Rat predation on eggs in the Wadden Sea. © Benjamin Gnep/Schutzstation Wattenmeer.

WORKSHOP REPORT
Protecting breeding birds in the Wadden Sea
Navigating the challenges of predation management on Wadden Sea islands

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Published: 24.09.2025

This publication should be cited as:
Meise, K., & Leyrer, J. (2025). Workshop report: Protecting breeding birds in the Wadden Sea – Navigating the challenges of predation management on Wadden Sea islands. Common Wadden Sea Secretariat, Wilhelmshaven, Germany.

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1. Introduction

The trilateral Wadden Sea is one of the most important breeding and resting areas for waterbirds, both nationally and internationally. For several species, the largely undisturbed area with natural dynamics offers one of the last refuges in Central Europe, where they still breed successfully. This is particularly true for many ground-breeding waders as well as geese, ducks and colonially breeding gulls, terns, and spoonbills that have adapted to coastal wetlands like the Wadden Sea where islands provide safe breeding spaces.

Predation is a natural ecological process and many bird species have developed valuable strategies to minimise predation risks. Avoiding breeding sites where they experienced high predation pressure, they instead settle in areas with low predation pressure, such as islands. This strategy has also been observed in the Wadden Sea region where some mainland breeding sites have been abandoned due to high predation pressure. While mammalian predators have historically been absent or extremely rare on the Wadden Sea islands, human interventions such as barrier dams connecting mainland and islands or increased ship movement for the transport of cargo have led to increased risk of mammalian predation on the islands. In addition, predation risk is enhanced by the introduction of neobiotic predator species (e.g. Racoon Dog) which are nowadays widespread along the Wadden Sea coast. Further, the populations of native predators like Red Fox have significantly increased in numbers and densities in the last decades due to large-scale changes of the landscape behind the dyke, but also because of systematic immunisation programmes of predators to extinct terrestrial rabies, for example. Higher abundance of mammalian predators along the Wadden Sea coast has increased the risk of predator crossings over the mudflats to the islands. This shows that the present pressure on ground-breeding breeding birds on the Wadden Sea islands by mammalian predators is man-made and originates from developments outside the Wadden Sea.

Despite extensive efforts in conservation, many breeding bird species in the Wadden Sea continue to face significant declines. Latest data show that populations of 19 out of 31 monitored breeding bird species are decreasing (Kees Koffijberg, personal information). Poor breeding success across the Wadden Sea is a key driver for these declines, being too low to keep many populations stable. Predation by mammalian predators is considered one of the major threats affecting breeding success and thus the survival of breeding birds on the Wadden Sea islands. The workshop “Protecting birds in the Wadden Sea: Navigating opportunities and constraints of predation management on Wadden Sea islands”, held on 9-10 September 2025, was organised by the Common Wadden Sea Secretariat (CWSS) and experts from the trilateral Expert Group Breeding Birds to assess the current status of predation management in the three Wadden Sea countries, exchange information on the latest developments in predation monitoring and management and to discuss opportunities and challenges emerging for managing breeding success on Wadden Sea islands. Over 50 participants from Denmark, Germany, the Netherlands, and the UK participated in the workshop.

The workshop was divided into two parts. The first day consisted of short presentations providing an overview of currently used methods and latest experiences. Based on the information exchange on the first day, the second day focused on in-depth discussions on how to improve the monitoring and management of mammalian predators for bird conservation purposes. The following sections summarise findings and discussion on Day 1 and Day 2.

2. Predator monitoring

Although not a frequent occurrence, most mammalian predators (apart from hedgehogs) are able to cross certain distances over the mudflats of the Wadden Sea. This likelihood is increased where certain infrastructures such as dams are in place for coastal protection and easier access to islands or high predator abundance on the mainland coast creates pressure on single individuals to explore new territories. As the early detection of predators is key for their effective management, a systematic monitoring approach is essential. This will also allow to estimate predator abundance and measure the success of predation management measures.

Depending on the species, the location and the size of the island to be monitored different methodologies have been discussed:

Presence of **footprints and faeces** are a good indicator of predators, also during early stages of a (re-)colonisation process. Given the difficult access for targeted predator monitoring purposes, all visitors to uninhabited islands should be advised to monitor for tracks. Focus should be given to areas with a high mud content and moist soil (although regular floodings would wash away footprints). Cards illustrating the shape and size of footprints can help to identify specific species, even by unfamiliar observers. For rats, this method is particularly effective as they are highly mobile, tend to follow clear structures (e.g. gullies) and even form visible ‘footpaths’ in the vegetation. Further, rats tend to defecate in elevated spots. Other mammalian predators can also be detected with this simple method. Trials with track fields or plates coated with clay on the other hand have not been successful to reliably indicated predator presence due to their limited spatial range and require intensive maintenance to keep them moist. On larger islands this method should be combined with other methods for early predator detection.

Camera traps can help with the early detection of predators on islands. Important is to consider the placement of cameras. Knowledge on behaviour and movement of specific predators allows to increase the efficiency of monitoring with camera traps as they can be placed in areas with a high likelihood of detection. Feeding stations and baiting stations increase the likelihood for capturing the first individuals on cameras. Monitoring of nest sites with camera traps in contrast is not effective for early detection as only a small proportion of nests can be monitored. Remotely operated cameras, especially if combined with automated AI recognition of predator species, have the advantage that information on predator detection is available immediately. It has been suggested that Wadden Sea countries should collaborate in the development of AI algorithms for predator recognition and detection, which requires large amounts of data, ensuring that systems are already trained for predators which have not yet become an issue in all Wadden Sea countries (e.g. racoon dogs). Legal requirements, such as information boards, for the placement of remote camera traps need to be clarified beforehand.

Sniffer dogs have been used on few occasions in the Wadden Sea, for example for the detection of hedgehogs on Norderney. However, for a systematic monitoring at a large scale, ensuring early detection of different predators, the use of sniffer dogs is very costly and labour intensive, and therefore not advised for early detection monitoring, only if fully trained dogs are available.

While **acoustic sensors** have been used for the detection of specific species (birds, bats), these have not been applied for the direct detection of mammalian predators due to the animals limited vocal repertoire.

Ground-based counts are conducted on most Wadden Sea islands for different predators. Trained observers follow specific transects or use focal points to document number of predators which allows for the assessments of presence and abundance of predators. However, due to the limited spatial coverage of most ground-based counts on larger islands, it is recommended to combine them with other monitoring methods. As these ground-based counts are often conducted at night-time during high predator activity, specialised equipment such as night-vision cameras is needed for all observers.

The most recommended method for monitoring presence of larger mammalian predators, but also rats, is the use of thermal cameras and drones. Surveys with **thermal drones/ cameras** should be conducted before the mating season when there is increased movement, increasing the detection probability. Monitoring with thermal drones in winter is particularly suitable due to larger thermal difference between predators and the ambient temperatures, something which could cause difficulties in summer. While smaller islands can be covered completely with a single drone flight, transect flights are conducted for larger islands, covering as much of the area as possible. For intermediate sized islands the time for a full spatial coverage is estimated at 1-2 days or more and repeated surveys are recommended before the breeding season. The flight altitude and speed will depend on the size of the predator species, with lower altitudes and slower speed recommended for smaller predators like rats. This will ensure accurate identification. Drone data allow for a more accurate estimation of predator presence and abundance. Used before and after predation management measures have been applied they are also a useful tool to assess success of such measures in reducing predator population sizes.

Given that a combination of methods is recommended for monitoring most predators and locations, the development of a best-practice manual is advised to guide the implementation of effective monitoring schemes for different predators on Wadden Sea islands. Generally, a high level of manpower, equipment and money is required for an effective monitoring of predators.

3. Predation management

Preventing access of predators to ground-breeding birds is key to minimise nest predation and increase the survival of the chicks. Historically, low densities of mammalian predators on the mainland and the natural barrier of the Wadden Sea mudflats meant that few mammalian predators ever made it to the islands and none seems to have established a population on the islands. Human activities, such as the construction of dams or frequent transport of people and cargo from the mainland to the islands has made the islands more accessible to predators, where in the absence of other predators and the presence of breeding bird colonies as food sources, they found ideal conditions to reproduce. The presence and increase in mammalian predator abundance had devastating consequences for many ground-breeding birds.

During the discussion, it became clear that the most suitable predation management measures differ between predator species as well as location, size and inhabitant status of the islands:

The first step in predation management should be to **prevent access and reproduction of mammalian predators** on the islands. This is a huge challenge where islands are connected to the mainland by dams, but also because most predators are able to cross the mudflats at low tide, swimming through tidal channels, there is no easy approach to prevent single individuals from crossing the Wadden Sea. Hence, steps can be taken to minimize the frequency of such crossings, by applying management measures on the mainland. Individuals are more likely to search for new territories and cross the Wadden Sea if predator abundance and thus competition for territories and food on the mainland is high. Specific controls of dams may be feasible but require constant monitoring of the dams at night. Transport of large equipment to uninhabited island should follow specific biosecurity protocols to prevent the introduction of rats. Infrastructural developments, including coastal protection measures should also consider predation and predation management, as for example the basalt basis of new dikes provide ideal hiding spots for rats.

To minimise the impact of predators, it is recommended **to improve habitat quality**, e.g. by increasing vegetation coverage and food availability in proximity of breeding sites (species-dependent). For avian predators, the removal of structures that these birds may perch on or breed in may be beneficial. The provision of habitat structures suitable for alterative prey, such as voles or rabbits, is being discussed but could lead to higher predator densities in an area, thereby minimising its benefits.

If predators are present in an area, access to colonies of ground-breeding birds should be prevented. While **artificial breeding islands** have often be created for this purpose, it is important to point out that most mammalian predators can swim and easily access those islands when there are no additional protection measures such as fences. The costs for the construction and maintenance of fences should always be budgeted for in such projects. When constructing artificial islands, it is important to choose materials (e.g. steel mill slag) that prevent rats from digging tunnels and breeding on the islands.

Predator-proof fencing around colonies has established itself as an important management tool in areas of high predation. The RSPB has published an in-depth manual of different fence practices and their effectiveness in different settings and for different predators. Considerations need to be given to the height (foxes can jump), mesh width (martens can pass through the nets), but also environmental conditions such as frequent flooding, dry conditions or presence of visitors. High fences with floppy tops that prevent them being jumped by larger predators are highly efficient but are visually very obtrusive. Fences including electric wires or electric mesh are generally good in keeping out predators but require high maintenance. Automatic voltage monitors can help ensure their efficiency. Still, predators occasionally cross the fence or learn how to adapt to specific fence designs, with gates being the weakest points, suggesting that additional control measures or modifications may be needed over time. The success of fencing can benefit from reducing predator abundance outside the fenced areas to reduce pressure and spillover effects. In addition, it is important to consider the placement of fences. Chicks of many species are highly mobile, and the area needs to provide enough food, so chicks do not immediately leave the predator-exclusion area. Generally, fencing off a large area can be quite costly, considering costs for material, maintenance and limited longevity in habitats like the Wadden Sea where metal fences corrode easily. Further, it requires sufficient manpower to maintain the fences – large or small, permanent or seasonal. Finally, predator fences should also be avoided for very small areas supporting nesting gulls and terns due to the risk of young birds flying into the fence and becoming entangled in it.

It is important to keep in mind that this method only works for larger mammalian predators and for example, not for rats. The reduced predation pressure from larger mammals in fenced-off areas may even lead to an increase of the rat population which may also benefit from the absence of larger predators (a concept called mesopredator release) and bird breeding success could still be impacted. Also, avian predators are not excluded by fences. Although avian predators are considered native to the Wadden Sea islands, and therefore not actively managed, their impact should be considered when assessing impact of fencing on breeding success.

Floating rope barriers can be applied around smaller islands as predator management tool. As foxes and other mainly terrestrial mammalian predators do not like to put their head under water, they cannot cross these barriers but simply push against them. Eventually, they will tire and return to the other side. The advantages of floating rope barriers over predator fences are their far lower cost and low visual obtrusiveness, but they only help protect very small islands in deep water bodies.

Lethal management of non-native mammalian predators on islands is often carried out as an emergency response measure. It is often seen as equal to hunting, both with regard to the applicability of the hunting laws, but also in terms of public perception. It should thus made clear that lethal management of non-native mammalian predators is a conservation measure. The removal of these predators from Wadden Sea islands is done with the sole purpose of improving the breeding success of ground-nesting species who are declining in the Wadden Sea at an alarming rate. Exceptions granted to hunting regulations by the respective authorities undergo extensive revision and permitting processes to ensure they are appropriate and necessary in each special context. Lethal management is often applied to mammalian predators which have historically not populated the Wadden Sea islands and have been shown to have considerable impact on local breeding populations, when non-lethal management measures have proofed unsuccessful. The methods used are predator-specific, adjusted to local contexts and mostly conducted by paid hunters. Due to the nocturnal behaviour of most predators, hunting takes largely place at night-time, using a combination of traps, baiting and active shooting, aided by thermal cameras. As the methodology being applied depends also on local hunting regulations, no general advice on the most suitable methodologies can be given here and it is recommended to plan any lethal management in advance, with involvement of all necessary stakeholder groups.

Invasive brown rats are notoriously difficult to eradicate, as they shelter in burrows and reproduce at high rates throughout the year. Of particular concern is their ability to reach and thrive on some of the most remote islands of the Wadden Sea as proven in many cases in recent years. While the reasons for this population expansion have not yet been studied in detail, it is likely linked to climate change, which enables rats to reproduce even during winter. In addition, intensive farming—especially the cultivation of maize near key breeding areas for seabirds—has probably further increased colonization risks.

Due to animal welfare concerns and environmental contamination, the use of poison has been restricted significant for private citizens, including farmers. Trapping (e.g. with non-toxic rat traps) and shooting (with the necessary permits) have been proven to be effective against single rats and small populations, but these methods are rather ineffective against larger and established populations. Recent field trials using **dry ice**, which sublimates into carbon dioxide, have shown promising results: complete eradication in one small and controlled setting and a 60-80% reduction at two larger sites after a single application. Using this method in combination with other low-density control measures, is most promising. On most inhabited islands, however, complete eradication is unlikely, though population levels can be effectively managed with high effort. Although carbon dioxide is approved as a rodenticide against rats within the EU, dry ice itself does not yet have product approval, meaning current field trials require a special permit.

House cats are well known to contribute to bird mortality, also on the Wadden Sea islands. Uncontrolled reproduction of pets that escaped has led to the establishment of feral cat populations on some islands which may need to be managed. To prevent this, all pet cats on islands should be **sterilised and chipped**. This should be made mandatory and followed up by the respective authorities.

4. Next steps

Establishing a functioning early detection monitoring system for mammalian predators on Wadden Sea islands will be an important next step. While the current monitoring programme of breeding success can help to quantify the impact of predation on breeding birds in the Wadden Sea, or assess the success of predation management measures, it is not suitable for early detection of predators. However, this early detection is key as it will minimise costs and efforts for managing the predators and ultimately ensure that the impact on breeding birds is as minimal as possible. At the workshop several different methods have been discussed, and it will be important to explore how effective monitoring programmes can be set up in the three Wadden Sea countries.

Besides the monitoring programme, there are specific research needs that if addressed can help to optimise predation management:

1) Which factors contribute to the distribution of predators, e.g. how are uninhabited islands colonised by rats?
2) How can knowledge on predator movement and behaviour be used to develop more effective management strategies?
3) What is the role of social learning among conspecifics in predation of ground-nesting breeding birds?
4) Does mesopredator release occur in areas where larger mammalian predators have been excluded or removed?

Regular exchanges among experts – encompassing the latest research findings, emerging technologies, practical experiences with existing methodologies, and open discussion about opportunities and failures – are essential for advancing effective solutions. Enhanced collaboration is critical to ensure that lessons learned from past are systematically integrated into future management plans. In this context, collaboration in the implementation of a trilateral AI system for the automatic detection of predators was proposed during the workshop as a potential tool for improving management.

While predation by mammalian predators is not the only threat faced by breeding birds on the Wadden Sea islands, but it is one that can be directly managed. Ensuring that these bird species have access to secure breeding habitats is a shared responsibility, and a key component of broader conservation efforts within the Wadden Sea ecosystem.

5. Acknowledgements

The workshop was organised in collaboration with experts from the Expert Group Breeding Birds, namely Benjamin Gnep (Schutzstation Wattenmeer), John Frikke (Danish Wadden Sea National Park Authority), Kees Koffijberg (Sovon) and Gundolf Reichert (Lower Saxon Wadden Sea National Park Authority), with support from Jutta Leyer and Jan Blew from Bioconsult SH. We would like to thank all presenters for their valuable contributions and the workshop participants for a lively discussion.

6. Annex: Workshop programme

WADDEN SEA WORKSHOP

Protecting birds in the Wadden Sea: Navigating opportunities and constraints of predation management

09 September 2025

Zoom

Welcome & Session 1

13:00	Welcome
13:05	Setting the scene Breeding Birds in Trouble: the latest information on breeding success and breeding bird trends in the Wadden Sea - Kees Koffijberg (Sovon)
13:20	Overview The status of predation management in DK, SH, LS, & NL
14:00	Monitoring & Research Predator monitoring (title to be confirmed) - Hana Tebelmann (Uni Oldenburg) Timely detection of pioneer rats and routine monitoring of rat populations - Benjamin Gnep (Schutzstation Wattenmeer) Telemetry of foxes and stone martens in the coastal zone of the dutch Wadden Sea: what can we learn for the protection of breeding birds? - Bob Jongepoerink (Ecosensys) Monitoring of mammalian predators in the East frisian Wadden Sea islands – lessons learned after 20 years of predation management - Hartmut Andretzke (BIOS Norderney) Discussion

15-minute coffee break

Session 2

15:20	Management The effectiveness and best practice design of predator-exclusion fences and floating ropes for protecting ground-nesting birds - Malcolm Ausden (RSPB) Rat management on Halligen and outer sandbanks of Schleswig-Holstein - Benjamin Gnep (Schutzstation Wattenmeer) Professional predation management in Beltringerharder Koog - Marcel Holy (Natur- und Umweltschutzvereinigung Dümmer) Management of foxes on the island of Langli: Challenges and consequences of failure - Thomas Bregnballe (Aarhus University) Managing foxes on Eastfrisian island: from detection to eradication - Gundolf Reichert (Lower Saxon Wadden Sea National Park Authority) Managing hedgehogs and feral cats on East frisian Wadden Sea islands - Hartmut Andretzke (BIOS Norderney) Predation management in the Danish National Park - John Frikke (Vadehavet National Park Authority) Discussion
16:55	Wrap up & Outlook