Monitoring Breeding Success of Coastal Breeding Birds in the Wadden Sea –

Methodological Guidelines and Field Work Manual

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1. Introduction

Since 1991, breeding bird surveys in the International Wadden Sea have been carried out as 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 scheme is supported by numerous NGOs, governmental agencies and volunteer bird counters, that are responsible for coordination and fieldwork in Denmark, Schleswig-Holstein, Niedersachsen/Hamburg and The Netherlands. Results of the surveys are published regularly as Wadden Sea Ecosystem (Koffijberg *et al.* 2006) or at the website of the Wadden Sea Secretariat, CWSS (www.waddensea-secretariat.org).

Due to the focus on distribution and trends, however, backgrounds for population changes often remain unknown, and links with management issues weak. Several breeding birds that currently experience declines in the Wadden Sea are also supposed to have a poor breeding success (de Boer *et al.* 2007, Koffijberg *et al.* 2010, van Kleunen *et al.* 2011), but trilateral data to assess its impact are scant. Most of the species dealt with in the trilateral monitoring scheme are long-lived and will therefore show a delayed response to deteriorating environmental conditions or human impact. The parameter 'breeding success' performs much better as an early-warning system to detect changes in the ecosystem or assess human impact, since it is more directly linked with changing conditions in the environment. Moreover, evaluation of the target 'natural breeding success', as addressed in the Wadden Sea Plan, is currently not possible with monitoring of only population size and distribution. Hence, 'breeding success' has been recognised as an important gap in the current monitoring in the Wadden Sea and has been proposed earlier to be included in TMAP, following a pilot project in 1996-97 (Becker 1992, Exo *et al.* 1996, Thyen *et al*. 1998, Becker *et al.* 1998, de Jong *et al.* 1999, Essink *et al.* 2005). As part of a revision of TMAP, it has been decided that from 2010 onwards, breeding success will finally be included in TMAP, and monitored for a selection of ten species.

Monitoring of breeding success will enhance the existing census work on breeding birds. It will not only allow evaluation of conservation issues (Wadden Sea Plan, EU Directives), it will also give insight in demographic processes that influence population trends in Wadden Sea breeding birds, especially when also linked to ringing and survival data ('Integrated Population Monitoring'; Greenwood *et al.* 1993, Thomas *et al.* 1995). The aims of the new monitoring scheme have already been put forward during the pilot-project 1996-97 and are still valid. In addition, assessment of the conservation status of birds, as requested by the EU-Bird Directive, has been added since a favourable conservation status has become a guiding principle for conservation of bird populations in the Wadden Sea. To summarize, the targets that monitoring of breeding success should address are:

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

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

This manual intends to provide a trilateral platform for methods of monitoring of breeding success in the Wadden Sea. The contents of the manual still has a provisional status and it will be improved during the first year(s) of fieldwork, when new experience and knowledge becomes available and meth-

ods have been validated. The manual contains guidelines for fieldwork and data collection that should be used in the new monitoring scheme, and preferably also in other work that is related to breeding success in the Wadden Sea (e.g. species that are not covered with the trilateral scheme). Trends in time, and comparisons of breeding success between the countries and regions will greatly benefit when all participants use the same methodological standards in fieldwork and data collection all over the Wadden Sea. Therefore, special attention is paid to methods of nest surveillance (hatching succcess) and assessment of the number of young of each brood after fledging (fledging success or breeding success). Methods are described in a more general context (chapter 3) and specifically for each of the selected species (chapter 4). Finally, chapter 5 describes data handling and data transfer to a trilateral database. The original project proposal that was used to implement breeding success as TMAP-parameter and that contains backgrounds of the setup of the scheme is included as an appendix.

BOX 1: Monitoring of breeding success - potential disturbance and communication to public

Compared to regular breeding bird monitoring, fieldwork to determine breeding success potentially poses a greater risk of disturbance to the birds, as individual nesting birds or breeding colonies get disturbed when visited for a prolonged time. Besides, also public might raise questions whether fieldwork is causing disturbance. Therefore it is important to communicate that the methods described in this manual have been tested extensively and have been optimized in order to cause the lowest possible disturbance effect. It is the duty of each single fieldworker to minimize the disturbance within the chosen method as far as possible. Moreover, note that most fieldwork is only possible with special (written) permission of national authorities and/or site managers like national park agencies.

First of all, it is important to have (written) permission to search and check nests and visit areas that are usually closed to the general public, like nature reserves or national park area. National coordinators (see chapter 2.3) can assist with getting the right type of permission (that will depend on national legislation and site management), which should be arranged well before the start of the breeding season in the 2nd half of April. In addition, when tracking chicks by capture-recapture techniques or when monitoring chicks within fenced areas, a ringing permit, issued by the national ring centre, is obligatory (check details with national coordinator).

Regarding disturbance it is important to note that most bird species are especially susceptible to disturbance in the initial settling and nesting phase, so avoid long searches in that period (especially when checking Avocet and terns colonies, see chapter 3.5.3 and species accounts for details). Besides, adverse weather conditions might be detrimental to clutches or chicks. Therefore, avoid cold and rainy weather or very hot weather for fieldwork. This is particularly important when small chicks, both from the studied species as other species, are present at the study site. Visits of breeding sites should be organised in a way that an individual bird does not suffer disturbance for more than one hour per visit.

Be aware that searching for nests or chicks might also raise questions by public visiting your study site, especially when it is part of a reserve or national park where public access is usually prohibited. In such cases it is important to communicate that your work is part of an international monitoring programme that collects data which are needed for conservation and management of the Wadden Sea and that is has been approved by national authorities. Also make clear that disturbance of birds is taken consideration of and is kept to a minimum level, allowing them to breed successfully. In some areas it might also be recommended to inform the local community about your intentions. Especially on small islands, meetings with local stakeholders and the interested public, well before the start of the field season, might help to avoid objections against conduction of the fieldwork during the field season. Eventually, check such issues with national coordinators.

And last but not least: if your study area is close to a public pathway or may well be seen by spectators as tourists, make sure they do not follow you into the (protected) area. Eventually, post flexible signs at the entrance to the area when you enter there, reading e. g. "Scientific work – please do not follow!".

2. Setup of the monitoring scheme on breeding success

2.1. Selection of species

The current breeding bird monitoring scheme focuses on 35 characteristic species in the Wadden Sea . However, to fulfill the aims formulated in the previous chapter, it is not necessary to include all these species in a breeding success monitoring scheme. Preferably, a selection of species to be monitored for breeding success should include a subset of species that can be used as indicators for different habitats and feeding strategies. During the pilot project in 1996-97, JMBB agreed on a list of six target species that were assumed to be suitable for monitoring of breeding success and match the aims of the project (Exo *et al.* 1996). Criteria to select species by that time were: (1) species should be typical breeding bird in the Wadden Sea; (2) species is abundant and (3) species occurs in all three countries NL, D and DK. In addition, species should represent a certain habitat or feeding strategy. For instance, Common Tern was regarded a dune-breeding species and Redshank a salt marsh breeder. Benthos-eating species were represented by Oystercatcher, Avocet and Redshank (partly Herring Gull), fish-eating species by Common Tern and Herring Gull. Besides, Oystercatcher and Common Tern were also chosen since they are included in the monitoring of the TMAP-parameter '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 pilot project 1996-97 and species used 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 new 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 with management issues. Additional criteria were that a species eventually should be abundant and/or is included in the TMAP programme 'contaminants in bird eggs'. A comprehensive overview of criteria according to which species were selected is given in appendix 1.

2.2. Selection of study sites

In order to retrieve representative data and allow regional comparisons of (differences in) breeding success, JMBB has designed a regional approach that distinguishes different regions throughout the Wadden Sea. Including mainland and islands, these regions are divided into 15 subregions (Figure 1). The boundaries of these subregions were derived from the census regions used in the breeding bird monitoring, i.e. they merely aggregate the existing 56 census regions into 15 larger units. These subregions are highly similar to those used in the TMAP-parameter 'contaminants in bird eggs', thus enhance direct comparisons with the results of that monitoring scheme. Within these 15 subregions, national coordinators are responsible for the setup of a network of study sites for each species. It is recommended to choose the same study sites to study breeding success each year. In Oystercatcher, this is even obligatory as this species is extremely site-faithful and therefore highly susceptible to very local conditions. In this species, the study site and its borders should be kept the same during the breeding season and between years. However, especially in species with dynamic breeding behaviour (e.g. colonial breeding birds), it might be necessary to shift the study site or change its borders between years to keep track on a suitable sample size or representative part of the local breeding population within the whole study area. In case of doubt, check with the national co-ordinator if the proposed change of your study site is agreed upon.

At all sites where breeding success is studied, it is important to have information on the total number of breeding pairs when assessing final fledging (breeding) success, as breeding density might affect reproductive output. Moreover, fledging success is calculated from the total number of breeding pairs. Hence, it is recommended to choose study sites where also a census of the breeding population is carried out. In rare or colonial breeding birds, that cover most of the scheme, this will not be a problem as they are counted at all sites anyway. However, common breeding birds like Oystercatchers usually are only surveyed in specific census areas. Therefore, study sites to assess breeding success should preferably match with census areas (in the framework of breeding success relevant for Oystercatcher), or any other areas where also the number of breeding pairs is assessed.

Furthermore, it is also important to anticipate on displacement of breeding sites during the breeding season. Especially colonial breeding birds easily get displaced after e.g. flooding. Replacement clutches should always be taken into account, even if the colony has moved to a different site (within the same study area). Also here, it is allowed to change the borders of the study site when field conditions require this. Note that in many cases, this will also expand the period that nests and chicks have to be monitored.

Finally, when designing study sites, it should be taken into account that the site comprises both nesting areas and chick-rearing areas. This is especially important in a precocial species like Avocet, which guide their chicks soon after hatching to specific chick-rearing areas (see species account in chapter 4 for specific guidelines). Also note special treatment of mixed colonies of gulls and terns in chapter 3.5.3.

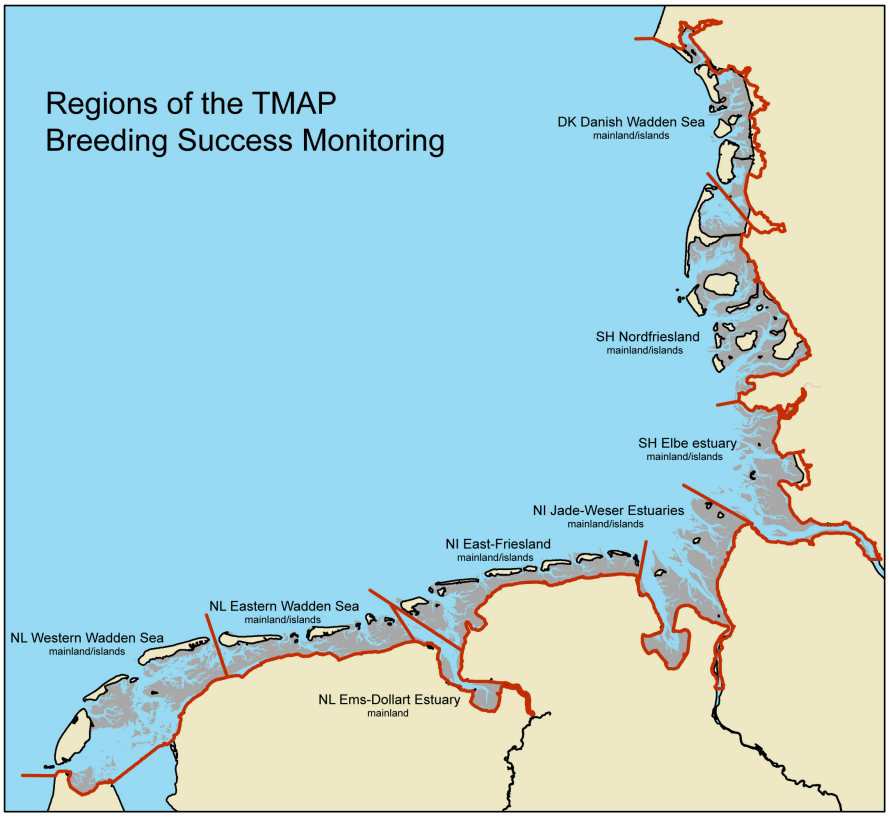

Figure 1. *Overview of regions and subregions to be used in the trilateral monitoring of breeding success in the Wadden Sea.*

2.3. Organisation and coordination

Coordination of the monitoring scheme on breeding success is carried out by the same institutions that also organise the breeding bird surveys in the Wadden Sea and are part of JMBB. National coordinators are the first to contact regarding all matters concerning monitoring of breeding success.

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3. General methodological guidelines

3.1. Target value of the studies

Breeding success, as it is understood within the framework of TMAP, concentrates on the success of breeding birds in raising their offspring upon fledging (i.e. fledging success). In addition, factors that influence breeding success are investigated. Therefore, the scheme focuses on both the nest period and the chick-rearing period. Hence, targets of the trilateral monitoring of breeding success are:

1. Determine hatching success of clutches by following their fate over the incubation period;
2. Determine fledging success by following the fate of the hatched chicks until fledging.

Both are surveyed on a geographical scale, allowing comparisons between sites within the Wadden Sea (see chapter 2.2). In Common Eider and Eurasian Spoonbill, assessment of hatching success is not carried out trilaterally for different reasons (risk of disturbance, practical difficulties). For Avocet, more focus is put on fledging success, as in this species mortality during the chick-rearing period is the most important factor influencing final breeding success. Note however, that also in Avocet, data from the fate of clutches are requested to assess e.g. local impact of flooding or predation (that predominantly play a role during incubation). Specific guidelines for each species are given in chapter 4.

3.2. Sample size

For statistical reasons it is recommended to achieve a sample of 60-80 clutches for each single species in a subregion as depicted in figure 1, i.e. 60-80 on the mainland and 60-80 on an island. This sample size refers to the initial sample when starting fieldwork. It is not requested to start new searches when part of the inititally sampled clutches vanish over time (e.g. due to predation). Furthermore, note that not in all Wadden Sea (sub)regions, study sites will be available that provide the requested number of clutches per species. In these cases, lower numbers of clutches are accepted and samples eventually have to be aggregated in analysis later on. If, for example, the only Avocet colony within the region comprises only 30 pairs, then this colony should be studied, and not be rejected for its small size (since it's the only available colony). Also when only smaller number of clutches can be surveyed, division to mainland (e.g. 30 clutches) and islands (30 clutches) might be useful; check with your national coordinator in case of doubt. Also in many colonial breeding birds, smaller samples will be more rule than exception since building enclosures that in total comprise 60-80 nests will not be practical to implement. Therefore, the part of the colony that is surveyed for hatching success (and fenced later on, prior to hatching) should at least include 20-40 nests, or less (5-15) in large gulls (see chapter 3.5.3. for details). Here, it is important to choose a representative part of the colony (not a site with low breeding densities at the edge) and use more enclosures within one colony, which increase total sample size. Guidelines how to select samples in colonial breeding birds are described in chapter 3.5.

3.3. Controlling interval

In order to minimise disturbance, intervals between two successive visits preferably should be about once every 6 days during incubation. When time is available, extra effort should preferably be put in finding new nests, instead of checking existing nests very frequently (i.e. more than twice a week). Frequent visits are not useful and might also enhance predators to get attention to the nest site. Planning control intervals should take notice of expected hatching dates, i.e. do visit the study area in the days that many clutches are expected to hatch (derive hatching dates from incubation stage, see chapter 5). During the chick-rearing phase, intervals between successive visits highly depend on method and species, see chapter 4 for species-specific guidelines.

3.4. How to determine hatching success

3.4.1. Marking and surveillance of clutches

Since not all the investigated species do build nests, the term clutches is used here for all species. Basically, a study site has to be searched for clutches of the intended target species, taking into account the guidelines for disturbance described in chapter 1. Colonies of gulls and terns usually will be visible from a distance, so discrete areas can be searched for nests. The same applies to most colonies of Avocet. In territorial breeding species like Oystercatcher, that breed individually and scattered, the study site has to 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) might help to locate individual nests or incubating birds.

The timing of nest searches is determined by the species that is studied. In general, nest surveillance in the Wadden Sea takes place from the 2nd half of April until June, but check the species accounts for details (see also overview in figure 2, chapter 4). The period that nests are surveyed should include the main part of the breeding season and should not start later than the estimated peak of egg-laying. Also, do include replacement clutches, which in some species might be found well into June. Note that in some colonial breeding birds, displacement of entire colonies, e.g. after flooding might expand the breeding season well into July. Also in such cases, replacement clutches should be taken into account.

When found, the position of a clutch may be stored in a GPS handheld device, of which coordinates can be used when reporting the data. Besides, as GPS might be inaccurate, it is recommended to plot the clutch site on a detailed map or aerial photograph of the study site (scale 1:2500 recommended). Distribution of the sampled clutches should be assessed by either method. Moreover, it is important to mark each clutch by an uniquely numbered marker that is used to keep track on the fate of the clutch and is usually placed 3-5 m from a clutch, using the same distance and same direction for each clutch within one study site. Only in colonial breeding birds (where nest density is higher), nests-markers are put right next to a clutch. Usually small bamboo canes with a red or yellow flag from fabric-tape are used as nest-marker. Alternatively, plastic canes, or small plastic boards like those used by gardeners can be used as well, especially when vegetation is not expected to grow high during the incubation period. On the tape or plastic board, the number of the clutch is written with a water- and UV light resistant pen, preferably black Edding markers (that have proven to be UV- and water resistant). Do take into account that in areas where livestock-grazing occurs, markers might get trampled or demolished by cattle or sheep. In areas with (presumed) high predation rates, use the largest possible distance to mark nests (better 5 than 3 m).

In some areas where high predation rates occur, there might be a high turn-over of nest sites and finding empty nests might be common practice. Nests that are never found with any eggs can not be used to analyse hatching success, but it is recommended to record the number of presumably empty nests whenever possible. Note, however, that these always refer to completed nests that could have contained eggs. Oystercatcher and colonial breeding birds are known to produce nest scrapes or play nest, which should not be recorded as empty nests.

Eggs should always be numbered to check the fate of single eggs (see table 1). Use the same marker as used to number the flaggs of the nest markings, but do make sure markers do not contain solvents. Alternatively a dull-edged pencil of type 6B can be used. Write the number on more than one side of the egg.

3.4.2. Parameters to be documented

To allow proper analyses it is important that all nest data are collected in a standardised way and recordings are harmonised between the countries. Table 1 gives the parameters that must be recorded for each clutch. Note that all parameters are recorded when finding a clutch for the first time, but not all should be recorded again during successive controls (egg measurements are only taken once). Determining the fate of single eggs might not always be possible, but suggestions are given in table 1. Clutches that contain cold or damp eggs during two successive visits should be treated as 'deserted'.

Look for possible tracks of predation, like footprints of predators, broken eggs, eggshell fragments or egg contents. Replacement clutches in the same nest are given clutch number 2 (clutch number 1 is the default for all clutches found). Replacement clutches in new nests get a new nest number (make a note under remarks if link with previous nest is clear). Data recording is dealt with in chapter 5.

Table 1: *Parameters to be documented for each clutch.*

Parameter	Description of parameter	Finding a clutch for the first time	Successive nest checks
species		x	
nest site	name of study site, island or mainland	x	
habitat	dune, beach, outer sand, salt marsh	x	
nest number	unique identifier of the nest	x	x
clutch number	in case of re-placement clutches, see text	x	x
date		x	x
number of eggs		x	x
number of chicks		x	x
mass, length and width of eggs	mass in gram, length and width in mm	x	x (only when new eggs)
possible reason for vanishing of single eggs[1]	record per egg!	x	x

[1] e.g. egg trampled by livestock, predated (mention possible predator if known), egg not fertile, failure due to cold or wet weather, inundated by storm tide, etc.

3.5. How to determine fledging success

As most species that are dealt with in the breeding success monitoring scheme are precocial, determining fledging success is generally less straightforward than assessing nest success. The following subchapters give a general description of the different methods available to determine fledging success, once chicks have hatched. Which method is preferred for a given species at a certain study site depends on different factors as the behaviour of the species, the visibility of the study site, the elevation of the area and the personal resources available. An overview of which method is used to study which species is given in chapter 3.6. Species-specific guidelines are given in the species accounts in chapter 4.

3.5.1. Method O: Observations of chicks / juveniles / families

This method is suitable for precocial species of which chicks leave their nest site quickly after hatching and that are often being reared in "feeding territories" by their parents. A prerequisite is the visibility of broods from a distance. This may not be given if broods remain concealed in high vegetation, ditches or creeks, or in study sites with very wide salt marshes. Breeding sites at remote islands, on the other hand, are very suitable as observations will always refer to the local breeding pairs. The idea of the method is to determine breeding success by observing and counting chicks or family parties, and in turn get the number of fledged chicks per pair. Therefore, the chicks have to be observed and counted up to an age immediately before fledging (age classification needed), so that the probability of fledging is as high as possible and a good proxy for breeding success is achieved.

In species like Oystercatcher it is possible to mark chicks individually and thus to follow the fate of the brood of a single clutch (see chapter 3.5.2.). In other species as Avocet, marking chicks is nearly impossible as they leave the nest site rather quickly and are being reared at muddy tidal flats where it will be rather difficult to catch them. For such a species, counts of chicks by observations from a distance is the best method to retrieve a proxy for fledging success.

The place to carry out observations has to be well selected as it should always be possible to link the broods observed during the survey to a known number of breeding pairs. In Oystercatcher, this will often be the same areas where clutches have been surveyed for nest succcess (Oystercatcher are highly territorial, also during the chick-rearing period). Alternatively, fledging success in Oystercatcher can also be assessed by extra visits after a regular breeding bird survey (so without checking nests). However, in Avocet, broods from more than one single colony often move to specific chick-rearing areas, so caution is needed when selecting survey area.

Observations will typically be carried out on mudflats or on sparsely vegetated salt marshes during high tide. Repeated counts are necessary in Oystercatcher (two) and Avocet (weekly counts), mainly because the breeding season in both species is long. Only for Common Eider, one single count is regarded sufficient. Plan counts well before all chicks have fledged. Once the chicks have fledged, it is in most species impossible to tell which area they come from (unless they have been marked). Counting immature birds at high tide roosts for instance, can therefore only be considered as an additional effort outside the monitoring scheme (except for Eurasian Spoonbill, see below). It will provide valuable data on breeding success in the whole population, but it can in most species not be linked to distinct breeding areas. For example, in gulls (at least Lesser Black-backed Gull and Herring Gull) juveniles quickly desert their native colony after fledging and immatures from other colonies may well appear in the studied colony although here a large number of chicks hasn't even fledged (for example observations of marked immature gulls from Helgoland on the island of Trischen in the beginning of August).

Methods to assess fledging success in Eurasian Spoonbill is somewhat different from what is described above, as one of the methods involves counts of the amount of juveniles at post-breeding roosts, like it is done in swans in geese in wintering areas (see chapter 4 for details).

3.5.2. Method R: Capture and recapture / Capture and resight

Just as the method described before, this technique is suitable for precocial species with chicks leaving their nests quickly after hatching, like Oystercatcher but also for colonial breeding birds if the preferred method of fencing (see chapter 3.5.3) 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 well visible from the distance. By capture, mark and recapture (or resighting) of chicks, survival of chicks and finally fledging success can be determined. So far, this method has been carried out succesfully in Schleswig-Holstein.

The method is based on capture-recapture methods that are commonly used to determine population demography and population size (e.g. White & Burnham 1999). A known number of individuals is captured and marked and then released. Afterwards, successive catching effort is undertaken. A suitable strategy involves ringing on two successive days (to enhance catching efficiency) and recaptures

in two successive days prior to fledging (Walsh *et al.* 1995). Alternatively, frequent recaptures until fledging can be made, depending on the local situation. This method only gives good results under the condition 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 from the first catch and the total number of captured marked individuals in a successive catch (Lincoln-Petersen-Index).

The chicks of the controlled clutches are ringed individually shortly after hatching (see details on age upon ringing in the species accounts in chapter 4). 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. In colonial breeding birds it is recommended to use a box to store chicks upon ringing (Wagener 1998). It is not necessary to catch each individual chick in each successive visit, it is just important that they all have the same chance of being picked up. 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 (peak in) hatching date (derived from 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. Recaptures during the chick-rearing period have to be done at high tide. It is optional to determine body condition of chicks (body mass in gram) during each catch, but is not obligatory within the framework of TMAP.

The method described above 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 were 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 prerequisite of similar chances of each fledgling to be found is not violated. Moreover, statistical analysis of the data requires some expert knowledge.

3.5.3. Method F: Fencing

This method is suitable for species which chicks stay in- or close to the nest after hatching, in our framework gulls and terns. It has proven a very successful and commonly used method for studies of breeding success in these species (details in e.g. Wagener 1998). Caution has to be taken at nest sites that are susceptible to flooding. It should be avoided that chicks get drowned in a fenced area during flooding after strong onshore wind or storm. 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 much as possible.

Depending on study site conditions as colony density, personal resources and infrastructure either single clutches or groups of several clutches (usually 5-15 in large gulls, 20-40 in terns) will be fenced. Always mark a larger sample of nests than the final number of nests that is being controlled, as some clutches will fail or will be deserted. To achieve the requested sample size for each subregion (see chapter 3.2), 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 fate 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. Also here, a box to store chicks that can be ringed is recommended to allow a smooth workflow (Wagener 1998).

In order to retrieve a representative sample of clutches it is important to select a 'representative' part of the colony. It is recommended to build two or more enclosures in two different parts of the colony if

density of nests varies a lot (especially recommended in large gulls). Avoid sites at the edge or other parts of the colony that are considered not to be representative for the colony as a whole, including the centre of the colony with usually very high density of nests.

Fences or enclosures are put 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.

Fencing of single clutches

The method originally tested in the 1990s was the fencing of single nests (Becker & Finck 1986, Becker & Anlauf 1988, Wagener 1998, Thyen *et al.* 1998). The idea was not only to assess hatching and breeding success but also to record the chicks' size and weight. Therefore, it seemed suitable to fence single nests as this makes the handling of the chicks much easier. Several types of fences were tested in order to find a type that as far as possible prevents that chicks would hurt themselves. A very stable type of fence was chosen and is still recommended for single nest-fencing (see details in BOX 2).

When controlling a clutch, all parameters may easily be recorded as the chicks are kept in a close distance to the nest. If the chicks are ringed individually with metal (or even colour) rings, further marking is not necessary.

BOX 2: How to install a single-clutch fence

Use stable, zinc coated steel wire (see picture). The height of the fence should be 50 cm. The mesh width should be 25.4 x 12.7mm (h*w) as this effectively prevents the chicks from injuring their bills. Iron bars of about 80 cm in length and ca. 6 mm in diameter are useful as fence posts and put 2 m apart and in the corners. As the fence is of a rather stable type, fixing it with iron bars is rather reliable. As the same length of fence (see below) is required to fence each respective clutch, the fences can be used again and again.

The fence put around each clutch is about 12.5 m in length (ca. 9 m^2) for Herring Gull and Lesser Black-backed Gull, and about 6.2 m (ca. $2m^2$) for Black-headed Gull and terns (note that multi-clutch fences are preferred in the latter two species). This proved to be well accepted by the adult birds and sufficient to easily track the chicks when controlled (Thyen *et al.* 1998). In sparsely vegetated, very weak sandy soil, more poles and possibly pegs may be required. It is recommended to use V-shaped pegs instead of special sand pegs. Alternatively, use 30-40cm long pieces of steel wire (3-4 mm in diameter) and U-shape them. Note that the entire nest territory must be included in the fence to avoid that food brought for the chicks is dropped outside the enclosure.

Installing the fence requires at least 2 persons. It should be made sure that within the fence the complete furnishing of a nest territory is included. In particular enough cover for the chicks and a landing place for the adults must lie within the fence. Furthermore, the fence must reliably prevent chicks from inside the fence from leaving the enclosure and prevent chicks from outside from entering the fenced area. Hence, no gaps are allowed between the lower edge of the fence and the ground surface. It may therefore be useful to start with digging a small ditch (10cm in depth) along the intended course of the fence. After putting up the fence, use soil material to cover the lower edge. In very weak sandy soil, additionally use pegs to fix the fence to the ground, at least every 2 m, in between the poles (before covering the fences lower edge with soil material). The fence has to be in upright position to keep chicks from climbing it up and escaping the enclosure. Also take care that chicks are not able to climb up the vegetation along the fence to get outside the fenced area.

Example of single clutch enclosure for Herring Gull or Lesser Black-backed Gull on the island of Mellum, Germany (Photo: K.-M. Exo).

Fencing groups of clutches

In dense colonies, or in most tern colonies, fencing of single clutches may be impossible or not practical. In that case, fencing of several nests is recommended. Different types of fences have been used here (see details in Box 3). As recording the development of the chicks' size and weight is not an obligatory (but optional) part of the monitoring scheme, fencing several nests will not result in different results, compared to fencing single nests. It's mainly for practical reasons what type of fence is chosen.

When controlling the fenced areas, the number of chicks found inside and outside the nests is recorded. When the chicks grow older, they will start to move away from the nests and might hide in vegetation. Even if they only move a few meters, it will no longer be possible to tell which clutch they originate from. Therefore, individual marking of the chicks is recommended. Next to using metal rings, fabric tape should be used to form small flags around the chicks' legs (not if colour rings are used). This can be done from the day after hatching on. Onto the flag, the number of the clutch has to be written. The flags will fall off some weeks later. After some days (check species-specific details in chaoter 4) they can be ringed with metal rings.

In mixed colonies of Lesser Black-backed Gull and Herring Gull, differently coloured fabric type has to be used for the chicks of the different species as it will otherwise be impossible to distinguish them in the controls.

BOX 3: How to install a multi-clutch fence

Also for multi-clutch fencing, the fence type used for single-clutch fences can be used. Due to costs and weight, this will, however, not be possible in all study sites. In that case, preferably use plastified chicken wire (see picture), sexangular or hexagonal in shape. The height of the fence should be 50 cm. The mesh width is preferably similar to those used in single-clutch fences (25.4 x 12.7 mm) as this mesh usually avoids the bills of the chicks to get hurt. In case smaller mesh width is used, it is recommended to install silage film (plastic foil from agricultural use) in the lowest 20 cm of the fence to

avoid chicks' bills get injured. This is important especially in terns. As fence posts, iron bars of about 65-105 cm in length and ca. 6-8 mm in diameter are useful (similar to those used for flexible pasture fences). As the fence itself is not of a very stable type, high effort has to be spent on fixing it. As the length of fence required will vary from year to year, it is recommended to keep the fence on the length of the original roles. After the breeding season, it has to be rolled-up again.

The length of fence required depends on colony density and geomorphology. Use poles every 1.5 m, and a peg in between each two poles. In sparsely vegetated, very weak sandy soil, more poles and pegs may be required. It is recommended to use V-shaped pegs instead of special sand pegs. Alternatively, use 30-40 cm long pieces of steel wire (3-4 mm in diameter) and U-shape them.

Installing the fence requires at least 2 persons. The fence must reliably prevent chicks from inside the fence from leaving the enclosure and prevent chicks from outside from entering the area. Hence, no gaps are allowed between the lower edge of the fence and the ground surface. It may therefore be useful to start with digging a small ditch (10 cm in depth) along the intended course of the fence. After putting up the fence, use pegs (at least one in between the poles) to fix the fence to the ground and use soil material to cover the lower edge. The fence has to be in upright position to keep chicks from climbing it up and escaping the enclosure.

In gulls, the fence should keep a minimum distance of 1 m to the clutches of Herring Gull and Lesser Black-backed Gull. To avoid aggression between the families fenced, the fenced area should not be too small as the chicks of the several clutches need shelter to hide away from the others. For terns, roof tiles might be provided as shelter during cold weather. On the island of Trischen, 62 clutches of Herring Gull and Lesser Black-backed Gull were fenced in 2009. This required 500 m of fence, 350 poles and 350 pegs on very weak soil. For terns, 25-50 m of fence are needed to fence about 25 clutches.

Example of multi-clutch fence for Sandwich Tern in Zeebrugge, Belgium (Photo: Wouter Courtens/INBO).

Example of multi-clutch fence for Herring Gull and Lesser Black-backed Gull on the island of Trischen, Germany (Photo: Janina Spalke).

3.6. Which method to choose?

Table 2 gives an overview on which of the three methods to determine fledging success can be used in which species. For most species, two methods are given. It's up to the national coordinators to decide, which method is used for which species in which study site. No matter which method is chosen: within one study site, the method must not be changed from year to year but it must be kept constant over time and should be documented when entering data in the recording sheets.

Both given methods are likely to produce comparable results, but experimental evidence is still missing and comparative studies have to be initiated to calibrate the results. However, keeping the method constant over time allows for the gathering of meaningful trends within the study sites.

Table 2: *Overview on suitable methods to determine hatching and fledging success in the respective species of the TMAP parameter 'breeding success'.*

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

4. Species accounts

This section is aimed to give practical guidelines for each species to be monitored. General aspects of fieldwork and assessment of nest success and fledging success, as well as an overview of methods to be used for each species have been presented in chapter 3. In the following chapters, specific instructions for individual species are given, along with remarks regarding their breeding behaviour. Some of the methods here are provisional, and further study is necessary to check their compatibility and calibrate the results. Lesser Black-backed Gull and Herring Gull as well as Common Tern and Arctic Tern have been combined as methods for these species-combinations are highly similar. Figure 2 summarizes the timing of the breeding season for all species monitored, showing the nest- and chick-rearing period. Table 3 lists for each species data on clutch size, incubation time and duration on chick-rearing period.

Figure 2: *Timing of breeding (nest period, chick-rearing period) in the species monitored in the TMAP parameter 'breeding success'. Season from April to August is divided in 10-day periods.*

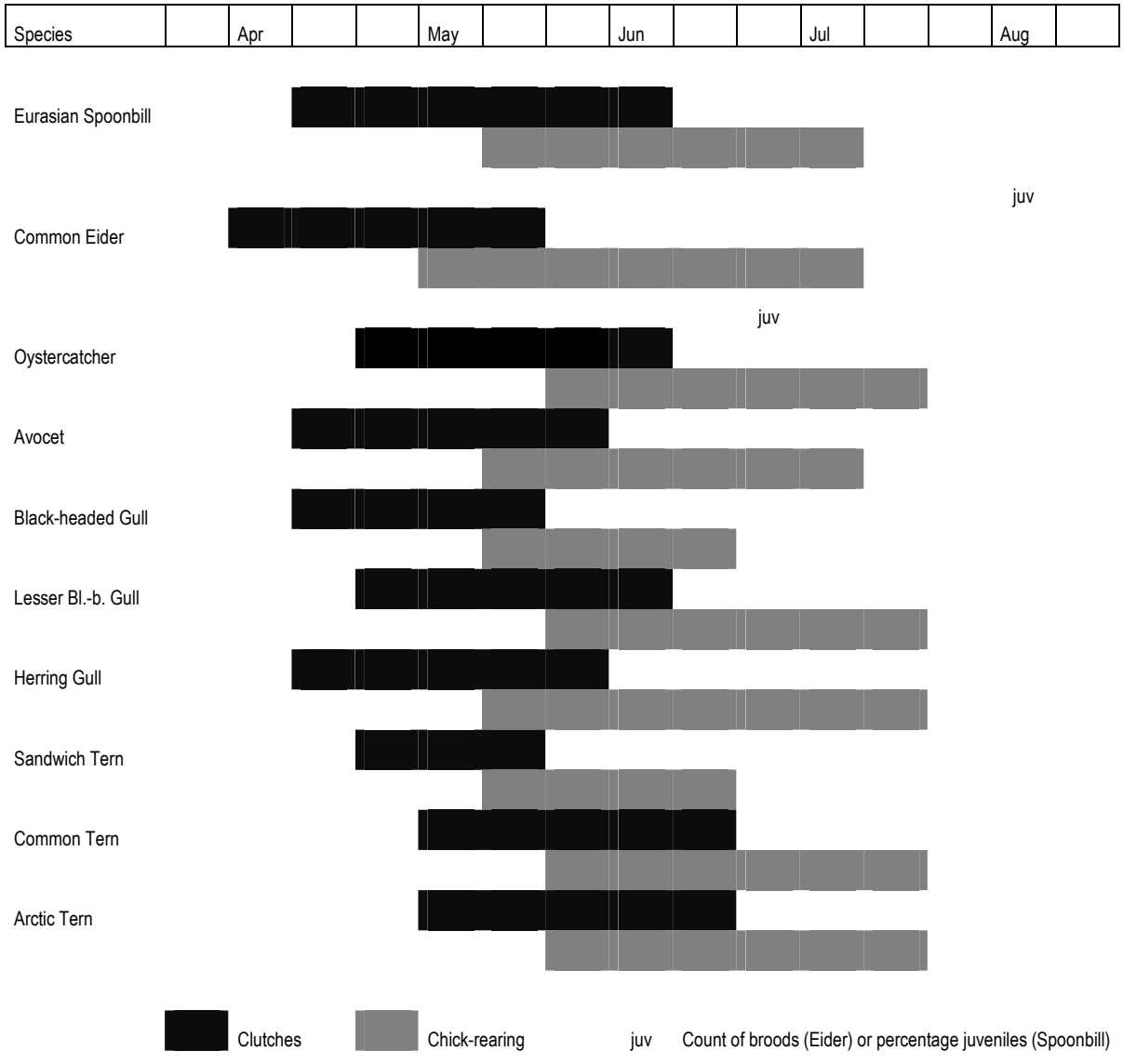

Table 3. *Baseline data on breeding biology of the species monitored in the TMAP parameter 'breeding success'. Data according to Cramp & Simmons 1977, Cramp & Simmons 1983 and Cramp 1985, updated with Exo et al. 1996, Südbeck et al. 2005, Thyen et al. 1998, van Dijk et al. 2009 and Camphuysen & Gronert 2010. Incubation period and chick-rearing period (i.e. chicks are independent and/or able to fly) are guidelines and might differ between years and regions within the Wadden Sea or depend on food availability (notably chick-rearing period).*

Species	Clutch size	Incubation period (d)	Chick-rearing period (d)
Eurasian Spoonbill	3-5	21-25	45-50
Common Eider	4-6	25-28	55-60
Oystercatcher	2-3	24-27	32-35
Avocet	3-4	23-25	35-42
Black-headed Gull	2-3	23-26	26-28
Lesser Black-b. Gull	2-3	28-29	30-40
Herring Gull	2-3	27-29	35-40
Sandwich Tern	1-2	22-26	25-35
Common Tern	2-3	21-24	23-27
Arctic Tern	2-3	21-22	21-24

4.1. Eurasian Spoonbill

Parameters to be monitored: Fledging success.

Methods: Ringing and count of chicks at colony site, age-ratio counts at roosts (method O).

Period: Mid May-mid July (number of chicks in colony), Early to Mid-August (age-ratio count).

What to record: Number of young during ringing (incl. those attending nests and too small for ringing) and number juveniles at post-fledging roosts (incl. details on colour rings).

Guidelines:

Eurasian Spoonbill is rather susceptible to disturbance and often breeds at remote islands. For this reason it was decided not to perform repeated nest controls but only focus on assessment of fledging success.

Fledging success is determined by two independent methods. First, the number of young in a colony is counted during ringing in May or June. Recorded are the number of (large) young that is ringed (or eventually escaped during ringing!), the number of smaller young still attending a nest (record number per nest) and the number of nests still containing clutches (record clutch size). Usually, ringing is carried out at an age that juveniles survive until fledging, so by this method a proxy for fledging success is recorded. However, as the breeding season is not synchronised, a second ringing occasion is recommended to check the last cohort of breeders, and combine data from both ringing occasions. A check for dead (eventually ringed) chicks at the colony site, after the colony has been deserted in the course of July is recommended to correct the data collected during ringing for chick-mortality.

The second method involves a count at all post-fledging roosting sites in the the Wadden Sea in the period 5-15 August (exact date to be fixed annually by the national coordinators). Nearly all Spoonbills breeding in the Wadden Sea gather at specific sites after they have deserted their colony and before they depart for migration. These sites are well-known, and during high tide the number of juveniles in roosting flocks can be counted. These age-ratio counts should be carried out before high tide,

i.e. in the period when the birds arrive at the roost. Therefore, it is recommended to start observations 3 hours before high tide, as birds usually start to arrive at the roost in this period. Moreover, best time for counting is the period before high tide, when birds are still feeding and have not congregated in a dense flock, not allowing separation of adults and juveniles properly. Juveniles are usually easily determined by their diagnostic pale pinkish bill and legs, and notably the black fringes on outer primaries, see the review by Hellquist at http://www.surfbirds.com/mb/Features/spoonbill/ageing-spoonbill-0402.html. The latter can also be present in subadult birds, which usually make up about 10% of the population (O. Overdijk pers. com.) and which are not treated separately. Often, due to distance or light conditions, proper identification of subadults will not be possible. For each flock the following is recorded: (1) total flock size, (2) number of individually determined adults/subadults and (3) number of individually determined juveniles. Note that birds should be checked individually. Never count the whole flock, and afterwards the number of juveniles, it will lead to biased results! Do check for ringed birds, when inscription can not be read, at least record the combination of colours at left and right leg. In this way, the flock can be assigned to their native colony. When just-fledged juveniles are present, reading rings also gives an opportunity to track family bonds between ringed juveniles and ringed adults (which can not be recorded during ringing). Details of ringed birds can be send to Otto Overdijk, o.overdijk@wxs.nl. Leave the roost when no new birds have arrived within the last full hour. Often, birds depart the roost a few hours after high tide. At some sites, mobile hides might be useful. Always check with local authorities or national park agencies when entering closed areas and avoid disturbance when approaching the roost.

4.2. Common Eider

Parameters to be monitored: Fledging success.

Methods: Age-ratio counts among roosting birds in chick-rearing areas (method O).

Period: Early July.

What to record: Number of ducklings among roosting flocks.

Guidelines:

Due to its concealed nesting-behaviour and the risk of disturbance, checking nests in Common Eider is not appropriate to study hatching success at larger scales. Therefore, in this species only fledging success is assessed, and no repeated controls are carried out to assess hatching success, at least in the framework of TMAP.

To assess fledging success, a single count of ducklings in roosting flocks is carried out in early (1-10) July. By this time, about 90% of all ducklings survive until fledging. The counts should be carried out in the period of two hours before and two hours after high tide and they should be performed synchronously at all surrounding breeding sites (i.e. within one region) to avoid duplicate counts between sites. Moreover, it is necessary to check all chick-rearing areas of a given breeding site since the number of ducklings will be related to the number of breeding pairs of a given site. Although there is some evidence that broods might wander over larger distances, this method is currently the best available proxy for the number of fledged ducklings per site. It has been carried out successfully in The Netherlands in recent years (de Boer *et al.* 2007, van Kleunen *et al.* 2010), but further research is desirable to check the viability of the method. Common Eider is also a notorious difficult species to monitor with regard to the number of breeding pairs. Also here, methodological research is required to retrieve better estimates for the number of breeding pairs.

4.3. Oystercatcher

Parameters to be monitored: Hatching success, fledging success.

Methods: Nest surveillance, observation of broods (method O), capture-recapture (method R).

Period: Early May – end of July.

What to record: Nest data, brood size, ringing data, recapture data on chicks.

Breeding biology: Clutch size usually 2-3 eggs, incubation time 24-27 days, chick-rearing period 32-35 days.

Guidelines:

Oystercatcher is one of the most abundant and obvious breeding birds in the Wadden Sea. Note that for monitoring of breeding success only breeding pairs on salt marshes are taken into consideration (i.e. the majority of breeding birds in the Wadden Sea). Birds are highly territorial, but territorial behaviour differs strongly among individuals.

To determine hatching success, an area has to be searched systematically for nests. Nests are often found in short vegetation (often well visible from a higher viewpoint like a dike) and rather easy to check. However, in areas with tall vegetation (e.g. *Elytrigia*) overview from viewpoints might be difficult, and searching the area itself is necessary to find nests. In areas with high predation pressure finding complete clutches might be troublesome, as most nest that are found remain empty or are predated between the first two nest checks. Such nests should be recorded separately. Date of first egg and hatching dates can be derived from egg measurements, using regression formula and the data in table 3.

For this purpose egg size (volume, cm^3) can be calculated by:

0.49 * (egg length [cm] * (egg width [cm])²) (after Jager *et al.* 2000).

Because Oystercatchers only start incubating after the last egg was laid, the number of days each egg in a clutch was already incubated can be determined from the formula:

199.0 - 183.5 * (weight [g]/egg size [cm^3]) for a one- to three-egg clutch and from

191.1 − 176.2 * (weight [g]/egg size [cm^3]) for a four-egg clutch (after Strijkstra 1986).

Assessing fledging success is more difficult. Although broods stay in their breeding territory, chicks easily remain concealed in vegetation when parents are alert, or hide in creeks in the salt marsh. Moreover, parents' behaviour to attack intruders highly differs between individuals. Two strategies are used to determine the number of fledglings per breeding pair. The first one is to check the study area for broods and determine brood size and age of the chicks. Since the breeding season might be extended, it is necessary to have two control vistits with 10-14 day interval, from the end of June or beginning of July onwards (depending on hatching dates). In this period it is most likely that chicks are near to fledging. During the count, broods are searched for, and age of the chicks is recorded (type 1-4, see Fig. 4). From both visits, chicks of type 4 are combined to retrieve the total number of nearly fledged chicks. It is recommend to map the broods as it improves searching efficiency during the 2^{nd} count.

Major drawback of this method is that it is mainly applicable in areas with short vegetation and good overview. In areas with taller vegetation and in very wide salt marshes without good viewpoints, mark-recapture technique is an alternative to assess fledging success (see chapter 3.5.2 for detailed approach). This involves ringing and smaller intervals between visits around peak-hatching time to be able to mark chicks individually, and successive visits during the chick-rearing period to recapture chicks.

Type 1: about one week.

Type 2: about 2 weeks.

Type 3: about 3 weeks.

Type 4: about 4 weeks.

Figure 4. *Identification of age in Eurasian Oystercatcher, to be recorded when assessing fledging success in July (Photo: Astrid Kant, after Ens et al. 2009). Chicks of type 4 are regarded as nearly fledged and used as a proxy to determine fledging success. Due to individual plumage development, some chicks of about 4 weeks old still can have very small downy patches on head and neck (not on the photograph). Further material to assess age of chicks is also available online at* http://www.khil.net/*, unter 'varia' (pdf download with photographs).*

4.4. Avocet

Parameters to be monitored: Hatching success, fledging success.

Methods: Nest surveillance, observation of broods (Method O).

Period: End of April to end of July.

What to record: Nest data, brood size.

Breeding biology: clutch size usually 3-4 eggs; incubation time is 23-25 days; usually chicks are able to fly at an age of at least 35 days.

Guidelines:

Avocet is a colonial breeding bird species that often breeds at sparsely vegetated sites, both in salt marshes and in coastal wetlands. Colonies can be large and to monitor hatching success, it might be necessary to take a smaller but representative sample of a larger colony, that takes 1,5 hrs at maximum to check all clutches. It is important not to start to visit the colony before all birds have settled, to avoid disturbance and resettlement of the colony. Often, activity in the colony can be followed from a distance, as nests and incubating birds are usually well visible. Since parents and their chicks abandon the colony quickly after hatching and move to specific chick-rearing areas (notably those breeding inland in coastal wetlands or arable fields), special attention should be paid to the selection of the site to monitor fledging success. Best study sites are those where broods can be followed from a higher viewpoint (e.g. a dike) and where origin of the birds is well-known in order to link the number and size of broods to the initial number of breeding pairs. Wide salt marshes and areas where origin of broods is unknown are less suitable as study site. As chick-mortality is high, it is recommended to focus effort on assessment of fledging success in a larger study site (eventually including several breeding colonies), and take a smaller sample of nests in one of the colonies to monitor hatching success.

Recently, Miether (2010) has presented data to calculate egg laying dates from egg measurements. First, egg volume is determined by the formula:

(1) egg volume [cm^3] = (egg length [mm] * (egg width [mm])²)/ 1000

Secondly, 'breeding index' (i.e. a proxy for time an egg has been incubated) is calculated by:

(2) breeding index = egg volume [cm^3] / egg mass [g]

Finally, the number of days that an egg has been incubated is calculated by:

(3) incubated days = (0.5493 – breeding index) / 0.004615

Fledging success is preferably determined by repeated counts of broods in chick-rearing areas. For this purpose, visits of 7-10 day intervals are carried out from mid-May to the end of July (depending on peak hatching dates). During each visit, the number of chicks per age class is recorded. Age classes are: <10 days, about 10 days, 15 days, 20 days, 25 days, 30 days and 35 days (see Fig. 5 for guidelines how to determine age classes). The final number of chicks to determine a proxy for fledging success is the sum of all chicks older than 25 days, observed during the successive visits.

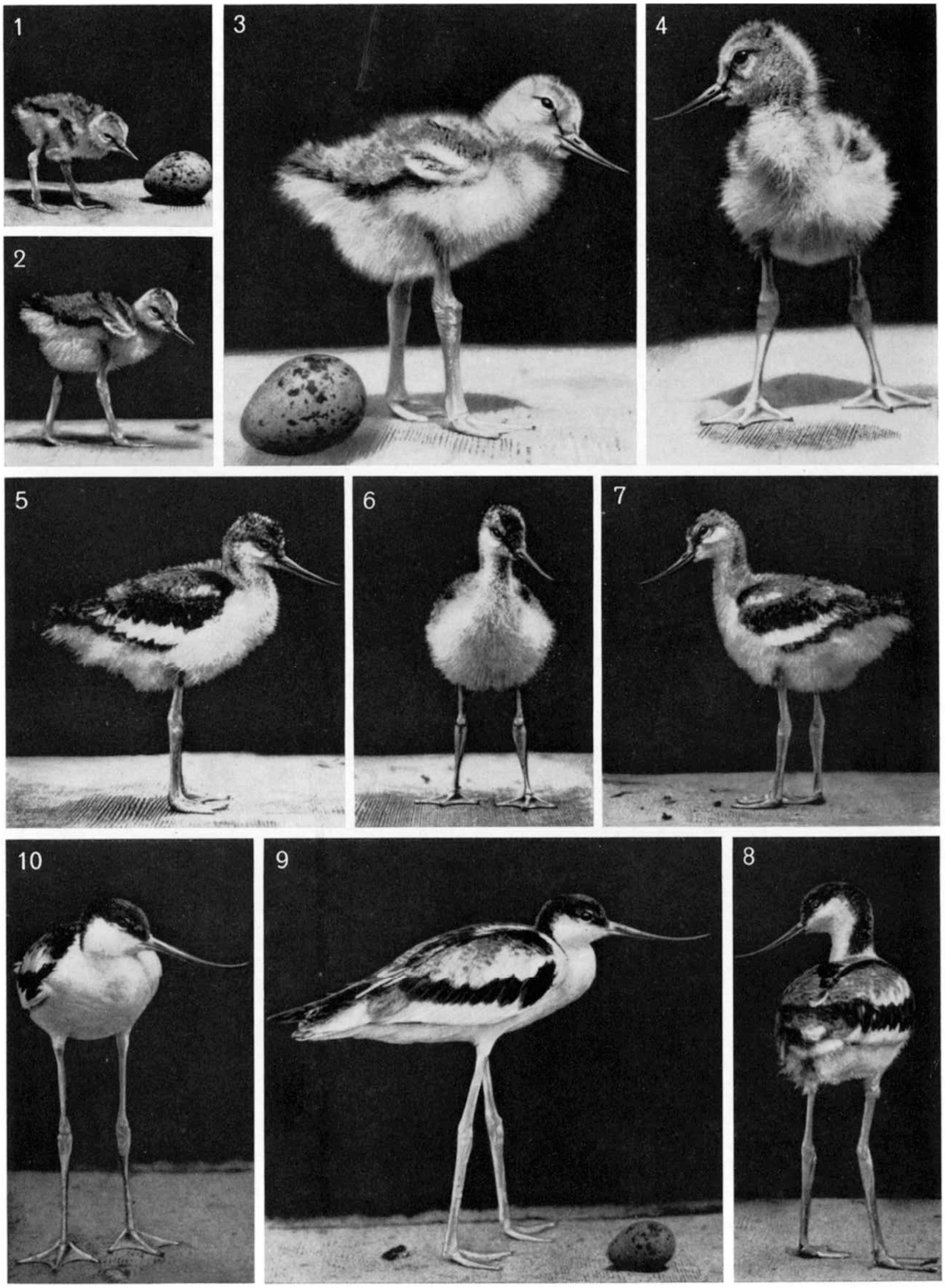

Figure 5. *Illustration of age of Avocet chicks: (1) 3 days; (2)-(4) 10 days; (5)-(7) 21 days; (8) 32 days, nearly flying; (9)-(10) juveniles (after Heinroth 1931). Note that size is not to scale; (3) and (4) are about half of actual size, others about 1/4. Age classes distinguished during fieldwork are: <10 days, about 10 days, 15 days, 20 days, 25 days, 30 days and 35 days.*

4.5. Black-headed Gull

Parameters to be monitored: Hatching success, fledging success.

Methods: Nest surveillance, fencing (Method F).

Period: End of April to end of June.

What to record: Nest data, including fledging success.

Breeding biology: Clutch size usually 2-3 eggs, incubation time 23-26 days; chicks can fly at an age of about 26-28 days.

Guidelines:

Being a strictly colonial breeding bird species, monitoring of breeding success in Black-headed Gull is entirely based on nest data in sampled colonies. It is recommended to use fencing in order to retrieve data on both nest success and fledging success from a colony site. Caution should be taken that a representative sample is taken, preferably choose two sub-sites with fences from different parts of the colony. Avoid fencing in mixed colonies with larger gulls (including Common Gull), as fences might facilitate predation and introduce bias in the results. Details on building fences have been given in chapter 3.5.3 (see Box 3). The fenced area (*enclosure*) preferably should cover about 20-40 nests. During each visit, nest fate and (later on) number of chicks are recorded. It is recommended to ring chicks to be able to monitor fate of individual chicks. Chicks can be ringed from about 4-5 days age. Prior to final ringing with metal rings, small plastic rings (or tape) can be used to enable individual marking. Assessing growth rate and biometrical data is not necessary within the framework of TMAP, but helpful to get insight in backgrounds for chick survival (e.g. starvation due to food shortage). Parameters to record growth rates in chicks are head+bill length (to the nearest mm), wing length (mm) and body mass (g). Chicks with wing length ≥200 mm or bill+head length ≥71 mm can be considered as fullgrown and able to fly (van Dijk *et al.* 2009). Growth rates for wing length are assumed to be 10 mm/day, for bill+head length 1.3 mm/day (Oosterhuis in van Dijk *et al.* 2009). Eventually, wing length (maximum chord) or bill+head length can be extrapolated to the next visit, and individuals that disappeared, but should have reached threshold values of 200 mm for wing or 71 mm for bill+head are regarded as fledged.

4.6. Lesser Black-backed Gull and Herring Gull

Parameters to be monitored: Hatching success, fledging success.

Methods: Nest surveillance, fencing (Method F).

Period: End of April to end of July, Herring Gull usually slightly earlier than Lesser Black-backed Gull

What to record: Nest data, including fledging success.

Breeding biology: Usually 2-3 eggs and incubation time 27-29 days; chicks are able to fly at an age of about 30-40 days.

Guidelines:

In major parts of the Wadden Sea, Lesser Black-backed Gull and Herring Gull breed in mixed colonies and guidelines given here apply to both species. Apart from regular nest surveys, monitoring of fledging success is done by fencing a representative part of a colony (see also chapter 3.5.3). Contrary to Black-headed Gull and terns, density of nests is often lower, allowing just 5-15 nests to be fenced. Hence, more smaller fences are necessary to achieve a suitable sample size. Usually, this also enables to put up single-species enclosures, to avoid identification problems between both species. Alternatively, also fencing of single nests is possible and carried out already in several colonies (see Box 2, chapter 3.5.3). During each visit nest fate and number of chicks are recorded. Ringing of chicks is recommended and small chicks can be ringed directly after hatching when putting the ring on the tibiotarsus. Assessing growth rate and biometrical data is not obligatory within the framework of TMAP (but see Black-headed Gull). Chicks of ≥ 40 days old are considered as fledged (Camphuysen

(but see Black-headed Gull). Chicks of ≥ 40 days old are considered as fledged (Camphuysen & Gronert 2010).

4.7. Sandwich Tern

Parameters to be monitored: Hatching success, fledging success.

Methods: Nest surveillance, fencing (Method F), capture-recapture, capture-resight (Method R).

Period: Early May to end of June.

What to record: Nest data, including fledging success.

Breeding biology: Clutch size usually 1-2 eggs, incubation time 22-26 days, chicks are able to fly at an age of approx. 25-35 days.

Guidelines:

Apart from nest surveillance, fledging success in Sandwich Tern is preferably studied with a fenced part of the colony. For this purpose, a representative part of the colony is chosen where about 20-40 nests are put in an enclosure prior to hatching (details see chapter 3.5.3, Box 3). Note that visits to the colony should not be done in the initital settling and nesting period, in order to avoid disturbance. Caution should also be taken when Sandwich Tern and Black-headed Gull breed closely together, as klepto-parasitism by Black-headed Gulls can trouble feeding of chicks of Sandwich Terns. Under such conditions, fencing is not recommended. During each visit nest fate and number of chicks are recorded. Ringing of chicks is recommended. Assessing growth rate and biometrical data is not necessary within the framework of TMAP (but see Black-headed Gull).

As an alternative to fencing, mark-recapture or mark-resight can be applied to determine fledging success, as done currently on the island of Griend (NL) and Norderoog (SH). For this purpose larger chicks are ringed and successive ringing is done in intervals of 2-3 days. A closed box where chicks are kept until ringing speeds up the fieldwork and minimizes disturbance. Note that chicks that have already been ringed tend to run away, so they should be paid first attention to. If observation conditions are excellent, resighting marked individuals may be as effective as recapturing, as done on Norderoog.

Within the framework of TMAP this species is monitored at a limited number of sites in closed areas. Fieldwork is entirely done by bird wardens.

4.8. Common Tern and Arctic Tern

Parameters to be monitored: Hatching success, fledging success.

Methods: Nest surveillance, fencing (Method F), capture-recapture (Method R).

Period: Mid May to end of July, occasionally until August.

What to record: Nest data, including fledging success.

Breeding biology: Clutch size usually 2-3 eggs, incubation time 21-26 days and chicks are able to fly at an age of 21-27 days.

Guidelines:

Apart from small and well-visible colonies, hatching and fledging success in Common- and Arctic Tern is best studied by use of enclosures. For this purpose, 20-40 nests are monitored in a representative part of the colony (see chapter 3.5.3, Box 3). Care should be taken during the initial settlement period, as the birds attending the colony are highly susceptible to disturbance. Avoid enclosures close to breeding gulls, as klepto-parasitism or predation of the fenced nests might be facilitated. Caution is taken in mixed Arctic and Common Tern colonies, especially in the western part of the Wadden Sea

(The Netherlands, Niedersachsen, Schleswig-Holstein) where both species might breed at close range. Preferably monitor single-species colonies where any confusion between the species is avoided. During each visit nest fate and number of chicks are recorded. Ringing of chicks is recommended and can be carried out 4-5 days after hatching (prior to ringing, tape can be used to mark chicks individually). Assessing growth rate and biometrical data is not necessary within the framework of TMAP (but see Black-headed Gull).

For both species, days until hatching can be calculated as follows (Reufsteck 2004).

(1) Egg volume [cm^3] = (egg length [cm] * egg width [cm])^2 / 1000

(2) 'Breeding index' = egg mass [g] / egg volume [cm^3]

(3) Day until hatching = (Breeding index – 0.4524) / 0.0063

When fencing is not possible, in some colonies capture mark-recapture might be carried out to determine fledging success (method R), see Sandwich Terns for details. In small colonies that are good to view from a distance, even the final number of chicks can be determined by counting nearly fledged young (method O). However, if possible, fencing is the recommended method as is has been commonly established as the standard monitoring method (Wagener 1998).

In case of mixed colonies and doubt of species, chicks of the two species can be separated from each other by morphological data. Use the proportion of length of Tarsometatarus to the length of middle toe + talon. In Arctic Tern this is 0.60–0.77, in Common Tern 0.80–0.95. Alternatively, development of tarsus length is a viable method to determine both species (Figure 6).

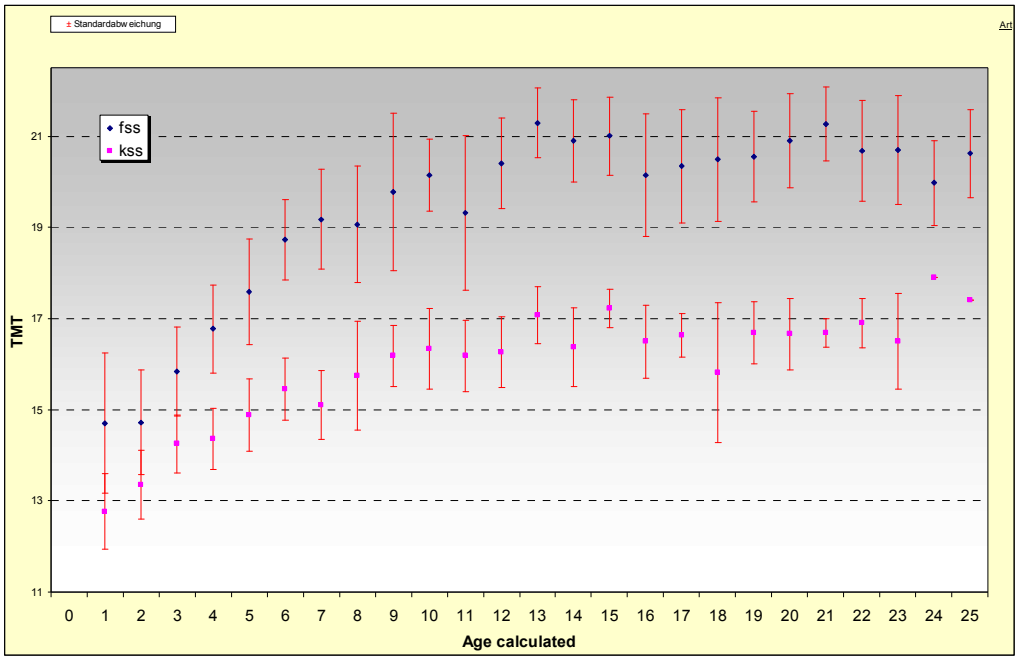

Figure 6. *Development of tarsus length (mm ± SD) in Common Tern (fss) and Arctic Tern (kss). Data: Veit Hennig/University of Hamburg.*

5. Data handling

This chapter aims to describe the storage and transfer of data to a trilateral database, in order to provide a trilateral platform for data management and generating output for reports. According to a data model prepared by Gerold Lüerßen (CWSS) a data entry sheet has been prepared in excel. We recommend to use this recording sheet, as it provides an efficient data flow that can be used to analyse the data. Below a description of the excel sheet is given:

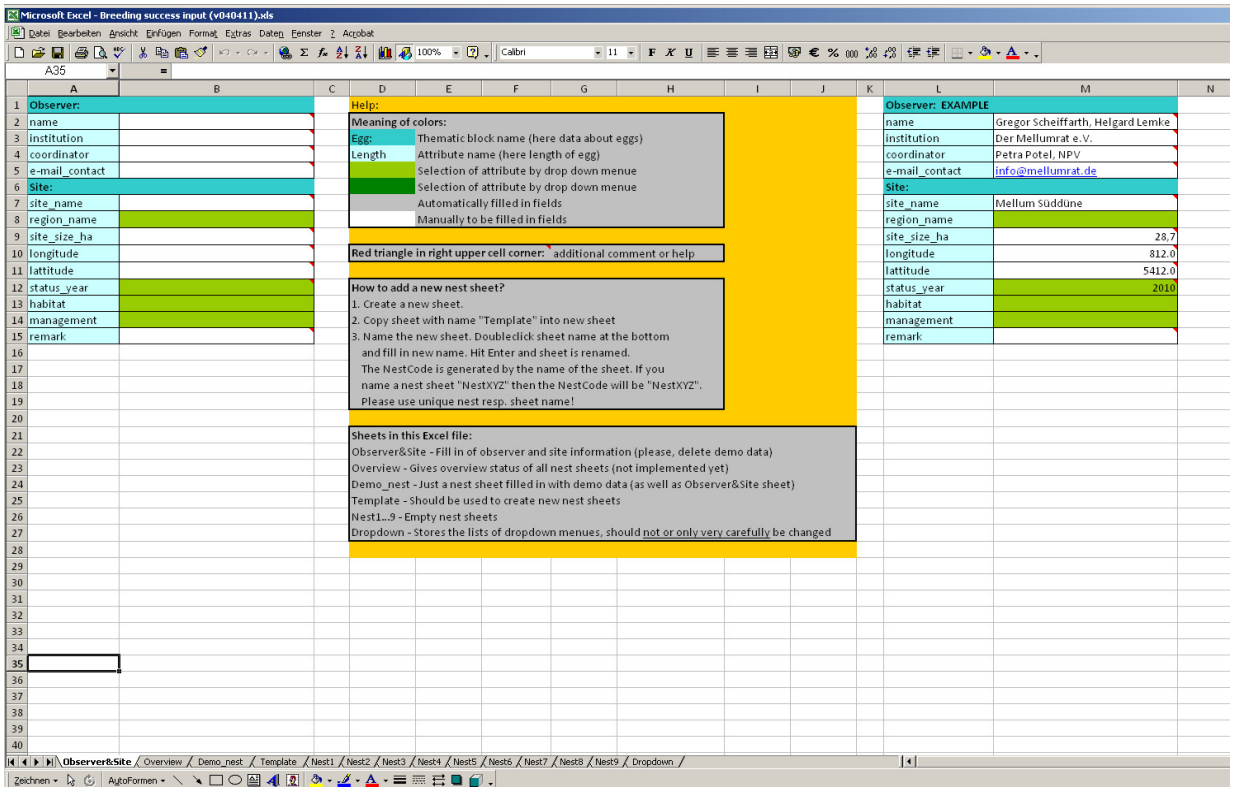

Figure 7. *Starting sheet with general data on observer and site.*

The excel data entry sheet included tabs for 'Observer&Site' data and tabs for each nest or chicks that were monitored ('Nest1' – 'Nest 9', further nests to be included by copying the tab 'template'). (Figure 7). An example of how sheets can be filled in is given in the tab 'Demo_nest' (Figure 8). Red markers include comments what format to use to fill in the fields correctly. The first tab 'Observer&Site' also contains a box with instructions how to use the tables ('Help'). The tab 'Overview' is not active yet.

When entering data, it is important to recognize that:

- Fields in dark blue are used to mark headings (e.g. observer, site, egg, chicks);
- Fields in light blue are used to fill in measurements (see red comment for format);
- Fields in green (dark and light) are filled in by using a drop-down menu that appears when entering the field. Descriptions of all drop-down menus are included in the tab 'Dropdown'. Note that it is important to stick to these descriptions as they allow standardised analyses;
- Fields in grey are automatically filled in automatically (nest number) or by data entered in the tab 'Observer&Site'.

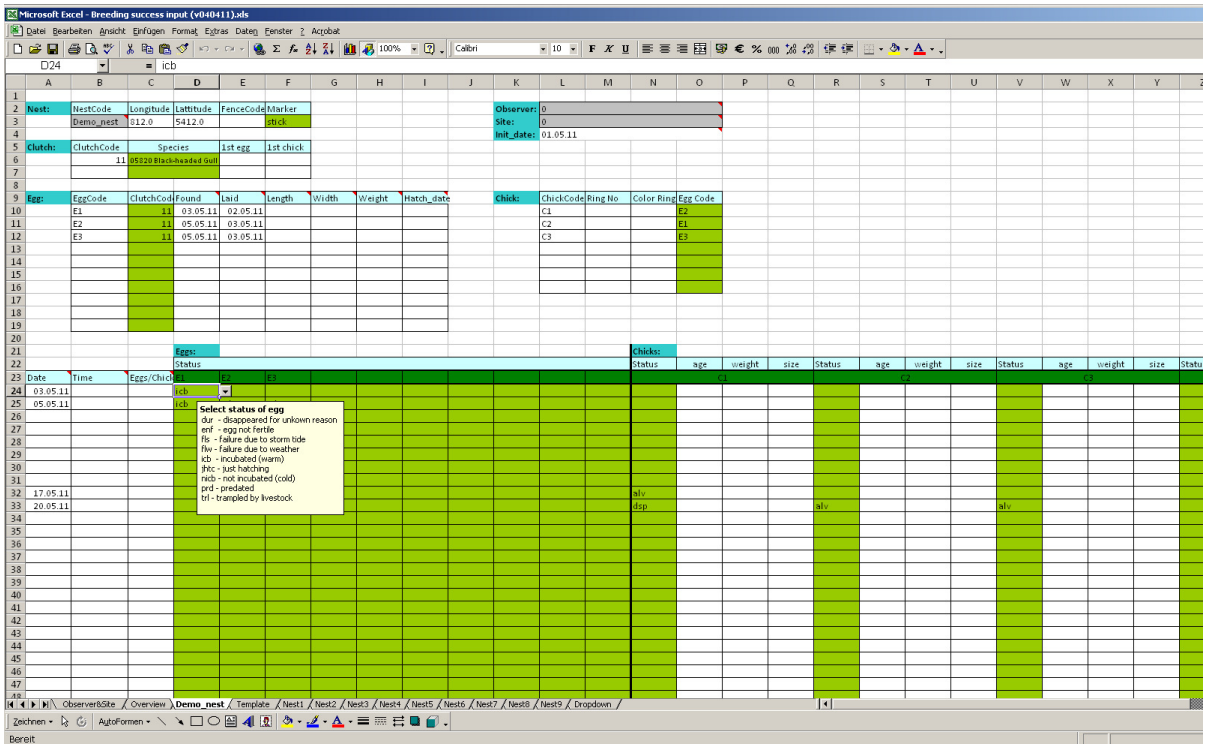

Figure 8. *Example of demo nest sheet, showing drop-down menu when recording egg status.*

Data for counts of broods of Eider, Oystercatcher and Avocet are collected in a separate tab 'Brood-Counts'. In Eurasian Spoonbill and Common Eider, this will often be the only tab filled in (as nest data are not collected). Fields to be filled in manually include species, date and time, number of broods recorded (Oystercatcher and Avocet) and the number of individuals in each age class. Age classes are

Eurasian Spoonbill:

number of adults/subadults, number of juveniles

Eider:

total number of ducklings

Oystercatcher:

number of chicks in each age class type 1,2,3,4 (see Fig. 4)

Avocet:

number of chicks in each age class type <10 days, 10 days, 15 days, 20 days, 25 days, 30 days and 35 days (see Fig. 5)

In case of Avocet make a remark on the colonies that have been monitored at the chick-rearing site (including the total number of breeding pairs in those colonies).

After completing the data entry, please send it in to your national coordinator, see chapter 2.3 for current addresses.

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Appendix 1: Project plan Implementation of 'breeding success' as new parameter within TMAP.

1. Introduction and backgrounds

Since its establishment in 1991, the trilateral monitoring of breeding birds that is carried out in the framework of TMAP has 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.* 2005). It is not only relevant with respect to the evaluation of targets in the Wadden Sea Plan, but also provides the necessary input for evaluation of the EU Bird- and Habitat Directives. Due to its focus on distribution and trends, however, backgrounds for population changes often remain unknown and links with management issues weak. Most of the species dealt with in the monitoring scheme are long-lived and will therefore show a delayed response to deteriorating environmental conditions or human impact. The parameter 'breeding success' performs much better as an early-warning system to detect changes in the ecosystem or assess human impact, since it is more directly linked with shifting conditions in the environment. Moreover, evaluation of the target 'natural breeding success', as addressed in the Wadden Sea Plan, is currently not possible with monitoring of only population size and distribution.

Hence, 'breeding success' has been recognised as an important gap in the current monitoring in the Wadden Sea and has been proposed earlier to be included in TMAP (Exo *et al.* 1996, Thyen *et al*. 1998, Becker *et al.* 1998, de Jong *et al.* 1999, Essink *et al.* 2005). It would allow an evaluation of the target 'natural breeding success', would enhance evaluation possibilities for the TMAP parameter 'contaminants in bird eggs' (e.g. Becker *et al.* 1998) and it would be an important step towards an 'Integrated Population Monitoring', in order to get insight in processes causing population fluctuations (Greenwood *et al.* 1993, Thomas *et al.* 1995). Although methodological aspects and application of the parameter 'breeding success' were successfully tackled in a pilot project in 1996-97 (Exo *et al.* 1996, Thyen *et al.* 1998), implementation within TMAP has not been achieved until today.

As part of the TMAP Revision (§ 23 Schiermonnikoog Declaration 2005), the Trilateral Monitoring and Assessment Group (TMAG) has recently proposed to include the parameter 'breeding success' in TMAP. The Trilateral Working Group (April 2007) instructed TMAG and JMBB with the preparation of an implementation plan for the parameter 'breeding success' for the next TWG meeting in 2008. The proposal presented here is an outline for implementing 'breeding success' as a parameter in TMAP, complement to the monitoring of numbers and distribution. It has been prepared by SOVON Vogelonderzoek Nederland, on behalf of the Joint Monitoring Group for Breeding Birds in the Wadden Sea (JMBB), and commissioned by the Common Wadden Sea Secretariat. It mainly builds on the previous recommendations from the pilot project made by Exo et al. (1996) and Thyen et al. (1998). It has been updated with new information or recent insights from projects carried out between 1998-2007. Focus is on the outline of the project, it does not cover methodological aspects in detail. Aspects that are reviewed are:

- Aims of a monitoring scheme for breeding success;
- Selection of species to be monitored;
- Selection of sites to be monitored;
- Sample size;
- Parameter selection;
- Practical aspects for implementation;
- Data and analyses;
- Estimates of annual costs.

2. General outlines

2.1. Aims of a monitoring scheme for breeding success

The aims of a monitoring scheme for breeding success in the trilateral Wadden Sea have already been listed by Exo *et al*. (1996) and Thyen *et al.* (1998) and are still valid. Moreover, assessment of the conservation status of birds, as requested by the EU-Bird Directive, has been added since a favourable conservation status has become the guiding principle for management of bird populations in the Wadden Sea.

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

In addition, a monitoring scheme for breeding success is beneficial to the assessment of the existing parameter 'contaminants in bird eggs' (there is a more direct link between contaminants and breeding performance than between contaminants and trends, Becker *et al.* 1998). Besides, it provides the necessary input for an Integrated Population Monitoring of breeding birds in the Wadden Sea.

2.2. Species to be monitored

The current breeding bird monitoring scheme focuses on 31 characteristic species in the Wadden Sea (Table 1). However, to match the aims mentioned in 2.1, it is not necessary to include all these species in a breeding success monitoring scheme. Preferably, a selection should include all important species that depend on the Wadden Sea for breeding and a set of species that can be used as indicators for different habitats and feeding strategies. During the pilot project in 1996-97, JMBB agreed on a list of 6 target species that were assumed to be suitable for monitoring of breeding success and fulfill the aims of the project (Exo *et al.* 1996). Criteria to select species by that time were: (1) species should be typical breeding bird in the Wadden Sea; (2) species is abundant and (3) species occurs in all three countries NL, D and DK. In addition, species should represent a certain habitat or feeding strategy. For instance, Common Tern was regarded a dune-breeding species and Redshank a salt marsh breeder. Benthos-eating species were represented by Oystercatcher, Avocet and Redshank (partly Herring Gull), fish-eating species by Common Tern and Herring Gull. Besides, Oystercatcher and Common Tern were also chosen since they are included in the monitoring 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.

A similar set of species as used in the pilot project 1996-97 is currently being used in a new scheme to monitor breeding success in the Dutch Wadden Sea (Willems *et al.* 2005). Basically, similar criteria for selection were followed. Due to the emphasis on benthos-feeders (in relation to evaluation of shellfish-fisheries), also Common Eider was included in the Dutch programme. Data for other species are collected in the scheme, but the 6 species are regarded target species and get most attention.

A third selection of species has recently been proposed for an integrated population monitoring of breeding and migratory birds in the Dutch Wadden Sea by Reneerkens *et al.* (2005). They selected species (1) according to their population share occurring in the Wadden Sea; (2) abundance; (3) specific feeding strategy; (4) specific habitat-use and (5) a specific migration strategy, preferably also species with different populations that have a different spatial or temporal occurrence, allowing comparisons between populations. For breeding birds, their proposal includes Eurasian Spoonbill (important part of the NW-European population in the Wadden Sea), Common Eider (abundant and feeding on sublittoral mussel beds), Oystercatcher (specific habitat use, feeding on littoral mussel beds) and Sandwich Tern (feeding on fish). Even if these approaches partly use the same criteria and arrive at higly similar species, only Oystercatcher has been included in all projects whereas slight differences in focus result in partly different species (see Annex 1 for review).

During an expert-meeting on 29 August 2007, JMBB discussed a final proposal for species to be included in a new scheme to monitor breeding success. Each species was reviewed with respect to:

- Importance of the Wadden Sea breeding population (national and international context);
- Habitat preferences;
- Food preferences;

- Link with management issues (e.g. salt marsh management, dune management, fisheries, beach tourism).

For discussion, recent data from the breeding bird monitoring scheme (Koffijberg *et al.* 2005) and the latest Quality Status Report (Essink *et al.* 2005) were used. Furthermore, practical considerations, based on the pilot project in 1996-97 and experiences from the Dutch monitoring project 2005-2007, were taken into account. Table 1 summarises the result of the discussion, annex 1 allows a more detailed look into the decision-process and gives pros and contras for inclusion of a species.

Table 1. *Selection and priority setting of species to be included in a TMAP monitoring scheme for breeding success. Criteria are summarised for each category, see annex 1 for a detailed review of selection.*

High priority species: • High importance Wadden Sea • Habitat specialist • Food specialist • Link with management	Medium priority species • As important as high priority species, but practical implementation difficult, or sensitive species (disturbance risk)	Low priority species • Not typical for Wadden Sea • Species too rare or breeding too locally • Practical implementation difficult or sensitive species (disturbance risk)
Eurasian Spoonbill[3]	Hen Harrier	Great Cormorant
Common Eider[23]	Great Ringed Plover	Shelduck
Oystercatcher[123]	Kentish Plover	Red-breasted Merganser
Avocet[12]	Northern Lapwing	Dunlin
Black-headed Gull[12]	Black-tailed Godwit	Ruff
Lesser Black-backed Gull[1]	Eurasian Curlew	Common Snipe
Herring Gull[12]	Common Redshank[(1)]	Turnstone
Sandwich Tern[3]	Little Tern	Mediterranean Gull
Common Tern[12]	Short-eared Owl	Little Gull
Arctic Tern		Common Gull
		Great Black-backed Gull
		Gull-billed Tern

[1] included in trilateral pilot 1996-97, Common Redshank left out for practical reasons (Exo *et al.* 1996)

[2] included in monitoring scheme Dutch Wadden Sea 2005-2007 (Willems *et al.* 2005)

[3] proposed to be included in Integrated Population Monitoring Dutch Wadden Sea (Reneerkens *et al.* 2005)

A total of 10 species is regarded 'high priority' species, and is proposed to be included in the new TMAP scheme on breeding success. Most of them were also included in earlier proposals. Compared to the pilot project 1996-97, the selection contains 4 new species: Eurasian Spoonbill, Common Eider, Sandwich Tern and Arctic Tern. These species were not breeding in the Wadden Sea in high numbers in the mid 1990s (Eurasian Spoonbill) and/or they were considered not abundant enough throughout the Wadden Sea. The latter, however, has not been used as a valid criterion here, since species that do breed in large numbers in only one or two countries, are important Wadden Sea breeding birds (e.g. Common Eider, occurring only in large numbers in the Dutch part of the Wadden Sea). Lesser Black-backed Gull/Herring Gull and Common Tern/Arctic Tern have been considered as a combined 'super-species' since they often breed in mixed colonies (fieldwork can be easily combined for both species). Moreover, they are considered competitive species, partly sharing the same food resources, and thus performance is studied best when both species are taking into account. For most of the 'high priority' species

listed in Table 1, also ringing data from other studies are available, enhancing possibilities to use breeding success data as input for Integrated Population Monitoring purposes.

2.3. Selection of sites to be monitored

2.3.1. Regional coverage

The current breeding bird monitoring of JMBB covers the Wadden Sea Area (cf. Fig. 1.1 in Essink *et al.* 2005). Data from breeding birds are processed according to 54 different census regions (cf. Fig. 2 in Koffijberg *et al.* 2005). Monitoring of breeding success should be set up in a way that the entire Wadden Sea is sampled and representative data are retrieved from all parts of the area. Exo *et al.* (1996) have proposed a set of reference areas (similar as the census areas for abundant breeding birds). Since most of the species to be covered are abundant, working with such reference areas was considered efficient and provides –when the right areas are covered!- representative figures on breeding success. For colonial breeding species like Avocet, Black-headed Gull, Herring Gull and Common Tern, two sites (colonies) for each country were proposed (Netherlands, Niedersachsen, Schleswig-Holstein, Denmark), thus 8 sites in total. For coastal waders like Oystercatcher and Redshank at least 4 sites were proposed, thus 16 sites in total. Additionally, criteria to be met when choosing sites were: (1) optimal and suboptimal breeding sites, (2) island and mainland sites and (3) match with sites covered in the monitoring of contaminants in bird eggs.

When applying strictly the criteria used by Exo *et al.* (1996), rather few sites per combination species-habitat or species-geographical situation remain, i.e. the sample size might be too small to unravel detailed patterns in breeding success and allow statistical analyses. Moreover, 'country' does not have an important influence (apart for some management issues) since it does not segregate between geomorphological differences within the Wadden Sea (e.g. estuarine and non-estuarine areas) and is merely a political unit. Therefore, we recommend a more detailed zoning within the Wadden Sea and we propose to adopt the delineation of regions that is used for the TMAP parameter 'contaminants in bird eggs' for this purpose. In this scheme, 12 regions are recognized (cf. Fig. 4.5.1. in Essink *et al.* 2005):

1. Western Wadden Sea NL (equivalent region 1-4, 9,10 in breeding bird monitoring)
2. Eastern Wadden Sea NL (region 5-8, 10, 11-12)
3. Ems-Dollart Estuary NL/NI (region 12, 14)
4. East-Friesland NI (region 13, 15-19)
5. Jade Estuary NI (region 20-23)
6. Weser Estuary NI (region 24-25)
7. Elbe Estuary NI/SH (region 26, 28, 29)
8. Dithmarschen SH (region 27-28, 30, 33, 35)
9. Nordfriesland SH (region 33, 35-41)
10. Southern Danish Wadden Sea DK (region 36, 41, 42, 49, 51)
11. Central Danish Wadden Sea DK (region 43-44, 47-48, 50-53)
12. Northern Danish Wadden Sea DK (region 45-47, 54)

This division in regions is highly suitable for monitoring of breeding success, except that regions.

5-6 (Jade-Weser Estuaries), 7-8 (Elbe estuary including northern extension) and 10-12 (entire Danish Wadden Sea) are rather small and preferably should be lumped. The remaining 8 regions distinguish e.g. estuarine from non-estuarine areas. Moreover, the fit with the situation of the census regions for breeding birds is good (only slight differences in borders).

Given the different trends in island and mainland-breeding populations, notably the impact of predation (cf. Fig. 52 in Koffijberg *et al.* 2005), segregation of mainland and islands is considered important. All 8 regions have islands. Region 3 has only one island (Borkum) and for practical reasons this island could be combined with the other East-Frisian islands in region 4. This results in 15 regions where samples have to be taken. In order to have a representative sample and possibilities to compare data for regions within the Wadden Sea, we propose to adopt these 15 regions for the setup of a TMAP breeding success monitoring programme.

2.3.2. Selection of sites

For colonial breeding birds, further splitting within the regions does not seem to be useful. These species are often mobile and easily witch breeding sites between years. For coastal waders (i.e. Oystercatcher, Redshank) segregation according to habitat has been proposed by Exo *et al.* (1996) in the pilot project 1996-97. Regarding high priority species only (Table 1), this applies to Oystercatcher. However, due to the low densities breeding in dunes nowadays and the fact that coastal grasslands in the Wadden Sea area are included only locally (mainly Denmark), we propose to conduct trilateral monitoring for breeding success in Oystercatcher only at salt marshes. For Avocet, sites along the mainland coast should preferably be added with at least one extra site behind the seawall (in NL and SH), as breeding success on salt marshes and colonies behind the seawall is often very different (Hötker & Segebade 2000).

Table 2 provides a framework for selection of sample sites where fieldwork in the breeding season has to be undertaken (see appendix 2 for details). Current distribution of a species (Koffijberg *et al.* 2005) was taken into account and only 'high priority' species (Table 1) were considered. Besides, some practical considerations were made, e.g. accessibility of a site or risk of disturbance when visiting the site. The number of sample sites per species ranges from 3 (Sandwich Tern) to 14 (Oystercatcher, Avocet) and clearly reflects the abundance or distribution of a species. Note that sample sites for individual species might overlap, so the true number of sites that actually has to be covered with fieldwork is much smaller than the total of 90 sites listed here. It will often depend on practical aspects like availability of fieldworkers, accessibility and risk of disturbance what sample sites are surveyed. Highest effort has to be made in the Netherlands and Schleswig-Holstein. In Denmark, effort is mainly concentrated on the island of Langli. National co-ordinators will be responsible for the final selection of sites within their part of the Wadden Sea.

Boundaries of sample sites are allowed to vary between years within one region (see par. 3.2.1), except for the strongly territorial and long-lived Oystercatcher and some rare colonial breeding birds (Eurasian Spoonbill, Sandwich Tern), for which sample sites with fixed borders should be used (similar to census areas in counts of breeding birds). During the pilot study 1996-97, Exo *et al.* (1996) and Thyen *et al.* (1998) used fixed sample sites in all species, but in order to anticipate on the sometimes dynamic settlement patterns in some species, we do not recommend this in all species since it might hamper collection of a suitable sample size and increase the time needed for fieldwork.

Table 2. *Species and stratification of a TMAP monitoring project for breeding success. Only 'high priority' species (Tab. 1) are listed. Usually two sample sites per region have been proposed, except where distribution of a species (Koffijberg et al. 2005) limits the number of sample sites. See appendix 2 for more details.*

Species	Number of sample sites	Remark
Eurasian Spoonbill	8	Only islands, NI Memmert/Mellum, SH Trischen/Oland
Common Eider	4	Only islands in Dutch Wadden Sea, elsewhere implementation difficult
Oystercatcher	14	Abundant species, so nearly all regions covered, only salt marshes
Avocet	14	Mainly mainland, incl. sites behind the seawall; none in DK where population very small
Black-headed Gull	12	NL mainland and islands, elsewhere mainly islands
L. Black-backed Gull	8	Only islands, too rare in DK
Herring Gull	9	Mainly islands
Sandwich Tern	3	NL Griend; SH Trischen or Norderoog; DK Langli
Common Tern	13	Mainly west of Elbe
Arctic Tern	5	Mainly north of Elbe, in NL only Island of Griend

2.4. Sample size

Exo *et al.* (1996) recommended 20-30 clutches to be monitored for each sample site, for Avocet 50-100 clutches. Beintema (1992) simulated several datasets to arrive at a reliable sample when using Mayfield to assess hatching success. As Mayfield is also the standard routine proposed here (see § 2.7), guidelines given by Beintema are preferably adopted in the TMAP breeding success monitoring scheme. As a rule of thumb, Beintema proposes 1000 nest days to get reliable estimates. The number of nests of course depends on the length of the period nests were checked (also in relation to incubation period) and daily survival of the nests (when nests disappear soon due to e.g. predation, the number of nest days declines and sample size has to increase to achieve the same number of nest days). If we estimate the period that nests were monitored at 15-20 days, about 50-70 nests would have to be checked in each sample area (or habitat) for each species, i.e. more or less similar to the figure given for Avocet by Exo *et al.* (1996). Given the fact that many species face predation or other causes for nest-losses, the higher sample size retrieved by Beintema's calculations is recommended here, in stead of the 20-30 clutches proposed earlier in the pilot project. Besides, as stated by Beintema (1992), a larger sample size is superior to nest checks with very short intervals. Thus effort should be concentrated on monitoring of a large number of nests instead of checking nests very frequently. An interval of 6 or 7 days, as proposed by Exo *et al.* (1996) and Willems *et al.* (2005) is suitable for this purpose and does also avoid the risk of disturbance at a nest site. We propose 70 nests as a minimum effort for each combination of species/region. We use the higher limit in Beintema's recommendation here because the number of sample areas to be covered within a region is often only one (see § 2.3.2).

2.5. Parameter selection

For the monitoring of breeding success, a well-established set of parameters is available (Exo *et al.* 1996, Thyen *et al.* 1998, Willems *et al.* 2005):

- Onset of laying
- Clutch size
- Hatching success
- Growth of chicks (as indicator for condition)
- Survival of chicks (fledging success)
- Reproductive success (final breeding success)

For practical reasons, not all parameters are relevant for all species. Some species can only be monitored during the nest-period, others only during the chick-rearing period (also with respect to disturbance, e.g. no visits to spoonbill-colonies during incubation because this species is easily disturbed). Table 3 lists all potential species ('high priority species', see Tab. 1) and relevant parameters for each species.

Hatching success can be assessed in most species by regular inspection of the nests (once every 6-7 days, see § 2.4). Only for Eurasian Spoonbill and Common Eider the nest-period is difficult to monitor since nests are well-hidden (Common Eider) or birds are highly susceptible to human disturbance (Eurasian Spoonbill). When checking nests in other species, also clutch size and onset of laying are recorded.

Reproductive success is defined here as the number of (nearly) fledged young per pair. This is the best parameter to assess breeding success in Eurasian Spoonbill and Common Eider. For Oystercatcher and Avocet, estimating the number of nearly fledged young requires some special field effort (as these species are mobile), but assessment is possible with specific census techniques. For all other (colonial) breeding birds, this parameter is relatively easy to estimate according to well-established and standardised routines. Both hatching success and reproductive success are given highest priority in a trilateral monitoring project on breeding success.

Table 3. *Species and parameters to be monitored in a TMAP monitoring scheme for breeding success in the Wadden Sea. x possible, - not possible or not recommended because of disturbance.*

Species	hatching success	clutch size	onset laying	reproductive success	growth chicks	survival chicks
Eurasian Spoonbill	-	-	-	x	-	-
Common Eider	-	-	-	x	-	-
Oystercatcher	x	x	x	x	-	x
Avocet	x	x	x	x	-	x
Black-headed Gull	x	x	x	x	x	x
L. Black-backed Gull	x	x	x	x	x	x
Herring Gull	x	x	x	x	x	x
Sandwich Tern	x	x	x	x	x	x
Common Tern	x	x	x	x	x	x
Arctic Tern	x	x	x	x	x	x
Priority	high	high	high	high	medium	medium

During the pilot project 1996-97, also parameters 'growth of chicks' and 'survival of chicks' were measured (Exo *et al.* 1996, Thyen *et al.* 1998). Data on these parameters give important additional information on the condition of the chicks (often direcly linked to food availability). Field effort, however, is considerable (measurements once every 3 days, survival in non-colonial species by extensive catching, ringing and sighting) and results might be too detailed regarding the aims of the new monitoring scheme. Therefore, we propose to give them 'medium priority' in a new TMAP monitoring project. Local studies carried out to estimate these parameters (see annex 3) should be stimulated and used to support the TMAP programme.

2.6. Practical aspects for implementation

As a result of the pilot project 1996-97, methods for fieldwork and practical aspects for data collection are already available and need to be communicated with potential fieldworkers to standardise and harmonise methods in the entire Wadden Sea. For this purpose, methodological aspects described by Exo *et al.* (1996) and Thyen *et al.* (1998), as well as new experience since 1997 should be included in a short manual, preferably made available as pdf on the internet (CWSS). This manual should contain information on:

- Outline and scope of the project;
- detailed description of field methods;
- Guidelines for fieldwork;
- Species-specific description of methods and guidelines;
- Data collection and storage;
- Introduction to data analyses.

Actions to be carried out before implementation are: (1) check if information from the pilot project needs to be updated and (2) transfer information into a practical manual.

Contrary to monitoring of numbers, it is recommended that monitoring of breeding success is mainly carried out by professional fieldworkers (i.e. people that are connected to a conservation agency, institute, etc.), or experienced volunteers that are aware of risks of disturbance when checking nests or visiting colonies. Preferably, less-

experienced volunteers should be trained to increase their skills and recruit them for fieldwork. Moreover, they can play an important role when assessing reproductive success, e.g. counts of nearly-fledged Avocets in an area.

Implementation of a TMAP project on breeding success is possible from spring 2009 onwards, when financial aspects have been tackled in the individual countries and a manual is available to all fieldworkers. In addition, it is proposed to collect data recorded so far in a standardised way in a co-ordinated database.

2.7. Data, analyses and report

It is important to establish a simple and efficient strategy to store data and prepare them for analyses in all four countries. For this purpose, the 'Nestkaart' application from SOVON could be adopted and extended to the requirements of the TMAP project. This sofware allows standardised input of all relevant parameters and has been tested by numerous observers in the Dutch nest record scheme in the past years. Sites are searched in Google-Maps, and the programme also allows input of biometrical data and ringing data. Baseline analyses of e.g. hatching success (Mayfield, adopted version with logistic regression) are possible as well. At the moment, it is only available in Dutch, so translation would be necessary, as well as a check if it serves all our purposes. The programme is available online at http://www.sovon.nl/default.asp?id=251 (download after registry of name and address). Willems *et al.* (2005) give some examples of data input (report also available online at http://www.sovon.nl/default.asp?id=135, look in 2005 for report 'Broedsucces kustvogels Waddenzee Ond 2005-07'). Online data input has the advantage that data are available soon after the breeding season. Data will be included in the TMAP data model at the Wadden Sea Secretariat. An annual report on breeding success will be included in the regular 'highlight' reports in the Wadden Sea Newsletter and annual presentation of monitoring results on the internet (as is done for trends in migratory and breeding birds at the website of CWSS). Comprehensive data analyses will be included in the report on the total count (with 6 year-interval, next on the total count in 2012).

3. References

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Appendices

1: Selection of species

2: Overview of proposed sample sites

Annex 1. *Selection of species used or proposed in monitoring of breeding success in the Wadden Sea. Given are all species currently included in the breeding bird monitoring programme of JMBB/TMAP (after Koffijberg et al. 2005), along with their listing on Annex 1 of the EU Bird Directive, share of the NW-European populationbreeding in the Wadden Sea (%) and their inclusion in breeding success monitoring schemes so far. 'Pilot 1996-96' refers to the TMAP-pilot study by Exo et al. 1996 and 'NL 2005-07' to the recent Dutch scheme by Willems et al. 2005. 'NL IPM' refers to a proposed scheme for an Integrated Population Monitoring in the Dutch Wadden Sea, made by Reneerkens et al. (2005). Priority setting has been made by expert judgement during a JMBB meeting on 29 August 2007, using information given by Essink et al. (2005) and Koffijberg et al. (2005).Pro and contra arguments are given to show decision process.*

Species	Annex 1	Pop. %	Pilot 1996-97	NL 2005-07	NL IPM	Priority	Motivation (+ pro / - contra arguments)
Great Cormorant *Phalacrocorax carbo*	-	1-5	-	-	-	Low	+: food specialist, link management - : not typical Wadden Sea species, disturbance
Eurasian Spoonbill *Platalea leucorodia*	x	>25	-	-	x	High	+: internationally important - : disturbance
Shelduck *Tadorna tadorna*	-	5-25	-	-	-	Low	+: abundant in entire Wadden Sea -: practical implementation (breeding in holes)
Common Eider *Somateria mollissima*	-	1-5	-	x	x	High	+: food specialist, link management - : only common in NL,
Red-breasted Merganser *Mergus serrator*	-	<1	-	-	-	Low	+: none - : rare species
Hen Harrier *Circus cyaneus*	x	<1	-	-	-	Medium	+: habitat specialist, link with management , declining species - : disturbance
Oystercatcher *Haematopus ostralegus*	-	5-25	x	x	x	High	+: abundant, food specialist, link management, declining species, contaminent in eggs programme (TMAP) - : none
Avocet *Recurvirostra avosetta*	x	>25	x	x	-	High	+: internationally important, food specialist, habitat specialist, link management - : none
Great Ringed Plover *Charadrius hiaticula*	-	1-5	-	-	-	Medium	+: habitat specialist, declining species - : practical implementation (low densities), disturbance
Kentish Plover *Charadrius alexandrinus*	x	5-25	-	-	-	Medium	+: habitat specialist, declining species

							- : practical implementation (low densities), disturbance
Northern Lapwing *Vanellus vanellus*	-	1-5	-	-	-	Medium	+: habitat specialist, link with management - : only common in DK, not typical Wadden Sea species
Dunlin *Calidris alpina schinzii*	x	1-5	-	-	-	Low	+: declining species - : only in DK, practical implementation (low densities)
Species	Annex 1	Pop. %	Pilot 1996-97	NL 2005-07	NL IPM	Priority	Motivation (+ pro / - contra arguments)
Ruff *Philomachus pugnax*	x	<1	-	-	-	Low	+: declining species - : only in DK, practical implementation (low densities)
Common Snipe *Gallinago gallinago*	-	<1	-	-	-	Low	+ : habitat specialist, declining species - : only in DK, not typical Wadden Sea species
Black-tailed Godwit *Limosa limosa*	-	1-5	-	-	-	Medium	+ : habitat specialist, link with management - : scattered distribution, not typical Wadden Sea species
Eurasian Curlew *Numenius arquata*	-	<1	-	-	-	Medium	+: habitat specialist, link management - : disturbance
Common Redshank *Tringa totanus*	-	5-25	x	-	-	Medium	+: abundant, habitat specialist, link management - : practical implementation (difficult species)
Turnstone *Arenaria interpres*	-	<1	-	-	-	Low	+: none - : rare species
Mediterranean Gull *Larus melanocephalus*	x	<1	-	-	-	Low	+: none - : rare species
Little Gull *Larus minutus*	x	<1	-	-	-	Low	+: none - : rare species
Black-headed Gull *Larus ridibundus*	-	5-25	x	x	-	High	+: abundant, ongoing studies already done - : not habitat or food specialist

Common Gull *Larus canus*	-	1-5	-	-	-	Low	+: abundant - : not typical Wadden Sea species
Lesser Black-backed Gull *Larus fuscus*	-	>25	proposed	-	-	High	+: internationally important, food specialist, link management, link herring gull - : only abundant in NL and NI
Herring Gull *Larus argentatus*	-	5-25	x	x	-	High	+: link management, link Lesser Black-b. Gull, contaminants in eggs programme (Germany) - : none
Great Black-backed Gull *Larus marinus*	-	<1	-	-	-	Low	+: none - : rare species
Gull-billed Tern *Gelochelidon nilotica*	x	>25	-	-	-	Low	+: internationally important - : rare species, disturbance
Sandwich Tern *Sterna sandvichensis*	x	>25	-	-	x	High	+: internationally important, food specialist, link management - : limited distribution
Common Tern *Sterna hirundo*	x	5-25	x	x	-	High	+: food specialist, contaminant in eggs programme (TMAP), link Arctic Tern - : none
Arctic Tern *Sterna paradisaea*	x	1-5	-	-	-	High	+: food specialist, link Common Tern - : limited distribution
Little Tern *Sterna albifrons*	x	5-25	-	-	-	Medium	+: food specialist, habitat specialist, link management - : practical implementation (remote sites), limited distribution, disturbance
Short-eared Owl *Asio flammeus*	x	<1	-	-	-	Medium	+: declining species, habitat specialist, link management - : disturbance, practical implementation (difficult species

Annex 2. *Overview of proposed sample sites per species in each region (see text, section 2.3.1) to be monitored in a TMAP monitoring project on breeding success. For each species/region two sample sites have been proposed, unless distribution of a species does not allow this (sample size would be too small since population size very small). Distribution taken from total count 2001, see Koffijberg et al. 2005.*

Species	NL Western Wadden Sea		NL Eastern Wadden Sea		NL-NI Ems-Dollart	NI East-Friesland		NI Jade-Weser Estuary		NI-SH Elbe estuary and Dithmarschen		SH Nordfriesland		DK Danish Wadden Sea	
	main	island	main	island	main	main	island	main	island	main	island	main	island	main	island
Eurasian Spoonbill[1]	-	2	-	2	-	-	1	-	1	-	1	-	1	-	-
Common Eider	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-
Oystercatcher	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1
Avocet	2	-	2	-	3	1	1	1	-	2	-	2	-	-	-
Black-headed Gull	1	1	1	1	1	-	1	-	1	1	1	1	1	-	1
Lesser Black-backed Gull	-	2	-	1	-	-	2	-	1	-	1	-	1	-	-
Herring Gull	-	2	-	1	-	-	2	-	1	-	1	-	1	-	1
Sandwich Tern		1	-	-	-	-	-	-	-	-	-	-	1	-	1
Common Tern	-	2	2	2	2	-	2	-	1	2	-	-	-	-	-
Arctic Tern	-	1	-	-	-	-	-	-	-	-	-	1	2	-	1
All species	4	14	6	10	7	2	10	2	6	6	5	5	8	0	5
Total/country	41					20				24				5	