BREEDING SUCCESS OF OYSTERCATCHER, TERNS AND GULLS IN THE DANISH WADDEN SEA

Technical Report from DCE – Danish Centre for Environment and Energy No. 60 2015

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Data sheet

Series title and no.:	Technical Report from DCE – Danish Centre for Environment and Energy No. 60
Title:	Breeding success of Oystercatcher, terns and gulls in the Danish Wadden Sea

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Publisher:	Aarhus University, DCE – Danish Centre for Environment and Energy ©
URL:	http://dce.au.dk/en
Year of publication:	2015
Referee:	Jana Kotzerka
Technical editor:	Tommy Asferg
Quality assurance, DCE:	Jesper R. Fredshavn
Financial support:	The Danish Nature Agency, Ministry of Environment
Please cite as:	Bregnballe, T., Thorup, O. Jensen, P.E., Nielsen, R.D., Pedersen, K.T. & Laursen, K. 2015. Breeding success of Oystercatcher, terns and gulls in the Danish Wadden Sea. Aarhus University, DCE – Danish Centre for Environment and Energy, 84 pp. Technical Report from DCE – Danish Centre for Environment and Energy No. 60. http://dce2.au.dk/pub/TR60.pdf

Abstract: Knowledge about breeding success is relevant for understanding the trends observed in local and regional breeding populations of waders, terns and gulls. This report compiles results from surveys of breeding success of Oystercatchers and terns breeding on the island of Mandø, and of terns and gulls breeding on the island of Langli. Both islands are located in the Danish Wadden Sea. Oystercatchers were monitored in 2010 and 2011 and bred successfully in one of these. Common Terns and Artic Terns were studied on Mandø mainly in 2009-2011 and they bred with very poor success in all years. Successful breeding of Sandwich Terns was recorded on Langli in most of the years during 2006-2010. The Lesser Black-backed Gulls and Herring Gulls that nested on Langli were fairly successful in raising young to fledging during 2009-2013, whereas Common Gulls suffered from predation by Herring Gulls and they hardly raised any young. It is concluded that a future low cost monitoring programme of breeding success could focus on Oystercatchers on Mandø and Herring Gulls on Langli.

Keywords:	breeding success, nesting success, census, Oystercatcher, Common Gull, Lesser Black-backed Gull, Herring Gull, Common Tern, Arctic Tern, Sandwich Tern.
Layout:	Graphic Group, AU Silkeborg
Front page photo:	Photo: Lars Maltha Rasmussen.
ISBN:	978-87-7156-153-1
ISSN (electronic):	2245-019X
Number of pages:	84
Internet version:	The report is available in electronic format (pdf) at http://dce2.au.dk/pub/TR60.pdf

Contents

Preface and acknowledgements

This report presents the results from a project aimed at monitoring breeding success of Oystercatchers, gulls and terns on two islands in the Danish part of the Wadden Sea. Another aim was to evaluate the applicability of various methods for a possible initiative of a low cost programme for monitoring breeding success of selected species in the Danish Wadden Sea.

Funding for the studies in the Danish part of the Wadden Sea during 2009-2011 was partly provided by the Danish Nature Agency under the Ministry of the Environment. Further funding was provided by a country-wide study of colonial waterbirds conducted by Aarhus University, DCE / Department of Bioscience.

We thank Ole Amstrup, Mogens Bak, Lars Dalby, Matthias Haupt, Thomas Eske Holm, Lars Maltha Rasmussen and Michael A. Schmidt for their assistance with field work on Langli.

The Danish Nature Agency is thanked for permissions to monitor breeding performance and ringing chicks of gulls and terns on Langli. We also thank Bjarne Slajkær from the Danish Nature Agency for his assistance by transportation of fieldworkers and equipment to and from Langli when waterlevels made walking to and from the island impossible. We thank Jan Steinbring Jensen, the Danish Nature Agency for commenting on the report.

Photo 0.1. Sandwich Tern with chick, Langli 2009. This species is no longer breeding on the island of Langli. Photo: Rasmus Due Nielsen.

Summary

Background and aim

Breeding performance can be an important bottleneck in the life cycle of waders, gulls and terns and may influence where individual birds decide to breed in subsequent seasons. The assessment of breeding success and knowledge about the causes of breeding failure is therefore of great value when attempting to identify reasons for changes in local and regional population size. The parameter 'breeding success' can also be applied as an early-warning system to detect changes in the ecosystem or assess human impact, because it is sensitive to changing conditions in the environment. Knowledge about breeding success and the main factors affecting it is also important when discussing management options aimed at improving the breeding conditions for the species.

In the trilateral collaboration between the Wadden Sea countries (NL, D, DK) it was recognised that the lack of knowledge on 'breeding success' was an important gap in the monitoring programme of the Wadden Sea. It was therefore decided that breeding success should be incorporated into the set of parameters that should be monitored within the Trilateral Monitoring and Assessment Program (TMAP). The plan was to fully implement a system for monitoring breeding success of coastal birds in all three Wadden Sea countries from 2010 onwards.

The plan for monitoring breeding success was developed during the TMAP revision. According to this plan monitoring in the Danish part of the Wadden Sea should provide information about breeding success of Oystercatcher *Haematopus ostralegus*, Black-headed Gull *Larus ridibundus*, Herring Gull *Larus argentatus*, Sandwich Tern *Sterna sandvicensis* and Arctic Tern *Sterna paradisaea* on islands (not necessarily the same island for all species). The monitored parameter for breeding success in the International Wadden Sea should be the number of young fledged per breeding pair, for the selected species and study sites.

This report is a compilation of the results from the monitoring of breeding parameters and breeding success of Oystercatchers on Mandø during 2010-2011, of terns on Mandø during 2008-2011 and of terns and gulls on Langli mainly during 2009-2013.

Breeding success

Oystercatchers breeding on Mandø saltmarsh produced 0.26 fledged young per breeding pair in 2010 and 0.01 young per breeding pair in 2011. This difference was mainly caused by a higher loss of clutches early in the breeding season in 2011. A total of 46% of the clutches initiated in 2010 survived until hatching whereas only 6% of the clutches initiated in 2011 hatched. Most losses of clutches were caused by predation and flooding by sea water. The fledging success measured in 2010 reached 76%.

Common Terns and the Arctic Terns breeding on Mandø performed poorly during 2008-2011. It was estimated that the Common Terns produced fewer than 0.5 fledged young per breeding pair in 2008, less than 0.3 in 2009 and 2010 and no fledged young in 2011. The success of the Arctic Terns was es-

timated at a maximum of 0.1, 0.3, 0.2 and 0.1 fledged young per breeding pair in 2008-2011. The low breeding success was mainly due to losses of egg clutches. The cause of the extensive losses of eggs was not identified, except for a few cases where colonies had been partially or completely flooded by sea water. Few chicks hatched and their survival was low. The causes of chick mortality could not be determined. There were some indications that human disturbance had caused at least some of the losses of eggs and chicks.

Common Gulls bred with extremely low success on the island of Langli in all years between 2008 and 2013. The counts of large young indicated that as few as 1-2 young fledged per 100 breeding pairs. It appeared from the detailed studies in 2009 that most losses took place during incubation and were caused by predation of eggs, mainly by Herring Gulls.

Lesser Black-backed Gulls bred with high success on Langli in 2008-2010, with very low success in 2011 and with low-moderate success in 2012-2013. The pattern was almost the same for the Herring Gulls which bred with high success in 2008-2010 and 2013, with very low success in 2011 and with low success in 2012. The reasons for the low breeding success could not be identified.

Arctic Terns that attempted to breed on Langli had poor breeding success. The observations suggested that none of the breeding attempts during 2008-2013 resulted in successful production of fledged young.

Sandwich Terns apparently bred with high success on Langli in 2006 and in 2008-2010 at least until the chicks became 5-12 days old. Later visits confirmed that chick survival was high during these years. Hatching success was reasonably good when studied in 2009.

Evaluation of methods

The monitoring of breeding success of Oystercatchers on the saltmarsh of Mandø successfully applied the recommended standard methods to determine hatching and fledging success. Breeding performance was recorded with high precision and the main causes of egg losses were identified. Furthermore, the monitoring could be carried out at a fairly low cost.

Photo 0.2. Common Gulls at Langli. Photo: Lars Maltha Rasmussen.

Attempts were made to monitor hatching success of terns breeding on Mandø by marking individual nests. This method was changed in subsequent years because the marking attracted the public and the other methods used gave only rough measures of breeding success.

The monitoring of hatching success on the island of Langli by following individually identifiable nests was very costly in terms of manpower. Furthermore, the Danish Nature Agency found that this method required an unacceptable high number of visits to the breeding areas. As an alternative a combination of data collected during ringing of chicks and counts of young near the age of fledging was used. This only provided rough estimates of year-to-year variation in the production of fledglings.

Future monitoring

According to the plan for monitoring of breeding success in the International Wadden Sea, Denmark should provide information about breeding success of Oystercatcher, Black-headed Gull, Herring Gull, Sandwich Tern and Arctic Tern on 1-2 of the Wadden Sea islands.

For Oystercatcher we recommend that future monitoring of breeding success covers breeders on Mandø saltmarsh by use of the same methods as in 2010 and 2011. Two other potential study sites could be included.

The Black-headed Gull colony on Langli has become very small in recent years and we do not recommend a full survey of this colony. Furthermore, monitoring of breeding success in the colony in 'Sneum Klæggrav' on the mainland coast - having 90% of the breeders in the Danish Wadden Sea – would disturb the colony to an extent where it would influence the overall production of fledglings in the colony.

For Herring Gull we recommend that breeding success on the island of Langli is monitored using a combination of standardised ringing and counting of chicks.

Sandwich Tern is no longer breeding in the Danish part of the Wadden Sea but may return in coming years.

Due to recent declines in breeding numbers of Arctic Terns on Langli and Mandø there are at present no sites in the Danish Wadden Sea that are suitable for monitoring breeding success of this species. Large colonies (with 150-200 pairs) are currently only found on Koresand and on the roof of a building in the harbour of Esbjerg. It would be a logistic challenge to monitor breeding success in the colony on Koresand and monitoring of the colony in Esbjerg Harbour would not provide information which is representative for the breeding conditions in natural Wadden Sea habitats.

Sammenfatning

Baggrund og formål

Ynglesuccesen blandt vadefugle, måger og terner kan have afgørende betydning for den fremtidige rekruttering af nye ynglefugle og påvirke, hvor fuglene vælger at yngle i efterfølgende sæsoner. Viden om ynglesucces og om årsagerne til, at fuglenes yngleforsøg kan slå fejl, er derfor værdifuld i forbindelse med forsøg på at forklare lokale og regionale forandringer i ynglefuglenes antal. Kendskab til fuglenes ynglesucces kan også i nogle tilfælde indikere, om levestederne har forandret sig, fordi ynglesuccesen ofte vil være følsom overfor naturlige eller menneskeskabte ændringer i det omgivende miljø. Viden om artens ynglesucces og de faktorer, som påvirker den lokalt, vil også være af værdi, hvis der opstår ønsker om at igangsætte lokale tiltag rettet mod at forbedre artens ynglebetingelser.

I det trilaterale samarbejde mellem vadehavslandene Holland, Tyskland og Danmark har der i en længere årrække været en erkendelse af, at der i moniteringsprogrammet for Vadehavet manglede en overvågning af fuglenes ynglesucces. Det blev derfor besluttet, at ynglesucces skulle indarbejdes i det sæt af parametre, som skulle undersøges inden for det trilaterale samarbejdsprogram (TMAP). Det var oprindeligt meningen, at en standardiseret monitering af ynglesucces skulle have været sat i værk i alle tre vadehavslande fra og med 2010.

Denne rapport er en sammenstilling af resultaterne fra en række forsøg på at undersøge yngleparametre (deriblandt ynglesucces) for strandskade og terner på Mandø, og for terner og måger på Langli.

Ynglesucces

På forlandet af Mandø producerede de ynglende strandskader i gennemsnit 0,26 unger pr. ynglepar i 2010, men kun 0,01 unge pr. ynglepar i 2011. Den lave succes i 2011 var hovedsagelig forårsaget af hyppige tab af ægkuld tidligt i ynglesæsonen. I 2010 overlevede 46% af ægkuldene til klækning, hvorimod det i 2011 blot var 6%. De fleste af de kuld, som gik tabt, blev mistet på grund af prædation eller oversvømmelser af forlandet. I 2010 blev overlevelsen fra klækning til ungerne var næsten flyvefærdige opgjort til 76%.

I årene 2008-2011 havde fjorternerne og havternerne, som ynglede på Mandø, særdeles ringe succes. Det blev estimeret, at fjordternerne producerede færre end 0,5 flyvefærdige unger pr. ynglepar i 2008, færre end 0,3 unger pr. par i 2009 og 2010, og ingen unger i 2011. For havternerne blev ynglesuccesen opgjort til maksimalt 0,1, 0,3, 0,2 og 0,1 flyvedygtige unger pr. par i hvert af årene 2008-2011. Den lave ynglesucces var hovedsagelig forårsaget af tab af ægkuld. Årsagerne til disse tab kunne i de fleste tilfælde ikke identificeres. I nogle få tilfælde blev kuldene mistet, fordi yngleområdet blev helt eller delvist oversvømmet af havvand. Overlevelsen var desuden lav blandt de få unger, som klækkede. Kun i få tilfælde kunne årsagerne til, at ungerne døde identificeres.

På øen Langli ynglede stormmåge med ekstrem ringe succes i alle årene mellem 2008 og 2013. Optællinger af store unger tydede på, at der kun blev produceret omkring 1-2 flyvefærdige unger pr. 100 ynglepar. Detaljerede studi-

er i 2009 tydede på, at langt de fleste af stormmågernes ægkuld gik tabt på grund af prædation fra de sølvmåger, som ynglede imellem eller i nærheden af stormmågerne.

Sildemåge ynglede med forholdsvis høj succes på Langli i 2008-2010, med meget lav succes i 2011 og med lav-moderat succes i 2012-2013. Mønsteret var stort set det samme for de sølvmåger, som ynglede på Langli, idet de ynglede med rimelig god succes i 2008-2010 og 2013, med meget lav succes i 2011 og med lav succes i 2012. Årsagerne til, at disse to arter af måger ynglede med lav succes i enkelte af årene, kunne ikke bestemmes.

De havterner, som forsøgte at yngle på Langli, ynglede med ringe succes. Registreringerne tydede på, at ingen af de havterner, som forsøgte at yngle i 2008-2013, fik unger på vingerne.

Splitterne ynglede talrigt på Langli i nogle af undersøgelsesårene, og de ynglede med høj succes i 2006 og 2008-2010, i det mindste frem til ungerne havde en alder på 5-12 dage. Besøg på øen senere i ynglesæsonerne tydede dog på, at ungerne havde god overlevelse frem til de blev flyvedygtige.

Evaluering

Anvendelsen af de anbefalede standardmetoder til monitering af ynglesucces blandt strandskader forløb uproblematisk på Mandø. Strandskadernes ynglesucces blev registreret med høj præcision, og de væsentligste årsager til tab af æg blev identificeret. Ydermere var det muligt at gennemføre moniteringen for forholdsvis beskedne midler.

I det første undersøgelsesår på Mandø blev klækningssuccesen i ternekolonierne opgjort ved at afmærke og følge de enkelte kulds skæbne. Denne metode blev fravalgt i efterfølgende år, fordi der var tegn på, at afmærkningen af reder tiltrak mennesker, hvorved tabene af ægkuld blev forøget. I stedet blev der benyttet mere 'grove' metoder i de efterfølgende sæsoner.

Photo 0.3. A section of the colony of Sandwich Tern on Langli, 2008. Photo: Lars Maltha Rasmussen.

På Langli blev mågernes og ternernes klækningssucces undersøgt ved at følge skæbnen i individuelt genkendelige reder. Denne fremgangsmåde krævede meget mandskab og mange timer i felten. Desuden fandt Naturstyrelsen, at metoden gav anledning til for mange forstyrrelser. Derfor blev der i de følgende år benyttet en kombination af ringmærkning og optælling af unger omkring det tidspunkt, hvor de var tæt på at være flyvedygtige. Denne metode gav grove estimater for år til år variationen i den gennemsnitlige produktion af flyvedygtige unger.

Fremtidig monitering af ynglesucces

Ifølge den foreslåede plan for monitering af fuglenes ynglesucces i det internationale Vadehav skulle Danmark tilvejebringe viden om ynglesucces for strandskade, hættemåge, sølvmåge, splitterne og havterne på 1-2 af vadehavsøerne. Så vidt muligt skulle moniteringen for hver art og ynglelokalitet bidrage med oplysninger om, hvor mange flyvedygtige unger der i gennemsnit blev produceret pr. ynglepar.

For strandskade anbefaler vi, at der på forlandet af Mandø gennemføres en monitering ved brug af de samme metoder, som blev afprøvet i denne undersøgelse. Desuden kan det overvejes at inddrage to andre studieområder.

Det kan ikke anbefales at igangsætte undersøgelser af ynglesuccesen blandt de hættemåger, som yngler på Langli, idet kolonien her er svundet ind til få par. Vi vurderer, at en undersøgelse af ynglesuccesen i Vadehavets største koloni, som findes ved Sneum Klæggrav, vil være vanskelig at gennemføre uden at forårsage betydelig forstyrrelse af kolonien.

For sølvmåge anbefaler vi, at der på Langli igangsættes en monitering af ynglesuccesen ved brug af standardiseret ringmærkning og optælling af store unger.

Splitterne yngler ikke længere på øerne i den det danske Vadehav, så ynglesuccesen af denne art vil ikke kunne overvåges, medmindre arten atter etablerer sig som ynglefugl.

På grund af markante nedgange i antallet af ynglende havterner på Langli og Mandø er det i disse år ikke muligt at finde steder på danske vadehavsøer, hvor havternernes ynglesucces vil kunne følges. De fleste større kolonier har i de senere år været lokaliseret på Koresand og på taget af bygninger i Esbjerg Havn. Det vil være logistisk krævende at følge havternernes ynglesucces på Koresand.

1 Introduction

Breeding bird surveys in the International Wadden Sea have been a part of the Trilateral Monitoring and Assessment Program (TMAP) and have proven to be a powerful tool to assess status, distribution and population changes in breeding birds in the Wadden Sea (Fleet *et al.* 1994, Melter *et al.* 1997, Rasmussen *et al.* 2001, Essink *et al.* 2005, Koffijberg *et al.* 2006). This is not only relevant with respect to local conservation and management issues, like evaluation of targets in the trilateral Wadden Sea Plan, but it also provides the necessary input for implementation of the EU Birds- and Habitats Directives.

The backgrounds for population changes often remain unknown, and the possibilities for advicing in management issues aimed at breeding birds are therefore not satisfactory. Several breeding birds that currently experience declines in the Wadden Sea were believed to have had poor breeding success, but the trilateral data to assess this were scant (de Boer *et al.* 2007, Koffijberg *et al.* 2010). Most of the bird species dealt with in the trilateral monitoring scheme are long-lived species and will therefore show a delayed response to deteriorating environmental conditions of human impact. However, the parameter 'breeding success' may be applied as an early-warning system to detect changes in the ecosystem or assess human impact, because it is sensitive to changing conditions in the environment. Moreover, knowledge about breeding success is of use in the attempts to provide a basic understanding of the trends observed in local and regional breeding populations of waders, terns and gulls. 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 (Becker 1992, Exo *et al.* 1996, Thyen *et al.* 1998, Becker *et al.* 1998, Essink *et al.* 2005).

Photo 1.1. The Herring Gull appeared to be an important predator affecting breeding success of Black-headed Gull, Common Gull and terns. Photo: Lars Maltha Rasmussen.

In the trilateral collaboration between the Wadden Sea countries it was decided that breeding success should be incorporated into the set of parameters to monitor within the reviewed TMAP concept initiated by the Schiermonnikoog Declaration (CWSS 2005). The plan was to fully implement a system for monitoring breeding success of coastal birds in all three Wadden Sea countries in 2010.

A plan for monitoring breeding success was developed during the TMAP revision (Koffijberg *et al.* 2011). According to this plan monitoring in the Danish part of the Wadden Sea should provide information about breeding success of Oystercatcher *Haematopus ostralegus*, Black-headed Gull *Larus ridibundus*, Herring Gull *Larus argentatus*, Sandwich Tern *Sterna sandvicensis* and Arctic Tern *Sterna paradisaea* on islands (not necessarily the same island for all species).

Funding for the studies in the Danish part of the Wadden Sea during 2009-2011 was provided by the Danish Nature Agency under the Ministry of Environment. Further funding was provided by a country-wide study of colonial waterbirds conducted by Aarhus University, Department of Bioscience.

A preliminary study was carried out in 2009 aimed at gathering experience on methods, time costs and difficulties. Based on this experience revised studies were conducted in the subsequent years. These studies were conducted on the island of Langli for nesting success of gulls and terns and on the island of Mandø for nesting success of Oystercatchers and terns.

This report aims at describing the methods used, the experience with applying these and the results obtained concerning breeding parameters and breeding success of Oystercatcher, Common Tern *Sterna hirundo* and Arctic Tern breeding on Mandø, and of Lesser Black-backed Gull *Larus marinus*, Herring Gull, Common Gull *Larus canus*, Sandwich Tern and Arctic Tern breeding on Langli. We also evaluate the applied methods and propose options for future monitoring of breeding success of the key species considering expected finansial constraints. Common tern, Lesser Black-backed Gull and Common Gull were also included due to an ongoing ringing programme.

Photo 1.2. A ringed Common Gull at its nest on Langli. Photo: Lars Maltha Rasmussen.

2 General methodological guidelines

2.1 Target value of the studies

This chapter describes the methods originally proposed to be used for measuring breeding success of waders, gulls and terns in the International Wadden Sea. For details see Koffijberg *et al.* (2011).

Breeding success within the framework of TMAP is described as the success of breeding birds to raise their offspring to fledging. Hence, the target value of monitoring breeding success is the number of fledged chicks per breeding pair, for a given species at a given study site. For this purpose, fieldwork should focus on the assessment of two parameters:

1. determine *hatching* success of a number of clutches by following their fate over the incubation period

2. determine *fledging* success by following the fate of the hatched chicks until fledging.

2.2 Selection of species

The current breeding bird monitoring scheme focuses on 35 characteristic species in the International Wadden Sea. However, it was judged that to fulfil the aims, it would not be necessary to include all 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 could be used as indicators for different habitats and feeding strategies. During the pilot project in 1996-97, JMBB (the Joint Monitoring of Breeding Bird group) 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). Criteria to select species by that time were: (1) the species should be a typical breeding bird in the Wadden Sea; (2) it should be abundant and (3) it should occur in all three Wadden Sea countries. In addition, the species should represent a certain habitat or feeding strategy. For instance, Common Terns were regarded as a dune-breeding species and Redshanks *Tringa totanus* as saltmarsh breeders. Benthos-eating species were represented by Oystercatchers, Avocet *Recurvirosta avosetta* and Redshank (partly Herring Gull), fish-eating species by Common Tern and Herring Gull. Oystercatcher and Common Tern were also chosen since they are included in the TMAP of 'contaminants in bird eggs'. Lesser Black-backed Gull was not included, but proposed for its presumed competition with Herring Gull and its marine feeding habits. During the fieldwork for the pilot project in 1996-97 it was decided to skip Redshank for practical reasons. This species is notoriously difficult to monitor, and its inclusion in the scheme would have increased the effort considerably.

Following experiences during the initial project in 1996-97 and species included in a monitoring programme for breeding success in the Dutch part of the Wadden Sea (Willems *et al.* 2005) a discussion among JMBB resulted in the following species to be included in the proposed monitoring scheme on breeding success:

1. Eurasian Spoonbill *Platalea leucorodia*
2. Common Eider *Somateria mollissima*
3. Oystercatcher *Haematopus ostralegus*
4. Avocet *Recurvirostra avosetta*
5. Black-headed Gull *Larus ridibundus*
6. Lesser Black-backed Gull *Larus fuscus*
7. Herring Gull *Larus argentatus*
8. Sandwich Tern *Sterna sandvicensis*
9. Common Tern *Sterna hirundo*
10. Arctic Tern *Sterna paradisaea.*

Guidelines for inclusion of these species were that they should represent internationally relevant species, act as habitat specialist, food specialist and/or have a link to management issues. Additional criteria were that a species eventually should be abundant and/or be included in the TMAP programme 'contaminants in bird eggs'.

2.3 Sample size

For statistical reasons it was recommended to achieve monitoring of a sample of 60-80 clutches for each single species in a subregion i.e. 60-80 on the mainland and 60-80 on an island. However, if, for example, the only Avocet colony within a region comprised only 30 pairs, then this colony should be studied, and not be rejected for its small size. In such cases, the number of clutches included in the study should be as high as possible and preferably include the whole colony. It was also noticed that in many colonial breeding birds, smaller samples would probably be more the rule than exception. For practical reasons, the part of the colony to survey for hatching success (and fenced later on, prior to hatching) should at least include 25-35 nests, possibly less in large gulls. It was described that it was of importance to choose representative parts of the colony (not just sited at the edges of colonies).

2.4 Interval between visits

In order to minimise disturbance, intervals between two successive visits preferably should be about 6 days during incubation. In situations where time was available, extra effort should preferably be put into finding new nests instead of checking existing nests very frequently (i.e. more than twice a week). During the chick-rearing phase, intervals between successive visits would depend on method and species.

2.5 How to determine hatching success

Basically, a study site had to be searched for nests/clutches of the target species, taking into account the guidelines for disturbance. Colonies of gulls and terns usually would be visible from a distance, so discrete areas could be searched for nests. In territorial breeding species like Oystercatchers, that breed individually and scattered, the study site should be searched systematically by looking for clutches while walking through the area. Only at study sites with narrow salt marshes and/or low vegetation cover, previews from a higher viewpoint (like a dike) would help to locate individual nests or incubating birds.

The timing of nest searches should be determined by the species studied. In general, nest surveillance in the Wadden Sea should take place from the 2nd half of April until June. The period of nest searches should not start later than the estimated peak of egg-laying. Also, replacement clutches should be

included and these may, in some species, be found well into June. Furthermore, it was noted that in some colonial breeding birds, displacement of entire colonies, e.g. after flooding, could expand the breeding season into July. Also in such cases, replacement clutches should be taken into account, also to enable analysis of differences between fledging success in first and replacement clutches.

When found, the position of a clutch should be stored in a handheld GPS device, of which coordinates could be used when reporting the data. As GPS might be inaccurate, it was recommended to plot the clutch site on a detailed map or aerial photograph of the study site (scale 1:2500 recommended). Moreover, it was recommended to mark each clutch by a unique number to keep track of the fate of the nest/clutch; a marker should usually be placed 3-5 m from the clutch, using the same distance and same direction for each clutch within one study site. Only in colonial breeding birds (where nest density would be higher), nests-markers should be put right next to the clutch. Usually small bamboo canes with a red or yellow flag from fabric-tape should be used as nest-marker. Alternatively, plastic canes, or small plastic boards like those used by gardeners, were recommended to be used as well, especially when vegetation was not expected to grow high during the incubation period. In areas with (presumed) high predation rates, the largest possible distance to mark nests (5 rather than 3 m) should be used.

2.6 How to determine fledging success

After hatching, a number of methods are available to determine fledging success. It was suggested to use one of the following three methods of measuring fledging success: (O) Observation of chicks, (R) Recapture of chicks and (F) Fencing of chicks.

Method O: Observations of chicks / juveniles / families

The idea of the method is to determine breeding success by observing and counting chicks, juveniles or family parties and in turn get the number of fledged chicks per pair. Therefore, the chicks have to be observed and counted until immediately before fledging, giving the best possible proxy for breeding success.

Photo 2.1. Counting of breeding gulls and terns on the island of Langli. Photo: Lars Maltha Rasmussen.

The place to carry out observations has to be well selected. It has to be made sure, that the chicks that hatched from the clutches studied can be found in the area that is surveyed. On one hand, the chicks observed should originate from the studied clutches. Immigration of chicks from other places should be low as should emmigration of chicks from the studied clutches to other places.

This method was described as being suitable for species like Oystercatchers and Avocets but not for all types of habitats.

Observations will typically be carried out on mudflats or on sparsely vegetated salt marshes during high tide. The main difficulty of the method is to repeatedly count the number of chicks that are just about to fledge. Especially if the egg-laying period is long, it is insufficient to conduct only one control at the end of the season but several controls are needed (applies notably to Avocet, less in Oystercatcher). Once the chicks have fledged, it is impossible in most species to definitely tell which area they come from (unless they have been marked). Counting immature birds at high tide roosts can therefore only be considered as an additional effort outside the monitoring scheme (except for Eurasian Spoonbill and Common Eider). In gulls (at least Lesser Black-backed Gull and Herring Gull) juveniles quickly desert their native colony after fledging and juveniles from other colonies may (well) appear in the studied colony although a large number of chicks hasn't even fledged (for example observations of marked juvenile gulls from Helgoland were seen / can be seen on the island of Trischen in the beginning of August).

Method R: Capture and recapture / Capture and resight

Just as the method described above, this technique is suitable for precocial species where the chicks leave their nests quickly after hatching, like Oystercatcher, but also for colonial breeding birds if the preferred method of fencing is not possible. It is a recommended method if the overview of an area is limited (due to geomorphology or vegetation structure) and the birds are not visible from a distance. By capture, mark and recapture (or resighting) of chicks, survival of chicks and finally fledging success can be determined.

The method is based on capture-recapture methods that are commonly used to determine population demography and population size. A number of individuals is captured, marked and then released. Afterwards, successive catching effort is undertaken with regular intervals (see below). Under the assumption that a marked individual has the same chance of being caught (recaptured) as a non-marked individual, the ratio of marked individuals (in the first catch) and the total population equals the ratio of recaptured marked individuals and the total number of captured marked individuals in a successive catch (Petersen-Index).

The chicks of the controlled clutches are ringed individually shortly after hatching. They are recaptured during the chick-rearing period until they fledge, by walking through the area and picking them up. The repeated controls until fledging monitor the fate of individual chicks. It is not necessary to catch each individual chick in each successive visit. By use of the statistical package MARK, the dataset is analysed and recapturing probability is calculated for each chick separately.

The method requires precise assessment of the (peak in) hatching date (derived from time of egg laying or egg measurements), and immediate ringing effort in first days or week after hatching (depending on the age when chicks

can be ringed). In that period, a 3-4 day controlling interval is necessary. Afterwards, searches can be done with an interval of 5-7 days. Chicks have to be marked individually – if colour ringing is not carried out, fabric tape can be used. The tape will fall off after some weeks. Recapturing during the chick-rearing period has to be done at high tide. It is also optimal to determine body condition of chicks (body mass in gram) during each catch, but it is not obligatory within the framework of TMAP.

The method "R" has proved to be well applicable in studies on Oystercatcher as well as Common Tern and Arctic Tern in Schleswig-Holstein, and results obtained so far are promising. Nonetheless, methodological research has to be carried out to calibrate the method with respect to its compatibility with method O and to verify that the important assumption of similar chances of each fledgling to be found is not violated. Moreover, statistical analysis of the data requires some expert knowledge.

Method F: Fencing

This method is suitable for species where the chicks stay in- or close to the nest after hatching, in our framework gulls and terns. It has proven a very succesful and commonly used method for studies of breeding success in these species. Caution has to be taken at nest sites that are susceptible to flooding. Hence, it must be safeguarded that fences will be removed or opened if flooding of the area is to be expected! In mixed tern and gull colonies, this method is less suitable, as increased predation and food parasitism might occur and will affect fledging success in terns. Hence, when choosing study sites for terns, interactions with gulls should be avoided as far as possible.

Depending on study site conditions as colony density, personal resources and infrastructure either single clutches or groups of several clutches (usually 15-20 in large gulls, 25-35 in terns) will be fenced. To achieve the requested sample size for each subregion, it is recommended to build more than one enclosure. The idea of fencing is to keep the chicks inside the fence until they fledge and thus to record precisely the number of fledged chicks per (fenced) pair. Note that fencing of single clutches is only appropriate in colonies with low densities of clutches and is usually only done in large gulls. It is highly recommended to ring the chicks individually (at least with metal rings), as the additional effort is relatively low and ringing helps to collect data on survival rates and monitor the fate of individual chicks. Ringing is not obligatory, as the ultimate result is the number of chicks that survive in the enclosure.

In order to retrieve a representative sample of clutches it is important to select a 'representative' part of the colony. Eventually put two or more enclosures in two different parts of the colony if density of nests varies a lot (especially recommended in large gulls). Fences or enclosures are erected just prior to hatching of the first chicks. This requires information on hatching dates. Eventually, split up the construction of the enclosure over two visits of less than an hour each, to minimize disturbance.

3 Oystercatchers on Mandø

3.1 The island of Mandø

Mandø (8 km^2) is situated in the middle part of the Danish Wadden Sea. It is surrounded by seawalls and extensive saltmarshes. Most of the island is marshland and managed by farmers and grazed by cattle and sheep. A small dune area is situated in the western part.

Potential disturbance from humans

On the island live c. 50 persons and in addition it is visited by thousands of one day visiters. There are also some summer houses and two houses for over night stays.

3.2 Breeding sites and numbers

The total breeding population of Oystercatchers on Mandø was monitored in 2012 and a total of 540 breeding pairs were recorded. They were distributed across the island with about 300 pairs in the polder areas inside the dike, and about 240 pairs in the saltmarsh outside the dikes. Most Oystercatchers were breeding at sites with short vegetation, mostly on grassland grazed by cattle or sheep. From 1996 to 2012 breeding numbers on Mandø declined by c. 50% (Thorup & Laursen 2012).

3.3 Method

Study site

The study was carried out in 2010 and 2011 on saltmarshes in front of the dike on the east coast of the island of Mandø. These saltmarshes are public land and are grazed by sheep.

Because of different habitat features and different bird population and potentially important predators the study site was divided into three subareas:

1) 'Nordøstlige forland': A very wide short-grazed saltmarsh (app. 18 ha),
2) 'Østlige forland, north': Narrow saltmarsh with the central parts overgrown by 25-40 cm high vegetation (app. 12 ha) and
3) 'Østlige forland, south': Narrow saltmarsh with short vegetation and with a narrow sandy beach in front of the saltmarsh (App. 26 ha).

For further details see Appendix 1.

Fieldwork

The study site was visited once a week from the period when the first nests were observed and until there were no more active nests. The intervals between visits were 4 to 10 days, on average 7 days.

In 2010 the first nests were established in late April (week 17) and the last nests were hatched, predated or deserted in late July (week 29). In total, 13 visits were performed between 29 April and 22 July. In 2011 the first nests were established in the second week of May (week 19) – two weeks later than in 2010 – and the last nest was predated in late July or early August (week 30-31). In total 15 visits were made between 29 April and 5 August.

The position of each nest was stored on a GPS-device (accuracy 4-5 m). In addition, the exact position of the nest in relation to different landscape features and a short description of the nest bowl and nest lining was noted.

The nest habitat was registered within five main categories: sandy beach, sandy patch in saltmarsh, saltmarsh grass, grass on dike and pile of dead vegetation from spring floods.

Assessment of fate of nests

In the nests of Oystercatchers shells of cockles, mussels and other shellfish often replaced nest lining of plant materials, and furthermore there were many Oystercatcher nests, especially in sand, without any lining at all.

The nest controls followed the same procedure as normally used for monitoring nesting success in meadow birds. When a nest without eggs or chicks was detected the observer (always the same person) looked for signs of predation or trampling in the nest and the immediate neighbourhood like pricked, bitten or smashed egg shells. In cases where there were no signs around the nest, the nest lining was carefully searched for the presence of egg shell fragments.

A nest was identified as hatched if chicks were seen in the nest (including eggs with a crack hole of minimum 5 mm), in its immediate surroundings (within 5 m) or if there were small egg shell fragments in or below the nest lining, among the shellfish shells or in the sand of the nest bowl.

If there were smashed or flattened eggs showing that trampling or a vehicle destroyed the nest, this was identified as the fate.

If there were signs of a recent flooding like a removed nest bowl or a flood line above the nest position and the eggs were no longer in the nest or in the neighbourhood, it was identified as flooded and destroyed.

Photo 3.1. Oystercatchers and terns were breeding on the saltmarsh on Mandø. Photo: Peter Emil Jensen.

If the eggs (or the egg) in a nest were not warm, or they were damp in parcticular on the lower side, the nest was identified as having been deserted. A nest that was first identified as deserted and was later predated is handled in the results as deserted and not as predated.

If no other fate could be established, the nest was identified as having been predated.

Nest success – data analysis

The Mayfield-method (Johnson 1979) based on nest exposure and daily survival was used to calculate nest survival and hatching success. A nest with eggs was used as the unit. An extensive partial predation on Oystercatcher nests took place on Mandø, and in all observed cases, the Oystercatcher continued incubation on the reduced clutch regardless whether it was reduced to three, two or one egg. This situation prevents measurements of the egg survival: the initial clutch size was rarely known, and the number of eggs that actually hatched was generally also unknown. See Appendix 1 for further details.

3.4 Results and discussion

The hatching and fledging success in 2010 and 2011 is described in detail in Appendix I and only a brief summary is given below.

Hatching success

Nest survival of 109 nests in 2011 and of 122 nests in 2011 showed a huge annual variation with 46% of nests with hatched eggs in 2010 but only 6% in 2011. The majority of losses of full clutches took place in the egg-laying and incubation period.

The most important cause of losses was predation with a rate of 39% in 2010 and 77% in 2011. Flooding by seawater was the second most important cause of losses with 4% of the nests flooded in 2010 and 16% in 2011.

The breeding season was protracted, and egg laying was observed over almost two months from early May until late June. Potentially, a breeding pair has the opportunity to replace a lost egg or the whole clutch repeatedly, and in some cases specific pairs were suspected to replace a full clutch once or twice.

Fledging success

In a smaller study site with c. 70 pairs present, the fledging success was investigated by searching for juveniles and pre-juveniles at a date, when the majority of chicks from hatched nests were expected to be visible and still be together with their parents not too far from their initial nests. This was done on 22 July 2010 and 12 August 2011. In 2010, 21 pairs had chicks on that date, whereas there was only one pair with fledged chicks in the same area in 2011.

In 2010, 16 of the 17 pairs (94%) with hatched chicks between 26 and 42 days before 22 July had fledged or almost fledged chicks. Based on the number of juveniles visible on 22 July, there were 0.26 fledged juveniles per breeding pair (with reference to the breeding pairs present on 3 June). This figure could be used as an index, but it is very likely well below the real figure. Thus if all older broods stayed in the area and are added, the fledging success would be 76% of the hatched broods.

The only pair with hatching success in 2011 still had a fledged chick 26-42 days after the date of hatching. With one fledged chick the production in 2011 was 0.01 fledged juvenile per breeding pair.

The most important cause of egg loss was predation with a predation rate in these two years of 39-77%. Flooding by sea water was the second most important cause of losses, being 4% in one year and 16% in the other.

Due to the huge difference in breeding success in the two study years, it is not possible to conclude whether the Oystercatchers in the study area in general have a sufficiently high breeding success to ensure that the production of new recruits can replace the loss of adults through mortality.

Oystercatchers in the Danish Wadden Sea are widely distributed and are found in various breeding habitats, and they face a large range of different breeding conditions concerning risk of losses due to predation, flooding and agricultural activities. The situation on the saltmarshes on Mandø with irregular occurrence of mammalian predators and a high flooding risk at the more exposed parts of the area is representative of 17-18% of the breeders in the Danish Wadden Sea. If the breeding success programme should be extended, selecting study sites in the polders of Mandø or on saltmarshes on the islands of Fanø or Rømø would give the highest representativity, as c. 23% of the Oystercatchers breed in each of these two types of breeding areas. The international scheme is only focussing on salt marshes, and this excludes a polder study site.

4 Terns on Mandø

4.1 Breeding areas and numbers

Common Terns bred on Mandø with ca. 45, 25, 29 and 12 pairs in 2008-2011, respectively. In 2008-2011 Common Terns bred in the saltmarsh at the northern part of the island (see Appendix 2); Common Terns had nested at this site regularly since at least 1980. The Common Terns were breeding in fairly tall vegetation dominated by (creeping red fescue) *Festuca rubra*.

The Arctic Terns bred with 340, 208, 286 and 170 pairs in 2008-2011 according to the Danish Wadden Sea Breeding Bird Database. During the study years (2008-2011) the Arctic Terns bred on the shallow sandy beach at the southeastern part of the island (on bare sand close to the high tide water line) as well as at the outermost part of the saltmarsh at the northeastern part of the island (on sand and in common salt marsh grass *Puccinellia maritima*. Positions of colonies A-D are given in Appendix 3).

The breeding pairs of the two tern species on Mandø constitute quite large proportions of the breeding pairs in the Danish Wadden Sea, for Common Terns c. 50% and Arctic Terns c. 40% in 2008-2010 (Thorup & Laursen 2011).

4.2 Methods

Monitoring of colonies

Depending on year and the breeding phenology of each colony between two and seven visits were made to each colony. To determine clutch size, breeding phenology as well as the 'fate' of the colonies, nests contents were noted for all nests (including unmarked nests) at each visit. However, to avoid disturbance, observations were only made from a distance when the terns were in the phase of establishing the colony. The specific dates of the visits are given in Appendix 2 and 3.

Hatching success of individually marked nests in 2009

In 2009 breeding performance of terns was monitored by following hatching success in individually marked nests of Common and Arctic Terns. Nests were selected and subsequently checked on the following dates: 13, 25 May, 8, 16 and 24 June and on 1 and 12 July 2009. Thus, the time interval between the seven visits was 12, 14, 8, 8, 7 and 11 days, respectively.

Common Terns. Searches for nests and chicks were carried out during all but the first visit. No searches for nests were made during the first visit, because it appeared that the terns were just about to establish the colony, i.e. birds were observed in the vegetation for short periods, but no or very few birds appeared to have initiated egg-laying. All 20 nests with eggs present on 25 May were marked with a small numbered stick. These nests were checked for nest contents, and searches for chicks and egg shells were made near to the nest if it was empty. The Common Tern chicks were well hidden in the fairly high vegetation and it is very likely that several chicks were not found during the visits to the breeding site. The chicks found were ringed with metal-rings. Nests established after 25 May were not marked and not followed as individual nests.

Arctic Terns. In the colony located near Mandø Låningsvej (colony C) all 60 nests that had eggs during the visit on 8 June were marked with small numbered sticks (for colony locations see Appendix 2). New nests initiated later were not marked. A total of 88 nests were recorded in this colony during the breeding season. The nests were checked for nest contents and searches for chicks and egg shells were made close to the nests on subsequent visits. The chicks found were ringed with metal-rings.

Ringing of chicks

Searches for tern chicks with the aim of ringing and subsequent recapture were conducted on 1-4 dates in each of the years 2008-2011.

Disturbance caused by monitoring

Nest checks were always conducted in a way to keep the level of disturbance at a minimum. The disturbance connected to the placement of the nest sticks lasted less than 15 min and subsequent visits usually lasted less than 10 min per colony.

There were no observations of predation incidents related to the disturbance caused by the placement of nest sticks and the subsequent nest visits in any of the tern colonies.

4.3 Results and discussion

Breeding phenology, clutch size and nest contents

Data on nest contents (such as clutch size and the number of chicks found alive or dead) are given for Common Terns in Appendix 2 for 2009-2010 and for Arctic Terns in Appendix 3 for 2008-2011.

The breeding phenology in 2009 is described in detail in Appendix 2 and 3 and some information on phenology for the other years can be extracted from the tables given in the two appendices.

Photo 4.1. Artic Tern. Photo: Lars Maltha Rasmussen.

Breeding performance of Common Terns

2008: A colony with 40-50 nesting pairs was recorded in the saltmarsh at the northern part of the island on 16 June. Six chicks were found and ringed, but it was assumed that there were more chicks which hid in the tall vegetation. At least half of the colony was flooded on 23 June and no chicks and only two adults were seen at the colony site on 2 July. It is possible that some of the chicks present on 16 June had survived the flooding and fledged before 2 July.

Overall, we estimate that less than 0.5 chicks fledged per breeding pair in 2008.

2009: Twenty nests with eggs were marked with small numbered sticks on 25 May and revisited on 8, 16 and 24 June, as well as on 1 and 13 July. From the revisits it was concluded that chicks had hatched in 10 of the nests (50 %). For eight of the 20 marked nests the fate of the clutch was unknown, because the nests were found empty. Two of the 20 nests were washed away during an extreme high tide on 12 June. In four of the marked nests the chicks were found dead (the reason is unknown); the fate of the chicks in the other six nests was unknown. The searches for chicks around the 20 marked nests were very thorough during the visits. A total of 11 1-10 day old chicks were found in or near to the 20 study nests and the 11 chicks were ringed. None of the ringed chicks were found alive at later visits.

A total of six chicks were found near unmarked nests and these were also ringed but none of them were found alive at subsequent visits. Overall, we judge that fewer than 0.3 chicks fledged per breeding pair in 2009.

The contents of all nests in the colony are given in Appendix 2.

2010: It was recorded that the colony had up to 27 nests with eggs (Appendix 2). About five of the nests were flooded on 19 June. On 21 and 25 June two chicks were found in the colony. Also two dead chicks were found on 21 June. On 1 July no chicks but eight nests with eggs were found (Appendix 2).

Overall, we judge that fewer than 0.3 chicks fledged per breeding pair in 2010.

2011: The traditional breeding area was flooded at an extreme high tide on 24 May. The number of breeding pairs affected by this is unknown, because the first visit took place on 26 May. There was no activity of breeders on 26 May, i.e. immediately after the flooding. On 4 June four nests with eggs were established and 12 nests with eggs were found on 28 June. The number of nests with eggs had declined to four on 7 July and one chick was found and ringed on this date. Four days later, on 11 July, there were no nests with eggs, and neither chicks nor adults were found.

Overall, we judge that no chicks of Common Terns fledged in 2011.

Breeding performance of Arctic Terns

2008: The ratio between the number of chicks ringed and the estimated minimum number of egg-laying breeding pairs indicated that breeding success was extremely poor in 2008. On 23 May 241 nests in three colonies had eggs and another 60 nests were still without eggs. On 16 June (i.e. after all eggs should have hatched) the three colonies were searched thouroughly twice in an attempt to find all chicks. A total of three chicks were found. There were

no signs of predation and no dead chicks or eggshells were found. A few adult Arctic Terns were seen at the colony site. The height of the highest high tide between the recording of nest contents and the visit on 16 June had not been sufficiently high to reach the colony. The cause of the disappearance of more or less the entire colony is unknown.

On 16 June a new colony was under establishment in a different part of the saltmarsh, but this colony was flooded on 23 June before any clutches had hatched. On 4 July a new colony was about to be founded on the southeastern coast of Mandø (where some of the former colonies had been located), but none of the nests had eggs. The Arctic Terns had left this colony before 23 July and most likely no clutches hatched in this late established colony.

Overall, we judge that fewer than 0.1 chicks fledged per breeding pair in 2008.

2009: Sixty nests (with 1 or 2 eggs) were marked with small numbered sticks on 8 June and revisited on 16 and 24 June as well as on 1 and 12 July (Appendix 3, Table A3.4). Chicks hatched in at least 32 (53 %) of the clutches. In another 26 nests (43 %) the clutch disappeared without signs of eggs having hatched (however, eggs may have hatched in some of these nests). In another two nests the eggs were found smashed / broken on 16 June. None of the clutches were lost due to the extreme high tide on 12 June.

In six nests one or more of the hatched chicks died. Thorough searches for chicks around nests were conducted as soon as the first hatched chick was found. These chicks found alive were ringed at the age of 1-10 days: 6 chicks ringed on 16 June, 20 chicks on 24 June and 7 chicks on 1 July. Six of the chicks ringed on 16 or 24 June were recaptured on 1 July. All nests in this colony were empty and no chicks were observed during the visit on 12 July.

In the two other colonies (without marked nests) eggs were found until the beginning of July, and young chicks were found over several weeks (Appendix 3). This may suggest that some birds laid replacement clutches. These two colonies were deserted and all nests were empty on 12 July. The reason for this desertion of nests from all three colonies (of which many had eggs on the visit on 1 July) is unknown.

In the three colonies a total of 86 chicks were ringed at the age of 0-10 days. Six of these were later found dead and 11 were found alive on 1 July.

Overall, we judge that fewer than 0.3 chicks fledged per breeding pair in 2009.

2010: The pattern in 2010 was quite similar to the pattern in 2008 and 2009: 1) A large number of Arctic Terns initiated nesting, 2) many clutches were lost, 3) re-nesting seemed to be frequent, 4) about half or fewer of the clutches hatched, 5) none or only a few of the hatched chicks survived to fledging.

In 2010, a total of 75 chicks were ringed at the age of 1-6 days, but only four of these chicks were found alive at later visits.

As in the previous years, the reasons for the apparent breeding failure could not be identified. Flooding of nests caused breeding failure in about 20 nests in colony D (flooding on 12 June) and in about 10 nests in colony C (flooding

on 19 June) (for colony location see Appendix 3). But flooding did not play an important role for the overall breeding performance in 2010. One person was observed collecting eggs in a Black-headed Gull colony near colony A on 31 May (such collecting of eggs has also been observed in other years prior to this study). It is unknown whether also tern eggs were collected and whether many or only a few nests were affected. It was noticed that a 4-wheeled motorbike had driven through colony D between 8 and 14 June and partly through colony C between 25 June and 1 July. This may have caused some disturbance, but clutches and chicks were also found in these colonies after these incidents. A few small chicks were found without heads, suggesting predation from a mammalian predator. Three dead adults were found in the colonies on 21 and 25 June, but the cause of their death remained unknown.

Overall, we judge that fewer than 0.2 chicks fledged per breeding pair in 2010.

2011: Large parts of the saltmarsh and beaches on the island of Mandø were flooded on 24 May and colonies B, C and D were flooded. As can be seen from the tables given in Appendix 3, colony A, B and C had fewer than eight nests each and the colonies were abandoned after a few weeks. Colony D, having up to 37 nests, was deserted after about four weeks.

On 7 July no terns were present in or near to colony A and B but three nests had eggs in colony C. Colony D had nests with eggs and at least one chick on 7 July, but none on 11 July when only a few adult birds were present at the colony.

Overall, we judge that fewer than 0.1 chicks fledged per breeding pair in 2011.

Photo 4.2. A nest with eggs of Arctic Terns at the island of Mandø. Photo: Peter Emil Jensen.

Effects of flooding

Exceptionally high water levels were recorded during several of the breeding seasons causing losses of some nests and, more rarely, losses of entire colonies. In several cases new colonies were formed within 1-2 weeks after flooding.

Effects of predators

We found very little documentation for predation. Nests of Herring Gulls were not found in the vicinity of the Arctic Tern colonies, and there were no observations of Herring Gulls attempting to predate on tern eggs or chicks. Carrion Crow *Corvus corone* and Hooded Crow *C. cornix* were present on the island but Crows were not observed predating eggs in the tern colonies. The findings in 2010 of small chicks without head suggest that some predation by mammalian predators did occur.

Effects of human activity

The island of Mandø is inhabited and the island is visited by tourists. The public had free access to all breeding areas on the island throughout each breeding season.

We did not observe presence of humans inside the breeding colonies. The frequency of human occurrence in the breeding areas along the beach on the east side of the island and in the saltmarsh to the northeast is unknown, but the occurrence of humans is known to be most frequent on the beach at the south-eastern coast. The Arctic Tern colonies on the southeast coast were located very close to sites where tourists as well as some of the islands' residents are walking (sometimes with dogs without leash). However, we have no information about the extent of disturbance caused by this recreational activity.

A four wheeled motorbike (an ATV) had driven through or close by two of the colonies but we have no indications that this had marked effects on hatching success or chick survival.

The terns were disturbed by the researchers when breeding parameters were recorded. The breeding areas were normally not entered when the birds were in the phase of establishing a colony. During the incubation and chick rearing period, the colonies were visited 2-7 times in 2008-2011. The time spent inside the colonies was kept at a minimum to limit the effects of the disturbance. We judge that the field activity inside the breeding colonies had no or only a neglible influence on hatching success and chick survival.

5 Gulls and terns on Langli

5.1 The island of Langli

Langli is a 2.1 km long island situated in the northern most part of the Wadden Sea. It is characterized by saltmarshes at the northern and southern parts of the island and dunes as well as meadows in the central part (Fig. 5.1).

Potential disturbance from humans

There were no inhabitants on the island during 2005-2013, i.e. the years covered by the present report. In these years, human occurrence in the breeding season was limited to 4-7 one-day visits by researchers. The public had free access to the island from 15 July onwards.

5.2 Numbers and distribution of breeding gulls and terns

More than 10,000 pairs of gulls, terns and waders bred on the island annually during 2005-2013. The development of breeding numbers of gulls and terns is given in Table 5.1. The distribution of the breeding colonies of gulls and terns surveyed in 2009 are shown in Fig. 5.1.

Black-headed Gull numbers ranged from 1890 to 5250 pairs during 2005-2012 but dropped to 1358 pairs in 2013 (Thorup & Laursen 2011, 2014). In most years, the Black-headed Gulls nested in 2-3 colonies on the northern saltmarsh.

Common Gull breeding numbers decreased from an average of 1575 pairs during 2005-2009 to an average of 1029 pairs during 2010-2013 (Thorup & Laursen 2011, 2014).

The numbers and distribution of breeding Herring Gulls increased markedly after 2009 (Thorup & Laursen 2011, 2014). In 2009 the vast majority of the Herring Gulls bred at the southern and middle part of the island. By 2012 the species had expanded its range to the entire island including the northern coast and saltmarsh, including the area where Black-headed Gulls and Sandwich Terns were breeding.

Photo 5.1. The numbers of Lesser Black-backed Gulls breeding on the island of Langli increased markedly between 2005 and 2013. Photo: Rasmus Due Nielsen.

Lesser Black-backed Gull began to breed in the Danish Wadden Sea in the 1990s, and numbers continued to increase in the 2000s. The main colony is found on Langli where breeding numbers increased from 631 pairs in 2005

to 2485 pairs in 2013 (Table 5.1). The majority of the Lesser Black-backed Gulls bred on the southern and middle part of Langli in 2009 when individually marked nests were followed. This species has also expanded its distribution over the years.

The numbers of breeding Arctic Terns have fluctuated during the survey period. Arctic Terns were breeding with 40 pairs in 2009 when nests of this species were followed (Thorup & Laursen 2011, 2014). The northernmost part of Langli was the preferred nesting area in most of the survey years.

Sandwich Tern numbers dropped from an annual number of 1183-3249 breeding pairs in 2005-2010 to 67-735 breeding pairs in 2011-2013 (Thorup & Laursen 2011, 2014). In 2009 the Sandwich Terns bred in three colonies that were in close proximity to each other on the northern part of Langli. All three sub-colonies were surrounded by large Black-headed Gull colonies.

Figure 5.1. The positions of the breeding colonies of gulls and terns surveyed in 2009 on Langli.

Table 5.1. Numbers of breeding pairs of gulls and terns at the island of Langli, 2005-2013. Source: The Danish Wadden Sea Breeding Bird Database. See Thorup & Laursen (2011, 2014).

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Black-headed Gull *Chroicocephalus ridibundus*	2331	2033	1890	3530	3920	5250	2240	3570	1358
Common Gull *Larus canus*	1769	1231	1936	1540	1400	1099	1082	963	970
Lesser Black-backed Gull *Larus fuscus*	631	975	987	843	721	1019	1988	1778	2485
Herring Gull *Larus argentatus*	5328	3345	5044	4508	5432	6230	6283	9143	8090
Arctic Tern *Sterna paradisaea*	195	69	90	182	40	177	139	48	22
Sandwich Tern *Thalasseus sandvicensis*	1183	3249	2660	3000	1855	2250	735	67	91

5.3 Methods

Counts and numbers of visits

The aim of some of the visits was to monitor the size of the breeding populations which was done by counting the number of individuals in the colony areas. These counts were made from elevated points such as the top of dunes. Other visits were aimed at ringing chicks of gulls and terns. Furthermore, the island was visited four times in 2009 with the aim of following nesting success in selected nests. Visits to the island lasted 1-2 days. Work inside colonies was kept at a minimum to limit the level of disturbance.

Monitoring of individually marked nests in 2009

In 2009 breeding performance of gulls and terns were monitored by following hatching success of individually marked nests of Common Gull, Herring Gull, Lesser Black-backed Gull, Arctic Tern and Sandwich Tern.

Nests were selected and subsequently followed during four visits to Langli on the following dates: 12-14 May, 20-21 May, 3 June and 11 June.

Contents of all selected nests were recorded at each visit to the island. To determine clutch size at the time of marking of nests, nest contents were also noted for a number of un-marked nests to increase sample size.

Selection and marking of nests. Within sectors of the colonies nests were selected and marked with flower sticks (tern colonies) or with bamboo sticks (gull colonies) (see photos 5.2 and 5.3). A small flag with an individual number had been attached to the top of each stick beforehand. In the gull colonies, nest sticks were placed one meter from the nest in the direction of the house on Langli.

All the surveyed Common Gull nests were located in the large colony at the north-eastern part of the island. Due to the high nest densities in this colony, some nests were assigned to the same stick. Therefore, for most nests small maps were made to denote the precise location of each nest in relation to the relevant stick.

The location of the selected nests of Herring Gulls and Lesser Black-backed Gulls were logged by use of GPS.

The dates of nest marking and the number of nests selected for monitoring is shown in Table 5.2.

Table 5.2. Dates of marking of nests and numbers of nests selected for monitoring in 2009.

Species	Date(s)	Number of nests marked
Common Gull	13 May	134
	21 May	27
Lesser Black-backed Gull	12 and 14 May	107
Herring Gull	12 and 14 May	107
Arctic Tern	20 May	20
Sandwich Tern	21 May	59

Photo 5.2. The nest sticks as they were used in the Common Gull colony. Photo: Rasmus Due Nielsen.

Photo 5.3. The Arctic Tern colony on the northern tip of Langli. Common Gull and Herring Gull nested within a meter of this Arctic Tern colony. Photo: Rasmus Due Nielsen.

Nest densities were high in the colonies of Arctic Terns and Sandwich Terns, and nest sticks were therefore placed at a foot's width from each of the selected nests in order to minimize the risk of confusion at succeeding nest visits.

In 2009 Arctic Terns only bred at two sites on Langli with one colony holding four pairs and one holding 18 pairs at the first visit. The colony of 18 nests was situated in the transitional zone between the sandy beach and the marsh on the northern part of the island (Photo 5.3).

In 2009 the Sandwich Terns bred in three dense colonies at the northern part of Langli (Photo 5.4). A total of 59 nest sticks were placed in two different parts of the colony. Nest sticks were placed so they were easily visible in order to minimize disturbance at subsequent visits.

Photo 5.4. A section of the Sandwich Tern colony on the northern part of Langli. Sticks with red flags denote the location of individually identifiable nests. Photo: Rasmus Due Nielsen.

Monitoring of hatching success. The contents of each of the marked nests were checked at up to four different dates. Some nest sticks disappeared in between visits and consequently not all nests could be followed throughout the incubation period.

Disturbance caused by monitoring. Nest checks were always conducted in an attempt to keep the level of disturbance at a minimum. For most Common Gulls one of the parents returned to the nests when the researcher had moved about 15 m away from the nest.

A total count of the Sandwich Tern colony, including placement of sticks at selected nests, lasted 20 min. The nest checks at the subsequent visits lasted 5-10 minutes. All birds had returned to their nest within 2-5 min, with the first birds arriving 1 min after leaving the colony.

In the Arctic Tern colonies the disturbance from placing the nest sticks lasted less than 5 min.

There were no observations of predation incidents related to the disturbance caused by the placing of nest sticks and the subsequent nest visits in any of the colonies of the four examined species. However, it is possible that unnoticed predation took place during the checking of nests in the colonies of Common Gulls, Lesser Black-backed Gulls and Herring Gulls.

Counts of chicks near to fledging

In 2009-2012 young gulls were counted on the entire island around the time of fledging. The counts covered the island itself as well as the shore and the sand- and mudflats around the island. The counts took place from vantage points, e.g. high dunes with a good overview. Chicks hiding in tall vegetation or behind shore brinks could not be detected and hence not all young were observed and counted. The number of counted chicks is therefore a minimum.

In some areas with tall vegetation chicks were counted from vantage points but also by thorough searches walking through the area. Based on these two sets of counts it was estimated that the number of Herring Gull chicks counted from vantage points should be multiplied by a factor of 1.4 and the number of chicks of Lesser Black-backed Gulls should be multiplied by a factor of 1.1 to correct for the undetected young. We use these correction factors for each year, even though they are very rough and the true conversion factors undoubtedly varied between years.

Ringing of chicks

In relation to a colonial waterbird project in Denmark, a large number of gull and tern chicks were ringed on Langli in most years between 2005 and 2013. The ringing took place during one or two annual visits. The ringing focused on Lesser Black-backed Gull, Herring Gull and Sandwich Tern. The ringing of large gulls in 2008 was limited to the central part of the island to minimize any possible disturbance to the Eurasian Spoonbills breeding on the southern part of the island. The ringing of large gulls carried out during 2009-2013 covered the same breeding areas every year, and the effort was almost constant from year to year. The aim was to use this information on the number of chicks ringed during 2009-2013 as a rough index of year-to-year variation in the total number of chicks alive at the age of 3-5 weeks.

Based on records of the number of ringed and un-ringed young observed on the mudflats and beaches in summer, it was estimated that the ringed chicks of Lesser Black-backed Gulls typically constituted 30-40% of the chicks present on the island and the ringed Herring Gull chicks constituted 15-20% of the chicks present at the time of ringing.

Lesser Black-backed Gull. In 2006 and 2008-2013 a total of 2553 chicks were ringed on Langli. The chicks were ringed in the last week of June and / or before 12 July, i.e. when the chicks were 3 weeks old or older; the vast majority being approximately 5 weeks old when ringed (Photo 5.5). The chicks ringed in 2006 were only ringed with metal-rings, whereas more than 95% of the chicks ringed in later years were ringed with colour-rings as well.

Photo 5.5. A newly colour-ringed chick of a Lesser Black-backed Gull ringed at the age of 5 weeks on Langli.

Herring Gull. In 2006 and 2008-2013 a total of 3311 chicks were ringed at Langli. The Herring Gull chicks were only ringed with metal-rings. The majority of the chicks were ringed along the coast of the island and were 4-5 weeks old when ringed.

Sandwich Tern. The ringing took place annually during 2005-2010. The chicks were ringed in the first half of June when the chicks were 5-12 days old. In some of the years, a smaller number of chicks were ringed in late June or early July. The number of chicks ringed in 2006-2010 can be used as a very rough index for the number of chicks reaching the age of 5-12 days per nesting pair. No ringing was carried out in 2011-2013 because of poor breeding success (2011) or because of low breeding numbers (2012 and 2013).

5.4 Results and discussion

Clutch size and brood size

Data and comments on clutch sizes and brood sizes as they were recorded in 2009 are given in Appendix 4.

Table 5.3. Hatching success in the nests that could be followed from after or around the end of egg-laying until the end of incubation for three species of gulls and two species of terns on the island of Langli in 2009.

Species	Proportion (%) of clutches hatched	N
Common Gull	18.9	122
Lesser Black-backed Gull	83.7	86
Herring Gull	85.9	78
Arctic Tern	0	17
Sandwich Tern	66.7	33

Table 5.4. The annual counts of gulls and their nearly fledged young during 2009-2012. The counts of young took place on 10, 12, 15 and 8 July, respectively.

Species	Year	Number of breeding pairs	Number of young	Number of young corrected	Ratio young/pair	Ratio young/pair corrected
Common Gull	2009	1400	7	14	0.005	0.010
	2010	1099	8	16	0.007	0.015
	2011	1082	6	12	0.006	0.011
	2012	963	10	20	0.010	0.021
Lesser Black-backed Gull	2009	721	775	891	1.08	1.24
	2010	1019	882	1014	0.87	1.00
	2011	1988	31	36	0.02	0.02
	2012	1778	170	196	0.10	0.11
Herring Gull	2009	5432	1584	2218	0.29	0.41
	2010	6230	1850	2590	0.30	0.42
	2011	6283	380	532	0.06	0.09
	2012	9143	1434	2008	0,16	0.22

Table 5.5. Number of chicks ringed of Lesser Black-backed Gull and Herring Gull during 2006-2013, of Sandwich Tern in 2005-2010 and of Arctic Tern in 2008. The 'estimated number of chicks per breeding pair' given for Lesser Black-backed Gull and Herring Gull denotes the number of chicks ringed roughly corrected for the assumed proportion of chicks present but not found and ringed.

Species	Year	Numbers ringed	Numbers ringed per breeding pair	Estimated numbers per breeding pair[1]
Lesser Black-backed Gull	2006	610		
	2008	235*		
	2009	493	0.68	1.95
	2010	437	0.43	1.23
	2011	119	0.06	0.17
	2012	206	0.12	0.33
	2013	453	0.18	0.52
Herring Gull	2006	15		
	2008	247*		
	2009	615	0.11	0.75
	2010	480	0.08	0.51
	2011	239	0.04	0.25
	2012	717	0.08	0.52
	2013	998	0.12	0.82
Sandwich Tern	2005	179	0.15	
	2006	748	0.23	
	2007	400	0.15	
	2008	831	0.28	
	2009	583	0.31	
	2010	779	0.35	
Arctic Tern	2008	41	0.23	

* Ringing limited to the central part of the island

[1] It is assumed that app. 35% of the LBBG and app. 15% of the HG chicks were found and ringed

Photo 5.6. Nest sticks were used to identify individual nests of Common Gulls breeding on the island of Langli. Photo: Rasmus Due Nielsen.

Common Gulls

Breeding performance of Common Gulls was extremely poor in all six years. Overall, we estimated that maximum 20 chicks fledged annually from the colony during 2008-2013. In most years the main cause of breeding failure was predation from Herring Gulls of especially eggs but also of small chicks.

The monitoring of individually identifiable nests in 2009 confirmed the observation in other years that hatching success was low (Table 5.3). The obseravtions and records made during ringing in 2008-2013 and the counts of nearly fledged young in 2009-2012 suggested that the production of fledged young was extremely low in all the years from 2008 to 2013. The estimated number of fledged young produced per breeding pair is given in Table 5.4. More detailed comments on the individual breeding seasons are presented below.

2008. Breeding success was extremely low, apparently due to a combination of predation from Herring Gulls and flooding by the sea of most of the colony in the second half of June. It was observed that 10-15 pairs of Herring Gulls were breeding inside the colony of Common Gulls. Some of these Herring Gulls were observed walking among the Common Gull nests taking eggs and chicks (this predation took place when there was no disturbance of the Common Gulls). During a visit to Langli on 1 July with the purpose of ringing chicks, no chicks were found in the Common Gull colony.

2009. The monitoring of 122 individually marked nests in 2009 revealed that hatching success was low (Table 5.3). From the first to the second visit the number of eggs per clutch had declined in 29 nests and all eggs had disappeared in 12 nests that were very close to each other. Overall it was estimated that at least 14 % of the clutches that were followed were lost due to predation. A large number of nests was just found empty and this may have been due to predation. Predated eggs were found in the Common Gull colony on every visit.

Photo 5.7. Few of the eggs laid by Common Gulls on the island of Langli survived until hatching. Photo: Lars Maltha Rasmussen.

Although chicks were observed in or near some of the nests at the second visit, no chicks were found in the colony area on subsequent visits despite thorough searches. Only 7 large young were recorded during the systematic count of fledged or nearly fledged young gulls on 10 July 2009 (Table 5.4). Herring Gulls were also nesting inside the Common Gull colony in 2009 with additional Herring Gulls nesting along the edges of the Common Gull colony. Herring Gulls were observed predating Common Gull eggs and chicks in 2009 and this was probably the main reason for the low breeding success that year.

2010-2013. The Common Gulls also bred with low success in 2010-2013 (Table 5.4). The Herring Gulls continued to expand their breeding range on Langli during 2010-2013 resulting in a gradual increase in the number of Herring Gulls breeding inside and near to the Common Gull colony. Predation from Herring Gulls was also judged as the main cause for breeding failure in these years.

Lesser Black-backed Gull

The Lesser Black-backed Gulls on Langli bred with reasonably high success in 2008-2010, with very low success in 2011 and with low-moderate success in 2012-2013 (Tables 5.3, 5.4 and 5.5). The following are comments to some of the breeding seasons.

2008: Compared with other years, a very high number of 3-5 weeks old chicks were found. From this we concluded that the Lesser Black-backed Gulls bred with high success in 2008.

2009: The survey of individually marked nests demonstrated that hatching success was high (84%) this year. All Lesser Black-backed Gull clutches from which no eggs hatched were apparently unsuccessful because of predation. Many findings of egg remains documented that predation by gulls on eggs and chicks took place.

2011: A fairly low number of chicks were found during ringing in 2011 (Table 5.5), and the count of fledged or nearly fledged young suggested that fledging success was very low on Langli in 2011 (Table 5.4). The cause for the low breeding success in 2011 is unknown, but it is suspected that one or more foxes had visited or stayed on the island, which mostly occurs after severe winters with ice cover. Periods with low food availability could also have been the cause. Furthermore, there were also more observations of predation from Herring Gulls than in previous years.

2012: Despite a very thorough search for chicks during ringing in 2012, a relatively low number of chicks were found. The reason for the poor breeding success is unknown. The count of fledged or nearly fledged young showed an intermediate breeding success: much lower than in 2008 and 2009 but 5-6 times higher than in 2011.

The recorded number of nearly fledged young per breeding pair (0.02-1.08, Table 5.4) suggest that the Lesser Black-backed Gulls bred with considerably lower success in 2009-2012 than in 2001 when 1.64 fledglings were recored per pair (Thorup 2001).

Herring Gull

Comparing the years 2009-2012 the Herring Gulls bred with reasonably high success in 2008-2010 and 2013, with very low success in 2011 and with low success in 2012 (Tables 5.3, 5.4 and 5.5). Further comments are given to some of the seasons.

2009: The hatching success was high (Tabel 5.3), but was not monitored in the other years.

2012: The number of young ringed in 2012 was high compared with the number of young counted around the time of fledging. This may have been due to a higher effort in ringing of Herring Gull chicks in 2012 than in other years.

On Langli, 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 in nine years between 1992 and 2001 (Thorup 2001).

The 0.06-0.30 nearly fledged young recorded per breeding pair during in 2009-2012 (Table 5.4) is considerably lower than the mean of 1.07 recorded in the nine year period 1992-2001 (Thorup (2001).

Photo 5.8. A pair of Herring Gulls with nearly fledged young. Photo: Lars Maltha Rasmussen.

Arctic Tern

Arctic Terns had a poor breeding success in all survey years. Thus, the observations made during various visits to the island (mainly those aimed at ringing) suggest that none of the breeding attempts during 2008-2013 resulted in successful production of fledged young. Searches of breeding Arctic Terns and chicks took place annually during 2008-2013 when the island was visited in order to ring chicks of terns and gulls. In two of the years we cannot exclude the possibility that birds might have fledged before the first ringing visit took place.

2008. On 20 May 182 nests were recorded. On 7 and 13 June a total of 41 chicks were ringed, but more chicks were present in the colony on these dates. At the visit on 24 June it was observed that the colony had been flooded but a few new nests had already been established again.

2009. Arctic Terns bred in two small colonies with 4 and 18 nests, respectively. None of the eggs in these two small colonies hatched and on the visit during 14-16 June no terns were observed in or near the colony area. The reasons for breeding failure are unknown, but all the nests were placed on the beach and thereby potentially exposed to flooding by the sea. Nests of Herring Gulls were also found in the near vicinity of the larger of the two Arctic Tern colonies and therefore predation could be a cause for the breeding failure as well.

Sandwich Terns

The Sandwich Terns apparently bred with high success in 2006 and 2008-2010, when visits early as well as late in the chick rearing period confirmed that chick survival was high.

2008. On 7 July, a large number of unfledged young and at least 200 fledged young were recorded in the colony area during a visit to the island.

2009. Two thirds of the 33 nests that could be followed until the time of hatching survived and hatched. The faith of the clutches that did not hatch could not be determined.

2010. This year was apparently the year with the highest fledging success during this investigation period. We base this judgement on the number of young observed in the colony during visits aimed at ringing large gulls.

2011. A pair of Herring Gulls had established a nest almost in the center of the main breeding colony and both birds were observed to predate eggs in the Sandwich Tern colony. No chicks were found during a visit on 2-3 July and it was concluded that none of the eggs in the colony survived to hatching.

2012 and 2013. There were no eggs or chicks in the breeding area during visits aimed at ringing. There were no indications that the breeding birds that were still present attempted to re-nest.

Photo 5.9. A section of the Sandwich Tern colony on the island of Langli, 2004. Photo: Lars Maltha Rasmussen.

Predators

Large gulls. Herring Gulls were observed to predate on eggs and chicks of Herring Gulls, Lesser Black-backed Gulls, Common Gulls, Black-headed Gulls, Arctic Terns (no observations of predation of chicks) and Sandwich Terns. Lesser Black-backed Gulls were observed taking eggs in nests of Herring Gulls and other Lesser Black-backed Gulls.

Crows. Carrion Crow *Corvus corone* and Hooded Crow *C. cornix* were seen entering gull colonies trying to predate eggs from all the four species of gulls. Crows were not observed predating eggs in the tern colonies.

Mammals. Foxes can reach the island by crossing the ice and some foxes may walk to the island during low tide. It is not clear to what extent foxes occurred on the island in the breeding seasons of 2008-2013. However, we know that foxes did breed on the island in 2011 and 2012, but the female fox and her cubs were removed from the island in March in both years. In 2009 an unidentified Mustelid was observed once at the house on the island.

6 Evaluation of applied methods

Here we evaluate our experience with the different methods that were applied during the present study of breeding success of Oystercatchers, terns and gulls breeding on Mandø and Langli in the Danish part of the Wadden Sea. We also discuss some of the advantages and disadvantages of the methods.

6.1 Oystercatcher

From the monitoring of breeding success of Oystercatchers on the island of Mandø in 2010 and 2011 we experienced that is was possible to assess the hatching success of the Oystercatchers that were breeding in high density along the driveway to the mainland and on the narrow eastern saltmarshes. It was possible to carry out the monitoring at a relatively low time cost per surveyed nest (Table 6.1). We judged the assessment of hatching success as being highly reliable and in many cases it was possible to identify the causes of losses of clutches.

We also experienced that it was possible to add an assessment of the fledging success of the Oystercatchers breeding on the narrow eastern saltmarsh. This monitoring only involved approximately five hours extra work per year by counting the present breeding pairs in early June and counting and ageing the pre-juveniles and juveniles in late July and mid-August.

Overall, we conclude that the methods applied in the study of breeding success of Oystercatchers were suitable and so was the selected study site at Mandø. From a cost efficient point of view we judged the Mandø site as being suitable for this kind of study.

Table 6.1. Amount of time (hours) used on the Oystercatcher studies on Mandø in 2010 and 2011 in comparison with the time consumption recorded during a study in Niedersachsen in 2009 (Thyen 2009) and own estimates of expected time needed for studies in low density areas.

Breeding area	Average transportation time to study site per nest	Average time to find a nest	Average time to perform a nest control	No of visits needed for nest controls	Total per nest
Mandø 2010 and 2011 - high density breeding	0.18	0.17	0.14	2.5	0.7
Niedersachsen in 2009 - medium density breeding and poor visibility					3.0
Estimate for low density breeding and good visibility	0.7	0.5	1.0	2.5	3.7
Estimate for low density breeding and poor visibility	0.7	1.5	1.0	2.5	4.7

6.2 Gulls

Hatching success

The hatching success of gulls was quantified at Langli in 2009 by monitoring the fate of individually identifiable nests. Koffijberg *et al.* (2011) had suggested that nests should be visited with an interval of 6-7 days. Unfortunately, the time and amount of manpower available only allowed us to visit the individually marked nests with an interval of 8-13 days.

We judge that the measured values for hatching success were reliable for the study plots selected. We believe that the hatching success measured for the Common Gull nests was representative for the overall breeding performance in the colony. However, we are less certain that this was also the case for the Lesser Black-backed Gulls and Herring Gulls which had larger breeding areas, including a larger range of 'environment types' (varying nest densities, vegetation structures etc.).

The monitoring of nests caused some disturbance and probably some losses of nests, although we did not observe this.

Subsequent to the breeding season in 2009, the Danish Nature Agency concluded that the monitoring of hatching success had required an unacceptable high number of visits to the breeding sites. They judged that it had caused too much disturbance of the birds breeding on Langli and they were not willing to give permission to more than a few visits to the island of Langli in 2010 and 2011. As a consequence in 2010 and 2011, we focused on 1) the ringing of chicks and 2) a total count of chicks of the larger gull species near fledging stage.

Ringing of chicks

Large numbers of 3-5 week old chicks of Lesser Black-backed Gulls and Herring Gulls were ringed on Langli during 2006-2013 (Table 5.5). The ringing took place during one or two annual visits in 2008 where the activity was limited to the central part of the island in order to avoid disturbance of the Eurasian Spoonbills breeding on the southern part of the island.

The overall experience was that a large number of gull chicks could be ringed in a short period of time and without causing extensive disturbance. We are, however, not certain about how reliable it is to use the total number of chicks ringed as a rough index of the year-to-year variation in the total number of chicks alive at the age of 3-5 weeks or in relation to the total number of eggs laid.

Theoretically, with a constant number of breeding pairs and a constant effort over years, the proportion of chicks ringed would be high in years with low breeding success and low in years with high breeding success. However, we have to take into account that breeding numbers of both Lesser Black-backed Gulls and Herring Gulls have increased markedly (Table 5.1). We therefore assessed that the index overestimated the number of young in the first years when breeding numbers were relatively low compared with the more recent years.

We judge that the precision of this index can be improved by a more careful recording of the distribution of breeders, the area searched for chicks and by checking the probability of failing to find and ring chicks that were actually present in the areas searched. However, an indication of the proportion of

chicks ringed in relation to those present can be gained by recording the number of ringed chicks among those observed when counting the nearly fledged and fledged chicks present on the island and surrounding mudflats later in summer.

Counts of large chicks

The total counts of chicks of the larger gull species at Langli covered the island itself as well as the shore and the sand- and mudflats around the island. The counts took place near the time of fledging. We judge that these counts generally were successful. However, the relationship between the number of chicks counted and the total number of young from the colony that reach the age of fledging will vary from year-to-year. The major reasons are a) that it is difficult to time the counts so they take place at exactly the same time in relation to breeding phenology (which will vary between years), and b) that the conditions during the counts (water levels, distribution of chicks) are likely to differ among years.

The experience showed that the chicks should be counted between low tide and high tide with the chicks present on the mud- and sandflats and thus easier to count. By walking on land at some distance from the coastline large chicks present on land near the shore will move out onto the mudflats.

Overall, we judge that it was possible to obtain a reasonable estimate of the production of nearly fledged young for Herring Gulls and Lesser Black-backed Gulls breeding on Langli. It is less certain that this method is applicable to obtain a reasonable value for the fledgling production for Common Gulls and Black-headed Gulls because the chicks of these two species may leave the island fairly quickly.

6.3 Terns

Hatching success

In 2009 the hatching success of terns at Langli and Mandø was monitored by following the fate of individually identifiable nests. Due to the lack of manpower it was not possible to follow the nests with an interval of 6-7 days as recommended by Koffijberg *et al.* (2011).

Our experience was that the method was useful for Common and Arctic Terns because it could be conducted without causing critical disturbance. However, we were less certain about the effect of our disturbance and effects on nesting success when checking marked nests in the colony of Sandwich Terns on Langli.

In relation to Mandø, we got the suspicion that one or several persons had used the small sticks - that were marking the tern nests - to find the nests and collect eggs and/or remove chicks. We therefore decided to skip the marking of individual nests in 2010 and 2011. Instead, nest contents were monitored in 'all' nests at each visit and as many chicks as possible were ringed.

Overall, the marking of nests did not add much to the precision of the records of hatching success or to the understanding of the reasons for egg-losses. However, the value of using individually marked nests would have been higher if we had not experienced a complete or almost complete loss of nests during incubation.

Photo 6.1. Sandwich Terns prefer to breed inside colonies of Black-headed Gulls, but few Black-headed Gulls are now breeding on the island of Langli. Photo: Lars Maltha Rasmussen.

Ringing of chicks

Tern chicks were ringed at Langli and Mandø. The number of young chicks recorded during ringing gave a reasonable indication of hatching success and the later visits aimed at ringing larger chicks gave indications of the survival of chicks. However, the method of ringing and later recaptures was not applied in a way that allowed us to use standard capture-recapture methods to quantify chick survival.

7 Recommendations for future monitoring in the Danish Wadden Sea

Based on the experience gained during the present study with pros and cons of different methods to monitor breeding success we present some suggestions for future monitoring of breeding success of Oystercatchers, terns and gulls in the Danish part of the Wadden Sea.

7.1 Main aims

Monitoring of breeding success of waders, gulls and terns in the Danish part of the Wadden Sea would be of greatest value if it could meet the following aims:

1. Provide information about breeding success for the key species and key areas selected by the trilateral collaboration between the Wadden Sea countries. The selected species for the Danish part of the Wadden Sea are Oystercatchers, Black-headed Gulls, Herring Gulls, Sandwich Terns and Arctic Terns. The breeding success of these species should be studied on at least one island (not necessarily the same island for all species).
2. Measure breeding success with methods that ensure that the obtained values could be used for comparisons among years.
3. Provide annual measures of breeding success in order to track gradual changes and fluctuations.
4. Provide measures that are also representative for breeding bird species in the Danish part of the Wadden Sea.
5. Use methods that ensure that values obtained in the Danish part of the Wadden Sea could be compared with values for breeding success measured in the German and Dutch parts of the Wadden Sea.
6. Identify the factors that play a major role for breeding performance of the key species breeding in the selected study sites in the Danish part of the Wadden Sea.

7.2 The cost of monitoring: A major constraint

Proper monitoring of breeding success is far more time consuming than monitoring of breeding numbers. Whereas a reasonable overview of breeding numbers of a species in many cases can be obtained by two visits at the peak of the breeding season – and more than one species can be counted at the same visit – the correct assessment of nesting success and fledging success of a species can only be achieved by repeated visits during the entire breeding period, which is often protracted to include three months or more for breeders in the Wadden Sea.

In order to assess nesting success, individual nests must be found, although finding nests of colonial birds breeding concentrated is fairly rapid and straightforward. In contrast, it is more time consuming for the solitarily breeding species. The major expense will often involve the repeated visits – with 6-7 days interval – to the breeding sites to check the contents of individually marked nests and later to follow the survival of the chicks until fledging.

7.3 Recommendations

The target value of monitoring breeding success in the International Wadden Sea is the number of young fledged per breeding pair. This value should be measured for selected species and study sites. The original suggestion was that Denmark should monitor breeding success of Oystercatcher, Black-

headed Gull, Herring Gull, Sandwich Tern and Arctic Tern on Langli and Mandø by use of the recommended standard methods for determining hatching and fledging success (Koffijberg 2008).

The opportunities for funding future monitoring of breeding success of waders, gulls and terns in the Danish part of the Wadden Sea are unknown at present. However, considering recent reductions in the funding of the basic monitoring of birds in the Danish Wadden Sea, we foresee a need for adjusting the goal and/or for selecting less costly – and thus less precise – methods for monitoring breeding success.

The cost of monitoring may be lowered by:

(1) Restricting the number of breeding sites monitored.

(2) Limiting monitoring activities to selected years, e.g. by monitoring during 2-3 years followed by 2-3 years without monitoring.

(3) Reducing the total number of visits to the breeding area within each season, allowing for a less precise determination of breeding success.

(4) Limiting the monitoring to either the egg stage or the chick stage.

(5) Using methods that only give rough estimates of the number of young fledged per breeding pair, e.g. a best estimate of a lower and upper value.

(6) Applying methods which only provide an index for the number of young fledged per breeding pair but allow for comparisons among years within the same locality.

There are obvious disadvantages of each of these ways of reducing the costs of monitoring breeding success.

It could be argued that it should be a top priority to trace whether or not the key species are breeding with poor, intermediate or high success in the individual years. In that case, a low level of precision might be acceptable. A strategy could therefore be to use simple and not very precise methods as long as a species was breeding with a reasonable success, but then initiate more detailed studies if the species' breeding performance deteriorates. Detailed studies would be needed if the causes of low breeding success have to be indentified. This knowledge will be essential to identify the options for improving breeding conditions through management.

Some of the disadvantages of limiting the initial monitoring to methods that only provide rough estimates of breeding performance and not specific values for hatching success and fledging success are:

1) It becomes difficult or impossible to make quantitative comparisons with the breeding performance of populations studied at other localities in the International Wadden Sea

2) The annual classification of breeding success potentially could vary depending on the person responsible for giving the best lower and upper values for the estimated number of young fledged per breeding pair.

Thefore the suggestions we give below are a compromise between the preferred solutions and possible solutions considering the restrictions impaired by limited funding, methodological obstacles and uncertainty about the representativeness of the study areas.

In the following we only describe suggestions for the species for which Denmark has been asked to monitor breeding success.

7.4 Oystercatcher

Selection of study areas

Oystercatchers in the Danish Wadden Sea are widely distributed and are found in various breeding habitats. They face a large range of different breeding conditions concerning risk of losses due to predation, flooding and agricultural activities (Table 7.1). According to the international guidelines (Exo *et al.* 1996, Koffijberg *et al.* 2011) the breeding success scheme is restricted to Oystercatchers breeding on saltmarshes, and this excludes the 35 % of the Danish Wadden Sea Oystercatchers breeding in polders and other inland sites (Table 7.1) and probably also a large fraction of the 10 % breeding on the island of Langli, which breeds in dunes. The study site on the saltmarshes on Mandø is representative of a breeding area type, which holds 17-18 % of the breeders in the Danish Wadden Sea: a type with irregular occurrence of mammalian predators, and a high flooding risk at the more exposed parts of the area (Table 7.1).

If the breeding success programme should be extended, and polders are avoided, additional study sites on saltmarshes on the islands of Fanø or Rømø would give the highest representativity, as 23 % of the Oystercatchers bred in this type of area at the last breeding survey with total coverage (Table 7.1).

The island of Langli holds another high-density population and a large number of breeding pairs (Table 7.1). Langli is a mixed multi-species bird colony, where 140 – and in some years more – pairs of Oystercatchers are breeding in dunes and saltmarshes mixed with up to 10,000 pairs of Common Gulls, Lesser Black-backed Gulls, Herring Gulls and Great Black-backed Gulls. The gulls are all potentially quite efficient egg and chick predators, and disturbance by humans in a colony like this inevitably increases such predation significantly. We see mainly two disadvantages of attempting to assess breeding performance of Oystercatchers at Langli. First, the observed predation rates would be, without doubt, artificially high compared to what they would have been without the disturbance by the observer. This would bias the results and compromise the bird protection at the site. Secondly, the breeding conditions with rare occurrence of mammalian predators, but with huge numbers and a high density of aerial predators, is unique for Langli and the conditions there are not representative for the breeding conditions anywhere else in the Danish Wadden Sea.

Proposed study areas and methods

Table 7.2 gives estimates of the time needed for a nesting success programme on Mandø, as it was performed in 2010 and 2011 and at two more sites:

a) A saltmarsh on Fanø on the north-west coast 'Fanø-Grønningen', most of which is already a reference site within the breeding bird survey programme. By combining the breeding bird surveys and the breeding success programme, transportation for four visits to the study site during the Oystercatcher breeding season is already covered, as well as a breeding success survey of Oystercatchers at the site.

b) Selected saltmarshes on the mainland between Kongeåen and 'Råhede Vade'. This is a low density breeding area, and two sites – 'Jedsted Forland kontrolområde' and 'Råhede Vade kontrolområde' – are already covered by three and five visits respectively, as they are both reference sites within the breeding bird survey programme. The second site is also a special counting area for breeding Dunlin *Calidris alpina* and Ruff *Philomachus pugnax*.

Table 7.1. Distribution of the breeding population of Oystercatchers in the Danish Wadden Sea in 2006 and 2012 which were the two most recent surveys when all breeding sites in the Wadden Sea were counted. The breeding areas are divided into different types of breeding areas. The study site used in the present study is named 'Mandø saltmarshes'. This study site had approximately 100 breeding pairs in 2010 and 2011, i.e. approximately 7% of the total breeding population of Oystercatchers in the Danish Wadden Sea.

	Location in the Danish	2006		2012	
Type of breeding area	**Wadden Sea**	**No of pairs**	**%**	**No of pairs**	**%**
Islands, almost fox-free	Langli, Peter Meyers Sand	244	10.5	145	10.2
Island, irregular fox presence saltmarshes	Mandø saltmarshes	436	18.8	254	17.9
Island, irregular fox presence polders	Mandø polders	492	21.2	286	20.2
Islands, with foxes saltmarshes	Fanø, Rømø, saltmarshes	421	18.2	328	23.1
Islands, with foxes polders and elsewhere inland	Fanø, Rømø, inland	64	2.8	43	3.0
Mainland saltmarshes		388	16.7	192	13.5
Mainland river valleys	Varde Å, Ribe Å, Vidå	3	0.1	4	0.3
Mainland polder wetlands		89	3.8	42	3.0
Mainland polder non-wetlands		181	7.8	124	8.7
Total		2318		1418	

Table 7.2. Estimated number of working hours needed to carry out field work related to a possible study of hatching success of Oystercatchers breeding at three different potential study sites in the Danish Wadden Sea. Working hours needed for reporting are not included.

	Potential study site		
	Mandø saltmarsh	**Fanø NW**	**Ribe saltmarsh**
Size (ha)	100	140	550
Pairs	100	17	25
Expected no. of nests possible to find	105	22	25
No. of visits	14	11	11
Transportation time	21	44	38.5
Time finding nests	25	33	38.5
Time nest controls	34	5	16.5
Time saved due to overlap with breeding surveys	0	16	12
Total time	80	66	105.5
Time per nest	0.76	3.00	4.22

Monitoring of fledging success

Table 7.3 shows estimates of the additional time needed to add monitoring of fledging success in the most visible parts at the sites that are suggested as the future study sites.

Exo *et al.* (1996) suggested that for Oystercatcher and Redshank breeding success should only be monitored by their hatching success, as no feasible method was developed to study the fledging success within the frames of a monitoring programme. In a later revision (Koffijberg *et al.* 2011) two methods are given to determine fledging success of Oystercatchers. One of the methods is only applicable to relatively narrow saltmarshes with short vegetation and good visibility and is not particularly labour intensive. Here, breeding numbers are assessed around the peak incubation period, and later, when the majority of the chicks approach fledging, the number of alarming pairs, the number of broods and young birds, and the age of the visible chicks are recorded. A second method which may be used in broader and less visible saltmarshes includes extensive ringing of chicks and a subsequent resighting programme. Such a method will be very time consuming, and apparently it has not been used in a monitoring programme in the Wadden Sea so far.

Table 7.3. Estimated additional number of working hours needed for field work in case fledging success of Oystercatchers should be assessed, given for each of three potential study sites. Working hours needed for reporting are not included.

	Potential study site		
	Mandø saltmarsh	**Fanø NW**	**Ribe saltmarsh**
Size (ha)	100	140	550
Pairs	100	17	25
No of visits	2	2	2
Transportation time	3	8	7
Time finding chicks	3	4	7
Time recording pairs	2	4	7
Time saved due to overlap with breeding surveys	0	8	7.5
Total time	8	8	13.5
Time per pair	0.11	0.47	0.54

Intensive studies of Oystercatchers have shown that there may be systematic differences in the chick survival within saltmarshes. In territories along the coastline adjacent to the mudflats, where Oystercatchers are holding a combined nest and feeding territory, chick survival has been found to be much higher than in nest territories away from the coastline and the mudflats, where parents have to establish additional feeding territories on the mudflats and have to fly with almost all their food from the feeding territory to the chicks in the nest territory (Ens *et al.* 1992). A sub-division between breeding success of different segments of breeders within a study site is not possible with the suggested method of assessment of fledging success.

7.5 Black-headed Gull

In recent years, the largest Black-headed Gull colony in the Danish part of the Wadden Sea has been the colony located in 'Sneum Klæggrav' – a small artificial lake in a polder area. This colony had 90% of the Danish Wadden Sea population of Black-headed Gulls in 2014 (Thorup & Laursen 2014). Monitoring of breeding success in this colony would probably cause an un-

acceptable high level of disturbance because the entire colony would be disturbed at each visit.

The island of Mandø only had a small colony of Black-headed Gulls in recent years (e.g. 115 pairs in 2014, Thorup & Laursen 2014).

The number of Black-headed Gulls breeding on Langli has declined during recent years. In 2013 Langli had 1358 breeding pairs but numbers had declined further to 326 pairs in 2014 (Thorup & Laursen 2013, 2014). The number of Black-headed Gulls breeding on Langli may decline even further because of the continued increase and further spread of the Herring Gulls breeding on the island.

We judge that it would require a high number of visits to quantify hatching success and fledging success in the colony at Langli. Determination of fledging success would probably require use of the method F, where several groups of nests are surrounded by fences in order to keep track of the individual chicks. It would probably not be possible to obtain reliable results of fledgling production by trying to count all chicks near the time of fledging, partly because many chicks will be well hidden in the vegation and partly because the timing of breeding is unlikely to be sufficiently syncronised. However, during visits to the island for other purposes it would be possible to make observations of the presence / absence of breeding activity and of chicks in the colony and such observations could be used to state whether or not the Black-headed Gulls completely failed in raising young in a given year.

Photo 7.1. Estimates of breeding success of large gulls were partly based on counts of large, nearly fledged young. Photo: Lars Maltha Rasmussen.

At present, we conclude that it will be too costly to carry out a proper monitoring of the breeding success of the Black-headed Gulls on Langli. Furthermore, a study of the currently small colony would not provide information about breeding success that would be representative for a large proportion of the breeding population in the Danish part of the Wadden Sea.

7.6 Herring Gull

In 2013-2014 the island of Langli had 92-93% of all breeding Herring Gulls in the Danish part of the Wadden Sea (Thorup & Laursen 2013, 2014).

Considering that following individually marked nests at Langli at 6-7 day intervals from egg-laying until fledging would be very costly and cause regular disturbance of the breeding birds on Langli, we propose to aim for a rough quantification of the annual production of nearly fledged young per breeding pair by applying the following steps:

1. *Estimating the number of breeding pairs.* This should be done by the currently used method where the total number of birds present in the colony is estimated based on counts. This number is then multiplied by 0.7 according to the standard method for monitoring the number of breeding pairs of colonial waterbirds in the International Wadden Sea (Hälterlein *et al.* 1995). Furthermore, the number of nests should be counted within defined sections of the colony where ringing will take place later in the season.

2. *Determining breeding phenology*. Information about breeding phenology is needed in order to time a later visit aimed at ringing and an even later visit aimed at counting the chicks shortly before fledging. Data on breeding phenology can be collected in one or two ways. One option is to check the development of the embryo in eggs from a large number of nests (Hays & LeCroy 1971). Possibly this could be done during a visit aimed at counting breeding birds. The other option is to visit the island around the time when most nests are expected to have hatched and record nest contents and age of chicks for a representative (and fairly large) number of nests.

3. *Ringing of 3-5 week old chicks.* A large number of 3-5 week old chicks should be ringed with metal-rings during a 1-2 day visit to the island. The ringing should be carried out in different parts of the colony whereby a representative sample of the chicks can be ringed. Ringing should – as a minimum – take place within the defined sections of the colony where the number of nests has been counted earlier in the season. The time invested in the search for chicks should be recorded and the areas sampled should be tracked by use of a GPS. For selected areas, records should be made of the number of overlooked chicks per chick found during ringing. The age of the chicks should be estimated based on wing-length and / or head-bill length. This visit should be timed so that the age distribution of the chicks present on the island is approximately the same from year to year. The collected information about hatching phenology is used for deciding when to visit the island in order to ring chicks.

4. *Count of all chicks.* All Herring Gull chicks present on and around the island should be counted as late as possible in the season but before the first fledged young start to leave the island. The number of ringed and un-ringed chicks should be recorded. This count must be timed so that

the age distribution of the chicks present on the island is approximately the same from year to year.

5. *Recording of the number of ringed and unringed chicks.* The chicks with rings should be counted during the count of all chicks. The knowledge about the number of chicks ringed and the record of the proportion of large chicks with rings among those counted can be used as a secondary method to estimate the total number of young. This method can be used to validate the count of all chicks.

7.7 Sandwich Tern

The Sandwich Tern is no longer a stable breeder in the Danish part of the Wadden Sea. In the TMAP monitoring period it bred in 1992-2002 and in 2004-2013, but not before 1992 and not in 2014. The island of Langli had 1200-3250 breeding pairs during 2004-2010, but numbers decreased subsequently and no pairs were breeding in 2014 (Thorup & Laursen 2014).

Between 15 and 196 pairs nested in Sneum Klæggrav in 2011-2013.

With the current absence of breeding Sandwich Terns it is not possible to monitor breeding success of this species in the Danish part of the Wadden Sea, but it will be reconsidered if the species starts breeding again.

7.8 Arctic Tern

The islands of Mandø and Langli each had 100-340 breeding pairs in most years during 1996-2011 (Thorup & Laursen 2014, the Danish Wadden Sea Breeding Bird Database). But the numbers of Arctic Terns breeding on these two islands has been low in recent years: 29-36 pairs on Mandø in 2013-2014 and 6-48 pairs on Langli during 2012-2014. The breeding colonies on these two islands are therefore currently not suitable for studying breeding success.

The sandy 'islet' of Koresand and Esbjerg Harbour have been the most important breeding areas for the species in recent years, each holding around 175 and 200 breeding pairs, respectively, in 2013-2014.

The islet of Koresand is located 2-4 km SW of Mandø which makes it logistically very difficult to carry out monitoring of breeding success. The breeding colony in Esbjerg Harbour is presently located on a roof and breeding success could fairly easily be studied in this colony. However, the breeders in this colony are well protected against mammalian predators and flooding so breeding success in this colony would not be representative of a colony located in a natural landscape in the Wadden Sea area.

It was suggested in the TMAP plan that for Common Tern and Arctic Tern high priority should be given to monitor hatching success, clutch size, date of onset of laying, and reproductive success (Koffijberg 2008). Clutch size and date of onset of laying could be monitored at a fairly low cost in Esbjerg Harbour and would probably be of some value for the overall survey of breeding parameters in the International Wadden Sea.

8 Conclusions

8.1 Breeding success on Mandø and Langli

The Oystercatchers breeding at Mandø saltmarsh produced 0.26 fledged young per breeding pair in 2010 and 0.01 young per breeding pair in 2011. This difference was mainly caused by a higher loss of clutches early in the breeding season in 2011. A total of 46% of the clutches initiated in 2010 survived until hatching whereas only 6% of the clutches initiated in 2011 hatched. Most losses of clutches were caused by predation and flooding by sea water. The fledging success could be measured in 2010 and reached 76%.

The Common Terns and the Arctic Terns breeding on Mandø performed poorly during 2008-2011. It was estimated that the Common Terns produced fewer than 0.5 fledged young per breeding pair in 2008, less than 0.3 in 2009 and 2010 and no fledged young in 2011. The success of the Arctic Terns was estimated at a maximum of 0.1, 0.3, 0.2 and 0.1 fledged young per breeding pair in 2008-2011. The low breeding success was mainly due to losses of egg clutches. The cause of the extensive losses of eggs was not identified, except for a few cases where colonies had been partially or completely flooded by sea water. Few chicks hatched and their survival was low. The causes of mortality among chicks could not be determined. There were some indications that human disturbance had caused at least some of the losses of eggs and chicks.

Common Gull breeding on the island of Langli bred with extremely low success in all years between 2008 and 2013. The counts of large young indicated that as few as 1-2 young fledged per 100 breeding pairs. It appeared from the detailed studies in 2009 that most losses took place during incubation and were caused by predation of eggs, mainly by Herring Gulls.

Photo 8.1. Artic Terns did not breed with success on the island of Langli during the years of the study. Photo: Lars Maltha Rasmussen.

The Lesser Black-backed Gulls at Langli bred with relatively high success in 2008-2010, with very low success in 2011 and with low-moderate success in 2012-2013. The pattern was almost the same for the Herring Gulls which bred with relatively high success in 2008-2010 and 2013, with very low success in 2011 and with low success in 2012. The reasons for the very low breeding success recorded in some of the years could not be identified. Overall, both species of large gulls bred with low success during the present study when compared with earlier studies at Langli (Thorup 2001). A higher breeding success among Herring Gulls was also recorded at the island of Mellum in the German part of the Wadden Sea during 1979-1990 (Becker & Exo 1991).

The Arctic Terns that attempted to breed on Langli had poor breeding success. The observations made suggested that none of the breeding attempts during 2008-2013 resulted in successful production of fledged young.

The Sandwich Terns apparently bred with high success on Langli in 2006 and in 2008-2010 at least until the chicks were 5-12 days old. Visits later in some of the seasons confirmed that chick survival was high in these years. Hatching success was reasonably good when studied in 2009.

Overall we found that the studied species generally bred with poor success at Mandø and Langli during the study years. It is characteristic for the life history of Oystercatchers, gulls and terns that they invest in survival and that they can sustain local breeding numbers despite successive years of low breeding success (Cramp & Simmons 1983, Cramp 1985). However, from the low production of fleglings we do not anticipate that number of breeding pairs of the studied species will increase in the Danish part of the Wadden Sea in the coming years.

8.2 Experiences with methods

The monitoring of breeding success of Oystercatchers breeding at the saltmarsh on Mandø was successful in applying the recommended standard methods to determine hatching and fledging success. Breeding performance was recorded with high precision and the main causes of egg losses were identified. Furthermore, the monitoring could be carried out at a fairly low cost. It is recommended that future monitoring of breeding success of Oystercatchers include studies at Mandø saltmarsh and that the same methods as those used in 2010 and 2011 are applied in the future. Two other potential study sites in the Danish Wadden Sea are identified.

Attempts were made to monitor the hatching success of terns breeding on Mandø by marking individual nests. This worked well when applied in 2009, but the causes of breeding failure could not be identified. The marking of nests was skipped in subsequent years because it may have attracted humans and thereby increased egg losses. Other, less precise, methods were applied in following years. These other methods gave a rough measure of how successful the terns were in raising young to fledging. The only identified cause of breeding failure was flooding by sea water, but this was only an important factor in some of the breeding seasons.

The monitoring of hatching success of gulls on the island of Langli by following individually identifiable nests was very costly in terms of manpower. Furthermore, the Danish Nature Agency found that this method required an unacceptable high number of visits to the breeding areas. As an alternative a

combination of data collected during ringing of chicks and counts of young near the age of fledging was used to reach rough estimates of year-to-year variation in the production of fledglings.

8.3 Recommendations

According to the plan for monitoring of breeding success in the International Wadden Sea, Denmark should provide information about breeding success of Oystercatcher, Black-headed Gull, Herring Gull, Sandwich Tern and Arctic Tern on 1-2 of the Wadden Sea islands.

For Oystercatcher we recommend that future monitoring of breeding success covers breeders on Mandø saltmarsh by using the same methods as in 2010 and 2011. Two other potential study sites could be included.

The Black-headed Gull colony on Langli has become very small in recent years and we do not recommend a full survey of this colony. Furthermore, we judge that monitoring of breeding success in the colony in 'Sneum Klæggrav' on the mainland coast - having 90% of the breeders in the Danish Wadden Sea – would disturb the colony to an extent where it would influence the overall production of fledglings in the colony. So at present there are no colonies of Black-headed Gulls in the Danish part of the Wadden Sea that are suitable for studying breeding success.

For Herring Gull we recommend that breeding success on the island of Langli is monitored by use of a combination of standardised ringing and counting of chicks.

Sandwich Terns are no longer breeding in the Danish part of the Wadden Sea but it may return in coming years.

Due to recent declines in breeding numbers of Arctic Terns on Langli and Mandø there are at present no sites in the Danish Wadden Sea that are suitable for monitoring breeding success of this species.

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Appendix 1

Monitoring breeding success of Oystercatcher at saltmarshes on the island of Mandø, Denmark 2010 and 2011

Ole Thorup

Introduction

The number of breeding Oystercatchers in NW Europe increased strongly in the latter half of the previous century (Thorup 2006). However, this trend changed to significant decreases in the three Wadden Sea countries, with the turning point being approximately around 1991-1995 in the Netherlands (Ens *et al.* 2009), 1997 in Germany (Hötker *et al.* 2007) and 1996 in Denmark (Thorup & Laursen 2008).

The Wadden Sea is supposed to hold 20-30% of the Danish breeding Oystercatchers (Thorup & Laursen 2008). Whereas a population size monitoring programme was active in the Wadden Sea since 1995, almost no systematic data have hitherto been collected on breeding success of the birds. In order to cast light on this crucial parameter to understand population trends, a study of the breeding performance of Oystercatchers on the eastern saltmarshes of the island of Mandø was carried out in the 2010 and 2011 breeding season. The study was performed within the framework of the Trilateral Wadden Sea cooperation, and the methodological guidelines from the Joint Monitoring Group for Breeding Birds (Koffijberg & Schrader 2010) were followed.

Methods

Study site

The study was carried out on saltmarshes in front of the dike on the east coast of the island of Mandø. These saltmarshes are public land and are grazed by sheep.

Because of different habitat features and different bird population structures of potentially important predators, the study site was divided into four subareas:

1) 'Nordøstlige forland': A very wide short-grazed saltmarsh area along the driveway to Mandø. Apart from Oystercatcher, Redshank *Tringa totanus* are the only other widespread breeding species in this area. However, this site is at the southern fringe of a large mixed-species colony with Arctic Tern *Sterna paradisaea*, Avocet *Recurvirostra avosetta* and Black-headed Gull *Larus ridibundus.* App. 18 ha.

2) 'Østlige forland, north': Narrow saltmarsh with the central parts overgrown by 25-40 cm high vegetation housing breeding colonies of Common Gull *Larus canus* and Herring Gull *Larus argentatus.* App. 12 ha.

3) 'Østlige forland, south': Narrow saltmarsh with short vegetation and with a narrow sandy beach in front of the saltmarsh. The saltmarsh is regularly interrupted by small patches with bare sandy soil. There are also two fairly large colonies of Arctic Tern and one of Black-headed Gull. In addition, there are a few breeding pairs of Ringed Plover *Charadrius hiaticula* and Common Tern *Sterna hirundo.* App. 26 ha.

4) 'Låningsvejen': In 2011, a few pairs of Oystercatcher built nests and laid eggs in road construction material along the road to the mainland. Only nests within 2 m from the road were included in this study. Very few other birds tried to breed there, but a few Avocets had nests there during a very short period.

The study site and the subareas are indicated on the Oystercatcher nest maps for 2010 in Fig. A1.1- A1.2 and for 2011 in Fig. A1.3-A1.6.

Fieldwork

The study site was visited once a week from the period of initiation of the first nests until there were no more active nests. The intervals between visits were 4 to 10 days, in average 7 days.

In case of an unpredicted change to unfavourable weather conditions, field work was stopped, and continued another day. This happened twice in 2010 and once in 2011, meaning that nest finding and nest controls took place at 15 and 16 visits to Mandø, resepctively.

In 2010 the first nests were established in late April (week 17) and the last nests had hatched, were predated or deserted in late July (week 29). During the 15 visits from 29 April – 22 July all nests that were active at the previous visit were controlled, the saltmarshes along the driveway ('Nordøstlige forland') were scanned for incubating birds and new nests were localized and recorded. Furthermore, the narrow saltmarshes 'Østlige forland, north and south' were walked through and searched for nests - along the shoreline, and 5-15 m in front of the dike. In addition, the front side of the dike was scanned at a distance in order to find additional incubating birds.

In 2011 the first nests were established in the second week of May (week 19) – two weeks later than in 2010 – and the last nest was depredated in late July or early August (week 30-31). During the 16 visits from 29 April – 5 August all nests that were active at the previous visit were controlled, the saltmarshes along the driveway ('Nordøstlige forland') were scanned for incubating birds and new nests were localized and recorded. The narrow saltmarshes 'Østlige forland, north and south' were walked through and searched for nests - along the shoreline, and 5-15 m in front of the dike. In addition, the front side of the dike was scanned at a distance in order to find additional incubating birds.

The position of each nest was stored in a fairly accurate GPS-device (accuracy usually within 4-5 m). In addition, the exact position of the nest in relation to different landscape features and a short description of the nest bowl and nest lining were noted, and a combination of these three types of information made it possible to relocate the nest in all cases, except for two: one hatched nest with a bowl of only sand was flooded in a way so that no signs of a nest bowl remained, and another nest on the sandy beach that was trampled by sheep in such a way that no remains of the nest persisted.

The nest habitat was registered within five main categories: sandy beach, sandy patch in saltmarsh, saltmarsh grass, grass on dike and pile of dead vegetation from spring floods.

Breeding numbers of Oystercatchers at the study site are not counted annually, but are only assessed at the Wadden Sea total counts, so far carried out in 1996, 2001 and 2006. In order to investigate if it was possible to monitor breeding success in the study site apart from nest success, breeding pairs at

the 'Østlige forland' saltmarshes were mapped and counted at an additional visit on 3 June 2010. On 22 July 2010 visible juveniles and nearly and fully fledged young were counted and mapped in the same area.

Pre-field work data organization

Large numbers and high densities of nests during the main part of the breeding season meant that field work was strongly time limited in order to minimize disturbance at the study site. One hour in the same part of the area was set as a maximum in 'normal' weather, whereas disturbance was kept to less than 30-40 minutes in hot weather or cool and windy conditions. Therefore, a clear and tight organization of data before each visit was needed in order to make it possible to visit the nests in the right sequence (minimizing walking time at the site) and not to have to spend too much time in actually finding and controlling the nests found previously. Data organization included updated information in the field nest files of: 1) exact descriptions of nest positions, 2) removal of no longer active nests from the nest files, 3) nests listed in a proper order for controls.

Assessment of fate of nests

Correct assessment of the fate of a nest is crucial in collecting information on nesting and breeding success. However, the fate of a nest is not always very obvious. For example, a nest may become empty because the eggs hatched, were eaten or were taken away by the water during a flood since the last visit.

However, when the chick leaves the cracked egg, the parents usually remove the large eggshell immediately in order to 'clean up' the nest. However, the smaller shell fragments from eggs that fell off during the cracking and hatching and landed in the nest lining are usually left there. During the chicks activity in the nest before leaving it, the shell fragments are working their way down into or under the nest lining. Before this study it was known to be the rule that a few egg shell fragments can be found in or below the nest lining in a hatched nest of meadowbirds where there are nest lining of straw almost without exception (Thorup 1998 and unpublished data).

In nests of Oystercatchers, however, shells of cockles, mussels and other shellfish often replaces nest lining of plant materials, and furthermore, there are many Oystercatcher nests, especially in sand, without any lining at all.

During nest controls, the same procedure as normally used for nests of meadowbirds was applied when a nest was found without eggs or chicks: 1) looking for signs of predation or trampling in the nest and the immediate neighbourhood like pricked, bitten or smashed egg shells, 2) if not so, searching carefully the nest lining, among the shellfish shells and the sand in the bottom of the nest bowl, for the presence of egg shell fragments.

A nest was identified as hatched if chicks were seen in the nest (including an egg with a crack hole with a diameter of minimum 5 mm), in its immediate surroundings (within 5 m) or if there were small egg shell fragments in or below the nest lining, among the shellfish shells or in the sand of the nest bowl.

If there were smashed or flattened eggs showing that trampling destroyed the nest or a vehicle drove over the nest, this was identified as the fate.

If there were signs of a recent flooding like a removed nest bowl or a flood line above the nest position and the eggs were no longer in the nest or in the neighbourhood, it was identified as flooded and destroyed.

If the eggs (or the egg) in a nest were not warm, or they were damp in particular on the lower side, the nest was identified as having been deserted. A nest that was first identified as deserted and was later predated is handled in the results as deserted and not as predated.

If there were no traces of another fate, the nest was identified as having been predated.

Nest success – data analysis

A method worked out by H. Mayfield (1961, 1975, Johnson 1979) based on nest exposure and daily survival was used to calculate nest survival and hatching success. A nest with eggs was used as the unit. Extensive partial predation on Oystercatcher nests took place on Mandø, and in all observed cases the Oystercatcher continued incubation on the reduced clutch regardless of whether it was reduced to three, two or one egg. This situation prevents measurements of the egg survival: the initial clutch size was rarely known, and the number of eggs that actually hatched was generally also unknown.

When calculating nest success an incubation period of 28 days was assumed. Clutches of 2 and 3 eggs appeared to be the most common, and 28 days, equivalent to 3 days of laying and 25 days of incubation in a three egg clutch or 2 days of laying and 26 days of incubation in a two egg clutch, are common values according to literature (e.g. Glutz von Blotzheim *et al.* 1975).

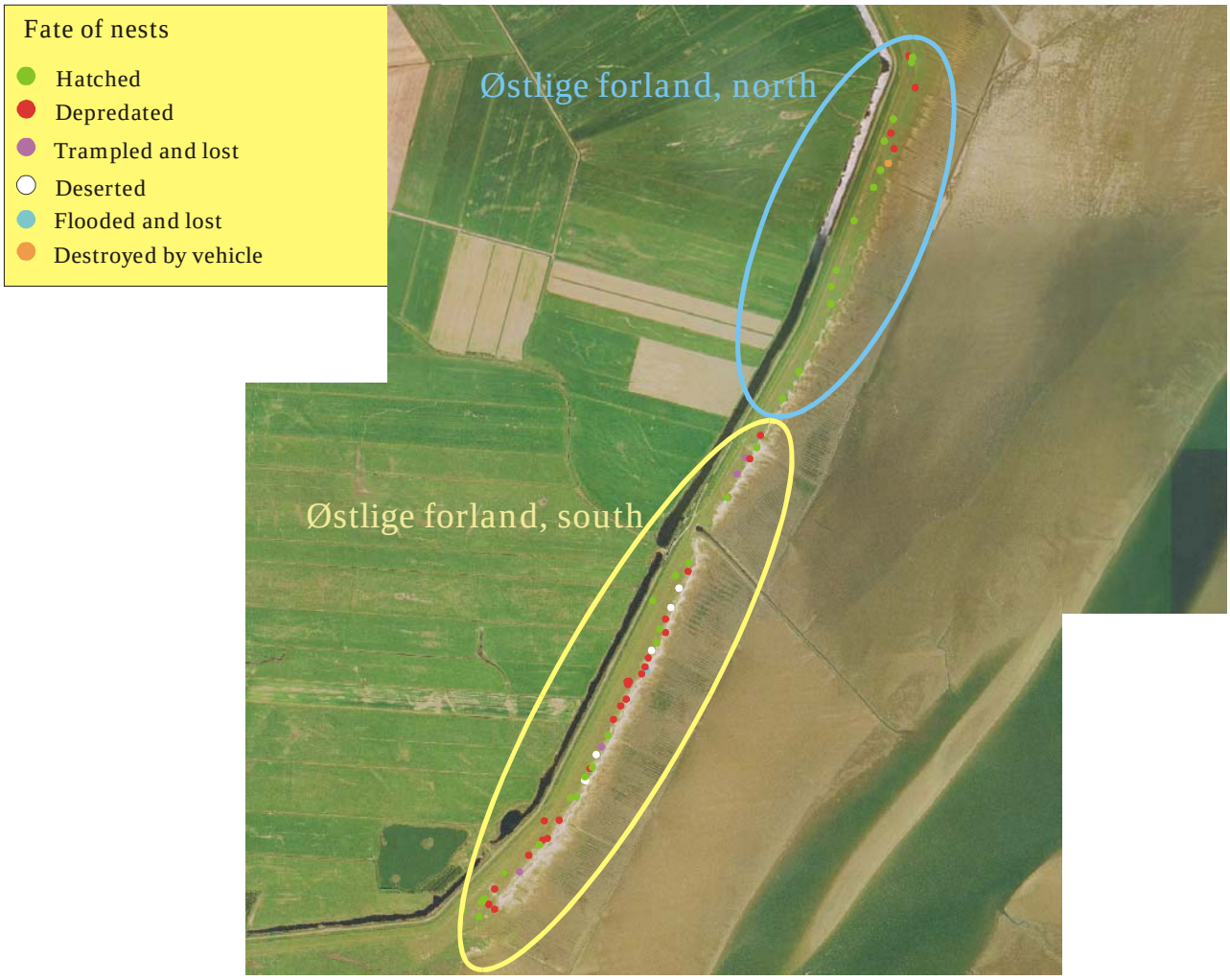


Figure A1.1. Position and fate of Oystercatcher nests at the 'Østlige forland' of Mandø in 2010.

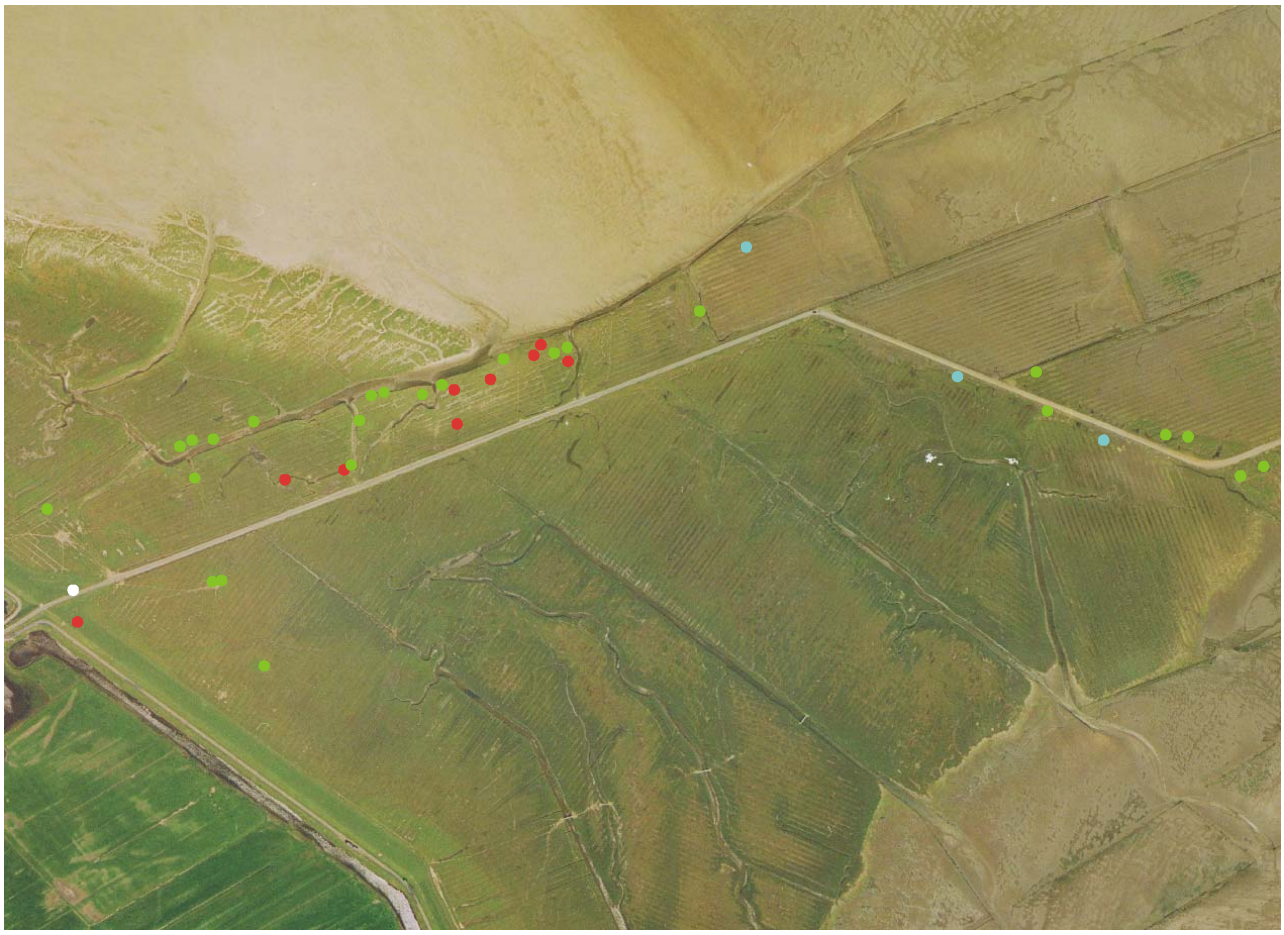


Figure A1.2. Position and fate of Oystercatcher nests at the 'Nordøstlige forland' of Mandø in 2010. Legend: see caption at Fig. A1.1.

Figure A1.3. Position and fate of Oystercatcher nests at the road edge along Låningsvejen, in 2011.

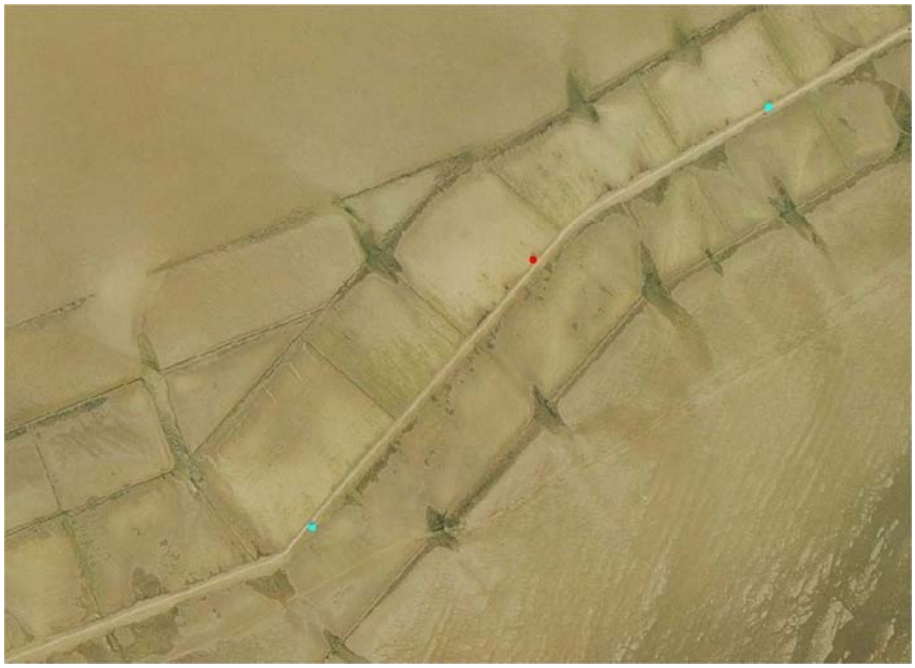
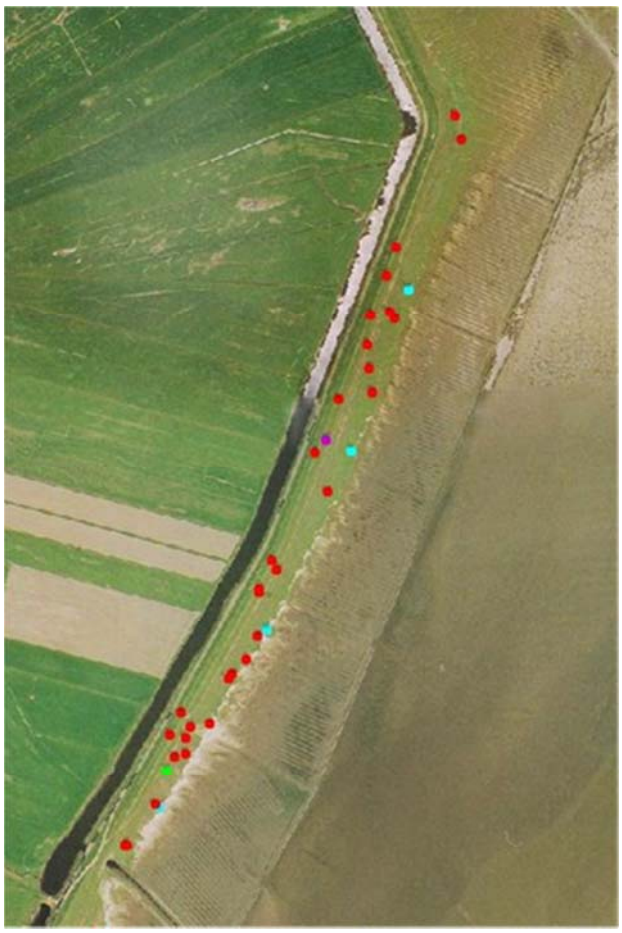


Figure A1.4. Position and fate of Oystercatcher nests at the ‘Nordøstlige forland’ of Mandø in 2011.

Figure A1.5. Position and fate of Oystercatcher nests at the 'Østlige forland north' of Mandø in 2011.



Figur A1.6. Position and fate of Oystercatcher nests at the 'Østlige forland south' of Mandø in 2011.

Results

In total, 109 and 122 nests of Oystercatchers were found at the study site in 2010 and 2011, respectively. They were all controlled until they were no longer incubated.

The distribution and the fate of the nests are shown for 2010 on the maps in Fig. A1.1-A1.2 and for 2011 in Fig. A1.3-A1.6.

Nest survival

In 2010 nests with hatched eggs dominated in most areas of the study site (Fig. A1.1 and A1.2). However, there is an exception in the 'Østlige forland, south', in which there were two sections completely dominated by predated nests (red dots). The two 'red sections' are situated in and around two colonies of Arctic Terns, and the southernmost area with many predated nests also had a colony of Black-headed Gulls.

In contrast, in 'Østlige forland, nord' where Oystercatcher bred together with Common Gulls and Herring Gulls – notorious egg predators – most nests hatched.

Not only visually but also statistically the breeding performance differed significantly between 'Østlige forland, south' and the other two areas. The proportion of hatched clutches was low and the daily predation rates more than the double at 'Østlige forland, south' compared to the other two areas (Tables A1.1 and A1.2).

Table A1.1. Hatching success of Oystercatchers in 2010 calculated from daily survival rates (Mayfield 1961, 1975). Predation calculated from its proportion of losses ((100 – hatching %) x (predations/all losses)).

	Hatching %	Predation %	n (nests)	Nestdays	Predations	All losses	Daily predation rate	Daily survival rate
Mandø study site	45,8	38,9	109	1925,5	38	53	0,0197	0,9725
Mandø 'Nordøstlige forland'	61,9	26,4	38	766,5	9	13	0,0117	0,9830
Mandø 'Østlige forland, north'	62,3	30,2	17	298	4	5	0,0134	0,9832
Mandø 'Østlige forland, south'	31,3	49,1	54	861	25	35	0,0283	0,9593

In 2011 very few nests survived until hatching, and predated nests (red dots) and flooded nests (blue dots) dominate the maps (Fig. A1.3 to A1.6).

At one occasion a very high high-tide (24 May) flooded the area 'Nordøstlige forland' completely, and two more high tides (18 June and 23 July) flooded the majority of the same area again. In contrast, the two areas on 'Østlige forland' were only flooded marginally. The predation level was very high in 2011 (Tables A1.3 andA1. 4), and in total only 8 out of the 122 nests hatched.

Table A1.2. Fates of Oystercatcher nests found on Mandø 2010.

	hatched	Predated	Fooded	Destroyed by vehicle	Destroyed by trampling	Deserted
Mandø study site total	55 (50,5%)	38 (34,9%)	4 (3,7%)	1 (0,9%)	4 (3,7%)	7 (6,4%)
Mandø 'Nordøstlige forland'	25 (66%)	9 (24%)	3 (8%)	0	0	1 (3%)
Mandø 'Østlige forland, north'	12 (71%)	4 (24%)	0	1 (6%)	0	0
Mandø 'Østlige forland, south'	18 (33%)	25 (46%)	1 (2%)	0	4 (7%)	6 (11%)

Note: One nest deserted when found is included in this table but not in table A1.1, as it was not 'exposed' for the events mentioned.

Table A1.3. Hatching success of Oystercatchers in 2011 calculated from daily survival rates (Mayfield 1961, 1975). Predation calculated from its proportion of losses ((100 – hatching %) x (predations/all losses)).

	Hatching %	Predation %	n (nests)	Nestdays	Predations	All losses	Daily predation rate	Daily survival rate
Mandø study site	6.1	76.6	122	1202.5	93	114	0.0773	0.9052
Mandø 'Nordøstlige forland'	15.3	57.1	50	662.5	29	43	0.0438	0.9351
Mandø 'Låningsvejen'	-	-	3	8	1	3	-	-
Mandø 'Østlige forland, north'	3.5	83.1	37	320	31	36	0.0969	0.8875
Mandø 'Østlige forland, south'	1.0	99.0	32	212	32	32	0.1509	0.8491

Table A1.4. Fates of Oystercatcher nests found on Mandø 2011.

	Hatched	Predated	Flooded	Destroyed by vehicle	Destroyed by trampling	Deserted
Mandø study site total	8 (6.6%)	93 (76.2%)	20 (16.4%)	1 (0.8%)	0	0
Mandø 'Nordøstlige forland'	7 (14%)	29 (58%)	14 (28%)	0	0	0
Mandø 'Låningsvejen'	0	1 (33%)	2 (67%)	0	0	0
Mandø 'Østlige forland, north'	1 (3%)	31 (84%)	4 (11%)	1 (3%)	0	0
Mandø 'Østlige forland, south'	0	32 (100%)	0	0	0	0

Table A1.5. 'Østlige forland' Mandø 2010. Number of pairs of Oystercatchers counted and mapped on 3 June, number of visible chicks/ juveniles on 22 July, and the number of hatched nests and approximate age of these clutches on 22 July if they were still all alive.

	Pairs 3 June	Hatched nests	Visible chicks/juveniles 22 July	min. no of alarming pairs with 'invisible' chicks 22 July	Hatched broods 0-25 days old 22 July	Hatched broods 26-42 days old 22 July	Hatched broods >42 days old 22 July
Østlige forland, north	27	12	8 (7 families)	2	4	8	0
Østlige forland, south	43	18	10 (9 families)	3	5	9	4

Fledging success – breeding success

Whereas nests are relatively easy to follow, assessment of fledging success in Oystercatchers is very complicated. Soon after hatching the chicks at Mandø saltmarshes spend most of the time hidden in the vegetation or in creeks where they are fed by their parents. Later the chicks are fairly conspicuous when not disturbed, and they walk around on the mudflats near the shore

and still inside a feeding territory together with one or two parents. Later they leave the feeding territory and distribute freely over the mudflats, in the beginning together with their parents, later – in late summer or early autumn – independently. The first flying attempts take place at the age of 28-31 days and the chicks fledge at the age of 32-35 days (Glutz von Blotzheim *et al.* 1975).

In 2010 the number of mapped pairs at Mandø 'Østlige forland', the number of hatched nests and the number of observed visible chicks and juveniles are shown in Table A1.5. If chicks are invisible until they are around 25 days old, visible and still faithful to their feeding territory when they are 26-42 days old and may have left their feeding territory when older than 42 days, almost all Oystercatchers that managed to hatch a clutch also managed to bring at minimum one chick to fledging (16 of 17 pairs with hatched chicks in the visible and site-faithful age were seen with one or two juveniles (94%), only one of the visible young was not yet fully fledged). If all older broods stayed in the area and are added, the fledging success was 76% of the hatched broods.

Based on visible juveniles on 22 July only, there were 0.26 fledged juveniles per breeding pair present on 3 June. This figure may be used as an index, but it is very likely well below the real figure.

In 2011 only one nest with one egg hatched in the two sub-areas of 'Østlige forland' (Table A1.6), and at the breeding success survey on 12 August one young juvenile just able to fly (estimated 30-35 days old) was seen less than 50 m from where most probably the same chick hatched 33-34 days earlier.

One fledged chick means that the production in 2011 here was down at 0.01 fledged juveniles per breeding pair.

Table A1.6. 'Østlige forland' Mandø 2011. Number of pairs of Oystercatchers counted and mapped on 3 June (see text), number of visible chicks/juveniles on 12 August, and the number of hatched nests and approximate age of clutches from the 12 August if they were still all alive.

	Pairs 3 June 2010	Hatched nests	Visible chicks/juveniles 12 August	Min. no of alarming pairs with 'invisible' chicks 12 August	Hatched broods 0-25 days old 12 August	Hatched broods 26-42 days old 12 August	Hatched broods >42 days old 12 August
Østlige forland, north	27	1	1 (1 family)	0	0	1	0
Østlige forland, south	43	0	0	0	0	0	0

Breeding phenology

In 2010 the date of the start of egg laying is known or can be estimated from the hatching date with an accuracy of less than 8 days for 68 nests (Table A1.7, Fig. A1.7). Most nests were initiated during May, and the number of active nests peaked in the last days of May and first 10 days of June (Fig. A1.8).

Table A1.7. Oystercatchers on Mandø in 2010. Dates of start of egg laying, known or calculated from hatching date. An incubation period of 25 days and a laying interval of 1,5 days between the eggs is assumed.

	First nest	25 percentile	Median	75 percentile	Last nest	n (nests)
2010 Mandø	(before 28.4.)	13.5.	21.5.	28.5.	24.6.	68

Figure A1.7. Oystercatchers at Mandø in 2010. Date of start of laying in 3-day periods. Same nests and calculations as depicted in Table 7.

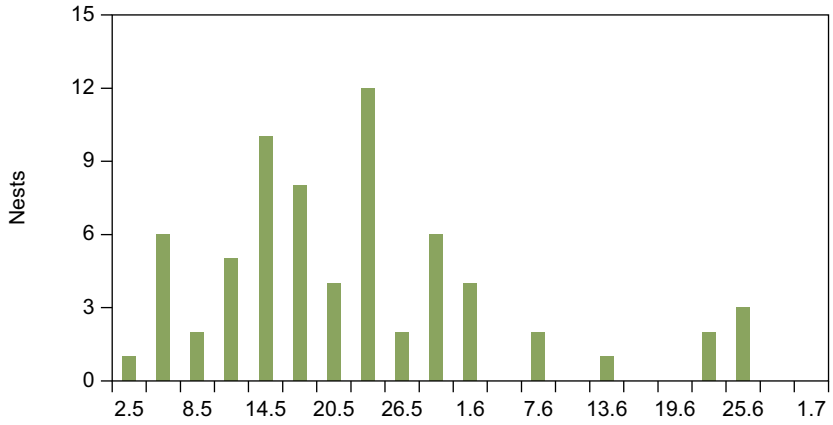


Figure A1.8. Oystercatchers at Mandø in 2010. Number of active nests at the weekly visits from 29 April – 22 July.

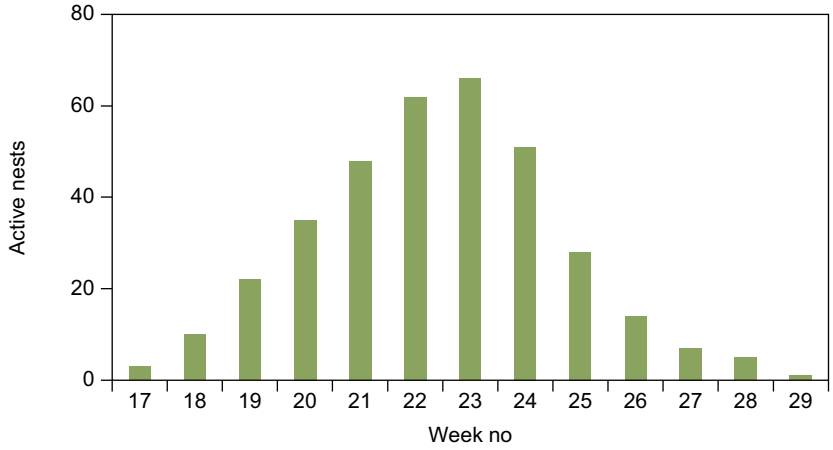


Figure A1.9. Oystercatchers at Mandø in 2010. Phenology of nest hatching. Number of nests that hatched between two of the weekly visits, and the proportion of the active nests at the last visit that hatched during that week.

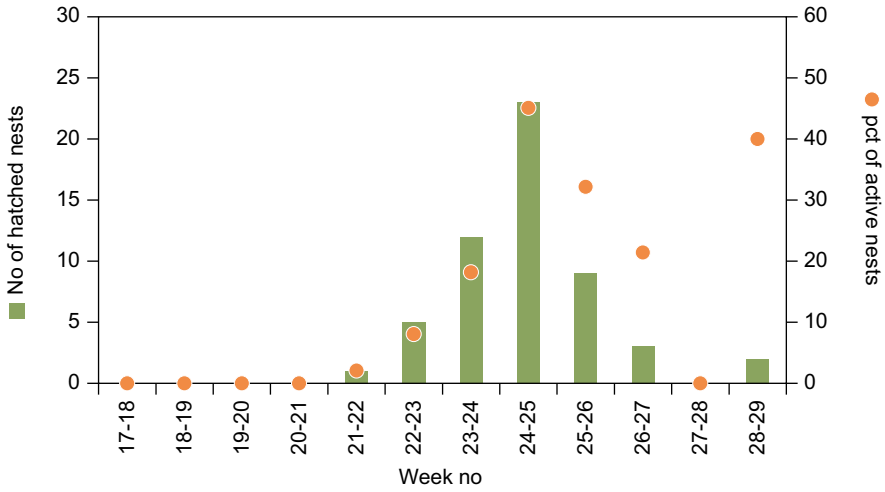
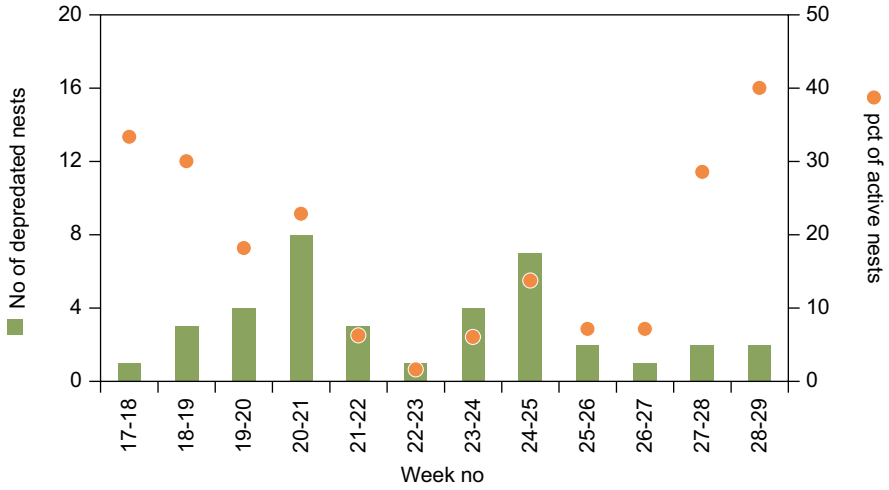


Figure A1.10. Oystercatchers at Mandø in 2010. Phenology of nest predation. Number of nests that were predated between two of the weekly visits, and the proportion of the active nests at the last visit that were predated during that week.



The majority of nests hatched in 2010 between the last days of May and first half of June (Fig. A1.9). This is also the period with the lowest proportion of predations (Fig. A1.10). The predation level is lowest when the number of active nests is highest, whereas the predation level is much higher early and late in the season (Fig. A1.10).

In 2011 the date of the start of egg-laying is either known or can be calculated from the hatching date for 26 nests (Table A1.8, Fig. A1.11). Most nests were initiated quite evenly distributed during May and early June, and the number of active nests peaked in the first half of June (Fig. A1.12).

Table A1.8. Oystercatchers at Mandø in 2011. Dates of start of laying, known or calculated from hatching date. An incubation period of 25 days and a laying interval of 1,5 days between the eggs is assumed.

	First nest	25 percentile	Median	75 percentile	Last nest	n (nests)
2011 Mandø	10.5.	19.5.	28.5.	4.6.	(after 1.7.)	26

Figure A1.11. Oystercatchers at Mandø in 2011. Date of start of laying in 3-day periods. Same nests and calculations as depicted in Table A1.8.

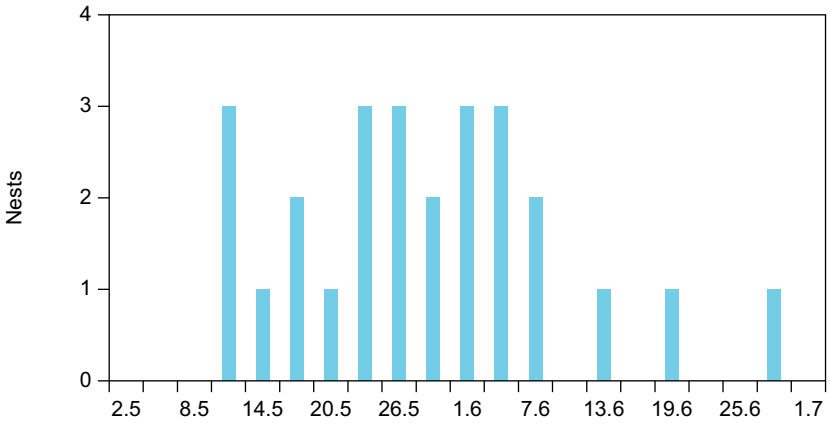


Figure A1.12. Oystercatchers at Mandø in 2011. Number of active nests at the weekly visits from 29 April – 27 July.

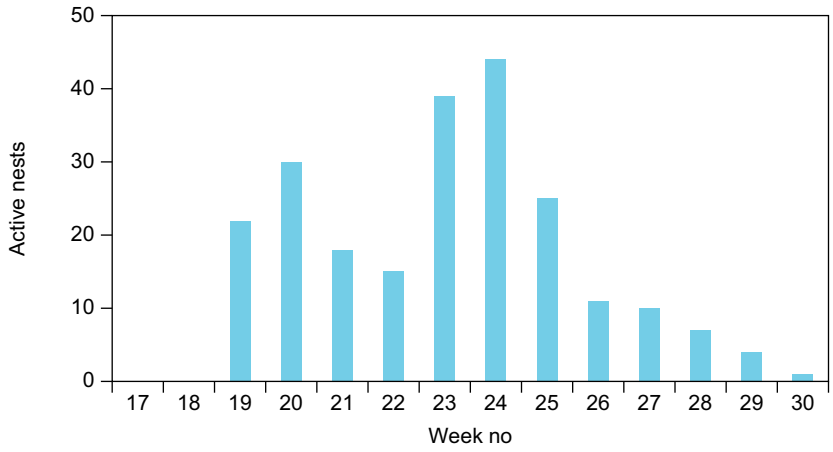


Figure A1.13. Oystercatchers at Mandø in 2011. Phenology of nest hatching. Number of nests that hatched between two of the weekly visits and the proportion of the active nests at the last visit that hatched.

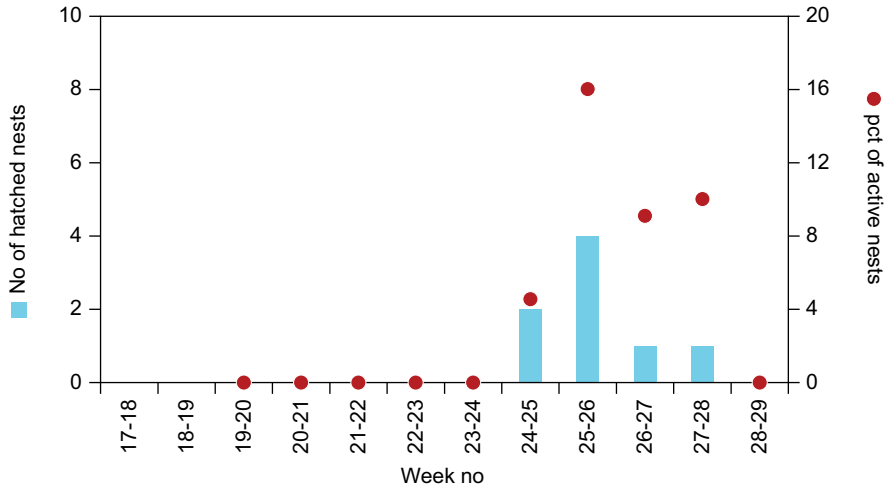


Figure A1.14. Oystercatchers at Mandø in 2011. Phenology of nest predation. Number of nests that were predated between two of the weekly visits and the proportion of the active nests at the last visit that were predated.

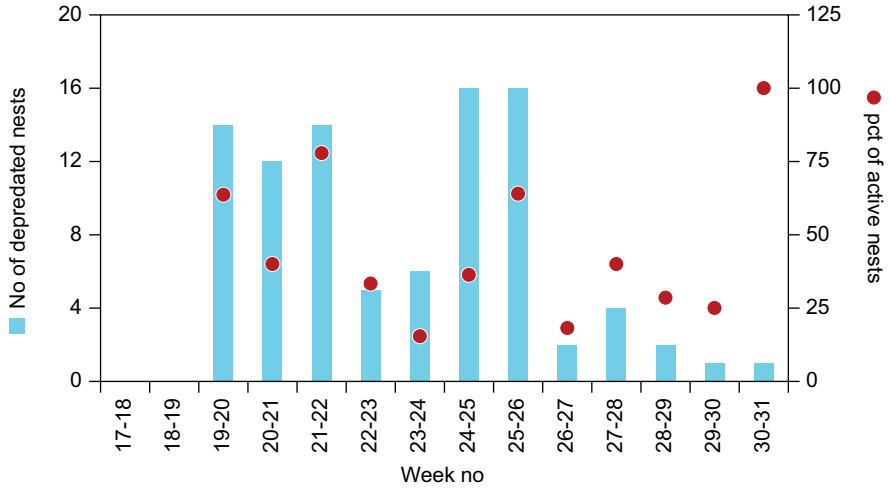
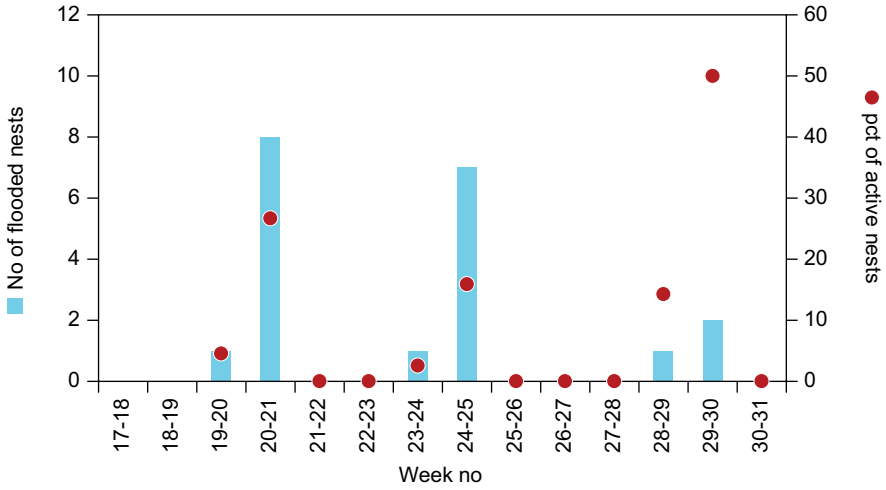


Figure A1.15. Oystercatchers at Mandø in 2011. Phenology of nest flooding. Number of nests that were flooded between two of the weekly visits, and the proportion of the active nests at the last visit that were flooded.



Only eight nests hatched in 2011, six of them in the second half of June and the remaining two in early July (Fig. A1.13). The proportion of active nests that were predated remained high during the entire season without a clear tendency of periods with fairly high survival (Fig. A1.14). The three high tides markedly above normal water levels on 24 May, 18 June and 23 July, respectively, obviously had an impact on the proportion of active nests flooded (Fig. A1.15).

Nest habitats

In 2010 and 2011 Oystercatchers chose nest sites primarily in three habitat types: saltmarsh grass, sandy patches in saltmarsh and sandy beach, with saltmarsh grass being by far the most used habitat (Fig. A1.16 and A1.17).

Figure A1.16. Nest habitats of Oystercatcher nests at Mandø in 2010 (n = 109).

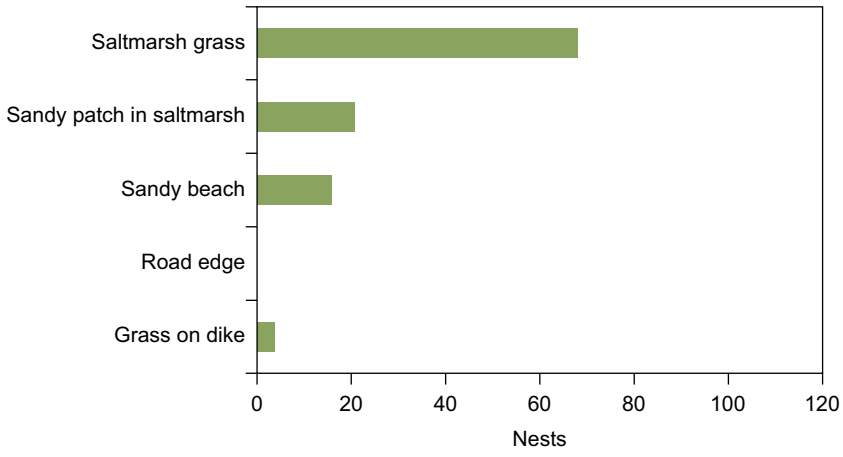
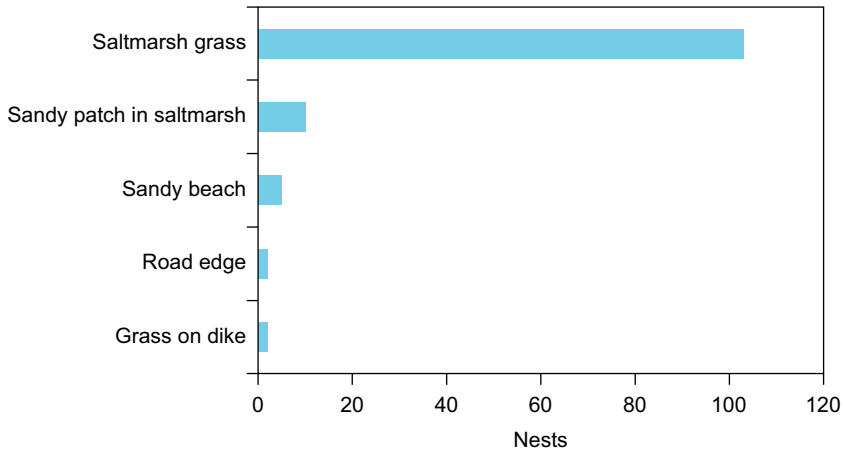


Figure A1.17. Nest habitats of Oystercatcher nests at Mandø in 2011 (n = 122).



Discussion

The reliability of the nest fate assessment method

The data, on which the present assessment method is based are collected in nests of meadowbirds that have somewhat different types of nest scrapes and nest lining. In order to check the applicability of the 'meadowbird assessment method' on Oystercatchers the following control data were selected:

Known hatched nests: Nests that had chicks (including cracked eggs) at the previous visit were checked. Of 16 nests known to have hatched 15 had eggshell fragments. The 16th nest was in sand without lining, and a flood destroyed / removed the nest in between. In conclusion, hatched nests also produce shell fragments in Oystercatcher nests. However, on average much fewer shell fragments were found in nests in sand compared to nests in grassland. More data may reveal that it is not always possible to find egg shell fragments in hatched nests in sand with no nest lining.

Nests known not to have hatched: In nests found during egg laying the earliest possible hatching date is known from literature (minimum 25 days from clutch completion, Glutz von Blotzheim *et al.* 1975). Nests where eggs disappeared 21 days or earlier after clutch completion were checked for egg shell fragments in the nest lining or in the sand in the nest bowl. In 7 nests found during egg laying, the nest was found empty 21 or fewer days after clutch completion. In no cases were there eggshell fragments in the nest lining or in the sand in the nest bowl.

Assessment of the original cause of nest losses

In some cases it is difficult to identify the original cause of the nest loss. For example Oystercatchers are strong and aggressive and are relatively efficient in keeping aerial predators away from active nests. When a nest for some reason is abandoned it is much more at risk to predation, and before the next nest control the nest may be predated and empty and will be identified as such. Similarly, if a nest was abandoned or hatched and was left by the Oystercatchers it may be trampled by sheep before the next nest control and therefore be registered as such. The reported proportion of desertions may thus be a slight underestimate and predations in parallel could be slightly overestimated. In one case, in the heavily sheep-trampled sand where a nest was present at the previous visit, only a few shells were found – the fate was

identified as destroyed by trampling, but the nest may in fact have hatched before the nest site was trampled.

Reliability of the breeding success assessment method

From the dike in the southern part of the study area it is possible to check for families with almost fledged young, newly fledged juveniles and the number of first-year birds accompanied by adults later on in July / August. As the young birds are not ringed or marked individually, it is generally not possible to check whether the families are so site-faithful that they can be assumed to reflect local breeding success, or the registered families are a mix of very local breeders and breeders from other parts of the island of Mandø. However, the observations from 2011 strongly support the assumption that the observed families in front of the narrow eastern saltmarsh do in fact consist of breeders from the same saltmarsh. In 2011, only one nest in this area hatched, and one chick fledged from this nest on 9 or 10 July. At a survey of Oystercatcher families in this area on 12 August – 33-34 days after the hatching – only one pair guarding one chick was observed. The chick was approximately 30-35 days old, and it was found less than 50 m from the hatched nest from which it very likely originated.

Can breeding success be assessed?

It seems impossible to count or calculate the total number of fledged chicks of Oystercatchers at the Mandø study site. The northern part of the study area is a wide saltmarsh with huge areas of low-lying parts with deep creeks where most chicks are invisible during the entire breeding season. In contrast, the southern part of the study area ('Østlige forland'), is a fairly narrow saltmarsh, bordered by silt trenches and partly by sandy beach. When Oystercatcher chicks reach a certain age they feed in the open areas, especially in the silt trenches, and are relatively easy to se from the dike.

Nevertheless, due to a very long breeding season with hatching of Oystercatcher chicks taking place from 30 May until 22 July in 2010, there will never be one date when all large chicks of the year visible. When the latest chicks get out on the mudflats and become visible, the earliest chicks fledged more than 7 weeks earlier and have been independent and have left the chick feeding territory weeks ago. But by choosing a count date when the majority of the chicks of the year are old enough to be visible and young enough to still be in the chick feeding territory, it may be possible to get an index value that reflects the productivity of the year of that sub-area.

Before using such an index, two assumptions must be met: 1) chicks / juveniles counted in the area must primarily be from local breeders and should not be dominated or outnumbered by broods that have dispersed to this feeding habitat from elsewhere, e.g. from the polders inside the dike where large numbers of breeding Oystercatchers are found (in 2006 492 of 928 pairs (53%) of Oystercatchers breeding on Mandø were found in the polders, Thorup & Laursen 2008), and 2) there has to be a sufficiently long period when the local chicks are both visible and still in or nearby their feeding territory, and this period should be predictable from year to year.

Nothing is known about assumption 1 from Mandø. However, studies on Schiermonnikoog in the Dutch Wadden Sea showed that Oystercatchers breeding near the shoreline were strongly territorial in the chick-rearing phase preventing families breeding further inland from bringing their chicks to the

food-rich mudflats (Ens 1992). Thus, it is very likely that local families dominate on the mudflats as long as the chicks are dependent of their parents.

Concerning assumption 2, it is not known exactly at what age chicks become visible, and at what age they disperse from their chick feeding territories. Judging from the age of the 18 chicks seen on the mudflats they primarily become visible when they fledge at an age of approximately four to five weeks – only one chick seen was a little younger, perhaps three-and-a-half weeks old. The maximum age of the observed juveniles is much more difficult to estimate, and thus that part of the question is unanswered. Four chicks from two broods were ringed in this sub-area in 2010. Unfortunately, they were not observed on 22 July, when they would have been 45 days, and 21 days old, respectively.

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Appendix 2

Breeding parameters recorded in Common Tern colonies on Mandø 2009-2010

2009

The number of nests counted and the number of chicks found alive or dead is given in Table A2.1.

Timing of breeding – 2009. At the first visit on 13 May the terns were just about to initiate the colony, i.e. birds were observed in the vegetation for short periods, but no or very few birds appeared to have initiated egg-laying. Searches for nests were not carried out during that visit to avoid disturbance during colony establishment. The records of nest contents suggest that the majority of nests were initiated between 14 and 25 May. The first eggs appeared to hatch on 8 June, i.e. one nest contained 1 newly hatched chick and 2 eggs. Most clutches had hatched before 24 June. No nests with eggs were found after 1 July 2009.

Table A2.1. Number of nests with eggs and number of chicks found alive or dead in the colony of Common Terns on Mandø North during the seven visits to the colony in 2009.

	13 May	**25 May**	**8 June**	**16 June**	**24 June**	**1 July**	**12 July**
Number of nests with eggs	-	20	25	12	6	6	0
Number of chicks found alive	0	0	1	13	2	3	0
Number of chicks found dead	0	0	0	0	6	0	0

Clutch size. Mean clutch size was highest on 8 June when nest numbers culminated (see Table A2.2).

The clutch size recorded is likely to be lower than the average number of eggs laid per clutch because some clutches were probably not completed when recorded and it is possible that eggs were lost from some of the clutches prior to the recordings of nest contents.

Table A2.2. Number of nests with 1, 2 or 3 eggs, mean clutch size and SD for all Common Tern nests found with eggs in the colony on Mandø in 2009.

	25 May	**8 June**	**16 June**	**24 June**	**1 July**
Nests with 1 egg	3	0	5	3	3
Nests with 2 eggs	10	13	7	3	3
Nests with 3 eggs	7	12	0	0	0
Mean clutch size	2.20	2.48	1.58	1.50	1.50
SD	0.696	0.509	0.515	0.548	0.548
Number of nests with eggs	20	25	12	6	6

Fate of selected nests. The fate in the 20 marked nests of Common Terns followed in 2009 is given in Table A2.3.

Table A2.3. The fate of the nests that could be followed from after or around the end of egg-laying until after the time of hatching for the 20 Common Tern nests followed on the island of Mandø in 2009. Only on 25 May all of the 20 marked nests had eggs

Record/fate	8 June	16 June	24 June	1 July	13 July
Clutch present	20[1]	9[2]	3	1	0
Replacement clutch	0	?[3]	?[4]	1	0
Nest and clutch lost due to extreme high tide on 12 June	0	2	0	0	0
The clutch had disappeared or all chicks had died and disappeard before the visit [5]	0	6	0	2	2
One or more eggs had hatched and chicks were found in or near to the nest	1	7	0	0	0
Dead chicks were found in or near to the nest	0	0	3	0	0

[1] One of 2 eggs had hatched in one nest.

[2] 1-2 eggs had hatched and 1-2 eggs were present in 5 nest.

[3] Compared with the previous visit clutch size was reduced by 1 egg in 2 nests.

[4] Compared with the previous visit clutch size was reduced by 1 egg in 1 nest.

[5] The nest is only included on the first day it was recorded empty.

2010

The content of the nests recorded at each of the visits to the colony is given in Table A2.4.

Table A2.4. Number of nests with 1, 2 or 3 eggs and records of chicks for all Common Tern nests found with eggs in the colony on Mandø in 2010.

	25 May	31 May	8 June	14 June	21 June	25 June	1 July
Nests with 1 egg	2	4	4	12	1	1	1
Nests with 2 eggs	9	12	13	2	2	5	5
Nests with 3 eggs	4	9	10	5	2	1	2
Chicks found alive	0	0	0	0	2	2	0
Chicks found dead	0	0	0	0	0	2	0

Appendix 3

Breeding parameters recorded in Arctic Tern colonies on Mandø 2008-2011

2008

The content of the nests recorded in three colonies present at the island of Mandø on 23 May 2008 is shown in Table A3.1. These colonies were located at the southeast coast of the island.

Table A3.1. Number of nests with 1, 2 or 3 eggs for all Arctic Tern nests found in the three colonies on Mandø on 23 May 2008.

	Colony		
	A	**B**	**C**
Nests with 0 eggs	21	19	20
Nests with 1 egg	7	9	6
Nests with 2 eggs	58	67	69
Nests with 3 eggs	7	7	11

2009

The records of nest contents and chicks are given in Table A3.2.

Timing of breeding – 2009. The records of nest contents and chicks suggest that the majority of nests were initiated between 20 May and 14 June. The maximum numbers of nests with eggs were found on 16 June in all three colonies. The first chicks hatched between 8 and 16 June in colony B and C, whereas in colony A the first chicks appeared to hatch between 16 and 24 June. However, some of the clutches recorded on 25 May in colony A might have hatched (without being recorded as hatched) before the visit on 16 June.

Table A3.2. Number of nests with eggs and number of chicks found alive or dead in the three colonies of Arctic Tern present on Mandø in 2009.

	13 May	**25 May**	**8 June**	**16 June**	**24 June**	**1 July**	**12 July**
Colony A, SE Mandø 55°16'21''-8°34'16''							
Nests with eggs	0	29	30	52	34	23	0
Chicks found alive	0	0	0	0	8	4	0
Chicks found dead	0	0	0	0	0	3	0
Colony B, SE Mandø 55°16'16''-8°34'10''							
Nests with eggs	0	12	23	29	29	12	0
Chicks found alive	0	0	0	5	3	2	0
Chicks found dead	0	0	0	0	0	0	0
Colony C, Mandø Låningsvej 55°17'36''-8°34'43''							
Nests with eggs	0	22	88	93	61	46	0
Chicks found alive	0	0	0	18	22	25	0
Chicks found dead	0	0	0	0	4	2	0

Clutch size - 2009. Clutch size is likely to be underestimated since some nests were probably not fully laid when recorded and it is possible that partial predation had taken place prior to the recordings of nest contents. The highest mean clutch sizes recorded were 1.79, 1.68 and 1.80 in colony A, B and C, respectively (Table A3.3). Clutches with 3 eggs were only recorded in colony B and only in two nests on 8 June and in one nest on 24 June.

The content of the nests and the number of chicks recorded at each of the visits to the colonies is given in Table A3.3.

Table A3.3. Mean clutch size in nests with eggs and number of chicks found alive and dead in the colonies of Arctic Terns on Mandø in 2009.

	25 May	**8 June**	**16 June**	**24 June**	**1 July**
Colony A, SE Mandø					
Nests with 1 egg	6	9	36	25	18
Nests with 2 eggs	23	21	16	9	5
Nests with 3 eggs	0	0	0	0	0
Mean clutch size	*1.79*	*1.70*	*1.308*	*1.265*	*1.22*
SD	*0.412*	*0.466*	*0.466*	*0.448*	*0.422*
Number of nests with eggs	*29*	*30*	*52*	*34*	*23*
Chicks found alive	0	0	0	8	3
Chicks found dead	0	0	0	0	4
Colony B, SE Mandø					
Nests with 1 egg	6	10	6	14	9
Nests with 2 eggs	6	11	13	14	3
Nests with 3 eggs	0	2	0	1	0
Mean clutch size	*1.50*	*1.65*	*1.68*	*1.48*	*1.25*
SD	*0.522*	*0.647*	*0.478*	*0.509*	*0.452*
Number of nests with eggs	*12*	*23*	*19*	*29*	*12*
Chicks found alive	0	0	5	3	2
Chicks found dead	0	0	0	0	0
Colony C, Mandø Låningsvej					
Nests with 1 egg	10	18	23	32	27
Nests with 2 eggs	12	70	70	29	19
Nests with 3 eggs	0	0	0	0	0
Mean clutch size	*1.55*	*1.80*	*1.75*	*1.48*	*1.41*
SD	*0.510*	*0.406*	*0.434*	*0.504*	*0.498*
Number of nests with eggs	*22*	*88*	*93*	*61*	*46*
Chicks found alive	0	0	18	22	25
Chicks found dead	0	0	0	4	2

Fate of study nests - 2009. The fate in the 60 marked nests of Arctic Terns followed in 2009 is given in Table A3.4.

Table A3.4. The fate of 60 individually identifiable nests of Arctic Terns located on Mandø North. All 60 nests were with eggs on 8 June.

	Number of nests
The nest was found empty on a visit subsequent to one or more visits where eggs had been present; unknown whether one or more eggs had hatched before the nest was found empty	26
The eggs were found broken before hatching	2
One or more eggs had hatched but the fate is not known for any of the chicks	24
One or more eggs had hatched but at least one chick was found dead	5
One or more eggs had hatched but the chicks died	3

2010

The content of the nests and the number of chicks recorded at each of the visits to the colonies is given in Table A3.5.

Table A3.5. Mean clutch size in nests with eggs and number of chicks found alive and dead in the colonies of Arctic Terns on Mandø in 2010.

	25 May	31 May	8 June	14 June	21 June	25 June	1 July
Colony A, SE Mandø (south) 55°16'14''-8°34'10''							
Nests with 1 egg	10	13	14	20	8	12	18
Nests with 2 eggs	13	38	40	31	12	27	35
Nests with 3 eggs	3	1	3	3	0	1	0
Chicks found alive	0	0	0	10	1	3	2
Chicks found dead	0	0	0	0	0	1	0
Colony B, SE Mandø (north) 55°16'23''-8°34'21''							
Nests with 1 egg	6	4	4	5	7	16	13
Nests with 2 eggs	11	17	29	26	16	17	12
Nests with 3 eggs	1	2	4	3	1	2	0
Chicks found alive	0	0	0	0	6	15	7
Chicks found dead	0	0	0	0	0	0	0
Colony C, Mandø north 55°17'45''-8°33'51''							
Nests with 1 egg	0	5	7	7	7	6	0
Nests with 2 eggs	0	7	23	22	9	7	6
Nests with 3 eggs	0	3	3	3	0	2	0
Chicks found alive	0	0	0	7	9	2	0
Chicks found dead	0	0	0	0	4	1	0
Colony D, Saltmarsh north of Mandø Låningsvej 55°17'36''-8°34'43''							
Nests with 1 egg	-	-	-	-	14	16	4
Nests with 2 eggs	-	-	-	-	18	27	15
Nests with 3 eggs	-	-	-	-	0	0	0
Chicks found alive	-	-	-	43	8	7	2
Chicks found dead	-	-	-	3	4	3	0

2011

The content of the nests and the number of chicks recorded at each of the visits to the colonies in 2011 is given in Table A3.6.

Table A3.6. Mean clutch size in nests with eggs and number of chicks found alive and dead in the colonies of Arctic Terns on Mandø in 2011.

	26 May	**4 June**	**28 June**	**7 July**	**11 July**
Colony A, South Mandø					
55°16'14''-8°34'10''					
Nests with 1 egg	6	3	0	0	0
Nests with 2 eggs	0	0	0	0	0
Nests with 3 eggs	0	0	0	0	0
Chicks found alive	0	0	0	0	0
Chicks found dead	0	0	0	0	0
Colony B, SE Mandø					
55°16'23''-8°34'21''					
Nests with 1 egg	4	3	0	0	0
Nests with 2 eggs	0	0	0	0	0
Nests with 3 eggs	0	0	0	0	0
Chicks found alive	0	0	0	0	0
Chicks found dead	0	0	0	0	0
Colony C, Mandø north					
55°17'45''-8°33'51''					
Nests with 1 egg	0	1	3	0	0
Nests with 2 eggs	0	0	4	3	0
Nests with 3 eggs	0	0	0	0	0
Chicks found alive	0	0	0	0	0
Chicks found dead	0	0	0	0	0
Colony D, Saltmarsh north of Mandø					
Låningsvej					
55°17'36''-8°34'43''					
Nests with 1 egg	0	15	19	11	0
Nests with 2 eggs	0	22	15	5	0
Nests with 3 eggs	0	0	0	0	0
Chicks found alive	0	0	0	1	0
Chicks found dead	0	0	0	0	0

Appendix 4

Clutch and brood sizes of Lesser Black-backed Gull, Herring Gull, Common Gull, Artic Tern and Sandwich Tern on Langli 2009

Clutch size

Clutch size is probably underestimated for most species as the nests were not followed closely around the time of egg-laying. Therefore, partial predation may have taken place prior to the first nest visit and probably not all clutches were fully laid at the first visit.

For example, at the first visit on 12-14 May the clutch size was 2.45 in the Common Gull colony and this is under the normal fixed clutch size of three eggs. Many nests contained only one or two eggs on the first visit. The number of eggs per nest had increased in the Common Gull colony at the second visit (Table A4.1), although some nests still had only one egg.

Table A4.1. Mean clutch size in the nests selected for studies of nesting success in three species of gulls and two species of terns on the island of Langli in 2009. Only nests with at least one egg were included in the calculation of the mean.

Species	Date(s)	Mean clutch size	N
Lesser Black-backed Gull	14 May	2.56	107
Herring Gull	12-14 May	2.50	107
Common Gull	12-14 May	2.45	161
	21 May	2.55	109
Arctic Tern	20 May	1.29	22
Sandwich Tern	21 May	1.32	59

Brood size

The mean brood size is given for broods with young chicks in the nests that were followed during the breeding season.

Table A4.2. Mean brood size for three species of gulls and for Sandwich Terns on the island of Langli in 2009. Brood sizes refer to broods where the chicks aged 1 to ca. 10 days.

Species	Mean brood size	N
Lesser Black-backed Gull	1.85	59
Herring Gull	1.70	46
Common Gull	1.57	14
Sandwich Tern	1.00	22

BREEDING SUCCESS OF OYSTERCATCHER, TERNS AND GULLS IN THE DANISH WADDEN SEA

Knowledge about breeding success is relevant for understanding the trends observed in local and regional breeding populations of waders, terns and gulls. This report compiles results from surveys of breeding success of Oystercatchers and terns breeding on the island of Mandø, and of terns and gulls breeding on the island of Langli. Both islands are located in the Danish Wadden Sea. Oystercatchers were monitored in 2010 and 2011 and bred successfully in one of these. Common Terns and Artic Terns were studied on Mandø mainly in 2009-2011 and they bred with very poor success in all years. Successful breeding of Sandwich Terns was recorded on Langli in most of the years during 2006-2010. The Lesser Black-backed Gulls and Herring Gulls that nested on Langli were fairly successful in raising young to fledging during 2009-2013, whereas Common Gulls suffered from predation by Herring Gulls and they hardly raised any young. It is concluded that a future low cost monitoring programme of breeding success could focus on Oystercatchers on Mandø and Herring Gulls on Langli.

ISBN: 978-87-7156-153-1
ISSN: 2245-019X