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Quickscan opportunities and constraints catching gulls at sea

A&W-report 2356

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Photograph front page
Lesser Black-backed Gull (Henry Bucklow)
(https://commons.wikimedia.org/wiki/File:Lesser_black_backed_gull_in_flight.jpg)

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offshore wind energy, collisions, gull species, foraging ecology, offshore distribution, capturing techniques, transmitters, legislation, scavenging seabirds, North Sea

1 Introduction

The total planned programme of offshore wind energy in Dutch coastal waters up to 2023 may result in significant cumulative effects on larger gull species. These effects result from the estimated numbers of victims of collisions with the rotors of the wind turbines at sea. According to calculations carried out to predict cumulative effects on natural values of all Dutch and foreign (plans for) offshore wind energy by 2023, significant effects at (North Sea) population level cannot be excluded for the Herring Gull (*Larus argentatus*), the Great Black-backed Gull (*Larus marinus*) and especially the Lesser Black-backed Gull (*Larus fuscus*) (Leopold *et al*. 2014). At the North Sea population level, the number of victims exceeds the PBR (= Potential Biological Removal, a measure of acceptable additional annual mortality without risk of (further) population decline) for the Lesser Black-backed Gull. This exceedance is almost the case for the Great Black-backed Gull and Herring Gull.

The Ministry of Economic Affairs has commissioned 'Rijkswaterstaat', part of the Ministry of Infrastructure and the Environment, to develop a new monitoring and research program for offshore wind energy and to execute the program in the period 2016-2021. The new knowledge about the (cumulative) effects of offshore wind farms, collected within this program can contribute directly to a better estimate of the effects on e.g. gull species. This new program is called 'Offshore wind energy ecological program' (*Wozep - Wind Op Zee Ecologisch Programma*).

A knowledge need is to know which populations are affected. One of the problems with 'assigning effects' is the uncertainty to which populations the victims are related. For at least the Herring Gull and the Lesser Black-backed Gull it is important to be able to determine to which populations the individuals belong. Population effects are better determined when more is known about the origin of gulls who regularly visit the offshore wind farms.

In addition to colour-ringing and research with transmitters from breeding sites, capturing gulls in offshore wind farms (instead of in a breeding colony) is seen as a possibility to gain insight into the question where individuals come from and to study how they behave in and around wind farms. Due to the relatively innovative nature of the fieldwork associated with capturing gulls at sea, it is necessary to study the opportunities and constraints in advance.

Therefore, in this report an overview is given of the (im)possibilities of catching gulls at sea, which transmitters to use, what kind of data are produced, and what ethical issues are involved. Focusing on the following:

- understanding the probability of a successful capture at sea of several large gull species (Great Black-backed Gull, Lesser Black-backed Gull and Herring Gull), distributed along different sexes and year classes, advising most promising methods, places and times of capture;
- suitable transmitters to use with respect to location of capture;
- chance of useful data of good quality and extent to answer the research question;
- what kind of additional data does the use of different transmitters provide (e.g. data about temperature, activity, migration) helping to reduce uncertainties in impact assessments about effects of offshore wind farms;
- animal welfare / ethical aspects.

Summarized in two research questions: 1) to which populations do the gulls, found in offshore wind farms, belong? 2) what is the behaviour of the gulls in offshore wind farms (flight speed, flight height, time spent inside / outside wind farm, etc.)

For additional information about the feasibility of capturing gulls (catchability) and which type of transmitter to use, we interviewed a number of gull experts: Frank Majoor, Ruben Fijn, Kees Camphuysen, Klaas van Dijk, Willem Bouten, Bruno Ens and Mardik Leopold.

It should be stressed that there is much known about the flight behaviour of large gull species, especially Herring Gull and Lesser Black-backed Gull, also around offshore wind farms (Camphuysen 2011). Many data are available or are currently collected of birds breeding on Texel (e.g. Camphuysen 2013). Less is known about a possible other origin (than Texel) of the gull species in offshore wind farms. Maybe a part of the gulls that are present in Dutch offshore wind farms originates from other colonies and roosts along the Dutch coast.

1.1 Ecology and (offshore) distribution

Before catching techniques and types of transmitters are discussed, it is necessary to know more about the ecology and (offshore) distribution of the three gull species, to determine where to catch. The three species of gulls have their own species specific annual cycle (with migratory movements to a greater or lesser extent), range of distribution along the coast, and other behavioural characteristics.

Figure 1.1 From left to right: Lesser Black-backed Gull, Great black-backed Gull (both by Andreas Trepte, www.photo-natur.net) and Herring Gull (by Kurt Kulac, https://commons.wikimedia.org/wiki/File:Larus_argentatus 01.jpg)

1.1.1 Lesser Black-backed Gull

Lesser Black-backed Gulls are sea-going birds that breed along the Dutch coastline. They migrate, leaving the Netherlands when the breeding season is completed (August/ September) to winter in southern areas (from South England, France, Portugal - south to The Gambia). In March, the gulls return to their breeding grounds.

From the Lesser Black-backed Gulls breeding at Texel (in a Natura 2000 protected area), it is known that they exploit a wide zone off the mainland coast of Noord-Holland and southwest Texel to forage. Most of the studied Lesser Black-backed Gulls do forage at a distance of 40 km from the breeding colony, with local clusters in abundance, usually caused by local food availability. Their diet is almost completely marine orientated and strongly dependant on commercial fisheries in the area. Natural prey items are obtained mostly within the 20 m depth contour and Lesser Black-backed Gulls do forage to some extent on land (Camphuysen *et al*. 2008).

Also Lesser Black-backed Gulls caught and transmitted in the UK and Belgium were located partially on Dutch parts of the North Sea, including (future) marine wind farm areas (Masden *et al.* 2017, Vanermen *et al.* 2017). Lesser (and Great) Black-backed Gulls in a Belgian offshore wind farm were most attracted to the outer turbines of the farm; they were mainly roosting on the turbine foundations; with low tide, they were also foraging on mussels growing on the lower parts of the foundation (Vanermen *et al.* 2017).

The age distribution of Lesser Black-backed Gulls at sea varies per season. In summer months (June/July) most of the gulls offshore are adults (around 90%; Camphuysen & Leopold 1994), and most movements in these months observed from the shore are feeding flights of mature birds towards and from the colonies. In August-September, at the end of the breeding season, after fledging of the offspring, the proportion of adult Lesser Black-backed Gulls at sea declines gradually (81.9% adult in August, 60.4% in September; Camphuysen & Leopold 1994) and the proportion of juvenile Lesser Black-backed Gull increases significantly at sea. In this period the gulls gather and prepare for departure to wintering grounds more southwards. In October/November total numbers of observed Lesser Black-backed Gulls in the southern North Sea became small and the proportion of adults offshore increased again, indicating that immature and juvenile Lesser Black-backed Gulls were the first to leave the area.

GPS tracking data of the foraging trips and dietary information revealed that there are sexually distinct foraging strategies. The marginally larger males travel farther from the colony than females and spend more time in the North Sea (78% of their foraging time), feeding mostly on fisheries discards at offshore trawlers with few alternative resources nearby. Females foraged predominantly on land (they spent only 33% of their foraging time at sea) or in the Wadden Sea, where they have multiple foraging options, including near shore shrimp fishing (Camphuysen 2011).

Camphuysen (e.g. 2011) has extensively studied Lesser Black-backed Gulls, also in relation to collision risk of offshore wind turbines. GPS logger data have demonstrated that the wind farms OWEZ (Offshore Windpark Egmond aan Zee) and Princess Amalia Wind Farm (in Dutch: *Prinses Amalia Wind Park* or PAWP) are within range of Lesser Black-backed Gulls breeding at Texel (see Figure 1.2). The Lesser Black-backed Gulls regularly moved through existing wind farm areas, and spent only a small amount of total trip time within the farm areas. Leopold *et al.* (2013) describe that concentrations over 1000 birds have been noted in the area of the two wind farms OWEZ and PAWP, associated with active fishing vessels, against a 'background density' of around 1 bird per square kilometer. Remarkably (as noted above), males spent twice as much time within or near a wind farm compared to females feeding offshore (Camphuysen 2011).

Skov *et al*. (2015) describe that also in the recently constructed offshore wind farm Luchterduinen (near OWEZ and PAWP) gull species (e.g. Lesser Black-backed Gull, Herring Gull, Great Black-backed Gull) were observed near to the coast of Noord-Holland, during a ship-based line transect monitoring program of wintering seabirds.

About the spatial use and the occurrence of Lesser Black-backed Gulls around offshore wind farms Leopold *et al.* (2013) found, during counting periods from survey ships along transect lines, that most birds seen during the surveys were often associated with, looking out for or resting in the wake of active fishing vessels. Lesser Black-backed Gulls were also often seen within the perimeters of the wind farms, sometimes resting on the water or on the foundation structures, sometimes feeding in the tidal wakes of the monopoles. Still the largest concentrations were invariably observed around fishing vessels.

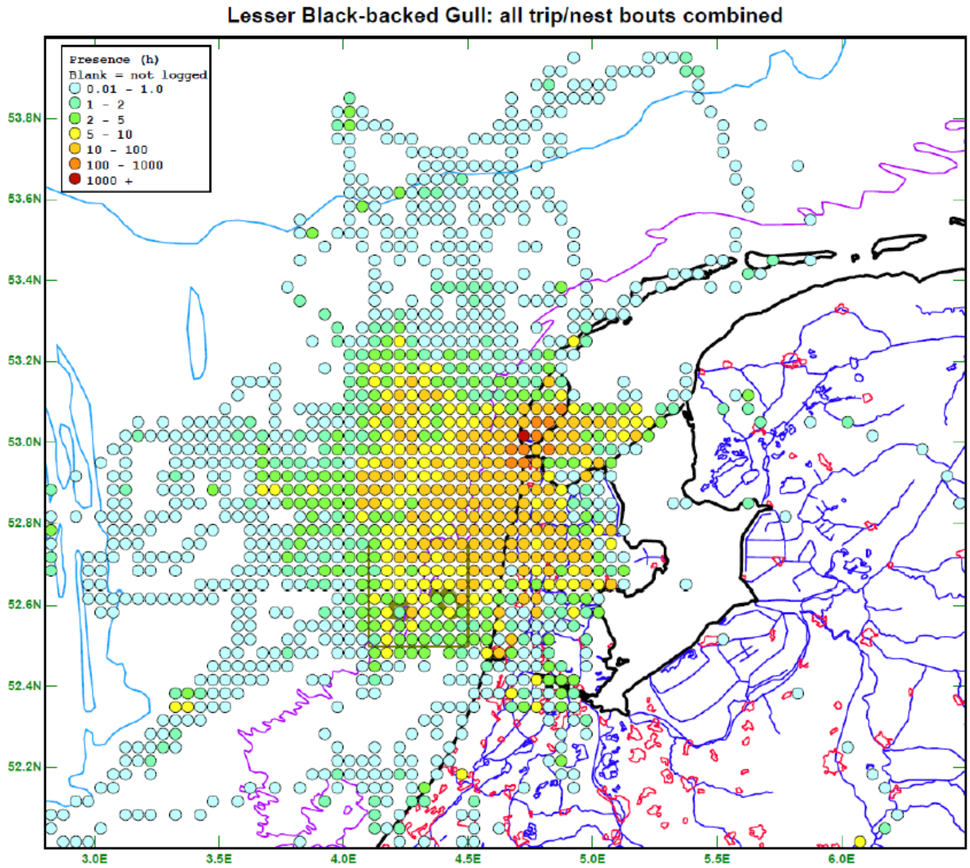

Figure 1.2 At-sea presence, relative amount of time (h) spent in 2'x3' rectangles within 52-54°N, of Lesser Black-backed Gulls, equipped with GPS loggers in their breeding colony at Texel (red dot). On feeding trips, the birds spread out over a very large area. Wind farm locations are shown in the square. (Figure taken from Camphuysen 2011).

1.1.2 Great Black-backed Gull

The Great Black-backed Gull is most common along the coast of Iceland, Norway and the British Isles. These gulls visit Dutch waters mainly as an important wintering area in the non-breeding season, being most numerous between September and March when they occur dispersed over the entire southern North Sea. They feed, as well as Lesser Black-backed Gulls and Herring Gulls, around fishing vessels but their numbers are often lower than those of other gull species in associated flocks (Camphuysen & Leopold 1994).

In the 'Atlas of seabirds in the southern North Sea' Camphuysen & Leopold (1994) describe the (age) distribution of Great Black-backed Gulls at sea. In June/July only low densities of this gull species are found at the Dutch coast, with slightly more adults than immatures. The numbers of Black-backed Gulls increase in August/September, with around two-thirds of the birds seen at sea identified as adults. Great Black-backed Gulls are numerous in the coastal zone and offshore area in autumn, especially during autumn passage (October), then around three quarters of the gulls were adults. Numbers of Great Black-backed Gulls further increase in winter, with generally more individuals further away from the coast than in autumn. The proportion adults: immatures remained the same as in autumn. In March, the proportion of adult birds declined to around 51% marking the departure of mature birds to more northerly breeding areas.

1.1.3 Herring Gull

The Herring Gull is a common breeding species around the North Sea. They are generally regarded as a common resident or short-distance migrant (refs in Camphuysen *et al*. 2011). In winter, large numbers are found offshore, but in the breeding season Herring Gulls are less sea-going than Lesser Black-backed Gulls. During the breeding season, foraging is confined to intertidal and near-shore areas. Fish is captured mostly at fishing vessels within 5 km from the nearest coast (Camphuysen *et al*. 2008).

Off the Dutch coast, the Herring Gull and the Lesser black-backed Gull are practically complementary in terms of their appearance. Lesser Black-backed Gulls (LBBG) are absent in this area in winter, when Herring Gulls (HG) are numerically at their peak (**Fout! Verwijzingsbron niet gevonden.**). In March and April, when Lesser Black-backed Gulls rapidly increase in numbers, Herring Gulls become quickly scarce and only in November, when the Lesser Black-Backed Gull has departed to more southerly wintering areas, their numbers at sea are increasing again. Both species are at sea in considerable higher densities in April and May (early breeding season) than in June (hatching eggs, start young care). The number of Lesser Black-backed Gulls at sea increases again in July and August, but the number of Herring Gulls gradually decreases until the lowest numbers are reached in August (Camphuysen *et al*. 2008).

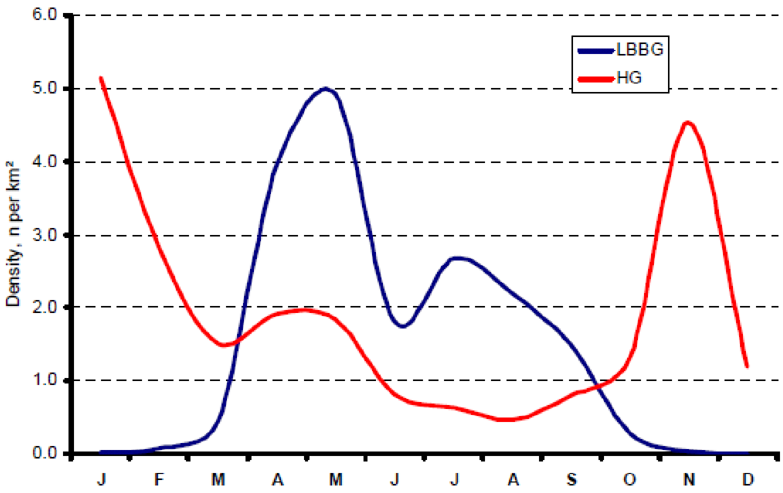

Figure 1.3 Average densities (n km^{-2}, y-axis) Lesser Black-backed Gulls (LBBG) and Herring Gulls (HG) throughout the year off the coast (0-100 km offshore) of NW Netherlands, 1987-2008 (from: Camphuysen et al. 2008).

The age distribution of Herring Gulls at sea has been recorded, in the same way as described for the other gull species, by Camphuysen & Leopold (1994).

In June/July most of the Herring Gulls at sea were found in the coastal zone, instead of more offshore, and the majority appeared to be adults (90%).

In August/September slightly more offshore birds were reported, while coastal numbers declined. The proportion of adult birds at sea decreased sharply in these summer months, to 67% in August en around 17% in September, explained by Camphuysen & Leopold (1994) as an indication that most breeding birds had left the sea during the post-nuptial (primary) moult.

As described before, Herring Gulls are again more abundant at sea in October/November, also offshore. At that time the proportion of adults at sea is around one-third in October and around two-thirds in November.

In December/January the number of Herring Gulls at sea further increased, apparently filling a niche which is abandoned by Lesser Black-backed Gulls in these months, caused by the species specific annual cycles. It is estimated that over two-thirds of the Herring Gulls wintering in the southern North Sea are adults.

In early Spring (February/March) Herring Gulls were widespread, both inshore and offshore, and the proportion adults remained roughly the same as the months before. A North Sea wide survey in February 1993 showed that Herring Gulls were among the most abundant and numerous offshore species all over the North Sea (Camphuysen & Leopold 1994).

In April/May the Herring Gulls move away from the offshore areas to the coastal zone. Adult birds form in these months just over half of the Herring Gulls found at sea indicating that for breeding Herring Gulls, feeding areas other than the coastal zone are of great significance for this species.

1.1.4 Abundance of the gull species in offshore wind farms

As already described, the gull species are seen in the wind farms PAWP and OWEZ (transmitted Lesser Black-backed Gulls; Camphuysen 2011), also during monitoring surveys (required during and after construction; Leopold *et al.* 2013). Figure 1.4 shows the mean abundance per km^2 per gull species per month over four years of survey in the PAWP and OWEZ study area. Also in the most recently built wind farm Luchterduinen, the three gull species are observed during surveys during the construction period (Skov *et al*, 2015). They counted in the whole study area in total 457 Lesser Black-backed Gulls in October 2014, 119 Herring Gulls and 233 Great Black-backed Gulls. In December 2014 the observed numbers were only 5 Lesser Black-backed Gulls, 39 Herring Gulls and 131 Great Black-backed Gulls (for details see Skov *et al*. 2015)

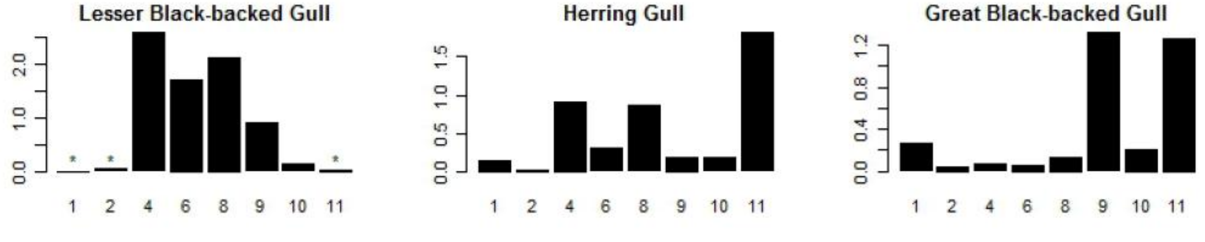

Figure 1.4 The mean abundance per gull species (per km^2) per month, over four years of surveys in the PAWP and OWEZ. Months marked with an asterisk are excluded from the analysis since the species is known to be virtually absent from Dutch waters (from: Leopold et al. 2013).

2 Capturing techniques

Based on literature research and consultation with experts, it appears that capturing gulls is possible. In literature though, hardly any study was found describing catching gulls specifically at sea. Most of the studies are focused on trapping birds on land (e.g. incubating birds on a nest).

In addition, it should be noted that, though the experts together have an incredible amount of knowledge and experience in working with gull species (and other sea- and shorebirds), only one of the respondents actually has experience with catching gull species at sea.

In the following subsections, possible capturing techniques are described.

2.1 Capturing by hand

Capturing gulls by hand from a boat is possible, as shown in Figure 2.1. Majoor *et al*. (www.frankmajoor.nl) have caught and colour-ringed many Lesser Black-backed Gulls as part of an investigation into the occurrence of avian influenza. They successfully did this on the ferry from Den Helder to Texel (crossing the Marsdiep, most western part of the Wadden Sea). Though it should be noted that the gull species occurring in this area are used to follow the ferry and to be fed by the passengers, there are also examples of hand-caught Lesser Black-backed Gulls at sea from a fishing vessel.

Figure 2.1 A gull being captured on the ferry from Den Helder to Texel (from: www.frankmajoor.nl).

Another example of successfully capturing gulls by hand, though on land, is described by Christmas *et al*. (1986). They used different trapping techniques for the Black-headed Gull in a park in London. All birds were caught by hand using bread, cheese or meat scraps as bait. Gulls were captured in flight as they approached to take food from the hand. Alternatively, birds were caught while they were feeding on the ground.

As described before, a common way for gull species to get food is by flying behind a fishing vessel (as shown in Figure 2.2), where discards (fish waste and non-target species) are flushed away or thrown over board, and form an important part of the menu of the three gull species, especially for the Lesser Black-backed Gulls.

Figure 2.2 Compact cloud of following gulls (Herring gulls and Common Gulls) behind a fishing boat off the coast of Noord-Holland in winter (from: Camphuysen et al. 2008)

Since gulls are generalists and opportunists, suddenly available opportunities for collecting food are usually found quickly, and through copying behaviour a foraging flock of gulls rapidly grows to a considerable extent. It is known of gulls associated with fishing vessel that they drift away of active fishing vessels at times when no fish waste is discharged, to return immediately when fish waste is available. Seabirds monitor ship-movements constantly and respond immediately on a vessel in which the nets are hauled (Camphuysen *et al*. 2008). This is advantageous in the context of attracting birds with bait to capture them.

Capturing gulls by hand, in an offshore wind farm, is recommended as a potential good capturing method. Capturing could be done by first luring the gulls with bait (discards, fish waste) from a fishing vessel, on a maintenance ship (bringing enough bait), sport fishing boat, or other ship to be determined (attractive for gulls) and then grab the gull with both hands out of the air, or with help of a hand-net.

2.2 Baited traps: drop-trap , walk-in cage, whoosh-net

Capturing gulls with cages or traps is described in literature as well as suggested by the experts. Many of the baited trap designs utilise self-contained wire cages or enclosures supported by posts that are baited with appropriate food stuffs for the target species. Below three different types of cages are described.

Drop-traps (Figure 2.3) are weighted nets set on a pole above the ground with a triggering device to release the net and allow it to drop on the birds. The top has a small hole (10x10 cm) in the center of the netting through which the captured bird can be held. The trap is propped open at an angle of about 33° by a split peg. A nylon line attached from half way up to the lower peg extends to the back of the base. The trap is usually placed over a nest (high chance of returning bird) and the bird is captured, when it disturbs the taut nylon line, causing the supporting split peg to break and the trap to drop. The trap is used at locations where birds gather to feed or roost and may be used over bait. With this method of drop-trapping many Red-billed- and Ring-billed Gulls were successfully caught on the nest, see **Fout! Verwijzingsbron niet gevonden.**-right (Mills & Ryder 1979; Canada). The trap was also used to capture Terns and Oystercatchers on the nest. Mills & Ryder (1979) mention that the trap can also be used to capture gulls away from the breeding colony, by using bait (bread or fish).

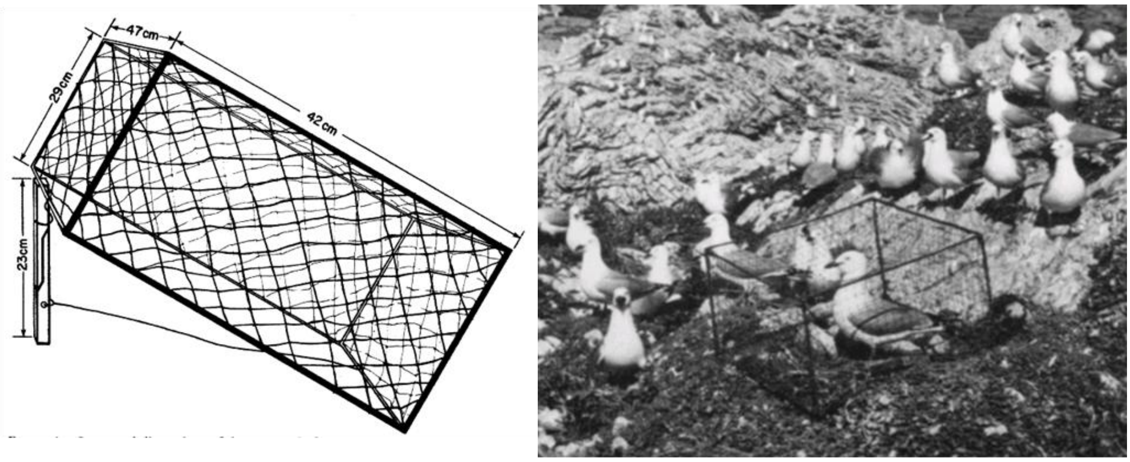

Figure 2.3 Suggested dimensions of an automatic drop-trap (left) and a trap with a captured gull (right) (from: Mills & Ryder 1979).

Walk-in cages generally consist of a large wire or net enclosure with funnel-like entrances that allows birds to easily walk into but not readily exit. There are numerous varieties, many use drift fences to guide birds toward the entrances. Bait is normally used to attract birds into the trap.

Whoosh-nets or clap-nets are a system of bungee cords which provide the energy to project a mesh net over an individual bird or small group of birds, frequently over bait. Training in the proper use of these nets is necessary. This type of nets is usually anchored with a peg, so when used at an offshore platform in a wind farm or on deck of the ship, the method needs to be adjusted to secure the net properly.

<u>Capturing gulls in an offshore wind farm with a drop-trap, walk-in cage or whoosh-net can be considered as a possible method,</u> though some technical modifications and solutions need to be devised for attachment on board (deck) or at the platform of a WTG (Wind Turbine

Generator) or OHVS (Offshore High Voltage Station) in the wind farm. In addition, permission will be required from the owners of the wind turbines. In general, a way of working may be to first place the cages (in safe mode) in the right position on the right spot, place some bait, to let the gulls get used to it. Coming back later to put the cages 'on' and capture.

2.3 Cannon netting or net gun

One of the experts suggested cannon netting or using a net gun, which is described in literature for capturing seaducks at sea, and for capturing gull species on land (urban environments; Solman 1994 & Belant 1997).

Birds that congregate in large numbers at roosting or feeding sites can be captured with large mesh nets attached to projectiles that are propelled over the roosting or feeding flocks by explosive charges. Cannon nets have been used to capture many species of waterfowl, wading birds such as herons and egrets, upland game birds, gulls and shorebirds (Whitworth *et al*. 2007). Normally this technique is used on land, but it could probably used on board in a modified way, or in a smaller version (net gun).

A net gun (Figure 2.4) was used in Chesapeake Bay to capture Surf Scoters (seaduck) from a boat. The net gun is a hand-held modified rifle that uses a blank rifle cartridge to project a small net approximately 5-15 m. Weights are attached to the corners of the net (usually 3.5 m X 3.5 m) and carry it over an individual bird or small group of birds. It is important to shoot the net on water with depths less than the retrieval line length (this might be a problem on the open sea near or in an offshore wind farm, since it is possibly too deep to handle the net properly). The success was in earlier studies dependent on calm seas to attain proper speed for capture and to safely operate the boat (https://www.pwrc.usgs.gov/).

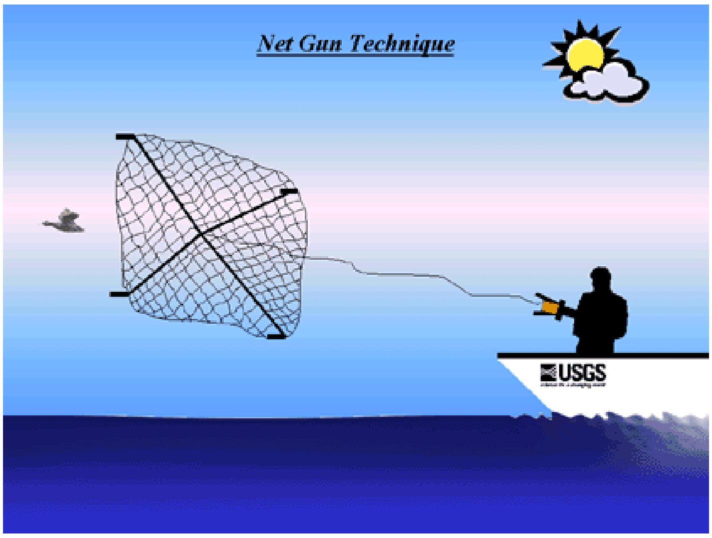

Figure 2.4 Net gun used to capture seaducks in Chesapeake Baye (USA) (source: Patuxent Wildlife Research Center; https://www.pwrc.usgs.gov/resshow/perry/scoters/CaptureTechniques.htm).

<u>Capturing gulls with a net gun can be considered as a possible method in this study, to capture in offshore wind farms,</u> though the net gun possibly needs some adjustments for capturing gulls offshore at sea. Gulls can drown, so probably buoys are needed on the corners of the net, but

even then there is a risk of drowning. It is recommended to do a test with this method first closer to the coast, to see if gulls can be caught successfully anyway with this method.

2.4 Overview

In Table 2.1, an overview is given of suitable capturing techniques and their features.

Table 2.1 Overview of suitable capturing techniques and their features, all mentioned techniques need calm weather conditions, the techniques should be carried out during daytime .

Capturing technique	By hand	Baited trap	Canon netting
Tools / devices	Bait, strong hands, hand-held net	drop-trap, walk-in cage, whoosh-net, bait	Cannon net or net gun
Point of attention		Proper attachment to surface	Net need adjustments (e.g. buoys)
Required ship	Fishing vessel or other vessel with enough bait	Maneuverable ship (CTV - crew transfer vessel) to reach platform (of WTG or OHVS) and place trap, or ship with large deck	Smaller boat, with adjustable speeds
Advantages	Not many equipments, only strong arms/hands	Choice of different types of cages, ideal when it is possible to place and capture on board	The gull can be captured from a distance
Disadvantages	Risk of attacking gull	Location of placement of the cage on a platform is uncertain	Risk of drowning the gull when capturing

3 Transmitters: types, options and costs

3.1 Transmitters

Tracking devices and bio-loggers provide crucial information on the positions and movements of animals in the wild and can relate these to environmental characteristics and human activities. Bird tracking methods such as radio tracking, geolocator loggers, satellite tracking or tracking via the use of the mobile telephone network, are rapidly evolving and offer high spatial and temporal resolution of bird movements. The most ideal tracking system should be lightweight (<3% of the bodyweight) (Barron *et al*. 2010), measure three-dimensional locations (x,y,z), enable flexible measurement schemes, transmit data remotely and measure biological and environmental parameters. Thanks to technological innovations the size and mass of tracking devices are decreasing, and the quality of measuring position, body movements, physiological parameters and environmental variables is increasing. However, each of the different tracking devices has its own pros and cons and one of the biggest issues nowadays is the trade-off between battery life, transmitter weight, signal interval and remote data transmission.

Specific for WOZEP, the goal is to determine to which populations gulls belong who regularly visit the offshore wind farms ('large' scale movements) and what their movements, flight height and speed are within the parks ('fine' scale movements). To answer these questions, transmitters need to meet the following requirements:

– High accuracy of data to follow both large scale movements to colonies and fine scale movements within the park
– Remote data download (the origin of the gulls cannot be determined in advance, so losing signal can be a problem for transmitters that need contact with base stations for transmitting data)
– Programmable measurement schemes (preferable flexible during transmitting to adjust the schemes based on locations and movements)
– Transmitter weight range 13-33 g (average < 20 g) for Lesser Black backed Gull (<3% of 450-1100 g)
– Transmitter weight range 30-69 g (average < 40 g) for Great Black-backed Gull (<3% of 1000-2300 g)
– Transmitter weight range 21-45 g (average < 30 g) for Herring Gull (<3% of 700-1500 g)
– Solar panel for charging battery (extends battery life exponentially and allows for much more detailed information compared to non-solar transmitters)
– Reliable flight height and speed measurements (indications for gull behaviour within the park). This type of data requires long battery life and data storage on the transmitter.

In this chapter, we will discuss different types of transmitters and their possibilities for tracking gulls at sea.

Radio tracking (VHF)
Radio tracking is the localization of an animal by receiving radio signals (VHF) using a hand-held antenna. The VHF transmitter can be fixed on an animal in the form of a small tag which sends pulsed electronic radio signals. The receiver, in combination with a directional antenna is used to find the direction from which the signal comes. In order to get a precise position, it is necessary to approach the transmitter very closely (~100m) or to acquire transmissions from

three (or more) different locations to triangulate the location of the transmitter (triangulation). It is possible to radio track from the ground or from an aircraft and it can be done manually or by automated devices with several linked antennae and a processing unit that calculates the position of the sender from the strength of signals arriving at the different antennae. Pros of this type of transmitters are the relatively low weight and costs and long battery life compared to other transmitter types. Cons are the limited range to follow animals, the lack of detailed information about the route over longer distances and the need for expensive tracking equipment and personnel. Based on these arguments, <u>the use of VHF transmitters is not recommended</u> for tracking gull species at sea.

Geolocators

Geolocators (or global location sensing/GLS logger) are small data loggers that measure light and have an accurate real-time clock to determine the time of sunrise and sunset. The estimated geographical position is obtained by calculating the day length which indicates latitude, and the time of solar noon, which indicates longitude. This type of transmitters can be used to study long range migration, but their location accuracy, ranging from 50 km up to 200 km, is low. While these loggers save weight and energy compared to long distance sending transmitters, animals need to be recaptured to read out the data. For these reasons, t<u>he use of geolocators is not recommended</u> for tracking gull species at sea.

GPS logger or trackers

GPS (Global Positioning System) loggers allow tracking animals remotely across the globe without the researcher needing to locate the signal. These loggers use satellites to fix their position with high accuracy (±10-20 m) and record the data on the logger. The data collected by loggers need to be downloaded via a base station (for example, by making contact with the logger by VHF, UHF or Zigbee). Base stations are supplied with software which enables automatic and remote GPS data download. These GPS data loggers have relatively low cost, low weight and increased battery life compared to GPS-PTT or GPS-GSM (see below). This type of logger is suitable to use on individuals in breeding colonies or on species with high site fidelity, but not preferable for species/individuals that disperse beyond the reach of the base station or antenna network. However, recent developments have created new possibilities. UvA-BiTS trackers, for example, are data loggers but also have an option to send SMS messages. The SMS is not replacing the downloading of data with the base station and relay network, but it is only meant to send a few GPS locations per day. This can be very useful if a bird disperses beyond the reach of the antenna network and can be traced in this way. An antenna can then be brought/ placed in the area where the bird is located and data can be retrieved. In this way, it still has relatively low cost, low weight and increased battery life compared to GPS-PTT or GPS-GSM, but only if costs and workload of placing new base stations becomes not disproportionally high. For this reason, <u>the use of GPS loggers with SMS function can be considered</u> for tracking gull species at sea.

GPS-PTT

Satellite tracking technology is evolving rapidly. The most widespread tracking system is maintained by the company Argos with five satellites circling around the earth on polar orbits (www.argos-system.org). Argos can be used in different ways. One way of localization is Doppler technology, which measures the interval of time between two consecutive signals. Each time a satellite passes over the transmitter or so called Platform Terminal Transmitter (PTT) it collects signals from the transmitter. Messages and measured frequencies are sent to the Argos processing centers via ground stations. Then, the locations are filtered and classified in classes based on their deviation in meters. In practice, the two most accurate classes (<250m & 250-500m) occur, but occur in approximately 10-20% of cases (Meyburg and Fuller

2007, Douglas *et al*. 2012, FEBI 2013, DIVER). Experienced expert Birgit Kleinschmidt (DIVER project) indicates that the most accurate class is around 100m.

Another way of localization is a combination of Argos PTT and GPS, so called GPS-PTT or PinPoint Argos. These, more advanced, satellite tracking systems make use of the global positioning system (GPS). GPS greatly increases location accuracy (10-20 m). With this system, transmitters make contact to a series of satellites (not only Argos satellites) and calculate their own position. Positions can then be sent through the Argos satellites to a ground station. They have much lower power consumption than Argos only tags (PTT). Argos messages require a lot of energy and many messages have to be sent to make sure that enough are received by the satellites (1-way communication, i.e. tag doesn't know if signal received or not). GPS-PTT and PinPoint Argos tags take GPS locations (better accuracy) and require much fewer Argos messages to be sent. 1 Argos message encodes 3 to 5 GPS coordinates, whereas 4 messages are required by Argos PTT for calculating a location (via Doppler Shift effect). The GP -PTT and PinPoint Argos tags with the new firmware use the latest GPS location to calculate the next pass of an Argos satellite over that latest location. Thereby it can focus the transmissions on that short period and save a lot of energy (more location fixes, longer battery life). Depending on the latitude, the GPS-PTT and PinPoint Argos tags with the pass prediction firmware are limited to ~30-40 locations per day. This is because of the limited number of Argos passes, which are more frequent in higher latitudes (polar orbits).

Both types of transmitters are relatively high in costs and low in battery life/signal interval, because extra costs are charged for transmitting data via Argos and transmitting data requires a lot of energy compared to storing data on the transmitter itself. In addition, PTT transmitters have lower accuracy compared to the GPS-PTT transmitters. The problem of low battery life can be partly solved with solar powered GPS-PTT's. GPS-PTT's can be considered for tracking gull species at sea.

GPS-GSM

Another option to map small-scale and large scale movements is the use of GPS-GSM transmitters (with a solar battery). GSM is an abbreviation of 'Groupe Special Mobile', a telecommunications standard set for digital cellular networks. The GSM system is used in 220 countries. Especially in populated areas, the range and accuracy of these stations are many times better than the PTT and GPS-PTT because it works with multiple satellites (not only polar) and can transmit data faster through the GSM network than the Argos system. In addition, these channels have the ability to send a lot more data (10,000 bytes per day GPS-GSM vs. 1000 bytes per day GPS-PTT), but also to save data on the transmitter. If the transmitter is out of range of a GSM cell for a long time, it can save positions and then forward up to 100,000 bytes in 1 day if the transmitter reverts. So even if a bird goes to a remote area without GSM network, it can still save and send positions when the transmitter is within range of GSM again. If a bird dies in remote area, data is lost from the point of the latest data download. Gulls in wind farms are expected to come often in 'urban' areas with a good GSM network. This type of transmitters is also relatively high in costs and low in battery life, because extra costs are charged for the mobile network and transmitting data requires a lot of energy, although less than when using Argos. GPS-GSM's is recommended for tracking gull species at sea.

Additional measurements and data possibilities

Due to technological innovations, the possibilities and quality of additional measurements such as body movements, physiological parameters and environmental variables is increasing.

Below are the currently available functions listed and per transmitter type (GPS logger, GPS-PTT and GPS-GSM), it is indicated if this function is working and what the settings are.

Accuracy and number of data points
Accuracy of GPS-loggers, GPS-PTT and GPS-GSM is around 10-20 meters. Number of data points per day depends on settings and how often transmitters can transmit the data to the base station. Roughly and based on settings used in other studies, GPS-loggers can generate most data points (x,y coordinates) per day (200-300, or more), followed by GPS-GSM (100-200) and then GPS-PTT (30-40).

Schedule interval and duty cycle
Transmitters can be programmed with different duty cycles of transmitting data and gps intervals. For example, transmitters can be programmed with high GPS intervals (sec-min) during breeding season and low during wintering season (hours), depending on species characteristics and research questions. The same applies for transmitting data to base stations. Transmitting data very often consumes much battery, but the risk of losing data when an animal dies is less. Reducing data transmission extends battery life and can give more detailed information in specific time periods. UvaBiTS loggers have the option of geofencing (see below), which makes it possible to intensify measurements in specific areas (for example in wind farms). Schedules of GPS-loggers and GPS-GSM transmitters can be changed by the researcher when the transmitters make contact to base station or GSM network.

General parameters
All transmitters and loggers have temperature, battery voltage & activity sensors. The temperature sensor is not very accurate and is used to identify mortality. The activity sensor is often set in low interval for identifying mortality as well, but can be used as accelerator meter (see below).

Accelerator measurements
Most GPS-loggers, GPS-PTT and GPS-GSM have accelerometers. The accelerometer measures the acceleration in 3D. Acceleration is caused by gravity and by a change in speed. Due to gravity, the pitch of a logger is thus translated into the values of z, x, y and results in speed, heading, flying and height. Most loggers have a standard activity sensor, which is not very accurate and measures only activity or no activity and is used as a mortality sensor. Accelerometers are often optional and consume data storage and battery. Therefore, accelerometer data is not included in every GPS measurement and scheduled separately. GPS-loggers consume less battery and can therefore generate the best accelerometer data. Next in line are the GPS-GSM transmitters and the GPS-PTT transmitters.

Geofencing
Geofencing uses polygons and associated GPS schedules to define areas of interest and their use. Latitude and longitude of each polygon corner defines the area and automatic GPS schedule changes can be made for ingress or egress of geofenced areas. At the moment UvABiTS are the only transmitters with geofencing.

Design
Some transmitters have an elevated base for protecting the solar charger against covering by feathers, but most designs of solar GPS transmitters work well on gulls.

Overview of potentially suitable transmitters and settings

Based on previous paragraphs, an overview of suitable transmitters is given in Table 3.1. To answer WOZEP's research questions, GPS-GSM transmitters are the best option. This is mainly determined by the facts that the origin of the gulls cannot be determined prior to catching, which can result in losing signal of GPS-loggers and that GPS-GSM transmitters can generate more locations and more accurate accelerometer data due to a more efficient data download via the GSM network then the GPS-PTT's. However, the network of base stations of the UvABiTS loggers is expanding and the SMS function of these loggers gives the opportunity to follow the gulls and place a new base station to download data, although the latter is logistically challenging and expensive. Perhaps these GPS-loggers can be used in the future.

Table 3.1 Overview of suitable transmitter type and their settings

	Transmitter type for tracking birds (all solar powered)		
	GPS logger (with remote SMS function and automatic download)	**GPS-PTT**	**GPS-GSM**
Range in weight (g) of available transmitters on the market	7,5 - 45	6 - 70	15 - 70
Gull species	Lesser Black-backed Gull, Great Black-backed Gull and Herring Gull	Lesser Black-backed Gull, Great Black-backed Gull and Herring Gull	Lesser Black-backed Gull, Great Black-backed Gull and Herring Gull
Species weight range based on transmitter weight (g) (<3%)	250 - 1500	200 - 2333	500 - 2333
Costs per transmitter	€ 1600 - 3000	€ 2000 - 4000	€ 1100 - 4000
Additional costs	€ 3000-5000 for a base station, € 3000 for an extra antenna. €15 per month per transmitter for prepaid SMS-service.	Argos transmission costs, roughly € 100,- per month	GSM mobile network costs, roughly €15 - 30 of data transfer fees per month for transferring data
Range	Unlimited	Unlimited	Unlimited
Tracking interval	sec-min-hours	hours	min-hours
Rough estimate of locations per day	200-300 >, depending on interval settings and how often data is downloaded	30-40, depending on settings and how often data is downloaded	100-300 >, depending on interval settings and how often data is downloaded
Storage	On logger until downloading, >1000 locations	Transmission, partly on logger (few locations)	On logger, until downloading, >1000 locations
Lifetime	Up to several years (1-5) Battery life depends on charging cycles, gps intervals, temperatures	Up to several years (1-5) Battery life depends on charging cycles, gps intervals, temperatures, Argos intervals	Up to several years (1-5) Battery life depends on charging cycles, gps intervals, temperatures, GSM intervals
Study time	years	years	years
Transmission - data download	Base station (VHF, UHF, Zigbee), sms function for few locations	Argos - worldwide but interval limited by Argos network	GSM - worldwide but interval limited by cellular network
Accuracy	10-30 m	10-30 m	10-30 m
Functions	Positions (x, y), heading, speed, altitude (z), temperature, battery voltage & activity sensors, geofencing, accurate accelerometer	Positions, heading, speed, altitude, temperature, battery voltage & activity sensors, low accurate accelerometer	Positions, heading, speed, altitude, temperature, battery voltage & activity sensors, medium to high accurate accelerometer
Changing operating parameters	Yes, when transmitters make contact with base station	Only by manufactory	Yes, via GSM network
Manufactory € low in costs €€ high in costs	Ecotone telemetry (€), TechnoSmart, UvABiTS (€€),	Lotek/Biotrack/Sirtrac (€), GeoTrakInc, North Star, Microwave telemetry (€€)	Ornitela (€), Ecotone telemetry (€), Cellular Tracking Technology, North Star, Microwave telemetry (€€)

4 Effects of transmitters and attachment methods

4.1 Effects of transmitters and attachment methods in general

Rapidly evolving transmitters create more and more opportunities to study bird behaviour and movements. Decreases in transmitter size and increases in battery life over the years, expanded the number of study species and study duration. However, the growing use of telemetry makes it important that we understand how transmitters affect birds.

A number of aspects can be affected by transmitters: nest success, clutch size, nesting propensity, nest initiation date, offspring quality, body condition, flying ability, foraging behaviour, device-induced behaviour (such as more preening), energetic expenditure, survival rate, nest abandonment, physical harm and device-induced mortality (Barron *et al.* 2010). Beside these aspects, effects of transmitters can be influenced by sex, age, locomotion, body mass and by the weight of transmitters (Barron *et al.* 2010). Overall, birds are negatively affected by attached transmitters, but to which extent differs per species and transmitter type and attachment. Barron *et al.* (2010) reviewed 192 studies and found that transmitters can have negative effects on all aspects mentioned above. Effects and their magnitude differed per species and most effects were 'small', but especially energetic expenditure increased a lot and individuals were much less likely to nest (Barron *et al.* 2010). In this review, birds were similarly affected regardless of age, mode of locomotion and body mass, with sex having some influence. Birds performed the most device-induced behaviour when wearing breast mounted devices and devices attached with harness. Mortality was most commonly reported in studies using subcutaneous anchors, followed by implants, harnesses, collars and glue, with no mortality reported in studies using tail mounts. A rule of thumb is that transmitters, weighing less than 3% of an animal’s body weight, have negligible effects. Studies testing this rule have different results, but in studies on seabirds the 3% rule is maintained (Barron *et al.* 2010, Phillips *et al.* 2003). Although glue and tail mount attachments result in low mortality rates, low duration rates of these attachments (until moult) limit their value (Woolnough *et al*. 2004).

4.2 Effects of transmitters and attachment method on seabirds

Several studies investigated the effects of transmitters and attachment method on seabirds. Phillips *et al*. (2003) examined the effects of satellite tag deployment (attached on mantle feathers with tape) in albatrosses and reviewed the literature for other albatrosses and petrels. They found that few individuals slightly extended their foraging trips, but overall there was no significant effect on trip duration, meal mass, breeding success or rate of return in the next season and birds flew to representative foraging areas. Other studies of albatrosses and petrels recorded extended trip durations and sometimes high rates of nest desertion as a result of PTT attachment (Phillips *et al.* 2003 and references therein). That occurred mainly when transmitter weight exceeded the 3% rule. Thaxter *et al*. (2015) studied the effects of a GPS device attached using a harness on Lesser Black-backed Gull and Great Skua. They found no short-term impacts on breeding productivity or long-term impacts on over-winter return rates for Lesser Black-backed Gulls, but Great Skua return rates were lower. Camphuysen (2011) found comparable results: breeding success and fledging rates of Lesser Black-backed Gulls were not significantly different from control pairs, but return rates of tagged birds one year later were lower and breeding attempts on the long run seem lower. Annual survival or return rates seem to be lower in gulls carrying GPS loggers. However, Camphuysen (2011) did not found evidence for continuous signals of prolonged physical stress.

4.3 Representative data and reducing transmitter effects

In general, GPS-transmitters and loggers (with harness attachments) are likely to have at least some handicapping effect on the birds and abnormal behaviour induced by transmitters can never be completely excluded (Camphuysen 2011). In several studies, there is firm evidence that the behaviour of transmitted birds was largely unaffected and the results are therefore considered representative for normally breeding individuals (Phillips *et al* .2003, Thaxter *et al*. 2015, Camphuysen 2011, Camphuysen 2013). However, for non-breeding individuals it is more difficult to judge whether data are representative since less is known about these individuals. Further research is necessary on the effects of transmitters on this type of individuals (for example by comparing colour ringed animals and behavioural observations).

Furthermore, only relatively few individuals can be provided with transmitters, so it will always be the question how representative these individuals are for the population. However, so far, mainly breeding individuals are provided with loggers and attaching transmitters to non-breeding individuals will give more insight in movements of 'different' members of a population.

Best option on the long term (>weeks/months) for transmitter attachment on gulls is harness attachment. Solar satellite transmitters should be positioned dorsally to improve transmitter-satellite communication and solar charging. Researchers can minimize the risks of transmitter effects by using adjustable harnesses to custom fit the bird and by adding a weak link that causes the device to detach if entangled. Because the birds are caught at sea and not in a colony, it is difficult to re-catch the birds and to free them from the transmitter. It is therefore assumed that the transmitter stays on the bird until the harness gets loose or the animal dies. Currently new types of harness are developed made from a soft, elastic, hypoallergenic, silicone-based compound called Silastic (Dow Corning Corporation, Midland, MI), but these harnesses are still in a test phase. To further minimize transmitter effects, transmitter weights should be reduced to a minimum and careful attention should be given to limiting handling times while placing transmitters.

To answer the WOZEP research questions, equipping gulls with transmitters can result in valuable information (e.g. where do gulls breed that fly in wind farms, what is their behaviour in the wind farms, how long do they stay there etc), However, transmitter data from gulls tagged at sea should be compared with counts and behavioural observations in the wind farms and with already available data on transmitted breeding individuals to investigate how representative the data are. Furthermore, a pilot study on catching and equipping gulls with transmitters at sea is a first step and results from this pilot can then be evaluated in order to design future studies.

5 Legislation

In order to be able to catch gulls and provide them with transmitters in wind farms on the North Sea, several silences and permits need to be obtained:

5.1 Catching and ringing birds

In order to be able to catch birds (catching and ringing), a license is needed for an exemption of the Wet Natuurbescherming, beschermde inheemse soorten (previously Flora - en Faunawet). This ring license is granted by the NIOO Vogeltrekstation. In order to get a license, a research plan with all aspects involved is needed and applicated to the NIOO Vogeltrekstation (e.g. problem statement, literature research, methodology, motivation for the birds to be captured, how many captive birds are needed, duration, evaluation times, end date, planned publications). It is the responsibility of the NIOO Vogeltrekstation to assess whether applications are good enough for a ring license. Participating in existing projects is possible.

5.2 Wet op de Dierproeven

In the Netherlands, the *Wet op de Dierproeven (WOD)* is applied. The purpose of this law is to test the experiments on animals beforehand: is the method accountable and does the expected discomfort and number of used animals outweigh the obtained data or are there alternatives etc? The WOD applied to invasive animal tests in which the skin barrier is passed (e.g. insertion of a needle for anesthesia or implantation of a transmitter). and therefore only a handling protocol was sufficient for attaching transmitters to birds with harnesses. However, this changed since January 1ste 2016 and <u>today it is mandatory to get a CCD/DEC license for attaching transmitters with harnesses.</u> Preparing an animal experiment proposal and testing by an Animal Experiments Commission (DEC) takes time (roughly 3 months, 40 days at least) and expertise is needed (applicant must be competent for conducting animal experiments).
The following aspects should be taken into account:

- License can only be requested by an institute with institution-permit,
- Application should be judged by IvD (*Instantie voor Dierwelzijn*),
- Application should be submitted to CCD together with independent advice of DEC,
- Detailed study-plan is needed after permission,
- Final report after study is done.

Some institutions have a ‘general’ license for bird research which can speed up the process if the scope of the proposed project matches with the ‘general’ scope (SOVON, BuWa, NIOZ).

5.3 Protected areas Natura 2000 - Wet Natuurbescherming

If gulls are captured and provided with transmitters within a Natura 2000-area, for example Voordelta, Noordzeekustzone or Duinen en Lage Land Texel, an exemption of the *Wet Natuurbescherming* (area protection) is needed. The Dutch wind farms on the North Sea are currently located outside these N2000 areas and the expectation is that an exemption is not needed. However, in case of the Lesser Black-backed Gull (target species in several Natura 2000 areas along the Dutch coast in the breeding season) external factors (*externe werking*) can play a role. Therefore it is recommended to conduct a *Voortoets* in order to prevent issues with legislation afterwards.

5.4 Permission to enter a wind farm

In the current situation, it is not allowed to enter a wind farm at sea. This is governed by a general decision (BAS) based on Article 6.10 of the *Waterwet* and Article 8 of the *Beleidsregels inzake toepassing Wet beheer Rijkswaterstaatswerken op installaties in de exclusieve economische zone*. This applies to the protection of wind turbines in wind farms and shipping safety. Therefore, part of the area around a wind farm is closed for shipping (500 m of the edge). However, the prohibition does not apply to ships that have permission of a wind farm operator or Rijkswaterstaat/Ministerie EZ.

6 Field set up

6.1 Research plan

In this chapter, we make a short proposal about the steps that can be taken next, in order to get the right data for answering the WOZEP research questions. Thereafter, we present a set up for a pilot field study on catching and placing transmitters on gulls. In general, we recommend the following steps:

1. Analyzing current available data on flight height, speed, routes etc. A large amount of data on these parameters is already available or is/will be analyzed in other projects (pers. comments Kees Camphuysen, Gyimesi *et al*. 2016, Gyimesi *et al.* 2017) and can (partly) answer the research question addressed in the WOZEP studies.

2. Parallel to this data analysis study, a pilot field study can be conducted to test catching techniques and different transmitter types/settings (manufactures, different interval etc.) and to get insight in the flight behaviour of (non-)breeding adults/juvenile gulls; during breeding season it can be possible to separate breeding and non-breeding individuals based on breeding spot (‘*broedvlek*’).

3. Based on the data analyses of existing data and on the outcomes of the pilot field study, further research can be adjusted, specified and scaled up if necessary.

In the paragraphs below, a short proposal is written in outlines for a pilot field study on catching and placing transmitters on gulls.

6.2 Pilot field study

A pilot field study on catching and placing transmitters on gulls in wind farms at the North Sea consist of the following components:

<u>*Suitable locations for catching*</u>
Realised offshore wind farms at the moment are wind farm Gemini (85 km north of the coast of Groningen), OWEZ (Offshore Windpark Egmond aan Zee; 11 km off the coast), PAWP (Prinses Amalia Windpark; 23 km off the coast to IJmuiden) and Luchterduinen (23 km off the coast to Noordwijk/Zandvoort), see also Figure 6.1.

It is known that the Lesser Black-backed Gull occurs in an at least 40 km wide zone from breeding colonies along the coast and can occur in the wind farms OWEZ, PAWP and Luchterduinen. Leopold *et al.* (2013) describe in their monitoring report that also Herring Gulls are frequently seen in the wind farms PAWP and OWEZ (e.g. resting on monopile foundations or foraging). Herring Gulls are often associated with fishing vessels, mostly closely inshore, but numbers could also increase significantly offshore, when the fishing fleet is working in these waters. Great Black-backed Gulls are present in small numbers offshore in the Southern North Sea in June/July (Camphuysen & Leopold 1994). They breed in more northerly areas and are most abundant in offshore Dutch waters in winter. The distribution of Great Black-backed Gulls mimicked the one of Herring Gulls with birds showing associations with fishing vessels. Only low numbers were recorded and their distribution may simply be related to fishing activities.

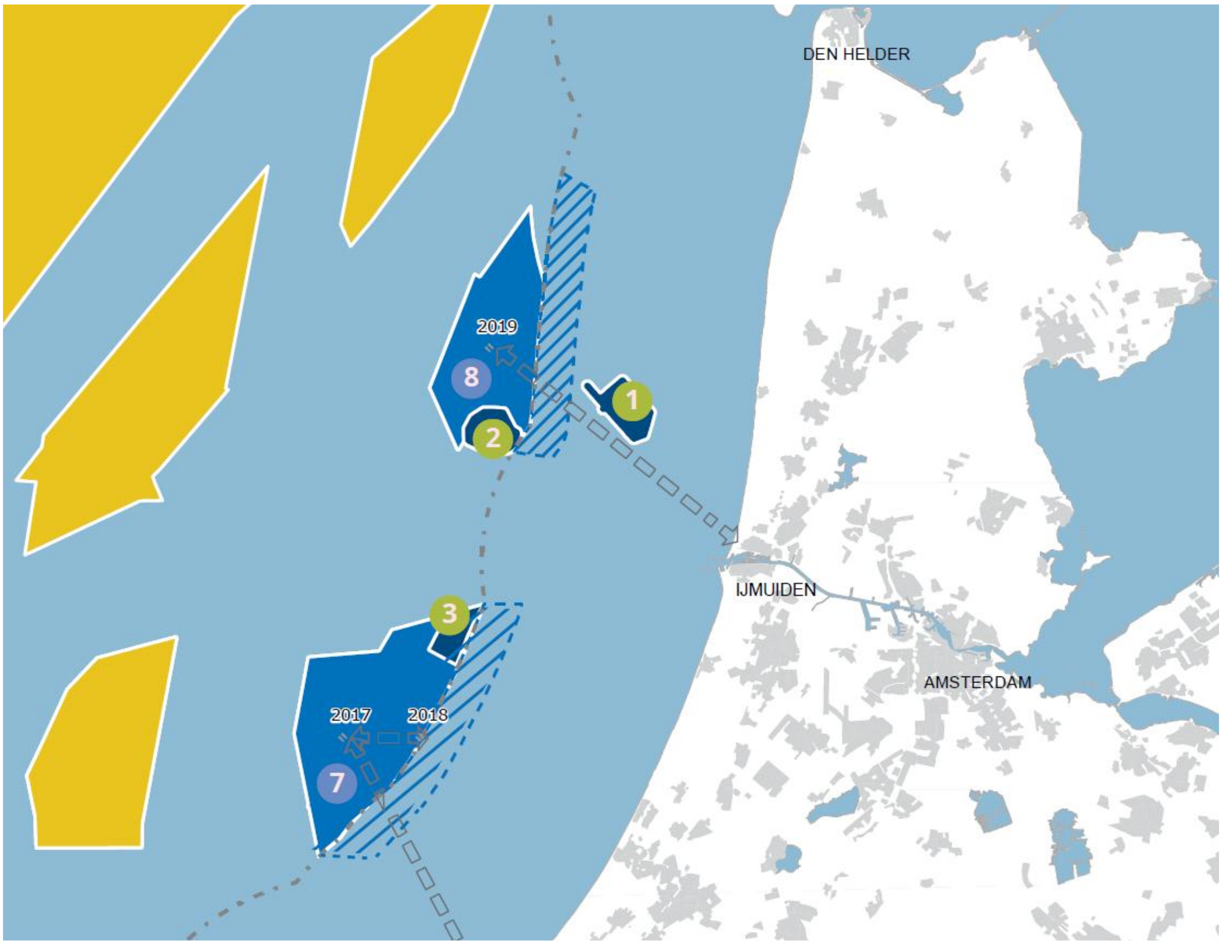

Figure 6.1 Overview of wind energy areas in the North Sea near the Dutch coast. 1.OWEZ (Offshore Windpark Egmond aan Zee; 11km off the coast) 2. PAWP (Princess Amalia Wind farm; 23km off the coast to IJmuiden) 3. Luchterduinen (23km off the coast to Noordwijk/Zandvoort). Yellow areas indicate designated areas (source: www.nwea.nl; Nederlandse WindEnergie Associatie)

The order of construction of the wind farms was as follows, OWEZ was operational at the end of the year 2006. Construction of PAWP commenced in October 2006 and the park became fully operational in June 2008. Construction of LUD started in 2014 and the wind farm became operational in summer 2015. Monitoring programmes on seabirds have been carried out for all three of the wind farms. All three wind farms are in the distribution range of the gull species (and in all three of the wind farms the gull species have been reported).

<u>*Season-period*</u>

Lesser Black-backed Gull: best period for catching is between April and September. If the focus of the pilot study lies on adults (and adults are probably the most representative in relation to the research question), April-May and July-August are the best periods. In August-September, the proportion of juvenile Lesser Black-backed Gull increases significantly at sea and would be the best time for catching juveniles.

Great Black-backed Gull: best period for catching is between September and March. Catching and attaching transmitters at sea should be conducted under calm weather conditions (which also applies to the other species) and catching in September is therefore recommended, since weather conditions can then still be good.

Herring Gull: Herring Gulls are more abundant at sea in October/November and in lower abundances in April-May, also offshore. Based on weather conditions, April-May is preferable.

Table 6.1 Monthly age composition in the three gull species (% adults) offshore in the southern North Sea, 1985-93 (From: Camphuysen & Leopold 1994).

Period / Species	Lesser Black-backed Gull		Great Black-backed Gull		Herring Gull	
	% offshore adult		% offshore adult		% offshore adult	
January	83		78		72	
February	72		64		73	
March	92		51		70	
April	92		46		63	
May	84		14		56	
June	90		37		90	
July	90		59		95	
August	82		57		67	
September	60		67		17	
October	67		72		34	
November	85		78		67	
December	84		74		63	

Depending on the exact aim of the pilot, it is advisable to focus on one species in the month(s) with highest numbers (for example Lesser Black-backed Gull in March-April or June-July), or on the month(s) where all three species occur in highest numbers and when weather is calm (based on Table 6.1, July for example).

Catching technique
In literature, hardly any study was found describing catching gulls at sea. Based on input from experts, catching by hand and catching by trap on deck is recommended. In a pilot study, it is advisable to test both methods. If possible to obtain access to the turbine foundation, catching with the 'old' and proven techniques of drop-traps or walk-in-cages on the turbine foundation may give the best results.

Catching effort in days
Catching effort is difficult to estimate, but probably 2-3 days at sea. Two expeditions of roughly a week, one in April-May-June and depending on the results of that expedition, another expedition in September-October, are recommended.

Transport & Vessels
Research vessels should have enough space for placing traps on deck and preferably have a quiet area/room where trapped gulls can be measured and where transmitters can be attached. In addition, a research vessel should have enough space to lodge a team of researchers (2-3 persons) for a week. For a first expedition, it is advisable to use a research vessel which is hired for scientific research only (for example for catching and counting gulls). This offers more flexibility. Depending on such a first trial, it can be considered to combine an expedition with vessels that conduct maintenance on wind farms or with fishing vessels.

Transmitters (which one to use, and how many)

GPS-GSM transmitters are the best option. Microwave telemetry is most reliable, but also most expensive and their delivery time is long (>6 months). Transmitters from Ornitela en Ecotone telemetry are good alternatives (almost 4 times cheaper and ± 2 months delivery time), but less is known about their reliability. It is recommended to order GPS-GSM transmitters from different manufactories to test their applications and reliability. For a pilot study, 5 individuals per species can be tracked initially, resulting in 15 GPS-GSM transmitters in total. Based on the cheapest version, costs for transmitters will be around € 17.000.

Permits

In order to be able to catch birds (catching and ringing), a license is needed for an exemption of the *Wet Natuurbescherming, beschermde inheemse soorten* (previous *Flora - en Faunawet*). Next, it is recommended to get advice from a DEC member to investigate what actions are necessary to meet the requirements of the WOD. For attaching transmitters to birds with harnesses, usually a handling protocol is sufficient. It is also recommended to conduct a *Voortoets* (*Wet Natuurbescherming*) in order to prevent issues with legislation afterwards. Prior to the expeditions, permission of a wind farm operator or Rijkswaterstaat/Ministerie EZ is necessary to enter the wind farm. It is advisable to apply for the licenses approximately 3 months in advance.

7 Conclusions

In this report, an overview is given of the possibilities of catching gulls (Lesser Black-backed Gull, Great Black-backed Gull and Herring Gull) at sea, which transmitters to use, what kind of data are produced, and what (animal) ethical issues are involved. Based on the previous chapters, the following conclusions can be drawn:

- Catching gulls at sea is possible, in theory with different methods. However, there is not much experience with catching gulls at sea and a pilot study is necessary to test different catching techniques.
- Based on literature and experts, catching by hand and by trap on deck seem to be the best catching techniques.
- Based on distribution ranges of the three gulls and the amount of available knowledge, all three locations (OWEZ, PAWP and LUD) are suitable for catching.
- Best period for catching is in April-May-June and September-October. Chances of catching Lesser Black-backed Gull are highest, while chances of catching Herring Gulls and Great Black-backed Gulls are much lower.
- Juveniles are less representative for the population then adults, in relation to the research question in this report. If possible, non-breeding and breeding adults should be captured and provided with transmitters. As males are more often found in wind farms at sea (based on males of the breeding colony on Texel), the chance is higher that more males are captured, but it is also interesting to catch some females as being part of the population.
- Solar GPS-GSM transmitters are the best option for tracking gulls that are captured at sea.
- When using GPS-GSM transmitters, gulls can be followed over longer distance (with remote data transmission) and their origin can be revealed. However, due to the low number of replicates it is difficult to assign numbers of gulls to certain population. A pilot study can gain more insight, especially if it can be combined with additional ring readings.
- Depending on settings (GPS-interval, transmitting interval), GPS-GSM can generate many GPS-locations and accurate accelerometer data (flight height, speed etc.) which can provide valuable information about behaviour.
- A pilot study can demonstrate which GPS-GSM transmitters work best for gulls at sea and which settings gain most data (schedule can be adjusted while being in service).
- For short term research (weeks), transmitters can be glued or taped on gulls. For the WOZEP research, this type of attachment is not sustainable and attachment by harnesses is recommended.
- For breeding gulls, transmitted birds with harness are considered representative for normally breeding individuals. For non-breeding individuals it is more difficult to judge if data are representative. Less is known about these individuals and when they make long (scouting) trips, their behaviour and survival can be affected by carrying transmitters. A

pilot study can gain more insight, especially if it can be combined with additional ring readings.

- Prior to catching at sea, several licenses need to be obtained.
- Currently, there is a great amount of data available on gull behaviour and movement in wind farms. It is recommended to analyze these data with the use of specific and detailed research questions.

Based on these conclusions, we recommend analyzing current available data and conducting a pilot study on catching gulls at sea and providing them with GPS- transmitters. Based on these data analyses and the outcomes of the pilot field study, further research can be adjusted, specified and scaled up if necessary.

8 References

Aanwijzingsbesluit (2008). Natura 2000-gebied Duinen en Lage Land Texel. Directie Regionale Zaken 1 DRZO/2008-002

Barron, D. G., J. D. Brawn, and P. J. Weatherhead (2010). Meta-analysis of transmitter effects on avian behaviour and ecology. Methods in Ecology and Evolution 1:180-187.

Belant, J.L. (1997). Gulls in urban environments: landscape-level management to reduce conflict. Landscape and Urban Planning 38: 245-258.

Camphuysen, C.J. & M.F. Leopold (1994). Atlas of seabirds in the southern North Sea. IBN Research Report 94/6, NIOZ-Report 1994-8, Institute for Forestry and Nature Research, Dutch Seabird Group and Netherlands Institute for Sea Research, Texel, 1-126 pp

Camphuysen, C.J. (2011). Lesser black-backed gulls nesting at Texel. Foraging distribution, diet, survival, recruitment and breeding biology of birds carrying advanced GPS loggers. NIOZ report 2011-05

Camphuysen, C.J., H.J.P. Vercruijsse & A.L. Spaans (2011). Colony- and age-specific seasonal dispersal of Herring Gulls *Larus argentatus* breeding in The Netherlands. Journal of Ornithology 152: 849-868.

Camphuysen, C.J., J. van Dijk, H. Witte, N. Spaans (2008). De voedselkeuze van Kleine Mantelmeeuwen en Zilvermeeuwen en andere indicaties die aanwijzingen geven over het ruimtegebruik van deze vogelsoorten in de Noord-Hollandse kustwateren. NIOZ rapport 2008-12

Camphuysen (2013). PhD thesis: A historical ecology of two closely related gull species (Laridae).

Christmas, S.E., T.J. Christmas, A.P. Gosling and A.J. Parr (1986). Feeding behaviour and geographical origins of Black-headed Gulls *Larus ridibundus* wintering in Central London. Ringing & Migration 7: 1-6.

Douglas, D. C., R.C. Weinzierl, S. Davidson, R. Kays, M. Wikelski, and G. Bohrer (2012). Moderating Argos location errors in animal tracking data. Methods in Ecology and Evolution 3:999-1007.

FEBI (2013). Fehmarnbelt Fixed Link EIA. Bird Investigations in Fehmarnbelt – Baseline. Volume II. Waterbirds in Fehmarnbelt. Report No. E3TR0011

Gyimesi, A., J.W. de Jong, M.P. Collier, W. Bouten & R.C. Fijn (2016). Validation of biological variables for use in the SOSS Band model for Lesser Black-backed Gull Larus fuscus and Herring Gull Larus argentatus. report nr. 16-042. Bureau Waardenburg, Culemborg

Gyimesi, A., T.J. Evans, J.F. Linnebjerg, J.W. de Jong, M.P. Collier & R.C. Fijn (2017). Review and analysis of tracking data to delineate flight characteristics and migration routes of birds over the Southern North Sea. report nr 16-139. Bureau Waardenburg, Culemborg

Leopold, M.F., M. Boonman, M.P. Collier, N. Davaasuren, R.C. Fijn, A. Gyimesi, J. de Jong, R.H. Jongbloed, B. Jonge Poerink, J.C. Kleyheeg-Hartman, K.L. Krijgsveld, S. Lagerveld, R. Lensink, M.J.M. Poot, J.T. van der Wal, M. Scholl (2014). A first approach to deal with cumulative effects on birds and bats of offshore wind farms and other human activities in the Southern North Sea. IMARES Report C166/14

Leopold, M.F, R.S.A. van Bemmelen & A.F. Zuur (2013). Responses of local birds to the offshore wind farms PAWP and OWEZ off the Dutch mainland coast. Report nr. C151/12

Masden, E., C.B. Thaxter, V.H. Ross-Smith, W. Bouten, N.A. Clark, G.J. Conway, G. Clewley, L. Barber & N.H.K. Burton (2017). Wide-scale movements of lesser black-backed gulls throughout the year and implications for cumulative impact assessments of wind farms. Poster CWW2017 Estoril. In: Book of Abstracts, Conference on Wind energy and Wildlife impacts 6-8 September 2017, Estoril, Portugal.

Meyburg, B. U., and M. Fuller (2007). Satellite Tracking. Raptor Research and Management Techniques. 242-255.

Mills, J.A. & J.P. Ryder (1979). Trap for capturing shore and seabirds. In: Bird-Banding. Spring 1979, 50(2): 121-123

Phillips, R.A., J.C. Xavier, & J.P. Croxall (2003). Effects of satellite transmitters on albatrosses and petrels. Auk 120: 1082-1090.

Solman, V.E.F. (1994). The Handbook: Prevention and Control of Wildlife Damage. Gulls. P.49-52.

Skov, H., S. Heinänen, M. Lazcny (2015). Offshore wind farm ENECO Luchterduinen. Ecological monitoring of seabirds. TConstr report. IfAÖ & DHI. Project number: 11813060.

Thaxter, C.B., V.H. Ross-Smith, J.A. Clark, N.A. Clark, G.J. Conway, E.A. Masden, H.M. Wade, E.H.K. Leat, S.C. Gear, M. Marsh, C. Booth, R.W. Furness, S.C. Votier, & N.H.K. Burton (2015). Contrasting effects of GPS device and harness attachment on adult survival of Lesser Black-backed Gulls *Larus fuscus* and Great Skuas *Stercorarius skua*. Ibis 158, 279-290.

Vanermen, N., W. Courtens, M. Van de Walle, H. Verstraete & E.W.M. Stienen (2017). Why are large gulls attracted to offshore wind farms? Poster CWW2017 Estoril. In: Book of Abstracts, Conference on Wind energy and Wildlife impacts 6-8 September 2017, Estoril, Portugal.

Woolnough, A.P., W.E. Kirkpatrick, T.J. Lowe, & K. Rose (2004). Comparison of three techniques for the attachment of radio transmitters to European Starlings. Journal of Field Ornithology, 75, 330–336.

Whitworth, D., S.H. Newman, T. Mundkur and P. Harris (2007). Wild Birds and Avian Influenza: an introduction to applied field research and disease sampling techniques. FAO Animal Production and Health Manual, No. 5. Rome.

Websites trapping techniques

- https://www.pwrc.usgs.gov/bbl/homepage/add_cap_tech.cfm
- https://www.pwrc.usgs.gov/resshow/perry/scoters/CaptureTechniques.htm

Appendix Manufactures GPS transmitters

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