Thanet Offshore Wind Farm

Ornithological Monitoring 2012-2013

Thanet Offshore Wind Limited

June 2013

Final Report

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1 INTRODUCTION

This report presents the results of the third winter of bird surveys that have been undertaken for the post-construction phase monitoring as part of the Thanet Offshore Wind Farm FEPA monitoring programme. The surveys reported here cover the monitoring work carried out between October 2012 and March 2013.

The main aim of the FEPA monitoring program is to determine the distribution and abundance of seabirds using the Thanet Offshore Wind Farm site and its surrounds before, during and after the construction phase of the wind farm. Standard survey methodologies have been used, following Camphuysen et al. (2004) and have remained consistent throughout the pre, during and post-construction monitoring.

The Thanet Offshore Wind Farm (Thanet) project is located in the Thames Estuary Strategic Environmental Assessment (SEA) area, approximately 11km off Foreness Point, within the Outer Thames Estuary. The Thanet project received consent in December 2006, with the most recent FEPA license being dated July 2010 (33119/10/1).

The Thanet project consists of 100 Vestas V90 3MW wind turbines located in water depths of 15-25m below chart datum, and extends over an area of 35km^2. Each turbine is 115m tall at its highest point, with a minimum clearance above sea level of 22m. The turbine separation is approximately 500m along rows and 800m between rows.

The 2012-13 surveys are considered to be post construction as the installation of the 100 turbines and the offshore substation has now been completed.

The FEPA Licence conditions relevant to ornithological monitoring are summarised in Section 4 of the Environmental Monitoring Plan for Thanet (Royal Haskoning 2011) and reported in the construction phase annual report (Royal Haskoning 2010). A number of conditions were imposed as part of the consents for the Thanet project, one of which relates to continued ornithological monitoring of the site, with the project's FEPA Licence (33119/10/1) stating:

"9.11 Ornithological monitoring must be carried out as outlined in Annex 2 attached to this Schedule. The full specification for the monitoring programme will be subject to separate written agreement with the Licensing Authority following consultation with Natural England prior to the proposed commencement of the monitoring work; and

9.12 Post-construction monitoring during the operational phase of the wind farm must be undertaken annually for three years. The level of any subsequent ornithological monitoring, during the lifetime of the wind farm's operation, will be determined, in consultation with Natural England, having regard to the magnitude of any change in bird populations observed during the initial monitoring period."

Further to this, Annex 2 of the FEPA Licence 33119/10/1 states that:

"Monitoring will comprise a Before and After Control Impact (BACI) design and will be undertaken at the survey areas consisting of the windfarm site, a 1km and 2–4km buffer zone surrounding the windfarm and the selected reference site. The monitoring programme will be implemented in advance of construction and continue through the

construction phase. There is also a requirement to conduct post-construction monitoring to provide a minimum of three years data from the operating phase. These data will need to be empirically comparative with baseline data provided within the project's Environmental Statement. The detailed specification for the monitoring programme, including the location and extent of the reference site, will be subject to separate written agreement with the Licensing Authority following consultation with Natural England prior to the proposed commencement of the monitoring work (see licence condition 9.11).

The need for additional ornithological monitoring, on-going during the lifetime of the wind farm's operation, will be determined, in consultation with Natural England and DEFRA and reviewed at agreed periods. This will have regard to the magnitude of any change in bird populations observed during the initial three years operational monitoring period (as per licence condition 9.12). The ornithological monitoring programme may have to be adapted and amended as new technologies and research findings become available, as determined by Natural England and the Licensing Authority. Ornithological monitoring reports will be provided to Natural England on a quarterly basis as a draft report update and as a final annual report. This may be more frequent where the results of the data may trigger further, more intensive monitoring work. Monitoring of the agreed reference site will also continue parallel to the wind farm site and the 1km and 2 – 4km buffer zones surrounding the wind farm. Monitoring will need to fulfil the following objectives:

1. Determine whether there is change in bird use and passage, measured by species (with particular reference to red-throated diver), abundance and behaviour, of the wind farm site, 1km and 2 – 4km buffer zones and the reference site;

2. Determine whether there is a barrier effect to movement of birds through the wind farm site and the 1km and 2–4km buffer zones;

3. Continue to determine the distribution of wildfowl and divers in the Greater Thames estuary, covering the Thanet windfarm site, 1km and 2–4km buffer zones and the reference site; and

4. If objectives 1 or 2 reveal significant change of use of the wind farm site and 1km and 2–4km buffer zones by populations of conservation concern, at heights that could incur collision, a programme of collision monitoring will be implemented."

2 PREVIOUS SURVEYS

A programme of baseline bird surveys was undertaken for the ornithological impact assessment of the project that was reported in the Environmental Statement for the Thanet application (Royal Haskoning 2005). Surveys were then conducted during the construction phase of the project in February - March 2009 and October 2009 - March 2010, reported by Royal Haskoning (2009, 2010) and the first two year post-construction (Percival 2012a and b). The data available for comparison with the third year's post-construction monitoring data therefore comprise:

Pre-construction:

- Boat-based surveys – twelve boat-based surveys were carried out at monthly intervals between November 2004 and October 2005; and

- Aerial surveys – four aerial surveys were carried out between November 2004 and March 2005.

Construction phase surveys:

- Boat-based surveys – one in February and two in March 2009; and
- Boat-based surveys – two per month from October 2009 – March 2010.

Post-construction phase surveys:

- Boat-based surveys – two per month from October 2010 – March 2011; and
- Boat-based surveys – two per month from October 2011 – March 2012.

This report presents the ornithological data collected during the third winter of the post-construction monitoring during the phase completed over the period October 2012 to March 2013.

3 STUDY AREA

The pre-construction boat surveys reported in the ES covered a smaller area (100km^2) than that being surveyed in the construction and post-construction periods, comprising the wind farm site plus a 1km buffer (67km^2) and a control area to the south (33km^2). The transects used for those surveys are shown in Figure 1.

The survey area was expanded in 2009 to a total area of 149km^2, to include the wind farm site plus a 2km buffer (111km^2) and a separate control area of 38km^2 to the south (see Figure 1), as agreed with DEFRA[1].

[1] Gary James, DEFRA, email of 13/3/09.

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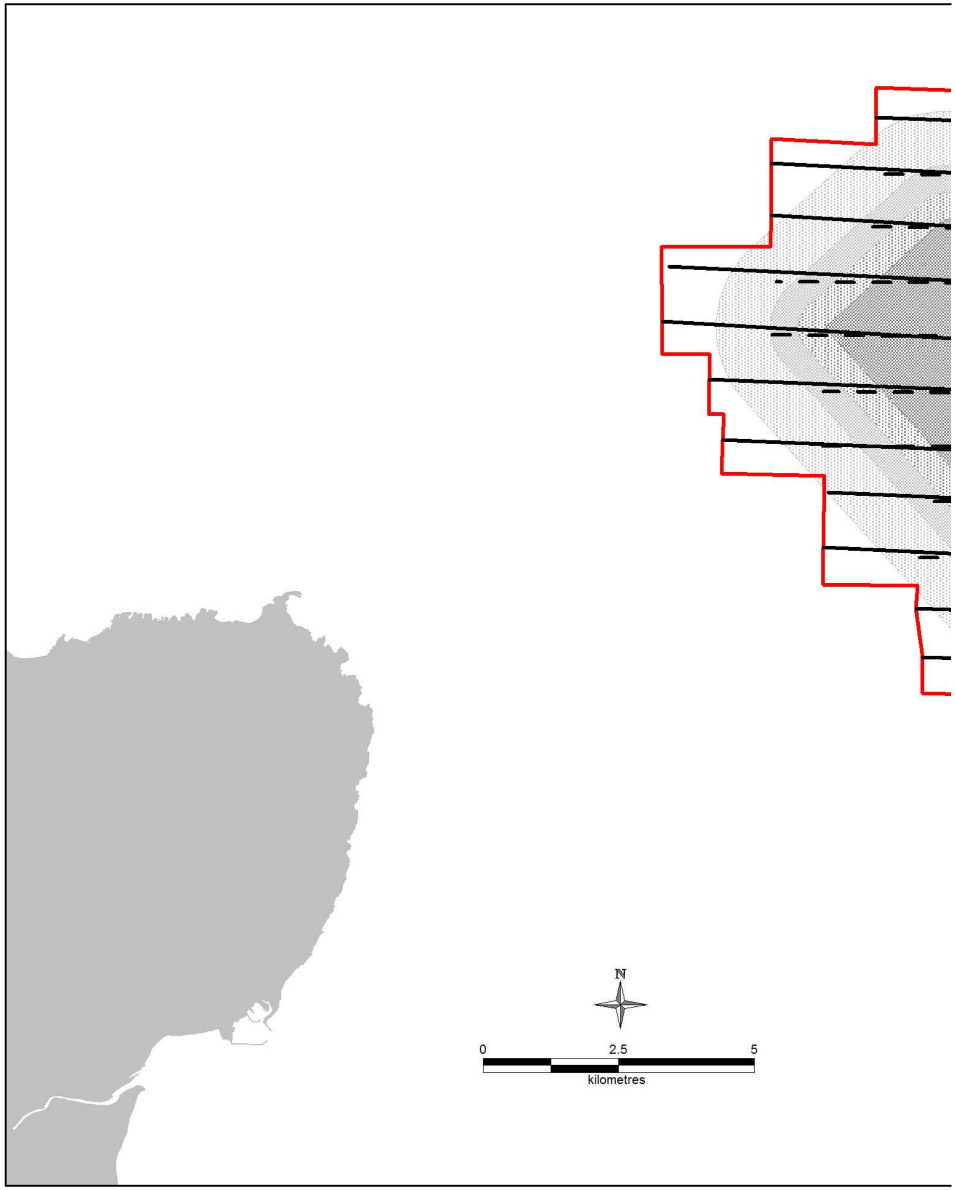

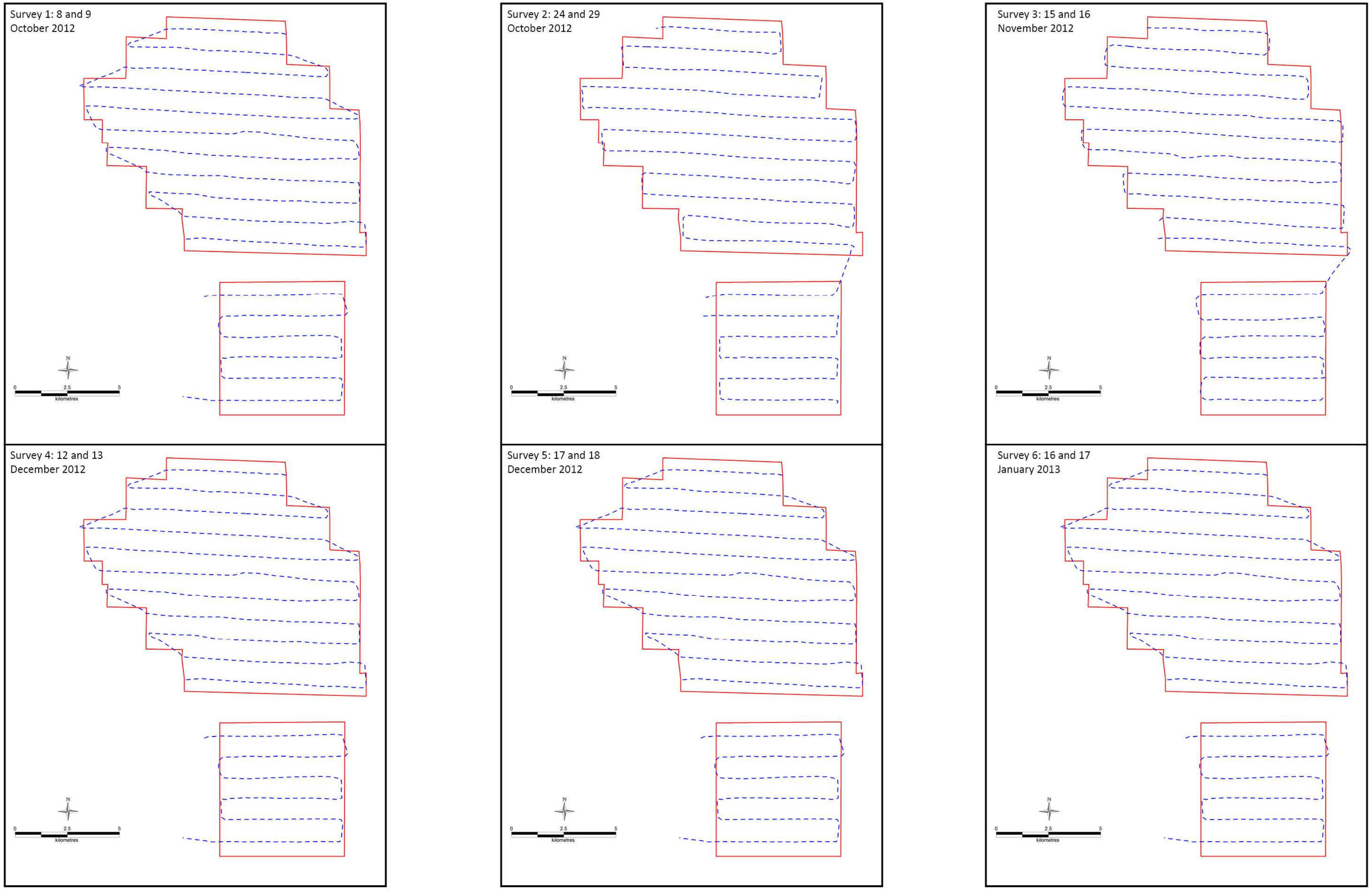

Figure 2a. GPS tracks from Thanet Offshore boat surveys, October 2012 – early January 2013.

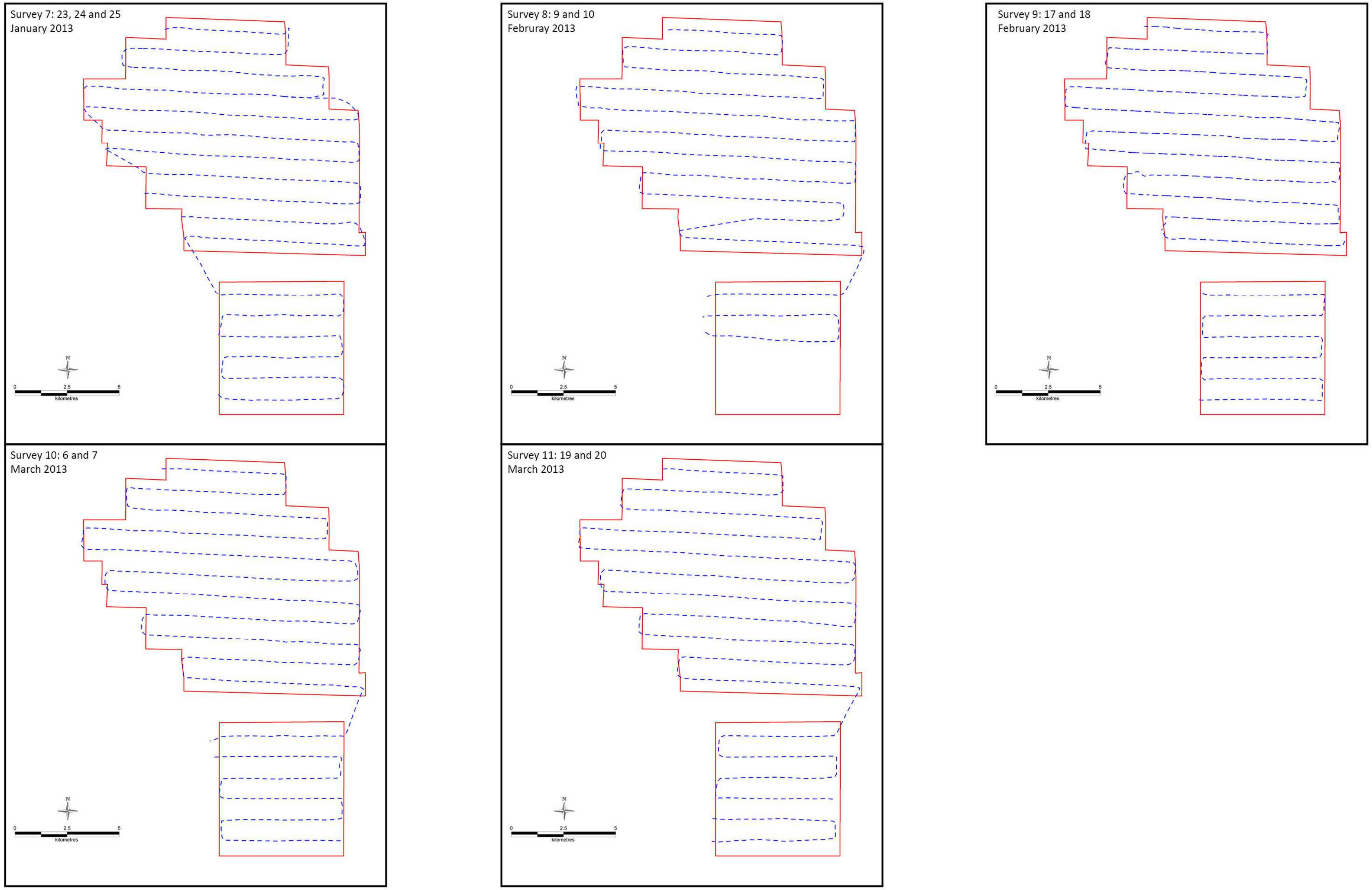

Figure 2b. GPS tracks from Thanet Offshore boat surveys, late January - March 2013

4 SURVEY METHODS

The survey methods follow those detailed in the Thanet Offshore Wind Farm – During and Post-Construction Bird Monitoring Protocol ('the Protocol') (Thanet Offshore Wind Limited (TOW), 2009). The Protocol was developed in consultation with Natural England and the Marine and Fisheries Agency (MFA) (now the Marine Management Organisation (MMO)) in order to meet the requirements of the Thanet FEPA licence. Further details of the survey methodology are provided in the Protocol.

The surveys comprise boat-based line transects of the study area, broadly following the methodology recommended in Camphuysen et al., (2004). The surveys in the second year of the post-construction phase were carried out using the same protocol as for the construction phase works, twice-monthly during the October – March period. Monitoring surveys will continue for a further (third) year during the project's operation, continuing the pattern of two surveys per month between October and March.

The same vessel was used for these surveys as for the pre-construction, the construction phase and the first winter's post-construction surveys, the 'Arie Dirk'. This vessel cruises the transects at about 8 knots and has a viewing height of about 5m above the level of the sea. It is ideal for the work being of a size and a manoeuvrability (with an experienced local crew) to enable safe operation close inshore and around busy shipping channels.

The same survey transects were used as for the pre-construction baseline surveys and construction phase surveys (Figure 1). The survey route was designed to provide approximately a 1km interval between transects; a total of 17 transects were surveyed, all running approximately east-west. This separation distance was chosen to ensure that an adequate sample of the study area was covered for all species, whilst minimising the likelihood that birds may be displaced from one transect to the adjacent one (and hence double-counted).

A GPS record of the precise route was taken on each trip, so that the location at all times was known. The GPS tracks for each survey are shown in Figure 2. A total of 10 surveys were undertaken during the 2011 -2012 winter on the following dates. Following a long period of inclement weather in November and December 2011 (during which only single surveys each month were possible, with the December survey only covering the wind farm site not the control area – see Figure 2), it was agreed with Natural England that surveys for the remaining part of the winter should continue at two per month through to the end of March.

- 8 and 9 October 2012;
- 24 and 29 October 2012;
- 15 and 16 November 2012;
- 12 and 13 December 2012
- 17 and 18 December 2013; and

- 16 and 17 January 2013.
- 23, 24 and 25 January 2013;
- 9 and 10 February 2013 (incomplete survey due to deteriorating weather conditions – southernmost three transects of control area not surveyed);
- 17 and 18 February 2013;
- 12 and 13 February 2013;
- 6 and 7 March 2013; and
- 19 and 20 March 2013.

The observation team in 2012-2013 comprised Jon Ford, Ian Harding, Peter Dodds, Trevor Charlton and Graham Elton, who were each involved in both observation and recording. Three surveyors were deployed at all times in order to allow rotation of duties and to enable one surveyor to be free to undertake continual forward scanning for the detection of species that may be flushed from the sea surface. The team are experienced ornithologists, well able to identify all the species encountered accurately. All observers also have a good knowledge of the area and its ornithological interests, and are also trained Marine Mammal Observers.

All birds encountered, their behaviour, flight height and approximate distance from the boat were recorded. Following the JNCC Seabirds at Sea recommendations, birds were recorded into five distance bands (0-50m, 50-100m, 100-200m, 200-300m and 300+m). Birds were recorded continuously, at a steady speed of approximately 8 knots, with the precise time of each observation recorded where possible to give as accurate a position as possible (linking to the GPS position information being recorded simultaneously). All records of birds observed flying as well as those on the sea were recorded. All sightings of marine mammals were also recorded during the surveys.

The approximate height above the sea of all flying birds was recorded. Flying birds were recorded using snapshot counts at one-minute intervals. Whilst all birds observed were recorded, a note of those “in transect” was made to facilitate later analysis. The flight height categories were as follows:

- <20m
- 20-120m (equivalent to the approximate height of the wind turbine rotors)
- >120m

5 SURVEY RESULTS

5.1 Study Area Population Estimates

The total population estimates within the study area for each survey, based on counts from the main survey transect sampling area (within 300m of the survey vessel) corrected for distance sampling and survey coverage, are shown in Table 1.

Table 1. Survey Area total population estimates corrected for distance sampling and survey coverage, October 2012 – March 2013.

Species	8 - 9 Oct 2012	24 - 29 Oct 2012	15 - 16 Nov 2012	12 - 13 Dec 2012	17 - 18 Dec 2012	16 - 17 Jan 2013	23, 24 and 25 Jan 2013	9-10 Feb 2013	17-18 Feb 2013	6-7 Mar 2013	19-20 Mar 2013
Brent goose	43	0	2	3	0	0	10	0	0	0	0
Wigeon	0	0	0	0	0	115	58	0	0	0	0
Gadwall	0	13	0	0	0	0	0	0	0	0	0
Teal	0	0	0	0	5	2	0	0	0	0	0
Shoveler	0	0	0	0	0	15	0	0	0	0	0
Eider	0	0	0	2	0	0	0	0	0	0	0
Common scoter	0	20	8	8	0	12	0	0	0	0	0
Red-breasted merganser	0	0	0	0	0	0	0	0	0	0	3
duck sp	0	2	4	0	0	0	0	0	0	0	0
Red-throated diver	0	0	11	40	57	30	5	88	10	58	65
Black-throated diver	0	0	2	0	2	0	0	0	0	2	0
diver sp	3	0	0	8	8	7	0	0	0	0	5
Great crested grebe	0	0	4	0	0	0	0	0	0	0	0
Fulmar	0	0	7	12	12	28	20	18	20	36	15
Gannet	168	207	332	10	123	67	60	358	318	256	409
Cormorant	2	0	2	0	0	0	0	0	0	0	0
Oystercatcher	0	0	0	0	0	0	2	0	0	0	0
Arctic skua	3	0	0	0	0	0	0	0	0	0	2
Great skua	9	2	0	0	2	0	0	0	4	2	2
skua sp	0	0	0	0	2	0	0	0	0	0	0
Common gull	7	37	95	120	50	72	79	35	57	378	24
Lesser black-backed gull	5	10	51	2	17	9	2	16	45	30	48
Herring gull	38	2	79	30	130	108	183	146	194	904	98
Great black-backed gull	189	142	409	48	193	71	119	121	100	366	142
Little gull	46	12	2	0	0	0	0	0	0	0	7
Black-headed gull	0	0	3	3	0	0	0	0	0	4	52
Kittiwake	168	43	153	88	158	194	177	82	163	61	45
black-backed gull sp	0	5	10	0	6	3	12	11	2	0	71
large gull sp	350	3	415	11	33	20	32	22	17	265	32
small gull sp	0	0	0	5	2	2	0	0	0	0	0

Species	8 - 9 Oct 2012	24 - 29 Oct 2012	15 - 16 Nov 2012	12 - 13 Dec 2012	17 - 18 Dec 2012	16 - 17 Jan 2013	23, 24 and 25 Jan 2013	9-10 Feb 2013	17-18 Feb 2013	6-7 Mar 2013	19-20 Mar 2013
gull sp	0	0	0	2	2	13	7	0	0	163	0
Guillemot	137	122	1130	1244	847	717	672	321	557	914	266
Razorbill	304	28	32	247	116	81	131	253	77	161	60
auk sp	145	79	471	775	653	1279	174	266	383	853	126
Skylark	0	0	0	0	0	0	0	0	2	0	0
Blackbird	0	0	3	0	0	0	0	0	0	0	0
Song Thrush	0	3	0	0	0	0	0	0	0	0	0
thrush sp	0	0	5	0	0	0	0	0	0	0	0
Goldcrest	0	0	2	0	0	0	0	0	0	0	0
Starling	3	10	30	0	0	0	0	0	0	0	310
Chaffinch	0	0	2	0	0	0	0	0	0	0	0
finch sp	0	5	0	0	0	0	0	0	0	0	0
small passerine sp	3	0	0	0	0	0	0	0	0	0	0
large passerine sp	0	2	0	0	0	0	0	0	0	0	0
passerine sp	0	0	0	0	2	0	0	0	0	0	0

The distribution of the birds in relation to the wind farm area has been summarised into 1km bands in Table 2. This Table gives the mean and peak counts recorded during 2012 - 2013 within the wind farm site, within a 1km buffer around the site, within the 1-2km zone and in the control area (6-11km from the nearest wind turbine). These areas cover 35, 27, 33 and 38 km^2 respectively.

Table 2. Mean and peak seabird population estimates for main species zones within and around the wind farm corrected for distance sampling and survey coverage in 2012-13.

Species	Mean estimate for each zone				Peak estimate for each zone			
	Wind farm site	0-1km	1-2km	Control	Wind farm site	0-1km	1-2km	Control
Red-throated diver	2	5	12	12	10	7	49	29
Black-throated diver	0	0	0	0	0	0	2	2
diver sp	0	0	2	1	2	2	10	3
Fulmar	1	1	3	9	12	2	10	24
Gannet	34	56	55	68	138	157	131	141
Common gull	27	15	22	11	120	42	105	30
Lesser black-backed gull	3	4	5	6	8	7	20	29
Herring gull	80	29	36	28	697	84	156	85
Great black-backed gull	54	42	32	37	176	101	76	90
Black-headed gull	0	2	1	2	3	25	5	17
Kittiwake	28	21	21	43	122	48	38	106
black-backed gull sp	3	4	3	1	10	17	24	3
large gull sp	28	70	21	37	144	356	169	333
Guillemot	107	129	149	213	405	161	344	727

Species	Mean estimate for each zone				Peak estimate for each zone			
	Wind farm site	0-1km	1-2km	Control	Wind farm site	0-1km	1-2km	Control
Razorbill	17	43	29	32	90	124	77	87
auk sp	41	65	110	246	103	124	401	834

The bird numbers recorded in each of these zones in the previous construction phase (2009-10) and post-construction (2010-11 and 2011-12) surveys are given in Tables 3a and 3b for comparison of the mean and peak counts respectively. Statistical analysis of these differences in bird numbers and a comparison with the pre-construction numbers are given in Section 8 of this report below.

Table 3a. Comparison of mean population estimates for key seabird species in zones within and around the wind farm based on 'in-transect' counts corrected for distance sampling and survey coverage in 2009-10 (construction phase), and 2010-11, 2011-12 and 2012-13 (post-construction).

Species	Wind farm site				0-1km				1-2km				Control			
	09-10	10-11	11-12	12-13	09-10	10-11	11-12	12-13	09-10	10-11	11-12	12-13	09-10	10-11	11-12	12-13
Red-throated Diver	1	2	2	2	1	5	7	5	3	7	11	12	2	8	23	12
Gannet	2	2	6	34	4	4	15	56	7	9	17	55	21	34	65	68
Common Gull	119	40	15	27	68	20	10	15	56	26	10	22	41	17	13	11
Lesser Black-backed Gull	25	14	22	3	13	14	35	4	23	31	30	5	16	42	27	6
Herring Gull	19	32	31	80	15	28	168	29	84	88	35	36	27	69	27	28
Great Black-blacked Gull	12	14	40	54	4	71	110	42	7	24	27	32	13	141	66	37
Kittiwake	29	54	32	28	15	26	31	21	44	27	45	21	10	44	57	43
Guillemot	10	14	56	107	20	38	90	129	28	62	128	149	22	58	172	213
Razorbill	1	1	24	17	3	3	29	43	6	3	30	29	8	15	22	32

Table 3b. Comparison of peak population estimates for main species zones within and around the wind farm based on 'in-transect' counts corrected for distance sampling and survey coverage in 2009-10 (construction phase), and 2010-11 and 2011-12 (post-construction).

Species	Wind farm site				0-1km				1-2km				Control			
	09-10	10-11	11-12	12-13	09-10	10-11	11-12	12-13	09-10	10-11	11-12	12-13	09-10	10-11	11-12	12-13
Red-throated Diver	6	7	13	10	3	41	23	7	8	24	106	49	10	27	156	29
Gannet	22	12	28	138	16	12	67	157	32	31	167	131	95	99	347	141
Common Gull	716	150	67	120	430	55	45	42	222	71	102	105	342	58	70	30
Lesser Black-backed Gull	132	28	81	8	66	27	153	7	125	200	298	20	43	253	45	29
Herring Gull	52	56	102	697	36	32	1437	84	663	276	355	156	116	167	62	85

Species	Wind farm site				0-1km				1-2km				Control			
	09-10	10-11	11-12	12-13	09-10	10-11	11-12	12-13	09-10	10-11	11-12	12-13	09-10	10-11	11-12	12-13
Great Black-blacked Gull	56	72	79	176	13	716	546	101	22	111	273	76	53	1,508	233	90
Kittiwake	141	287	84	122	43	52	67	48	302	62	453	38	33	145	138	106
Guillemot	95	79	187	405	93	130	234	161	99	213	1281	344	70	175	552	727
Razorbill	6	9	91	90	21	7	84	124	54	11	304	77	61	94	71	87

The bird densities recorded in each of these zones in 2012-13 are compared in Table 4. This takes into account the differing extents of these zones (standardising for area by presenting the data as densities). Densities of divers and auks were clearly lower within the wind farm site than elsewhere (as had been noted in the 2010-11 surveys but were broadly similar across the buffers zones and in the control area. Gull densities across these zones were variable, with no clear relationship to distance from the wind farm, as had been found in 2010-11. Statistical analysis of the differences in bird numbers and a comparison with the pre-construction numbers are given in Section 8 of this report below.

Table 4. Mean and peak bird densities for zones within and around the wind farm based on counts corrected for distance sampling and survey coverage in 2012-13.

	Mean density for each zone				Peak density for each zone			
Species	Wind farm site	0-1km	1-2km	Control	Wind farm site	0-1km	1-2km	Control
Red-throated diver	0.07	0.17	0.35	0.32	0.29	0.25	1.48	0.77
Black-throated diver	0	0	0.005	0.01	0	0	0.05	0.05
diver sp	0.01	0.02	0.07	0.03	0.05	0.06	0.30	0.09
Fulmar	0.04	0.04	0.09	0.25	0.35	0.06	0.30	0.64
Gannet	0.96	2.06	1.68	1.79	3.93	5.82	3.97	3.70
Common gull	0.77	0.55	0.68	0.29	3.43	1.55	3.18	0.79
Lesser black-backed gull	0.08	0.16	0.16	0.16	0.24	0.25	0.61	0.76
Herring gull	2.30	1.07	1.10	0.74	19.92	3.13	4.73	2.24
Great black-backed gull	1.53	1.54	0.96	0.96	5.04	3.73	2.30	2.36
Black-headed gull	0.01	0.08	0.03	0.04	0.10	0.93	0.15	0.44
Kittiwake	0.81	0.79	0.64	1.14	3.50	1.76	1.16	2.79
black-backed gull sp	0.07	0.13	0.08	0.03	0.28	0.62	0.74	0.09
large gull sp	0.79	2.60	0.62	0.98	4.13	13.18	5.11	8.77
Guillemot	3.07	4.78	4.50	5.60	11.57	5.95	10.41	19.13
Razorbill	0.48	1.59	0.87	0.85	2.58	4.58	2.34	2.29
auk sp	1.17	2.42	3.32	6.47	2.94	4.60	12.16	21.95

The bird densities recorded in each of these zones in 2009-10 and 2010-11 are given in Table 5a, 5b and 5c for comparison.

Table 5a. Mean and peak bird densities for zones within and around the wind farm based on 'in-transect' counts corrected for distance sampling and survey coverage in 2009-10.

	Mean density for each zone				Peak density for each zone			
Species	**Wind farm site**	**0-1km**	**1-2km**	**Control**	**Wind farm site**	**0-1km**	**1-2km**	**Control**
Red-throated diver	0.03	0.01	0.08	0.05	0.17	0.11	0.24	0.26
Gannet	0.07	0.14	0.20	0.55	0.63	0.59	0.97	2.50
Common gull	3.39	2.51	1.68	1.07	20.46	15.93	6.73	9.00
Lesser black-backed gull	0.71	0.50	0.70	0.41	3.77	2.44	3.79	1.13
Herring gull	0.55	0.57	2.53	0.72	1.49	1.33	20.09	3.05
Great black-blacked gull	0.33	0.15	0.21	0.33	1.60	0.48	0.67	1.39
Kittiwake	0.81	0.56	1.34	0.27	4.03	1.59	9.15	0.87
Guillemot	0.29	0.73	0.84	0.57	2.71	3.44	3.00	1.84
Razorbill	0.02	0.09	0.19	0.21	0.17	0.78	1.64	1.61

Table 5b. Mean and peak bird densities for zones within and around the wind farm based on counts corrected for distance sampling and survey coverage in 2010-11.

	Mean density for each zone				Peak density for each zone			
Species	**Wind farm site**	**0-1km**	**1-2km**	**Control**	**Wind farm site**	**0-1km**	**1-2km**	**Control**
Red-throated diver	0.06	0.20	0.20	0.22	0.19	1.50	0.72	0.72
Black-throated diver	0.00	0.06	0.03	0.08	0.00	0.19	0.10	0.50
diver sp	0.02	0.15	0.05	0.06	0.10	0.86	0.17	0.54
Fulmar	0.00	0.03	0.03	0.14	0.05	0.12	0.15	0.35
Gannet	0.05	0.16	0.28	0.89	0.33	0.43	0.93	2.62
Common gull	1.15	0.75	0.80	0.46	4.30	2.04	2.14	1.53
Lesser black-backed gull	0.40	0.53	0.93	1.11	0.81	0.99	6.06	6.67
Herring gull	0.90	1.03	2.67	1.81	1.60	1.18	8.36	4.39
Great black-backed gull	0.39	2.63	0.74	3.72	2.05	26.52	3.37	39.68
Black-headed gull	0.02	0.04	0.04	0.05	0.10	0.19	0.25	0.48
Kittiwake	1.55	0.97	0.81	1.17	8.19	1.93	1.88	3.82
large gull sp	0.43	0.68	2.00	0.77	1.37	2.22	14.77	4.43
Guillemot	0.39	1.43	1.89	1.52	2.25	4.80	6.46	4.60
Razorbill	0.03	0.11	0.08	0.38	0.25	0.25	0.32	2.47
auk sp	0.16	0.48	0.80	1.69	1.02	2.81	3.14	7.03

Table 5c. Mean and peak bird densities for zones within and around the wind farm based on counts corrected for distance sampling and survey coverage in 2011-12.

	Mean density for each zone				Peak density for each zone			
Species	**Wind farm site**	**0-1km**	**1-2km**	**Control**	**Wind farm site**	**0-1km**	**1-2km**	**Control**
Red-throated diver	0.06	0.25	0.32	0.61	0.37	0.83	3.22	4.10
Black-throated diver	0	0.01	0.01	0.02	0	0.06	0.06	0.09
diver sp	0.01	0.11	0.04	0.07	0.05	0.59	0.39	0.20
Fulmar	0	0.05	0.13	0.21	0.05	0.25	1.34	0.84
Gannet	0.17	0.57	0.51	1.72	0.81	2.47	5.05	9.12
Common gull	0.42	0.37	0.31	0.35	1.90	1.67	3.08	1.84
Lesser black-backed gull	0.62	1.29	0.90	0.71	2.32	5.68	9.04	1.20
Herring gull	0.87	6.23	1.08	0.70	2.92	53.21	10.75	1.62
Great black-backed gull	1.16	4.06	0.83	1.73	2.25	20.22	8.26	6.14
Black-headed gull	0.02	0	0.01	0	0.10	0	0.10	0
Kittiwake	0.92	1.14	1.37	1.50	2.40	2.48	13.72	3.62
black-backed gull sp	0.14	0.14	0.06	0.13	0.72	0.97	0.63	0.50
large gull sp	1.10	0.33	0.42	0.89	8.39	1.11	4.15	5.52
Guillemot	1.59	3.35	3.88	4.53	5.33	8.68	38.82	14.52
Razorbill	0.68	1.08	0.92	0.57	2.61	3.10	9.23	1.88
auk sp	0.61	1.78	1.80	3.30	1.81	5.36	18.00	13.93

A comparison between the densities of the main species found during the pre-construction (ES) surveys in 2004 -2005, the construction phase (2009 -2010) and the first two year's post-construction surveys (2010-11 and 2011-12) is shown in Table 6. Data from 1-2km buffer are not included as that zone was not fully surveyed in the ES surveys (though some sample areas were covered enabling some analysis of that area to be undertaken – see Section 8 below). Statistical analysis comparing the differences in bird numbers between the pre-construction, construction and post-construction periods are given in Section 8 of this report below.

Table 6. Densities of the main seabird species present in the survey area during Oct-Mar in the pre-construction (ES), construction (2009-10) and post-construction (2010-11, 2011-12 and 2012-13) surveys. Densities are given as mean numbers per km^2.

	Wind Farm					**0-1km Buffer**					**Control**				
	ES	**09-10**	**10-11**	**11-12**	**12-13**	**ES**	**09-10**	**10-11**	**11-12**	**12-13**	**ES**	**09-10**	**10-11**	**11-12**	**12-13**
All Divers	0.29	0.03	0.08	0.07	0.08	0	0.01	0.41	0.38	0.19	0.04	0.05	0.36	0.7	0.37
Gannet	0.05	0.07	0.05	0.17	0.96	0	0.14	0.16	0.57	2.06	0.06	0.55	0.89	1.72	1.79
Common Gull	1.7	3.39	1.15	0.42	0.77	0	2.51	0.75	0.37	0.55	0.03	1.07	0.46	0.35	0.29
Lesser Black-backed Gull	0.33	0.71	0.41	0.62	0.08	1.44	0.5	0.53	1.29	0.16	0.76	0.41	1.11	0.71	0.16
Herring Gull	1.95	0.55	0.9	0.87	2.30	0.3	0.57	1.04	6.23	1.07	0.97	0.72	1.81	0.7	0.74

	Wind Farm					0-1km Buffer					Control				
	ES	09-10	10-11	11-12	12-13	ES	09-10	10-11	11-12	12-13	ES	09-10	10-11	11-12	12-13
Great Black-blacked Gull	0.02	0.33	0.39	1.16	1.53	0.11	0.15	2.63	4.06	1.54	0.08	0.33	3.72	1.73	0.96
Kittiwake	0.2	0.81	1.56	0.92	0.81	0.15	0.56	0.98	1.14	0.79	0.14	0.27	1.17	1.5	0.64
All Gulls	4.32	5.79	4.83	5.24	6.36	2.81	4.29	6.59	13.5	6.93	1.98	2.8	9.02	6.01	4.35
Guillemot	0.69	0.29	0.39	1.59	3.07	0.65	0.73	1.43	3.35	4.78	1.32	0.57	1.53	4.53	5.60
Razorbill	0.22	0.02	0.03	0.68	0.48	0.22	0.09	0.11	1.08	1.59	0.14	0.21	0.39	0.57	0.85
All Auks	1	0.31	0.58	2.88	4.72	0.26	0	2.01	6.21	8.79	0.1	0	3.6	8.4	12.92

5.2 Seabird Distributions

The distributions of the main bird species observed during the 2012–13 surveys are shown in **Figures 3 - 11**. These show all of the data obtained during the surveys, not just those that were used to derive the population estimates presented above. They also show the extent of the wind farm site, the 1km and 2km buffers, the control reference area and the study area as a whole. Each of the main species is discussed in turn.

Divers (Figure 3): divers were widely distributed at low density across most of the study area, including the control area to the south. As in the previous post-construction winter, a lower density of divers was recorded within the wind farm site itself, particularly within its central core.

Gannet: (Figure 4): gannets were more frequently recorded in the eastern part of the survey area, as they had been in 2010-11 and 2011-12, though with more records within the wind farm site than had been seen in the previous post-construction surveys.

Common Gull (Figure 5): common gulls were widely distributed over the whole study area, including within the wind farm.

Lesser Black-backed Gull (Figure 6): this was a widely distributed gull species, found in all parts of the study area including the wind farm at quite an even low density, with no particular aggregations noted in 2012-13.

Herring Gull (Figure 7): another widely distributed gull species, found in all parts of the study area including the wind farm, largely at quite an even low density but a small number of aggregations in the northern part of and to the north of the wind farm, flocks associating with fishing trawlers.

Great Black-backed Gull (Figure 8): this was a widely distributed gull species, found in all parts of the study area including the wind farm, largely at quite an even low density and with no particular aggregations in 2012-13.

Kittiwake (Figure 9): this was another widely distributed gull species, found in all parts of the study area including the wind farm, which, as in 2010-11 and 2011-12, held several of the larger aggregations of this species.

Guillemot (Figure 10): guillemots were widely distributed across the survey area, with more records within the wind farm than in the previous two post-construction years. Numbers were again higher in the eastern part of the survey area.

Razorbill (Figure 11): this species was widespread again 2012-13, found in all parts of the study area including the wind farm.

As in previous surveys a small number of records of land-based species were also seen over-flying the survey area, including brent goose, teal, wigeon, gadwall, oystercatcher, skylark, blackbird, song thrush, goldcrest, starling and chaffinch.

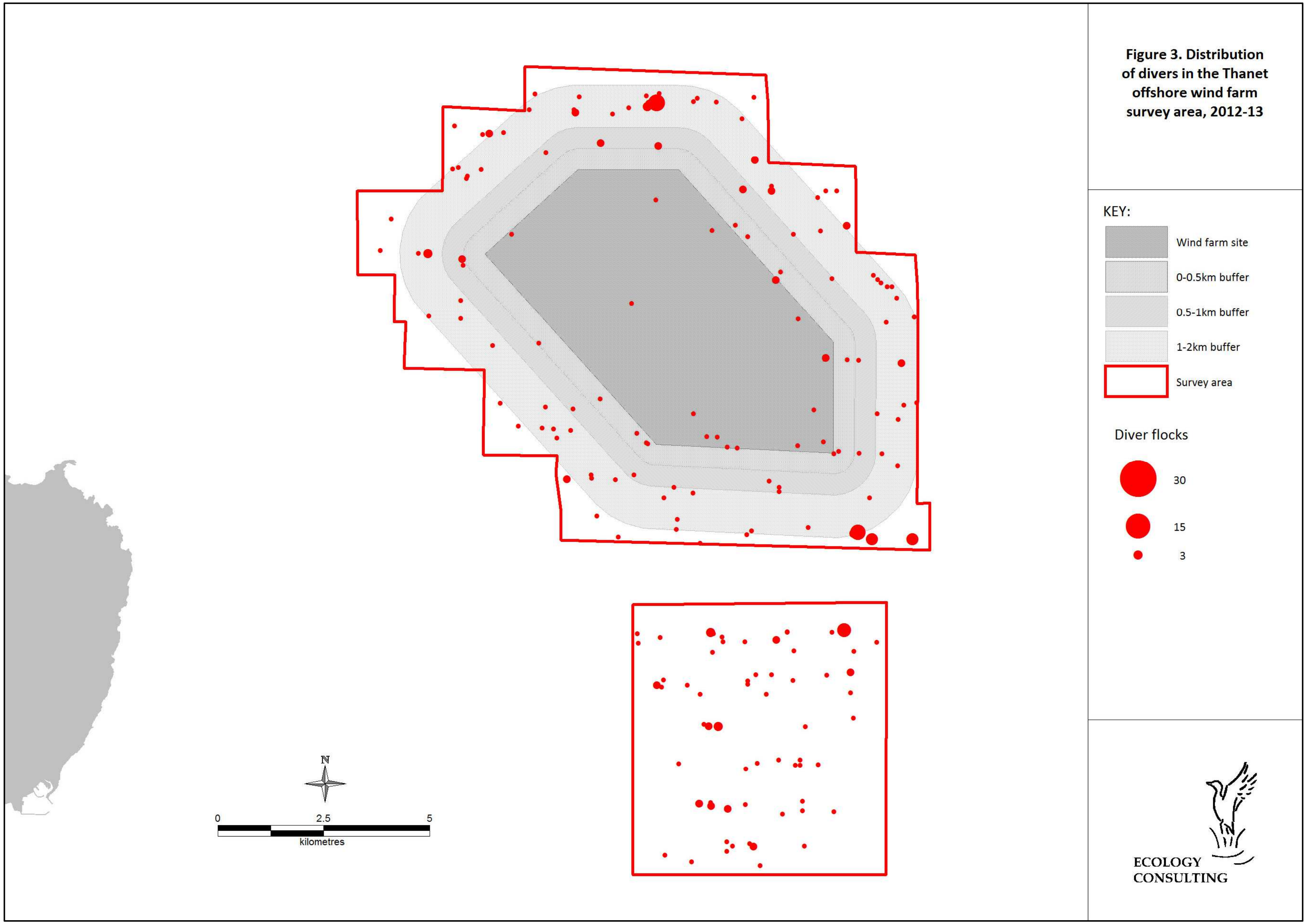
Figure 3. Distribution of divers in the Thanet offshore wind farm survey area, 2012-13
KEY:
Wind farm site
0-0.5km buffer
0.5-1km buffer
1-2km buffer
Survey area
Diver flocks
30
15
3
N
0
2.5
5
kilometres
ECOLOGY CONSULTING

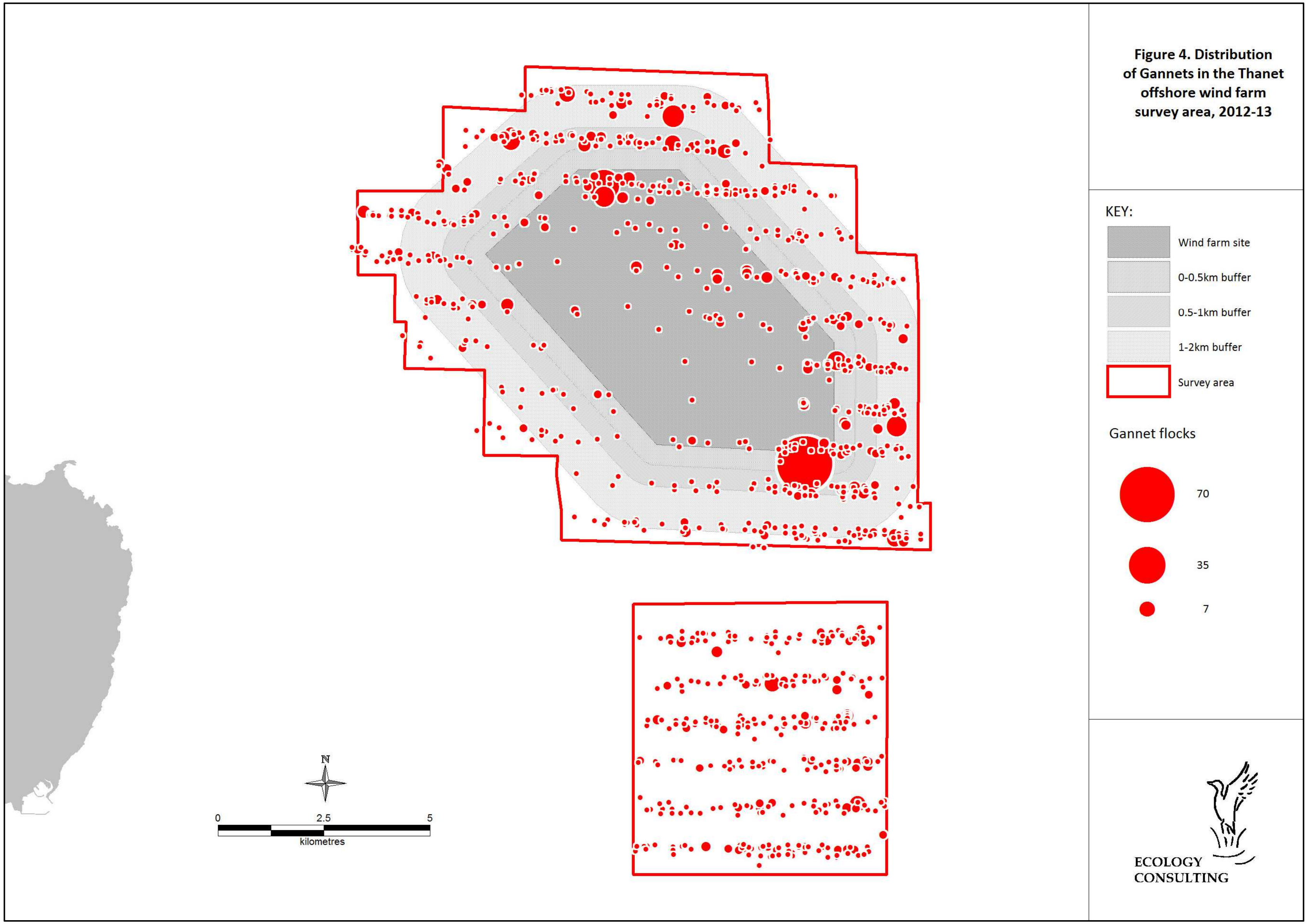

Figure 4. Distribution of Gannets in the Thanet offshore wind farm survey area, 2012-13

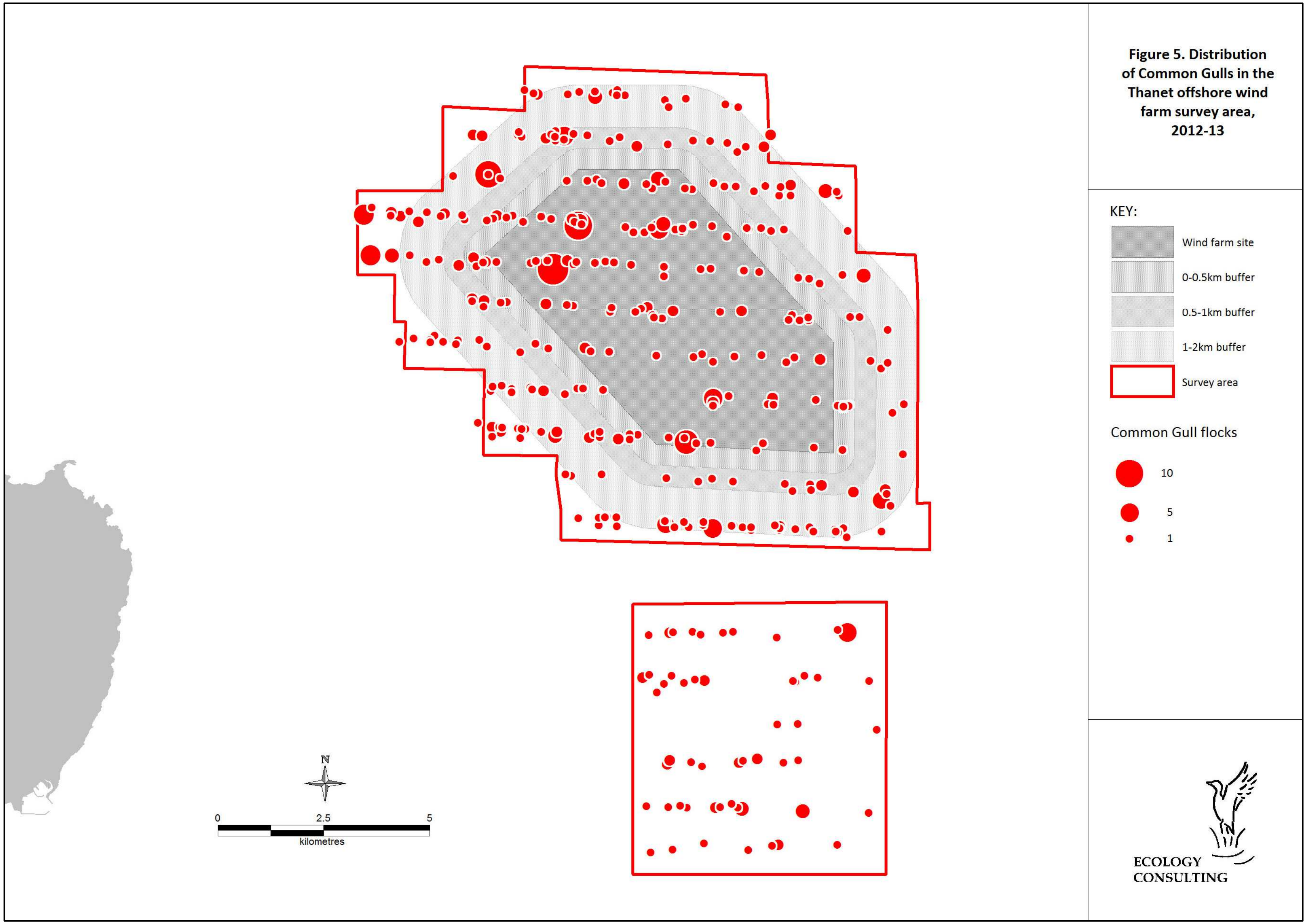

Figure 5. Distribution of Common Gulls in the Thanet offshore wind farm survey area, 2012-13

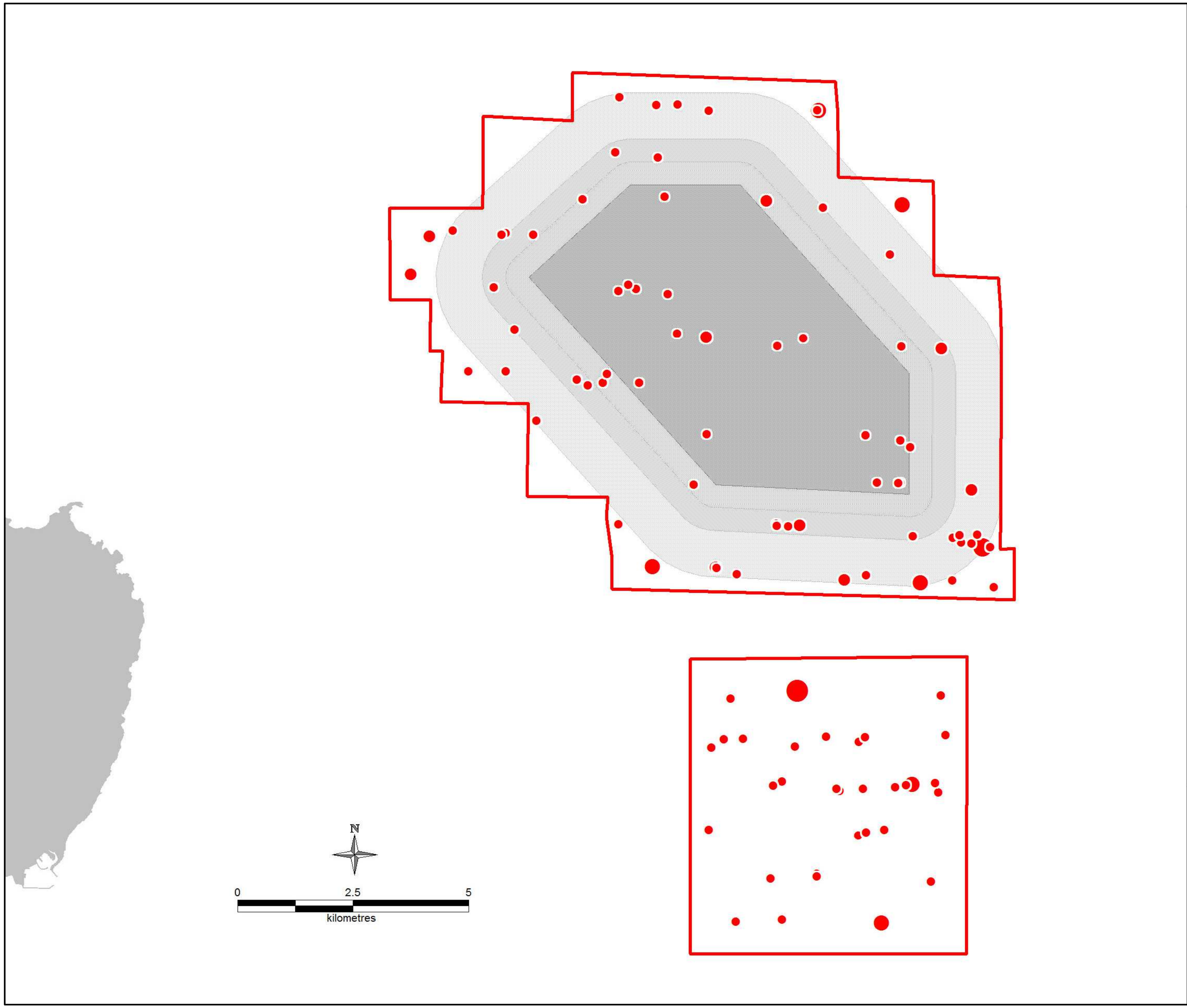

Figure 6. Distribution of Lesser Black-backed Gulls in the Thanet offshore wind farm survey area, 2012-13

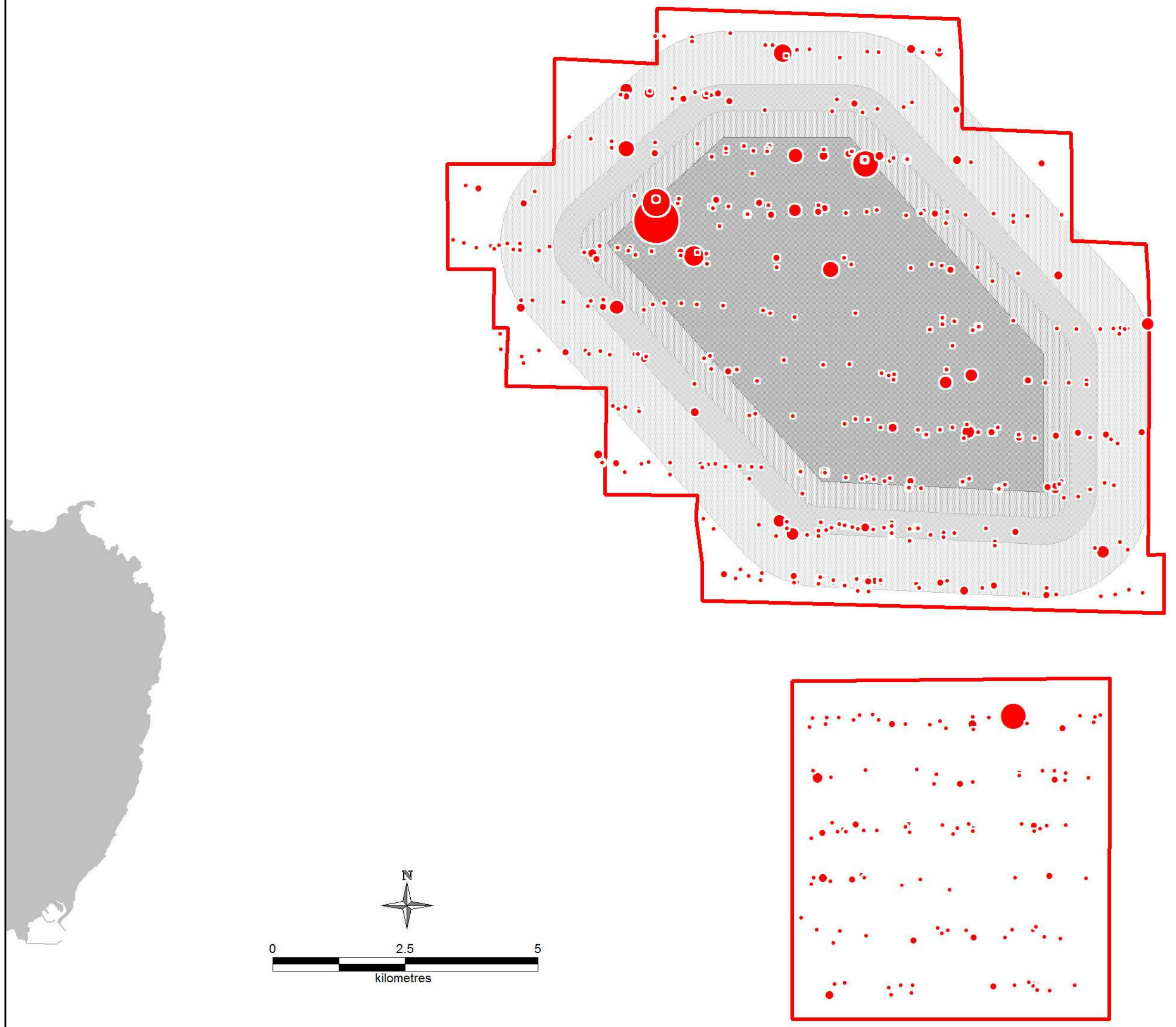

Figure 7. Distribution of Herring Gulls in the Thanet offshore wind farm survey area, 2012-13

KEY:

Wind farm site

0-0.5km buffer

0.5-1km buffer

1-2km buffer

Survey area

Herring Gull flocks

100

50

10

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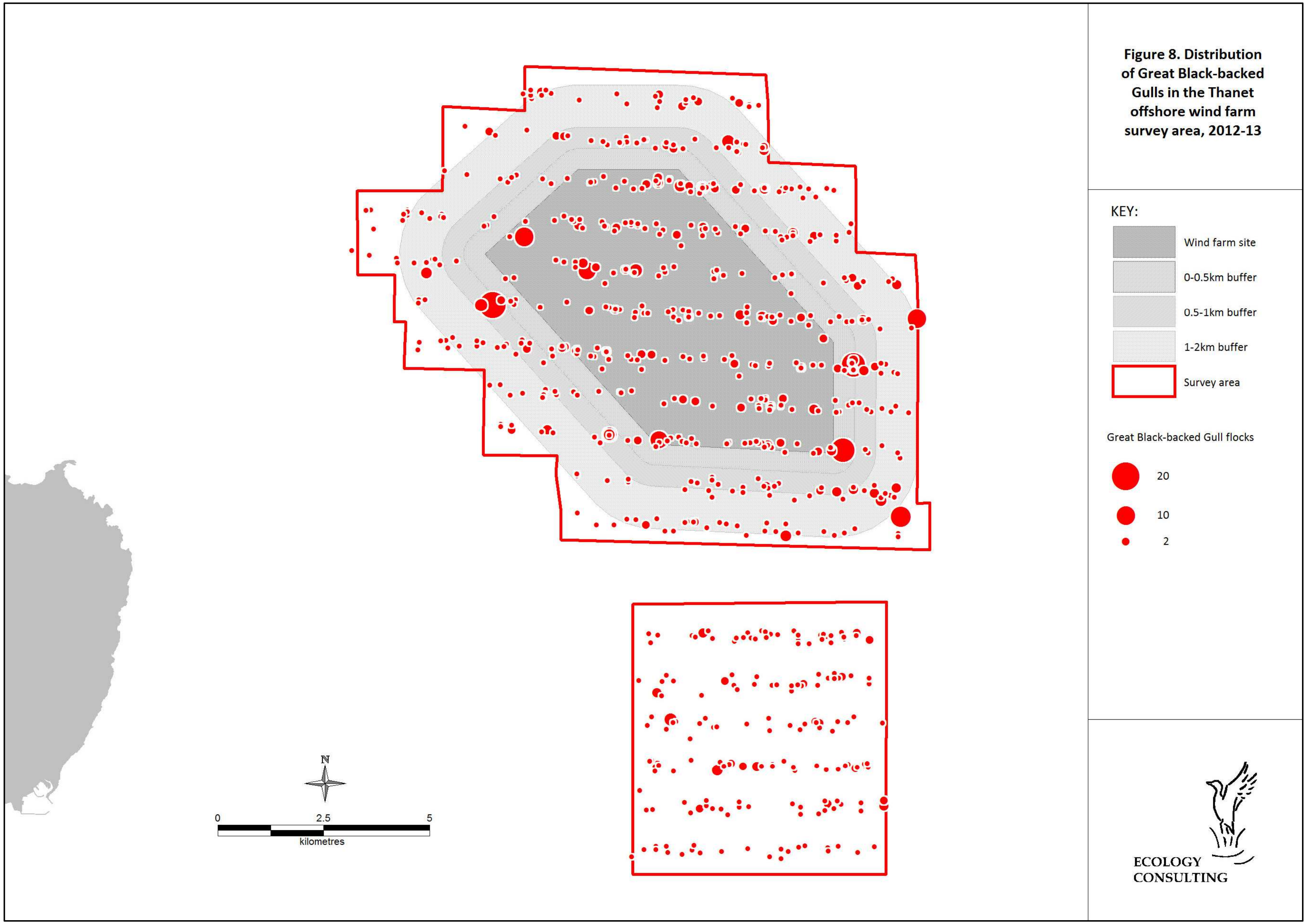

Figure 8. Distribution of Great Black-backed Gulls in the Thanet offshore wind farm survey area, 2012-13

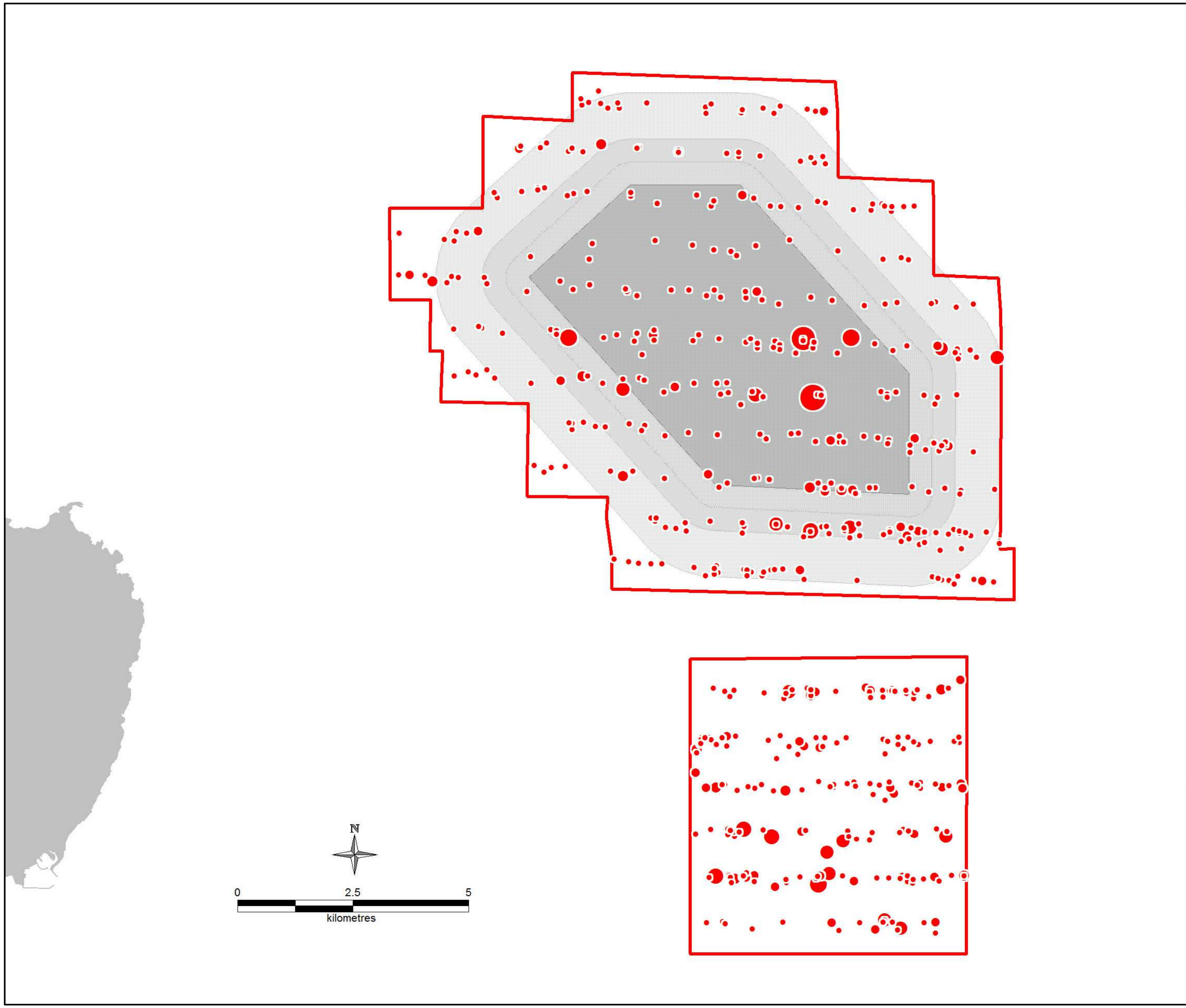

Figure 9. Distribution of Kittiwakes in the Thanet offshore wind farm survey area, 2012-13

KEY:

Wind farm site
0-0.5km buffer
0.5-1km buffer
1-2km buffer
Survey area

Kittiwake flocks

30
15
3

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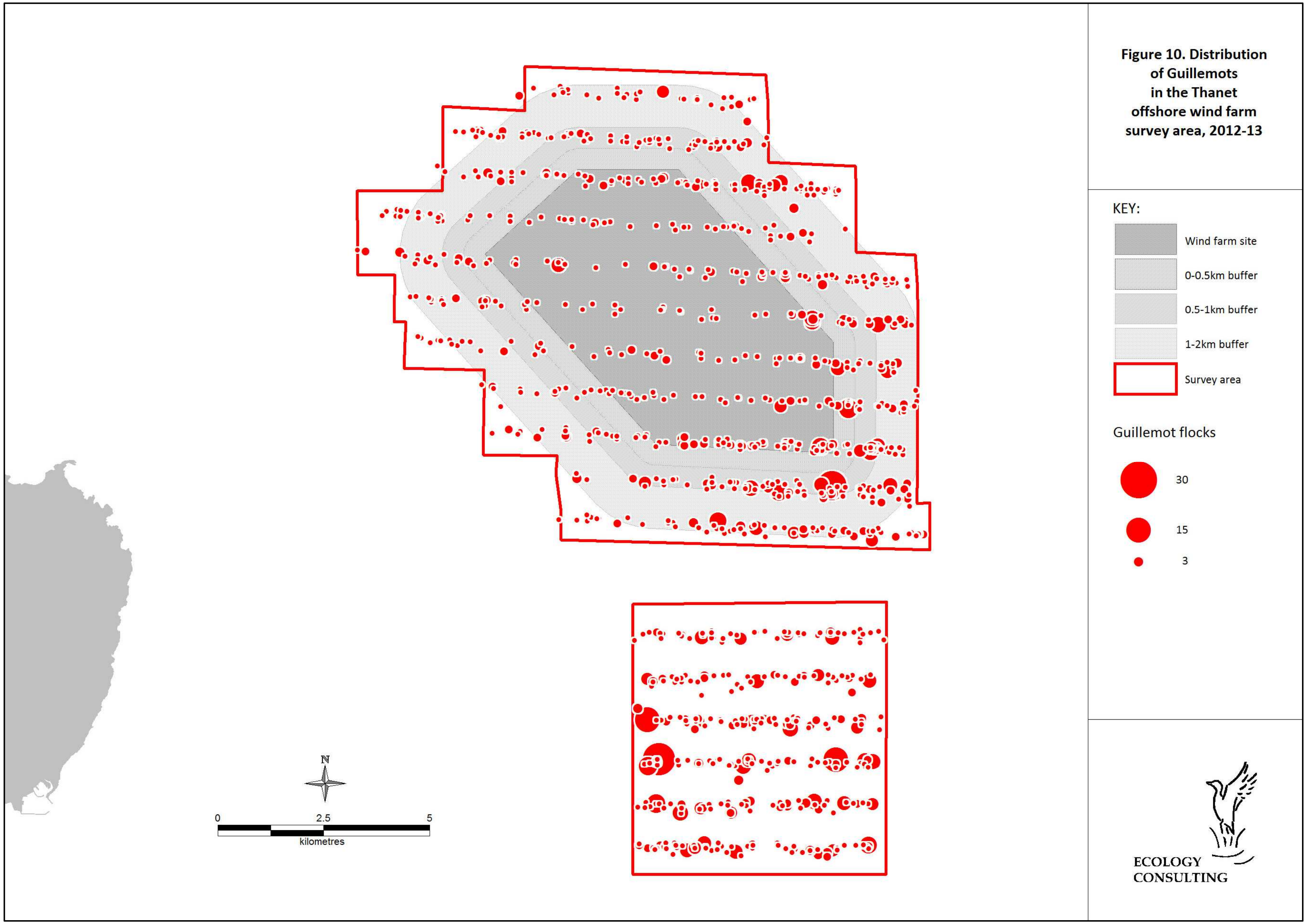
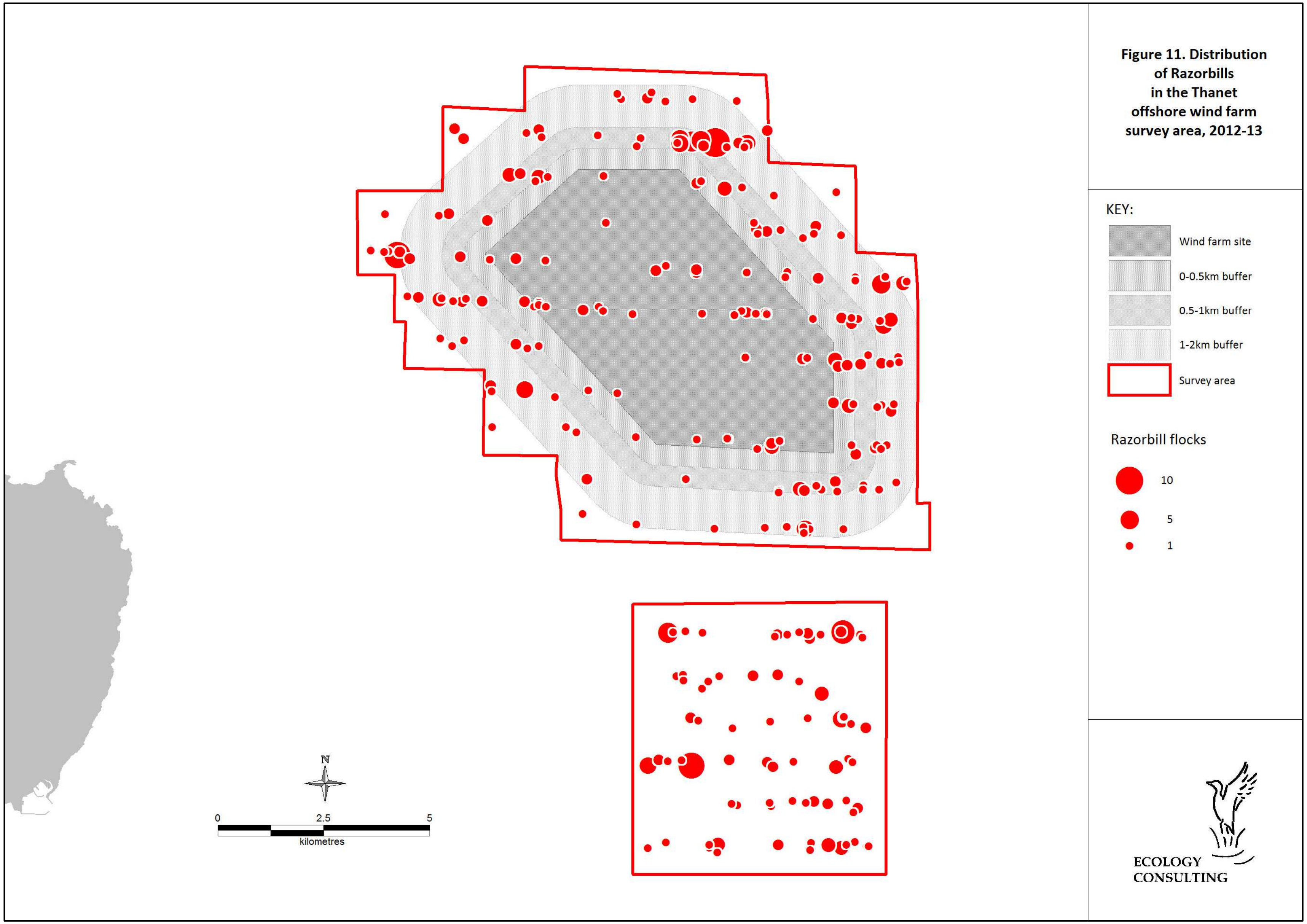


Figure 10. Distribution of Guillemots in the Thanet offshore wind farm survey area, 2012-13


N
0
2.5
5
kilometres
Figure 11. Distribution of Razorbills in the Thanet offshore wind farm survey area, 2012-13
KEY:
Wind farm site
0-0.5km buffer
0.5-1km buffer
1-2km buffer
Survey area
Razorbill flocks
10
5
1
ECOLOGY CONSULTING

6 FLIGHT ACTIVITY, COLLISON RISK AND BARRIER EFFECTS

The flight heights recorded during the 2012-13 surveys are summarised in Table 7. This Table gives the flight height distribution (by band) for each species seen over-flying, and the percentage of flights at rotor height (taken as all flights between 20m and 120m). The sample unit was taken as the flock rather than the individual as individuals within a flock do not provide an independent sample.

Table 7. Flock flight height distribution observed in 2012-13. Values indicate the number of flocks in each category and the approximate percentage of flying flocks at rotor height.

	Not flying	<20m	20-120m	>120m	% at rotor height
Brent goose	0	4	5	0	56%
Wigeon	2	3	1	0	25%
Gadwall	0	1	0	0	0%
Teal	1	1	0	0	0%
Shoveler	0	2	1	0	33%
Eider	0	1	0	0	0%
Common scoter	0	6	0	0	0%
Red-breasted merganser	0	1	0	0	0%
duck sp	2	1	2	1	50%
Red-throated diver	49	102	7	0	6%
Black-throated diver	1	2	0	0	0%
diver sp	4	24	2	0	8%
Great crested grebe	1	0	0	0	-
Fulmar	12	84	1	0	1%
Gannet	290	591	181	1	23%
Cormorant	1	1	0	0	0%
Oystercatcher	0	1	0	0	0%
Arctic skua	0	3	0	0	0%
Great skua	3	8	0	0	0%
skua sp	0	1	0	0	0%
Common gull	60	235	82	0	26%
Lesser black-backed gull	32	33	39	0	54%
Herring gull	100	271	172	3	39%
black-backed gull sp	12	6	11	0	65%
Great black-backed gull	284	243	219	5	47%
Little gull	3	21	3	0	13%
Black-headed gull	1	10	5	0	33%
Kittiwake	76	418	80	0	16%
large gull sp	22	52	46	4	45%
small gull sp	0	2	3	0	60%
gull sp	10	6	2	1	22%
Guillemot	923	207	1	0	0.5%
Razorbill	216	45	0	0	0%
auk sp	244	292	0	0	0%

	Not flying	<20m	20-120m	>120m	% at rotor height
Skylark	0	1	0	0	0%
Blackbird	0	1	1	0	50%
Song Thrush	0	1	0	0	0%
thrush sp	0	1	1	0	50%
Goldcrest	1	0	0	0	-
Starling	2	11	2	0	15%
finch sp	0	1	0	0	0%
small passerine sp	0	1	0	0	0%
large passerine sp	0	1	0	0	0%
Chaffinch	1	0	0	0	-
passerine sp	0	1	0	0	0%

The specific flights within the wind farm at rotor height (i.e. those where the birds would be at risk of colliding with the turbine rotors) are summarised in Table 8, with allowance made for the survey area coverage to produce an estimate for the whole of the wind farm. Much of the greatest bird flight activity within this zone was of gulls, as previously noted in the ES and the subsequent survey reports, with a very low number of diver and gannet flights in this zone.

Table 8. Bird flight activity at rotor height within the Thanet offshore wind farm site, 2012-13 (population estimate for each survey).

Species	8 - 9 Oct 2012	24 - 29 Oct 2012	15 - 16 Nov 2012	12 - 13 Dec 2012	17 - 18 Dec 2012	16 - 17 Jan 2013	23, 24 and 25 Jan 2013	9-10 Feb 2013	17-18 Feb 2013	6-7 Mar 2013	19-20 Mar 2013	Mean	Peak
Wigeon	0	0	0	0	0	6.7	0	0	0	0	0	0.6	7
Gannet	0	1.7	0	0	0	0	0	11.7	3.3	1.7	20.0	3.5	20
Common gull	1.7	0	6.7	5	3.3	6.7	11.7	10.0	0	0	0	4.1	12
Lesser black-backed gull	0	0	0	0	0	1.7	0	1.7	1.7	3.3	1.7	0.9	3
Herring gull	0	0	10.0	3.3	6.7	0	10.0	10.0	1.7	23.3	5.0	6.4	23
black-backed gull sp	0	0	0	0	0	1.7	3.3	0	0	0	1.7	0.6	3
Great black-backed gull	6.7	13.3	25.0	1.7	11.7	5.0	10.0	11.7	3.3	8.3	11.7	9.8	25
Black-headed gull	0	0	0	0	0	0	0	0	0	0	3.3	0.3	3
Kittiwake	1.7	0	10.0	1.7	3.3	13.3	1.7	6.7	3.3	0	3.3	4.1	13
large gull sp	0	0	1.7	1.7	5	1.7	0	3.3	0	3.3	5.0	2.0	5
Guillemot	0	0	0	1.7	0	0	0	0	0	0	0	0.2	2

Collision Risk

One of the objectives of the bird monitoring programme is to determine whether the collision risk might be significant (testing the conclusions reached in the ES that it would not). Table 9 compares the mean number in flight at rotor height (i.e. those at risk of collision with the wind turbine rotors), to make a relative comparison of the likely collision risk[2] over the pre-construction (ES – 2004 - 2005), construction (2009 - 2010) and post-construction (2010 – 2011, 2011-12 and 2012-13) periods.

Diver and auk numbers in this zone declined during construction and the first post-construction winter, but auk numbers were higher than recorded previously in 2011-12. Collision risk to auks would still be only negligible however, given the very low proportion of flights observed at rotor height (0.5% - see Table 7). Gull numbers have been broadly similar during post-construction and construction as assessed in the pre-construction surveys carried out for the ES baseline, though with more Kittiwake activity in 2010-11 (an increase in which was seen generally within the Thames in that year, J. Ford pers. comm.; Percival et al. 2011). As a result whilst collision risk is likely to have increased for this species, for the others (and species of higher conservation interest, particularly divers) there has not been any notable increase in flight activity within the wind farm site since the ES assessment. There is no evidence to suggest that the conclusion reached in the ES (that there would not be any significant collision risk) would be changed by the recent post-construction data.

[2] The collision risk will be directly proportional to flight activity in the collision zone at rotor height, so this flight activity can be used to compare the change in risk from the ES to the post-construction phase.

Table 9. Mean count in flight at rotor height for each winter within the wind farm site, Oct-Mar.

	ES (2004 – 2005)	Construction (2009 – 2010)	Post-construction yr 1 (2010 – 2011)	Post-construction yr 2 (2011 – 2012)	Post-construction yr 2 (2012 – 2013)
Wigeon	0	0	0	0	0.6
All divers	0.8	0.1	0.2	0.1	0
Gannet	0.2	0.1	0.1	0.3	3.5
Common Gull	4.9	35.0	13.5	4.2	4.1
Lesser Black-backed Gull	3.3	9.1	5.5	6.5	0.9
Herring Gull	14.9	5.6	8.6	7.4	6.4
Great Black-blacked Gull	0.1	2.0	2.9	6.7	9.8
Kittiwake	0.4	4.4	8.7	4.9	4.1
All gulls	28.9	43.3	49.3	45.4	28.2
Guillemot	0	0.1	0	0.1	0.2
Razorbill	0	0	0	0	0
All auks	0.1	0.1	0	0.2	0.2

Barrier Effects

Whilst specific testing of any barrier effect is not possible without data on bird flight lines through the wind farm before and after construction (which did not form part of the agreed monitoring programme), the observed changes in flight activity within the wind farm do give some indication as to whether a barrier effect may have been operating.

Three species showed reduced activity within the wind farm after construction, red-throated diver (for all three post-construction years) and guillemot and razorbill (the latter two for the first post-construction year only). As numbers of guillemots and razorbills within the wind farm increased above the pre-construction baseline levels in the second and third post-construction years, the evidence for any barrier effect on these species was weak, and if at all was clearly only short-term.

Diver flight activity was reduced within the wind farm, so a barrier effect on this species could not be discounted, in that there was reduced flight activity through the wind farm (though it should also be noted that flight activity pre-construction in this area was also low, and it is not really possible from the data available to separate the barrier effect out from the displacement of birds through disturbance).

7 CONSERVATION EVALUATION

The conservation importance of the bird populations recorded during these surveys has been assessed by reference to Table 10 (taken from Percival 2007) and by using the standard 1% criterion method (Holt et al., 2012); (>1% national population = nationally important, >1% international population = internationally important). The national baseline populations have been taken from Baker et al. (2006) and Musgrove et al. (2011). A further category of 'local importance' has been used for species that are not considered to be of regional importance, but were still of some ecological value. This included all species on the red or amber lists of the RSPB et al.'s (Eaton et al., 2009) 'Birds of Conservation Concern'.

Table 10. Sensitivity (Conservation Importance) of bird species

Sensitivity	Definitions
Very High	Species for which at site is designated (Special Protection Areas (SPAs) / Special Areas of Conservation (SACs)) or notified (Sites of Special Scientific Interest (SSSIs)). A local population of more than 1% of the international population of a species.
High	Other species that contribute to the integrity of an SPA or SSSI. A local population of more than 1% of the national population of a species. Any ecologically sensitive species, e.g. large birds of prey or rare birds (<300 breeding pairs in the UK). EU Birds Directive Annex 1, EU Habitats Directive priority habitat/species and/or Wildlife and Countryside Act 1981 (as amended) Schedule 1 species (if not covered above). Other specially protected species.
Medium	Regionally important population of a species, either because of population size or distributional context. UK Biodiversity Action Plan (BAP) priority species (if not covered above).
Low	Any other species of conservation interest, e.g. species listed on the Birds of Conservation Concern not covered above.

The evaluation of the conservation importance of the bird populations observed in the survey area during the surveys has been summarised in Table 11. Six additional species were seen in 2012-13 that had not been seen previously; gadwall, shoveler, eider, oystercatcher, arctic skua and goldcrest. All of the sightings of these species were of small numbers migrating through the survey area, rather than using any of its ecological resources. The key seabird species using the survey area in 2012-13 in at least regionally important numbers were the same as those recorded previously; red-throated and black-throated divers, common, lesser black-backed, herring, great black-backed and little gulls, kittiwake, guillemot and razorbill.

Table 11. Evaluation of the conservation importance of the bird populations using the Thanet Offshore Wind Farm site and its surrounds, 2011-12. Species in red seen in 2012-13 but not previously.

Species	SPA sp[3]	Population Importance[4]	EU Birds Directive Annex 1	Red [R]/ Amber [A] List	UK BAP Priority Species	Sensitivity
Brent goose	Q	Regional		A	✓	Very high
Shelduck	Q	Local		A		Very high
Wigeon	Q	Local		A		Very high
Gadwall		Local		A		Low

[3] Q = SPA qualifying species, A = SPA assemblage species

[4] On the basis of peak numbers in whole survey area and the 1% threshold (Baker et al. 2006, Holt *et al*., 2009, Musgrove et al. 2011).

Species	SPA sp[3]	Population Importance[4]	EU Birds Directive Annex 1	Red [R]/ Amber [A] List	UK BAP Priority Species	Sensitivity
Teal	Q	Local		A		Very high
Mallard		Local		A		Low
Shoveler		Local		A		Low
Common scoter		Local		R	✓	Medium
Eider		Local		A		Low
Red-breasted merganser		Local				Low
Red-throated diver	Q	Regional	✓	A		Very high
Black-throated diver		Regional	✓	A	✓	High
Great crested grebe	A	Local				Very high
Fulmar		Local		A		Low
Gannet		Regional		A		Medium
Cormorant	A	Local				Very high
Shag		Local		A		Low
Oystercatcher		Local		A		Low
Ringed Plover	Q	Local		A		Very high
Lapwing	A	Local		R	✓	Very high
Curlew	Q	Local		A	✓	Very high
Arctic Skua		Local		R	✓	Medium
Great Skua		Local		A		Low
Common gull		Regional		A		Medium
Lesser black-backed gull		Regional		A		Medium
Herring gull		Regional		R	✓	Medium
Great black-backed gull		National		A		High
Little gull		Regional	✓	A		High
Black-headed gull		Local		A		Low
Kittiwake		Regional		A		Medium
Sandwich tern	Q	Local	✓	A		Very high
Common tern	Q	Local	✓	A		Very high
Guillemot		Regional		A		Medium
Razorbill		Regional		A		Medium
Short-eared owl		Regional	✓	A		High
Skylark		Local		R	✓	Medium
Sand martin		Local		A		Low
Swallow		Local		A		Low

Species	SPA sp[3]	Population Importance[4]	EU Birds Directive Annex 1	Red [R]/ Amber [A] List	UK BAP Priority Species	Sensitivity
Meadow pipit		Local		A		Low
Pied wagtail		Nil				Nil
Robin		Nil				Nil
Whinchat		Local		A		Low
Black redstart		Local		A		Low
Blackbird		Nil				Nil
Fieldfare		Local		A		Low
Song thrush		Local		R	✓	Medium
Redwing		Local		A		Low
Goldcrest		Nil				Nil
Starling		Local		R	✓	Medium
Chaffinch		Nil				Nil
Goldfinch		Nil				Nil

8 ANALYSIS OF CHANGES IN BIRD DENSITIES THROUGH THE PRE-CONSTRUCTION, CONSTRUCTION AND POST-CONSTRUCTION PHASE SURVEYS IN RLEATION TO PROXIMITY TO THE WIND FARM

8.1 Analysis Methods

This Section presents a statistical analysis comparing the differences in bird numbers between the pre-construction, construction and post-construction periods. The ES pre-construction baseline did not cover as large a buffer zone around the wind farm as the later construction and post-construction phase surveys, limiting the sample from the 1-2km buffer zone in particular. The comparative analysis across the full survey period presented in this Section was therefore limited to those parts of the main survey area covered during all surveys (Figure 1). In addition the transect locations within the control area were changed between the pre-construction and the construction phase surveys (after agreement with Natural England and DEFRA) so direct spatial before/after comparison with that zone is not possible.

The species included in this analysis are all those present in sufficient numbers/frequency for a meaningful analysis to be undertaken: divers (predominantly red-throated), gannet, common gull, lesser black-backed gull, herring gull, great black-backed gull, kittiwake, guillemot and razorbill.

The monitoring was originally designed with each transect forming the main sample unit. However this design does not allow for examination of changes in bird abundance in relation to distance from the wind farm, as each transect was aligned to pass through the wind farm and the buffer zones (to 2-3km from the site). Therefore to aid the spatial analysis and help determine if there were any relationships between changes in bird abundance and proximity to the wind farm, each transect was sub-divided into 500m lengths. End sections of each transect of less than 500m were discarded from the analysis. The 500m distance was chosen using professional judgement to give a reasonable sample unit whilst at the same time sufficiently high spatial precision for the analysis. This enabled much better spatial precision of the analysis to be undertaken, but did introduce the potential issue of spatial autocorrelation between samples. This was taken into account in the analysis using a Generalised Least Squares statistical modelling approach (Zuur et al. 2009), with the location of each transect sub-section – easting and northing – incorporated as explicit spatial variables.

A GIS (MapInfo) was used to extract bird numbers in each 500m transect sub-section from the main survey database, summed over each survey year (one pre-construction, one construction and three post-construction) and standardised as the mean count per survey visit in each year (to take into count different numbers of surveys in each period - there were 9 surveys during the pre-construction period during the Oct-Mar period, 10 during the construction phase in 2009-10, 12 in 2010-11 in the first of the post-construction winters, 10 in 2011-12 and 11 in 2012-13). This mean count per 500m sub-section of transect was use in the further analysis as an index of bird abundance.

Mean bird abundance was calculated for each wind farm zone/buffer (wind farm, 500m, 1km, 2km, 3km and control) each period to provide an initial visual summary of the data. Contrasts were then made for each transect sub-section, calculating the change in bird numbers between the pre-construction and the construction phase, the pre-construction with each of the post-construction years and construction phase with each of the post-construction phases. The key null hypothesis tested was that there was no difference between bird abundance for each contrast, i.e. the difference in bird abundance in the transect sub-sections was not significantly different from zero.

An additional gradient analysis was undertaken for each survey year, testing the null hypothesis of no difference in bird abundance across each wind farm zone/buffer (wind farm, 500m, 1km, 2km, 3km and control). As above the 500m sub-sections of each transect were used as the sample unit, taking into account spatial correlation as described above.

8.2 Analysis Results

The mean bird abundance for each wind farm zone/buffer (wind farm, 500m, 1km, 2km, 3km and control) for each period for each of the key species is shown in Figure 12-19. The results for each species (and of the statistical tests for each) are examined and interpreted in turn below.

Red-throated diver: within the wind farm the surveys suggest that there was a decline in diver abundance during and after construction (to 18% of pre-construction level during construction and mean of 27% of pre-construction level over the three post-construction years, with no evidence of any trend over those three years (Figure 12). Outside the wind farm, no evidence was apparent of any reduction from the pre-construction level, with increases observed in most zones over the pre-construction baseline (notably in the control zone in the second post-construction year).

Figure 12. Diver abundance through the pre-construction ('Pre'), construction ('Constr') and three post-construction years of the Thanet offshore wind farm in relation to distance from the wind farm (WF).

Table 12 summarises the results of the statistical analysis of the change in diver abundance between zones across the survey years. There was no statistically significant overall difference in the level of change between zones (p>0.05) in the pre-construction and construction phases, and between the construction phase and the first and third post-construction years, though there was a difference in the changes in the other period comparisons. Examining the differences by individual zone, most of the abundance changes within the wind farm during the construction and post-construction phase were statistically significantly lower than the pre-construction baseline. Outside the wind farm, however, those changes were either not statistically significant or were significant increases (apart from the decline in the control zone in the third post-construction year from a high in the previous year), so there was no evidence of any displacement effect extending beyond the wind farm itself.

The lack of any statistically significant change within the wind farm after construction would suggest that the decline observed during construction has not been reversed and that diver abundance in that zone has remained at its reduced construction phase level.

Table 12. Change in diver abundance in relation to distance from the Thanet offshore wind farm comparing the pre-construction ('Pre'), construction ('Con') and three years of post-construction ('Post 1-3') monitoring.

	Pre v Con	Pre v Post yr1	Pre v Post yr2	Pre v Post yr3	Con v Post yr1	Con v Post yr2	Con v Post yr3	Post 1 v Post 2	Post 2 v Post 3
Overall F	1.3	5.5	6.8	3.0	1.9	2.3	1.4	2.5	2.5
Overall p	0.29	0.001	<0.001	0.03	0.09	0.045	0.24	0.03	0.03
Wind farm	- - -	-	ns	- -	ns	ns	ns	ns	ns
0-500m	ns	+	ns	+	ns	ns	ns	ns	ns
500m-1km	ns	+++	ns	ns	++	ns	+	ns	ns
1-2km					ns	ns	ns	ns	ns
2-3km					ns	ns	ns	ns	ns
Control	ns	+	+++	-	ns	+++	ns	++	- -

+++ = increase p<0001, ++ = increase, p<0.01, + = increase p<0.05, - - - = decrease p<0001, - - = decrease, p<0.01, - = decrease p<0.05, ns = no statistically significant difference (p>0.05).

The results of the gradient analysis of diver abundance with distance from the wind farm found no statistically significant different in abundance between the distance zones in the pre-construction year ($F_{3,148}$=2.3, p=0.08), but the differences between zones were significant for the construction phase ($F_{5,272}$=3.5, p=0.005), and for each of the three post-construction years ($F_{5,272}$=5.0, p<0.001, $F_{5,272}$=3.8, p=0.002 and $F_{5,272}$=5.7, p<0.001 for each of the three post-construction years respectively). This adds further support to the conclusion that there has been a statistically significant decline in diver abundance within the wind farm.

In conclusion there was evidence of a statistically significant decline in diver abundance within the wind farm during the construction phase (to 18% of the level recorded pre-construction). That reduction has persisted through all three post-construction monitoring years, though at a slightly lower reduction from the pre-construction baseline, at an average of a reduction to 27%. The analyses undertaken found no evidence was apparent of any statistically significant displacement in any buffer zone around the wind farm.

Gannet: gannet abundance was highly variable between years, with comparatively high numbers being observed in the third of the post-construction years in particular, though there was no evidence of any significant reduction in abundance in any zone in comparison with the pre-construction baseline (though comparatively low numbers were seen in that year across the whole survey area); see Figure 13.

Figure 13. Gannet abundance through the pre-construction ('Pre'), construction ('Constr') and three post-construction years of the Thanet offshore wind farm in relation to distance from the wind farm (WF).

In the third post-construction year when numbers of gannets overall were higher, gannet density within the wind farm was clearly lower than outside. The mean density within the wind farm was 43% of that in the zones more than 1km from the wind farm and 67% in the 500m buffer. This was suggestive of some displacement when larger numbers were present and has been investigated further in the statistical analysis presented in the following paragraphs.

Table 13 summarises the results of the statistical analysis of the change in gannet abundance between zones across the survey years. There was no statistically significant overall difference in the level of change between zones (p>0.05) in the pre-construction and construction phases, and between the construction phase and the first post-construction year. There was a difference in the changes in other period comparisons, largely as a result of increases observed, particularly in the control zone. Examining the differences by individual zone, no statistically significant decline was recorded in any zone over the whole survey period. There were some statistically significantly increases noted, mainly in the control zone. These analyses indicated that there did not appear to be any statistically significant adverse effects on this species as a result of the construction and operation of the wind farm.

Table 13. Change in gannet abundance in relation to distance from the Thanet offshore wind farm comparing the pre-construction ('Pre'), construction ('Con') and three years of post-construction ('Post 1-3') monitoring.

	Pre v Con	**Pre v Post yr1**	**Pre v Post yr2**	**Pre v Post yr3**	**Con v Post yr1**	**Con v Post yr2**	**Con v Post yr3**	**Post 1 v Post 2**	**Post 2 v Post 3**
Overall F	2.6	2.2	6.4	2.1	1.2	1.6	2.4	4.2	3.3
Overall p	0.052	0.09	<0.001	0.01	0.30	0.16	0.04	0.001	0.007
Wind farm	ns	ns	ns	+	ns	ns	+	ns	+
0-500m	ns	ns	ns	ns	ns	ns	ns	ns	Ns
500m-1km	ns	ns	ns	+	ns	ns	++	ns	+
1-2km					ns	ns	ns	ns	ns
2-3km					ns	ns	ns	ns	ns
Control	++	+	+++	ns	ns	+	ns	+++	ns

+++ = increase p<0001, ++ = increase, p<0.01, + = increase p<0.05, - - - = decrease p<0001, - - = decrease, p<0.01, - = decrease p<0.05, ns = no statistically significant difference (p>0.05).

The results of the gradient analysis of gannet abundance with distance from the wind farm found a statistically significant different in abundance between the distance zones in the pre-construction year ($F_{3,148}$=3.6, p=0.015), during the construction phase ($F_{5,272}$=4.9, p<0.001), and for the first two post-construction years ($F_{5,272}$=7.6, p<0.001, and $F_{5,272}$=9.7, p=0.002, for the first two post-construction years respectively). Gannet abundance across all of the zones was not statistically significantly different in the third of the post-construction surveys years ($F_{5,272}$=2.0, p=0.08), when gannet numbers overall were considerably higher. These results show further than the wind farm site has tended to hold lower abundance of gannets, but this has been through the whole of the survey period, without any apparent impact of the wind farm.

In conclusion, there was no evidence of any effect of the wind farm on gannets, other than the fact that the wind farm supported lower densities in the third of the post-construction monitoring years in comparison with elsewhere in the survey area (though this reduced density was also apparent in the other surveys years, suggesting that it was not a result of the presence of the wind farm).

Common Gull: the most striking feature of common gull abundance during the surveys was the much higher numbers recorded during the construction phase surveys; Figure 14. With regard to the spatial distribution of those birds during the construction surveys, the highest abundance was recorded within the wind farm site suggestive that there may have been some element of attraction to the construction works through increased feeding opportunity. Outside that period common gull densities were similar across zones between years, with no indication of any adverse effects of the wind farm.

Figure 14. Common gull abundance through the pre-construction ('Pre'), construction ('Constr') and three post-construction years of the Thanet offshore wind farm in relation to distance from the wind farm (WF).

Table 14 summarises the results of the statistical analysis of the change in common gull abundance between zones across the survey years, supporting the conclusions drawn above. There was no statistically significant overall difference in the level of change between zones (p>0.05) in the pre-construction and construction phases, and in comparison of the pre-construction phase with all three post-construction years. There was a difference in the changes between the post-construction years, though this was not likely to result from any wind farm effect. Examining the differences by individual zone, the only statistically significant declines were recorded in comparisons of the construction phase with the post-construction surveys, as a result of the much higher numbers recorded during the construction phase.

Table 14. Change in common gull abundance in relation to distance from the Thanet offshore wind farm comparing the pre-construction ('Pre'), construction ('Con') and three years of post-construction ('Post 1-3') monitoring.

	Pre v Con	**Pre v Post yr1**	**Pre v Post yr2**	**Pre v Post yr3**	**Con v Post yr1**	**Con v Post yr2**	**Con v Post yr3**	**Post 1 v Post 2**	**Post 2 v Post 3**
Overall F	0.2	0.15	0.42	0.11	0.77	1.0	0.96	2.4	3.6
Overall p	0.90	0.93	0.74	0.95	0.57	0.40	0.44	0.04	0.004
Wind farm	++	ns	ns	ns	- - -	- - -	- - -	- - -	+
0-500m	ns	ns	ns	ns	ns	ns	ns	ns	ns
500m-1km	ns	ns	ns	ns	ns	ns	ns	ns	ns
1-2km					ns	ns	ns	ns	ns
2-3km					ns	ns	ns	ns	ns
Control	ns	ns	ns	ns	ns	+	ns	+++	-

+++ = increase p<0001, ++ = increase, p<0.01, + = increase p<0.05, - - - = decrease p<0001, - - = decrease, p<0.01, - = decrease p<0.05, ns = no statistically significant difference (p>0.05).

The results of the gradient analysis of common gull abundance with distance from the wind farm found no statistically significant different in abundance between the distance zones in the pre-construction year ($F_{3,148}$=0.34, p=0.79), the construction phase ($F_{5,272}$=1.0, p=0.4) or the second of the post-construction years ($F_{5,272}$=0.5, p=0.79). There was a statistically significant different in common gull abundance between the distance zones in the first and third pre-construction years ($F_{5,272}$=2.1, p=0.015, and $F_{5,272}$=3.5, p=0.004). In those years the common gull density within the wind farm was significantly higher and the control zone significantly lower.

In conclusion, there was no evidence of any adverse effect of the wind farm on common gull, with the wind farm supporting higher densities in several of the survey years (including during construction) and no indication apparent of any reduced density within the wind farm.

Lesser Black-backed Gull: another species with highly variable numbers between years, particularly low in third post-construction year (Figure 15). Numbers in wind farm were reduced post-construction but a similar reduction was observed over the rest of the survey area as well, suggesting that this was unlikely to be a result of the presence of the wind farm.

Figure 15. Lesser black-backed gull abundance through the pre-construction ('Pre'), construction ('Constr') and three post-construction years of the Thanet offshore wind farm in relation to distance from the wind farm (WF).

Table 15 summarises the results of the statistical analysis of the change in lesser black-backed gull abundance between zones across the survey years, supporting the conclusions drawn above. There was no statistically significant overall difference in the level of change between zones (p>0.05) in the pre-construction and construction phases, and in comparison of the pre-construction phase with two of the three post-construction years. There was a difference in the change in the third of the post-construction years, though this was not likely to result from any wind farm effect (with much lower numbers recorded across all of the survey area in the third post-construction year). As well as that overall decline though, there were proportionately lower numbers within the wind farm in the third post-construction year, which were reflected in statistically significantly greater reductions in that year in comparison with the construction and second post-construction year (Table 15). It is considered unlikely however, that this was a result of any negative effect of the wind farm, particularly given the results of the gradient analysis in the following paragraph.

Table 15. Change in lesser black-backed gull abundance in relation to distance from the Thanet offshore wind farm comparing the pre-construction ('Pre'), construction ('Con') and three years of post-construction ('Post 1-3') monitoring.

	Pre v Constr	Pre v Post yr1	Pre v Post yr2	Pre v Post yr3	Con v Post yr1	Con v Post yr2	Con v Post yr3	Post 1 v Post 2	Post 2 v Post 3
Overall F	1.5	1.1	2.0	3.7	0.26	0.95	0.76	1.1	0.95
Overall p	0.22	0.35	1.1	0.01	0.93	0.45	0.58	0.36	0.45
Wind farm	ns	ns	ns	ns	ns	ns	-	ns	- -
0-500m	ns	ns	ns	ns	ns	ns	ns	ns	ns
500m-1km	ns	ns	ns	ns	ns	ns	ns	ns	ns
1-2km					ns	ns	ns	ns	ns
2-3km					ns	ns	ns	ns	ns
Control	ns	ns	ns	ns	ns	ns	ns	ns	ns

+++ = increase p<0001, ++ = increase, p<0.01, + = increase p<0.05, - - - = decrease p<0001, - - = decrease, p<0.01, - = decrease p<0.05, ns = no statistically significant difference (p>0.05).

The results of the gradient analysis of lesser black-backed gull abundance with distance from the wind farm found a statistically significant different in abundance between the distance zones in the pre-construction year ($F_{3,148}$=3.0, p=0.03), with higher numbers in the 500m-1km and control zones, but not during the construction phase ($F_{5,272}$=0.8, p=0.55) or any of the three post-construction years ($F_{5,272}$=1.1, p=0.36; $F_{5,272}$=1.2, p=0.32; and $F_{5,272}$=1.7, p=0.13).

In conclusion, there was no evidence of any adverse effect of the wind farm on lesser back-backed gulls.

Herring Gull: numbers of herring gulls were highly variable between years but showed a drop in numbers across the survey area during construction and a slight increase in numbers post-construction (though not within the wind farm site or the control area); see Figures 16.

Figure 16. Herring gull abundance through the pre-construction ('Pre'), construction ('Constr') and three post-construction years of the Thanet offshore wind farm in relation to distance from the wind farm (WF).

Table 16 summarises the results of the statistical analysis of the change in herring gull abundance between zones across the survey years. There was no statistically significant overall difference in the level of change between zones (p>0.05) in the pre-construction and construction phases, and in comparison of the pre-construction phase with two of the three post-construction years. There was a difference in the change in the third of the post-construction years, though this was not likely to result from any wind farm effect (with the significant difference largely arising from an increase in the 500m-1km zone in contrast – from a single larger flock observed there on one survey - to decreases across the rest of the survey area). No statistically significant differences were found in the level of change between zones in any of the construction and post-construction phase comparisons. Examining the differences by individual zone, statistically significant declines were recorded in comparisons of the pre-construction phase with the construction and post-construction surveys within the wind farm, suggesting a possible displacement effect. However, a similar magnitude of decline was observed in the other parts of the survey area (hence the lack of statistical significance for the overall data set) so this was probably not actually a result of the wind farm but rather of other factors such as food availability operating over the wider area.

Table 16. Change in herring gull abundance in relation to distance from the Thanet offshore wind farm comparing the pre-construction ('Pre'), construction ('Con') and three years of post-construction ('Post 1-3') monitoring.

	Pre v Constr	Pre v Post yr1	Pre v Post yr2	Pre v Post yr3	Con v Post yr1	Con v Post yr2	Con v Post yr3	Post 1 v Post 2	Post 2 v Post 3
Overall F	0.81	1.2	1.1	3.1	0.37	1.5	2.0	1.6	1.5
Overall p	0.49	0.32	0.35	0.03	0.87	0.19	0.09	0.16	0.19
Wind farm	- - -	- - -	ns	- - -	ns	ns	ns	ns	ns
0-500m	ns	ns	ns	+	ns	ns	ns	ns	ns
500m-1km	ns	ns	ns	ns	ns	+	ns	+	+
1-2km					ns	ns	ns	ns	ns
2-3km					ns	ns	ns	ns	ns
Control	ns	ns	ns	ns	ns	ns	+	ns	ns

+++ = increase p<0001, ++ = increase, p<0.01, + = increase p<0.05, - - - = decrease p<0001, - - = decrease, p<0.01, - = decrease p<0.05, ns = no statistically significant difference (p>0.05).

The results of the gradient analysis of herring gull abundance with distance from the wind farm found no statistically significant different in abundance between the distance zones in the pre-construction year ($F_{3,148}$=1.5, p=0.22), the construction phase ($F_{5,272}$=1.0, p=0.43) or the second and third of the three post-construction years ($F_{5,272}$=1.4, p=0.22 and $F_{5,272}$=2.1, p=0.07 respectively). There was a statistically significant difference in the densities recorded across the zones in the first of the post-construction years ($F_{5,272}$=4.1, p=0.001), with higher numbers recorded in the wind farm, the 500m-1km and control zones.

Overall, though herring gull numbers did decline within the wind farm during and after construction of the wind farm, similar declines elsewhere in the survey area and generally high variability in numbers between years would suggest that this was unlikely to be attributable to any effect of the wind farm.

Great Black-backed Gull: the numbers of this species during the pre-construction surveys were very low, making it difficult to draw comparisons with the construction and operational phase other than to note that there have been substantially more birds recorded in those years, including within the wind farm (Figure 17). Comparisons of the densities within the wind farm site with those elsewhere suggest that this species has not been adversely affected by the wind farm construction or operation.

Figure 17. Great black-backed gull abundance through the pre-construction ('Pre'), construction ('Constr') and three post-construction years of the Thanet offshore wind farm in relation to distance from the wind farm (WF).

Table 17 summarises the results of the statistical analysis of the change in great black-backed gull abundance between zones across the survey years, supporting the conclusions drawn above. There was no statistically significant overall difference in the level of change between zones (P>0.05) in any of the comparisons of the pre-construction, and post-construction phases. Examining the differences by individual zone, there were no statistically significant declines recorded in any comparisons in any of the zones.

Table 17. Change in great black-backed gull abundance in relation to distance from the Thanet offshore wind farm comparing the pre-construction ('Pre'), construction ('Con') and three years of post-construction ('Post 1-3') monitoring.

	Pre v Constr	Pre v Post yr1	Pre v Post yr2	Pre v Post yr3	Con v Post yr1	Con v Post yr2	Con v Post yr3	Post 1 v Post 2	Post 2 v Post 3
Overall F	0.19	1.5	1.2	1.6	0.5	1.6	2.1	1.0	1.2
Overall p	0.91	0.21	0.32	0.19	0.74	0.17	0.07	0.43	0.31
Wind farm	+	ns	ns	+++	ns	ns	+++	ns	ns
0-500m	ns	ns	ns	ns	ns	+	ns	ns	+
500m-1km	ns	ns	ns	ns	ns	ns	ns	ns	ns
1-2km					ns	ns	ns	ns	ns
2-3km					ns	ns	ns	ns	ns
Control	ns	+	ns	ns	ns	ns	ns	ns	ns

+++ = increase p<0001, ++ = increase, p<0.01, + = increase p<0.05, - - - = decrease p<0001, - - = decrease, p<0.01, - = decrease p<0.05, ns = no statistically significant difference (p>0.05).

The results of the gradient analysis of great black-backed gull abundance with distance from the wind farm found no statistically significant differences in abundance between the distance zones during the pre-construction year ($F_{3,148}$=1.0, p=0.39), the construction phase ($F_{5,272}$=0.9, p=0.46) or the three post-construction years ($F_{5,272}$=0.6, p=0.70; $F_{5,272}$=1.6, p=0.17; and $F_{5,272}$=2.1, p=0.07).

In conclusion, there was no evidence of any adverse effect of the wind farm on great back-backed gull, with an increase in numbers recorded over the pre-construction baseline across the survey area during construction and in the post-construction periods.

Kittiwake: the survey results did not indicate any negative effect of the wind farm on this species, with the use of the wind farm site itself during both construction and operation generally higher than during the pre-construction surveys (Figure 18).

Figure 18. Kittiwake abundance through the pre-construction ('Pre'), construction ('Constr') and three post-construction years of the Thanet offshore wind farm in relation to distance from the wind farm (WF).

Table 18 summarises the results of the statistical analysis of the change in kittiwake abundance between zones across the survey years. There was no statistically significant overall difference in the level of change between zones (p>0.05) in any of the comparisons of the pre-construction, and post-construction phases. Examining the differences by individual zone, the only statistically significant changes recorded were in a single zone in comparisons between the post-construction years. The 1-2km zone had a statistically significantly increase in numbers of kittiwakes in the second year and a decrease in the following year.

Table 18. Change in kittiwake abundance in relation to distance from the Thanet offshore wind farm comparing the pre-construction ('Pre'), construction ('Con') and three years of post-construction ('Post 1-3') monitoring.

	Pre v Constr	Pre v Post yr1	Pre v Post yr2	Pre v Post yr3	Con v Post yr1	Con v Post yr2	Con v Post yr3	Post 1 v Post 2	Post 2 v Post 3
Overall F	1.2	0.83	1.1	0.45	0.49	0.52	0.60	2.1	1.9
Overall p	0.29	0.48	0.37	0.72	0.79	0.76	0.70	0.06	0.09
Wind farm	ns	ns	ns	ns	ns	ns	ns	ns	ns
0-500m	ns	ns	ns	ns	ns	ns	ns	ns	ns
500m-1km	ns	ns	ns	ns	ns	ns	ns	ns	ns
1-2km					ns	ns	ns	++	-
2-3km					ns	ns	ns	ns	ns
Control	ns	ns	ns	ns	ns	ns	ns	ns	ns

+++ = increase p<0001, ++ = increase, p<0.01, + = increase p<0.05, - - - = decrease p<0001, - - = decrease, p<0.01, - = decrease p<0.05, ns = no statistically significant difference (p>0.05).

The results of the gradient analysis of kittiwake abundance with distance from the wind farm found no statistically significant differences in abundance between the distance zones in the pre-construction year ($F_{3,148}$=2.6, p=0.054), the construction phase ($F_{5,272}$=0.34, p=0.89) and the first of the three post-construction years ($F_{5,272}$=0.88, p=0.49). There were statistically significant differences in densities across the zones in the second ($F_{5,272}$=3.0, p=0.01) and third ($F_{5,272}$=4.7, p<0.001) post-construction years, with higher densities then particularly in the control zone.

In conclusion, the results showed no evidence that kittiwakes have been adversely affected by the wind farm construction or operation. Some population changes between years were observed but no changes that would indicate any effect of the wind farm.

Guillemot: there was a reduced density of guillemots in the wind farm site during construction (to 33% of pre-construction level) and the first year of operation (to 21% of pre-construction level), and to a lesser amount up to 1km from the site (to 75% of pre-construction level during construction and 77% during the first year of operation); see Figure 19. There was an increase in numbers in the second and third year of post-construction surveys across the whole survey area in comparison with the construction phase and first year of operation, with highest densities in the control zone (but similar to the densities that had been recorded there in the pre-construction baseline).

Figure 19. Guillemot abundance through the pre-construction ('Pre'), construction ('Constr') and three post-construction years of the Thanet offshore wind farm in relation to distance from the wind farm (WF).

Table 19 summarises the results of the statistical analysis of the change in guillemot abundance between zones across the survey years. There was no statistically significant overall difference in the level of change between zones ($p>0.05$) in the pre-construction and construction phases, and between the construction phase and the first and third post-construction years, though there was a difference in the changes in the other period comparisons. Examining the differences by individual zone, the abundance changes within the wind farm during the construction and first post-construction year were statistically significantly lower than the pre-construction baseline (though there was an increase in this zone comparing the construction and the third post-construction year). Outside the wind farm, however, the observed changes were either not statistically significant or were significant increases.

Table 19. Change in guillemot abundance in relation to distance from the Thanet offshore wind farm comparing the pre-construction ('Pre'), construction ('Con') and three years of post-construction ('Post 1-3') monitoring.

	Pre v Constr	Pre v Post yr1	Pre v Post yr2	Pre v Post yr3	Con v Post yr1	Con v Post yr2	Con v Post yr3	Post 1 v Post 2	Post 2 v Post 3
Overall F	2.2	1.1	0.87	1.6	0.66	1.3	3.7	0.68	0.29
Overall p	0.09	0.37	0.46	0.20	0.65	0.28	0.003	0.64	0.92
Wind farm	-	- -	ns	ns	ns	ns	+++	ns	ns
0-500m	ns	ns	ns	ns	ns	ns	ns	ns	ns
500m-1km	ns	ns	ns	ns	ns	ns	ns	ns	ns
1-2km					ns	ns	+	ns	ns
2-3km					ns	ns	ns	ns	ns
Control	ns	ns	ns	ns	ns	+	+++	ns	ns

+++ = increase p<0001, ++ = increase, p<0.01, + = increase p<0.05, - - - = decrease p<0001, - - = decrease, p<0.01, - = decrease p<0.05, ns = no statistically significant difference (p>0.05).

The results of the gradient analysis of guillemot abundance with distance from the wind farm found a statistically significant difference in abundance between the distance zones in the pre-construction year ($F_{3,148}$=4.5, p=0.005), the construction phase ($F_{5,272}$=3.3, p=0.007), and for the first and third of the post-construction years ($F_{5,272}$=4.9, p<0.001, and $F_{5,272}$=5.7, p<0.001). The only year in which there was not a statistically significant variation in the guillemot density between zones was the second post-construction year, though even then the statistical test was only just below the threshold for significance ($F_{5,272}$=2.1, p=0.06). These differences were largely attributable to higher densities in the control zone, with lower numbers recorded in the wind farm, though this was true of the pre-construction baseline as well as the construction and post-construction phases. Thus the wind farm held relatively lower densities of guillemots prior to construction and continued to do so through the rest of the surveys.

In conclusion there was evidence for a statistically significant decline in guillemot abundance within the wind farm during the construction phase (to 33% of the level recorded pre-construction). That reduction persisted in the first post-construction monitoring year, with a reduction to 21% of the pre-construction baseline. There was also evidence of a smaller reduction (to 75% of pre-construction level during construction and 77% during the first year of operation) within 1km of the wind farm. However, the decline in the construction and first post-construction year also occurred across the remainder of the survey area, including the control zone, suggesting that the reduction within the wind farm may not have been a result of the construction/initial operation of the wind farm but rather part of wider scale population changes. By the third year of post-construction monitoring guillemot numbers within the wind farm were higher than those recorded in the pre-construction baseline. Whilst there was evidence of a decline in guillemot numbers within the wind farm plus up to a 1km buffer, that decline was only apparent in the construction and first year post-construction, with numbers in the second and third post-construction years exceeding those of the pre-construction baseline (including within the wind farm).

Razorbill: lower numbers of this species were recorded than of guillemot, but it exhibited similar behaviour, with reduced density in wind farm site during construction (to 11% of pre-construction level) and first year of operation (to 5% of pre-construction level), with any effect beyond the wind farm extending only up to 500m; see Figure 20. Like guillemot, numbers were much in the second and third year of post-construction monitoring. It would appear that there was some partial displacement of this species from the wind farm (and up to a 500m buffer) during construction and operation, though only during construction and the first year of operation.

Figure 20. Razorbill abundance through the pre-construction ('Pre'), construction ('Constr') and three post-construction years of the Thanet offshore wind farm in relation to distance from the wind farm (WF).

Table 20 summarises the results of the statistical analysis of the change in razorbill abundance between zones across the survey years. There was a statistically significant overall difference in the level of change between zones ($p<0.05$) in the pre-construction and construction phases, and between the pre-construction phase and the second and third post-construction years. No such overall difference was found for any of the other period comparisons. Examining the differences by individual zone, the abundance changes within the wind farm during the construction and the first year of the post-construction phase were statistically significantly lower than the pre-construction baseline. Outside the wind farm, however, those changes were either not statistically significant or were significant increases, indicating a lack of statistical evidence of any displacement effect extending beyond the wind farm itself.

Table 20. Change in razorbill abundance in relation to distance from the Thanet offshore wind farm comparing the pre-construction ('Pre'), construction ('Con') and three years of post-construction ('Post 1-3') monitoring.

	Pre v Constr	Pre v Post yr1	Pre v Post yr2	Pre v Post yr3	Con v Post yr1	Con v Post yr2	Con v Post yr3	Post 1 v Post 2	Post 2 v Post 3
Overall F	3.4	2.0	3.0	5.5	1.2	0.53	0.78	1.2	0.75
Overall p	0.02	0.12	0.03	0.001	0.31	0.76	0.56	0.32	0.59
Wind farm	- -	- - -	ns	ns	ns	++	ns	++	ns
0-500m	ns	ns	ns	ns	ns	ns	ns	ns	ns
500m-1km	+	ns	++	+++	ns	ns	ns	ns	ns
1-2km					ns	ns	ns	ns	ns
2-3km					ns	ns	ns	ns	ns
Control	+	+	ns	+	ns	ns	ns	ns	ns

+++ = increase p<0001, ++ = increase, p<0.01, + = increase p<0.05, - - - = decrease p<0001, - - = decrease, p<0.01, - = decrease p<0.05, ns = no statistically significant difference (p>0.05).

The results of the gradient analysis of razorbill abundance with distance from the wind farm found no statistically significant difference in abundance between the distance zones in the pre-construction year ($F_{3,148}$=0.75, p=0.53), but the densities did differ significantly between zones in the construction phase ($F_{5,272}$=3.1, p=0.01), and for the first of the post-construction years ($F_{5,272}$=3.1, p=0.01). There was no statistically significant difference between razorbill densities across the zones in the second and third post-construction years ($F_{5,272}$=0.39, p=0.85 for the second and $F_{5,272}$=1.8, p=0.12 for the third).

In conclusion there was evidence for a statistically significant decline in razorbill abundance within the wind farm during the construction phase (to 11% of the level recorded pre-construction). As for guillemot, that reduction persisted in the first post-construction monitoring year, with a reduction to 5% of the pre-construction baseline. There was also some evidence of a similar reduction within 500m of the wind farm, though this was not statistically significant. Razorbill numbers declined in the wind farm (and to a lesser extent in the 0-500m zone), but there were increases apparent in the other zones, particularly in the control zone, suggesting that the reduction within the wind farm was probably a result of the construction/initial operation of the wind farm, though that effect appeared short-term and was not apparent by the second year of operation. Whilst there was evidence of a decline in razorbill numbers within the wind farm, that decline was only apparent in the construction and first year post-construction, with numbers in the second and third post-construction years exceeding those of the pre-construction baseline (including within the wind farm).

9 MARINE MAMMALS

The numbers of marine mammals recorded during each survey are shown in Table 12. Only low numbers of seals were seen through the whole survey period, as in previous years. The numbers of harbour porpoises recorded in 2012-13, however, was considerably higher in than previously, particularly in March when a peak of 265 was seen (compared with peaks of 87 and 21 in the previous two winters, those peaks again being seen in March). A similar seasonal pattern of occurrence was observed during the construction phase surveys.

Table 12. Numbers of marine mammals observed during each of the boat surveys during 2012-13.

Species	8 - 9 Oct 2012	24 - 29 Oct 2012	15 - 16 Nov 2012	12 - 13 Dec 2012	17 - 18 Dec 2012	16 - 17 Jan 2013	23, 24 and 25 Jan 2013	9-10 Feb 2013	17-18 Feb 2013	6-7 Mar 2013	19-20 Mar 2013	PEAK
Common seal			2		2			1				2
Grey seal		1					1	11		2		11
Harbour porpoise	1	2	5	3	18	52	10	22	21	265	112	265
seal sp			1	1			1	3				3

Harbour porpoises were recorded across most of the survey area during 2012-13, though with higher numbers in the eastern part of the survey area, including within the wind farm, and in the control area (Figure 21).

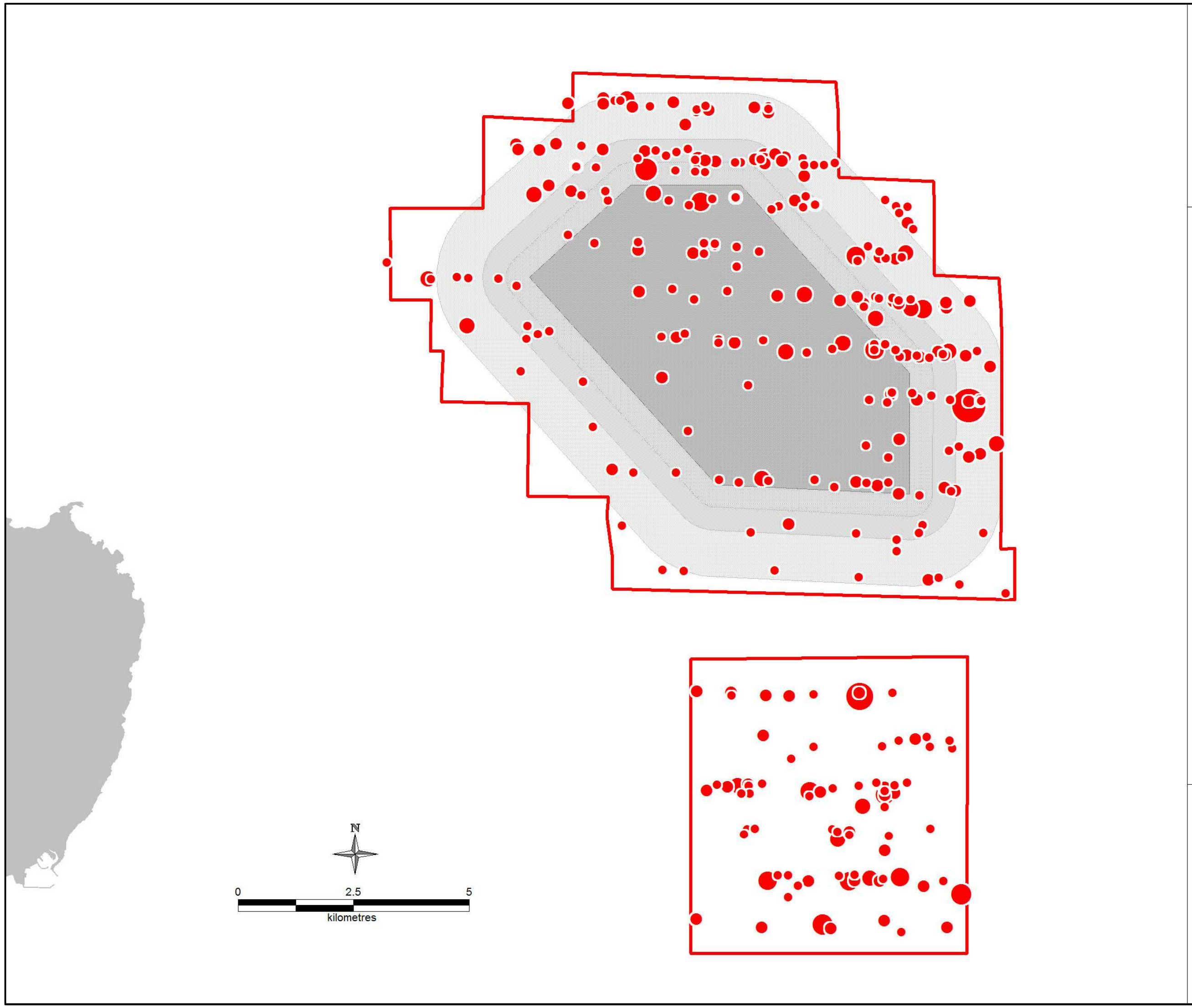


Figure 21. Distribution of Harbour Porpoise in the Thanet offshore wind farm survey area, 2012-13

KEY:

Wind farm site
0-0.5km buffer
0.5-1km buffer
1-2km buffer
Survey area

Harbour Porpoise records

10
5
1

ECOLOGY CONSULTING

A similar analysis has been undertaken for harbour porpoise as for the key bird species above, as there were sufficient records to carry out a meaningful analysis (though numbers seen during the pre-construction, construction phases and in the first post-construction year were low so some caution in required in the interpretation of the results for those periods). Records of harbour porpoise decline during the construction period within the wind farm and within a 500m buffer, and this decline continued into the first post-construction year, but after that numbers increased substantially across the whole survey area, including within the wind farm. It would appear that there was some partial displacement of this species from the wind farm (and up to a 500m buffer) during construction and operation, though only during construction and the first year of operation.

Figure 22. Harbour porpoise abundance through the pre-construction ('Pre'), construction ('Constr') and three post-construction years of the Thanet offshore wind farm in relation to distance from the wind farm (WF).

Table 21 summarises the results of the statistical analysis of the change in razorbill abundance between zones across the survey years. There was a statistically significant overall difference in the level of change between zones (p<0.05) in the pre-construction and construction phases (statistically significant decline within wind farm and increase in the control area), but not between any of the other periods. Examining the differences by individual zone, the decline in abundance within the wind farm during the construction phase was statistically significantly lower than the pre-construction baseline. Outside the wind farm, however, those changes were either not statistically significant or were significant increases, indicating a lack of statistical evidence of any displacement effect extending beyond the wind farm itself. No statistically significant declines were apparent after the construction period.

Table 21. Change in razorbill abundance in relation to distance from the Thanet offshore wind farm comparing the pre-construction ('Pre'), construction ('Con') and three years of post-construction ('Post 1-3') monitoring.

	Pre v Constr	Pre v Post yr1	Pre v Post yr2	Pre v Post yr3	Con v Post yr1	Con v Post yr2	Con v Post yr3	Post 1 v Post 2	Post 2 v Post 3
Overall F	4.3	1.4	1.2	1.4	0.2	0.8	1.4	1.2	0.5
Overall p	0.006	0.25	0.33	0.24	0.96	0.53	0.23	0.32	0.80
Wind farm	-	ns	ns	++	ns	+	+++	+	+
0-500m	ns	ns	ns	ns	ns	ns	ns	ns	ns
500m-1km	+	ns	ns	ns	ns	ns	ns	ns	ns
1-2km					ns	ns	+	ns	ns
2-3km					ns	ns	ns	ns	ns
Control	+++	ns	ns	ns	ns	ns	ns	ns	ns

+++ = increase p<0001, ++ = increase, p<0.01, + = increase p<0.05, - - - = decrease p<0001, - - = decrease, p<0.01, - = decrease p<0.05, ns = no statistically significant difference (p>0.05).

The results of the gradient analysis of harbour porpoise abundance with distance from the wind farm found no statistically significant difference in abundance between the distance zones in the pre-construction year ($F_{3,148}$=0.18, p=0.91), but the densities did differ significantly between zones in the construction phase ($F_{5,272}$=5.6, p<0.001), and for the first ($F_{5,272}$=3.8, p=0.002) and second ($F_{5,272}$=3.0, p=0.012) of the post-construction years. There was no statistically significant difference between harbour porpoise densities across the zones in the third post-construction year ($F_{5,272}$=2.0, p=0.072).

In conclusion there was evidence for a statistically significant decline in harbour porpoise abundance within the wind farm during the construction phase (with no records of this species there during the construction phase, a 100% reduction albeit from a low baseline level). That reduction persisted in the first post-construction monitoring year, with a reduction to 25% of the pre-construction baseline. There was also some evidence of a similar reduction within 500m of the wind farm, though this was not statistically significant. Whilst the numbers declined in the wind farm (and to a lesser extent in the 0-500m zone), there were increases apparent in the other zones, particularly in the control zone, suggesting that the reduction within the wind farm was probably a result of the construction/initial operation of the wind farm, though that effect appeared short-term and was not apparent by the second year of operation.

10 CONCLUSION AND SUMMARY

The inherent variability in seabird numbers between years and the changes made to the survey area after the completion of the pre-construction ES baseline surveys have both made interpretation of the results of the monitoring programme challenging, but the analytical approach used here has facilitated that interpretation and enabled robust conclusions to be reached about changes that have resulted from the construction and operation of the wind farm. The main conclusions reached about each of the main seabird species found was as follows:

- **Divers**: there was evidence of a statistically significant decline in diver abundance within the wind farm during the construction phase (to 18% of the level recorded pre-construction). That reduction has persisted through all three post-construction monitoring years, though at a slightly lower reduction from the pre-construction baseline, at an average of a reduction to 27%. The analyses undertaken found no evidence was apparent of any statistically significant displacement in any buffer zone around the wind farm.
- **Gannet**: there was no evidence of any effect of the wind farm on gannets, other than the fact that the wind farm supported lower densities in the third of the post-construction monitoring years in comparison with elsewhere in the survey area (though this reduced density was also apparent in the other surveys years, suggesting that it was not a result of the presence of the wind farm).
- **Common Gull**: there was no evidence of any adverse effect of the wind farm on common gull, with the wind farm supporting higher densities in several of the survey years (including during construction) and no indication apparent of any reduced density within the wind farm.
- **Lesser Black-backed Gull**: there was no evidence of any adverse effect of the wind farm on lesser back-backed gulls.
- **Herring Gull**: though herring gull numbers did decline within the wind farm during and after construction of the wind farm, similar declines elsewhere in the survey area and generally high variability in numbers between years would suggest that this was unlikely to be attributable to any effect of the wind farm.
- **Great Back-backed Gull**: there was no evidence of any adverse effect of the wind farm on great back-backed gull, with an increase in numbers recorded over the pre-construction baseline across the survey area during construction and in the post-construction periods.
- **Kittiwake**: the results showed no evidence that kittiwakes have been adversely affected by the wind farm construction or operation. Some population changes between years were observed but no changes that would indicate any effect of the wind farm.
- **Guillemot**: there was evidence for a statistically significant decline in guillemot abundance within the wind farm during the construction phase (to 33% of the level recorded pre-construction). That reduction persisted in the first post-construction monitoring year, with a reduction to 21% of the pre-construction baseline. There was also evidence of a smaller reduction (to 75% of pre-construction level during construction and 77% during the first year of operation) within 1km of the wind farm. However, the decline in the construction and first post-construction year also occurred across the remainder of the survey area, including the control zone, suggesting that the reduction within the wind farm may not have been a result of the construction/initial operation of the wind farm but rather part of wider scale population changes. By the third year of post-construction monitoring guillemot numbers within the wind farm were higher than those recorded in the pre-construction baseline.
- **Razorbill**: there was evidence for a statistically significant decline in razorbill abundance within the wind farm during the construction phase (to 11% of the level recorded pre-construction). As for guillemot, that reduction persisted in the first post-construction monitoring year, with a reduction to 5% of the pre-construction baseline. There was also some evidence of a similar reduction within 500m of the wind farm, though this was not statistically significant. Whilst the numbers declined in the wind farm (and to a lesser extent in the 0-500m zone), there were increases apparent in the other zones, particularly in the control zone, suggesting that the

reduction within the wind farm was probably a result of the construction/initial operation of the wind farm, though that effect appeared short-term and was not apparent by the second year of operation.

10.1 Population context of changes in numbers observed

The results of the Thanet offshore wind farm bird monitoring programme have indicated that there has been a statistically significant decline in the numbers of divers, guillemots and razorbills following the construction of the wind farm. For divers it is considered that this is likely to be attributable to the presence of the wind farm, but results for the other two species were more equivocal (with declines across the survey area not just in proximity to the wind turbines). The purpose of this section of the report is to put these observed population changes into a wider population conservation context.

For **red-throated divers**, there was a statistically significant drop in diver numbers within the wind farm, equivalent to about a 82% decline during construction, and a 73% reduction in diver density there post-construction (again only within the wind farm). In population terms, this meant a reduction from a population within the wind farm from a peak population of 25 pre-construction to about 5 during construction and 7 post-construction. The population was determined to be regionally important pre-construction. Though reduced, the construction and post-construction phases would still be considered regionally important. In the context of that regional population, the Greater Thames region has been estimated to support 8,130 red-throated divers (O'Brien et al. 2008) and the Outer Thames Estuary SPA citation gives a designated population of 6,466 individuals (Natural England/JNCC, 2010). Partial loss of a relatively low density diver foraging area outside the SPA, involving displacement of approximately 18-20 individuals is not considered ecologically significant. Caution does need to be applied to these results at this stage however as the wind farm site has supported only low numbers of this species throughout the surveys, so the sample of birds exposed to potential displacement is only small.

Guillemot showed a statistically significant drop in numbers within the wind farm during construction but a subsequent increase in the second and third post-construction years. There was a 67% reduction in density within the wind farm during construction and a 25% reduction in the 0-1km buffer within that period. A 79% reduction in guillemot numbers within the wind farm was also recorded in the first post-construction year in comparison with the pre-construction baseline and a 23% reduction in the 0-1km buffer. No reductions were apparent beyond those zones, or in the second or third post-construction year. With a pre-construction peak population in these zones estimated at about 200, this would equate to a loss of about 100 guillemots from the wind farm plus 1km buffer during construction and about 50 in the first post-construction year (though still retaining its status as regionally important in the survey area). Such losses would, in the context of this species' regional population, be negligible and not ecologically significant. It should also be noted that for this species these changes occurred across the survey area with less evidence of a greater effect within the wind farm, so the evidence for displacement of that this is more equivocal.

Razorbill also showed a statistically significant drop in numbers within the wind farm during construction but a subsequent increase in the second and third post-construction years. There was an 89% reduction in density within the wind farm during construction. A 79% reduction in razorbill numbers within the wind farm was also recorded in the first post-construction year in comparison with the pre-construction baseline. No statistically significant reductions were apparent outside the wind farm, or in the second or third post-construction year. With a pre-construction peak population within the wind farm estimated at about 20, this would equate to a loss of about 18 razorbills from the wind farm during construction and about 19 in the first post-construction year (though still retaining its status as regionally important within the survey area). Such losses would, in the context of this species' regional population, be negligible and not ecologically significant. It should also be noted that for this species these changes occurred across the survey area with less evidence of a greater effect within the wind farm, so the evidence for displacement of that this is more equivocal.

10.2 Comparison with ES Predictions

In the ES it was predicted that disturbance to and displacement of feeding seabirds during construction would be short term and of minor adverse significance, as a result of overall low densities of birds observed throughout the year and availability of similar feeding areas close by.

The results of the construction phase monitoring supported this conclusion, with some minor displacement observed of some species including divers, gannets, guillemots and razorbills.

Disturbance impacts during the operational phase of the wind farm were also predicted in the ES to result in only minor adverse effects, particularly on divers and auks. No disturbance effects were predicted on gulls This again appears from the results to date to be borne out by the results of the monitoring programme, with evidence of displacement of divers, gannets, guillemots and razorbills, and none for gulls.

In relation to collision risk, the data on bird flight activity collected as part of the post-construction monitoring has not found any evidence to suggest that the conclusion reached in the ES (that there would not be any significant collision risk) would be changed by the recent post-construction data (though no direct monitoring of collision risk has been undertaken).

Overall, therefore, the predictions made in the ES relating to the ornithological impacts of the wind farm have been supported by the results of the post-construction monitoring.

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