Local birds in and around the Offshore Wind Farm Egmond aan Zee (OWEZ)

Local Birds in and around the Offshore Wind Farm Egmond aan Zee (OWEZ) (T-0 & T-1, 2002-2010)

MF Leopold, EM Dijkman, L. Teal & the OWEZ-Team*

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IMARES Wageningen UR

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Location Texel

Client: NoordzeeWind
2e Havenstraat 5-B
1976 CE IJmuiden
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P.O. Box 68
1970 AB IJmuiden
Phone: +31 (0)317 48 09 00
Fax: +31 (0)317 48 73 26
E-Mail: imares@wur.nl
www.imares.wur.nl

P.O. Box 77
4400 AB Yerseke
Phone: +31 (0)317 48 09 00
Fax: +31 (0)317 48 73 59
E-Mail: imares@wur.nl
www.imares.wur.nl

P.O. Box 57
1780 AB Den Helder
Phone: +31 (0)317 48 09 00
Fax: +31 (0)223 63 06 87
E-Mail: imares@wur.nl
www.imares.wur.nl

P.O. Box 167
1790 AD Den Burg Texel
Phone: +31 (0)317 48 09 00
Fax: +31 (0)317 48 73 62
E-Mail: imares@wur.nl
www.imares.wur.nl

* OWEZ-Team:

Wageningen IMARES:

- Mardik Leopold (project leader; 8 T-0 & 15 T-1 surveys; cruise reports)
- Hans Verdaat (17 T-1 surveys, photography)
- Steve Geelhoed (5 T-1 surveys, photography, cruise reports)
- Rob van Bemmelen (3 T-1 surveys, cruise reports)
- Luc te Marvelde (2 T-0 surveys)
- Janne Ouwehand (1 T-0 survey)
- Peter Spannenburg (1 T-0 survey)
- Erwin Winter (1 T-1 survey)
- Geert Aarts (1 T-1 survey; statistical analyses)
- Marijke de Boer (1 T-1 survey)
- Martin de Jong (1 T-1 survey)
- Kees Kersting (temperature/salinity measurements, T-0)
- Erik Meesters (statistical analyses)
- Lorna Teal (statistical analyses)
- Elze Dijkman (database, GIS, mapping)

Nederlands Instituut voor Onderzoek der Zee

- Kees Camphuysen (8 T-0 & 15 T-1 surveys; cruise reports; photography

Bureau Waardenburg

- Ruben Fijn (9 T-1 surveys)
- Martin Poot (7 T-1 surveys and photography)
- Suzan van Lieshout (6 T-0 surveys)
- Rob Lensink (2 T-0 surveys)
- Richard Witte (2 T-0 surveys)
- Marc Collier (3 T-1 surveys)
- Camiel Heunks (2 T-1 surveys)
- Theo Boudewijn (1 T-0 survey)

Dutch Seabird Group:

- Ico Hoogendoorn (1 T-0 survey)

RIKZ:

- Mariska Harte (1 T-0 survey)

Biometris:

- Cajo ter Braak (statistical analyses T-0 data)

Ecologic :

Martin Biuw, Paul Lepper & Caroline Weir (towed hydrophone for porpoise acoustical detections, T-0)

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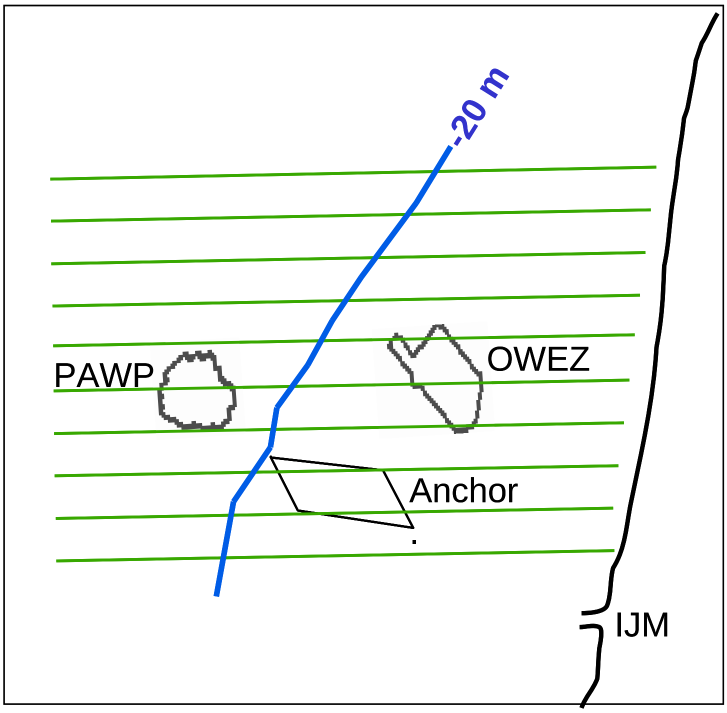
Summary

This report presents the final results of a four-year study of seabird distribution patterns in and around the first offshore wind farm in Dutch North Sea waters. This wind farm, known as OWEZ (Offshore Wind farm Egmond aan Zee) is situated 10 - 18 km off the Dutch mainland coast, northwest of the port of IJmuiden. Seabirds were repeatedly surveyed along pre-set survey lines, covering a rather large area around OWEZ. This survey design was chosen to make comparisons between the presence of birds within the wind farm and in the surrounding area, while taking into account the general distribution patterns in the general area. The latter were modelled as a function of distance to the coast and north to south clines in density patterns. Temporal differences could be explored by comparing the distribution patterns in one year before construction of the wind farm (T-0 surveys) with three years of post-construction surveys. Both the spatial and the temporal patterns were under influence of other factors than of the wind farm OWEZ alone, however. The Dutch government allowed for a second wind farm to be built in close proximity to OWEZ, in the early years of this study. This second offshore wind farm (known as Princess Amalia Windpark, PAWP) came into operation shortly after OWEZ and the area taken up by this second wind farm should be seen as a second impact area within the larger study area. A third anomaly in the study area is an intensively used anchorage area, where ships destined for IJmuiden port wait to enter. Some 20 ships were usually anchored here; numbers seemed somewhat higher (but went unrecorded) in the last year of the study. Within the general study area, seabirds thus had a choice to go into OWEZ, PAWP, Anchorage or to stay out of these areas, in the remaining, open sea. This reference area surrounding the impact areas was not free from human impacts either, however. Shipping is intensive in Dutch nearshore waters. In the study area shipping comprised traffic approaching or leaving IJmuiden port, ships in transit and fishing. The latter in particular has an influence of the distribution patterns of some seabirds: those scavenging for fishery waste, like gulls. As fishing is not allowed inside the wind farms, the largest concentrations of gulls and allies during the T-1 surveys were likely found in the reference area, where fishing continued. Another large source of variation was changing habitat from closely inshore to further offshore. On top of these rather predictable sources of variation, there was considerable between-years variation for most seabirds and survey months. Such variation usually impacted the whole study area (and probably much larger parts of the North Sea), making year-to-year comparisons, or T-0/T-1 comparisons, more difficult. These sources of variation hindered to some extent the primary aim of this study, which was to determine whether seabirds would be avoiding the wind farm, or be attracted to it, or be indifferent.



The schematic map to the left shows the locations of OWEZ (with 36 turbines), PAWP (60 turbines) and the Anchorage area (mostly between 10 and 30 moored ships), relative to the mainland coastline on the right and the entrance to the port of IJmuiden (bottom right). The three impact areas are grouped around the 20 m isobath (in blue). The horizontal green lines are the pre-set transect lines that were surveyed during each of the T-0 and T-1 (Before and After, respectively) surveys. The total area covered per survey measured roughly 725 km^2 (ca 22 x 33 km), with the wind farms centrally situated.

Initially, a BACI (Before-After Control Impact) approach was used to address this question, at the level of individual seabird species. First, a series of Before surveys was carried out, covering one whole year (these surveys ran from 2002-2004). Next, three sets of After surveys were carried out (2007-2010). This set-up allowed for comparisons between the Before (construction) and After (the wind farm had become operational) situations, but also between "wind farm" (as well as the other anomalies) and "not-wind farm" within any given survey. The considerable year-to year variation in seabird presence made comparisons between the single set of T-0 surveys and the three sets of subsequent T-1 surveys difficult. Within-survey comparisons were therefore more informative. Within survey comparisons do not rely on T-0/T-1 comparisons, which might be impacted by other factors than the presence of the wind farm, Spatial variation, i.e. general changes in seabird density related to distance to coast and/or northing, were taken into account in these comparisons.

When sufficient data were collected for a given seabird species and month, Generalised Additive Mixed Models (GAMM) or Generalised Additive Models (GAM) were used to explore the relative contributions of location, expressed as distance to shore and latitude and the presence of one of three anomalies or impact areas within the study area: the OWEZ wind farm, the adjacent Princess Amalia Wind Farm, or the Anchorage off IJmuiden, to the distribution patterns found. Presence/absence data, rather than densities of seabirds were used because these data were less affected by both large numbers of zero-counts within the data set and a few counts with very large numbers, or between-observer differences. Between-observer differences were minimised, by using the same principal observers over long time spans and by always using observers in teams of two.

Within-survey comparisons have four possible outcomes: Attraction, Avoidance, Indifference or Non-significance, and Insufficient data. **Attraction** means that the probability of finding birds within the perimeter of the wind farm is significantly higher than expected on the basis of the general distribution pattern in the larger study area. Conversely, **Avoidance** means that the probability of finding birds within the perimeter of the wind farm is significantly reduced. **Indifference** means that the probability of finding birds is not impacted by the presence of the wind farm. However, indifference is hard to separate from lack of statistical significance, the so-called Type II error. A Type II error is made when the data show no significant difference between expected and found presence, while in fact the presence was elevated or reduced. Lack of statistical power is a general problem while examining distribution patterns, especially when densities are low, or distributions very clumped. Low densities imply high probabilities of local zero-densities which are not necessary related to wind farm presence. Clumped distribution imply high probabilities of local peaks and lows, again not necessary impacted by the presence of a wind farm. Note in this respect that the offshore wind farm studied represents only a very small area as compared to the distribution ranges of offshore seabirds, which usually show considerable variation in local densities. Finally, in some situations birds are largely not present at all, or only present in very low densities (e.g. in the season when they are breeding in other parts of the world), or are present in only one part of the study area (e.g. closely inshore). In such situations survey results do not render themselves for analysis (**Insufficient data**).

Different results were found for different seabird species. Little impact of the wind farm on most of the so-called nearshore species was found, as these birds rarely ventured out so far to sea, that they would reach OWEZ latitudes. This result is different from Indifference, as the birds concerned simply did not venture out to sea far enough to meet up with the wind farm; this resulted in "Insufficient data" when comparisons between the wind farm and surrounding areas had to be made. This group comprises the Red- and Black-throated Divers, Great Crested Grebe, Common Scoter, Black-headed Gull and "Commic" Terns (Common and Arctic Terns taken together as these could not always be specifically identified). Densities of all these birds at wind farm latitudes were mostly so low, that few individuals were available to fly or swim into the wind farm.

A similar, but mirrored pattern was found in species that mostly occur further offshore, to the west of OWEZ. Densities of Northern Fulmars were always low around OWEZ, most of these birds occurred further west. None were ever seen to enter the wind farm, but ecological consequences of the loss of a small surface area of sea at the fringe of its huge range, must be negligible. Two other birds that tended to occur mostly offshore showed different reactions to the wind farm. Northern Gannets tended to fly around the wind farm, while Black-legged Kittiwakes seemed mostly indifferent to the wind farm.

Large gulls, the most numerous seabirds in the general area, were mostly found associated with fishing vessels. As fishing is no longer allowed in the wind farms, gull numbers were never very high here during the T-1 surveys. Gull distributions were always very patchy around it, as most gulls go where the fishers go. Most gulls seemed rather unconcerned about the presence of offshore turbines, flying through the wind farm without visible behavioural adjustment and resting on the foundation poles of the turbines in small numbers. The main effect of the wind farms on gull distribution patterns is that trawlers are kept at bay and that the largest concentrations of gulls now occur outside the wind farms, around the trawlers that keep working the general area.

Sandwich Terns and Little Gulls occurred throughout the study area while migrating across the study area, and were expected to be able to profit from the presence of the wind farm, by exploiting it for feeding, resting or courtship. These birds reportedly fed in the tidal wakes behind the monopoles of the Danish Horns Rev wind farm (Elsam Engineering & Energi 2005; Elsam Engineering 2005; Petersen & Fox 2007) and are known to extensively use navigational buoys for resting and courtship display in Dutch waters (Tulp & Schekkerman 1997) and were thus expected to also use OWEZ in these respects. However, although both Sandwich Terns (very rarely) and Little Gulls (rarely) were seen inside the wind farm on occasions, most of these birds seemed to prefer flying around the wind farm rather than entering it.

One species, the Great Cormorant, was clearly attracted to the wind farm. Birds from two mainland (coastal) colonies, Zwanenwater (Petten, at 30.3 km from the metmast) and Hoefijzermeer (Castricum, at 18.7 km) were quick to discover that the wind farm provided good offshore feeding and resting conditions. Resting (out of the water) is critically important for cormorants, that need to dry their feathers after feeding bouts under water. Birds commuted between the mainland and OWEZ (and later further on, to PAWP as well) in rather large numbers, while OWEZ and certainly PAWP latitudes were off limits to these birds when no seating was provided.

Auks, in these parts Guillemots and Razorbills, offered the best possibilities to study avoidance from wind farms. Earlier studies, in and around the Horns Rev wind farm, had indicated strong avoidance in auks (Elsam Engineering & Energi 2005; Elsam Engineering 2005; Petersen & Fox 2007). Results for OWEZ were less clear-cut. Both species showed Indifference/Insufficient data in many situations, and Avoidance in some. However, when avoidance was found, this was not total, and Guillemots and Razorbills were both seen inside the wind farm, and also inside the neighbouring wind farm PAWP, with a much higher turbine density. Turbine density probably did have an effect on avoidance though, avoidance being apparently stronger in PAWP (but not 100% either). Measuring the effect of relatively small wind farms on birds that occur in rather low general densities, requires more effort inside the wind farms than was realised in most of our T-1 surveys, due to a rather broad line spacing. Therefore, after an evaluation of the results obtained until 2008 (as outlined in report OWEZ_R_221_T1_20100329_local_birds) more transect lines were introduced in the last set of surveys, and an extra winter survey was carried out in the last year, when auks were present. This approach yielded better results than earlier surveys, but with only one winter's worth of such data, we still have few statistically significant cases of avoidance. Future work on these species, focussing on the wind farms themselves, is likely to shed more light on the exact amount of disturbance, as a function of both bird density and turbine density.

The data for all species may be summarised as follows (Table 0), given the four possible outcomes of inside/outside wind farm comparisons (with inside wind farm meaning: within the OWEZ perimeter and outside wind farm meaning: outside either OWEZ, PAWP or Anchorage). A total of 17 T-1 surveys were conducted and analysed (see Table 2). Statistical analysis was only possible in situations (bird/month combinations) with sufficient number of birds found within the whole study area and also at longitudes of the wind farm. In other cases, a statistical test of the survey results was not possible: the data were **Not applicable**. When sufficient birds were available for analysis the outcome of the statistical test was either: **Attraction, Avoidance** or **Non-significance**. In Table 0 the numbers of times either result was achieved are summed for all species considered. From this overview it is clear that an effect of the wind farm, in terms of statistically significant **Avoidance Attraction** could not be demonstrated for most situations, either because the results were **Not significant**, or because the data were **Not applicable**. Note, however, that the **Not significant** category may contain **Type II errors** due to insufficient statistical power. **Attraction** was clear in one species, the Great Cormorant. **Attraction** was also found in some months for several gull species, but gulls also showed **Avoidance** or **Indifference** (Non significance) in other situations. Significant **Avoidance** was found in divers, grebes, gannets, Little Gulls and both auks (Guillemot and Razorbill), but for all of these in only in a minority of surveys with sufficient numbers of birds present.

Species	Attraction	Avoidance	NS	Not applicable
Divers	0	3	5	9
Great Crested Grebe	0	1	3	13
Northern Fulmar	0	0	1	16
Northern Gannet	0	2	8	7
Great Cormorant	10	0	4	3
Common Scoter	0	0	1	16
Little Gull	0	1	6	10
Black-headed Gull	0	0	1	16
Common Gull	1	0	11	5
Lesser Black-backed Gull	0	1	11	5
Herring Gull	1	3	10	3
Greater Black-backed Gull	4	2	11	0
Black-legged Kittiwake	1	0	4	12
Sandwich Tern	0	0	2	15
Common & Arctic Tern	0	0	3	14
Common Guillemot	0	2	9	6
Razorbill	0	1	5	11

Table 0. *Summary of results. For a total of 17 T-1 surveys (see Table 2) the summed numbers of surveys are given per species in which either Attraction or Avoidance (statistically significant) was found, or a Non-significant result, or when insufficient numbers of birds were present (off-season surveys for that particular species).*

Average seabird densities (not corrected for birds missed by the observers) during each survey are presented in Appendix 1, separately for the strata OWEZ, PAWP, Anchorage, and the remaining Reference area. Total numbers of all birds and marine mammals observed per survey are given in Appendix 2.

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The Offshore Wind Farm Egmond aan Zee has a subsidy of the Ministry of Economic Affairs under the CO_2 reduction scheme of The Netherlands.
We want to thank all captains and crews of our survey vessels, BCE vessel control and Martin Dekker for excellent co-operation and working conditions.

Assignment

This study has been commissioned by Noordzeewind. Noordzeewind owns and operates the first offshore wind farm in Dutch North Sea waters. This 'T-1' study is a follow up of the 'T-0' study, commissioned by the Dutch government and aims at determining reactions of local (sea)birds to the wind farm, during its operational phase.

Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 57846-2009-AQ-NLD-RvA). This certificate is valid until 15 December 2012. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

Introduction

The Dutch consortium "NoordzeeWind" (a joint venture of Nuon and Shell) operates the first offshore wind farm in Dutch North Sea waters. The wind farm, consisting of 36 turbines on monopiles, is located NW of IJmuiden harbour, 10 - 18 km off the Dutch mainland coast. Named after the nearest town ashore, the wind farm is known as "Offshore Wind farm Egmond aan Zee" (OWEZ; Figure 1). A second offshore wind farm has also become operational, at a short distance to the west of OWEZ. This wind farm, Princes Amalia Wind Farm (PAWP) has a smaller total surface area, but nearly twice the number of turbines (60), also on monopiles. The OWEZ turbines are taller and more powerful than the PAWF turbines, but are spaced more widely at sea, giving the impression of a more “open” site.

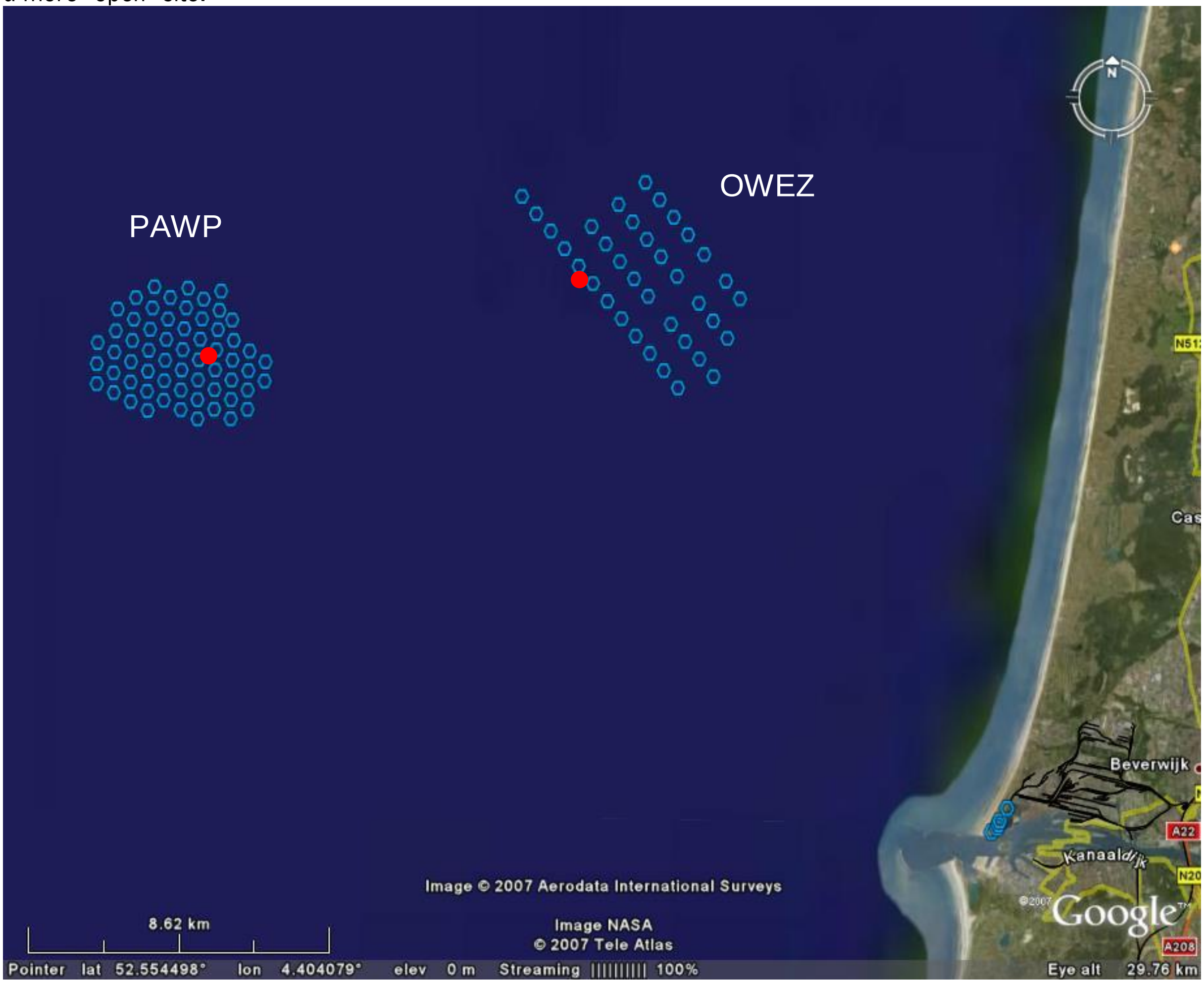


Figure 1. *Location of the 36 OWEZ turbines (right) and the 60 PAWP 60 turbines left, to the northwest of the port of IJmuiden (lower right). In addition to the turbines, OWEZ has a 116 m high met-(meteo)mast situated centrally on the seaward (SW) side of the wind farm, and PAWF has a transformer platform within the wind farm. Image from: http://home.planet.nl/~windsh/Offshorelocaties.jpg. The red dots (added to the original picture) represent the OWEZ metmast and PAWP transformer platform.*

This report has been commissioned by Noordzeewind, and deals specifically with the possible impact on local seabirds of OWEZ. However, the presence of PAWF at a short distance from OWEZ cannot be ignored and the combined impact of both wind farms on the local seabirds is therefore also explored.

Figure 2. *OWEZ wind turbines and the 116 m high OWEZ metmast off the Dutch mainland coast. The turbines are situated 10 to 18 km offshore. On clear days, the wind farm is well visible from land, and vice versa. The skyline on land is dominated by Corus steelworks, just north of IJmuiden. The ship at the lower right is the 44 m long coastguard (Rijkswaterstaat) vessel Terschelling. Photos: Hans Verdaat, IMARES.*

Figure 3. *Transformer platform and three of the 60 turbines of PAWP. The PAWP turbines are smaller, but placed closer together than the OWEZ turbines. Note that both the PAWP transformer platform and the OWEZ metmast offer a platform for roosting seabirds, such as cormorants and gulls. Photo: Hans Verdaat, IMARES.*

The OWEZ site has 36 turbines (with hub height at 70 m amsl), each equipped with three rotor blades, reaching up to 115 m amsl. The turbine type used is Vestas V90 - 3MW. The turbines are put on top of a foundation built up of monopole foundation piles and (yellow painted) transition pieces. These monopiles (250 tonnes, 45 meter long) have been driven into the seabed between April and July 2006. Putting the turbines on top started shortly after the first piles and transition pieces were in place and then happened intermittedly with pile driving. The first turbine was installed in May 2006 and by the end of August all 36 turbines were in place. The wind farm produced the first electricity in September 2006 and was commissioned on 1 January 2007. OWEZ is built in slightly shallower waters (18-20 m) than PAWP (19-24 m) and closer to shore (ca 10 - 18 versus ca 23 km).

Construction of PAWP started shortly after OWEZ became operational, in October 2006. Building PAWP took longer than did building OWEZ (Figures 6, 9). PAWP was fully operational by June 2008. The turbines used in this wind farm are smaller than in OWEZ: Vestas V80 - 2 MW, at 59 m amsl, with a rotor diameter of 80 m.

OWEZ is a much more "open" wind farm than is PAWP (Figure 4). The 36 OWEZ turbines are situated in an area of 27 km^2, while the 60 PAWP turbines are placed within 14 km^2. Distances between turbines are circa 550 m in PAWP, in all directions (Figure 3 and http://www.prinsesamaliawindwind farm.eu/nl/index.asp). OWEZ has a very different design (Figure 1). It has been built to take maximum advantage of prevailing SW winds. The turbines have been put into 4 rows, that are 1000 m apart, while inter-turbine distance in each row is 640 m.

Figure 4. *Seabirds survey in OWEZ, April 2007. Three rows of turbines are (partly) visible. Note the amount of open space between rows of turbines. Photo: Hans Verdaat, IMARES.*

Both wind farms have electricity cables trenched into the sea floor, connecting the turbines to each other and the wind farm to the mainland (each wind farm operates through its own cables). Operations also involve frequent servicing, using small, fast personnel ships (Figure 5) and large maintenance and repair ships, barges and cranes; aerial supervision by the Dutch coastguard (by low-flying planes and helicopters) and scientific research visits (by various ships). Both the moving turbine blades and the aircraft and ships connected to the wind farm may impact local seabirds. These impacts may range from attraction to deterrence from the site and, in a worst case scenario (collisions), to the death of some individuals. Attraction is often easily recognized, when seabirds roost on wind farm installations (Figure 7). Avoidance is less easily seen. To demonstrate avoidance, specific seabird densities in the operation wind farms have to be compared to pre-construction densities and to densities at comparable sites outside the wind farm. Deciding what such "comparable sites" might be is not a simple task, as bird densities at sea are not uniform and do not always show clear spatial patterns. Avoidance and attraction by the wind farm are the main topics of this report; flight patterns and behaviour around individual turbines are considered elsewhere (Krijgsveld et al. 2009 and the final report (2010) in prep).

Figure 5a. *Maintenance in OWEZ: a daily feature on good-weather days. Photo: Hans Verdaat, IMARES.*

Figure 5b. *Major maintenance in OWEZ during the T-1 phase of the project (10 April 2008). Photo: Kees Camphuysen, NIOZ.*

Figure 6. *Construction activities in PAWP: preparations for hoisting a turbine. Building PAWP took place while OWEZ was already fully operational and while T-1 seabirds surveys (see main text) for OWEZ were conducted. Photos: Hans Verdaat, IMARES (top) Kees Camphuysen, NIOZ (bottom).*

Figure 7. *Attraction. Great Cormorants roosting on OWEZ metmast (top) and Cormorants and Lesser Black-backed Gulls roosting on the PAWP transformer platform (bottom). Photos: Hans Verdaat, IMARES.*

This report describes the distribution patterns of seabirds in an area of approximately 725 km^2 (ca 22 x 33 km), around the OWEZ and PAWP wind farms (Figure 8). A total of 25 surveys of this area is available for analysis, comprising 8 so-called T-0 surveys (see Leopold et al. 2004 for a full analysis) and 17 T-1 surveys. The T-1 surveys were carried out in three clusters of six surveys each: T-1a from April 2007 to January 2008; T-1b from April 2008 to January 2009 and T-1c from June 2009 to April 2010. The T-1 surveys were timed to match T-0 surveys, but with only six (per cluster) T-1 surveys against eight T-0 surveys full matching was not possible. One of the T-0 surveys, conducted in May 2003 (see: Table 1 in Methods section) was not repeated in the T-1 phase, and is not further treated here. Bad weather in September 2008 and again in September 2009 frustrated two autumn T-1 surveys. The September 2008 had to be cancelled altogether, while the September 2009 survey was postponed to October. As T-0 surveys were made both in September and October, both were kept for analysis.

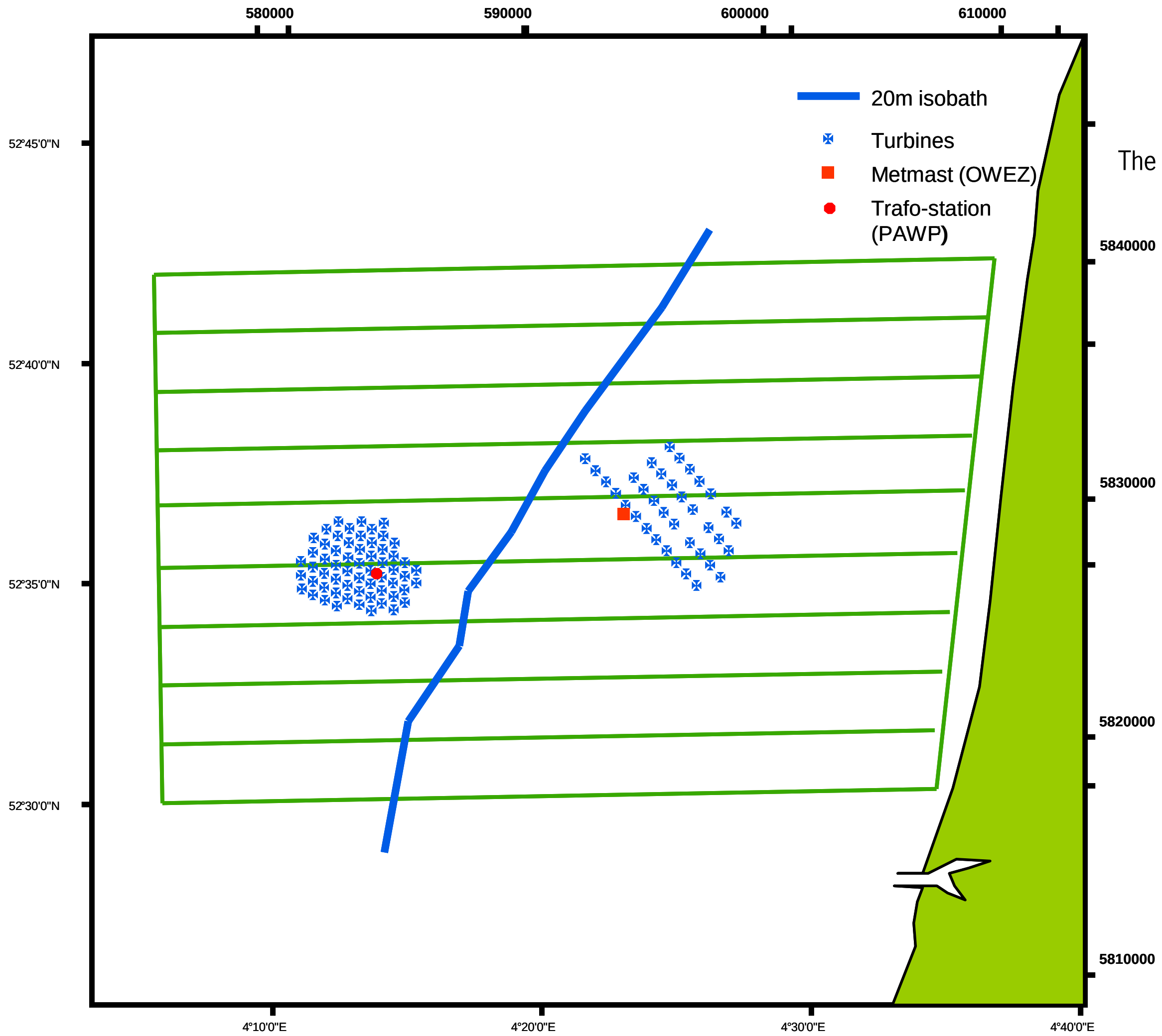


Figure 8. *Location of OWEZ with 36 turbines and of PAWP with 60 turbines, to the northwest of the port of IJmuiden. The two wind farms are situated on either side of the -20 m isobath (blue thick line). In addition to the turbines, OWEZ has a 116 m high met-(meteo)mast situated on the seaward side of the wind farm, and PAWF has a transformer platform within the wind farm (both indicated by red symbols). The green lines running E-W are the principal survey lines (see methods section).*

The T-0 surveys were carried out before either wind farm was in place, while the T-1 surveys were conducted after OWEZ became operational. Note however, that PAWP was still being built during the T-1a surveys and the first (April) T-1b survey: for this wind farm these surveys should probably be regarded as 'T-construction' surveys (Figure 9). As this report deals primarily with OWEZ, this complication is further ignored here. In any case, PAWP became progressively more visible at the surface as building progressed, and the fleet of working ships involved also impacted the site. Still, avoidance/attraction at the building site of PAWP might have differed between T-1a and T-1b/c surveys.

Figure 9. *PAWP under construction: April 2007 (top) and April 2008 (bottom). OWEZ was fully operational by then; these pictures were taken during T-1a surveys. Photos: Hans Verdaat, IMARES and Kees Camphuysen, NIOZ.*

Distribution patterns of seabirds in the general area may thus be compared in situations before (T-0) and after (T-1) the construction of OWEZ in the study area (between-surveys comparisons). Secondly, seabird densities may be compared between the wind farm and the surrounding sea area (within-survey comparisons). Adjustments of distribution patterns may occur over time, as local birds may get used to the presence of a wind farm (Petersen & Fox 2007). For this reason, distribution patterns are presented and analysed separately for each individual survey. Comparisons are made between the appropriate T-0 survey (month) and three subsequent T-1 surveys.

OWEZ is situated well away from recognised seabird hotspots and other sites of special ecological interest (Skov et al. 2007; Lindeboom et al. 2005; Arends et al. 2008). Still, the general area may hold important numbers of seabirds at certain times of year (Skov et al. 1995). The site is within reach of some birds breeding on the Dutch shores (including species breeding in protected nature reserves); is situated within the coastal migration route of other (protected) seabirds and may provide an important habitat to birds migrating offshore and wintering offshore ('offshore' meaning here: outside the most turbid, nearshore waters, generally outside the -20m isobath). The Dutch government, NoordzeeWind and other parties developing plans for more offshore wind farms in Dutch waters were thus keen to learn more about possible effects of this first wind farm on the local seabirds and this study addresses this problem during the post-construction, or operational phase of OWEZ.

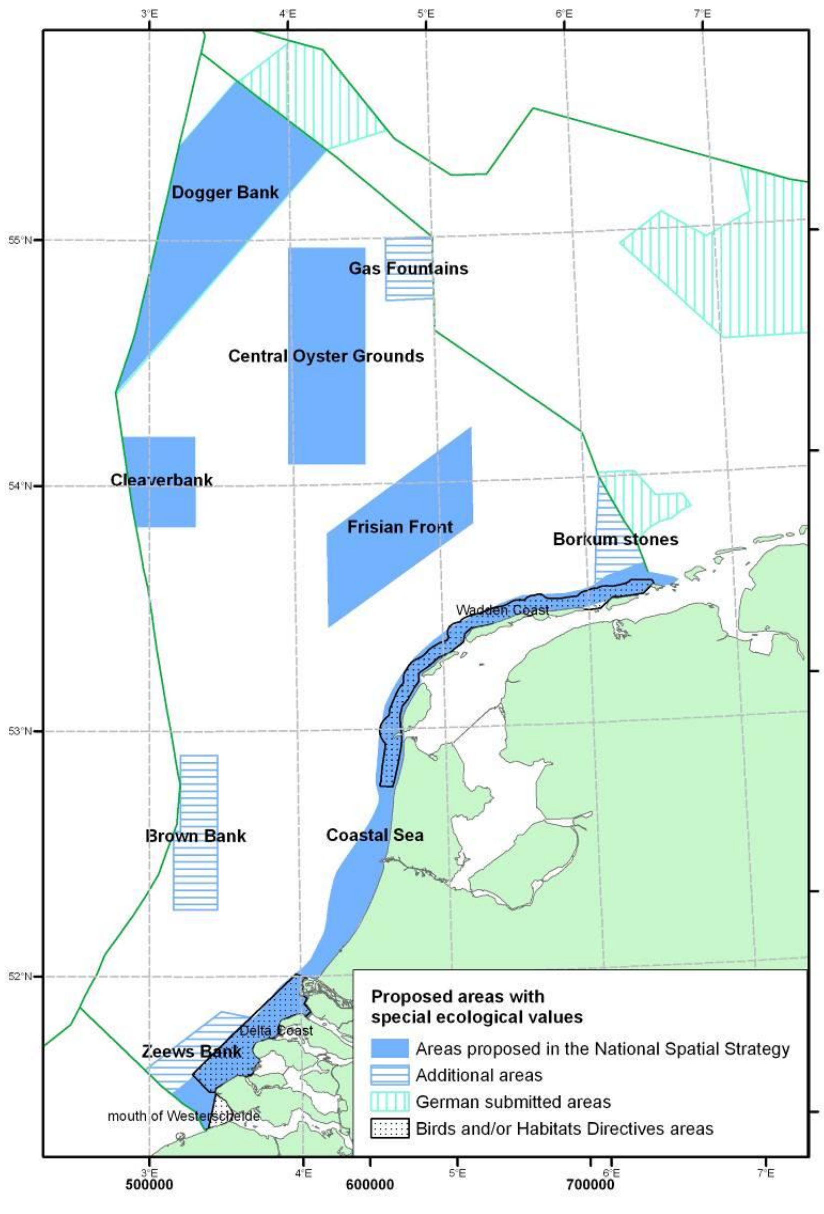


Figure 10. *Areas within the Dutch sector of the North Sea that have special ecological values (Lindeboom et al. 2005). The areas 'Wadden Coast' and 'Delta Coast' are protected under the Birds/Habitats Directives, as Natura 2000 sites. The areas Dogger Bank, Cleaver Bank and Frisian Front will soon follow. Other areas are still under consideration. The 'Coastal Sea', that is, the part between 'Wadden Coast' and 'Delta Coast' will not be proposed as a Natura 2000 site by the Dutch government. OWEZ is situated near the 'Coastal Sea' mark.*

Even though OWEZ and PAWP are not situated within marine Natura 2000 sites, any part of the sea holds certain ecological values and wind farms may be at odds with these because they are unnatural structures at sea. For flying or swimming birds, the open sea is –in a way- a more two-dimensional environment than many terrestrial landscapes: lacking tall vertical structures such as mountains, forests (trees) or tall buildings. Only the sea's surface itself may become quite three-dimensional at times, during stormy weather. However, obstacles on top of the sea's surface are rare: passing ships, islands and (cliff)-coasts. Seabirds may thus be ill-adapted to deal with obstacles in their environment. This is a situation that is quite different from terrestrial habitats, such as forests or urban environments. Wind turbines are alien objects in the marine environment, and are large structures that are also moving. Therefore, turbines may scare off seabirds from a wind farm area and thus reduce or degrade seabird habitat locally.

The first wind farm impact studies have suggested that some birds in particular may avoid the impacted site. At Horns Rev (Jutland, Denmark), (Elsam Engineering & Energi, 2005; Elsam Engineering, 2005), some bird species such as divers, gannets, seaducks and auks appeared to stay away from the wind farm, possibly even for several km outside the perimeter of the wind farm. Other species (gulls and terns) ignored the turbines or even were more abundant around them, possibly seeking easy pickings around maintenance vessels or in turbulent waters at the lee side of the monopiles. The first Belgian study yields ambiguous results. Large year to year variation dominated local seabird densities. This, and the small size of the wind farm (six turbines in a single row), prevented any firm conclusions on possible impacts (Vanermen & Stienen 2009).

There may also be habituation after some time as local birds learn that turbines are not a real danger. Seaducks were first found to avoid the Horns Rev wind farm, but later assembled between the turbines, possibly after successful recruitment of benthic prey (Petersen & Fox 2007). An important finding of the Horns Rev studies, however, was that some birds clearly avoided the site (divers, gannet and auks) and this is generally seen as a problem for future developments of more offshore wind farms (Dierschke & Garthe 2006). The first Dutch wind farm (OWEZ) is situated in waters that are somewhat similar to the Danish site, in that both divers and auks may winter here in good numbers, while gannets pass by in large numbers in autumn (Camphuysen & Leopold 1994; Leopold *et al.* 2004). Divers are protected under the EU's Bird Directive (Annex I) while gannets and auks are also protected, as migrating birds. Therefore, it is important to study effects of wind farms in Dutch waters and to map effects on local seabirds. Effect of a study in Danish waters cannot simply be extrapolated to other sites, as circumstances may be different. For instance, the Dutch sector of the North Sea has more shipping traffic than Horns Rev and birds may be more habituated to disturbance. Alternatively, birds that are disturbed more frequently, may be more inclined to leave the area altogether after another source of disturbance is added, and effects may thus be more severe. A site-specific study is therefore required.

This study deals with the local seabirds, that is the birds that might reside for some time within the study area. It is not always clear which seabirds are true residents and which ones are merely passing through, so all seabirds seen in the study area are considered. Impacts on truly migrating birds (both seabirds and land birds) are considered in a separate study (Krijgsveld et al. 2009 and in prep.). Migrants generally avoid flying through offshore wind farms, thus avoiding collisions (Kahlert et al. 2004ab; Arends et al. 2008; Krijgsveld et al. 2009). Local seabirds, particularly while in flight, may do the same, but may also respond differently. They may use vantage points within the wind farm for resting or (while swimming) may drift into the wind farm and e.g. continue feeding within its perimeter. They may also use changed hydrography (turbid patches of water to the lee side of the turbines) or seabed morphology (boulders supplied around the base of the turbines) for feeding. No seabird remains in the study area for its entire life span, and all "local" birds may thus also be regarded as passers by. The distinction between local birds and migrants is therefore not clear-cut and in the field, this distinction cannot be made with certainty. This report treats all seabirds seen in the area as local birds.

The wind farms themselves are seen as single entities. Disturbance levels probably vary through time, but to what extent is not clear, and cannot unambiguously be measured from a passing survey ship. Sources of variation in this respect are due to weather: light and visibility conditions; wind force, to maintenance activities in the wind farm (additional ships of different sizes, different shipping activities, people visiting turbines or the metmast) or to performance of the wind farm (often one or more turbines did not work during passages through a wind farm). Effects of these on seabird presence or behaviour, if any, can only be studied by prolonged presence in the wind farm itself and fall outside the scope of this study. On the other hand, all variations in disturbance are directly related to the normal operation of any offshore wind farm. Hence, this kind of variation is ignored here, and included in the factor "wind farm".

Study Area

The study area comprises waters that run from closely nearshore (just beyond the surf zone) to nearly 20 nm offshore, reaching nearly 25 m water depths. It is situated off the sandy Dutch mainland coast, bottom sediments across the entire study area are also sandy, with grain sizes slightly increasing from fine to slightly coarser sands as depths increase. The depth profile is such, that depths only very slowly increase with distance to the coast. OWEZ is situated just inshore of the -20 isobath; PAWP just outside this depth contour (Lindeboom et al. 2008). Local salinities are influenced by riverine run off (River Rhine). Fresh water gradually travels north along the mainland coast, mixing only slowly with more saline offshore waters. This results in a long-shore coastal front, separating the “coastal river” from more offshore saline waters. However, due to wind and tides, this coastal front is not always very clear, but salinities always increase from inshore to offshore; isohalines mostly run parallel to the coast. Water temperatures show similar inshore/offshore trends, although temperatures are lowest inshore in winter, and offshore in summer (see also Leopold et al. 2004). Water clarity generally increases from shore to offshore. The area is thus characterised by a concurrent changes of depth, salinity, temperature, turbidity and sediment characteristics from the shore to the offshore.

This suit of habitat characteristics have a clear influence on many seabirds. There is a clear nearshore bird community, represented by divers, grebes, seaducks, terns and some of the smaller *Larus*-gulls. These birds do not venture out to offshore waters in large numbers; beyond the -20 m depth isobaths the bird community comprises large gulls, Northern Gannets, Northern Fulmars, and Kittiwakes. Auks (Guillemots and Razorbills in these parts) both occur nearshore and offshore (Camphuysen & Leopold 1994). The two wind farms present in the study area are thus situated in waters that are neither the prime habitats for nearshore seabirds, nor for offshore seabirds.

Precise food availabilities for different seabirds are known imperfectly, as are dietary details in most situations. Some larger diet studies (e.g. Ouwehand et al. 2004; Leopold & Camphuysen 2006; Camphuysen et al. 2008) indicate that sandeels (*Ammodites* spec.), gobies (*Pomatoschistus* spec) and clupeids (sprat *Sprattus sprattus* and juvenile herring (*Clupea harengus*) are important food species for many seabirds in the area. Discards from fisheries are a very important addition to the diet of many gulls (Camphuysen et al. 2005; 2008) while bivalve shellfish, when suitable and occurring in high densities in relatively shallow waters, might attract very large numbers of seaducks (Leopold et al. 1995).

Study Methods

Before any turbines were in place, a T-0 study was carried out (Leopold et al. 2004). A survey design was chosen, in which a much larger area than the OWEZ site was repeatedly surveyed. At the time of designing this T-0 study, it was not yet certain whether PAWP would be built as well, but a site for this wind farm was already marked. It was therefore decided to include this site within the larger study area, and a study area was chosen that had both future wind farms more or less in its centre. The wind farms are situated in the south-eastern North Sea, directly west of the Dutch mainland coastline, northwest of the port of IJmuiden. The study area encompasses the two wind farms, and covers an area between the coast and about 18 nm offshore (out to nearly 4°E), and from about 52°30’N (IJmuiden) to about 52°45’N (Hondsbossche Zeewering). The size of the study area is circa 725 km^2 (ca 22 x 33 km), which is some 18 times the surface area of the two future wind farms combined (Figure 8). Ten equidistant (1.33 nautical miles or 2.47 km apart) transect lines, running from East to West over the full width of the study area, were sailed during each survey. On each run, counts were done simultaneously in two parallel strips, each 300 m wide, at both sides of the ship (weather permitting), and if time allowed, all transects were sailed twice during a full survey. This quadrupled the effort compared to a single passage, single transect approach and made that a large relative surface area was studied in relation to the total study area (Table 2). Transect orientation was deliberately chosen to be perpendicular to the main physical and ecological parameters, such as distance from the coast, water depth, temperature and salinity and from that, seabird community parameters. This, with the rather even coverage of the study area, should facilitate later spatial modelling of the results.

To rule out, as much as possible effects of survey day (within surveys) and time of day, survey lines were sailed in this order: 1-3-5-7-9-10-8-6-4-2 (twice if possible). This ensured that the greater survey area was covered several times and that nearshore and offshore parts were not always surveyed at similar times of day.

Seabird presence in a nearshore study area such as covered here, is likely to vary with the distance to the mainland coast (or water depth, or salinity or temperature; these variables are often highly correlated). These physical parameters were studied during the T-0 phase of the project (Leopold et al. 2004). Indeed, distance to shore correlated strongly with water depth, water temperature and salinity, in all seasons. We therefore used distance to shore in our subsequent spatial modelling, and excluded the other, correlated factors.

Clearly, seabird presence would also vary substantially between seasons. Eight T-0 surveys were conducted from 2002 to 2004, that covered the yearly seabirds' calendar. The T-0 surveys were scheduled in February (mid-winter), April (spring migration), May (early breeding), June (chick-phase; parent breeders fetching food at sea), August (dispersal of juveniles), September, October, and November (autumn migration, onset of winter).

The T-1 phase comprised three years of surveys, and six surveys per year. The T-1 surveys were to be timed to match the T-0 surveys. It was decided not to repeat the May survey, as bird densities were very low in that month and surveys were conducted both one month earlier (April) and one month later (June). Likewise, it was decided to skip surveying in October, but bad weather in two T-1 surveys frustrated work in later September T-1 surveys. By combining September and October surveys, still a time series of autumn T-0 through T-1 surveys is kept. Finally, during the last set of T-1 surveys, it was decided to put more effort in the winter period when more birds that might be susceptible to disturbance (divers, auks) were present. The T-1c August survey was therefore replaced by a February survey, which also better matched the T-0 situation (Table 1).

The area surveyed (=km travelled times strip width, times the number of strips) differed between survey, mainly in response to the amount of daylight within the survey weeks and wind condition (Table 2), and rain and mist. Relatively little effort could be realized in some autumn and winter surveys, when short days and poor weather conditions sometimes prevented counting on both sides of the survey vessel, or completing all survey lines twice. However, all ten principal survey lines were always covered at least once, in each survey.

T-0	T-0	T-0	T-1a	T-1a	T-1a	T-1b	T-1b	T-1b	T-1c	T-1c	T-1c
Year	Month	Ship	Year	Month	Ship	Year	Month	Ship	Year	Month	Ship
2002	9	Mitra	2007	9	Osterems	**2008**	**9**	**Vos Shelter**			
2002	10	Zirfaea							2009	10	Oil Express
2003	4	Orca I	2007	4	Vos Baltic	2008	4	Vos Baltic	2010	4	Vos Northwind
2003	**5**	**Orca I**									
2003	6	Orca I	2007	6	Vos Baltic	2008	6	Oil Express	2009	6	Vos Northwind
2003	8	Orca I	2007	8	Osterems	2008	8	Vos Baltic			
2003	11	Orca I	2007	11	Vos Baltic	2008	11	Vos Shelter	2009	11	Oil Express
2004	2	Orca I	2008	1	M. Cornelis	2009	1	Vos Shelter	2010	1	Vos Northwind
									2010	2	Vos Baltic

Table 1. *Surveys conducted. The table presents the years and months of each survey (T-0 through T-1) and the names of the ships used. Surveys in bold are not analysed. Different grey tones mark coherent sets of surveys: the September/October surveys are analysed as one set, as are the January/February surveys.*

The T-1 surveys are a continuation of the T-zero surveys and follow the same methods as much as possible (see also Leopold & Camphuysen 2009). Seabird distributions are notoriously patchy, both in time and in place. At-sea seabird counts usually contain many zero values, with some positive counts intermingled. This makes statistical analyses difficult. Large-scale variation in occurrence is usually easy to spot, such as a reliance on coastal waters in some species. As seabirds are highly mobile, fine-scale variation is often not discernible from noise in the data. It should be noted at the onset of at-sea seabird studies, that variation at the spatial level of an offshore wind farm, will be difficult to quantify. After two sets of T-1 surveys (T-1a and T-1b) it became clear that too little time and effort was spent within the wind farms themselves. It was therefore decided to add eight extra lines through the wind farms, after an evaluation of a try-out during the January 2008 survey (Leopold et al. 2009). Because these lines were meant to highlight wind farm effects, their orientation was along presumed seabird presence gradients (parallel to the isobaths; Figure 11). These eight extra lines (four for each wind farm) came at a cost, in that during the T-1c surveys no attempt was made to complete the principal survey lines twice, so that each survey could still be completed within one week. The ten principal lines were always covered, however.

					Seastate (Bft)							
Survey	Month	Year	km^2	km	0	1	2	3	4	5	≥ 6	Average (Bft)
T-0	2	2004	368.2	1227.3	61.3	191.2	213.9	179.3	266.1	266.2	49.4	3.14
T-0	4	2003	487.4	1624.7	6.4	159.1	696.1	514.2	209.1	39.9		2.54
T-0	5	2003	403.9	1351.0				54.6	645.3	356.9	294.2	4.66
T-0	6	2003	461.8	1539.2			157.1	715.0	616.0	51.1		3.36
T-0	8	2003	456.8	1522.7	68.7	138.2	295.4	422.1	446.4	152.0		2.98
T-0	9	2002	417.7	1392.4			72.1	297.5	724.7	298.1		3.90
T-0	10	2002	237.2	790.8			29.3	59.6	259.1	291.2	151.6	4.60
T-0	11	2003	320.8	1069.3	33.9	35.2	214.3	313.7	441.9	30.2		3.11
T-1a	1	2008	285.5	951.7				14.1	98.9	597.7	240.9	5.12
T-1a	4	2007	444.9	1483.1	225.4	44.3	281.8	733.8	197.8			2.43
T-1a	6	2007	375.5	1251.7						973.2	278.5	5.22
T-1a	8	2007	400.3	1334.3	53.6	149.5	235.6	352.6	225.8	83.8	233.4	3.30
T-1a	9	2007	114.8	382.8				15.5	23.4	112.6	231.3	5.46
T-1a	11	2007	26.6	88.8					39.0	18.0	31.8	4.92
T-1a	11	2007	359.9	1202.0			83.2	198.9	362.6	297.9	259.4	4.38
T-1b	1	2009	221.8	739.4				37.6	332.4	253.9	115.6	4.61
T-1b	4	2008	447.6	1491.8	53.8	94.1	471.0	611.8	257.5	3.6		2.63
T-1b	6	2008	437.0	1456.6		95.6	336.4	408.7	538.4	77.6		3.11
T-1b	8	2008	429.3	1480.8				36.5	497.9	692.2	254.2	4.79
T-1b	9	2008	83.8	279.5						128.0	151.4	5.54
T-1b	11	2008	376.1	1253.8	7.0	203.9	246.5	290.4	465.1	41.0		2.90
T-1c	1	2010	378.3	1261.2	74.4	74.9	147.5	401.6	471.8	91.1		3.11
T-1c	2	2010	375.8	1313.8		22.8	255.3	181.2	327.2	256.1	271.1	4.03
T-1c	4	2009	293.8	979.3	59.5	144.3	447.2	199.5	36.5	89.2	3.1	2.30
T-1c	6	2009	382.0	1273.2			111.0	519.1	535.7	107.4		3.50
T-1c	10	2009	376.4	1254.6			31.4	461.4	501.4	231.5	28.8	3.81
T-1c	11	2009	370.6	1235.4			163.2	310.4	667.4	94.4		3.56

Table 2. *Total area (km^2) and km travelled in the study area, per survey. The summed km travelled has been split up in km travelled per Beaufort seastate (Columns 0 to ≥6). The column AVG(Bft) gives unweighted average seastates. These figures are not exact measures for average wind speed, as the Beaufort scale is logarithmic; but provide an impression of conditions during various surveys. The T-0 May 2003 survey and two broken off T-1 surveys (all marked grey) are omitted from further analyses.*

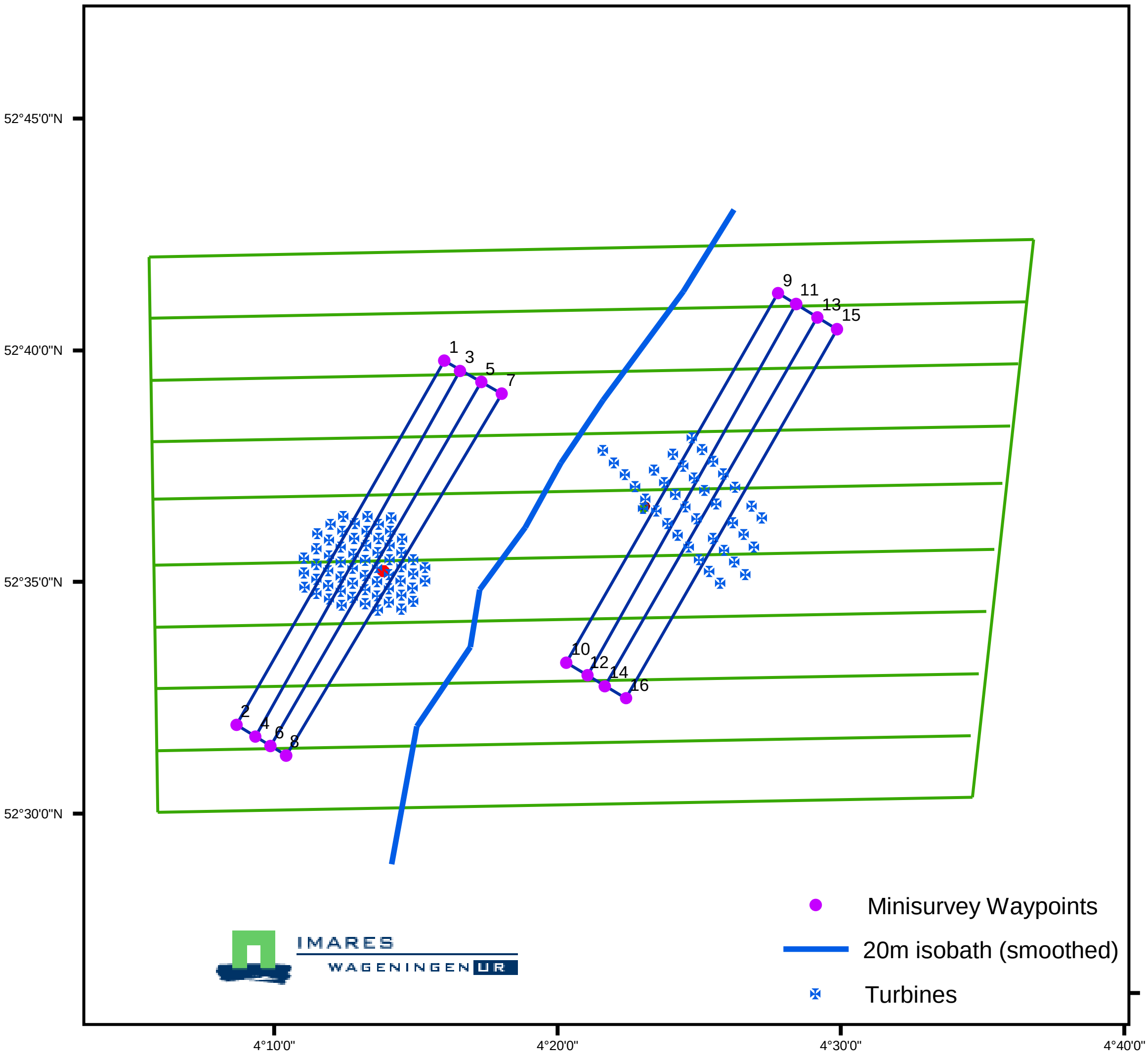


Figure 11. *The ten principal survey lines (in green, running E-W) and the eight extra lines through the two wind farms, running parallel to the 20 m isobath, surveyed during T-1c.*

Seabirds were continuously counted along all lines included in the survey, if possible at both sides of the vessel, by two separate teams of two observers. Data on bird presence and bird densities were collected at sea, using strip-census techniques (Tasker et al. 1984; and see Leopold et al. 2004 for an extensive explanation of the particular techniques used in the OWEZ studies). In summary, birds were counted in one or (mostly) two, 300 m wide strips on either side of the survey vessel, while sailing through the area along fixed survey lines. Although considerable numbers of seabirds were also seen beyond the 300 m limits, or at close range but outside the snap-shots used in the strip counts (Tasker et al. 2004), only birds seen 'in transect' were used for modelling purposes. Transect lines were broken up into 5 minute (time) stretches and birds seen in each individual 5 minute count were pooled (from t=0 to t=5 mins and for portside and starboard). At t=5 mins, the next count commenced, from t=5 mins to t=10 mins, etc. Presence/absence data were used for modelling, regardless of numbers seen in 5 minutes if these numbers were equal to, or larger than one. Densities were used for mapping only. In either case, only birds seen 'in transect', that is, within 300 m perpendicular distance to the ship's transect line and in the case of flying birds, at the right snapshot moments (see Tasker et al. 1984) were included for modelling. Densities were calculated as numbers seen in transect, divided by area surveyed. Area surveyed is the way length covered in that particular 5 minute period (depending on sailing speed, which was continuously monitored) and strip width (300 or 600 m). The location of each count was taken as the mid-position between the positions at t=0 and t=5 mins, for each count, on the ship's transect line.

Within the study area, there are three anomalies: OWEZ, PAWP and an anchorage area for ships waiting to enter the port of IJmuiden. Usually, some 10 to 30 ships were moored at this site during the surveys and numbers of ships appeared higher during T-1c, in response to the financial crisis (Figure 12).

Figure 12. *View of the anchorage area at IJmuiden Approach, January 2010. Photo: Martin Poot, Bureau Waardenburg.*

During the T-0 surveys, the two wind farms only existed on the drawing table, but the anchorage area was already in use. During T-1a, OWEZ was operational, while the anchorage area remained active, and PAWP was being built. During T-1b and T-1c all three areas were in use. The terms T-0 and T-1 thus specifically refer to the situation in OWEZ. PAWP and the anchorage are complications, that cannot be ignored as they are of similar nature and magnitude as OWEZ. In our modelling therefore, all three areas are additional factors to the general smoothers in the models.

This study uses two means of identifying possible impact of the OWEZ wind farm on local seabirds. First, differences in distribution patterns between the T-0 and T-1 situation may be apparent. Second, within individual surveys deviations from the general distribution pattern at the location of OWEZ may be present. We therefore always consider sets of surveys (January February; April, June, August, September/October and November surveys; see Table 1) and compare distribution patterns between surveys in different years and within surveys (probability of occurrence within OWEZ, within PAWF, within the anchorage area or outside either area). Bird distributions were modelled in R (v2.9.2; R Development Core Team 2009; see next section of this report for further details on the modelling procedure), using northing and distance to coast and as smoothers and 'area' (counts within OWEZ, within PAWF, within the Anchorage, or outside either of these) as additional factors. The data were analysed at the level of individual surveys, after a selection for sufficient data. Sufficient data was taken as surveys with more than 10 counts with birds of a given species 'in transect'.

We confined the modelling to using presence/absence data. This approach often has greater predictive ability than presence-only approaches, is less susceptible to large numbers of counts with no birds and less sensitive to errors with determining exact densities (e.g. Philippart et al. 1992; MacLeod et al. 2008). Both the problem of large numbers of zero counts and problems with assessing exact bird densities, in a situation with two teams of different observers operating from the same vessel, under various light and weather conditions, are considerable (see van der Meer & Camphuysen 1996 and Leopold et al. 2004 for discussions of these problems). Our presence/absence modelling generated predicted probabilities of occurrence (between 0 and 1) for the whole study area, in 250 x 250 m grid cells. These probabilities were mapped on a 0.1 point colour scale and differences at the three special sites within the larger study area were tested by Analysis of Variance (ANOVA). For birds that showed more or less consistent patterns, density data were used, to explore the size of the effect of the three areas on the occurrence of these birds on-site.

For all bird/month combinations with sufficient data, Generalised Additive Mixed Models (GAMM) were applied first. If the amount of data was insufficient to apply a GAMM, a more simple Generalised Additive Model (GAM) was used. Both models predict bird distribution for the entire study area on the basis of all data gathered (separately for each individual survey). A GAM uses just the two smoothers (northing and distance to coast), while a GAMM also considers the temporal autocorrelation within the dataset. Significance (P-values) of the effects of distance to coast, northing and OWEZ, PAWP and Anchorage were estimated.

A full description of the statistical analyses techniques is provided in the next chapter of this report.

Statistical analysis

In order to determine whether or not the three impact areas (two wind farms and one anchorage area) have an effect on the distribution of different bird species, their natural distribution patterns must be taken into account. Because these cannot necessarily be described using linear relationships, Generalised Additive Modelling (GAM), which uses smoothing functions to model non-linear relationships (Wood 2006; Zuur et al. 2007), was applied to the data.

Bird counts from the surveys were used as the response variable. Count data can be affected by an abundance of zero data, which causes a difficulty in statistical modelling, because the data do not fit the assumed distributions (zero inflation, Zuur et al. 2007). As this was the case for many species in this study, presence/absence data was used as the response variable, instead of actual counts, and the model was fitted to a binomial distribution of data to account for the binary nature of such data.

Presence/absence (*P/A*) data were thus modelled as a smoothing function of "Distance" (from the coast) and "Northing" (latitude), to describe the spatial distribution within the greater study area, and a function of the factor "Impact Area":

$$P / A = \alpha + f(Dist) + f(Northing) + factor(Park) + \varepsilon$$

where α is the intercept, f the smoothing function, *Dist* the distance to the coast and ε the error (unexplained variance). "Impact Area" consisted of four levels, describing the OWEZ, PAWP and Anchorage areas as well as the remaining area outside of these three.

Due to the sequential nature of observations during the survey, there is the potential for "time of observation" to cause temporal auto-correlation within the data, i.e. the probability of observing a bird is higher if birds were also observed in the previous observation, or (*vice versa*) lower if no birds were observed in the previous observation (Legendre and Legendre 1998, Zuur et al. 2009). Temporal auto-correlation is taken into account where possible by applying Generalised Additive Mixed Models (GAMM), which include "time since first observation" as a correlation structure in the model.

The data were analysed for each species separately at the level of individual surveys, after a selection for sufficient data. Sufficient data was taken as surveys where birds were counted (present) on at least ten occasions. This was a conservative precaution, allowing for a selection of bird/month combinations to be analysed, out of a total of 600.

For all bird/month combinations, Generalised Additive Mixed Models (GAMM) were first applied. If the amount of data was insufficient to apply a GAMM, a more simple Generalised Additive Model (GAM) was used (ignoring the effect of temporal auto-correlation).

Both models estimate P-values of the effects of distance to coast, northing and Impact Area. These describe the significance of each of these variables in determining the probability birds being present. Where Impact Areahas a significant effect, the output allows an evaluation of which of the three impacted areas have significantly different (either positive or negative) probabilities of occurrence in comparison to the area outside and what would be expected based on the distance from shore and latitude.

The model output was then used to predict (and map) the probability of birds occurring across the survey area. Due to the binomial family used for the model, the predictions are given by:

$$\pi_i = \frac{e^{\alpha + f(Dist_i) + f(Northing_i) + \beta_1 \times OWEZ_i + \beta_2 \times PAWP_i + \beta_3 \times Anchorage_i + \varepsilon}}{1 + e^{\alpha + f(Dist_i) + f(Northing_i) + \beta_1 \times OWEZ_i + \beta_2 \times PAWP_i + \beta_3 \times Anchorage_i + \varepsilon}}$$

Where π is the probability of a bird occurring at location i, α the intercept, f the smoothing function, β the respective estimates for a given factor level (provided in the model output), and ε the error (unexplained variance). The factor levels OWEZ, PAWP and Anchorage are given either a 0 or 1 in the above formula, depending on whether or not a given count location is within one of these areas or not. If the significance level for a given area was above 10%, the estimate provided was omitted from the calculation and the area was treated the same as the outside area.

Deviance:

The deviance of a model describes the difference between the model used (model) and the "perfect" model (saturated model) that produces an exact fit of the data. The deviance is defined as

$$D = 2 \times (L'\text{saturated model} - L'\text{model})$$

where L' is the log likelihood of the respective model (Zuur et al. 2007). The deviance will always be positive and the smaller the value, the better the model (the less the deviation from the "perfect" model).

All analyses were performed in the 'R' statistical and programming environment (v2.9.2; R Development Core Team 2009), using packages 'mgcv' (Wood 2009) and 'nlme' (Pinheiro et al. 2006).

Model problems

A common problem with using binary data (such as presence/absence data) is that of "sparsity", i.e. a lack of sufficient information for the algorithm to derive reasonable estimates. For the smoothers in the model this is not a problem as the model can extrapolate from the data available. However, in the case of the model intercept and the factor levels (associated with the three impact areas) the model may not correctly converge when the data contained within one or more of these levels is either lacking in abundance (few observations made) or is all of the same result (i.e. all presence or all absence data). Whilst this is a common problem, no straightforward solution for sparsity in GAM(M)s is available. As it is a problem related to a lack of data, a qualitative approach, being sensible about what can or cannot be inferred given the data, to data interpretation may be advisable. Where sparsity was encountered in this report we have therefore refrained from mapping the model predictions and instead rely on a qualitative assessment of the available data.

These problems are aptly illustrated by the January 2009 map (Figure 36, T-1b). The map does reflect the results, but sparcity is a problem here. In OWEZ, there are three "presence" and 3 "absence" datapoints so with a probability of encounter being at 50% the wind farm seems a favourable area, although looking at the data overall we would say it is really not. Also note the striking difference regarding the appreciation of the situation in PAWP, between January 2008 and January 2009. This too is a data sparsity problem where a few gulls inside, or just outside the wind farm make all the difference! These situations presented strong arguments for doing extra survey lines through the wind farms, to get more observations here!

Data quality

As seabird distribution patterns vary over time, and may also vary within an observation week, care was taken to sail transects in such a sequence, that the whole survey area was effectively surveyed several times. The ten transects , if numbered 1-10 from North to South were sailed in this order: 1-3-5-7-9-10-8-6-4-2. We always aimed to survey each line twice, so this sequence was repeated. However, due to spells of bad weather a full second coverage was not always possible. The minimum requirement, that each transect line was covered once, was met in all surveys.

Ideally, bird counts are conducted in good weather, as spotting birds on a rough sea surface during a storm is often difficult. Beaufort sea states of 6 and more are thus less suitable for survey work (Camphuysen et al. 2004). This division in "good" and "bad" survey conditions is not always clear-cut, however. Working from a large ship, in coastal waters and with good light conditions may prove useful in Bft 6 conditions and even worse. In some situations, work had to be conducted in high winds (6-7 Bft) but this was only done if other conditions permitted collection of useful data. Note that there is always a trade-off between working in less than optimal conditions and not working. The logistics of the surveys were such, that the full set of 20 survey lines could only be sailed within one observation week, if conditions were good throughout. Loss of survey time because of weather, also results in loss of data. During windy weeks, optimal solutions were always sought, by first and foremost covering all transects once. Some weeks, however, were windy throughout and in such cases the whole survey had to be done in >5 Bft sea states (Table 2). As the aim of this project is to discriminate between bird densities inside and outside the wind farm perimeter, in other words, to compare relative densities, this was generally not seen as a very large problem. However, it is pointless to keep surveying in very bad weather, and in some cases (see Tables 1-3) surveys had to be terminated.

Between-observers variation is an important source of heterogeneity (van der Meer & Camphuysen 1996) and if different observers are used between surveys, data quality may be affected. It has not been possible to use exactly the same observers throughout, but we used three lines of defence against this source of heterogeneity. First, two observers always watched the counting strip. Two observers see more than one and therefore miss fewer birds, reducing error. Second, two principal observers (Leopold and Camphuysen; see Table 3) were almost always used during T-0 through T-1b. During T-1c Camphuysen was replaced by Verdaat as a principal observer, who had received ample training (from Camphuysen) during the T-1a and T-1b series of surveys. Each side of the ship thus had a principal observer more or less throughout the whole time series (reducing variation), who was assisted by a second observer (reducing the number of birds missed). Finally, all observers contributing to this program had ample previous experience in marine ornithology and several observers were repeatedly engaged in this series of surveys (up to nine times; see Table 3 for details).

Results

Completed surveys and weather conditions

A total of eight T-0 surveys were carried out, six of these were repeated during the T-1 phase of the project (Table 1). The T-0 surveys of May 2003 cannot be used for comparison with T-1 surveys as no matching surveys were conducted during T-1. Two T-1 surveys had to be broken off after one or two days of bad weather, and are also omitted from the analyses (grey lines in Table 3. Surveys in September and October, and in January and February, respectively, are grouped between T-0 and T-1 periods.

Survey	Month	Year	From	To	Area surveyed (km^2)	Observers
T-0	2	2004	16	19	368.20	Leopold, Camphuysen, van Lieshout, Ouwehand
T-0	4	2003	7	11	487.42	Leopold, Camphuysen, van Lieshout, Boudewijn
T-0	5	2003	19	23	403.85	Leopold, Camphuysen, te Marvelde, Witte
T-0	6	2003	23	27	461.76	Leopold, van Lieshout, te Marvelde, Spannenburg
T-0	8	2003	11	15	456.81	Leopold, Camphuysen, Witte, Harte
T-0	9	2002	23	27	417.72	Leopold, Camphuysen, van Lieshout, Lensink
T-0	10	2002	21	24	237.23	Leopold, Camphuysen, van Lieshout, Lensink
T-0	11	2003	12	19	320.80	Leopold, Camphuysen, van Lieshout, Hoogendoorn
T-1a	1	2008	14	18	285.50	Leopold, Camphuysen, Verdaat, Poot
T-1a	4	2007	9	12	444.92	Leopold, Camphuysen, Verdaat, Fijn
T-1a	6	2007	27	29	375.51	Leopold, Camphuysen, Verdaat, Fijn
T-1a	8	2007	19	22	400.30	Leopold, Camphuysen, Verdaat
T-1a	9	2007	24	27	114.84	Leopold, Camphuysen, Verdaat, Fijn, Heunks
T-1a	11	2007	5	6	26.64	Leopold, Camphuysen, Verdaat, Poot
T-1a	11	2007	20	24	359.91	Leopold, Camphuysen, Verdaat, de Boer
T-1b	1	2009	19	22	221.83	Leopold, Camphuysen, Verdaat, Poot
T-1b	4	2008	7	10	447.55	Camphuysen, Verdaat, Fijn, Winter
T-1b	6	2008	23	26	436.98	Camphuysen, Verdaat, Poot, Aarts
T-1a	8	2008	11	14	429.29	Leopold, Camphuysen, Verdaat, Fijn
T-1b	9	2008	30	30	83.80	Leopold, Camphuysen, Verdaat, Heunks
T-1b	11	2009	3	7	376.14	Leopold, Camphuysen, Verdaat, Poot, Fijn
T-1c	1	2010	18	22	378.36	Leopold, Verdaat, Poot, Geelhoed
T-1c	2	2010	22	26	375.75	Leopold, Poot, Fijn, Geelhoed
T-1c	4	2009	6	9	293.79	Leopold, Verdaat, Fijn, van Bemmelen, Collier
T-1c	6	2009	22	25	381.95	Leopold, Verdaat, Geelhoed, Collier
T-1c	10	2009	5	9	376.37	Leopold, Verdaat, Geelhoed, Fijn
T-1c	11	2009	2	6	370.62	Verdaat, Geelhoed, van Bemmelen, Collier

Table 3. *Dates (columns Month, Year and From…To) of the conducted T-0 and T-1 surveys. Surveys in dark grey were not used for further analysis. Area surveyed gives the sum of strip area (300 wide times transect length times number of repetitions), summed for the whole survey, in km^2 (excluding transit lines from and to port, outside the main study area). See page 2 for full names of observers.*

Several surveys were hampered by bad weather, particularly high winds and rain. The aim was to survey all ten transect lines within the study area twice, keeping watch on both sides of the ship (port and starboard). However, high winds and heavy rain prevented this on some parts of the surveys, and cut some surveys short. This inevitably resulted in some data loss, but the minimum requirement, that during each survey, each transect line was covered at least once, was met in every survey, except the T1b-September survey.

On the following pages, maps of the survey effort are given, graded by seastate conditions encountered (Figure 13). These range from seastate 0 Bft (completely flat) in green to seastate 6 and above (large waves with lots of white foam) in read. Comparable surveys (same month or nearly same month) are plotted from top to bottom.

The mid-winter surveys January and February had rather poor weather. The T-0 (February) survey and the two T-1c surveys (January and February) were conducted under better average conditions than the T-1a and T-1b surveys.

The April surveys were all conducted under good conditions.

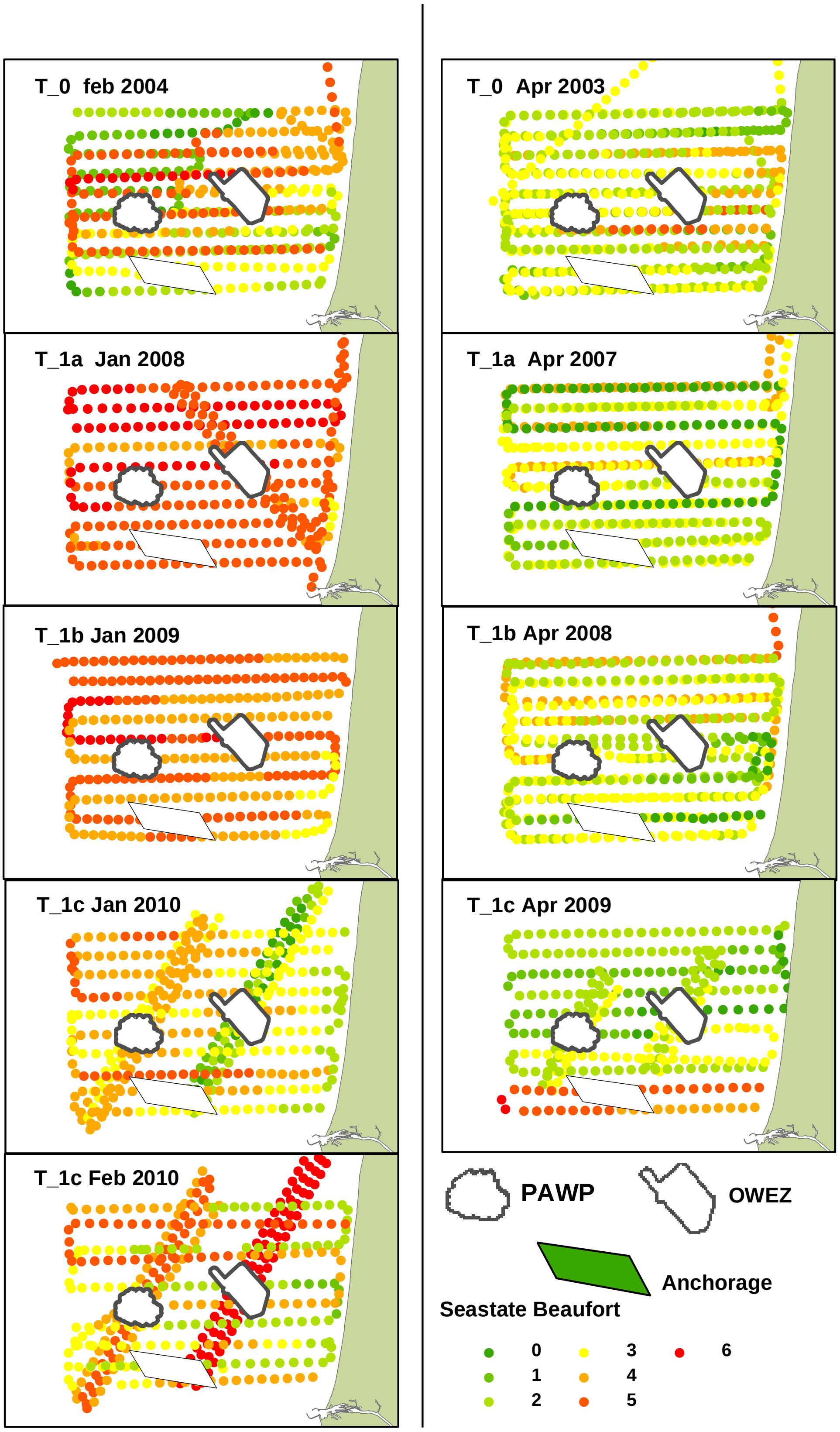
The first T-1 (a) June survey had unexpected bad conditions; the T-0, T-1b and T-1c surveys had good seastates, generally.

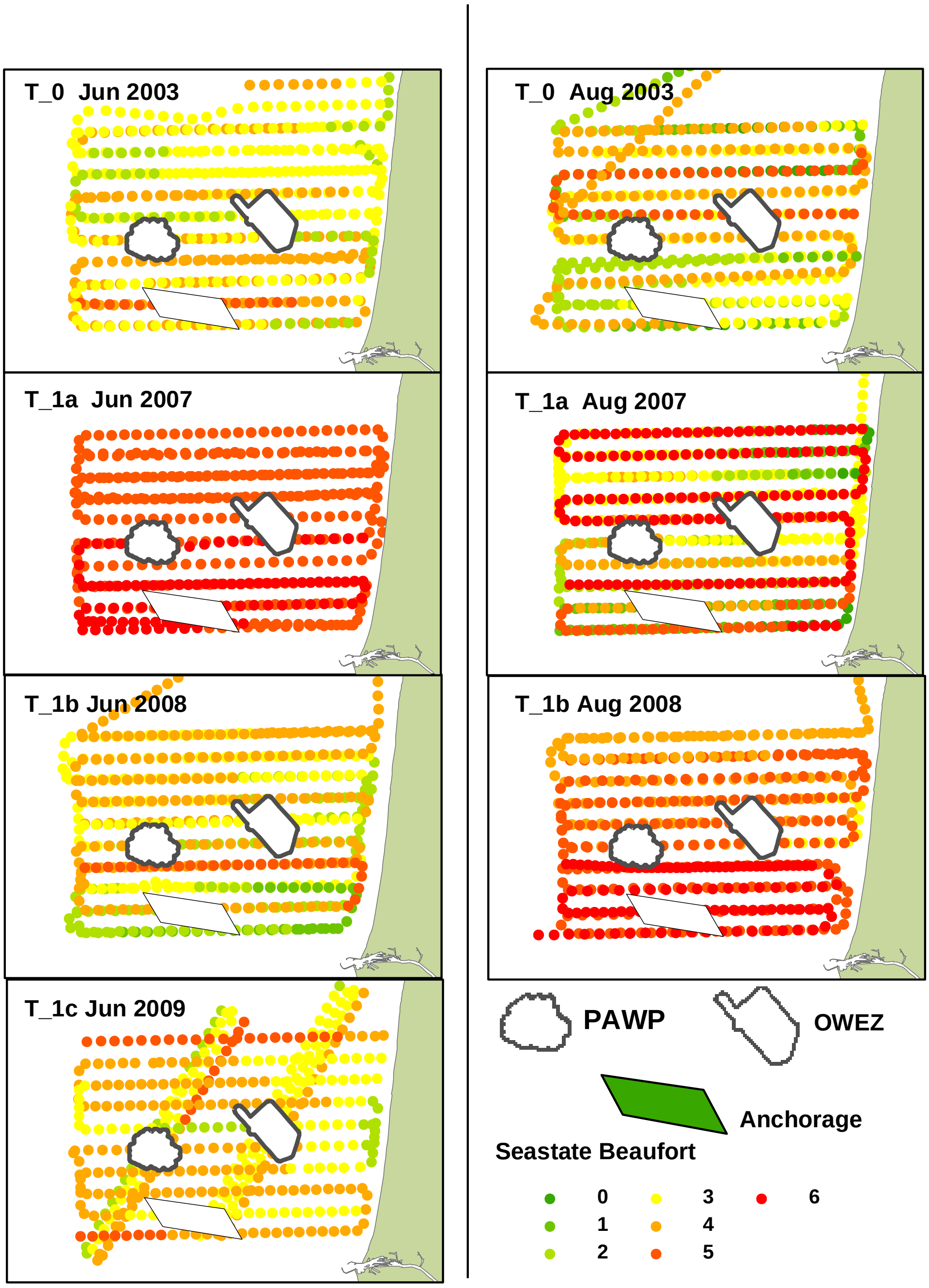
The three August surveys had progressively worse weather, as had the September surveys. The T-1b survey had to be terminated after two days of poor weather and the data collected (one day in ≥ 5 Bft) are not further used. Also the two October surveys were conducted in moderate to rather poor conditions.

The November surveys had a mix of good and moderate to poor conditions, but mostly conditions were rather good for autumn. Only the T-1a survey had moderate conditions.

Generally, seastate conditions were best close to the shore, where the sea is more shallow and where the coast gives some protection from easterly winds.

Figure 13 (overleaf): *Seastate conditions (broken up in 5 minute counts) for all surveys that produced good data. The surveys have been grouped per month or combination of months. The figure should be read from top to bottom, and from left to right.*


T_0 feb 2004
T_0 Apr 2003
T_1a Jan 2008
T_1a Apr 2007
T_1b Jan 2009
T_1b Apr 2008
T_1c Jan 2010
T_1c Apr 2009
T_1c Feb 2010
PAWP
OWEZ
Anchorage
Seastate Beaufort
0
1
2
3
4
5
6


T_0 Jun 2003
T_0 Aug 2003
T_1a Jun 2007
T_1a Aug 2007
T_1b Jun 2008
T_1b Aug 2008
T_1c Jun 2009
PAWP
OWEZ
Anchorage
Seastate Beaufort
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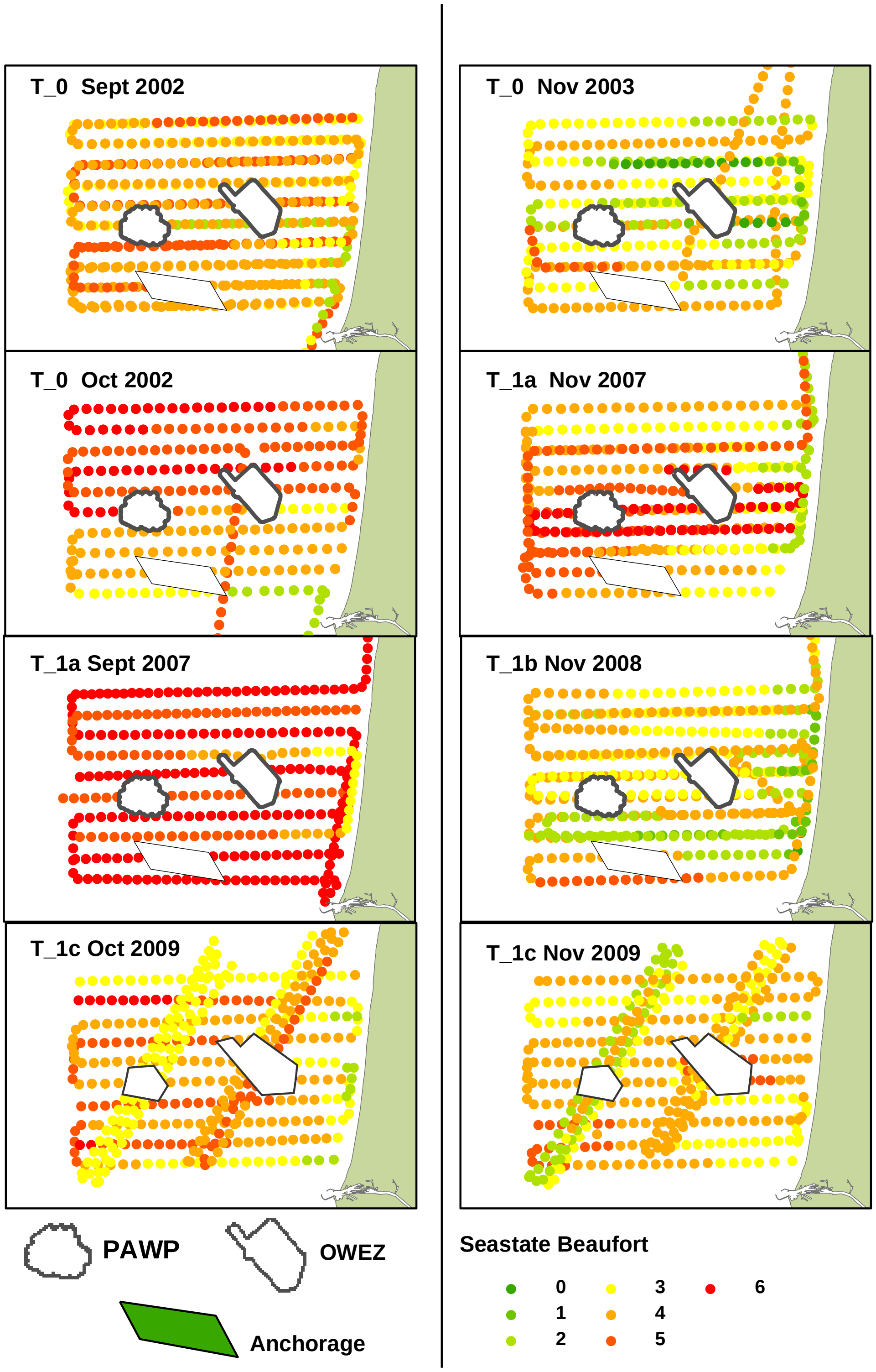

T_0 Sept 2002
T_0 Nov 2003
T_0 Oct 2002
T_1a Nov 2007
T_1a Sept 2007
T_1b Nov 2008
T_1c Oct 2009
T_1c Nov 2009
PAWP
OWEZ
Anchorage
Seastate Beaufort
0
1
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3
4
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6

Species accounts

In this section, all seabird species that were seen in substantial numbers during the surveys are treated separately. The general distribution in the study area is described and total numbers of the species during each survey are presented in a table. In these totals, all birds seen during the survey are included, the ones seen within the 300 m wide counting strips and those seen beyond these strips, or (flying birds) outside snapshot moments (see methods section). Bird numbers are grouped by season (month or combination of two months in some cases) in these tables, with the T-0 surveys clearly marked.

A second table for each species gives the modelling results (presence/absence). Modelling was only attempted when that particular seabird was sighted in more than 10 counts (each count lasting 5 minutes; see methods section). The N-column gives the number of non-zero for each survey, Surveys with N≤10 (10 or less non-zero counts) were considered to have insufficient data for modelling (marked “ins. Data” in the Model column). Results of analyses of variance of the data (ANOVA) give the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ alone. Significance levels are put at P<0.1 (meaning: the probability that an effect of the impact area(s) is incorrectly assigned is smaller than 10%). The direction of an effect of OWEZ can either be positive (attraction) or negative (avoidance). These are marked either “+” or “-“ in the column Est_OWEZ. Note that these plusses and minuses are only meaningful if P_OWEZ <0.1: **these cases are marked bold**.

The modelling results should always be considered together with the distribution maps, presented at the end of each species account. Maps are also grouped by season (month or combination of two months in some cases), but only presented if at least of the surveys from a given season had sufficient data for modelling. All maps show the coastline of Noord-Holland or geographical reference, and the outlines of the two wind farms and the anchorage area. Counts without birds are indicated by –, counts with birds by circles. Circles represent bird densities: numbers seen in that 5 minute count within the counting strips (port side and starboard combined) divided by total surface area surveyed in that count. On each page, the first map or maps give the T-0 results (indicated by heading in red); the other maps represent the results for subsequent T-1 surveys (heading in blue).

Our presence/absence modelling generated predicted probabilities of occurrence (between 0 and 1) for the whole study area, in 250 x 250 m grid cells. These probabilities were mapped on a 0.1 point colour scale, from very light yellow to dark brown. If modelling was not possible, the background was left blank. There are a few cases with seemingly sufficient data (more than 10 circles on the map) that still have a blank background. These are cases where the modelling suffered from sparcity problems (see: Statistical analyses section). As the generated output was not particularly helpful in these cases (only 0 or 1 predictions were generated with nothing in-between), these results were omitted and the maps left blank. Note also that the modelling tended to “overreact” in some cases where the majority of the birds were found on one side of an impact area: in such cases the effect of that impact area was often seen as significant, while the distribution maps show that that bird species, in that month, hardly reached that particular impact area. “Significance” should therefore always be considered together with the distribution pattern.

Divers Gadidae (duikers)

Figure 14. *Red-throated Diver, offshore near PAWP, 8 October 2009. Photo: Steve Geelhoed, IMARES.*

Three species of divers were noted during the surveys. The vast majority were certain or probable Red-throated Divers *Gavia stellata*. Some Black-throated Divers *G. arctica* were seen, during their spring migration in April (cf seawatching data; see: Camphuysen & van Dijk 1983; Platteeuw et al. 1994; www.trektellen.nl), but also in mid-winter (Table 4). Some 9% of the two smaller species (Red- or Black-throated) could not be identified to species. In November, Great Northern Divers *G. immer* were seen on two occasions. Divers were absent in summer and generally most numerous during the mid-winter surveys. For modelling purposes, all diver species were summed.

Diver distribution patterns were mostly rather coastal, from autumn through winter, with OWEZ situated at the offshore fringe of the area occupied by divers and PAWF offshore of these parts. The pattern during the T-0 spring (April) survey was markedly different, when relatively large numbers were seen throughout the study area, but particularly far offshore. Numbers were much lower in subsequent spring surveys, indicating much year to year variation. With only high numbers offshore during one T-0 survey, it is difficult to show clear effects of the wind farms. PAWP was always outside the range of the divers, at least during all T-1 surveys. Given the generally low diver densities, at the longitudes of OWEZ, it is not surprising that very few birds were actually seen within this wind farm. Still, divers tended to occur mostly around, rather than inside OWEZ (see maps for April 2007, October 2009, November 2009. The modelling results for presence/absence data mostly show significant contributions of distance to coast and northing. In most cases, divers are significantly more likely to be seen near the coast than further offshore, only in April 2003 this trend was opposite, and significantly so. The model picks up significant avoidance of OWEZ in January 2009, January 2010 and November 2009. Inspection of the distribution maps shows, however, that this “avoidance” in all three cases might be caused by clusters of divers north to northwest of the wind farm (November 2009 and January 2010), or (a very small number of birds) south of the wind farm (January 2009; see Figure 15) and might thus have been Type I errors. In contrast, divers did enter the wind farm in January 2008, when numbers close to OWEZ were relatively high. With most birds being found between the wind farm and the shoreline, the model may be over-sensitive in finding avoidance.

Month	year	Survey	Red-throated	Black-throated	Red/Black	Great Northern
2	2004	T-0	256	12	38	
1	2008	T-1a	600	10	6	
1	2009	T-1b	330	10	12	
1	2010	T-1c	244	0	16	
2	2010	T-1c	66	2		
4	2003	T-0	346	10	98	
4	2007	T-1a	52	18	6	
4	2008	T-1b	10	12	4	
4	2009	T-1c	4	8	2	
9	2002	T-0	4	0	4	
10	2002	T-0	28	0	4	
9	2007	T-1a	0	0	0	
10	2009	T-1c	56	0	2	
11	2003	T-0	90	4	14	2
11	2007	T-1a	102	0	18	2
11	2008	T-1b	88	2	4	0
11	2009	T-1c	102	6	14	0

Table 4. *Total numbers of divers seen during the surveys (surveys without diver observations omitted). All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Some divers were thus seen within the perimeter of OWEZ during the T-1 survey of January 2008, while during other T-1 surveys these birds did not seem to venture into the wind farm's perimeter (Figure 15). Note that such a pattern is likely to be caused, at least partly by the fact that densities at the latitude of OWEZ were often low, as shown by the same patterns found during several T-0 surveys. A single Red-throated Diver was seen flying through OWEZ, at less than 25 m asl on 20 January 2010, but because this birds was seen further than 300 m from the ship, it has not been included in Figure 15. Likewise, a Red-throated Divers was seen swimming and diving just within the OWEZ perimeter during the October 2009 (T-1c) cruise, but it was spotted too far away from the ship's trackline to be included in the map.

Divers that were seen swimming within OWEZ were all seen near the wind farm's perimeter. Two (unidentified divers) that were apparently migrating to the Southwest, were seen flying towards PAWP at rotor height on 8 October 2009. When they got close to the wind farm, they changed course to fly parallel to its perimeter, until they came onto a larger gap through the wind farm, as seen into their original flight direction. The two birds took this opportunity to fly through the heart of the wind farm, continuing on a south-westerly course, and on rotor height. Visibility was good during that encounter. These birds thus clearly reacted to the presence of the wind farm, but did not fly around the site but through it, and did so at rotor height, without changing altitude.

Given that some birds were actually seen inside the wind farm when it was operational, avoidance, if this is a reality, is less than 100% (contra the preliminary results of the studies at the Horns Rev wind farm, off Blåvandshuk, Denmark).

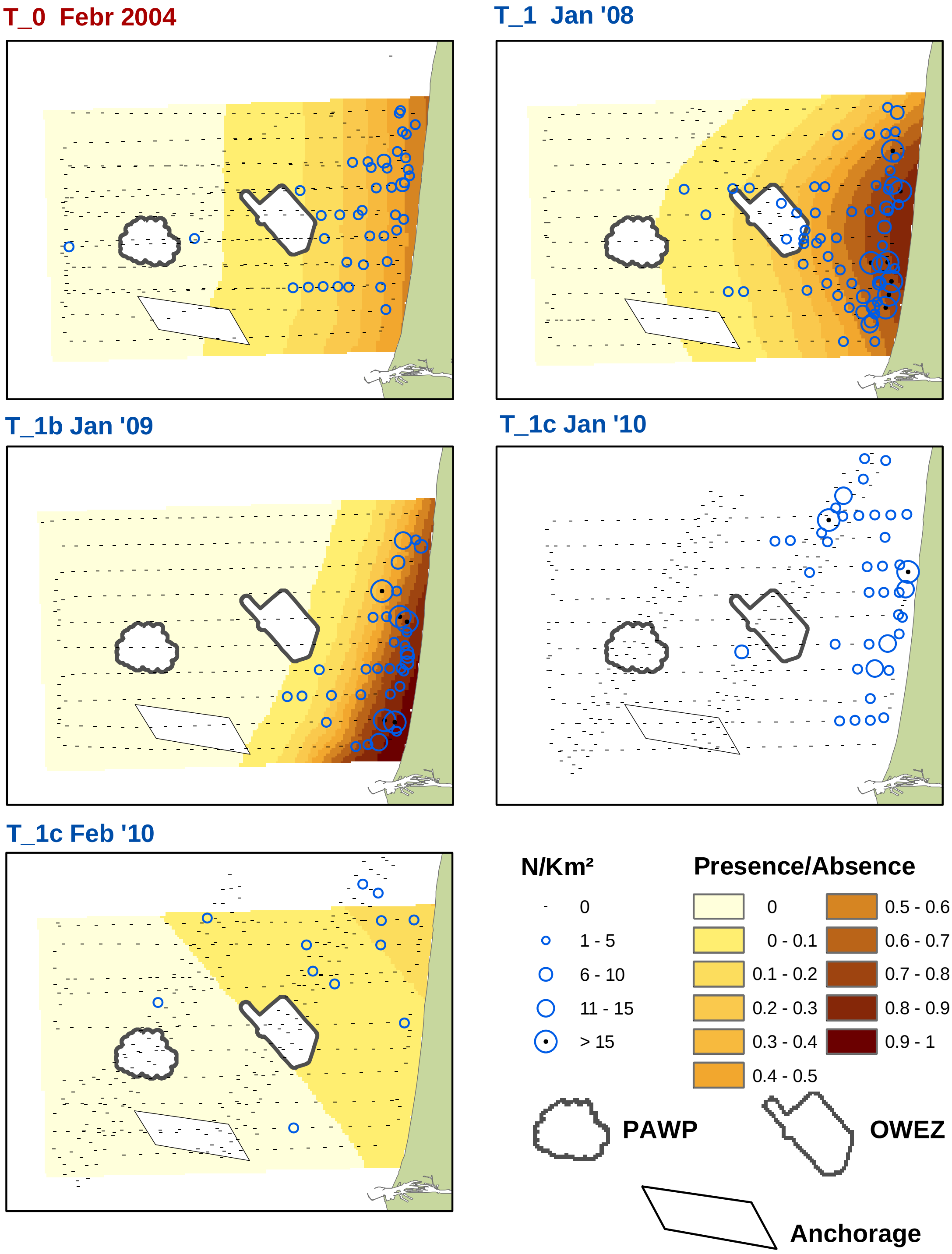
The situation in April 2003, with large numbers of divers occurring far offshore, may seem exceptional because in all other surveys most divers were seen nearshore. Offshore occurrence may be a feature of spring migration. It is yet unclear if this phenomenon is short-lived and thus unlikely to be picked up, or that is shows large year to year variation. Offshore distribution of divers in spring was also noted by Baptist & Wolf (1993) and Poot et al. (2004), but not in other surveys (Camphuysen & Leopold 1994), indicating that it might be a rather rare or short-lasting situation. However, offshore presence of divers in spring was again noticed in recent surveys conducted for the Masterplan Wind project (van Bemmelen et al. 2011; Poot et al. 2011).

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	**0.003**	0.728	0.704	0.704	-	GAMM	NA	41
2008	1	**0.000**	**0.003**	1.000	0.926	-	GAM	0.4	64
2009	1	**0.000**	**0.000**	**0.000**	**0.000**	-	GAMM	NA	35
2010	1	**0.000**	**0.023**	**0.004**	**0.034**	-	GAMM	NA	40
2010	2	**0.008**	**0.021**	1.000	1.000	-	GAMM	NA	12
2003	4	**0.004**	**0.051**	0.149	0.304	+	GAMM	NA	56
2007	4	0.558	0.869	1.000	0.999	-	GAMM	NA	11
2008	4	NA	NA	NA	NA	NA	ins. data	NA	3
2009	4	NA	NA	NA	NA	NA	ins. data	NA	2
2003	6	NA	NA	NA	NA	NA	ins. data	NA	0
2007	6	NA	NA	NA	NA	NA	ins. data	NA	0
2008	6	NA	NA	NA	NA	NA	ins. data	NA	0
2009	6	NA	NA	NA	NA	NA	ins. data	NA	0
2003	8	NA	NA	NA	NA	NA	ins. data	NA	0
2007	8	NA	NA	NA	NA	NA	ins. data	NA	0
2008	8	NA	NA	NA	NA	NA	ins. data	NA	0
2002	9	NA	NA	NA	NA	NA	ins. data	NA	0
2002	10	NA	NA	NA	NA	NA	ins. data	NA	6
2007	9	NA	NA	NA	NA	NA	ins. data	NA	0
2009	10	**0.000**	**0.036**	1.000	1.000	-	GAM	0.11	13
2003	11	**0.007**	**0.001**	1.000	1.000	-	GAMM	NA	20
2007	11	NA	NA	NA	NA	NA	ins. data	NA	7
2008	11	**0.000**	**0.097**	1.000	0.928	-	GAMM	NA	15
2009	11	**0.000**	0.401	**0.000**	**0.000**	-	GAMM	NA	19

Table 5. *Modelling results (presence/absence) for divers. Significant contributions (P<0.1) are put in **bold**. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ*) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 15 (overleaf): *Distribution maps of divers, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one diver in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without divers indicated by -.*

Divers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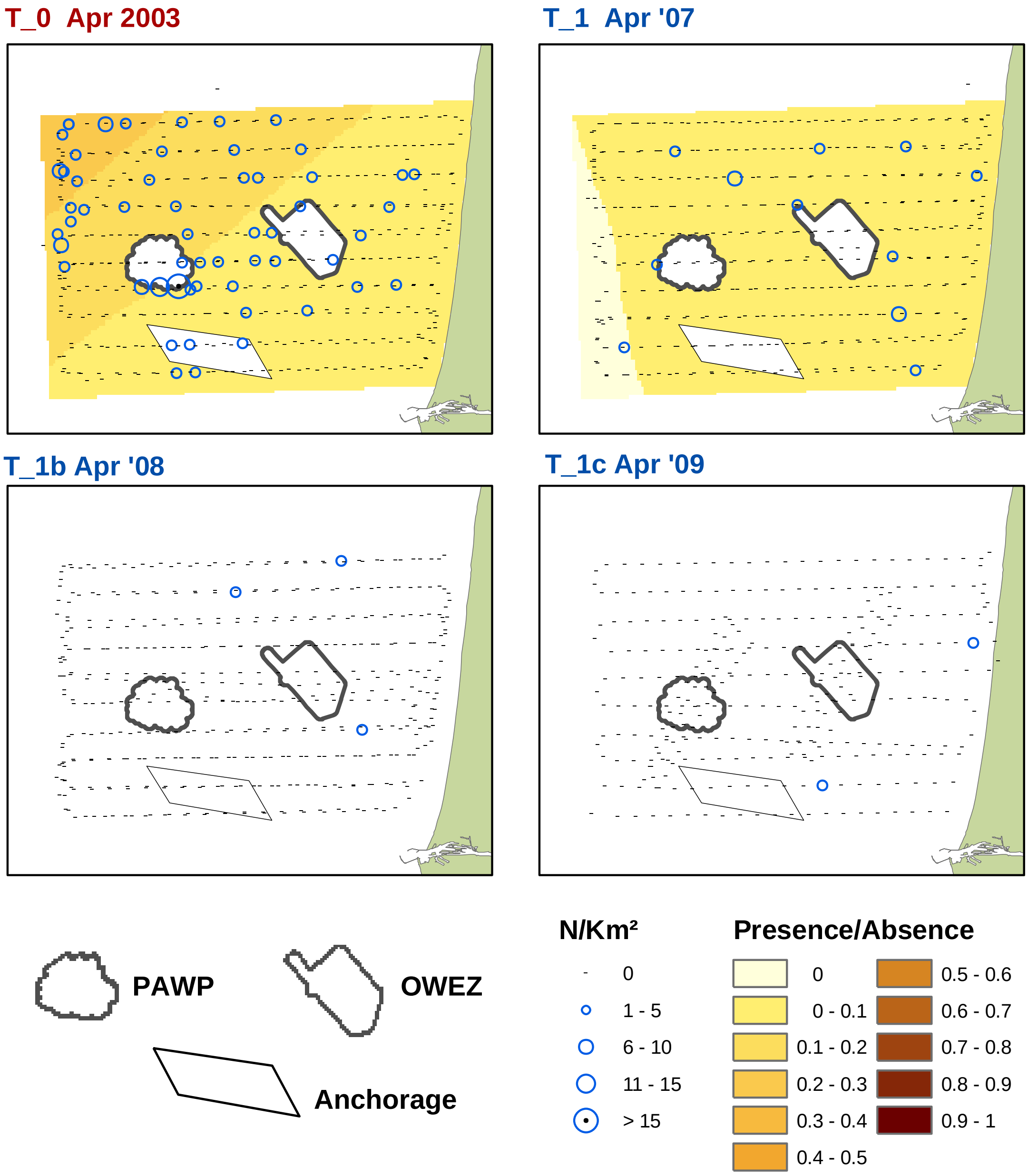
T_1 Jan '08
T_1b Jan '09
T_1c Jan '10
T_1c Feb '10
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
PAWP
OWEZ
Anchorage

Divers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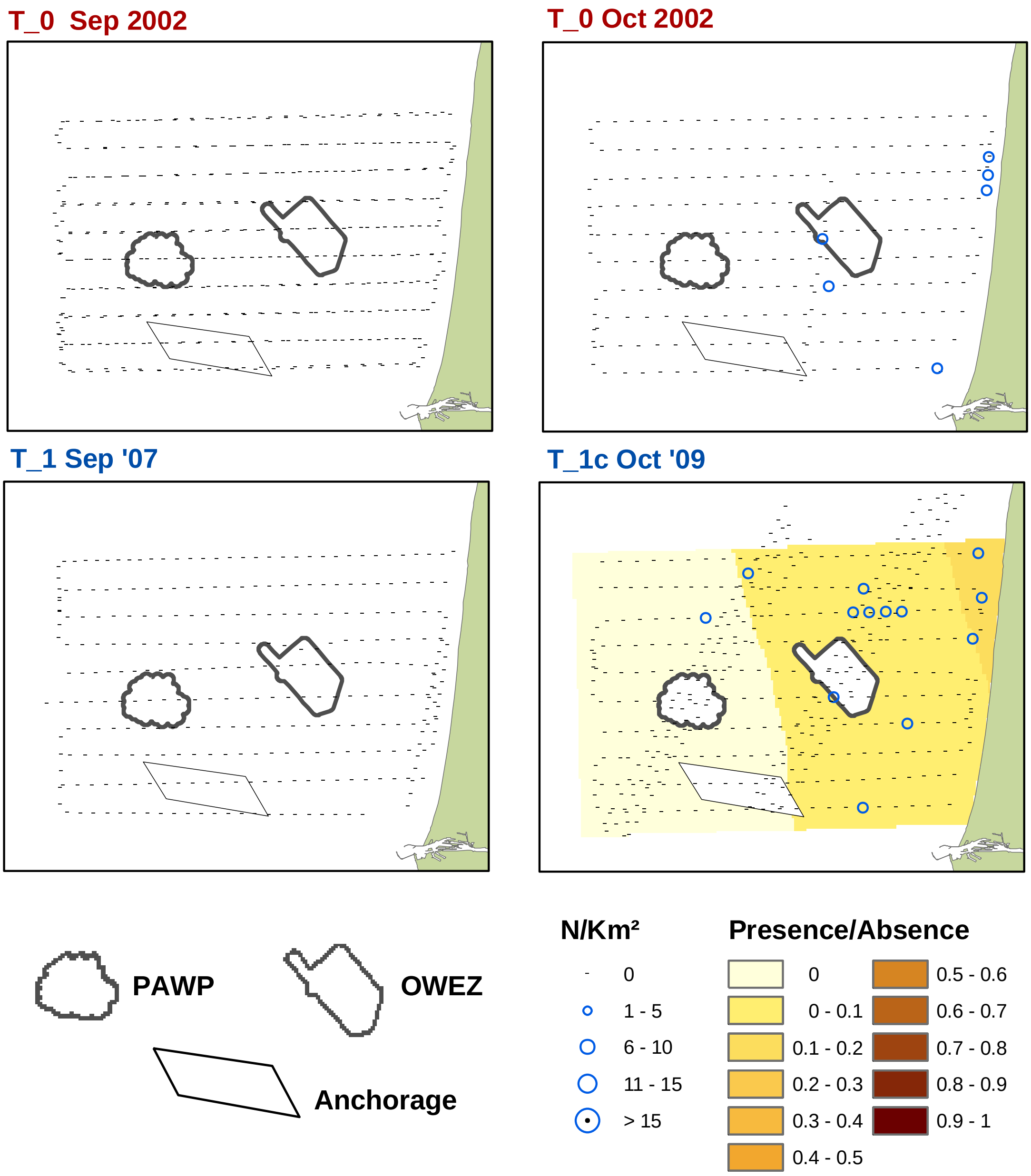
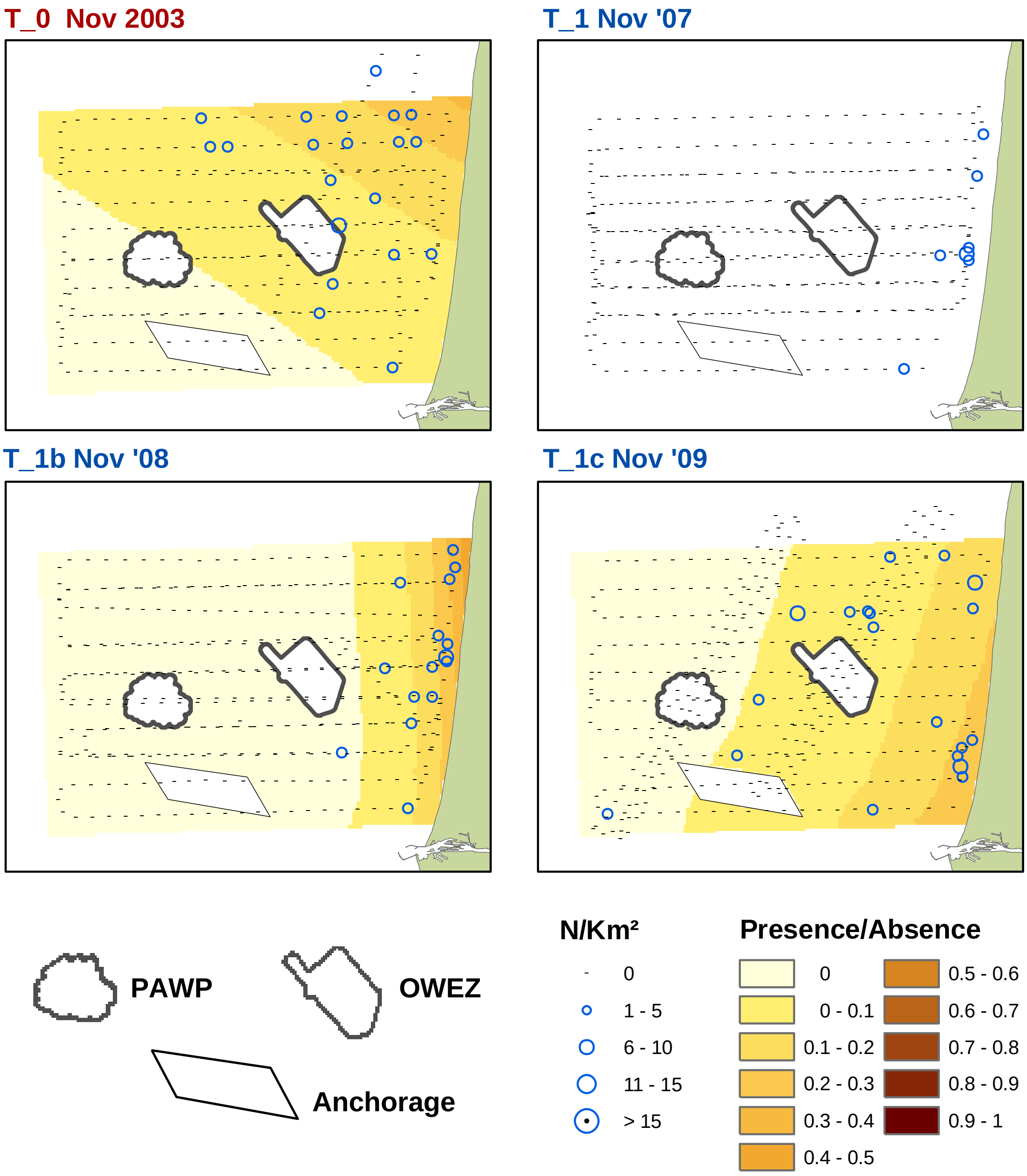
T_1 Apr '07
T_1b Apr '08
T_1c Apr '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Divers


T_0 Sep 2002
T_0 Oct 2002
T_1 Sep '07
T_1c Oct '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Divers



T_0 Nov 2003
T_1 Nov '07
T_1b Nov '08
T_1c Nov '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Great Crested Grebe *Podiceps cristatus* (Fuut)

Figure 16. *Part of a larger wintering flock of Great Crested Grebes, off the coast near Egmond aan Zee, Noord-Holland, February 2010. Photo: Steve Geelhoed, IMARES.*

Since the turn of the century, Great Crested Grebes have been wintering in increasing numbers in North Sea coastal waters off the Dutch mainland coast. Total numbers have been estimated at 28,000 birds, with significant numbers due east of the wind farms (Leopold et al. in prep.). An increasing trend was also apparent in the series of OWEZ mid-winter surveys. Relatively small numbers were seen during the first mid-winter survey, in February 2004 (108), compared to much larger numbers during the T-1 mid-winter surveys in 2008-2010 (510-912). Grebes were only seen in good numbers during the mid-winter surveys (Table 6); low numbers were seen during spring and autumn surveys; no grebes were seen in summer.

The distribution patterns were always very similar. Very highest densities were found in all winter surveys closely inshore, tapering off very quickly to zero a few kilometres into the sea. The location of OWEZ is clearly beyond the normal realm of the Grebes, although some stray ones were found on either side (but never within) OWEZ. The extra survey lines sailed in January 2010 highlighted this, resulting in lowered probabilities of occurrence of grebes within the OWEZ perimeter. Only in January 2010 significant avoidance was found (Table 7, Figure 17) and although distribution patterns in January and February 2010 were quite similar, the February survey produced just too few sighting of grebes south of the wind farm to get significant results. However, even though grebes tended to avoid the wind farm, densities at offshore latitudes around OWEZ are mostly so low, that this avoidance effects only small numbers of grebes (Figure 17).

Month	year	Survey	N
2	2004	T-0	108
1	2008	T-1a	698
1	2009	T-1b	764
1	2010	T-1c	912
2	2010	T-1c	510
4	2003	T-0	6
4	2007	T-1a	2
4	2008	T-1b	6
4	2009	T-1c	0
9	2002	T-0	2
10	2002	T-0	2
9	2007	T-1a	0
10	2009	T-1c	0
11	2003	T-0	16
11	2007	T-1a	32
11	2008	T-1b	10
11	2009	T-1c	18

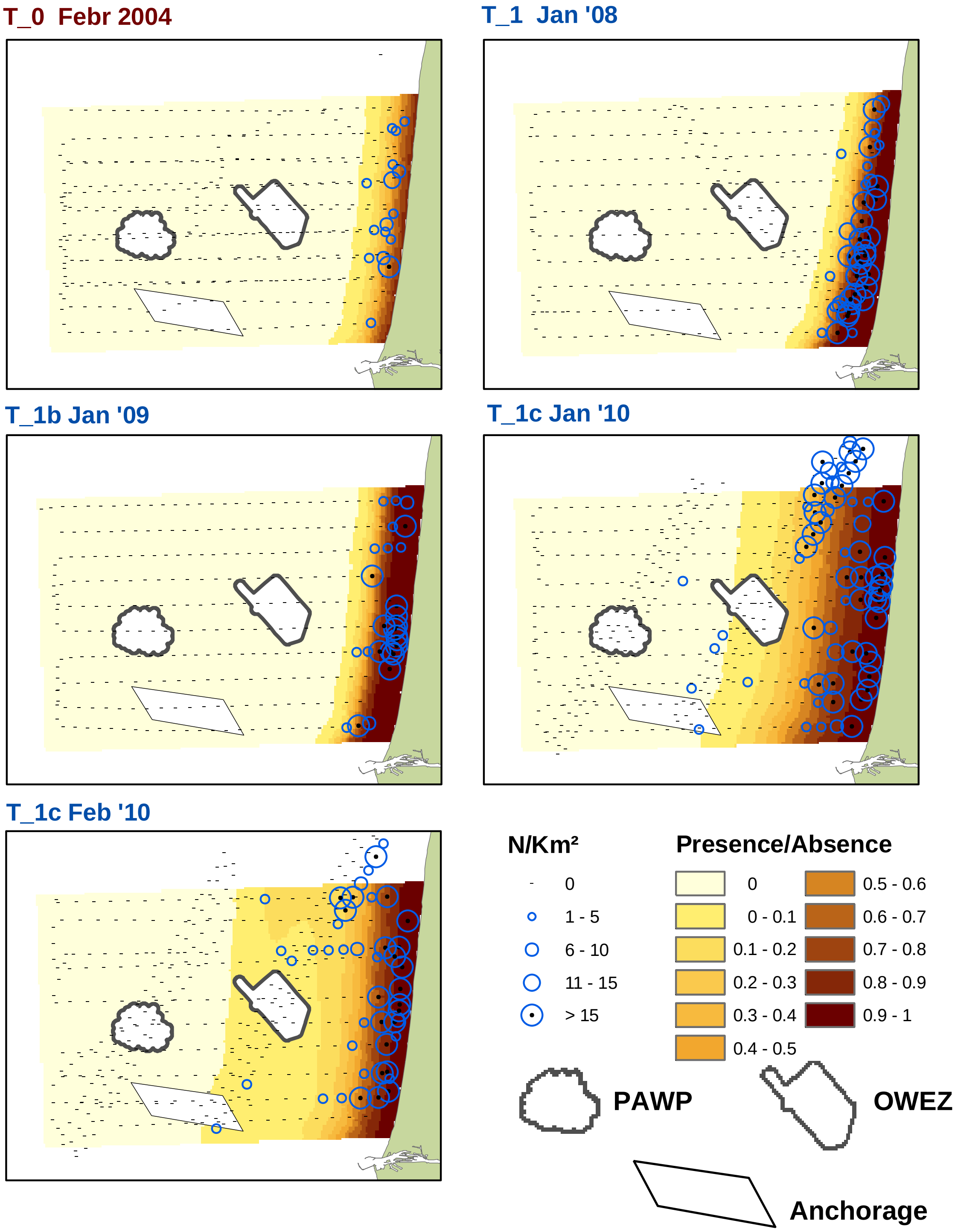
Table 6. *Total numbers of Great Crested Grebes seen during the surveys (sets of surveys without grebe observations omitted). All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	**0.000**	0.844	1.000	0.984	-	GAMM	NA	16
2008	1	**0.000**	0.000	1.000	1.000	-	GAM	0.79	40
2009	1	**0.000**	0.933	1.000	0.996	-	GAMM	NA	33
2010	1	**0.000**	0.980	**0.000**	**0.000**	-	GAMM	NA	69
2010	2	**0.000**	0.061	1.000	1.000	-	GAM	0.58	51
2003	4	NA	NA	NA	NA	NA	ins. data	NA	2
2007	4	NA	NA	NA	NA	NA	ins. data	NA	0
2008	4	NA	NA	NA	NA	NA	ins. data	NA	1
2009	4	NA	NA	NA	NA	NA	ins. data	NA	0
2003	6	NA	NA	NA	NA	NA	ins. data	NA	0
2007	6	NA	NA	NA	NA	NA	ins. data	NA	0
2008	6	NA	NA	NA	NA	NA	ins. data	NA	0
2009	6	NA	NA	NA	NA	NA	ins. data	NA	0
2003	8	NA	NA	NA	NA	NA	ins. data	NA	0
2007	8	NA	NA	NA	NA	NA	ins. data	NA	0
2008	8	NA	NA	NA	NA	NA	ins. data	NA	0
2002	9	NA	NA	NA	NA	NA	ins. data	NA	0
2002	10	NA	NA	NA	NA	NA	ins. data	NA	0
2007	9	NA	NA	NA	NA	NA	ins. data	NA	0
2009	10	NA	NA	NA	NA	NA	ins. data	NA	0
2003	11	NA	NA	NA	NA	NA	ins. data	NA	2
2007	11	NA	NA	NA	NA	NA	ins. data	NA	9
2008	11	NA	NA	NA	NA	NA	ins. data	NA	2
2009	11	NA	NA	NA	NA	NA	ins. data	NA	2

Table 7. *Modelling results (presence/absence) for Great Crested Grebes. Significant contributions (P<0.1) are put in **bold**. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column Est_OWEZ) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 17 (overleaf). *Distribution maps of Great Crested Grebes, for the only set of months (January/February) in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one grebe in transect; see Table 7). All maps show the coastline of Noord-Holland, and the outlines of the two wind farms and the anchorage area. Counts without grebes indicated by -.*

Great Crested Grebe



Northern Fulmar *Fulmarus glacialis* (Noordse Stormvogel)

Figure 18. *Northern Fulmar, in the western part of the study area in high winds (6 Bft). Photo: Hans Verdaat, IMARES.*

Most Fulmars were seen during the T-0 and T-1a winter and spring surveys. A remarkable drop in numbers was noted during all T-1b and T-1c surveys (Table 8), compared to the earlier surveys. Typically, Fulmars were seen in the western parts of the study area and when sufficient numbers per survey for modelling were available, distance to coast contributed significantly to the distribution pattern. With only one T-1 survey with sufficient data (Table 9 and Figure 19) and low numbers of Fulmars around the OWEZ latitudes, there is little scope for exploring possible effects in this offshore species by these two relatively nearshore wind farms. The modelling results for the T-1a April survey (Table 9) do not show a clear influence of OWEZ on the distribution pattern of this species (and neither do the results for the two T-0 surveys that hold sufficient data). Fulmars were never seen to enter either wind farm during the T-1 phase of the project, but numbers of Fulmars were mostly so low then, that this was hardly possible (Figure 19). Results for this species are therefore inconclusive.

Month	year	Survey	N
2	2004	T-0	114
1	2008	T-1a	20
1	2009	T-1b	4
1	2010	T-1c	0
2	2010	T-1c	0
4	2003	T-0	142
4	2007	T-1a	238
4	2008	T-1b	6
4	2009	T-1c	0
6	2003	T-0	24
6	2007	T-1a	84
6	2008	T-1b	0
6	2009	T-1c	0
8	2003	T-0	24
8	2007	T-1a	12
8	2008	T-1b	0
9	2002	T-0	62
10	2002	T-1a	42
9	2007	T-1b	30
10	2009	T-1c	0
11	2003	T-0	10
11	2007	T-1a	8
11	2008	T-1b	0
11	2009	T-1c	0

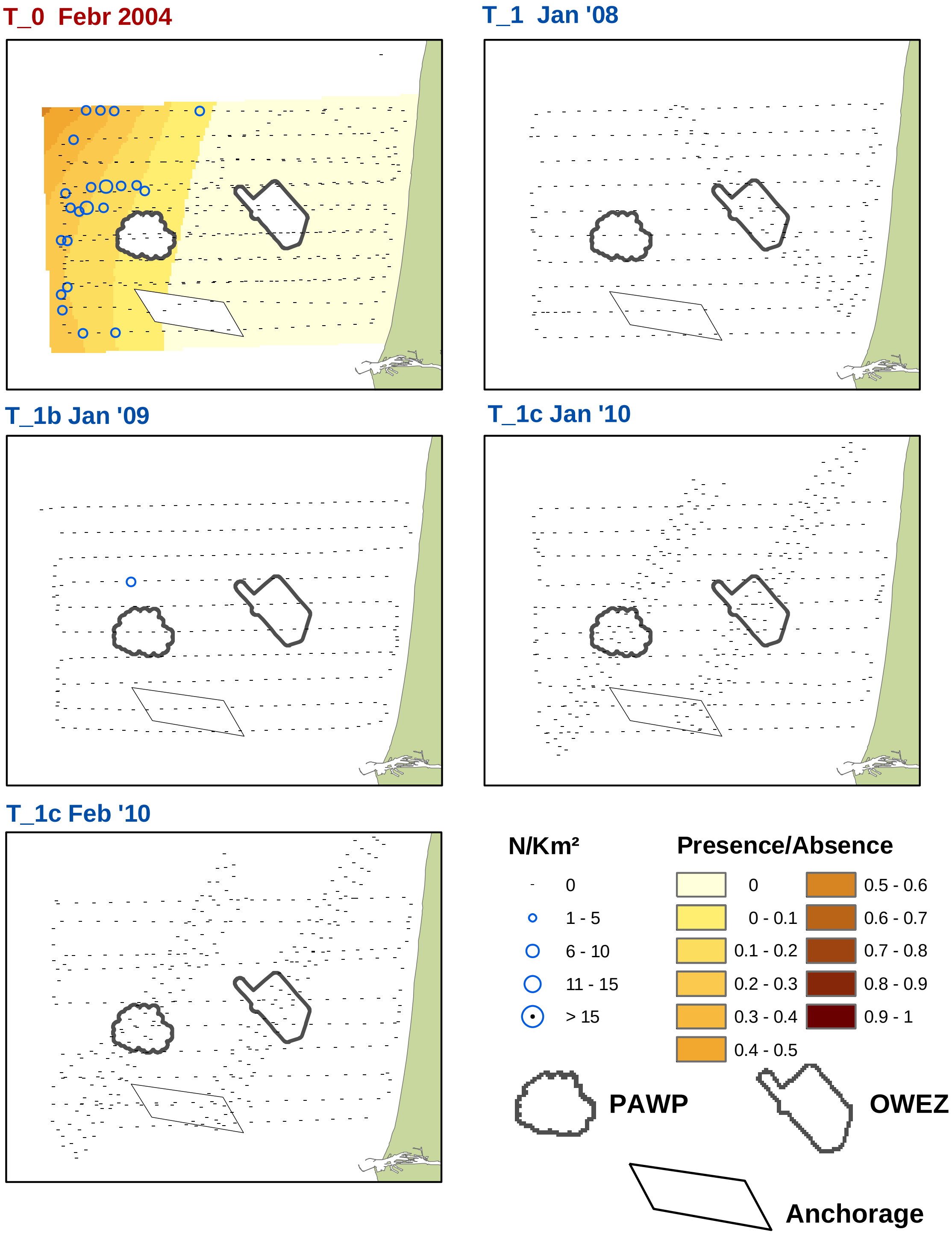
Table 8. *Total numbers of Fulmars seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	**0.004**	**0.005**	1.000	1.000	-	GAMM	0.36	22
2008	1	NA	NA	NA	NA	NA	ins. data	NA	0
2009	1	NA	NA	NA	NA	NA	ins. data	NA	1
2010	1	NA	NA	NA	NA	NA	ins. data	NA	0
2010	2	NA	NA	NA	NA	NA	ins. data	NA	0
2003	4	**0.000**	**0.016**	1.000	1.000	-	GAM	NA	15
2007	4	**0.001**	0.716	1.000	0.998	-	GAM	NA	35
2008	4	NA	NA	NA	NA	NA	ins. data	NA	0
2009	4	NA	NA	NA	NA	NA	ins. data	NA	0
2003	6	NA	NA	NA	NA	NA	ins. data	NA	4
2007	6	NA	NA	NA	NA	NA	ins. data	NA	9
2008	6	NA	NA	NA	NA	NA	ins. data	NA	0
2009	6	NA	NA	NA	NA	NA	ins. data	NA	0
2003	8	NA	NA	NA	NA	NA	ins. data	NA	1
2007	8	NA	NA	NA	NA	NA	ins. data	NA	1
2008	8	NA	NA	NA	NA	NA	ins. data	NA	0
2002	9	NA	NA	NA	NA	NA	ins. data	NA	9
2002	10	NA	NA	NA	NA	NA	ins. data	NA	4
2007	9	NA	NA	NA	NA	NA	ins. data	NA	1
2009	10	NA	NA	NA	NA	NA	ins. data	NA	0
2003	11	NA	NA	NA	NA	NA	ins. data	NA	3
2007	11	NA	NA	NA	NA	NA	ins. data	NA	0
2008	11	NA	NA	NA	NA	NA	ins. data	NA	0
2009	11	NA	NA	NA	NA	NA	ins. data	NA	0

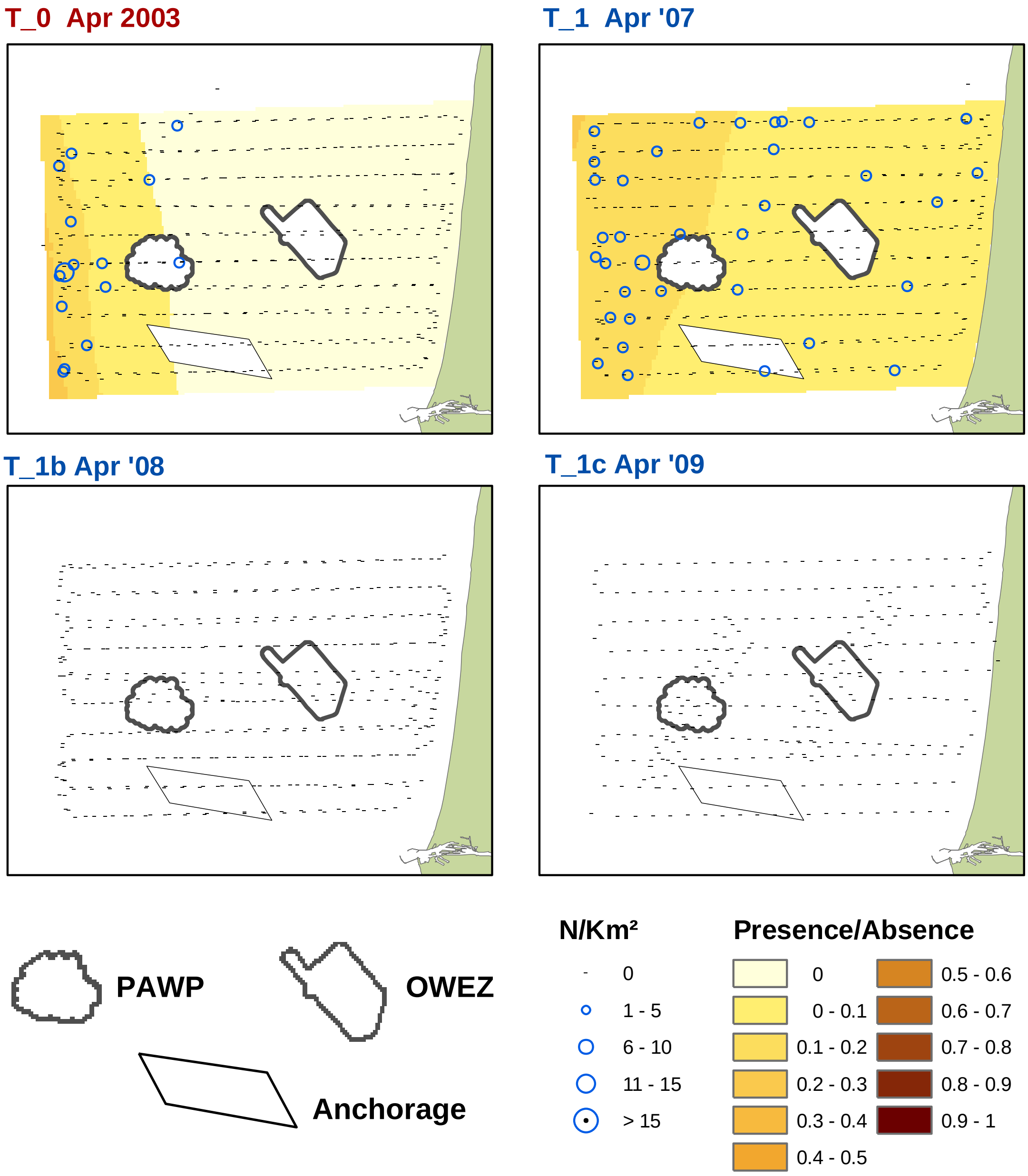
Table 9. *Modelling results (presence/absence) for Northern Fulmars. Significant contributions (P<0.1) are put in **bold**. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ*) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 19 (overleaf): *Distribution maps of Northern Fulmars, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Fulmar in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Fulmars indicated by -.*

Northern Fulmar



Northern Fulmar



Northern Gannet *Morus bassanus* (Jan van Gent)

Figure 20. *Northern Gannet, taking a close look at the seabird observers, January 2010. Photo: Hans Verdaat, IMARES.*

Gannets were seen in sufficient numbers (dozens to hundreds) in most surveys (Table 9) and the data usually showed some geographical structure, with significant contributions of the smoothers distance to coast and northing to the distribution. Exceptional numbers were seen in January 2009, particularly in the central northern part of the study area (Figure 21). This marked an unusual winter, with very high numbers of Gannets along the northern shores of the Netherlands (Arts 2009). Gannets are, in most years, most numerous in Dutch coastal waters in autumn (October-November; Leopold & Platteeuw 1987; Arts 2009), which is, to some extent, also visible in our data (Table 10). Gannets showed varying distribution patterns, often tending towards a slightly offshore distribution but they also occurred widely spread with nearshore concentrations at other times. Large numbers were seen nearshore, northeast of OWEZ in August 2003. Hundreds of Gannets (and gulls and terns) were circling, looking down into the water, but with little diving behaviour. Possibly, large fish schools were present, but swimming just too deep for the birds at the time of the passage of the research vessel. During this T-0 survey, higher than expected numbers were seen at OWEZ, but this was due to the proximity of the main concentration (Figure 21). Generally, Gannets occurred on all sides of the wind farms, but only rarely within the perimeters of either wind farm during the T-1 surveys (Table 11; Figure 21). The modelling results therefore show OWEZ to have a negative coefficient during most T-1 surveys (Table 11; and significant avoidance on two occasions). Only in September 2007 (T-1b) was a small flock of 6 Gannets seen just within the OWEZ perimeter, resulting in a positive but non-significant coefficient for OWEZ (Table 11). Mostly, Gannets flew around the wind farms and those few birds that did enter, only went “one turbine deep” into the wind farm, crossing the site at its fringe. This is in contrast to several situations during T-0, when Gannets did not avoid the (then future) locations of the wind farms (note the positive coefficients for OWEZ in most T-0 surveys; one of them significant). During T-1, Gannets were never seen to enter PAWP, with its higher turbine density as compared to T-0. The single Gannet seen at the fringe of PAWP in November 2009 (Figure 21) was in fact seen just east of the perimeter.

Hesitance of Gannets to enter the wind farm during the T-1 surveys was also apparent in the Gannets' behaviour (Krijgsveld et al. 2009): birds on a flight path towards the wind farm mostly veered off course shortly before they would have entered the wind farm. Only some birds cut through the wind farm, mostly just around one of the outer turbines, and mostly during high winds. These observations are very similar to our experience within the OWEZ perimeter. Gannets flying into the wind farm invariably descended to a low altitude, stopped apparent searching behaviour (which in Gannets is characterized by flying at 10-40 m above sea level with the bill pointing downward), and cut through the wind farm quickly and at only 1 or 2 m above sea level (bill pointing forward). No searching (bill pointing downward), feeding (diving) or resting (swimming on the water's surface) was seen in any of the wind farms during any of the T-1 surveys.

Month	year	Survey	N
2	2004	T-0	34
1	2008	T-1a	22
1	2009	T-1b	2079
1	2010	T-1c	51
2	2010	T-1c	414
4	2003	T-0	293
4	2007	T-1a	82
4	2008	T-1b	364
4	2009	T-1c	14
6	2003	T-0	42
6	2007	T-1a	55
6	2008	T-1b	51
6	2009	T-1c	4
8	2003	T-0	647
8	2007	T-1a	65
8	2008	T-1b	191
9	2002	T-0	378
10	2002	T-1a	70
9	2007	T-1b	708
10	2009	T-1c	65
11	2003	T-0	103
11	2007	T-1a	277
11	2008	T-1b	423
11	2009	T-1c	457

Table 10. *Total numbers of Gannets seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	NA	NA	NA	NA	NA	ins. data	NA	8
2008	1	NA	NA	NA	NA	NA	ins. data	NA	3
2009	1	**0.090**	**0.000**	**0.000**	0.751	-	GAMM	NA	47
2010	1	NA	NA	NA	NA	NA	ins. data	NA	7
2010	2	**0.000**	**0.000**	1.000	1.000	-	GAM	0.13	49
2003	4	**0.000**	**0.003**	**0.000**	**0.000**	+	GAMM	NA	37
2007	4	NA	NA	NA	NA	NA	ins. data	NA	5
2008	4	**0.000**	0.891	**0.000**	**0.000**	-	GAMM	NA	42
2009	4	NA	NA	NA	NA	NA	ins. data	NA	1
2003	6	NA	NA	NA	NA	NA	ins. data	NA	5
2007	6	NA	NA	NA	NA	NA	ins. data	NA	10
2008	6	**0.014**	0.296	0.866	0.985	-	GAMM	NA	12
2009	6	NA	NA	NA	NA	NA	ins. data	NA	0
2003	8	0.955	**0.083**	**0.000**	0.394	+	GAMM	NA	70
2007	8	NA	NA	NA	NA	NA	ins. data	NA	9
2008	8	0.931	**0.000**	**0.000**	**0.000**	-	GAMM	NA	32
2002	9	**0.001**	0.654	0.240	0.140	+	GAMM	NA	39
2002	10	NA	NA	NA	NA	NA	ins. data	NA	6
2007	9	**0.003**	0.543	1.000	0.366	+	GAMM	NA	23
2009	10	0.473	0.682	1.000	1.000	-	GAMM	NA	17
2003	11	**0.005**	0.299	1.000	1.000	-	GAMM	NA	14
2007	11	**0.002**	0.302	1.000	1.000	-	GAM	0.07	27
2008	11	**0.000**	0.904	1.000	1.000	-	GAM	0.09	66
2009	11	**0.013**	**0.000**	1.000	1.000	-	1	0.1	48

Table 11. *Modelling results (presence/absence) for Northern Gannet. Significant contributions (P<0.1) are put in **bold**. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ) *are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 21 (overleaf): *Distribution maps of Northern Gannets, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Gannet in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Gannets indicated by -.*

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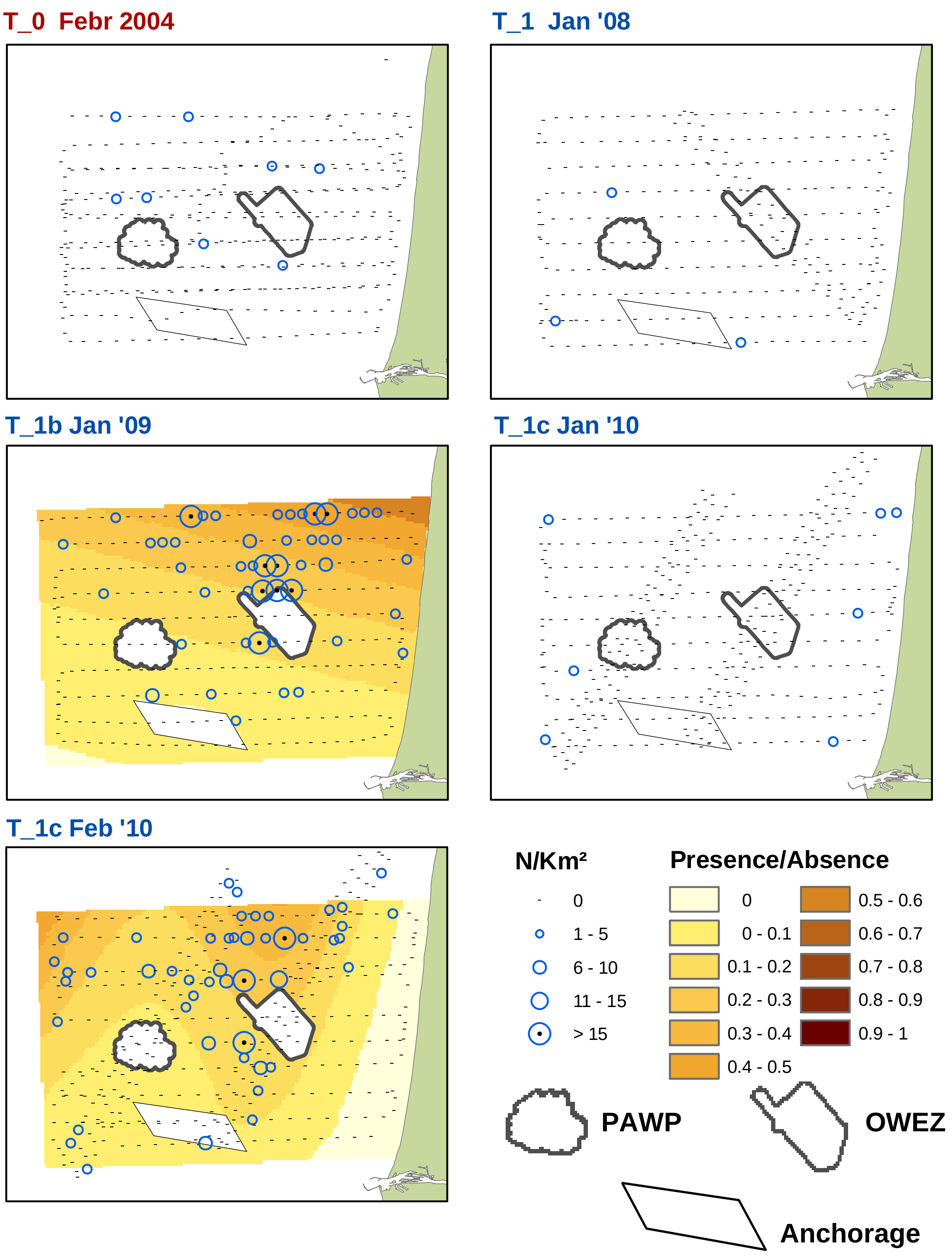
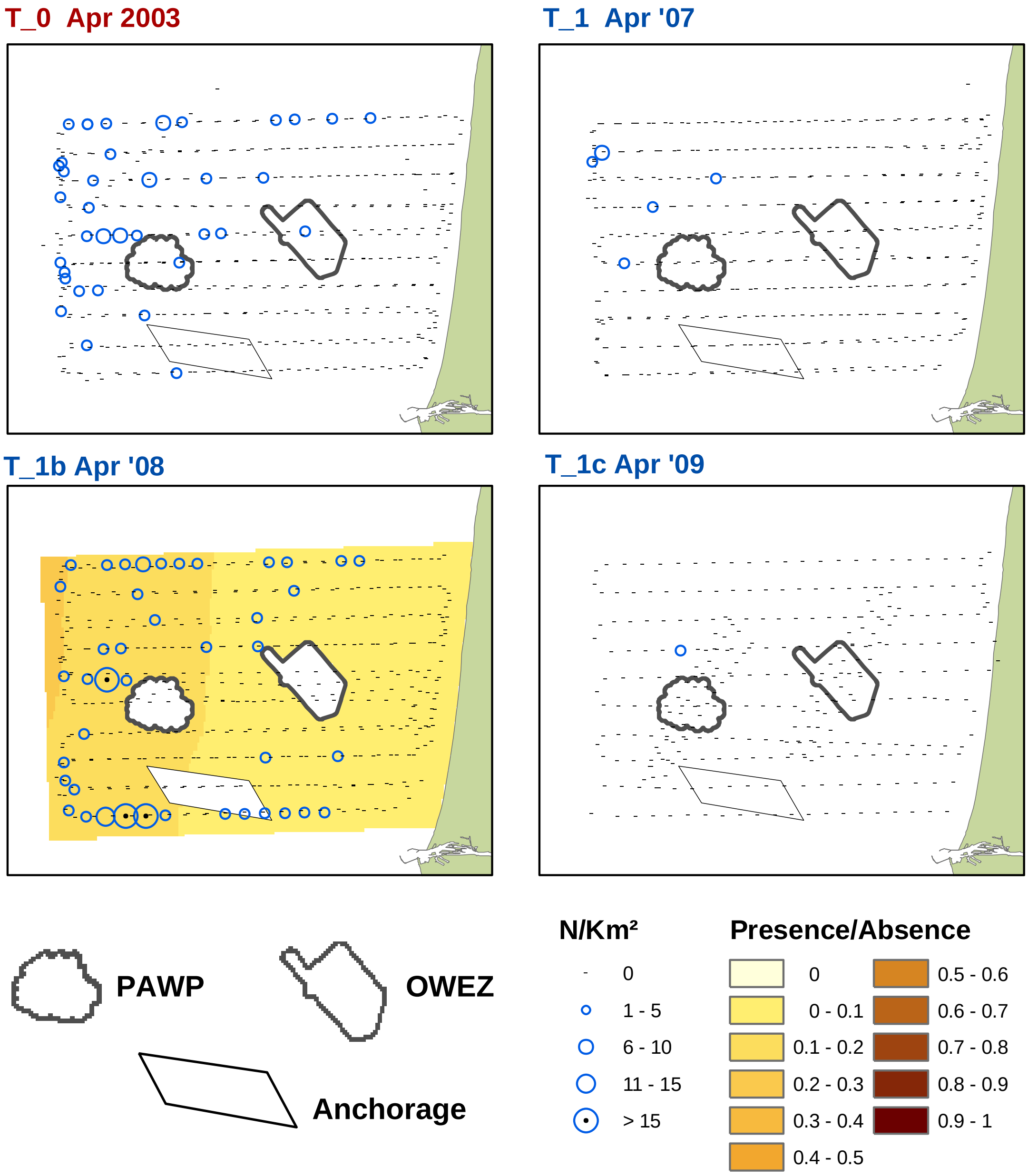
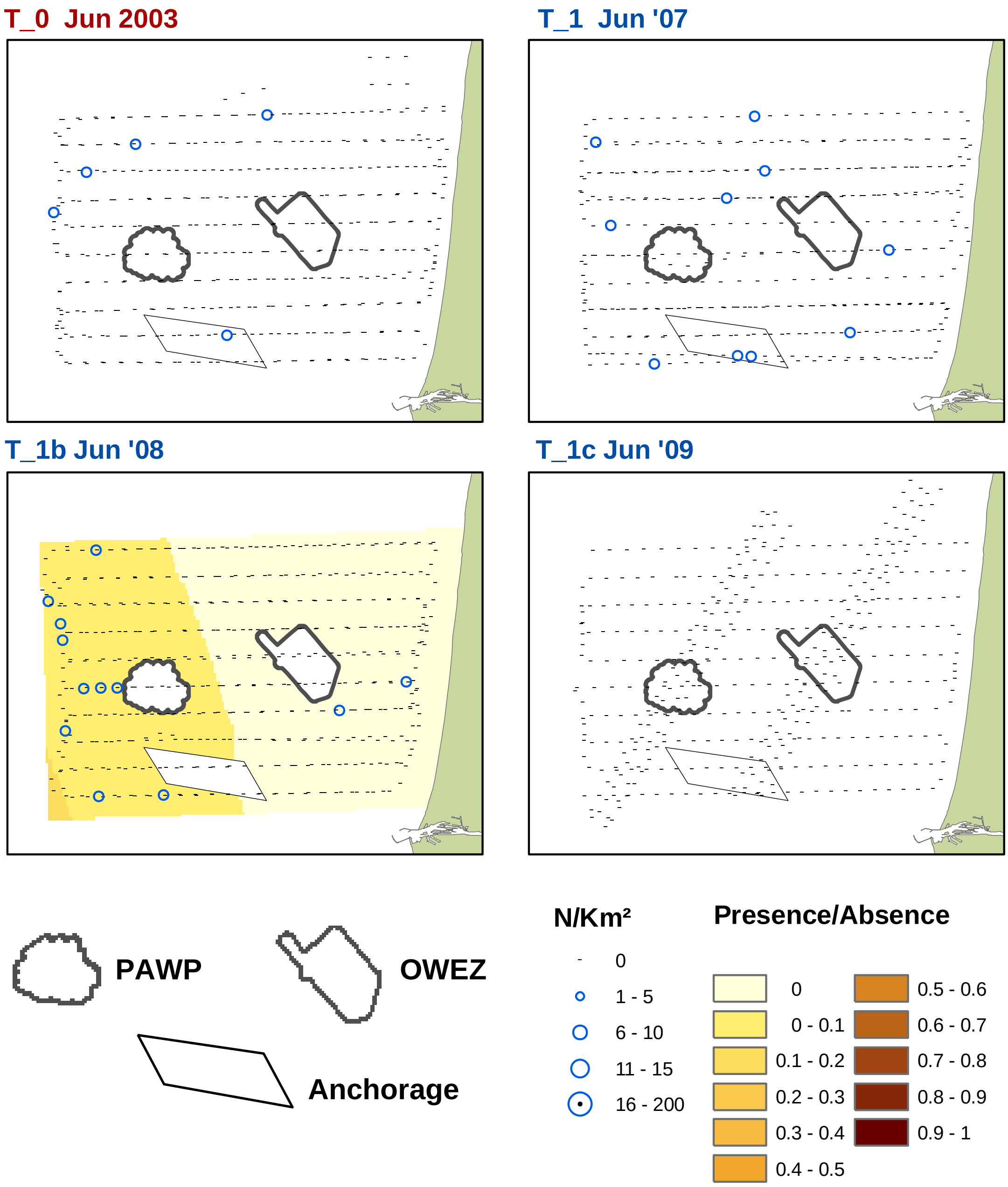
Northern Gannet



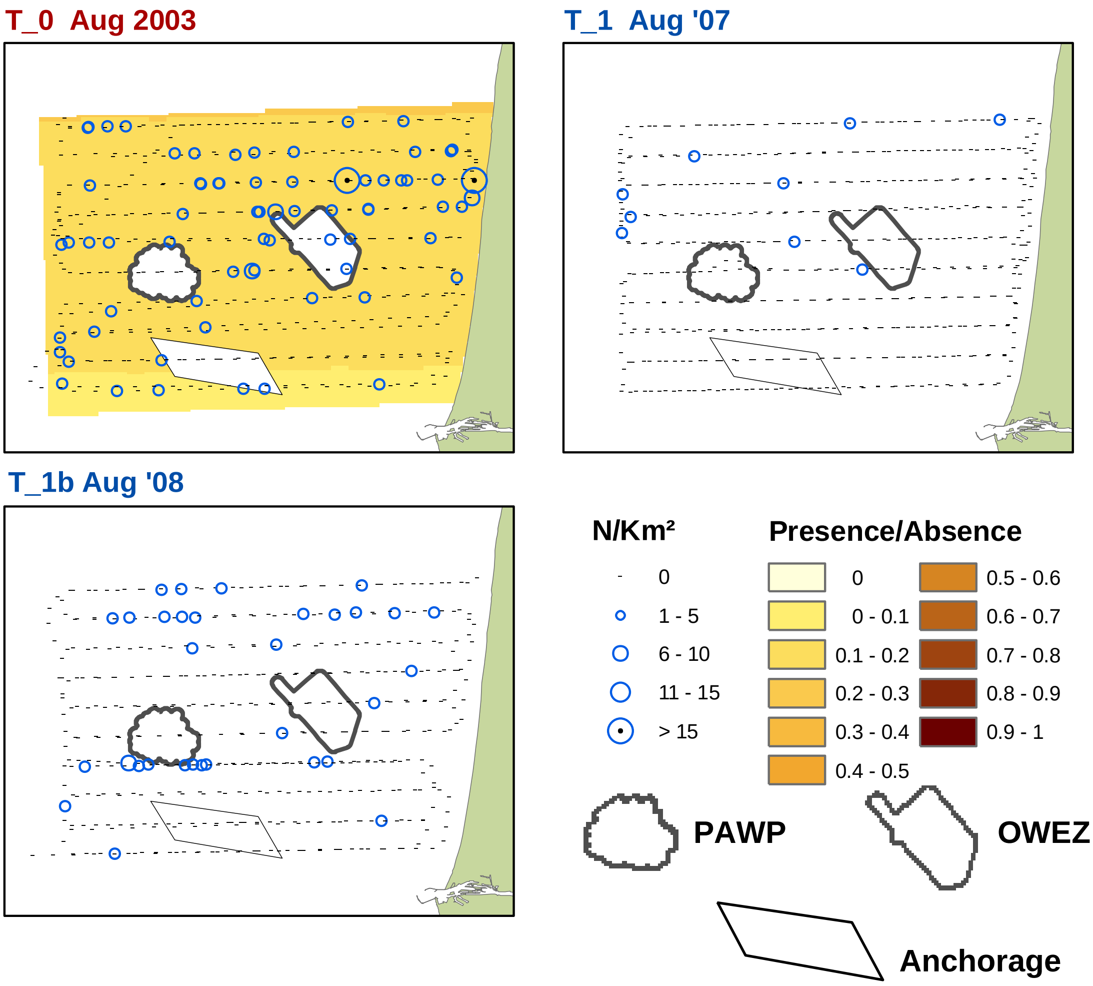
Northern Gannet



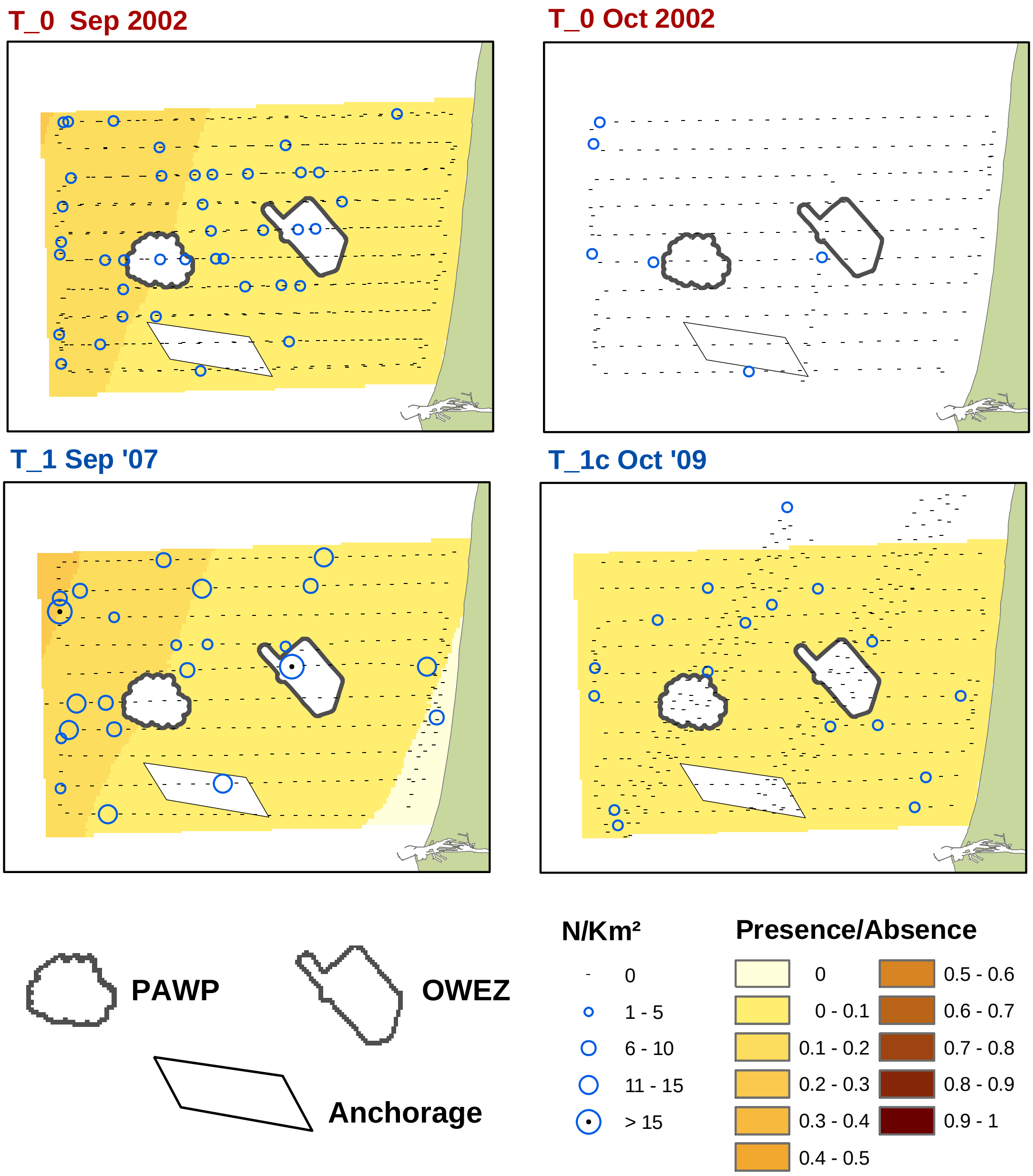
Northern Gannet



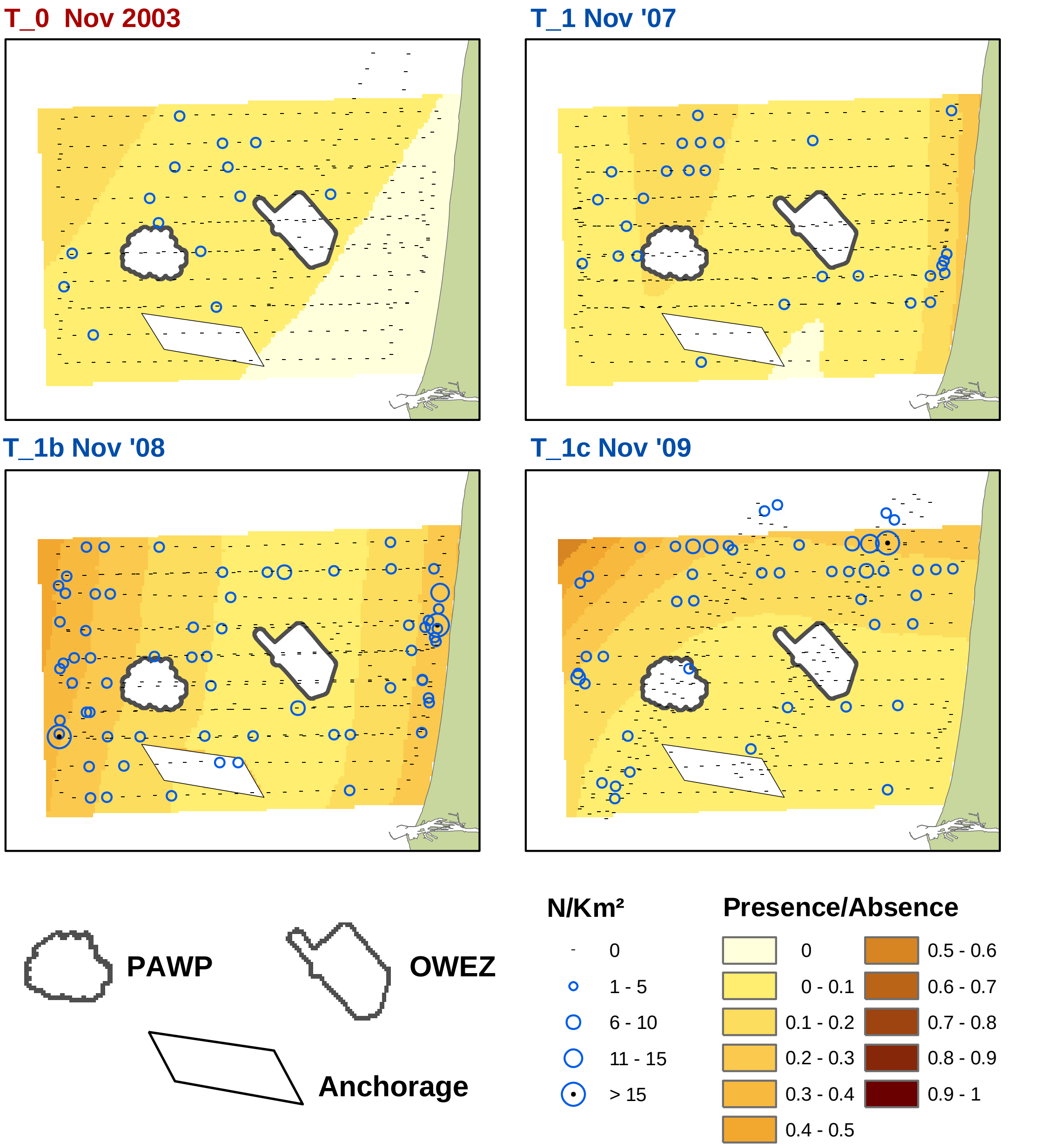
Northern Gannet



Northern Gannet



Northern Gannet



Great Cormorant *Phalacrocorax carbo* (Aalscholver)

Figure 22. *Two first-winter Great Cormorants, discussing the pros and cons of offshore wind farms, while resting on one of the PAWP foundation poles, 18 January 2010. Photo: Hans Verdaat, IMARES.*

Great Cormorants were seen during all surveys, with suitable numbers from spring through autumn and lower numbers in winter (Table 12) and the data usually showed clear geographical structure, with significant contributions of the smoothers distance to coast (more birds nearshore than offshore) and northing (often most birds centrally in the study area in this respect) to the distribution. Cormorants usually showed a clear-cut distribution pattern. Birds commuted between two breeding colonies on the mainland (Zwanenwater near Petten and Hoefijzermeer, near Castricum) to OWEZ and further on, to PAWF. These birds used the wind farms for resting and feeding. Typically, several dozens of birds rested on the met-mast on the seaward side of OWEZ and made short feeding trips to the sea below, both around the wind farm and inside the wind farm. Cormorants flew often, and without any visible hesitation, through the wind farm, at varying altitudes, including rotor height (cf Krijgsveld et al. 2009). Cormorants also used the foundation structures for resting (Figure 22) and occurred throughout OWEZ (flying, swimming, resting and feeding). The modelling results and distribution maps (Table 12; Figure 24) confirm these observations, showing clear attraction during many T-1 surveys (and indifference during T-0, when the wind farm sites were beyond the range of the Great Cormorants). However, Great Cormorants also occurred in large numbers around OWEZ, particularly on the landward side (commuting birds to and from colonies).

As some birds that were associated with OWEZ sometimes moved to the nearby gas platform, or foraged just outside the wind farm, the fact that Great Cormorants were attracted to the wind farm was even underestimated. Birds that moved temporarily outside the wind farm and that were seen there (and not inside the wind farm where they would have been some time before or after our observation), were noted as “outside the wind farm”.

Another important feature for the Great Cormorants in the area is an offshore gas-production platform just one km north of OWEZ. Cormorants used this platform as an alternative resting site when service personnel or ornithologists were working on the met-mast. Over 100 birds could be resting on this platform and the combination of the gas platform and the wind farms clearly attracted hundreds of Great Cormorants to the general area. Other concentrations occurred near the coast (unrelated to the wind farm) and in the wake of fishing vessels, where Great Cormorants competed with gulls for fishery waste (also unrelated to the wind farm; Figure 23). This hampers the statistical analysis as concentrations of Great Cormorants were found in different areas within the study area, for different reasons. Still, birds resting on the monopiles and met-mast could not have done this if the wind farm had not been built, so these birds were clearly attracted to the site.

Month	year	Survey	N
2	2004	T-0	20
1	2008	T-1a	81
1	2009	T-1b	217
1	2010	T-1c	145
2	2010	T-1c	197
4	2003	T-0	323
4	2007	T-1a	1080
4	2008	T-1b	683
4	2009	T-1c	137
6	2003	T-0	1393
6	2007	T-1a	2247
6	2008	T-1b	1171
6	2009	T-1c	717
8	2003	T-0	483
8	2007	T-1a	1234
8	2008	T-1b	1242
9	2002	T-0	338
10	2002	T-1a	92
9	2007	T-1b	512
10	2009	T-1c	983
11	2003	T-0	75
11	2007	T-1a	40
11	2008	T-1b	309
11	2009	T-1c	215

Figure 23. *Cormorant amongst the gulls in the wake of a fishing vessel near the Dutch mainland coast (arrow), April 2007. Photo: Hans Verdaat, IMARES.*

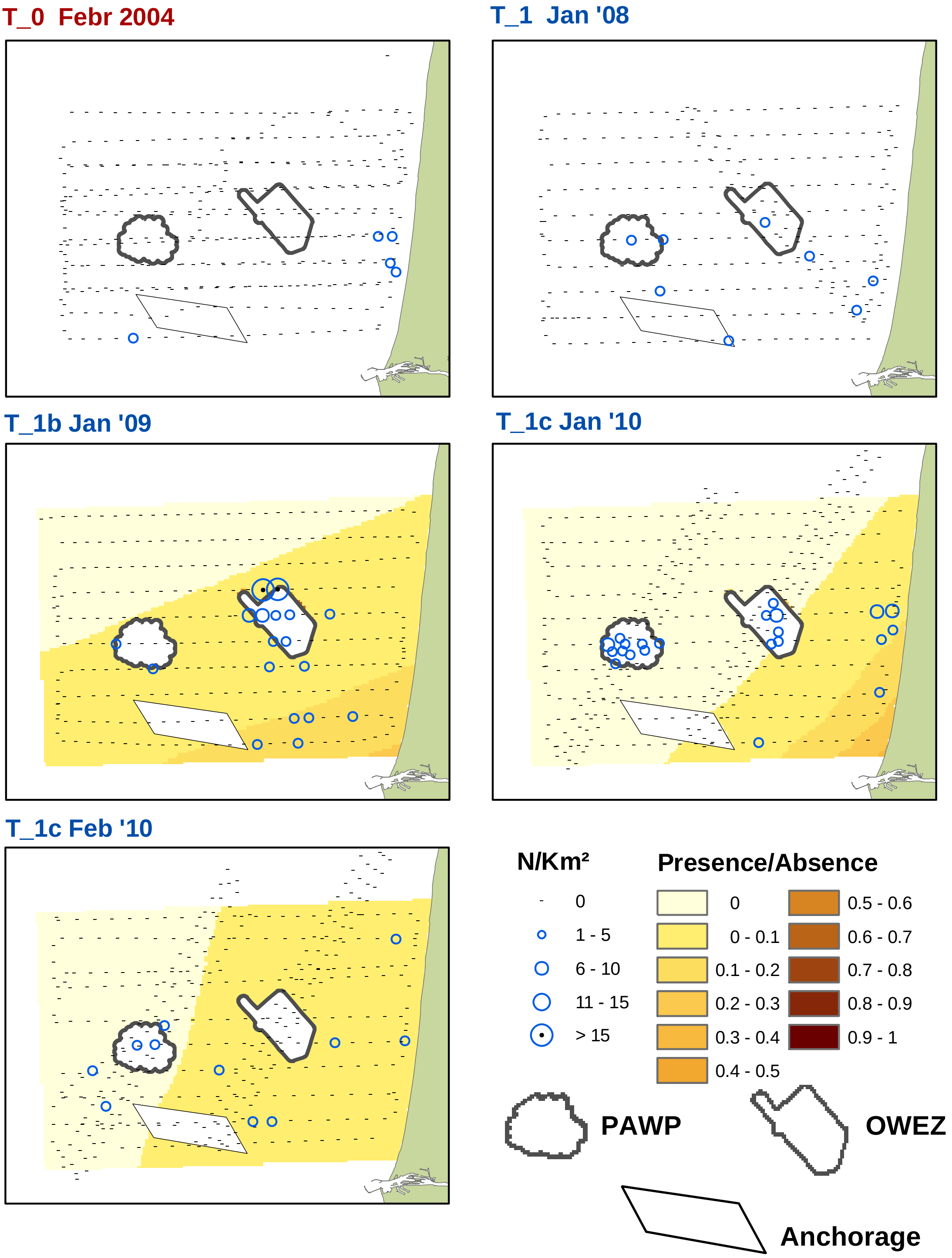
Table 12. *Total numbers of Great Cormorants seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	NA	NA	NA	NA	NA	ins. data	NA	5
2008	1	NA	NA	NA	NA	NA	ins. data	NA	8
2009	1	0.106	**0.020**	0.437	**0.000**	+	GAMM	NA	18
2010	1	**0.027**	0.131	**0.000**	**0.000**	+	GAMM	NA	22
2010	2	**0.090**	0.838	**0.000**	**0.000**	+	GAMM	NA	22
2003	4	**0.000**	0.966	**0.000**	0.812	-	GAMM	NA	16
2007	4	**0.000**	**0.000**	1.000	0.496	+	GAM	0.28	46
2008	4	**0.000**	**0.017**	**0.000**	**0.000**	+	GAMM	NA	44
2009	4	**0.000**	**0.006**	**0.000**	**0.008**	+	GAMM	NA	21
2003	6	**0.000**	0.774	**0.000**	**0.000**	-	GAMM	NA	42
2007	6	**0.035**	0.713	0.569	0.288	+	GAMM	NA	85
2008	6	**0.000**	**0.083**	**0.000**	**0.015**	+	GAMM	NA	44
2009	6	No	No	No	No	No	No	No	53
2003	8	**0.000**	0.162	**0.000**	**0.000**	-	GAMM	NA	30
2007	8	**0.000**	0.288	**0.000**	**0.003**	+	GAMM	NA	79
2008	8	**0.000**	**0.022**	**0.000**	**0.001**	+	GAMM	NA	71
2002	9	**0.000**	0.798	**0.000**	0.780	-	GAMM	NA	38
2002	10	**0.002**	**0.000**	1.000	0.637	-	GAM	0.29	11
2007	9	0.811	0.905	**0.028**	**0.065**	+	GAMM	NA	19
2009	10	**0.003**	**0.019**	**0.077**	0.191	+	GAMM	NA	48
2003	11	NA	NA	NA	NA	NA	ins. data	NA	3
2007	11	NA	NA	NA	NA	NA	ins. data	NA	7
2008	11	**0.000**	**0.000**	1.000	1.000	-	GAM	0.48	22
2009	11	**0.015**	0.198	**0.000**	**0.000**	+	GAMM	NA	42

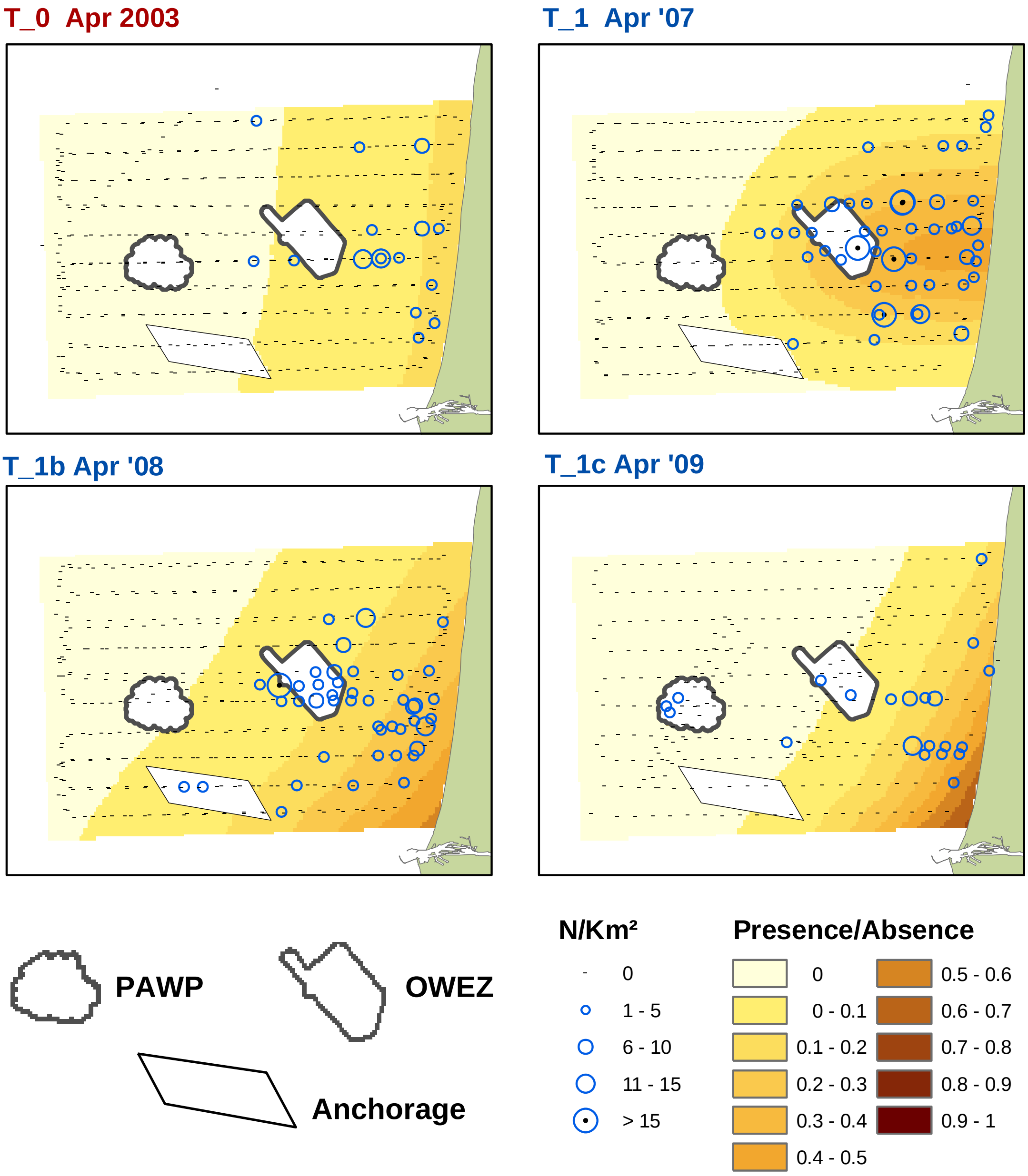
Table 13. *Modelling results (presence/absence) for Great Cormorant. Significant contributions (P<0.1) are put in **bold**. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ*) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 24 (overleaf): *Distribution maps of Great Cormorant, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Great Cormorant in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without cormorants indicated by -.*

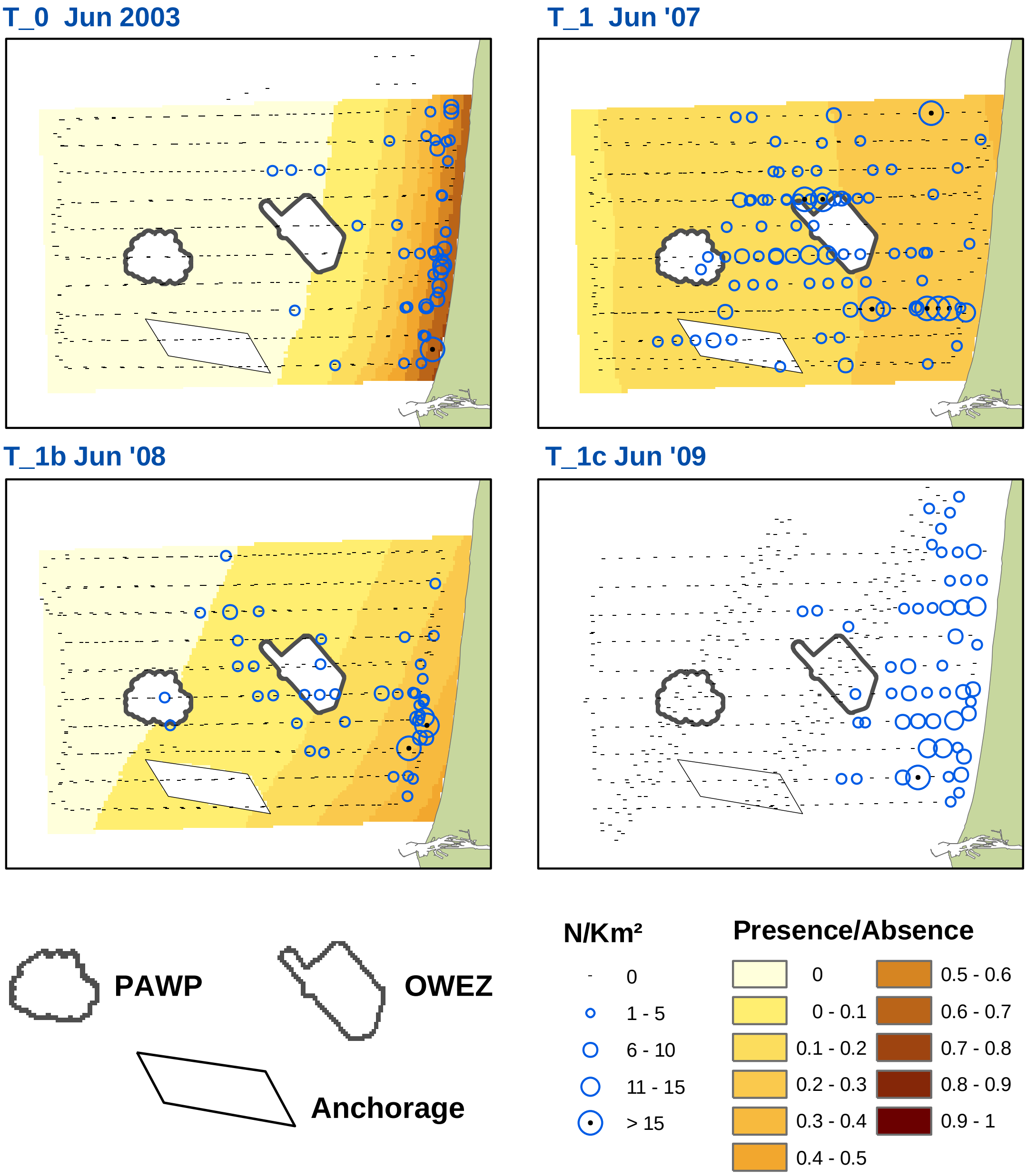
Great Cormorant



Great Cormorant

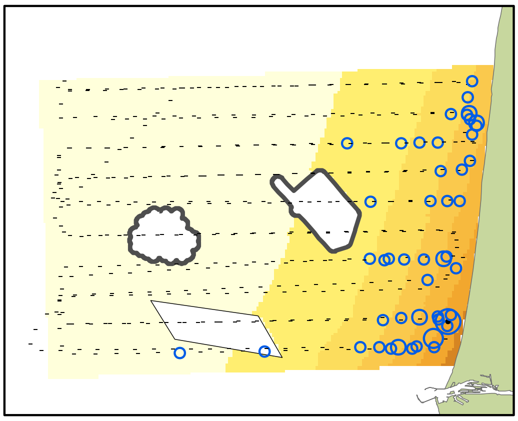


Great Cormorant

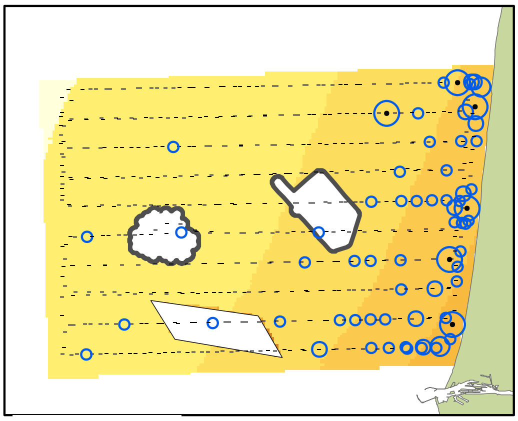


Great Cormorant

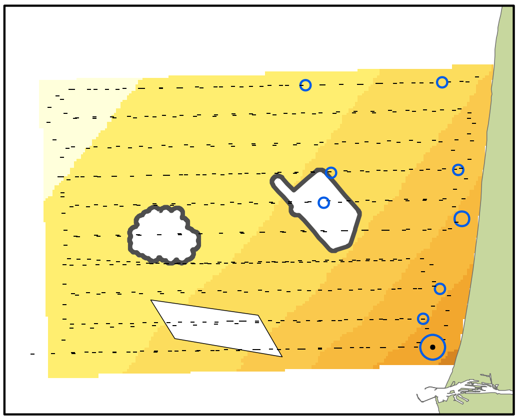
T_0 Aug 2003

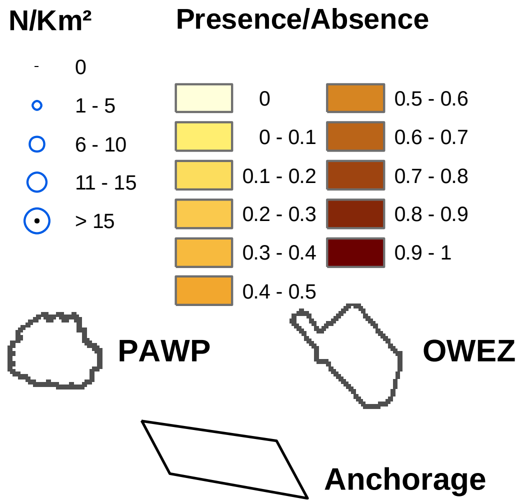


T_1 Aug '07

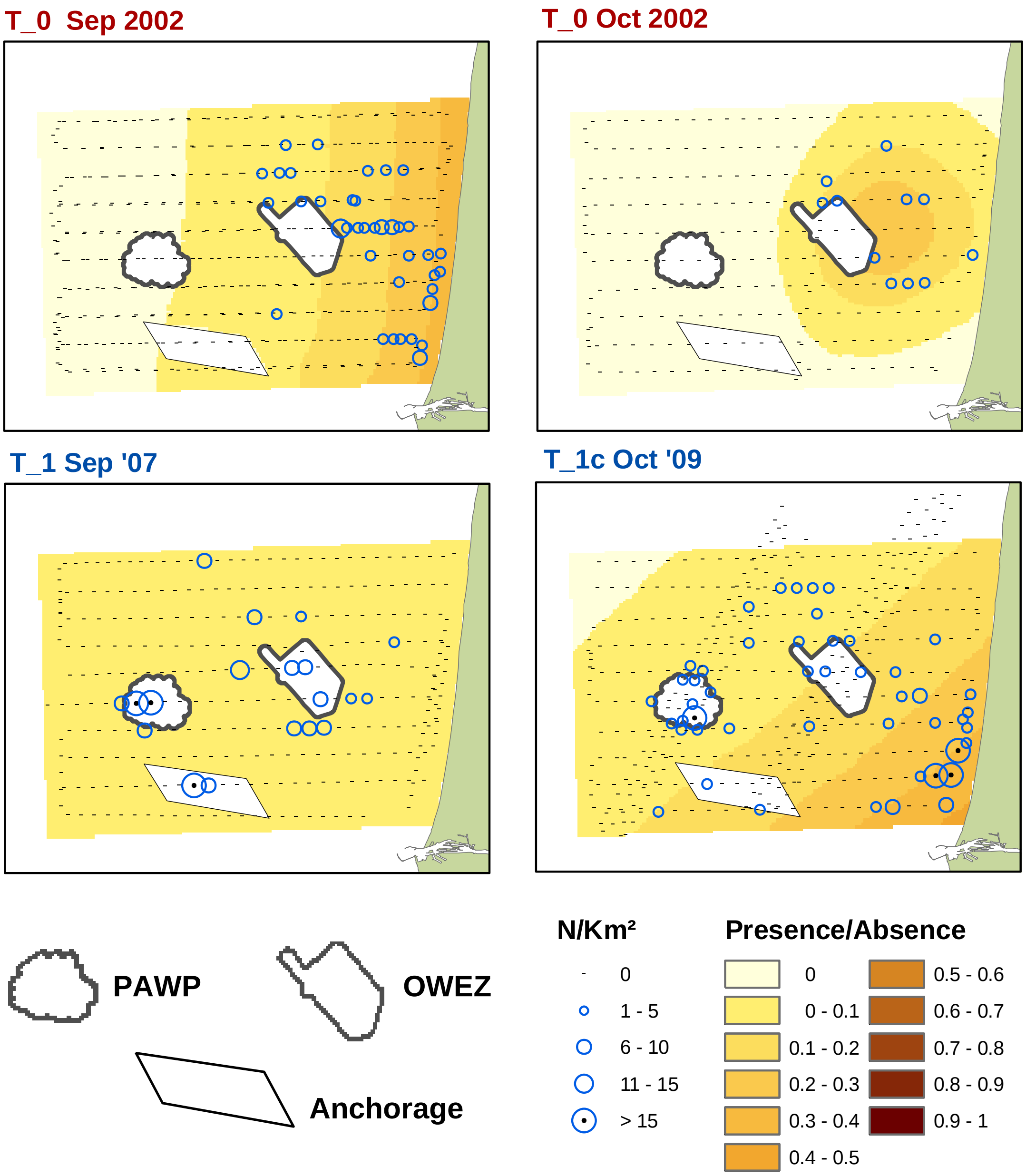


T_1b Aug '08

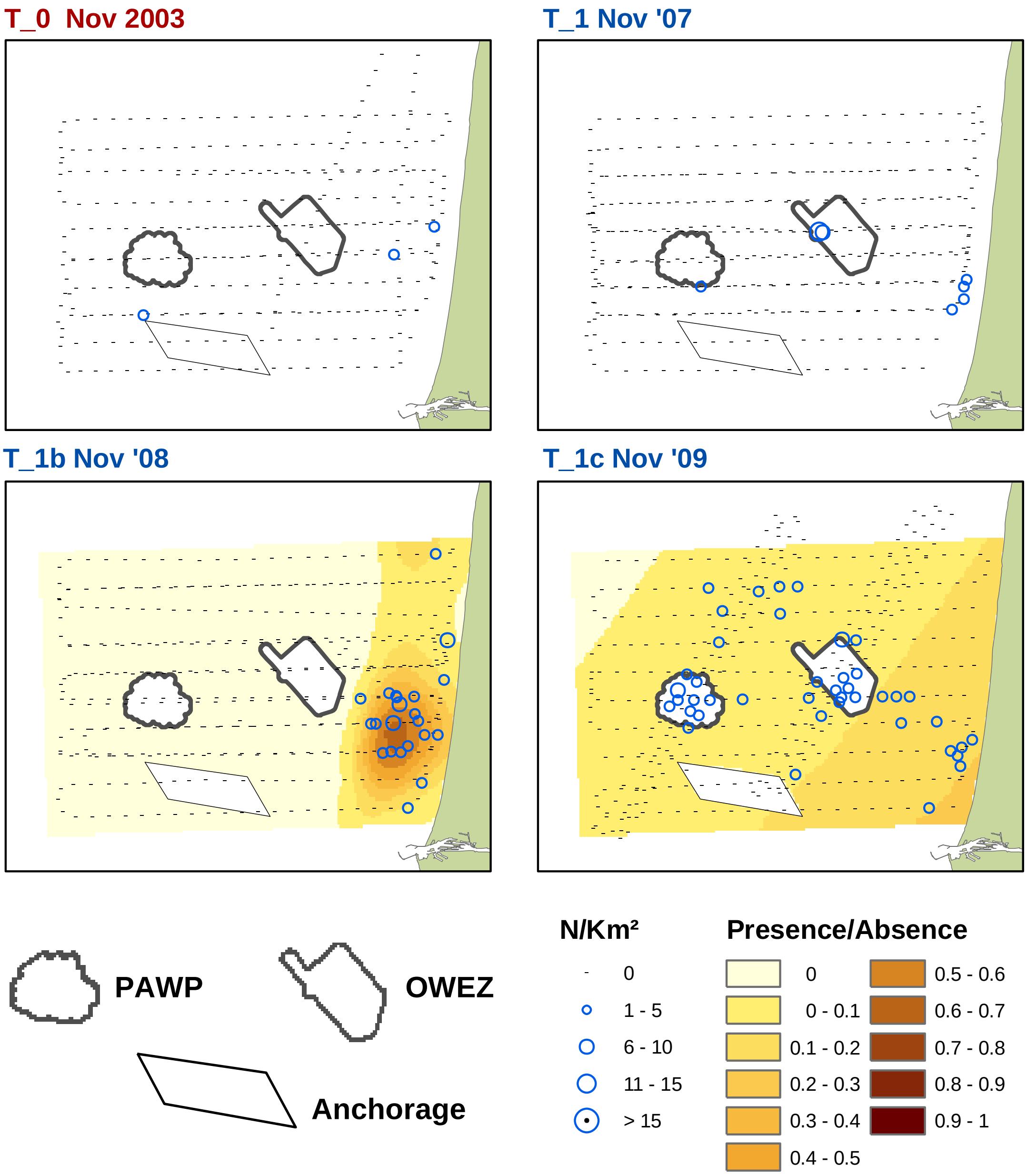




Great Cormorant



Great Cormorant



Common Scoter *Melanitta nigra* (Zwarte Zee-eend)

Figure 25. *Common Scoters flying northward along the Dutch mainland coast, 11 April 2007 Photo: Hans Verdaat, IMARES.*

Common Scoters (and Velvet Scoters *M. fusca* and Eiders *Somateria mollissima*) have used the coastal waters off Noord-Holland at times in large numbers (up to circa 100,000; Leopold et al. 1995) and because of this, the coastal waters north of the town of Bergen have been designated as a Natura 2000 site (see: Lindeboom et al. 2005). In recent years however, the staple food of these ducks, *Spisula subtruncata*, was largely absent and no large flocks of seaducks have been using the area since 1999 (Craeymeersch & Perdon 2006; Goudswaard et al. 2008; Baptist & Leopold 2009). When *Spisula* stocks were large off Noord-Holland, these shellfish occurred over a wide area, and the ducks, feeding on this resource were also found quite far offshore in these parts. OWEZ was within the range of these ducks when *Spisula* were plentiful, but after numbers dwindled, the area around the wind farm was no longer of interest to the ducks. No significant numbers of seaduck were encountered during any of the T-0 or T-1 surveys, but this may, of course, change again in future years. Surveys at sea, such as our own or aerial surveys have not found any offshore concentrations lately and at present, the offshore waters around the wind farms appear unattractive for seaducks. Scoters still migrate through the study area in large numbers (www.trektellen.nl). Most of these birds follow the coastline and pass through the corridor between the shore and the wind farm.

Scoters were seen in nearly all surveys (Table 14), but mostly flying up and down the coast, in groups ranging in size from several individuals to circa 100 birds. Such groups are mostly quite wary, and avoid obstacles at sea, including wind farms (Krijgsveld et al. 2009) but also survey ships. Most groups, and particularly the larger groups, were seen at rather large distances from the ship and mostly in nearshore waters. However, a second component of flight directions (ca 15% of all Scoters seen across all survey) was towards the West and Southwest, most likely birds flying to the UK. Such a course would take the birds offshore, and into the longitudes of OWEZ and PAWP. These birds were never seen flying through OWEZ. Birds that were seen crossing the North Sea on a heading that would take them directly into a wind farm, always reacted strongly when they apparently first noticed the wind farm and changed course markedly to avoid the wind farm. As most Scoters were seen outside the 300 m wide counting strips, only relatively few data are available for modelling effects and significant results were not found (Table 15). This is due to low numbers residing in offshore waters and avoidance of both wind farm and ship at large distances. In all likelihood, Common Scoters avoid the wind farm when they fly across the North Sea but in the situations studied, this affected only a minority of the migrating birds. These are dealt with separately by Krijgsveld et al. (2010). Most birds seen during our survey flew up and down the mainland coast, well inshore of OWEZ.

Only during the T-1b survey of April 2008 were sufficient numbers of groups of Scoters seen within the counting strips to allow modelling. By coincidence, several groups were seen due east of OWEZ (note that the ship sailed E-W and vice versa, perpendicular to the main direction of migration in spring, which is northward. Other groups were seen in between the two wind farms, possibly suggesting avoidance. While the avoidance is probably a real feature of seaducks flying through the area, numbers seen were too low to get statistically significant results. The low numbers are primarily due to the low food availability. In absence of abundant food, numbers of seaducks residing in the area are low, and detecting effects of OWEZ will be difficult.

Month	year	Survey	N
2	2004	T-0	641
1	2008	T-1a	108
1	2009	T-1b	234
1	2010	T-1c	157
2	2010	T-1c	933
4	2003	T-0	1325
4	2007	T-1a	2080
4	2008	T-1b	626
4	2009	T-1c	496
6	2003	T-0	443
6	2007	T-1a	133
6	2008	T-1b	126
6	2009	T-1c	33
8	2003	T-0	67
8	2007	T-1a	171
8	2008	T-1b	0
9	2002	T-0	667
10	2002	T-1a	189
9	2007	T-1b	176
10	2009	T-1c	131
11	2003	T-0	1137
11	2007	T-1a	28
11	2008	T-1b	108
11	2009	T-1c	91

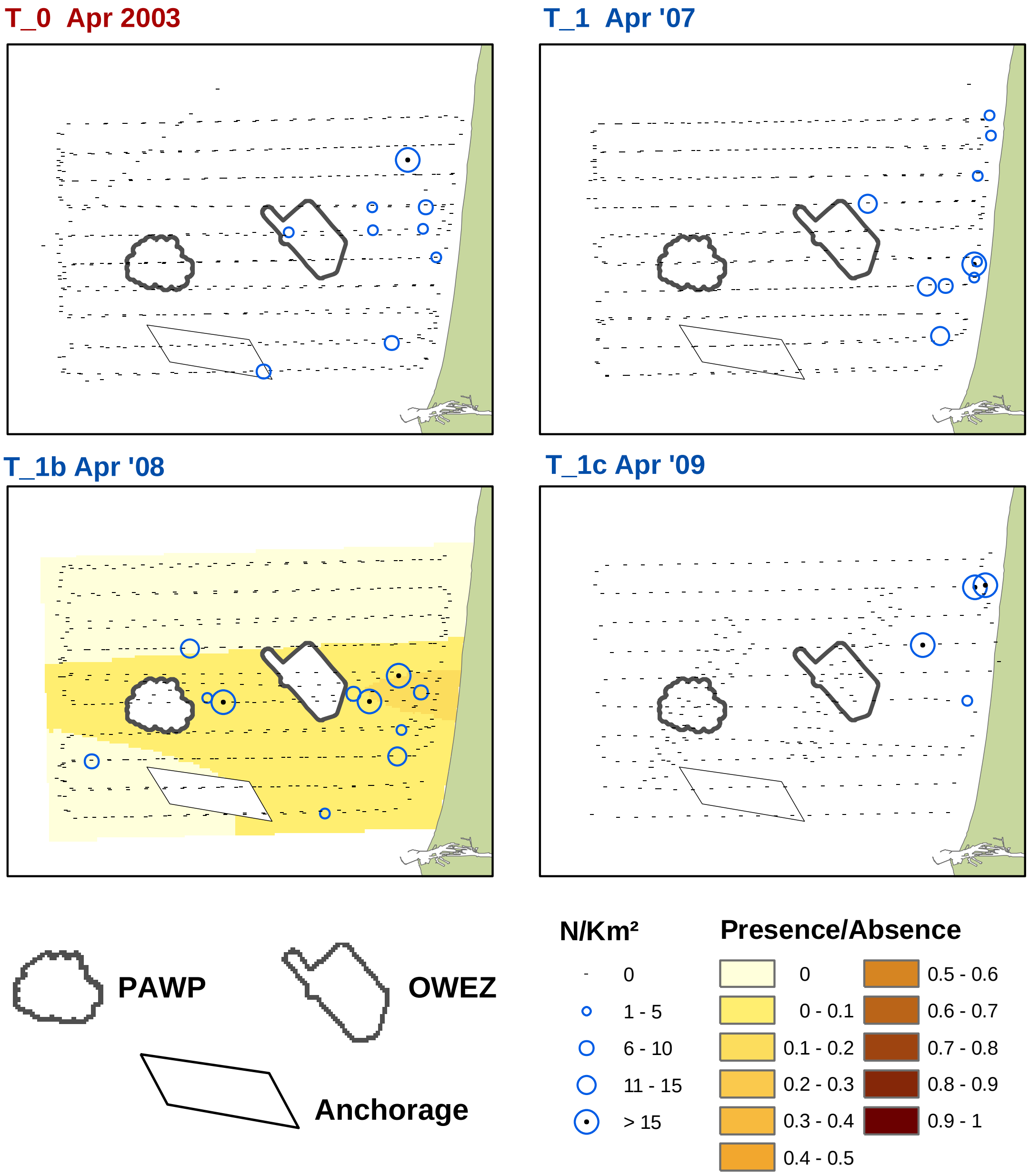
Table 14. *Total numbers of Common Scoters seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	NA	NA	NA	NA	NA	ins. data	NA	7
2008	1	NA	NA	NA	NA	NA	ins. data	NA	0
2009	1	NA	NA	NA	NA	NA	ins. data	NA	6
2010	1	NA	NA	NA	NA	NA	ins. data	NA	3
2010	2	NA	NA	NA	NA	NA	ins. data	NA	6
2003	4	NA	NA	NA	NA	NA	ins. data	NA	9
2007	4	NA	NA	NA	NA	NA	ins. data	NA	10
2008	4	**0.001**	**0.000**	1.000	1.000	-	GAM	0.16	11
2009	4	NA	NA	NA	NA	NA	ins. data	NA	4
2003	6	NA	NA	NA	NA	NA	ins. data	NA	1
2007	6	NA	NA	NA	NA	NA	ins. data	NA	2
2008	6	NA	NA	NA	NA	NA	ins. data	NA	3
2009	6	NA	NA	NA	NA	NA	ins. data	NA	1
2003	8	NA	NA	NA	NA	NA	ins. data	NA	2
2007	8	NA	NA	NA	NA	NA	ins. data	NA	1
2008	8	NA	NA	NA	NA	NA	ins. data	NA	0
2002	9	NA	NA	NA	NA	NA	ins. data	NA	1
2002	10	NA	NA	NA	NA	NA	ins. data	NA	0
2007	9	NA	NA	NA	NA	NA	ins. data	NA	2
2009	10	NA	NA	NA	NA	NA	ins. data	NA	3
2003	11	NA	NA	NA	NA	NA	ins. data	NA	7
2007	11	NA	NA	NA	NA	NA	ins. data	NA	0
2008	11	NA	NA	NA	NA	NA	ins. data	NA	2
2009	11	NA	NA	NA	NA	NA	ins. data	NA	1

Table 15. *Modelling results (presence/absence) for Common Scoter. Significant contributions (P<0.1) are put in* ***bold****. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ) *are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 26 (overleaf): *Distribution maps of Common Scoter, for the only set of months (April) in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Scoter in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Scoters indicated by -.*

Common Scoter



Little Gull *Larus minutus* (Dwergmeeuw)

Figure 27. *Little Gull, adult, moulting to breeding plumage. Photo: Martin Poot, Bureau Waardenburg.*

Little Gulls are mainly migrants through Dutch waters although some might winter off our coast (Camphuysen & Leopold 1994). Most Little Gulls are seen in autumn and spring, with a spectacular migration peak in April (Camphuysen & van Dijk 1983; Platteeuw et al. 1994; www.trektellen.nl). During spring migration, nearly the entire European population of Little Gulls may pass along our mainland shoreline and thousands may stage in these waters for several weeks in April, if conditions are favourable (den Ouden & Stougie 1987, 1990; Keijl & Leopold 1997).

In accordance to this known phenology, Little Gulls were seen in largest numbers during the April surveys (Table 16). Little Gulls may occur quite far offshore, particularly during their spring migration, but also during winter, when flocks of feeding and resting birds, several dozens to hundreds strong, were found scattered over the entire study area (cf. Keijl & Leopold 1997; Leopold et al. 2004). During the T-0 April survey such a pattern was found, with relatively low numbers in the central part, where the wind farms were to be constructed. This pattern was found again during the T-1b survey in April 2008, but even more pronounced: densities of Little Gulls were low in a large area around the two wind farms, resulting in only significant effect for PAWP (Table 17). Modelling showed negative coefficients also for other months, but mostly this was not significant, or based on low numbers of birds (Table 17; Figure 28). Some birds did enter OWEZ during T-1 surveys, but only the outer parts of the wind farm (April 2007 & 2008; November 2009). Little Gulls were never seen to enter PAWP.

Some avoidance may thus have occurred. The distribution patterns indicate that Little Gulls do not venture (much) into OWEZ and not at all into PAWP, but numbers seen were often too low to allow firm conclusions. On several occasions, some birds were seen within the perimeter of OWEZ, showing that avoidance was less than 100% , at least for OWEZ, the wind farm with the lower turbine density.

Month	year	Survey	N
2	2004	T-0	19
1	2008	T-1a	29
1	2009	T-1b	7
1	2010	T-1c	21
2	2010	T-1c	59
4	2003	T-0	2029
4	2007	T-1a	1788
4	2008	T-1b	6698
4	2009	T-1c	443
6	2003	T-0	0
6	2007	T-1a	0
6	2008	T-1b	0
6	2009	T-1c	2
8	2003	T-0	0
8	2007	T-1a	22
8	2008	T-1b	0
9	2002	T-0	65
10	2002	T-1a	109
9	2007	T-1b	82
10	2009	T-1c	3
11	2003	T-0	254
11	2007	T-1a	38
11	2008	T-1b	30
11	2009	T-1c	408

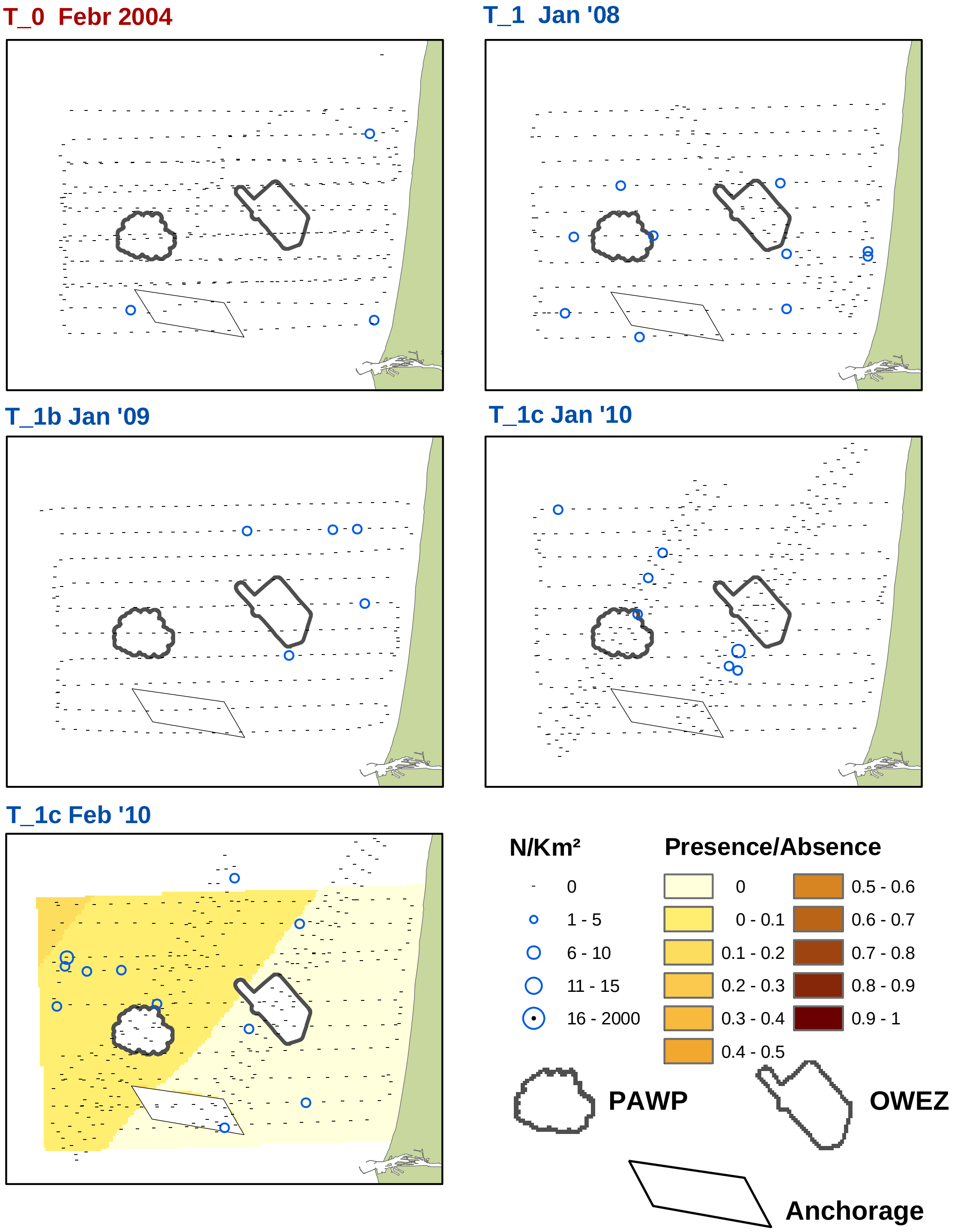
Table 16. *Total numbers of Little Gulls seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	NA	NA	NA	NA	NA	ins. data	NA	3
2008	1	NA	NA	NA	NA	NA	ins. data	NA	10
2009	1	NA	NA	NA	NA	NA	ins. data	NA	5
2010	1	NA	NA	NA	NA	NA	ins. data	NA	7
2010	2	0.049	0.269	**0.000**	0.627	-	GAMM	NA	11
2003	4	0.967	0.464	0.706	0.310	-	GAMM	NA	94
2007	4	**0.001**	0.018	**0.000**	0.629	+	GAMM	NA	28
2008	4	0.491	0.019	**0.000**	0.709	-	GAMM	NA	74
2009	4	**0.000**	0.139	1.000	1.000	-	GAM	0.18	27
2003	6	NA	NA	NA	NA	NA	ins. data	NA	0
2007	6	NA	NA	NA	NA	NA	ins. data	NA	0
2008	6	NA	NA	NA	NA	NA	ins. data	NA	0
2009	6	NA	NA	NA	NA	NA	ins. data	NA	1
2003	8	NA	NA	NA	NA	NA	ins. data	NA	0
2007	8	NA	NA	NA	NA	NA	ins. data	NA	6
2008	8	NA	NA	NA	NA	NA	ins. data	NA	0
2002	9	NA	NA	NA	NA	NA	ins. data	NA	5
2002	10	NA	NA	NA	NA	NA	ins. data	NA	9
2007	9	0.035	0.752	**0.000**	**0.000**	-	GAMM	NA	12
2009	10	NA	NA	NA	NA	NA	ins. data	NA	1
2003	11	**0.000**	0.016	**0.000**	0.158	+	GAMM	NA	48
2007	11	NA	NA	NA	NA	NA	ins. data	NA	9
2008	11	0.410	0.180	1.000	0.937	-	GAMM	NA	11
2009	11	**0.000**	0.017	**0.000**	0.577	-	GAMM	NA	59

Table 17. *Modelling results (presence/absence) for Little Gull. Significant contributions (P<0.1) are put in* ***bold***. *The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ*) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

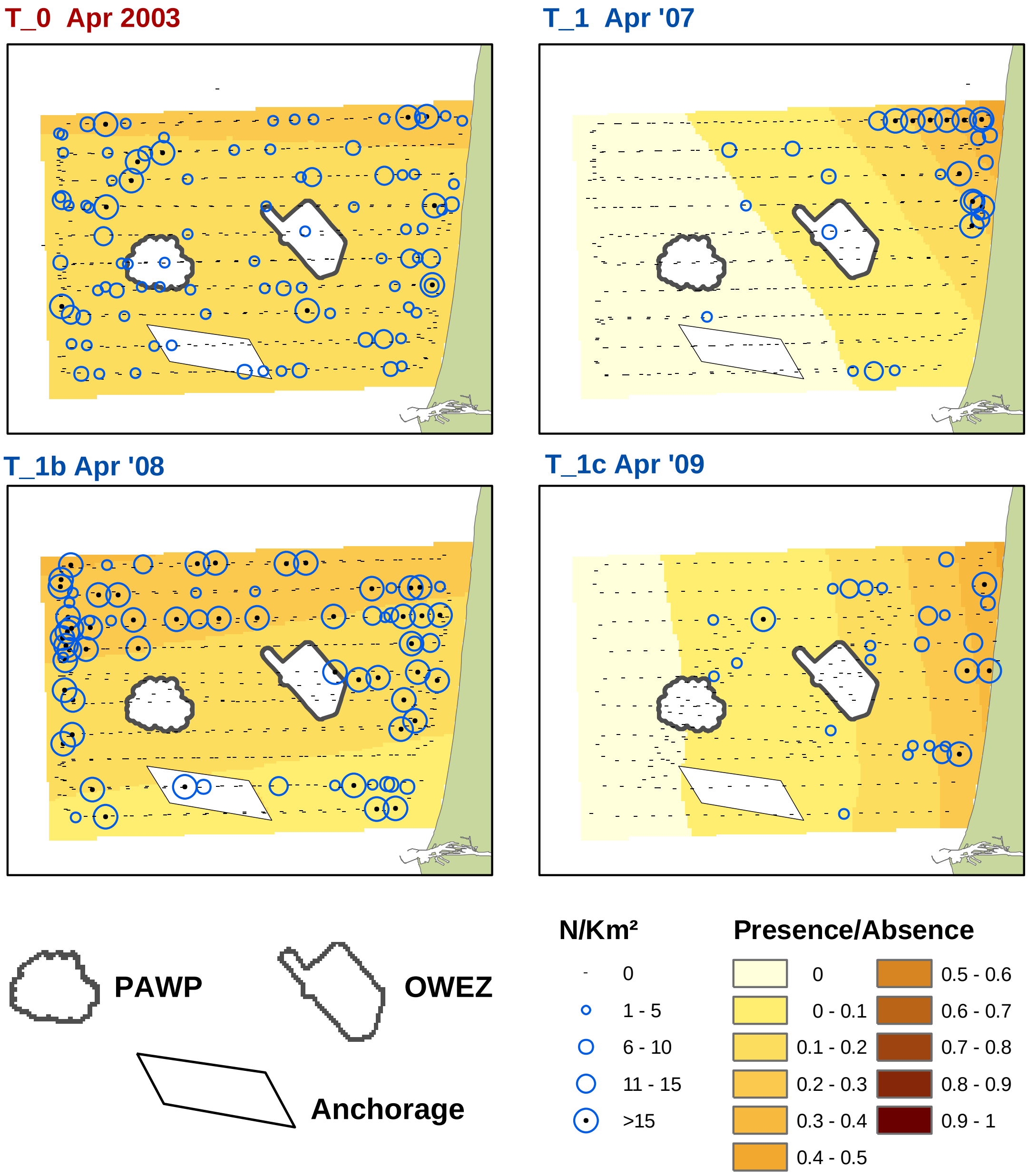
Figure 28 (overleaf): *Distribution maps of Little Gull, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Little Gull in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Little Gulls indicated by -.*

Little Gull



T_0 Febr 2004
T_1 Jan '08
T_1b Jan '09
T_1c Jan '10
T_1c Feb '10
N/Km²
0
1 - 5
6 - 10
11 - 15
16 - 2000
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
PAWP
OWEZ
Anchorage

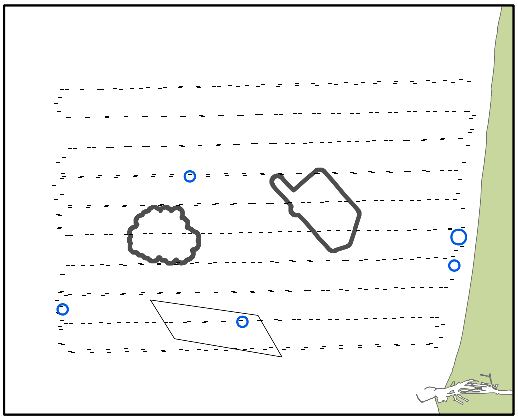
Little Gull



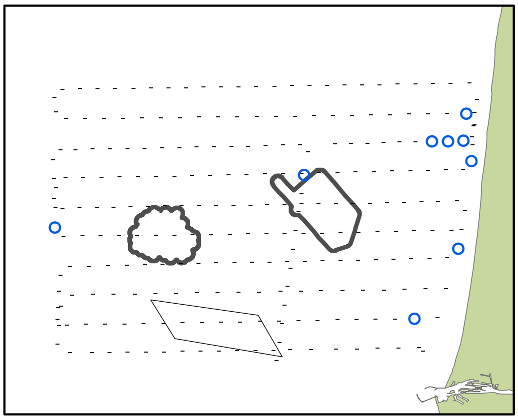
T_0 Apr 2003
T_1 Apr '07
T_1b Apr '08
T_1c Apr '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
>15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Little Gull

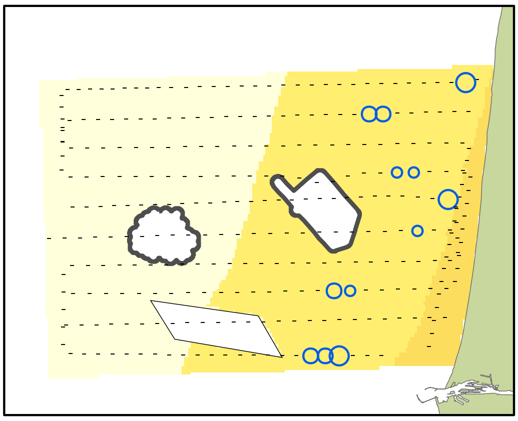
T_0 Sep 2002



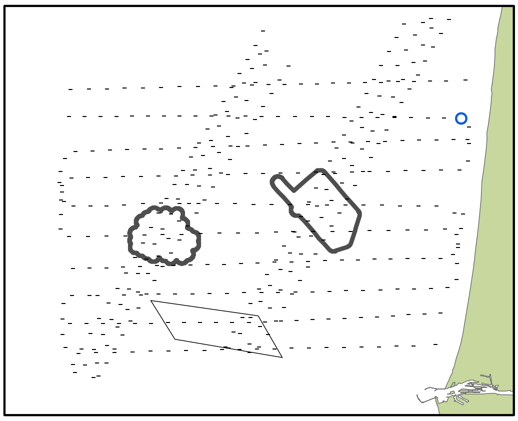
T_0 Oct 2002

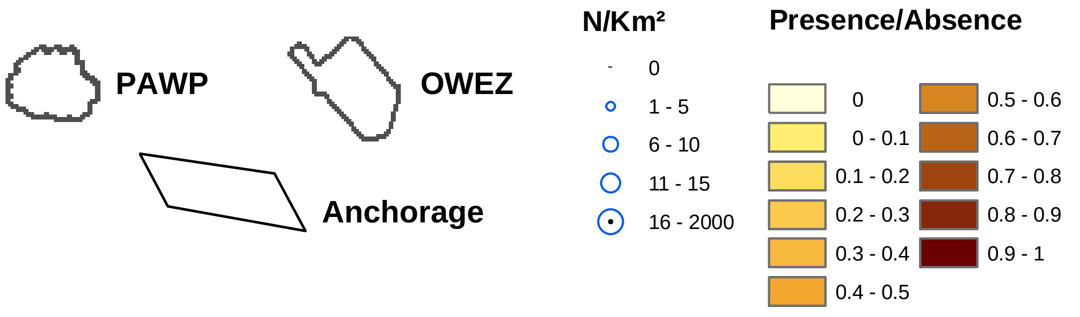


T_1 Sep '07

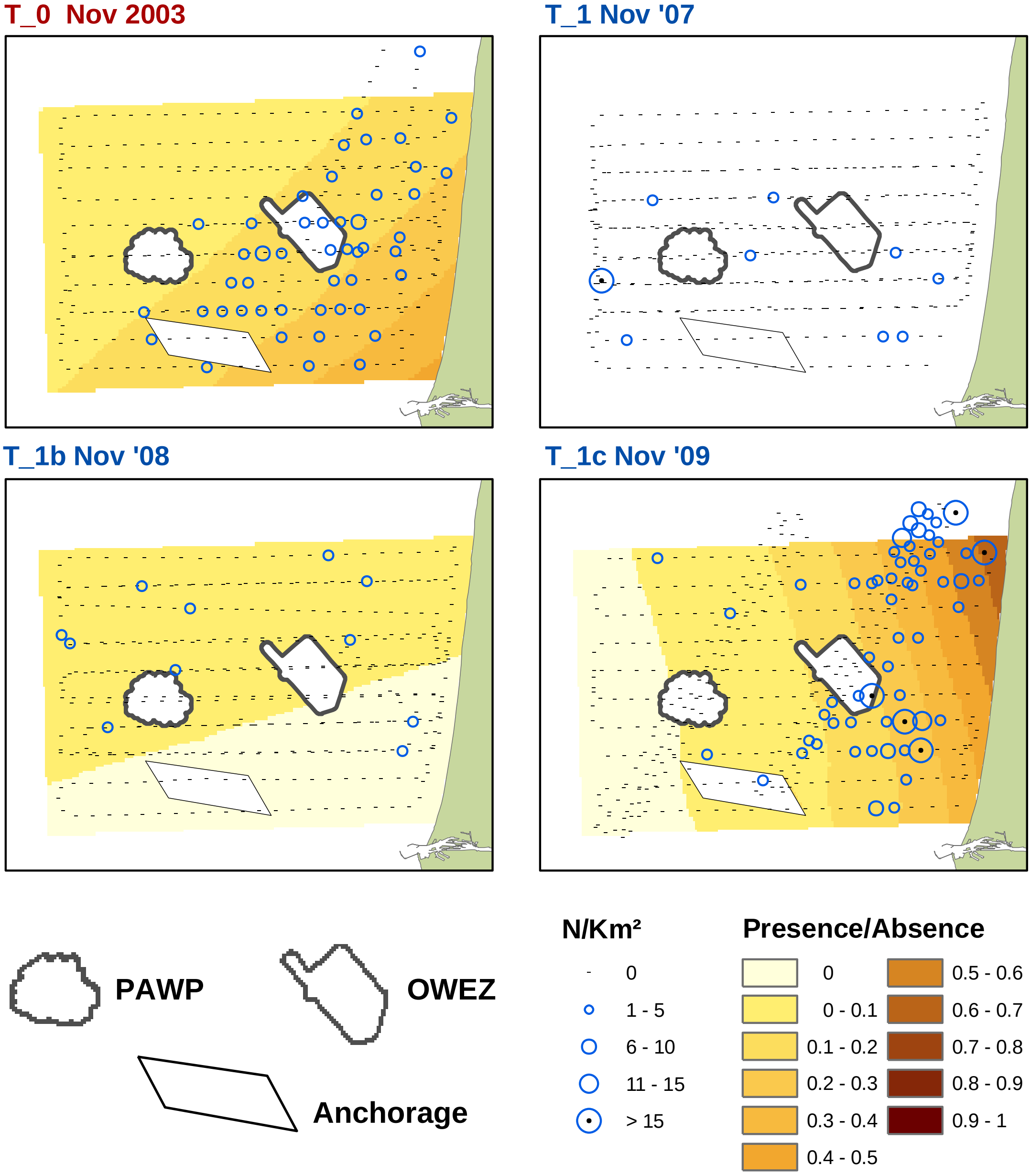


T_1c Oct '09





Little Gull



T_0 Nov 2003
T_1 Nov '07
T_1b Nov '08
T_1c Nov '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Black-headed Gull *Larus ridibundus* (Kokmeeuw)

Figure 29. *Black-headed Gull in summer plumage, Texel, 30 June 2010. Photo: Hans Verdaat, IMARES.*

Black-headed Gulls are mainly coastal gulls in Dutch waters but they show complex moult migrations that involve crossings to the British Isles (Camphuysen & Leopold 1994). Most Black-headed Gulls are therefore seen closely to the coast, but groups of migrants might be seen anywhere in the study area. Black-headed Gulls were seen during nearly all surveys, in varying numbers without a clear temporal pattern (Table 18; Figure 30). Presence in nearshore waters appears to be rather erratic, with little consistence between years. Although dozens to hundreds were usually seen per survey, most were usually seen beyond the counting strips. Only in a few surveys, numbers were high enough for modelling, but these indicated that the wind farms were generally too far offshore to interfere with this species' distribution – no significant effects were found. Although Black-headed Gulls were not seen to fly through the wind farms (Figure 30), offshore densities were generally too low to model any effect on this species, if existent (Table 19).

Month	year	Survey	N
2	2004	T-0	32
1	2008	T-1a	107
1	2009	T-1b	15
1	2010	T-1c	824
2	2010	T-1c	36
4	2003	T-0	76
4	2007	T-1a	94
4	2008	T-1b	28
4	2009	T-1c	23
6	2003	T-0	59
6	2007	T-1a	3
6	2008	T-1b	66
6	2009	T-1c	21
8	2003	T-0	63
8	2007	T-1a	108
8	2008	T-1b	39
9	2002	T-0	32
10	2002	T-1a	329
9	2007	T-1b	272
10	2009	T-1c	106
11	2003	T-0	531
11	2007	T-1a	33
11	2008	T-1b	41
11	2009	T-1c	34

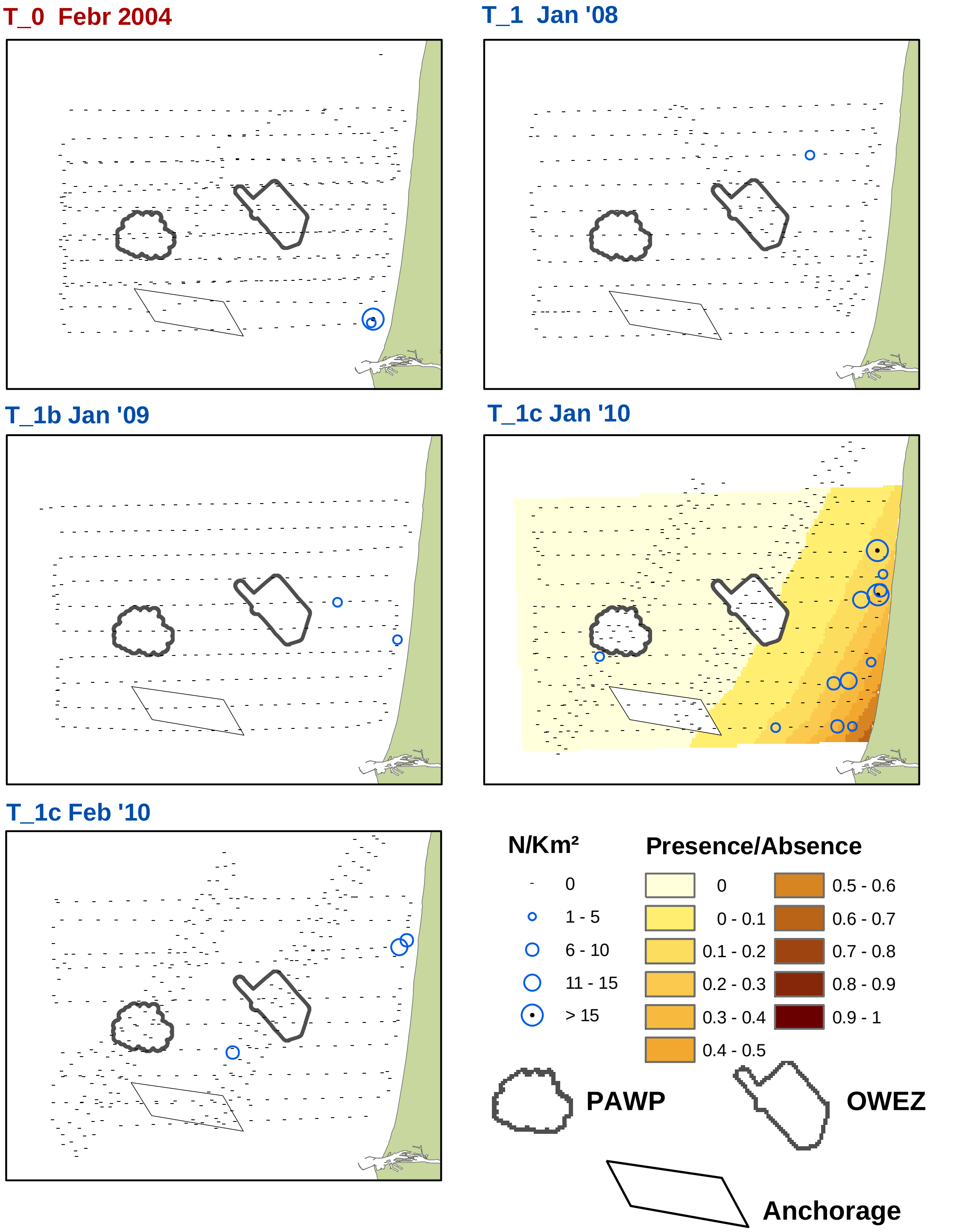
Table 18. *Total numbers of Black-headed Gulls seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	NA	NA	NA	NA	NA	ins. data	NA	2
2008	1	NA	NA	NA	NA	NA	ins. data	NA	1
2009	1	NA	NA	NA	NA	NA	ins. data	NA	2
2010	1	0.142	0.384	1.000	0.989	-	GAMM	NA	13
2010	2	NA	NA	NA	NA	NA	ins. data	NA	3
2003	4	NA	NA	NA	NA	NA	ins. data	NA	9
2007	4	NA	NA	NA	NA	NA	ins. data	NA	6
2008	4	NA	NA	NA	NA	NA	ins. data	NA	5
2009	4	NA	NA	NA	NA	NA	ins. data	NA	1
2003	6	NA	NA	NA	NA	NA	ins. data	NA	1
2007	6	NA	NA	NA	NA	NA	ins. data	NA	0
2008	6	NA	NA	NA	NA	NA	ins. data	NA	5
2009	6	NA	NA	NA	NA	NA	ins. data	NA	2
2003	8	NA	NA	NA	NA	NA	ins. data	NA	5
2007	8	NA	NA	NA	NA	NA	ins. data	NA	6
2008	8	NA	NA	NA	NA	NA	ins. data	NA	4
2002	9	NA	NA	NA	NA	NA	ins. data	NA	3
2002	10	NA	NA	NA	NA	NA	ins. data	NA	4
2007	9	NA	NA	NA	NA	NA	ins. data	NA	2
2009	10	NA	NA	NA	NA	NA	ins. data	NA	8
2003	11	**0.000**	0.387	0.998	0.978	-	GAMM	NA	26
2007	11	NA	NA	NA	NA	NA	ins. data	NA	2
2008	11	NA	NA	NA	NA	NA	ins. data	NA	6
2009	11	NA	NA	NA	NA	NA	ins. data	NA	2

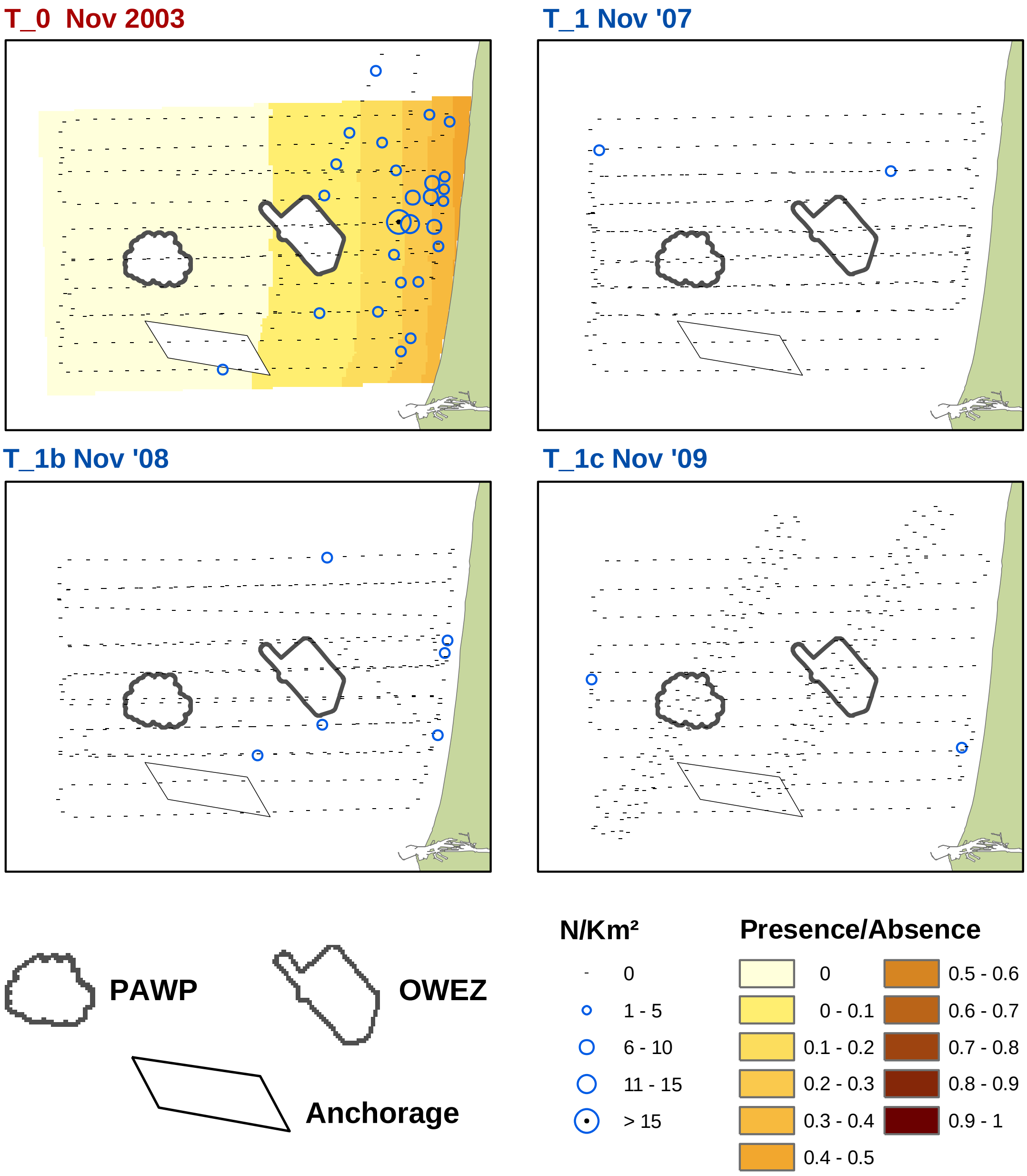
Table 19. *Modelling results (presence/absence) for Black-headed Gull. Significant contributions (P<0.1) are put in **bold**. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ*) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 30 (overleaf): *Distribution maps of Black-headed Gull, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Black-headed Gull in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Black-headed Gulls indicated by -.*

Black-headed Gull



Black-headed Gull



Common Gull *Larus canus* (Stormmeeuw)

Figure 31. *Common Gull in winter plumage. Photo: Hans Verdaat, IMARES.*

Common Gulls occur in the study area throughout the year, but the highest densities occur usually in nearshore waters (Table 20, Figure 32). The largest numbers were seen in autumn and winter and the modelling results clearly indicated the importance of the smoother distance to coast (Table 21). The presence of the wind farms had little impact on the occurrence of Common Gull. There are as many positive coefficients as negative ones across the T-1 surveys, and none of these are statistically significant. Given the amount of noise in the data in all situations encountered, the impact of the wind farms on this species seems negligible (Table 21).

Month	year	Survey	N
2	2004	T-0	508
1	2008	T-1a	290
1	2009	T-1b	822
1	2010	T-1c	2775
2	2010	T-1c	206
4	2003	T-0	1484
4	2007	T-1a	5520
4	2008	T-1b	2764
4	2009	T-1c	244
6	2003	T-0	416
6	2007	T-1a	5
6	2008	T-1b	61
6	2009	T-1c	45
8	2003	T-0	40
8	2007	T-1a	6
8	2008	T-1b	1
9	2002	T-0	35
10	2002	T-1a	340
9	2007	T-1b	36
10	2009	T-1c	160
11	2003	T-0	3841
11	2007	T-1a	797
11	2008	T-1b	1169
11	2009	T-1c	171

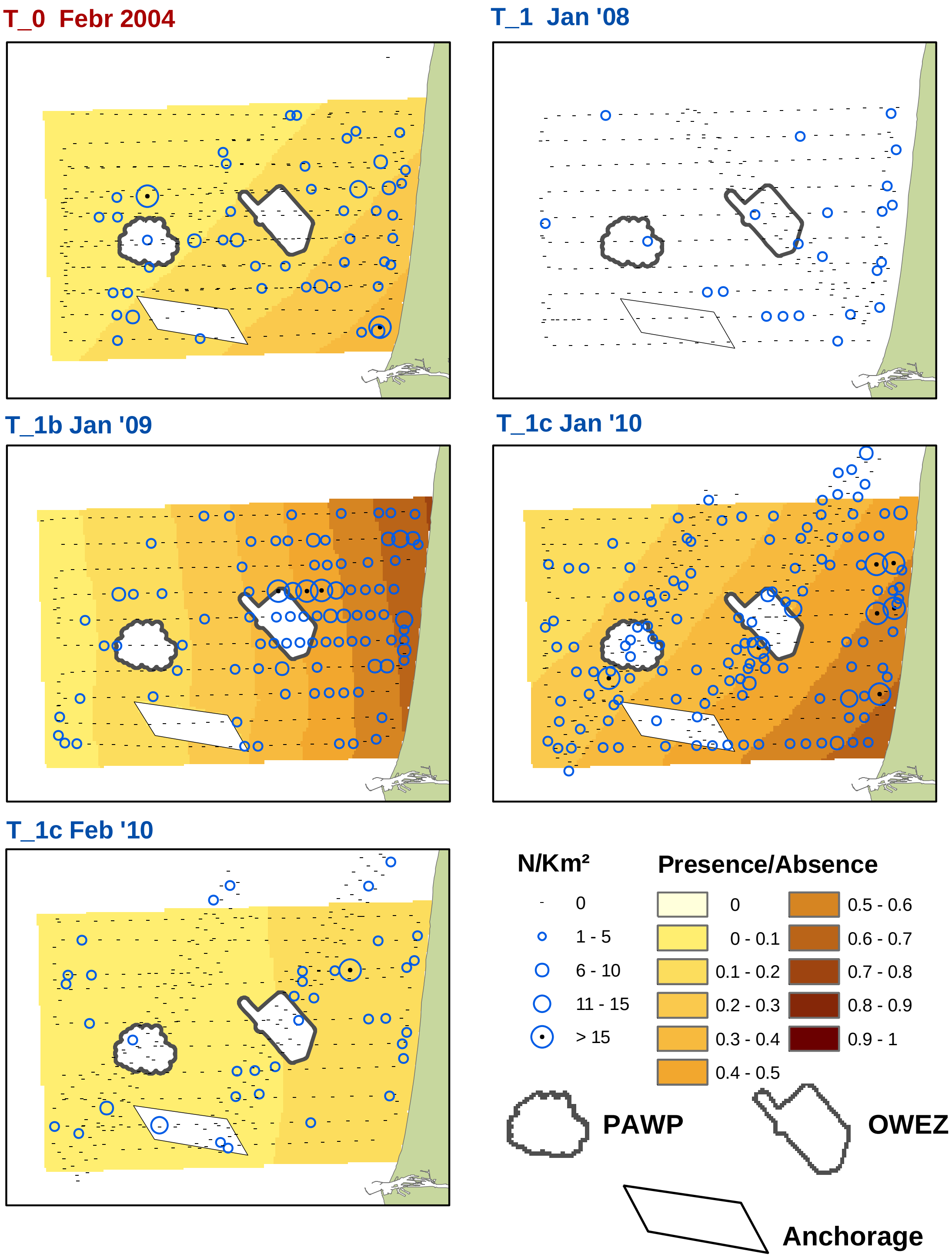
Table 20. *Total numbers of Common Gulls seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	**0.000**	**0.041**	1.000	1.000	-	GAM	0.07	48
2008	1	0.449	0.834	0.132	0.142	+	GAMM	NA	23
2009	1	**0.000**	0.342	0.293	0.068	+	GAMM	NA	91
2010	1	**0.000**	**0.025**	0.127	0.103	-	GAMM	NA	136
2010	2	**0.038**	0.723	0.449	0.617	-	GAMM	NA	39
2003	4	**0.000**	0.842	1.000	0.958	-	GAM	0.14	95
2007	4	**0.000**	0.799	0.265	0.322	+	GAMM	NA	127
2008	4	**0.000**	0.789	0.885	0.595	+	GAMM	NA	142
2009	4	**0.000**	**0.063**	1.000	1.000	-	GAMM	NA	28
2003	6	**0.000**	0.735	0.014	0.923	-	GAMM	NA	14
2007	6	NA	NA	NA	NA	NA	ins. data	NA	0
2008	6	NA	NA	NA	NA	NA	ins. data	NA	7
2009	6	**0.000**	**0.000**	**0.000**	**0.000**	+	GAMM	NA	12
2003	8	NA	NA	NA	NA	NA	ins. data	NA	7
2007	8	NA	NA	NA	NA	NA	ins. data	NA	0
2008	8	NA	NA	NA	NA	NA	ins. data	NA	0
2002	9	NA	NA	NA	NA	NA	ins. data	NA	5
2002	10	**0.001**	0.289	1.000	0.992	-	GAMM	NA	14
2007	9	NA	NA	NA	NA	NA	ins. data	NA	0
2009	10	**0.000**	0.311	1.000	0.989	-	GAMM	NA	14
2003	11	**0.000**	0.027	1.000	0.127	-	GAM	0.21	93
2007	11	**0.000**	0.652	0.259	0.996	-	GAMM	NA	39
2008	11	**0.000**	0.804	0.434	0.512	-	GAMM	NA	106
2009	11	**0.000**	0.475	0.890	0.434	-	GAMM	NA	39

Table 21. *Modelling results (presence/absence) for Common Gull. Significant contributions (P<0.1) are put in* ***bold****. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ) *are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

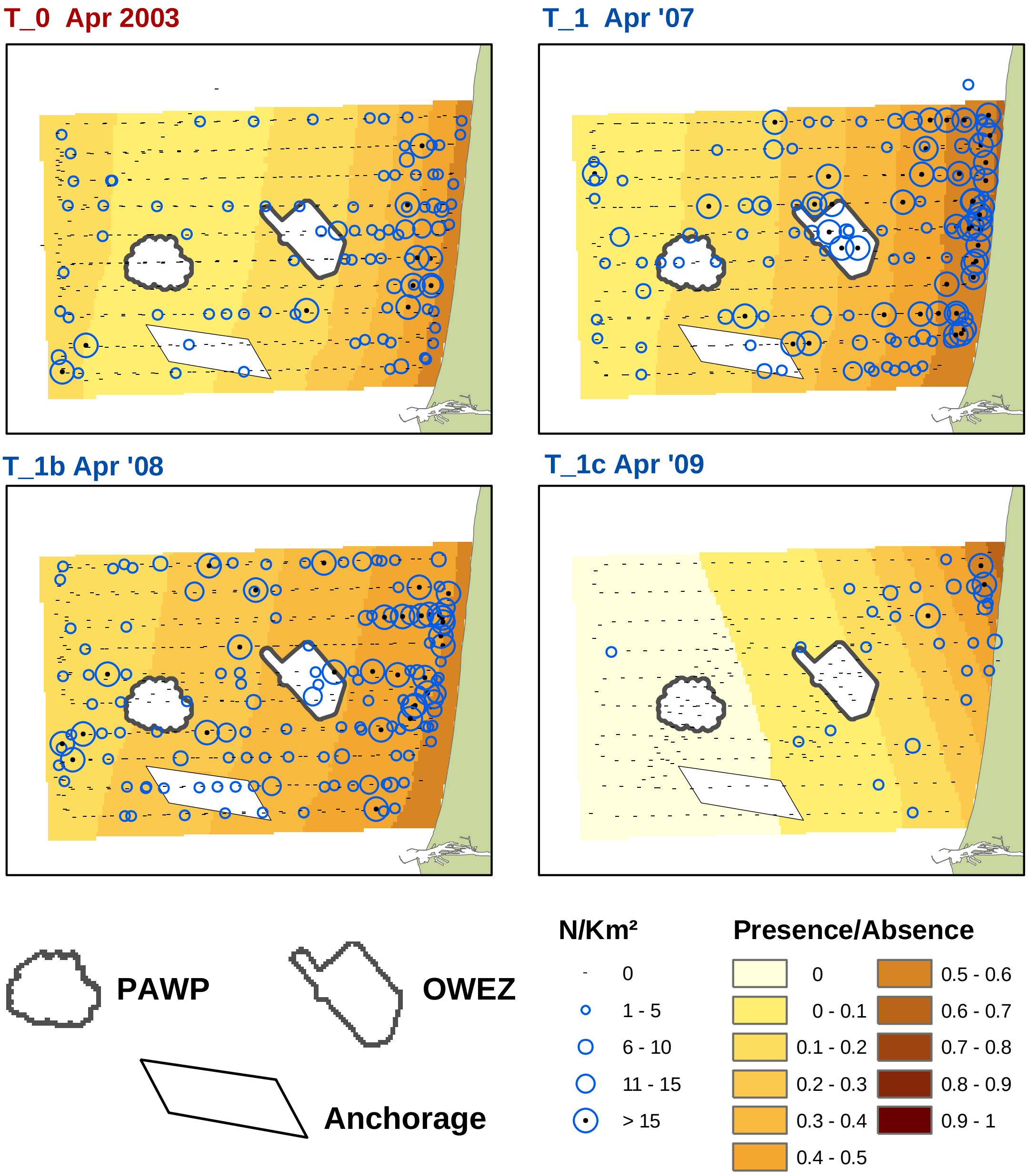
Figure 32 (overleaf): *Distribution maps of Common Gull, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Common Gull in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Common Gulls indicated by -.*

Common Gull

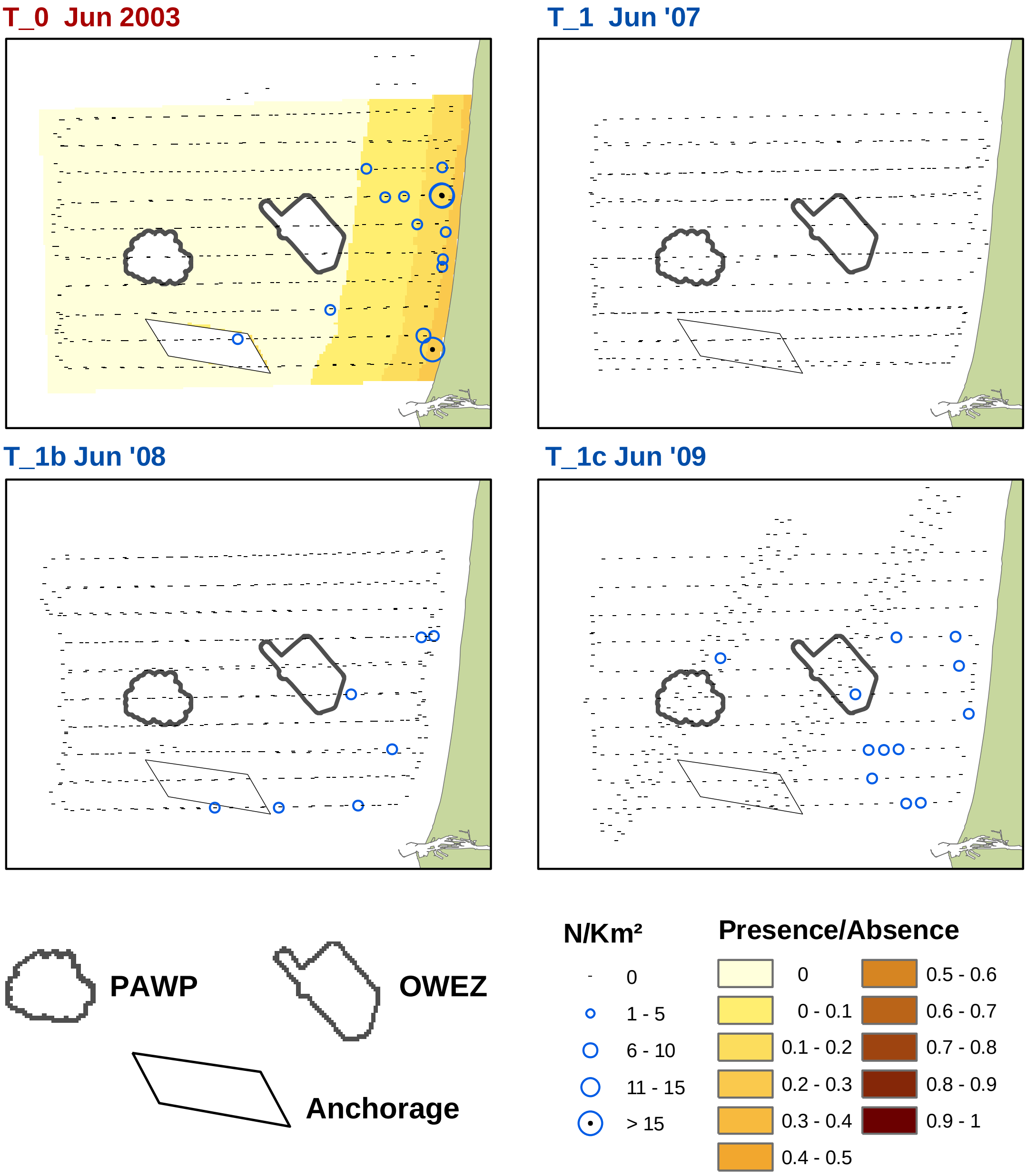


T_0 Febr 2004
T_1 Jan '08
T_1b Jan '09
T_1c Jan '10
T_1c Feb '10
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
PAWP
OWEZ
Anchorage

Common Gull

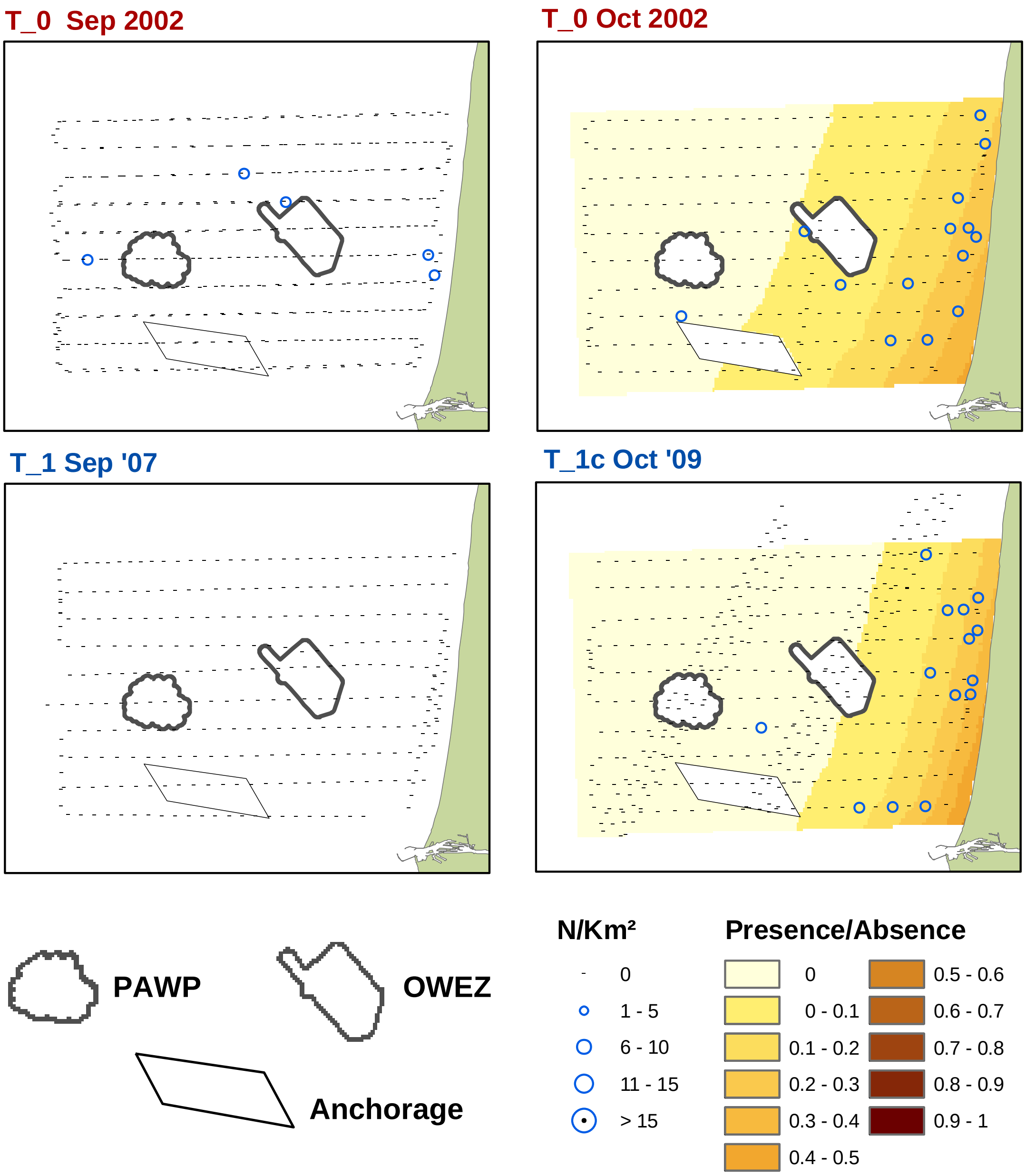

T_0 Apr 2003
T_1 Apr '07
T_1b Apr '08
T_1c Apr '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Common Gull



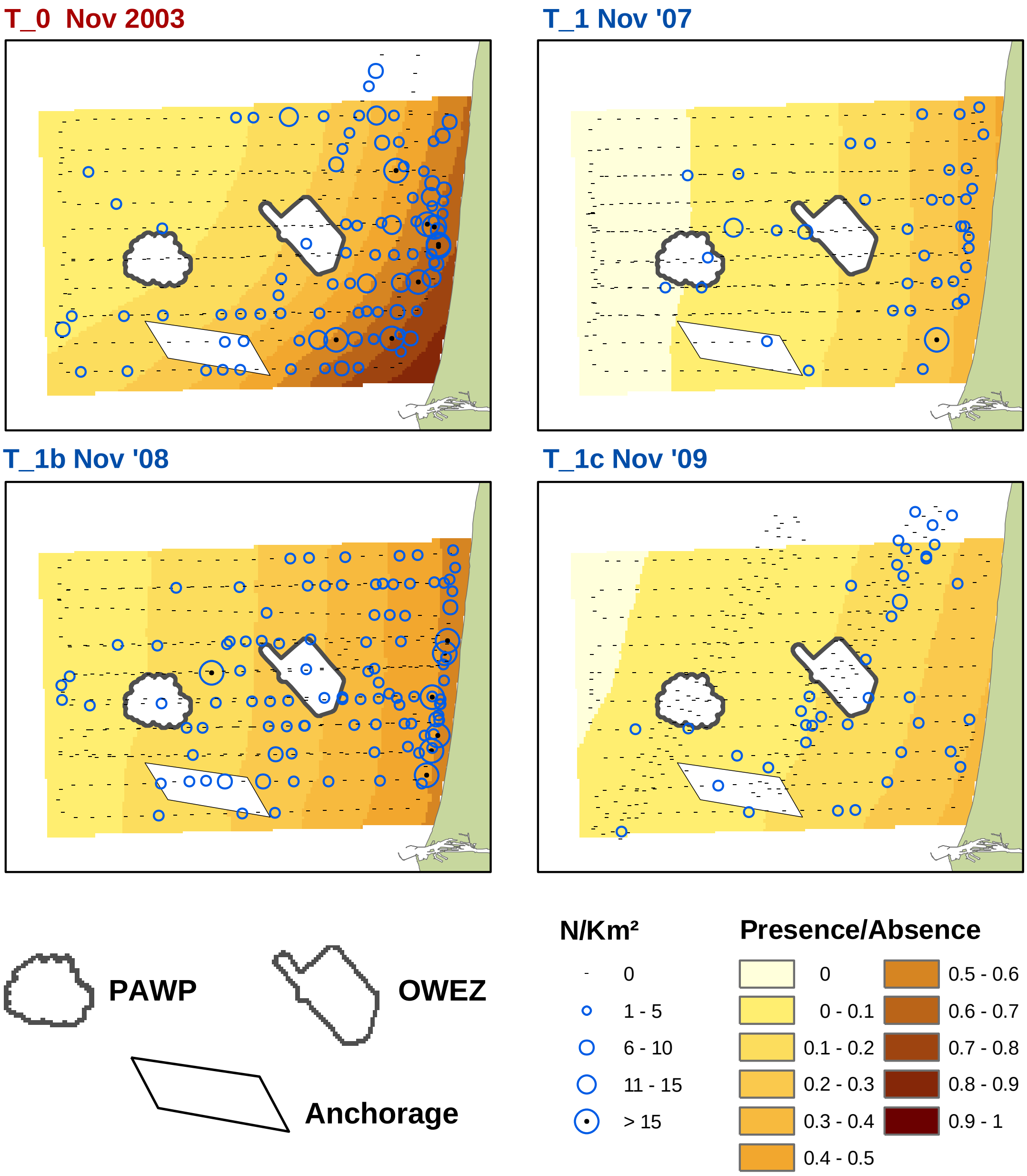
T_0 Jun 2003
T_1 Jun '07
T_1b Jun '08
T_1c Jun '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Common Gull



T_0 Sep 2002
T_0 Oct 2002
T_1 Sep '07
T_1c Oct '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Common Gull



T_0 Nov 2003
T_1 Nov '07
T_1b Nov '08
T_1c Nov '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Lesser Black-backed Gull *Larus fuscus* (Kleine Mantelmeeuw)

Figure 33. *Adult Lesser Black-backed Gull in summer plumage, Texel, 30 June 2010. Photo: Hans Verdaat, IMARES.*

Lesser Black-backed Gulls are sea-going birds that breed along the Dutch coastline. Colonies near Egmond are small (IJmuiden) or have become small and are now rather insignificant after Red Foxes *Vulpes vulpes* entered the area. Recent work with GPS loggers put on a limited number of birds and modelling work on the birds' dispersal at sea during the breeding season, has shown that breeders from as far away as Texel and Maasvlakte/Europort will reach the OWEZ location (Ens 2007; Camphuysen et al. 2008; Arends et al. 2008). Non-breeders and passing migrants obviously also cross the general area in large numbers. The Texel and Maasvlakte/Europort colonies are home to tens of thousands of breeding Lesser Black-backed Gulls and are probably the sources of most of the gulls sighted in and around the offshore wind farms. Most Lesser Black-backed Gulls winter in SW Europe and numbers start to drop in the study area from September onwards (Table 22). From spring to autumn, Lesser Black-backed Gulls were the most numerous birds in the general study area.

Although Lesser Black-backed Gulls are well capable of catching live fish at sea (Camphuysen et al. 2008) most birds seen during our surveys were often associated with, looking out for or resting in the wake of active fishing vessels. Concentrations of over 1000 birds have been noted in the study area against a "background density" of around 1 bird per square kilometre. Such concentrations greatly impact modelled distribution patterns. Part of the contributions of the smoothers distance to coast and northing are without doubt attributable to the presence of fishing vessels in certain parts of the study area. Lesser Black-backed Gulls were often seen within the perimeters of the wind farms (Figure 34), sometimes resting on the water or on the foundation structures, sometimes feeding in the tidal wakes of the monopiles. From the perspective of these gulls, probably the largest impact of the wind farms is that fishing vessels never operate within their boundaries. Large, fishing-vessel related concentrations of gulls therefore by definition occur only outside the wind farms and this should, with sufficient data, result in apparent avoidance of the wind farms. This, however was hardly visible in the presence/absence modelling results (Table 23) or distribution maps (Figure 34).

Month	year	Survey	N
2	2004	T-0	44
1	2008	T-1a	6
1	2009	T-1b	3
1	2010	T-1c	0
2	2010	T-1c	68
4	2003	T-0	10384
4	2007	T-1a	6610
4	2008	T-1b	4652
4	2009	T-1c	4014
6	2003	T-0	5899
6	2007	T-1a	4237
6	2008	T-1b	5957
6	2009	T-1c	7700
8	2003	T-0	8274
8	2007	T-1a	5303
8	2008	T-1b	1603
9	2002	T-0	1896
10	2002	T-1a	285
9	2007	T-1b	1282
10	2009	T-1c	347
11	2003	T-0	104
11	2007	T-1a	3
11	2008	T-1b	44
11	2009	T-1c	45

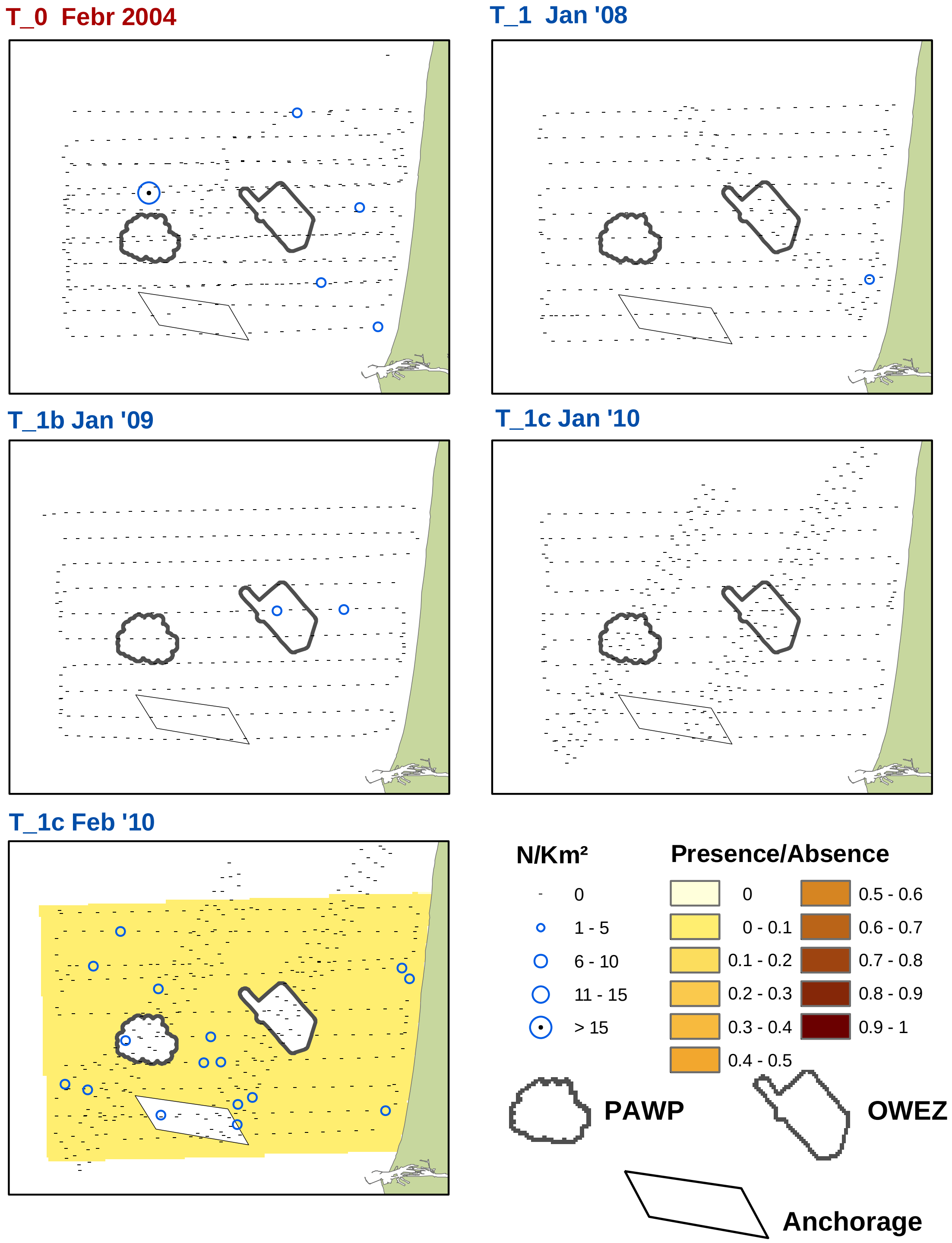
Table 22. *Total numbers of Lesser Black-backed Gulls seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	NA	NA	NA	NA	NA	ins. data	NA	5
2008	1	NA	NA	NA	NA	NA	ins. data	NA	1
2009	1	NA	NA	NA	NA	NA	ins. data	NA	2
2010	1	NA	NA	NA	NA	NA	ins. data	NA	0
2010	2	0.916	**0.010**	1.000	1.000	-	GAM	0.03	16
2003	4	0.013	0.717	0.671	0.706	-	GAMM	NA	112
2007	4	0.031	0.676	0.513	0.179	-	GAMM	NA	143
2008	4	0.945	0.450	0.863	0.958	-	GAMM	NA	155
2009	4	**0.000**	0.212	**0.055**	0.982	-	GAMM	NA	131
2003	6	**0.000**	**0.065**	0.175	0.290	+	GAMM	NA	147
2007	6	**0.029**	**0.000**	0.913	0.564	+	GAMM	NA	187
2008	6	**0.002**	**0.000**	0.744	0.561	+	GAMM	NA	178
2009	6	**0.000**	0.544	0.210	0.175	-	GAMM	NA	197
2003	8	**0.000**	**0.000**	0.454	0.160	-	GAMM	NA	230
2007	8	**0.039**	**0.000**	0.267	**0.048**	-	GAMM	NA	241
2008	8	**0.000**	0.472	**0.044**	0.293	-	GAMM	NA	127
2002	9	**0.000**	0.154	**0.001**	**0.050**	+	GAMM	NA	120
2002	10	**0.001**	**0.009**	1.000	0.011	+	GAM	0.11	20
2007	9	0.125	0.291	0.520	0.520	-	GAMM	NA	26
2009	10	**0.008**	0.741	0.958	0.958	-	GAMM	NA	17
2003	11	**0.000**	0.480	**0.000**	**0.000**	-	GAMM	NA	15
2007	11	NA	NA	NA	NA	NA	ins. data	NA	0
2008	11	NA	NA	NA	NA	NA	ins. data	NA	6
2009	11	0.917	0.449	1.000	1.000	-	GAMM	NA	13

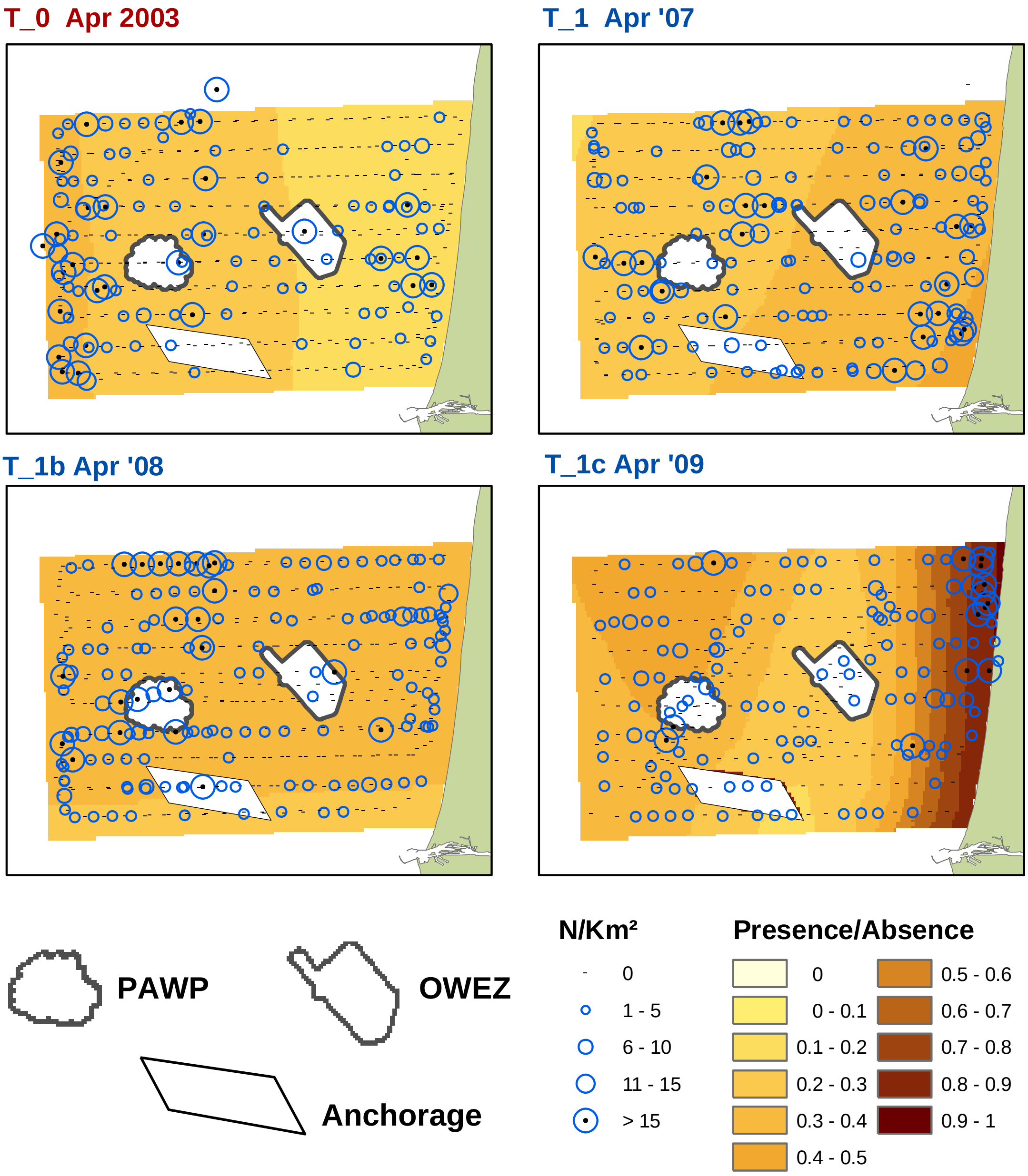
Table 23. *Modelling results (presence/absence) for Lesser Black-backed Gull. Significant contributions (P<0.1) are put in **bold**. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column Est_OWEZ) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 34 (overleaf): *Distribution maps of Lesser Black-backed Gull, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Lesser Black-backed Gull in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Lesser Black-backed Gulls indicated by -.*

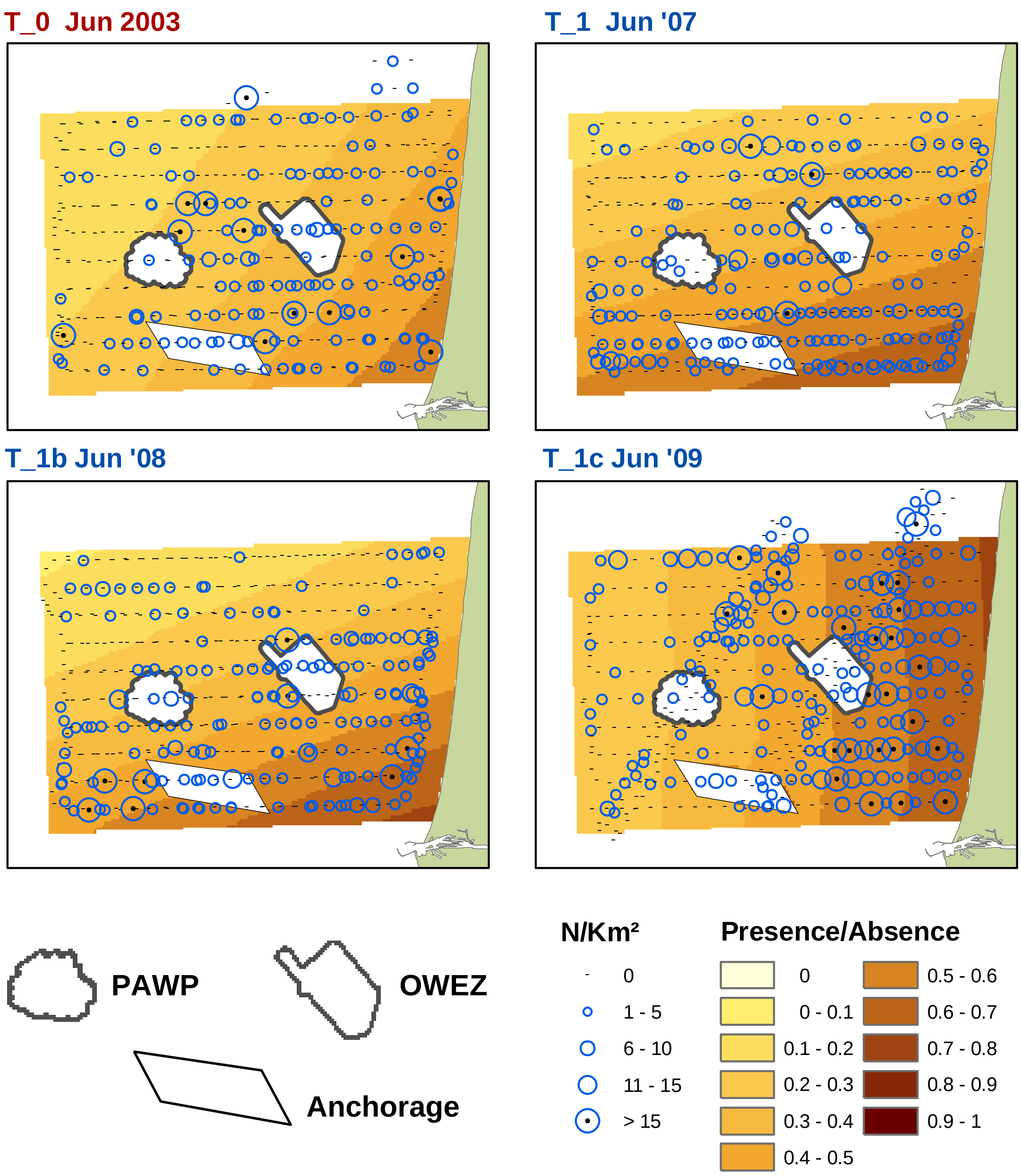
Lesser Black-backed Gull



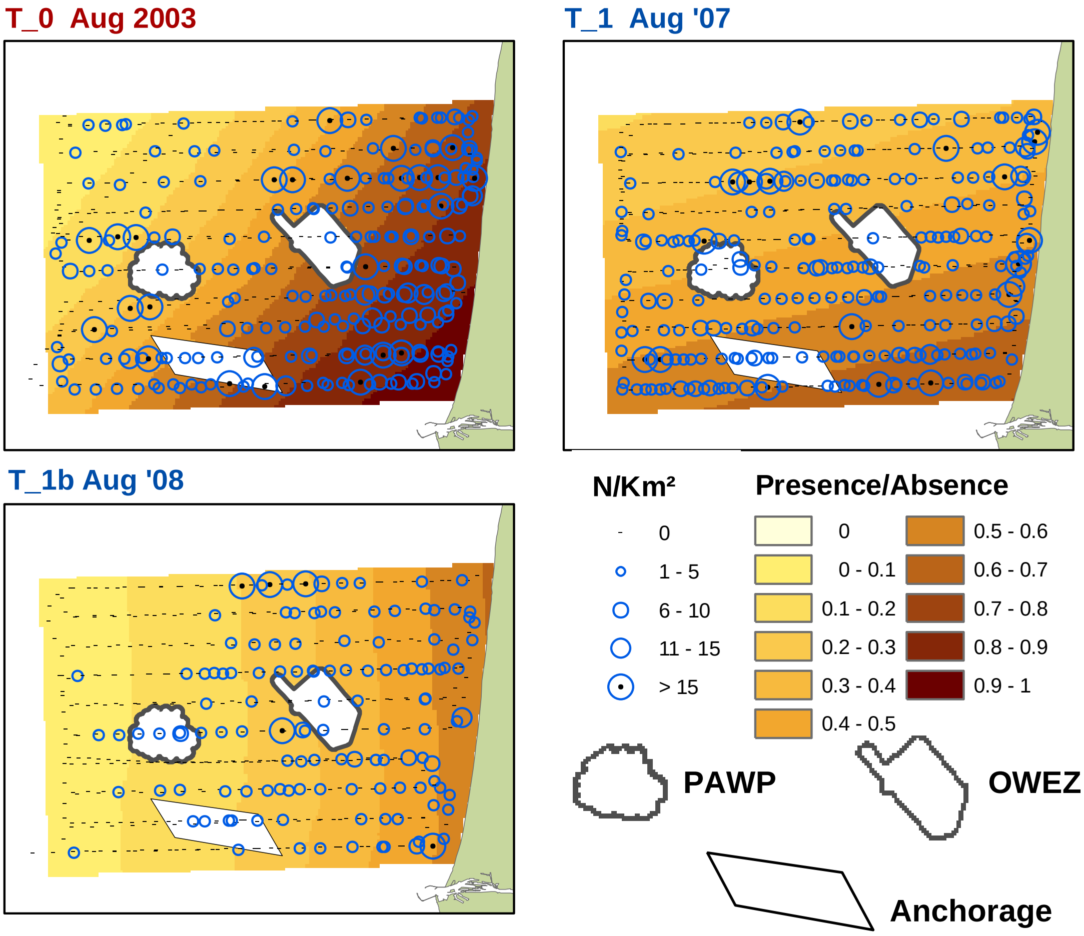
Lesser Black-backed Gull



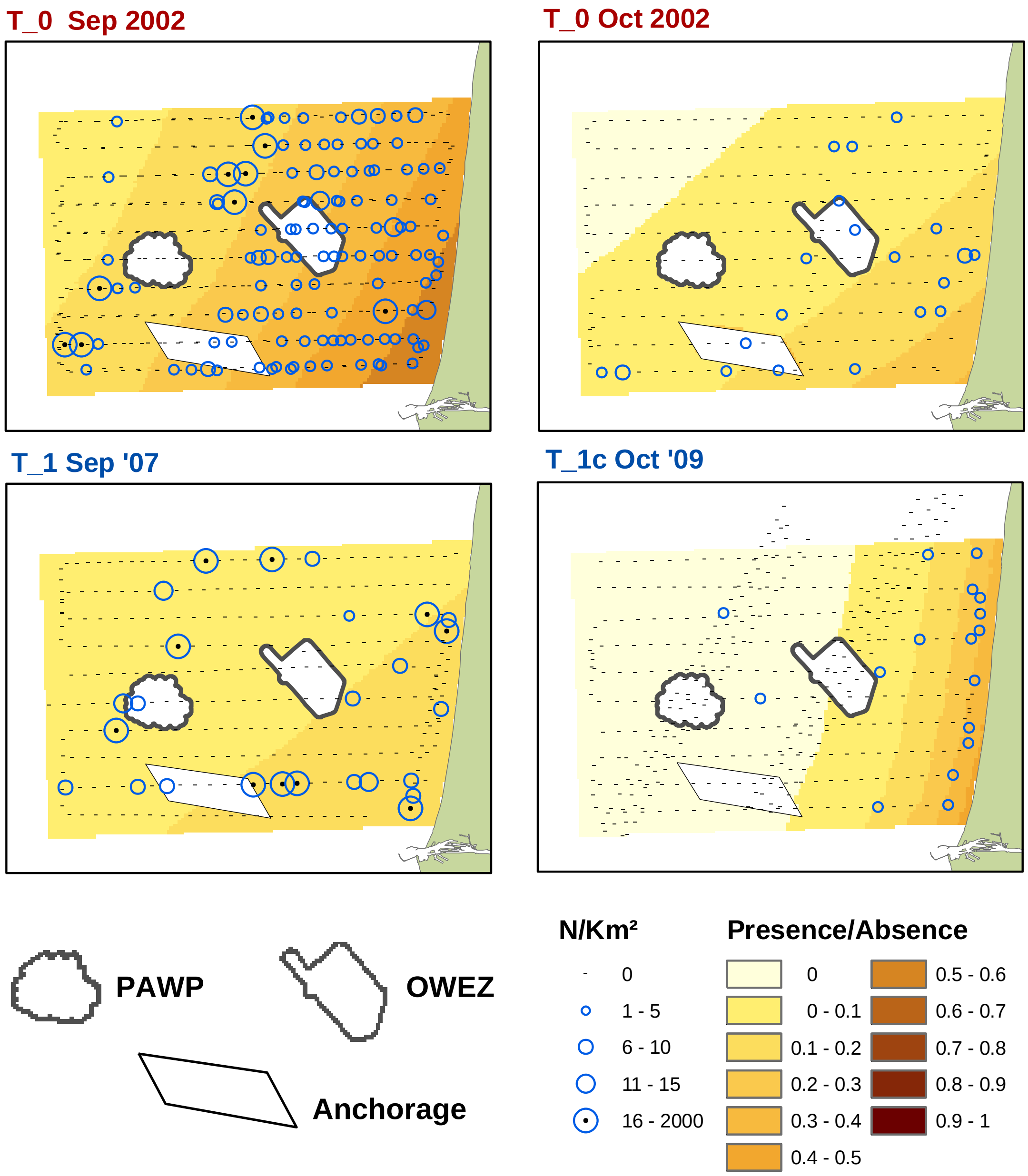
Lesser Black-backed Gull



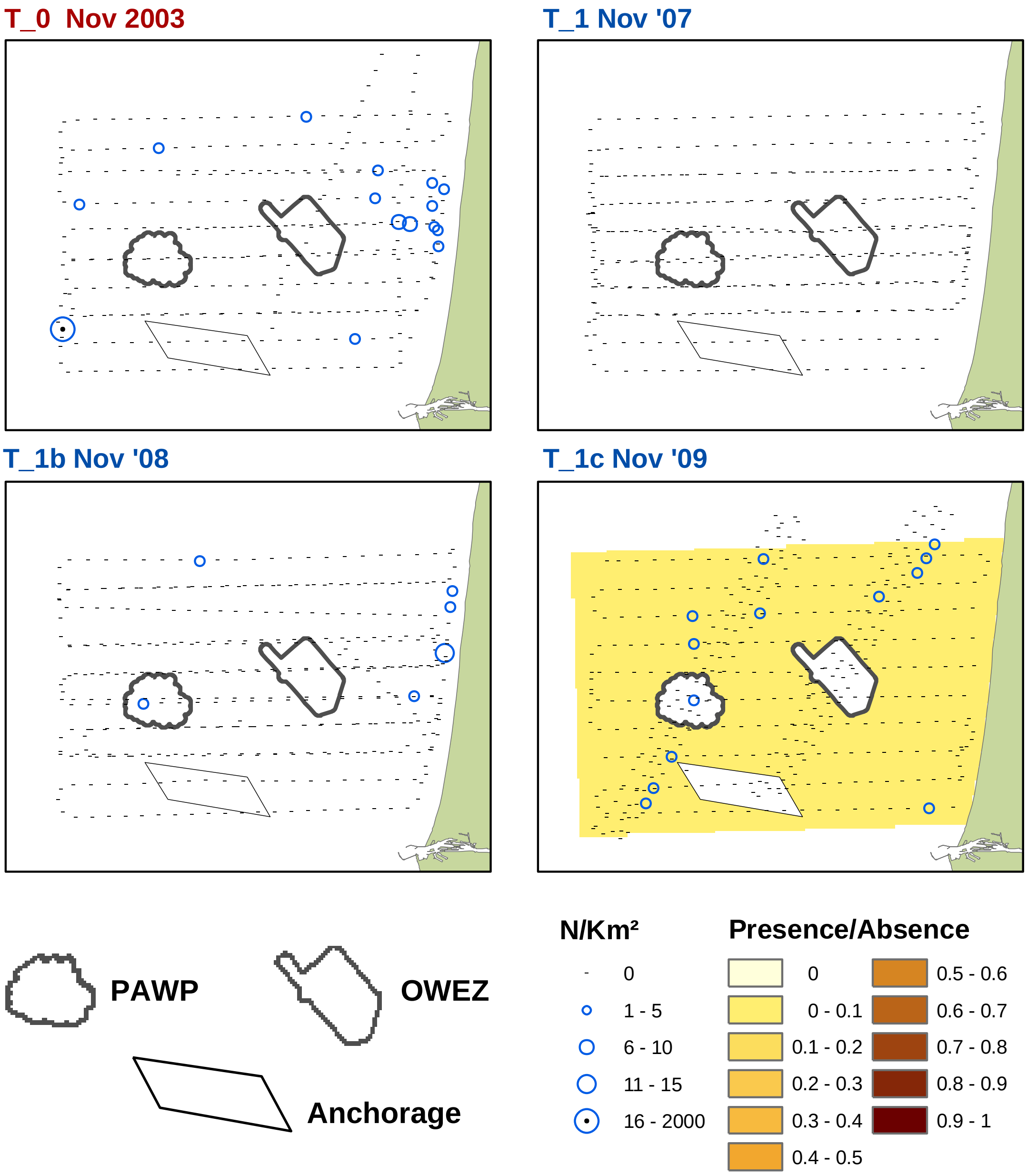
Lesser Black-backed Gull



Lesser Black-backed Gull



Lesser Black-backed Gull



Herring Gull *Larus argentatus* (Zilvermeeuw)

Figure 35. *Herring Gull in winter plumage, 26 January 2010. Photo: Hans Verdaat, IMARES.*

Herring Gulls are less sea-going than Lesser Black-backed Gulls (Camphuysen 1995; Figure 36). In the breeding season, Herring Gulls hardly take to the North Sea (June maps, Figure 36). Also in August, Herring Gulls remain mostly nearshore. Dispersing birds in autumn and wintering birds however, are found throughout Dutch offshore waters (Camphuysen & Leopold 1994; Camphuysen et al, 1995; Figure 35, November maps) and Herring Gulls were the most abundant birds in the study area in autumn (Table 24). Herring Gulls were abundantly present in all seasons, be it in widely fluctuating numbers (Table 24). Like the Lesser Black-backed Gulls discussed in the previous paragraph, Herring Gulls are often associated with fishing vessels. Concentrations of over 1000 birds have been noted in this species as well, particularly closely inshore, but numbers could also build up steeply offshore, around fishing fleets working these waters. The smoother distance to coast therefore has a profound impact on most distribution patterns found (Table 25, Figure 36)

An impact of OWEZ was difficult to assess during the T-1 surveys (Table 25, Figure 36). Like in the Lesser Black-backed Gull, the data show a great deal of noise caused by fishing vessels attracting large numbers of gulls from large distances. All large concentrations of gulls (any species) during the T-1 phase of the project were therefore found outside the perimeters of the wind farms. Several cases of avoidance were thus found (April 2008, June 2009, November 2008) but distribution patterns seem much impacted by concentrations outside the wind farm, or low densities at latitudes of OWEZ. Herring Gulls were seen inside OWEZ (and PAWP) on many occasions, often resting on monopile foundations (attraction). There is thus little evidence of an impact of the wind farm on these gulls, other than keeping fishing vessels at a distance.

Month	year	Survey	N
2	2004	T-0	344
1	2008	T-1a	340
1	2009	T-1b	484
1	2010	T-1c	115
2	2010	T-1c	55
4	2003	T-0	3910
4	2007	T-1a	2418
4	2008	T-1b	983
4	2009	T-1c	1349
6	2003	T-0	2714
6	2007	T-1a	278
6	2008	T-1b	1200
6	2009	T-1c	2223
8	2003	T-0	327
8	2007	T-1a	1602
8	2008	T-1b	164
9	2002	T-0	2474
10	2002	T-1a	3486
9	2007	T-1b	386
10	2009	T-1c	653
11	2003	T-0	11024
11	2007	T-1a	465
11	2008	T-1b	4399
11	2009	T-1c	55

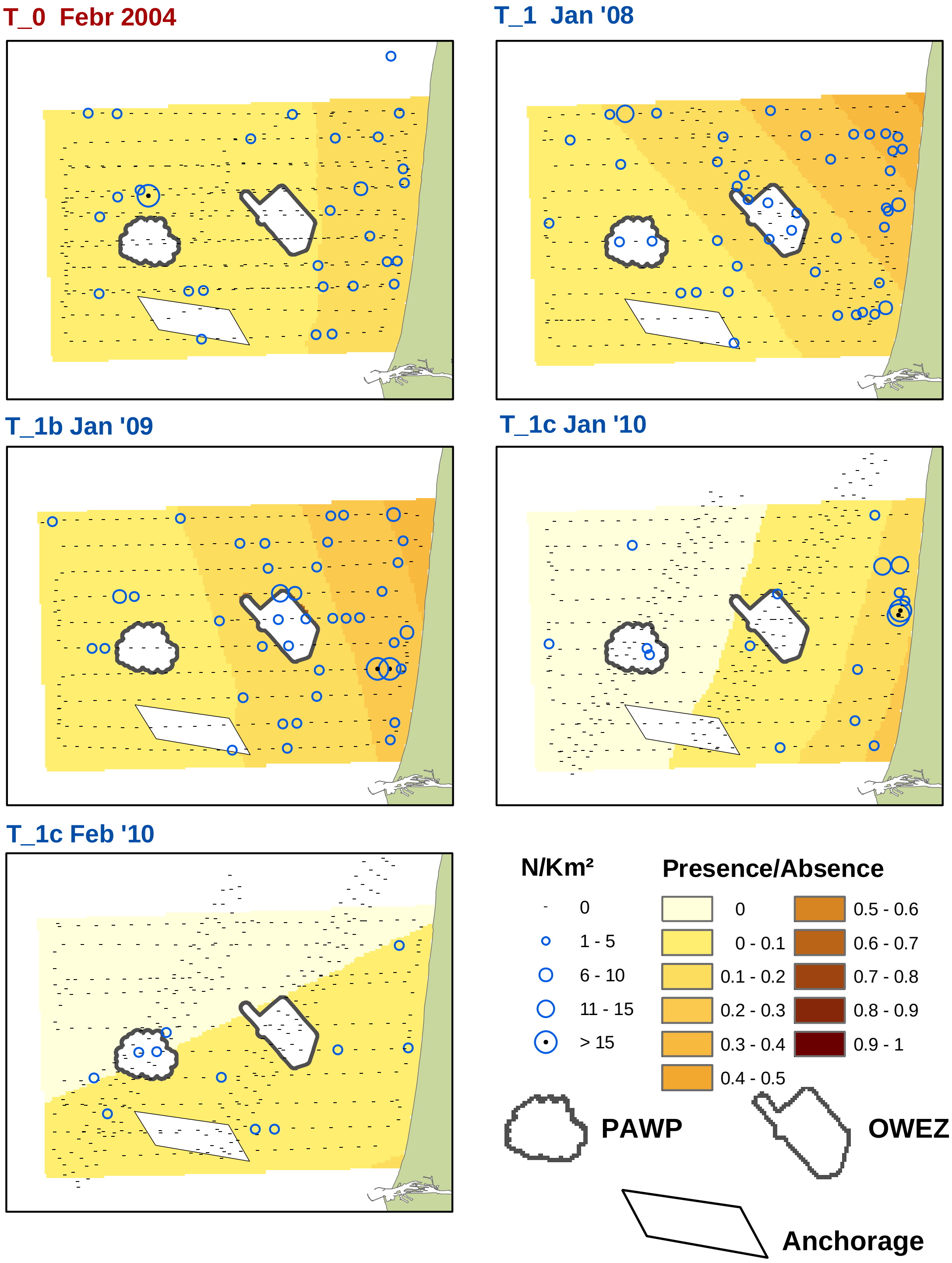
Table 24. *Total numbers of Herring Gulls seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	0.015	0.831	0.862	0.939	-	GAMM	NA	29
2008	1	**0.002**	**0.030**	**0.043**	0.285	+	GAMM	NA	45
2009	1	**0.001**	0.313	**0.000**	**0.013**	+	GAMM	NA	41
2010	1	**0.027**	0.610	0.310	0.749	+	GAMM	NA	17
2010	2	0.016	**0.000**	1.000	1.000	-	GAM	0.09	11
2003	4	**0.000**	0.015	1.000	0.921	-	GAM	0.12	83
2007	4	**0.000**	0.083	0.274	0.962	+	GAMM	NA	73
2008	4	**0.079**	0.904	**0.000**	**0.000**	-	GAMM	NA	61
2009	4	**0.002**	0.281	0.679	0.383	+	GAMM	NA	32
2003	6	**0.000**	0.569	0.815	0.834	-	GAMM	NA	79
2007	6	**0.002**	0.125	1.000	1.000	-	GAMM	NA	27
2008	6	**0.000**	**0.008**	**0.000**	0.744	+	GAMM	NA	34
2009	6	**0.000**	0.257	**0.000**	**0.000**	-	GAMM	NA	63
2003	8	**0.000**	**0.009**	0.503	0.503	-	GAMM	NA	47
2007	8	**0.000**	0.129	0.375	0.911	-	GAMM	NA	68
2008	8	NA	NA	NA	NA	NA	ins. data	NA	9
2002	9	**0.000**	0.950	0.345	0.112	+	GAMM	NA	110
2002	10	**0.000**	**0.029**	1.000	1.000	-	GAM	0.23	42
2007	9	NA	NA	NA	NA	NA	ins. data	NA	8
2009	10	NA	NA	NA	NA	NA	ins. data	NA	10
2003	11	**0.000**	0.223	1.000	1.000	-	GAM	0.28	67
2007	11	**0.000**	**0.036**	1.000	1.000	-	GAM	0.14	18
2008	11	**0.000**	0.933	**0.000**	**0.000**	-	GAMM	NA	39
2009	11	**0.040**	0.495	0.842	0.578	+	GAMM	NA	12

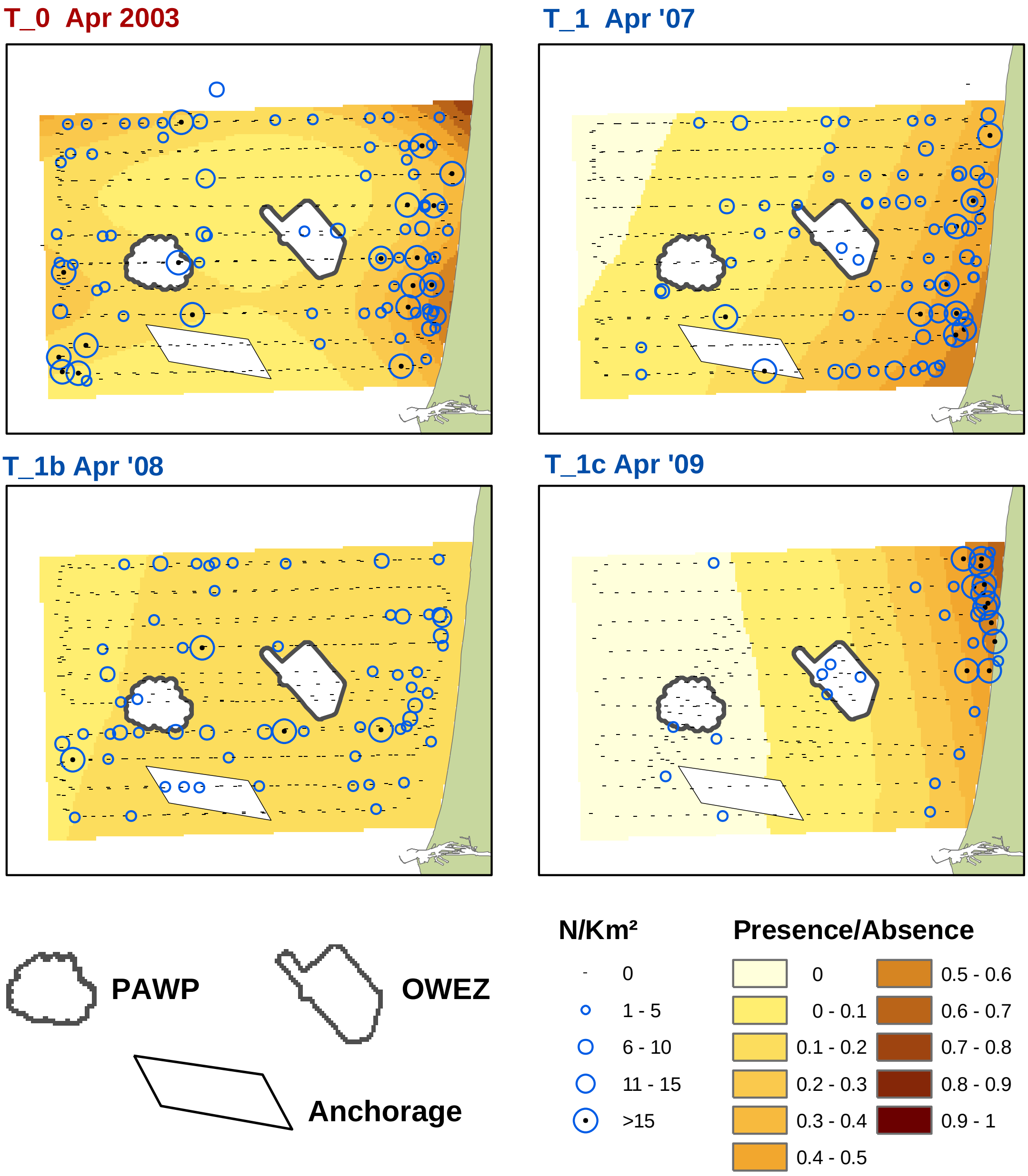
Table 25. *Modelling results (presence/absence) for Herring Gull. Significant contributions (P<0.1) are put in **bold**. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ) *are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 36 (overleaf): *Distribution maps of Herring Gull, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Herring Gull in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Herring Gulls indicated by -.*

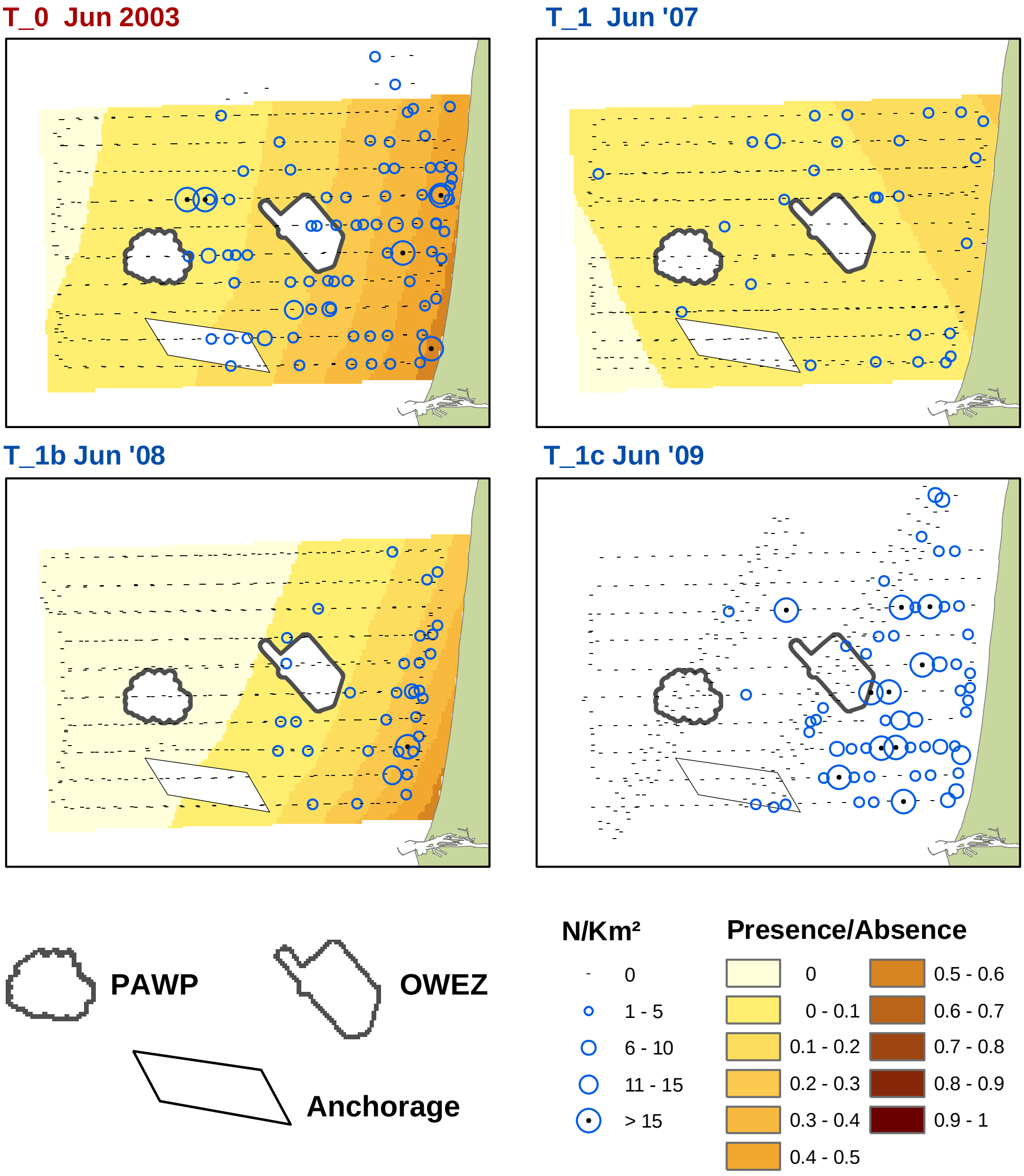
Herring Gull



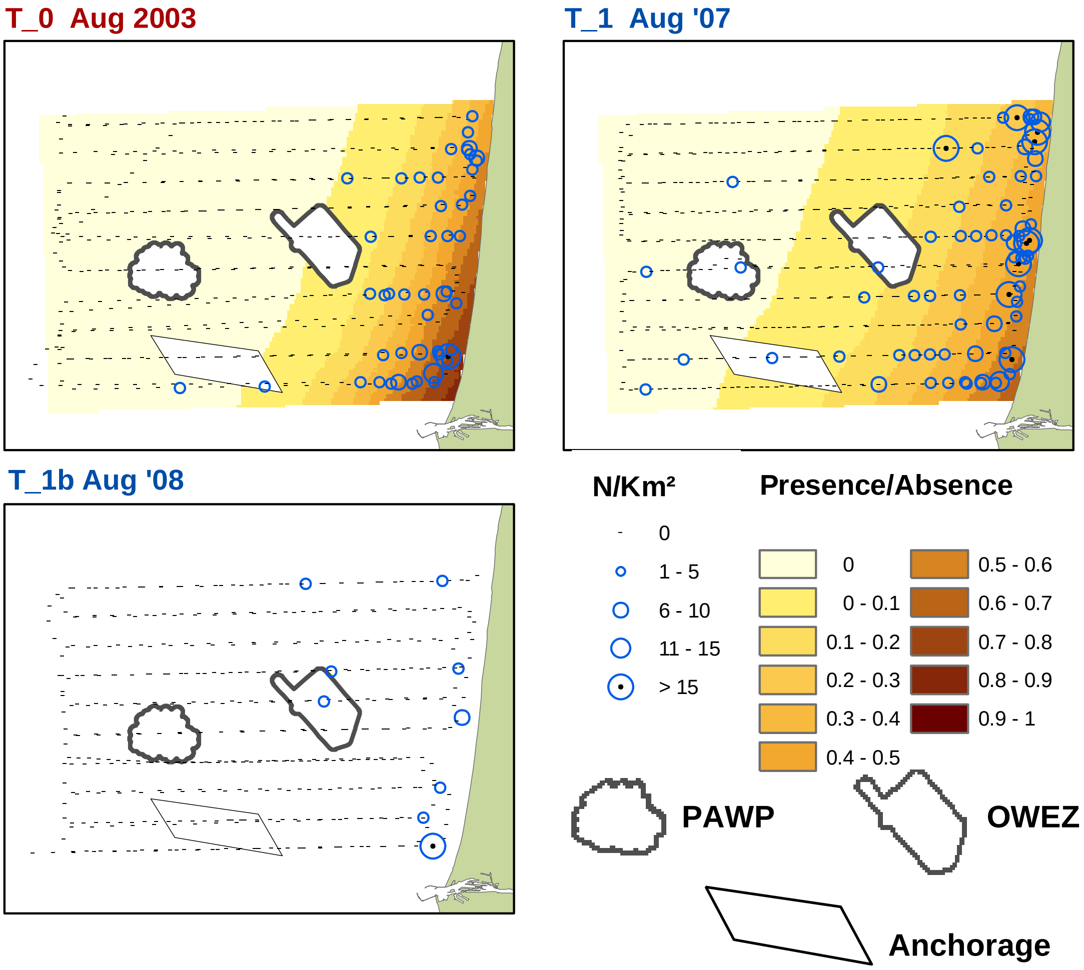
Herring Gull



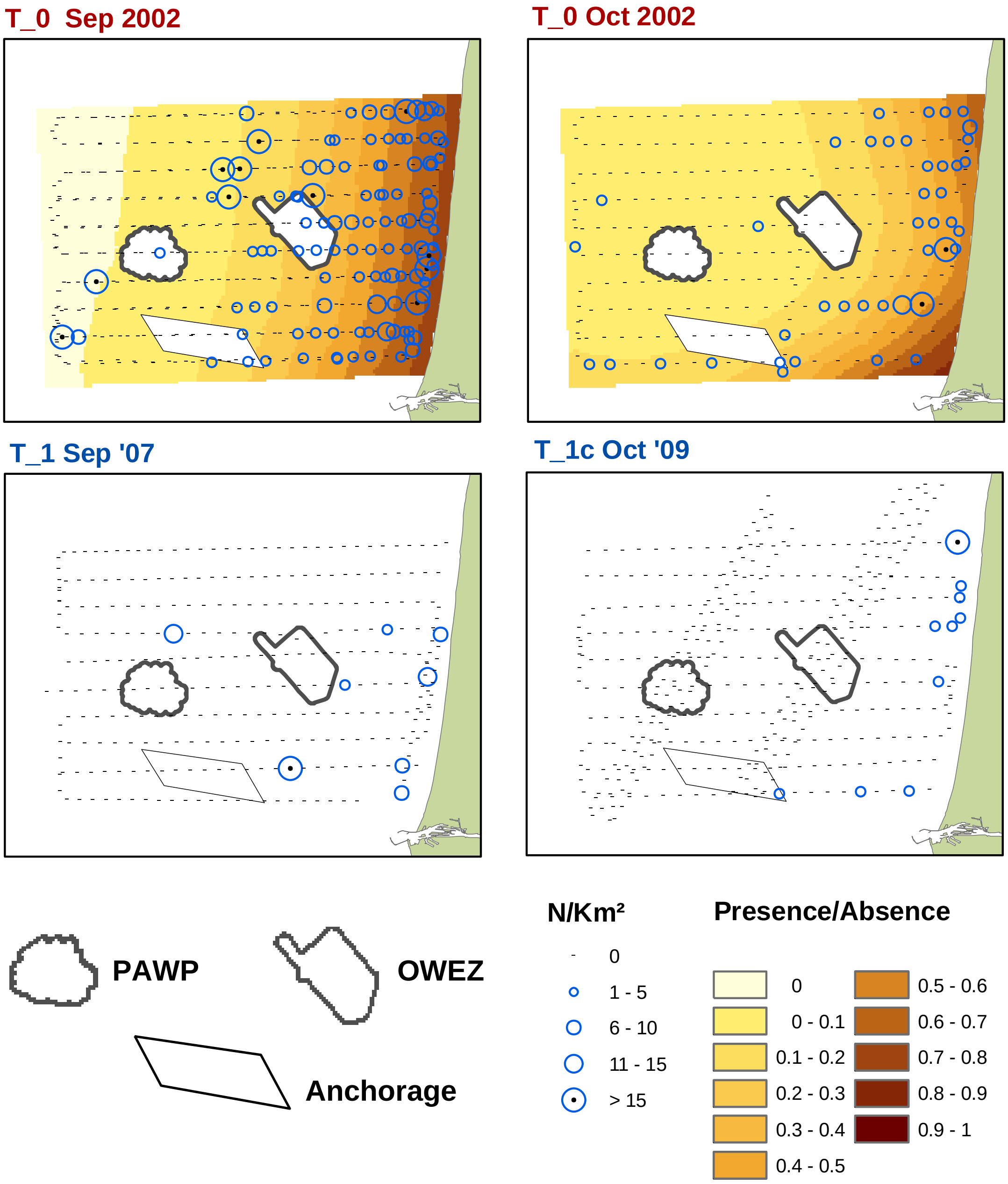
Herring Gull



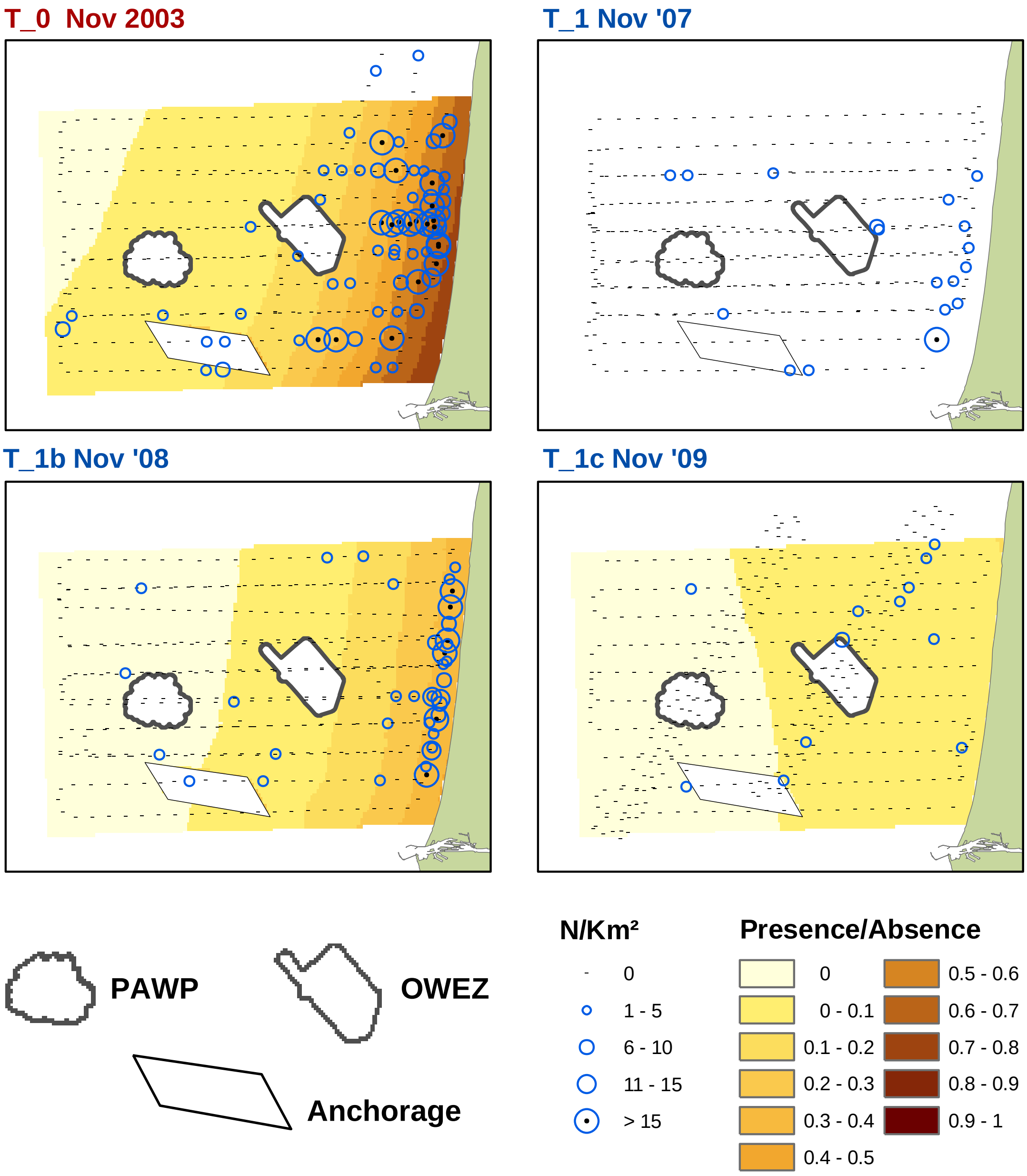
Herring Gull



Herring Gull



Herring Gull



Greater Black-backed Gull Larus marinus (Grote Mantelmeeuw)

Figure 37. *Greater Black-backed Gull (third-winter immature; note black-tipped outer tail feathers and upper wings that are not quite black). Photo: Steve Geelhoed, IMARES.*

Greater Black-backed Gulls visit Dutch waters mainly in the non-breeding season and they occur dispersed over the entire southern North Sea (Camphuysen & Leopold 1994). Like the Lesser Black-backed and Herring Gulls discussed in the previous paragraphs, Greater Black-backed Gulls feed around fishing vessels but their numbers were often lower than those of other species in the associated flocks. Numbers encountered were generally largest during the autumn surveys (Table 26). Greater Black-backed Gulls tended to be slightly more numerous in nearshore waters, but concentrations also occurred in different parts of the study area at times (Figure 38).

Statistically significant impacts of OWEZ during T-1 surveys, both positive and negative, were picked up by the models (Table 27), but only in low density situations (Table 26) when a few gulls resting on wind farm structures (attraction) or a few gulls resting on a gas platform outside the wind farm or feeding behind a trawler ("avoidance") would make this difference. The distribution maps provide very little reason to suggest that OWEZ has a significant impact on the distribution of this large gull. In high density situations, with gulls spread out over the entire study area, no effect of OWEZ was found. Only the largest concentrations were always found outside the wind farms, like in the other large gulls. Presence/absence models suffer little from a few large concentrations, as numbers are transformed to 0 or 1 for any given count.

Month	year	Survey	N
2	2004	T-0	64
1	2008	T-1a	352
1	2009	T-1b	652
1	2010	T-1c	127
2	2010	T-1c	80
4	2003	T-0	370
4	2007	T-1a	106
4	2008	T-1b	74
4	2009	T-1c	93
6	2003	T-0	12
6	2007	T-1a	157
6	2008	T-1b	169
6	2009	T-1c	67
8	2003	T-0	388
8	2007	T-1a	265
8	2008	T-1b	184
9	2002	T-0	3257
10	2002	T-1a	1042
9	2007	T-1b	1294
10	2009	T-1c	472
11	2003	T-0	2357
11	2007	T-1a	611
11	2008	T-1b	3222
11	2009	T-1c	408

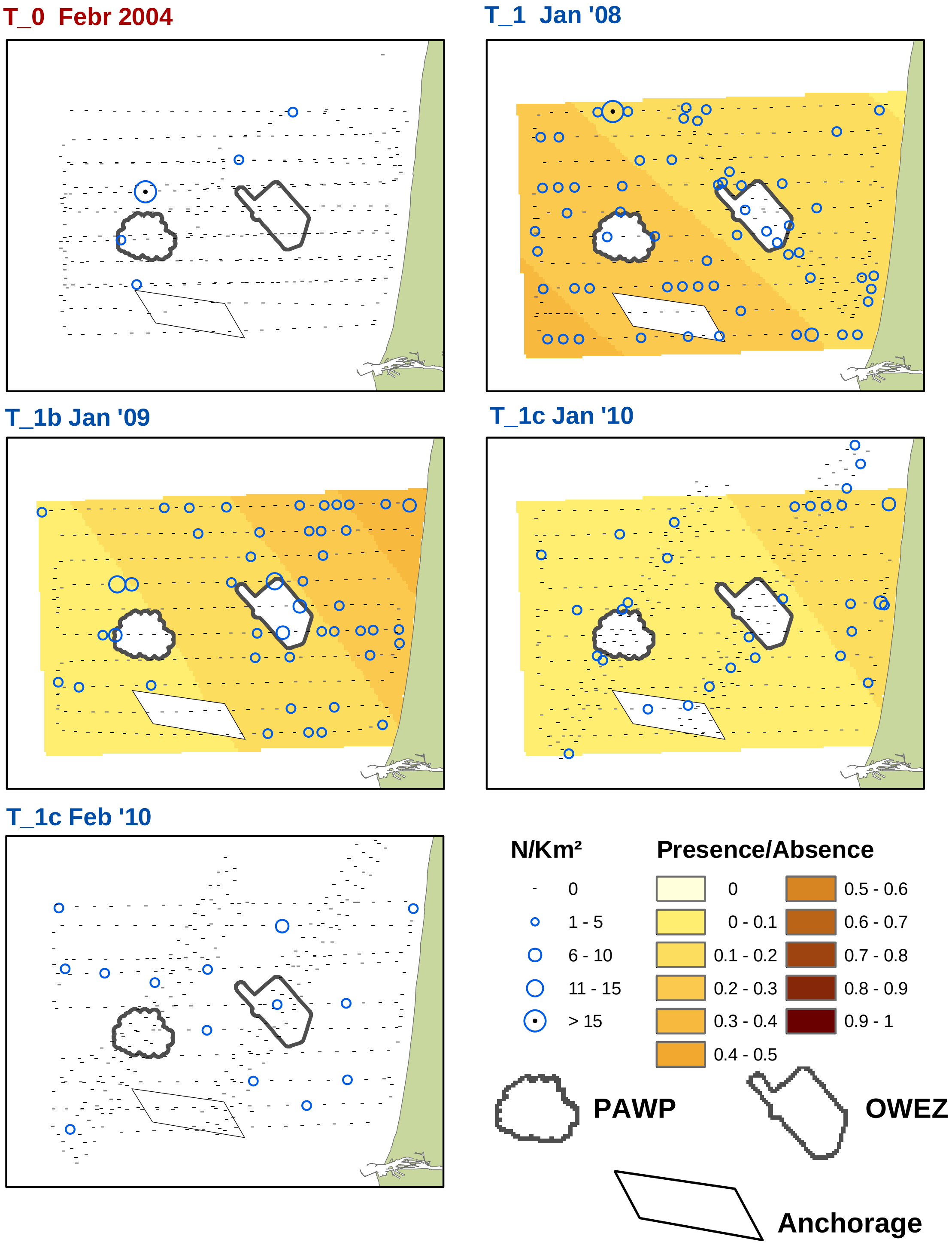
Table 26. *Total numbers of Greater Black-backed Gulls seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	NA	NA	NA	NA	NA	ins. data	NA	5
2008	1	0.106	0.196	0.850	0.525	+	GAMM	NA	60
2009	1	**0.003**	0.085	0.353	0.103	+	GAMM	NA	46
2010	1	0.063	0.216	1.000	1.000	-	GAMM	NA	31
2010	2	0.685	0.958	1.000	0.528	+	GAMM	NA	14
2003	4	**0.002**	0.258	1.000	1.000	-	GAM	0.04	23
2007	4	0.872	0.575	**0.000**	0.495	+	GAMM	NA	23
2008	4	0.000	**0.000**	1.000	**0.012**	+	GAM	0.11	19
2009	4	0.019	0.023	1.000	1.000	-	GAMM	NA	15
2003	6	NA	NA	NA	NA	NA	ins. data	NA	2
2007	6	**0.002**	0.151	**0.000**	**0.051**	+	GAMM	NA	28
2008	6	**0.080**	0.271	0.187	**0.029**	+	GAMM	NA	14
2009	6	**0.000**	0.482	**0.000**	**0.000**	-	GAMM	NA	20
2003	8	**0.000**	0.157	**0.000**	0.677	+	GAMM	NA	46
2007	8	0.827	**0.079**	**0.020**	**0.063**	+	GAMM	NA	45
2008	8	**0.000**	0.593	**0.000**	0.389	-	GAMM	NA	34
2002	9	**0.000**	0.952	0.381	0.103	+	GAMM	NA	79
2007	9	0.135	0.719	0.155	0.979	+	GAMM	NA	32
2002	10	**0.000**	**0.001**	1.000	1.000	-	GAM	0.15	44
2009	10	**0.000**	0.648	**0.000**	0.680	-	GAMM	NA	47
2003	11	**0.000**	0.605	1.000	0.159	-	GAM	0.2	84
2007	11	**0.000**	**0.000**	1.000	**0.071**	-	GAM	0.11	91
2008	11	**0.000**	0.392	0.150	0.699	-	GAMM	NA	137
2009	11	**0.010**	0.664	0.624	0.301	-	GAMM	NA	75

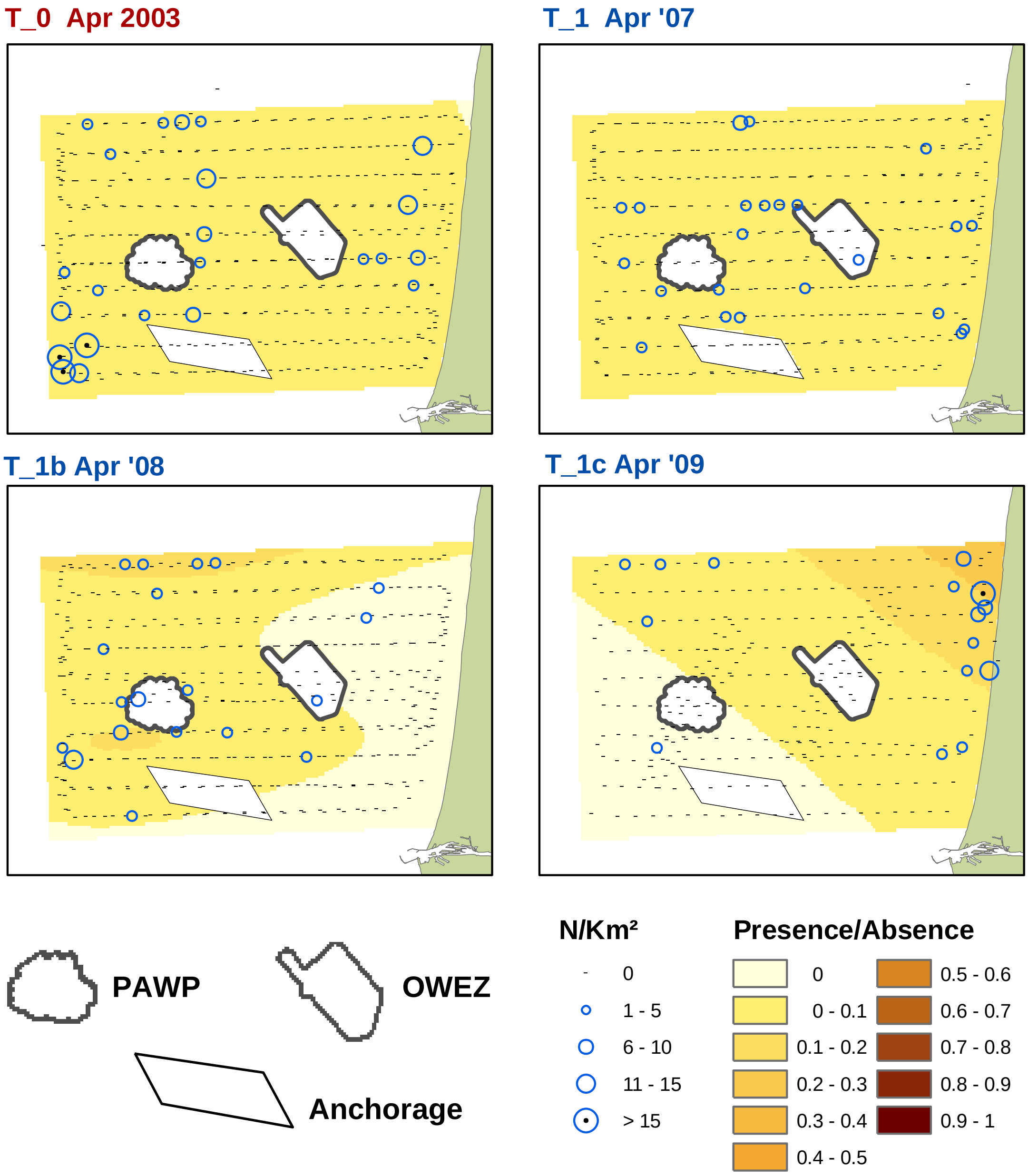
Table 27. *Modelling results (presence/absence) for Greater Black-backed Gull. Significant contributions (P<0.1) are put in **bold**. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column Est_OWEZ) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 38 (overleaf): *Distribution maps of Greater Black-backed Gull, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Greater Black-backed Gull in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Greater Black-backed Gulls indicated by -.*

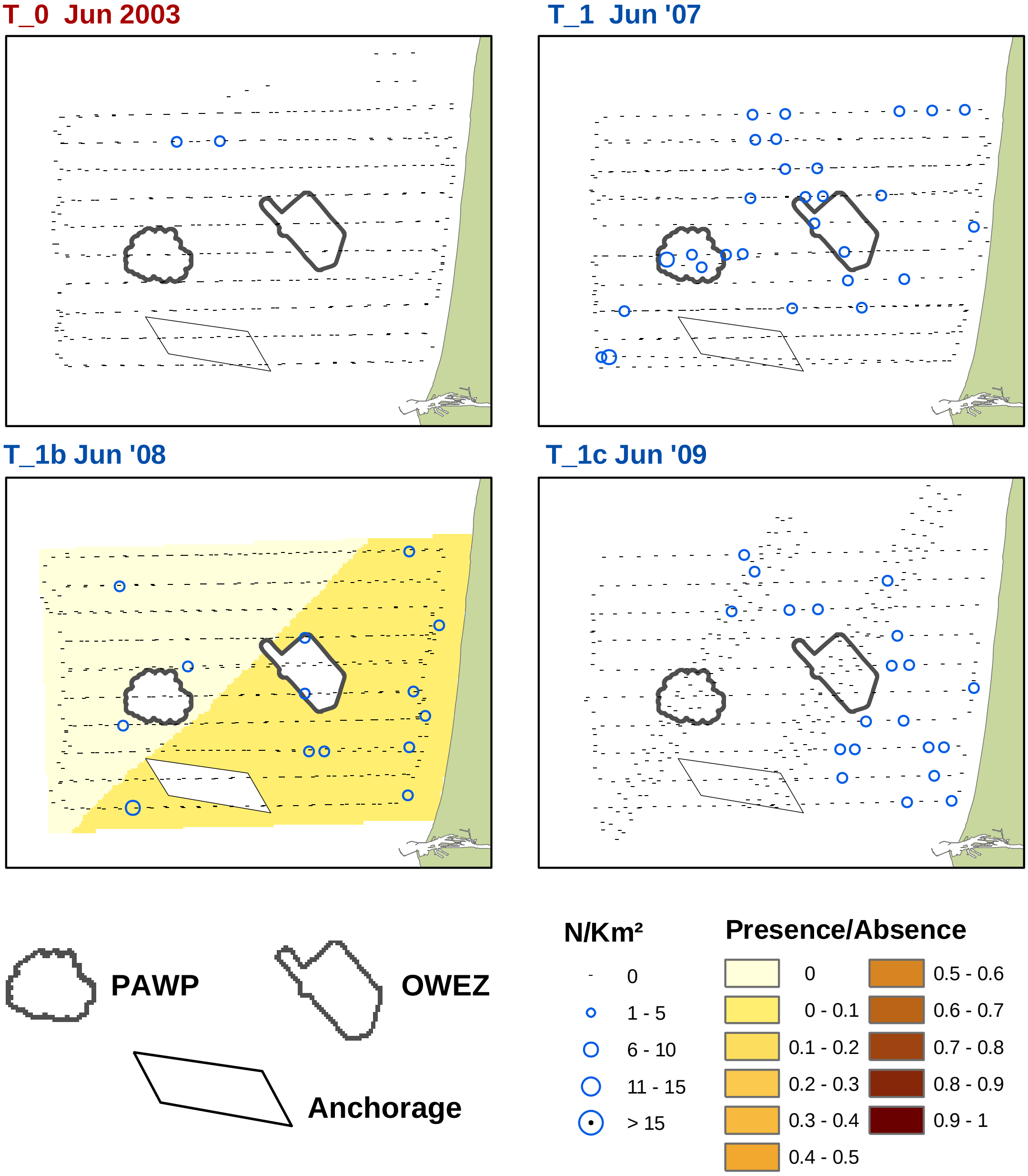
Great Black-backed Gull



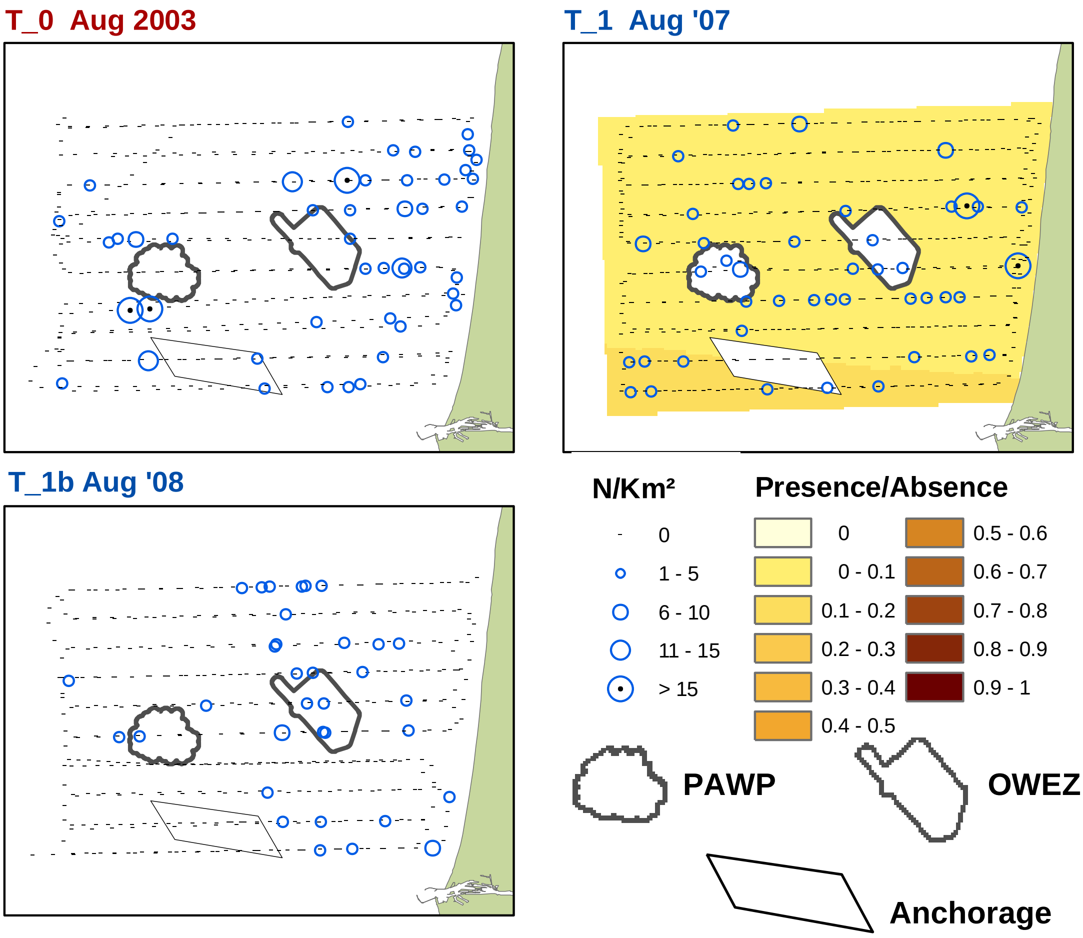
Great Black-backed Gull



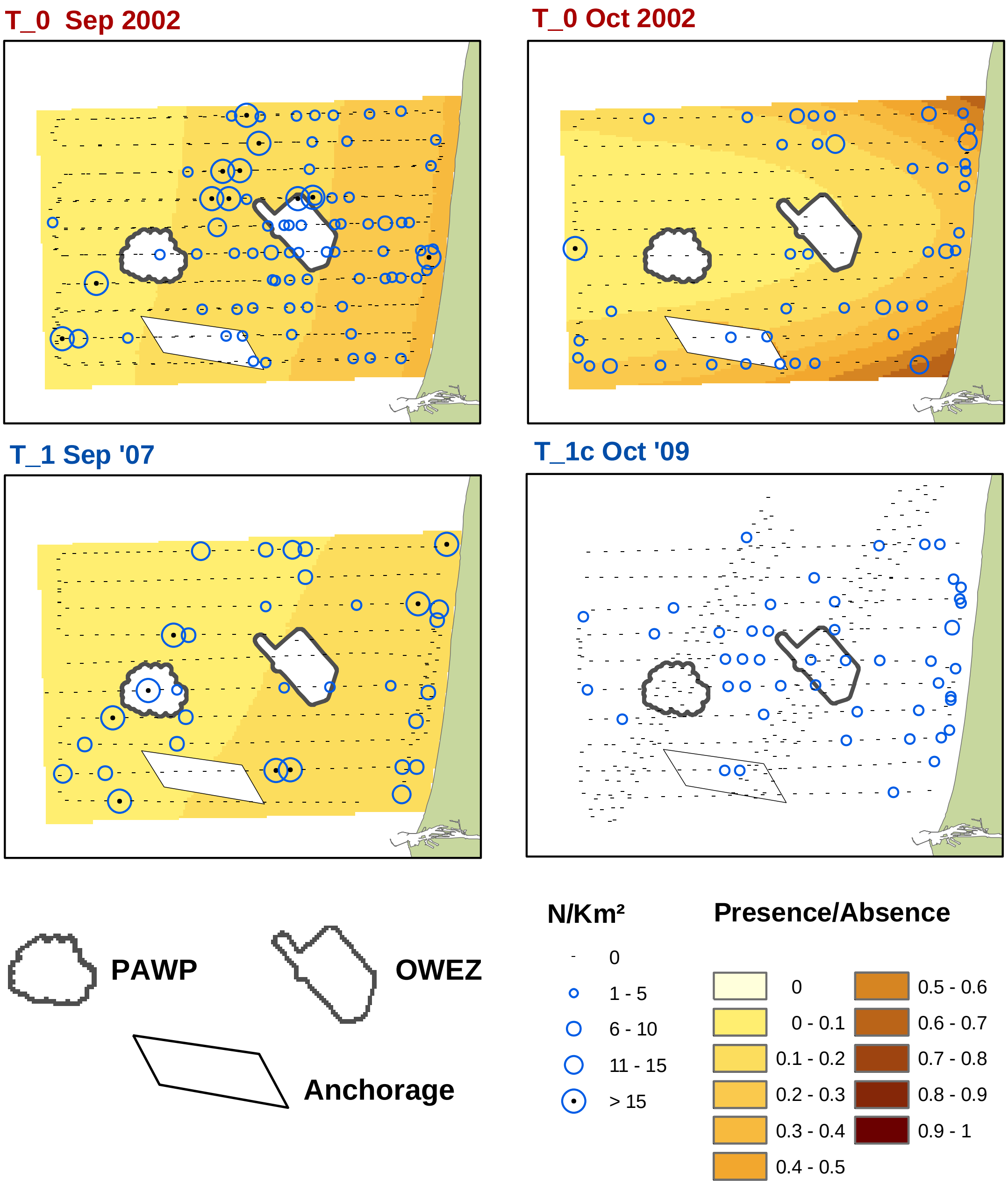
Great Black-backed Gull



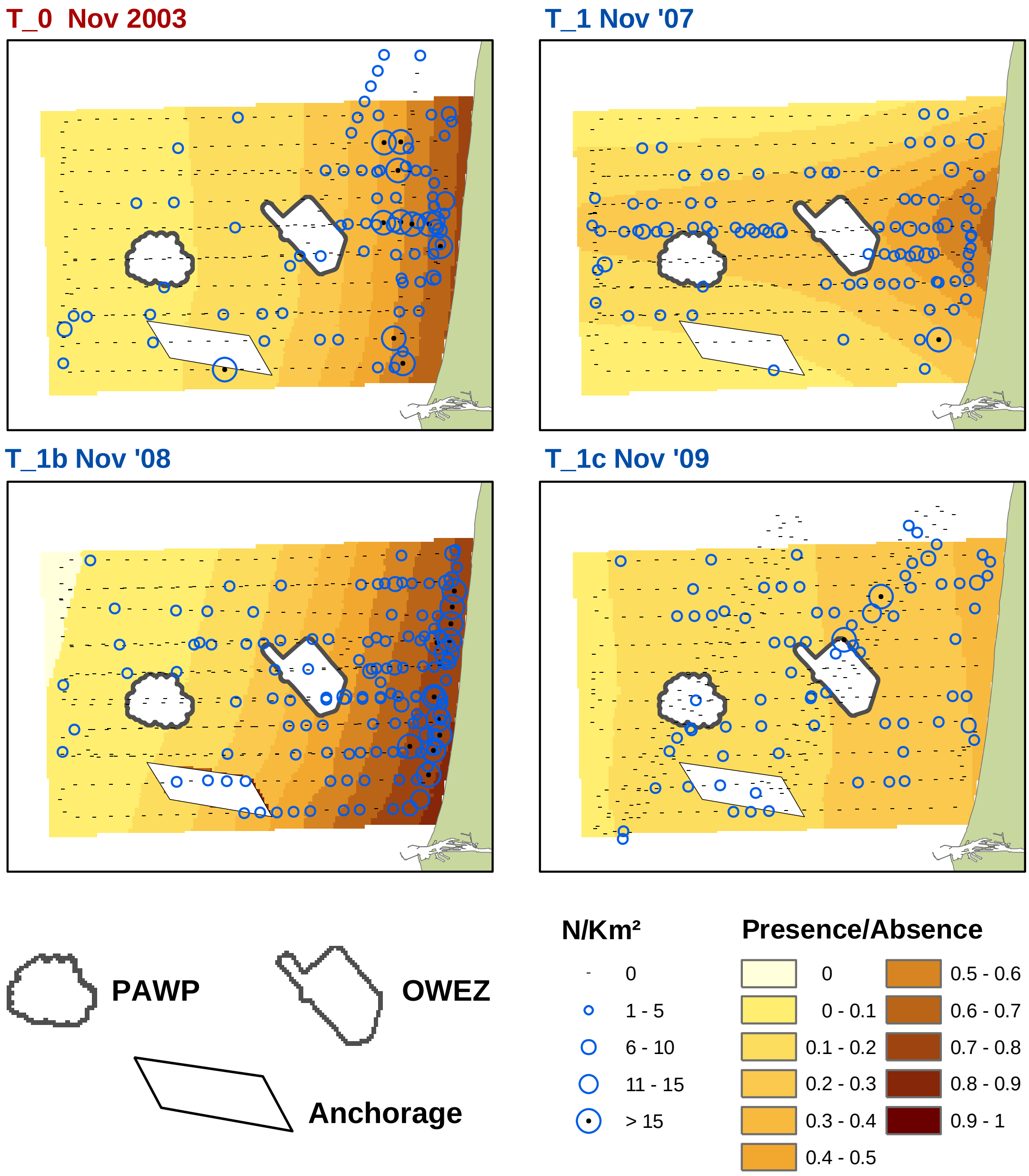
Great Black-backed Gull



Great Black-backed Gull



Great Black-backed Gull



Black-legged Kittiwake *Rissa tridactyla* (Drieteenmeeuw)

Figure 39. *Juvenile Kittiwake, 6 November 2007, passing PAWP during high winds. Photo: Hans Verdaat, IMARES.*

Kittiwakes visit Dutch waters mainly in the non-breeding season (Table 28) and like other wintering gulls they occur dispersed over the entire North Sea (Camphuysen & Leopold 1994). However, unlike many other wintering gulls, they normally avoid nearshore waters and numbers in the shallow Southern North Sea vary greatly between years (Camphuysen & van Dijk 1983; Platteeuw et al. 1994). Distance to coast often greatly influences distribution patterns (Table 28), but this pattern broke down during the autumn migration period (all four November surveys) and the 2009 mid-winter survey (Figure 40). Kittiwakes join mixed feeding flocks with larger gulls less readily and fishing vessels probably have less impact on their general distribution, in a study area where large gulls predominate such as the current study area. They readily entered OWEZ and an effect of the wind farm on their distribution pattern could not be detected in the collected data. One case of significant attraction (in November 2007) should be considered with caution, given the wider distribution pattern found during that particular autumn survey (Table 29; Figure 40).

Month	year	Survey	N
2	2004	T-0	108
1	2008	T-1a	385
1	2009	T-1b	800
1	2010	T-1c	17
2	2010	T-1c	43
4	2003	T-0	197
4	2007	T-1a	16
4	2008	T-1b	3
4	2009	T-1c	0
6	2003	T-0	0
6	2007	T-1a	12
6	2008	T-1b	0
6	2009	T-1c	0
8	2003	T-0	16
8	2007	T-1a	0
8	2008	T-1b	4
9	2002	T-0	15
10	2002	T-1a	243
9	2007	T-1b	164
10	2009	T-1c	24
11	2003	T-0	1298
11	2007	T-1a	1739
11	2008	T-1b	93
11	2009	T-1c	459

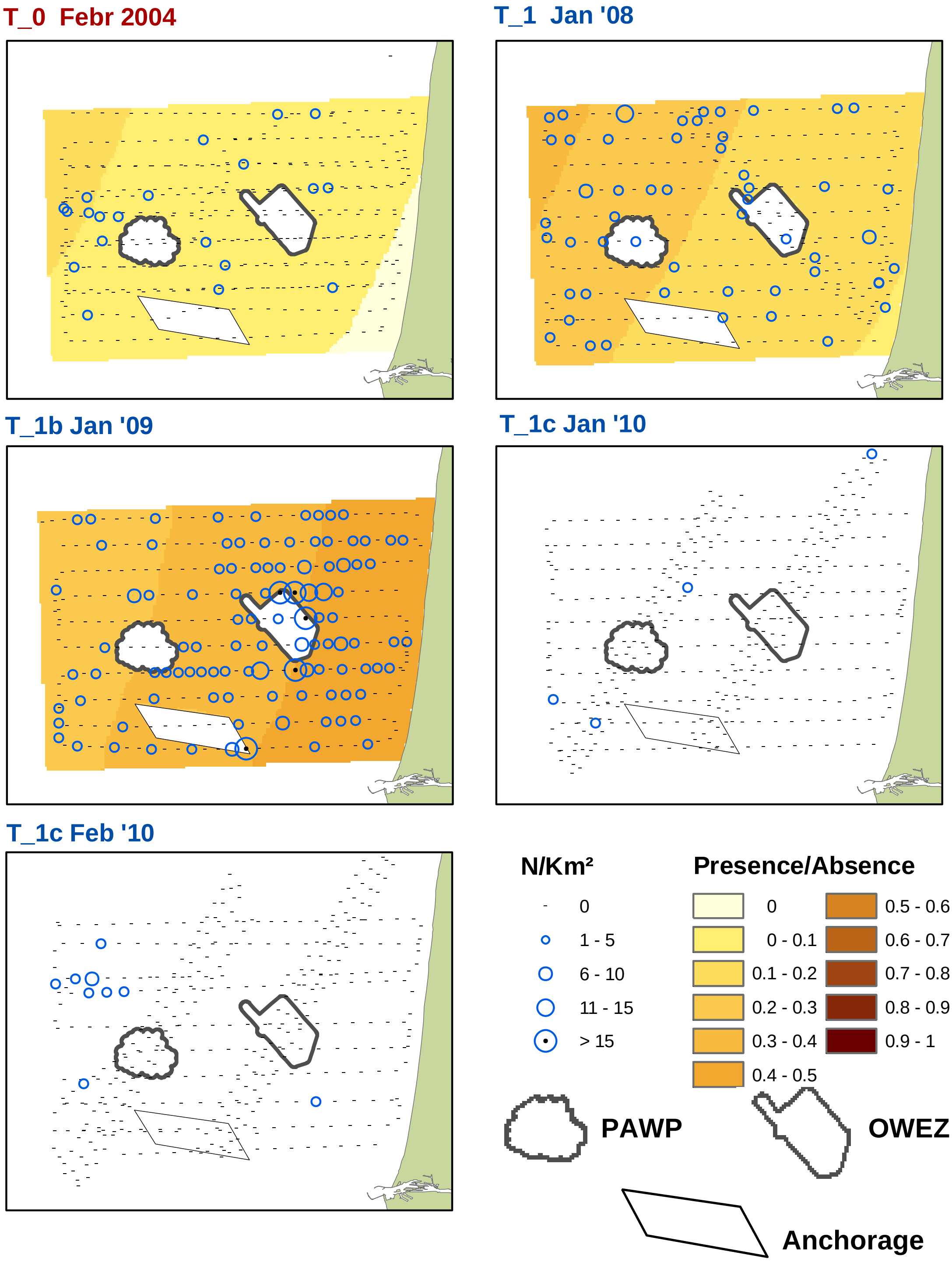
Table 28. *Total numbers of Kittiwakes seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	**0.000**	0.284	1.000	1.000	-	GAM	0.06	20
2008	1	**0.015**	0.567	1.000	0.330	-	GAMM	NA	53
2009	1	**0.025**	0.871	**0.000**	0.492	+	GAMM	NA	104
2010	1	NA	NA	NA	NA	NA	ins. data	NA	4
2010	2	NA	NA	NA	NA	NA	ins. data	NA	9
2003	4	**0.000**	0.691	1.000	1.000	-	GAMM	NA	29
2007	4	NA	NA	NA	NA	NA	ins. data	NA	2
2008	4	NA	NA	NA	NA	NA	ins. data	NA	1
2009	4	NA	NA	NA	NA	NA	ins. data	NA	0
2003	6	NA	NA	NA	NA	NA	ins. data	NA	0
2007	6	NA	NA	NA	NA	NA	ins. data	NA	2
2008	6	NA	NA	NA	NA	NA	ins. data	NA	0
2009	6	NA	NA	NA	NA	NA	ins. data	NA	0
2003	8	NA	NA	NA	NA	NA	ins. data	NA	1
2007	8	NA	NA	NA	NA	NA	ins. data	NA	0
2008	8	NA	NA	NA	NA	NA	ins. data	NA	2
2002	9	NA	NA	NA	NA	NA	ins. data	NA	2
2002	10	**0.001**	**0.000**	1.000	1.000	-	GAM	0.21	24
2007	9	NA	NA	NA	NA	NA	ins. data	NA	5
2009	10	NA	NA	NA	NA	NA	ins. data	NA	4
2003	11	**0.073**	0.163	0.831	0.536	-	GAMM	NA	91
2007	11	0.294	**0.004**	0.310	**0.072**	+	GAMM	NA	132
2008	11	0.232	0.525	1.000	1.000	-	GAMM	NA	19
2009	11	0.178	0.010	0.567	0.232	+	GAMM	NA	73

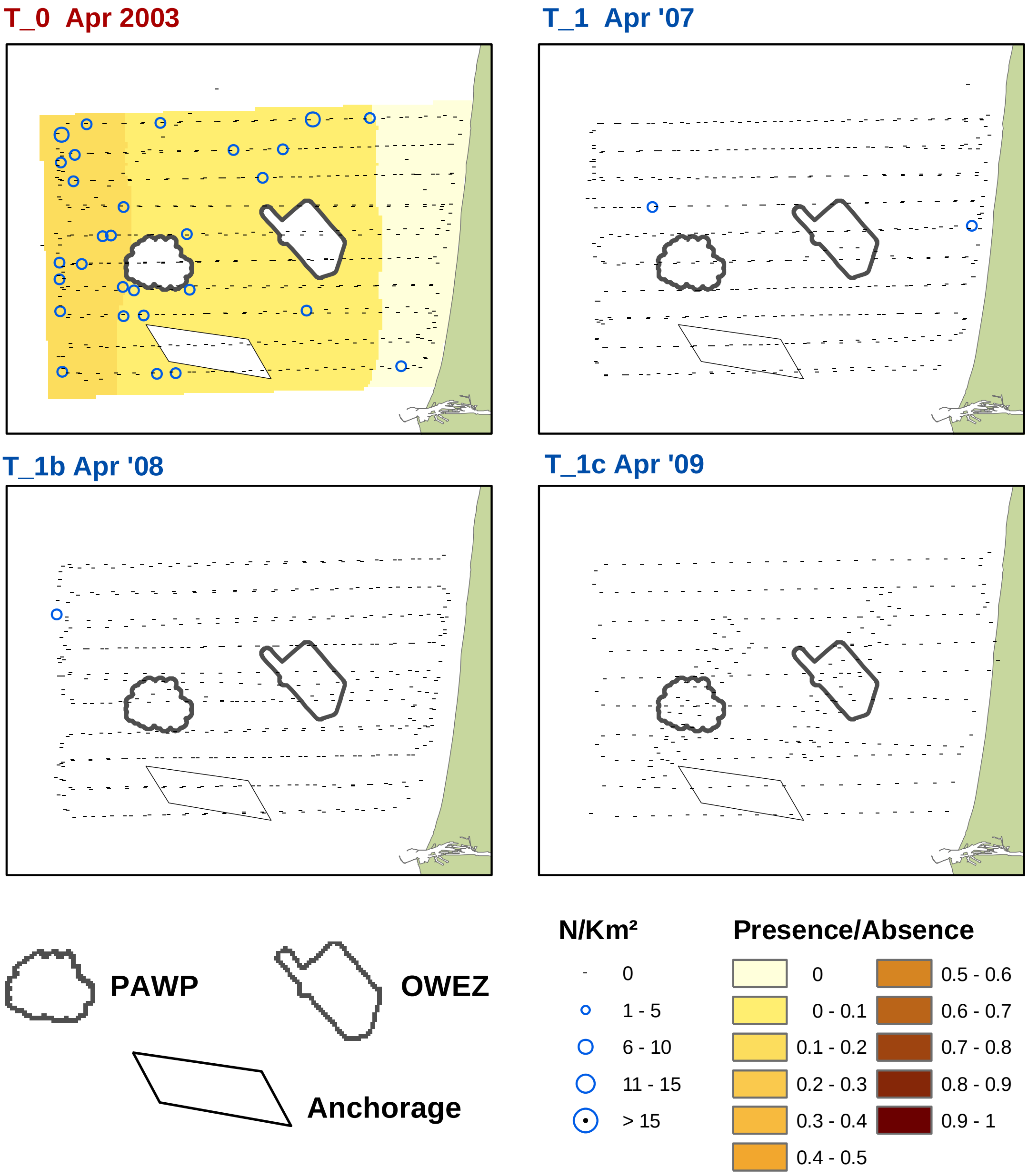
Table 29. *Modelling results (presence/absence) for Kittiwake. Significant contributions (P<0.1) are put in* ***bold****. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ*) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 40 (overleaf): *Distribution maps of Kittiwakes, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Kittiwake in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Kittiwakes indicated by -.*

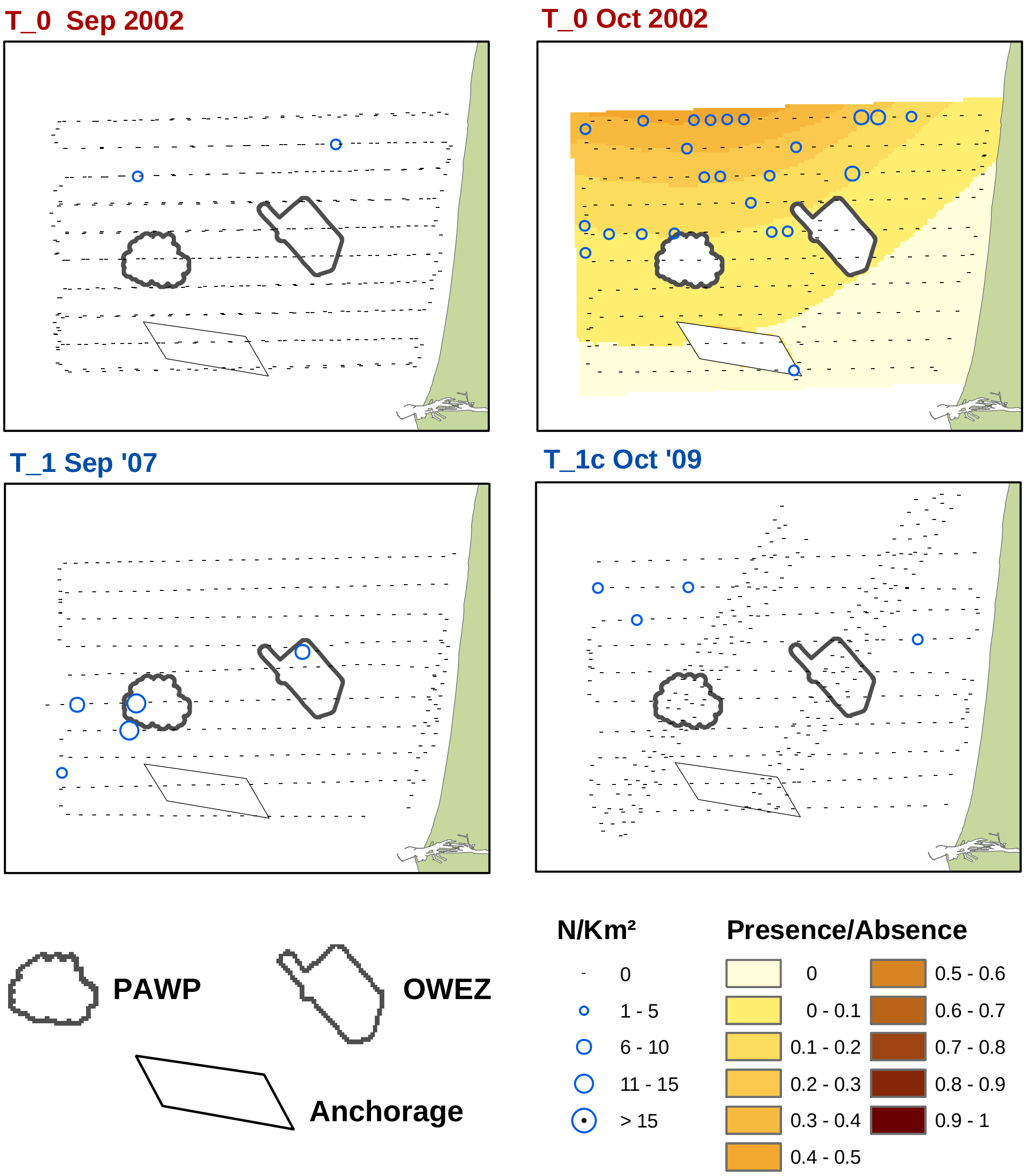
Black-legged Kittiwake



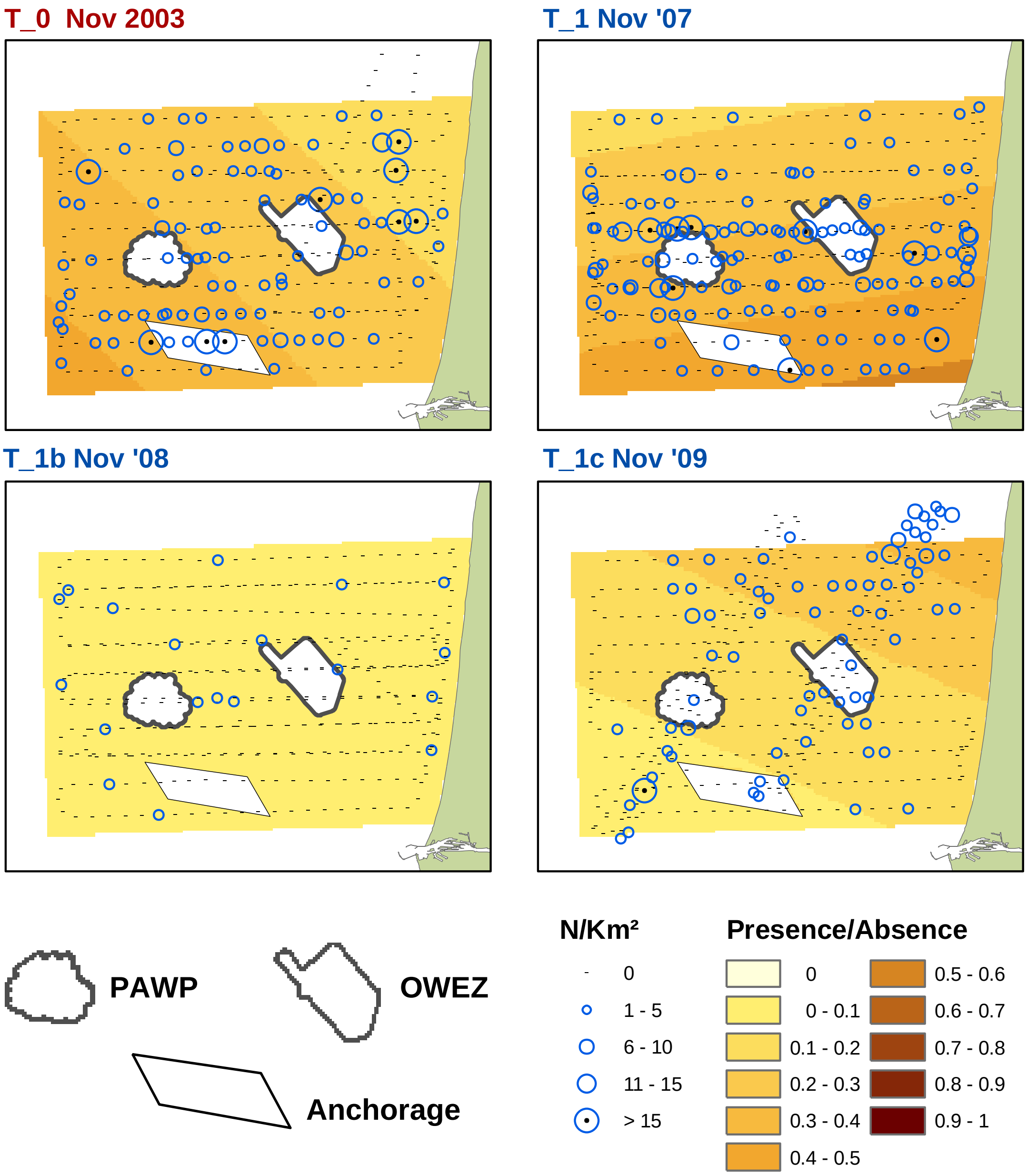
Black-legged Kittiwake



Black-legged Kittiwake



Black-legged Kittiwake



Sandwich Tern *Sterna sandvicensis* (Grote Stern)

Figure 41. *Sandwich Terns resting on a marker buoy AT ("Alterra") 3. This buoy marked a TPoD system, used for continuous registration of Harbour Porpoises in and around OWEZ (Brasseur et al. 2008; Scheidat et al. 2010). Resting on offshore buoys is typical early spring behaviour of Sandwich Terns off the Dutch coast. Photo: Hans Verdaat, IMARES.*

Sandwich Terns are visitors to Dutch coastal waters from spring to autumn that come here to breed and to pass through, to more northerly breeding sites. Terns were therefore only seen from spring to autumn in the migration and breeding seasons (Table 30) and mostly in nearshore waters (Figure 42). Breeding birds that have nests with eggs or unfledged chicks in colonies in the Wadden Sea or in the Delta are unlikely to reach OWEZ on their foraging trips (Arends et al. 2008) but non-breeders, failed breeders, birds (parents and fledged young) after the breeding season and particularly migrants are fully capable of using the site (Leopold et al. 2004). Breeding birds remain mostly nearshore, but the study area is too far removed from the nearest colony (De Petten, at SE Texel; Baptist & Leopold 2007), to be of any importance for breeders, so numbers were very low in the study area in mid-summer (Table 30). Therefore, numbers were highest during spring migration (April) and after fledging (August) (Table 30) and modelling was only possible for some of these survey months (Table 31).

Distance to coast influenced distribution patterns in August, when most Sandwich Terns were found near the mainland coast (Table 31, Figure 42). The opposite was found in April, when relatively large numbers were found far offshore. Numbers were never very high at wind farm latitudes. A single Sandwich Tern was seen in transect inside OWEZ during the April T-0 survey, a few more were seen within the wind farm perimeter during T-1 (Leopold et al. 2004), but not within the counting strips. Most Sandwich Terns were seen outside the wind farm. The T-1b August distribution hints at avoidance (Figure 42), with small flocks of terns all around the wind farm, but none within its perimeter. However, the GAM for August 2008 did not pick up any clear influence of the presence of the wind farms. With no Sandwich Terns counted inside the wind farm, there was certainly no attraction. This is in contrast to work in the offshore wind farm Horns Rev (Denmark) where terns supposedly flocked around the outer turbines, to feed in the tidal wakes behind the monopiles (Elsam Engineering & Energi 2005; Elsam Engineering 2005; Petersen & Fox 2007). No Sandwich Terns (or any other tern species) showed this behaviour in OWEZ..

Month	year	Survey	N
2	2004	T-0	0
1	2008	T-1a	0
1	2009	T-1b	0
1	2010	T-1c	0
2	2010	T-1c	0
4	2003	T-0	362
4	2007	T-1a	59
4	2008	T-1b	160
4	2009	T-1c	143
6	2003	T-0	114
6	2007	T-1a	20
6	2008	T-1b	127
6	2009	T-1c	182
8	2003	T-0	306
8	2007	T-1a	111
8	2008	T-1b	326
9	2002	T-0	46
10	2002	T-1a	0
9	2007	T-1b	132
10	2009	T-1c	3
11	2003	T-0	0
11	2007	T-1a	0
11	2008	T-1b	1
11	2009	T-1c	0

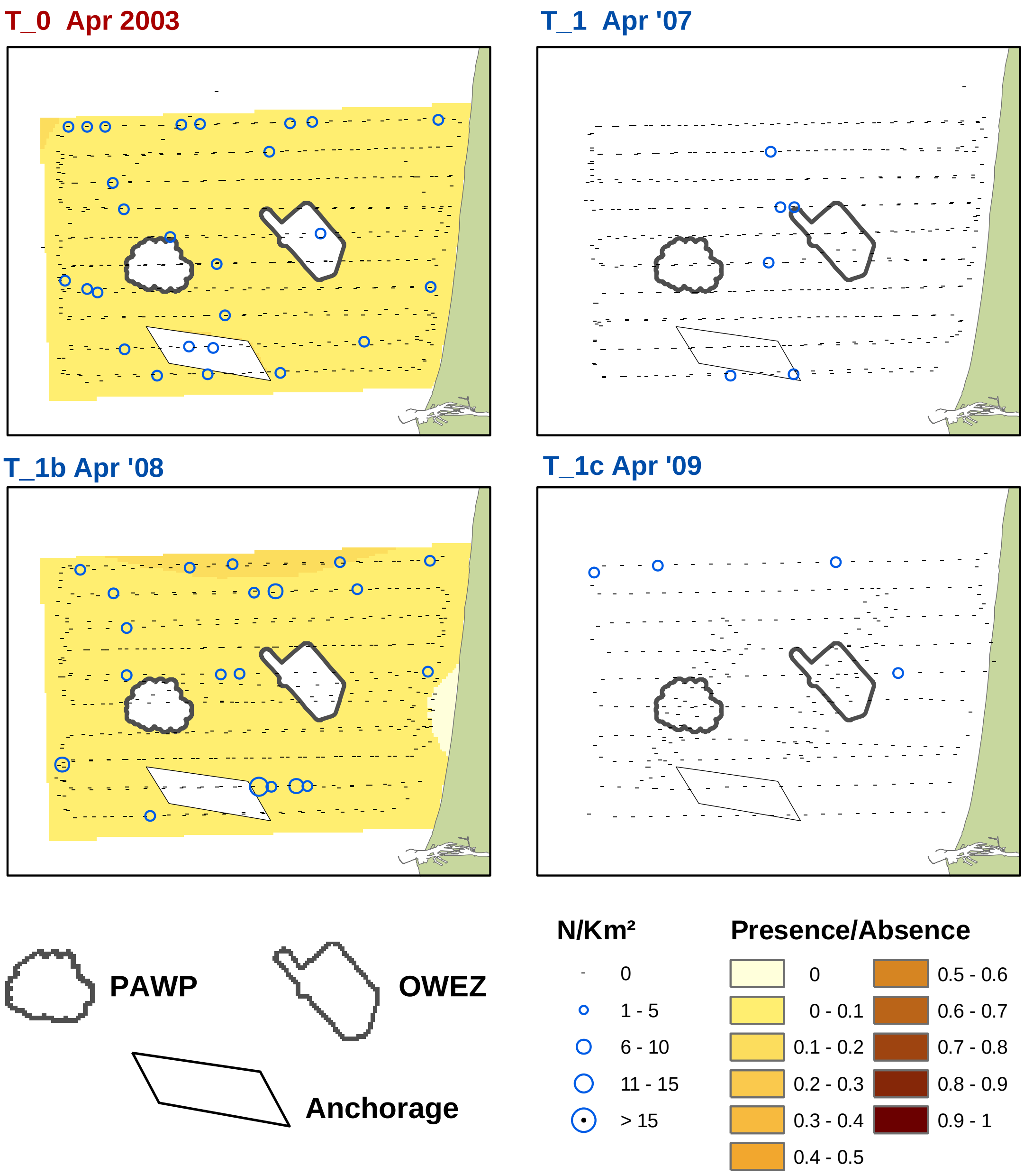
Table 30. *Total numbers of Sandwich Terns seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	NA	NA	NA	NA	NA	ins. data	NA	0
2008	1	NA	NA	NA	NA	NA	ins. data	NA	0
2009	1	NA	NA	NA	NA	NA	ins. data	NA	0
2010	1	NA	NA	NA	NA	NA	ins. data	NA	0
2010	2	NA	NA	NA	NA	NA	ins. data	NA	0
2003	4	**0.067**	0.605	0.456	0.517	+	GAMM	NA	26
2007	4	NA	NA	NA	NA	NA	ins. data	NA	6
2008	4	0.337	**0.001**	1.000	1.000	-	GAM	0.07	20
2009	4	NA	NA	NA	NA	NA	ins. data	NA	4
2003	6	NA	NA	NA	NA	NA	ins. data	NA	7
2007	6	NA	NA	NA	NA	NA	ins. data	NA	2
2008	6	NA	NA	NA	NA	NA	ins. data	NA	7
2009	6	NA	NA	NA	NA	NA	ins. data	NA	8
2003	8	**0.000**	0.218	**0.000**	**0.000**	-	GAMM	NA	14
2007	8	NA	NA	NA	NA	NA	ins. data	NA	7
2008	8	**0.000**	0.736	1.000	1.000	-	GAM	0.14	43
2002	9	NA	NA	NA	NA	NA	ins. data	NA	5
2002	10	NA	NA	NA	NA	NA	ins. data	NA	8
2007	9	NA	NA	NA	NA	NA	ins. data	NA	3
2009	10	NA	NA	NA	NA	NA	ins. data	NA	0
2003	11	NA	NA	NA	NA	NA	ins. data	NA	0
2007	11	NA	NA	NA	NA	NA	ins. data	NA	0
2008	11	NA	NA	NA	NA	NA	ins. data	NA	0
2009	11	NA	NA	NA	NA	NA	ins. data	NA	0

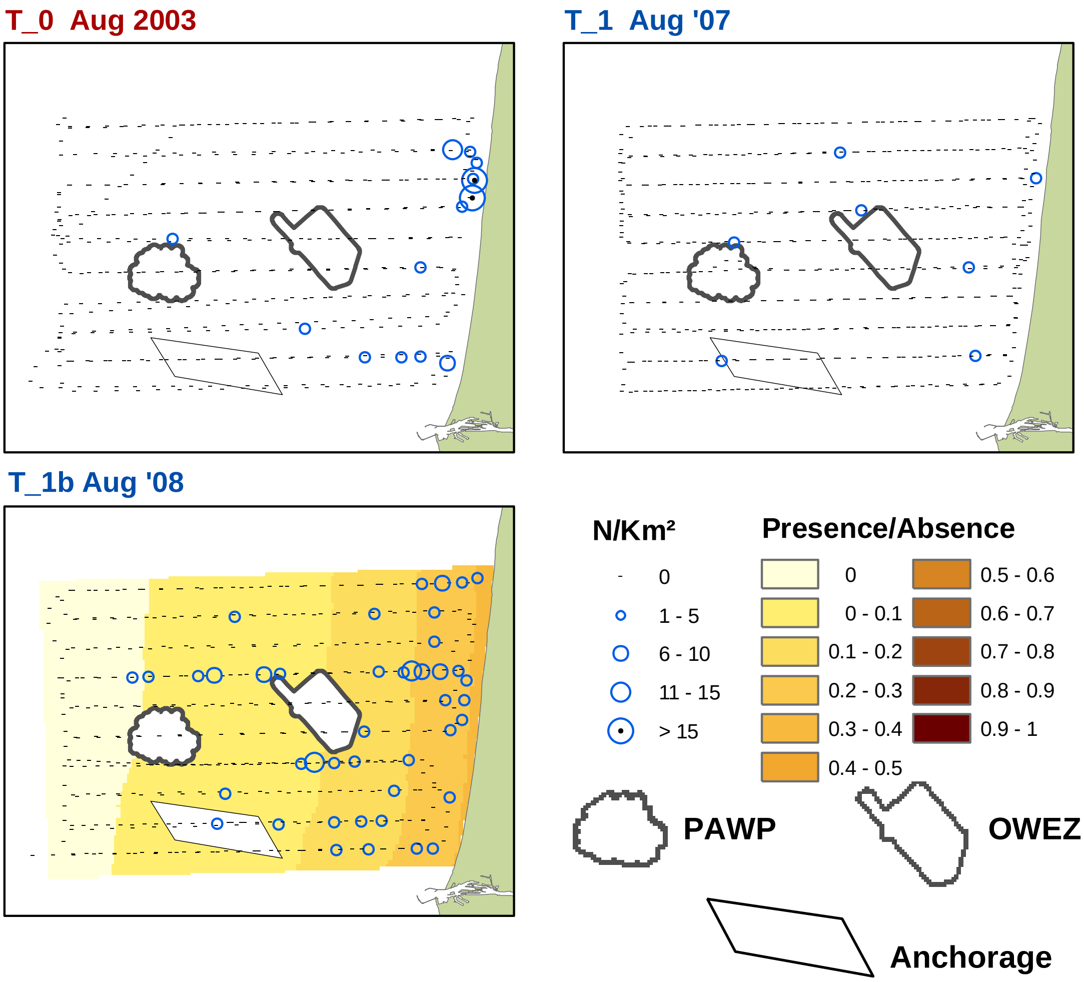
Table 31. *Modelling results (presence/absence) for Sandwich Tern. Significant contributions (P<0.1) are put in* ***bold****. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ) *are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 42 (overleaf): *Distribution maps of Sandwich Tern, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Sandwich Terns in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Sandwich Terns indicated by -.*

Sandwich Tern



Sandwich Tern



Common *Sterna hirundo* & Arctic Tern *S. paradisaea* (Visdief en Noordse Stern)

Figure 43. *Common Tern off the Dutch coast, summer 2006. Photo: Hans Verdaat, IMARES.*

Common and Arctic Terns have a very similar appearance and behaviour at sea and cannot always be separated during surveys. Therefore, these two species are treated together as "Commic" Terns (cf Leopold et al. 2004). Like the Sandwich Terns discussed above, Common and Arctic Terns are summer visitors to Dutch coastal waters. Comic Terns were only seen in significant numbers from April through September, with the largest numbers just after the breeding season, in August (Table 32).

Comic Terns tended to occur closer inshore than Sandwich Terns, but were fully capable of reaching OWEZ although this location is clearly beyond the coastal stretch where the majority of Common and Arctic Terns feed and migrate (Figure 44). Breeding birds that are attached to colonies in the Wadden Sea or in the Delta range less far afield than Sandwich Terns and cannot reach OWEZ on their foraging trips (Arends et al. 2008). Modelling was only possible for some of the results of the summer survey months (June and August; Table 33). After effects of distance to coast and northing were removed, no significant effect remained of the wind farms in the study area.

Month	year	Survey	N
2	2004	T-0	0
1	2008	T-1a	0
1	2009	T-1b	0
1	2010	T-1c	0
2	2010	T-1c	0
4	2003	T-0	168
4	2007	T-1a	31
4	2008	T-1b	110
4	2009	T-1c	70
6	2003	T-0	106
6	2007	T-1a	119
6	2008	T-1b	87
6	2009	T-1c	85
8	2003	T-0	1460
8	2007	T-1a	264
8	2008	T-1b	397
9	2002	T-0	32
10	2002	T-1a	0
9	2007	T-1b	56
10	2009	T-1c	11
11	2003	T-0	1
11	2007	T-1a	0
11	2008	T-1b	0
11	2009	T-1c	0

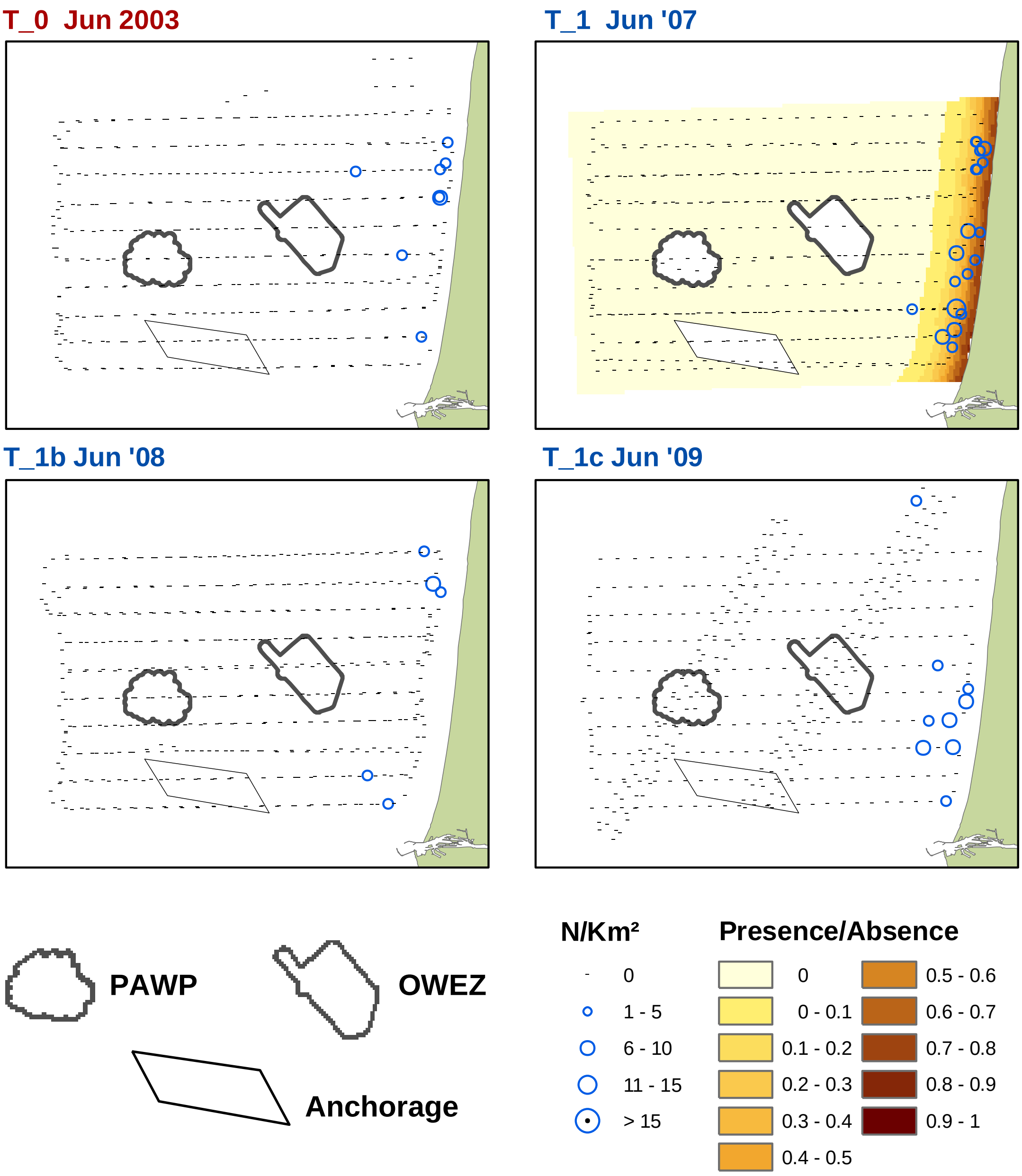
Table 32. *Total numbers of 'Common' Terns seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	NA	NA	NA	NA	NA	ins. data	NA	0
2008	1	NA	NA	NA	NA	NA	ins. data	NA	0
2009	1	NA	NA	NA	NA	NA	ins. data	NA	0
2010	1	NA	NA	NA	NA	NA	ins. data	NA	0
2010	2	NA	NA	NA	NA	NA	ins. data	NA	0
2003	4	NA	NA	NA	NA	NA	ins. data	NA	10
2007	4	NA	NA	NA	NA	NA	ins. data	NA	2
2008	4	NA	NA	NA	NA	NA	ins. data	NA	10
2009	4	NA	NA	NA	NA	NA	ins. data	NA	4
2003	6	NA	NA	NA	NA	NA	ins. data	NA	8
2007	6	**0.000**	0.625	1.000	0.998	-	GAMM	NA	19
2008	6	NA	NA	NA	NA	NA	ins. data	NA	5
2009	6	NA	NA	NA	NA	NA	ins. data	NA	10
2003	8	**0.006**	0.784	1.000	0.954	-	GAMM	NA	24
2007	8	**0.000**	0.154	1.000	1.000	-	GAM	0.18	24
2008	8	**0.000**	0.903	0.798	0.962	-	GAMM	NA	45
2002	9	NA	NA	NA	NA	NA	ins. data	NA	3
2002	10	NA	NA	NA	NA	NA	ins. data	NA	0
2007	9	NA	NA	NA	NA	NA	ins. data	NA	3
2009	10	NA	NA	NA	NA	NA	ins. data	NA	1
2003	11	NA	NA	NA	NA	NA	ins. data	NA	1
2007	11	NA	NA	NA	NA	NA	ins. data	NA	0
2008	11	NA	NA	NA	NA	NA	ins. data	NA	0
2009	11	NA	NA	NA	NA	NA	ins. data	NA	0

Table 33. *Modelling results (presence/absence) for 'Common' Terns. Significant contributions (P<0.1) are put in* ***bold****. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ*) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

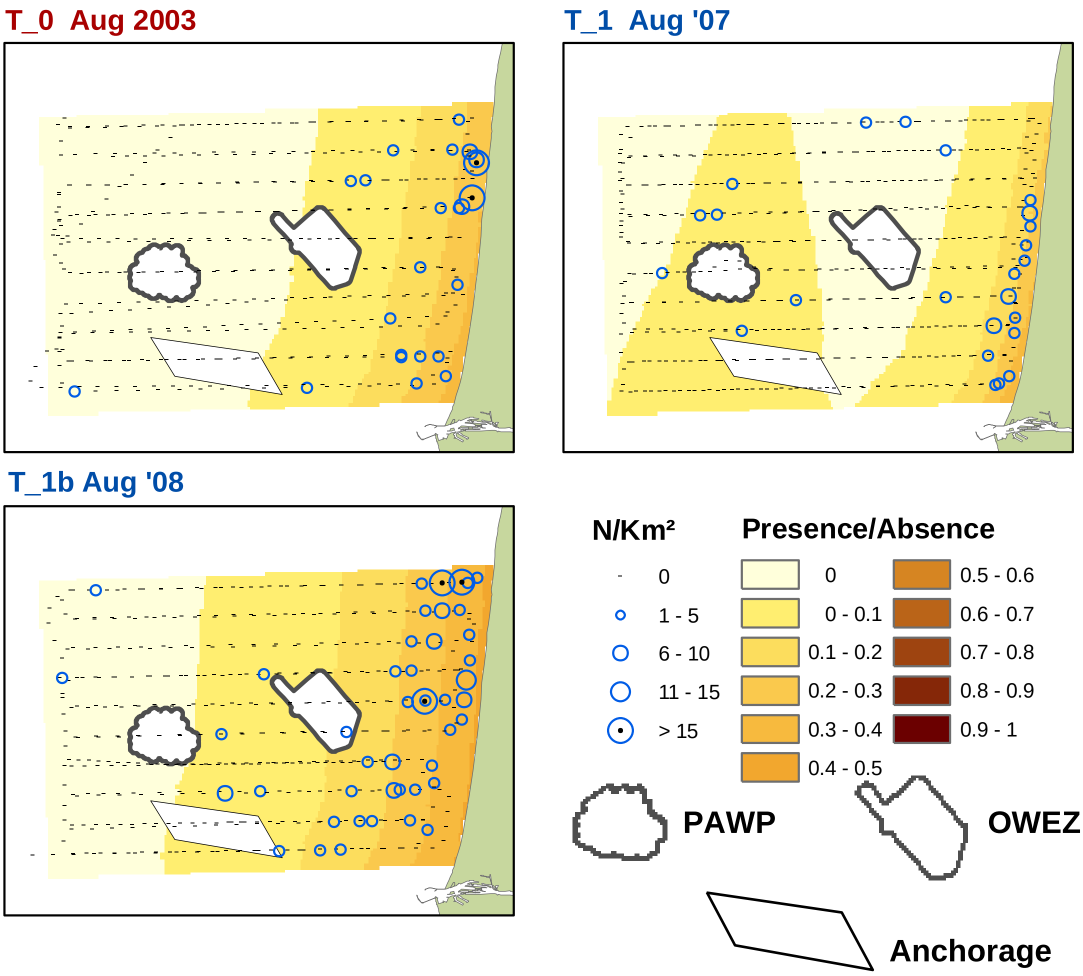
Figure 44 (overleaf): *Distribution maps of 'Common' Terns, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Common or Arctic Tern in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without 'Common' Terns indicated by -.*

Commic Tern



T_0 Jun 2003
T_1 Jun '07
T_1b Jun '08
T_1c Jun '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Commic Tern


T_0 Aug 2003
T_1 Aug '07
T_1b Aug '08
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
PAWP
OWEZ
Anchorage

Common Guillemot *Uria aalge* (Zeekoet)

Figure 45. *Common Guillemot in full breeding plumage, 28 January 2010, Brown Ridge area, just west of the study area. Photo: Hans Verdaat, IMARES.*

Guillemots breed on cliff-coasts and visit Dutch waters in large numbers in the non-breeding season (Camphuysen & Leopold 1994). Table 34 shows numbers seen during all surveys. Unlike most other birds, Guillemots are not often seen at large distances from the ship's transect lines, and most birds detected are seen within the counting strips. Guillemots are relatively abundant and occur widely dispersed in Dutch waters, at least outside their breeding season, do not fly around much as they spend most of their time swimming, and do not flock around fishing vessels. These features make them ideal for spatial modelling and because Guillemots occur abundantly across the Dutch sector of the North Sea (unlike divers, grebes, seaducks, terns and some gulls), lessons learned around OWEZ are likely to be useful for other sites. The studies at Horns Rev wind farm suggested that Guillemots avoid offshore wind farms to a large extent (Elsam Engineering & Energi 2005; Elsam Engineering 2005; Petersen & Fox 2007) but densities in those studies were much lower than in the present study area.

Year to year variation was sometimes large: compare for instance the September 2002 and 2007 surveys (Figure 46). Within-survey comparisons are therefore probably more important than between-survey, T-0 vs T-1 comparisons.

The first Guillemots arrive in the study area in August, shortly after the summer moult of their flight feathers (Table 34). In our study, little indication was found in the modelled results of the data that Guillemots avoided the wind farm OWEZ to some extent. Significant avoidance was found twice: in April 2008, but densities were very low at the time with most birds residing in the northwest of the general study area, away from OWEZ (Figure 46), and in November 2007 at much higher densities. Additionally, the combined effects of the three impact areas (OWEZ, PAWP and the Anchorage area) indicated significant avoidance in slightly more situations (Table 35, column "ANOVA"). Note that the ANOVA treats all areas in concert (OWEZ, PAWP, Anchorage and remaining reference area) while P_OWEZ singles out the effects of OWEZ. This suggests that OWEZ had relatively mild effects, while the other areas deterred Guillemots stronger.

Guillemots were seen swimming inside OWEZ on several occasions, underlining that avoidance, if occurring, is less than 100% (contra the Danish results). Even inside PAWF, where the turbine density is much higher than in either OWEZ or Horns Rev wind farm, several Guillemots were found swimming (Figure 46).

Month	year	Survey	N
2	2004	T-0	502
1	2008	T-1a	1086
1	2009	T-1b	2524
1	2010	T-1c	399
2	2010	T-1c	124
4	2003	T-0	72
4	2007	T-1a	20
4	2008	T-1b	30
4	2009	T-1c	0
6	2003	T-0	0
6	2007	T-1a	2
6	2008	T-1b	0
6	2009	T-1c	0
8	2003	T-0	0
8	2007	T-1a	5
8	2008	T-1b	15
9	2002	T-0	12
10	2002	T-1a	287
9	2007	T-1b	533
10	2009	T-1c	109
11	2003	T-0	1328
11	2007	T-1a	2480
11	2008	T-1b	190
11	2009	T-1c	938

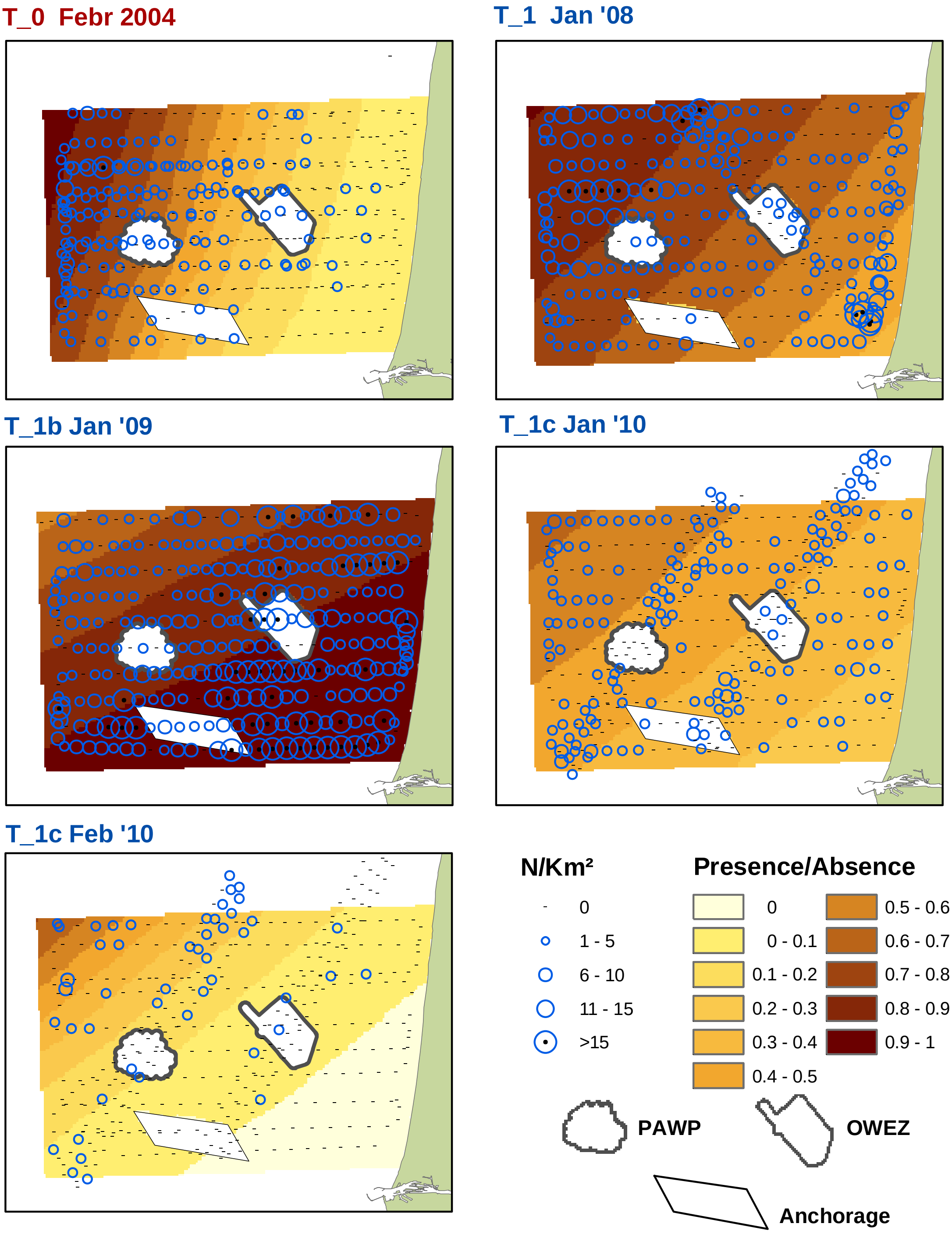
Table 34. *Total numbers of Common Guillemots seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	**0.000**	0.208	0.106	**0.018**	+	GAMM	NA	160
2008	1	**0.002**	0.125	0.170	0.208	-	GAMM	NA	197
2009	1	**0.013**	**0.006**	0.283	0.161	-	GAMM	NA	251
2010	1	**0.019**	**0.067**	**0.000**	0.146	-	GAMM	NA	167
2010	2	**0.000**	**0.000**	**0.000**	0.739	+	GAMM	NA	48
2003	4	**0.000**	**0.041**	1.000	1.000	-	GAMM	NA	44
2007	4	**0.000**	0.800	1.000	0.990	-	GAMM	NA	15
2008	4	**0.000**	**0.000**	**0.000**	**0.000**	-	GAMM	NA	13
2009	4	NA	NA	NA	NA	NA	ins. data	NA	0
2003	6	NA	NA	NA	NA	NA	ins. data	NA	0
2007	6	NA	NA	NA	NA	NA	ins. data	NA	0
2008	6	NA	NA	NA	NA	NA	ins. data	NA	0
2009	6	NA	NA	NA	NA	NA	ins. data	NA	0
2003	8	NA	NA	NA	NA	NA	ins. data	NA	0
2007	8	NA	NA	NA	NA	NA	ins. data	NA	4
2008	8	NA	NA	NA	NA	NA	ins. data	NA	8
2002	9	NA	NA	NA	NA	NA	ins. data	NA	0
2002	10	0.119	0.676	**0.000**	0.389	+	GAMM	NA	59
2007	9	**0.077**	0.394	0.740	0.704	+	GAMM	NA	95
2009	10	**0.000**	**0.014**	**0.000**	0.689	+	GAMM	NA	48
2003	11	**0.000**	0.182	0.631	0.291	-	GAMM	NA	199
2007	11	0.843	**0.000**	**0.021**	**0.013**	-	GAMM	NA	316
2008	11	**0.000**	**0.086**	1.000	1.000	-	GAM	0.15	69
2009	11	**0.004**	**0.010**	0.424	0.686	-	GAMM	NA	213

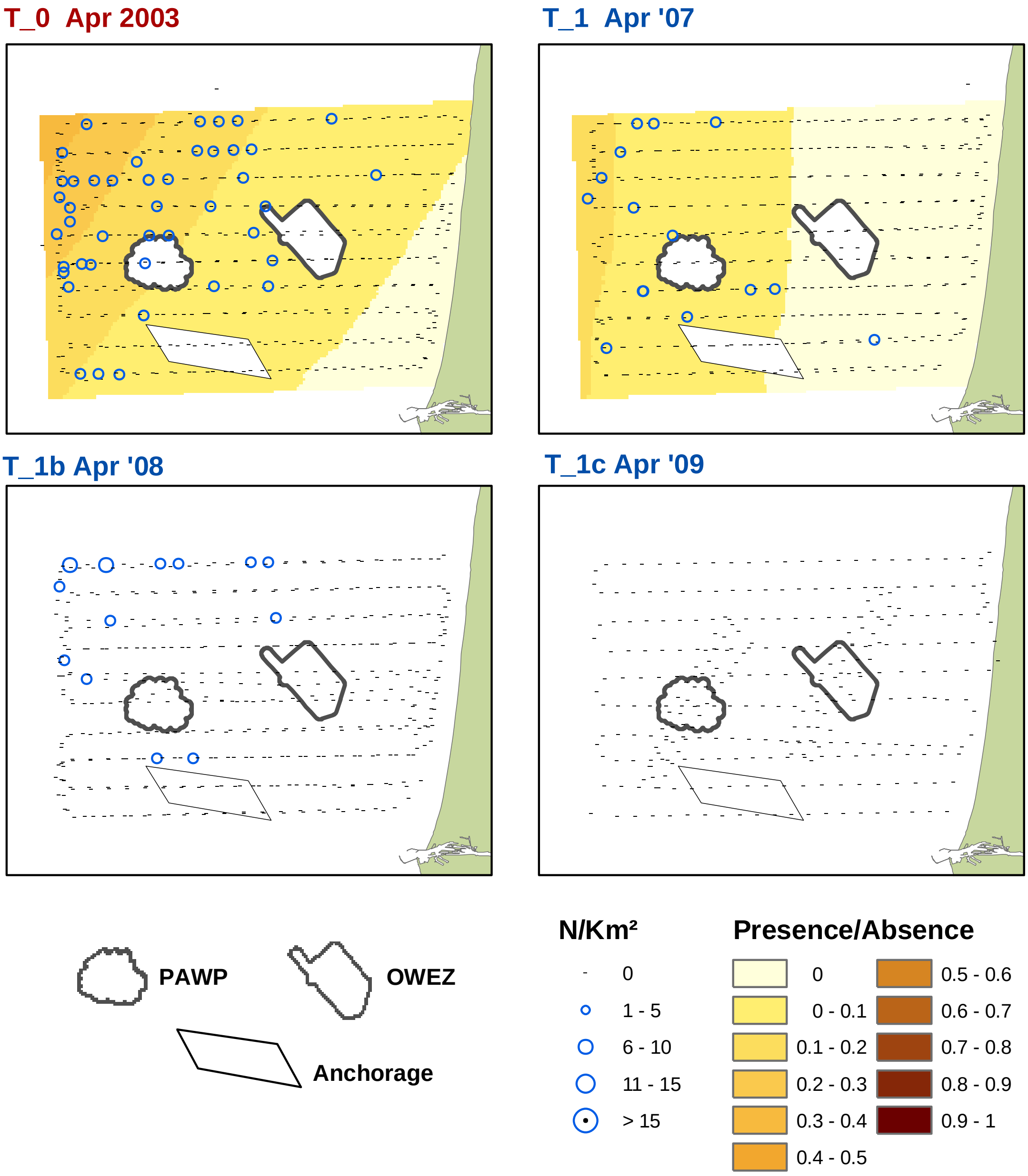
Table 35. *Modelling results (presence/absence) for Common Guillemot. Significant contributions (P<0.1) are put in* ***bold****. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column* Est_OWEZ) *are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 46 (overleaf): *Distribution maps of Common Guillemot, for all months in which surveys were carried out. Modelling was only possible when they were present in sufficient numbers for modelling (>10 5 min counts with at least one Guillemot in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Guillemots indicated by -.*

Guillemot

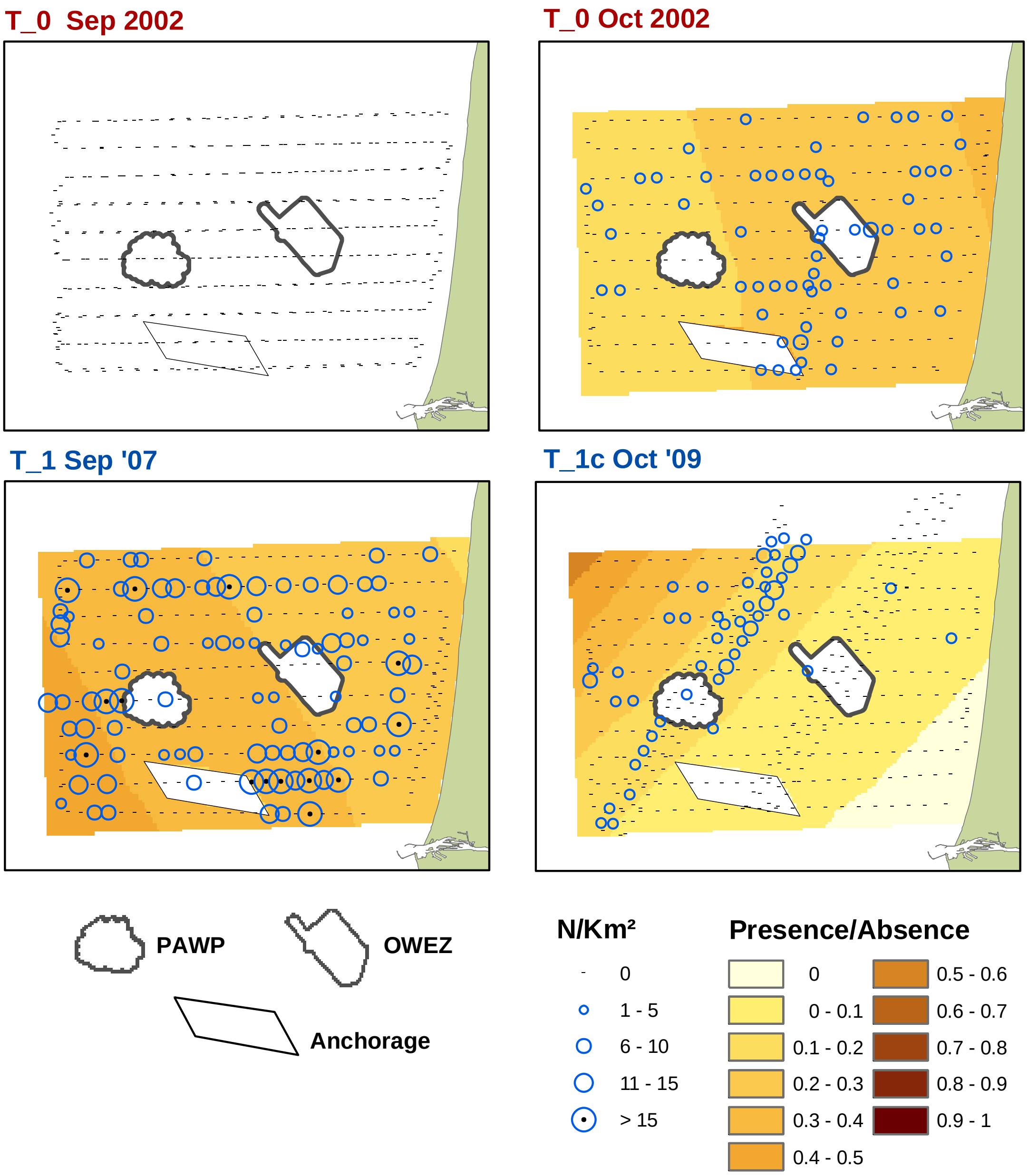

T_0 Febr 2004
T_1 Jan '08
T_1b Jan '09
T_1c Jan '10
T_1c Feb '10
N/Km²
0
1 - 5
6 - 10
11 - 15
>15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
PAWP
OWEZ
Anchorage

Guillemot



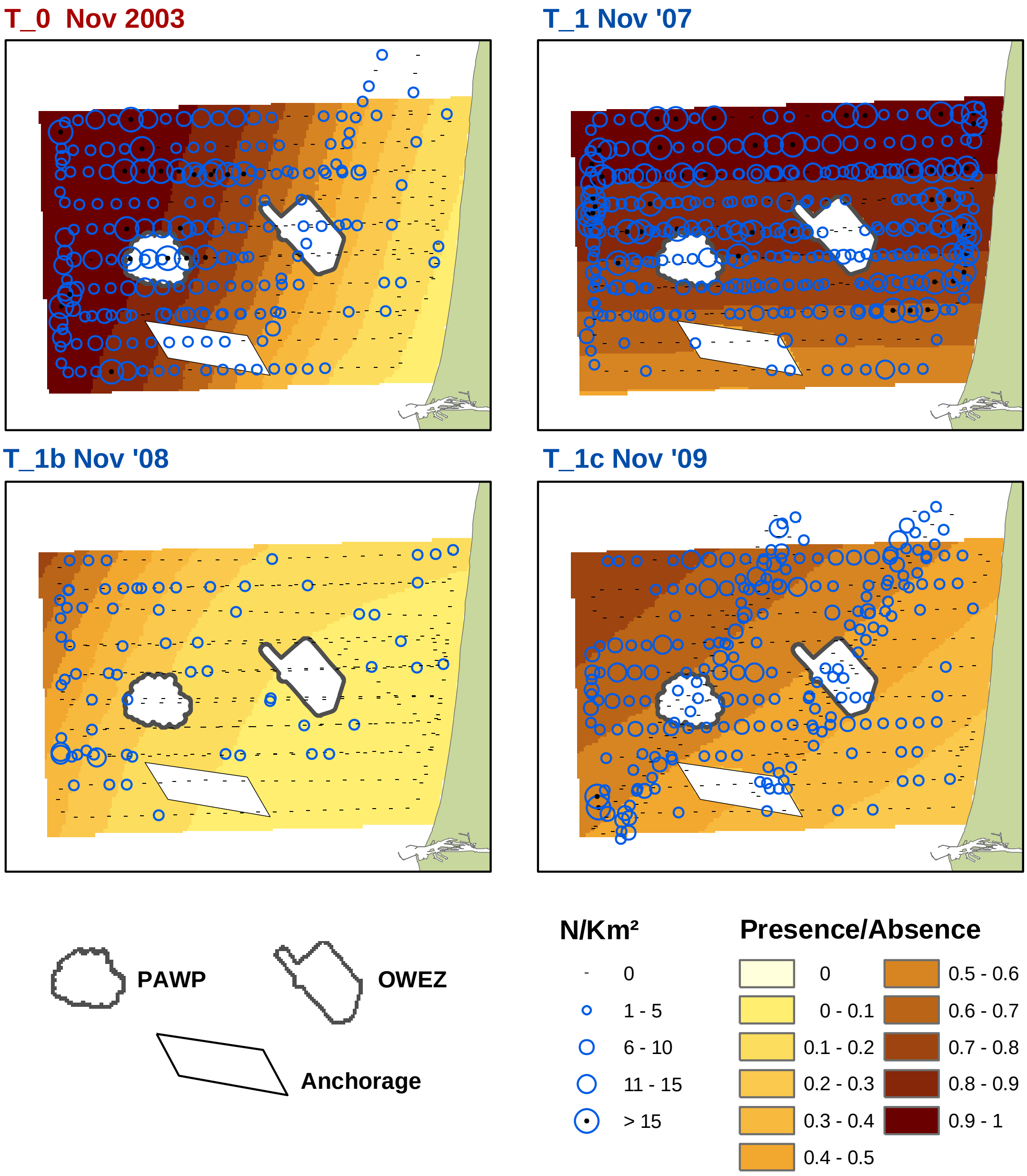
T_0 Apr 2003
T_1 Apr '07
T_1b Apr '08
T_1c Apr '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Guillemot



T_0 Sep 2002
T_0 Oct 2002
T_1 Sep '07
T_1c Oct '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Guillemot



T_0 Nov 2003
T_1 Nov '07
T_1b Nov '08
T_1c Nov '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
> 15
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Razorbill *Alca torda* (Alk)

Figure 47. *A flock of Razorbills flying over the Brown Ridge area, just west of the study area, 26 January 2010. Photo Hans Verdaat, IMARES.*

Razorbills are in many ways similar to Guillemots and also visit Dutch waters only in the non-breeding season (Camphuysen & Leopold 1994). They are probably more dependent on a specialised diet of small schooling fish such as herring, sprat or sandeels than Guillemots, that have a much broader diet in the general wintering area in the Southern Bight (Ouwehand et al. 2004). This may make Razorbills more susceptible to between-year differences in preferred prey stocks and variations in occurrence of suitable fish schools. Indeed, considerable year to year variation was found, e.g. in the September data, but these were not much different from those in the Guillemot (Tables, 34, 36).

Razorbills are less numerous in the study area than Guillemots and potential susceptibility to disturbance from wind farms is therefore harder to assess. Razorbill distributions in September 2007, November 2007 and November 2009 appear to be “wrapped around OWEZ”. However, the distribution pattern in September 2007 shows that OWEZ was situated at the fringe of a Razorbill concentration area (Figure 48), while the negative coefficient for OWEZ during the two mentioned November surveys was non-significant (Table 37). The extra survey lines in January 2010 yielded avoidance in PAWP, but not in OWEZ (Table 37, Figure 48). In any case, some Razorbills, like some Guillemots, were found amidst the OWEZ turbines (but never within PAWP), showing that avoidance was not 100%, at least not in OWEZ.

Month	year	Survey	N
2	2004	T-0	90
1	2008	T-1a	32
1	2009	T-1b	145
1	2010	T-1c	90
2	2010	T-1c	62
4	2003	T-0	23
4	2007	T-1a	5
4	2008	T-1b	13
4	2009	T-1c	0
6	2003	T-0	0
6	2007	T-1a	0
6	2008	T-1b	2
6	2009	T-1c	0
8	2003	T-0	0
8	2007	T-1a	1
8	2008	T-1b	0
9	2002	T-0	0
10	2002	T-1a	15
9	2007	T-1b	712
10	2009	T-1c	4
11	2003	T-0	36
11	2007	T-1a	156
11	2008	T-1b	11
11	2009	T-1c	109

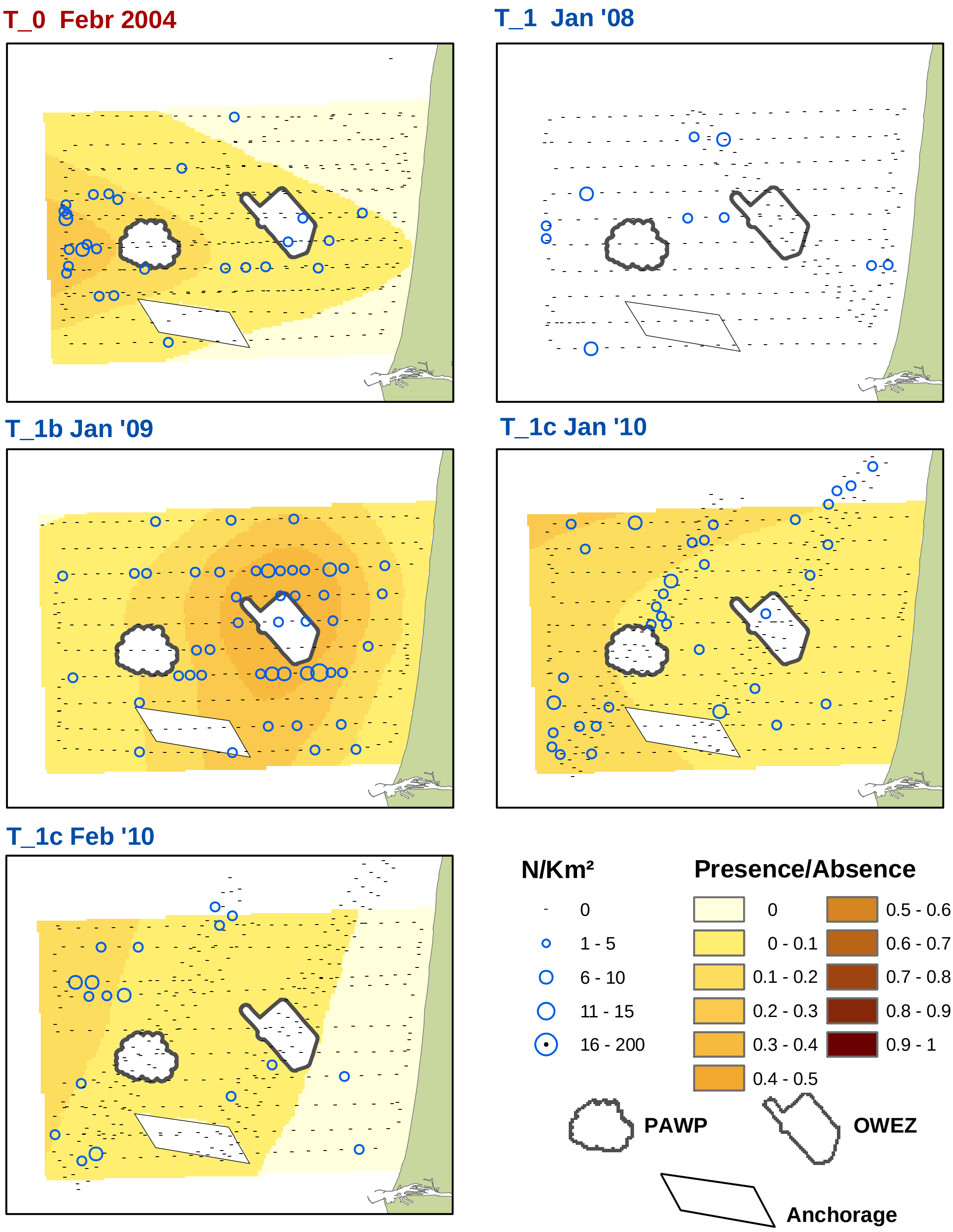
Table 36. *Total numbers of Razorbills seen during the surveys. All birds seen are included, both inside and outside the 300 m wide counting strips. T-0 surveys marked grey.*

Year	Month	p_Coast	p_North	ANOVA	P_OWEZ	Est_OWEZ	Model	dev_expl	N
2004	2	**0.000**	**0.015**	1.000	**0.015**	+	GAM	0.15	27
2008	1	NA	NA	NA	NA	NA	ins. data	NA	10
2009	1	**0.002**	0.108	1.000	0.832	+	GAM	0.12	47
2010	1	**0.002**	**0.024**	1.000	0.855	+	GAM	0.06	35
2010	2	**0.007**	0.603	**0.000**	0.926	-	GAMM	NA	18
2003	4	NA	NA	NA	NA	NA	ins. data	NA	9
2007	4	NA	NA	NA	NA	NA	ins. data	NA	4
2008	4	NA	NA	NA	NA	NA	ins. data	NA	3
2009	4	NA	NA	NA	NA	NA	ins. data	NA	0
2003	6	NA	NA	NA	NA	NA	ins. data	NA	0
2007	6	NA	NA	NA	NA	NA	ins. data	NA	0
2008	6	NA	NA	NA	NA	NA	ins. data	NA	1
2009	6	NA	NA	NA	NA	NA	ins. data	NA	0
2003	8	NA	NA	NA	NA	NA	ins. data	NA	0
2007	8	NA	NA	NA	NA	NA	ins. data	NA	1
2008	8	NA	NA	NA	NA	NA	ins. data	NA	0
2002	9	NA	NA	NA	NA	NA	ins. data	NA	0
2002	10	NA	NA	NA	NA	NA	ins. data	NA	8
2007	9	**0.018**	0.297	**0.000**	**0.000**	-	GAMM	NA	31
2009	10	NA	NA	NA	NA	NA	ins. data	NA	3
2003	11	**0.003**	**0.000**	**0.000**	**0.000**	-	GAMM	NA	18
2007	11	**0.024**	0.572	**0.000**	0.636	-	GAMM	NA	37
2008	11	NA	NA	NA	NA	NA	ins. data	NA	5
2009	11	**0.000**	**0.000**	1.000	0.433	-	GAM	0.22	39

Table 37. *Modelling results (presence/absence) for Razorbill. Significant contributions (P<0.1) are put in **bold**. The ANOVA gives the combined contribution for OWEZ, PAWP and Anchorage area; P_OWEZ gives the contribution of OWEZ. Note that "positive" or "negative" effects of the presence of OWEZ (column Est_OWEZ) are in fact negligible effects if P_OWEZ is larger than 0.1. N gives the number of non-zero counts, which are deemed too low for modelling if ≤10 (insufficient data).*

Figure 48 (overleaf): Distribution maps of Razorbills, for months in which they were present in sufficient numbers for modelling (>10 5 min counts with at least one Razorbills in transect; see Table 5). All maps show the coastline of Noord-Holland, the outlines of the two wind farms and the anchorage area. Counts without Razorbills indicated by -.

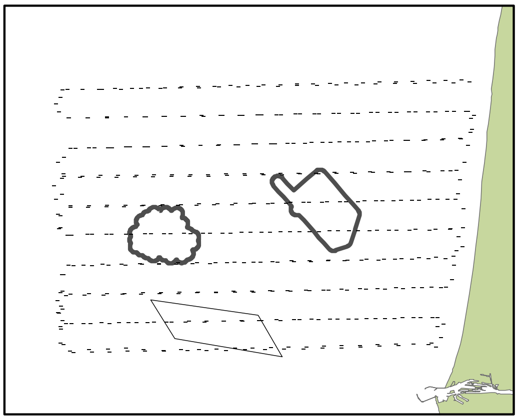
Razorbill



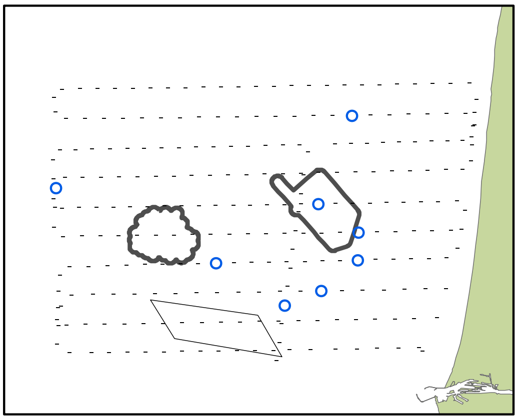
T_0 Febr 2004
T_1 Jan '08
T_1b Jan '09
T_1c Jan '10
T_1c Feb '10
N/Km²
0
1 - 5
6 - 10
11 - 15
16 - 200
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
PAWP
OWEZ
Anchorage

Razorbill

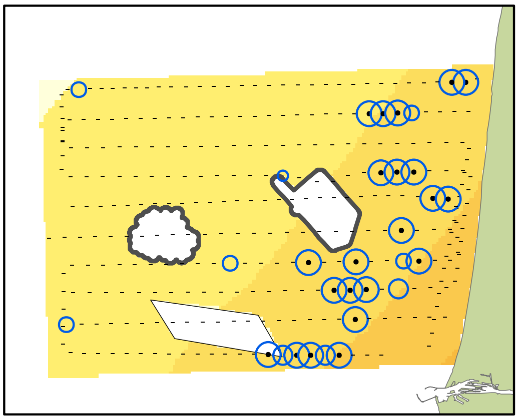
T_0 Sep 2002



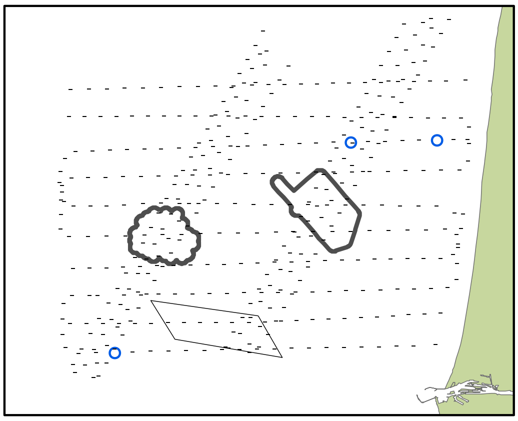
T_0 Oct 2002

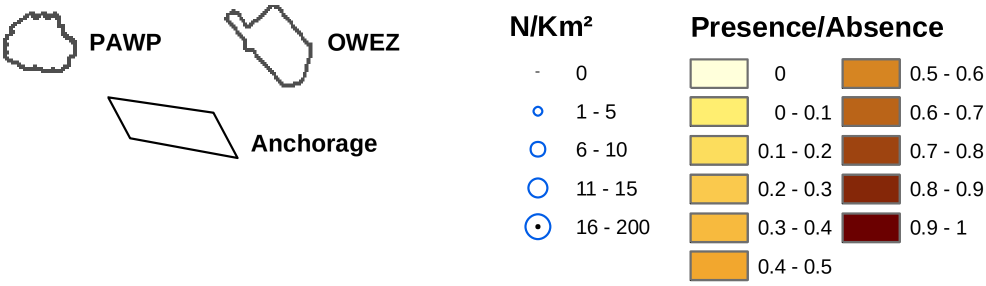


T_1 Sep '07

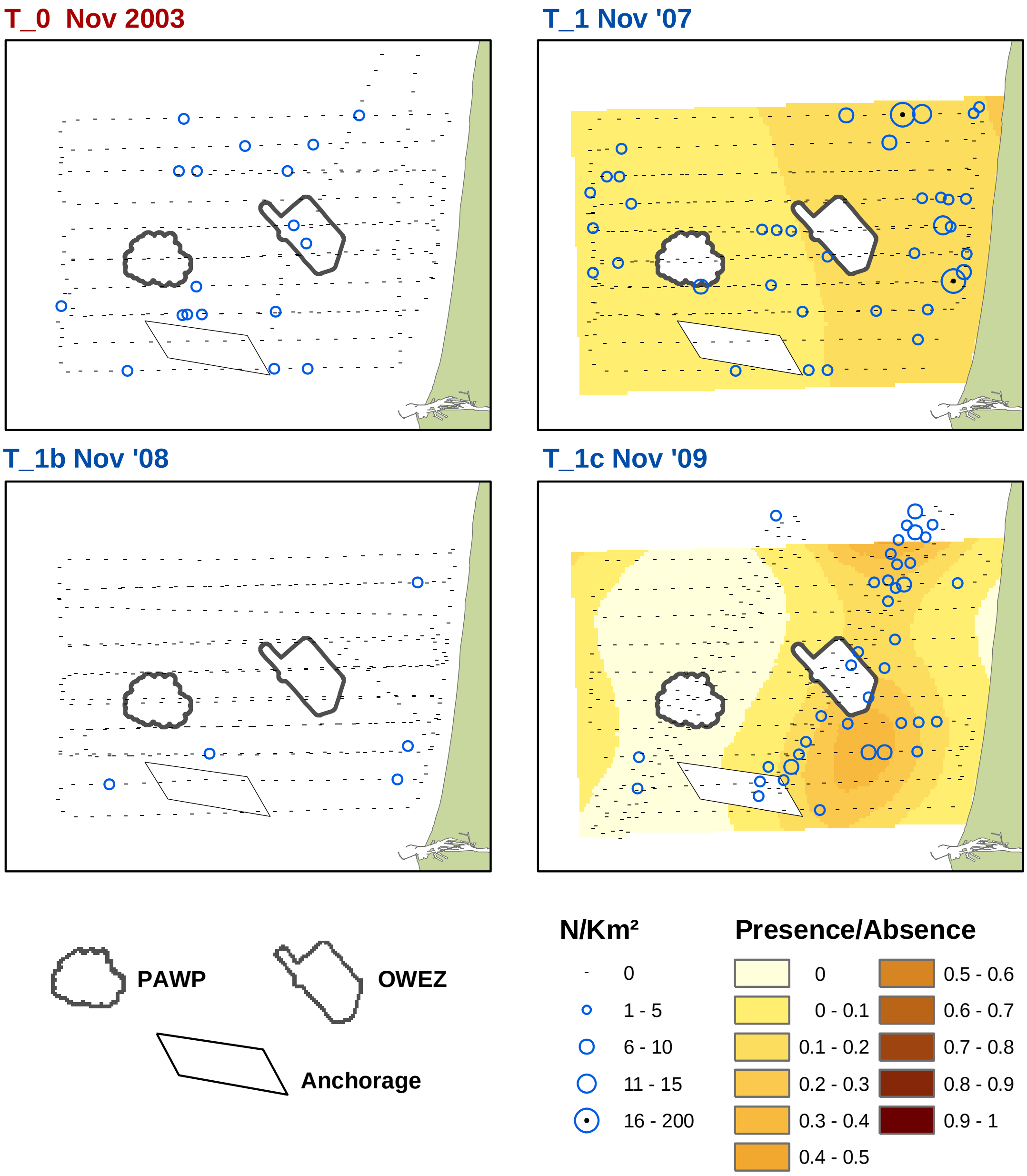


T_1c Oct '09





Razorbill


T_0 Nov 2003
T_1 Nov '07
T_1b Nov '08
T_1c Nov '09
PAWP
OWEZ
Anchorage
N/Km²
0
1 - 5
6 - 10
11 - 15
16 - 200
Presence/Absence
0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1

Discussion and Conclusion

This report describes the results of three years of T-1 Local Bird surveys around the Dutch offshore wind farm OWEZ in comparison to the results of a one-year T-0 study. Contrary to expectation (based on earlier studies around Horns Rev that indicated clear-cut avoidance, in some birds even beyond the wind farm's perimeter: Elsam Engineering & Energi 2005; Elsam Engineering 2005; Petersen & Fox 2007).), our results do not suggest large effects on seabirds residing in Dutch waters. The wind farm, however, is situated in a location that is not particularly rich in seabirds. Located between truly coastal waters and offshore, Central Southern Bight North Sea waters, the area lacks high densities of nearshore species (divers, grebes, seaduck) and also high densities of offshore species (Northern Fulmar, Kittiwake, auks). Some caution is needed however, as large concentrations of seaducks have been found in the general area in years preceding the T-0 surveys (Leopold et al. 1995) and divers apparently do occur rather far offshore in some years. Large gulls are the most numerous seabirds in the general area, but particularly so around fishing vessels discarding easy meals. As fishing is no longer allowed in the wind farm, gull numbers are never very high in the wind farm, but still very patchy around it, as most gulls go where the fishers go. Most gulls seemed rather unconcerned about the presence of offshore turbines, flying through the wind farm without visible behavioural adjustment and resting on the foundation poles of the turbines in small numbers. The main effect of the wind farms on gull distribution patterns is that trawlers are kept at bay and that the largest concentrations of gulls now occur around the wind farms, around the trawlers that keep working around the wind farms.

Figure 49. *Gull density was largely dependent on the availability of discards from fishing vessels. Fishing was no longer allowed in the wind farm, and all large gull flocks were found outside the wind farm during T-1. Photo: Kees Camphuysen, NIOZ, 20 August 2007.*

A wind farm situated in waters with low general seabird densities seems ill-fitted for effect studies (although well-put in terms of possible seabirds habitat loss!). Several factors, other than the presence of the wind farm, were of overriding importance in determining seabird occurrence across the study area. The activity of fishing vessels largely steered the distribution of the most numerous seabirds, the large to medium-sized gulls. Still, modelling their distribution by analyses of presence/absence patterns did not pick up a systematic avoidance from the wind farm. Gull distribution is probably too erratic, while many individuals fly around a great deal, looking for feeding opportunities and flying across counting strips anywhere in the study area in the process. Also, we noted no behavioural evidence of gulls avoiding the wind farm: during many of our crossings through the wind farm, gulls were seen flying through the wind farm, or sitting on the water's surface or resting on foundations. To these gulls, the wind farm seemed just another bit of sea that offered certain benefits, be it no short-lived easy pickings from fishing vessels. The conclusion for Common Gull, Lesser and Greater Black-backed Gull, Herring Gull and Kittiwake must therefore be, that there is hardly any effect of the wind farm on their distribution. The fact that feeding frenzies behind trawlers are displaced some distance because fishing within the wind farm's perimeter is no longer allowed is of no ecological consequence, given the fact that the exact spot of the wind farm had no particular effect on these birds (T-0 surveys). Clearly, a displacement of trawlers over a few kilometres is insignificant, given the erratic occurrence of discards over the study area and the high mobility of these gulls.

Most other seabird distribution patterns were linked to a large extent to factors other than 'wind farm', particularly distance to shore. Several species had a clear preference for nearshore waters and hardly reached the latitude of the wind farm. Most extreme in this respect was the Great Crested Grebe, that only very rarely reached the wind farm. Other species sharing this preference for nearshore waters were the Red-throated and Black-throated Divers, Common Scoter, Black-headed Gull and "Commic" Terns. Densities of all these birds at wind farm latitudes were mostly so low, that few individuals were available to fly or swim into the wind farm. Whether or not avoidance in these species, as picked up by the modelling in some cases in which such birds did venture out to sea in numbers that allowed modelling in the first place was biologically significant, seems questionable. Still, most birds in this group were never seen to enter the wind farm, even though quite a few individuals were seen at wind farm latitudes across all surveys. There may thus be little incentive for these birds to enter a wind farm at the edge of their natural range at sea, but ecological consequences, even of strong avoidance at the margins of a species' range are negligible. Red-throated Divers, marked in the Horns Rev studies are highly sensitive to wind farm disturbance, were the remarkable exception to this pattern. Red-throated Divers were seen inside OWEZ during several T-1 surveys, and in one situation, a bird was even seen diving in a fashion that suggested normal foraging, i.e. diving from the water's surface, not avoiding the research vessel.

A similar, but mirrored pattern as compared to the coastal birds, was found in species that mostly occur offshore, further west than were OWEZ is situated. The obvious case here was the Northern Fulmar, that had OWEZ latitudes as the eastern fringe of its distribution during most surveys in which it was seen in fair numbers. Like most of the nearshore birds on the other side of the wind farm, Fulmars were never seen between the OWEZ turbines, but again, ecological effects of a single wind farm, at the edge of this species' (vast) offshore range, does not have any biological significance.

This leaves the species that occurred across the study area (nearshore and offshore) as the most interesting species for the analyses of possible effects on habitat use from the wind farm. These species were: Northern Gannet, Little Gull, Sandwich Tern, Common Guillemot and Razorbill. Gannets were found across the study area during many surveys, but only very rarely in numbers that allowed proper analyses. Still, Gannets probably avoided the wind farm mostly. The few birds that were seen within the wind farm's limits cut across its margin quickly, and had always clearly stopped foraging. For this species, avoidance was thus nearly total, at least in ecological terms (no feeding inside the wind farm). The general area in which the wind farm has been built only rarely attracted many Gannets. Gannets mostly showed a tendency to occur further offshore in the highest densities (thus resembling Fulmars in this respect), while in some surveys also nearshore waters attracted rather large numbers. The central part of the study area rarely had high numbers of Gannets, so the waters around the wind farms seemed mostly of relatively little importance. However, relatively high numbers were found centrally in the study area in two T-1 mid-winter surveys (Figure 21) and in these situations the micro-distribution patterns stopped short at the wind farm's edge. Relatively high numbers were also found just inshore of the wind farm during an August survey, but this happened to be a T-0 survey and this pattern was not found again, during the T-1 phase. In situations with high numbers of birds present near the wind farm, the presence of the turbines is likely to deter the birds from the site, and good, local feeding opportunities may be lost to them.

Sandwich Terns and Little Gulls were only abundantly present across the study area during their migration periods. Migration often is taken at leisure, and birds feed intensively on the way. Moreover, Sandwich Terns are also involved in courtship display (spring) and do so mostly on and around large shipping buoys at sea (Figure 41). Both species often feed along small fronts or tidal rips at sea. Both resting platforms and tidal rips, at the lee side of the monopoles, are present in the wind farm. These species might thus be expected to take advantage of the wind farm, but attraction was never found. Both Sandwich Terns (very rarely) and Little Gulls were seen inside the wind farm on occasions, but birds never concentrated in the wind farm. Overall, these birds seemed to prefer flying around the wind farm rather than entering it (contra suggestions from the work in Horns Rev, where these birds were supposedly attracted to some extent).

The most suitable species for studying presumed avoidance from wind farms were the auks, the Guillemot and Razorbill. Even though Guillemots were much more abundant than Razorbills and thus offered more opportunities for modelling responses, both species showed similar reactions to the presence of the wind farm. Non-significant results were obtained in most situations, but significant avoidance was also found in both species However, avoidance, when found, was not total, and both Guillemots and Razorbills were seen inside the wind farm, and also inside the neighbouring wind farm PAWP, with a much higher turbine density. Turbine density probably did have an effect on avoidance though, avoidance being apparently stronger in PAWP (but not 100% either). Measuring the effect of relatively small wind farms on birds that occur in rather low general densities, requires more effort inside the wind farms than was realised in most of our T-1 surveys, due to rather broad spacing of the rows of wind turbines. Therefore, more transect lines were introduced in the last set of surveys, and an extra winter survey was carried out in the last year, when auks were present, rather than in summer. This approach yielded better results than earlier surveys, but with only one winter's worth of such data, we still have few statistically significant cases of avoidance. Future work on these species, focussing on the wind farms themselves, is likely to shed more light on the exact amount of disturbance, as a function of both bird density and turbine density.

Figure 50. *Four wary Guillemots at sea, looking "over their shoulders" to the approaching survey vessels. This posture is typical for auks at sea at short range, and these birds dove to escape from the nearing ship shortly after their picture was taken, as is also typical. Photo: Steve Geelhoed, IMARES.*

We used presence-absence statistics to test for significance. Such statistical treatment is considered the most appropriate for the type of data we are dealing with (Strayer 1999; Zuur et al. 2007), but statistical power, particularly when subjects occur clumped, or when densities are low, or when few impact areas (wind farms) are available for testing, is generally low. Power analyses of similar data have shown that only strong effects (generally >50% population change) might be expected to be detected (Straver 1999). The location of OWEZ was rather unsuitable for finding effects in several (nearshore) seabirds, although effects that were found in both divers and grebes had the expected sign (avoidance), based on results in the earlier Horns Rev studies. The location of OWEZ, and indeed of all future offshore wind farms planned in Dutch waters, is more suitable for testing effects of the wind farm on auks. Auks appear in higher densities and more uniformly spaced in offshore parts of the North Sea than divers and grebes, that are more coastal in their distribution. Clear avoidance was expected in auks, based on the Horns Rev results, but significant avoidance was only found twice for the

Guillemot and once for the Razorbill. This indicates that the magnitude of the effect is generally less than 50% (as also indicated by the fact that some birds that did enter the wind farm). Clear effects were only rarely found, but both Type I and Type II errors may have occurred. More surveys (at the appropriate times of year) and particularly more comparable studies in other wind farms, are likely to increase statistical power in the near-future (c.f. Straver 1999).

A problem with interpretation of avoidance, if this is found, is that feeding behaviour is hard to study from moving survey ships. Currently, it is not known if auks that were seen inside OWEZ, were feeding like their conspecifics outside the wind farm. Birds seen inside the wind farm were mostly quite wary, checking out the approaching survey vessel (as were birds outside the wind farms). Studying feeding behaviour of auks inside a wind farm probably is best done from a non-moving platform that is part of the wind farm. The OWEZ metmast is poorly situated for this, as it was erected just outside the wind farm. The PAWP transformer platforms seems rather ideal, but auks densities in PAWP were always very low, providing little scope for behavioural studies.

One species, the Great Cormorant, showed clear attraction to the wind farms. Cormorants were nearshore birds before OWEZ was built (Camphuysen & Leopold 1994) that were rarely found at OWEZ latitudes, and never at PAWP latitudes. Birds from nearby colonies quickly discovered the OWEZ metmast, that was erected long before the wind farm itself was built, thus unduly influencing the T-0 surveys. However, during T-0, the offshore gas platform CP-Q8-B, situated just NE of OWEZ, already was a resting site for offshore Great Cormorants (Figure 51). Still, only after the wind farm was built, did offshore numbers in and around OWEZ increase markedly and this process was repeated even further offshore, during and after construction of PAWP. Around 100 cormorants are now regularly present in OWEZ (concentrating around the metmast), even in winter (Figure 52).

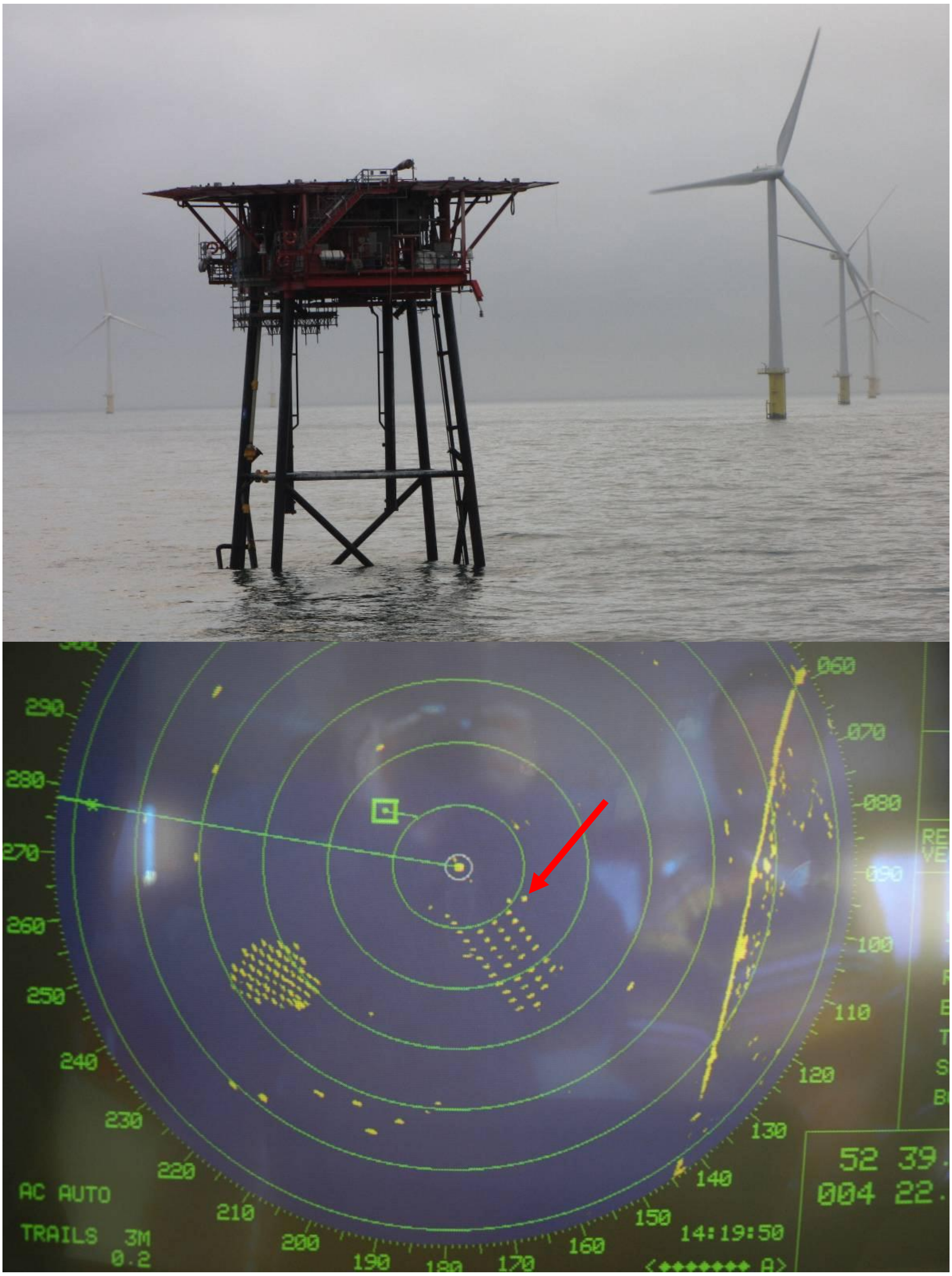


Figure 51. Top: *Platform CP-Q8-B, just NE of OWEZ, Jan 2010, Photo: Martin Poot, Bureau Waardenburg.* ***Bottom****: Radar image of the study area, From left to right: PAWP, OWEZ (note metmast: see Figure 1), offshore platform CP-Q8-B (arrow) and mainland coastline. Seven or eight ships are moored in the anchorage area, to the southwest of OWEZ. Photo: Kees Camphuysen, NIOZ.*

Figure 52. *Around 50 Great Cormorants resting on the OWEZ metmast, 14 January 2009. Photo: Marcel van der Tol, Waterdienst, Rijkswaterstaat.*

In conclusion, the Great Cormorant showed the most clear-cut behavioural response to the presence of the wind farms as it was attracted in rather large numbers to offshore parts of Dutch waters, where it did not occur earlier. Cormorants are also the most truly “local” birds, being present year-round, commuting to breeding colonies on the nearby coastline and resting (including spending the nights in many cases in summer) in the wind farms. There were continuous flights of groups of Great Cormorants, to and from the shore (or the wind farm), particularly in the breeding season when the wind farm acted as an outpost for offshore feeding for local breeders. As the metmast is on the seaward side of the wind farm, and birds had learned their way around the site, Great Cormorants flew straight through the wind farm in large numbers on a daily basis, without visible hesitation (Figure 53).

Figure 53. *Great Cormorant flying from the metmast back to shore, through OWEZ, 13 September 2007. Photo Hans Verdaat, IMARES.*

Other seabirds showed avoidance to some extent. This was clear only in situations with relatively high densities at OWEZ latitudes. Low densities at these latitudes, a rather common feature across many different seabirds, often prevented firm conclusions (due to lack of birds). However, birds with sufficient densities often showed avoidance. Total avoidance was only found in birds with low local densities, and these may have been artefacts of these low densities (mostly statistically not significant). Birds occurring in higher densities (divers, auks, Little Gull) usually did enter the wind farm, but never in large numbers and numbers seemed even lower in PAWP, which has a higher turbine density (Figure 54.).

Many birds, particularly the gulls, the most numerous species, also respond to variables that could not be included in the models, such as temporary concentrations of fish (food) or weather (either in the study area or much further away, displacing birds), that have very little to do with a response to a wind farm. Seabird distribution data generally showed considerable noise, year to year variation and patchiness (i.e. birds often occurred in dense but rather unpredictable concentrations while such temporary “hotspots” could be devoid of birds during a subsequent passage of the research vessel), which makes finding effects of an offshore wind farm difficult. With the influences of gross topography, i.e. distance to coast and northing removed, few indications of avoidance became apparent.

Figure 54. *Aerial view of OWEZ in the foreground and PAWP in the background. Photo Hans Verdaat, IMARES, 7 July 2010.*

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Referees Dr H.J. Lindeboom, overall project leader OWEZ work, for IMARES

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This report has been professionally prepared by Wageningen IMARES. The scientific validity of this report has been internally tested and verified by another researcher and evaluated by the Scientific Team at Wageningen IMARES.

Read by: Dr H.J. Lindeboom & Drs F.C. Groenendijk

Date: 20 December 2011

Approved: drs F.C. Groenendijk
Head of Dept. Ecosystems

Signature:

Date: 20 December 2011

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Appendices

Appendix 1a. Seabird densities for different strata within the larger survey area, for each survey in January or February.
Densities are calculated as total numbers seen within the counting strips and within snapshots for flying birds, divided by the summed area of strips surveyed.

Survey	T0	T0	T0	T0	T1a	T1a	T1a	T1a	T1b	T1b	T1b	T1b	T1c	T1c	T1c	T1c	T1c	T1c	T1c	T1c
Year	2004	2004	2004	2004	2008	2008	2008	2008	2009	2009	2009	2009	2010	2010	2010	2010	2010	2010	2010	2010
Month	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2
Area	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP
Km² surveyed	343.31	5.97	12.13	6.79	260.11	6.48	16.11	2.81	206.01	6.61	5.46	3.76	334.58	14.44	15.34	14.01	336.56	12.82	14.96	11.41
divers	0.20	0.00	0.00	0.00	1.28	0.00	0.37	0.00	1.16	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.04	0.00	0.00	0.00
Great Crested Grebe	0.19	0.00	0.00	0.00	8.05	0.00	0.00	0.00	12.71	0.00	0.00	0.00	12.89	0.07	0.00	0.00	8.77	0.00	0.00	0.00
Northern Fulmar	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Gannet	0.03	0.00	0.00	0.00	0.02	0.00	0.00	0.00	2.10	0.00	18.23	0.00	0.03	0.00	0.00	0.00	0.72	0.37	0.00	0.00
Great Cormorant	0.03	0.00	0.00	0.00	0.02	0.31	0.07	0.36	0.13	0.00	6.47	0.27	0.06	0.00	0.75	1.13	0.09	0.00	0.38	0.96
Common Scoter	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.34	0.00	0.00	0.00
Little Gull	0.02	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.04	0.00	0.00	0.13	0.06	0.11	0.00	0.00
Black-headed Gull	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	2.15	0.00	0.00	0.00	0.06	0.00	0.00	0.00
Common Gull	0.57	0.00	0.00	0.14	0.09	0.00	0.06	0.36	1.03	0.32	3.88	0.80	7.53	0.54	0.78	0.42	0.18	0.82	0.06	0.09
Lesser Black-backed Gull	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.04	0.11	0.00	0.11
Herring Gull	0.49	0.00	0.00	0.00	0.27	0.16	0.30	0.71	0.54	0.16	2.79	0.00	0.19	0.00	0.07	0.14	0.04	0.00	0.00	0.30
Great Black backed Gull	0.09	0.00	0.00	0.31	0.41	0.16	0.38	0.36	0.37	0.00	3.02	1.87	0.14	0.20	0.00	0.00	0.06	0.00	0.12	0.00
Black-legged Kittiw ake	0.07	0.00	0.00	0.00	0.32	0.00	0.13	0.36	1.10	5.24	6.24	0.00	0.02	0.00	0.00	0.00	0.05	0.00	0.00	0.00
Sandw ich Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common/Arctic Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Guillemot	1.03	0.50	0.55	1.92	3.29	0.15	0.54	1.07	9.64	6.00	9.95	1.33	0.94	0.85	0.24	0.00	0.24	0.00	0.06	0.16
Guillemot/Razorbill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Razorbill	0.19	0.00	0.24	0.00	0.10	0.00	0.00	0.00	0.50	0.16	1.08	0.00	0.22	0.00	0.13	0.00	0.13	0.00	0.00	0.00
Harbour Porpoise	0.51	0.34	0.09	0.87	0.13	0.00	0.00	0.00	0.27	0.15	0.00	0.00	0.16	0.22	0.00	0.00	0.10	0.11	0.07	0.00
Grey & Harbour Seals	0.01	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.18	0.00	0.09	0.00	0.00	0.00	0.02	0.00	0.07	0.00

Appendix 1b. Seabird densities for different strata within the larger survey area, for each survey in April.

Survey	T0	T0	T0	T0	T1a	T1a	T1a	T1a	T1b	T1b	T1b	T1b	T1c	T1c	T1c	T1c
Year	2003	2003	2003	2003	2007	2007	2007	2007	2008	2008	2008	2008	2009	2009	2009	2009
Month	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Area	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP
Km² surveyed	447.14	14.21	13.45	12.62	412.93	14.28	10.84	6.87	413.03	13.83	11.98	8.71	258.53	5.74	15.39	14.12
divers	0.21	0.43	0.22	2.40	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Great Crested Grebe	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Fulmar	0.08	0.00	0.00	0.23	0.12	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Gannet	0.17	0.00	0.16	0.08	0.04	0.00	0.00	0.00	0.42	0.41	0.00	0.00	0.00	0.00	0.00	0.00
Great Cormorant	0.12	0.00	0.00	0.00	0.44	0.00	2.15	0.00	0.24	0.14	1.85	0.00	0.17	0.00	0.19	0.36
Common Scoter	0.10	0.62	0.16	0.00	0.17	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.40	0.00	0.00	0.00
Little Gull	1.71	0.63	0.08	0.40	1.69	0.00	0.81	0.00	8.37	11.41	20.84	0.00	1.28	0.00	0.00	0.00
Black-headed Gull	0.04	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Gull	1.52	0.28	0.16	0.00	7.44	1.07	6.66	0.44	3.68	0.60	3.88	0.22	0.75	0.00	0.00	0.00
Lesser Black-backed Gull	10.30	0.07	1.28	13.77	4.44	0.89	0.81	0.58	6.27	1.94	1.58	22.47	5.02	0.88	0.53	0.75
Herring Gull	3.67	0.00	0.08	1.51	3.27	1.08	0.19	0.00	0.68	0.36	0.00	0.13	2.70	0.00	0.19	0.00
Great Black backed Gull	0.55	0.00	0.00	0.00	0.11	0.00	0.18	0.00	0.08	0.00	0.09	1.00	0.22	0.00	0.00	0.00
Black-legged Kittiw ake	0.14	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sandw ich Tern	0.09	0.28	0.16	0.00	0.02	0.06	0.00	0.00	0.14	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Common/Arctic Tern	0.05	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.17	0.00	0.00	0.00
Guillemot	0.12	0.00	0.00	0.08	0.05	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Guillemot/Razorbill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Razorbill	0.03	0.14	0.00	0.00	0.01	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harbour Porpoise	0.07	0.14	0.00	0.24	0.07	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Grey & Harbour Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00

Appendix 1c. Seabird densities for different strata within the larger survey area, for each survey in April.

Survey	T0	T0	T0	T0	T1a	T1a	T1a	T1a	T1b	T1b	T1b	T1b	T1c	T1c	T1c	T1c
Year	2003	2003	2003	2003	2007	2007	2007	2007	2008	2008	2008	2008	2009	2009	2009	2009
Month	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Area	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP
Km² surveyed	428.61	13.48	11.69	7.98	344.19	15.73	9.02	6.58	404.16	14.01	11.85	6.96	338.61	14.14	16.00	13.20
divers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Crested Grebe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Fulmar	0.01	0.00	0.00	0.00	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Gannet	0.01	0.08	0.00	0.00	0.03	0.22	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Cormorant	0.41	0.00	0.00	0.00	1.03	0.89	2.30	0.78	0.37	0.00	0.52	0.15	0.58	0.00	0.06	0.00
Common Scoter	0.01	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Little Gull	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Black-headed Gull	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Common Gull	0.43	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.04	0.00	0.06	0.00
Lesser Black-backed Gull	2.77	1.18	1.19	0.37	1.51	1.52	0.86	0.47	2.18	1.53	0.78	0.95	4.71	1.91	0.72	0.29
Herring Gull	1.70	0.46	0.34	0.23	0.10	0.00	0.00	0.00	0.27	0.00	0.08	0.00	1.55	0.15	0.07	0.00
Great Black backed Gull	0.00	0.00	0.00	0.00	0.10	0.00	0.22	1.07	0.05	0.00	0.17	0.00	0.11	0.00	0.00	0.00
Black-legged Kittiw ake	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sandw ich Tern	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.06	0.00	0.00	0.00
Common/Arctic Tern	0.05	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.10	0.00	0.00	0.00
Guillemot	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Guillemot/Razorbill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Razorbill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harbour Porpoise	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Grey & Harbour Seals	0.00	0.00	0.00	0.00	0.01	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix 1d. Seabird densities for different strata within the larger survey area, for each survey in August.

Survey	T0	T0	T0	T0	T1a	T1a	T1a	T1a	T1b	T1b	T1b	T1b
Year	2003	2003	2003	2003	2007	2007	2007	2007	2008	2008	2008	2008
Month	8	8	8	8	8	8	8	8	8	8	8	8
Area	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP
Km² surveyed	425.69	13.05	11.48	6.59	370.10	12.46	11.45	6.28	398.00	13.65	11.42	6.22
divers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Crested Grebe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Fulmar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Gannet	0.34	0.07	0.50	0.00	0.03	0.00	0.00	0.00	0.14	0.00	0.00	0.00
Great Cormorant	0.25	0.00	0.00	0.00	0.70	1.01	6.84	0.00	0.36	0.32	4.64	0.00
Common Scoter	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Little Gull	0.00	0.00	0.00	0.00	0.04	0.00	0.09	0.00	0.00	0.00	0.00	0.00
Black-headed Gull	0.03	0.07	0.00	0.00	0.06	0.00	0.00	0.00	0.04	0.00	0.00	0.00
Common Gull	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lesser Black-backed Gull	5.01	5.21	0.60	0.15	5.54	1.57	0.17	2.11	1.08	0.76	0.38	2.25
Herring Gull	0.29	0.13	0.00	0.00	2.90	0.08	0.09	0.17	0.10	0.00	0.10	0.00
Great Black backed Gull	0.37	0.28	0.08	0.00	0.28	0.08	0.50	0.98	0.12	0.00	0.36	0.16
Black-legged Kittiw ake	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sandw ich Tern	0.22	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.29	0.09	0.00	0.00
Common/Arctic Tern	0.93	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.44	0.00	0.24	0.00
Guillemot	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Guillemot/Razorbill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Razorbill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harbour Porpoise	0.02	0.00	0.35	0.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Grey & Harbour Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix 1e. Seabird densities for different strata within the larger survey area, for each survey in September or October.

Survey	T0	T0	T0	T0	T1a	T1a	T1a	T1a	T1b	T1b	T1b	T1b	T1c	T1c	T1c	T1c
Year	2002	2002	2002	2002	2007	2007	2007	2007	2008	2008	2008	2008	2009	2009	2009	2009
Month	9	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10
Area	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP
Km² surveyed	385.75	12.87	12.19	6.91	107.50	2.29	3.47	1.57	74.74		5.76	3.34	330.79	15.31	17.68	12.59
divers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nd	0.00	0.00	0.05	0.00	0.00	0.00
Great Crested Grebe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nd	0.00	0.00	0.00	0.00	0.00	0.00
Northern Fulmar	0.07	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	nd	0.00	0.00	0.00	0.00	0.00	0.00
Northern Gannet	0.11	0.00	0.42	0.29	0.55	1.74	1.93	0.00	0.25	nd	0.00	0.00	0.06	0.00	0.00	0.00
Great Cormorant	0.21	0.00	0.25	0.00	0.25	4.36	2.37	7.74	0.20	nd	0.15	0.30	0.49	0.20	0.27	2.85
Common Scoter	0.12	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	nd	0.00	0.00	0.02	0.00	0.00	0.00
Little Gull	0.03	0.07	0.00	0.00	0.29	0.00	0.00	0.00	0.00	nd	0.00	0.00	0.00	0.00	0.00	0.00
Black-headed Gull	0.01	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	nd	0.00	0.00	0.05	0.00	0.00	0.00
Common Gull	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nd	0.00	0.00	0.06	0.00	0.00	0.00
Lesser Black-backed Gull	3.06	0.44	1.08	0.00	2.91	0.87	0.00	1.29	0.48	nd	0.19	0.00	0.08	0.00	0.00	0.00
Herring Gull	2.00	0.29	0.74	0.14	0.47	0.00	0.00	0.00	0.09	nd	0.00	0.30	0.09	0.06	0.00	0.00
Great Black backed Gull	5.46	0.38	4.24	0.14	4.19	0.00	0.54	7.66	0.33	nd	0.00	0.00	0.21	0.20	0.11	0.00
Black-legged Kittiw ake	0.01	0.00	0.00	0.00	0.07	0.00	0.99	2.58	0.03	nd	0.00	0.00	0.01	0.00	0.00	0.00
Sandw ich Tern	0.02	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	nd	0.00	0.00	0.00	0.00	0.00	0.00
Common/Arctic Tern	0.01	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.01	nd	0.00	0.00	0.01	0.00	0.00	0.00
Guillemot	0.00	0.00	0.00	0.00	3.60	0.87	2.07	1.29	0.02	nd	0.00	0.00	0.32	0.00	0.05	0.08
Guillemot/Razorbill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nd	0.00	0.00	0.00	0.00	0.00	0.00
Razorbill	0.00	0.00	0.00	0.00	3.66	0.00	0.00	0.00	0.03	nd	0.00	0.00	0.01	0.00	0.00	0.00
Harbour Porpoise	0.01	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.01	nd	0.00	0.00	0.04	0.00	0.26	0.00
Grey & Harbour Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	nd	0.00	0.00	0.00	0.00	0.00	0.00

Appendix 1f. Seabird densities for different strata within the larger survey area, for each survey in January or February.

Survey	T0	T0	T0	T0	T1a	T1a	T1a	T1a	T1b	T1b	T1b	T1b	T1c	T1c	T1c	T1c
Year	2003	2003	2003	2003	2007	2007	2007	2007	2008	2008	2008	2008	2009	2009	2009	2009
Month	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Area	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP	Ref	Anchor	OWEZ	PAWP
Km² surveyed	292.52	6.70	13.87	7.71	336.45	5.69	11.23	6.54	352.62	6.17	8.91	8.44	331.13	10.64	15.21	13.63
divers	0.11	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.30	0.00	0.00	0.00
Great Crested Grebe	0.01	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Northern Fulmar	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Gannet	0.06	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.43	0.29	0.00	0.00	1.00	0.00	0.00	0.15
Great Cormorant	0.02	0.00	0.00	0.00	0.02	0.00	1.29	0.00	0.12	0.00	0.00	0.00	0.13	0.00	2.52	1.13
Common Scoter	0.90	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00
Little Gull	0.28	0.00	0.37	0.00	0.09	0.00	0.00	0.00	0.06	0.00	0.00	0.00	1.51	0.18	0.90	0.00
Black-headed Gull	0.32	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Common Gull	4.51	0.74	0.15	0.00	0.54	0.53	0.00	0.16	1.77	1.51	0.22	0.23	0.41	0.09	0.05	0.00
Lesser Black-backed Gull	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.12	0.12	0.00	0.00	0.07
Herring Gull	13.13	0.44	0.00	0.00	0.30	0.70	0.00	0.00	12.14	0.19	0.00	0.00	0.09	0.00	0.89	0.00
Great Black backed Gull	3.60	0.00	0.13	0.00	0.70	0.00	0.17	0.00	7.03	0.92	0.44	0.00	0.84	0.33	4.66	0.22
Black-legged Kittiwake	1.20	19.66	0.35	0.38	1.39	5.77	1.63	1.10	0.06	0.00	0.00	0.00	0.91	0.56	0.72	0.07
Sandwich Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common/Arctic Tern	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Guillemot	3.65	1.51	0.51	8.20	6.39	0.89	1.46	2.21	0.35	0.00	0.00	0.23	2.88	0.67	0.76	0.45
Guillemot/Razorbill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Razorbill	0.07	0.00	0.22	0.00	0.42	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.44	0.41	0.30	0.00
Harbour Porpoise	0.08	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.09	0.00	0.24	0.00	0.33	0.00	0.00	0.00
Grey & Harbour Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.05	0.00

Appendix 2. Total numbers of all birds and mammals seen during all surveys, including those seen within the counting strips and beyond, and within and outside snapshot moments.

Scientific name	English name	2002_09	2002_10	2003_04	2003_05	2003_06	2003_08	2003_11	2004_02	2007_04	2007_06	2007_08	2007_09	2007_11	2008_01	2008_04	2008_06	2008_08	2008_09	2008_11	2009_01
Gavia stellata	Red-throated Diver	2	17	232	2	0	0	67	161	34	0	0	0	79	1035	5	0	0	1	57	476
Gavia arctica	Black-throated Diver	0	0	7	1	0	0	2	5	13	0	0	0	0	8	6	0	0	0	1	5
Gavia immer	Great Northern Diver	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Gavia spec.	unidentified diver	2	2	57	0	0	0	10	23	15	0	0	0	21	6	3	0	0	0	2	14
Podiceps cristatus	Great Crested Grebe	1	0	7	1	0	0	10	87	0	0	3	0	30	4513	3	0	0	0	6	3440
Podiceps griseigena	Red-necked Grebe	1	0	4	0	0	0	0	3	0	0	0	0	0	7	2	0	0	0	0	0
Podiceps auritus	Slavonian Grebe	0	0	0	0	0	0	0	2	5	0	0	0	3	0	0	0	0	0	0	0
Fulmarus glacialis	Northern Fulmar	51	24	92	127	12	11	5	76	129	45	6	45	9	15	3	0	0	0	0	2
Puffinus griseus	Sooty Shearwater	4	0	0	0	0	0	0	0	0	0	0	15	1	0	0	0	0	11	0	0
Puffinus puffinus	Manx Shearwater	0	0	0	11	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Sula bassana	Northern Gannet	361	67	256	89	31	616	103	34	80	55	68	840	217	23	354	50	370	141	411	2079
Phalacrocorax carbo	Great Cormorant	285	86	150	666	496	292	75	20	772	2247	1276	750	46	67	506	993	2382	152	308	217
Ardea cinerea	Grey Heron	0	0	0	0	0	0	1	0	1	0	27	9	0	0	0	0	0	0	1	0
Platalea leucorodia	European Spoonbill	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cygnus columbianus	Bewick's Swan	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Anser fabalis	Bean Goose	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anser anser	Greylag Goose	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	144	0
Branta bernicla	Brent Goose	320	8	9	11	0	0	0	74	113	0	0	0	35	0	73	0	0	0	15	11
Alopochen aegyptiacus	Egyptian Goose	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tadorna tadorna	Shelduck	6	0	3	1	52	23	0	0	0	10	0	0	0	0	1	13	0	0	0	0
Anas penelope	Wigeon	7	64	22	0	0	0	4	151	2	0	0	0	0	16	0	0	0	0	73	7
Anas strepera	Gadwall	0	0	16	0	0	0	4	0	0	0	0	0	0	0	10	0	0	0	0	0
Anas crecca	Common Teal	2	9	157	2	0	0	2	4	16	0	0	3	0	0	5	0	0	0	24	2
Anas platyrhynchos	Mallard	0	10	2	5	0	2	0	0	0	2	1	0	0	0	2	2	0	0	2	0
Anas domesticus	domestic duck	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Anas acuta	Northern Pintail	0	0	74	0	0	0	0	68	0	0	0	0	0	2	0	0	0	0	0	0
Anas querquedula	Garganey	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anas clypeata	Northern Shoveler	0	0	80	0	0	0	1	0	7	0	0	0	0	0	6	0	0	0	1	0
Aythya fuligula	Tufted Duck	0	0	0	0	0	0	0	24	0	0	0	3	0	0	0	0	0	0	1	0

Scientific name	English name	2002_09	2002_10	2003_04	2003_05	2003_06	2003_08	2003_11	2004_02	2007_04	2007_06	2007_08	2007_09	2007_11	2008_01	2008_04	2008_06	2008_08	2008_09	2008_11	2009_01
Aythya marila	Greater Scaup	0	0	2	0	0	0	0	115	0	0	0	0	1	0	0	0	0	0	0	0
Somateria mollissima	Common Eider	24	52	66	2	0	9	35	761	0	4	1	0	30	4	6	0	0	0	82	15
Clangula hyemalis	Long-tailed Duck	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Melanitta nigra	Common Scoter	542	168	1114	78	196	67	386	614	1814	133	171	54	71	168	604	126	0	19	88	234
Melanitta fusca	Velvet Scoter	0	1	8	0	0	0	12	15	3	0	0	0	5	13	18	0	0	0	1	0
Bucephala clangula	Common Goldeneye	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mergus serrator	Red-br. Merganser	0	0	45	1	0	0	6	0	9	0	0	0	3	0	31	0	0	0	0	1
Circus cyaneus	Hen Harrier	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipiter nisus	Sparrowhawk	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0
Falco peregrinus	Pergrine Falcon	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Fulica atra	Common Coot	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Haematopus ostralegus	Eurasian Oystercatcher	0	0	0	1	0	1	0	4	0	0	5	0	0	0	0	0	16	0	0	0
Charadrius hiaticula	Ringed Plover	0	0	1	0	0	4	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Charadrius alexandrinus	Kentish Plover	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pluvialis apricaria	Golden Plover	12	6	0	0	0	0	0	0	0	0	7	33	0	0	0	0	20	0	0	0
Pluvialis squatarola	Grey Plover	1	0	16	0	0	3	0	1	5	0	1	0	0	0	0	0	36	0	1	0
Calidris canutus	Knot	0	0	20	0	0	9	8	0	15	5	0	0	0	0	0	0	0	0	0	0
Calidris alba	Sanderling	0	0	0	0	0	0	1	11	1	0	3	0	0	0	0	0	8	0	0	0
Calidris maritima	Purple Sandpiper	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Calidris alpina	Dunlin	1	0	0	0	0	1	1	3	23	0	0	45	0	0	0	0	0	0	0	0
Philomachus pugnax	Ruff	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lymnocryptes minimus	Jacksnipe	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Gallinago gallinago	Snipe	0	0	0	0	0	0	9	0	0	0	3	0	4	0	0	0	26	0	0	0
Limosa lapponica	Bar-tailed Godwit	0	0	0	0	0	4	0	1	25	0	1	0	0	0	0	0	2	0	0	0
Numenius phaeopus	Whimbrel	0	0	0	0	0	1	0	0	0	0	4	0	0	0	0	0	18	0	0	0
Numenius arquata	Curlew	0	0	0	0	3	18	7	8	12	2	0	0	0	0	0	21	0	0	0	5
Tringa totanus	Redshank	0	0	0	0	1	4	1	0	0	1	28	0	0	0	0	0	0	0	0	0
Arenaria interpres	Turnstone	0	0	0	0	0	13	0	0	0	0	0	6	0	0	0	0	0	0	0	0
Phalaropus fulicaria	Grey Phalarope	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
unidentified wader	unidentified wader	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0
Stercorarius parasiticus	Arctic Skua	3	0	1	0	0	2	2	0	5	0	1	21	0	0	0	1	0	3	0	0

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Stercorarius skua	Great Skua	3	4	2	14	1	5	2	0	0	3	5	60	7	1	0	2	22	17	3	1
Larus melanocephalus	Mediterranean Gull	0	0	0	0	0	0	0	0	0	1	0	0	0	2	3	0	0	0	0	0
Larus minutus	Little Gull	57	40	1965	0	0	0	242	17	1202	0	13	123	81	34	6698	0	0	2	29	7
Larus ridibundus	Black-headed Gull	6	55	59	5	20	50	454	25	13	3	77	57	77	20	27	64	72	0	30	15
Larus canus	Common Gull	25	59	1372	14	392	31	3719	482	4559	5	4	33	564	307	2625	48	0	8	1104	822
Larus fuscus	Lesser Bl.-backed Gull	1752	81	10109	6949	4790	7110	99	42	5432	4236	5251	1845	16	5	4610	5353	3152	143	44	3
L. fuscus / argentatus	Herring / LBB gull	0	0	60	0	0	0	0	0	0	150	0	0	0	0	0	1640	0	0	0	0
Larus argentatus	Herring Gull	2136	508	3725	2481	2434	247	10984	329	2128	277	1587	489	341	359	947	957	258	37	4381	484
Larus cachinnans	Yellow-legged Gull	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larus hyperboreus	Glaucous Gull	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Larus marinus	Great Bl.-backed Gull	3226	317	363	146	9	284	2285	60	87	157	269	1884	708	377	71	159	360	165	3173	650
Larus spec.	unidentified large gull	1384	17	0	4105	646	673	50	0	5	100	200	0	210	0	301	0	120	0	0	0
Rissa tridactyla	Kittiwake	15	189	194	48	0	7	1284	108	16	12	0	246	1938	443	3	0	8	15	81	796
Larus spec.	unidentified gull	0	0	600	0	1085	0	1720	70	0	0	0	0	0	0	0	0	0	0	0	120
Sterna sandvicensis	Sandwich Tern	32	0	260	75	74	277	0	0	35	20	78	177	0	0	156	63	538	2	0	0
Sterna hirundo	Common Tern	22	0	47	33	29	1041	1	0	14	116	229	75	0	0	110	56	624	1	0	0
Sterna paradisaea	Arctic Tern	0	0	0	19	0	32	0	0	0	3	2	0	0	0	0	0	36	1	0	0
S. hirundo / paradisaea	Common/Arctic tern	0	0	18	98	30	142	0	0	0	0	1	0	0	0	0	0	16	1	0	0
Sterna albifrons	Little Tern	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	8	0	0	0
Chlidonias niger	Black Tern	0	0	0	0	0	11	0	0	0	0	15	3	0	0	0	0	14	0	0	0
Uria aalge	Guillemot	11	246	71	1	0	0	1313	488	20	2	5	800	2523	1290	30	0	20	3	163	2524
Alca torda / Uria aalge	"Razormot"	0	6	0	0	0	0	7	42	0	0	0	6	0	0	0	0	0	0	0	0
Alca torda	Razorbill	0	14	23	1	0	0	35	90	5	0	1	1068	170	37	13	2	0	3	7	145
Fratercula arctica	Atlantic Puffin	0	2	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Columba 'domestica'	Feral Pigeon	1	0	0	1	23	2	2	0	0	2	0	0	0	0	0	0	14	0	1	0
Asio otus	Long-eared Owl	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apus apus	Swift	0	0	0	0	15	2	0	0	0	1	0	0	0	0	0	66	8	0	0	0
Lullula arborea	Woodlark	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Alauda arvensis	Skylark	4	22	0	0	0	0	313	4	0	0	0	18	0	0	0	0	0	0	18	0
Hirundo rustica	Swallow	0	0	0	3	0	0	0	0	6	0	2	0	0	0	0	0	0	0	0	0
Anthus pratensis	Meadow Pipit	89	9	3	1	0	0	36	3	3	0	0	30	0	0	15	0	0	0	10	0

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Anthus spinoletta	Rock Pipit	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Motacilla flava	Blue-headed Wagtail	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Motacilla alba	White Wagtail	3	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Motacilla alba	Pied Wagtail	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Erithacus rubecula	Robin	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	8	0
Phoenicurus ochruros	Black Redstart	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Turdus merula	Blackbird	0	16	0	0	0	0	11	0	0	0	0	0	23	0	0	0	0	0	175	0
Turdus pilaris	Fieldfare	0	9	0	0	0	0	6	0	0	0	0	3	5	0	0	0	0	0	305	0
Turdus philomelos	Song Thrush	0	7	0	0	0	0	6	0	0	0	0	3	0	0	0	0	0	0	4	0
Turdus iliacus	Redwing	0	57	0	0	0	0	42	0	1	0	0	261	28	0	0	0	0	0	239	0
P. collybita / trochilus	Chiffchaff/Wil. Warbl.	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Regulus regulus	Goldcrest	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
Ficedula hypoleuca	Pied Flycatcher	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corvus frugilegus	Rook	0	0	2	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Sturnus vulgaris	Starling	0	1418	0	0	3	0	3890	18	5	0	0	90	74	0	1	14	0	0	1315	0
Fringilla coelebs	Chaffinch	0	5	0	0	0	0	9	0	0	0	0	9	0	0	0	0	0	0	7	0
Fringilla montifringilla	Brambling	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
unid. passerine	unid. passerine	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0
Phocoena phocoena	Harbour Porpoise	12	7	48	9	0	12	21	211	42	2	14	6	22	54	22	9	16	2	35	63
unidentified pinniped	unidentified seal	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
Halichoerus grypus	Grey Seal	0	0	1	0	0	0	0	0	0	2	0	3	0	4	0	0	0	5	6	3
Phoca vitulina	Common Seal	1	0	0	0	0	0	1	3	1	1	0	0	1	6	2	0	2	0	3	1