Managing predation risk for breeding birds in the Wadden Sea

Results from a workshop in Tönning, Schleswig-Holstein, 7-8 March 2017

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2019
Common Wadden Sea Secretariat
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Content

Executive Summary

Summary

Long-term data from the Wadden Sea monitoring programme TMAP show that only 10 out of 29 breeding bird species have experienced increasing or stable population trends in the past 20-30 years. Most have faced (serious) declines. Low reproductive success has been identified as the main demographic parameter driving the declines, as shown by results from breeding success monitoring. In addition to habitat deterioration or loss and an increasing risk of clutches being flooded due to sea-level rise, there is growing evidence that clutch predation poses a growing threat to ground-nesting birds at many coastal breeding sites.

In March 2017, the Joint Monitoring Breeding Bird Group (JMBB) of the Trilateral Wadden Sea Cooperation held a workshop "Breeding bird predation management in the Wadden Sea" in Tönning, Germany. The workshop was convened to take a closer look into managing predation risk to protect ground-nesting birds in the Wadden Sea. 13 presentations from The Netherlands, Germany, Denmark and the UK provided information on various management techniques, from short-term (fencing) to long-term (altering landscapes) measures, to provide more sustainable conditions for breeding waders. Moreover, the ecology of (mammalian) predators was discussed, especially with respect to potential measures to carry out predator control.

Guidelines to managing predation risk to ground-nesting birds in the Wadden Sea were collated in a plenary discussion at the end of the workshop. It was recommended, as a guiding principle, to follow a decision tree on whether or not conservation interventions should be taken up to counteract the impact of predation on the breeding success of ground nesting birds. Essential elements of this decision tree include analyzing the status of breeding bird populations at a given site and assessing the overall importance of this site for breeding birds. When breeding success is poor and the site is significant, the next step should focus on improving nesting (and foraging) conditions for birds by improving the habitat. The following phase should then concentrate on gaining knowledge of predator species and densities affecting breeding birds at the site. Lastly, any techniques adopted should comply with current law and favour non-lethal methods such as altering habitat to make life more difficult for predators or excluding them by fencing off breeding areas. Scaring off predators can be an effective tool as well. Lethal control of aerial predators is mostly illegal, while most mammalian ground predators are commonly the subjects of national and regional hunting legislation and regulations. However, lethal control at a local level is unlikely to help reduce predation risk on a wider scale and in a sustainable manner.

Landscape management is likely to provide a sustainable method of reducing predation risk, but it rarely yields immediate results and costs are potentially high. Predator exclusion can result in immediate success, however, although if carried out for several seasons, costs, especially staff costs to maintain e.g. fences, can be high. Predator control also potentially shows an immediate effect, but, again, if carried out over several seasons, costs can be high.

This workshop and report is part of the implementation of *Breeding birds in trouble: A framework for an action plan in the Wadden Sea* 4.

Zusammenfassung

Langzeittrends des Wattenmeer Monitoringprogramms TMAP zeigen, dass lediglich 10 von 20 Brutvogelarten zunehmende bzw. stabile Bestände aufweisen, die Mehrzahl der Arten jedoch in den vergangenen 20 bis 30 Jahren zum Teil stark abnahmen. Hauptverantwortlich hierfür scheint der anhaltend geringe Bruterfolg zu sein, der durch Lebensraumverlust und der allgemeinen Verschlechterung des Bruthabitats sowie einem steigenden Überflutungsrisiko durch die Erhöhung des Meeresspiegels mit verantwortet wird. Zudem verdichten sich jedoch die Hinweise darauf, dass vor allem ein erhöhtes Prädationsrisiko den bodenbrütenden Vögeln an vielen Küstenstandorten Probleme bereitet.

Im März 2017 veranstaltete die Joint Monitoring Group for Breeding Birds (JMBB) der Trilateralen Wattenmeerkooperation in Tönning, Deutschland, einen Workshop mit dem Titel "Breeding bird predation management in the Wadden Sea". Dieser Workshop wurde initiiert, um Strategien und Wege zu entwickeln, das Prädationsrisiko für Brutvögel im Wattenmeer zu verringern. Insgesamt präsentierten 13 Vorträge aus den Niederlanden, Deutschland, Dänemark und Großbritannien Lösungsansätze wie das Prädationsrisiko minimiert und den Vögeln nachhaltig bessere Brutbedingungen geboten werden können. Die Bandbreite der vorgestellten Projekte reichte dabei von kurzfristigen (Einzäunungen) bis langfristigen Maßnahmen (Habitatveränderungen).

Am Ende des Workshops wurden im Rahmen einer Plenumsdiskussion Vorschläge zur zukünftigen Ausrichtung eines Prädadtionsrisikomanage-

ment für das Wattenmeer gesammelt. Es wurde vorgeschlagen, in einem Ersten Schritt anhand eines Entscheidungsbaums zu bewerten, ob in einem bestimmten Gebiet Naturschutzmaßnahmen, die den negativen Auswirkungen der Prädation entgegenwirken sollen, ergriffen werden sollten oder nicht. Wesentliche Elemente in diesem Prozess sind eine Analyse der aktuellen Situation der dortigen Brutvögel, sowie eine fundierte Einschätzung über die Bedeutung dieses Gebietes für den Erhalt der Brutvogelbestände im Wattenmeer. Wenn das Gebiet eine hohe Bedeutung besitzt, der Bruterfolg aber niedrig ist, sollten in jedem Falle Naturschutzmaßnahmen umgesetzt werden, und zwar solche, die zu allererst auf eine Verbesserung des Habitats zielen. In einer dann folgenden Phase sollten Informationen über Artzusammensetzung und Dichte möglicher Prädatoren in diesem Gebiet analysiert werden. Im darauffolgenden Schritt können dann Wege in Betracht gezogen werden, die es erlauben, anwesende Prädatoren innerhalb des gesetzlichen Rahmens zu managen. Hierbei sollte zuerst auf nicht-letale Maßnahmen zurückgegriffen werden, wie z.B. das Ausschließen von Prädatoren durch Zäune und das (weitergehende) Verändern des Habitats dahingehend, dass sich die Lebensbedingungen für Prädatoren verschlechtern. Vergrämung der Prädatoren kann ebenfalls ein wirksames Werkzeug sein. Während eine letale Kontrolle von Luftprädatoren in den meisten Fällen illegal ist, unterliegen die meisten Bodenprädatoren dem nationalen bzw. regionalen Jagdrecht. Es ist jedoch unwahrscheinlich, dass eine Bejagung dazu beiträgt, die Prädatorenbestände großflächig zu reduzieren.

Das Verändern der Landschaft bietet einen nachhaltigen Weg, um großflächig gleichzeitig eine Verbesserung für die Lebensbedingungen der Brutvögel und eine Verschlechterung der Lebensbedingungen der Prädatoren zu erreichen. Die Wirkungen treten jedoch erst mit einiger zeitlichen Verzögerung zu Tage und die Kosten hierfür sind hoch anzusetzen. Das Ausschließen von Prädatoren (z.B. durch Zäune) hingegen kann einen unmittelbaren Erfolg zeigen. Wenn es jedoch über viele Jahre hin ausgeführt wird, sind die Kosten, vor allem für das die Maßnahmen betreuende Personal, ebenfalls als hoch anzusetzen. Auch eine letale Kontrolle der Prädatoren kann, auf lokaler Ebene, zu einem unmittelbaren Erfolg führen, aber auch hier sind die Kosten als hoch anzusetzen, wenn diese Maßnahmen über mehrere Jahre durchgeführt werden soll.

Der Workshop und dieser Bericht sind Teil des Aktionsplans *Breeding birds in trouble: A framework for an action plan in the Wadden Sea*.

Samenvatting

De resultaten van het trilaterale TMAP monitoringprogramma voor broedvogels laten zien dat slechts 10 van de 29 algemenere soorten een toename, of op z'n minst een stabiel aantalsverloop in broedparen laten zien. De meeste soorten namen sinds de start van het programma in 1991 significant af. Op grond van de recent gestarte monitoring van het broedsucces blijkt dat veel broedvogels in de Waddenzee te weinig jongen grootbrengen om de populatie in stand te houden. Dit lage broedsucces wordt gezien als één van de hoofdoorzaken voor de waargenomen afnames. Naast negatieve habitatveranderingen en een toenemende kans dat legsels wegspoelen door hoog water, zijn er veel aanwijzingen dat de broedvogels in de Waddenzee op dit moment worden geconfronteerd met een hoog predatierisico.

In maart 2017 organiseerde de Joint Monitoring Group for Breeding Birds (JMBB), die de trilaterale broedvogelmonitoring coördineert, een workshop in Tönning in Sleeswijk-Holstein, getiteld "Breeding bird predation management in the Wadden Sea". Deze workshop, en dit verslag, ontstonden uit het eerdere actieplan "Breeding birds in trouble: a framework for an action plan in the Wadden Sea". Doel van de workshop was vooral om meer inzicht te krijgen in de hele problematiek rond predatie van kustbroedvogels. Er waren 13 presentaties uit Nederland, Duitsland en Denemarken en uit Groot-Brittannië. Aan bod kwamen mogelijkheden om op korte termijn (bijv. door elektrische afrastering) en op lange termijn (door inrichtingsmaatregelen) een grotere kans op succesvolle broedgevallen te bewerkstelligen. Daarnaast werd ingegaan op de ecologie van de predatoren zelf, om aanknopingspunten te vinden voor maatregelen ten aanzien van predatoren.

In een plenair deel aan het einde van de workshop werden handreikingen geformuleerd hoe om te gaan met predatie van kustbroedvogels. Er wordt aanbevolen voor de predatieproblematiek een goede leidraad te ontwikkelen en breder te kijken dan alleen de predatoren. Met hulp van een beslisboom moet in eerste instantie worden beoordeeld of maatregelen tegen predatie zinvol zijn. Afwegingen zijn dan hoe de ontwikkeling in aantallen verloopt, en of het om een belangrijk broedgebied gaat. Prioritaire maatregelen bij belangrijke gebieden en een laag broedsucces zouden zich in eerste instantie moeten richten op verbetering van nestel- en foerageermogelijkheden. Bij predatie is het van groot belang het type predator en hun voorkomen in kaart te brengen (vindt predatie bijv. juist 's nachts plaats, of overdag). Er zijn tal van maatregelen mogelijk om het predatierisico te verlagen. Die kunnen bestaan

uit inrichtingsmaatregelen om het leven voor predatoren moeilijker te maken, of maatregelen om broedvogels actief tegen predatie te beschermen, bijv. door gebruik van een elektrisch raster. Verstoring van predatoren kan eveneens helpen. Afschot of vangen van vogel-predatoren is doorgaans geen optie omdat het om beschermde vogelsoorten gaat. Bij zoogdieren zijn die mogelijkheden er wel, al bestaan er tussen de landen onderling, of binnen afzonderlijke regio's verschillen in regelgeving t.a.v. de jacht. Jacht (of wegvangen) heeft bovendien meestal alleen een lokaal effect en werkt niet of amper door op grotere schaal.

Inrichtingsmaatregelen om predatoren een minder geschikt leefgebied te bieden werken op een structurelere manier om het predatierisico te verlagen. Nadeel is dat het een zaak van lange adem is, en de kosten doorgaans hoog. Afweer tegen predatoren met bijv. een elektrisch raster werkt op zijn beurt direct, maar is bij langdurig gebruik (plaatsen raster, onderhoud, etc.) eveneens kostbaar, en soms na enkele jaren minder effectief. Afschot en wegvangen werken eveneens op de korte termijn, maar zijn opnieuw op lange duur arbeidsintensief en kostbaar: het vergt een jaarlijks terugkerende inspanning.

Resumé

Langsigtede data fra moniteringsprogrammet for Det Trilaterale Vadehav (TMAP) viser, at blot 10 ud af 29 arter af ynglende fugle er genstand for en stigende eller stabil bestandsudvikling i de seneste 20-30 år. De fleste har vist (betydelige) bestandsnedgange. Overvågningen af fuglenes ynglesucces i vadehavsområdet har desuden vist, at dårlig ynglesucces er den mest betydende faktor for bestandene og den væsentligste årsag til tilbagegangen. I tillæg til forringelser og tab af egnede levesteder og en voksende risiko for oversvømmelse af ynglefuglenes reder på grund af havspejlsstigninger, er prædation af æg og unger en voksende trussel mod jordrugende fugle i mange af de kystnære yngleområder.

I marts 2017 afholdt ekspertgruppen, "Joint Monitoring Breeding Bird Group" (JMBB) under Det Trilaterale Vadehavssamarbejde, en workshop med titlen "Breeding bird predation management in the Wadden Sea" (forvaltning af prædation på ynglefugle i Vadehavet) i Tönning i Tyskland. Workshoppen blev arrangeret for at sætte fokus på mulighederne for at nedbringe risikoen for prædation som en vej til bedre beskyttelse af jordrugende ynglefugle i Vadehavet. Gennem tretten præsentationer fra Holland, Tyskland, Danmark og England blev der videregivet viden om en række forskellige forvaltningsmæssige værktøjer, lige fra tidsbegrænsede (f.eks. udhegninger i yngletiden) til vedvarende (f.eks. tilpasninger af landskaber) metoder til fordel for mere bæredygtige forhold for ynglende vadefugle og terner. Desuden blev rovdyrenes økologi (primært pattedyrenes) præsenteret og diskuteret, især i forhold til mulighederne for at gennemføre en regulering af deres antal og fordeling i landskabet.

Anbefalinger til hvordan prædation af jordrugende fugle og deres afkom kan begrænses i Vadehavet blev drøftet ved en fælles diskussion, som afrundede workshoppen. Det blev som hovedprincip anbefalet, at der altid foretages en analyse af, hvorvidt de forskellige beskyttelsestiltag bør tages op for at modvirke prædationens indflydelse på ynglesuccesen hos de jordrugende fugle. Væsentlige elementer i denne analyse omfatter: (a) at redegøre for status for de relevante ynglefuglebestande på den givne lokalitet, og (b) at vurdere lokalitetens overordnede betydning for de ynglende fugle. Hvis ynglesuccessen er dårlig og lokaliteten er vigtig, skal det næste skridt fokusere på at styrke yngleforholdene (og mulighederne for fødesøgning) for fuglene ved at forbedre levestedet. Den følgende fase skal så koncentreres om at få kendskab til arterne og tæthederne af rovdyr, der påvirker ynglefuglene i området. Overordnet set skal alle anvendte teknikker overholde gældende lov og ikke-dødelige metoder skal favoriseres, som f.eks. tilpasninger af levestederne så livet gøres vanskeligere for rovdyr eller at udelukke dem med hegn omkring yngleområder. Bortskræmning af rovdyr kan også være et effektivt værktøj. Bortskydning eller fangst og aflivning af flyvende prædatorer er som oftest ikke lovligt, mens de fleste firbenede rovdyr (pattedyr) generelt set er omfattet af national og regional jagtlovgivning samt af bestemmelser om regulering. Imidlertid vil regulering (aflivning) af prædatorer på lokalt plan i nogle tilfælde ikke reducere prædationsrisikoen på et større plan og på en bæredygtig måde.

Den rette forvaltning af landskabet er sandsynligvis den mest bæredygtige metode at reducere risikoen for prædation på, men det giver sjældent hurtige resultater og omkostningerne er ofte høje. Udhegning af prædatorer kan resultere i øjeblikkelig succes, men når det gennemførers over flere sæsoner, kan omkostningerne, især til personale til at opsætte og tilse hegn og udstyr, være store. Direkte regulering af prædatorer har potentielt også en umiddelbar virkning, men kan imidlertid også medføre store omkostninger, hvis den udføres over flere sæsoner.

Denne workshop og rapport er en del af implementeringen af "Breeding birds in trouble: A framework for an action plan in the Wadden Sea" ("Ynglefugle i knibe: Rammerne for en handlingsplan i Vadehavet").

Introduction

The Wadden Sea hosts more than 30 breeding bird species. For some, like Eurasian spoonbill *Platalea leucorodia*, Eurasian oystercatcher *Haematopus ostralegus*, pied avocet *Recuvirostra avosetta*, Kentish plover *Charadrius alexandrinus*, common redshank *Tringa totanus*, lesser black-backed gull *Larus fuscus*, gull-billed tern *Gelochelidon nilotica* and sandwich tern *Thalasseus sandvicensis*, the Wadden Sea represents one the most important breeding sites in north-western Europe (1,2). A number of species is listed in Annex I of the EU Birds Directive or listed as Species of European Concern (SPEC). The European population of Eurasian oystercatchers is listed as Vulnerable (VU) on the European Red List, and as SPEC13 (European species of global concern), and so are black-tailed godwit *Limosa limosa*, Eurasian curlew *Numenius arquata*, common eider *Somateria mollissima* and northern lapwing *Vanellus vanellus*; herring gull *Larus argentatus* and common redshank are listed as SPEC23 (species whose global population is concentrated in Europe and are listed on the European Red List). Many of the other breeding bird species are listed on national Red Lists. Hence, there is an obligation for the Wadden Sea authorities to develop, support and implement effective conservation measures.

Long-term data from the Wadden Sea monitoring programme TMAP show that only 10 out of 29 species have experienced increasing or stable trends; the majority have faced (serious) declines in the past 20-30 years (1,2). Low reproductive success has been identified as the main demographic parameter for this. There is growing evidence that, in addition to habitat deterioration or loss and an increasing risk of clutches being flooded due to sea-level rise, the risk of clutches being predated poses a major constraint on ground-nesting birds at many coastal breeding sites (4).

The Wadden Sea area, and especially the islands and sandbanks separated from the mainland by intertidal mudflats, forms the last refuge for many wet-grassland waders and beach-breeding bird species such as Eurasian oystercatchers, sandpipers, gulls and terns. Over the past centuries, anthropogenic changes in the hinterland of the Wadden Sea region have transformed the landscape first from moorlands to low productivity semi-natural wet grasslands and then to the intensively agriculturally cultivated landscape that we witness today. With this transformation, wader species like e.g. black-tailed godwit or Eurasian curlew have lost large parts of their original breeding range, and the marshes of the Wadden Sea area have become important breeding habitats.

Ground predators, on the other hand, seem to be able to make a good living in these heavily altered landscapes and correspondingly, the risk for ground-nesting birds of clutches being predated has been increasing (5-7). Because of their separation from the mainland through regularly inundated mudflats, the islands and Halligen of the Wadden Sea have traditionally been havens naturally free of ground-predators. However, as shown later in this report, this is not true anymore.

Hence, the future for ground-nesting birds in the Wadden Sea appears grim. Planned action programs are needed to lower the risk of predation. On 7-8 March 2017, the Joint Monitoring Breeding Bird Group (JMBB) of the Trilateral Wadden Sea Cooperation held a workshop "Breeding bird predation management in the Wadden Sea". 13 presentations from The Netherlands, Germany, Denmark and the UK provided information on various ways to manage predation risk, from short-term (fencing) to long-term (altering landscapes) measures to provide more sustainable conditions for breeding waders. This report summarises each of the presentations, as well as presenting guidelines on how to manage predation risk for ground-nesting birds.

The current situation of ground-nesting birds in the Wadden Sea

Poor breeding success has been identified as the main driver for declining populations in the Wadden Sea (Table 1)(1,2). The main causes are predation and flooding, but food shortage (starvation of chicks) and adverse weather (thermal control, food accessibility) also play important roles (2). The workshop was initiated to take a closer look into managing predation risk to protect ground-nesting birds in the Wadden Sea. For conservation management actions dealing with the other issues, see Koffijberg *et al.* (4).

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

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

Table left: Assessment of breeding success in the Wadden Sea, as recorded by the TMAP parameter "Breeding success" in 2009-2012 (after Thorup & Koffijberg (1), from Koffijberg *et al.* (4)

Photo: Martin Stock

Talk 1

Vulnerability of different waterbird species to a diverse and changing community of predators

Ole Thorup, Denmark

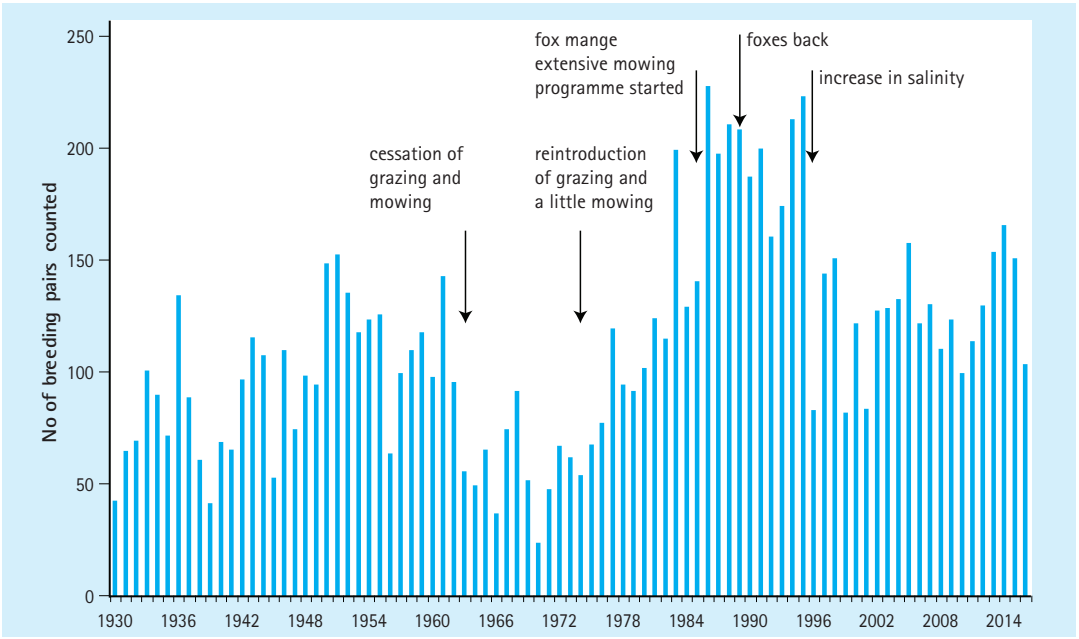
Decades of monitoring breeding birds and their predators at Tipperne, a nature reserve about 30km from the Danish Wadden Sea coast, have shown that key predators on adult birds, eggs and chicks of shorebirds (waders), gulls and terns were mainly red fox, marsh harrier, peregrine falcon, and, to a lesser extent, common gull and hooded and carrion crows.

Population dynamics of predators: While numbers of red fox *Vulpes vulpes* families have fluctuated in the past, they have stayed relatively stable for the past 40 years. Years with higher numbers of fox observations have coincided with lower proportions of common redshank families with chicks. Marsh harriers *Circus aeruginosus* have levelled at around 1-2 breeding pairs in the past 30 years. The number of peregrine falcon *Falco peregrinus* observations in late spring has increased in the past 30 years from 0 to around 7. Common gulls *Larus canus* bred with numbers of 400 and more pairs from the 1920s to the 1950s. Since the 1950s, they have decreased so dramatically that nowadays they no longer breed regularly. There are currently 6 to 7 pairs plus some single individuals of stationary carrion *Corvus corone* and hooded *Corvus cornix* crows. New predator species have arrived in the past 5-20 years: greater black-backed gull *Larus marinus*, common crane *Grus grus*, white-tailed eagle *Haliaeetus albicilla*, Eurasian otter *Lutra lutra*, racoon dog *Nyctereutes procyonoides*, American mink *Neovison vison*, grey heron *Ardea cinerea*, herring gull *Larus argentatus*, common buzzard *Buteo buteo*, Eurasian kestrel *Falco tinunculus*, merlin *Falco columbarius*, gyr-falcon *Falco rusticolus*, European badger *Meles meles*, European polecat *Mustela putorius*. stoat *Mustela erminea*, common weasel *Mustela nivalis*, brown rat *Rattus norvegicus* and gull-billed tern have decreased during the past years.

Population dynamics of breeding birds: The dynamics of northern lapwing breeding populations are heavily dependent on land management techniques: the cessation of grazing and mowing has led to a decrease in numbers, while resuming grazing and mowing has led to an increase. During outbreaks of fox mange and when implementing rigorous habitat management programs, lapwing populations have increased as well. However, an increase in salinity has led to lapwing numbers decreasing again. Nest survival in the past decades has averaged 43% in northern lapwing nests, 24% in ruff *Philomachus pugnax* and common redshank nests, 26% in Baltic Dunlin *Calidris alpina schinzii* nests. Colonial breeders such as terns and pied avocet have remained stable. Dispersed breeders such as most meadow bird species have increased in numbers and with increasing densities, breeding success seems to have increased as well. Yet, high predation rates affect breeding bird numbers.

Take home message: Habitat management can improve numbers and densities of breeding birds, and also affects predation risk.

Figure right: Lapwing breeding numbers at Tipperne and key features in management



Here today, gone tomorrow – managing predation in lowland waders

Jen Smart, United Kingdom

Predation is a natural process but when the natural balance between predator and prey is disturbed, predation can become an issue. Furthermore, many potential suspects not only interact with their prey but also with each other, forming a complex web of inter- and intraspecific interactions. Breeding wader populations have been declining for many decades. While these declines have been linked to large-scale changes in habitat extent and quality, these reduced wader populations are now additionally facing increasing predator populations.

Why are predators increasing? There a many reasons why predators are increasing, and among the most important are (i) the way humans have altered natural landscapes, providing more opportunities for these predators, (ii) an increase in the amount of food in the environment esp. at traditionally difficult times of year, but also (iii) successful conservation programmes on e.g. peregrine falcons, and (iv) the introduction of non-native predators and the spread of a range of predator species from eastern to western Europe.

What makes ground-nesting birds vulnerable to the effects of predation? Nesting on the ground makes these birds easily accessible for ground predators. Additionally, good quality breeding habitat can attract many birds to nest in close vicinity. This represents a profitable foraging resource for predators. Both nests and chicks are vulnerable to predation and thus widens the time window of vulnerability to up to two months.

Nest and chick predation: Many years of research and the analysis of thousands of nests from breeding sites in the UK has revealed that a very large proportion of nests are predated at night, the majority by red fox and European badger. Tracking of over 200 wader chicks has shown that for a little more than 1/3 of the chicks, the predator either could not be identified or the chicks were predated by mammals (mainly red fox, stoat and weasel), and a little less than 1/3 of the chicks were taken by avian predators. [1]

1 Mason, L. R., Smart, J. and Drewitt, A. L. (2018), Tracking day and night provides insights into the relative importance of different wader chick predators. Ibis, 160: 71-88. doi:10.1111/ibi.12523

What are the options for managing predation and how effective are they?

Lethal control: Lethal control of predators can reduce predator populations, yet whether this results in increased nest and chick survival differs among sites. Predator control measures seem more likely to be beneficial for nesting birds at sites where predator densities are high. However, before embarking on predator control measures at particular sites, information on predator densities and the impact of predators on nest and chick survival is needed. [2]

Fencing: Predator fencing is an attractive and widely used option, which is less contentious than lethal control. Fencing is generally very successful at excluding foxes and European badgers. Studies have shown that e.g. lapwing productivity increases with using predator exclusion fences. Different designs and methods of fencing have been tested resulting in different levels of success. Fences combining different designs and powered with electricity performed best . Future studies will improve our understanding of long-term effects of predator fencing to improve the overall breeding success of waders.

Diversionary feeding: There have been first trials to use diversionary feeding as a way to reduce the impacts of e.g. red kites (or other protected predator species). Whether this method results in long-term increases in wader productivity is not yet known. It appears to be effective when done correctly, however it is an expensive and intensive option.

Laser hazing: Another potential solution to avian predation problems is laser hazing but again this is quite an intensive solution. This method is widely used at airports, but as yet there are no studies of its efficacy for conservation uses.

Habitat management to influence predation: Managing breeding habitat for waders in order to make life difficult for predators and to provide means to waders for self help seems the most sustainable way to increase wader productivity. Water influences predation rates by influencing how predators can hunt in the fields. Manipulating the wetness of the landscape is thus likely to be beneficial for breeding waders. Studies also have shown that verge habitats may provide alterna-

2 Bolton, M., Tyler, G., Smith ,K. and Bamford, R. (2007) The impact of predator control on lapwing Vanellus vanellus breeding success on wet grassland nature reserves. J Appl Ecol 44: 534-544.

Talk 3

Figure right:
Red line, blue rhomb: The average litter size of a non-regulated red fox population in a dune area decreases over time.
Blue lines: The average litter size in regulated (lower line, Zuid Limburg) and intensively regulated (upper line, Overijssel) red fox populations remains high.

tive food resources for predators and hence lower predation pressure on breeding birds [3,4,5,6].

3 Malpas, L.R., Kennerley, R.L., Hirons, G.J.M., Sheldon, R.D., Ausden, M., Gilbert, J.C. and Smart, J. (2013) The use of predator-exclusion fencing as a management tool improves the breeding success of waders on lowland wet grassland. Journal for Nature Conservation 21: 37-47

4 Laidlaw, R.A., Smart, J., Smart M.A. and Gill, J.A. (2013) Managing a food web: impacts on small mammals of managing grasslands for breeding waders. Animal Conservation, 16, 207–215.

5 Laidlaw, R. A., Smart, J., Smart, M. A., & Gill, J. A. (2015). The influence of landscape features on nest predation rates of grassland-breeding waders. Ibis, 157, 700–712. doi: 10.1111/ibi.12293

6 Laidlaw, R. A., Smart, J., Smart, M. A., & Gill, J. A. (2017). Scenarios of habitat management options to reduce predator impacts on nesting waders. Journal of Applied Ecology, 54, 1219–1229.

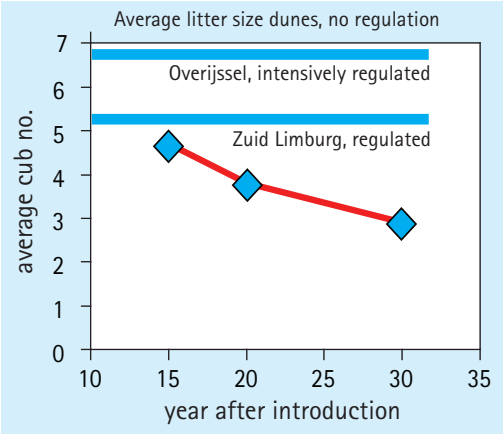
Population biology and management of red fox – experiences from research in The Netherlands

Jaap Mulder, The Netherlands

Are ground-breeding birds threatened by predation or is habitat quality more important? Is hunting red foxes the answer to the problem? And if yes, how would it work most efficiently? What is known about red foxes?

Studying the behavioural ecology of red foxes: The study population at Castricum (The Netherlands) is strongly territorial, both pairs and small family parties. Telemetry studies have shown that the same seems to be true for other fox populations in The Netherlands. Generally, the size of a territory varies and seems to depend on the quality of the territory. Smallest territories have been observed in urban areas, followed by agricultural habitats, the largest territories have been observed in alpine meadows and highlands.

A territory has to secure the needs for reproduction: it has to (i) provide sufficient food and (ii) reduce competition. The territorial system as such is a mechanism to limit population growth as it is density-dependent. However, red foxes can tolerate extra-pair females in their territory.



Regulating or controlling red fox populations stabilized average litter size at a high level, while average litter size in non-regulated red fox populations decreased over time. Urban red foxes and populations that are non-regulated generally have small litter sizes.

Young foxes start roaming around from August /September onwards in search of their own territories. They have been observed to both just move "next door" or to travel several tens to hundreds of kilometres. As soon as a territory becomes vacant, they quickly settle in. Aside from territory holders, there are also so-called "vagabonds" or "floaters". These individuals are in a position to quickly occupy any vacant territory throughout the year and also to colonize new areas.

With an equal sex ration of 1:1 in the den, natural mortality of pups in a non-regulated population is higher in females (70%) than in males (30%). During the first year of life, overall annual mortality is at 60%, afterwards natural mortality stays around 20-30% per year. The main drivers for death rates are food availability and competition for food.

Early in their own breeding season, red foxes can benefit from even earlier breeding greylag geese as they provide a good food resource at a time when other birds such as waders, gulls and terns have not yet started breeding. Later in the season, red foxes then also make use of others species, like e.g. waders, where they generally have a significant impact on clutch survival.

Fencing against red foxes can be efficient but is mostly only temporarily effective.

When to control red foxes effectively?

Regulating or controlling red foxes is foremost a political decision, as they are naturally occurring predators. When red foxes are controlled, it is most beneficial to aim at reducing numbers at the

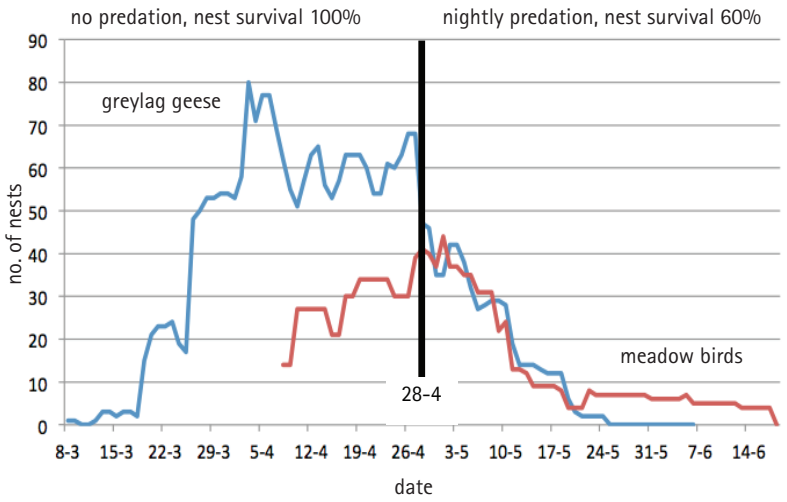


Figure left: From early March on, greylag geese Anser anser start laying eggs (blue line). From end of April onwards (black vertical line), clutch survival decreases from 100% to 60%. Predation occurs mainly during the night. This also affects nesting meadow birds that start breeding later than greylag geese (red line) D.J.Gijsbertsen, 2012. Student report. Sovon/Alterra).

start of the breeding season. There is only limited research on the efficiency of fox hunting but it seems that a "regular" effort in large areas seems to have only little impact while a concerted effort in a small area can often be more successful.

To understand why increasing hunting of red foxes in spring would be more effective in managing predation risk for ground-nesting birds, one needs to look at the annual cycle of red foxes from a population dynamics point of view. In autumn and winter, hunting induced mortality coincides with the elevated natural mortality (due to food shortage, adverse weather, etc.). Consequently, hunting has a minimal effect on population size at that time of year. Also during that period, red foxes disperse to search for free territories. Thus, territories available because the former holder was shot will be occupied quickly again. In spring though, red foxes reproduce and tend to stay in their existing territories. A territory that becomes available at that time of the year might stay vacant for a while. This is because (i) red foxes show less dispersal behaviour then, and (ii) non-territorial individuals have to move much more slowly through occupied territories than in winter, when there is less territorial behaviour.

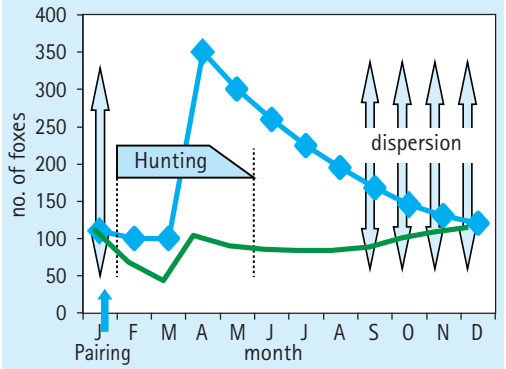


Figure left: "Regular" hunting effort (green line) is highest in winter, when fox numbers are lowest (blue squares) and lowest in early spring, when fox numbers are highest. Non-territorial foxes tend to disperse (light blue arrows) in autumn and winter, potentially counteracting the hunting success. Hunting seems most effective in spring (blue bar).

Moreover, when taking out a territorial reproducing female, her offspring has to be taken out at the same time. This implies that additionally the number of offspring entering the population is kept down, and hence, the overall population is kept down. Lastly, any newcomer at that time of the year is likely to be without offspring. This means it is likely to need less food than the former territory owner, so reducing predation pressure on breeding birds there.

Telemetry of foxes and raccoon dogs in Schleswig-Holstein

Philipp Schwemmer, Germany

There has been a strong decline in mainland breeding ground-nesting birds over the past 30 years, and an increase of red foxes hunted in Schleswig-Holstein since the 1950s. rabies no longer occurs, supporting the increase of red foxes, and raccoon dog numbers have gone up. This study aims to collect data to support an effective predation management scheme within the trilateral Wadden Sea as well as developing an extension to the Marine Strategy Framework Directive (MSFD) by the indicator: "Mammals not naturally occurring on islands and Halligen".

This talk presented preliminary data of satellite tracked red foxes and raccoon dogs. A publication of these results in an international scientific journal is in preparation.

Talk 5

Predation management with regard to foxes in Tønder-marsken, Denmark

Preben Clausen, Denmark

This study has presented monitoring results from a predation risk management programme in Tøndermarsken, Denmark. In summary, predation risk by ground predators negatively influenced hatching and breeding success of ground-nesting birds. Outbreaks such as sarcoptic mange and canine distemper naturally controlled red fox populations and helped ground-nesting birds to achieve a higher hatching success. Managing the habitat to suit the needs of ground-nesting birds is essential.

Overall numbers of mammalian predators such as red fox, European badger, martens, stoat polecat and mink have increased since the 1950s, making future predation management very challenging. Yet, how the habitat is managed (e.g. agri-environment schemes) influences hatching and breeding success as well.

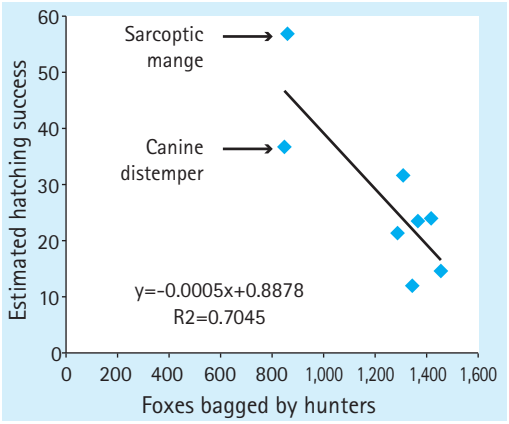


Figure right: Relation between between foxes bagged by hunters and hatching success.in Tøndermarsken

Lessons learned: if we want waders, we need

- wet meadows – whether farmers like it or not
- grazed/hay-cut meadows under controlled conditions – and consumers need to pay for this in the form of higher prices for dairy products, else the cattle will stay inside
- predator control, temporary at least, but probably permanent – whether we like it or not, as ignoring this may be the end of the waders

and: we need all these measures at the same time!

Further information can be found at:

Clausen, P., Hounisen, J.P., Asferg, T., Thorup, O., Nielsen, H.H. & Vissing, M.S. 2016. Ynglefugle i Tøndermarsken og Margrethe Kog 1975-2014. En evaluering af effekt af en intensiveret ræve-bekæmpelse på antallet af ræve og ynglefugle, eksempler på optimeret engfugleforvaltning og anbefalinger til forvaltningstiltag. DCE – Nationalt Center for Miljø og Energi, 84 s. – Videnskabelig rapport fra DCE - Nationalt Center for Miljø og Energi nr. 160.

Clausen, P. & Kahlert, J. (Eds.) 2010: Ynglefugle i Tøndermarsken og Margrethe Kog 1975-2009. En analyse af udviklingen i fuglenes antal og fordeling med anbefalinger til forvaltningstiltag. Danmarks Miljøundersøgelser, Aarhus Universitet. - Faglig rapport fra DMU nr. 778, 206 s. http://www2.dmu.dk/pub/fr778.pdf

Damm to Hallig Nordstrandischmoor Photo: LKN-SH, National-parkverwaltung, R. Kruse

Predation management in the SPA "Unterelbe"

Uwe Andreas, Germany

The SPA "Unterelbe", Lower Saxony, Germany, hosts high numbers of the Lower Saxonian breeding populations of black-tailed godwit (10%), common redshank (5%) and northern lapwing (5%). In the years before predation risk management, numbers of northern lapwing and black-tailed godwit were going down and predation of clutches was at 100%.

A predation risk management project was initiated, and a group was formed to implement management actions. The set-up of this group can be seen below:

A professional hunter and the SPA wardens mainly manage the close cooperation between administration and private hunters. They organise government financed traps and artificial dens for private hunters and offer guidance and advice on setting the traps. They also assist with monitoring active traps if needed.

Private hunters involved are expected to help with installing the traps and keeping them activated between 16 June and 28 February. They also need to log their trapping activities continuously for evaluating the effort that is needed to trap red foxes.

The total hunting bag per year is dominated by red foxes; however it also contains significant numbers of beech marten, raccoon dog, Eurasian polecat and Eurasian badger.

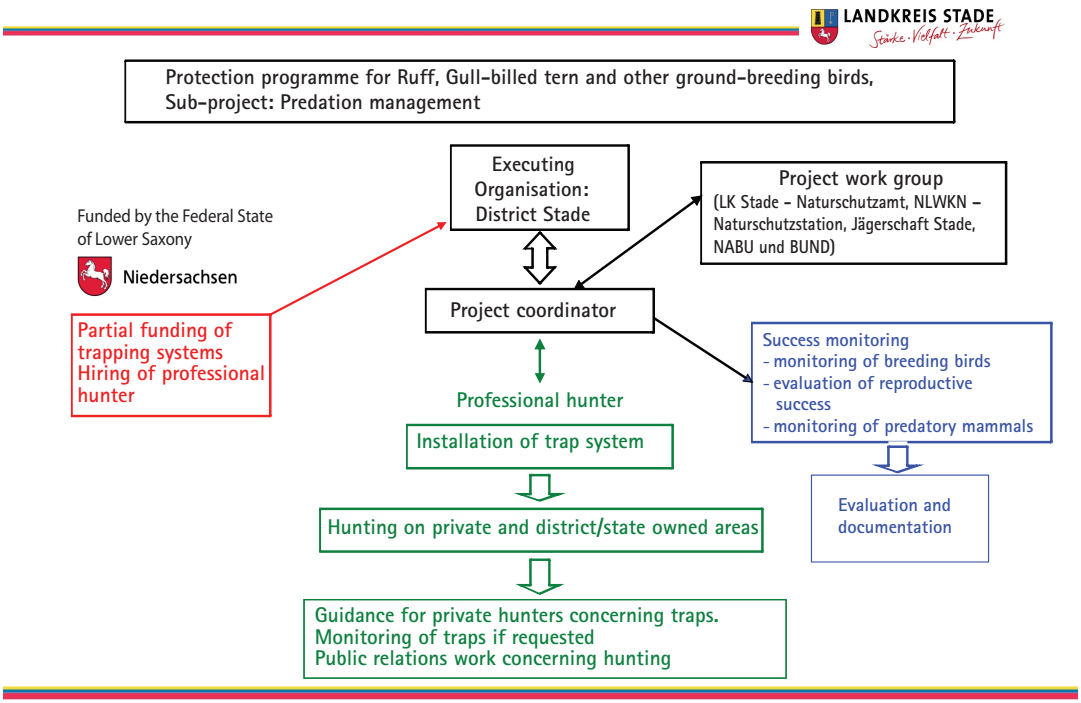
The reproductive success of ground-nesting birds within the study area has increased since taking up predation risk management.

Experiences with predation management in the Beltringharder Koog and other embanked areas

Walther Petersen-Andresen, Germany

The Beltringharder Koog area, Schleswig-Holstein, Germany, was embanked in the mid 1980s and became a nature reserve in 1991. Since 2000, there has been a planned program of hunting of the meadow birds' main predators, red foxes and raccoon dogs. The nature reserve is managed for ground-nesting meadow birds and the area is closed to the general public. The nature reserve is a very important breeding site for ringed and Kentish plovers. Predation risk management includes hunting, baiting, artificial dens and traps.

Meadow bird numbers have responded well to predation risk management measures. Numbers of breeding birds have remained stable. Predation risk management activities have been successfully implemented in similar habitats.



Talk 8 & 9

Predation management on the Baltic coast of Schleswig-Holstein

Hermann Hötker, Heike Jeromin, Kai-Michael Thomsen, Germany

The aim of the study was to review actual predation risk and predation risk management in reserves on the Baltic coast of Schleswig-Holstein, Germany. Focal area was the bird sanctuary of Graswarder, Schleswig-Holstein, Germany, where breeding success of ground-nesting birds has been low. Red foxes were identified as main predators, but in many incidents predator species remained unknown. Possible ways to manage predation risk were suggested.

Interviews with site managers and experts at various reserves along the Baltic coast established that predators had a highly negative impact on bird breeding success. Predation risk management was implemented at 13 sites (8 sites using non-lethal methods, 5 using hunting). 4 sites had no predation risk management in place. A wide range of predators was identified, including mammals and birds, with main predators being red foxes.

Non-lethal methods included installing electric and non-electric fences, fences in ditches, habitat alterations such as e.g. the creation of breeding islets, and deterrence. Fencing had a positive impact, but it required resources for permanent surveillance and maintenance. This was particularly the case with fences built into water, where constant work was required to negate the effects of waves and moving sand to keep the fence effective. The types of fences differed and predator specific precautions were required, e.g. extra protection to exclude hedgehogs and extra measures to prevent digging under the fence. Overall, additionally creating an open landscape seemed important in order to reduce predation risk.

Conclusion of the interviews:

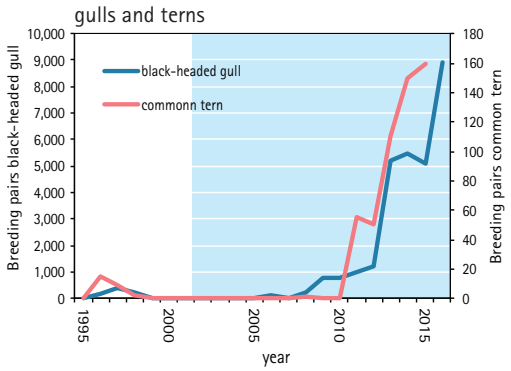
- Predation had an impact on breeding success in many sites.
- The main predators were Red foxes.
- The effects of fences varied between sites.
- Permanent surveillance and repair at least once a year were obligate.
- Openess of the site seemed to reduce predation.
- Fencing often had a positive impact, sometimes only if in combination with hunting.

Experiences with predation management on breeding sites of coastal breeding birds in the German Baltic

Frank Joisten, Christof Herrmann, Germany

In 2006, the Federal State of Mecklenburg-Western Pomerania, Germany, adopted a management strategy for predatory mammals in coastal bird sanctuaries. The aim was to exclude predatory mammals such as red fox, mink, raccoon dog, marten and European polecat, but also wild boar Sus scrofa. The focus was to exclude predators from sensitive areas on a local scale; it was not to control predator population levels at a larger scale.

To prioritize management actions, sites were classified into three categories: Category 1 was sites with high priority and need for managing predatory mammals. Category 2 was sites experiencing high predation rates but where intervention was likely to have only limited success. Category 0 included sites without management needs, i.e. sites currently without significant bird populations and without a real chance of restoring their past importance.



Figures right: Success of the management of predatory mammals on islands, e.g. Riether Werder:

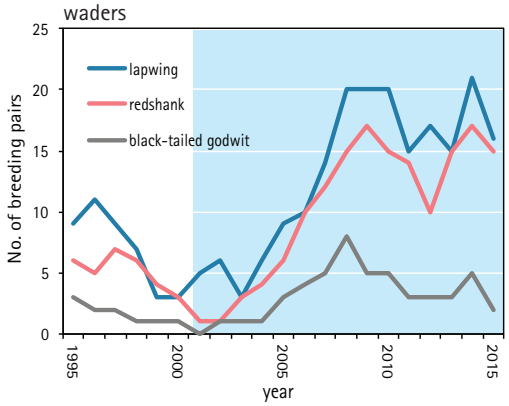


Figure left:
Success of the management of predatory mammals on islands, e.g. Riether Werder:

Measures to manage predation risk included hunting, habitat alterations to make life more difficult for predators, and fencing.
Management measures have been successful and ground-nesting bird numbers have increased again.

Predation management on the East Frisian islands Norderney, Borkum and Langegoog – possibilities and limitations

Hartmut Andretzke, Gundolf Reichert, Germany

Predation risk management has been implemented on three East Frisian islands of Lower Saxony, Germany, to reduce predation rates and to improve breeding success of ground-nesting birds.

Overall requirements for predation risk management are: (1) the identification of predators, (2) the definition of goals, (3) legal requirements, (4) the realization of possibilities, (5) monitoring success, (6) identifying socio-political parameters, and (7) secure financial resources.

The islands of Borkum, Norderney and Langeoog each have their own suite of predators that have an impact ground-nesting birds: e.g. ferrets were significant on Norderney, hedgehogs were causing problems on both Norderney and Borkum, red foxes were impacting on breeding birds on Norderney, feral cats and brown rats potentially played an important role on Borkum and Langeoog.

Predation risk management was presented for hedgehogs on Borkum was presented as an example. Successful measures to manage hedgehogs included trapping, spotlighting and hedgehog detection dogs. These dogs search areas systematically at night and indicate when they find hedgehogs. The animals are then collected and transferred from Borkum to the mainland coast.

Hatching success has gone up following the predation risk management program. Yet there are limitations, such as the size of the areas managed, and human settlements. Moreover, predators removed from a core breeding area to another part of the island may be able to re-immigrate again. Human activities could also lead to a (re) introduction of predators such as e.g. feral ferrets and cats to the island.

Merlin with Kentish Plover meat, Fanø, Denmark
Photo: Kim Fischer

Talk 11

Trying to keep predators out: Predation and measures on Hallig Oland after reinforcing the dam to the mainland coast, SH

Stefan Schrader, Maria Schiffler, Karsten Lutz, Germany

A dam that connects Hallig Oland and Hallig Langeness to the mainland was reinforced in 2006-2010. Before reinforcement, the dam was at mean high tide level and the work raised it by 0.5 m. This improved the accessibility for predators. Flooding of the dam has dropped from 350 to 50 events per year, while increased sedimentation and thus a rapidly growing salt marsh along the dam has proven to be the more important driver for predator access to the Halligen. The dam and the adjacent salt marshes offer ample opportunities for predators to reach Hallig Oland, and even smaller stretches of soft mud flats or gullies are regularly being crossed.

An environmental impact assessment looked at the potentially enhanced accessibility of the Halligen for ground predators. Permission to raise the dam height was given on the condition that mitigation measures would be undertaken. These mandatory measures included the construction of a fox barrier, collecting bird carcasses from the driftline to avoid attracting mammal predators, and developing further measures if if the initial ones proved insufficient. There was a further obligation, to monitor the breeding bird populations on Hallig Oland.

Hallig Oland is an important breeding site for Eurasian oystercatcher, common gull but also Eurasian spoonbill. Evidence of the growing impact of predation on breeding success has been observed. Until 2008 there were very few hints that mammalian predators had an impact on ground-nesting birds. However, since 2013 predators have inflicted severe losses on breeding birds. Predators have been recorded using camera traps, albeit with limited success. A systematic search for tracks has been more informative. Main mammal predators identified have been red fox and beech marten.

Yet, although predators cause high losses of clutches in some years, still about 10% of the German breeding population of Eurasian oystercatcher is breeding on Hallig Oland, with a potentially very high breeding success. For this reason, measures have been taken to reduce the impact of predators on ground-nesting birds.

Measures taken include installing "fox barriers" along the dam, i.e. structures that red foxes do not like to cross like. This has included setting rail tracks on sheet pilings and installing metal grids, as well as removing structures that can help the foxes circumvent the above mentioned measures. Over the years, the fox barrier has been optimized several times. Additionally, in 2015 a small creek was formed to alter sedimentation and the growth of the saltmarsh adjacent to the dam. Further measures included hunting of red foxes using various stationary and mobile traps, and battue, both on the Hallig and on the adjacent mainland coast. Additionally, hunting of the source population on the mainland coast has increased.

These measures have the potential to improve the breeding situation on the Hallig, yet a high personal and maintenance effort is needed. Additionally, legal rules, i.e. prohibiting hunting during the birds' breeding season, cause difficulties at times, as taking out individual red foxes can be extremely beneficial for breeding birds during these times.

Damm zur Hallig Oland
Photo:LKN-SH, Nationalparkverwaltung,
B. Hälterlein

Protection of the gull-billed tern colony at the Elbe-saltmarshes Neufelderkoog against mammalian predators

Markus Risch, Germany

Gull-billed terns are threatened by extinction in north western Europe. For this reason, a species conservation project has been running since 2011 to protect the last remaining breeding pairs on the Wadden Sea coast. Numbers have gone down from almost 500 pairs in the 1940s to nowadays less than 50. One of the main threats has been predation.

Fencing has been installed to protect gull-billed terns against mammalian predators. Each year, electric fences have been erected to protect the core of the breeding colony. Traps have been installed along the fence. Despite this, some adult birds have been killed in some years by mammals, probably European polecat, mink or stoat.

Since the beginning of the conservation project, numbers of fledging gull-billed terns have increased, while the number of breeding pairs has remained stable. Fencing has been shown to have a positive effect on the breeding success, but fences are not 100% effective against smaller mammals.

The large red fox source population living nearby poses main challenges for a successful management of predation risk. Consequently, managing predators on a confined local level is hardly efficient when there is apparent unlimited potential for new individuals to immigrate into the gull-billed tern breeding site.

Detailed results of this project have been published in the following article (German with English summary): Risch, M., W. Denker, H. Förster, K. Günther, B. Hälterlein, V. Hennig, C. Herden, I. Mauscherning, A. Miehe & C. Wiedemann (2018): Lachseeschwalben Gelochelidon nilotica in Dithmarschen – die letzte Kolonie Mitteleuropas. Corax 23: 412 - 439.

Do electrical fences protect coastal wetlands for predation: examples from the Groningen coast, NL

Peter de Boer, Kees Koffijberg, The Netherlands

There has been a strong decline of breeding pied avocets along the Dutch Wadden Sea coast.

Setting up electric fences has helped to increase nesting success of pied avocets, yet the installation of an electric fence seems to have only short-term effects so regular improvement of the fence is needed. Various projects have revealed that either predators learn to overcome the fence, or that the original fence design has failed to repel new predators. Improvements and alterations to the fence, e.g. the setting up of a permanent fence along the entire breeding site (see picture), have led to an increase in nesting success again, yet this increase seemed to level out when the modified fence had been in place for some years. Further alterations are potentially required.

Setting up a permanent fence in 2014 (entire area of 17 ha)

Yet, even if using electric fences has improved nesting success, the numbers of chicks fledged stayed low, i.e. breeding success has not (yet) increased.

Summary of the talks

Predation, especially by red fox and other mammalian ground predators, **has a significant impact on ground-breeding bird numbers and breeding success**. Predation management has been in place in all cases, ranging from non-lethal methods, such as fencing, to lethal control.

All methods of managing predation risk are labour intensive and require dedicated people to implement, run and maintain e.g. traps and fences. In particular, fences which seem very efficient at first are likely to lose their effectiveness over time when predators find ways to get around them. Consequently, regular improvements and alterations to the fencing system are needed. It is crucial to be aware that fences need to be maintained throughout the season so they do not lose their effectiveness. This is very labour intensive.

Lethal control can be very effective, too, yet **the timing of hunting activities seems crucial** for success. Hunting activities in autumn and winter merely act at a time when natural mortality is high. As a consequence, they will not have a permanent effect on the population level. Fox populations could be more effectively regulated by hunting in spring, when foxes reproduce and new offspring eventually enter the population. Managing foxes during this time would be most beneficial for the breeding birds in this season. Because red foxes are territorial and relatively stationary at this time of the year, there is a good chance that a cleared territory will stay vacant for some time. At the least, a new occupier is unlikely to have offspring which in turn would reduce the need for food and hence, predation pressure. However, in some areas legal requirements prohibit hunting in and taking out territorial, reproducing individuals. Like the implementation of non-lethal methods, lethal control needs to be carried out each year or even several times in one season, and is thus very labour intensive.

Improving breeding habitat, preferably at a large scale, seems to have the most sustainable effect on improving breeding success. Habitat alterations should focus on helping ground breeding birds to "self help". Managing water levels seems to be a crucial factor to provide sufficient food resources for wader chicks. Non-intensive, low-profit farming activities such as cattle grazing at low densities or haymaking provide suitable habitat for breeding waders. Improving habitats by removal or reduction of vegetation preferred by predators or to attract alternative prey for them might also help in reducing predation pressure on ground-nesting birds.

The outcomes of the subsequent discussion are summarized and supplemented in the following section

Fox track
Photo: Klaus Günther

When facing a situation in which predation is thought to have a significant impact on breeding bird numbers, conservation interventions might be in order to reduce this impact. Such interventions include habitat management, excluding or removing predators and other.

The following decision tree is based on Bolton *et al.* 8. Following this decision tree will help to answer the following questions:

- Is there a need to take up conservation interventions to reduce predation rates?
- How to successfully mitigate or even avoid predation on ground-nesting birds?

1. Monitoring breeding success

The first step should be to establish whether nest survival or breeding success is poor in the respective area/site. If this question cannot be answered, then data on nest survival and breeding success should be collected and analysed. The Joint Monitoring of Breeding Birds (JMBB) has published a field manual on how to monitor breeding bird numbers 9 and their breeding success 10-12. If this question is answered with 'yes', the following question will be whether the area/site is an important breeding site or not.

2. Is the site of concern an important breeding refuge? Is the local breeding population a source population?

In "sink" populations, within-habitat reproduction is insufficient to balance the local mortality. Populations may nevertheless persist in such habitats,

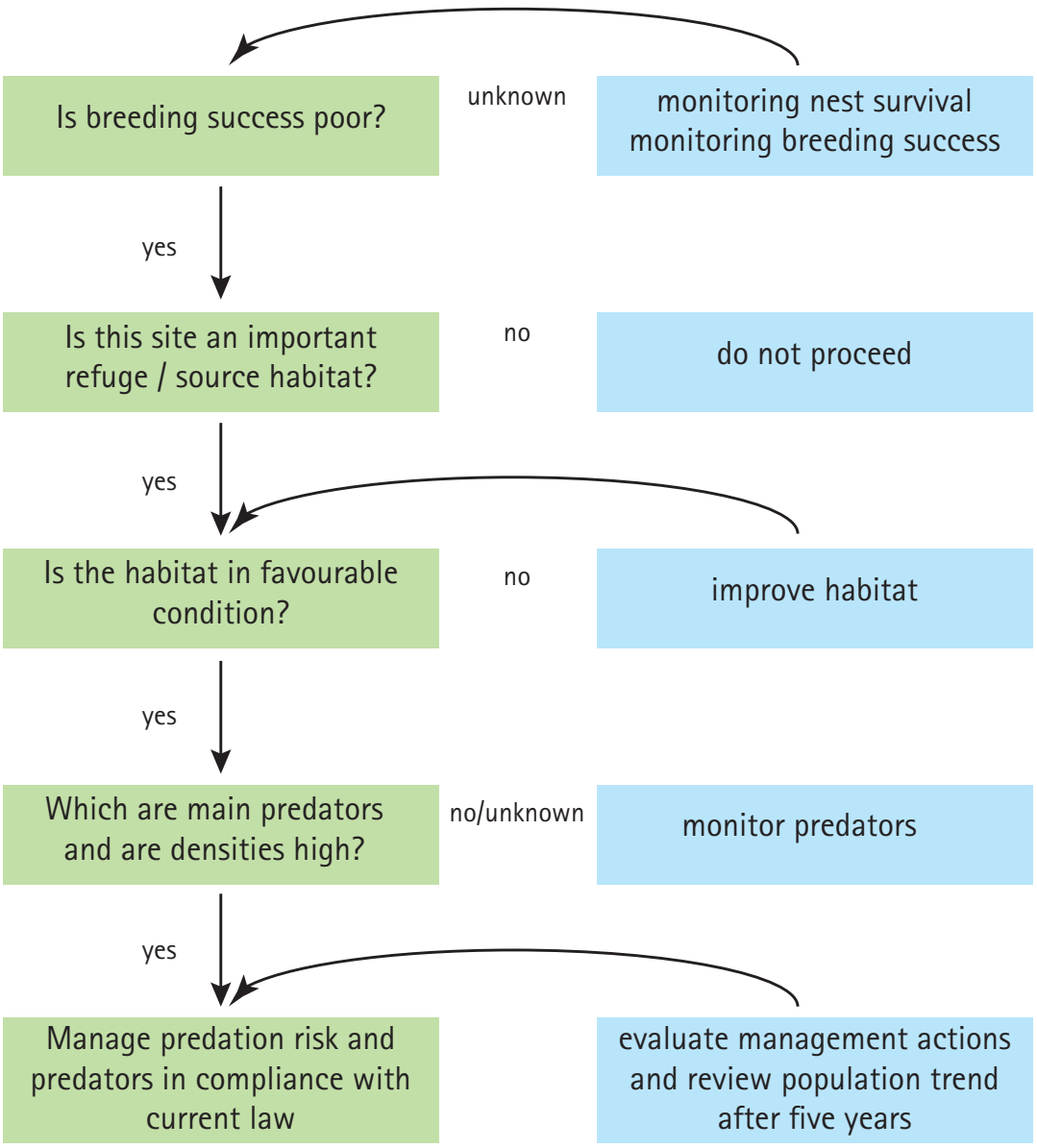


Figure left:
Decision tree on whether or not conservation interventions should be taken up to counteract the impact of predation on the breeding success of ground-nesting birds, adapted8.

especially when they are locally maintained by continuous immigration from more productive "source" populations nearby 13,14. Identifying source populations can be crucial when taking decisions as to where and when to become active in managing predation risk.

Source populations can e.g. often be found on islands, where predation pressure by ground predators naturally should be low or even negligible 7,15. Islands, Halligen and sandbanks thus are highly important breeding refuges for ground breeding bird species, hence implementing management actions there to reduce predation risk should have top priority. Consequently, keeping islands predator-free is an important prerequisite to maintain their special status as refuge habitats (or safe havens) for ground-nesting birds. In fact, predator control there will be more effective than at the mainland coast, where vacant territories of predators will be filled-in again by "floaters" coming from areas behind the seawall.

Yet that is not to say that breeding sites on the mainland coast are less important. Common redshanks breeding in mainland saltmarshes e.g. might still find excellent nesting and foraging conditions 16 and managing ground predators might transform a sink population into a source population. The Beltringharder Koog currently hosts the largest breeding colony of Kentish plovers in the Wadden Sea 17. Given the Kentish plover's precarious status elsewhere in the Wadden Sea, intensive predation management measures seem to be crucial. Similarly, e.g. managing predation pressure in a colony of common terns and gull-billed terns on the mainland coast of Neufeld, Dithmarschen should be a priority with respect to protecting a highly threatened species18,19.

3. Is the habitat in favourable condition?

Managing habitat is important in two ways:

- Providing good feeding conditions for birds is crucial.
- And, making habitat less attractive for predators can cut predator abundance and hence predation risk 20,21,22. Currently, there are also studies on the potential benefits of improving habitat for alternative prey for predators to ease predation pressure on the birds 23,22,24.

Special attention should be paid to islands that (inadvertently?) have been made accessible for ground predators by human interaction, like the improved barrier dams to Hallig Oland, Schleswig-Holstein. This "improvement" has led to an increasing occurrence of red foxes, beech martens and others, causing local breeding bird populations to fail to breed. This is especially dire as even today, despite a high predation pressure, the Halligen still host significant proportions of several breeding bird species, e.g. breeding Eurasian oystercatcher.

In contrast to managing (regulating) predators directly, improving habitat condition holds several benefits: it provides good nesting sites and good feeding conditions for birds, and potentially reduces predator abundance. Its effects are long-term. However, managing habitat can be at odds with existing conservation concepts: e.g. in the German part of the Wadden Sea, national parks' guidelines require natural processes to take place without human intervention. This conflicts with any policy of management activities that aims to alter habitat features permanently. So-called wilderness areas allowing for free succession might impede management activities that e.g. aim at preserving primarily open landscapes that are needed by ground–nesting birds. However, most breeding bird species are listed under the EU Birds Directive and most breeding areas are part of the Natura 2000 network, with specific regulations concerning the conservation of ground-nesting birds.

4. Which are the main predators and are densities high?

Predators affecting ground-nesting birds can be grouped into ground predators, mostly mammals, and aerial predators. Knowledge on the impact and species of a predator is needed in order to decide which management actions to choose. Equally important are data on abundance and densities of main predators, as management options might differ when dealing with single or numerous, transient or territorial predators.

Camera traps near nests can help to identify predators and their impacts at a given site 25. And so do other indicators, e.g. bite marks on eggs or tracks on the ground 20,21. Radio-tagging 26,27 is an efficient tool to follow and monitor the fate of chicks. Observations on hatching success are relatively easy to collect, but when it comes to estimating the influence of predators on breeding success, data are hardly available. Estimating predator densities can be quite straightforward when dealing with avian predators that mostly breed in the adjacent vicinity. Yet, when it comes to ground (mammalian) predators, estimating densities is difficult.

Generally, the red fox seems to be an important

predator in almost all case studies presented during the workshop. Yet, there are also other mammal predators, including raccoon dog, European badger, beech marten, mink, European polecat and others. Estimating densities of red fox is extremely challenging, estimating densities of the others is almost impossible if no in-depth approach and thorough monitoring protocols are put into place. Knowledge of predator behaviour is vital if management actions are to be successful. There are valuable studies on red fox behaviour from The Netherlands (see this report), and there is an ongoing study in the Schleswig-Holstein Wadden Sea (see this report). Such studies should be continued and expanded, in other areas and to other species, as their results will provide the base for successful management actions.

Overall, aerial predators appear to have less impact than mammalian ground predators, yet data to quantify their real influence (see this report) are extremely scarce. Contrary to mammalian ground predators, the majority of aerial predators is listed as protected, and management actions to control their abundances and thus their impact are limited. Yet, there are also protected species amongst the mammalian ground predators, e.g. hedgehogs (see this report). Finding and exploring different ways to counteract the high impact of predators (including aerial predators) on ground-nesting birds, both effectively and legally, is a challenge that should be taken up now.

5. Manage predation risk and predators in compliance with current law

There are numerous ways to manage (reduce) predation risk: landscape (habitat) alterations, excluding predators, scaring off predators, controlling predators.

a. Habitat alterations

As described above, habitat (or landscape) alterations are likely to have long-term effects. They can either aim to improve conditions for nesting birds in terms of improving nesting habitat and foraging conditions for chicks 28,29,16,15, or they can aim to make habitat less welcoming to predators by e.g. removing linear structures to prevent birds of prey or corvids breeding in the near vicinity. Removing structures where ground predators like to build dens can help to reduce predator abundance in an area. As mentionend earlier, minimizing the number of artifical structures (e.g. dams) that can form land bridges to islands can effectively reduce the occurrence of ground predators on those islands. At times, conservation aims may lead to the use of controversial techniques, e.g. installing nesting boxes for peregrine falcon in important ground-nesting bird areas. A thorough planning and consultation process is needed to discuss integrated management plans for areas of such importance.

Habitat alterations are expensive, labour intensive and invasive, but have a long-term effect.

b. Excluding predators

A highly effective way to exclude predators from a nest or a nesting area is to set (electric) fences 30,19. Yet, maintaining electric fences is necessary, costing time and other resources. Fencing out predators is very effective, but predators seem to become used to fences and a race of arms has to start if one wants to stay on top (this report). Electric fences do help against larger ground predators but are ineffective against airborne predators.

Single nest cages, as used for e.g. common ringed plovers, might help against aerial predators, but reports reveal that they just as easily become traps for the very birds that they were designed to protect.

Excluding predators is labour intensive and therefore potentially expensive, it is not invasive, and has a short- to mid-term effect. When fences are regularly altered and improved, the effect can also become long-term.

c. Scaring off predators

Scaring off predators might be done using olfactory agents, noise or light. So far, there is no scientific evidence that these measures are effective. Scaring off predators is potentially labour intensive, and only effective in the short term.

d. Controlling predators

Controlling predators usually includes lethal methods. Shooting and thus removing them from the site/population is effective, but only as long as the newly cleared territory is not occupied immediately again (but also see earlier in this report on the potential benefits of removing territorial individuals at certain times of the year).

Lethal control of aerial predators is mostly illegal as nearly all are protected for conservation reasons. However, there is open season for crow and herring gull in Denmark.

Mammalian ground predators are mostly subject to national and regional shooting rights. A large-scale reduction of ground predator populations by hunting is highly unlikely. Hence, lethal predator control will mostly take place at a local level. Taking out ground predators from local territories is only effective if the newly vacant territories are not occupied immediately again. For this measure to work well, detailed knowledge is

needed on how territories are distributed and how individuals move within and between territories. There is evidence that, when it comes to e.g. red fox, taking out individuals at the correct time can buy time for ground-nesting birds and thus stabilize breeding success (this report). Very often, the timing of such a conservation interaction will be at odds with shooting rights as the avian and mammalian breeding seasons coincide.

Lacking also is scientific knowledge on e.g. territory sizes, densities and behaviour of ground predators. Such knowledge is urgently needed to guide conservation management decisions. Care has to be taken when interfering with ecological, trophic networks. Taking out top predators such as red fox from within a food web may interfere with the network and result in increasing abundances of other, more difficult to control predators.

e. Comparing approaches

	management options		
	predator control	predator exclusion	landscape management
reaction time			
duration of action[1]			
costs[2]			

 reaction time is immediate, duration of action is long-term

 reaction time is not immediate, costsare not low (but see[2])

 duration of action is short-term (but see[1]), costs are potentially high

[1] if predator control and predator exclusion are carried out one time only, then duration of action is potentially very short-term, i. e. one season

[2] if predator control and predator exclusion are carried outover several years, then staff costs will be not low

What is lacking? What does it need?

The workshop has identified that ways to work efficiently and effectively within the framework of "shooting rights – conservation issues – animal rights" are limited and need to be improved. Evidently, animal rights are to be respected and there is a legal, and certainly moral issue when it comes to e.g. lethally controlling reproducing female mammals, resulting in their offspring lying motherless in an undiscovered den. Modern technology (e.g. GPS transmitters) can help to find solutions to this issue, enabling operatives to locate the offspring in time.

The workshop further identified that what is often lacking is the political will to apply existing law, or to change laws accordingly. Also lacking is well-thought-through, informative public relations work to win the understanding and approval of the general public, which is always very important when it comes to applying lethal methods to control predators.

There is also a lack of conservation managers, i.e. professional hunters or wildlife managers. These managers should coordinate predation management strategy at a regional level and be responsible for overseeing predation risk projects more locally and within specific breeding sites, on a long-term basis.The workshop concluded that a promising set-up for successful predation management might be a collaboration among (private, volunteer) hunters, researchers, site managers and nature conservationists. This requires coordination which could be done by such a conservation manager. For this to happen, managing predation risk needs to be lodged on the agenda of a state's administration for nature conservation. This is vital to secure sufficient funding for the long-term implementation of area-wide predation management policies and specific measures to deal with local and site-specific situations.

Literature cited

1. Koffijberg, K, K Laursen, B Hälterlein, G Reichert, J Frikke & L Soldaat (2015) Trends of Breeding Birds in the Wadden Sea 1991 - 2013. Page Common Wadden Sea Secretariat, Joint Monitoring Group of Breeding Birds in the Wadden Sea, Wilhelmshaven, Germany.
2. Thorup, O & K Koffijberg (2016) Breeding success in the Wadden Sea 2009 - 2012. A review., Page Common Wadden Sea Secretariat, Wilhelmshaven, Germany.
3. BirdLife International (2017) European birds of conservation concern: populations, trends and national responsibilities. Page BirdLife International, Cambridge, UK.
4. Koffijberg, K, J Frikke, B Hälterlein, G Reichert & H Andretzke (2016) Breeding birds in trouble: A framework for an action plan in the Wadden Sea. Common Wadden Sea Secretariat, Wilhelmshaven.
5. Ausden, M, M Bolton, N Butcher, DG Hoccom, J Smart & G Williams (2009) Predation of breeding waders on lowland wet grassland—Is it a problem? British Wildlife 21, 29.
6. Hötker, H & A Segebade (2000) Effects of predation and weather on the breeding success of Avocets Recuvirostra avosetta. Bird Study 47, 91-101.
7. Thyen, S & K-M Exo (2003) Wadden Sea saltmarshes: Ecological trap or hideaway for breeding Redshanks Tringa totanus? Wader Study Group Bulletin 100, 43-46.
8. Bolton, M, G Tyler, K Smith & R Bamford (2007) The impact of predator control on lapwing Vanellus vanellus breeding success on wet grassland nature reserves. Journal of Applied Ecology 44, 534-544.
9. Hälterlein, B, DM Fleet, HR Henneberg, T Mennebaek, RL M, P Südbeck, O Thorup & RL Vogel (1995) Guidelines for monitoring breeding birds. Page, Wilhlemshaven.
10. Koffijberg, K, S Schrader & V Hennig (2011) TMAP Manual breeding success, 2nd version 2011. Common Wadden Sea Secretariat, Wilhelmshaven 46.
11. Thyen, S, PH Becker, K-M Exo, B Hälterlein, H Hötker & P Südbeck (1998) Monitoring breeding success of coastal birds. Wadden Sea Ecosystem 8, 7-55.
12. Thyen, S, PH Becker, K-M Exo, B Hälterlein, H Hötker & P Südbeck (2000) Bruterfolgsmonitoring bei Küstenvögeln im Wattenmeer 1996 und 1997. Vogelwelt 121, 269-280.
13. Pulliam, HR (1988) Sources, sinks, and population regulation. The American Naturalist 132, 652-661.
14. Pulliam, HR & BJ Danielson (1991) Sources, sinks, and habitat selection: a landscape perspective on population dynamics. American Naturalist 137, S50-S66.
15. Thyen, S, H Büttger & K-M Exo (2005) Nistplatzwahl von Rotschenkeln Tringa totanus im Wattenmeer: Konsequenzen für Reproduktion, Prädation und Salzrasen-Management. Vogelwelt 126, 365-369.
16. Thyen, S & K-M Exo (2005) Interactive effects of time and vegetation on reproduction of redshanks (Tringa totanus) breeding in Wadden Sea salt marshes. Journal of Ornithology 146, 215-225.
17. Cimiotti, DV, M Ave, H Hoffmann, J Leyrer, B Klinner-Hötker, R Schulz & H Hötker (2016) Möglichkeiten zum Erhalt der Brutopulation des Seeregenpfeifers in Schleswig-Holstein. Page, Bergenhusen.
18. Hennig, V, R Heinig, L Mendel & E Tilse (2016) Flussseeschwalben (Sterna hirundo L.) und Stinte (Osmerus eperlanus L.) in der Elbmündung - Die einzigartige Bestandsentwicklung und Nahrungsökologie der größten deutschen Flussseeschwalbenkolonie. Corax 23, 87-113.
19. Risch, M, W Denker, H Förster, K Günther, B Hälterlein, V Hennig, C Herden, I Mauschern-ing, A Miehe & C Wiedemann (2018) Lachseeschwalben Gelochelidon nilotica in Dithmarschen – die letzte Kolonie Mitteleuropas. Corax 23, 412-439.
20. Laidlaw, R, J Smart, M Smart & J Gill (2013) Managing a food web: impacts on small mammals of managing grasslands for breeding waders. Animal Conservation 16, 207-215.
21. Laidlaw, RA, J Smart, MA Smart & JA Gill (2015) The influence of landscape features on nest predation rates of grassland-breeding waders. Ibis 157, 700-712.
22. Laidlaw, RA, J Smart, MA Smart & JA Gill (2017) Scenarios of habitat management options to reduce predator impacts on nesting waders. Journal of Applied Ecology 54, 1219-1229.

23. Bertholdt, NP, JA Gill, RA Laidlaw & J Smart (2017) Landscape effects on nest site selection and nest success of Northern Lapwing Vanellus vanellus in lowland wet grasslands. Bird Study 64, 30-36.

24. Smart, J (2016) A question of scale – from nature reserves to landscape-scale conservation. Wader Study 123, 81-83.

25. Salewski, V & L Schmidt (2016) Beeinflussen Nestkameras den Schlupferfolg von Uferschnepfen Limosa limosa. Bericht Vogelwarte Hiddensee 23, 47-57.

26. Mason, LR, J Smart & AL Drewitt (2018) Tracking day and night provides insights into the relative importance of different wader chick predators. Ibis 160, 71-88.

27. Salewski, V & J Schütze (2016) Bruterfolg von Uferschnepfen an der Westküste Schleswig-Holsteins - ein Methodenvergleich. Vogelwarte 55, 187-198.

28. Eglington, SM, JA Gill, M Bolton, MA Smart, WJ Sutherland & AR Watkinson (2008) Restoration of wet features for breeding waders on lowland grassland. Journal of Applied Ecology 45, 305-314.

29. Eglington, SM, JA Gill, MA Smart, WJ Sutherland, AR Watkinson & M Bolton (2009) Habitat management and patterns of predation of Northern Lapwings on wet grasslands: the influence of linear habitat structures at different spatial scales. Biological Conservation 142, 314-324.

30. Malpas, LR, RJ Kennerley, GJ Hirons, RD Sheldon, M Ausden, JC Gilbert & J Smart (2013) The use of predator-exclusion fencing as a management tool improves the breeding success of waders on lowland wet grassland. Journal for Nature Conservation 21, 37-47.

Young red fox
Photo: John Frikke

List of relevant literature

Ausden, M., Bolton, M., Butcher, N., Hoccom, D. G., Smart, J., & Williams, G. (2009). Predation of breeding waders on lowland wet grassland—Is it a problem? British Wildlife, 21, 29.

Baines, D. (1990). The roles of predation, food and agricultural practice in determining the breeding success of the lapwing (Vanellus vanellus) on upland grasslands. The Journal of Animal Ecology, 915–929.

Bellebaum, J., & Bock, C. (2009). Influence of ground predators and water levels on Lapwing Vanellus vanellus breeding success in two continental wetlands. Journal of Ornithology, 150, 221–230.

Berg, Å., Lindberg, T., & Källebrink, K.-G. (1992). Hatching success of lapwings on farmland: differences between habitats and colonies of different sizes. Journal of Applied Ecology, 61, 469–476.

Bertholdt, N. P., Gill, J. A., Laidlaw, R. A., & Smart, J. (2017). Landscape effects on nest site selection and nest success of Northern Lapwing Vanellus vanellus in lowland wet grasslands. Bird Study, 64, 30–36.

Bolton, M., Tyler, G., Smith, K. E. N., & Bamford, R. O. Y. (2007). The impact of predator control on lapwing Vanellus vanellus breeding success on wet grassland nature reserves. Journal of Applied Ecology, 44, 534–544.

Brown, C. R. (2016). The ecology and evolution of colony-size variation. Behavioral Ecology and Sociobiology, 70(10), 1613–1632. doi:10.1007/s00265-016-2196-x

Cervencl, A., Esser, W., Maier, M., Oberdiek, N., Thyen, S., Wellbrock, A., & Exo, K.-M. (2011). Can differences in incubation patterns of Common Redshanks Tringa totanus be explained by variations in predation risk? Journal of Ornithology, 152, 1033–1043.

Clausen, P., Hounisen, J.P., Asferg, T., Thorup, O., Nielsen, H.H. & Vissing, M.S. 2016. Ynglefugle i Tøndermarsken og Margrethe Kog 1975-2014. En evaluering af effekt af en intensiveret rævebekæmpelse på antallet af ræve og ynglefugle, eksempler på optimeret engfugleforvaltning og anbefalinger til forvaltningstiltag. DCE – Nationalt Center for Miljø og Energi, 84 s. – Videnskabelig rapport fra DCE - Nationalt Center for Miljø og Energi nr. 160.

Clausen, P. & Kahlert, J. (Eds.) 2010: Ynglefugle i Tøndermarsken og Margrethe Kog 1975-2009. En analyse af udviklingen i fuglenes antal og fordeling med anbefalinger til forvaltningstiltag. Danmarks Miljøundersøgelser, Aarhus Universitet. - Faglig rapport fra DMU nr. 778, 206 s. http://www2.dmu.dk/pub/fr778.pdf

Cimiotti, DV, M Ave, H Hoffmann, J Leyrer, B Klinner-Hötker, R Schulz & H Hötker (2016) Möglichkeiten zum Erhalt der Brutopulation des Seeregenpfeifers in Schleswig-Holstein. Page, Bergenhusen.

Eglington, S. M., Gill, J. A., Bolton, M., Smart, M. A., Sutherland, W. J., & Watkinson, A. R. (2008). Restoration of wet features for breeding waders on lowland grassland. Journal of Applied Ecology, 45, 305–314.

Eglington, S. M., Gill, J. A., Smart, M. A., Sutherland, W. J., Watkinson, A. R., & Bolton, M. (2009). Habitat management and patterns of predation of Northern Lapwings on wet grasslands: the influence of linear habitat structures at different spatial scales. Biological Conservation, 142, 314–324.

Eglington, S. M., Bolton, M., Smart, M. A., Sutherland, W. J., Watkinson, A. R., & Gill, J. A. (2010). Managing water levels on wet grasslands to improve foraging conditions for breeding northern lapwing Vanellus vanellus. Journal of Applied Ecology, 47, 451–458.

Evans, K. L. (2004). The potential for interactions between predation and habitat change to cause population declines of farmland birds. Ibis, 146, 1–13.

Gibbons, D. W., Amar, A., Anderson, G., Bolton, M., Bradbury, R. B., Eaton, M. A., ... Wilson, J. D. (2007). The predation of wild birds in the UK: a review of its conservation impact and management. Sandy: RSPB.

Hälterlein, B, DM Fleet, HR Henneberg, T Mennebaek, RL M, P Südbeck, O Thorup & RL Vogel (1995) Guidelines for monitoring breeding birds. Page, Wilhlemshaven.

Hennig, V, R Heinig, L Mendel & E Tilse (2016) Flussseeschwalben (Sterna hirundo L.) und Stinte (Osmerus eperlanus L.) in der Elbmündung - Die einzigartige Bestandsentwicklung und Nahrungsökologie der größten deutschen Flussseeschwalbenkolonie. Corax 23, 87-113.

Hötker, H., & Segebade, A. (2000). Effects of predation and weather on the breeding success of Avocets Recurvirostra avosetta. Bird Study, 47(1), 91–101. doi:10.1080/00063650009461163

Kahlert, J., Clausen, P., Hounisen, J. P., & Petersen, I. K. (2007). Response of breeding waders to agri-environmental schemes may be obscured by effects of existing hydrology and farming history. Journal of Ornithology, 148(2), 287–293. doi:10.1007/s10336-007-0181-x

Kentie, R., Both, C., Hooijmeijer, J. C., & Piersma, T. (2015). Management of modern agricultural landscapes increases nest predation rates in Black-tailed Godwits Limosa limosa. Ibis, 157, 614–625.

Koffijberg, K, S Schrader & V Hennig (2011) TMAP Manual breeding success, 2nd version 2011. Common Wadden Sea Secretariat, Wilhelmshaven 46.

Koffijberg, K, K Laursen, B Hälterlein, G Reichert, J Frikke & L Soldaat (2015) Trends of Breeding Birds in the Wadden Sea 1991 - 2013. Common Wadden Sea Secretariat, Joint Monitoring Group of Breeding Birds in the Wadden Sea, Wilhelmshaven, Germany.

Koffijberg, K, J Frikke, B Hälterlein, G Reichert & H Andretzke (2016) Breeding birds in trouble: A framework for an action plan in the Wadden Sea. Page Common Wadden Sea Secretariat, Wilhelmshaven.

Laidlaw, R. A., Smart, J., Smart, M. A., & Gill, J. A. (2013). Managing a food web: impacts on small mammals of managing grasslands for breeding waders. Animal Conservation, 16, 207–215.

Laidlaw, R. A., Smart, J., Smart, M. A., & Gill, J. A. (2015). The influence of landscape features on nest predation rates of grassland-breeding waders. Ibis, 157, 700–712. doi:10.1111/ibi.12293

Laidlaw, R. A., Smart, J., Smart, M. A., & Gill, J. A. (2017). Scenarios of habitat management options to reduce predator impacts on nesting waders. Journal of Applied Ecology, 54, 1219–1229.

Malpas, L. R., Kennerley, R. J., Hirons, G. J., Sheldon, R. D., Ausden, M., Gilbert, J. C., & Smart, J. (2013). The use of predator-exclusion fencing as a management tool improves the breeding success of waders on lowland wet grassland. Journal for Nature Conservation, 21, 37–47.

Mason, LR, J Smart & AL Drewitt (2018) Tracking day and night provides insights into the relative importance of different wader chick predators. Ibis 160, 71-88.Mason, L. R., Smart, J., & Mason, L. (n.d.). Wader chick condition is not limited by resource availability on wader-friendly lowland wet grassland sites in the UK.

Meisner, K., Sunde, P., Kuhlmann Clausen, K., Clausen, P., Faelled, C. C., & Hoelgaard, M. (2014). Foraging ecology and spatial behaviour of the red fox (Vulpes vulpes) in a wet grassland ecosystem. Acta Theriologica, 59(3), 377–389.

Oosterbeek, K. H., van de Pol, M., de Jong, M. L., Smit, C. J., &

Ens, B. J. (2006). Scholekster populatie studies; bijdrage aan de zoektocht naar de oorzaken van de sterke achteruitgang van de Scholekster in het Waddengebied. Alterra.

Pakanen, V.-M., Luukkonen, A., & Koivula, K. (2011). Nest predation and trampling as management risks in grazed coastal meadows. Biodiversity and Conservation, 20, 2057–2073.

Pakanen, V.-M., Rönkä, N., Thomson, R. L., & Koivula, K. (2014). Informed renesting decisions: the effect of nest predation risk. Oecologia, 174, 1159–1167.

Paton, P. W. (1994). The effect of edge on avian nest success: how strong is the evidence. Conservation Biology, 8(1), 17–26.

Phillips, J. B. (1990). Lek behaviour in birds: do displaying males reduce nest predation? Animal Behaviour, 39, 555–565.

Previtali, M. A., Lima, M., Meserve, P. L., Kelt, D. A., & Gutiérrez, J. R. (2009). Population dynamics of two sympatric rodents in a variable environment: rainfall, resource availability, and predation. Ecology, 90, 1996–2006.

Pulliam, HR (1988) Sources, sinks, and population regulation. The American Naturalist 132, 652-661.

Pulliam, HR & BJ Danielson (1991) Sources, sinks, and habitat selection: a landscape perspective on population dynamics. American Naturalist 137, S50-S66.

Risch, M, W Denker, H Förster, K Günther, B Hälterlein, V Hennig, C Herden, I Mauscherning, A Miehe & C Wiedemann (2018) Lachseeschwalben Gelochelidon nilotica in Dithmarschen — die letzte Kolonie Mitteleuropas. Corax 23, 412-439.

Robinson, W. D., Styrsky, J. N., Brawn, J. D., & Stouffer, P. C. (2005). Are artificial bird nests effective surrogates for estimating predation on real bird nests? A test with tropical birds. The Auk, 122, 843–852.

Roos, S., Smart, J., & Gibbons, D. (2012). The predation of wild birds in the UK: an updated review (2007-2011) of its conservation impact and management (RSPB Research Report No. 50.).

Salek, M., & Smilauer, P. (2002). Predation on Northern Lapwing Vanellus vanellus nests: the effect of population density and spatial distribution of nests. Ardea, 90, 51–60.

Salewski, V & L Schmidt (2016) Beeinflussen Nestkameras den Schlupferfolg von Uferschnepfen Limosa limosa. Bericht Vogelwarte Hiddensee 23, 47-57.

Salewski, V & J Schütze (2016) Bruterfolg von Uferschnepfen an der Westküste Schleswig-Holsteins - ein Methodenvergleich. Vogelwarte 55, 187-198.

Schekkerman, H. (2008). Precocial problems - Shorebird chick performance in relation to weather, farming, and predation. University of Groningen, Groningen.

Schekkerman, H., Teunissen, W., & Oosterveld, E. (2009). Mortality of Black-tailed Godwit Limosa limosa and Northern Lapwing Vanellus vanellus chicks in wet grasslands: influence of predation and agriculture. Journal of Ornithology, 150, 133–145.

Sharps, E., Smart, J., Skov, M. W., Garbutt, A., & Hiddink, J. G. (2015). Light grazing of saltmarshes is a direct and indirect cause of nest failure in Common Redshank Tringa totanus. Ibis, 157, 239–249. doi:10.1111/ibi.12249

Smart, J., & Gill, J. A. (2003). Climate change and the potential impact on breeding waders in the UK. Wader Study Group Bulletin, 100, 80–85.

Smart, M., & Coutts, K. (2004). Footdrain management to enhance habitat for breeding waders on lowland wet grassland at Buckenham and Cantley Marshes, Mid-Yare RSPB Reserve, Norfolk, England. Conservation Evidence, 1, 16–19.

Smart, J., Gill, J. A., Sutherland, W. J., & Watkinson, A. R. (2006). Grassland-breeding waders: identifying key habitat requirements for management. Journal of Applied Ecology, 43, 454–463.

Smart, J., Wotton, S. R., Dillon, I. A., Cooke, A. I., Diack, I., Drewitt, A. L., … Gregory, R. D. (2014). Synergies between site protection and agri-environment schemes for the conservation of waders on lowland wet grasslands. Ibis, 156, 576–590.

Smart, J. (2016). A question of scale – from nature reserves to landscape-scale conservation. Wader Study, 123, 81–83.

Smith, R. K., Pullin, A. S., Stewart, G. B., & Sutherland, W. J. (2010). Effectiveness of Predator Removal for Enhancing Bird Populations: Predator Removal and Enhancement of Bird Populations. Conservation Biology, 24(3), 820–829. doi:10.1111/j.1523-1739.2009.01421.x

Smith, R. K., Pullin, A. S., Stewart, G. B., & Sutherland, W. J. (2011). Is nest predator exclusion an effective strategy for enhancing bird populations? Biological Conservation, 144, 1–10.

Teunissen, W., Schekkerman, H., & Willems, F. (2006). Predation on meadowbirds in the Netherlands–results of a four-year study. Ökologie Und Schutz von Wiesenvögeln in Mitteleuropa, 137–143.

Teunissen, W., Schekkerman, H., Willems, F., & Majoor, F. (2008). Identifying predators of eggs and chicks of Lapwing Vanellus vanellus and Black-tailed Godwit Limosa limosa in the Netherlands and the importance of predation on wader reproductive output. Ibis, 150, 74–85.

Thorup, O & K Koffijberg (2016) Breeding success in the Wadden Sea 2009 - 2012. A review., Page Common Wadden Sea Secretariat, Wilhelmshaven, Germany.

Thuman, K. (2003). Female reproductive strategies in the ruff (Philomachus pugnax). Uppsala University, Uppsala.

Thyen, S, PH Becker, K-M Exo, B Hälterlein, H Hötker & P Südbeck (1998) Monitoring breeding success of coastal birds. Wadden Sea Ecosystem 8, 7-55.

Thyen, S, PH Becker, K-M Exo, B Hälterlein, H Hötker & P Südbeck (2000) Bruterfolgsmonitoring bei Küstenvögeln im Wattenmeer 1996 und 1997. Vogelwelt 121, 269-280.

Thyen, S & K-M Exo (2003) Wadden Sea saltmarshes: Ecological trap or hideaway for breeding Redshanks Tringa totanus? Wader Study Group Bulletin 100, 43-46.

Thyen, S, H Büttger & K-M Exo (2005) Nistplatzwahl von Rotschenkeln Tringa totanus im Wattenmeer: Konsequenzen für Reproduktion, Prädation und Salzrasen-Management. Vogelwelt 126, 365-369.

Thyen, S & K-M Exo (2005) Interactive effects of time and vegetation on reproduction of redshanks (Tringa totanus) breeding in Wadden Sea salt marshes. Journal of Ornithology 146, 215-225.

Valkama, J., Currie, D., & Korpimäki, E. (1999). Differences in the intensity of nest predation in the curlew Numenius arquata: a consequence of land use and predator densities? Ecoscience, 6, 497–504.

Van De Pol, M., Ens, B. J., Heg, D., Brouwer, L., Krol, J., Maier, M., Eising, C. M. (2010). Do changes in the frequency, magnitude and timing of extreme climatic events threaten the population viability of coastal birds? Journal of Applied Ecology, 47, 720–730.

Webbon, C. C., Baker, P. J., & Harris, S. (2004). Faecal density counts for monitoring changes in red fox numbers in rural Britain: Faecal density counts for monitoring foxes. Journal of Applied Ecology, 41(4), 768–779. doi:10.1111/j.0021-8901.2004.00930.x

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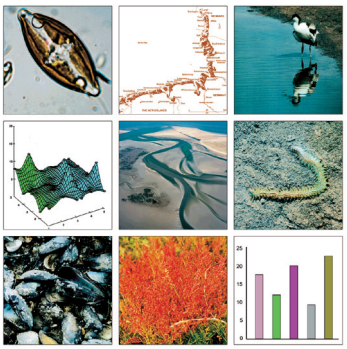

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