

Wadden Sea Board

**WSB 16
9-10 March 2016
Leeuwarden**



Agenda Item:	5.2
Subject:	Breeding Bird Action Plan
Document No.	WSB 16/5.2/2
Date:	2 March 2016
Submitted by:	Koffijberg/JMBB

Proposal: The meeting is invited to adopt the report

Breeding birds in trouble: a framework for an action plan in the Wadden Sea

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18 February 2016

Status:

3rd draft after consultation within TG-MM 14

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Summary

Data from the bird monitoring schemes within TMAP have shown that breeding birds in the Wadden Sea are generally not doing well at the moment. Recent results show that 18 out of 29 monitored bird species are in decline. Among them are species for which the Wadden Sea hosts an important share of the flyway population, e.g. Redshank, Oystercatcher and Avocet. In the group of species showing "steady" declines, many breeding birds of coastal grasslands are found, for instance Lapwing, Black-tailed Godwit, Common Snipe and Ruff. Common Snipe, Dunlin and Ruff are on the brink of extinction as breeding birds. Compared to previous assessments in Quality Status Reports, the number of species showing negative trends has further increased recently. Moreover, the rate of decrease has accelerated in several species, indicating breeding conditions are getting worse.

Poor breeding success has been identified as an important driver for the declining populations. Especially in species like Oystercatcher, Avocet and Arctic Tern, there is a clear association between low breeding success, the general decline in numbers and the recent acceleration in the rate of decline. Causes for failure are not always known in detail and also inter-related, but predation risk and flooding were among the most frequent causes observed during monitoring of breeding success in 2009-2012. Other causes include starvation and unfavourable weather, locally also trampling by livestock-grazing. Predation especially occurs along the mainland coast, where mammalian predators like Red Fox and Beech marten (locally also invasive species like Mink and Raccoon Dog) are more abundant than on islands. At some salt marshes which have a gradient from high to low salt marsh from the dike to the sea, breeding birds see themselves faced with a dilemma: breeding closer to the dike is likely to increase predation risk, whereas breeding close to the edge of salt marshes increases the risk of flooding. An aspect that was not well assessed by the monitoring scheme, is the role of food limitations. Especially in colony-breeding birds (incl. Avocet), it was observed that several species face problems during the chick-rearing period and not so much in the incubation period, which is an indication that food resources might be an important constraint. Contaminants in bird eggs are currently assumed not to have an impact on breeding success of coastal breeding birds.

In the past decades, several initiatives have been taken to improve breeding conditions for breeding birds or implement compensation measures in order to compensate for habitat loss. However, they often are treated as stand-alone projects, lack trilateral coordination as well as a wider perspective. This report aims to provide a framework for action, in order to minimise the different adverse factors causing low breeding success, in order to make populations more robust for 'natural' extreme events like flooding (which cannot be managed easily as it is part of global changes). Specific measures include habitat restoration (re-wetting of salt marshes or coastal grasslands, creating more dynamics in dune areas or embanked salt marshes), establishing new and well-managed breeding sites behind the seawall, salt marsh management with livestock grazing (by manners that do not have a negative impact on breeding birds), predation management (mainly aiming to make habitat less attractive or accessible to predators, incl. predator control on islands which are naturally free of mammalian predators), reduction of artificial barrier structures and visitor management. For each of the aspects recommendations for trilateral guidance and routines, as well as research questions for further research are given.

1. Introduction and backgrounds

The Wadden Sea supports large numbers of breeding and migratory birds. Its global importance as an ecosystem has been recognised in several international conventions and treaties, like the Ramsar Convention and the EU Bird Directive. In 2009 it became also listed as a UNESCO World Heritage Site. In addition, several breeding birds in the Wadden Sea are listed on national or international Red Lists (e.g. European Red List of Birds, BirdLife International 2015) or qualifying species for implementation of Natura 2000. Recent analyses of monitoring data derived from the Trilateral Monitoring and Assessment Programme (TMAP) have shown that especially breeding birds in the Wadden Sea have increasingly suffered losses in the past decade. The latest update on trends even shows that nearly 60 % of the monitored species are declining (Koffijberg *et al.* 2015). These downward trends also affect the number of migratory birds in some species, as TMAP-data show for the Wadden Sea (Blew *et al.* 2015), and international counts carried out within the Wadden Sea Flyway Initiative point out for the entire flyway (van Roomen *et al.* 2015). In several species, targets set in the Wadden Sea Plan and conservation objectives of the EU Bird Directive are not met. This has also raised attention during the last trilateral Wadden Sea conference in Tønder in 2014, where the governmental council meeting expressed its concern about the persistent decrease of breeding bird populations in the Wadden Sea and their low breeding success, for which the Wadden Sea Board was instructed to develop and implement a trilateral Action Plan on improving conditions for breeding birds.

This report provides the framework for such an Action Plan. In order to understand current developments in breeding birds in the Wadden Sea, it first gives a concise overview of the observed trends in numbers and breeding success in the Wadden Sea and provides available background information on causes which are thought to drive the negative trends. Finally, it presents an action framework for measures to halt the ongoing declines. For this purpose, the recent trend updates from TMAP-data were reviewed (Koffijberg *et al.* 2015a), as well as a recent report on the new parameter "breeding success" of breeding birds in the Wadden Sea (Thorup & Koffijberg 2015). The latter was added to TMAP in 2009-2010 and has proven important to assess the bottlenecks breeding birds are currently faced with. Also a short summary of results from TMAP parameter monitoring of contaminants in bird eggs is given (Becker & Dittmann 2009, Dittmann *et al.* 2011).

Furthermore, data from more detailed and long-term studies on breeding success and annual survival in the Dutch part of the Netherlands are reviewed (Koffijberg & Smit 2013, van der Jeugd *et al.* 2014, Koffijberg *et al.* 2015b). The framework for action is derived from the output of the workshop 'Breeding Birds in trouble', organised by the Wadden Sea Secretariat in Wilhelmshaven in April 2013. The results of this workshop dealt with management measures and provided an overview of potential threats to breeding birds at local levels. These are summarised in this report to set up a framework for action, aiming to transfer expert-knowledge to nature conservation agencies, site-managers and organisations involved in coastal protection, in order to improve breeding conditions for breeding birds in general terms.





2. TMAP breeding bird monitoring

Breeding birds in the international Wadden Sea have been monitored since 1991, after establishment of the trilateral TMAP-programme (national monitoring schemes even go back earlier). It uses standardised methods which have been largely harmonised throughout the international Wadden Sea. Fieldwork is carried out by a large group of dedicated volunteers, NGOs, and professional staff from nature conservation agencies and governmental organisations. Regular so-called Quality Assurance Meetings (QAM) are organised to evaluate counting methods or develop new counting techniques. Counting strategy anticipates on the distribution of species. They differ between rare and colonial breeding birds, often occurring in clusters at specific sites, and the more common, widely distributed breeding birds (Tab. 1). Trends in numbers are determined in close collaboration with Statistics Netherlands (CBS).

Since 2010, also breeding success has been monitored in a selection of 10 abundant species that are considered representative for the different food guilds and habitats within the Wadden Sea (Koffijberg et al. 2011). As many coastal breeding birds are long-lived species, breeding success was considered an important addition to TMAP in order to function as an early warning indicator, and to provide backgrounds for changes in numbers observed (Thyen et al. 1998). Since 1998, contaminants in bird eggs, i.e. mercury, PCBs and a number of organochlorides, have been investigated to keep track on the biological impact of these substances on breeding birds (Becker & Dittmann 2009). Trilateral sample species in this scheme are Oystercatcher and Common Tern.

Results of the monitoring data serve several purposes. Within the Wadden Sea, they provide data for the evaluation of the six targets of the Wadden Sea Plan (2010), frequently reviewed in the Quality Status Reports. On a European scale, large parts of the Wadden Sea have been designated as Natura 2000 site under the EU-Bird and Habitats Directive, aiming for a favourable conservation status. Furthermore, the Wadden Sea is subject to the EU Water Framework Directive (WFD) and the EU Marine Strategy Framework Directive (MSFD), which request a good ecological status / potential & good chemical status (WFD) or a good environmental status (MSFD). For the latter, biodiversity indicators have been developed which make use of bird abundance data (indicator B1) and data on breeding success to assess the status in biodiversity of the marine environment (indicator B3) (Cook et al. 2015). For contaminants in bird eggs, so-called Ecological Quality Objectives (EcoQOs) have been set up within the framework of the Oslo-Paris Convention (OSPAR, Dittmann et al. 2011). Besides, bird data are used on a national level, e.g. the indicator "species diversity and landscape quality" within the German biodiversity programme (Sukopp et al. 2010).

Table 1. Overview of bird monitoring carried out in the framework of TMAP. Details on the trilateral monitoring schemes are given by Becker et al. (2001), Koffijberg et al. (2015a) and Thorup & Koffijberg (2015).

	Numbers, distribution and trends		Breeding success	Contaminants in bird eggs
	since 1991		since 2010	since 1998
Species monitored	29 rare and colonial breeding bird species	8 common breeding bird species	Selection of 10 representative species	Selection of 2 representative species
				
Counting strategy	<ul style="list-style-type: none"> Total count annually 	<ul style="list-style-type: none"> Count in census areas annually Total count once every 5-6 years: 1991, 1996, 2001, 2006, 2012 	<ul style="list-style-type: none"> Sample sites annually 	<ul style="list-style-type: none"> Sample sites annually

3. Breeding birds in trouble?

3.1. Trends in numbers

Since its start in 1991, several assessments of trends in breeding numbers have been made, both for the purpose of the Quality Status Reports and for reports issued by the Joint Monitoring Group for Breeding Birds (JMBB). During the past decade, there has been a clear tendency that the number of decreasing species has become larger, whereas the number of species with increasing numbers has gone down (Fig. 1). Already during the QSR 2009, species with negative trends were prevailing (based on data collected in 1991-2006), and this position has become even more pronounced with the latest progress report of JMBB (based on data 1991-2011). This implicates that a growing number of breeding bird species has an unfavourable conservation status within the EU Bird- and Habitat Directive and does not meet the targets set in the Wadden Sea Plan.

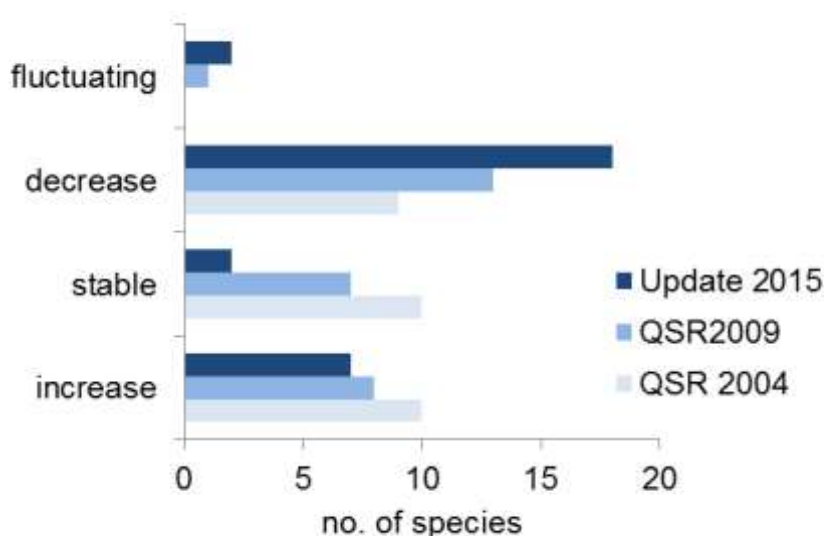
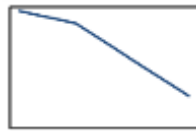
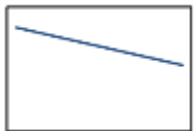

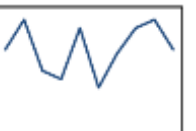
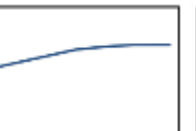
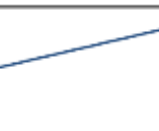


Figure 1. Summary of trends in breeding birds in the Wadden Sea, assessed during QSR 2004 (Essink *et al.* 2004), QSR 2009 (Marencic & de Vlas 2009) and the latest update of trends in 2015 (Koffijberg *et al.* 2015a).

The latest information on trends from June 2015 shows that 18 out of 29 monitored breeding bird species (62 %) are subject to downward trends. In six species, the annual rate of decline has even accelerated after 2002, suggesting (breeding) conditions in the Wadden Sea and/or wintering conditions are getting worse (Tab. 2). Among this group of species are some typical Wadden Sea breeders, for which the area also supports an important share of the flyway population, e.g. Redshank, Oystercatcher and Avocet. In the group of species showing "steady" declines, many breeding birds of coastal grasslands are found, for instance Lapwing, Black-tailed Godwit, Common Snipe and Ruff. Common Snipe, Dunlin and Ruff are on the brink of extinction as breeding birds, only having some small and local relict-populations.

Table 2. Summary of trends in breeding birds in the Wadden Sea in 1991-2011. Shown are six different trend models. For each model the species showing this trend is listed. Species for which the Wadden Sea supports >5% of the flyway population (see Koffijberg et al. 2006) are printed in bold.

Decrease, recently acceleration	Decrease	Stable	No sign. trend - fluctuating	Increase, recently levelling off	Increase
					
Common Gull ¹ Redshank Arctic Tern Eider Oystercatcher Avocet Hen Harrier	Black-headed Gull Curlew Common Tern Short-eared Owl Herring Gull Lapwing Kentish Plover ² Great Ringed Plover Black-tailed Godwit Common Snipe Dunlin Ruff	Sandwich Tern Little Tern	Red-breasted Merganser Gull-billed Tern	Mediterranean Gull Cormorant Spoonbill Lesser Black-backed Gull Shelduck	Great Black-backed Gull

¹ Common Gull: long term increasing trend has changed towards decrease after 2002

² Kentish Plover: long term decline has slowed off after 2002

For Common Gull, the long-term upward trend, reversed in a decrease after 2002. Species showing growing numbers are mainly some colonial breeding bird species (Shelduck being the only exception). For most of them, the rate of increase has slowed down after 2002. Only numbers of Great Black-backed Gull have shown similar increase rates over the entire period 1991-2011.

Only a minority of species show consistent trends in numbers throughout the Wadden Sea over the period 1991-2011. Among increasing species this is true for Great Cormorant, Spoonbill, Lesser Black-backed Gull and Great Black-backed Gull. On the contrary, in Oystercatcher, Great Ringed Plover, Black-tailed Godwit, Eurasian Curlew trends point downward in all relevant countries. Previous analyses have shown that in the western part of the Wadden Sea, more species are subject to negative trends than in the northern part, i.e. Schleswig-Holstein and Denmark (Koffijberg et al. 2006). Some species even show a clear overall gradient, e.g. Arctic Tern which declined in The Netherlands and in Niedersachsen and remained stable in the north. Table 3 shows all species that are an 'exception to the rule', i.e. their trend in one country differs (positively or negatively) from the other countries. Often it refers to species which have remained stable in one country, but declined in all other. Pronounced differences are especially observed in Common Gull (moderate decrease in The Netherlands, moderate to strong increases in other countries) and Kentish Plover (moderate

increase in Denmark, moderate to strong decreases in other countries). In Hen Harrier and Short-eared Owl, the 'better' situation in Niedersachsen mainly reflects the fact that the decline started later than in the Netherlands.

To what extent differences in environmental conditions or management can be identified as drivers between the different trends is not clear yet. A comparison of trends for an even more detailed, and ecological shaped division of the Wadden Sea leads to remarkable observations (Koffijberg et al. 2015a). For instance, Lapwing and Redshank show significant increases in the eastern part of the Dutch Wadden Sea, whereas declines or stable trends dominate in all surrounding regions. Even in species which are declining all over the Wadden Sea, marked exceptions occur, like stable Oystercatcher numbers in Estuaries from Eems-Dollard and Weser-Elbe. Determining these regional differences has only started recently. Further exploration of the data will perhaps provide clues for drivers causing numbers to go down.

Table 3. Comparison of trends in breeding birds in the Wadden Sea between the four countries. Listed are species that have a different trend compared to all other countries (period 1991-2011). Also given is an indication for the species involved (aggregated to + increase, = stable/fluctuating, - decrease).


Country	Species doing "better"	Species doing "worse"
The Netherlands	Lapwing (=)	Common Gull (-)
Niedersachsen/Hamburg	Hen Harrier (=) Short-eared Owl (=)	Shelduck (=)
Schleswig-Holstein	Avocet (=) Redshank (=) Black-headed Gull (=)	
Denmark	Kentish Plover (+)	





3.2. Breeding success

As a TMAP-parameter, breeding success was implemented in the Wadden Sea in 2009-2010. On a national scale however, data on breeding success were collected much earlier, e.g. specific projects in Niedersachsen (Common Tern, Herring Gull/Lesser Black-backed Gull) and the monitoring scheme on breeding success that started in the Dutch Wadden Sea in 2005 as part of management of shellfish fisheries.

Assessment of breeding success shows that especially Oystercatcher, Avocet and Artic Tern indeed have a very low breeding success, insufficient to maintain the population even at a stable level. All three species have shown an acceleration in the rate of decline recently (see Tab. 2), which is likely to be associated with the persistent low breeding success. Also Black-headed Gull, Lesser Black-backed Gull and Common Tern have an overall poor breeding success. Of these species, only Lesser Black-backed Gull has increased until recently, albeit the rate of increase has levelled-off.

Table 4. Assessment of breeding success in the Wadden Sea, as recorded by the TMAP parameter breeding success in 2009-2012 (after Thorup & Koffijberg 2015)

	WADDEN SEA	NL	DE-NDS	DE-SH	DK
Spoonbill					
Eider					
Oystercatcher - islands					
Oystercatcher - mainland					
Avocet - islands					
Avocet - mainland					
Black-headed Gull					
Lesser Black-backed Gull					
Herring Gull					
Sandwich Tern					
Common Tern					
Arctic Tern					

-  : Breeding success without doubt so low that reproduction does not compensate mortality
-  : Fairly low breeding success most or all years and sites, reproduction may not compensate mortality
-  : High or fairly high breeding success most or all years and sites
-  : Variable - some sites and years with high, some with low breeding success

When compared to the longer-term data from the breeding success monitoring in the Dutch Wadden Sea (2005-2013, Koffijberg et al. 2015b), most of the assessment in table 2 is confirmed. On a longer term, however, also Common Eider has a lower reproduction than needed for a stable population whereas recently Sandwich Terns has faced problems at its largest colony on the island of Griend. Moreover, trends in reproduction in the Dutch Wadden Sea show that in many species, breeding success has declined between 2005-2013, although only statistically significant in Spoonbill and Black-headed Gull. In Spoonbill, this is regarded as a response to the increased population growth, so-called density-dependence (Lok et al. 2009). Several studies have pointed out that decreasing trends in breeding success already started in the late 1990s or early 2000s, e.g. in Oystercatcher (van der Jeugd et al. 2014) and Common Tern (e.g. Dänhardt & Becker 2010) and thus are not a recent phenomenon. But due to the fact that coastal breeding birds are long-lived species, failed breeding will usually affect numbers with a delay of several years.

Van der Jeugd et al. (2014) reviewed demographic drivers of population changes in Wadden Sea birds, and concluded that for most breeding bird species poor breeding success was an important driver for declines observed in the past decades. This also applied to species which are not covered in the breeding success monitoring, such as Great Ringed Plover, Kentish Plover and Redshank. Only in few species, changes in annual survival played an important role in the decrease in numbers, e.g. in Black-headed Gull (1st year-survival) and Herring Gull. A species like Oystercatcher both experiences poor breeding success and lower annual survival rates, whereas in Eider condition of breeding females may limit the performance of the breeding population. Both Oystercatcher and Eider might also be affected by the situation in the Wadden Sea in winter. In most other species, it is likely that the low breeding success is caused by factors operating in the Wadden Sea during the breeding season.

3.3. Contaminants in bird eggs

Since 1998, contaminants in bird eggs have been monitored at 16 sample sites throughout the Wadden Sea. Especially in the 1960s, populations of several coastal breeding birds crashed due to accumulation of contaminants in the Wadden Sea. Today, levels of contaminants are thought to be below thresholds that affect breeding birds (Becker & Dittmann 2009). This is also confirmed by high nest success of Common Tern in the Elbe Estuary (Neufeld) and nest success of Oystercatcher in Delfzijl, two areas which are still hot spots regarding contaminants (Thorup & Koffijberg 2015). In the past decades, overall levels of contaminants have decreased and have remained at a stable (low) level since the 1990s (Becker & Dittmann 2009). Hot spots of concentrations of contaminants were identified in the estuary of the River Elbe and in the Eems-Dollard area. Moreover, Common Terns showed generally higher accumulations than Oystercatcher.

Recent data showed that especially in the area around Delfzijl increases in some compounds occurred after 2004, showing that contaminants are still well-present and new inputs of pollutants into the Wadden Sea still takes place. Also levels of dioxin-like PCB congeners in eggs are still elevated in some areas, and much higher than EU targets set for chicken eggs for human consumption. Even if levels of contaminants in general have decreased on a longer term, the accumulation of several compounds is still above the targets set in the Wadden Sea Plan and exceeds ECOQo objectives from OSPAR (Dittmann et al. 2011).

4. Backgrounds for observed trends

The TMAP-monitoring schemes for birds aim to assess the status of birds in the Wadden Sea and monitor changes in numbers and distribution. Hence, they do not always allow detailed identification of causes and backgrounds that have driven the observed changes in numbers or distribution (this aspect usually requests further detailed research). Only a comparison of trends between countries and regions (recently added to the trend analysis of breeding birds, see Koffijberg et al. 2015), and a combination with data from other parameters (e.g. vegetation data, Erb 2012, Maier 2014, Mandema et al. 2015) may provide clues for processes that have caused bird numbers to change. With the addition of the parameter breeding success, however, one of the driving demographic parameters has been added to the monitoring program (the other one being annual survival). During fieldwork for this parameter, also causes of failure are recorded.

For those species that had a very low breeding success in 2009-2012, predation (27 % of species/study sites) and flooding (22 %) were the most observed causes of failure (Thorup & Koffijberg 2015). Others were starvation and unfavourable weather. These findings are in line with the data from the Dutch Wadden Sea, which additionally also mention trampling of nests as a local problem (Koffijberg & Smit 2013, Koffijberg et al. 2015b). Thorup & Koffijberg (2015) also showed that, relatively speaking, predation is more an issue along the mainland coast than on islands, whereas flooding was relatively more important on the islands. The importance of predation along the mainland coast is due to the occurrence of mammalian predators like Red Fox and mustelids (locally also invasive species like Mink and Raccoon Dog), which do not occur on most islands. Indeed, the abandonment of large colonies of gulls and terns along the mainland coast of the Dutch Wadden Sea after 2000 is assumed to be a response to the high predation risk (Bos et al. 2015). Coastal breeding birds at some sites along the mainland coast find themselves in a dilemma: breeding closer to the seawall might protect them for flooding, but this comes with a higher predation risk (Cervencl et al. 2011), whereas those breeding sites close to edge of the salt marsh are more safe for predation, but likely to be flooded more often. In salt marsh areas where the lowest parts are situated close to the dike and the highest part on the fringe of the salt marsh (e.g. in Dithmarschen/Schleswig-Holstein) safest breeding sites may be well away from the dike. Flooding has long been ignored as an important issue, but has got more attention recently, since Van de Pol et al. (2010) showed its impact on Wadden Sea breeding birds.

The aspect of starvation, or lack of sufficient food resources, is not very clear from the results of the TMAP-monitoring, as it is far more difficult to prove as 'visible' impact like predation or flooding. From the available data, it is assumed to play a role in Eider and Oystercatcher (mainly in winter, affecting condition prior to breeding) and colony-breeding gulls and terns, perhaps also Avocet (Koffijberg & Smit 2013, van der Jeugd et al. 2014, Thorup & Koffijberg 2015). This is also suggested by the fact that colonial breeding birds (incl. Avocet) face most problems during the chick-rearing phase, when food provisioning is of prime importance. Several detailed population studies throughout the Wadden Sea have shown losses during the chick-rearing period by either starvation, or intra- and inter-specific predation (e.g. large gulls, Camphuysen 2013, Volmer et al. 2013).

Another factor that is not covered by the breeding success monitoring scheme is lack of undisturbed breeding sites. This has been thought to play an important role in beach-breeding species like Kentish Plover and Great Ringed-Plover (Tulp 1998, Schulz 1998), as well as Little Tern, but for these species breeding success is not monitored in the entire Wadden Sea within TMAP.

Finally, some factors are not independent and might be inter-related, e.g. climate change and its impact on environmental conditions that cause distribution of pelagic fish populations to shift, and hence affect food provisioning for terns (e.g. Dänhardt & Becker 2010).

For the framework of action, presented in the next chapter, it is important to consider the different scales on which the factors causing breeding failure operate. These include:

- Global causes: for instance sea level rise and climate change, causing more frequent extreme high water situations during the breeding season and flooding of breeding sites. Moreover, shifts in distribution of pelagic fish species, affected by climate conditions, and affecting food resources for terns;
- Regional causes: e.g. high (increased) predation risk and limitation of food stocks;
- Local causes: e.g. trampling of nests by livestock grazing, local disturbance of nest sites (e.g. beaches) or general agricultural activities (e.g. fertilization and intensive agricultural practice) in coastal grasslands, mainly behind the dikes.

5. Framework for action

5.1. Overall perspectives for action

Coastal breeding birds are generally well-adapted to dynamic environments, and periodic natural (extreme) events like flooding or predation. Most of them are long-lived species that usually cope well with occasional breeding failures. Moreover, they often easily anticipate on new breeding habitat (or feeding opportunities) and in some species breeding strategy includes fast replacement clutches when first clutches get lost. However, the situation among breeding birds in the Wadden Sea now seems to have reached a stage where problems have accumulated and operate at different scales. Hence, low breeding success, or even breeding failure, has become a rule in many species, causing numbers to go down (see previous chapters).

The strategy for action described below aims to improve overall breeding conditions for breeding birds in the Wadden Sea, but will achieve no full coverage of all aspects. Some issues will be very difficult to tackle directly, e.g. the increased flooding risk that has been observed in the past decade. The overall aim is, however, to minimise the different adverse factors causing low breeding success, in order to make populations more robust for 'natural' extreme events like flooding. Hence, focus of measures is put on practical measures that can be carried out within existing site- and habitat management, creation of new habitat and providing baseline breeding conditions for breeding birds.

5.2. Specific management measures

During the workshop 'Breeding Birds in trouble', organised by the Wadden Sea Secretariat in Wilhelmshaven in April 2013, several measures were discussed that could help to improve breeding conditions of breeding birds in the Wadden Sea.

Habitat restoration (local)

- Restoration of salt marshes, i.e. allowing a more natural water regime and high vegetation diversity, by closing artificial drainage works. Moreover, salt marshes should be re-wetted to provide more habitat dynamics. This is also assumed to slow down settlement of mammalian predators (Langgemach & Bellebaum 2005).
- Opening of summer dikes or relocation of dikes, as done e.g. on the island of Langeoog, along the Wurster Küste in Niedersachsen and in Friesland, The Netherlands, aims to provide more habitat dynamics and increase the area of salt marshes. Examples from Niedersachsen show that opened summer polders can be successfully recolonised by characteristic coastal breeding birds and/or let increase their numbers (e.g. Redshank). However, caution should be taken if the potential de-banked areas support high densities of breeding birds (e.g. Friesland coast, Bos et al. 2015). Furthermore, risk of flooding might increase when summer dikes are removed.
- Restoration of dune areas, as done e.g. on the islands of Terschelling and Schiermonnikoog in The Netherlands. Removal of protecting sand dikes, and allowing wash-overs to occur. These measures generally provide more diverse habitat structures for breeding birds, especially species like Great Ringed Plover, Kentish Plover and Little Tern.
- Restoration of coastal grasslands, both along the mainland coast and on the islands (polders). Re-wetting coastal grasslands, along with a low-intensity agriculture, as e.g. currently planned on the island of Terschelling in The Netherlands, is regarded an important measure to improve breeding conditions (and breeding success) in coastal waders (i.e. meadow birds).

- Creation of inland breeding sites, like Utopia on the island of Texel, Klutenplas, Ruidhorn and Polder Breebaart along the coast of Groningen/The Netherlands and clay pits along the Jadebusen in Niedersachsen and Sneum Digesø in Denmark. Coastal wetlands in Schleswig-Holstein and Denmark function in the same way but have a different history. Such breeding sites are protected against flooding, but often they are susceptible to predation (unless islands are created as breeding site). For instance in the Klutenplas, successful nesting in Avocet is only possible by setting up a strong electrical fence (de Boer 2014). One other aspect of creating new breeding sites is that they should be situated in areas where sufficient food is assumed to be available during the chick-rearing period. For species like Avocet, this means that inland breeding sites only work when a salt marsh area is situated opposite of it. For colonial breeding birds, suitable feeding sites should be well within reach. Creation of new breeding sites inland should always be accompanied by ongoing management of vegetation (see below).
- Implementation of meadow-bird friendly farming practices in coastal grasslands (mainland as well as islands), avoiding losses by mowing and providing feeding opportunities for chicks.

Guidance of these issues can be provided by analysis of existing trilateral breeding bird data and salt marsh data (showing which areas support high densities in what species, and appointing sites of special value in order to concentrate measures at the best sites). Moreover, more information about the link between breeding sites and feeding sites is needed, in order to be able to plan potential new breeding sites in the right place. Also, best practice experiences in management should be more often exchanged among site managers or via regional experts.

Habitat management (local)

- Management with livestock-grazing. Especially grazing management of salt marshes has been subject to ongoing discussions within the trilateral cooperation. Denmark and The Netherlands generally allow more livestock-grazing on salt marshes than Schleswig-Holstein and Niedersachsen. Since different breeding birds have different habitat requirements, some species benefit from (low intensity) grazing (e.g. Lapwing, Avocet) whereas other species prefer tall, ungrazed vegetation (e.g. Redshank). Livestock grazing, however, poses the risk of nest trampling (e.g. Mandema et al. 2013, Sharps et al. 2015). Trampling rates of horse-grazing are larger than with cattle (Mandema et al. 2013), but horse-grazing is still common practice on salt marshes of the mainland coast of Friesland and Groningen in The Netherlands, which are observed to cause losses among breeding birds. Reducing the conflict between livestock-grazing and breeding birds might be done by introduction of grazers after the main breeding season has advanced (but this should be reviewed against targets for vegetation).
- Creation of new breeding sites inland (see above) should always be accompanied by ongoing management of vegetation (mowing or other measures to prevent expansion of vegetation), as most of the sites will become less attractive in time due to vegetation succession. If no action will be undertaken, coastal breeding birds will desert the site, within a few years as they usually prefer sparsely vegetated sites to breed.

Several studies have addressed the impact of livestock-grazing and trampling risk of breeding birds. Less is known about the impact of large numbers of Barnacle Geese that stay in the

Wadden Sea well into May. Earlier, it has been hypothesized that they might have an impact on habitat structure for species like Redshank (Esselink 2000). In this context, the large decline of Redshank in the Dollard area is intriguing (see Koffijberg et al. 2015). Studies in the interior parts in the Netherlands did not show significant impact of geese on breeding birds (e.g. Kleijn & Bos 2010), but the situation on salt marshes in the Wadden Sea might be different, and we recommend to initiate (experimental) studies to get insight in the interaction between goose grazing and breeding birds. As a first step, data from migratory bird counts and breeding bird counts could be combined to search for potential conflict areas. This also has a link to goose management issues, discussed e.g. in Wadden Sea Forum.

Predation management (regional)

- Predation management should aim to make overall predation risk lower, not only by just taking away predators (i.e. predator control), but especially by making settlement and living conditions more difficult (see also habitat restoration). Predator control has been carried out at many sites along the Wadden Sea coast for Red Fox, but this has not reduced predation risk for breeding birds. Predation control on islands will be generally more successful, as shown with Ferret and Hedgehog on the islands of Norderney and Borkum, Niedersachsen.
- Regarding predation by mammalian predators, islands are an important, natural predator-free environment for coastal breeding birds. Hence, opportunities for predators to have access to islands should be reduced or minimised. Recent improvement of the barrier dam to the Hallig Oland in Schleswig-Holstein (and in conjunction with that, Hallig Langeness) and to Hallig Nordstrandischmoor, has recently lead to increased occurrence of Red Fox and Beech marten, causing local breeding bird populations to fail breeding. Keeping islands free of predators is an important prerequisite to maintain the special status of islands to coastal breeding birds. On islands, predator control will be more effective than on the mainland coast, where vacant territories of predators will be filled-in soon by continuous dispersion from the areas behind the seawall.
- Locally, fences (colonies) or cages (Ringed Plover) might protect nests from predation, as carried out e.g. in the large tern colony at Neufelder Koog, Schleswig-Holstein and nests for Ringed Plover and Kentish Plover along the coast of Niedersachsen.

Given the important role of predation in the overall low breeding success along the mainland coast and little knowledge about predators in general, we recommend to set-up a joint (trilateral) predation management plan, in which also experiences from e.g. the Baltic Sea and the British Isles (Scotland) are taken into account as well. A start-up for such a plan could be a trilateral workshop, addressing the various issues of predation in the Wadden Sea countries and abroad, including living conditions for predators on e.g. salt marshes (e.g. role of vegetation cover). This also would allow an exchange of best-practice experiences. Moreover, it would give insight in gaps in knowledge, and eventually address research questions that can support predation management. Behaviour of predators occurring in the Wadden Sea is still only little known.

Reduction of barrier effects and artificial structures (local)

- During the first years of breeding success monitoring, it was shown that locally, barriers like stone walls or groynes in the salt marshes might pose a huge barrier for chicks to get access to feeding sides, or anticipate on the tide (examples groynes at island of Norderney, Hallig Süderoog, Neufelder Koog). Low stone barriers put up as

coastal defence do not have a negative impact on movements of chicks, but offer some protection of exceptional high tides (Vollmer et al. 2015). In The Netherlands, it was shown earlier, that pipes used for sand supply created a barrier for Avocet families moving from inland breeding sites to the mud flats. The same also applied to ditches having a wooden or concrete structure to prevent erosion of the slope of the ditch (chicks enter such ditches, but are not able to get out). Locally, also barbed wire fences are a problem for birds moving between breeding and feeding sites.

Visitor management (regional)

- Reduce visitor pressure for beach-breeding bird species like Great Ringed Plover, Kentish Plover and Little Tern, by providing visitor-free areas at the most likely breeding sites. This is already common practice at several islands and beach areas (e.g. St. Peter-Ording), but not at all breeding sites, and not always effective (often surveillance of such sites is lacking, as well as maintenance of the signal posts and fences). This issue has even become more important as new recreational activities as kite-surfing and beach-buggies have put new constraints on use of beaches. In the early 2000s, a trilateral project was run to tackle the issues around beach-breeding birds, but this project has ceased.
- Implement zoning and surveillance to segregate sites used by tourists and sites kept visitor-free for undisturbed breeding. This strategy is used at several sites within the Wadden Sea (zoning e.g. is part of the national parks in the German Wadden Sea), but surveillance often is necessary to avoid such sites being visited. In the Dutch and Danish Wadden Sea, a comprehensive zoning system does not occur.

5.3. Other issues

Two aspects have not been tackled in chapter 5.2., i.e. food provisioning and flooding risk. Food provisioning is assumed to play a key-role in the current poor breeding performance of a number of breeding birds (see chapter 4), but there is a general lack of knowledge about the precise mechanisms and the causes. Earlier, large-scale and commercial shellfish-fisheries have been known to have significant impact on (breeding) birds in the Wadden Sea (e.g. Ens et al. 2004, Laursen et al. 2009). Large-scale commercial fishery activities have now been restricted, but fisheries still take place at smaller scale, or with different methods. The current impact of fishery activities on breeding birds is not well known, but still might put constraints on food resources for breeding birds like Eider and Oystercatcher. Moreover, climate change has altered the way fish populations utilise the Wadden Sea (e.g. Dänhardt & Becker 2010), and affect food availability of terns.

Besides, for species relying on benthos on the mudflats or in the gullies in salt marshes, the impact of food stocks on their breeding performance is not known at all. For Avocet, it has been hypothesized that food might be a limiting factor in the Dutch Wadden Sea, and this will be subject of further research in 2016.

Increased flooding risk has been a major issue in the Wadden Sea recently, since Van de Pol et al. (2010) revealed flooding being detrimental to breeding birds breeding at exposed sites in the Wadden Sea. In the past decade, the occurrence of onshore winds, in combination with spring tide (and general sea level rise) has increased flooding risk during the breeding season, causing frequent losses among nests and drowning of chicks. Extensive research on this issue has been carried out in the Dutch Wadden Sea, also in conjunction with soil subsidence caused by gas exploitation (e.g. Ens et al. 2008). Flooding risk is not an issue to be managed easily, as it is caused by global mechanisms

affecting climate and sea level. Measures to minimise impact of flooding are e.g. creation of safe breeding sites behind the seawall (see above). Besides, removal of summer dikes or relocation of dikes should be reviewed against the risk of flooding. Improving habitat quality by allowing more dynamics is generally welcomed in the Wadden Sea, but locally it might lead to losses of important breeding sites (as shown for salt marshes of Friesland, Bos et al. 2015). Improving protection against flooding, by establishing dams or improving coastal protection is not beneficial to breeding birds at all, as it will come with major losses of habitat quality.

6. Recommendations for implementation

6.1. National organisation

In order to implement the framework for action presented in this report, it is recommended that the national authorities responsible for management issues in the Wadden Sea initiate measures and coordinate initiatives that will follow from the recommendations given in chapter 5. For Denmark, Schleswig-Holstein and Niedersachsen/Hamburg, this is rather straightforward, as only few agencies are primarily responsible for implementation. In the Netherlands, responsibilities are more scattered over different organisations, and more co-ordination effort will be necessary to be able to implement actions successfully (Tab. 5).

Table 5. *National organisations responsible for management of Wadden Sea breeding birds.*

Denmark	Schleswig-Holstein	Niedersachsen/Hamburg	The Netherlands
Naturstyrelsen	Nationalparkverwaltung Schleswig-Holsteinisches Wattenmeer im Landesbetrieb für Küstenschutz, Nationalpark und Meeresschutz Landesamt für Landwirtschaft, Umwelt und Ländliche Räume	Nationalparkverwaltung Niedersächsisches Wattenmeer Nationalparkverwaltung Hamburgisches Wattenmeer	-Ministerie van Economische zaken -Provincie Noord- Holland -Provincie Friesland -Provincie Groningen -Landschap Noord- Holland -It Fryske Gea -Groninger Landschap -Staatsbosbeheer -Natuur- monumenten

6.2. Guidance for implementation and priority-setting

As shown previously in chapter 4 and 5, causes for breeding failure and actions necessary to improve the overall conditions for breeding birds in the Wadden Sea differ widely between species and between regions. Moreover, they can be separated according to "global" causes, for instance increased flooding risk or changes in food abundance as a result of e.g. climate change and reduced nutrient input, and specific, local or regional causes. The framework for action in chapter 5 mainly focuses on the latter aspect, as these eventually can be tackled by implementation of specific measures, whereas the global causes will not be solved in the Wadden Sea, and partly (e.g. reduced input of nutrients or reduced discards in fisheries) are also welcomed as part of a recovery towards a more natural ecosystem. Hence, a strategy for action aims to improve overall breeding conditions for breeding birds in the Wadden Sea, in order to make populations more robust for 'natural' extreme events like flooding. Table 6 gives an overview for each species, which kind of measures are needed to improve breeding conditions, and in which regions (measures refer to those listed in chapter 5, see also explanation below table). The importance of regions for each species has been derived from the results of the total counts in 2006 and 2012. For actions also mainland- breeding sites and island-breeding sites have been distinguished, as these differ with respect to the issue of predation risk. The aim of the overview given in table 6 is to give guidance what kind of measures would potentially be most successful for a species (given the current state of knowledge), and what would be priority regions to implement them. Hence, this overview aims to help in the priority-setting of measures and improve coordination among the agencies and organisations involved in implementation and execution of measures.

Explanation Table 6:

Measures appropriate: listed are all species that are monitored within the TMAP-breeding bird monitoring, along with an indication if measures are not applicable (N) or appropriate to improve breeding conditions. Focus species for measures (marked Y) are those which are in decline, and are known to face problems during the breeding season.

Geographical scope: listed are all five countries (or federal states) within the Wadden Sea. Marked are those countries which are relevant for the species concerned, based on results from the total counts in 2006 and 2012 (i.e. share of the population breeding in a particular country). Hence, measures for these species should be primarily carried out in these countries to be most effective in terms of numbers involved.

Islands or mainland: as measures might differ between islands and mainland (especially regarding predation management), and some species inhabit specifically one or both, it is stated where measures should preferably be carried out

Measures: derived from framework for action in chapter 5. Based on known causes for breeding failure and other data, the most appropriate measures for each species are proposed. Habitat restoration does not include creation of new habitat, as currently planned e.g. in the Dutch Wadden Sea for colonial breeding birds (terns). In such cases, it is important that new habitat is created at sites which are known or expected to provide enough food for successful breeding. This also applies for creation of new coastal wetlands, which – when created without a salt marsh area in front of the dike- will usually be of little importance for a species like Avocet. Habitat management also includes habitat measures and adaption of agricultural practices in agricultural areas behind the seawall in the Wadden Sea Area. Predation management includes both habitat management and predator control. Both focus on mammalian predators like Red Fox and mustelids.

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