CHAPTER 3

BELGIAN SEABIRD DISPLACEMENT MONITORING PROGRAM

MACRO-AVOIDANCE OF GPS-TAGGED LESSER BLACK-BACKED GULLS & POTENTIAL HABITUATION OF AUKS AND GANNETS

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Abstract

This study illustrates macro-avoidance by GPS-tagged lesser black-backed gulls at the Norther wind farm, by comparing the presence of tagged birds before and after construction and comparing the observed trend with the trend in two nearby control areas. The results mirror those obtained at the Thornton Bank wind farm just north of the study site (Vanermen *et al*. 2019a). Collision risk models should thus always take into account post-construction avoidance to reliably estimate the number of expected collision fatalities in lesser black-backed gull, a species highlighted to potentially suffer population impact following current wind farm development plans in the North Sea. The second part of this chapter reports the results of the first two-day monitoring survey of the full Belgian wind farm concession zone, performed in February 2021. Though much too soon to draw any conclusions, the findings are quite remarkable as we encountered good numbers of northern gannet *Morus bassanus*, common guillemot *Uria aalge* and razorbill *Alca torda* inside the concession zone, all species generally perceived to actively avoid offshore wind farms across European waters (Vanermen & Stienen 2019). Coming surveys should tell whether these first results were anecdotic, or alternatively fit into a trend of actual habituation of seabirds to the presence of offshore wind farms.

1. Introduction

In this chapter we will elaborate on the progress of two (sub)studies following the feasibility study (Vanermen *et al*. 2020) on targeted monitoring of seabirds at offshore wind farms (OWFs) in the Belgian Part of the North Sea (BPNS). One of the proposals was to take advantage of the momentum of the construction of the Norther wind farm in 2018–2019, coinciding with the availability of GPS data of lesser black-backed gulls *Larus fuscus*, tagged in the nearby colonies of Ostend, Zeebrugge and Vlissingen in the period 2013–2020 (Stienen *et al*. 2016). As such we have data on the habitat use of the wind farm area from before the wind farm construction up to one year after installation, allowing to perform a BACI analysis (§2).

Secondly, Vanermen *et al.* (2020) proposed a new strategy for the monitoring of OWF-induced seabird displacement. This strategy includes a full coverage of the entire concession zone alongside a wide reference area, thus stepping away from the earlier adopted farm-by-farm approach. The intense coverage of the study area will allow state of the art spatial analyses once enough data are collected. As such we aim to gain insight in the effect of turbine density on seabird displacement rates and the use of corridors between individual farms for local or migration movements. In February 2021 we sailed the proposed two-day monitoring route for the first time and in §3 we discuss the numbers and distribution of six key seabird species encountered during this trip.

2. Lesser black-backed gull presence in the Norther wind farm: a BACI analysis of GPS data

2.1. Methods

2.1.1. BACI set-up

The recent installation of the Norther wind farm in the most south-east part of the Belgian wind farm concession zone offered the opportunity to compare the distribution of tracked lesser black-backed gulls in and around this particular OWF site before, during and after construction of the turbines by applying a classic BACI set-up. To this end, one impact and two equally-sized control areas were delineated as illustrated in Fig. 1.

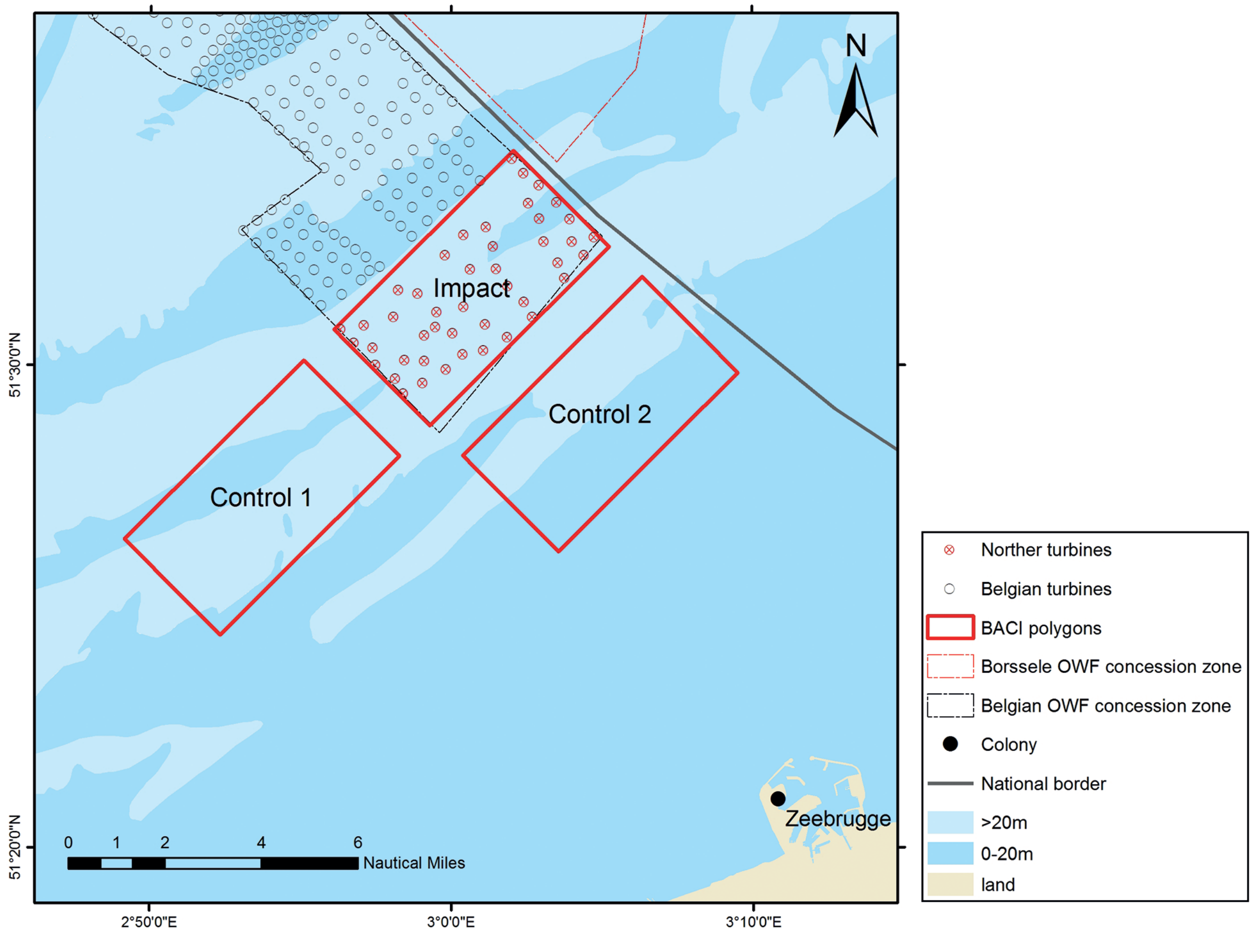

Figure 1. BACI setup to study the impact of the construction of the Norther OWF on the habitat use of lesser black-backed gulls.

Based on the project timeline (https://www.norther.be/#timings), we defined the different periods for application in the BACI analysis as follows:

- Pre-construction period: 01/01/2017 – 30/06/2018
- Construction period: 01/07/2018 – 31/08/2019
- Impact period: 01/09/2019 – present

2.1.2. GPS data

Between 2013 and 2020, 156 lesser black-backed gulls breeding in Zeebrugge (n = 83), Ostend (n = 6) and Vlissingen (n = 67) were equipped with a UvA-BiTS tracker generating three-dimensional GPS fixes (Bouten *et al.* 2013, Stienen *et al.* 2016). The deployment of the trackers was authorized by the ethical committee for animal experiments (license number CDE2013–73) and conducted in accordance with Flemish and Belgian legislation. To fit the GPS trackers, all individuals were caught on their nests during incubation using walk-in traps or clap nets. Trackers were attached using a wing harness of Teflon ribbon threaded with a nylon string (Stienen *et al.* 2016). The collected data were remotely transmitted to a base station located inside each colony. Tagging effort strongly decreased after 2018, with only 6 more birds tagged in 2019 and 2020 (Fig. 2). Since the trackers generate data for an average period of about one year and a half (due to loss of the tracker, tracker malfunctioning or birds moving to other colonies), this implies an overall decrease in the number of records in the study area over time.

In the raw database, the sampling rate of GPS fixes varied strongly from 10 to 3600 seconds resulting from the different needs and priorities of the data end-users. In order to obtain an unbiased dataset and meanwhile avoid temporal correlation between records (Ross-Smith *et al.* 2016; Shamoun-Baranes *et al.* 2017), data were subsampled to a minimum frequency of 1100 seconds, after which tracks with a frequency of more than 1500 seconds were omitted as well. This way the sampling frequency of the resulting dataset is in line with the principal frequency of 20 minutes (Fig. 3).

2.1.3. Model

We estimated the effect of the installation of the Norther OWF on the area use of lesser black-backed gull by modelling the number of GPS records in the study area (Fig. 1). The response variable in our model was the number

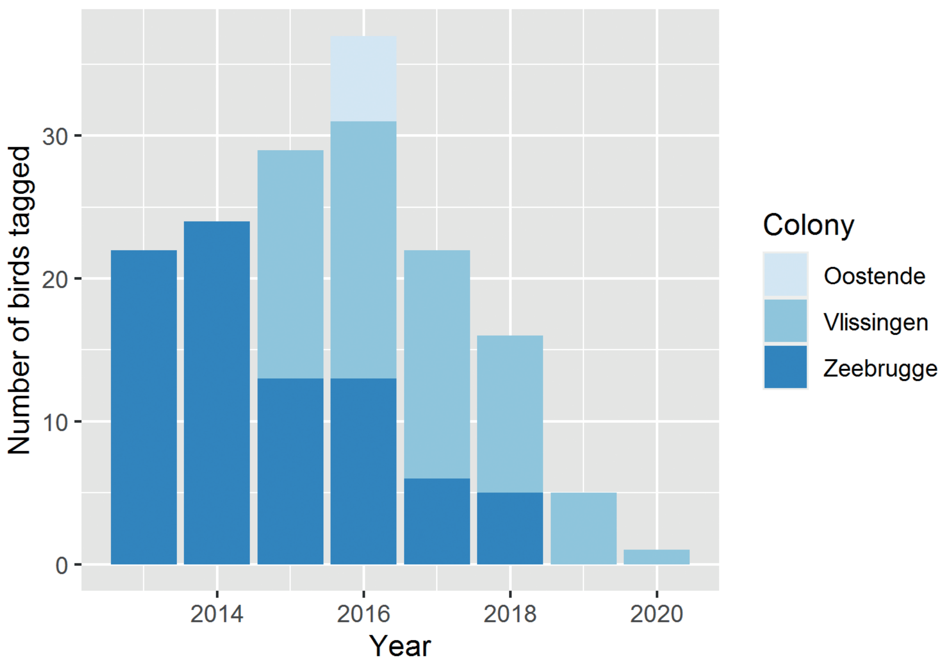

Figure 2. Tagging effort of lesser black-backed gulls per year and per colony.

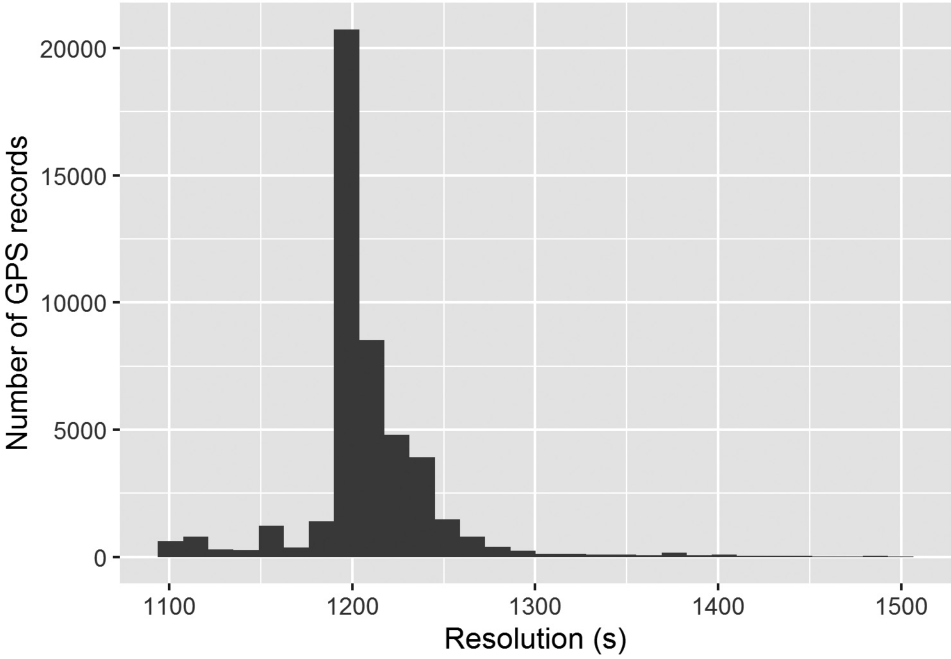

Figure 3. Sampling frequency of the GPS records after subsampling.

of records per day per area, and as covariates we chose month, area (impact area and two reference areas) and period (pre-construction, construction and post-construction), allowing interaction between the two latter. We only considered days between the 1st of March and the 31st of August, as the species is largely absent outside this period. With 306, 246 and 184 days of sampling, respectively in the pre-construction, construction and impact period, and three areas considered, the database holds 2208 unique day-area combinations. The estimated coefficients of the interaction between the impact area factor level on the one hand and the construction / impact period levels on the other hand are thus a measure of the (indirect) effect of the OWF construction / presence. We tested 4 distributions, *i.e.* Poisson, negative binomial, zero-inflated Poisson and zero-inflated negative binomial, and chose the best fitting distribution based on the resulting AIC value (Akaike 1974).

2.2. Results

2.2.1. Maps

Though difficult to interpret visually due to an overall decreasing number of records over time, related to the decreased tagging effort after 2016 (Fig. 2), Figs 4 to 6 illustrate a clear change in the spatial distribution of lesser black-backed gull presence following the construction of the Norther OWF. The northern part of the wind farm in particular seems to be largely avoided by the gulls during the operational impact period (Fig. 6).

2.2.2. Model results

The best model fit was obtained through a negative binomial distribution based on the corresponding AIC, and the model summary is shown in Table 1. The factors ‘periodConstruction’ and ‘periodAfter’ were significantly (and progressively) negative, which reflects the overall decrease in the number of tagged birds since 2016 (see Fig. 2). The factor ‘areaControl2’ was significantly positive, implying a consistently higher number of records inside Control area 2 compared to Control area 1. Importantly, the interactions ‘periodAfter:areaControl2’ and ‘periodConstruction:areaControl2’ were not significant, in line with the assumption that the trend in the number of records in Control area 2 should not be any different from that in Control area 1.

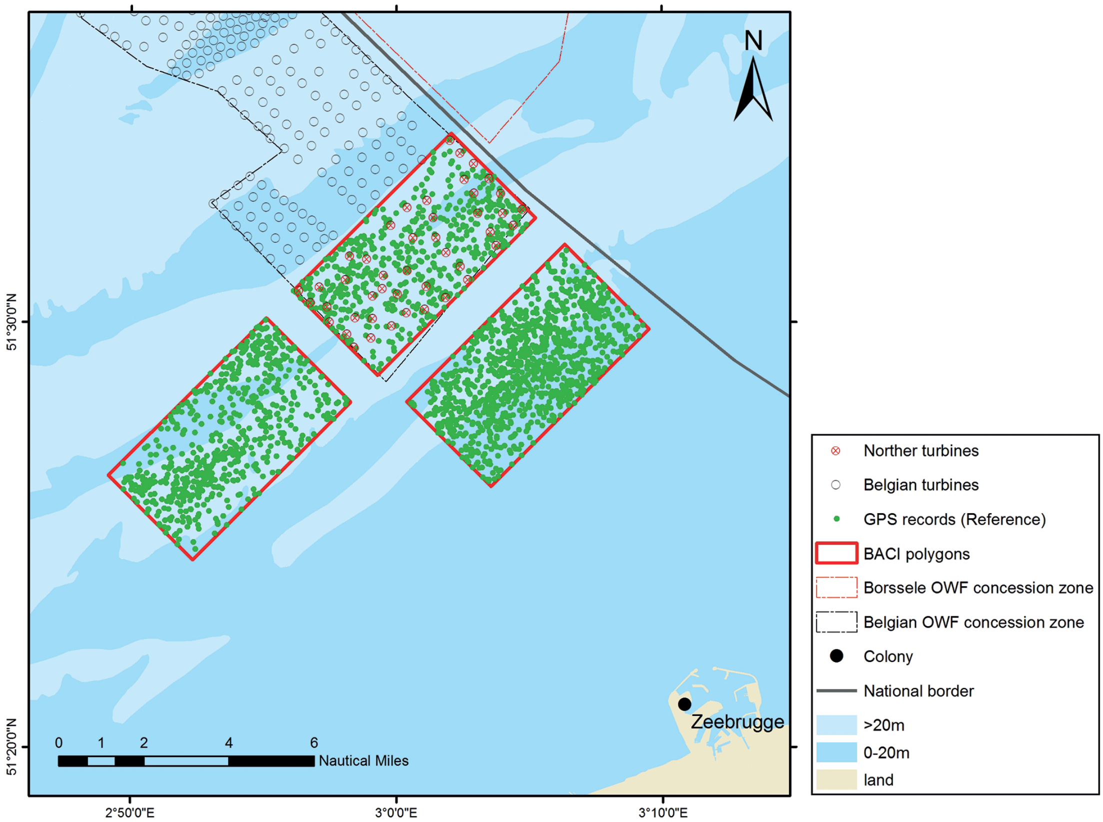

Figure 4. GPS records inside the BACI polygons during the pre-construction period (01/01/2017 – 30/06/2018; N = 2174).

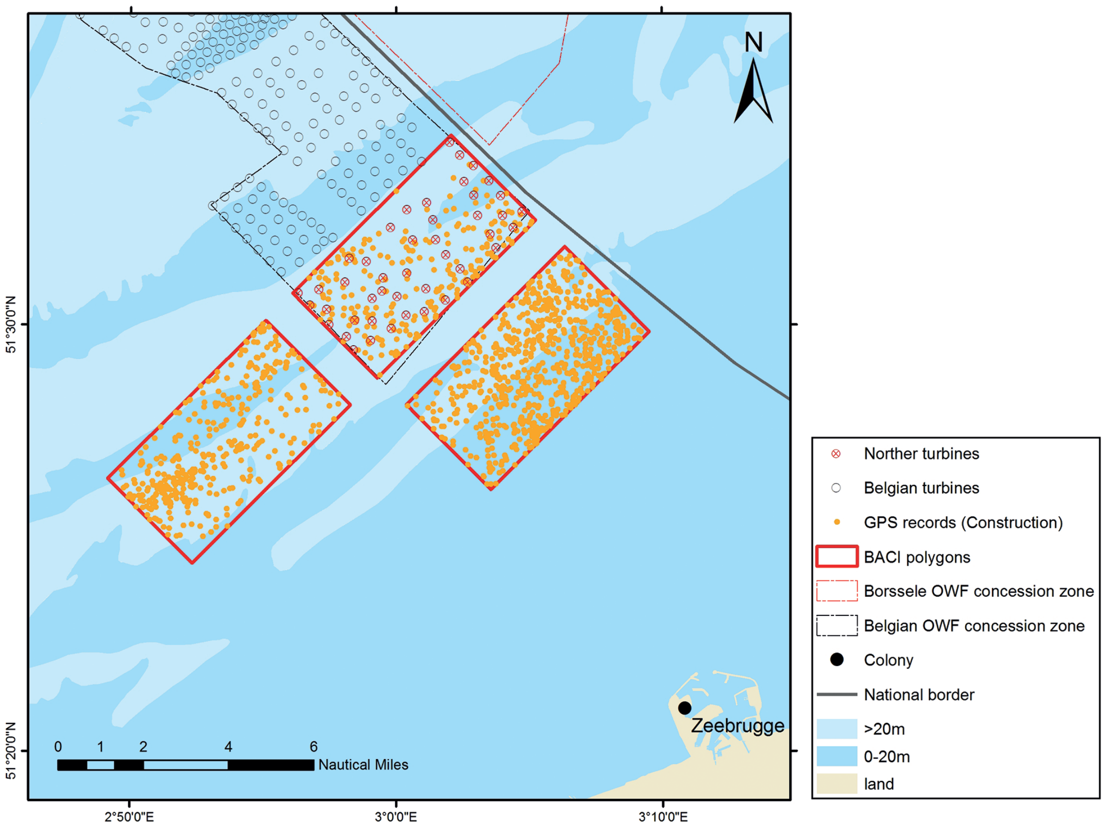

Figure 5. GPS records inside the BACI polygons during the construction period (01/07/2018 – 31/08/2019; N = 1274).

Table 1. BACI model summary results (P < 0.1., P < 0.05*, P < 0.01**, P < 0.001***; the coefficient of the estimated wind farm impact is indicated in red).

	Estimate	Std. Error	Z-value	P-value
(Intercept)	-0.156	0.180	-0.866	0.387
as.factor(month)4	1.078	0.183	5.886	0.000***
as.factor(month)5	1.059	0.182	5.824	0.000***
as.factor(month)6	0.812	0.184	4.402	0.000***
as.factor(month)7	1.278	0.184	6.930	0.000***
as.factor(month)8	0.398	0.190	2.097	0.036*
periodConstruction	-0.375	0.207	-1.814	0.070.
periodAfter	-0.943	0.231	-4.086	0.000***
areaControl2	0.524	0.188	2.784	0.005**
areaImpact	0.010	0.190	0.053	0.958
periodConstruction:areaControl2	0.109	0.284	0.383	0.701
periodAfter:areaControl2	-0.178	0.321	-0.554	0.579
periodConstruction:areaImpact	-0.363	0.291	-1.250	0.211
periodAfter:areaImpact	-1.252	0.352	-3.553	0.000***

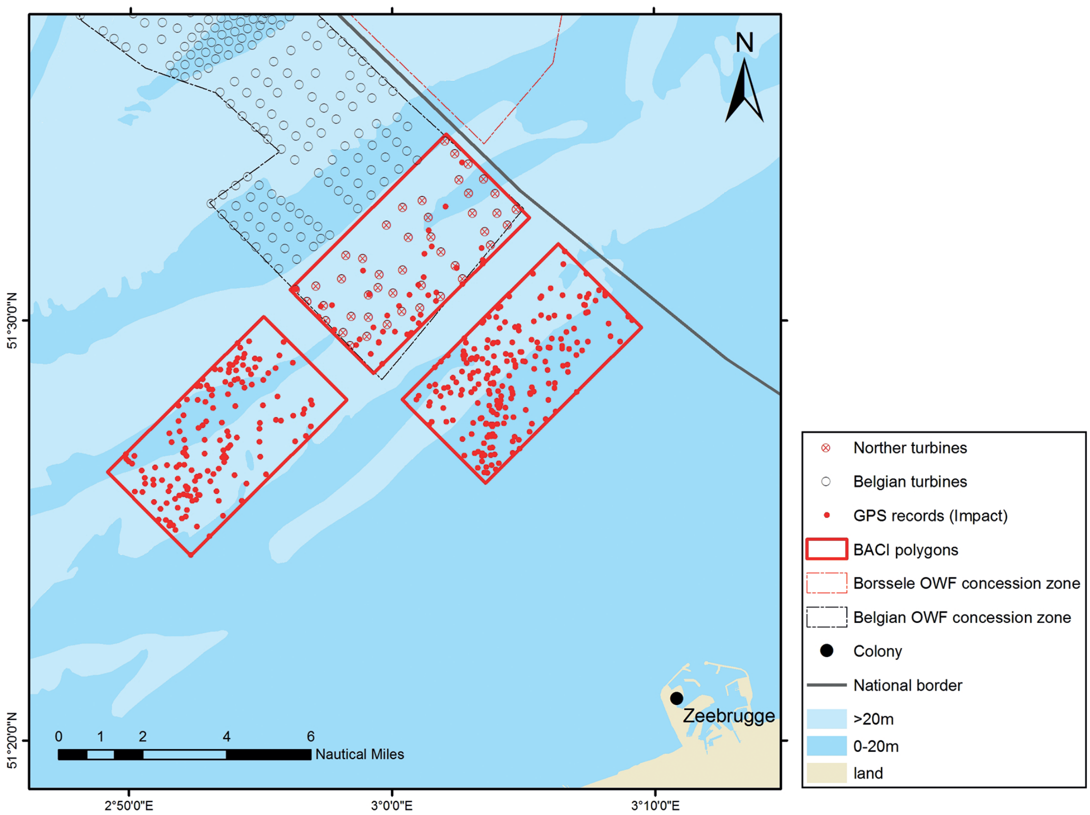

Figure 6. GPS records inside the BACI polygons during the impact period (01/09/2019 – present; N=412).

Lastly, though negative, the interaction between 'periodConstruction' and 'areaImpact' was not significant, implying that the construction activities did not affect the distribution of tagged lesser black-backed gulls to a statistically discernible extent. The interaction between 'periodAfter' and 'areaImpact' on the other hand was significant, confirming our earlier visual interpretation of Figs 4 to 6 and the effect of the presence of the Norther turbines on the distribution of lesser black-backed gulls in the study area. The coefficient of -1.252 stands for a decrease in lesser black-backed gull occurrence by 71% compared to the pre-construction period and taking account of the trend in the control areas.

2.3. Discussion BACI analysis GPS data

For the Thornton Bank wind farm, Vanermen *et al*. (2019a) already showed how lesser black-backed gulls avoided the wind farm interior, but were attracted to the outer edge turbines for roosting. This study again illustrates the general avoidance of OWFs by tagged lesser black-backed gulls, at yet another location just south-east of the earlier mentioned Thornton Bank. Interestingly, the results obtained through GPS studies counter earlier reported results from designated ship-based surveys, pointing towards attraction of lesser black-backed gulls to the Bligh Bank OWF (Vanermen *et al*. 2019b). Part of the explanation could be that the Bligh Bank is located outside the foraging range of the (adult) birds breeding in the study colonies, and that the perceived attraction effect thus involves birds on migration, immature birds and/or birds with another provenance.

As tagging effort in the colonies of Zeebrugge, Ostend and Vlissingen has decreased over the last few years, a general decrease in the number of GPS records has occurred in the study area. Though easily accounted for by the model, it would be interesting to be able to include more post-construction records to build an even stronger case. In this respect, about ten more birds will be tagged in Zeebrugge in the breeding season of 2021. We may further opt to include GPS data from individuals tagged in the Dutch colony of Neeltje Jans, the foraging range of which is expected to overlap with the study area.

Another step forward would be the analysis of the accelerometer data, that allows to classify GPS records in behavioural categories, most interesting of which is the category 'pecking', indicating foraging behaviour. Analysing the (change in) behaviour in the impact area may give further insight in the habitat use of OWFs by lesser black-backed gulls.

As argued before, the prohibition for trawlers to fish between the turbines is likely to be at least a co-driving force behind the observed decrease in records of lesser black-backed gulls in the impact area. The offshore density of GPS records is indeed closely related to fishery activities. Within Control area 1 for example, the density of GPS records is highest both north and south of the Gootebank (Figs 4 to 6), which relates to less intense fishery activity on sandbank ridges across the BPNS (data download from https://globalfishingwatch.org/). Whether wind farm avoidance is due to a disturbance effect induced by the turbines, the absence of fisheries or a combination of both, however, is hard to assess. To stay close to the set-up of this study, one would actually need to include an additional control area from which all fishery activity can be excluded, in order to 'isolate' its particular effect. Regardless of what actually induces the wind farm avoidance, we should note that the main concern regarding lesser black-backed gulls and OWFs is still the potential population level impact due to increased (collision) mortality, rather than the impact of habitat loss. Importantly, collision risk studies often use pre-construction bird densities to feed the collision models, yet this strategy is expected to result in an overestimation of the number of expected victims by not taking account of post-construction avoidance.

3. Ship-based monitoring of seabird displacement in the Belgian OWF concession zone

3.1. Methods

Since the end of 2020, the Belgian OWF concession zone is fully operational. This new context allows seabird monitoring across the concession zone without any access restrictions due to construction works. In the feasibility study of last year (Vanermen *et al*. 2020), a new monitoring strategy was therefore outlined (Fig. 7), aiming to continue assessing species-specific displacement rates by means of ship-based counts and meanwhile looking for correlations with wind farm configuration characteristics.

Ship-based seabird counts are conducted according to a standardised and internationally applied method, combining a 'transect count' for birds in contact with the water and repeated 'snapshot counts' for flying birds (Tasker *et al*. 1984). For the 'transect count', the focus is on a 300 m wide transect along one side of the ship's track, and while steaming at a speed of about 10 knots, all birds in touch with the water (swimming, dipping, diving) within this transect are counted. The distance to each observed bird (group) is estimated, allowing to correct for decreasing detectability with increasing distance afterwards. The transect is thus divided in four distance categories (A=0-50 m; B=50-100 m; C=100-200 m; D=200-300 m). Counting all flying birds inside the transect, however, would cause an overestimation and would be a measure of bird flux rather than bird density (Tasker *et al*. 1984). The density of flying birds is therefore assessed through one-minute interval counts of birds flying within a quadrant of 300 by 300 m inside the transect (the so-called 'snapshot counts'). As the ship covers a distance of approximately 300 m per minute when sailing the prescribed speed of 10 knots, the full transect is covered by means of these subsequent 'snapshots'.

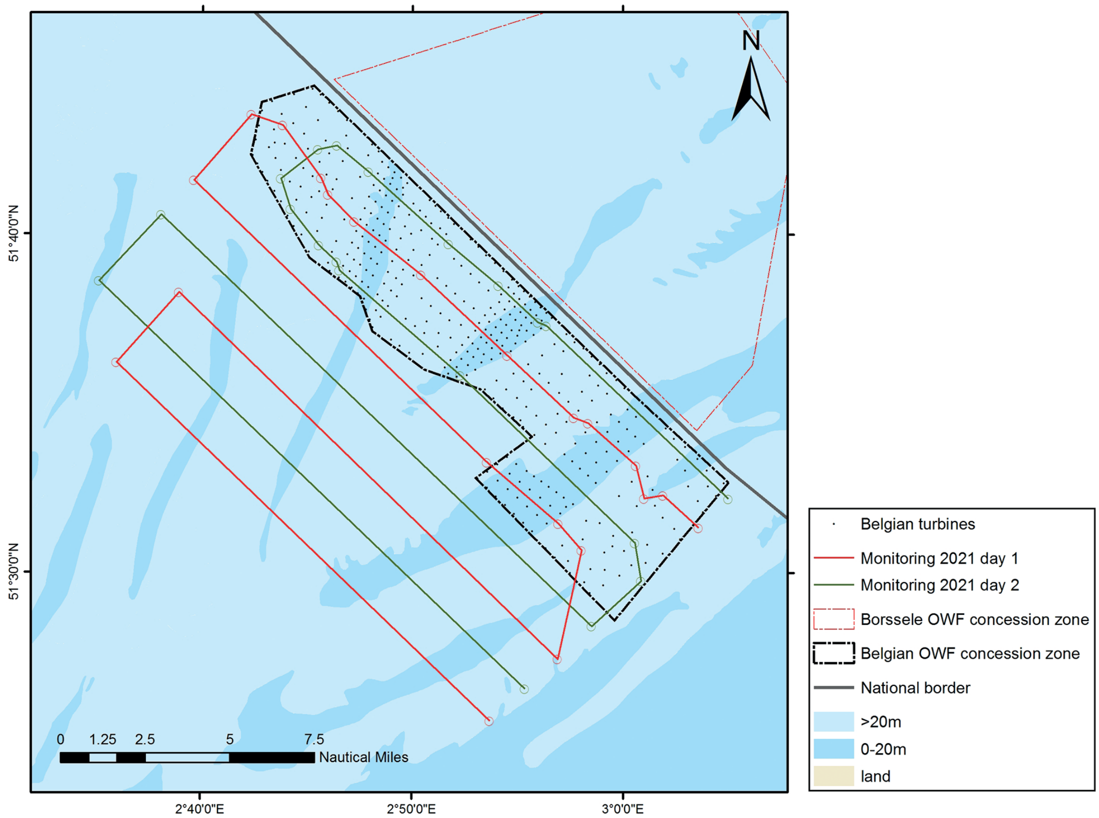

Figure 7. The new seabird displacement monitoring route, which can be covered in the course of two (preferably consecutive) days and is planned to be sailed five times per year.

3.2. Results

The newly proposed monitoring route was sailed for the first time on the 23rd and 24th of February 2021, two days with favourable conditions (wind force of at most 5 Beaufort and significant wave heights below 1 m). Below, the count results for six key seabird species will be discussed by showing distribution maps and comparing the densities encountered inside versus outside the concession zone.

3.2.1. Northern gannet

No less than 84 northern gannets (*Morus bassanus*) were observed between the turbines of the Belgian OWF concession zone (Fig. 8). Most were observed in the south-east part of the wind farm zone, coinciding with increased razorbill densities. Outside the concession zone, northern gannets were most common in the north-western part of the study area, near active fishery activity. Likely due to the latter, densities of northern gannet were eventually much higher outside compared to inside the wind farms (0.8 versus 0.3 birds / km², respectively, see Table 2).

3.2.2. Large gulls

The numbers of large gulls were generally low inside the wind farm concession zone (Figs 9 to 11), with lesser black-backed gull being the most numerous species (0.4 birds/ km²). In contrast, gull densities were particularly high in the north-western part of the study area, near active beam trawlers. Overall, lesser black-backed gull reached a density of 14.3 birds / km² outside the OWF concession zone. For herring and great black-backed gull (*Larus argentatus* and *marinus*) as well, densities were clearly higher outside compared to inside the wind farms (Table 2).

3.2.3. Auks

The south-east edge of the Thornton Bank held particularly high densities of razorbill (*Alca torda*), both in- and outside the OWF concession zone (Fig. 13). Overall, densities inside the concession zone appeared about twice as high compared to densities outside (4.59 versus 2.36 birds / km² respectively, see Table 2). Common guillemot (*Uria aalge*) occurred more homogenously spread across the study area (Fig. 12), with comparable densities inside and outside the concession zone (1.2 and 1.0 birds / km² respectively).

3.2.4. Summarising table

All species known to aggregate near fishing vessels showed clearly increased densities outside the wind farm concession zone. During our campaign, seven fishing vessels were active near our monitoring route (see Figs 8 to 11), with high numbers of associated gulls and gannets near some of them. Inside the wind farms, gulls occurred much more dispersed, while northern gannets concentrated in the south-east part of the concession zone, alongside feeding flocks of razorbill. Worth mentioning also is the relatively large number of yellow-legged gulls (*Larus michahellis*) encountered in the

Table 2. Densities (n / km²) of six key seabird species inside and outside the wind farm concession zone; bold figures indicate where the species reaches its highest density.

	Inside	Outside
Northern gannet	0.29	**0.80**
Lesser black-backed gull	0.43	**14.27**
Herring gull	0.10	**0.37**
Great black-backed gull	0.00	**0.11**
Common guillemot	**1.18**	1.03
Razorbill	**4.59**	2.36

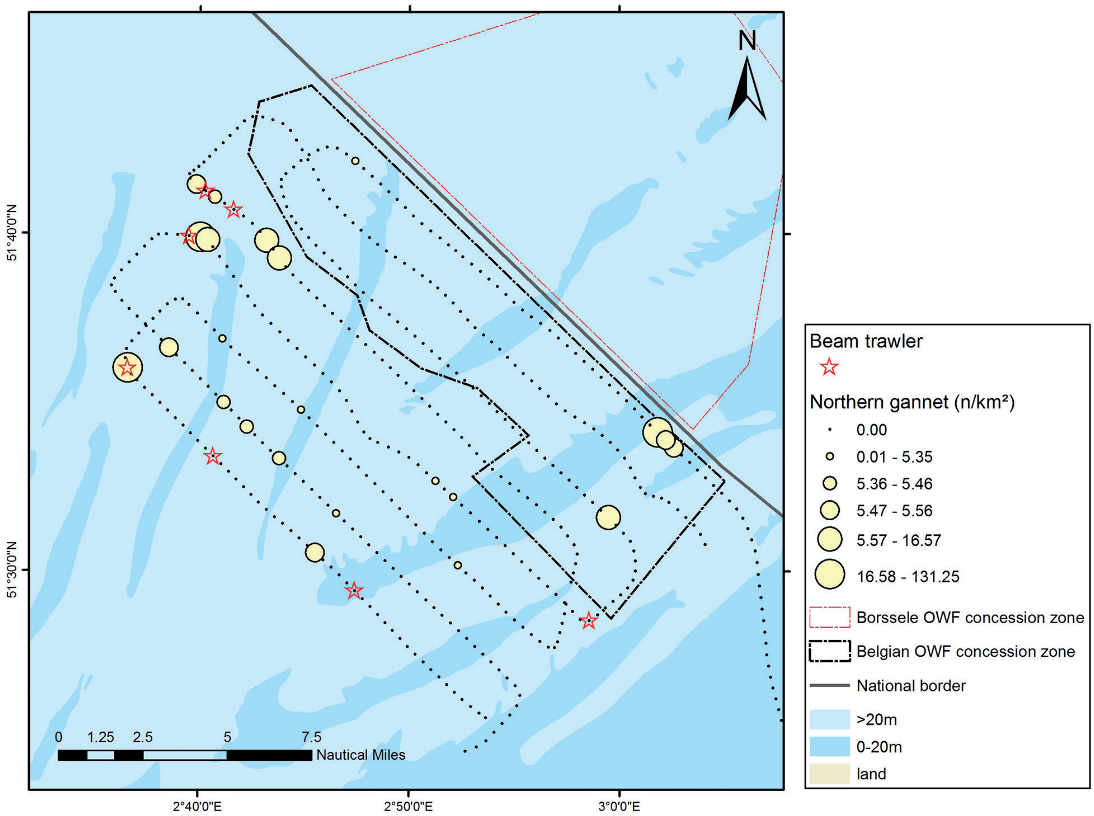

Figure 8. Northern gannet densities encountered during the two-day seabird displacement monitoring on 23 & 24/02/2021.

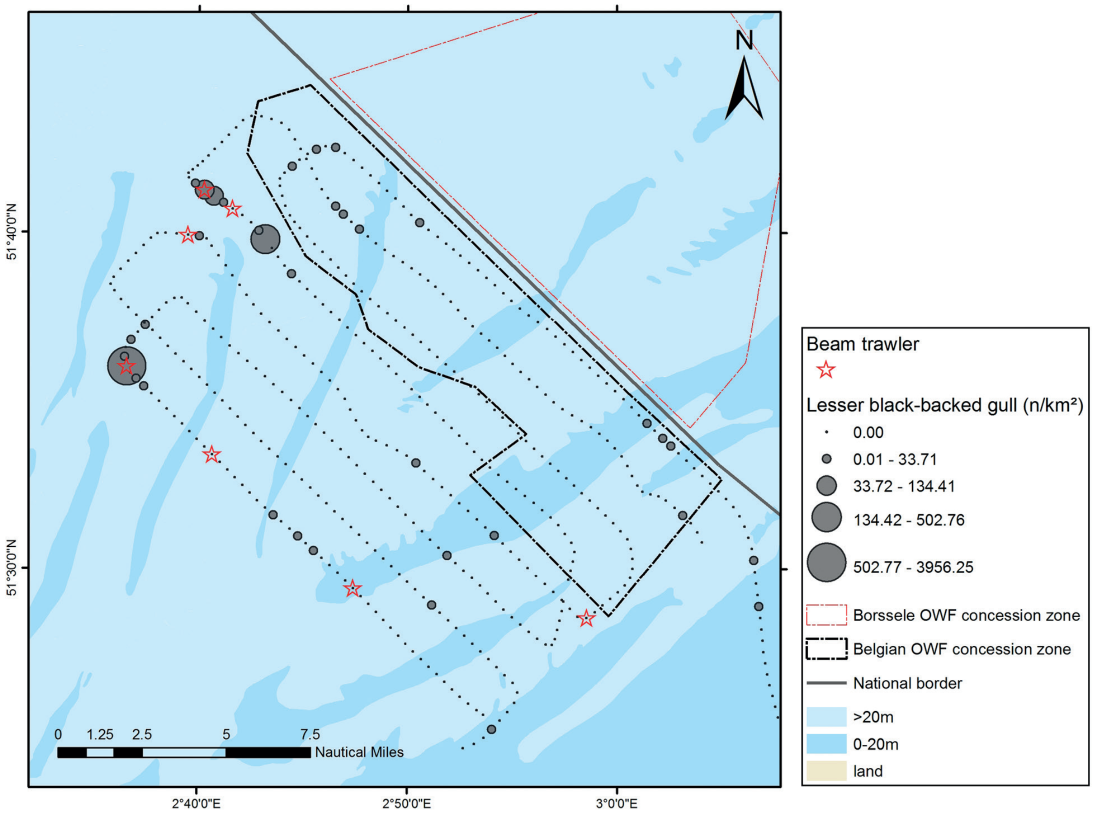

Figure 9. Lesser black-backed gull densities encountered during the two-day seabird displacement monitoring on 23 & 24/02/2021.

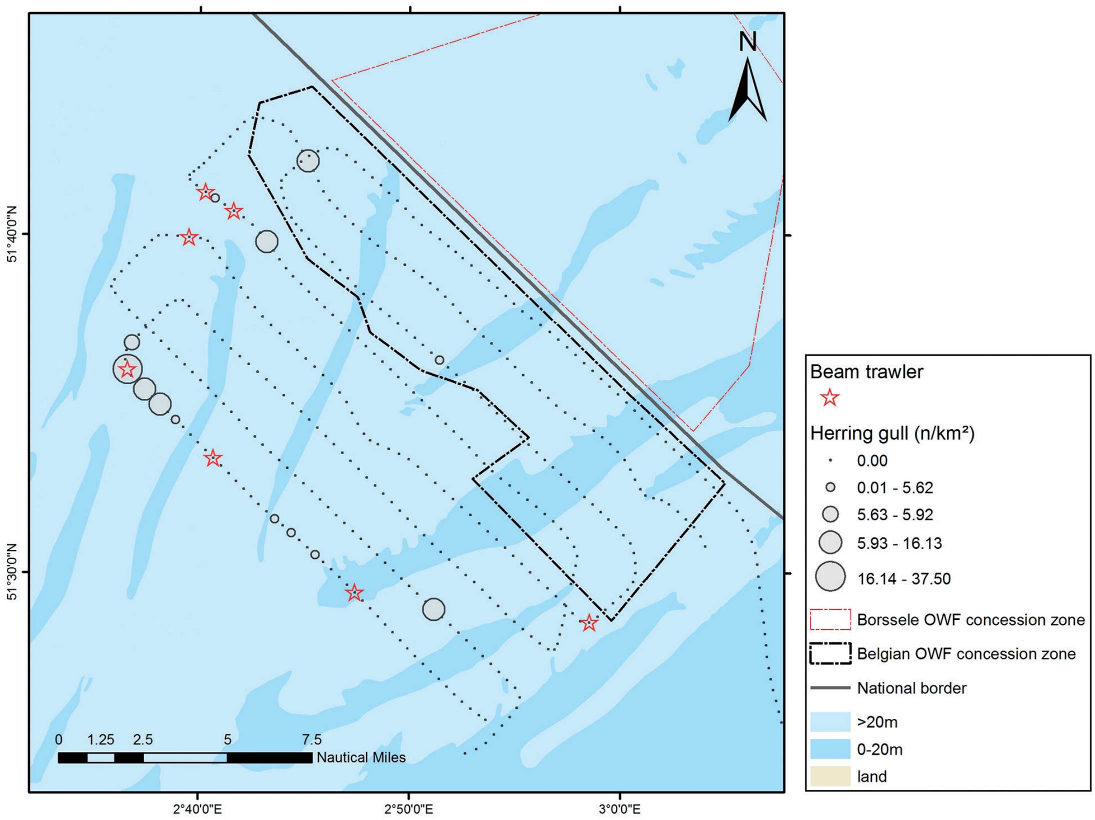

Figure 10. Herring gull densities encountered during the two-day seabird displacement monitoring on 23 & 24/02/2021.

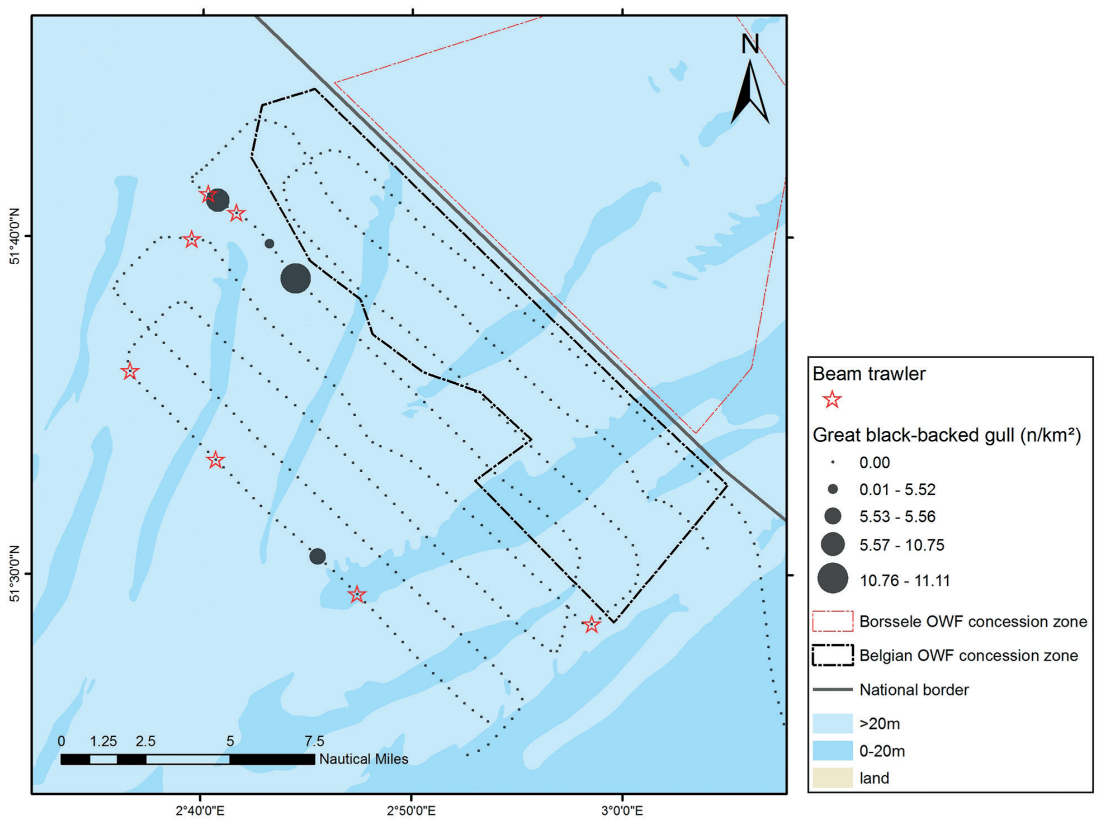

Figure 11. Great black-backed gull densities encountered during the two-day seabird displacement monitoring on 23 & 24/02/2021.

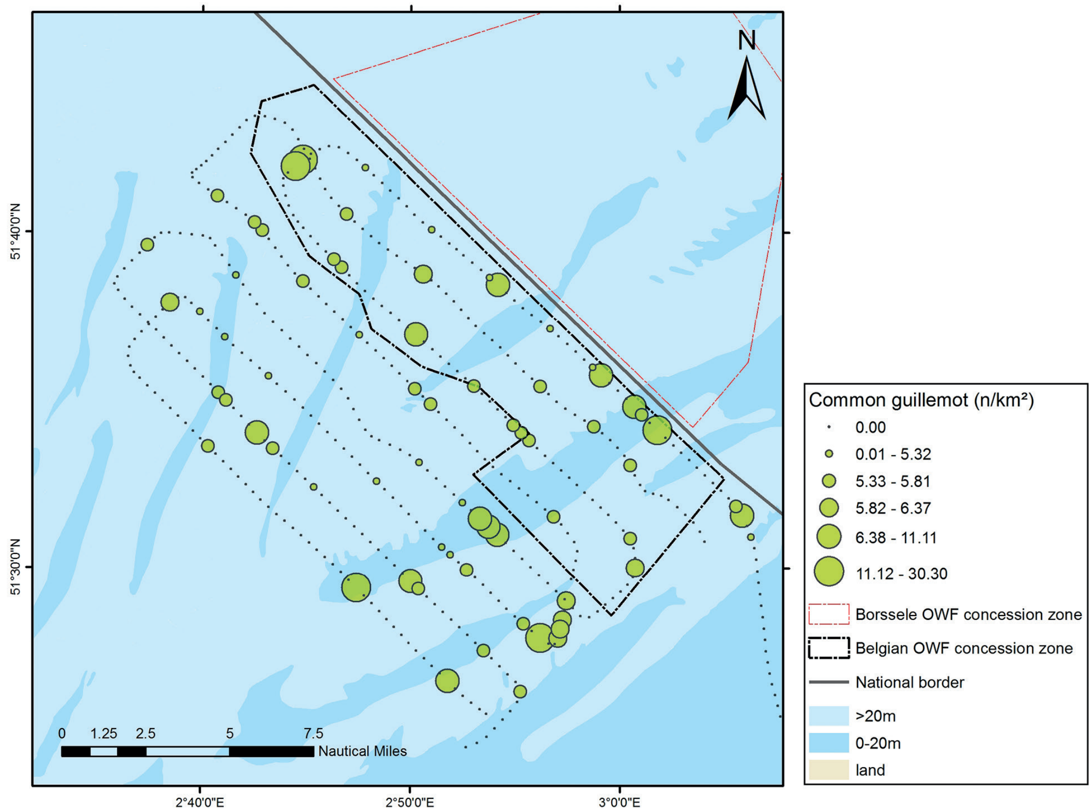

Figure 12. Common guillemot densities encountered during the two-day seabird displacement monitoring on 23 & 24/02/2021.

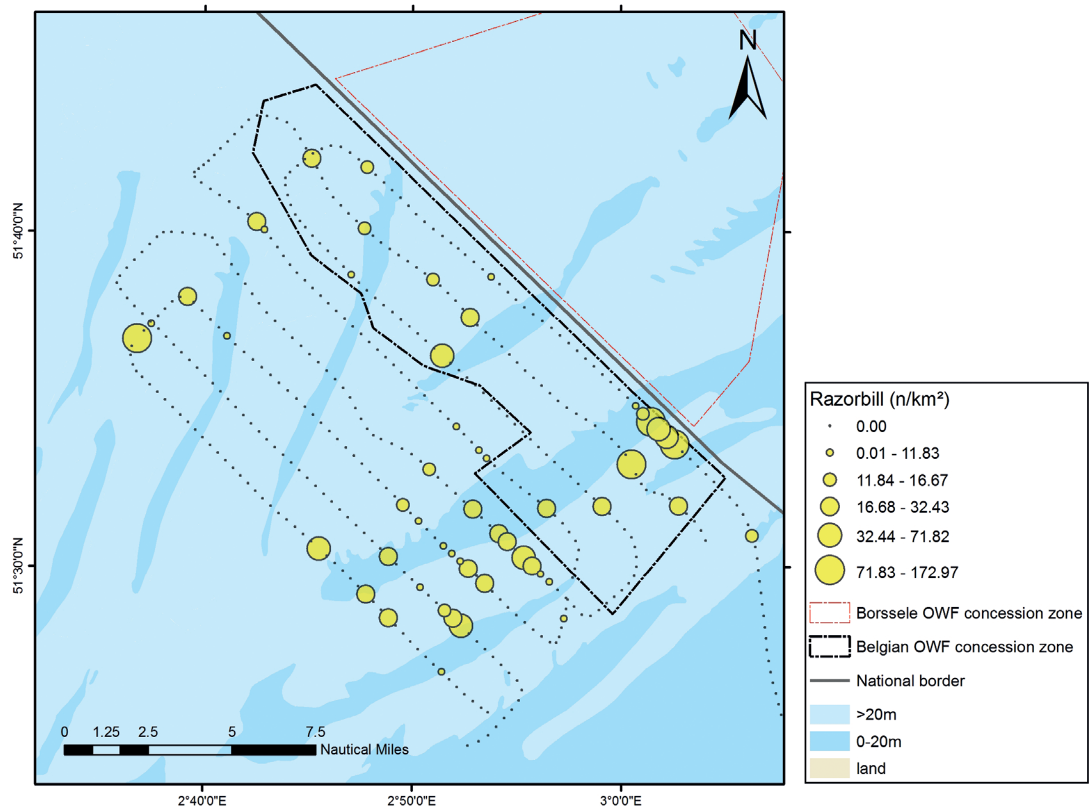

Figure 13. Razorbill densities encountered during the two-day seabird displacement monitoring on 23 & 24/02/2021.

course of the two monitoring days, totalling 31 individuals (14 inside compared to 17 outside the concession zone).

No less than 396 auks were observed between the turbines. When transforming the counted numbers to densities, the density of razorbill was almost twice as high inside compared to outside the wind farms. For common guillemot, densities inside and outside are comparable, yet slightly higher between the turbines (see Table 2).

3.3. Discussion ship-based seabird displacement monitoring

Clearly, the results from one monitoring survey are insufficient to perform statistical analyses, nor to draw any firm conclusions. On the other hand, the first findings are quite remarkable considering the relatively large numbers of auks and gannets observed in the concession zone (razorbill in particular), species generally perceived to actively avoid OWFs across European waters (reviewed in Vanermen & Stienen 2019). This could be a sign of habituation, whether or not in combination with a scale effect. One can indeed imagine how the same birds tending to avoid single wind farms might find it harder to avoid wind farm areas as extensive as the Belgian OWF concession zone. Birds that are now 'forced' into the wind farms in turn can be expected to increasingly habituate to their presence. For low-flying species such as common guillemot and razorbill, this can be regarded as good news as it might cancel out the potential impact of habitat loss, while the increased densities are not expected to lead to more collision victims. This, however, is not the case for northern gannet, a much more airborne species. About 7% of gannet flight movements are known to occur at collision risk height (Johnston *et al*. 2014), implying that habituation and increased presence between wind turbines might lead to a higher collision mortality. It will be very interesting to see whether coming surveys can confirm these first findings, and to perform spatial analyses on the resulting data. These analyses should further take in account the effect of active beam trawling on bird distribution in the area, which is now somehow blurring the raw results.

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