the Wadden Sea as a stop-over in late spring (May) and summer (July-September) (Figure 3).

Hunting activities are considered to be the most disturbing human activity (Madsen, 1998). A moderate to heavy hunting pressure was observed in up to 33% of all sites in Denmark. Laursen (2005) showed a severe impact of hunting in the Danish Wadden Sea on the Eurasian curlew and it was concluded that the gradual hunting restrictions and the final hunting ban in Denmark in 1992-94 resulted in an increase of this species in the entire Wadden Sea at least during winter in the mid 1990s.

Regarding protection regimes, most countries have more than 80% of their high tide roosts inside areas designated as Special Protection Areas (SPA) under the Birds Directive and/or as Ramsar sites; distributional data show that these 80% of roosts are used by more than 90% of the species (Koffijberg *et al.*, 2003). However, in The Netherlands and Niedersachsen, the protection level is somewhat lower since both countries have large proportions of inland agricultural areas among their roosting sites which are subject to limited protection measures. Only in Niedersachsen, Schleswig-Holstein and Denmark are some of these areas included in the SPA, whereas in The Netherlands agricultural areas behind the dikes are not. Especially species as the barnacle goose and the dark-bellied brent goose, Eurasian golden plover and the curlew are known to utilize inland roosts in large numbers. In addition these areas become important for other species during particularly high water levels, when the regular roosting sites are flooded.

3.3 Sufficient large undisturbed moulting areas

Several waterbird species such as swans, geese and ducks moult their flight feathers simultaneously during a period of several weeks between May and September. During this period they are not able to fly, and the birds are extremely vulnerable to predators and human disturbance and therefore congregate in remote places. In the Wadden Sea and adjacent areas in the North Sea common shelduck, common eider and common scoters *Melanitta nigra* gather for their wing-moult in numbers of international importance. Thus, the Wadden Sea countries have a great responsibility for the protection of these species. However, the species moulting behaviors and phenologies differ, thus the management requires a species-specific approach.

The most important moulting sites for shelduck are almost exclusively situated within the southern Schleswig-Holstein Wadden Sea in the outer Elbe-estuary (Kempf and Eskildsen, 2000; Kempf, 2007). Up to 200,000 individuals concentrate at this site during late July and August, but they have shown decreases during recent years. Smaller but increasing numbers (10,000-20,000 birds) are moulting in The Netherlands (Leopold, 2003), where a new roosting site was found at Ballastplaat with 12,500 individuals during 2003-2004 and 23,000 birds in 2005 (Kraan *et al.*, 2006).

Common eiders moult from July until the end of August and beginning of September. The birds prefer areas with low disturbance levels, rich in shellfish stocks and roosting sites on sand banks. The moulting populations in the German and Danish Wadden Sea add up to 170,000-230,000 individuals during the last two decades (Laursen *et al.*, 1997a, Mendel *et al.*, 2008). However, the numbers have decreased from 1989 and onwards (Desholm *et al.*, 2002), with a steep decline since 1994 in the major moulting sites, the North-Friesian Wadden Sea (Scheiffarth and Frank, 2005). In the Dutch Wadden Sea up to 40,000 eiders were recorded in the 1980s. However, recent information is sporadic and suggests lower numbers. Other concentrations

are located in remote areas such as the Randzel area near Borkum, the Hohe Weg near Mellum and the area between Elbe and Weser in Niedersachsen. The East-Frisian Wadden Sea between Juist and Wangerooge however is only sparsely used by eiders during the moulting season, probably due to tourist activities (Nehls, 1999). In Denmark, a negative relationship was demonstrated between the number of moulting eiders and the numbers of boats at sea, indicating that the eiders avoid sites with human activity (Laursen *et al.*, 1997)(Figure 4). In the Königshafen on the island of Sylt it could be demonstrated directly that wind surfing activity drove moulting eiders away from a rich feeding area (Ketzenberg, 1993).

Common scoters have the longest moulting period from June to October, since immature birds, males and females have consecutive moulting schedules. Compared to the other species, phenology and distribution of the moulting birds is less known, since this species prefers to moult in offshore areas and in dispersed flocks. The species is very susceptible to any source of disturbance; for instance the flight distance for an approaching ship is about two km and even longer. Intensive aerial counts in the late 1980s in Denmark reveal that about 110,000 common scoters were located off the Danish Wadden Sea during moult, and counts during the last decade show that at least 40,000 birds are still moulting there (Laursen *et al.*, 1997a; NERI data). Seaside of the German Wadden Sea about 65,000 common scoters are present during the moulting period (Deppe, 2005; Mendel *et al.*, 2008). However, it is likely that numbers of moulting scoters in Germany and The Netherlands are underestimated, making a proper assessment difficult.

3.4 Protection of moulting sites

Several activities such as boating, air traffic and oil spills can disturb birds or can have a big impact on the birds at their moulting sites. In some parts of the Wadden Sea these activities are regulated. Oil spills pose an immense potential threat during the entire year, more so for common scoters than for other sea bird species, since they occur near shipping lanes where most oil spills are observed (see QSR 2009 Thematic Report No. 5). In 1998 about 11,400 eiders and 3,700 scoters died due to the Pallas accident (Günther, 1998). Construction of offshore wind parks within the 12-mile-zone and the associated boat traffic would potentially reduce the area available for the moulting duck species. At least outside the moulting season, common scoters have apparently adapted to the presence of offshore wind parks (Petersen and Fox, 2007). Special Protection Areas (SPA) within and outside the Wadden Sea have been designated and offer a better protection with regard to offshore wind farms and other sources of disturbance. In Denmark, an offshore area of 2,463 km^2 was designated as an SPA in 2004 to protect especially red and black throated divers (*Gavia stellata* and *arctica*) and little gull *Larus minutus*, but other

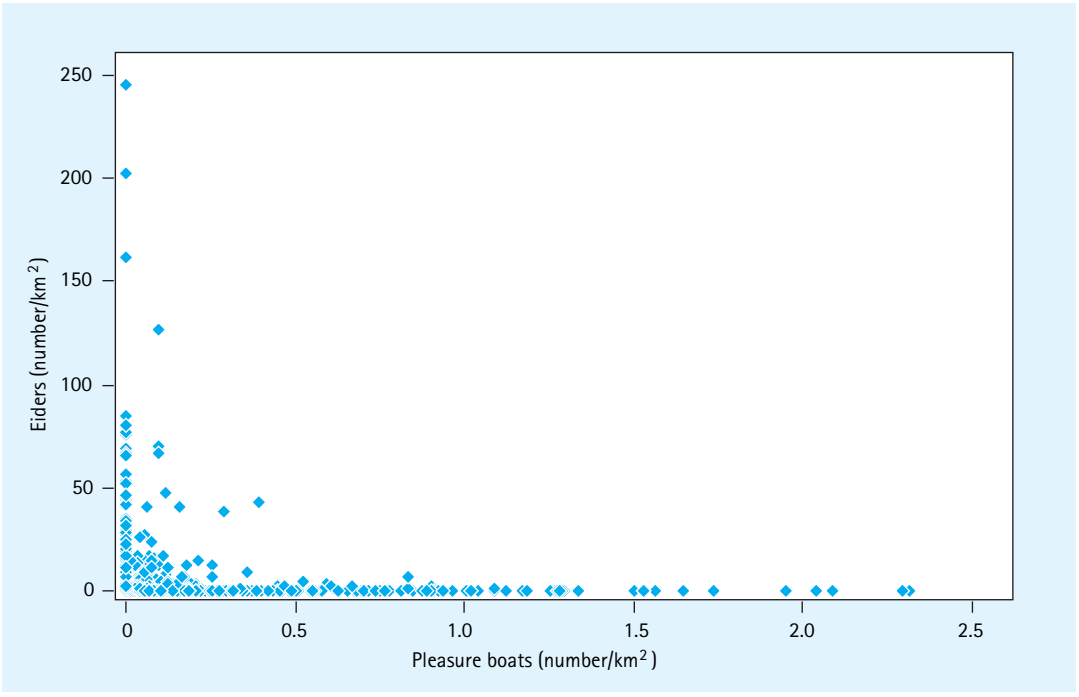

Figure 4: Relationship between the density of pleasure boats and moulting eiders (15 July–15 September) recorded during 37 aerial surveys during 1980–1995 in the Danish Wadden Sea. Windsurfers are not included, since they are restricted inside two specific sites. Redrawn after Laursen *et al.* (1997).

species, including the common scoter *Melanitta nigra,* may also benefit. In Niedersachsen, an additional offshore area of 680 km² was designated as a nature reserve in 2007 (also appointed as SPA) to protect birds like sandwich tern *Sterna sandvicensis,* little gull, common gull, lesser black-backed gull and red-throated diver.

3.5 Favorable food availability: grazing and salt marsh management

The Wadden Sea region is an important staging area for the Arctic breeding barnacle goose and dark-bellied brent goose. In particular during spring large proportions (85 %) of both species stay in the Wadden Sea Area to prepare their spring migration to the Arctic breeding areas. Trend analyses of the barnacle goose show a strong increase during the last 20 years; for the dark-bellied brent geese an increase up to 1995 was followed by a decrease thereafter, overall resulting in a stable 20-year trend. Studies of the two goose species' habitat use, phenology and management have shown that the barnacle goose has expanded along the mainland coast and into regions outside the Wadden Sea especially during spring. During winter, the Wadden Sea area has become less important since a larger part of the population is grazing inland in Niedersachsen and the Netherlands (Blew *et al.*, 2005b). In addition, the species' staging period in the Wadden Sea is prolonged by 4-6 weeks into May, which means that the Wadden Sea has become increasingly important for the species to accumulate body reserves (Koffijberg and Günther, 2005). This change in migration strategies is supposedly caused by the extended breeding range to the western White Sea area, resulting in much shorter migration distance and increasing food competition on the Baltic staging grounds (Eichhorn *et al.*, 2009).

The dark-bellied brent goose population has decreased in numbers during a longer period after the mid-1990s due to low breeding success. However, the numbers have become stable and increasing numbers are seen in the core staging areas on the islands in The Netherlands and on the Halligen in Schleswig-Holstein. For both species changes on the breeding grounds can probably explain the change in numbers in the Wadden Sea. However, their feeding opportunities in the Wadden Sea have changed as well during the past decades by abandonment of livestock grazing in the salt marshes of Schleswig-Holstein and Niedersachsen. It is suggested that the number of dark-bellied brent geese could be four times higher during spring if all salt marshes were to be livestock-grazed (Bos *et al.*, 2005). Moreover, competition between the two goose species could also contribute to a change in their distribution (Koffijberg and Günther, 2005).

Other waterbird species as mallard and teal are depending on salt marshes as a feeding habitat, but, like the two goose species, they can also feed in inland polders. However, both species are declining in the Wadden Sea during the 20-year period. Only about 6%-8% of the flyway population of mallard and teal occur in the Wadden Sea, but due to their large population size, the maximum numbers are high, with up to 150,000 mallard and 40,000 teal counted in the Wadden Sea during autumn. A study of the feeding ecology shows that teal feed on seeds of *Suaeda maritima* and *Atriplex littoralis* in the salt marshes (Madsen, 1988). When these food resources are depleted, most teal leave the area and some switch to inland-feeding during night. The numbers of teal counted in the Wadden Sea fluctuate greatly from year to year, and in the Danish Wadden Sea, it is shown that these annual variations are highly correlated to the breeding success (Laursen and Frikke, 2006). Thus it is likely that changes in teal numbers are governed by conditions on the breeding grounds. Guillemain *et al.* (2005) also consider the distribution of teal on a larger geographical scale and argue that the milder climate during the last decade has changed the teal distribution from southern to more northerly areas closer to the breeding grounds. Thus the reason for the change in numbers is not likely to be found in the Wadden Sea.

Three species, Eurasian golden plover, whimbrel and ruff depend on inland marshes in polder areas. All species show declining numbers during the last 20 year period. Up to 6,000 individuals of whimbrels and ruffs only, but up to 130,000 individuals of Eurasian golden plovers, were recorded in the Wadden Sea area, which represents only a small proportion of the flyway population of each species. The habitats they use range from wetland areas used by the ruff to the drier grazed areas used by the Eurasian golden plover and whimbrel, which also use mowed meadows and (dune) heathlands. At present it is not likely that the causes for the decreasing numbers of these species are to be found inside the Wadden Sea region.

3.6 Favourable food availability: benthic feeders and shellfish fishery

Three species, the common eider, Eurasian oystercatcher and the herring gull, have declined in numbers during the past 20 years. These species are all feeding on shellfish, mainly blue mussels *Mytilus edulis* and cockles *Cerastoderma edulis,* which they take in the littoral (oystercatcher and herring gull) or the sublittoral zone (common eider). The red knot, also an obligate shellfish eater, was formerly also recorded as declining (Blew *et al.*, 2005a), but it is now considered as stable, due to increasing numbers in recent years in Denmark and The Netherlands (Laursen *et al.*, 2009a). The common eider is covered by aerial midwinter counts and analyses show strong declining numbers for the Baltic/Wadden Sea population during the 1990s (Desholm *et al.*, 2002); in the Wadden Sea winter numbers have also decreased during the last 10 years.

Blue mussel fishery occurs in all parts of the Wadden Sea, with the largest culture lots and landings being in The Netherlands and Schleswig-Holstein (see QSR Thematic Report No. 3.4). Mechanized cockle fishery was allowed in The Netherlands up to 2004 and in a few areas in Denmark (about 1% of the intertidal area)[1]. Due to depletion of the mussel stocks in Denmark in the late 1980s and low numbers of common eider (Dahl *et al.*, 1994; Laursen *et al.*, 1997b), the management of the mussel fishery was restricted to a few vessels; about half of the Danish Wadden Sea was closed to mussel fishery, and an annual setaside of about 10,000 tons of mussels for the mussel eating birds species was achieved (Kristensen and Borgstrøm, 2005). Due to the impact of the shellfish fishery and observed declines and/or mass mortality in common eider, Eurasian oystercatcher and red knot, a new management scheme was introduced in 1993 for the Dutch Wadden Sea and the Dutch Oosterschelde, including intertidal areas closed for cockle and mussel fishery and a policy of food reservation for shellfish-eating bird species, mainly oystercatcher. The effectiveness of this policy was evaluated after a 10-year period (Ens *et al.*, 2004). During the evaluation period from 1993-2003 there was virtually no fishery on intertidal mussel beds, eventually leading to the return of intertidal mussel beds, especially in the eastern part of the Dutch Wadden Sea. Despite this success, the measurements that were part of the new fishery policy introduced in 1993 were unable to halt the decline in the bird populations in general. Return of the intertidal mussel beds occurred only at the very end of the evaluation period and too little food was reserved for the birds. Instead of reserving the ecological food needs, the policy of food reservation was based on the physiological food needs which were less than a third of the ecological food needs (Goss-Custard *et al.* 2004; Ens, 2006). The results showed that a complex set of factors led to an unfavorable food situation for birds. Both the common eider and the Eurasian oystercatcher suffered because of the low level of blue mussels and cockle after the intense period of fishery at the beginning of the 1990s (Ens *et al.*, 2004; Leopold *et al.*, 2004; Ens, 2006). Storms and severe winters can destroy mussel beds and decrease the food stocks. Eurasian oystercatchers can therefore be forced to switch to cockle stocks for which they have to compete with the cockle fisheries (Rappold *et al.*, 2003). The red knot may be taken as another example: the mechanical cockle fishery not only removed a considerable proportion of the cockles, but also changed the upper sediment layer, which severely reduced the ability of cockle larvae to settlethere. In consequence, the density of small sized cockles, suitable for the knots to feed on became too low to support the usual numbers of knots occurring in the Dutch Wadden Sea (Piersma *et al.*, 2001; van Gils *et al.*, 2006). Whereas shellfish stocks suffer, there are suggestions that kagworm *Nereis diversicolor* may benefit from mechanized cockle fishery (Leopold *et al.,* 2004; Kaan *et al.*, 2007).

The Dutch studies demonstrated that several years with massive die-offs of eiders were caused by food shortage, especially of sublittoral mussels (Camphuysen *et al.* 2002; Ens, 2006). When the eiders are weakened by starvation, parasites can kill the birds (Camphuysen *et al.*, 2002; Kats, 2007). From the Danish Wadden Sea it has been shown that a positive relationship exists between blue mussel stocks and the number of common eiders (Laursen and Frikke, 2008). Danish studies also demonstrated that during intensive mussel fishery in the 1980s the common eiders' body condition was good for those individuals feeding on blue mussels, while individuals feeding on alternative prey (including cockles) had a lower body weight (Laursen *et al.*, 2009b). Experiments on captive eiders indicated that thin-shelled (sublittoral) mussels were the preferred prey and the birds could not maintain their body condition when forced to feed on cockles with poor flesh content (Ens

[1] Gathering cockles by hand (via a kind of rake called "wonderklauw") is still allowed in the Netherlands to a maximum of 5% of the annual stock.

and Kats, 2004). In addition to the significance of the amount of blue mussels, (Nehls, 2001) has shown that also the quality of the mussels (*e.g.* thin shells and the right size interval) is important for the eiders.

For the Eurasian oystercatcher, results from the Dutch Wadden Sea showed that those individuals feeding at sites with mechanized cockle fishery had a poorer body condition and higher estimated mortality than those feeding in areas protected from mechanized cockle fishery (Verhulst *et al.*, 2004). Also, the breeding population of the oystercatcher in the entire Wadden Sea shows declines (Koffijberg *et al.*, 2009). A negative relationship between the consumption of the common eider and the Eurasian oystercatcher in relation to the amount of landed blue mussels in the Wadden Sea was found by Scheiffarth and Frank (2005), demonstrating that there is a conflict between the fishery and the bird species. The decline of the oystercatcher population in the Dutch Wadden Sea was primarily due to the removal of the intertidal mussel beds and to a lesser extent to mechanized cockle fishery (Rappoldt *et al,* 2003). According to recent estimates the current low population of oystercatchers wintering in the Dutch Wadden Sea is in accordance with the carrying capacity (Rappoldt *et al.,* 2008). For the herring gull, the shellfish fishery only partly explains the decreasing numbers. Herring gulls also experienced a decrease in the breeding population in the Wadden Sea region due to their reduced access to waste dumps (since 2004, most dumps have been covered and inaccessible), one of their feeding habitats.

3.7 Favorable food availability: prolonged stay during autumn and winter

Analyses of the species phenology in the Wadden Sea during the last 20 years (period 1987/88-1994/95 compared 1999/00-2006/07) show that during the recent period 61% of the species arrive earlier in autumn and 66% stay longer, before they continue their migration further south and west (Laursen *et al.*, 2009a). Both the Arctic breeding species and those species breeding in more southern latitudes show these differences, and they are more pronounced for the Wadden Sea region north of the River Elbe than for the south-western part. What this means for the management measures is not clear at the moment, but in general many species will spend more time in the Wadden Sea in the coming years, increasing the pressure on its food resources.

3.8 Natural escape distances

Natural escape distances have not been a part of the trilateral monitoring program in the Wadden Sea. However, a study in the Danish Wadden Sea shows that the escape distances are influenced by a number of species-specific parameters, such as wind force and visibility, flock size, body size, and area management *e.g.* if hunting is allowed (Laursen *et al.*, 2005). Comparisons between the escape distances in the Danish and the Dutch Wadden Sea showed that for the Eurasian oystercatcher, Eurasian golden plover, Eurasian curlew, bar-tailed godwit and the black-headed gull the mean escape distances were 1.4-2 times longer in the Danish than in the Dutch Wadden Sea (Laursen *et al.*, 2005, Smit and Visser, 1993). These differences were partly explained by higher human activities (both quality and regularity) in the Dutch Wadden Sea with the birds adapting to these higher disturbance levels, but more importantly to hunting, which during the study period was still allowed in parts of the Danish Wadden Sea; this potentially increased the species' alertness, leading to longer escape distances. A comparison of escape distances between hunted and non-hunted species showed that hunting increased escape distances significantly.

On the other hand, using the escape distance as a management measure is probably not straightforward. Experiments in Britain show that ruddy turnstones which were offered extra food at one site had a longer escape distance and were scanning more frequently for predators and flying further when disturbed, than individuals not offered extra food (Beale and Monaghan, 2004). These results made it difficult to interpret measured escape distances since birds exposed to a heavy disturbance stimulus (such as hunting activity) and birds having a good body condition both exhibit long escape distances.

4. Conclusions

4.1 Trends in waterbirds numbers

Trends for 34 waterbirds are now available for a 20-year period from the Wadden Sea (common eider only for 15 years), and show that 8 species have strong or moderate increases, 12 species are stable, and 14 species are decreasing. Thus, compared to the QSR 2004 there has been some improvement in the development for several species.

Based on a simple assessment, taking some approximations from the species' general biology, it shows that the species with strong increases in the Wadden Sea have also increased in their overall flyway populations. There have been moderate increases in species which winter in tropical Africa and breed in the Arctic. Of those species with stable numbers, more than half also have stable flyway numbers. The 'stable' species are breeding and wintering in the Arctic/Europe and have their wintering grounds in tropical Africa and Europe. Species that are in decline in the Wadden Sea are dominated by species breeding in North, Central and Western Europe. In addition, a large proportion of the declining species uses the inland polder areas or mussel beds for feeding.

Overfishing of mussel beds certainly contributed to the decline of species depending on mussels, but the reasons for the changes in numbers for most other species are not yet known. A more detailed approach to look at possible underlying factors has been undertaken with limited success. While high-quality bird data are available, some of the other factors (benthic fauna, sediments, etc.) are not available in the desired spatial and temporal resolution for the entire Wadden Sea area, preventing sophisticated statistical analyses. Some time series, *e.g.* benthos data, exist but may not be representative for the relevant Wadden Sea regions and some area-wide data series are too short or based on different methods and parameters. Suggestions for improvements has been provided in Ens *et al.* (2009).

4.2 Sufficient large undisturbed roosting areas

National and international protection regimes are covering most parts of the Wadden Sea including the majority of the roosting sites. However, the actual status regarding high tide roosts is not satisfactory (see Koffijberg *et al.*, 2003), and there has not been significant progress since the QSR 2004. The most serious potential conflicts are caused by recreational activity and its disturbance impacts. Outdoor activities take place near large roosting sites and tourist-related activities are reported to be expanding into late spring and early autumn, when some of the bird species are present in high numbers, putting an extra constraint on some of the declining species.

4.3 Sufficient large undisturbed moulting areas

In the Wadden Sea and its offshore area, large numbers of moulting common shelduck, common eider and common scoter occur, and several sites have numbers of international importance. The most important site for common shelduck in the southern Schleswig-Holstein Wadden Sea is considered sufficiently protected (National Park law and mandatory as well as voluntary regulations). Moulting shelducks are monitored in Denmark and Germany, but not in The Netherlands, where large numbers have been reported in recent years (Leopold, 2003), sometimes occupying completely new sites (Kraan *et al.*, 2006). A proposal has now been submitted by the JMMB group to establish an annual survey of the moulting duck species in the entire Wadden Sea.

Common eiders' moulting numbers and locations are available for Denmark and Germany, with sparse data from The Netherlands. Changes in distribution and numbers have been observed in the North-Frisian part of the Wadden Sea, but it is not known whether the numbers had decreased or moved to another site. While most moulting sites are well protected from disturbances, potential

sites in the East-Frisian Wadden Sea between Juist and Wangerooge are hardly used by common eiders and it is assumed that the disturbance level, especially from recreational activities (e.g. pleasure boats), is too high.

For common scoter, only few details of the moulting population and distribution in the Wadden Sea and offshore areas exist; still many questions remain with regard to their ecology. Recent studies have been performed in Denmark and Germany within assessments for offshore wind farms. A more correct assessment of the escape distances of this shy species would require an experimental study design to be carried out before proposing concrete 'moulting reserves'.

More information is also urgently needed in relation to the planning of offshore wind farms and the associated traffic of maintenance ships, which can potentially affect the distribution and activity of common scoter at sea during the moulting season (*e.g.* Garthe and Hüppop, 2004; Petersen and Fox, 2007). An evaluation of suggested protection regimes was recently conducted for the German Exclusive Economic Zone of the North Sea (Garthe, 2003). A further assessment of the need of undisturbed moulting sites in and outside the Wadden Sea is needed.

4.4 Favorable food availability for herbivores

There are three herbivorous waterbird species (barnacle goose, dark-bellied brent goose, and Eurasian wigeon) and two semi-herbivorous waterbird species (mallard and common teal) in the Wadden Sea. Of these the barnacle goose shows a steady strong increase, the dark-bellied brent goose and the Eurasian wigeon are stable after a steep decrease in the mid-1990s and the common teal and mallard are decreasing. For none of these species does food seem to be the cause of their decreasing trends. With regard to the goose populations, salt marsh management and the use of inland feeding sites has been discussed, for example, in the Leybucht in Niedersachsen (Bergmann and Borbach-Jaene, 2001; Lutz *et al.,* 2003). The question is whether the salt marshes can or should be managed in a way that can support a maximum number of geese in order to reduce feeding in agricultural areas in contrast to other nature values such as climax salt marsh vegetation communities. This is a discussion occurring in Denmark, where barnacle goose numbers have increased. However, fertilized grasslands will always be of higher food quality and thus more attractive for the geese during some periods than the natural salt marshes. Since these conflicts only arise in a part of the species' yearly life-cycle and involve several countries, they are best solved on the species flyway level. Such a flyway plan had been put forward for the dark-bellied brent goose (van Nugteren, 1997), but has not been endorsed by the countries involved. In the years that have passed since then, barnacle goose numbers have increased further and with them also conflicts (Koffijberg and Günther, 2005). Here, solutions regarding special goose management schemes are to be developed (Laursen, 2002), aiming at a satisfactory co-existence. The Wadden Sea Forum recommends that the best way to deal with geese is a strategic, long-term international approach in which refuge areas for geese are designated. Within these areas farmers should be paid for tolerating grazing geese as well as for improving conditions for the geese, such as reducing disturbance. Outside these areas geese may be chased away or even hunted when necessary (Wadden Sea Forum, 2008).

The declining numbers of mallard, teal, golden plover, ruff and whimbrel that all partly use the polder areas are probably not caused by conditions in the Wadden Sea region, but for at least some of these species the declining numbers are likely to be caused by changes in climate conditions (Laursen *et al.*, 2009a).

4.5 Favorable food availability for benthivores

The QSR 2004 showed that four species depending on shellfish had declining trends. The situation seems to have improved for one of these species, the red knot, but common eider, Eurasian oystercatcher and herring gull are still decreasing. After the intensive mussel fishery in the 1980s and 1990s, regulations have been introduced in all three Wadden Sea countries. In the Dutch Wadden Sea, mechanized cockle fishery was stopped in 2004. At the same time the number of licenses for gathering cockles by hand was increased and the policy of food reservation was abandoned. Irrespective of the size of the stock, hand gatherers may fish 5% of that stock (which is close to the 6% annually fished by the mechanical cockle boats (Ens *et al.,* 2004), thereby probably decreasing the carrying capacity of the Dutch Wadden Sea for wintering oystercatchers (Rappoldt *et al.* 2008). Recently, the Dutch ministry of agriculture, nature and food quality, the mussel farmers and the major nature conservation organizations agreed to completely phase out dredging of sublittoral mussel seed in the years to come. The aim is

to develop sustainable mussel fishery in the next decade, probably relying on artificial mussel seed collectors suspended in the water. In Denmark, improved calculation methods were applied and showed that the amount of blue mussels to be set aside for the mussel eating birds must be estimated based on the birds' ecological need, and not based on the physiological conditions; the ecological estimations are 5-7 times larger than the physiological values (Goss-Custard, 2004; Ens *et al.*, 2004; Ens, 2006); consequently during the winter of 2008/2009 a permission for mussel fishery was withdrawn.

Except for hand gathering of cockles in the Dutch Wadden Sea, these are important steps towards the targets of favorable food availability for birds; a further step could be to assess the blue mussel fishery policies in all Wadden Sea regions. However, to do that, regular monitoring of blue mussel stocks in both the littoral and sublittoral zones is needed, using the same or comparable methods in all the Wadden Sea regions.

4. 6 Natural flight distances

Knowledge of flight distances is an important tool in reserve designs (Fox and Madsen, 1997). In the Wadden Sea, moulting species such as the common scoter, common eider and shelduck are strongly affected by human activity during their moult season, which occurs from July to September, in the same period where many people enjoy their summer holidays. The birds gather in remote areas when moulting, and it is especially sailing with small pleasure boats that occurs in many parts of the Wadden Sea at that time of the year, that affects the moulting common eiders and common shelducks. The common scoters occur in more remote offshore areas, where they are vulnerable to larger ships and sailing boats; special concerns for this species are necessary when planning offshore wind farms due to the large associated ship traffic. However, to establish areas for common scoter, it is necessary to know their natural flight distance, and this has to be investigated using an experimental design.

For a number of waterbird species the natural flight distance is also an important aspect when improving the conditions on their roosting sites and when planning tourist activities, zoning regulations, onshore wind farms and other industrial and infrastructural developments. The phasing out of hunting activities, especially in Denmark, has reduced the natural flight distances for geese and considerably increased the number of curlew (Laursen, 2005). This development is an achievement complying with the target of natural flight distances.

5. Recommendations

Recommendations are listed in accordance with the ecological targets of the Wadden Sea Plan.

5.1 Sufficient large undisturbed roosting and moulting areas

Management

- Further develop spatial and temporal zoning for recreational activities;
- Acquire more information on natural flight distances when managing public access close to roosting sites;
- Assess impact of ultra light aircraft;
- Assess impact of small boats and canoes that have become popular and are able to sail in areas where the water depth is only a few cm;
- Provide sufficient protection to high tide roosts not included in designated SPA; especially a problem in The Netherlands;
- Evaluate potential disturbance from offshore wind farms and the associated ship traffic, with special attention for offshore moulting common scoters.

Monitoring and research

- Initiate a trilateral monitoring program for moulting common shelduck, common eider and common scoter;
- Investigate macrozoobenthos communities in the offshore area as food for the common scoter.

5.2 Favourable food availability

Management

- Evaluation of changes in the extent and method of shellfish fishery;
- Monitoring of the shellfish fishery including the seed fishery and the impact on bird species;
- Harmonisation of methods used for assessing and monitoring shellfish stocks;
- Support initiatives to manage goose species on trilateral level to reduce conflicts between farmers and geese;
- Encouragement to manage goose species on the flyway level.

Monitoring and research

- Include parameters (from a birds point of view) for benthos mass and benthos quality in the TMAP to facilitate assessment of bird numbers and their changes;
- Assess causal relationships between occurrence of birds and the availability of food stocks;
- Assess changes in distribution of geese in relation to changes in salt marsh management;
- Initiate studies of the origin/breeding areas of the bird populations using the Wadden Sea, thus allowing an improved assessment for changes observed;
- Introducing an alert system in the reporting system of species trends.

5.3 Natural flight distances

- Investigate escape flight distances of birds during roosting, moulting and under the influence of recreational activity.

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