Offshore Wind Farm

Eneco Luchterduinen

Ecological monitoring of seabirds

TConstr report

August 2015

ENECO

T-Constr report

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The expert in **WATER ENVIRONMENTS**

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TConstr report

Prepared for ENECO

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Executive summary

Construction of the Offshore Wind Farm Eneco Luchterduinen (LUD) started in 2014 by piling of monopile foundations and installation of secondary steel, cable lay and cable burial, rock installation cable crossings and export cable installation. The 129 MW (43 turbines) are expected to be fully operational by summer 2015. According to the license permit, LUD is obliged to carry out a 3-5 year monitoring program on seabirds focused on assessing any location specific and cumulative avoidance behaviour which can be measured in LUD and the two existing offshore wind farms (OWEZ and PAWP). For this purpose, a ship-based line transect monitoring program of wintering seabirds has been approved by the Competent Authority, which covers pre-construction (baseline), construction and post-construction phases. This report covers the results of the seabird monitoring for the construction period (TConstr) carried out during two surveys in October and December 2014.

As the two TConstr surveys cover a phase which is intermediate between the baseline and the post-construction periods and as neither the turbines nor the rotors were installed prior to the surveys the collected data are expected only to reflect the seabird fauna during the installation phase. Further, due to the low sample size given by the small number of surveys the results in terms of changes *sensu* the baseline are mainly descriptive rather than quantitative. For this reason distribution of seabirds was described using the general characteristics of the dynamic distribution model framework developed during the baseline without attempting to quantify changes in the distribution of seabirds. The assessment of potential changes in the distribution following the construction of LUD will be the focus of the report from the T1-T3 surveys. In order to map the monthly distribution of seabirds during the LUD-TConstr winter of 2014-2015, prediction models were applied taking both habitat conditions and current infrastructures in the survey area into account.

All primary transects were covered, as were a number of the secondary transects, especially in the southern part of the area. Yet, due to construction activities some parts of the primary and secondary transects in LUD could not be surveyed. During the LUD-TConstr survey in October 2015 gulls, especially Lesser Black-backed Gulls *Larus fuscus*, and Great Cormorants *Phalacrocorax carbo* dominated the observations. During the second survey in December, cormorants, Common Gulls *Larus canus*, Black-legged Kittiwake *Rissa tridactyla* and Common Guillemot *Uria aalge* were recorded in relatively large numbers. During the December survey, a patch of Red-throated Divers *Gavia stellata* was recorded at the western edge of and inside the LUD.

The model results indicated displacement impacts of the existing wind farms and LUD on the distribution of Northern Gannet *Morus bassanus* and Common Guillemot. A negative relationship between the distribution of Northern Gannet and the two existing windfarms was indicated up to a distance of about 2 km, where the probability of presence is highest. The relationship to LUD was negative up to the 4 km defined as potential disturbance distance. However, the distance variables to windfarms were not significant. The model for Common Guillemot provided indications of avoidance of all three wind farms to a distance of 2-2.5 km. As for the baseline, high ship density also affected the distribution of Common Guillemots negatively during the TConstr surveys. The model for Great Cormorant indicated that both PAWP and OWEZ had an attraction effect on cormorants, whereas LUD had no influence on their numbers. The distribution of gulls and Black-legged Kittiwakes in relation to LUD did not indicate any obvious patterns of avoidance. Although Herring Gulls were seen in larger numbers just outside the boundaries of LUD and OWEZ, this distribution may simply be related to fishing activities. Black-legged Kittiwakes were observed in LUD as well as in OWEZ and PAWP, and their distribution seemed mainly to be determined by water depth.

CONTENTS

1 Abbreviations

AIC	Akaike Information Criterion
AUC	Area Under Curve. Probability of correctly predicting presence of species
EEZ	Dutch Exclusive Economic Zone
EIA	Environmental Impact Assessment
ESW	Effective Strip Width
GAM	Generalized Additive Model
LUD	Offshore Wind Farm Eneco Luchterduinen
MEP	Monitoring and Evaluation Program
OWF	Offshore Wind Farm
PAWP	Prinses Amalia wind farm
TOR	Terms of Reference
UTM	Universal Transverse Mercator
WTG	Wind Turbine Generator

2 Introduction

Construction of the Offshore Wind Farm Eneco Luchterduinen (LUD) started in 2014, and the 129 MW (43 turbines) are expected to be fully operational by summer 2015. The construction activities during 2014 included: piling of monopile foundations and installation of secondary steel, cable lay and cable burial, rock installation cable crossings and export cable installation. Before Tconstr-1 started, a few infield cables were already installed and most of the monopiles (29 of the 43). During the first survey period from 3-6 october there were some activities within the wind farm area: the installation of 2 infield cables (form OHVS- pile20 and from OHVS to pile 21) and the piling and installation of secundary steel of monopiles 13,19, 25 and 26. During the second survey (Tconstr-2) no specific activities took place in the area: all cables were laid and buried and the monopiles and secondary steel installed. The wind farm covers an area of 16 km^2. The location for the LUD is 17 km south of the existing Prinses Amaliawindpark (PAWP), roughly 23km off the coast of IJmuiden in block Q10 of the Netherlands Continental Shelf (NCS) in the Dutch Exclusive Economic Zone (EEZ). The water depth at this location ranges between 19 m and 24 m relative to LAT. The water depth and composition of the sediment underground allows for steel mono-piles to be used in conjunction with the preferred wind turbine generator (WTG) type which, under these circumstances, is the most cost effective solution. At a water depth of 25 m the WTGs require mono-piles of 51.5 m in length, with a diameter between 4.2 and 4.6 m and a transition piece of 19.1 m in length with a diameter of 4.5 m. Pile penetration in the seabed is approximately 23 m. An offshore high voltage station (OHVS) will collect the generated energy at all WTGs and transforms the voltage from MV level to HV level, suited for export to shore. The wind farm shall be connected to the 150 kV onshore substation in Sassenheim.

OWEZ was constructed between April and August 2006, while PAWP was constructed between October 2006 and June 2008. The two wind farms have very different designs; PAWP has a much higher turbine density than OWEZ, and has been built in slightly deeper waters (19-24 m versus 18-20 m) and further offshore (ca 23 km versus ca 15 km) than OWEZ.

As part of the Wbr-permit application an ‘Environmental Impact Assessment’ (EIA) and an ‘Appropriate Assessment’ were carried out. The outcome of these studies resulted in the requirement by the Competent Authority for a ‘Monitoring and Evaluation Program’ (MEP). The MEP is undertaken in conjunction with and for approval by the Competent Authority. Currently the MEP consists of eleven monitoring topics, of which seabirds is one topic. LUD is obliged to carry out a 3-5 year monitoring program on seabirds. According to the license permit the objective of the Luchterduinen seabird monitoring program is to conduct the seabird monitoring program in a way that location specific and cumulative avoidance behaviour can be measured in LUD and the two existing offshore wind farms (OWEZ and PAWP). For this purpose, a ship-based line transect monitoring program of seabirds focusing on the winter season has been proposed by the Client’, and approved by the Competent Authority. The program covers pre-construction (baseline), construction and post-construction phases. This report covers the results of the seabird monitoring for the construction period (TConstr) carried out during two surveys in October and December 2014.

3 Materials and methods

3.1 Monitoring approach

The TORs for the seabird monitoring are to study the distribution and abundance of seabirds in the region of the three wind farms before, during and after construction of the LUD wind farm. After the post-construction surveys, the results will be evaluated (once or twice) to determine to what extent the behavioural responses of species of seabirds have been determined, and whether the ship-based surveys can be curtailed. The collected data should be used to assess the avoidance behaviour of seabirds both in relation to the LUD wind farm and as a secondary priority cumulatively to the LUD, OWEZ and PAWP wind farms. The study should be undertaken using three sets of four NE-SW oriented transects traversing the three wind farms. Each of the proposed transects measures approximately 20 km. Results of the monitoring of habitat displacement of seabirds and waterbirds at other offshore wind farms have strongly indicated displacements to a distance of 1-2 kilometers (Petersen et al. 2006, Skov et al. 2012). Hence, the use of relatively short transect lines in the three wind farms is suitable for detecting gradients in abundance which can be attributed to the wind farms (Skov et al. 2015). This means that the degree of habitat displacement from all three wind farms can be tested statistically by gradient analysis.

In addition to the three series of four 20 km long primary transects through each of the LUD, OWEZ and PAWP wind farms, the monitoring approach includes a number of 30-40 km long secondary transects running east-west through the entire survey region. As habitat displacement of seabirds from offshore wind farms is typically short-scaled, this survey design provides a good basis for determining to what degree the different species of seabirds are impacted by habitat displacement, which can be determined by testing for changes in densities at increasing distances from the wind farms.

3.2 Survey design and available data

The survey design is given in Figure 1, showing the three series of four dense primary transects through LUD, OWEZ and PAWP designed to detect habitat displacement and the coarse set of secondary transects covering a larger region surrounding the three wind farms designed to describe distributions over a wider region. Between LUD and PAWP-OWEZ the shipping lane to/from IJmuiden is located. Two anchoring sites are associated with the shipping lane. The study area extends from about 52°30'N (Noordwijk) to about 52°45'N (Hondsbossche Zeewering) and from the shore to circa 18 nm out to sea. The size of the study area is circa 725 km^2. The primary transects are oriented NE-SW to capture the expected density gradient in seabirds, whereas the secondary transects are largely perpendicular to the main physical and ecological parameters, such as distance from the coast, water depth, temperature and salinity.

Two surveys in October and December 2014 were planned to be undertaken following the construction of the LUD wind farm. Each survey was planned for a period of five days (if permitted by the weather). The survey strategy has been to cover primary transects during all surveys, and as many of the secondary transects as possible. The primary transects were surveyed first, and surveying of the secondary transects was only initiated once the primary transects had been surveyed. The primary transects measure 209 km (+ 11 km transit) which can be covered in 12-14 hours of survey time. The secondary transects measure 660 km (+ 48 km transits). It was the strategy to achieve as much coverage as possible in the coastal and offshore environment surrounding the Luchterduinen survey area. The coverage of the secondary transects was therefore designed to achieve as much survey effort as possible on the secondary transects in the southern part of the survey region.

In order to avoid survey artefacts due to effects of diurnal patterns in distribution each survey started with different primary transects. When crossing the three wind farms a safety distance of 250 m was kept to the turbines. During crossing of the shipping lane a minimum distance of 1000 m was maintained to all vessels in the shipping lane.

Surveys were initiated only on the basis of a forecasted weather window (less than Beaufort 5, good visibility (>= 2 km), no heavy precipitation) of at least 2 days. Surveys should only be undertaken during sea states less than or equal to 4 and visibility of 2 km or more. Cancellation of a survey would only take place in situations with adverse weather conditions in relation to surveying (sea state above 4, visibility < 2 km) extending beyond the 5 day period of a survey.

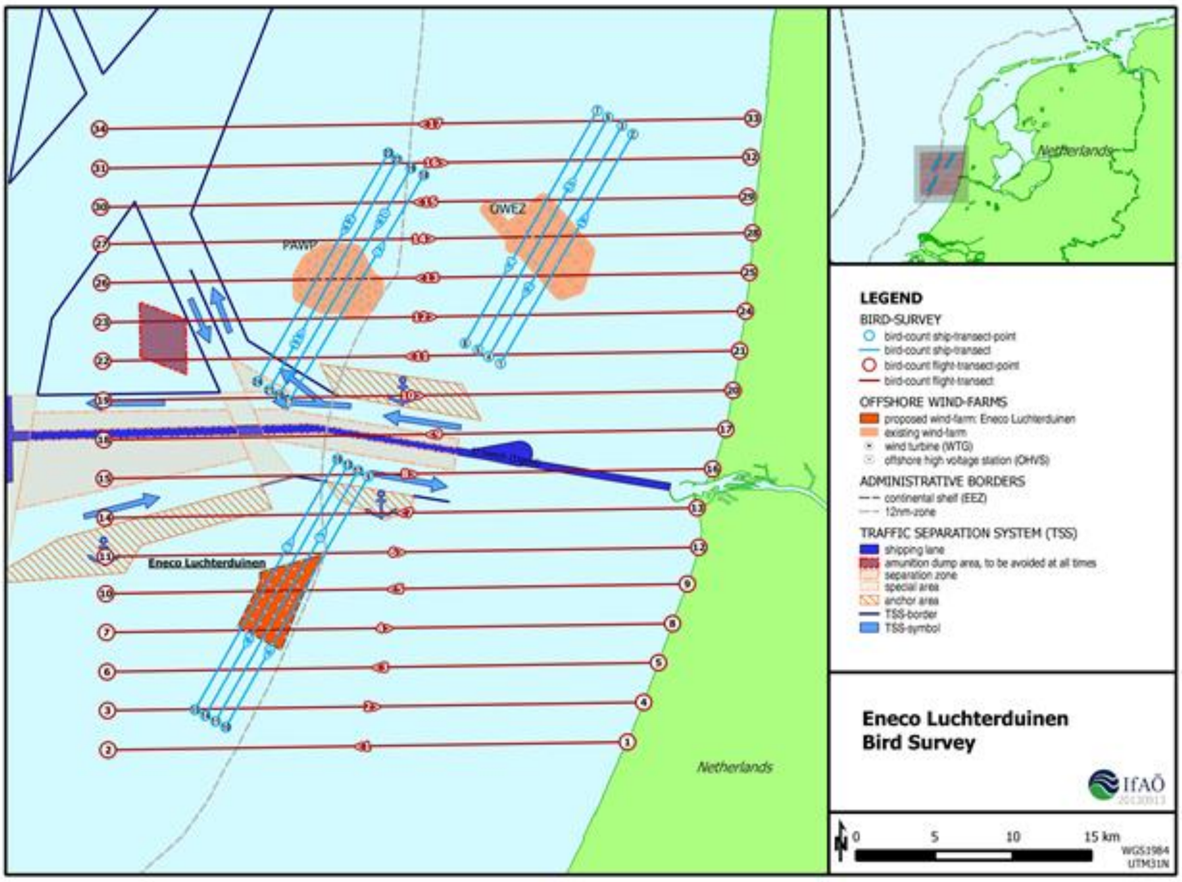

Figure 1. *Primary (blue) and secondary (red) transects with indications of Luchterduinen, Prinses Amalia and Egmond aan Zee wind farms indicated.*

3.3 Seabird counting techniques

Seabirds were recorded according to the method for surveying seabirds from ship by means of the strip-transect method as suggested by Tasker et al. 1984, Camphuysen & Garthe 2004, Camphuysen et al. 2004 and Leopold et al. 2004, and implemented as a standard by the European Seabirds at Sea Database (ESASD). As the search mode used during previous surveys for OWEZ and PAWP was 'naked-eye' (Leopold et al. 2013) this mode was also used during the monitoring of seabirds for LUD. The observation height was between 6.5 and 10 m above sea level. The method is a modified strip transect with a width of 300 meter, and five perpendicular distance sub-bands:

A. 0-50 m;
B. 50-100 m;
C. 100-200 m;
D. 200 – 300 m;
E. ≥ 300 m.

Transect lines were broken up into 1 minute (time) stretches and birds seen "in transect" in each individual 1 minute count were pooled (from t=0 to t=1 mins and for portside and starboard). At t=1 mins, the next count commenced, from t=1 mins to t=2 mins, etc. Densities were calculated as numbers seen in transect, divided by area surveyed. Area surveyed is the segment length covered in that particular 1 minute period, depending on sailing speed (average 9 knots) and strip width (300 m), which were both continuously monitored, corrected for the proportion of birds that were missed by the observers (see next section: distance sampling). The location of each count was taken as the mid-position between the positions at t=0 and t=1 mins, for each count, on the ship's transect line.

Birds were counted from the roof of the survey ship by four bird observers (Table 1), two on each side of the ship (Figure 2). Swimming seabirds were counted on both sides of the ship, and snap-shot counts of flying birds were made whereby every minute all birds will be counted within an area of 300 by 300 m transverse and directly in front of the ship (Figure 3).

Figure 2. The 'Ivero' used as the survey ship.

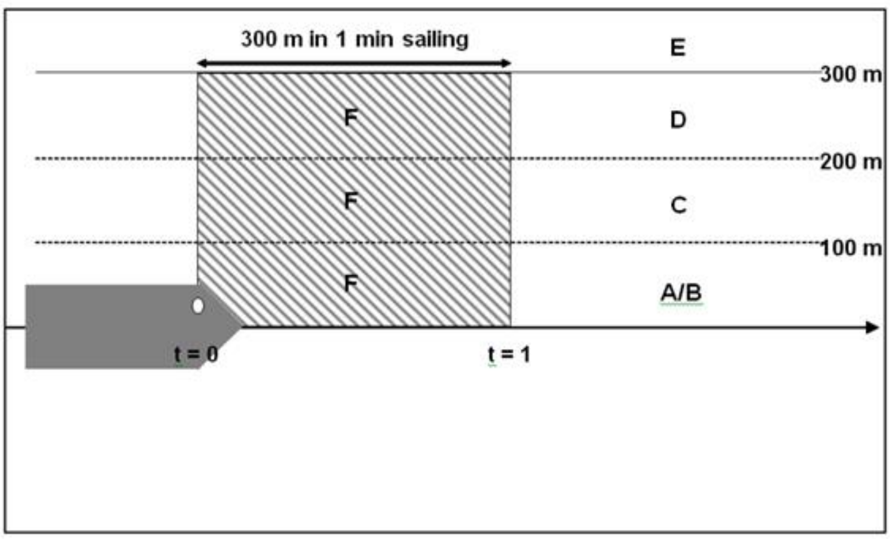

Figure 3. Schematic overview of the seabird survey method (see above for definitions of bands A-E).

Table 1. List of observers engaged in the LUD-T0 seabird surveys.

Survey	Observers
LUD-TConstr-01	Jörn Hartje*, Thomas Schubert, Lars Maltha Rasmussen, Ernst Eric Schrijver
LUD-TConstr-02	Jörn Hartje*, Thomas Schubert, Troels Eske Ortvad, Juan Miguel Perea Gozalez

*Cruise leader

3.4 Quality control and post-processing of survey data

General quality assurance and management were conducted and documented in accordance with internationally accepted principles for quality and environmental management as described in the DS/EN ISO 9001 standard. Post-processing of the survey data followed Leopold et al. (2013).

Before and after every survey an equipment check was carried out following an approved checklist. On the ship all routines followed strictly briefing rules with the party chief as outlined in the Work Method Statement. All observations of seabirds, marine mammals and ships were recorded on sheets and the ship's position and speed in a GPS. After each survey the GPS-track was downloaded to a computer and checked for completeness. As soon as possible after the survey the sheets were transcribed by one of the observers directly into a special developed database. Unusual data were marked and commented and the observers were asked for clarification or confirmation if needed. This procedure is very important to get rid of erroneous data as soon as possible. Later on, the data sets were run through different automated routines to detect mistyping and other errors.

All observations and GPS positions were stored in a special SQL geo-database (FULMAR) held by IfAÖ for aerial and ship-based surveys, which is linked to ArcGIS, and which exports the results to a Microsoft Access® database. The post-processing chain starts by transcribing the general survey data (e.g. date, observer, observation height etc.) from the observation sheets into the database. The next step is to import the GPS-track into the database by using a special extension for ArcGIS, which is started by the database. In ArcGIS the whole track is shown. The start and end points of each transect lines are marked and then the track points with their position and time are imported into the database. The user of the database can now view track points, time and the columns for the sightings. Every observation will be sorted by time to the nearest 1 minute count period. Also the weather conditions are stored into the database during this step.

After finishing the data input, different tools are used to visualize the observed seabirds along the transect lines. The next step is the validation of the data by a senior biologist, who will also check the weather conditions along all the transect lines on each side of the ship according to sea state, glare and visibility. If the observations of parts of the lines are affected by strong glare, sea state over Bft 4 or poor visibility, he will mark that period as "invalid". After the evaluation, and if necessary by additional confirmation of the observer, the data will be exported to a report-file, which is a Microsoft Access® database file. Here, all common types of results are generated by queries. Two tools are generating the export files for ArcGIS and population estimation in Distance.

3.5 Distance analysis

The term 'Distance analysis' used in this report refers to analyses conducted using Distance software (Distance v.6. r2, http://www.ruwpa.st-and.ac.uk, Thomas et al. 2010). These analyses were conducted to calculate distance detection functions for swimming seabirds. Sitting seabirds like auks or divers may be difficult to detect in the outer distance bands, and hence the collected densities of sitting seabirds are biased. As flying seabirds are comparatively easy to detect the collected densities of flying seabirds have been treated as unbiased, and no distance correction was applied. The Distance software takes account of the effect of distance by integration of the sources of variance for three parameters: encounter rate, detection probability, and cluster size. By dividing the detection probability function by the integral of the function over the survey area, a probability density function was estimated. Uniform, Hazard rate and half-normal functions available in the Conventional Distance Sampling engine (CDS), and the best fitting function was chosen on the basis of the smallest Akaike Information Criterion (AIC) values (Burnham and Anderson 2002). Parameter estimates were obtained by maximum likelihood methods.

Detection functions were calculated for the entire dataset for each species with sufficient number of observations, assuming that detectability of bird species was similar among surveys, as two of four observers were the same during both surveys. Estimated detection functions were used to estimate species-specific effective strip widths (ESW), which represent the width within which the expected number of detected seabirds would be the same as the numbers actually detected within the full width of 300 m (Buckland et al. 2001). Correction factors were then calculated by 1/(ESW/300). In line with Leopold et al. (2013), seabird species were pooled into species groups before Distance analysis (Table 2).

Table 2. Grouping of species for distance analysis. Some individuals were only identified to species group level, but could be used in distance analyses for groups: small divers (G stellata/G arctica), 'commic' terns (S hirundo/S paradisaea) and large auks (U aalga/A torda).

Group	Species
Divers	Red-throated Diver (Gavia stellata)
Divers	Black-throated Diver (Gavia arctica)
Gannets	Northern Gannet (Morus bassanus)
Cormorants	Great Cormorant (Phalacrocorax carbo)
Small gulls	Little Gull (Hydrocoloeus minutus)
Small gulls	Black-headed Gull (Chroicocephalus ridibundus)
Small gulls	Common Gull (Larus canus)
Small gulls	Black-legged Kittiwake (Rissa tridactyla)
Large gulls	Herring Gull (Larus argentatus)
Large gulls	Lesser Black-backed Gull (Larus fuscus)
Large gulls	Great Black-backed Gull (Larus marinus)
Auks	Common Guillemot (Uria aalge)
Auks	Razorbill (Alca torda)

3.6 Statistical analysis

For the assessment of potential impacts from LUD and cumulative impacts with PAWP and OWEZ, fine-scale distribution models capable of describing the distribution during the LUD construction period were developed in line with the baseline models (Skov et al. 2015). For the purpose of this LUD TConstr report the distribution models were mainly developed with the aim to describe the spatial distribution of seabirds. The assessment of potential changes in the distribution following the construction of LUD will be the focus of the report from the T1-T3 surveys. Detailed description of the model framework is given in Skov et al. (2015). In order to map the monthly distribution of seabirds during the LUD-TConstr winter of 2014-2015, prediction models were applied taking both habitat conditions and current infrastructures in the survey area into account. Generalized additive models (GAMs) were used as these are capable of fitting different family distributions and nonlinear responses (Hastie & Tibshirani 1990), which are expected between seabirds and habitat variables. To account for zero inflation a two-step model was fitted consisting of a presence-absence model and a positive model part (densities) where all zeroes were excluded.

The species specific models (all data used) were finally used for predicting the distribution of mean densities in the whole study area during the 2014-2015 winter.

3.7 Presentation of data

Maps showing mean distributions (mean observed and modelled densities) during the LUD TConstr surveys in the winter 2014-2015 have been produced in UTM 32N WGS84 projection. The mean density is presented for cells with a resolution of 1 km. For the observed densities, parts of the area which were not surveyed are shown as blank. The three disturbance areas (LUD, PAWP, OWEZ and the anchorage areas found along the shipping to/from IJmuiden) and the 20 m depth contour are indicated.

4 Results

4.1 Effort and sample sizes

Two surveys were undertaken during the 2014-2015 winter. The first survey was undertaken between 3rd and 6th of October and the second between 1st and 6th of December 2014 using the Ivero. During the LUD TConstr surveys, the primary transects within PAWP, OWEZ and LUD and the secondary transects around LUD were completed. Yet, due to construction activities some parts of the primary and secondary transects in LUD could not be surveyed. An overview of the survey effort is given in Table 3 and Figure 4.

Table 3. *Survey effort (km^2 covered by observation transect) obtained during the two ship-based surveys in the LUD TConstr winter season (2014-2015).*

Period	Survey	Area covered (km^2)
LUD-TConstr-01	3-6/10 2014	334.91
LUD-TConstr-02	1-6/12 2014	297.99

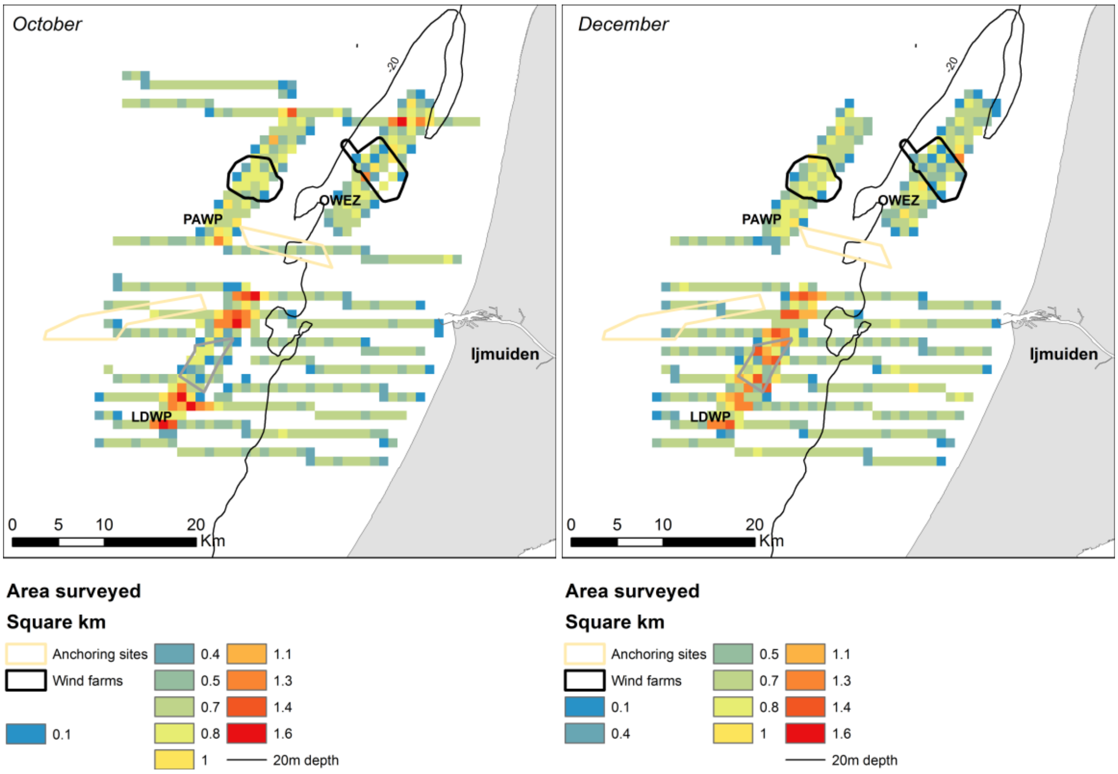

Figure 4. The spatial coverage of survey effort (km^2) *obtained during the two ship-based surveys in the LUD TConstr season (2014-2015).*

Observed abundance (uncorrected) of each species is given in Table 4. During the October survey gulls, especially Lesser Black-backed Gulls *Larus fuscus* and Great Cormorants *Phalacrocorax carbo* dominated the observations. During the second survey in December, cormorants, Common Gulls *Larus canus*, Black-legged Kittiwake *Rissa tridactyla* and Common Guillemot *Uria aalge* were recorded in relatively large numbers.

Table 4. *Numbers of seabirds observed during the two LUD TConstr surveys in winter 2014/2015.*

Species	Total Oct 2014	Total Dec 2014
Red-Black-throated Diver	2	41
Great Crested Grebe	0	14
Northern Fulmar	1	0
Northern Gannet	24	139
Great Cormorant	217	282
Common Scoter	13	6
Little Gull	11	18
Black-headed Gull	81	54
Common Gull	122	512
Lesser Black-backed Gull	457	5
Herring Gull	119	39

Great Black-backed Gull	233	131
Black-legged Kittiwake	9	258
Common Guillemot	105	309
Razorbill	2	35
Total	**1,396**	**1,843**

4.2 Distance analysis

Table 5 gives an overview of the selected models used for estimating detection of sitting birds with distance for the different species groups.

Table 2. Distance statistics for sitting birds in each species group.

Species group	Sample size	Key function*	Adjustment term	Effective strip width (ESW)	% CV ESW
Gannets	21	HN	polynomial	240	23.3
Cormorants	36	HN	cosinus	180	25.4
Small gulls	91	HN	cosinus	120	12.2
Large gulls	186	HN	cosinus	120	8.1
Auks	191	HR	cosinus	119	17.1

* HN=Half normal, HR= Hazard rate

4.3 Species accounts

In this chapter an account of the results of the analyses and modelling of the LUD-TConstr data is given. For each species the description of the LUD-Constr status starts with a general introduction in which the results of the LUD-T0 surveys during the 2013-2014 winter are summarised. The results of the species distribution models are given in a separate subsection called 'model results'.

4.3.1 Divers: Red-throated *Gavia stellata* and Black-throated Divers *Gavia arctica*

The LUD-T0 surveys in 2013-2014 showed distribution patterns similar to those described for the winter surveys from 2002-2011 and earlier with high densities close to the coast and low densities at the LUD, and higher densities during mid winter as compared to the autumn. During the LUD TConstr surveys only Red-throated Divers were observed and almost exclusively during the December survey (Figure 5). Here, most divers were recorded in two patches; one in the coastal area off Ijmuiden and one along the western edge of and inside the LUD. The number of observations did not allow for distribution modelling.

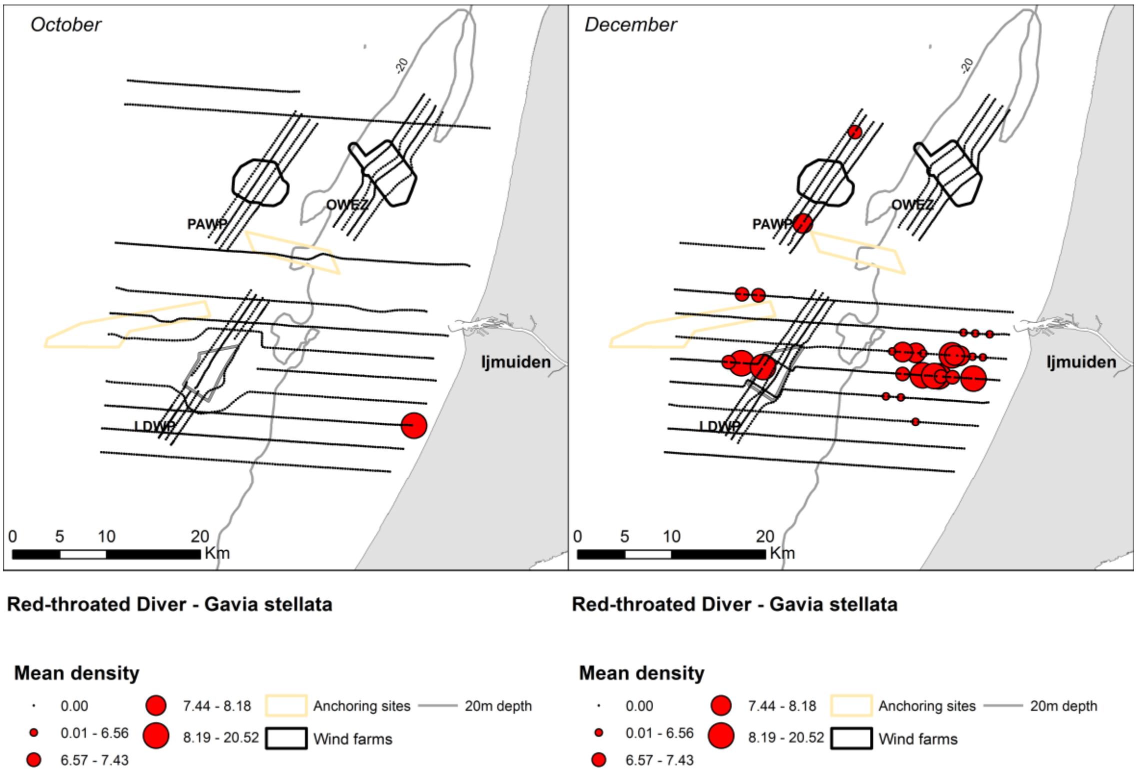

Figure 5. Observed densities of Red-throated Diver during LUD TConstr surveys 2014-2015.

4.3.2 Great Crested Grebe *Podiceps cristatus*

Only 14 Great Crested Grebe were recorded in the coastal zone during the TConstr-02 survey.

4.3.3 Northern Fulmar *Fulmarus glacialis*

One Northern Fulmar was recorded during the TConstr-01 survey.

4.3.4 Northern Gannet *Morus bassanus*

The LUD-T0 surveys in 2013-2014 showed a wide offshore distribution pattern similar to that described for the winter surveys from 2002-2011 and earlier, with Gannets displaying clear avoidance patterns in relation to OWEZ and PAWP. During the TConstr surveys avoidance was also recorded in relation to LUD, although Gannets were seen quite close to the wind farm (Figure 6). High densities were observed during the December survey, when large numbers were found near PAWP.

Model results

The explanatory power of the distribution model for the Northern Gannet was fair for the positive part, whereas the deviance explained was poor for the presence-part of the model (Appendix A). The AUC indicated that the binomial model part had a quite poor predictive ability while the Spearman's correlation coefficient indicated that predicted densities are similar to the observed, although not very accurate (Appendix A). The modelling results indicated that the Northern Gannets preferred deeper waters with intermediate current speeds. There was a negative relationship to the two existing windfarms up to a distance of about 2 km, where the probability of presence is highest. The relationship to LUD was negative up to the 4 km defined as potential disturbance distance. However, the distance variables to windfarms were not significant, which was also reflected in the uncertainty maps (Appendix A).

The predicted patterns described a general increasing density gradient from the coast to the offshore and indicated a displacement from the LUD area (Figure 7). However, the model uncertainty, proportional model standard error, in the LUD area was very high, close to 1 (or 100%).

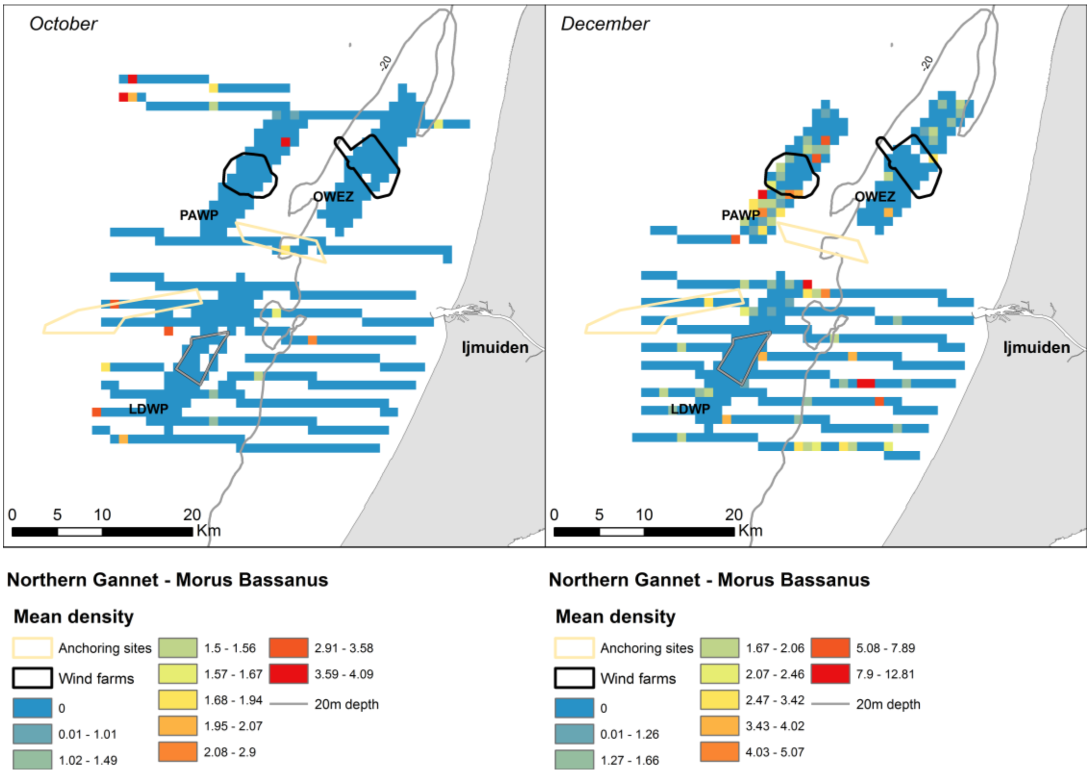

Figure 6. Mean observed density (n/km^2) of Northern Gannet during LUD TConstr surveys 2014. Densities have been corrected for distance bias.

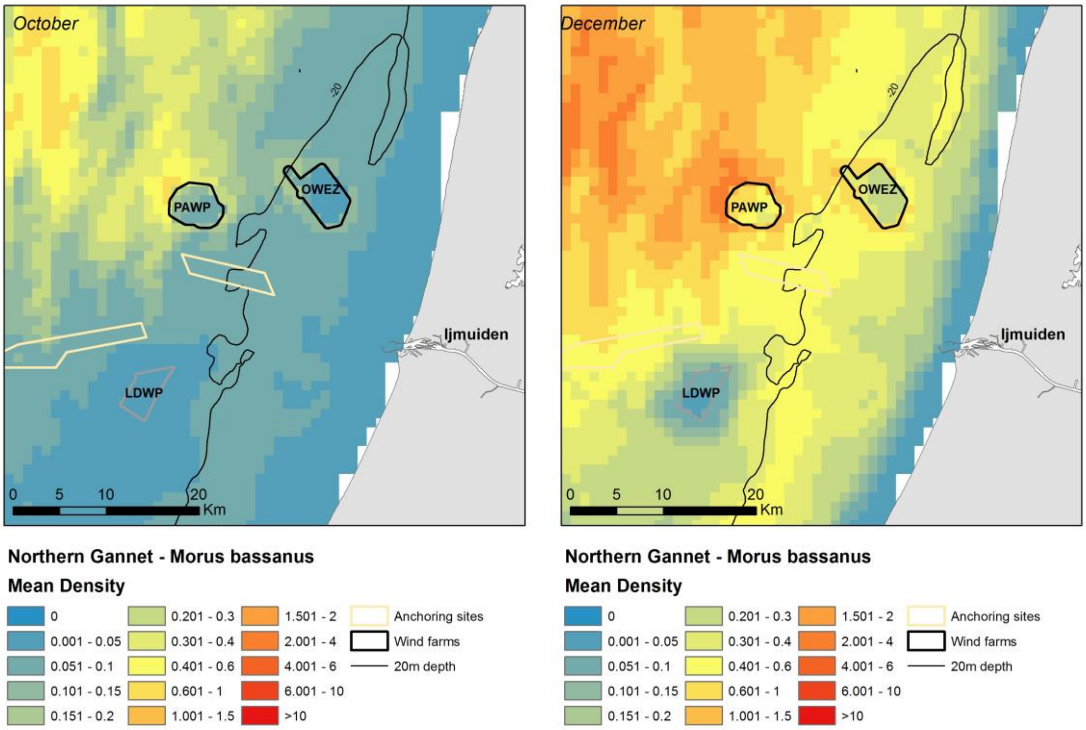

Figure 7. Predicted monthly distribution (n/km^2) of wintering Northern Gannet during the TConstr surveys 2014.

4.3.5 Great Cormorant *Phalacrocorax carbo*

The LUD-T0 surveys in 2013-2014 reflected the association with PAWP and OWEZ, and also indicated few Cormorants outside the footprint of the wind farms in offshore waters. This pattern was also found during the LUD TConstr surveys (Figure 8). Surprisingly, no cormorants were observed within LUD.

Model results

The explanatory power of the distribution model for the Great Cormorant was fair for the presence-absence model part and good for the density part (Appendix A). The predictive accuracy of the binomial part was also fair according to the AUC statistics while the accuracy of the density predictions was no better than random (Appendix A). The modelling results stressed the importance of PAWP and OWEZ for the presence of cormorants, whereas LUD was not influential in the model and therefore not included (Appendix A). Water depth was also included in the presence-absence model part indicating that the cormorants preferred shallow water (areas closer to land).

The predicted patterns of mean density in the LUD area indicated low density of cormorants during both survey months (Figure 9). Highest densities were predicted close to land, around and within OWEZ and within PAWP. Further data may help to interpret differences between cormorant distributions in OWEZ and PAWP. Model uncertainty was highest in areas with least survey effort, furthest offshore and closest to land (Appendix A).

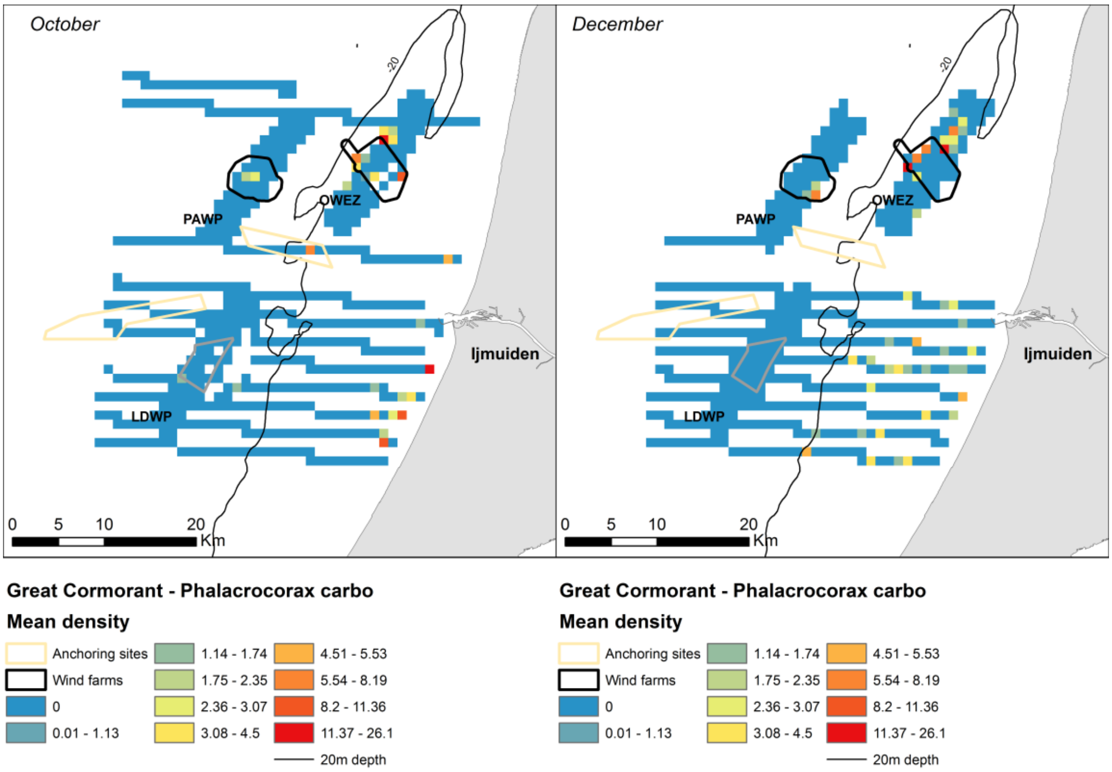

Figure 8. Mean observed density (n/km^2) of Great Cormorant during the two LUD TConstr surveys 2014. Densities have been corrected for distance bias.

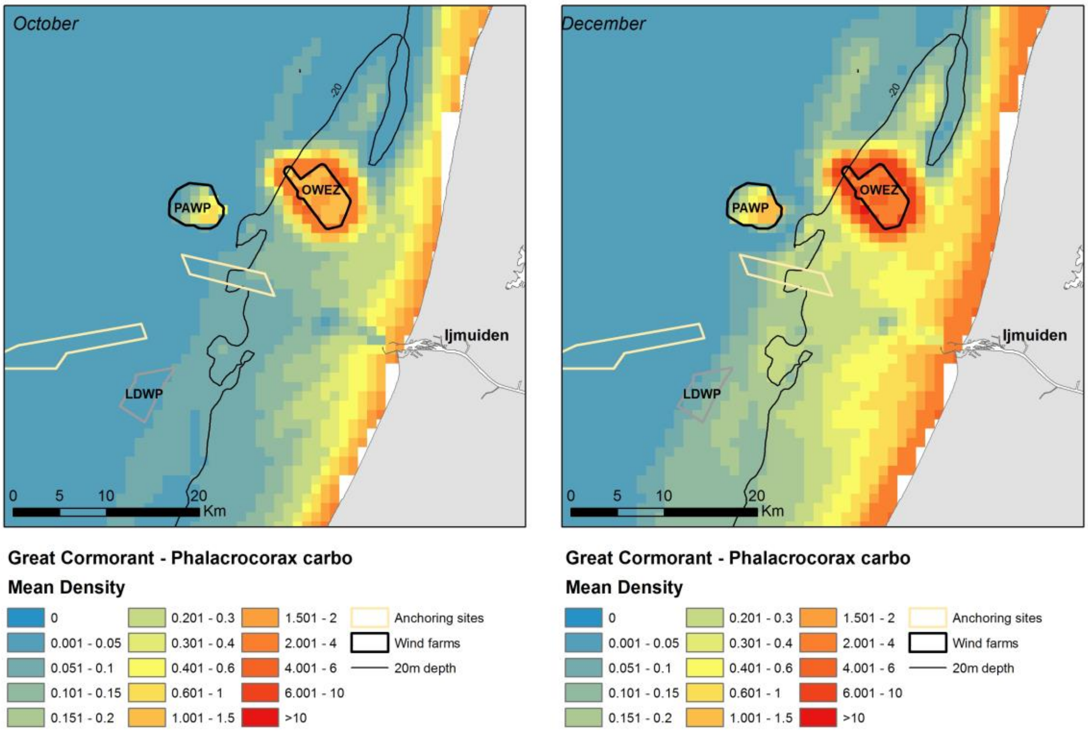

Figure 9. Predicted monthly distribution (n/km^2) of wintering Great Cormorant during the LUD TConstr surveys 2014.

4.3.6 Common Scoter *Melanitta nigra*

Only 13 and 6 Common Scoter were recorded in the coastal zone during the TConstr-01 and TConstr-02 surveys.

4.3.7 Little Gull *Hydrocoloeus minutus*

Like during the LUD-T0 surveys in 2013-2014 Little Gulls were seen scattered over the area with most birds being observed to the south (Figure 10).

Sample sizes were too low to allow for modelling of distribution patterns.

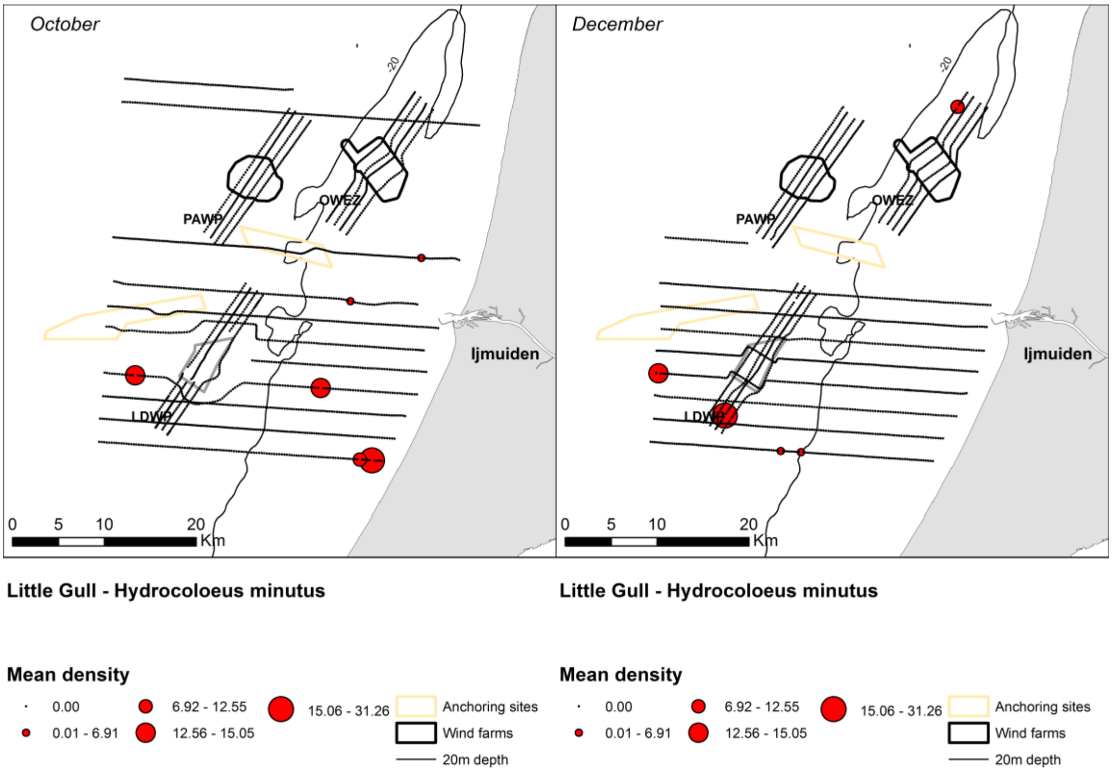

Figure 10. Observed densities of Little Gull during LUD TConstr surveys 2014.

4.3.8 Black-headed Gull *Chroicocephalus ridibundus*

During the LUD-T0 surveys in 2013-2014 the distribution of Black-headed Gulls was similar to the one found during the earlier surveys, with peak densities in nearshore waters and birds frequenting both OWEZ and PAWP. During the LUD TConstr survey Black-headed Gulls were mainly recorded inshore, in OWEZ and LUD (Figure 11). Again, no obvious avoidance of the wind farms was observed.

Sample sizes were too low to allow for modelling of distribution patterns.

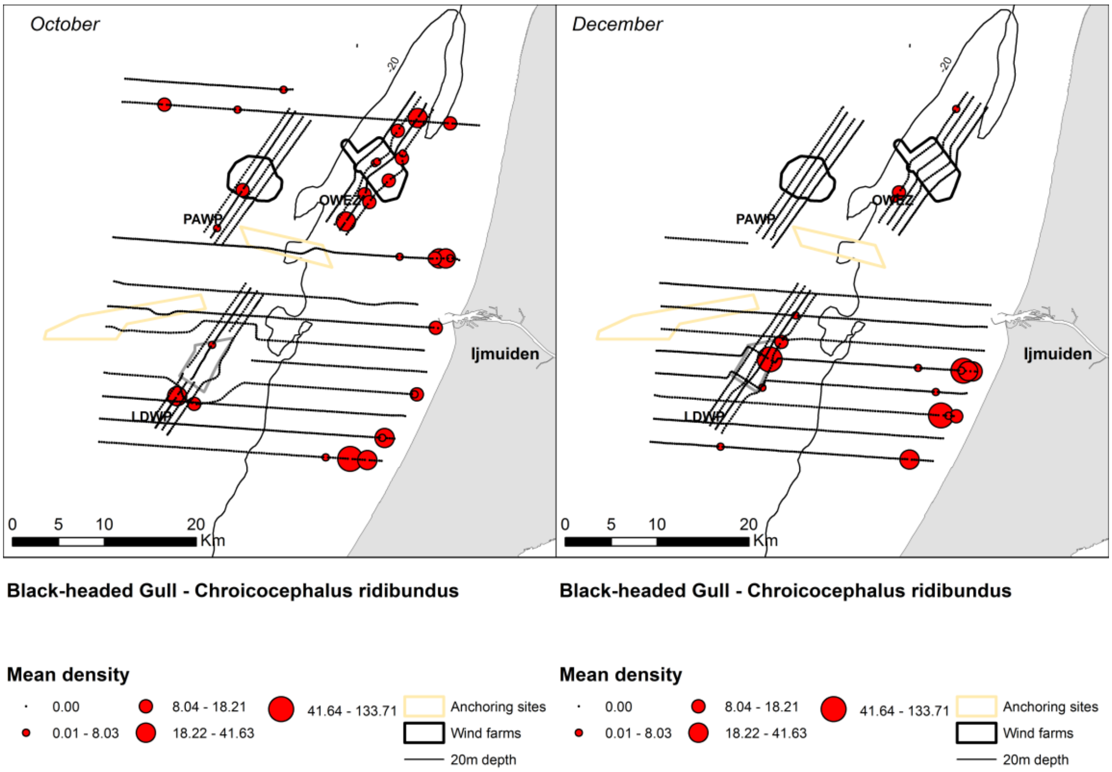

Figure 11. Observed densities of Black-headed Gull during LUD TConstr surveys 2014.

4.3.9 Common Gull *Larus canus*

During the LUD-T0 surveys in 2013-2014 the distribution of Common Gulls was similar to the one found during the earlier surveys with densities being highest in mid winter and birds concentrated within the 20 m depth contour and seen both in OWEZ and PAWP. During the LUD TConstr surveys Common Gulls seemed quite widespread and like during T0 abundance was highest during winter (Figure 12). No indications of avoidance of LUD, OWEZ and PAWP were observed.

Model results

The explanatory power of the distribution model for the Common Gull was poor for the presence-absence part, but fair for the positive part of the model (Appendix A). The evaluation statistics indicated that the predictive accuracy of the model was poor (Appendix A). The model indicated that the probability of presence of Common Gulls is higher in shallow water, about two km from OWEZ and PAWP and with decreasing distance from Q10 and low shipping intensity (Appendix A). Higher densities were explained by increasing Current gradient, in shallow water and depths around 20 m as well as a distance of about 1 km to Q10.

The predicted patterns of mean densities showed higher densities in shallower waters, less than 20 m (Figure 13), however the model accuracy was poor.

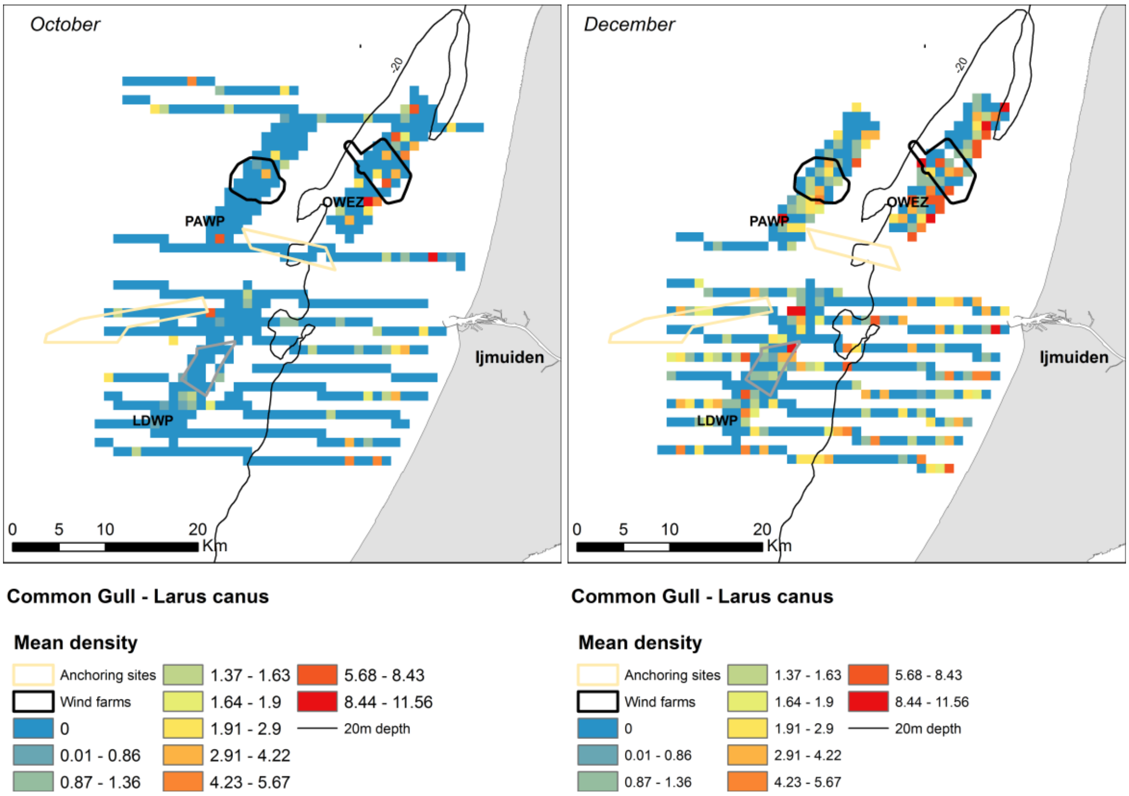

Figure 12. Mean observed density (n/km^2) of Common Gull during LUD TConstr surveys 2013-2014. Densities have been corrected for distance bias.

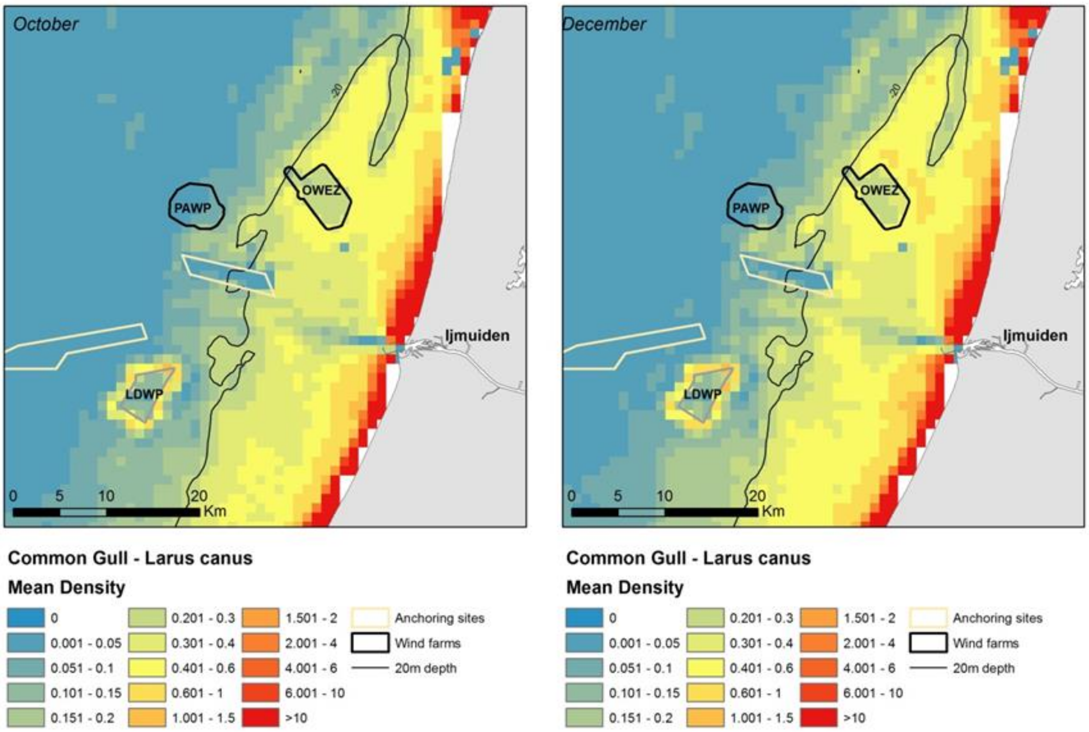

Figure 13. Predicted monthly distribution (n/km^2) of wintering Common Gull during the LUD TConstr surveys 2014.

4.3.10 Lesser Black-backed Gull *Larus fuscus*

During the LUD-T0 surveys in 2013-2014 Lesser Black-backed Gulls appeared widespread and were recorded in both OWEZ and PAWP. During the LUD TConstr survey in October observations ranged across the entire study area but with highest densities in the coastal zone (Figure 14). Birds were observed in all three wind farms, and no indication of avoidance was apparent.

Model results

The explanatory power of the distribution model for the Lesser Black-backed Gull was poor for the presence-absence part, but relatively good for the positive part of the model (Appendix A). The evaluation statistics indicated that the predictive accuracy of the model was poor (Appendix A). The model indicated that the presence of Lesser Black-backed Gulls is related to intermediate current gradient values, low current speed, intermediate water depths and decreasing distance from the windfarms (Appendix A). Higher densities were explained with low eddy activity, water depths around 13 m and increasing distance from LUD.

The predicted patterns of mean densities showed peak densities in shallower waters, (Figure 15), however the model accuracy was poor.

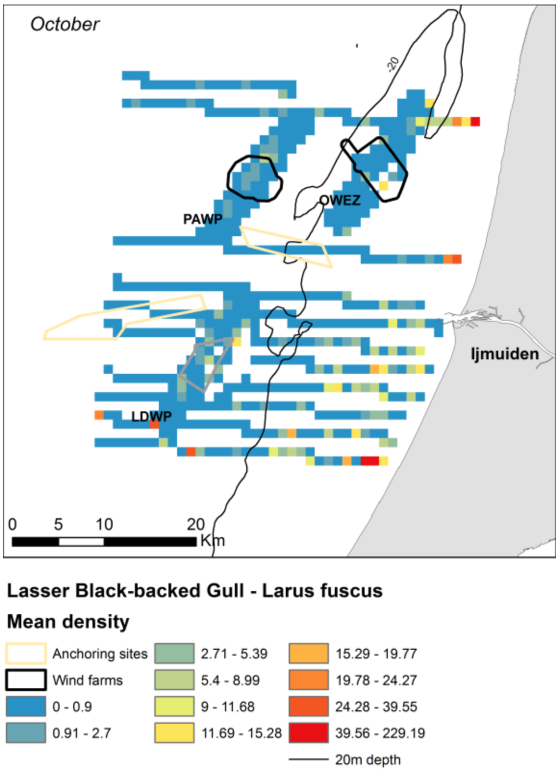

Figure 14. Mean observed density (n/km^2) of Lesser Black-backed Gull during LUD TConstr surveys 2013-2014. Densities have been corrected for distance bias.

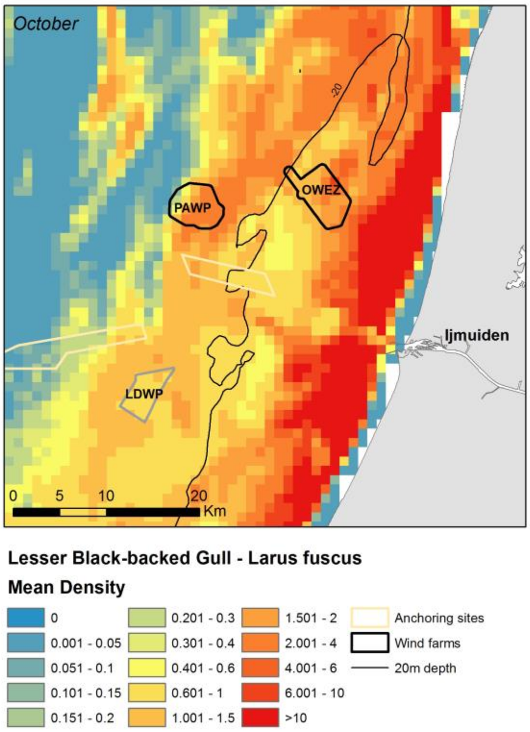

Figure 15. Predicted monthly distribution (n/km^2) of wintering Herring Gull during the LUD TConstr surveys 2014.

4.3.11 Herring Gull *Larus argentatus*

During the LUD-T0 surveys in 2013-2014 the distribution of Herring Gulls was similar to the one found during the earlier surveys, yet with seemingly fewer birds clustered (at fishing vessels) in offshore waters and more birds at the 10 m depth contour. Few birds were seen both in OWEZ and PAWP. During the LUD TConstr surveys clusters of Herring Gulls were recorded close to LUD and OWEZ as well as in the coastal zone (Figure 16). This pattern could be interpreted either as wind farm avoidance or concentrations associated with trawling activities just outside LUD and OWEZ.

Model results

The explanatory power of the distribution model for the Herring Gull was poor for the presence-absence part, but good for the positive part of the model (Appendix A). The evaluation statistics also indicated that the predictive accuracy of the model was fair (Appendix A). The highest probability of presence of Herring Gulls was related to increasing current gradient, water depths around 15-20 m, low shipping intensity (not significant), a distance of around 1.5 km from the existing wind farms (OWEZ and PAWP, not significant) and an attraction to LUD (Appendix A). In the density part of the model distance to the windfarms were included, however the relationships were weak and non-significant, whereas the relationship to water depth indicated that highest densities of Herring Gulls occurred in water depths of about 15 m.

The predicted patterns of mean densities showed peak densities in coastal waters, and indicated a potential displacement from LUD (Figure 17). The densities were higher in October than in December (Figure 17). The uncertainty was however very high in the windfarm areas and the areas furthest offshore (Appendix A).

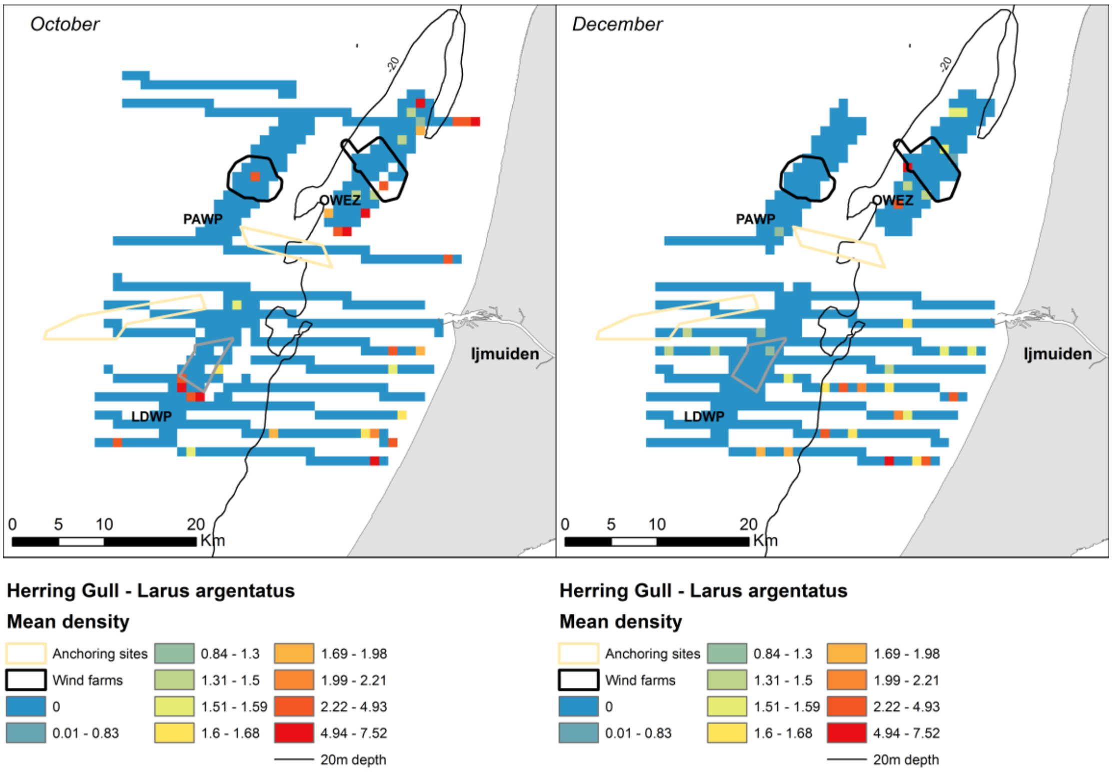

Figure 16. Mean observed density (n/km^2) of Herring Gull during LUD TConstr surveys 2014. Densities have been corrected for distance bias.

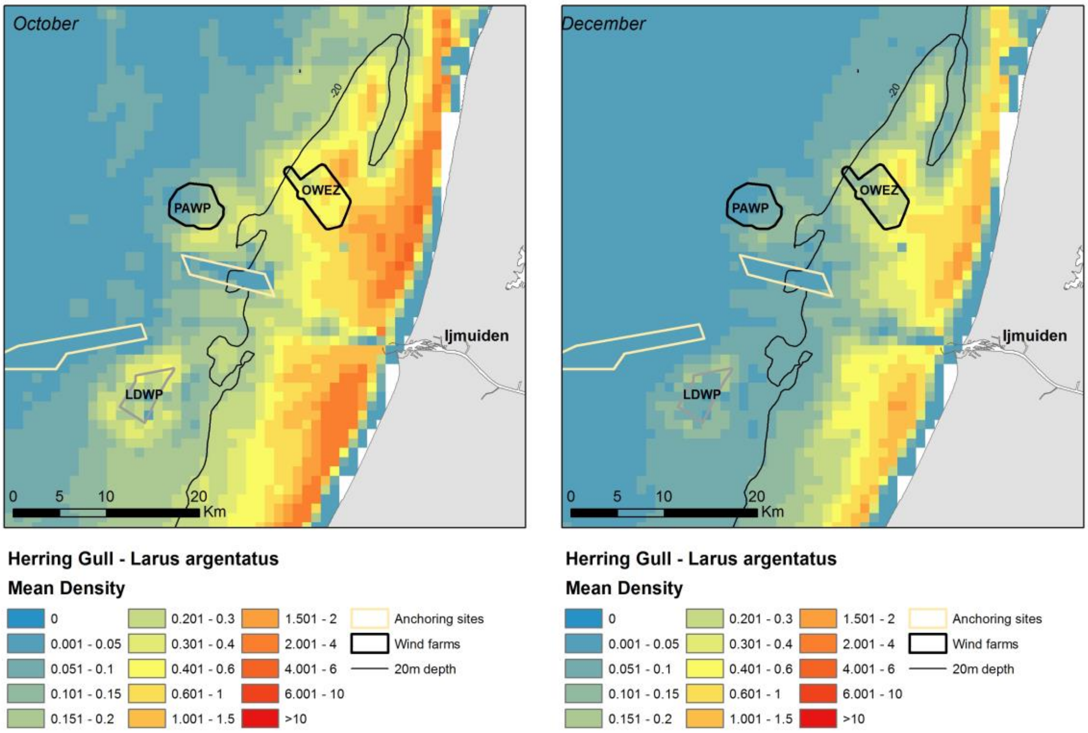

Figure 17. Predicted monthly distribution (n/km^2) of wintering Herring Gull during the LUD TConstr surveys 2014.

4.3.12 Great Black-backed Gull *Larus marinus*

During the LUD-T0 surveys in 2013-2014 the distribution of Great Black-backed Gulls mimicked the one of Herring Gulls with birds showing associations with fishing vessels. Few birds were seen both in OWEZ and PAWP. During the TConstr surveys, higher densities of Great Black-backed Gulls were recorded in OWEZ and PAWP, and in several patches over the southern part of the study area (Figure 18). Relatively few birds were recorded in LUD.

Model results

The explanatory power of the distribution model for the Great Black-backed Gull was very low for the presence-absence part, and low for the positive part of the model (Appendix A). The evaluation statistics indicated also poor predictive accuracy (Appendix A). The presence-absences model part indicated that the probability of presence of Great Black-backed Gulls increased with increasing current speed and eddy potential as well as decreasing water depth. Increasing density was described in the model by decreasing water depth, decreasing distance to the existing windfarms (OWEZ and PAWP) and higher densities about 1 km from LUD.

As the model was poor no strong conclusion should be based on these predictions, however the predictions indicate higher densities in coastal areas as well as in the vicinity of the existing windfarms (OWEZ and PAWP) and a potential attraction to these (Figure 19).

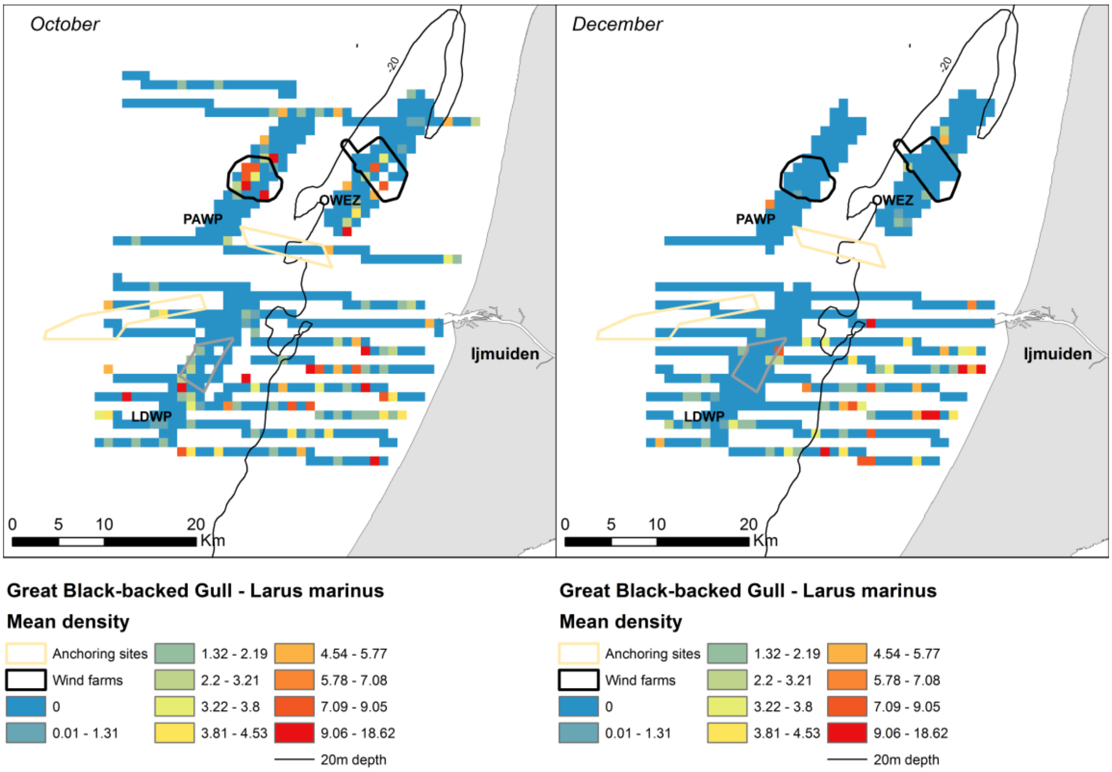

Figure 18. Seasonal mean observed density (n/km^2) of Great Black-backed Gull during LUD TConstr surveys 2014. Densities have been corrected for distance bias.

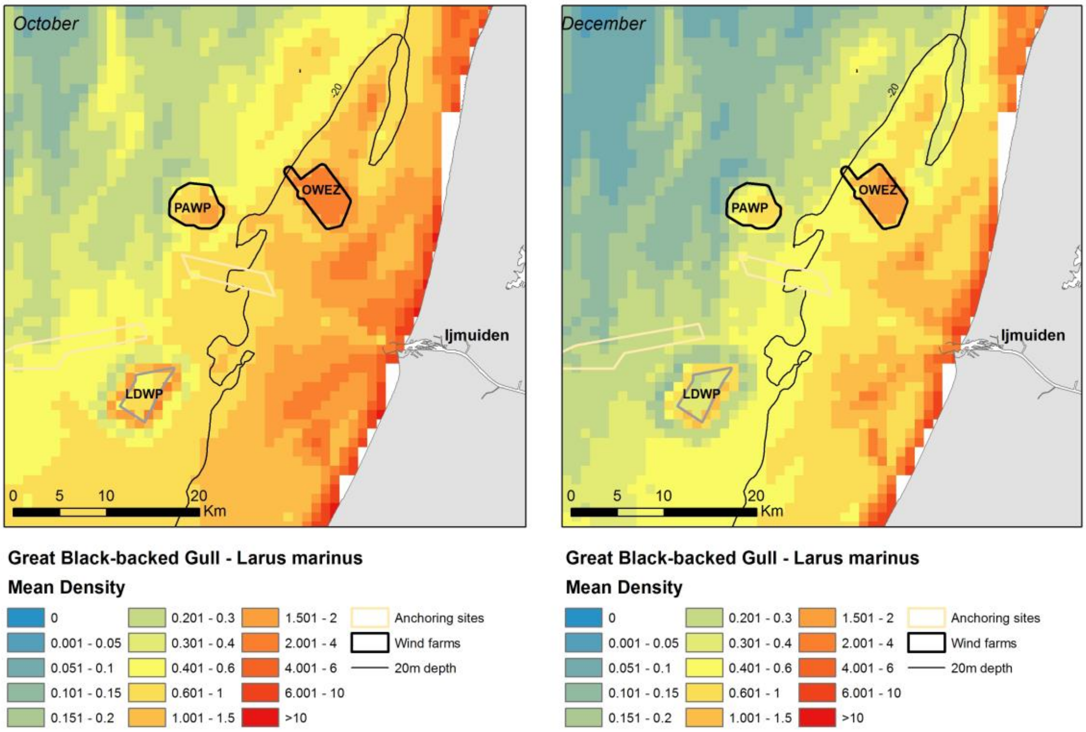

Figure 19. Predicted monthly distribution (n/km^2) of wintering Great Black-backed Gull during the LUD TConstr surveys 2014.

4.3.13 Black-legged Kittiwake *Rissa tridactyla*

During the LUD-T0 surveys in 2013-2014 the distribution of Black-legged Kittiwakes was similar to the one found during the earlier surveys, and birds were both dispersed, seen in OWEZ and PAWP and concentrated at the 10 m depth contour. Although kittiwakes were observed during the LUD TConstr survey within all three wind farms the overall distribution pattern was rather dissimilar to the one found during the T0 surveys, as birds displayed a clear increasing gradient towards offshore waters (Figure 20).

<u>Model results</u>

The explanatory power of the distribution model for the Black-legged Kittiwake was fair for the presence-absence part, but low for the positive part of the model (Appendix A). The evaluation statistics indicated good predictive accuracy (Appendix A). According to the model higher probability of presence was related to intermediate current speeds increasing water depth, about 2 km from the existing windfarms (OWEZ and PAWP) and a decreasing distance to LUD, however only water depth was significant (Appendix A). In the positive model part increasing current gradient, increasing water depth and increasing distance from LUD was included, but again only water depth was significant (Appendix A).

The predicted patterns of mean densities showed higher densities further offshore in December and relatively high densities in LUD, OWEZ and PAWP (Figure 20). Low densities were predicted in October in correspondence with the observations (Figure 21).

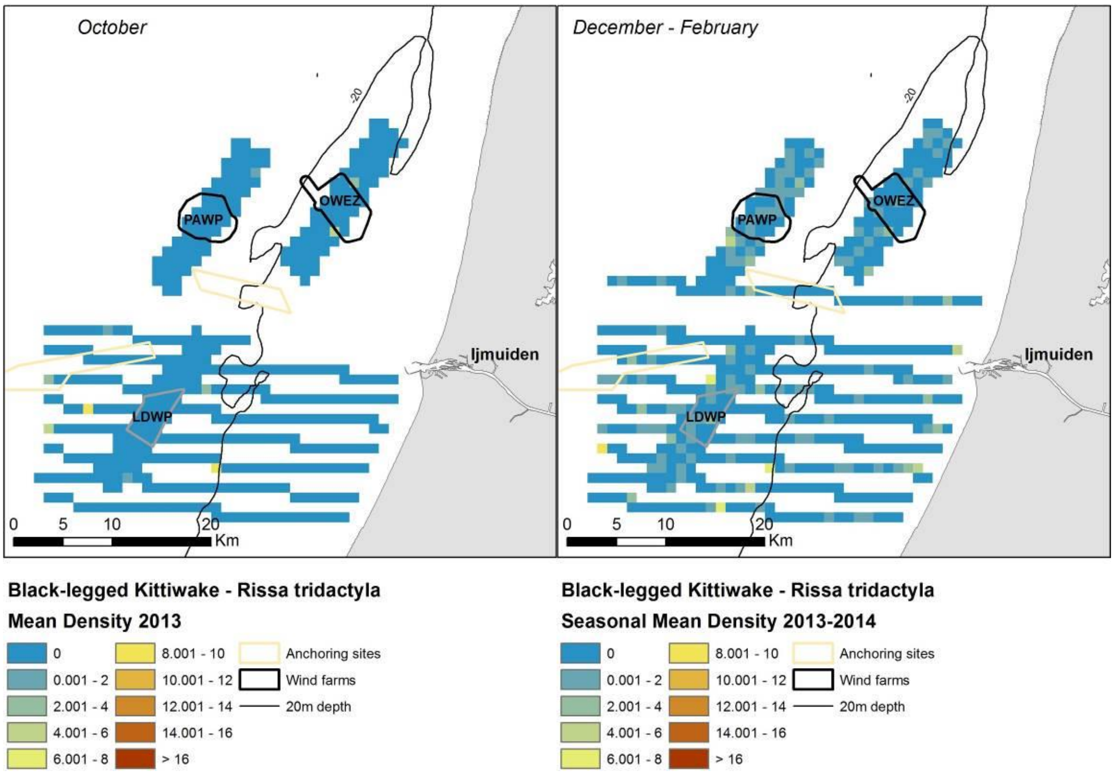

Figure 20. Seasonal mean observed density (n/km^2) of Black-legged Kittiwake during LUD TConstr surveys 2014. Densities have been corrected for distance bias.

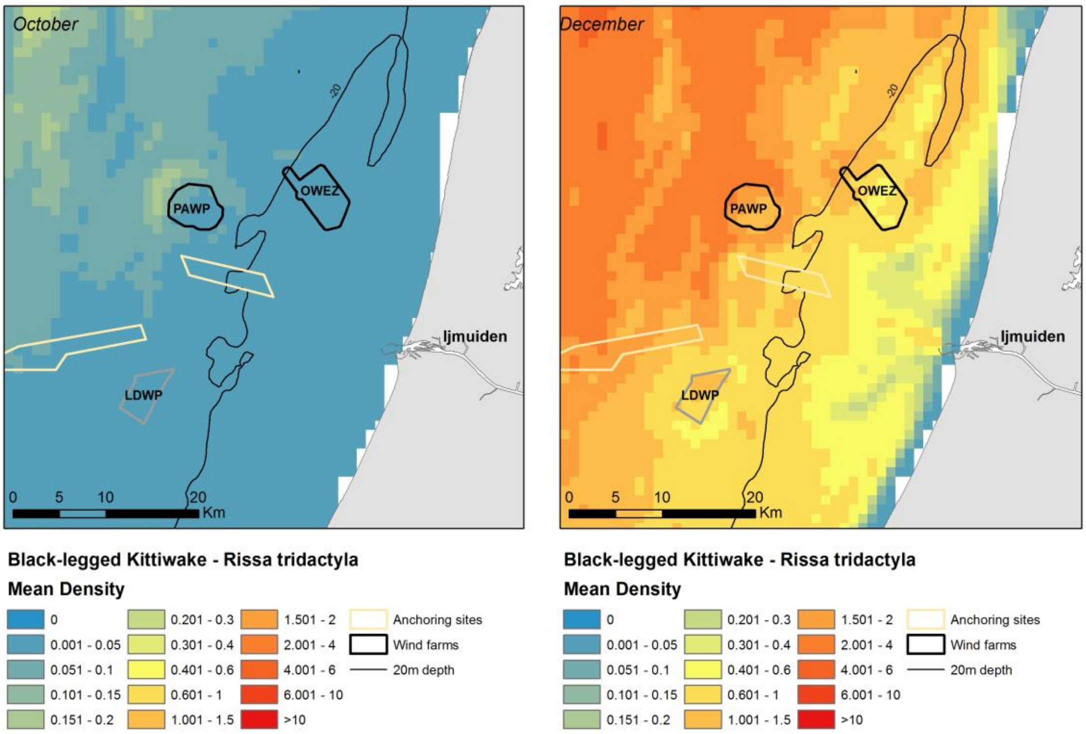

Figure 21. Predicted monthly distribution (n/km^2) of wintering Black-legged Kittiwake during the LUD TConstr surveys 2014.

4.3.14 Sandwich Tern *Sterna sandvicensis*

No Sandwich Tern were recorded during the TConstr surveys.

4.3.15 'Commic' terns: Common Tern *Sterna hirundo* and Arctic Tern *Sterna paradisaea*

No Commic Tern were recorded during the TConstr surveys.

4.3.16 Common Guillemot *Uria aalge*

During the LUD-T0 surveys in 2013-2014 the densities of Common Guillemot increased markedly between October 2013 and January 2014, and birds were seen both in OWEZ and PAWP. The overall distribution reflected higher mean densities in the southern part, including LUD, than recorded during earlier surveys in the region. The same overall spatio-temporal trends were seen during the TConstr surveys (Figure 22). Although guillemots were recorded within all the wind farms the observed densities seemed clearly lower in the wind farms as compared to adjoining waters.

Model results

The explanatory power of distribution model for the Common Guillemot was relatively poor for both the presence-absence and the positive part of the model (Appendix A). Which could be expected as the species is so widely distributed in the whole area. The predictive accuracy was however fair according to the evaluation statistics (Appendix A). According to the model the probability of presence increased with increasing current speed, increasing water depth, a distance of around 2 km from existing windfarms (OWEZ and PAWP), increasing distance from LUD and decreasing shipping activity. Hence, the model provided indications of partial avoidance of all three wind farms to a distance of 2-2.5 km. The higher density at 2 km distance from OWEZ and PAWP may be directly linked to displacement of guillemots from the wind farm footprints. Higher density was further explained by increasing water depth, about 2 km from the existing windfarms, 2.5 km from LUD and decreasing shipping activity (Appendix A).

The predicted patterns of mean densities showed high densities throughout most of the study area during both months, with higher densities in December. Low densities were predicted in all three wind farm areas and in areas with highest shipping activity, i.e. anchoring sites (Figure 23). Model uncertainty was reasonably low in the whole area, except for the windfarm areas and anchoring sites were the uncertainty was high (Appendix A).

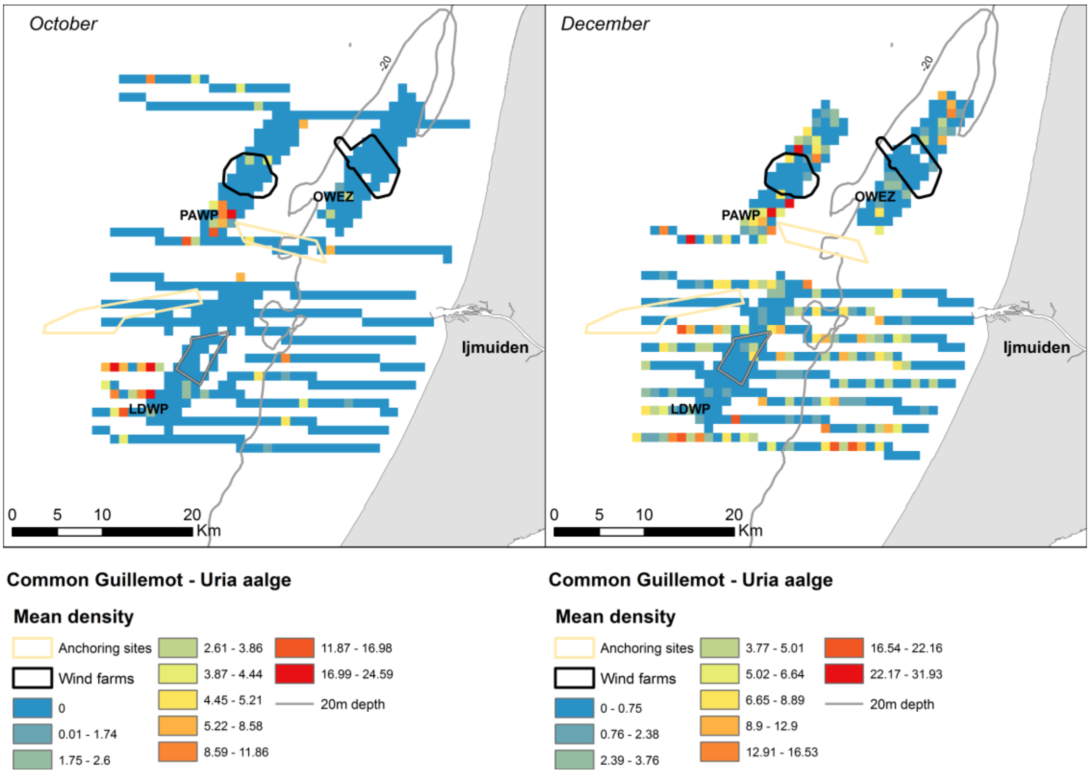

Figure 22. Seasonal mean observed density (n/km^2) of Common Guillemot during LUD TConstr surveys 2014. Densities have been corrected for distance bias.

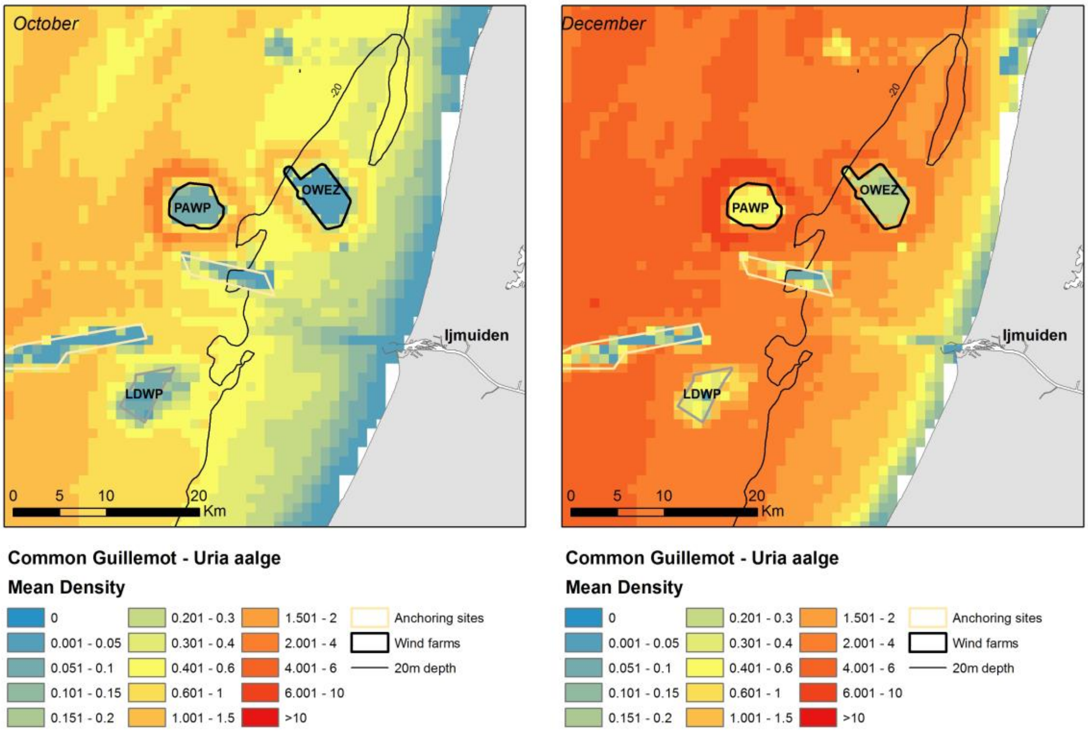

Figure 23. Predicted monthly distribution (n/km^2) of wintering Common Guillemot during the LUD TConstr surveys 2014.

4.3.17 Razorbill *Alca torda*

During the LUD-T0 surveys in 2013-2014 the distribution of Razorbills was similar to the one found during the earlier surveys, and birds were seen over a large area. Few Razorbills were recorded during the LUD TConstr surveys, and mainly in the southern part of the study area (Figure 24).

Sample sizes were too low to allow for modelling of distribution patterns.

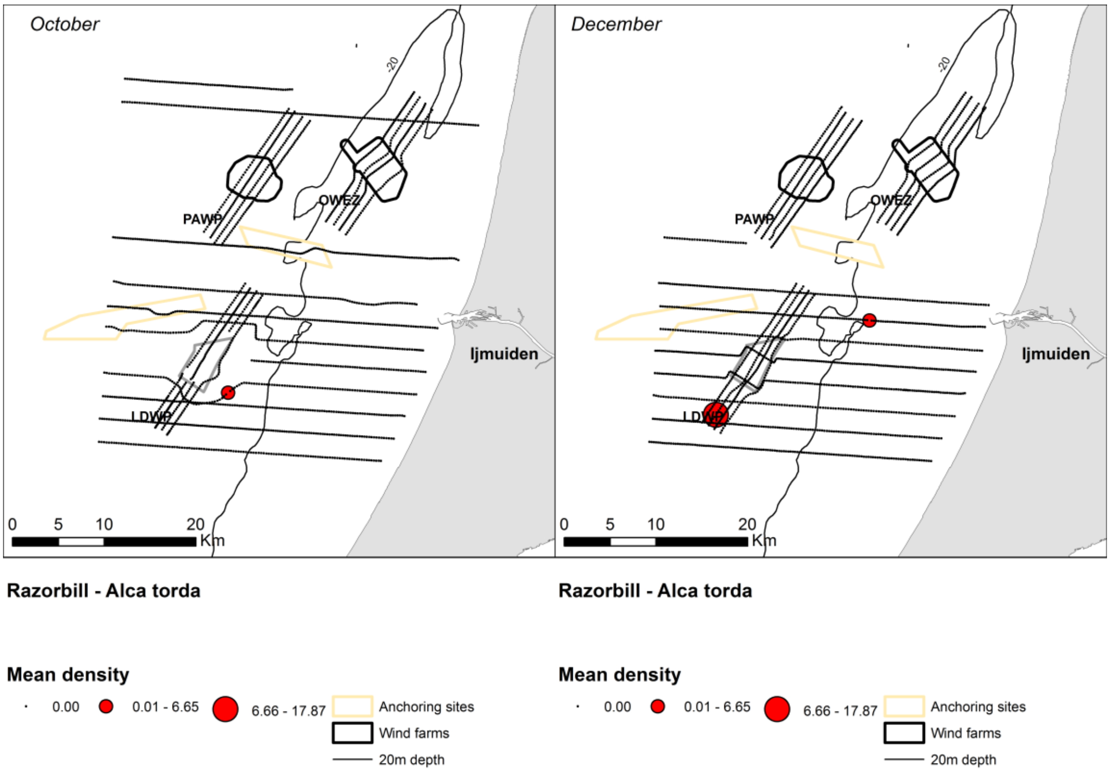

Figure 24. Observed densities of Razorbill during LUD TConstr surveys 2014.

4.3.18 Marine mammal observations

Like during the T0 Harbour Porpoise *Phocoena phocoena* was commonly observed in the whole area with most sightings in southern part during the December survey (Figure 25). Piling of monopole foundations took place during the October survey. The recordings included two groups of porpoises in the LUD in December.

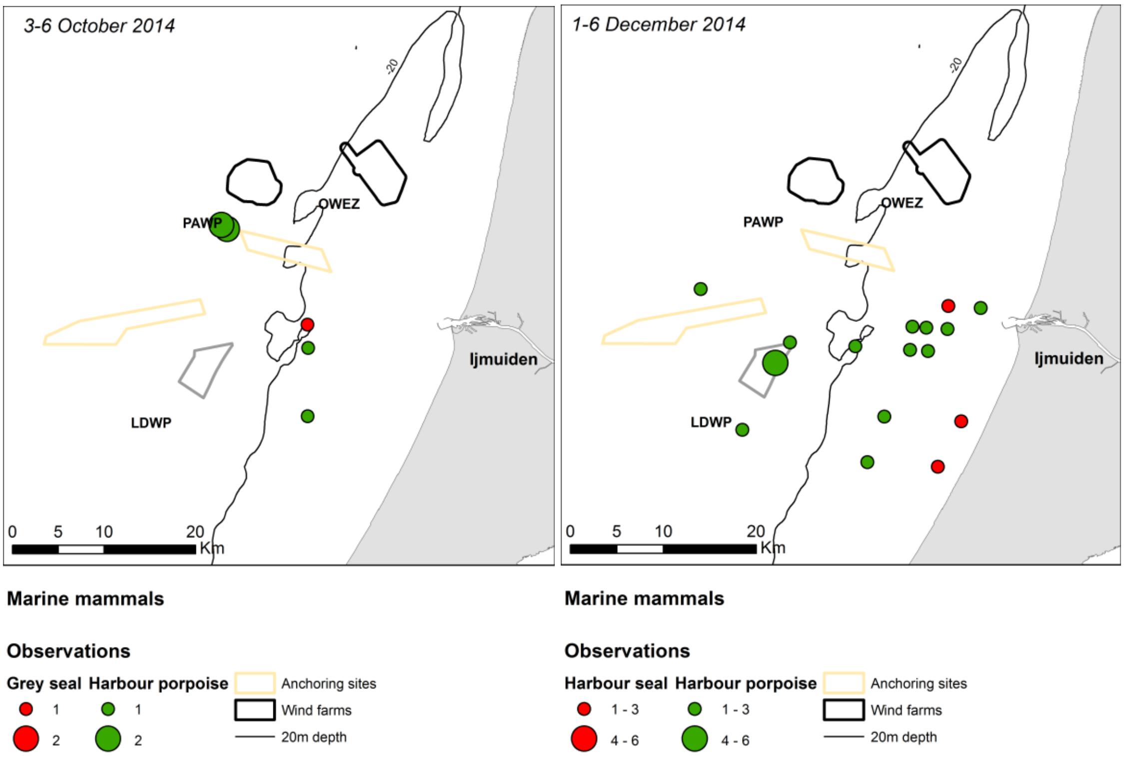

Figure 25. Observations of marine mammals during the LUD TConstr surveys 2014-2015. No corrections for possible double registrations have been made.

5 Discussion

The two LUD-TConstr surveys provided knowledge about the distribution and abundance of seabirds during the period of constructing the Offshore Wind Farm Eneco Luchterduinen LUD. The two surveys undertaken supplemented the LUD-T0 data comprised by the PAWP-T0/ T1 and OWEZ-T0/T1 data near these two wind farms as well as the survey data for the area south of PAWP and OWEZ. Although variations in the distribution of seabirds, especially with respect to large gulls and Black-legged Kittiwake, were recorded during these two surveys as compared to the LUD baseline the overall impression remains that the waters around LUD are mainly characterised by high densities of Common Guillemot and low densities of other species of seabirds.

The approved post-construction monitoring for LUD should be undertaken for at least one year, and possibly for two or three years. Accordingly, the results of the LUD-TConstr surveys should be seen as the first step in the collection of evidence regarding potential displacement impacts of LUD on seabirds. For the same reason, no attempts have been made in this report to make conclusions regarding habitat displacement of Common Guillemots or other species from LUD. After LUD-T1 in the 2015/2016 winter, the power of the monitoring data will be assessed. Yet, some of the results of the LUD-TConstr surveys are worth mentioning, as they corroborate findings of the distribution models applied for the LUD-T0 (Skov et al. 2015). It should also be noted that although installation started in 2014 no WTGs were yet installed during the time of the TConstr surveys, - the surveys should be regarded as reflecting an intermediate phase between baseline and post-construction periods.

The LUD-T0 distribution models indicated negative responses of divers (2 km avoidance), Northern Gannets (2 km avoidance) and Common Guillemot (5 km avoidance) to PAWP and OWEZ, as well as a positive response (attraction) of Great Cormorants to these wind farms. Northern Gannet observations during the 2014 surveys again showed a negative relationship to the two existing windfarms up to a distance of about 2 km, and up to a distance of 4 km to LUD. However, the distance variables in the model were not significant. Both observations and model results for Common Guillemot indicated avoidance of all three wind farms to a distance of 2-2.5 km, and low densities were predicted in all three wind farm areas. However, model uncertainty was rather high in the wind farm areas. Monitoring during the following winter will no doubt increase the sample size on gannets and guillemots, and improve both the explanatory and predictor power of the distribution models.

The attraction of Great Cormorants to OWEZ and PAWP was also apparent during the LUD TConstr surveys. However, attraction of cormorants was not recorded in LUD. LUD T1 surveys will reveal whether this situation will change post construction. The distribution of gulls and Black-legged Kittiwakes in relation to LUD did not indicate any obvious patterns of avoidance. Although Herring Gulls were seen in larger numbers just outside the boundaries of LUD and OWEZ, this distribution may simply be related to fishing activities. Black-legged Kittiwakes were observed in LUD as well as in OWEZ and PAWP, and their distribution seemed mainly to be determined by water depth.

6 References

Camphuysen, C.J. & Garthe, S., 2004. Recording foraging seabirds at sea: standardised recording and coding of foraging behaviour and multi-species foraging associations. Atlantic Seabirds 5: 1-23.

Camphuysen CJ, Fox TJ, Leopold MF & Petersen IK, 2004. Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the U.K. - A comparison of ship and aerial sampling methods for marine birds, and their applicability to offshore wind farm assessments. NIOZ Report to Cowrie / The Crown Estate.

Leopold M.F., Camphuysen C.J., ter Braak C.J.F., Dijkman E.M., Kersting K. & van Lieshout S.M.J. 2004. Baseline studies North Sea wind farms: Lot 5 marine birds in and around the future sites Nearshore Windfarm (NSW) and Q7. Alterra-rapport 1048.

Leopold, M.F., van Bemmelen, R.S.A. & Zuur, A.F. 2013. Responses of Local Birds to the Offshore Wind Farms PAWP and OWEZ off the Dutch mainland coast. Report number C151/12. Imares Report.

Petersen I.K., Christensen T.K., Kahlert J., Desholm M. & Fox A.D. 2006. Final results of bird studies at the offshore wind farms at Nysted and Horns Rev, Denmark. NERI Report, commissioned by DONG energy and Vattenfall A/S.

Skov, H., Leonhard, S.B., Heinänen, S., Zydelis, R., Jensen, N.E., Durinck, J., Johansen, T.W., Jensen, B.P., Hansen, B.L., Piper, W., Grøn, P.N. 2012. Horns Rev 2 Monitoring 2010-2012. Migrating Birds. Orbicon, DHI, Marine Observers and Biola. Report commis-sioned by DONG Energy.

Skov, H., Heinänen, S., Nyborg, L. & M. Lazcny. 2015. Offshore Wind Farm Eneco Luchterduinen Ecological monitoring of seabirds. T0 report. DHI report.

Tasker M.L., Jones P.H., Dixon T.J. & Blake B.F. 1984. Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardized approach. Auk 101: 567-577.

APPENDICES

APPENDIX A – Detailed results of species distribution models for the TConstr surveys

In the following, supplementary results from the species distribution models to those described in chapter 4.3 are presented. For each species the following are provided:

1. Table showing the deviance explained and evaluation statistics for the presence/absence and the positive parts of the mean distribution models;
2. Map with proportion standard errors of predicted mean densities;
3. Predicted densities from the dynamic distribution models during different periods of contrasting extent of the coastal current are provided.

Northern Gannet

Table B.3. Smooth terms, deviance explained and evaluation statistics for the Northern Gannet distribution model. The z-values and significance for the parametric terms are shown and for the smooth terms the approximate significance and chi-square/F statistics. Variables not included in either the binomial or positive model part are indicated with a dash.

Smooth terms	Presence/absence		Positive density	
	chi-sqr	p	F	p
Current speed	10.419	<0.05	2.254	
Eddy potential	-		-	
Current gradient	-		-	
Water depth	23.435	<0.001	2.284	
Slope of seafloor	-		-	
Distance to OWEZ	-		-	
Distance to PAWP	-		-	
Distance to LDWP	3.538		-	
Distance to wind farm	0.766		1.623	
Density of ships	-		-	
Parametric terms	z	p	t	p
Winter 2	6.536	<0.001	1.082	
Sample size (n)	1034		98	
Dev. Exp.	0.14		0.289	
AUC	0.6997			
Spearman's corr.	0.25			

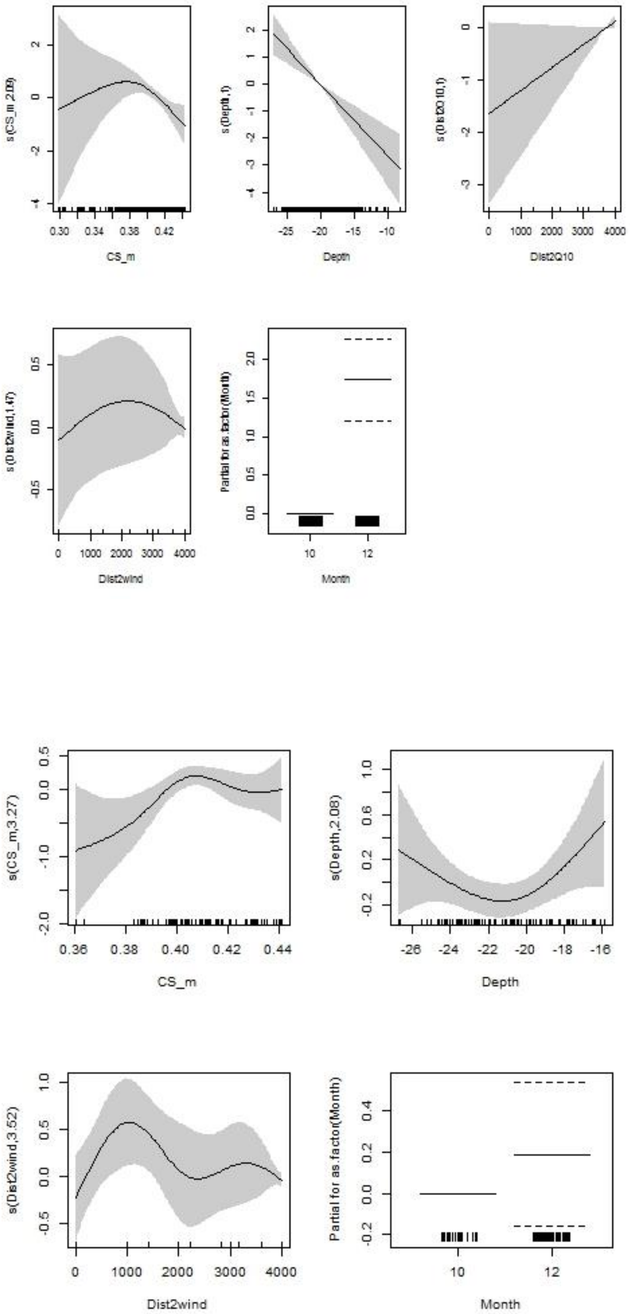

Figure B.7. Partial GAM plots for the Northern Gannet distribution model – presence-absence (upper panel) and positive (lower panel) parts. The values of the environmental variables are shown on the X-axis and the probability on the Y-axis in the scale of the linear predictor. The grey shaded areas and the dotted lines (for factors) show the 95% Bayesian confidence intervals. The degree of smoothing is indicated in the legend of the Y-axis.

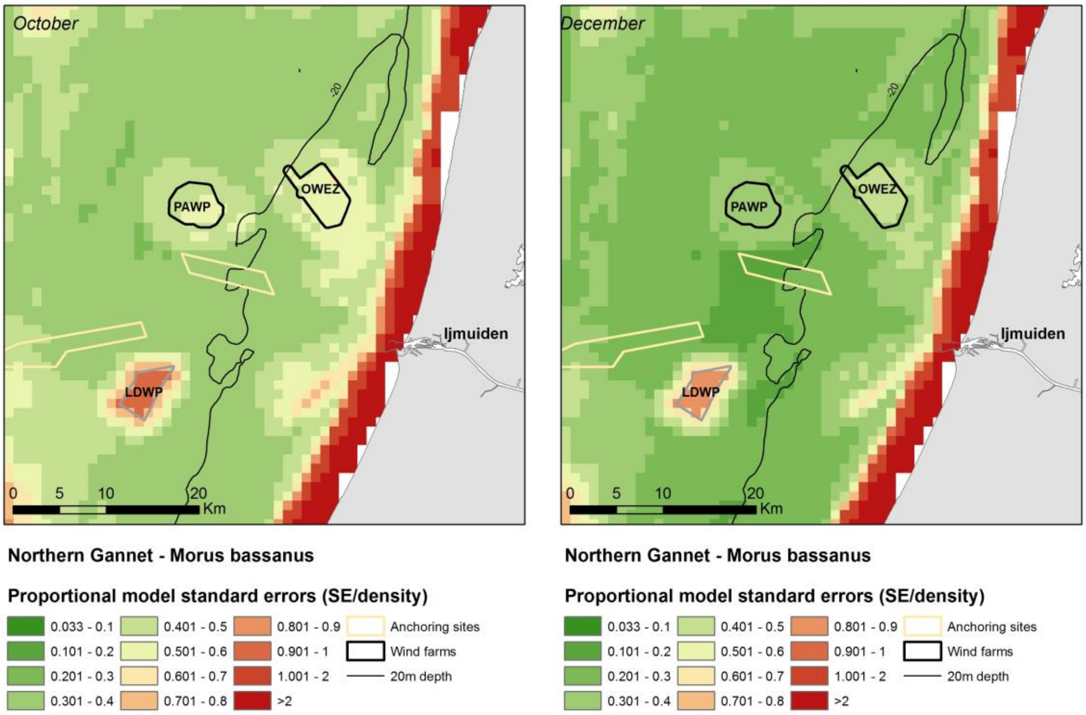

Figure B.8. Model uncertainty. Proportional model standard errors for the distribution (probability) model of wintering Northern Gannet during the LUD TConstr surveys 2014.

Great Cormorant

Table B.4. Smooth terms, deviance explained and evaluation statistics for the Great Cormorant distribution model. The z-values and significance for the parametric terms are shown and for the smooth terms the approximate significance and chi-square/F statistics. Variables not included in either the binomial or positive model part are indicated with a dash.

Smooth terms	Presence/absence		Positive density	
	chi-sqr	p	F	p
Current speed	-		-	
Eddy potential	-		-	
Current gradient	-		-	
Water depth	47.793	<0.001	-	
Slope of seafloor	-		-	
Distance to OWEZ	22.594	<0.001	7.758	<0.001
Distance to PAWP	18.981	<0.001	-	
Distance to LDWP	-		-	
Distance to wind farm	-		-	
Density of ships	-		-	
Parametric terms	z	p	t	p
Winter 2	2.339	<0.05	1.41	
Sample size (n)	1034		71	
Dev. Exp.	0.253		0.589	
AUC	0.7029			
Spearman's corr.	0.01			

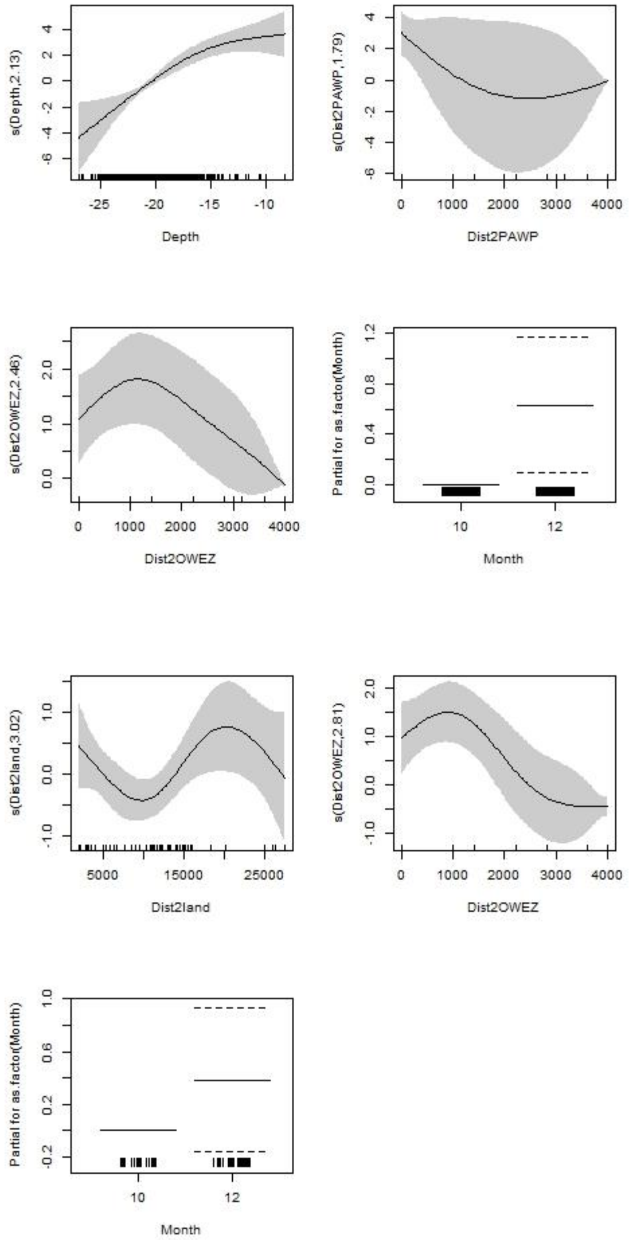

Figure B.10. Partial GAM plots for the Great Cormorant distribution model – presence-absence (upper panel) and positive (lower panel) parts. The values of the environmental variables are shown on the X-axis and the probability on the Y-axis in the scale of the linear predictor. The grey shaded areas and the dotted lines show the 95% Bayesian confidence intervals. The degree of smoothing is indicated in the legend of the Y-axis and for the interaction terms (Easting, Northing) in the heading.

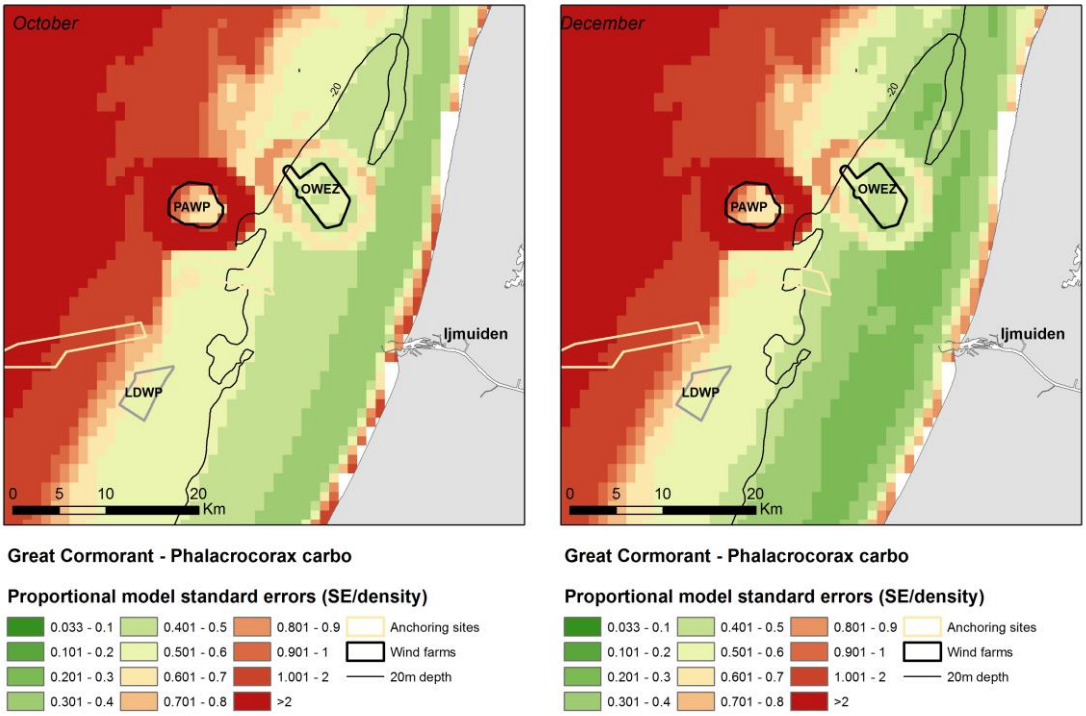

Figure B.11. Model uncertainty. Proportional model standard errors for the distribution (probability) model of wintering Great Cormorant during the LUD TConstr surveys 2014.

Common Gull

Table B.5. Smooth terms, deviance explained and evaluation statistics for the Common Gull distribution model. The z-values and significance for the parametric terms are shown and for the smooth terms the approximate significance and chi-square/F statistics. Variables not included in either the binomial or positive model part are indicated with a dash.

Smooth terms	**Presence/absence**		**Positive density**	
	chi-sqr	**p**	**F**	**p**
Current speed	4.296		-	
Eddy potential	-		-	
Current gradient	13.381	<0.01	6.788	<0.01
Water depth	8.829		6.032	<0.001
Slope of seafloor	-		-	
Distance to OWEZ	-		-	
Distance to PAWP	-		-	
Distance to LDWP	9.544	<0.01	7.327	<0.001
Distance to wind farm	3.671		-	
Density of ships	-		-	
Parametric terms	**z**	**p**	**t**	**p**
Winter 2	-		0.754	
Sample size (n)	545		224	
Dev. Exp.	15.9%		25.4%	
AUC	0.62			
Spearman's corr.	0.17			

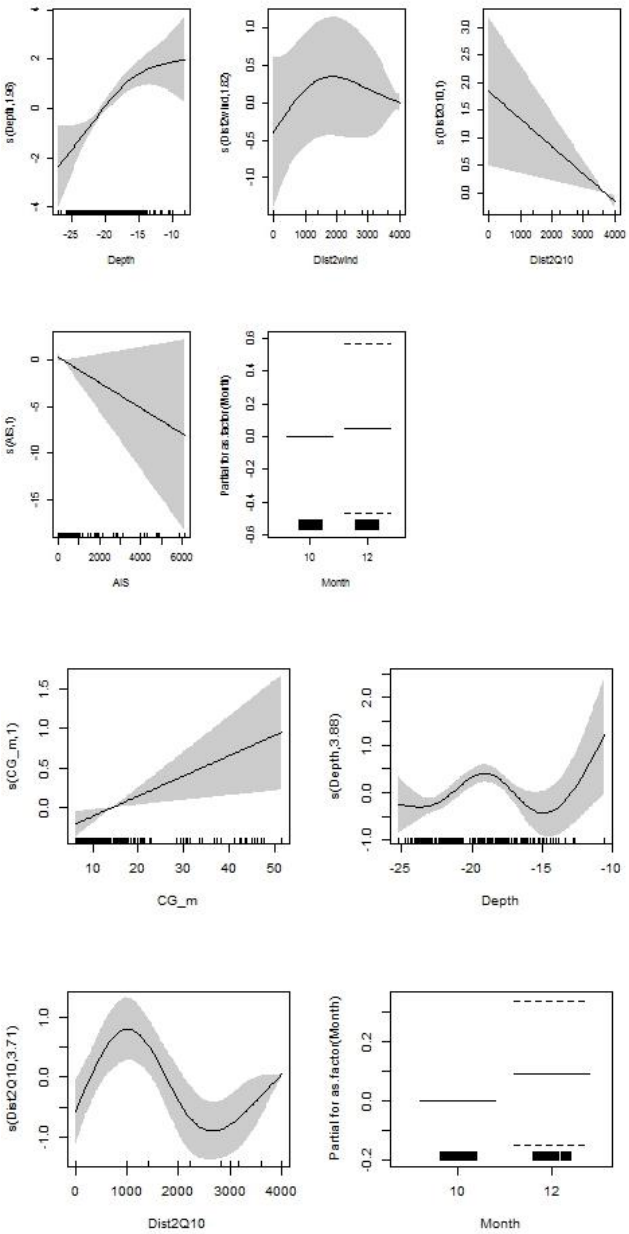

Figure B.12. Partial GAM plots for the Common Gull distribution model – presence-absence (upper panel) and positive (lower panel) parts. The values of the environmental variables are shown on the X-axis and the probability on the Y-axis in the scale of the linear predictor. The grey shaded areas and the dotted lines (for factors) show the 95% Bayesian confidence intervals. The degree of smoothing is indicated in the legend of the Y-axis.

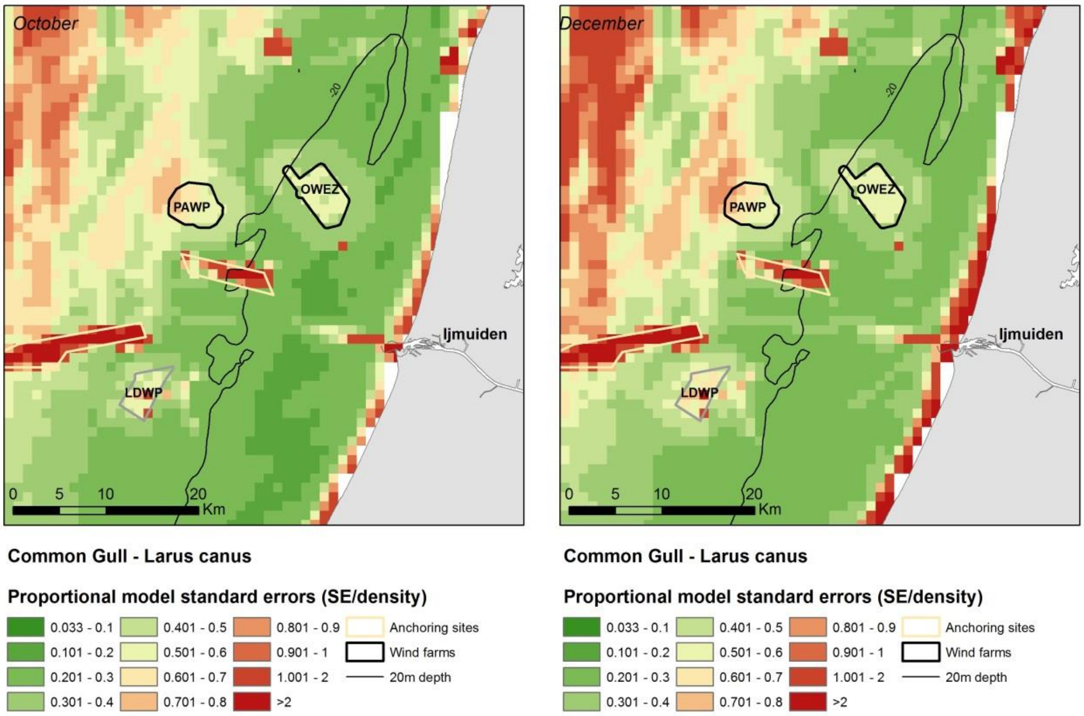

Figure B.13. Model uncertainty. Proportional model standard errors for the distribution (probability) model of wintering Common Gull during the LUD T-Constr surveys 2014.

Lesser Black-backed Gull

Table B.6. Smooth terms, deviance explained and evaluation statistics for the Lesser Black-backed Gull distribution model. The z-values and significance for the parametric terms are shown and for the smooth terms the approximate significance and chi-square/F statistics. Variables not included in either the binomial or positive model part are indicated with a dash.

Smooth terms	Presence/absence		Positive density	
	chi-sqr	p	F	p
Current speed	4.296		-	
Eddy potential	-		4.709	<0.05
Current gradient	13.381	<0.01	-	
Water depth	8.829		11.279	<0.001
Slope of seafloor	-		-	
Distance to OWEZ	-		-	
Distance to PAWP	-		-	
Distance to LDWP	9.544	<0.01	4.85	<0.05
Distance to wind farm	3.671		-	
Density of ships	-		-	
Parametric terms	z	p	t	p
Winter 2	-		-	
Sample size (n)	545		120	
Dev. Exp.	0.159		0.349	
AUC	0.623			
Spearman’s corr.	0.09			

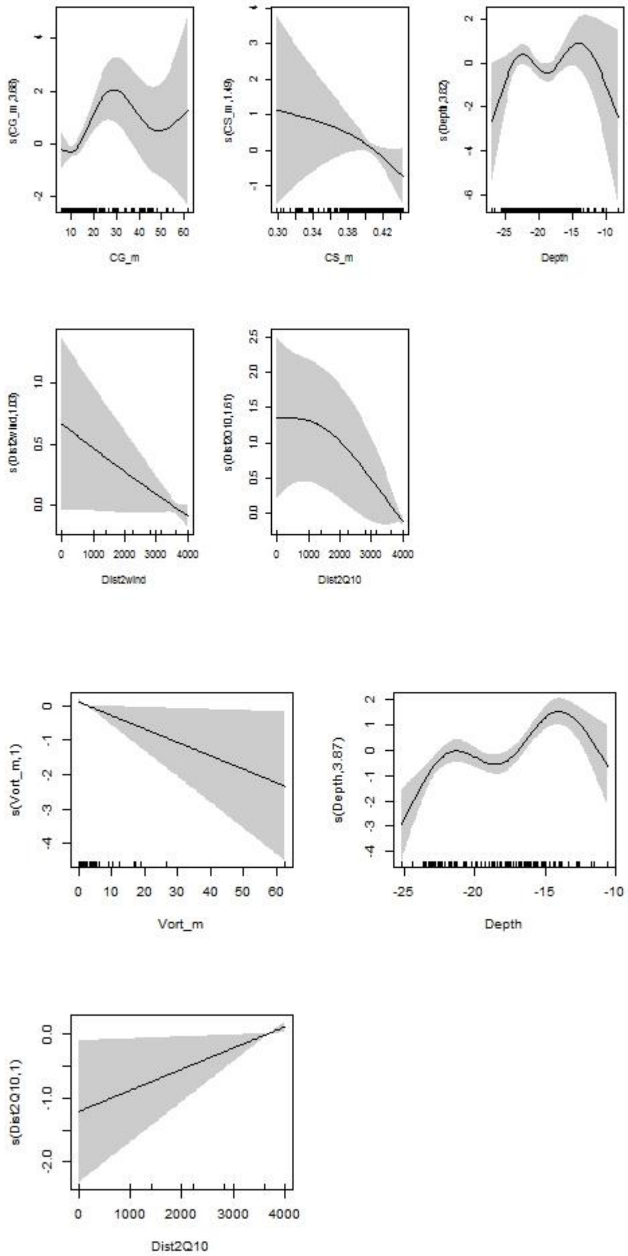

Figure B.14. Partial GAM plots for the Lesser Black-backed Gull distribution model – presence-absence (upper panel) and positive (lower panel) parts. The values of the environmental variables are shown on the X-axis and the probability on the Y-axis in the scale of the linear predictor. The grey shaded areas show the 95% Bayesian confidence intervals. The degree of smoothing is indicated in the legend of the Y-axis. The variable called Vort_m is the eddy potential.

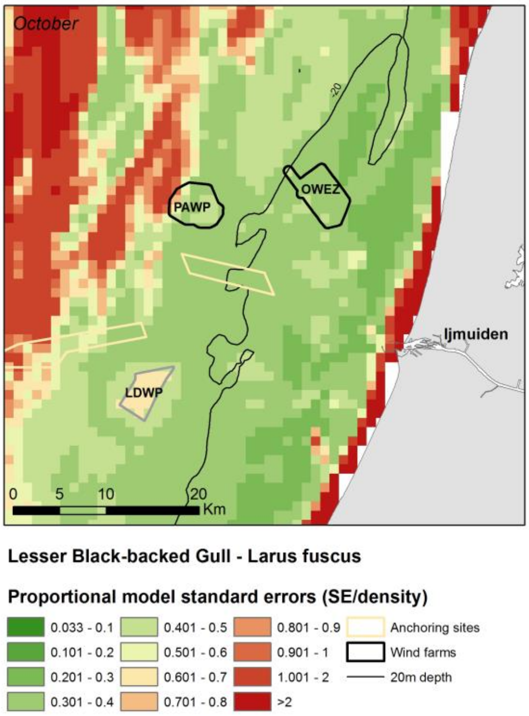

Figure B.15. Model uncertainty. Proportional model standard errors for the distribution (probability) model of wintering Black-headed Gull during the LUD TConstr surveys 2014.

Herring Gull

Table B.8. Smooth terms, deviance explained and evaluation statistics for the Herring Gull distribution model. The z-values and significance for the parametric terms are shown and for the smooth terms the approximate significance and chi-square/F statistics. Variables not included in either the binomial or positive model part are indicated with a dash.

Smooth terms	Presence/absence		Positive density	
	chi-sqr	p	F	p
Current speed	-		-	
Eddy potential	-		-	
Current gradient	5.33	<0.05	-	
Water depth	12.343	<0.01	2.586	<0.05
Slope of seafloor	-		-	
Distance to OWEZ	-		-	
Distance to PAWP	-		-	
Distance to LDWP	8.488	<0.01	0.531	
Distance to wind farm	1.439		0.735	
Density of ships	2.723		-	
Parametric terms	z	p	t	p
Winter 2	0.157		-3.699	<0.001
Sample size (n)	1034		67	
Dev. Exp.	0.107		0.428	
AUC	0.7538			
Spearman's corr.	0.26			

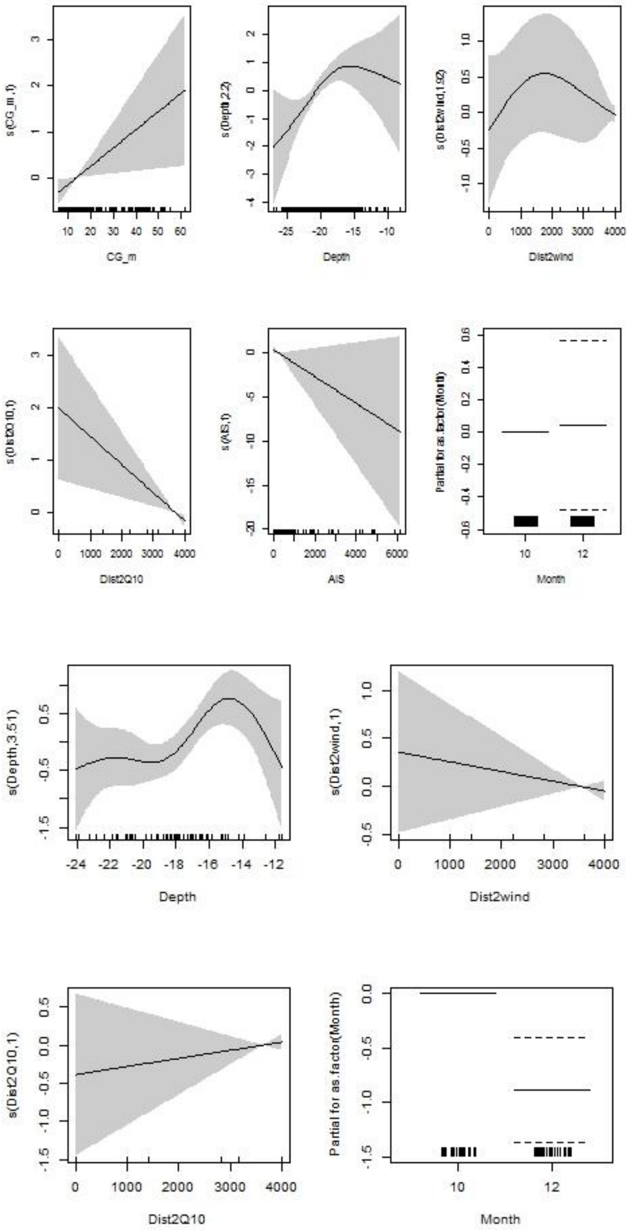

Figure B.20. Partial GAM plots for the Herring Gull distribution model – presence-absence (upper panel) and positive (lower panel) parts. The values of the environmental variables are shown on the X-axis and the probability on the Y-axis in the scale of the linear predictor. The grey shaded areas and the dotted lines (for factors) show the 95% Bayesian confidence intervals. The degree of smoothing is indicated in the legend of the Y-axis.

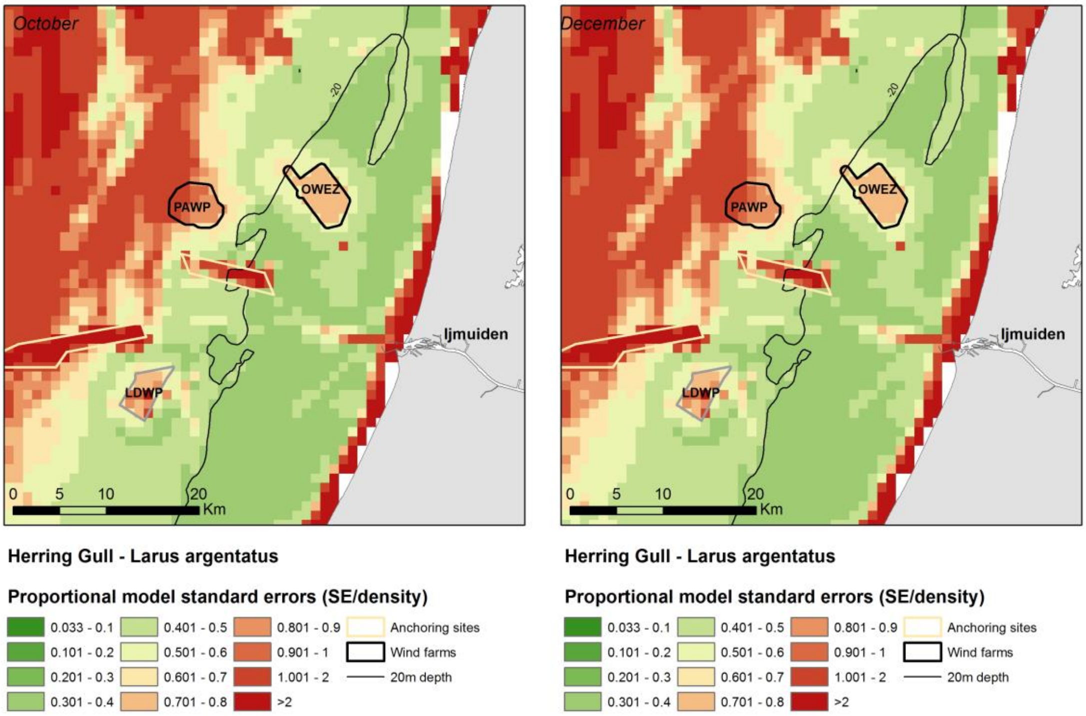

Figure B.21. Model uncertainty. Proportional model standard errors for the distribution (probability) model of wintering Herring Gull during the LUD TConstr surveys 2014.

Great Black-backed Gull

Table B.9. Smooth terms, deviance explained and evaluation statistics for the Great Black-backed Gull distribution model. The z-values and significance for the parametric terms are shown and for the smooth terms the approximate significance and chi-square/F statistics. Variables not included in either the binomial or positive model part are indicated with a dash.

Smooth terms	Presence/absence		Positive density	
	chi-sqr	p	F	p
Current speed	6.752	<0.05	-	
Eddy potential	4.702	<0.05	-	
Current gradient	-		-	
Water depth	20.92	<0.001	10.326	<0.01
Slope of seafloor	-		-	
Distance to OWEZ	-		-	
Distance to PAWP	-		-	
Distance to LDWP	-		3.107	<0.05
Distance to wind farm	-		6.166	<0.001
Density of ships	-		-	
Parametric terms	z	p	t	p
Winter 2	-3.233	<0.001	-0.957	
Sample size (n)	1034		187	
Dev. Exp.	0.05		0.199	
AUC	0.643			
Spearman's corr.	0.10			

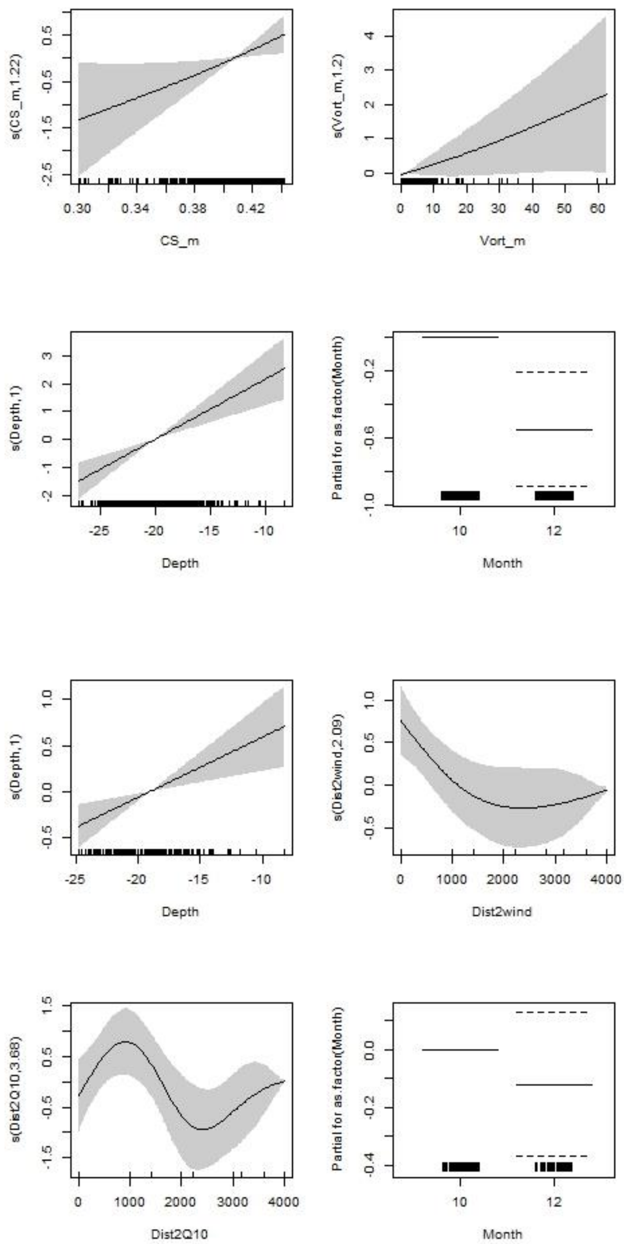

Figure B.23. Partial GAM plots for the Great Black-backed Gull distribution model – presence-absence (upper panel) and positive (lower panel) parts. The values of the environmental variables are shown on the X-axis and the probability on the Y-axis in the scale of the linear predictor. The grey shaded areas and the dotted lines (for factors) show the 95% Bayesian confidence intervals. The degree of smoothing is indicated in the legend of the Y-axis.

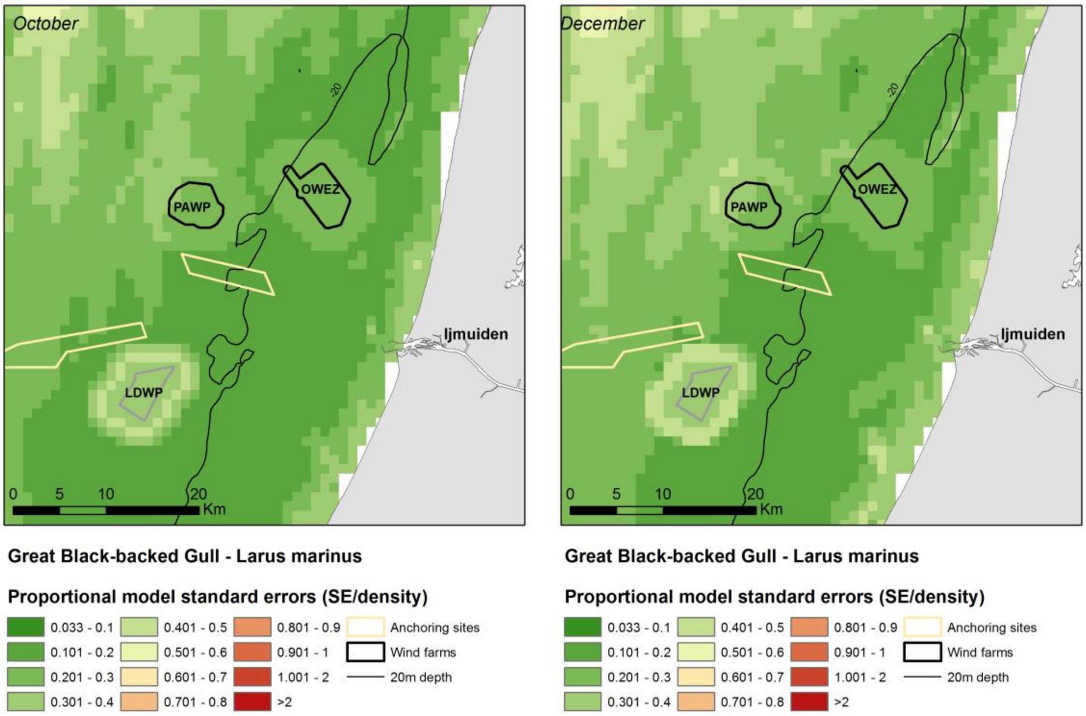

Figure B.24. Model uncertainty. Proportional model standard errors for the distribution (probability) model of wintering Great Black-backed Gull during the LUD TConstr surveys 2014.

Black-legged Kittiwake

Table B.10. Smooth terms, deviance explained and evaluation statistics for the Black-legged Kittiwake distribution model. The z-values and significance for the parametric terms are shown and for the smooth terms the approximate significance and chi-square/F statistics. Variables not included in either the binomial or positive model part are indicated with a dash.

Smooth terms	Presence/absence		Positive density	
	chi-sqr	p	F	p
Current speed	2.104		-	
Eddy potential	-		-	
Current gradient	-		1.115	
Water depth	13.225	<0.001	7.987	<0.01
Slope of seafloor	-		-	
Distance to OWEZ	-		-	
Distance to PAWP	-		-	
Distance to LDWP	4.322		3.561	
Distance to wind farm	4.988		-	
Density of ships	-		-	
Parametric terms	z	p	t	p
Winter 2	9.3	<0.001	2.543	<0.05
Sample size (n)	1034		155	
Dev. Exp.	0.263		0.116	
AUC	0.8594			
Spearman's corr.	0.38			

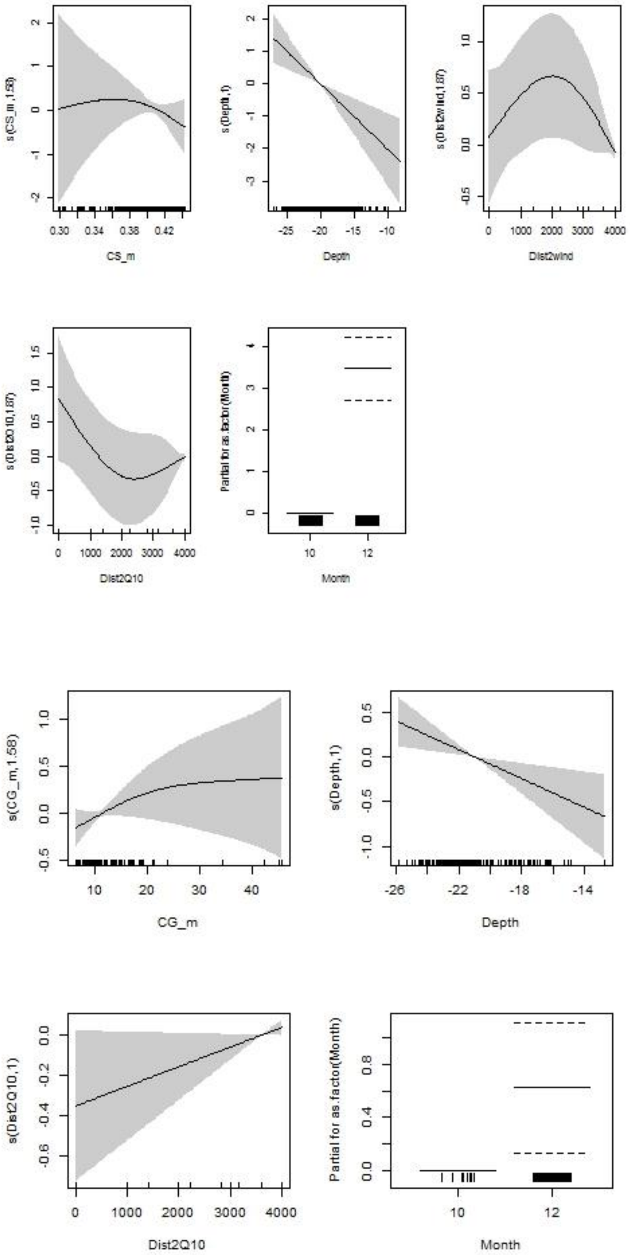

Figure B.26. Partial GAM plots for the Black-legged Kittiwake distribution model – presence-absence (upper panel) and positive (lower panel) parts. The values of the environmental variables are shown on the X-axis and the probability on the Y-axis in the scale of the linear predictor. The grey shaded areas and the dotted lines (for factors) show the 95% Bayesian confidence intervals. The degree of smoothing is indicated in the legend of the Y-axis.

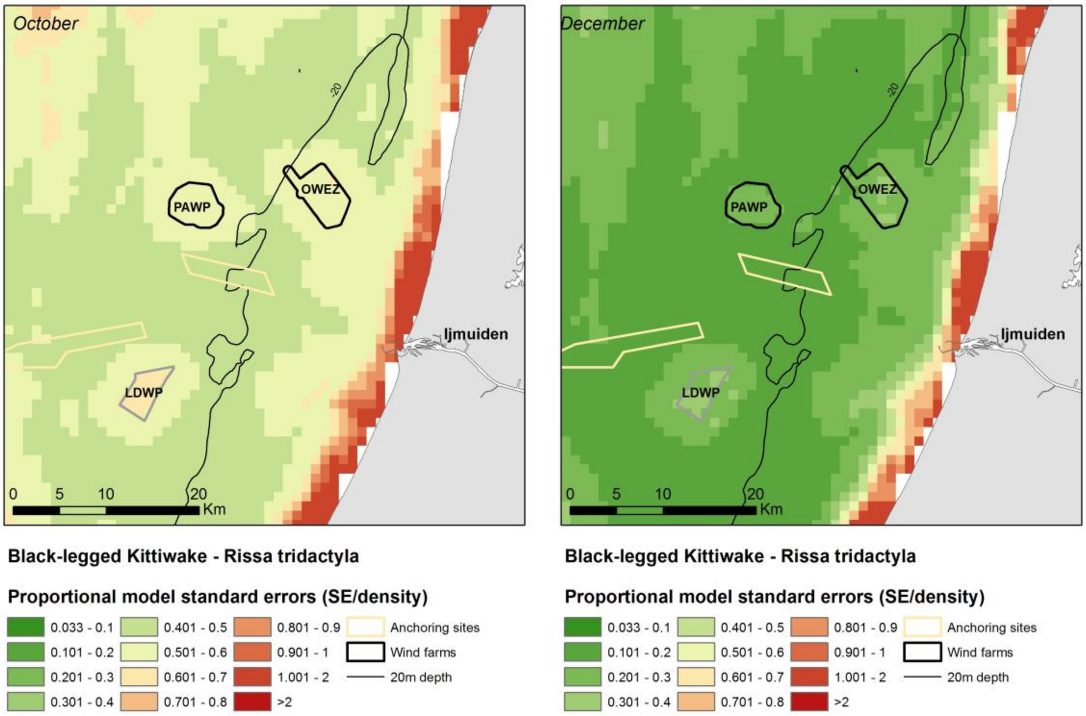

Figure B.27. Model uncertainty. Proportional model standard errors for the distribution (probability) model of wintering Black-legged Kittiwake during the LUD TConstr surveys 2014.

Common Guillemot

Table B.11. Smooth terms, deviance explained and evaluation statistics for the Common Guillemot distribution model. The z-values and significance for the parametric terms are shown and for the smooth terms the approximate significance and chi-square/F statistics. Variables not included in either the binomial or positive model part are indicated with a dash.

Smooth terms	Presence/absence		Positive density	
	chi-sqr	p	F	p
Current speed	4.243	<0.05	-	
Eddy potential	-		-	
Current gradient	-		-	
Water depth	2.527		9.641	<0.01
Slope of seafloor	-		-	
Distance to OWEZ	-		-	
Distance to PAWP	-		-	
Distance to LDWP	6.615	<0.01	0.404	
Distance to wind farm	15.91	<0.001	2.249	
Density of ships	7.601	<0.01	3.734	
Parametric terms	z	p	t	p
Winter 2	9.547	<0.001	1.239	
Sample size (n)	1034		208	
Dev. Exp.	0.163		0.099	
AUC	0.7931			
Spearman's corr.	0.22			

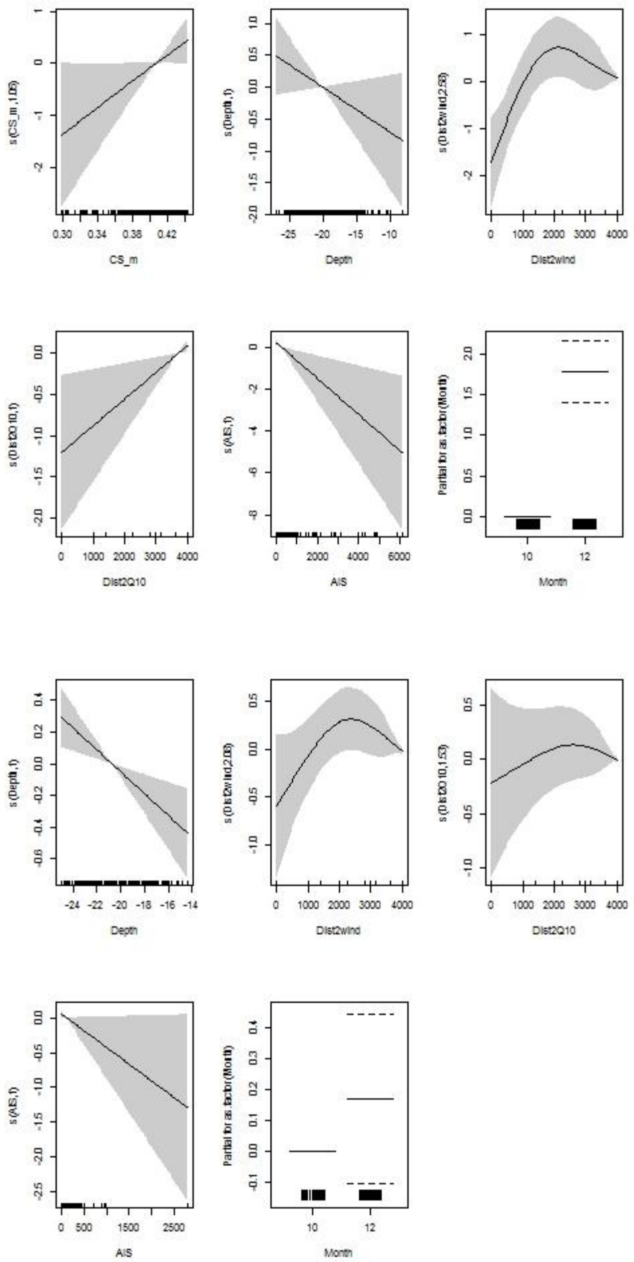

Figure B.29. Partial GAM plots for the Common Guillemot distribution model – presence-absence (upper panel) and positive (lower panel) parts. The values of the environmental variables are shown on the X-axis and the probability on the Y-axis in the scale of the linear predictor. The grey shaded areas and the dotted lines (for factors) show the 95% Bayesian confidence intervals. The degree of smoothing is indicated in the legend of the Y-axis.

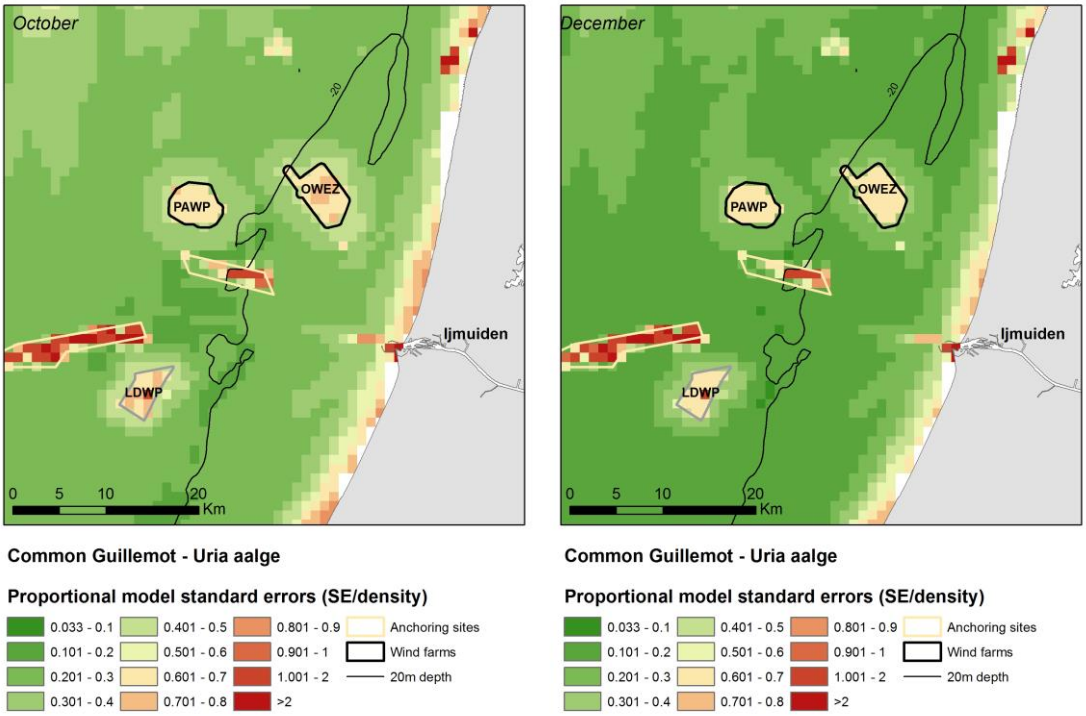

Figure B.30. Model uncertainty. Proportional model standard errors for the distribution (probability) model of wintering Common Guillemot during the LUD TConstr surveys 2014.