Breeding success in the Wadden Sea 2009-2012

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A review

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Summary

Acknowledging that "breeding success" would be a crucial parameter to collect in order to increase the understanding of important processes in breeding birds the Wadden Sea, a TMAP-breeding success monitoring programme was initiated in 2009 and fully implemented in 2010. It was partly based on experiences collected during a pilot project in the 1990s. The breeding success monitoring programme is focusing on the number of fledged young per breeding pair in a number of study plots. Ten characteristic breeding species in the Wadden Sea were selected for the programme, representing different habitats and feeding strategies: Spoonbill, Eider, Oystercatcher, Avocet, Black-headed Gull, Lesser Black-backed Gull, Herring Gull, Sandwich Tern, Common Tern and Arctic Tern. Although not achieving the aimed full coverage of monitoring breeding success of the ten selected species in each of 15 designated subregions of the Wadden Sea, breeding success was assessed in a total of 273 species-sites-years in 2009-2012, and additionally the hatching success was assessed in 161 species-sites-years, with a large overlap with the breeding success assessments. Hence, they provide an overall good sample of breeding success within the international Wadden Sea.

The monitoring of breeding success in the Wadden Sea 2009-2012 provided a picture of that breeding success of the ten selected species, despite being quite variable, was insufficient to keep populations in balance in several of the species. In three of the species – Oystercatcher, Avocet and Arctic Tern – the reproduction was so poor, that they at present seem to have no chance to reproduce themselves, and in an additional four species – Black-headed Gull, Lesser Black-backed Gull, Herring Gull and Common Tern – the found breeding success values are so fairly low that some or all of these species may also not reproduce sufficiently to balance mortality. When comparing breeding success with the recent trends in the ten species, it can be seen that the three species with the poorest reproduction all had a negative population trend recently. Low breeding success is very likely an important driver of the observed population declines. Also two of the four species with fairly low breeding success values in this programme – Herring Gull and Common Tern – declined recently, and in these species as well low breeding success may be an important, or at least a contributing driver of the declines, although a population study found the survival to be the most crucial limitation in the Herring Gull. Also Black-headed Gull is faced with a lower annual survival. These trilateral findings are very similar to earlier assessments made for the Dutch section of the Wadden Sea.

For several species it was possible to identify the contribution of the hatching success to the breeding success. Generally, the species were performing better in the incubation period than in the chick-rearing phase. Predation and flooding, as a result of storm tides during the breeding season, are among the most frequent causes for failure.

Resumé

I anerkendelse af at ynglesucces ville være et essentielt parameter at indsamle for at øge forståelsen for vigtige processer i Vadehavet, blev der iværksat et overvågningsprogram for ynglesucces i 2009, og det kørte i fuldt omfang fra 2010. Med ynglesucces menes der antal flyvedygtige unger per ynglepar i en række undersøgelsesområder. Der blev udvalgt ti karakteristiske ynglefuglearter i Vadehavet, der repræsenterer forskellige habitater og fødestrategier: Skestork, Ederfugl, Strandskade, Klyde, Hættemåge, Sildemåge, Sølvmåge, Splitterne, Fjordterne og Havterne. Selvom det ikke lykkedes at opnå fuld dækning med overvågning af alle arterne i hver af 15 udpegede underregioner i Vadehavet, blev ynglesuccesen undersøgt i i alt 273 "artslokalitetsår" i 2009-2012, og desuden blev klækningssuccesen undersøgt i 161 "artslokalitetsår" med et stort overlap med arter, lokaliteter og år, hvor ynglesuccesen blev undersøgt.

Overvågning af ynglesucces i Vadehavet 2009-2012 viste ret tydeligt, at selvom resultaterne varierede noget fra sted til sted og fra år til år, var der flere arter, hvor ynglesuccesen var så lav, at der ikke blev produceret tilstrækkeligt med unger til at holde bestandene i balance. For tre arter – Strandskade, Klyde og Havterne – var reproduktionen så ringe, at de i den nuværende situation ikke synes at have nogen chance for at reproducere sig selv. For yderligere fire arter – Hættemåge, Sildemåge, Sølvmåge og Fjordterne – var værdierne for deres ynglesucces så lave, at nogle af eller alle disse arter heller ikke får tilstrækkelig mange flyvefærdige unger til, at det kan balancere dødeligheden blandt de voksne fugle. Når ynglesuccesen sammenlignes med den aktuelle bestandsudvikling i Vadehavet for de ti arter, ses det, at de tre arter med den ringeste ynglesucces alle har en negativ bestandsudvikling, og sandsynligvis er den dårlige ynglesucces

en vigtig årsag til, at arterne går tilbage. Også to af de fire arter med ret lave værdier for deres ynglesucces i dette program, sølvmåge og fjordterne, er gået tilbage i Vadehavet de senere år, og også for disse arter kan hovedårsagen til tilbagegangen være dårlig ynglesucces, eller den kan i hvert fald være en medvirkende årsag. Et nyere populationsstudie af sølvmåge i Holland viser dog, at det her er de voksne fugles lave overlevelse, der er den vigtigste årsag til tilbagegangen.

For flere af arterne var det muligt at udskille klækningssuccesen og vurdere dennes betydning for den samlede ynglesucces. Generelt klarede arterne sig bedre i rugetiden end i ungeføringstiden.

Zusammenfassung

Der Parameter „Bruterfolg" wurde 2009/2010 in das ‚Trilateral Monitoring and Assessment Program' (TMAP) aufgenommen und ist eine wichtige Ergänzung zur bereits vorhandenen Überwachung der Bestände und Verbreitung von Brutvögeln im Wattenmeer. Bruterfolgsdaten helfen, die Änderungen der Bestände zu verstehen. Da die meisten Küstenvögel zu langlebigen Arten gehören, ermöglicht das Messen des Bruterfolgs eine erheblich zeitnähere Bewertung der Bestände („Early Warning") als jährliche Zählungen bei denen sich z.B. eine Abnahme erst viel später zeigt. Die Arbeitsweise der aktuellen Bruterfolgsüberwachung basiert auf Erfahrungen aus einem Pilotproject der 1990-ziger Jahre. Das Ziel ist den Bruterfolg als Anzahl der flüggen Küken pro Brutpaar zu erfassen. Dabei werden 10 Vogelarten erfasst: Löffler, Eiderente, Austernfischer, Säbelschnäbler, Lachmöwe, Heringsmöwe, Silbermöwe, Brandseeschwalbe, Flussseeschwalbe und Küstenseeschwalbe. Auch wenn aus finanziellen und praktischen Gründen weniger Geländetätigkeiten als geplant durchgeführt wurden, ist insgesamt doch einen guten Überblick des Bruterfolgs erzielt worden. Insgesamt wurden 273 Datensätze zu Brut- und 161 Datensätze zu Schlupferfolg erhoben, die sich aus der Anzahl der Arten, Gebiete und Jahre ergeben. Darüber hinaus wurden Daten erhoben die nicht rechtzeitig für diesen Bericht bereitgestellt werden konnten.

Trotz erheblicher Fluktuationen in den Ergebnissen aus den Jahren 2009-2012 zeigt sich, dass aktuell nur wenige Arten im internationalen Wattenmeer erfolgreich brüten. Vornehmlich bei Austernfischer, Säbelschnäbler und Küstenseeschwalbe ist der Bruterfolg viel zu niedrig, um den Bestand zu erhalten. Lachmöwe, Heringsmöwe, Silbermöwe und Flussseeschwalbe erzielen generell ebenfalls einen zu geringen Bruterfolg (aber mit örtlich positive Ausnahmen). Auffällig ist, dass die Arten mit dem schlechtesten Bruterfolg auch die Arten mit stark rückläufigen Beständen im internationalen Wattenmeer sind, wie Austernfischer, Säbelschnäbler und Küstenseeschwalbe. Somit ist der schlechte Bruterfolg ein wesentlicher Grund für die beobachteten Bestandsabnahmen. Literaturdaten zeigen, dass sich bei Lachmöwe und Silbermöwe auch die jährlichen Überlebensraten verringert haben. Die in diesem Bericht präsentierten Daten decken sich gut mit bereits publizierten Ergebnissen aus dem niederländischen Wattenmeer ab (wo bereits seit 2005 Bruterfolgsdaten erhoben werden, und 2014 eine umfassende Analyse von sowohl Bruterfolg als auch Überlebensraten erfolgte).

Für einige Arten konnte die Analyse auch der Grund für den schlechten Bruterfolg nennen. Generell waren die Vögel in der Nestphase erfolgreicher als in der Kükenphase, obwohl es Unterschiede in den Regionen gibt (an der Festlandküste litten mehr Nester unter Räubern als auf den Inseln, wo ein engeres Spektrum an Nesträubern (Prädatoren) beheimatet ist). Prädation und Überflutungen durch Sturmtiden waren die am häufigsten festgestellten Ursachen für den geringen Bruterfolg.

Samenvatting

In 2009-2010 werd de parameter "broedsucces" toegevoegd aan het trilaterale monitoring programma van TMAP. Het vormt een belangrijke aanvulling op de bestaande monitoring van aantallen en verspreiding omdat met behulp van informatie over broedsucces ook achterliggende oorzaken voor aantalsveranderingen kunnen worden onderzocht. Bovendien fungeert het als een "early-warning" voor op stapel staande aantalsveranderingen, aangezien de kustbroedvogels die in TMAP worden gevolgd doorgaans langlevende soorten zijn, en slechte broedjaren pas jaren later kunnen doorwerken in de aantallen. Voor de opzet van het nieuwe meetprogramma kon gebruik worden gemaakt van eerdere trilaterale ervaringen in de jaren negentig. Het zwaartepunt ligt op het vaststellen van het uiteindelijke broedsucces (aantal vliegvlugge jongen per paar). Er worden gegevens van tien soorten verzameld, elk representatief voor een bepaalde voedselgroep of een bepaald broedhabitat: Lepelaar, Eider, Scholekster, Kluut, Kokmeeuw, Kleine Mantelmeeuw, Zilvermeeuw, Grote Stern, Visdief en Noordse Stern. Hoewel de meet-inspanning niet overal de eerder voorgestelde dekking benaderde (zowel vanwege financiële als praktische beperkingen), geven de in dit rapport gepresenteerde gegevens voor het eerst goed inzicht in het broedsucces van kustbroedvogels in de internationale Waddenzee. De gegevens zijn gebaseerd op 273 soort x gebied x jaar combinaties gedurende de jaren 2009-2012 (Nederlandse Waddenzee 2010-11). Het nestsucces werd vastgelegd voor 161 soort x gebied x jaar combinaties. Deze cijfers onderschatten de werkelijke veldinspanning nog iets, omdat niet alle gegevens tijdig beschikbaar waren voor opname in deze rapportage.

Hoewel de variatie aanzienlijk is, komt uit de gegevens verzameld in 2009-2012 een beeld naar voren dat veel soorten te weinig jongen produceren om de populatie op peil te houden. Voor drie soorten is het broedsucces ver onder de maat: Scholekster, Kluut en Noordse Stern. Kokmeeuw, Kleine Mantelmeeuw, Zilvermeeuw en Visdief hadden eveneens slechte reproductiecijfers, zij het plaatselijk met uitzonderingen. Opvallend is dat de soorten met slechte broedresultaten samenvallen met de soorten die de sterkste afname in broedaantallen laten zien. Het uitblijven van voldoende broedsucces kan bij de meeste soorten dan ook worden gezien als een belangrijke drijfveer voor de waargenomen aantalsveranderingen. Literatuurgegevens laten zien dat Zilvermeeuw en Kokmeeuw ook worden geconfronteerd met lagere overlevingscijfers. De situatie voor de internationale Waddenzee komt goed overeen met eerdere analyses die voor de Nederlandse Waddenzee werden gedaan (en die zowel betrekking hadden op analyse van broedsucces als jaarlijkse overleving).

Voor een aantal soorten kon ook de reden van mislukken worden achterhaald. In het algemeen deden soorten het gedurende de nestfase beter dan in de jongenfase, maar dit kan verschillen per gebied (doorgaans meer mislukte nesten langs vastelandskust door groter predatierisico). Predatie en overstromingen behoorden tot de meest voorkomende oorzaken voor mislukking.

Arctic Tern, Norderoog, Schleswig-Holstein. Photo: B. Hälterlein

Spoonbills, Vlieland, The Netherlands. Photo: Peter de Boer

Eider females with 2-3 weeks old ducklings at high tide, Vlieland, The Netherlands. Photo: Peter de Boer

1. Introduction and background

Since 1991, breeding bird surveys in the International Wadden Sea have been carried out as part of the Trilateral Monitoring and Assessment Program (TMAP). They have proven to be a powerful tool to assess status, distribution and population changes in breeding birds in the Wadden Sea (e.g. Koffijberg *et al.* 2006; Koffijberg *et al.* 2015b). This is not only relevant with respect to local conservation and management issues, like evaluation of targets in the trilateral Wadden Sea Plan, but the monitoring data also provide the necessary input for implementation of the EU Birds- and Habitats Directives and recently also the Marine Strategy Framework Directive (MSFD). The breeding bird monitoring scheme is supported by numerous NGOs, governmental agencies and volunteer and professional bird counters, which are responsible for coordination and fieldwork in Denmark, Schleswig-Holstein, Niedersachsen/Hamburg and The Netherlands. Results of the surveys are published annually as Wadden Sea Ecosystem and reviewed regularly in the Quality Status reports.

Due to the focus on distribution and trends, however, backgrounds for population changes often remain unknown, and links with management issues weak. Several breeding birds that currently experience declines in the Wadden Sea are also supposed to have a poor breeding success (de Boer *et al.* 2007; Koffijberg *et al.* 2010), but trilateral data to assess its impact are scant. Most of the species dealt with in the trilateral monitoring scheme are long-lived coastal breeding birds and will therefore show a delayed response to deteriorating environmental conditions or human impact. The parameter 'breeding success' performs much better as an early-warning system to detect changes in the ecosystem or assess human impact, since it is more directly linked with changing conditions in the environment. Moreover, evaluation of the target 'natural breeding success', as addressed in the Wadden Sea Plan, is not possible with monitoring of only population size and distribution. Hence, 'breeding success' has been recognised as an important gap in the current monitoring in the Wadden Sea and has been proposed earlier to be included in TMAP, following a pilot project in 1996-97 (Exo *et al.* 1996; Thyen *et al.* 1998; de Jong *et al.* 1999; Essink *et al.* 2005). As part of a revision of TMAP, it has been decided that from 2010 onwards, breeding success will be included in TMAP, and monitored for a selection of ten species. Monitoring of breeding success will enhance the existing census work on breeding birds. It will give insight in demographic processes that influence population trends in Wadden Sea breeding birds, especially when also linked to ringing and survival data ('Integrated Population Monitoring'; Greenwood *et al.* 1993; Thomas *et al.* 1995; van der Jeugd *et al.* 2014).

In addition, assessment of the conservation status of birds, as requested by the EU-Bird Directive, has been added as an aim, since a favourable conservation status has become a guiding principle for management of bird populations in the Wadden Sea. To summarize, the targets that monitoring of breeding success should address are:

1. Evaluate favourable conservation status requested by the EU Bird Directive;
2. Evaluate the target 'natural breeding success' in the Wadden Sea Plan (1997);
3. Provide an 'early-warning' system to detect changes in the Wadden Sea ecosystem;
4. Explain observed trends in breeding bird numbers.

Furthermore, a monitoring scheme for breeding success is beneficial to the assessment of the existing parameter 'contaminants in bird eggs' as there is a more direct link between contaminants and breeding performance than between contaminants and trends in numbers (Becker *et al.* 1997; 1998). Thus, inclusion of breeding success in TMAP does also support other monitoring schemes than just birds.

This report provides a first baseline review of the collected breeding success data in the international Wadden Sea in 2009-2012. Its aim is to assess the reproductive status of the 10 selected species, by presenting trilateral and national data on nest success and reproductive output (number of fledged chicks/pair). For some species, specific long-term data, derived from national reports of national research programmes have been included to put the data collected recently in a long-term perspective. Finally, some recommendations are made regarding the organisation and set-up of the monitoring scheme.

2. Methods

Selection of species

The current breeding bird monitoring scheme focuses on 35 characteristic species in the Wadden Sea.

However, to fulfil the aims described in chapter 1, it was not regarded necessary to include all these species in a breeding success monitoring scheme. Preferably, a selection of species to be monitored for breeding success should include a subset of species that can be used as indicators for different habitats and feeding strategies. During the pilot project in 1996-97, JMBB agreed on a list of six target species that were assumed to be suitable for monitoring of breeding success and match the aims of the project (Exo *et al.* 1996): Oystercatcher, Avocet, Redshank, Black-headed Gull, Herring Gull and Common Tern. In the evaluation of the pilot project, the monitoring of Redshank was considered too time consuming, and that species was skipped. Based on the experience from a monitoring programme for breeding success in the Dutch part of the Wadden Sea (Willems *et al.* 2005) a further five species were added to the programme. The ten programme species which were finally included are:

- Spoonbill, *Platalea leucorodia*
- Eider, *Somateria mollissima*
- Oystercatcher, *Haematopus ostralegus*
- Avocet, *Recurvirostra avosetta*
- Black-headed Gull, *Chroicocephalus ridibundus*
- Lesser Black-backed Gull, *Larus fuscus*
- Herring Gull, *Larus argentatus*
- Sandwich Tern, *Sterna sandvicensis*
- Common Tern, *Sterna hirundo*
- Arctic Tern, *Sterna paradisaea*

Selection of study sites and sample sizes

In order to aim for representativity the Wadden Sea is subdivided into 7 island subregions and 8 mainland subregions, and within each subregion it is intended to select a network of study sites that cover those of the ten programme species found in that subregion. For statistical reasons it is aimed at achieving a sample of 60-80 clutches (or breeding pairs) in each subregion, wherever this is possible. The subregions are the same as those recently used to present trends within the Wadden Sea (Koffijberg *et al.* 2015a).

Field work

Breeding success as it is understood within the framework of TMAP concentrates on the success of breeding birds in raising their offspring until fledging (BOX 1). Hence, the target value of monitoring breeding success is the number of fledged chicks per pair, for a given species in a given study site. For this purpose, fieldwork focuses on the assessment of two parameters:

- Determine hatching success of a number of clutches by following their fate over the incubation period;
- Determine breeding success by following the hatched chicks until fledging and relate the number of fledged chicks to the number of breeding pairs.

In Spoonbill, and in some cases in Eider, assessment of hatching success is not carried out for different reasons (risk of disturbance, practical difficulties). Inclusion of hatching success in other species is important as it gives insight in the backgrounds for failure like flooding or predation rate (Tab. 1).

Tab. 1: Suitable methods for assessment of breeding success (see Koffijberg *et al.* 2011 for details).

Species	Study of hatching success	Study of breeding succes	Method 'O' (observation)	Method 'R' (mark and recapture)	Method 'F' (fencing)
Spoonbill		x	x		
Eider		x	x		
Oystercatcher	x	x	x	x	
Avocet	x	x	x		
Black-headed Gull	x	x			x
Lesser Black-backed Gull	x	x			x
Herring Gull	x	x			x
Sandwich Tern	x	x			x
Common Tern	x	x			x
Arctic Tern	x	x			x

In order to facilitate consistency in data collection, trilateral monitoring guidelines were elaborated in 2010 and revised in 2011 (Koffijberg *et al.* 2011). They are still provisional and will be finalised with the experiences collected in the first years of the programme, especially with regard to mark and recapture techniques in colonial breeding birds.

Hatching success

Nests or egg clutches were searched for during the entire nesting season in order to attain realistic values for hatching. The nesting period starts mid April in several species and lasts until early (several species) or mid July (Oystercatcher). The nests or egg clutches were marked individually and were controlled approximately once a week until they hatched or got lost. If possible, causes of failure were recorded.

Two different ways were used to monitor and to present hatching success data: the "apparent hatching success" and the "calculated hatching probability" (see Box 1), and the method used to calculate hatching success will be indicated and presented in this report.

Breeding success

Except Spoonbill, all species monitored in this scheme are precocial, and assessment of breeding success is therefore not very straightforward. Three different methods have been used: 'O' for observations of chicks, juveniles and families, 'R' for capture and marking chicks and later recaptures or resighting of these and 'F' for fencing either of one clutch or of groups of clutches. Table 1 lists appropriate methods to use for the different species, as proposed in the trilateral manual.

Disturbance

Fieldwork regarding monitoring breeding success poses a potential risk of serious disturbance to the breeding birds. In order to avoid such disturbance, the written guidelines have included codes of conduct like listing in which situations disturbance should be avoided, limitations of time spent in the breeding areas etc. These guidelines are prepared on methods, which have been tested extensively and have been optimized in order to cause the lowest possible disturbance effect.

BOX 1: Terminology

Breeding success and fledging success:
In technical reports and scientific literature the terms 'breeding success' and 'fledging success' are regularly used indiscriminately to describe either 1) the proportion of hatched chicks that fledge or 2) the number of chicks per pair that fledge or 3) the number of chicks per initiated nest that fledge. Furthermore, the term breeding success is sometimes used also in cases, when only data on hatching success exist.
In this review, the terms are consistently used in the following way:

- Breeding success: the number of fledged chicks per pair
- Fledging success: the proportion of hatched chicks that fledge

Hatching success and nest success:
In this review, hatching success and nest success is used indiscriminately for the same: The proportion of nests where at least one chick hatch.
Two different ways have been used to monitor and present the hatching success:

- Apparent hatching success (or classical hatching success): The proportion of found nests, which eventually hatch
- Calculated hatching probability (Mayfield method): The probable hatching success of the controlled nests calculated from the average daily survival of a nest

Many studies have looked at the advantages and limitations by the use of the two methods (e. g. Johnson & Shaffer 1990). Generally, the "apparent hatching success" is working better, when most nest/clutch mortality is taking place during catastrophic events (typically flooding or predation of an entire colony), whereas the "Mayfield method" is performing better, when nest/clutch mortality is relatively constant over the season.

Breeding success content:
In conclusion, three elements together generate the breeding success: hatching success, fledging success and replacement rate. None of the study species produce more than one successful clutch per year.

3. Breeding success of coastal breeding birds in the Wadden Sea 2009-2012

The extent of the breeding success monitoring activities in 2009-2012 is listed in Tab. 2, and the study sites are demarcated on the map in Figure 1. For preparation of this report, not all data were available in time, so the actual number of sites monitored is somewhat larger than shown in the table. Data from the Dutch Wadden Sea only refer to 2010-11. National reports which cover the 2009-2012 period have been published for the Dutch Wadden Sea (van Kleunen *et al.* 2012; Koffijberg *et al.* 2015b) and for Denmark (Bregnballe *et al.* 2015).

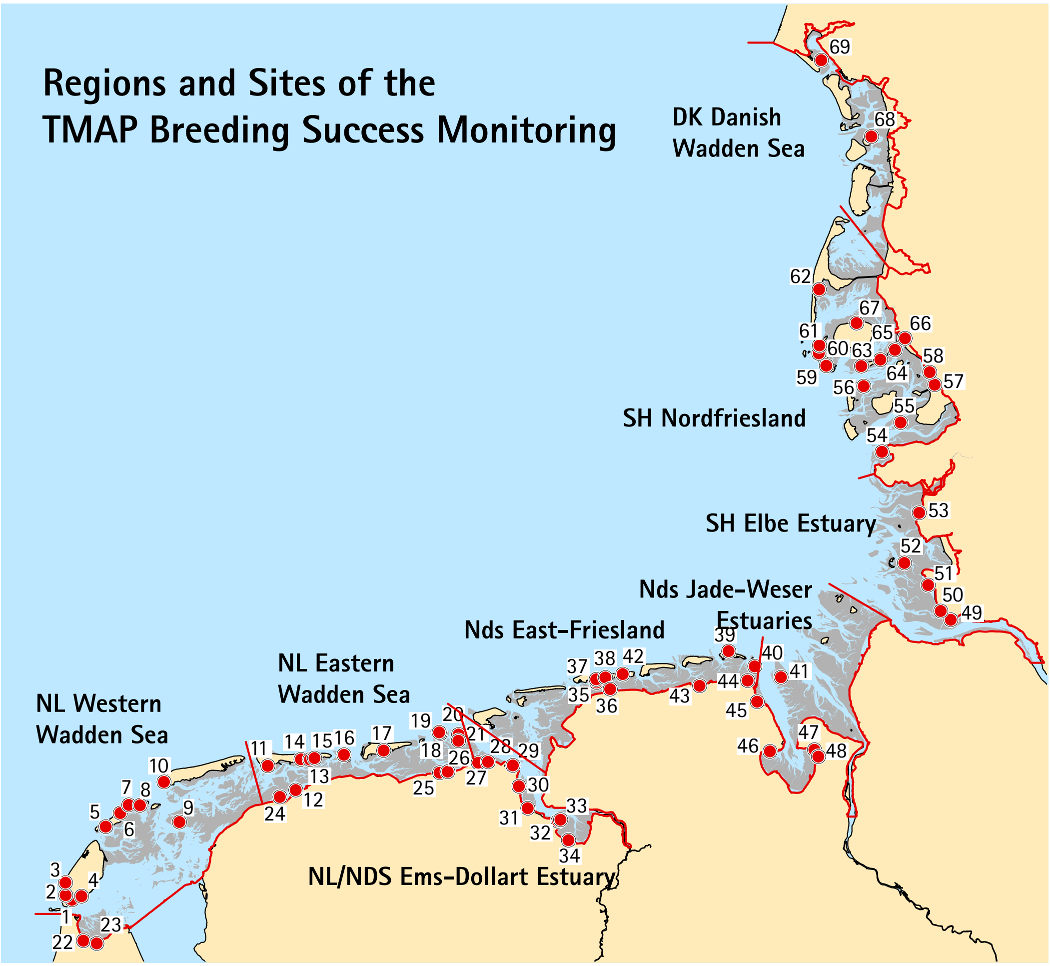

Fig. 1: Overview of sample sites where breeding succes in the Wadden Sea was monitored. Site names and location are listed in Annex 1.

Tab. 2: Monitoring activities 2009-2012. Given is the number of monitoring sites for each species, where data on nest success or breeding success were available for this report. The breeding success monitoring scheme was fully implemented in 2010.

Species	Country	Hatching success				Breeding success			
		2009	2010	2011	2012	2009	2010	2011	2012
Spoonbill	Netherlands	0	0	0	0	0	3	2	1
Spoonbill	Germany Niedersachsen	0	0	0	0	0	0	1	0
Spoonbill	Germany Schleswig-Holstein	0	0	0	0	3	4	4	4
Eider	Netherlands	0	2	2	1	0	7	5	4
Oystercatcher	Netherlands	0	8	7	4	0	14	9	10
Oystercatcher	Germany Niedersachsen	3	6	6	3	3	3	3	1
Oystercatcher	Germany Schleswig-Holstein	2	2	3	5	2	2	3	5
Oystercatcher	Denmark	0	1	1	0	0	1	1	0
Avocet	Netherlands	0	2	1	2	0	6	5	5
Avocet	Germany Niedersachsen	0	2	3	2	0	2	3	2
Avocet	Germany Schleswig-Holstein	2	2	1	1	4	4	3	3
Black-headed Gull	Netherlands	0	2	2	1	0	8	7	4
Black-headed Gull	Germany Niedersachsen	0	1	2	1	0	1	2	1
Black-headed Gull	Germany Schleswig-Holstein	0	0	1	3	0	0	1	3
Lesser Black-backed Gull	Netherlands	0	3	3	3	0	4	2	0
Lesser Black-backed Gull	Germany Niedersachsen	0	1	2	2	0	1	2	2
Lesser Black-backed Gull	Germany Schleswig-Holstein	0	0	3	2	0	1	4	2
Lesser Black-backed Gull	Denmark	1	0	0	0	1	1	1	1

Tab. 2 continuation.

Species	Country	Hatching success				Breeding success			
		2009	2010	2011	2012	2009	2010	2011	2012
Herring Gull	Netherlands	0	3	2	3	0	4	1	0
Herring Gull	Germany Niedersachsen	0	1	2	2	0	1	2	2
Herring Gull	Germany Schleswig-Holstein	0	0	3	2	0	1	4	2
Herring Gull	Denmark	1	0	0	0	1	1	1	1
Lesser Black-backed/ Herring Gull combined	Germany Schleswig-Holstein	0	1	1	0	0	0	0	0
Sandwich Tern	Netherlands	0	0	0	0	0	3	3	3
Sandwich Tern	Denmark	1	0	0	0	0	0	0	0
Common Tern	Netherlands	0	4	1	2	0	7	9	4
Common Tern	Germany Niedersachsen	0	1	0	1	0	1	1	2
Common Tern	Germany Schleswig-Holstein	4	1	4	3	4	3	4	3
Common Tern	Denmark	1	0	0	0	0	0	0	0
Arctic Tern	Netherlands	0	0	1	1	0	5	6	3
Arctic Tern	Germany Schleswig-Holstein	2	0	2	2	4	2	2	2
Arctic Tern	Denmark	2	0	0	0	0	0	0	0

BOX 2: Breeding success – which level is necessary to counterbalance mortality?

Breeding success is one factor out of several that determines whether a population grows, is stabile or declines. In a closed population other determining factors are:

- adult survival
- juvenile and immature survival
- age at first breeding

In an open population, also dispersal has an effect (emigration and immigration) on growth in a given (sub)population.

In order to be able to calculate the necessary breeding success for a given species in the Wadden Sea, data shall be available on all the other relevant factors, including dispersal. With a changing environment also outside the breeding site, the various survival figures etc. may also change, which has an effect on the sufficient level of breeding success.

As a guideline for when breeding success is estimated to be sufficient to keep a population in balance, we have used a set of reference values, used before in the Dutch Wadden Sea (van Kleunen *et al.* 2010; Koffijberg & Smit 2013), based on demographic data from various population studies.

Species	Demographic study value	Guideline level value
Spoonbill		
Eider		0.4 – 1
Oystercatcher	0.30-0.40[1]	0.3 – 0.4
Avocet		0.5 – 1
Black-headed Gull	0.9 – 1.4[2]	1
Lesser Black-backed Gull		0.6 – 1
Herring Gull		0.6 – 1
Sandwich Tern		0.6 – 1
Common Tern	0.75[3]	0.65 – 0.75
Arctic Tern		0.4 – 1

[1] Oosterbeek *et al.* 2006; [2] Bensch & Källander 1997, [3] Stienen *et al.* 2009

Relating to these values, the following terms are used in this review:

- **too low breeding success**: without doubt insufficient reproduction to counterbalance mortality, i.e. below the lowest guideline reference value
- **fairly low breeding success**: the breeding success is around the lower end of the sufficient reproduction to counterbalance mortality. The breeding success may still be too low to maintain the present population size
- **fairly high breeding success**: the breeding success value is within the estimated interval where it is most likely sufficiently high to counterbalance mortality
- **moderate breeding success**: fairly low to fairly high breeding success
- **high breeding success**: without doubt sufficient reproduction to counterbalance mortality

3.1 Spoonbill

Hatching success

Hatching success of Spoonbills was not monitored in the Wadden Sea 2009-2012 as the species is considered too sensitive to regular nest checks. Hence only data was available about the number of chicks fledged.

Breeding success

Breeding success was monitored in 2009-2012 in Schleswig-Holstein (4 colonies 4 years), the Netherlands (1 colony 3 years, 1 colony 2 years, 1 colony 1 year), and Niedersachsen (1 colony 1 year) (Table 3).

In the Dutch colonies, the breeding success was low to moderate, whereas it was high in Niedersachsen and almost consistently very high in Schleswig-Holstein (Table 3). The un-weighted mean in the Netherlands was 0.46 fledged young per pair, 1.32 in the one studied plot and year in Niedersachsen, and the mean was 2.05 fledged young per pair in Schleswig-Holstein.

In the colonies at Schiermonnikoog, the breeding success has been studied ever since the Spoonbill established a breeding population on the island in 1992. In the establishment period with a strong population increase 1992-2002, the breeding success was consistently 2.0 fledged young per pair or above, except in 2001 and 2002, when the colony was hit by extensive flooding (Lok *et al.* 2009; Overdijk 2012). In 2002-2009, when the breeding numbers stabilized, the breeding success was between 1 and 2 fledged young per pair (Overdijk 2012), whereas in 2010-2012 within this monitoring project the value fell to between 0.3 and 0.9. Lok *et al.* (2009) found in addition to the decreasing breeding success also a decreasing adult survival in the Netherlands with increasing breeding numbers and densities, and from these figures they predict that the steep increase in the Dutch Wadden Sea will cease and the population become stable from around 2020.

In the early 1990s, Spoonbill was only breeding in the western (Dutch) part of the Wadden Sea. Subsequently, it expanded its distribution. In 1995 Spoonbills started breeding in Niedersachsen, in 2000 for the first time in Schleswig-Holstein and in 2007 also in Denmark (Rasmussen *et al.* 2000, Koffijberg *et al.* 2010a). The observed very high breeding success in the four studied Schleswig-Holstein colonies, still in their establishment phase, is in line with breeding success values observed at the Schiermonnikoog colonies the first ten years after the establishment. The higher rate of success in the eastern and northern part of the Wadden Sea also explains that the species is still thriving in this part, whereas the population growth has levelled-off in the oldest colonies in the Dutch part of the Wadden Sea.

Tab. 3: Breeding success of Spoonbill in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
NL	Schiermonnikoog, Oosterkwelder	saltmarsh	2010	192	0.3		O Observation
NL	Schiermonnikoog, Oosterkwelder	saltmarsh	2011	231	0.42		O Observation
NL	Schiermonnikoog, Oosterkwelder & Westerplas	beach	2012	210	0.9		O Observation
NL	Rottumerplaat	outer sand	2010	33	0.45	Flooding	O Observation
NL	Rottumerplaat	outer sand	2011	35	0.71		O Observation
NL	Balgzand	saltmarsh	2010	30	0	Predation	O Observation
DE-NDS	Mellum	dunes	2011	60	1.32		O Observation
DE-SH	Trischen	saltmarsh	2009	25	2.7		O Observation
DE-SH	Trischen	saltmarsh	2010	41	1.7		O Observation
DE-SH	Trischen	saltmarsh	2011	45	2.04		O Observation
DE-SH	Trischen	saltmarsh	2012	45	2.63		O Observation
DE-SH	Südfall	saltmarsh	2010	6	2.26		O Observation
DE-SH	Südfall	saltmarsh	2011	13	1.46		O Observation
DE-SH	Südfall	saltmarsh	2012	14	2.61		O Observation
DE-SH	Oland	saltmarsh	2009	44	1.98		O Observation
DE-SH	Oland	saltmarsh	2010	54	1.3		O Observation
DE-SH	Oland	saltmarsh	2011	62	2.08		O Observation
DE-SH	Oland	saltmarsh	2012	57	1.95		O Observation
DE-SH	Föhr	saltmarsh	2009	6	1.28		O Observation
DE-SH	Föhr	saltmarsh	2010	8	1.6		O Observation
DE-SH	Föhr	saltmarsh	2011	14	2.36		O Observation
DE-SH	Föhr	saltmarsh	2012	11	2.8		O Observation

3.2 Eider

Hatching success

Hatching success is not an official TMAP monitoring parameter but it was studied on Vlieland in the Netherlands in 2010-2012 (Tab. 4a and b), as part of a specific population study on this species. The hatching success was moderate to fairly high, and the most important cause of egg failures was predation, partly due to a deliberate introduction of Red Fox to the island. In addition, Brown rat is an important predator. In other years in the past, breeding females have also faced a poor condition at the start of the breeding season, possibly also affecting nest attendance and increasing the risk of nest-loss (de Boer *et al.* 2007), but this an issue was not apparent in 2010-2012 (P. de Boer/Sovon).

Breeding success

Breeding success was monitored on several Dutch islands 2010-2012, by carrying out a simultaneous count of chicks in early July (along with an assessment of the number of breeding females at each island during the breeding season) (Table 5). The observed breeding success values were very variable from 0 to 2.17. In the small population on Texel the fledging success was consistently high with an un-weighted mean of 1.46 young per pair. The un-weighted mean from all Dutch Wadden Sea islands was 0.60 young per pair. An analysis of data from the Dutch Wadden Sea during 2005-2013 showed that, apart from 2005, the number of chicks remained below 0.50 pairs in all years without a clear trend when using weighted figures, accounting e.g. for differences in population size (Koffijberg *et al.* 2015b). Nothing is known about the causes of failures in chick survival.

On the island of Vlieland the breeding success has been followed in a large number of years between 1944 and 2011 (BOX 3 Figure 2). In three of the 40 years (8%) the value was above 1.0 young per pair, in another six (including the programme year 2010; Table 5) it was between 0.4 and 1.0, whereas in five (21%) it was between 0.25 and 0.4. In almost two out of three years the fledging success was below 0.25. In 1944-2010 there were two periods with strong increases and two periods with strong decreases on Vlieland (van Kleunen *et al.* 2012).

Even if the data presented here are only from one country, they provide a sample of the largest breeding population in the Wadden Sea, and therefore are considered reflecting the situation in the international Wadden Sea. They may not be representative, however, as conditions are assumed to be very different in other parts of the Wadden Sea, as is also suggested by different trends in breeding numbers (Koffijberg *et al.* 2015a). Over the entire Wadden Sea, there has been a decline since 1991, mainly occurring after the late 1990s. Ringing data from the Dutch Wadden Sea have pointed out that adult survival is very likely to affect population changes, with periodical occurrence of so-called kill-years due to food shortage in winter and spring (Camphuysen *et al.* 2002; van der Jeugd *et al.* 2014). Food shortage in winter, may also lead to poor breeding condition in breeding females (so-called carry-over effect), as has been observed on Vlieland in some years (see above).

Country	Sitename	Habitat	Year	Sample size	Apparent hatching success (%)	Calculated hatching probability
NL	Vlieland, Bomenland	dunes	2010	15	66	0.85
NL	Vlieland, Bomenland	dunes	2010	25	40	0.10
NL	Vlieland, Bomenland	dunes	2012	30	56	0.28
NL	Vlieland, Kroon's Polders	saltmarsh	2011	20	70	0.35
NL	Vlieland, Kroon's Polders	saltmarsh	2011	29	65	0.45

Tab. 4a: Hatching success of Eider in the Wadden Sea 2009-2012.

Country	Sitename	Year	Cause of egg losses in %						
			Predation	Flooding	Trampling	Unfavourable weather	Food shortage	Other factors	Unknown
NL	Vlieland, Bomenland	2010	60	0	0	0	0	20	20
NL	Vlieland, Bomenland	2010	84	0	0	0	0	5	11
NL	Vlieland, Bomenland	2012	67	0	0	0	0	33	0
NL	Vlieland, Kroon's Polders	2011	40	0	0	0	0	0	60
NL	Vlieland, Kroon's Polders	2011	87	0	0	0	0	13	0

Tab. 4b: Hatching success of Eider in the Wadden Sea 2009-2012. Causes of egg losses.

Tab. 5: Breeding success of Eider in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
NL	Texel	dunes/ saltmarsh	2010	330	1.12		O Observation
NL	Texel	dunes/ saltmarsh	2011	311	1.08		O Observation
NL	Texel	dunes/ saltmarsh	2012	159	2.17		O Observation
NL	Vlieland	dunes/ saltmarsh	2010	1,076	0.51		O Observation
NL	Vlieland	dunes/ saltmarsh	2011	946	0.2		O Observation
NL	Griend	outer sand	2010	78	0.67		O Observation
NL	Griend	outer sand	2011	65	0	various causes	O Observation
NL	Ameland	dunes/ saltmarsh	2010	382	1.4		O Observation
NL	Ameland	dunes/ saltmarsh	2012	538	0.2		O Observation
NL	Schiermonnikoog	dunes/ saltmarsh	2010	338	0.6		O Observation
NL	Schiermonnikoog	dunes/ saltmarsh	2011	165	0.76		O Observation
NL	Schiermonnikoog	dunes/ saltmarsh	2012	356	0.35		O Observation
NL	Rottumerplaat	dunes/ saltmarsh	2010	1,736	0.06		O Observation
NL	Rottumeroog & Zuiderduin	outer sand	2010	175	0.07		O Observation
NL	Rottumeroog & Zuiderduin	outer sand	2011	353	0.09	unknown	O Observation
NL	Rottumeroog & Zuiderduin	outer sand	2012	1,165	0.34		O Observation

BOX 3: Long term trends in breeding success in Common Eider in the Dutch Wadden Sea

The Dutch Wadden Sea supports the majority of breeding Common Eider in the international Wadden Sea. The population of one of the core breeding sites, the island of Vlieland, showed pronounced fluctuations throughout the past decades (Fig. 2). After initial increases, declines were observed in the early 1960s and early 1980s. After 2000 the population seems to subject to a structural decrease. Scarce data on breeding success show years with high productivity in the 1940s and 1960s, but also years with very poor breeding success accumulating after 2000. It is hypothesized that the low reproductive output is mainly caused by poor condition of breeding females prior to breeding (van Kleunen *et al.* 2012).

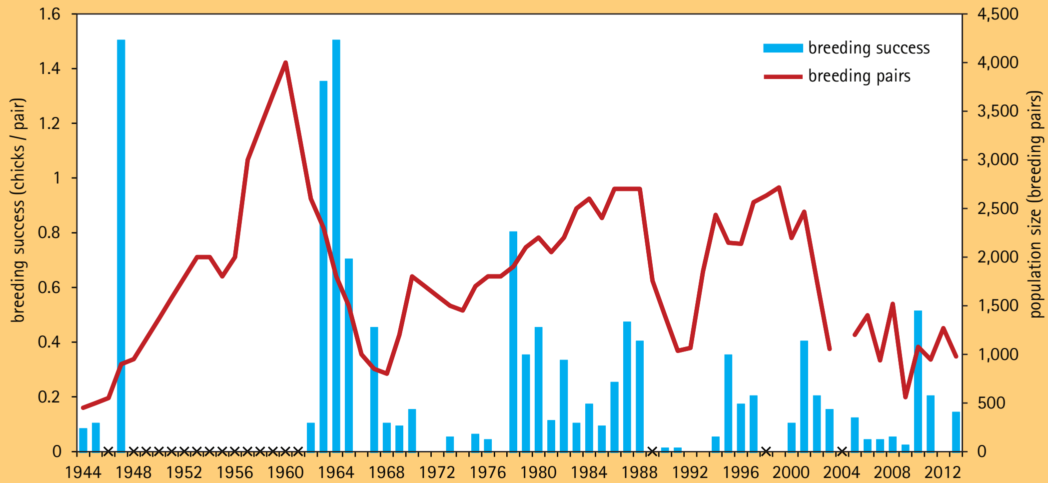

Fig. 2: Trend in breeding population (right axis) and breeding success (expressed as the number of chicks per pair/ female) of Common Eider on the island of Vlieland. x no data. Source: Kats 2007, Sovon Vogelonderzoek Nederland).

3.3 Oystercatcher

Hatching success

Hatching success has been monitored at several sites in the Netherlands, Niedersachsen and Schleswig-Holstein, both on the islands and on the mainland coast. In Denmark hatching success was monitored at one site in two years on an island (Tab. 6a and b).

Generally, hatching success at all sites on the mainland coast was very low, and in several cases there was no hatching success at all. The only exceptions were the two Dutch sites Biltpollen in Noord Friesland and the Schermpier in Delfzijl (a very long harbour pier which is *de facto* not really 'mainland'), with hatching successes around 50%. In the remaining 18 sites and years monitored on the mainland coast, the un-weighted mean of the apparent hatching success was only 5%, and in 10 of the sites and years (56%) there was no hatching success at all. This means that failure in breeding Oystercatcher along the mainland coast is usually occurring during the incubation period.

On the Wadden Sea islands, hatching success was much more variable and often high (compared to the mainland coast). The un-weighted mean apparent hatching success at the 27 sites and years was 51%. At sites where both the apparent hatching success and the hatching probability is known, the apparent hatching success is 15% higher, so the real hatching success was probably around 45% at the island sites. The highest hatching success was found at the three sites on islands in Schleswig-Holstein, where the apparent hatching success was 74%. The apparent hatching success at the island sites in Niedersachsen was 54%, in the Netherlands 44% and at the only Danish site 29%.

Where the dominant cause of egg losses was reported, predation was by far the most common cause. In 23 of the 30 instances (77%) predation was the most important cause, in the remaining 7 it was flooding. In 12 sites and years with no or very low hatching success (<10% apparent hatching success) the main cause of the egg failure was known, and in 11 cases (92%) predation was the main cause, whereas flooding was only the main cause in one. Predation was a much

BOX 4: Long term trends in nest success and breeding success in Oystercatcher the Dutch Wadden Sea

Oystercatcher is one of the species that currently fails to breed successfully at many sites throughout the Wadden Sea. Data from the Dutch Wadden Sea, starting in the early 1980s, show that this failure is not an incident, but part of a long-term trend. Both at the islands of Texel and Schiermonnikoog a significant downward trend in nest success has been observed since 1983 (Fig. 3). Compared to Texel, nest success at Schiermonnikoog showed less annual fluctuations, and remained at a much lower level after 2000. Especially between 2000 and 2005 many nests at Schiermonnikoog even failed in producing any fledged young (Oosterbeek *et al.* 2006, van Kleunen *et al.* 2010). The decline in nest success and breeding success in Oystercatcher is attributed to a mix of factors, including predation of clutches and chicks, losses caused by storm flooding during the breeding season and assumed poor condition prior to breeding (van de Pol *et al.* 2010, Ens *et al.* 2011). The precise interplay of these factors is not fully understood yet, and may also be different at breeding sites elsewhere in the Wadden Sea.

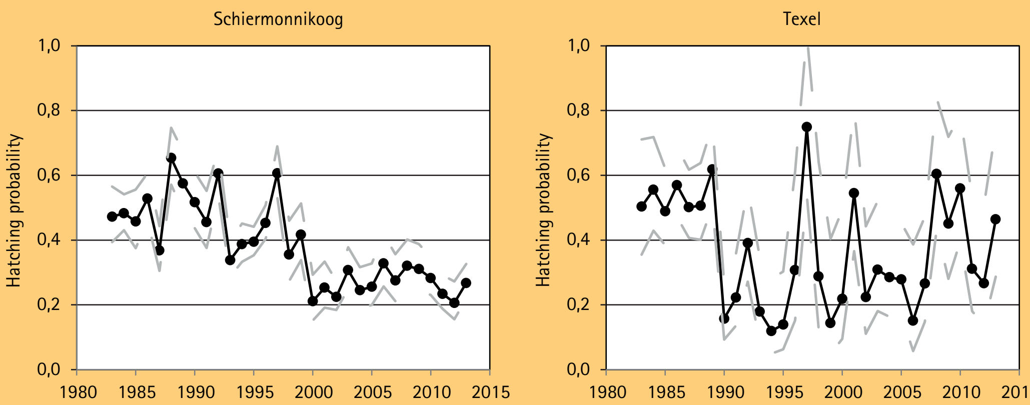

Fig. 3: Hatching success in Oystercatcher (calculated according to Mayfield, incl. 95% c.l.) on the islands of Schiermonnikoog and Texel (source: Sovon Vogelonderzoek Nederland & IMARES, see e.g. Oosterbeek *et al.* 2006).

Table 6a: Hatching success of Oystercatcher in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Apparent hatching success (%)	Calculated hatching probability
NL	Texel, 't Stoar	coastal wetland	2010	1	0	
NL	Texel, Studiegebied 't Stoar/Kikkert	coastal wetland	2011	4	100	
NL	Texel, Studiegebied 't Stoar/Kikkert	coastal wetland	2012	2	0	
NL	Texel, Studiegebied De Petten	coastal wetland	2011	12	46	
NL	Texel, Studiegebied Joost Dourleinkazerne	saltmarsh	2011	21	45	
NL	Vlieland, Vliehors, Schelpenbank	beach	2011	6	0	
NL	Ameland, Kwelder Ferwerd Oost-West	saltmarsh	2011	19	36	0.19
NL	Ameland, Buurdergrie	polder	2010	75	86	
NL	Ameland, Buurdergrie	polder	2012	72	86	
NL	Ameland, Nieuwlandsreid Oost	saltmarsh	2010	41	39	
NL	Ameland, Nieuwlandsreid Oost	saltmarsh	2012	16	81	
NL	Schiermonnikoog, Hoge Kwelder 1e Slenk	saltmarsh	2010	22	22	
NL	Schiermonnikoog Populatiestudie Oosterkwelder	saltmarsh	2010	86	36	
NL	Noord Friesland Buitendijks, Biltpollen	saltmarsh	2010	33	60	0.51
NL	Groninger Kust, Emmapolder	polder	2011	27	0	0.003
NL	Delfzijl, Schermpier	beach	2011	26	53	0.46
NL	Delfzijl, Schermpier	beach	2012	24	62	0.54
DE-NDS	Norderney Grohdenvorland	saltmarsh	2010	150	60	0.58
DE-NDS	Norderney Grohdenvorland	saltmarsh	2011	129	41	0.36
DE-NDS	Norderney Grohdenvorland	saltmarsh	2012	112	71	0.67
DE-NDS	Norderney Ostheller	saltmarsh/dunes	2010	32	72	0.68
DE-NDS	Norderney Ostheller	saltmarsh/dunes	2011	59	66	0.60
DE-NDS	Norderney Ostheller	saltmarsh/dunes	2012	44	71	0.64
DE-NDS	Wangerooge	saltmarsh	2010	44	14	0.10
DE-NDS	Wangerooge	saltmarsh	2011	49		0.29
DE-NDS	Mellum Süddüne	dunes	2012	46	39	
DE-NDS	Mainland coast - Norderland	saltmarsh	2009	22	0	0.001
DE-NDS	Mainland coast - Norderland	saltmarsh	2010	9	11	0.06
DE-NDS	Mainland coast - Norderland	saltmarsh	2011	6	17	0.006
DE-NDS	Mainland coast - Elisabeth-Außengroden	saltmarsh	2009	15	0	0.008
DE-NDS	Mainland coast - Elisabeth-Außengroden	saltmarsh	2010	9	0	0.007
DE-NDS	Mainland coast - Elisabeth-Außengroden	saltmarsh	2011	3	0	0.003
DE-NDS	Mainland coast - Crildumersiel	saltmarsh	2009	8	0	0.001
DE-NDS	Mainland coast - Crildumersiel	saltmarsh	2010	6	17	0.002
DE-NDS	Mainland coast - Crildumersiel	saltmarsh	2011	5	0	0.002
DE-SH	Hedwigenkoog-Vorland	saltmarsh	2009	140	15	
DE-SH	Hedwigenkoog-Vorland	saltmarsh	2010	142	13	
DE-SH	Hedwigenkoog-Vorland	saltmarsh	2011	106	11	
DE-SH	Hedwigenkoog-Vorland	saltmarsh	2012	107	2	
DE-SH	Westerhever-Vorland	saltmarsh	2009	45	0	
DE-SH	Westerhever-Vorland	saltmarsh	2010	36	0	
DE-SH	Westerhever-Vorland	saltmarsh	2011	19	0	
DE-SH	Westerhever-Vorland	saltmarsh	2012	32	6	
DE-SH	Langeness, Westen	saltmarsh	2012	157	61	0.66
DE-SH	Langeness, Honkenswarft Ost	saltmarsh	2012	55	71	0.72
DE-SH	Oland	saltmarsh	2011	152	80	0.69
DE-SH	Oland	saltmarsh	2012	162	85	0.72
DK	Mandø east and northeast	saltmarsh	2010	109	50	0.46
DK	Mandø east and northeast	saltmarsh	2011	122	7	0.06
DK	Mandø east (sub-sample of above data set)	saltmarsh	2010	71	42	0.37
DK	Mandø east (sub-sample of above data set)	saltmarsh	2011	69	1	0.02

more dominant cause of egg losses on the mainland sites but does also occur on the islands.

Oystercatcher is also included in the TMAP parameter contaminants in bird eggs, and that monitoring programme has shown that estuaries of the two rivers Elbe and Ems had the highest concentrations of most contaminant groups (Becker & Dittmann 2009). Hatching success of Oystercatchers was not monitored in the Elbe estuary, but at the one study plot in the Ems estuary in Delfzijl, Oystercatchers had a high hatching success (Tab. 6a). Thus there is no indication of a relation between areas with high concentrations of contaminants and lower hatching success. This would also not be expected as the current levels of most contaminants in bird eggs are below the known threshold concentrations for affecting the reproduction of birds (Becker & Dittmann 2009).

Breeding success

Breeding success was monitored at several sites and years in the Netherlands, Niedersachsen and Schleswig-Holstein and at one site in two years in Denmark. In the Netherlands and Schleswig-Holstein both sites on the islands and at the mainland coast were monitored, whereas in Niedersachsen and Denmark only island sites were covered (Tab. 7).

In six out of eight mainland sites and years (75%) in Schleswig-Holstein not one Oystercatcher chick fledged, and in the remaining two, the values were also very low. At the mainland sites in the Netherlands, the breeding success varied more, with the extremes of one site without any fledging success, and the best site having a breeding success of 0.39 fledged young per pair. The un-weighted mean of the eight Dutch mainland sites and years was 0.21 fledged young per pair. Data from the Netherlands from 2005-2013, including a weighting routine, showed similar figures (Koffijberg *et al.* 2015b).

In contrast to the hatching success, the breeding success was not better at the island sites than at the mainland sites in the Netherlands. At the 25 island sites and years the un-weighted mean was 0.15 fledged young per year. In Schleswig-Holstein, on the other hand, the breeding success was significantly higher on the islands with 0.42 young per pair compared to 0.02 on the mainland coast. Although the breeding success was not monitored at the mainland coast of Niedersachsen, the observed hatching success of 5% on the nine sites and years means that also the breeding success must have been very low. On the islands in Niedersachsen, the breeding success was 0.13 young per pair at the five monitored sites and years, and then there are four less accurate estimates of the breeding success at four other sites and years of which two were estimated to have a ‘very low’ and two a ‘high’ breeding success.

In 32 of the 56 sites and years the main cause of breeding failure was reported, in four cases there were two main causes. Predation was the single-most important cause of breeding failure, in 12 cases predation of chicks, in another 11 predation of eggs. Flooding was the main cause in 11 cases, unfavourable weather in 4, starvation in two and trampling and disturbance was the most important cause at one site each. However, starvation and predation are hardly independent causes of failure, as starvation may cause chicks to behave in a way that makes them more vulnerable to predation (Safriel *et al.* 1996).

The current data on breeding success show that Oystercatcher experience serious problems to reproduce successfully in most parts of the Wadden Sea. Even at some island sites where nest success is quite high, only few chicks are raised. These findings fit into the observed long-term trend in the Dutch Wadden Sea, where breeding success has declined with 75% in the past three decades (van der Jeugd *et al.* 2014). High predation rates are considered the main cause for the poor breeding performance along the mainland coast, but for factors like breeding condition of the breeding adults and flooding it is not clear how they affect breeding success as they are less easy to detect or (in case of flooding) operate locally (cf. Oosterbeek *et al.* 2006; van de Pol *et al.* 2010). For the island of Schiermonnikoog it has been shown that the increased frequency of flooding during the breeding season is one of the causes for the poor reproduction rates and low breeding numbers at a longer term.

In their study on Schiermonnikoog, Ens (1992), Ens *et al.* (1996) and Safriel *et al.* (1996) found a large variation in territory quality between so-called ‘residents’, where the territory included a feeding area, and ‘leapfrogs’ where the nesting territory was away from the feeding site (leading to lower chick survival due to food shortage). In 1984-1989, a period with stable breeding numbers, the un-weighted breeding success was 0.86 fledged young per pair in resident territories, and 0.21 fledged young per pair in leapfrog territories, or in the two types of territories combined 0.50 fledged young per pair (from data in Ens 1992). A breeding success of 0.50 or above was only reached at four of the 52 sites and years (8%) within this programme in 2009-2012, and half of

Tab. 6b:
Hatching success of Oystercatcher in the Wadden Sea 2009-2012. Causes of egg losses

Country	Sitename	Year	Cause of egg losses						
			Predation (%)	Flooding (%)	Trampling (%)	Unfavourable weather (%)	Food shortage (%)	Other factors (%)	Unknown (%)
NL	Texel, 't Stoar	2010		0					
NL	Texel, Studiegebied 't Stoar/Kikkert	2011		0					
NL	Texel, Studiegebied 't Stoar/Kikkert	2012		0					
NL	Texel, Studiegebied De Petten	2011		0					
NL	Texel, Studiegebied Joost Dourleinkazerne	2011		0					
NL	Vlieland, Vliehors, Schelpenbank	2011							
NL	Ameland, Kwelder Ferwerd Oost-West	2011	7	54	0	0	0	7	31
NL	Ameland, Buurdergrie	2010		0					
NL	Ameland, Buurdergrie	2012		0					
NL	Ameland, Nieuwlandsreid Oost	2010							
NL	Ameland, Nieuwlandsreid Oost	2012							
NL	Schiermonnikoog, Hoge Kwelder 1e Slenk	2010							
NL	Schiermonnikoog Populatiestudie Ooster-kwelder	2010							
NL	Noord Friesland Buitendijks, Biltpollen	2010	0	0	0	0	0	0	100
NL	Groninger Kust, Emmapolder	2011	20	0	0	0	0	80	0
NL	Delfzijl, Schermpier	2011	25	17	0	0	0	25	33
NL	Delfzijl, Schermpier	2012	44	0	0	0	0	56	0
DE-NDS	Norderney Grohdenvorland	2010	5	33	2	0	0	55	5
DE-NDS	Norderney Grohdenvorland	2011	0	85	1	0	0	9	5
DE-NDS	Norderney Grohdenvorland	2012	12	27	0	0	0	24	37
DE-NDS	Norderney Ostheller	2010	67	11	0	0	0	22	0
DE-NDS	Norderney Ostheller	2011	10	33	0	0	0	33	24
DE-NDS	Norderney Ostheller	2012	23	0	0	0	0	38	39
DE-NDS	Wangerooge	2010	45	53	0	0	0	0	3
DE-NDS	Wangerooge	2011	29	43	0	0	0	26	3
DE-NDS	Mellum Süddüne	2012	18	3	0	0	0	17	63
DE-NDS	Mainland coast - Norderland	2009	86	9	5	0	0	0	0
DE-NDS	Mainland coast - Norderland	2010	75	25	0	0	0	0	0
DE-NDS	Mainland coast - Norderland	2011	100	0	0	0	0	0	0
DE-NDS	Mainland coast - Elisabeth-Außengroden	2009	67	33	0	0	0	0	0
DE-NDS	Mainland coast - Elisabeth-Außengroden	2010	78	11	11	0	0	0	0
DE-NDS	Mainland coast - Elisabeth-Außengroden	2011	33	67	0	0	0	0	0
DE-NDS	Mainland coast - Crildumersiel	2009	75	25	0	0	0	0	0
DE-NDS	Mainland coast - Crildumersiel	2010	60	40	0	0	0	0	0
DE-NDS	Mainland coast - Crildumersiel	2011	80	20	0	0	0	0	0
DE-SH	Hedwigenkoog-Vorland	2009	69	22	2	0	0	7	0
DE-SH	Hedwigenkoog-Vorland	2010	79	17	1	0	0	3	0
DE-SH	Hedwigenkoog-Vorland	2011	75	17	5	0	0	3	0
DE-SH	Hedwigenkoog-Vorland	2012	67	32	1	0	0	0	0
DE-SH	Westerhever-Vorland	2009	89	11	0	0	0	0	0
DE-SH	Westerhever-Vorland	2010	89	11	0	0	0	0	0
DE-SH	Westerhever-Vorland	2011	62	38	0	0	0	0	0
DE-SH	Westerhever-Vorland	2012	63	35	0	0	0	2	0
DE-SH	Langeness, Westen	2012	71	0	3	0	0	26	0
DE-SH	Langeness, Honkenswarft Ost	2012	56	0	0	0	0	44	0
DE-SH	Oland	2011	14	0	0	0	0	53	33
DE-SH	Oland	2012	26	0	0	0	0	47	27
DK	Mandø east and northeast	2010	70	7	7	0	0	16	0
DK	Mandø east and northeast	2011	81	17	0	0	0	1	0
DK	Mandø east (sub-sample of above data set)	2010	72	2.5	10	0	0	15	0
DK	Mandø east (sub-sample of above data set)	2011	93	6	0	0	0	1	0

Tab. 7:
Breeding success of Oystercatcher in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
NL	Texel, Studiegebied De Petten	coastal wetland	2010	16	0.06		
NL	Texel, Studiegebied De Petten	coastal wetland	2011	12	0	Unknown	O Observation
NL	Texel, Studiegebied Joost Dourleinkazerne	saltmarsh	2010	24	0.04		
NL	Texel, Studiegebied Kikkert	coastal wetland	2010	2	0		
NL	Texel, 't Stoar	coastal wetland	2010	2	0	Unknown	O Observation
NL	Texel, Studiegebied 't Stoar/Kikkert	coastal wetland	2012	2	0	Unknown	O Observation
NL	Vlieland, Vliehors	saltmarsh	2011	24	0	Flooding	O Observation
NL	Vlieland, Vliehors, Schelpenbank	beach	2011	8	0	Flooding	O Observation
NL	Vlieland, Vliehors	saltmarsh	2012	34	0.24	Disturbance	O Observation
NL	Vlieland, Westerseveld	saltmarsh	2011	12	0.08	Trampled	O Observation
NL	Vlieland, Westerseveld	saltmarsh	2012	14	0.57		O Observation
NL	Vlieland, Strand	beach	2010	10	0.1	Unknown	O Observation
NL	Ameland, Hollumerkwelder	saltmarsh	2011	14	0	Flooding	O Observation
NL	Ameland, Buurdergrie	polder	2010	125	0.8		O Observation
NL	Ameland, Buurdergrie	polder	2012	75	0.28	Starvation	O Observation
NL	Ameland, Nieuwlandsreid Oost	saltmarsh	2010	55	0.2	Flooding	O Observation
NL	Ameland, Nieuwlandsreid Oost	saltmarsh	2012	55	0	Predation	O Observation
NL	Schiermonnikoog, Banckspolder Oost	polder	2010	98	0.73	Unknown	O Observation
NL	Schiermonnikoog, Banckspolder Oost	polder	2012	98	0.18	Predation	O Observation
NL	Schiermonnikoog, Hoge Kwelder 1e Slenk	saltmarsh	2010	32	0.06	Predation	O Observation
NL	Schiermonnikoog Populatiestudie Oosterkwelder	saltmarsh	2010	89	0.24	Flooding	O Observation
NL	Rottumerplaat	outer sand	2010	206	0.1		O Observation
NL	Rottumerplaat	outer sand	2011	232	0.03		O Observation
NL	Rottumeroog	outer sand	2011	95	0.02		
NL	Zuiderduin	saltmarsh	2011	26	0	Flooding	O Observation
NL	Balgzand	saltmarsh	2010	62	0	Predation	O Observation
NL	Balgzand	saltmarsh	2012	73	0.05	Predation	O Observation
NL	Noord-Hollandse Kust, Balgzand	saltmarsh	2012	87	0.39		O Observation
NL	Groninger Kust, Klutenplas	coastal wetland	2010	9	0.33		O Observation
NL	Groninger Kust, Klutenplas	coastal wetland	2011	9	0.22	Predation	O Observation
NL	Groninger Kust, Klutenplas	coastal wetland	2012	8	0.38	Unknown	O Observation
NL	Delfzijl, Schermpier	beach	2010	54	0.15	Flooding	O Observation
NL	Delfzijl, Schermpier	beach	2012	60	0.18		O Observation
DE-NDS	Norderney Grohdenvorland	saltmarsh	2010	147	0.35	Not specified	O Observation
DE-NDS	Norderney Grohdenvorland	saltmarsh	2011	99	0.13	Not specified	O Observation
DE-NDS	Norderney Grohdenvorland	saltmarsh	2012	127	0.14	Flooding	O Observation
DE-NDS	Norderney Ostheller	saltmarsh/dunes	2010		very low		
DE-NDS	Norderney Ostheller	saltmarsh/dunes	2011		high		
DE-NDS	Norderney Ostheller	saltmarsh/dunes	2012		high		
DE-NDS	Wangerooge	saltmarsh	2010	44	0.3	Flooding	O Observation
DE-NDS	Wangerooge	saltmarsh	2011	62	0	Flooding	O Observation
DE-NDS	Mellum Süddüne	dunes	2012		very low		

Tab. 7 contiuation.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
DE-SH	Hedwigenkoog-Vorland	saltmarsh	2009	126	0.07	Predation	R Mark-recapture
DE-SH	Hedwigenkoog-Vorland	saltmarsh	2010	126	0.05	Predation, Weather	R Mark-recapture
DE-SH	Hedwigenkoog-Vorland	saltmarsh	2011	98	0	Predation	R Mark-recapture
DE-SH	Hedwigenkoog-Vorland	saltmarsh	2012	88	0	Weather, Flooding	R Mark-recapture
DE-SH	Westerhever-Vorland	saltmarsh	2009	39	0	No hatching success	R Mark-recapture
DE-SH	Westerhever-Vorland	saltmarsh	2010	34	0	No hatching success	R Mark-recapture
DE-SH	Westerhever-Vorland	saltmarsh	2011	17	0	No hatching success	R Mark-recapture
DE-SH	Westerhever-Vorland	saltmarsh	2012	26	0	Predation	R Mark-recapture
DE-SH	Langeness, Westen	saltmarsh	2012	59	0.4	Gull predation, cold weather	R Mark-recapture
DE-SH	Langeness, Honkenswarft Ost	saltmarsh	2012	20	0.22	Gull predation, cold weather	O Observation
DE-SH	Oland	saltmarsh	2011	49	0.59	Frequent heavy rainfall over several days	R Mark-recapture
DE-SH	Oland	saltmarsh	2012	52	0.45	Bad nutritional condition	R Mark-recapture
DK	Mandø east	saltmarsh	2010	70	0.26	Low failure rate	O Observation
DK	Mandø east	saltmarsh	2011	70	0.01	Low failure rate	O Observation

that reproduction (0.25 fledged young per pair) or above was only found at an additional seven sites and years (21%, Table 7). The representativity of the breeding success figures presented here is a bit uncertain, as no segregation was made according to the quality of the territories.

In the Schiermonnikoog study area, Ens *et al.* (1996) also found that 31% of the adult birds present were non-breeders, of which a significant proportion held territories. More recently, the cohort of non-breeders has declined (B. Ens). It is not known, how large a portion of the 'breeding pairs' in the present monitoring programme that were in fact non-breeding territorial pairs. Numbers counted during the standardized breeding bird surveys (Hälterlein *et al.* 1995) do include non-breeding pairs, as the counting method does not distinguish between birds present according to their behaviour. This means that the reported breeding success may to a certain degree be underestimates because the number of breeding pairs in the calculations may include an unknown proportion of non-breeders.

The low breeding success is likely to be the main driver behind the decline in observed numbers of breeding Oystercatchers in the Wadden Sea. In Denmark breeding numbers halved between 1996 and 2012 (Thorup & Laursen 2013a). In general, Oystercatchers show moderate declines in the international Wadden Sea between 1991 and 2011, the decline starting later in Niedersachsen than in the other countries (Koffijberg *et al.* 2015a). Periodically, also low survival (e.g. due to ice winters) contribute to the downward trend (van der Jeugd *et al.* 2014), and along with the poor breeding performance, Oystercatcher are not able to recover after such winters.

3.4 Avocet

Hatching success

Hatching success has been monitored in a number of plots in the Netherlands, Niedersachsen and Schleswig-Holstein (Table 8a and b), which represent the main breeding areas within the international Wadden Sea. In the Niedersachsen study plots, the hatching success was largely high, with a success above 40% in five out of seven plots and years. In the Netherlands and Schleswig-Holstein on the other hand, most results showed a very low hatching success, with only one year at one site in the Netherlands having a hatching success above 40% and none at all in the Schleswig-Holstein plots.

The dominant causes of egg losses were predation and flooding.

At some sites in The Netherlands, electrical fences have been used to increase nest success, but even in such areas final breeding success is often too low (van Kleunen *et al.* 2012). Earlier studies in The Netherlands have also pointed at possible problems with food provisioning in the chick-rearing period (Willems *et al.* 2005).

Breeding success

Breeding success was monitored at several sites and years in the Netherlands, Niedersachsen and Schleswig-Holstein (Table 9). In 15 out of 38 plots and years (39%) not a single Avocet chick fledged, and in another 7 (18%) less than one chick per 10 pairs fledged. The Dutch sites had the lowest performance with 0.04 fledged chicks per pair, whereas the values were a little higher in Niedersachsen (0.15) and Schleswig-Holstein (0.10). Data from the Dutch Wadden Sea in 2005-2013 (incl. weighting) show high variation between years, but never years when more than 0.3 chicks were raised to independence. These data fit in a long term decline in breeding success in the Dutch Wadden Sea (Willems *et al.* 2005, see below).

At the sites monitored within this programme, Avocets hardly have reproduced themselves in 2009-2012 (perhaps with the exception of Fahretofter Westerkoog in Schleswig-Holstein). It is likely that the ongoing decline in many parts of the Wadden Sea (Thorup & Laursen 2013b; Koffijberg *et al.* 2015a) is mainly driven by a poor reproductive output. The current low level of reproduction is confirmed by a comparison with long-term data. In a study in the Schleswig-Holstein Wadden Sea 1988-1997 covering two sites which were also part of this programme, 9 out of 14 sites and years (64%) had a fledging success of 0.3 juveniles per pair or higher (Hötker & Segebade 2000). In this monitoring programme a similar level was only reached in one plot and year (3%), indicating that Avocets were facing very bad breeding conditions in Germany and the Netherlands in 2009-2012. Long-term data from the Netherlands also point at a decline in breeding performance in the past two decades (Willems *et al.* 2005). The study by Hötker and Segebade (2000) showed that chick survival had a much larger impact on breeding success than hatching success, and that breeding success was strongly positively correlated with June temperature. There is, however, no clear (negative) trend in June temperatures in the Wadden Sea (data by www.wetteronline.de).

Tab. 8a: Hatching success of Avocet in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Apparent hatching success (%)	Calculated hatching probability
NL	Texel, De Petten/'t Stoar	coastal wetland	2010	5	0	
NL	Groninger Kust, Klutenplas	coastal wetland	2010	40	72	0.55
NL	Groninger Kust, Noordpolder	saltmarsh	2011	29	6	0.03
NL	Eems, Hoogwatum	polder	2012	31	0	
NL	Groninger Kust, Dollard	saltmarsh	2012	78	1	0.07
DE-NDS	Norderney	saltmarsh	2010	34	79	0.76
DE-NDS	Norderney	saltmarsh	2011	44	16	0.12
DE-NDS	Norderney	saltmarsh	2012	29	66	0.61
DE-NDS	Iheringsgroden	polder (clay pit)	2012	20	85	
DE-NDS	Beckmannsfeld	saltmarsh	2010	30	58	
DE-NDS	Beckmannsfeld	saltmarsh	2011	15	2	
DE-NDS	Binnenpütten Augustgroden	polder (clay pit)	2011	20	47	
DE-SH	Kaiser-Wilhelm-Koog-Vorland	saltmarsh	2009	108		0.18
DE-SH	Kaiser-Wilhelm-Koog-Vorland	saltmarsh	2010	209		0.13
DE-SH	Kaiser-Wilhelm-Koog-Vorland	saltmarsh	2011	146		0.21 - 0.37
DE-SH	Kaiser-Wilhelm-Koog-Vorland	saltmarsh	2012	142		0.15
DE-SH	Hamburger Hallig	saltmarsh	2009	61		0.11
DE-SH	Hamburger Hallig	saltmarsh	2010	36		0

Tab. 8b: Hatching success of Avocet in the Wadden Sea 2009-2012. Causes of egg losses

Country	Sitename	Year	Cause of egg losses in %						
			Predation	Flood-ing	Tram-pling	Unfa-vourable weather	Food short-age	Other factors	Un-known
NL	Texel, De Petten/'t Stoar	2010	0	0	0	0	0	0	100
NL	Groninger Kust, Klutenplas	2010	60	0	0	0	0	20	20
NL	Groninger Kust, Noordpolder	2011	38	25	0	0	0	25	12
NL	Eems, Hoogwatum	2012	0	0	0	0	0	100	0
NL	Groninger Kust, Dollard	2012	11	0	0	0	5	10	74
DE-NDS	Norderney	2010	43	0	0	0	0	43	14
DE-NDS	Norderney	2011	11	75	0	0	0	14	0
DE-NDS	Norderney	2012	40	10	0	0	0	40	10
DE-NDS	Iheringsgroden	2012	46	0	0	0	0	18	36
DE-NDS	Beckmannsfeld	2010	33	40	0	0	0	3	25
DE-NDS	Beckmannsfeld	2011	64	31	0	0	0	0	4
DE-NDS	Binnenpütten Augustgroden	2011	0	0	0	0	0	22	78
DE-SH	Kaiser-Wilhelm-Koog-Vorland	2009	100	0	0	0	0	0	0
DE-SH	Kaiser-Wilhelm-Koog-Vorland	2010	48	34	0	0	0	2	0
DE-SH	Kaiser-Wilhelm-Koog-Vorland	2011	ca 47	ca 53	0	0	0	0	0
DE-SH	Kaiser-Wilhelm-Koog-Vorland	2012	63	37	0	0	0	0	0
DE-SH	Hamburger Hallig	2009	69	21	0	0	0	10	0
DE-SH	Hamburger Hallig	2010	86	8	0	0	0	6	0

Avocet. Photo: G. Reichert

Tab. 9:
Breeding success of Avocet in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
NL	Terschelling, Noordvaarder	dunes	2012	2	0		O Observation
NL	Rottumerplaat	outer sand	2010	2	0		O Observation
NL	Balgzand	saltmarsh	2010	35	0	Predation	O Observation
NL	Groninger Kust, Klutenplas	coastal wetland	2010	101	0.26	Predation	O Observation
NL	Groninger Kust, Klutenplas	coastal wetland	2011	61	0.05	Predation	O Observation
NL	Groninger Kust, Klutenplas	coastal wetland	2012	22	0	Predation	O Observation
NL	Groninger Kust, Ruidhorn	coastal wetland	2012	194	0.12		O Observation
NL	Eems, Hoogwatum	polder	2011	7	0	Agricultural activities	O Observation
NL	Eems, Hoogwatum	polder	2012	31	0	Agricultural activities	O Observation
NL	Groninger Kust, Polder Breebaart	coastal wetland	2010	22	0	Predation	O Observation
NL	Groninger Kust, Polder Breebaart	coastal wetland	2011	30	0	Predation	O Observation
NL	Groninger Kust, Punt Van Reide	saltmarsh	2011	30	0	Predation	O Observation
NL	Groninger Kust, Dollard	saltmarsh	2010	45	0.13	Flooding	O Observation
NL	Groninger Kust, Dollard	saltmarsh	2011	75	0	Flooding	O Observation
NL	Groninger Kust, Dollard	saltmarsh	2012	111	0	Predation	O Observation
DE-NDS	Norderney	saltmarsh	2010	33	0.15	Flooding	O Observation
DE-NDS	Norderney	saltmarsh	2011	26	0	Unfavourable weather	O Observation
DE-NDS	Norderney	saltmarsh	2012	24	0.13	Unfavourable weather	O Observation
DE-NDS	Iheringsgroden	polder (clay pit)	2012	111	0.26	Disturbance	O Observation
DE-NDS	Beckmannsfeld	saltmarsh	2010	57	0.19		O Observation
DE-NDS	Beckmannsfeld	saltmarsh	2011	8	0		O Observation
DE-NDS	Binnenpütten Augustgroden	polder (clay pit)	2011	204	0.32		O Observation
DE-SH	Kaiser-Wilhelm-Koog-Vorland	saltmarsh	2009	392	0.04	Flooding	O Observation
DE-SH	Kaiser-Wilhelm-Koog-Vorland	saltmarsh	2010	222	0.05		O Observation
DE-SH	Kaiser-Wilhelm-Koog-Vorland	saltmarsh	2011	146	0		O Observation
DE-SH	Kaiser-Wilhelm-Koog-Vorland	saltmarsh	2012	195	0.04		O Observation
DE-SH	Beltringharder Koog	polder (freshwater and saltwater lakes)	2009	140	0.04		O Observation
DE-SH	Beltringharder Koog	polder (freshwater and saltwater lakes)	2010	273	0.14		O Observation
DE-SH	Beltringharder Koog	polder (freshwater and saltwater lakes)	2011	452	0.15		O Observation
DE-SH	Beltringharder Koog	polder (freshwater and saltwater lakes)	2012	298	0.09		O Observation
DE-SH	Hamburger Hallig	saltmarsh	2009	40	0.05		O Observation
DE-SH	Hamburger Hallig	saltmarsh	2010	36	0		O Observation
DE-SH	Fahretofter Westerkoog	polder (freshwater lake)	2009	144	0.17		O Observation
DE-SH	Fahretofter Westerkoog	polder (freshwater lake)	2010	250	0.18		O Observation
DE-SH	Fahretofter Westerkoog	polder (freshwater lake)	2011	383	0.29		O Observation
DE-SH	Fahretofter Westerkoog	polder (freshwater lake)	2012	348	0.15		O Observation

3.5 Black-headed Gull

Hatching success

Hatching success was monitored in the Netherlands (5 colonies 1 year), in Niedersachsen (1 colony 3 years, 1 colony one year) and in Schleswig-Holstein (1 site 2 years) (Table 10a, b).

The hatching success was very variable, from complete failure to 98% hatching, and the variation from failure to a high hatching success was found within each country. Even at the same site in the same year, Friedrichskoog Vorland in Schleswig-Holstein in 2012, a large variation was found among the colonies, from an almost complete failure (5% hatching) in one colony to a very high hatching success (98%) in another. The un-weighted mean of the apparent hatching success in all the studied colonies and years was 40%.

Only in 4 out of 13 study plots and years, the most important cause of egg losses was determined. In three cases the main cause of failure was predation and the last one flooding.

Breeding success

Breeding success was assessed in the Netherlands (1 colony 3 years, 3 colonies 2 years, 10 colonies 1 year), in Niedersachsen (1 colony 3 years, 1 colony 1 year) and in Schleswig-Holstein (1 site 2 years) (Table 11).

In 6 colonies and years (22%) the breeding success was above 0.5 young per pair, and in 5 of these (19%) at 0.9 or above. In 2 (7.5%) the breeding success was moderate between 0.3 and 0.5 young per pair, another 3 (11%) had a low breeding success between 0.1 and 0.29 young per pair, whereas the remaining 16 (59.5%) had complete or almost complete breeding failure (Tab. 11). The un-weighted mean was 0.30 fledged young per pair in the entire Wadden Sea, with the highest value 0.63 in Schleswig-Holstein. In the Netherlands there were 0.25 fledged young per pair and in Niedersachsen 0.23.

The main causes of fledging failure was determined in 11 out of the 27 monitored colonies and years, and all of these 11 had a high failure rate with only 0 to 0.29 fledged young per pair. In 5 (45%) flooding was the main cause of failure, in 4 (36%) it was predation, whereas in one case starvation and in one unfavourable weather was the main cause of breeding failure. In addition, predation was the possible main cause of failure in one case.

Black-headed Gull decreased moderately in the Wadden Sea between 1991 and 2011 except in Denmark, where the species tended to increase (not statistically significantly), and in Schleswig-Holstein where it remained stable (Koffijberg *et al.* 2015a). This is in line with the fact that Schleswig-Holstein also supported the best breeding performance, compared to Niedersachsen and the Netherlands, although even in the monitored site in Schleswig-Holstein the found mean value is well below the assumed necessary 0.9-1.4 fledged young per pair to retain stability. In the Dutch Wadden Sea, the low reproductive output even declined significantly during 2005-2013 and was exceptionally low in 2010-2013 (Koffijberg *et al.* 2015b). Most of the mainland coast has been abandoned as a breeding site, which is assumed to be linked to disturbance by predators (Bos *et al* 2015). This seems to be a rather recent phenomenon, as breeding success was higher around 2000. A study of the breeding success in seven Dutch coastal breeding sites 1997-2003 – including some of the same colonies monitored within the present programme – found a breeding success of 0.7 young per pair (van Dijk *et al.* 2009), much higher than the 0.25 in 2010-2012 in the Netherlands or 0.3 across the Wadden Sea, found in this study (see also BOX 5). But even 0.7 young per pair is hardly enough to counterbalance mortality. Bensch and Källander (1997) estimated that between 0.7 and 1.5 young per pair is necessary (most likely 0.9-1.4) for a balanced population development. Inconsistencies among published adult and first year survival rates is the main reason for the quite large margin in these figures (Bensch & Källander 1997).

BOX 5: Long term trends in breeding success in Black-headed Gull

In the past decade, an increasing share of the breeding population of Black-headed Gull in the Dutch Wadden Sea breeds at the island of Griend. This colony is less susceptible to higher flooding and free of mammalian predators. Hence, breeding success on average showed a high level until 2010. In 2011 the colony failed entirely, whereas in 2012 only few chicks were observed. The poor breeding success after 2010 is probably associated with starvation of chicks due to food shortage (D. Lutterop & G. Kasemir/Natuurmonumenten).

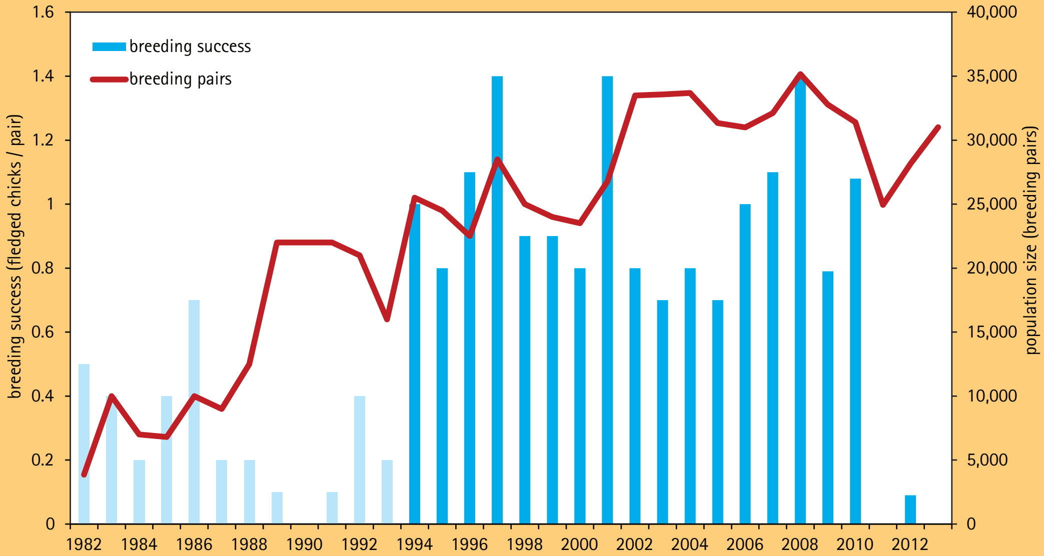

Fig. 4: Long term trends in breeding numbers (right axis) and breeding success (left axis) of Black-headed Gull on the island of Griend. Note the difference in method before and after 1994. Before 1994 the number of chicks was assessed by visual observations (which finally underestimates breeding success), after 1994 it was determined in a sample of the colony with help of enclosures. Source: van Dijk & Oosterhuis 2010, D. Lutterop & G. Kasemir/Natuurmonumenten, Sovon Vogelonderzoek Nederland).

Tab.10a: Hatching success of Black-headed Gull in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Apparent hatching success (%)	Calculated hatching probability
NL	Griend	outer sand	2011	18	39	
NL	Ameland, Schelpenpolle	outer sand	2011	3,500	0	
NL	Schiermonnikoog, Ooster-kwelder 8e Slenk	saltmarsh	2012	22	0	
NL	Groninger Kust, Klutenplas	coastal wetland	2010	25	68	0.58
NL	Delfzijl, Schermpier	beach	2010	24	0	
DE-NDS	Baltrum	saltmarsh	2011	35	21	
DE-NDS	Minsener Ostdünen	dunes	2010	48	67	
DE-NDS	Minsener Ostdünen	dunes	2011	36	65	
DE-NDS	Minsener Ostdünen	dunes	2012	31	96	
DE-SH	Friedrichskoog Vorland	saltmarsh	2011	140	0	
DE-SH	Friedrichskoog Vorland 1	saltmarsh	2012	65	5	
DE-SH	Friedrichskoog Vorland 2	saltmarsh	2012	99	59	
DE-SH	Friedrichskoog Vorland 3	saltmarsh	2012	33	98	

Tab. 10b: Hatching success of Black-headed Gull in the Wadden Sea 2009-2012. Causes of egg losses

Country	Sitename	Year	Cause of egg losses in %						
			Preda-tion	Flooding	Tram-pling	Unfa-vourable weather	Food short-age	Other factors	Un-known
NL	Griend	2011		0					
NL	Ameland, Schelpenpolle	2011							
NL	Schiermonnikoog, Ooster-kwelder 8e Slenk	2012		0					
NL	Groninger Kust, Klutenplas	2010	50	0	0	0	0	50	0
NL	Delfzijl, Schermpier	2010							
DE-NDS	Baltrum	2011	5	0	0	0	0	0	95
DE-NDS	Minsener Ostdünen	2010	65	0	0	0	0	0	35
DE-NDS	Minsener Ostdünen	2011	100	0	0	0	0	0	0
DE-NDS	Minsener Ostdünen	2012	0	0	0	0	0	0	100
DE-SH	Friedrichskoog Vorland	2011	0	100	0	0	0	0	0
DE-SH	Friedrichskoog Vorland 1	2012							
DE-SH	Friedrichskoog Vorland 2	2012							
DE-SH	Friedrichskoog Vorland 3	2012							

Tab. 11: Breeding success of Black-headed Gull in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
NL	Texel, 't Stoar	coastal wetland	2010	454	0.61	Unknown	O Observation
NL	Texel, 't Stoar	coastal wetland	2011	525	0	Unknown	O Observation
NL	Texel, De Petten	coastal wetland	2011	107	0.01	Unknown	O Observation
NL	Texel, Oude Molenkolk	coastal wetland	2010	14	0.5	Various causes	O Observation
NL	Griend	outer sand	2010	25	1.08		F Fencing
NL	Griend	outer sand	2011	24,942	0	Starvation	F Fencing
NL	Griend	outer sand	2012	28,157	0.09	Unknown	O Observation
NL	Ameland, Hollumerkwelder	saltmarsh	2011	3,000	0	Flooding	O Observation
NL	Ameland, Feugelpôlle	saltmarsh	2012	2,850	0	Flooding	O Observation
NL	Ameland, Schelpenpolle	outer sand	2011	3,500	0	Flooding	O Observation
NL	Schiermonnikoog, Ooster-kwelder 8e Slenk	saltmarsh	2012	22	0	Unknown	O Observation
NL	Rottumerplaat	outer sand	2010	20	0	Unknown	O Observation
NL	Rottumerplaat	outer sand	2011	28	0	Unknown	O Observation
NL	Balgzand	saltmarsh	2010	167	0	Predation	O Observation
NL	Amstelmeer Bij Verzakking	coastal wetland	2011	3,025	0.02	Predation	O Observation
NL	Groninger Kust, Klutenplas	coastal wetland	2010	353	0.13	Predation	F Fencing
NL	Delfzijl, Schermpier	beach	2010	24	0	Predation	F Fencing
NL	Delfzijl, Schermpier - Ponton	artificial struc-ture	2010	38	1.37		F Fencing
NL	Delfzijl, Schermpier - Ponton	artificial struc-ture	2012	259	0.97	Unknown	F Fencing
DE-NDS	Baltrum	saltmarsh	2011	28	0	Predation possible	F Fencing
DE-NDS	Minsener Ostdünen	dunes	2010	47	0.21	Not speci-fied	F Fencing
DE-NDS	Minsener Ostdünen	dunes	2011	34	0.29	weather	F Fencing
DE-NDS	Minsener Ostdünen	dunes	2012	31	0.42	Not speci-fied	F Fencing
DE-SH	Friedrichskoog Vorland	saltmarsh	2011	140	0	Flooding	O Observation
DE-SH	Friedrichskoog Vorland 1	saltmarsh	2012	65	0.02	Flooding	O Observation
DE-SH	Friedrichskoog Vorland 2	saltmarsh	2012	99	1.6		O Observation
DE-SH	Friedrichskoog Vorland 3	saltmarsh	2012	33	0.9		O Observation

3.6 Lesser Black-backed Gull

Hatching success

Hatching success was monitored in the Netherlands (1 colony 3 years, 2 colonies 2 years, 2 colonies 1 year), Niedersachsen (1 colony 3 years, 1 colony 2 years), Schleswig-Holstein (1 colony 3 years, 1 colony 2 years, 2 colonies 1 year) and Denmark (1 colony 1 year) (Table 12a, b).

The hatching success was consistently high in the colonies in Niedersachsen, Schleswig-Holstein and Denmark at between 70 and 93%, whereas it was more variable in the Netherlands at between 28 and 100%. The un-weighted mean of the apparent hatching success was 60% in the Netherlands and 80% in Germany and Denmark combined.

In 5 out of 22 study plots and years, the principal cause of egg losses was determined, and in all five cases, predation was the most important cause of egg loss.

Breeding success

Breeding success was assessed in the Netherlands (2 colonies 2 years, 2 colonies 1 year), Niedersachsen (1 colony 3 years, 1 colony 2 years), Schleswig-Holstein (1 colony 3 years, 1 colony 2 years, 2 colonies 1 year) and Denmark (1 colony 4 years) (Table 13).

In 7 colonies and years (32%) the breeding success was above 0.6 young per pair, in 5 (23%) the breeding success was moderate between 0.3 and 0.6 young per pair, another 5 (23%) had a low breeding success between 0.1 and 0.29 young per pair, whereas 5 (23%) had complete or almost complete breeding failure (Table 13). The un-weighted mean was 0.42 fledged young per pair in the entire Wadden Sea, with the highest value 0.65 in Niedersachsen, in Denmark 0.59 young per pair fledged, in the Netherlands 0.33 and in Schleswig-Holstein 0.25.

Lesser Black-backed Gull colonised the Danish Wadden Sea in the 1990s, and continued to increase steeply in the 2000s. The main colony is found on Langli, and here the breeding success was studied in 2001, when 1.64 fledged young per pair was found (Thorup 2001). The present 0.59 fledged young per pair in 2009-2012 is considerably lower.

The main causes of fledging failure was determined in 12 out of the 21 monitored colonies and years, of which 7 had a low or moderate breeding success (0.6 young per pair or lower). Out of the seven colonies, predation was the main cause of failure in two, starvation in one, predation and unfavourable weather in one, possibly predation in combination with disturbance in another two, and possibly predation in one.

There has been a strong increase in Lesser Black-backed Gull breeding numbers in the entire Wadden Sea 1991-2011(Koffijberg *et al.* 2015a). The low breeding success in Schleswig-Holstein and the Netherlands 2010-2012 found in the TMAP-scheme, may indicate that Lesser Black-backed Gulls will have problems to maintain the population at the present level, and with such levels of breeding success declines are likely to occur (Camphuysen 2013). In the Dutch Wadden Sea, data after 2010 (weighted values) suggest that Lesser-Black Backed Gulls were performing better than in the period prior to 2010 (Koffijberg *et al.* 2015b).

Tab.12a:
Hatching success of Lesser Black-backed Gull in the Wadden Sea 2009-2012. For Trischen 2010-2011, data are from unspecified Lesser Black-backed Gull and Herring Gull nests.

Country	Sitename	Habitat	Year	Sample size	Apparent hatching success (%)	Calculated hatching probability
NL	Texel, Kelderhuispolder	dunes	2010	65	84	
NL	Texel, Kelderhuispolder	dunes	2011	32	71	
NL	Texel, Kelderhuispolder	dunes	2012	30	68	
NL	Texel, Westerduinen-Proefvlak	dunes	2010	7	71	
NL	Texel, Westerduinen	dunes	2011	9	100	
NL	Vlieland, Vliehors, Middelste Stuifdijk	beach	2010	32	28	0.66
NL	Vlieland, Vliehors	beach	2012	20	30	0.47
NL	Rottumerplaat, Zuidkwelder	outer sand	2011	19	31	0.81
NL	Rottumerplaat, Noordkwelder	outer sand	2012	22	54	0.89
DE-NDS	Norderney Ostheller	dunes	2011	76	93	0.92
DE-NDS	Norderney Ostheller	dunes	2012	79	87	0.87
DE-NDS	Minsener Ostdünen	dunes	2010	20	85	
DE-NDS	Minsener Ostdünen	dunes	2011	21	81	
DE-NDS	Minsener Ostdünen	dunes	2012	21	70	
DE-SH	Trischen	dunes	2010	129	84	
DE-SH	Trischen	dunes	2011	199	76	
DE-SH	Trischen	dunes	2012	80	74	
DE-SH	Amrum, Schwimmbad	dunes	2011	50	90	
DE-SH	Amrum, Schwimmbad	dunes	2012	108	72	
DE-SH	Amrum, Himmelsleiter	dunes	2011	28	75	
DE-SH	Amrum, Vogelkoje	dunes	2011	63	73	
DK	Langli	dunes	2009	86	84	

Tab. 12b:
Hatching success of Lesser Black-backed Gull in the Wadden Sea 2009-2012. For Trischen 2010-2011, data are from unspecified Lesser Black-backed Gull and Herring Gull nests. Causes of egg losses.

Country	Sitename	Year	Cause of egg losses in %						
			Predation	Flooding	Trampling	Unfavourable weather	Food shortage	Other factors	Unknown
NL	Texel, Kelderhuispolder	2010		0					
NL	Texel, Kelderhuispolder	2011		0					
NL	Texel, Kelderhuispolder	2012		0					
NL	Texel, Westerduinen-Proefvlak	2010		0					
NL	Texel, Westerduinen	2011		0					
NL	Vlieland, Vliehors, Middelste Stuifdijk	2010	33	0	0	0	0	61	6
NL	Vlieland, Vliehors	2012	46	0	0	0	0	54	0
NL	Rottumerplaat, Zuidkwelder	2011	0	0	0	0	0	0	0
NL	Rottumerplaat, Noordkwelder	2012	0	0	0	0	0	0	0
DE-NDS	Norderney Ostheller	2011	60	0	0	0	0	0	40
DE-NDS	Norderney Ostheller	2012	20	0	0	0	0	20	60
DE-NDS	Minsener Ostdünen	2010	100	0	0	0	0	0	0
DE-NDS	Minsener Ostdünen	2011	82	0	0	0	0	18	0
DE-NDS	Minsener Ostdünen	2012	53	0	0	0	0	24	24
DE-SH	Trischen	2010	64	0	0	0	0	0	36
DE-SH	Trischen	2011							
DE-SH	Trischen	2012							
DE-SH	Amrum, Schwimmbad	2011							
DE-SH	Amrum, Schwimmbad	2012							
DE-SH	Amrum, Himmelsleiter	2011							
DE-SH	Amrum, Vogelkoje	2011							
DK	Langli	2009							100

Tab. 13: Breeding success of Lesser Black-backed Gull in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
NL	Texel, Kelderhuispolder	dunes	2010	65	0.71	Canibalism	F Fencing
NL	Texel, Kelderhuispolder	dunes	2011	32	0.69	Canibalism	F Fencing
NL	Texel, Westerduinen-Proefvlak	dunes	2010	7	0	Predation	F Fencing
NL	Texel, Westerduinen	dunes	2011	9	0.22	Various causes	F Fencing
NL	Vlieland, Vliehors	saltmarsh	2010	36	0.36		F Fencing
NL	Balgzand	saltmarsh	2010	117	0	Predation	O Observation
DE-NDS	Norderney Ostheller	dunes	2011	51	0.9	Predation/starvation	F Fencing
DE-NDS	Norderney Ostheller	dunes	2012	46	0.54	Starvation	F Fencing
DE-NDS	Minsener Ostdünen	dunes	2010	19	0.16	Predation, hot weather	F Fencing
DE-NDS	Minsener Ostdünen	dunes	2011	21	0.9	weather	F Fencing
DE-NDS	Minsener Ostdünen	dunes	2012	20	0.75	weather	F Fencing
DE-SH	Trischen	dunes	2010	14	0.43		
DE-SH	Trischen	dunes	2011	21	0.25		
DE-SH	Trischen	dunes	2012	31	0.26		
DE-SH	Amrum, Schwimmbad	dunes	2011	50	0.30	Possibly predation, disturbance	R Mark and recapture
DE-SH	Amrum, Schwimmbad	dunes	2012	108	0.06	Weather, possibly predation, disturbance	R Mark and recapture
DE-SH	Amrum, Himmelsleiter	dunes	2011	28	0.43	Possibly predation	R Mark and recapture
DE-SH	Amrum, Vogelkoje	dunes	2011	63	0	Possibly predation, disturbance	R Mark and recapture
DK	Langli	dunes	2009	721	1.24		O Observation
DK	Langli	dunes	2010	1019	1.00		O Observation
DK	Langli	dunes	2011	1988	0.02	Unknown	O Observation
DK	Langli	dunes	2012	1778	0.11	Unknown	O Observation

3.7 Herring Gull

Hatching success

Hatching success was monitored in the Netherlands (1 colony 3 years, 2 colonies 2 years, 1 colony 1 year), Niedersachsen (1 colony 3 years, 1 colony 2 years), Schleswig-Holstein (1 colony 3 years, 1 colony 2 years, 2 colonies 1 year) and Denmark (1 colony 1 year) (Table 14a,b).

The hatching success was consistently high in the colonies in Niedersachsen, Schleswig-Holstein and Denmark between 64 and 92%, whereas it was more variable in the Netherlands between 28 and 95%. The un-weighted mean of the apparent hatching success was 60% in the Netherlands and 77% in Germany and Denmark combined.

In 6 out of 21 study plots and years, the principal causes of egg losses was determined, and only in one of the six plots, there was failure rate of above 50%. In four colonies predation was the most important cause of egg loss, and in two, infertile eggs was the most important cause of hatching failure.

Breeding success

Breeding success was assessed in the Netherlands (1 colony 2 years, 3 colonies 1 year), Niedersachsen (1 colony 3 years, 1 colony 2 years), Schleswig-Holstein (1 colony 3 years, 1 colony 2 years, 2 colonies 1 year) and Denmark (1 colony 4 years) (Table 15).

In 6 colonies and years (29%) the breeding success was above 0.6 young per pair, in 10 (48%) the fledging success was moderate between 0.3 and 0.6 young per pair, another 3 had a low fledging success, whereas 2 had complete or almost complete breeding failure (Table 15). The un-weighted mean was 0.49 fledged young per pair in the entire Wadden Sea, with the highest value 0.73 in Niedersachsen, in the Netherlands 0.63 young per pair fledged, 0.32 in Schleswig-Holstein and 0.29 in Denmark.

The main cause of fledging failure has been determined in 12 out of the 21 monitored colonies and years, of which 7 had a low or moderate fledging success (0.6 young per pair or lower). Out of the seven colonies, predation was the main cause of failure in one, possibly predation

BOX 6: Long-term trends in breeding success in Herring Gull

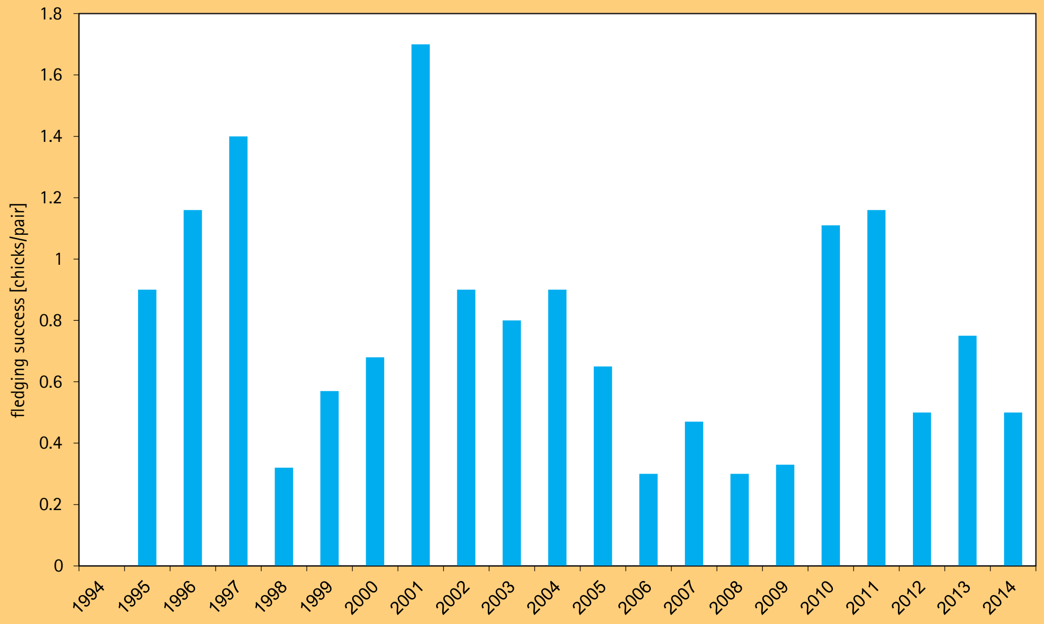

Fig. 5: Breeding success (chicks/pair) of Herring Gulls on a sample plot on Mellum island Niedersachsen from 1995 onwards. For measuring fledging success 20 nests were individually fenced and checked every 3 days. At the same interval body mass of the chicks was measured. Breeding success shows strong fluctuations, the overall mean is 0.77 chicks per pair which is considered to be sufficient for a stable population. Breeding successes is weakly correlated to body mass increase rate of the chicks at an age between 5 and 25 days. A preliminary analysis showed no density dependence of breeding success within the study plot. Data source: Institute for Avian Research & Der Mellumrat e.V.

in another two, and predation or starvation in two. In one weather or starvation were the main causes, and in the last colony with low or moderate fledging success a combination of unfavourable weather, disturbance and possibly also predation was given as the main causes.

Becker and Exo (1991) studied the breeding success of Herring Gulls on Mellum in Niedersachsen in four years between 1979 and 1990. Their study took place in a period with a population recovery, and they found an un-weighted mean breeding success of 0.9 fledged young per pair. Within this monitoring programme, a very similar breeding success of 0.92 young per pair was found in 2010-2012 at the monitored Mellum colony (see BOX 6 for long-term data from a Mellum study plot 1994-2014). On Langli in Denmark, on the other hand, the un-weighted mean of 0.29 fledged young per pair found in 2009-2012 is a considerably lower fledging success than the 1.07 found as the mean in nine years between 1992 and 2001 (Thorup 2001).

The monitoring of breeding numbers 1991-2011 shows an overall moderate decline in the Wadden Sea including the two largest populations in the Netherlands and Niedersachsen. On the other hand, numbers are stable in Schleswig-Holstein and increasing in the Danish Wadden Sea (Koffijberg *et al.* 2015a).These findings contradict with the data found on breeding success. It is not clear if this is caused by the relatively small sample, by the delay in which low breeding success will be working at population level or it is because population sizes are not regulated primarily by the breeding success. The normal age at start of breeding is around 4-5 years (Pierotti & Good 1994), so the breeding success in the years 2009-2012 will first be expected to impact the recruitment in the coming years. Camphuysen (2013) found that the decline in the Herring Gull population in his study plot on Texel was primarily the result of low annual survival (see also van der Jeugd *et al.* 2014). In the Dutch Wadden Sea, breeding success also increased during 2005-2013, though not statistically significant (Koffijberg *et al.* 2015b). Recent census data from the Dutch Wadden Sea also point at a slight increase (or a recovery from lower population levels) (Boele *et al.* 2016).

Tab. 14a:
Hatching success of Herring Gull in the Wadden Sea 2009-2012. For Trischen 2010-2011, data are from unspecified Lesser Black-backed Gull and Herring Hull nests.

Country	Sitename	Habitat	Year	Sample size	Apparent hatching success (%)	Calculated hatching probability
NL	Texel, Kelderhuispolder	dunes	2010	24	82	
NL	Texel, Kelderhuispolder	dunes	2011	23	65	
NL	Texel, Kelderhuispolder	dunes	2012	23	71	
NL	Texel, Westerduinen- Proefvlak	dunes	2010	64	95	
NL	Vlieland, Vliehors, Middelste Stuifdijk	beach	2010	21	42	0.62
NL	Vlieland, Vliehors	beach	2012	15	46	0.48
NL	Rottumerplaat, Noordkwelder	outer sand	2011	14	28	1.00
NL	Rottumerplaat, Noordkwelder	outer sand	2012	19	47	0.92
DE-NDS	Norderney Ostheller	dunes	2011	36	64	0.55
DE-NDS	Norderney Ostheller	dunes	2012	36	92	0.88
DE-NDS	Mellum Süddüne	dunes	2010	65	84	
DE-NDS	Mellum Süddüne	dunes	2011	44	82	
DE-NDS	Mellum Süddüne	dunes	2012	46	69	
DE-SH	Trischen	dunes	2010	129	84	
DE-SH	Trischen	dunes	2011	199	76	
DE-SH	Trischen	dunes	2012	98	68	
DE-SH	Amrum, Schwimmbad	dunes	2011	46	72	
DE-SH	Amrum, Schwimmbad	dunes	2012	68	68	
DE-SH	Amrum, Himmelsleiter	dunes	2011	24	82	
DE-SH	Amrum, Leuchtturm	dunes	2011	32	74	
DK	Langli	dunes	2009	78	86	

Tab. 14b:
Hatching success of Herring Gull in the Wadden Sea 2009-2012. For Trischen 2010-2011, data are from unspecified Lesser Black-backed Gull and Herring Gull nests. Causes of egg losses.

Country	Sitename	Year	Cause of egg losses in %						
			Predation	Flooding	Trampling	Unfavourable weather	Food shortage	Other factors	Unknown
NL	Texel, Kelderhuispolder	2010		0					
NL	Texel, Kelderhuispolder	2011		0					
NL	Texel, Kelderhuispolder	2012		0					
NL	Texel, Westerduinen- Proefvlak	2010		0					
NL	Vlieland, Vliehors, Middelste Stuifdijk	2010	27	0	0	0	0	64	9
NL	Vlieland, Vliehors	2012	50	0	0	0	0	50	0
NL	Rottumerplaat, Noordkwelder	2011							
NL	Rottumerplaat, Noordkwelder	2012							
DE-NDS	Norderney Ostheller	2011	31	8	0	0	0	53	8
DE-NDS	Norderney Ostheller	2012	33	0	0	0	0	0	67
DE-NDS	Mellum Süddüne	2010	3	0	0	0	0	97	0
DE-NDS	Mellum Süddüne	2011	46	0	0	0	0	55	0
DE-NDS	Mellum Süddüne	2012	74	0	0	0	0	24	3
DE-SH	Trischen	2010	64	0	0	0	0	0	36
DE-SH	Trischen	2011							
DE-SH	Trischen	2012							
DE-SH	Amrum, Schwimmbad	2011							
DE-SH	Amrum, Schwimmbad	2012							
DE-SH	Amrum, Himmelsleiter	2011							
DE-SH	Amrum, Leuchtturm	2011							
DK	Langli	2009							100

Tab. 15: Breeding success of Herring Gull in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
NL	Texel, Kelderhuispolder	dunes	2010	24	1.33	Predation	F Fencing
NL	Texel, Kelderhuispolder	dunes	2011	23	0.48		F Fencing
NL	Texel, Westerduinen- Proefvlak	dunes	2010	62	0.73	Predation	F Fencing
NL	Vlieland, Vliehors	saltmarsh	2010	27	0.63		F Fencing
NL	Balgzand	saltmarsh	2010	86	0	Predation	O Observation
DE-NDS	Norderney Ostheller	dunes	2011	20	0.45	Predation/starvation	F Fencing
DE-NDS	Norderney Ostheller	dunes	2012	20	0.45	Predation/starvation	F Fencing
DE-NDS	Mellum Süddüne	dunes	2010	18	1.11	Starvation	F Fencing
DE-NDS	Mellum Süddüne	dunes	2011	19	1.16	Starvation	F Fencing
DE-NDS	Mellum Süddüne	dunes	2012	20	0.5	Weather/ starvation	F Fencing
DE-SH	Trischen	dunes	2010	14	0.43		
DE-SH	Trischen	dunes	2011	21	0.25		
DE-SH	Trischen	dunes	2012	34	0.18		
DE-SH	Amrum, Schwimmbad	dunes	2011	46	0.63	Possibly predation, disturbance	R Mark and recapture
DE-SH	Amrum, Schwimmbad	dunes	2012	68	0.12	Weather, possibly predation, disturbance	R Mark and recapture
DE-SH	Amrum, Himmelsleiter	dunes	2011	24	0.33	Possibly predation	R Mark and recapture
DE-SH	Amrum, Leuchtturm	dunes	2011	32	0.31	Possibly predation	R Mark and recapture
DK	Langli	dunes	2009	5,432	0.41		O Observation
DK	Langli	dunes	2010	6,230	0.42		O Observation
DK	Langli	dunes	2011	6,283	0.09	Unknown	O Observation
DK	Langli	dunes	2012	9,143	0.22	Unknown	O Observation

3.8 Sandwich Tern

Hatching success

Apart from a very small sample from Langli in Denmark in 2009, where 22 of 33 marked nests hatched (67%), hatching success of Sandwich Terns was not monitored in the Wadden Sea in 2009-2012.

Breeding success

Breeding success was monitored in three colonies each year 2010-2012 in the Netherlands (Table 16). In the colonies on Texel and Ameland, the fledging success was every year fairly high to very high, between 0.31 to 1.2 fledged young per pair. In contrast, at the third (and main) site, the outer sand islet Griend, almost no young fledged in two out of the three study years (see also BOX 7). In the colony Feugelpolle on Ameland, part of the colony was flooded in two of the years, since this colony is situated at a very exposed side of the island (van Kleunen *et al.* 2012).

Sandwich Terns increased in the Netherlands the last 30-40 years, after a population low in the 1960s and 1970s due to impact of pesticides (Fleet *et al.* 1994, Koffijberg *et al.* 2015a). In most years Griend is by far the largest colony in the Wadden Sea, supporting 30-50% of the Wadden Sea breeding population (e.g. Fleet *et al.* 1994; Koffijberg *et al.* 2006). Hence, the frequency of breeding failure on this islet will most likely affect the total population size strongly in the Wadden Sea in the future. Recent declines at Griend were to some part compensated by Texel and Ameland, but also imply an overall decline in the breeding population in the Dutch Wadden Sea (Koffijberg *et al.* 2015a, Boele *et al.* 2016).

Tab. 16: Breeding success of Sandwich Tern in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
NL	Texel, De Petten	coastal wetland	2010	1,668	0.52		O Observation
NL	Texel, De Petten	coastal wetland	2011	1,200	1.2		O Observation
NL	Texel, 't Stoar	coastal wetland	2012	920	0.35		O Observation
NL	Griend	outer sand	2010	6,019	0.7		O Observation
NL	Griend	outer sand	2011	8,487	0.01	Predation	O Observation
NL	Griend	outer sand	2012	2,796	0	Unknown	U Unknown
NL	Ameland, Feugelpôlle	saltmarsh	2010	2,700	0.56		O Observation
NL	Ameland, Feugelpôlle	saltmarsh	2011	4,650	0.31	Flooding	O Observation
NL	Ameland, Feugelpôlle	saltmarsh	2012	3,270	0.39	Flooding	O Observation

BOX 7: Long term trends in breeding success in Sandwich Tern in the Dutch Wadden Sea

The island of Griend is the largest settlement of Sandwich Terns in the Wadden Sea. Only very recently (2014-2015) numbers sharply declined and a large increase took place at the island of Texel (not compensating entirely for the loss in numbers at Griend). Breeding success fluctuated throughout the years, but shows signs of a decline after 2003. By the same time, also a downward trend in breeding numbers started. Nearly complete failures occurred both in 2011 and 2012. In 2011 this was caused by the abandonment of the colony of Black-headed Gulls (deserted the colony because of food shortage), which usually prevent large gulls to predate on Sandwich Terns. In 2012 both Black-headed Gull and Sandwich Tern left the colony around the time of first egg-laying. Remaining birds failed due to wet and windy weather and predation by large gulls.

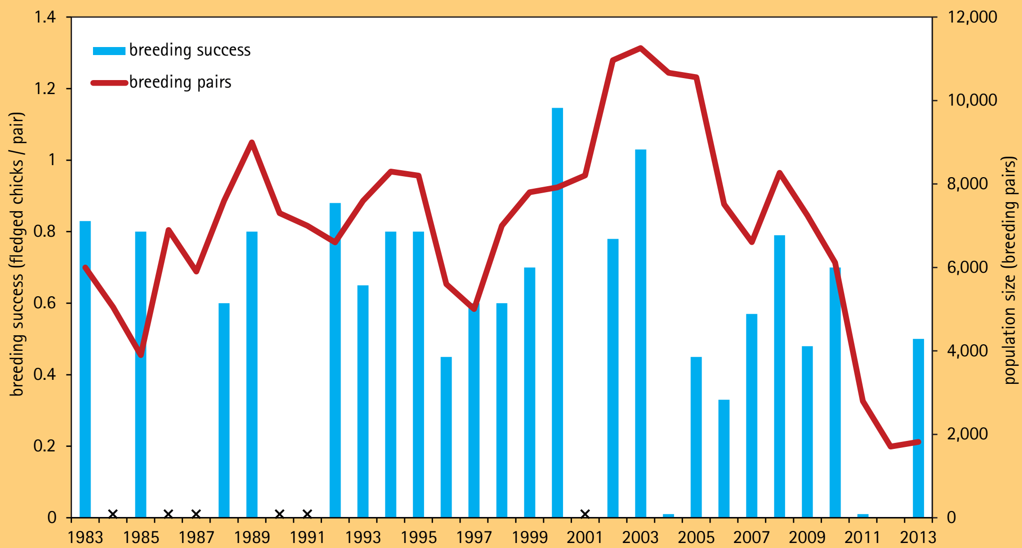

Fig. 6: Trends in breeding numbers (right axis) and breeding success (left axis) of Sandwich Tern on the island of Griend. x no data. Source: D. Lutterop & G. Kasemir/ Natuurmonumenten.

3.9 Common Tern

Hatching success

Hatching success has been monitored in the Netherlands (1 colony 2 years, 5 colonies 1 year), Niedersachsen (2 colonies 1 year), Schleswig-Holstein (2 colonies 2 years, 3 colonies 1 year) and Denmark (1 colony 1 year) (Table 17a and b). In general, the hatching success was high. In Niedersachsen, Schleswig-Holstein and Denmark the success was mostly 50% or higher, with only 3 out of 15 (20%) colonies and years with a lower – and then much lower – hatching success. In the Netherlands the rate of nest failure was lower, with 6 out of 8 colonies and years (75%) having a very low or no hatching success, whereas the remaining two colonies had a high hatching success in one year.

In four cases food shortage was found to be the main cause of nest losses, in two cases unfavourable weather, in another two cases predation, and in two cases flooding was the main cause of nest losses. In one case damage of egg shells was the single most important cause of nest losses.

The monitoring programme of contaminants in bird eggs shows that estuaries of the two rivers Elbe and Ems had the highest concentrations of most contaminant groups, and in eggs of Common Terns in particular eggs from the Elbe estuary had high concentrations (Becker & Dittmann 2009). This breeding success assessment shows no relation between areas with high concentrations of contaminants and lower hatching success. On the contrary, the Neufeld Vorland colonies in the Elbe estuary had a consistent very high hatching success of between 72 and 86% in the four studied years, and also a colony in Delfzijl, situated in the Ems estuary, monitored in 2010, had a very high hatching success (Table 17a). This is in line with the fact that the current levels of most contaminants in bird eggs are below the known threshold concentrations for affecting the reproduction of birds (Becker & Dittmann 2009).

Breeding success

Breeding success was assessed in the Netherlands (1 colony 3 years, 5 colonies 2 years, 8 colonies 1 year), Niedersachsen (1 colony 3 years, 1 colony 1 year) and Schleswig-Holstein (1 colony 4 years, 4 colonies 2 years, 1 colony 1 year) (Table 18). The un-weighted mean of all 38 sites and years is 0.41 fledged young per pair, with the highest value from Niedersachsen with 0.83, Schleswig-Holstein had 0.45 and the Netherlands 0.29 fledged young per pair.

Only the value from Niedersachsen is above the 0.75 fledged young per pair that Stienen *et al.* (2009) modelled from local survival figures collected at the island of Griend necessary to counterbalance mortality in a closed population. Only in eight colonies and years (21%) there was a fledging success above 0.75: in two colonies on Griend in 2011, in two years on an artificial island in Delfzijl, in three years on an artificial island in Banter See in Wilhelmshaven, and in one year in a colony on Hallig Hooge. Hence, the reproductive output in Common Terns in the Wadden Sea is rather low.

On artificial breeding islands in Banter See, Niedersachsen, Becker *et al.* (2001) also found a very high fledging success at 1.3 young per pair in 1992-1999, and in this period the number of breeders increased strongly. In contrast, the fledging success at Griend has for a longer period been well below the 0.75 mark, with 0.41 fledged young per pair 1992-2007 within a study enclosure and an estimated 0.49 in the entire colony (Stienen *et al.* 2009).

In the large Wadden Sea colony Minsener Oldeoog in Niedersachsen there was a weighted mean of 0.82 young per clutch in 1981-1990 (Becker 1992), a period when the number of pairs in this colony was stable (Fleet *et al.* 1994). Burger & Gochfeld (1991) showed, however, that pairs in large colonies consistently had lower fledging success than in smaller colonies in their study area in north-eastern US. In one salt marsh study area the category with the smallest colonies had a mean of approximately 0.35 fledged young per pair, and the category with the largest just above 1.0.

In our monitoring programme a very high 45% of the study plots and years (17 of 38) had no or almost no breeding success at all (<0.02 young per pair). In ten cases the main cause of the lack of breeding success was given (Table 18). In five study plots flooding was the main cause, in four starvation and in one predation. For comparison, in ten seasons 1981-1990 at Minsener Oldeoog only one season had a similar lack of breeding success (Becker 1992). For Griend, Stienen *et al.* (2009) suggest food shortage as one of the causes for the low breeding success.

From 1991 onwards, Common Terns have declined moderately in the Netherlands, Niedersachsen and Denmark. In contrast, breeding numbers fluctuated but remained at a stable overall level in Schleswig-Holstein (Koffijberg *et al.* 2015b). This difference in trends cannot be fully explained by the breeding success monitoring programme, as the observed breeding success was higher in Niedersachsen than in Schleswig-Holstein. Being a mobile species, it is also likely that exchange between colonies occur (see also Stienen *et al.* 2009). Because some catastrophic events in a colony is often explained primarily by local conditions, it is also difficult to evaluate whether the sampled sites are representative for all sites and thereby the total Wadden Sea population. Moreover, it seems that Common Tern perform best at artificial islands (like Banter See) where risk of predation is lower than on natural breeding sites.

For the Dutch Wadden Sea, a more comprehensive analysis of demographic parameters has shown that the low breeding success is the main driver for the observed population decline (van der Jeugd *et al.* 2014). In 2005-2013 breeding success showed considerable variation without a significant trend (Koffijberg *et al.* 2015b).

Country	Sitename	Habitat	Year	Sample size	Apparent hatching success (%)	Calculated hatching probability
NL	Vlieland, Vliehors, Schelpenbank	beach	2010	29	86	0.57
NL	Vlieland, Vliehors, Schelpenbank	beach	2012	24	4	0.01
NL	Ameland, Oostoever Oerdsloot	saltmarsh	2010	26	0	0.01
NL	Rif, Engelsmanplaat	outer sand	2011	75	0	
NL	Schiermonnikoog, Oostoever 3e Slenk	saltmarsh	2010	41	0	0.002
NL	Schiermonnikoog, Oosterkwelder 8e Slenk	saltmarsh	2012	22	0	
NL	Delfzijl, Schermpier, Ponton	artificial structure	2010	31	80	0.54
DE-NDS	Minsener Ostdünen	dunes	2012	25	8	
DE-NDS	Banter See, island B	man-made gravel island	2010	60	71	
DE-SH	Neufeld Vorland	saltmarsh	2009	231	72	
DE-SH	Neufeld Vorland	saltmarsh	2010	158	81	
DE-SH	Neufeld Vorland	saltmarsh	2011	130	86	
DE-SH	Neufeld Vorland	saltmarsh	2012	140	85	
DE-SH	Hallig Hooge Kolonie 1	saltmarsh	2009	3	0	
DE-SH	Hallig Hooge Kolonie 2	saltmarsh	2009	33	74	
DE-SH	Hallig Hooge Kolonie 3	saltmarsh	2009	6	24	
DE-SH	Hallig Hooge Kolonie A	saltmarsh	2011	64	55	
DE-SH	Hallig Hooge Kolonie A	saltmarsh	2012	83	53	
DE-SH	Hallig Hooge Kolonie Da	saltmarsh	2011	58	58	
DE-SH	Hallig Hooge Kolonie Db	saltmarsh	2011	27	71	
DE-SH	Hallig Hooge Kolonie D	saltmarsh	2012	43	70	
DK	Mandø North	saltmarsh	2009	20	50	

Tab. 17a: Hatching success of Common Tern in the Wadden Sea 2009-2012.

Country	Sitename	Year	Cause of egg losses in %						
			Predation	Flooding	Trampling	Unfavourable weather	Food shortage	Other factors	Unknown
NL	Ameland, Oostoever Oerdsloot	2010	85	0	0	0	0	4	11
NL	Vlieland, Vliehors, Schelpenbank	2010	0	0	0	0	0	100	0
NL	Vlieland, Vliehors, Schelpenbank	2012	0	95	0	0	0	0	5
NL	Rif, Engelsmanplaat	2011							
NL	Schiermonnikoog, Oostoever 3e Slenk	2010	0	91	0	0	0	9	0
NL	Schiermonnikoog, Oosterkwelder 8e Slenk	2012		0					
NL	Delfzijl, Schermpier, Ponton	2010	0	0	0	0	0	67	33
DE-NDS	Minsener Ostdünen	2012	75	0	0	0	0	25	0
DE-NDS	Banter See, island B	2010	12	0	0	0	0	88	0
DE-SH	Neufeld Vorland	2009	0	32	0	10	58	0	0
DE-SH	Neufeld Vorland	2010							
DE-SH	Neufeld Vorland	2011	0	0	0	30	0	0	70
DE-SH	Neufeld Vorland	2012							
DE-SH	Hallig Hooge Kolonie 1	2009	20	0	0	20	60	0	0
DE-SH	Hallig Hooge Kolonie 2	2009	20	0	0	20	60	0	0
DE-SH	Hallig Hooge Kolonie 3	2009	20	0	0	20	60	0	0
DE-SH	Hallig Hooge Kolonie A	2011	0	0	0	0	0	0	100
DE-SH	Hallig Hooge Kolonie A	2012	10	0	0	70	20	0	0
DE-SH	Hallig Hooge Kolonie Da	2011	0	0	0	0	0	0	100
DE-SH	Hallig Hooge Kolonie Db	2011	5	0	0	0	0	0	95
DE-SH	Hallig Hooge Kolonie D	2012	10	0	0	70	20	0	0
DK	Mandø North	2009	0	20	0	0	0	0	80

Tab. 17b: Hatching success of Common Tern in the Wadden Sea 2009-2012. Causes of egg losses

Tab. 18:
Breeding success of Common Tern in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
NL	Texel, De Petten	coastal wetland	2011	37	0	Unknown	O Observation
NL	Texel, 't Stoar	coastal wetland	2011	130	0	Unknown	O Observation
NL	Texel, Oude Molenkolk	coastal wetland	2010	15	0.33	Various causes	O Observation
NL	Vlieland, Vliehors, Schelpenbank	beach	2010	75	0.01	Flooding	F Fencing
NL	Vlieland, Vliehors, Schelpenbank	beach	2011	87	0	Flooding	F Fencing
NL	Vlieland, Vliehors	saltmarsh	2012	25	0.2	Flooding	F Fencing
NL	Griend 1	outer sand	2010	721	0.01		O Observation
NL	Griend 1	outer sand	2011	678	0.93		O Observation
NL	Griend 2	outer sand	2010	32	0.56		F Fencing
NL	Griend 2	outer sand	2011	25	1.4		F Fencing
NL	Ameland, Feugelpôlle	saltmarsh	2012	90	0	Flooding	O Observation
NL	Rif, Engelsmanplaat	outer sand	2011	75	0	Flooding	O Observation
NL	Schiermonnikoog, Oosterkwelder 8e Slenk	saltmarsh	2012	26	0	Unknown	O Observation
NL	Rottumerplaat	outer sand	2010	336	0	Unknown	O Observation
NL	Rottumerplaat	outer sand	2011	71	0	Unknown	O Observation
NL	Balgzand	saltmarsh	2010	51	0	Flooding	O Observation
NL	Balgzand, Balgzandpolder Vlotten	artificial structure	2011	8	0.5		O Observation
NL	Balgzand, Van Ewijcksluisschor	saltmarsh	2011	13	0	Unknown	O Observation
NL	Delfzijl, Schermpier - Ponton	artificial structure	2010	197	1.17		F Fencing
NL	Delfzijl, Ponton	artificial structure	2012	384	0.77		F Fencing
DE-NDS	Minsener Ostdünen	dunes	2012	25	0	Predation	F Fencing
DE-NDS	Banter See	man-made gravel islands	2010	435	1.20	Not specified	O Observation
DE-NDS	Banter See	man-made gravel islands	2011	435	1.13	Not specified	O Observation
DE-NDS	Banter See	man-made gravel islands	2012	410	0.99	Not specified	O Observation
DE-SH	Neufeld Vorland	saltmarsh	2009	231	0	Starvation / Weather	O Observation
DE-SH	Neufeld Vorland	saltmarsh	2010	158	0.45	Starvation	O Observation
DE-SH	Neufeld Vorland	saltmarsh	2011	130	0.61		O Observation
DE-SH	Neufeld Vorland	saltmarsh	2012	140	0.51		O Observation
DE-SH	Hallig Hooge Kolonie 1	saltmarsh	2009	3	0	Starvation	O Observation
DE-SH	Hallig Hooge Kolonie 2	saltmarsh	2009	33	0.03	Starvation	O Observation
DE-SH	Hallig Hooge Kolonie 2	saltmarsh	2010	20	1.16		O Observation
DE-SH	Hallig Hooge Kolonie 3	saltmarsh	2009	6	0	Starvation	O Observation
DE-SH	Hallig Hooge Kolonie 3	saltmarsh	2010	17	0.73		O Observation
DE-SH	Hallig Hooge Kolonie A	saltmarsh	2011	64	0.71		O Observation
DE-SH	Hallig Hooge Kolonie A	saltmarsh	2012	83	0.48	Weather	O Observation
DE-SH	Hallig Hooge Kolonie Da	saltmarsh	2011	39	0.58		O Observation
DE-SH	Hallig Hooge Kolonie Db	saltmarsh	2011	27	0.58		O Observation
DE-SH	Hallig Hooge Kolonie D	saltmarsh	2012	43	0.53	Weather	O Observation

3.10 Arctic Tern

Hatching success

Hatching success has been monitored in the Netherlands (2 colonies 1 year), Schleswig-Holstein (2 colonies 2 years, 2 colonies 1 year) and Denmark (2 colonies 1 year) (Table 19a and b). In the Netherlands both sites had a very low hatching success, and in Denmark one site had a high hatching success, the other one no hatching success at all. At the German site, four of six colonies and years had a high hatching success between 46 and 57%, one a fairly low and one no success.

In one case with no hatching success this was caused by flooding, in another two food shortage was concluded to be the main cause of no or low hatching success. In the remaining two cases with low or no hatching success the main cause could not be identified.

Due to the position and the low number of study sites, it is not possible to investigate whether there is a relationship between hatching success and contamination with organochlorines.

Breeding success

Breeding success was assessed in the Netherlands (1 colony 3 years, 2 colonies 2 years, 7 colonies 1 year) and Schleswig-Holstein (4 colonies 2 years, 2 colonies 1 year) (Table 20). The un-weighted mean of all 24 sites/colonies and years is 0.17 fledged young per pair, with 0.26 in Schleswig-Holstein and 0.11 in the Netherlands. These values are very low and without doubt well below the threshold necessary for the Arctic Terns to achieve in order to reproduce themselves.

No less than 58% of the study plots and years (14 of 24) had no or a negligible breeding success (0.03 or fewer young per pair). In 13 cases the main cause of the lack of breeding success was given (Table 20). In six study plots flooding was the main cause, in five starvation and in two predation.

The Arctic Tern declined strongly the last 10-15 years, in particular in the Dutch and the Danish Wadden Sea (Thorup & Laursen 2013b, Koffijberg *et al.* 2015b), and the very low breeding success found in the Netherlands in this programme is very much in line with the trends. However, despite low breeding success values in Schleswig-Holstein as well, stable numbers were found here over 1991-2011.

Tab. 19a: Hatching success of Arctic Tern in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Apparent hatching success (%)	Calculated hatching probability
NL	Vlieland, Vliehors, Schelpenbank	beach	2011	9	0	
NL	Delfzijl, Schermpier	beach	2012	17	17	0.03
DE-SH	Hallig Hooge Kolonie 3	saltmarsh	2009	2	0	
DE-SH	Hallig Hooge Kolonie 4	saltmarsh	2009	49	24	
DE-SH	Hallig Hooge Kolonie B	saltmarsh	2011	43	51	
DE-SH	Hallig Hooge Kolonie B	saltmarsh	2012	55	46	
DE-SH	Hallig Hooge Kolonie C	saltmarsh	2011	67	49	
DE-SH	Hallig Hooge Kolonie C	saltmarsh	2012	66	57	
DK	Mandø Låningsvej	saltmarsh	2009	60	53	
DK	Langli	beach	2009	22	0	

Tab. 19b: Hatching success of Arctic Tern in the Wadden Sea 2009-2012. Causes of egg losses.

Country	Sitename	Year	Cause of egg losses in %						
			Predation	Flooding	Trampling	Unfavourable weather	Food shortage	Other factors	Unknown
NL	Vlieland, Vliehors, Schelpenbank	2011	0	100	0	0	0	0	0
NL	Delfzijl, Schermpier	2012	29	14	0	0	0	50	7
DE-SH	Hallig Hooge Kolonie 3	2009	20	0	0	20	60	0	0
DE-SH	Hallig Hooge Kolonie 4	2009	20	0	0	20	60	0	0
DE-SH	Hallig Hooge Kolonie B	2011							
DE-SH	Hallig Hooge Kolonie B	2012	10	0	0	70	20	0	0
DE-SH	Hallig Hooge Kolonie C	2011							
DE-SH	Hallig Hooge Kolonie C	2012	10	0	0	70	20	0	0
DK	Mandø Låningsvej	2009	0	0	0	0	0	0	100
DK	Langli	2009	0	0	0	0	0	11	89

Tab. 20:
Breeding success of Arctic Tern in the Wadden Sea 2009-2012.

Country	Sitename	Habitat	Year	Sample size	Breeding success (juveniles per pair)	Main cause of chick mortality	Assessment method
NL	Vlieland, Vliehors, Schelpenbank	beach	2010	40	0.03	Flooding	F Fencing
NL	Vlieland, Vliehors, Schelpenbank	beach	2011	9	0	Flooding	F Fencing
NL	Vlieland, Vliehors	saltmarsh	2012	10	0.4	Flooding	F Fencing
NL	Griend	outer sand	2010	302	0.01	Starvation	O Observation
NL	Ameland, Feugelpôlle	saltmarsh	2011	167	0	Flooding	O Observation
NL	Ameland, Feugelpôlle	saltmarsh	2012	80	0	Flooding	O Observation
NL	Rottumerplaat	outer sand	2010	40	0	Predation	O Observation
NL	Rottumerplaat	outer sand	2011	33	0	Unknown	O Observation
NL	Balgzand	saltmarsh	2010	2	0	Flooding	O Observation
NL	Groninger Kust, Klutenplas	coastal wetland	2011	4	0	Predation	F Fencing
NL	Eemshaven	beach	2011	150	0.67		O Observation
NL	Delfzijl, Schermpier	beach	2010	39	0.21	Flooding	F Fencing
NL	Delfzijl, Schermpier	beach	2012	20	0.25	Predation	F Fencing
NL	Groninger Kust, Punt Van Reide	saltmarsh	2011	5	0	Unknown	F Fencing
DE-SH	Hallig Hooge Kolonie 1	saltmarsh	2009	10	0	Starvation	O Observation
DE-SH	Hallig Hooge Kolonie 1	saltmarsh	2010	43	0.57		O Observation
DE-SH	Hallig Hooge Kolonie 3	saltmarsh	2009	2	0	Starvation	O Observation
DE-SH	Hallig Hooge Kolonie 4	saltmarsh	2009	49	0	Starvation	O Observation
DE-SH	Hallig Hooge Kolonie 4	saltmarsh	2010	63	0.65		O Observation
DE-SH	Hallig Hooge Kolonie 5	saltmarsh	2009	26	0	Starvation	O Observation
DE-SH	Hallig Hooge Kolonie B	saltmarsh	2011	43	0.51		O Observation
DE-SH	Hallig Hooge Kolonie B	saltmarsh	2012	55	0.11	Weather	O Observation
DE-SH	Hallig Hooge Kolonie C	saltmarsh	2011	67	0.37		O Observation
DE-SH	Hallig Hooge Kolonie C	saltmarsh	2012	66	0.41	Weather	O Observation

Arctic Tern breeding, Delfzijl harbour, The Netherlands. Photo: Peter de Boer

4. Conclusion and discussion

Main findings

For the first time, the parameter breeding success, as it was implemented within TMAP in 2009-10, was assessed for a number of important coastal breeding birds in the international Wadden Sea. Since, the database was still being established by the time this report was prepared, not all data collected in the field was available in time for inclusion in the report. Nevertheless, the data provided in this report provide a large sample of the data actually collected. The results show that breeding success of several of the ten selected species is currently insufficient to keep populations in balance. In three of the species, Oystercatcher, Avocet and Arctic Tern, the recorded reproduction in 2009-2012 is so poor, that they at present seem to have no chance to reproduce sufficiently. In an additional four species, Black-headed Gull, Lesser Black-backed Gull, Herring Gull and Common Tern, the breeding success values found are fairly low, and some or all of these species may also not reproduce sufficiently to balance mortality (Table 21). These findings are confirmed by a recent analysis of breeding success in the Dutch Wadden Sea, which started already 2005 and was able to put data collected recently in the context of the entire period 2005-2013 (Koffijberg *et al.* 2015b). In the Dutch Wadden Sea, breeding success in Spoonbill, Black-headed-Gull, Sandwich Tern, Common Tern and Arctic Tern even tended to decline since the start of the scheme in 2005 (only significant in Spoonbill and Black-headed Gull).

For several of the monitored species, poor reproduction rates associate well with a decline in breeding numbers (Table 22). The three species with the poorest reproduction all had a negative population trend recently. Low breeding success is very likely an important driver of the observed population declines in these species (see also van der Jeugd *et al.* 2014). Also two of the four species with fairly low breeding success in 2009-10, Herring Gull and Common Tern, experienced recent declines in numbers. Also in these species low breeding success may be an important, or at least a contributing driver of the downward trend. In the Dutch Wadden Sea, breeding success data from 2005-2013 showed that Oystercatcher, Black-headed Gull, Sandwich Tern, Common Tern and Arctic Tern all had poor reproductive output, and were in decline during the past decade (Koffijberg *et al.* 2015). Van der Jeugd *et al.* (2014) showed that in the Netherlands poor breeding years were the most important driver of observed population trends. But there are also exceptions. Annual survival was proven to be an important bottleneck in Herring Gull (Camphuysen 2013). Survival also was a limiting factor in Black-headed Gull (van der Jeugd *et al.* 2014).

For those species where it was possible to distinguish the contribution of hatching success (i.e. incubation period) to the breeding success (i.e. chick-rearing period) (Table 23), species were generally performing better in the incubation period than later during chick-rearing. This is a little bit biased though, as it is assumed that e.g. colony breeding birds have deserted the mainland coast because of disturbance of predators (mainly mammalian predators, causing nest losses) (Bos *et al.* 2015), and thus are under-represented in the study.

Tab. 21: Breeding success in the Wadden Sea 2009-2012. The level of breeding success in each species at all sites and years within regions. Data for Common and Arctic Tern in Denmark are from less standardized surveys conducted 2009-2011.

	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

Causes of failure

What were the main causes of breeding failures then? Selecting the species, sites and years with the poorest breeding success and by looking at the main cause of breeding failure in cases with a breeding success of less than 0.25 fledged young per pair (Figure 7), the main cause recorded was predation (in 27% of the species, sites and years) followed by flooding (22%), starvation (6%) and unfavourable weather (4%). But in no less than 38% of the cases, the main cause was unknown or at a few sites a mixture of different causes. Even if areas were checked frequently for fate of nests and chicks, it is not always easy to determine causes of failure. Flooding is generally the easiest cause to identify, and most likely it is very few of the cases with unknown main cause where flooding was the main cause of breeding failure. Other causes likely to affect breeding failures are more difficult to detect with the current design of the monitoring scheme (e.g. an additional measuring of growth of chicks could identify possible problems with food provisioning). Hence, the methods how breeding success data were collected do bring along a bias towards "easy" visible causes of failure, like flooding and predation, whereas hidden causes like food shortage are less easy to detect, but likely to occur in some species (see the species accounts).

This dataset is dominated by the monitoring of dense breeding colonies on Wadden Sea islands (as many colony-breeding birds have abandoned the mainland coast, see above). In two species, Oyster-

Tab. 22: Recent trends (2002-2011) in the Wadden Sea of the ten species, which had their breeding success monitored in this programme (after Koffijberg *et al.* 2015b). Trends are expressed as ++ strong increase, + moderate increase, ? uncertain, 0 stable, - moderate decline.

	Trends	Breeding success
Spoonbill	++	🟢
Eider	-	
Oystercatcher	-	🔴
Avocet	-	🔴
Black-headed Gull	?	🟡
Lesser Black-backed Gull	+	🟡
Herring Gull	-	🟡
Sandwich Tern	?	
Common Tern	-	🟡
Arctic Tern	-	🔴

Tab. 23: Hatching success in the Wadden Sea 2009-2012. The level of hatching success in each species at all sites and years within regions.

	WADDEN SEA	NL	DE-NDS	DE-SH	DK
Eider		🟢			
Oystercatcher - islands	🟢	🟢	🟢	🟢	🟣
Oystercatcher - mainland	🔴	🟣	🔴	🔴	
Avocet - islands			🟢		
Avocet - mainland	🟣	🟣	🟢	🔴	
Black-headed Gull	🟣	🟣	🟢	🟣	
Lesser black-backed Gull	🟢	🟢	🟢	🟢	🟢
Herring Gull	🟢	🟢	🟢	🟢	🟢
Common Tern	🟣	🟣	🟣	🟢	🟢
Arctic Tern	🟣	🔴		🟣	🟣

🔴 Low hatching success most or all years and sites
🟡 Fairly low hatching success most or all years and sites
🟢 High or fairly high hatching success most or all years and sites
🟣 Variable - some sites and years with high, some with low hatching success

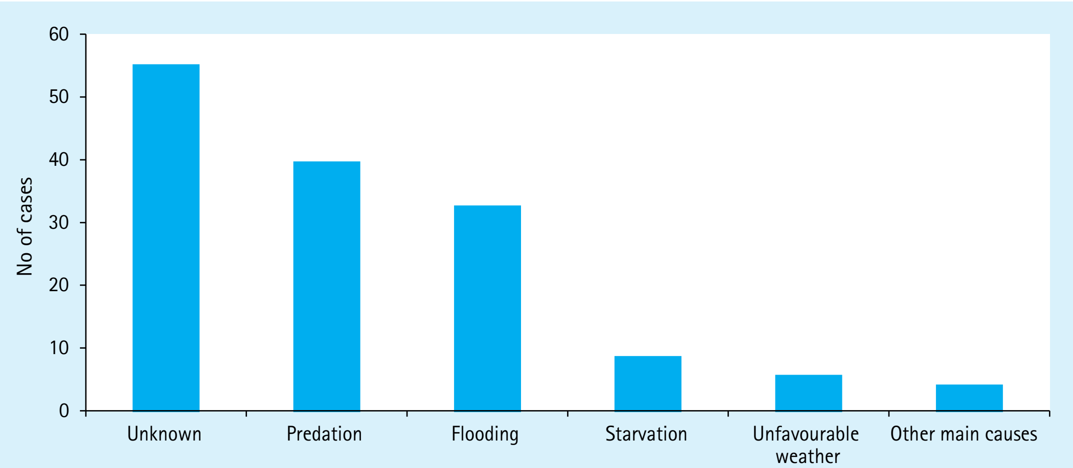

Fig. 7: The main cause of breeding failure 2009-2012 at sites and in species and years when the fledging success was poor (below 0.25 fledged young per pair). Other main causes of breeding failures were destruction by agriculture, trampling by livestock and disturbance, reported in one or two cases each.

catcher and Avocet, it was possible to separate data collected at sites on the islands and on the mainland coast. On the islands, flooding was more often the main cause of breeding failure in the two species (30% of the cases) than at the mainland coast (16%). On the other hand, predation was reported as the main cause of breeding failure in 54% of the cases on the mainland coast compared to 15% on the islands. This is not unexpected, as predation risk by mammalian predators is likely to occur more often along the mainland coast, compared to most of the islands, except for those islands which are connected with a dam to the mainland.

However, when assessing the main causes of breeding failure it is difficult to identify a specific cause because some of the causes are interrelated. When looking at predation versus flooding there is a clear trade- off: if birds settle higher in order to avoid flooding they usually increase their risk of having the eggs depredated. Or expressed in another way: breeders often settle at low-lying spots far from the mainland in order to reduce predation risk from ground predators. But thereby, they increase their risk of having their eggs or chicks flooded. So, many breeding birds face the dilemma of two evils. Only salt marshes where the highest elevated areas are situated close to the sea (e.g. Dithmarschen, Schleswig-Holstein) this situation does not occur.

Furthermore, it has also been described that in some species starvation affects the behaviour of the chicks in a way, that they become more vulnerable to predation. This means that in cases where chick predation is judged to be the main cause of breeding failure, starvation due to lack of food and/ or unfavourable weather may be the trigger behind the elevated level of predation. This is probably in particular relevant for Oystercatcher and Avocet.

Role of contaminants

The level of contaminants has been studied in eggs of Oystercatcher and Common Terns, and a decrease in the concentration has been found in both species between 1998 and 2008, and it has also been found that the concentrations of most contaminants were higher in the Ems and Elbe estuaries than elsewhere. No relationship has been found between hatching success of Oystercatchers and Common Terns and the level of contamination, probably reflecting that the present concentrations of important contaminants are well below the known threshold concentrations for affecting the reproduction of birds (Becker & Dittmann 2009).

Targets Wadden Sea Plan

According to the Wadden Sea Plan (CWSS 2010), the targets are that breeding sites shall support natural populations of breeding birds, and that the breeding success shall be determined by natural processes. The breeding birds are mostly breeding and feeding in landscapes strongly formed and affected by humans so it is quite difficult to identify completely natural processes from processes in nature partly influenced by human activities. However, the fact that many of the ten selected species for this monitoring programme are declining on a Wadden Sea and/or regional scale, and the large proportion of dots in Table 21 that are red or yellow reflecting unfavourable breeding conditions, are strong indications of that the situation is not sustainable.

Artificially high numbers of ground predators can be mentioned as an example of a link between human activities and unfavourable breeding conditions. In several former ground predator-free Wadden Sea islands predators like naturalized feral cats, hedgehogs and foxes have been introduced by man (or have used man-made structures to enter the islands), and this has increased predation pressure significantly on in particular colonial breeders on these islands (e.g. Norderney, H. Andretzke/BIOS). As a consequence of improvements of the dam between the mainland and Hallig Oland and Hallig Langeness, predation also became an issue on these Halligen in recent years (B. Hälterlein). Also along the mainland coast, predators have more favourable living conditions than in the past. Until recent decades, polder areas in mainland Netherlands were flooded in winter, causing very low densities of rodents and thus attracting less ground predators. In the 1960s Red Fox was not found near the Wadden Sea coast (Bouwmeester *et al.* 1989). During the last decades, more and more polder areas have been kept dry during the winter for agricultural purposes, and gradually ground predators like Foxes have established in the polders (Beintema *et al.* 1995). In the 2000s Foxes and Stouts were among the most important predators of eggs and chicks of breeding shorebirds (Schekkerman *et al.* 2009). Artificially high Fox population densities are also achieved by vaccination of foxes preventing outbreaks of some lethal canine diseases (e.g. Hoffmann & Hoffmann without year). Hence, predator densities are likely to be much higher in relevant breeding areas for coastal breeding birds than they have been before.

Oystercatcher feeding chick in nest, Vlieland, The Netherlands. Photo: Peter de Boer

5. Recommendations

As mentioned in the introduction, in the planning the breeding success monitoring programme it was decided to define a number of subregions and to monitor the breeding success of the selected ten species in each of these subregions if the species was breeding here, in order to achieve a geographical representative sample and make site by site comparisons (see Koffijberg *et al.* 2011 for details).

For financial and practical reasons it was never possible to achieve this aimed coverage during 2009-2012 (Table 24). The coverage in the western part of the Wadden Sea – the Netherlands and East Friesland in Niedersachsen – was a much better (32 of 48 possible species-subregions were covered; 67%), compared to the eastern part – Jade-Weser Estuaries in Niedersachsen, Schleswig-Holstein and Denmark (23 of 56 possible species-subregions covered; 41%). In Schleswig-Holstein, the actual situation is better than expressed in table 24, as some of the collected data (notably Common and Arctic Tern and Sandwich Tern) were not available in time for inclusion in this report.

Such geographical representativity is one aspect, and it is relatively easy to evaluate. It also means that accurate comparisons between sites are difficult because sample sizes are too small (but this problem becomes less relevant when analyses are made on country level or for the international Wadden Sea as a whole). When it is only possible to sample data from a fraction of the population of a species, as is the case in many of the species selected for the breeding success monitoring programme, other types of representativity become a major issue. In particular in widespread species like Eider, Oystercatcher and Avocet, and also in species where there may be a major difference in the breeding success in small and in big colonies like Black-headed Gull, Common Tern and Arctic Tern, an analysis of the representativity of the sample could be important in order to avoid a biased sampling. Such an analysis is out of the scope for this review, but in order to give an example of how such an analysis can be worked out, one made for the Danish Oystercatchers (Thorup unpubl.) is included here. The breeding Oystercatchers were stratified into habitat type categories with different breeding conditions (Table 25). The Danish study plot in the breeding success programme 2010-2011 on Mandø is situated within the second category: 'Saltmarshes on islands with irregular visits of ground predators', a category holding 18% of the Danish Oystercatchers in 2012. The plot is situated in an area with good feeding conditions and a fairly low predation risk, and the birds concentrate heavily here, also making it possible to monitor a large number of nests in a quite short time. An almost similar proportion of the Danish Oystercatchers, 14%, are found on mainland saltmarshes, but here they use a completely different strategy and disperse over huge areas. The 254 pairs found in the Mandø category are concentrated on 270 ha, whereas the 192 pairs on the mainland saltmarshes are distributed over

Subregion	Spoonbill	Eider	Oystercatcher	Avocet	Black-headed Gull	Lesser Black-backed Gull	Herring Gull	Sandwich Tern	Common Tern	Arctic Tern
DK - Wadden Sea mainland	grey	grey	red	red	red	grey	grey	grey	red	red
DK - Wadden Sea islands	red	red	green	red	red	green	green	yellow	yellow	yellow
SH - Nordfriesland mainland	grey	grey	green	green	red	grey	red	grey	red	red
SH - Nordfriesland islands	green	red	green	red	red	green	green	red	green	green
SH - Elbe Estuary mainland	grey	grey	green	green	green	grey	red	grey	green	red
SH - Elbe Estuary islands	green	grey	red	grey	red	green	green	red	red	red
NDS - Jade-Weser Estuaries mainland	grey	grey	green	green	red	grey	grey	grey	green	red
NDS - Jade-Weser Estuaries islands	green	red	yellow	grey	red	red	green	grey	red	red
NDS - East-Friesland mainland	grey	grey	green	yellow	grey	grey	grey	grey	grey	grey
NDS - East-Friesland islands	red	red	green	green	green	green	green	red	yellow	red
NL - Ems-Dollart Estuary mainland	grey	grey	green	green	green	grey	grey	grey	green	green
NL - Eastern Wadden Sea mainland	grey	grey	green	green	yellow	grey	grey	grey	red	yellow
NL - Eastern Wadden Sea islands	red	green	green	yellow	green	green	green	green	green	green
NL - Western Wadden Sea mainland	grey	grey	green	yellow	green	yellow	yellow	grey	green	yellow
NL - Western Wadden Sea islands	red	green	green	yellow	green	green	green	green	green	green

Tab. 24:
Achieved coverage in the breeding success monitoring programme. The aimed for coverage according to the programme manual is an annual sample in each subregion with breeding populations. Colours depict: grey: not breeding or scarce breeder in the subregion, green: covered 2-4 Years 2009-2012, yellow: partly covered - monitored 1 year 2009-2012, red: uncovered - not monitored 2009-2012

5,700 ha. A third category, saltmarshes on islands with ground predators is somewhat intermediate: here Oystercatchers do not concentrate in dense populations, but on the other hand densities are much higher than on the mainland saltmarshes. Due to these large differences, the study plot on Mandø is very unlikely to provide a representative breeding success value for habitat types in any of the other categories.

Based on these findings, it is recommended that JMBB will review the original geographical set up of the monitoring scheme in the context of overall effort (the total number of species monitored) and the achievable sample size. Alternatively, or in addition, a routine could be developed which allows calculation of weighted nest success and breeding success values. Such a routine has been developed for the Dutch Wadden Sea already (van der Jeugd *et al.* 2014, Koffijberg *et al.* 2015b) and might also be of use for the trilateral approach. Preferably such a routine is established along with a structural trilateral database approach. Collection and management of the data (i.e. data processing, not fieldwork) still differs between the countries, and establishing a central database and fixed import routines (as they do exist for the database with numbers and distribution) would greatly enhance accessibility of the data and make regular reviews of the data possible, without too much effort spend to collate and administrate the data.

Regarding the discussion which species to include in the monitoring scheme, we also recommend to check whether it is possible (and manageable) to reconsider inclusion of Redshank. A guiding principle for the selection of species for this programme has been that species can be used as indicators for different habitats and feeding strategies. Species were selected in two steps. The first list contained six target species, which fulfilled the aim: Oystercatcher, Avocet, Redshank, Black-headed Gull, Herring Gull and Common Tern (Exo *et al.* 1996). After a pilot study phase, it was evaluated that the monitoring of Redshank was too time consuming and this species was removed from the list, while a further five species, which were already a part of a Dutch scheme (Willems *et al.* 2005) were added. Arctic Tern and Lesser Black-backed Gull were also added for practical reasons, as fieldwork can easily be combined with that for Herring Gull and Common Tern. The present list of selected species for this programme is well-suited when it comes to monitoring breeding success in species with different feeding strategies and various food types. However, Redshank, as a typical salt marsh breeder and a species with precocial chicks, would give an added value. It is one of the most abundant non-passerine species on the salt marshes. For practical reasons, it will not be possible to use the conventional methods described in chapter 2, by assessing the number of fledged juveniles per pair. Even nest searches might be too time-consuming. However, the number of pairs can be counted in the traditional way (Hälterlein *et al.* 1995), after which the successful proportion of the breeding pairs can then be assessed by so-called "alarm-counts" performed three to five times in the study area between late May and early July. This method is already used in the interior parts in the Netherlands (e.g. Nijland *et al.* 2008), and in Denmark (e.g. Amstrup *et al.* 2012, 2013). It gives reliable but relative measures for breeding success, useful for comparisons over time, among sites and among years. With use of this method, it would be realizable to obtain a valuable index figure for the breeding success in Redshanks based on such repeated mapping of families, because one or two successful parents are alarming conspicuously around the chicks until fledging. Part of this fieldwork can also be combined with regular fieldwork to count numbers.

Tab. 25: Stratification of breeding oystercatchers in the Danish Wadden Sea cooperation area into habitat type categories with very different breeding conditions concerning in particular predation and farming activities. 'Saltmarshes' includes other coast.

	No of pairs 2012	Percent of pairs 2012	Change 1996 to 2012
Saltmarshes islands, almost free of ground predators	145	10	3%
Saltmarshes islands, irregular visits of ground predators	254	18	-53%
Saltmarshes islands, accessible for ground predators	328	23	-51%
Saltmarshes mainland	192	14	-63%
Polders islands, irregular visits of ground predators	286	20	-47%
Polders islands, accessible for ground predators	43	3	-32%
Polders mainland	166	12	-64%
River valleys mainland	4	0	-83%
Total	1,418	100	-52%

6. Acknowledgements

The two different ways to collect and report hatching success: 1) the apparent hatching success and 2) the hatching probability (also named the 'Mayfield-method') have been used indiscriminately in this report. It is well known, in which situations the one or the other method is preferable to use in order to get the most realistic results (Johnson & Shaffer 1990; Beintema 1992; Beintema *et al.* 1995). The 'apparent hatching success' overestimates hatching success in dispersed nests when all nests are not found during the first days of laying, because clutches lost before the average nest finding day will be underrepresented in the sample. In contrast, the 'Mayfield-method' overestimates hatching success in dense colonies, where losses are mostly complete due to 'catastrophic events' like a visit of a ground predator or flooding. Among the ten species selected for this programme, the 'Mayfield-method' is without doubt the best method for estimating hatching success in Eider, Oystercatcher, Lesser Black-backed Gull and Herring Gull, whereas the best results will be achieved by the 'apparent hatching success' method in Spoonbill, Black-headed Gull and Sandwich Tern. Avocet, Common Tern and Arctic Tern are somewhat intermediate because a certain fraction of the birds are breeding dispersed, but because the majority are breeding concentrated in colonies, the 'apparent hatching success' must be the most appropriate method to use for these species. It is recommended to use one method consistently in a species in the future to improve the possibility to compare hatching success among sites and years.

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Eggs of Common and Arctic tern after spring-tide in tidemark,Vlieland, The Netherlands. Photo: Peter de Boer

Annex 1 – List of sites

Tab. 25:
Sitenames and location.
x° = latitude, degrees
x' = latitude, minutes
x'' = latitude, seconds
y°= longitude, degrees
y'= longitude, minutes
y''= longitude, seconds

#	Sitename	Region	x°	x'	x''	y°	y'	y''
1	Texel, De Petten/Kikkert/'t Stoar/ J.Dourleinkazerne	NL Western Wadden Sea	53	00-01		4	45-46	
2	Texel, Kelderhuispolder	NL Western Wadden Sea	53	1	14	4	43	37
3	Texel, Westerduinen	NL Western Wadden Sea	53	3	23	4	43	19
4	Oude Molenkolk	NL Western Wadden Sea	53	1	12	4	48	10
5	Vlieland, Vliehors	NL Western Wadden Sea	53	13-14		4	53-55	
6	Vlieland, Kroon's Polders/Bomenland	NL Western Wadden Sea	53	16		4	58	
7	Vlieland, Strand	NL Western Wadden Sea	53	17	29	5	0	17
8	Vlieland, Westerseveld	NL Western Wadden Sea	53	17	31	5	3	34
9	Griend	NL Western Wadden Sea	53	15	0	5	15	13
10	Terschelling, Noordvaarder	NL Western Wadden Sea	53	21	49	5	10	9
11	Ameland, Feugelpôlle/Schelpenpolle/ Hollumerkwelder	NL Eastern Wadden Sea	53	25	30	5	40	
12	Ameland, Kwelder Ferwerd Oost-West	NL Eastern Wadden Sea	53	21	31	5	48	27
13	Ameland, Buurdergrie	NL Eastern Wadden Sea	53	26	52	5	49	33
14	Ameland, Oostoever Oerdsloot	NL Eastern Wadden Sea	53	26	55	5	52	9
15	Ameland, Nieuwlandsreid Oost	NL Eastern Wadden Sea	53	27	11	5	53	31
16	Rif, Engelsmanplaat	NL Eastern Wadden Sea	53	28	30	6	3	13
17	Schiermonnikoog, Banckspolder/Hoge Kwelder/ Oosterkwelder/Oostoever/Westerplas	NL Eastern Wadden Sea	53	29		6	12-14	
18	Rottumerplaat	NL Eastern Wadden Sea	53	32	18	6	29	44
19	Rottumerplaat	NL Eastern Wadden Sea	53	32-33		6	29-30	
20	Rottumeroog	NL Eastern Wadden Sea	53	32	15	6	35	10
21	Zuiderduin	NL Eastern Wadden Sea	53	31	10	6	35	8
22	Balgzand, entire site	NL Western Wadden Sea	52	53-54		4	48-51	
23	Amstelmeer Bij Verzakking	NL Western Wadden Sea	52	53	11	4	53	22
24	Noord Friesland Buitendijks, Biltpollen	NL Eastern Wadden Sea	53	20	11	5	43	56
25	Groninger Kust, Klutenplas	NL Eastern Wadden Sea	53	25-26		6	29-31	
26	Groninger Kust, Noordpolder	NL Eastern Wadden Sea	53	25	45	6	32	21
27	Groninger Kust, Ruidhorn	NL/Nds Ems-Dollart Estuary	53	27	28	6	41	8
28	Groninger Kust, Emmapolder	NL/Nds Ems-Dollart Estuary	53	27	42	6	43	59
29	Eemshaven	NL/Nds Ems-Dollart Estuary	53	27	13	6	51	17
30	Eems, Hoogwatum	NL/Nds Ems-Dollart Estuary	53	23	37	6	53	12
31	Delfzijl, Schermpier	NL/Nds Ems-Dollart Estuary	53	19-20		6-7	57-0	
32	Groninger Kust, Polder Breebaart	NL/Nds Ems-Dollart Estuary	53	17	44	7	4	47
33	Groninger Kust, Punt Van Reide	NL/Nds Ems-Dollart Estuary	53	18		7	5-6	
34	Groninger Kust, Dollard	NL/Nds Ems-Dollart Estuary	53	14-15		7	8	
35	Norderney/Norderney Grohdenvorland	Nds East-Friesland	53	42		7	14-16	
36	Norderney Grohdepolder	Nds East-Friesland	53	42	32	7	14	53
37	Norderney Ostheller	Nds East-Friesland	53	42	53	7	17	34
38	Baltrum	Nds East-Friesland	53	43	32	7	22	37
39	Wangerooge	Nds East-Friesland	53	47	54	7	53	30
40	Minsener Ostdünen	Nds East-Friesland	53	45	18	8	1	13
41	Mellum/Mellum Süddüne	Nds Jade-Weser Estuaries	53	43-44		8	9	
42	Mainland coast - Norderland	Nds East-Friesland	53	40	54	7	19	2
43	Iheringsgroden	Nds East-Friesland	53	41	48	7	45	11
44	Mainland coast - Elisabeth-Außengroden	Nds East-Friesland	53	42	50	7	59	14
45	Mainland coast - Crildumersiel	Nds Jade-Weser Estuaries	53	39	12	8	2	6
46	Banter See	Nds Jade-Weser Estuaries	53	30	36	8	6	0
47	Beckmannsfeld	Nds Jade-Weser Estuaries	53	30	57	8	18	57
48	Binnenpütten Augustgroden	Nds Jade-Weser Estuaries	53	29	46	8	20	7
49	Neufeld Vorland	SH Elbe Estuary	53	53	38	8	58	41
50	Kaiser-Wilhelm-Koog-Vorland	SH Elbe Estuary	53	55	9	8	55	46
51	Friedrichskoog Vorland	SH Elbe Estuary	53	59	40	8	52	2
52	Trischen	SH Elbe Estuary	54	3-4		8	41-49	
53	Hedwigenkoog Vorland	SH Elbe Estuary	54	12	12	8	49	23
54	Westerhever Vorland	SH Nordfriesland	54	22	46	8	38	15
55	Südfall	SH Nordfriesland	54	27	53	8	43	43
56	Hallig Hooge	SH Nordfriesland	54	34	8	8	32	39
57	Beltringharder Koog	SH Nordfriesland	54	34	26	8	53	53
58	Hamburger Hallig	SH Nordfriesland	54	36	38	8	52	24
59	Amrum, Leuchtturm	SH Nordfriesland	54	37	39	8	21	27
60	Amrum, Vogelkoje	SH Nordfriesland	54	39	46	8	19	8
61	Amrum, Schwimmbad	SH Nordfriesland	54	41	10	8	19	19
62	Amrum, Himmelsleiter	SH Nordfriesland	54	50	52	8	19	3
63	Langeness, Westen	SH Nordfriesland	54	37	38	8	31	54
64	Langeness, Honkenswarft Ost	SH Nordfriesland	54	38	47	8	37	38
65	Oland	SH Nordfriesland	54	40-41		8	41-43	
66	Fahretofter Westerkoog	SH Nordfriesland	54	42	30	8	44	57
67	Föhr	SH Nordfriesland	54	45	6	8	30	25
68	Mandø east and northeast	DK Danish Wadden Sea	55	16-18	30	8	34-35	
69	Langli	DK Danish Wadden Sea	55	30	39	8	19	1

Annex 2 - Field workers

The Netherlands

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Denmark

Mandø: O. Thorup, P. E. Jensen, T. Bregnballe - **Langli**: R. D. Nielsen and others

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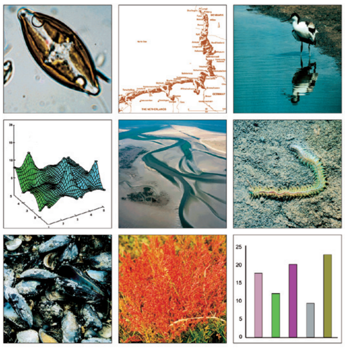

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