12.2 Migratory Birds

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Shelducks on Trischen (Photo: M. Stock)

12.2.1 Introduction

The Wadden Sea is of outstanding international importance as a staging, moulting and wintering area for at least 52 populations of 41 migratory waterbird species that use the East Atlantic flyway and originate from breeding populations as far away as northern Siberia or Northeast Canada (Meltofte *et al.*, 1994). Numbers of 44 populations of 34 species occurring in the Wadden Sea are so high that this area can be considered their indispensable and main stepping stone during migration, or their primary wintering or moulting habitat. Nearly the entire population of the dark-bellied brent goose *Branta b. bernicla* and the entire North-European population of dunlin *Calidris alpina* use the Wadden Sea during some periods of their annual cycle. For an additional seven species more than 50% of the total population uses the Wadden Sea, and a further 14 species are present with more than 10% of their flyway population. These figures may in fact be much higher when considering turnover (see Meltofte *et al.*,1994 and below). In addition, the Wadden Sea and the coastal zone of the adjacent North Sea are used by high numbers of moulting and feeding common eider *Somateria mollissima* and support the entire Northwest-European population of common shelduck *Tadorna tadorna* during moult in summer (Blew *et al.*, 2005).

In recent decades, the amount and quality of data on migratory waterbirds has increased considerably. Being part of the International Waterbird Census of Wetlands International, surveys used to focus mainly on wintering numbers and distribution (Meltofte *et al.*, 1994). The current Joint Monitoring of Migratory Birds (JMMB), carried out in the framework of TMAP, consists of two synchronous (complete) counts each year (in some countries more than two) and bi-monthly counts during spring tide at numerous sample sites (Rösner, 1993). All these counts are carried out during high tide, when most birds congregate at high tide roosts, within reach of observers (see Koffijberg *et al.*, 2003 and Blew *et al.*, 2005 for details). These surveys allow assessments of numbers, distribution, phenology and trends. Knowledge of trends has much improved over the past years, since not only wintering numbers (which are often small and fluctuate according to the weather) but also the more important migration periods can be fully taken into consideration. Therefore, for the first time, overall trends of the most important species can be calculated for the entire Wadden Sea including all months of the year.

This chapter summarizes the results of the latest review of migratory bird numbers in 1992 – 2000 and provides information on trends during this time period. Maximum bird numbers given are 'estimated numbers' which take missing counts into account by calculating estimates for areas which were not covered during a count ('imputing', see Blew *et al.*, 2005 for details). In addition, particular assessments with regard to the ecological targets for migratory waterbirds will be given (see chapter 12.2.4). Some of this data has been retrieved from projects which were conducted as part of the Wadden Sea Plan, *e.g.* a review of sea-duck moulting sites (Hennig and Eskildsen, 2001), an overview of goose management schemes (Laursen, 2002) and an inventory of roosting sites (Koffijberg *et al.*, 2003).

The ecological targets for migratory birds, formulated in the Wadden Sea Plan are:

Targets

Favorable conditions for breeding and migratory birds:

- favorable food availability
- natural breeding success *
- sufficiently large undisturbed roosting and moulting areas
- natural flight distances

* mainly relevant for breeding birds

Table 12.2.1:
Maximum numbers in the Wadden Sea per species during 1980–1991 (Meltofte *et al.*, 1994) and during 1992–2000 (Blew *et al.*, 2005). Population estimates and ranges are taken from Wetlands International (2002). ‚winter' behind a scientific name indicates a population that winters in the Wadden Sea area; species included in Annex I of the EC Birds Directive are marked with an asterisk (*); species which are also typical breeding birds in the Wadden Sea, are printed in bold.

Species		1980–1991 Maximum number in the Wadden Sea	1992–2000 estimated	Population Estimate	Population Range
Great cormorant	*Phalacrocorax carbo sinensis*	4,660	17,200	275,000- 340,000	N, Central Europe
Eurasian spoonbill *	*Platalea leucorodia*	262	1,090	9,950	East Atlantic
Barnacle goose *	*Branta leucopsis*	103,000	278,000	360,000	N Russia, E Baltic (breeding)
Dark-bellied brent goose	*Branta b. bernicla*	220,000	255,000	215,000	W Siberian (breeding)
Common shelduck	*Tadorna tadorna*	254,000	219,000	300,000	NW Europe (breeding)
Eurasian wigeon	*Anas penelope*	320,000	333,000	1,500,000	NW Europe (non-breeding)
Common teal	*Anas crecca*	56,600	38,700	400,000	NW Europe (non-breeding)
Mallard	*Anas platyrhynchos*	165,000	170,000	4,500,000	NW Europe (non-breeding)
Northern pintail	*Anas acuta*	16,200	15,900	60,000	NW Europe (non-breeding)
Northern shoveler	*Anas clypeata*	3,960	6,030	40,000	NW & C Europe (non-breeding)
Common eider	*Somateria mollissima*	309,000[1]	311,000[1]	850,000-1,200,000	Baltic, Wadden Sea
Eurasian oystercatcher	*Haematopus ostralegus*	739,000	582,000	1,020,000	Europe, NW Africa
Pied avocet *	*Recurvirostra avosetta*	44,600	46,400	73,000	W Europe (breeding)
Great ringed plover	*Charadrius h. hiaticula* winter *Charadrius h. tundrae* *Charadrius h. psammodroma*	14,100	32,900 {	73,000 145,000-280,000 190,000	Europe, N Africa (non-breeding) SW Asia, E&S Africa (non-breeding) W&S Africa (non-breeding)
Kentish plover *	*Charadrius alexandrinus*	812	704	62,000-70,000	E Atlantic, W Mediterranean
Eurasian golden plover *	*Pluvialis apricaria* *Pluvialis apricaria* winter	168,000	153,000 {	69,000 930,000	NW Europe (non-breeding) W & S Continental Europe, NW Africa (non-breeding)
Grey plover	*Pluvialis squatarola*	140,000	106,000	247,000	E Atlantic (non-breeding)
Northern lapwing	*Vanellus vanellus*	132,000	113,000	2,800,000-4,000,000	Europe (breeding)
Red knot	*Calidris c. canutus* *Calidris c. islandica* winter	433,000	339,000 {	340,000 450,000	C Siberia (breeding) Greenland, High Arctic Canada (breeding)
Sanderling	*Calidris alba*	20,200	20,300	123,000	E Atlantic, W&S Africa (non-breeding)
Curlew sandpiper	*Calidris ferruginea*	6,680	10,700	740,000	W Africa (non-breeding)
Dunlin	*Calidris alpina* *Calidris alpina schinzii* * [2]	1,200,000	1,380,000 {	1,330,000 3,600-4,700	W Europe (non-breeding) Baltic (breeding)
Ruff *	*Philomachus pugnax*	19,800	5,250	2,200,000	W Africa (non-breeding)
Bar-tailed godwit *	*Limosa l. lapponica* winter *Limosa l. taymyrensis*	341,000	273,000 {	120,000 520,000	Coastal W Europe, NW Africa (non-breeding) Coastal W & SW Africa (non-breeding)
Whimbrel	*Numenius phaeopus*	1,330	2,120	160,000-300,000	NE Europe (breeding)
Eurasian curlew	*Numenius arquata*	227,000	279,000	420,000	W, Central & N Europe (breeding)
Spotted redshank	*Tringa erythropus*	15,200	18,800	77,000-131,000	Europe (breeding)
Common redshank	*Tringa t. robusta* winter *Tringa t. totanus*	59,600	65,100 {	64,500 250,000	Iceland & Faeroes (breeding) E Atlantic (non-breeding)
Common greenshank	*Tringa nebularia*	15,000	18,800	234,000-395,000	Europe (breeding)
Ruddy turnstone	*Arenaria interpres* winter *Arenaria interpres*	7,020	6,960 {	94,000 46,000-119,000	NE Canada, Greenland (breeding) Fennoscandia, NW Russia (breeding)
Common black-headed gull	*Larus ridibundus*	242,000	499,000	5,600,000-7,300,000	N & C Europe (breeding)
Common gull	*Larus canus*	103,000	198,000	1,300,000-2,100,000	Europe, N Africa (non-breeding)
Herring gull	*Larus a. argentatus* winter *Larus a. argenteus*	328,000	243,000 {	1,100,000-1,500,000 1,090,000	N & W Europe (non-breeding) NW Europe S to N Iberia (non-breeding)
Great black-backed gull	*Larus marinus*	15,400	16,300	420,000-510,000	NE Atlantic

[1] Numbers of common eider are derived from extra aerial counts.
[2] Only the population *Calidris alpina schinzii* is included in the Annex I of the EC Birds Directive.

12.2.2 Quality Status Report 1999

During assessments for the 1999 QSR, numbers of great cormorant *Phalacrocorax carbo*, dark-bellied brent goose, barnacle goose *Branta leucopsis*, Eurasian wigeon *Anas penelope*, Eurasian oystercatcher *Haematopus ostralegus*, grey plover *Pluvialis squatarola* and several gull species all showed thriving populations and long-term increases. For many species, this was attributed to improved protection measures in the past decades (*e.g.* a hunting ban on dark-bellied brent goose) and improved food availability through eutrophication, intensification of agriculture and fisheries (*i.e.* discards). Problems were especially noted in species feeding on blue mussels *Mytilus edulus*. In Denmark, distribution and numbers of both the common eider and the Eurasian oystercatcher were affected by shellfish-fisheries (Laursen and Frikke, 1987; Laursen *et al.*, 1997; CWSS, 2002). Both species experienced declines (along with mass-mortality in severe winters) also in the Dutch Wadden Sea. Here, mussel (and also cockle *Cerastoderma edule)* fisheries in combination with occurrence of severe winters were the main cause for declines in common eider and the Eurasian oystercatcher (Camphuysen *et al.*, 1996, 2002). Another matter of concern was the changed management of salt marshes (from livestock-grazed towards natural succession, possibly affecting food availability of herbivores, *e.g.* geese), the unsatisfactory management of human disturbance at roosting sites and the development of wind farms in the coastal zone behind the sea dike (a threat to migrating birds, disturbing feeding sites and high tide roosts). These topics will be reviewed in more detail in chapter 12.2.4.

12.2.3 Numbers and trends in 1992-2000

12.2.3.1 Maximum numbers and international importance

A total of 34 species with 44 distinct geographical populations have to be regarded as typical migratory and wintering birds of the Wadden Sea occurring in high numbers (Table 12.2.1; Blew *et al.*, 2005). Adding up the maximum numbers for each species results in some 6.1 million waterbirds present in the Wadden Sea. Besides the great cormorant and Eurasian spoonbill *Platalea leucorodia*, this comprises 1.66 million ducks and geese, 3.36 million waders and 955,000 gulls. These figures, however, do not take into account turnover. When considering the continuous arrival and departure of many migratory birds, many more individuals utilize the Wadden Sea: 10-12 million as estimated by Meltofte *et al.* (1994). Most species reach highest numbers during autumn migration from July onwards; wader numbers are almost as high during spring, whereas ducks and geese winter in high numbers. Only gulls reach considerable numbers in summer. The share of the international population that regularly uses the Wadden Sea gives an impression of its importance for the conservation of the total flyway population. All but two species fulfill the 1%-criterion of international importance according to the Ramsar Convention, more than 10% of 23 of the considered populations utilize the Wadden Sea (Figure 12.2.1).

12.2.3.2 Calculation of trends

Trends provide important information concerning the status of the Wadden Sea for waterbird popu-

Barnacle geese fouraging in Ballum Enge, Denmark. (Photo: J. Frikke)

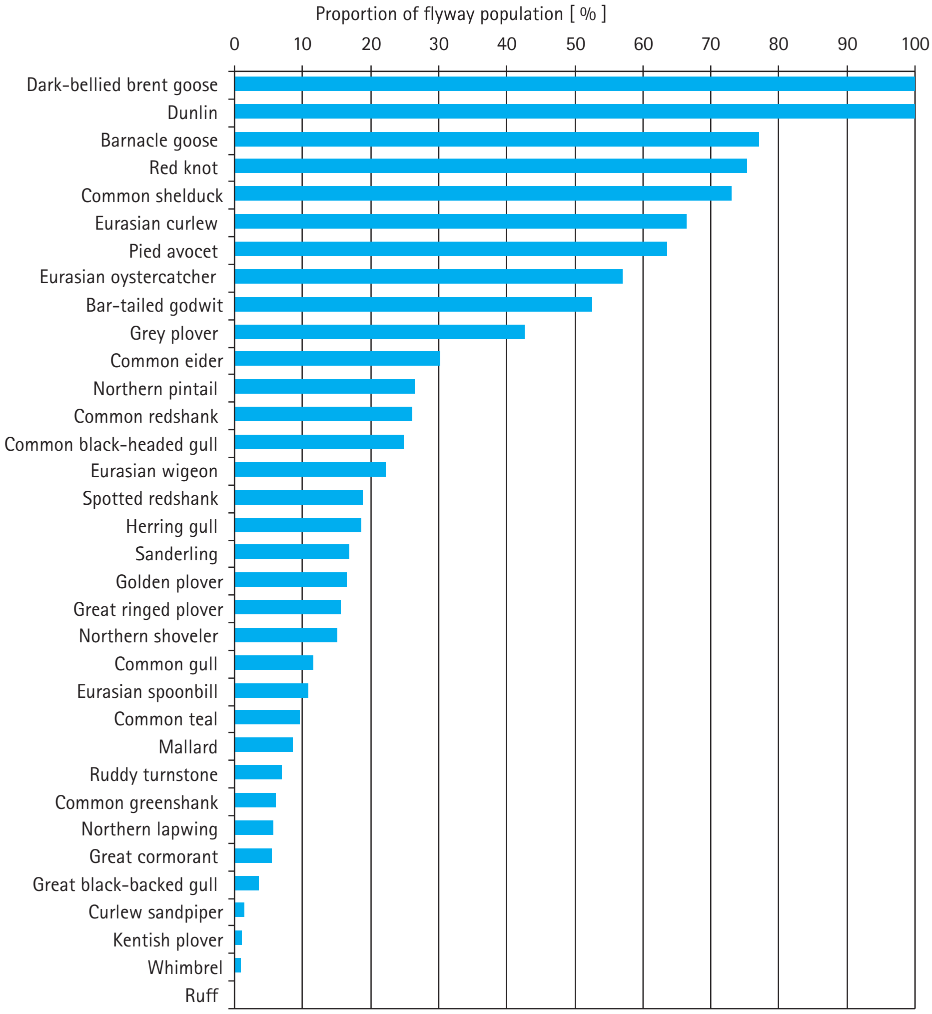

Figure 12.2.1: Maximum estimated numbers 1992-2000 (Blew *et al.*, 2005) given as proportion of flyway populations (Wetlands International, 2002).

lations. Calculations of trends were made for winter (January) and for all months (overall trends). Winter trends are based on the international synchronous counts in January and are also used for international comparisons with regard to the relevant flyway populations (Wetlands International, 2002). Only a few species, however, winter in considerable numbers in the area. Most species use the Wadden Sea as a staging habitat. For these species, overall trends, which include peak migration periods in spring and autumn, are a more reliable parameter for detecting changes in numbers using the Wadden Sea since they take into account all important stages of the annual cycle (Table 12.2.2).

12.2.3.3 Winter trends

During January 1980-2000, peak numbers of 25 species (involving varying proportions of their geographical populations) exceeded 1,000 individuals and allowed a proper trend estimate. Only few species showed pronounced trends, such as grey plover, Eurasian wigeon, great cormorant, barnacle goose, common eider and common gull *Larus canus* (Table 12.2.2). For great cormorant and barnacle goose, this development reflects the expansion of the total flyway population; for Eurasian wigeon and grey plover, this reflects an increase in wintering numbers of these species in Northwest-Europe (Wetlands International, 2002). Most species, however, experience fluctuations without showing a trend. The lack of clear trends in winter is mainly caused by the alternating impact of severe and mild winters. This pattern leads to a long-term increase of most species during 1980-2000, but a short-term decrease during 1992-2000 (giving an overall fluctuating trend). Cold spells and (partial) ice-cover occurred, for example, in January 1982, 1985, 1986, 1987, 1996 and 1997. In these years, species such as Eurasian wigeon, mallard *Anas platyrhynchos*, northern pintail *Anas acuta*, Eurasian oystercatcher, and Eurasian curlew *Numenius arquata* declined in the Wadden Sea and subsequently showed high numbers in France (Deceuninck and Maheo, 2000), suggesting southbound displacements of birds that usu-

Table 12.2.2:
Trend estimates of migratory birds in the Wadden Sea with the importance of season and indication of food preference, listed according to ‚overall trend'.
*** A = autumn, W = winter, S = spring, xx = season is important, x = season is less important, – = season is unimportant for trend estimation;**
**** ++/–– substantial increase/decrease (> 20% in 10 years); +/– increase/decrease (< 20% in 10 years); 0 stable; F fluctuating; n.s. trend estimate not significant; *** Wetlands International (2002).**

Species	Wintering grounds	Breeding grounds	Food preference (in Wadden Sea)	Importance of season* A	W	S	Overall trend** 1992 to 2000	January trend** 1980 to 2000	Flyway population trend*** most recent years
Ruddy turnstone	trop. Afr. / W Eur	arctic	benthos	xx	x	xx	--	+ (n.s.)	+
Common redshank	trop. Afr. / W Eur	non-arctic	benthos	xx	x	x	--	F	- / 0 / +
Red knot	trop. Afr. / W Eur	arctic	benthos-shellfish	xx	x	xx	--	++ (n.s.)	-
Eurasian oystercatcher	W Eur	non-arctic	benthos-shellfish	xx	xx	x	--	F	-
Grey plover	trop. Afr. / W Eur	arctic	benthos-worm	xx	x	xx	--	++	+
Dunlin	W Eur / Med.	arctic	benthos-worm	xx	x	xx	--	++ (n.s.)	0
Curlew sandpiper	trop. Afr.	arctic	benthos-worm	xx	-	-	--		+
Pied avocet	trop. Afr. / Med.	non-arctic	benthos-worm	xx	-	x	--		0
Mallard	W Eur	non-arctic	herbivore/benthos	x	xx	-	--	+ (n.s.)	-
Dark-bellied brent goose	W Eur	arctic	herbivore	x	x	xx	--	+ (n.s.)	-
Eurasian wigeon	W Eur	non-arctic	herbivore	xx	xx	x	--	++	+ ?
Spotted redshank	trop. Afr.	arctic	benthos	xx	-	xx	-		0
Eurasian curlew	W Eur	non-arctic	benthos	xx	xx	x	-	++ (n.s.)	+ / 0
Common greenshank	trop. Afr.	non-arctic	benthos	xx	-	x	-		0
Bar-tailed godwit	trop. Afr. / W Eur	arctic	benthos-worm	x	x	xx	-	++ (n.s.)	- / 0
Herring gull	W Eur	non-arctic	benthos-shellfish/generalist	xx	xx	x	--(n.s.)	++ (n.s.)	-
Sanderling	trop. Afr. / W Eur	arctic	benthos-worm	x	x	xx	- (n.s.)	++ (n.s.)	0 / +
Golden plover	Med. / W Eur	non-arctic	benthos-worm/terrestrial	xx	x	xx	- (n.s.)	++ (n.s.)	0 / +
Northern lapwing	Med. / W Eur	non-arctic	benthos-worm/terrestrial	xx	-	x	- (n.s.)	++ (n.s.)	-
G. black-backed gull	W Eur	non-arctic	generalist	xx	xx	x	- (n.s.)	++	0
Northern pintail	Med. / W Eur	non-arctic	herbivore/benthos	xx	x	x	- (n.s.)	+ (n.s.)	-
Great cormorant	Med. / W Eur	non-arctic	fish	xx	-	-	++	++	+
Barnacle goose	W Eur	arctic	herbivore	xx	x	xx	++	++	+
Eurasian spoonbill	Trop. Afr. / Med.	non-arctic	benthos-shrimp	xx	-	-	+		+
Common shelduck	W Eur	non-arctic	benthos	xx	xx	-	+ (n.s.)	F	0
Ringed plover	trop. Afr.	arctic	benthos-worm	xx	-	xx	+ (n.s.)		+
Whimbrel	trop. Afr.	arctic	benthos-crustaceae/frugivore	xx	-	-	F		+ / 0
Common eider	W Eur	non-arctic	benthos-shellfish	-	xx	-	F	++	-
Ruff	trop. Afr.	arctic	benthos-worm	xx	-	xx	F		-
Kentish plover	trop. Afr. / Med.	non-arctic	benthos-worm	xx	-	x	F		-
C. black-headed gull	W Eur	non-arctic	generalist	xx	x	x	F	+ (n.s.)	+
Common gull	WS	non-arctic	generalist	xx	x	x	F	++	-
Common teal	Med. / W Eur	non-arctic	herbivore/benthos	xx	x	x	F	F	+
Northern shoveler	Med. / W Eur	non-arctic	herbivore / benthos / plancton	xx	x	x	F	+ (n.s.)	+

ally winter in the Wadden Sea. Considering the expectation of more frequently occurring milder winters in the longer term (*cf.* chapter 3), wintering numbers and distribution over the Wadden Sea might change for some species in future. Such a change has already been reported for wintering wader populations in the UK, which have partly switched from the west to the east coast (Austin *et al.*, 2003).

12.2.3.4 Overall trends

During autumn and spring, when the Wadden Sea serves as a migration, moulting, staging and roosting habitat, the impact of weather is not as great as during winter, allowing a more robust trend assessment. Looking at the 34 species considered, the alarming fact arises that 15 species (44% out of 34 species considered) experienced a significant decrease in the 1990s (Table 12.2.2). Among these are species of which more than 50% of the total flyway population migrates through, or stays within the Wadden Sea (*cf.* Figure 12.2.1), such as red knot *Calidris canutus*, Eurasian oystercatcher, dunlin, pied avocet *Recurvirostra avosetta*, dark-bellied brent goose, Eurasian wigeon, Eurasian curlew *Numenius arquata* and bar-tailed godwit *Limosa lapponica.* Another seven species (21%) show a decline as well, although not a statistically significant one. Many of the declining species have in common that they are long-distance migrants and their life strategy includes periods of fast refueling of body reserves in the Wadden Sea, en route to their high arctic breeding areas or African wintering sites. Since the declining numbers for these species have not been confirmed elsewhere in Europe (*e.g.* UK: Austin *et al.*, 2003; France: Deceunick and Maheo, 2000), the underlying causes for the downward trends are to be sought in the Wadden Sea (Davidson, 2003). This is also supported by declining breeding populations in resident species such as the Eurasian oystercatcher (*cf.* Table 12.1.1 in chapter 12.1). At a local scale, declines in breeding populations have been also noticed recently in pied avocet and herring gull (Dijksen *et al.*, in prep.), of which major parts of the population stay in the Wadden Sea after the breeding season.

The causes for the observed population declines are not known in detail for all species, and cannot be assessed by monitoring alone. At least for dark-bellied brent goose, there is a clear relationship with poor breeding seasons (see section 'Favorable food availability' below). For several benthos-eaters (common eider, Eurasian oystercatcher) there is evidence that food availability has deteriorated in the past decades (see below).

Compared to the many declining species, rather few species show significant upward overall trends. For the great cormorant, Eurasian spoonbill and barnacle goose, the entire Northwest-European populations have increased in the past decade (Wetlands International, 2002). For many other species (*e.g.* whimbrel *Numenius phaeopus*, ruff *Philomachus pugnax*) only fluctuating trends could be observed, mainly because these species utilize the Wadden Sea in rather low numbers (*cf.* Figure 12.2.1).

12.2.4 Target evaluation

12.2.4.1 Sufficiently large undisturbed roosting areas

Since most of the waterbirds in the Wadden Sea gather at specific roosts during high tide, the safeguarding of these high tide roosts is an issue for the conservation and protection of birds in the Wadden Sea. In order to assess possible conflicts between nature and human interests, the current status of roosts (bird numbers, protection regimes and anthropogenic disturbance) was recently reviewed (Koffijberg *et al.*, 2003). In general terms, numbers and species observed at a high tide roost in a dynamic area like the Wadden Sea are influenced by many factors, including actual water tables, distance to the nearest favorable feeding areas, preferred roosting habitat, site-tenacity and social status of the birds. As a result, species often use a network of roosting sites. For mobile species such as red knot, this might within a short run of tidal cycles even cover an area of 800 km², whereas others, such as dunlin, are extremely faithful to certain feeding areas and high tide roosts. The largest roosting sites are located where large intertidal mudflats occur at close range and low levels (or absence) of human disturbance prevail. This combination is found especially on some remote and uninhabited islands, such as Süderoogsand and Trischen (Schleswig-Holstein), Scharhörn (Hamburg), Memmert and Mellum (Niedersachsen), Griend and Richel (both The Netherlands) (Figure 12.2.2).

12.2.4.2 Disturbance and protection of roosting sites

The level of anthropogenic disturbance is one of the most important factors regulating bird numbers at high tide roosts, and often puts an extra constraint on the birds' narrow energetic balance and tight time schedule for migration. Case studies in several parts of the Wadden Sea have pointed out that recreational activities are among the most frequently observed sources of anthropogenic disturbance. This is confirmed by the recent inventory by Koffijberg *et al.* (2003), which points out that 29% to 42% of all roosting sites are subject to an estimated moderate to heavy recreational pressure (Figure 12.2.3). Moreover, data on phenology show that the seasonal occurrence of some species is affected by recreation pressure and birds tend to avoid roosts visited by many people in the summer holiday season. As this holiday season is extending to spring and autumn, it is expected that more recreational pressure will arise in near future, especially when regarding the timing of migration of long-distance migrants, for which important numbers use the Wadden Sea as a stop-over in late spring (May) and summer (July-September).

Another, more local source of disturbance is hunting, which is observed at many sites (up to 33% of all sites in Denmark when regarding moderate to heavy hunting pressure). Laursen (2005) has demonstrated the severe impact of hunting in the Danish Wadden Sea. For the Eurasian curlew, it is concluded that the gradual hunting restrictions and the final hunting ban in Denmark in 1992-94 resulted in a population increase in this species in the entire Wadden Sea (at least during winter) in the mid 1990s. Although the hunting of migratory waterbirds was gradually phased out in the entire Wadden Sea during the 1990s, hunting small mammals such as hares *Lepus europaeus* and rabbits *Oryctolagus cuniculus* is still common practice and also occurs on salt marshes close to important high tide roosts, thus causing disturbance.

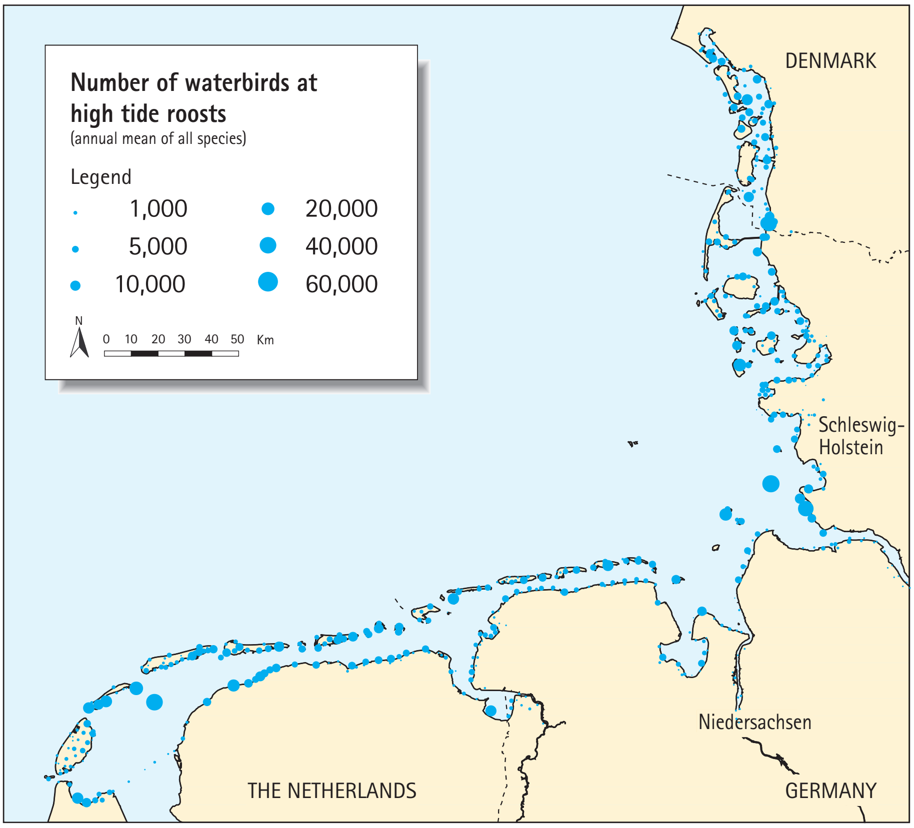

Figure 12.2.2: Overview of high tide roosts in the Wadden Sea, expressed by the sum of all annual means of all relevant species. Large roosts occur in areas close to large intertidal flats and at sites with low anthropogenic disturbance (Koffijberg *et al.*, 2003).

Additional sources of potential anthropogenic disturbance, also at a limited number of sites, are civil air traffic, military training activities and inland wind farms. The latter have been reported to affect inland roosting behavior close to the seawall, especially for coastal waders and geese.

Regarding protection regimes, most countries have more than 80% of their high tide roosts (supporting for most species >90% of the birds observed) within areas that have been designated as a Special Protection Area (SPA) under the Birds Directive and/or as a Ramsar site. The majority of sites are therefore subject to regulations addressing bird conservation targets. In The Netherlands and Niedersachsen, this figure is somewhat lower, since both countries have a large proportion of inland agricultural areas among their roosting sites which are subject to limited special protection measures. Only in Niedersachsen and in Denmark have some of these agricultural areas been included within SPAs, whereas in The Netherlands agricultural areas behind the seawall were not taken into account at all in the last SPA designation of 2000. Especially species such as the barnacle and dark-bellied brent goose, Eurasian golden plover *Pluvialis apricaria* and the Eurasian curlew are known to utilize inland roosts in large numbers. Moreover, inland sites are part of the network of existing roosting sites and increase in importance for all species during high water tables when regular coastal high tide roosts are flooded.

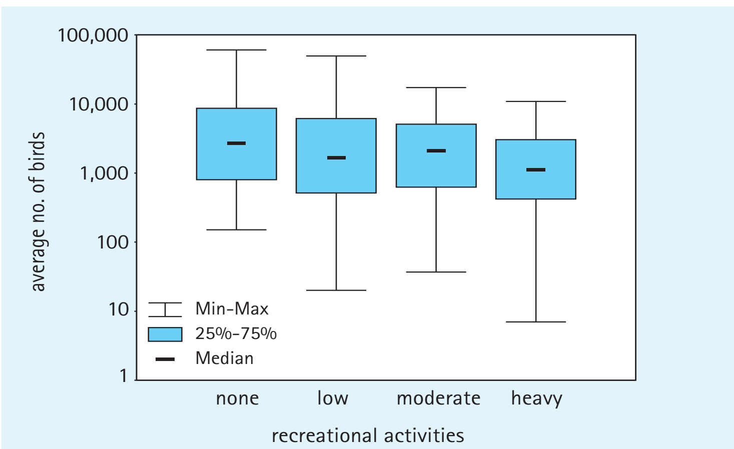

Figure 12.2.3: Bird numbers at high tide roosts in relation to different levels of recreational activities. Although variation is large there is a significant impact of recreational pressure on the number of roosting birds (Koffijberg *et al.*, 2003).

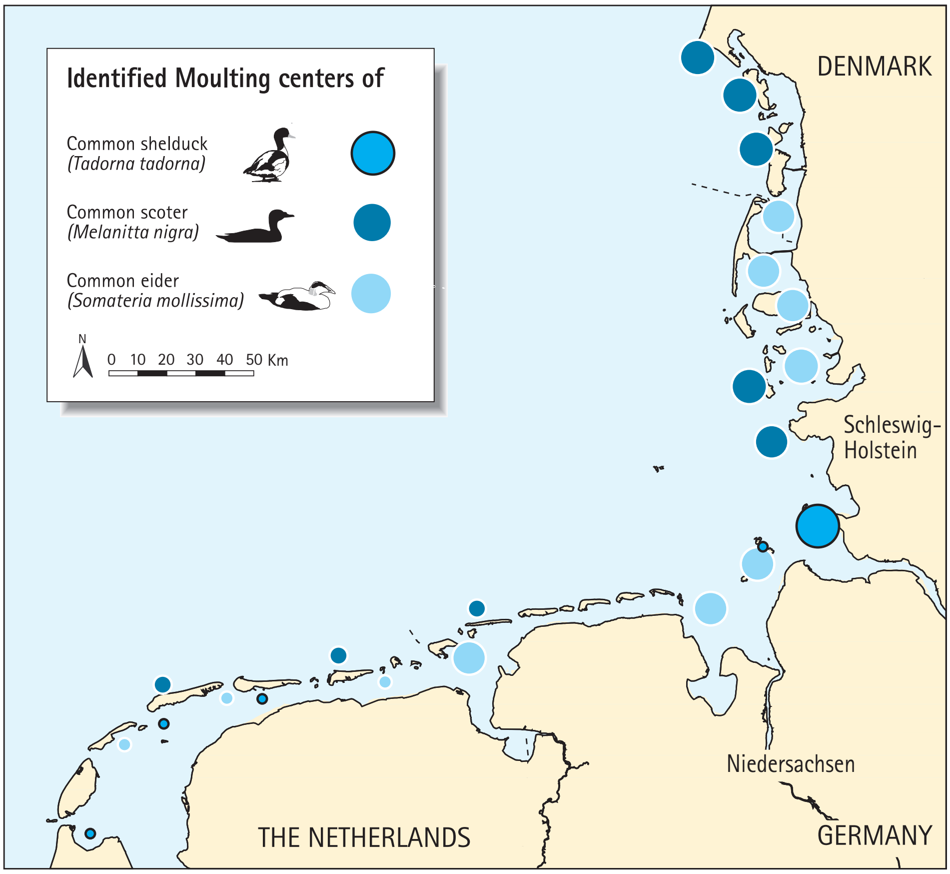

Figure 12.2.4: Moulting distribution of common shelduck, common scoter and common eider (Kempf, 2001; Henning unpubl.; Scheiffarth and Frank, 2005). Size of circles according to the importance of the moulting site for each species.

12.2.4.3 Sufficiently large undisturbed moulting areas

Several bird species, particularly waterbirds such as grebes, swans, geese and ducks, moult their flight feathers simultaneously during a period of several weeks in summer during which they cannot fly. In this period, they are extremely vulnerable to predators and anthropogenic disturbance and often concentrate in remote areas. The Wadden Sea and the adjacent North Sea area support internationally important moulting concentrations of common shelduck, common eider and common scoter *Melanitta nigra* (Figure 12.2.4). Thus, the Wadden Sea countries have a great responsibility for the protection of these species. Moulting behavior and phenology differs among the three species and management thus requires a species-specific approach.

Common shelduck moult from late June to early September in the vicinity of undisturbed and extended mudflats. The most important moulting sites for shelduck have recently shifted and are now almost exclusively situated within the southern Schleswig-Holstein Wadden Sea (Kempf, 1999, 2001) (Figure 12.2.4). Up to 2002, a large proportion of the entire Northwest-European shelduck population, regularly exceeding 200,000 individuals, synchronously concentrated at this moulting site during late July and August. Smaller numbers (10-20,000 birds) moult in The Netherlands (Leopold, 2003), although reliable information is lacking here due to the absence of offshore counts in summer.

Concentrations of moulting common eider are found from July until the end of August, particularly in large areas with very low disturbance levels, rich shellfish resources and roosting sites on sand banks. Their moulting areas are less concentrated compared to those for scoters and shelducks. Moulting populations in the German and the Danish Wadden Sea involved 170,000–230,000 individuals in the last two decades. Numbers have decreased from 1989 onwards (Desholm *et al.*, 2002), with a steep decline since 1994 in the major moulting area, the North-Friesian Wadden Sea (Scheiffarth and Frank, 2005). Other concentrations are found in remote areas such as the Randzel area near Borkum, Niedersachsen. The East-Friesian Wadden Sea between Juist and Wangerooge is not used for moulting, although in some years favorable feeding conditions seem to exist here. This area is intensively used for tourist activities and thus might be exposed to high levels of disturbance. In Denmark, a negative rela-

Common eiders (Photo: G. Nehls).

tionship was found between the number of moulting eiders and the number of boats at sea (Laursen *et al.*, 1997) and in the Königshafen area on the island of Sylt it could be directly shown that wind surfing activities drove moulting eiders away from a rich food source (Ketzenberg, 1993). Hardly any recent information on Dutch moulting eider numbers is available. In the 1980s, this part of the Wadden Sea supported about 40,000 birds (Swennen *et al.*, 1989). Recent information is sporadic, but suggests some smaller concentrations.

Common scoters show the longest moulting period (June to October) since immature birds, males and females have consecutive moulting schedules. Compared to the other two species, moulting behavior is less well-known, as they prefer offshore feeding sites and usually occur highly dispersed over the sea surface, making counts difficult. With regard to food, scoters seem to be highly opportunistic. While for The Netherlands, scoters are considered highly dependent on *Spisula* as an important food resource (Leopold *et al.*, 1995; Leopold and Van den Land, 1996), they seem to focus on other food resources in Germany and Denmark. Due to the dispersed flocking behavior, common scoters are very susceptible to any source of disturbance; with approaching ships for instance, a flight distance of about two km has been reported. The importance of the entire Wadden Sea for moulting scoters decreases from Denmark over Germany to The Netherlands. Moulting centers of common scoter in all three Wadden Sea countries have been identified (Hennig, unpubl.) and have recently been confirmed for the federal state of Schleswig-Holstein (Hennig and Eskildsen, 2001; Deppe, 2003) (Figure 12.2.4). However, numbers of moulting scoters seem to be underestimated in Germany and The Netherlands, making proper assessments in those countries difficult.

12.2.4.4 Disturbance and protection of moulting sites

Sources of disturbance of the moulting flocks range from commercial fisheries to boat and air traffic and oil spills. Some of these activities are regulated in parts of the Wadden Sea. In Germany, the national parks established a zoning system regulating many uses. Together with additional mandatory and voluntary regulations with regard to boat traffic, this system regulates the spatial and temporal use of certain areas and involves commercial and non-commercial fishery, leisure activities such as sailing, motor-boating (including commercial tourist ships and their excursions), surfing and canoeing. The effectiveness of these measures is monitored within the TMAP ('migratory birds' and 'boats at sea'). Oil spills pose an immense potential threat during the entire year, but seem to affect common scoters more than the other seabird species (see also chapter 4.4). However, in 1998, some 11,400 eider and 3,700 scoter died due to the *Pallas* accident (Günther, 1998). If marine wind farms were to be constructed within the 12-mile-zone, this and the associated boat traffic and other indirect effects would potentially reduce the areas available for moulting shelducks, eiders and scoters. Special Protection Areas (SPAs) within and outside the Wadden Sea have recently been designated and offer additional protection with regard to marine wind farms and other sources of disturbance. This additional protection, however, is not satisfactory for all species.

Barnacle geese on the Hamburger Hallig (Photo: M. Stock).

12.2.4.5 Favorable food availability: goose grazing and salt marsh management

The Wadden Sea region is an important staging area for arctic geese. Especially in spring, a major proportion of the Russian-Baltic population of barnacle geese and the entire West-Siberian population of dark-bellied brent geese stay in the Wadden Sea to accumulate body reserves for spring migration and breeding (Ebbinge *et al.*, 1999; Ganter *et al.*, 1999). Data from the trilateral goose counts in the Wadden Sea and a review of recent changes in staging habits of both species have been used to evaluate the overall population trend, habitat use, phenology and goose management (Koffijberg and Günther, 2005). Goose-directed management in the Wadden Sea countries was reviewed by Laursen (2002) as part of the Wadden Sea Plan. In recent decades, the numbers, distribution and phenology of geese in the Wadden Sea have experienced major changes:

Barnacle goose

- Due to the increase of the Russian-Baltic flyway population, numbers and feeding range in the Wadden Sea have expanded considerably, 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 was concentrated in the Wadden Sea (March); recently, the Wadden Sea has become less important for wintering birds, which switch increasingly to inland grasslands in Niedersachsen and The Netherlands;
- Along with the expansion in numbers and feeding sites, barnacle geese have prolonged their stay in spring by 4-6 weeks and now leave around mid May;
- As a result of the delayed spring departure, the Wadden Sea has become increasingly important for accumulating body reserves for breeding, especially for Russian barnacle geese.

Dark-bellied brent goose

- Low reproduction rates have initiated a decline in the population of dark-bellied brent geese, resulting in lower numbers in the Wadden Sea;
- Despite this 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 in the core staging areas on the barrier islands in The Netherlands and on the Halligen in Schleswig-Holstein.

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 itself have contributed to the decline or increase in either species, although feeding opportunities did change during the past decades with, for example, the abandoning of livestock grazing in large parts of the mainland salt marshes of Schleswig-Holstein and Niedersachsen. Bos *et al.* (in press) concluded that if all salt marshes were livestock-grazed, the number of dark-bellied brent geese supported in spring could be four times higher compared to a situation with no livestock grazing at all. However, Bos *et al.* showed that many suitable sites were used less than expected from their vegetation composition and were thus available as alternative sites when conditions elsewhere deteriorated. Similar findings were produced by a monitoring program in Schleswig-Holstein. Although the geese re-distributed over the area, the maximum numbers and duration of staging has not changed since livestock-grazing was reduced (Stock and Hofeditz, 2000, 2002). However, 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 might be an expression of a re-distribution process on a larger scale which could be related to changes in salt marsh management in the eastern part of the Wadden Sea. Analysis of re-sightings of individually marked birds could bring further evidence with regard to changes in site-use. In addition, distribution could be a result of competition between both species.

12.2.4.6 Favorable food availability: benthic feeders and shellfish fisheries

The trilateral Wadden Sea monitoring in the past decade has revealed strong overall declines for species which depend on shellfish (notably bivalves such as blue mussels and cockles) in the intertidal area, for example, the Eurasian oystercatcher and red knot (*cf.* Table 12.2.2). In addition, the Baltic/Wadden Sea population of common eider experienced a strong decline during the 1990s (Desholm *et al.*, 2002) and winter numbers in the Wadden Sea dropped to a low in 2001/2002 (the overall Wadden Sea trend 1992-2000, however, is fluctuating). Numbers of herring gulls increased between 1980 and 1990, but have shown declines since then, both in breeders and non-breeders (*cf.* chapter 12.1).

Blue mussel fisheries occur in all sections of the Wadden Sea, with the largest culture lots and landings in The Netherlands and Schleswig-Holstein (CWSS, 2002). Cockle fisheries have been allowed only in The Netherlands and a few small areas in Denmark. In Denmark, mussel fisheries were discussed (and consequently restricted in the 1980s), after additional mortality had occurred among several waterbirds (Laursen and Frikke, 1987; Laursen *et al.*, 1997; CWSS, 2002; Kristensen and Laursen, in prep.). Because of the presumed impact of shellfish fisheries and the observed declines and mass-mortality in several bird species, a comprehensive evaluation of fishery effect and bird numbers was carried out in the Dutch Wadden Sea and Oosterschelde recently (Ens *et al.*, 2004). This study, called EVA II, was a follow-up of previous assessments of a management regime of closed and open areas for cockle fisheries in the Dutch Wadden Sea, and an annual quota accounting for food reserves for waterbirds. However, these measures were unable to halt the observed declines in bird populations. The EVA II study aimed to unravel the links between activities of blue mussel and cockle fisheries and the observed bird numbers, in order to balance the interests of shellfish fisheries and nature conservation.

The EVA II project has demonstrated that a complex set of factors led to an unfavorable food situation for birds, and finally caused a decrease in numbers in species such as common eider, Eurasian oystercatcher, red knot and perhaps herring gull. For the common eider and Eurasian oystercatcher, this confirms the hypothesis of Scheiffarth and Frank (2005) that in the Wadden Sea there is a conflict between these species and fishery. They compared consumption of mussel and cockle stocks by the Eurasian oystercatcher, common eider and herring gull in the entire Wadden Sea with data on mussel and cockle landings (as an indicator of the food stock available to the birds), and found a negative correlation between mussel landings and the consumption by the common eider and Eurasian oystercatcher. The EVA II study revealed that in the Dutch Wadden Sea both species suffered losses due to low blue mussel stocks, since these had been removed by mussel fisheries in the beginning of the 1990s (Ens *et al.*, 2004; Leopold *et al.*, 2004a). Severe winters (also affecting oystercatcher numbers), lower reproduction rates of blue mussels and perhaps also increased storminess contributed to the deteriorating food stocks as well (Ens *et al.*, 2004). As a result, oystercatchers had to switch to cockle stocks, for which they had to compete with cockle fisheries (Rappoldt *et al.*, 2003).

Common eiders especially were faced with lower mussel and cockle stocks and were not able to compensate for this by, for example, switching to alternative food stocks (*e.g. Spisula subtruncata* banks in the coastal zone of the North Sea) as the energy profitability of alternative prey is lower (Nehls, 2001) and competition with shellfish-fisheries also occurs on *Spisula* banks (Camphuysen *et al.*, 2002; Ens and Kats, 2004). For herring gull, fishery may provide only part of the explanation for the lower numbers, especially since the breeding population of this species is known to have suffered competition with increased numbers of lesser black-backed gull and reduced access to waste dumps (see chapter 12.1), both of which have reduced reproductive output (and thus num-

‚Geese days' on the Halligen (Photo: H.-U. Rösner)

bers counted after the breeding season). For the red knot, it is assumed that the recent population decline is related to changes in sediment, caused by the mechanical fishing devices used by cockle fisheries, rendering this sediment unsuitable for settlement of bivalve spat for a number of years (Piersma and Koolhaas, 1997; Piersma *et al.*, 2001). The impact on macrozoobenthos by cockle fisheries, however, is not yet clearly understood. There are indications that ragworm *Nereis diversicolor* densities have increased as a result of cockle fisheries (Leopold *et al.*, 2004b; Kraan *et al.*, 2004), but it remains difficult to isolate these changes from long-term increasing trends in worms (see chapter 8.2).

12.2.4.7 Natural flight distances: the Eurasian curlew and hunting

While little information is available about flight distances in general, it has been demonstrated that flock size and different weather conditions (*e.g.* wind force, visibility) influence the flight distances of several waterbird species (Laursen *et al.*, 2005). For geese, Wille (2000) showed that areas with and without hunting have significant differences in flight distance and goose flocks in areas where hunting takes place were more likely to take off when disturbed. Similar findings have been published for other goose species (Madsen, 1985, 1988) and in a study on Eurasian curlew in the Danish Wadden Sea (Laursen *et al.*, 2005). Here, it was also demonstrated that hunted species show longer flight distances from an approaching person than non-hunted species. A comparison of the Dutch and Danish Wadden Sea demonstrated that in the Danish Wadden Sea flight distances are 1.4-2 times longer for seven species of waders and gulls. This could imply that birds may have habituated to the far higher number of people walking along the beaches and on the intertidal flats in the Dutch Wadden Sea, but also (and more likely) the far greater hunting activity in the Danish Wadden Sea at the time of the study may have led to a longer flight distance in this area. Since the seven species included both hunted and non-hunted species, the results also indicate that hunting activity influences flight distance for both groups of birds. Thus, hunting in general, regardless of the species, has a clear impact on the distribution and feeding behavior of waterbirds. This is not only confined to hunters' activities, but birds also respond earlier to other sources of anthropogenic disturbance in areas where hunting occurs. Another example is the reduced flight distance of geese as a consequence of both limited hunting and a wise tourism management in specific areas (Mock *et al.*, 1998; Liebmann, 1999; Stock and Hofeditz, 2002; Rösner, 2003).

12.2.5 Conclusions

12.2.5.1 Trends in waterbird numbers

A review of trends of waterbirds utilizing the Wadden Sea reveals that 22 out of the 34 species considered experienced declines in 1992-2000, of which 15 are (statistically) significant (Table 12.2.2). This is an alarming development since the 1999 QSR. Moreover, similar declines in these species have not been observed elsewhere, suggesting the Wadden Sea is the main bottleneck in these birds' lifecycle (Davidson, 2003). Among the species showing significant decreases, there is a large proportion for which the Wadden Sea represents an indispensable stop-over to refuel body reserves on migration routes between (often African) wintering grounds and the high arctic breeding range, *i.e.* those species of which a large proportion of the population uses the Wadden Sea. The causes of the observed trends are not known in detail yet for all species concerned. Therefore, besides the measures proposed in the following chapters, more ecological research is needed to understand and reverse the negative trends detected by monitoring. Comparing trends in the different countries and relating them to differences in policy and management might be a fruitful first step forward to understanding the causes behind the population changes, as between countries often different (and sometimes opposite) trends are found for the same species (Günther, 2003; van Roomen *et al.*, 2003, 2005), which might be related to differences in management between the Wadden Sea countries.

12.2.5.2 Sufficiently large undisturbed roosting areas

Despite the extensive national and international protection regimes now covering major parts of the Wadden Sea and the majority of roosting sites, the actual status regarding high tide roosts is not satisfactory (see also Koffijberg *et al.*, 2003), and has not made significant progress since the 1999 QSR. Potential conflicts relate especially to outdoor recreation and its disturbing impact. Some kinds of outdoor recreation already occur near a major part of the roosting sites (Figure 12.2.3) and tourism-related activities are reported to be expanding to late spring and early autumn, when many of the species for which declines have been observed recently stop over in the Wadden Sea to replenish body reserves. Hence, an increase of recreational pressure would be an extra constraint on these species.

Another aspect which deserves attention is the hunting of small mammals in the vicinity of roosting sites. Although major achievements have been made concerning phasing out hunting of migratory waterbirds in the Wadden Sea in the past decades and since the 1999 QSR, any hunting activity (either of birds or mammals) close to birds' roosting sites causes disturbance. Moreover, hunting affects natural flight distances, and increases the disturbing impact of other anthropogenic activities.

The impact of civil air traffic (including ultralight aircraft), military training activities and wind farms on roosting sites should be assessed in more detail. Civil air traffic has been largely regulated by trilateral standards now and is decreasing in volume (see chapter 2.5), but severe disturbance is still reported from a number of roosting sites. Military training activities have been partly phased out since the 1999 QSR (*e.g.* Terschelling NL) and occur only at a few sites, but one of these (Vliehors at Vlieland) ranks among the most important high tide roosts in the entire Wadden Sea, presenting a continued conflict situation.

The establishment of wind farms in the Wadden Sea Cooperation Area is currently largely regulated, but conflicts may arise, especially when planning wind farms in inland areas close to the seawall. These areas, which for some species are important roosting sites, have not always been included within the boundaries of protected areas. Especially in the Dutch Wadden Sea, all important waterbird concentrations and roosting sites behind the seawall have not been taken into account with the designation of Natura 2000 areas (see Koffijberg *et al.*, 2003).

12.2.5.3 Sufficiently large undisturbed moulting areas

The Wadden Sea supports important concentrations of moulting common shelduck, common eider and common scoter. Since the 1999 QSR, the knowledge of the issue of undisturbed moulting sites has improved. The three species considered differ with respect to their moulting period, distribution and moulting behavior. The moulting sites for common shelduck, concentrated in one area in the southern Schleswig-Holstein Wadden Sea, are probably sufficiently protected under the current protection regimes (National Park law and mandatory regulations). Monitoring covers both numbers of shelduck and sources of disturbance. In The Netherlands, where large moulting flocks were known in the past and have been re-discovered recently (Leopold, 2003) more information is needed on present-day moulting shelduck. The moulting distribution of the common eider is well known in the German and Danish Wadden Sea. Again, no data is available from The Netherlands. Since the decrease in numbers in the North-Frisian part of the Wadden Sea coincided with an increase in adjacent areas, it is possible that there has been a shift from the northern moulting areas towards more western parts of the Wadden Sea, and this should be investigated. While some of the moulting sites are sufficiently undisturbed and protected by regulations, potential sites in the East-Frisian Wadden Sea between Juist and Wangerooge are not used and it is assumed that the disturbance level, especially from recreational activities, is too high.

For the common scoter, so far, no realistic estimate of the total moulting population in the Wadden Sea area exists. Recently, in Schleswig-Holstein and Niedersachsen, new offshore counts have been organized in order to collect data with regard to proposed marine wind farms. However, several open questions with regard to common scoter population biology, feeding and moulting behavior and spatial and temporal distribution patterns still exist. Scoters seem to be very susceptible to human disturbance by ships or planes. To propose 'moulting reserves' for scoters, it would be helpful to know their flight distances, which can only be evaluated by an experimental approach. This is also urgent in relation to the planning of marine wind farms plus the associated ship traffic, which can potentially affect the distribution and activity of common scoters at sea during the moulting season (*e.g.* Garthe and Hüppop, 2004). An evaluation of suggested protection regimes was recently conducted for the German Exclusive Economic Zone of the North Sea (Garthe, 2003). A further assessment with regard to undisturbed moulting sites within and outside the Wadden Sea is needed.

12.2.5.4 Favorable food availability for herbivores

Of the three true herbivore aquatic bird species in the Wadden Sea, the dark-bellied brent goose and Eurasian wigeon are decreasing, and the barnacle goose is increasing. For none of these species, however, does food seem to be the sole or even the main factor causing these trends. With regard to the changes in goose populations, salt marsh management and the availability of alternative feeding sites has been an issue of discussion, for example, in the Leybucht in Niedersachsen (1999 QSR; Bergmann and Borbach-Jaene, 2001; Lutz *et al.*, 2003). A debate exists as to whether salt marshes should be managed in such a way that they can support maximum numbers of geese in order to reduce feeding in agricultural areas. However, when considering the high goose numbers and the naturally lower quality and quantity of food on salt marshes in autumn and winter (as compared to fertilized grassland), such a management scenario - working long-term against sharp gradients of habitat quality - would not solve the conflict between farmers and goose grazing since, at least in winter, fertilized grassland will remain the more attractive food resource. Moreover, trilateral targets concerning salt marsh management, which are also in line with the EC Habitats Directive, do not recommend such a species directed management, but aim to both increase the area of natural salt marshes, and provide favorable conditions for (all) migratory and breeding birds. Since both 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. Such a flyway management plan was recently put forward for dark-bellied brent geese by the African Eurasian Waterbird Agreement (AEWA) (van Nugteren, 1997), but has not yet been endorsed by the governments involved. In the coming years, further expansion of feeding areas in the Wadden Sea and its immediate surroundings, *e.g.* agricultural areas along the mainland coast and polders at the islands, is likely for barnacle geese and potential conflicts with farmers might therefore increase (Koffijberg and Günther, 2005). Here, solutions regarding special goose management schemes (Laursen, 2002) are to be developed, aiming at a satisfactory co-existence of farmers and geese. Experiments in The Netherlands have shown that such an approach might also encourage public awareness and stimulate guidance for visitors in order to reduce general pattern of disturbance (Ebbinge *et al.*, 2003).

12.2.5.5 Favorable food availability for benthivores

One of the most alarming issues concerning migratory waterbirds in the Wadden Sea has been the decline in many important species for which the Wadden Sea provides an indispensable stepping stone during migration and for which a major part of the total flyway population migrates through the Wadden Sea. The downward trends observed in many species are new since the 1999 QSR. For several species, notably the common eider and Eurasian oystercatcher, the recent EVA II project in The Netherlands provided evidence that the downward trends are related to deteriorating food stocks of blue mussels and cockles, this being due to both fisheries and natural conditions (weather, reproduction rates in bivalves), especially in the Dutch Wadden Sea. In addition, Scheiffarth and Frank (2005) indicated a Wadden-Sea wide conflict between birds (*e.g.* the common eider and Eurasian oystercatcher) and mussel fisheries. In the Danish Wadden Sea, mussel fisheries had been already restricted in the 1980s, after additional mortality had occurred among several waterbirds. In the Dutch Wadden Sea, in the late 1990s, licenses for shellfish (cockle) fisheries became subject to designation of closed areas and limitation of harvestable biomass in order to prevent overexploitation. However, these measures were not able to stop the decline in waterbird populations. In June 2004, the Dutch government decided to phase out mechanical cockle fisheries from 2005 onwards, and to aim at the development of sustainable blue mussel fisheries in the next decade. In September 2004, licenses for mechanical cockle fisheries were withdrawn completely and a complete cessation of the mechanical cockle fisheries was decided upon starting 1st January 2005. In the Dutch Wadden Sea, this is an important step towards the target of a favorable food availability for birds. Concerning the development of sustainable blue mussel fisheries, however, monitoring and scientific investigations should be carried out to be able to enhance proper management and evaluate the policy decisions taken. Similar assessments should also be made if other countries decide to expand shellfish fisheries in their territory. This implies that monitoring of mussel parameters in the entire Wadden Sea should be continued to be able to assess available food stocks for benthic feeders and to understand the underlying causes of changes in bird populations. Commercial landings of mussels provide only indirect evidence of the amount of mussels available for the birds, because most mussels landed for human consumption are already too large for the birds. Mussels fished for cultivation on subtidal culture lots (seed mussels), however, are of an appropriate size for the birds (Scheiffarth and Frank, 2005).

12.2.5.6 Natural flight distances

Natural flight distances are an important issue for several species (*e.g.* moulting common scoter, roosting Eurasian curlew), species-groups (seabirds, roosting birds, quarry species) and relate to a variety of human activities (hunting, marine wind farms, air traffic, outdoor recreation). Our knowledge, however, of flight distances, whether natural or disturbance induced, is rather limited for most species. Habituation may occur, and proper management measures are an issue of concern. Little is known of the flight distance of the common scoter or common eider with regard, for example, to the offshore wind farm developments and the associated ship traffic. There is also a need for better information on most roosting wader species in order to determine the key factors for flight distances to be used for better management of high-tide roosting sites with regard to tourists, zoning regulations, inland wind farms and other industrial and infrastructural developments. Experimental designed studies might be necessary in order to obtain essential data on this issue.

The study of the Eurasian curlew and the changes of hunting regime in Denmark have demonstrated that a rather minor change in hunting practice (the reduction of the period of open season) can considerably influence population dynamics of a species, whereas a seemingly major change, such as a hunting ban in a large area, later had less pronounced effects in this specific case. Curlews can now distribute according to the ecological conditions in the Danish Wadden Sea. In other areas, flight distances of geese have decreased as a consequence of both limitation of hunting and wise management of tourism. This development is an achievement complying with the target of natural flight distances

12.2.6 Recommendations

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

12.2.6.1 Sufficiently large undisturbed roosting and moulting areas

Management

- Further develop spatial and temporal zoning of recreational activities as well as a convincing visitor information system in order to reduce conflicts between roosting birds and recreational activities. In addition, more information is needed concerning natural flight distances, which is necessary to manage public access to areas in vicinity of roosting sites;
- Regulate hunting of small mammals (*e.g.* hare, rabbit) through trilateral management decisions in order to effectively reduce anthropogenic disturbance of roosting sites in salt marshes or inland during high tide;
- Assess the impact of civil air traffic (notably ultra-light aircraft) and introduce regulations at sites where severe disturbance is still reported, and also assess the remaining military training activities at important roosts (*e.g.* Vliehors at Vlieland, NL) and investigate impact of wind farms, especially for species other than geese;
- Provide sufficient protection measures for those sites that are part of the network of high tide roosts in the Wadden Sea but have been excluded from SPA designations. This especially applies to The Netherlands, where important inland roosts at agricultural sites behind the seawall are not fully subject to protection;
- Evaluate the potential disturbance from (offshore) marine wind farms and associated activities, with special attention for offshore-moulting common scoters.

Monitoring (TMAP) and research

- Start trilateral surveys of moulting concentrations of common shelduck, common eider and common scoter in the entire Wadden Sea, preferably by coordinated trilateral aerial surveys during early autumn, conducted as part of the JMMB monitoring program within the TMAP framework;
- Continue assessments of current status (numbers, distribution, threats) of moulting sites and develop conservation measures where necessary;
- Investigate macrozoobenthos communities in the offshore areas to assess factors determining the distribution of moulting common scoter.

12.2.6.2 Favorable food availability

Management

- Carefully evaluate the changes in the extent and methods of shellfish-fisheries, especially with regard to 'favorable food availability' for shellfish-eating birds';
- Monitor the remaining shellfish-fisheries (incl. fishing of seed mussels) and investigate their impact on food availability for birds;
- Encourage management on a flyway level for the barnacle goose and dark-bellied brent goose by including countries outside the Wadden Sea when developing further management plans;
- Seek solutions for the co-existence of farmers and geese through balanced management schemes, especially in agricultural feeding areas adjacent to salt marshes. This would also be beneficial to the target of natural flight distances (see below).

Monitoring (TMAP) and research

- Include parameters for 'benthos mass' and 'benthos quality' in the TMAP and evaluate current research programs on the macrozoobenthic communities with regard to assessments of available food stocks for shellfish-eating birds. This will enhance the possibilities to investigate backgrounds and causes for overall population changes in waterbirds observed in the Wadden Sea;
- Assess causal relationships between the occurrence of waterbirds and the availability of food stocks, preferably by experimental studies and modeling, in order to understand the processes involved in changes in waterbird numbers;
- Investigate trends in the different Wadden Sea countries in more detail and relate them to differences in policies and management in order to obtain insight into potential management-related causes behind the observed population changes;
- Assess possible changes in the distribution of geese caused by changes in salt marsh management using an analysis of re-sightings of individually marked birds.

12.2.6.3 Natural flight distances

- Investigate natural flight distances of birds in different situations (*e.g.* roosting, moulting, hunting and non-hunting areas, areas with different recreational pressure), preferably by experimental designed projects, with the aim of providing information to be applied for better protection of roosting and moulting sites.

Ringing of common eider (Photo: G. Nehls).

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