KENTISH FLATS OFFSHORE WIND FARM EXTENSION: ORNITHOLOGICAL SURVEY ANNUAL REPORT, OCTOBER 2016 – MARCH 2017 (POST-CONSTRUCTION YEAR 2)

VATTENFALL

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ECOLOGY CONSULTING

On behalf of Vattenfall

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CONTENTS

1 INTRODUCTION

1.1 Background

This report presents the results of the bird monitoring programme that has been undertaken between October 2016 and March 2017. It forms the second year of the post-construction phase monitoring of the Kentish Flats Offshore Wind Farm Extension. The purpose of this report is to document the surveys that have been undertaken during this period, including the survey routes covered, present estimates of the bird populations present, and discuss the main findings of the surveys including a comparison with the previous survey results and assessment of any influence of weather conditions and other relevant information that may have affected species abundance and behaviour.

The main aim of this phase of the work is to determine the distribution and abundance of seabirds using the Kentish Flats Offshore Wind Farm Extension (KFE) site and its surrounds after construction of the wind farm, and compare this with the pre-construction baseline. Standard survey methodologies have been used, following Camphuysen *et al*. (2004) and have remained consistent throughout the surveying undertaken.

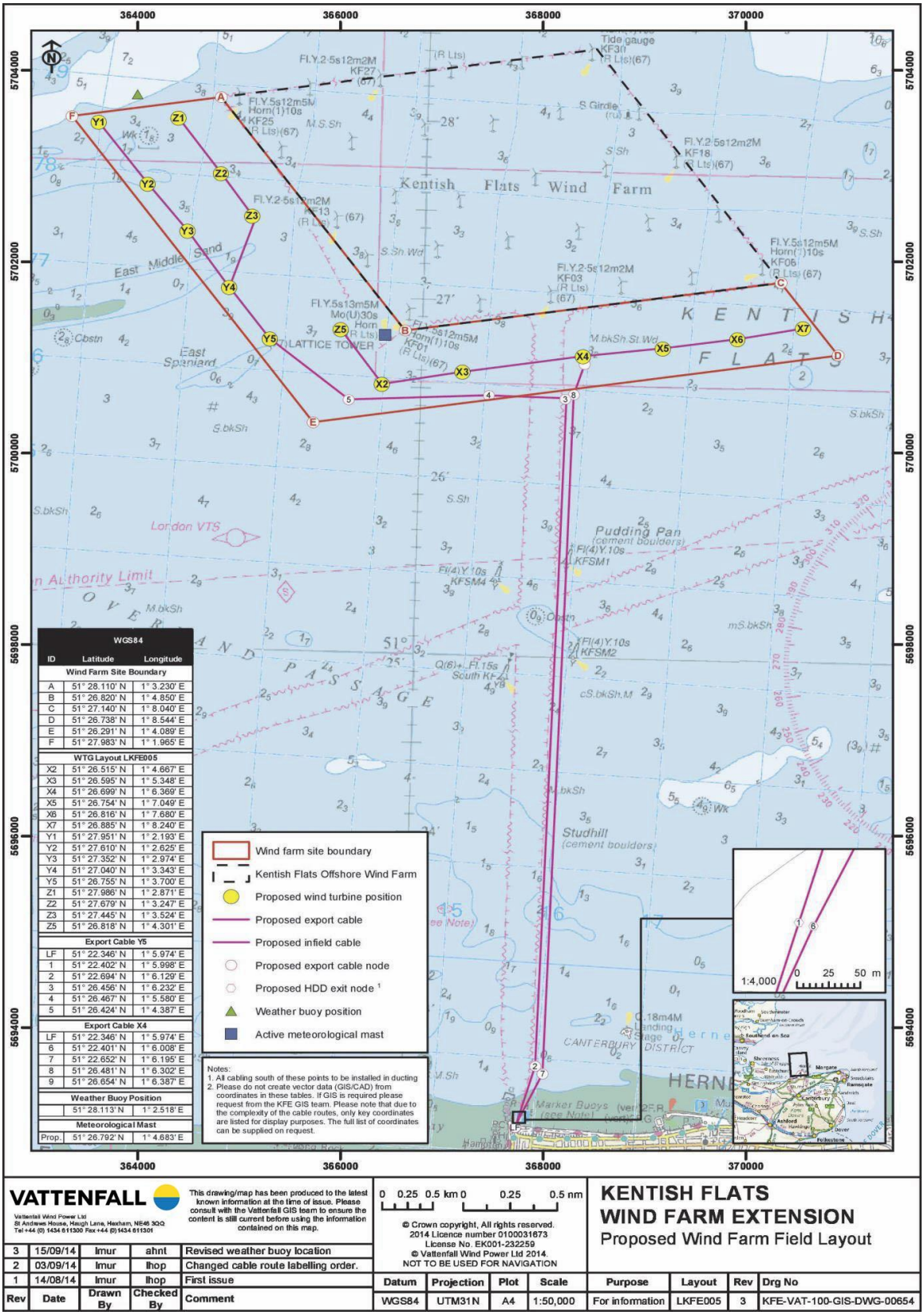
The KFE is located in the Outer Thames Estuary, approximately 7 kilometres off the north Kent coast. KFE extends over an area of 7.8km^2. The original Kentish Flats Offshore Wind Farm has been operational since 2005 and consists of 30 x 3MW wind turbines.

Offshore construction of the KFE commenced in April 2015 with the installation of turbine foundations. Piling of the turbine foundations was completed on 23 May 2015. Turbine installation was completed on 10 August 2015, and all 15 turbines were generating power to the National Grid from 12 September 2015.

The KFE development comprises 15 x 3.3MW wind turbines. Two export cables have been installed alongside the existing cables and come ashore near to Hampton Pier, Herne Bay. The onshore cable route follows the existing Kentish Flats cable route to the Red House Farm substation on Thornden Wood Road. The export cable is 18km, with 12km of inter-array cables connecting the turbines into strings. The cables were installed using a water jetting method with a final burial depth in the range of 0.5 to 2m below the seabed.

The site layout as constructed, comprising 15 Vestas V112 turbines with a rotor diameter of 112m and tip height of 139.6m, is shown in **Figure 1**.

Figure 1. Kentish Flats Wind Farm Extension.



WGS84		
ID	Latitude	Longitude
Wind Farm Site Boundary		
A	51° 28.110' N	1° 3.230' E
B	51° 26.820' N	1° 4.850' E
C	51° 27.140' N	1° 8.040' E
D	51° 26.738' N	1° 8.544' E
E	51° 26.291' N	1° 4.089' E
F	51° 27.983' N	1° 1.965' E
WTG Layout LKFE005		
X2	51° 26.515' N	1° 4.667' E
X3	51° 26.595' N	1° 5.348' E
X4	51° 26.699' N	1° 6.369' E
X5	51° 26.754' N	1° 7.049' E
X6	51° 26.816' N	1° 7.680' E
X7	51° 26.885' N	1° 8.240' E
Y1	51° 27.951' N	1° 2.193' E
Y2	51° 27.610' N	1° 2.625' E
Y3	51° 27.352' N	1° 2.974' E
Y4	51° 27.040' N	1° 3.343' E
Y5	51° 26.755' N	1° 3.700' E
Z1	51° 27.986' N	1° 2.871' E
Z2	51° 27.679' N	1° 3.247' E
Z3	51° 27.445' N	1° 3.524' E
Z5	51° 26.818' N	1° 4.301' E
Export Cable Y5		
LF	51° 22.346' N	1° 5.974' E
1	51° 22.402' N	1° 5.998' E
2	51° 22.694' N	1° 6.129' E
3	51° 26.456' N	1° 6.232' E
4	51° 26.467' N	1° 5.580' E
5	51° 26.424' N	1° 4.387' E
Export Cable X4		
LF	51° 22.346' N	1° 5.974' E
6	51° 22.401' N	1° 6.008' E
7	51° 22.652' N	1° 6.195' E
8	51° 26.481' N	1° 6.302' E
9	51° 26.654' N	1° 6.387' E
Weather Buoy Position		
	51° 28.113' N	1° 2.518' E
Meteorological Mast		
Prop.	51° 26.792' N	1° 4.683' E

Notes:
1. All cabling south of these points to be installed in ducting
2. Please do not create vector data (GIS/CAD) from coordinates in these tables. If GIS is required please request from the KFE GIS team. Please note that due to the complexity of the cable routes, only key coordinates are listed for display purposes. The full list of coordinates can be supplied on request.

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This drawing/map has been produced to the latest known information at the time of issue. Please consult with the Vattenfall GIS team to ensure the content is still current before using the information contained on this map.

0 0.25 0.5 km 0 0.25 0.5 nm

Rev	Date	Drawn By	Checked By	Comment
3	15/09/14	lmur	ahnt	Revised weather buoy location
2	03/09/14	lmur	lhop	Changed cable route labelling order.
1	14/08/14	lmur	lhop	First issue

KENTISH FLATS WIND FARM EXTENSION
Proposed Wind Farm Field Layout

Datum	Projection	Plot	Scale	Purpose	Layout	Rev	Drg No
WGS84	UTM31N	A4	1:50,000	For information	LKFE005	3	KFE-VAT-100-GIS-DWG-00654

The scope of 2016-17 ornithological surveys comprised the following:

- 12 x boat based ornithology surveys, October 2016 to March 2017;
- Data analysis; and
- Year 2 post-construction monitoring reporting (this annual report).

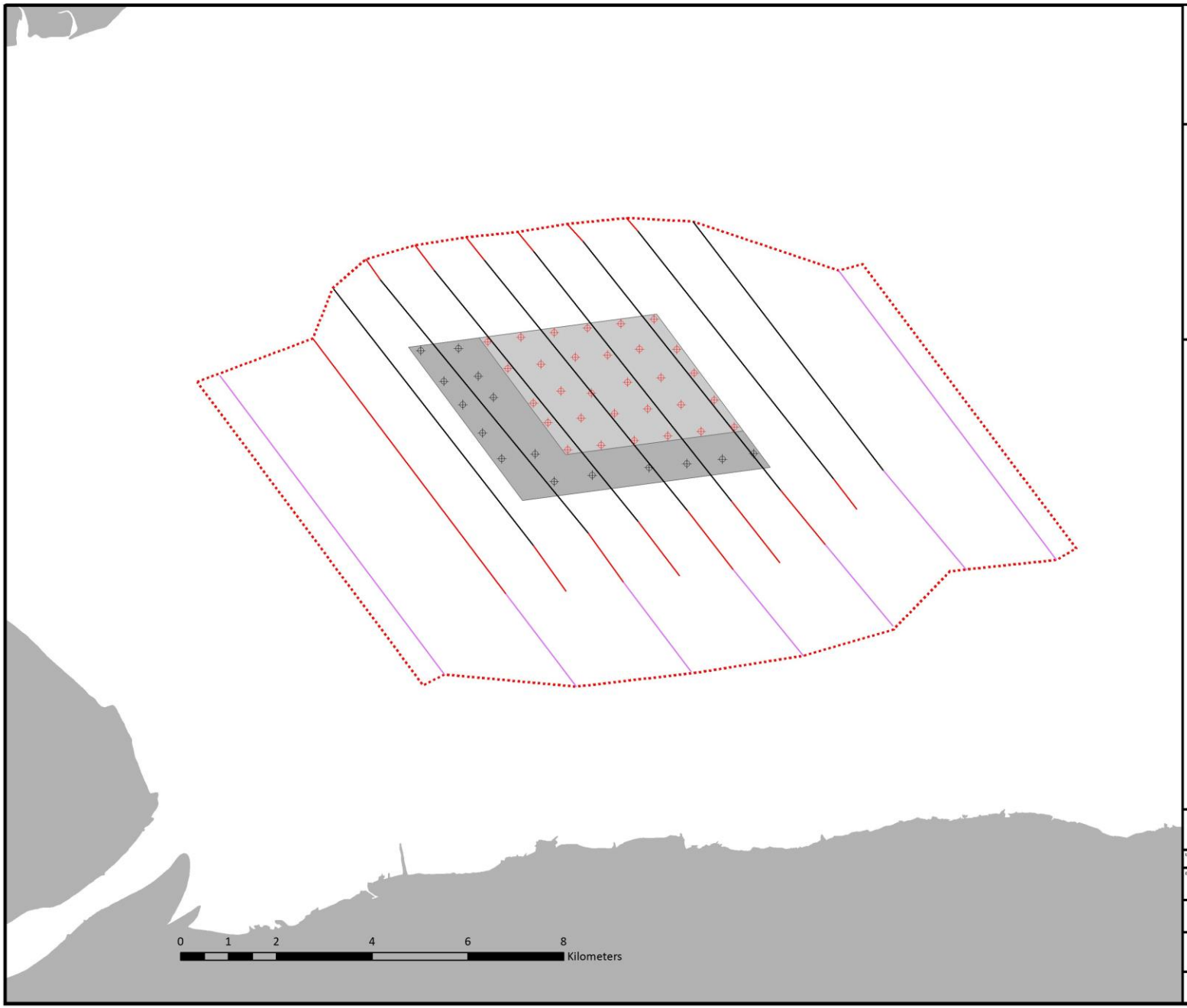
2 LICENSE CONDITIONS

The surveys presented in this report have been undertaken to satisfy section 14 (e) of the Development Consent Order (DCO), which sets out that Post-Construction Phase ornithological monitoring will be carried out. The methodology for those surveys, including the timing, frequency, survey area and transect design were all agreed with the MMO (as confirmed in its letter of 25/8/15). MMO confirmed in that letter that it was "*satisfied that the proposed methodology to undertake two boat-based surveys per month for the wintering period, for three consecutive years, is appropriate*."

3 BOAT-BASED SURVEYS 2016-17

3.1 Survey Area

The 2016-17 surveys reported here cover the survey area as set out in the agreed monitoring programme, and include the KFE site, the original Kentish Flats Offshore Wind Farm site, plus a buffer zone up to 6km from the original wind farm and the now constructed KFE turbines. The transect spacing used in 2016-17 was 1km within the main part of the survey area where previous baseline surveys have been undertaken (using that same 1km transect separation) and 2km on the more peripheral areas (to provide additional information on bird populations further from the wind farms), with a total length of 100km. The total area surveyed was 122km^2 (**Figure 2**). These survey areas and transects were the same as those used in the 2014-15 pre-construction baseline and the 2015-16 first year post-construction surveys. The distance zones around the KFE wind farm are shown in **Figure 2b**.



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Kentish Flats Offshore Wind Farm Extension

FIGURE 2

Ornithological Monitoring Survey Area and Transects

KEY:

- KFE turbines
- Kentish Flats turbines
- Survey area
- KFE wind farm
- Kentish Flats wind farm

Survey transects

- Original baseline
- Extension baseline
- New KFE monitoring

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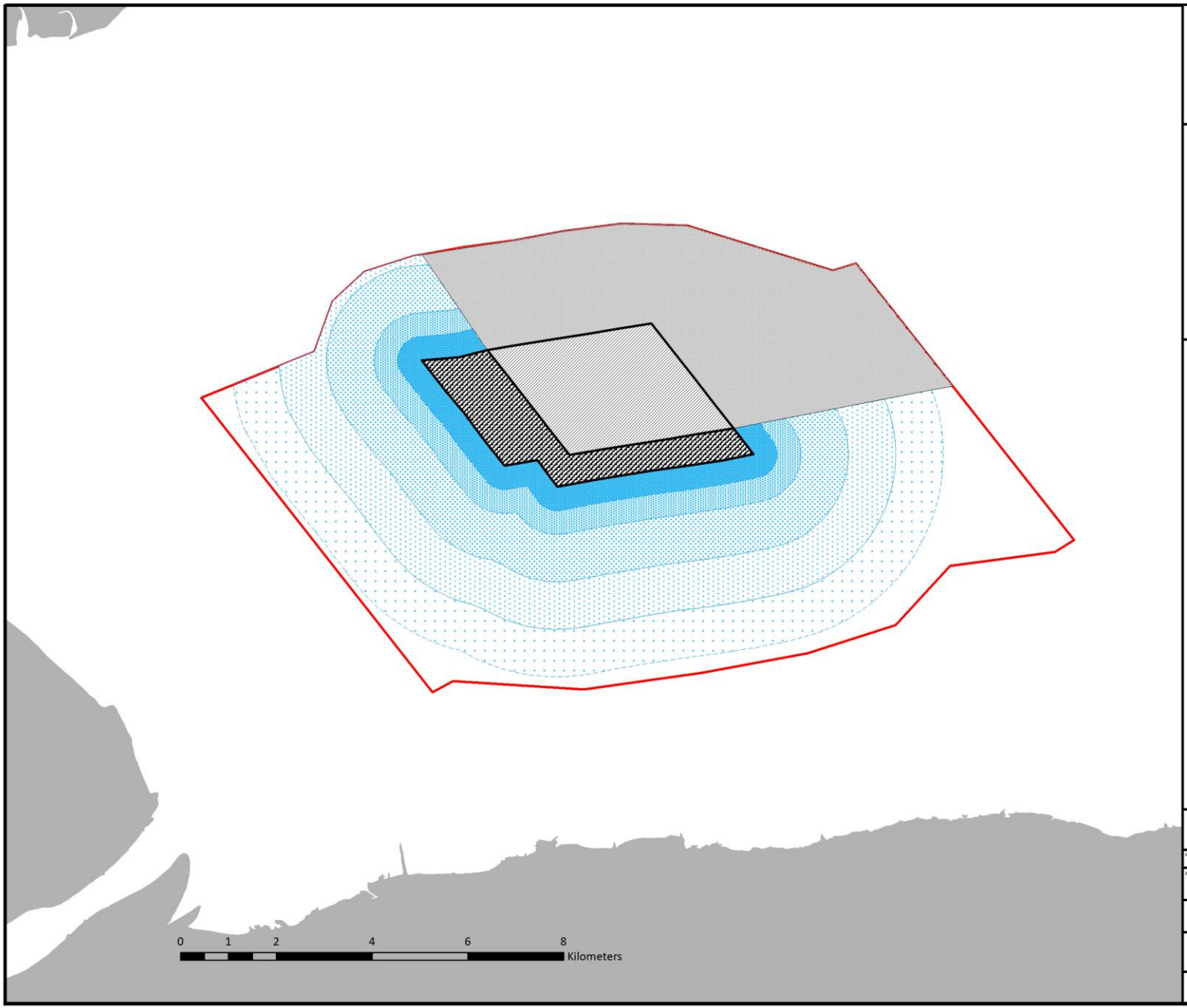
N

LAYOUT DWG N/A | P LAYOUT NO. N/A

DRAWING NUMBER OFF2016-1

SCALE - 1:75,000 @ A3

KENT FLATS EXTENSION MONITORING 2015-16



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Kentish Flats Offshore Wind Farm Extension

FIGURE 2b

Ornithological Monitoring KFE Distance Zones

KEY:

- KF1 wind farm
- KFE wind farm
- Area excluded from KFE zone anlaysis

KFE distance zones

- >4km
- 500m
- 1km
- 2km
- 3km
- 4km
- KFE monitoring survey area

ECOLOGY CONSULTING

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LAYOUT DWG N/A | P-LAYOUT NO. N/A

DRAWING NUMBER OFF2016-1

SCALE - 1:75,000 @ A3

KENT FLATS EXTENSION MONITORING 2015-16

A total of 12 surveys have been carried out during October 2016 – March 2017, at approximately fortnightly intervals, as scheduled. The GPS tracks showing the routes followed on each survey are shown in **Appendix 1**. The surveys were carried out on the following dates:

- 8 and 10 November 2016 (delayed from October because of logistical issues);
- 23 and 30 November 2016;
- 6 and 16 December 2016;
- 5 and 17 January 2017;
- 6 and 17 February 2017; and
- 7 and 28 March 2017.

3.2 Survey methods

The survey methods follow those detailed in the KFE Offshore Wind Farm Bird Monitoring Protocol. These surveys comprised boat-based line transects, following the methodology recommended in Camphuysen *et al*. (2004) and as reviewed by Maclean *et al*. (2009).

The previously used survey vessel, the 'Arie Dirk', was unavailable this winter, so an alternative vessel, the 'Predator' was used. This vessel cruised the transects at about 10 knots and has a viewing height of about 4.9m 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.

A GPS record of the precise route was taken on each trip, so that the location at all times was known.

The observation team on the surveys comprised Jon Ford, Trevor Charlton and Gary Elton (with three surveyors on each survey), who were all involved in both observation and recording. All surveyors were JNCC ESAS qualified. Three surveyors were deployed to allow recording on both sides of the survey vessel simultaneously, 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 all highly 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 10 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 (and identified to species level when possible).

The approximate height above the sea of all flying birds was recorded, estimated as accurately as possible (for later conversion to height bands for presentation and assessment as required). Flying birds were recorded using snapshot counts at two-minute

intervals. Whilst all birds observed were recorded, a note of those "in transect" was made to facilitate later analysis.

The weather conditions during the surveys were recorded, including sea state, wind speed and wind direction. Any specific conditions in the area that may affect bird abundance/behaviour (e.g. if a storm has passed the area in advance of a survey, many construction vessels etc.) were additionally noted.

For each bird observation, the following is being recorded:

- Observation time;
- Latitude and longitude (WGS84 UTM30N);
- Species;
- Numbers; age classes;
- Distance band from the vessel;
- Sitting/flight height;
- Flight direction;
- Behaviour; Association (e.g. with fishing vessels).

In addition, fishing vessels and other vessels (e.g. construction vessels or ferries) are also recorded. For registration of behaviour, the standards outlined in Camphuysen and Garthe (2004) are being used.

3.3 Distance Modelling to Determine Population Estimates

The data have been analysed in accordance with the standard principles of distance sampling, but the generally low numbers of records per species recorded on the sea during each survey meant that it was not possible to use the Distance 6 software (Thomas *et al*. 2009) to generate reliable distance correction factors for each survey. Instead therefore a simpler approach was adopted. The raw count data from the boat-based surveys were adjusted to take into account the fact that the likelihood of a bird being seen declines with distance from the observer (i.e. detectability is a function of distance from the transect line). Put simply, the chance of seeing a bird close to the observer would be higher than if it were at greater distance. The relationship between detectability and distance can be modelled using software packages such as Distance (Buckland *et al*. 2001), but for the purposes of this assessment a simpler approach was adopted (mainly because the limited number of distance bands makes modelling of the distance function difficult for many of the species encountered in this study, and the limited number of records on the sea). The approach used here is similar to that used by JNCC in their Seabirds at Sea surveys (e.g. Stone *et al*. 1995), with correction factors calculated for each major species group specifically using the data collected from the boat survey. Species were assigned to these groups on their similarly of likely detectability and pooled to give a robust sample size for each group. Group compositions are given in **Table 1**. The correction factors were calculated using the pooled data for each species group from all of the surveys. The low densities of birds recorded on the sea overall meant that it was not possible to provide robust estimates of visit-specific correction factors.

Table 1. Species groups used in calculation of distance correction factors

Species Group	Species
Divers	Divers, cormorants, auks and seaduck
Gannet	Gannet
Gulls	Gulls, skuas, terns, shearwaters

The process in calculating those correction factors was as follows:

- The total numbers of birds of each species group were calculated for each distance band during each of the surveys.
- Differences in the width of the distance bands were taken into account by dividing the total number by the band width, to give a standardised total (density index).
- It was assumed that bird detectability in the closest transect to the observer was 100% (a standard assumption of the Distance sampling methodology).
- As detectability of birds on the sea and flying were different from the boat survey data separate correction factors were used for each of these. In fact, detectability of flying birds was so high that no correction factors were necessary for these birds – effectively all of these birds were detected within the main transect.
- For each of the other bands, the percentage difference between that band's standardised total and the closest band to the observer were calculated.
- These differences were then applied as the correction factors, dividing each count by the appropriate factor.

The correction factors used for each species group are shown in **Table 2**.

Table 2. Distance correction factors used for the boat survey data 2016-17, for birds observed on the sea.

Species Group	A [0-50m]	B [50-100m]	C [100-200m]	D [200-300m]
Divers	100%	58%	57%	57%
Gannet	100%	100%	100%	100%
Gulls	100%	100%	100%	100%

There could be potential for bias in the distance corrections used for gulls, given that most were larger gulls that could have caused the distance correction to underestimate small gulls (if they had lower detectability). However Stone *et al* (1995) reported identical corrections for small and large gull species, suggesting that their detectability is actually very similar.

3.4 Data Analysis Methods

Further statistical analysis has been undertaken on the 2014-15 (pre-construction), 2015-16 (post-construction phase, year one) and 2016-17 (post-construction year two) data, as direct comparison is possible given that the same transect routes were used on each. This analysis focussed on the key species for which sufficient data were available to carry out a meaningful analysis, i.e. red-throated diver, cormorant, common gull, herring gull and great black-backed gull.

Each transect was split into equal segments of approximately 500m. The 500m distance was selected using professional judgment to give a reasonable sample unit whilst at the same time sufficiently high spatial precision for the analysis. The bird numbers recorded in each of these segments was determined using ArcGIS, allocating each bird sighting to its closest segment and totalling the counts (corrected for distance sampling) for each species for each segment. These were then converted to a mean encounter rate for each species for each winter (dividing by the number of surveys and the length of each segment (500m). This enabled all data recorded within the main 300m transects to be used in this analysis, maximising the sample sizes.

The statistical analysis was based on a comparison of the change in encounter rate for each species in each zone. It tested the null hypothesis that there was no difference in the change in encounter rate in each year between the zones. Using the 500m transect segments enabled more robust statistical testing to be undertaken, but introduced the potential issue of spatial autocorrelation between samples. This was initially taken into account in the analysis using a Generalised Least Squares (GLS) statistical modelling approach (Zuur *et al*. 2009), with the location of each transect sub-section – easting and northing – incorporated as explicit spatial variables (and spatial autocorrelation taken into account in the model structure). This approach also enabled heterogeneity in the data to be taken into account in the analysis. There were, though, a small number of distant outliers in the key species data (locations where the small number of larger diver flocks were seen) that were strongly affecting results, so an alternative approach, robust regression analysis was undertaken, as this is a statistical technique that is less sensitive to outliers (NCSS 2016), with sea depth class, seabed sediment type, latitude and longitude included in the analysis as well as the KFE distance zone.

3.5 Diver Habitat Analysis

Previous studies of diver site selection and habitat preferences were undertaken for the KFE ornithological assessment and were presented in the ES (Appendix 9.2), and similar analyses were carried out for the London Array wind farm assessment in that ES. These showed that a range of features were important in the determination of habitat suitability for divers, including:

- **Water depth** - divers showed a clear preference for depths under 10m and little use of deeper waters in excess of 20m. Most of the KFE survey area falls into this preferred depth range;
- **Shipping lanes** - divers avoid areas within main shipping lanes at both KFE and London Array, with the London Array study also reporting reduced numbers up to 1km around them;
- **Proximity to the coast** also appeared to be a factor in reducing diver numbers, with lower numbers than expected found up to 5km from the coast;
- **Seabed sediment type and biotope** – divers showed a strong preference for sandy substrates and their associated biotope.

These previous analyses have been repeated here using the 2016-17 diver data, and to enable these habitat preferences to be taken into account whilst analysing the displacement effects of the wind farm on this key species.

4 BIRD SURVEY NUMBERS AND DISTRIBUTIONS

4.1 Survey Count Totals and Densities 2016-17

The raw count totals for the surveys from all of the 2016-17 survey data (including out of transect observations) are summarised in **Table 3**. This gives the total (uncorrected) numbers of each species counted during each survey.

The bird population estimates for the survey area for each survey, based on in-transect counts from the main survey transect sampling area (within 300m of the survey vessel) with a correction for distance sampling and survey coverage, are shown in **Table 4**.

Table 5 gives the density of each recorded during each survey, again based on the main 300m in-transect data.

Table 3. Survey area total raw bird counts during the October 2016 - March 2017 surveys.

Species	8 Nov	10Nov	23 Nov	30 Nov	6 Dec	16 Dec	5 Jan	17 Jan	6 Feb	17 Feb	7 Mar	28 Mar
Brent goose	37	0	0	0	0	0	1	0	0	0	0	7
Shelduck	0	1	0	0	0	0	0	0	8	0	0	0
Wigeon	1	0	0	0	0	0	0	0	0	0	0	0
Common Scoter	24	31	43	15	3	3	2	0	196	0	0	220
Velvet scoter	0	0	0	0	0	0	2	0	0	0	0	0
Goldeneye	0	0	0	1	0	0	0	0	0	0	0	0
duck sp	0	2	0	0	0	0	0	0	0	0	0	0
Red-throated diver	6	3	35	72	146	48	83	197	99	20	56	10
diver sp	2	2	1	29	24	13	19	43	26	32	3	27
Little grebe	0	0	0	0	1	0	0	0	0	0	0	0
Great Crested Grebe	1	0	0	1	2	1	0	0	1	0	0	0
Fulmar	0	0	0	0	0	0	0	0	1	0	0	0
Gannet	0	4	1	0	0	0	0	0	1	0	1	1
Cormorant	28	67	434	69	793	2558	75	251	10	17	22	104
Peregrine	1	1	0	0	0	0	0	0	1	0	1	0
Lapwing	0	50	0	0	0	0	0	0	0	0	0	0
plover sp	0	0	0	1	0	0	0	0	0	0	0	0
Dunlin	16	1	0	0	0	0	0	0	0	0	0	0
small wader sp	1	0	0	0	0	0	0	0	0	0	0	0
Great skua	0	0	0	0	0	0	1	0	0	0	1	0
Mediterranean gull	0	1	0	1	0	0	0	0	1	0	0	0
Common gull	27	33	43	24	32	29	20	112	60	91	19	3
Lesser black-backed gull	2	3	0	1	0	0	0	0	0	0	0	3
Herring gull	2	8	57	45	30	26	10	10	27	46	16	7
Great black-backed gull	38	45	98	209	81	120	25	25	18	13	40	22
Black-headed gull	10	0	2	4	2	0	2	1	10	10	1	0
Kittiwake	0	0	0	0	0	2	0	1	0	0	0	0
gull sp	0	0	0	0	200	0	500	0	0	0	250	0
large gull sp	2	0	5	150	2	0	1	0	0	1	3	0
Sandwich tern	0	0	0	0	0	0	0	0	0	0	0	2

Species	8 Nov	10Nov	23 Nov	30 Nov	6 Dec	16 Dec	5 Jan	17 Jan	6 Feb	17 Feb	7 Mar	28 Mar
Guillemot	0	0	0	1	3	5	4	0	0	0	0	0
Skylark	3	0	0	0	0	0	0	0	0	0	0	0
Meadow pipit	0	0	0	0	0	0	0	0	0	0	0	5
Blackbird	2	1	0	0	0	0	0	0	0	0	0	0
Starling	235	6	2	0	0	0	0	0	0	0	0	0
Chaffinch	3	0	0	0	0	0	0	0	0	0	0	0
small passerine sp	2	0	0	0	0	0	0	0	0	0	0	0
passerine sp	0	0	0	2	0	0	0	0	0	0	0	0

Table 4. Survey area total seabird population estimates corrected for distance sampling and survey coverage, October 2016 - March 2017 *Note: estimates based on 'in-transect' data only.*

Species	8 Nov	10Nov	23 Nov	30 Nov	6 Dec	16 Dec	5 Jan	17 Jan	6 Feb	17 Feb	7 Mar	28 Mar
Brent goose	25	0	0	0	0	0	0	0	0	0	0	14
Wigeon	4	0	0	0	0	0	0	0	0	0	0	0
Common Scoter	21	107	73	0	11	11	4	0	408	0	0	0
Velvet scoter	0	0	0	0	0	0	4	0	0	0	0	0
Red-throated diver	11	9	40	96	165	40	83	241	216	18	52	24
diver sp	0	0	0	9	14	4	7	11	34	8	2	95
Little grebe	0	0	0	0	4	0	0	0	0	0	0	0
Great Crested Grebe	0	0	0	0	0	4	0	0	4	0	0	0
Gannet	0	8	0	0	0	0	0	0	2	0	0	0
Cormorant	55	118	187	30	156	5055	137	792	22	9	39	83
Peregrine	2	0	0	0	0	0	0	0	2	0	2	0
Great skua	0	0	0	0	0	0	2	0	0	0	2	0
Mediterranean gull	0	2	0	0	0	0	0	0	0	0	0	0
Common gull	28	24	53	20	12	20	18	142	81	104	22	4
Lesser black-backed gull	2	0	0	0	0	0	0	0	0	0	0	2
Herring gull	2	6	41	43	18	26	10	10	26	41	20	2
Great black-backed gull	63	57	110	289	73	195	26	41	12	14	51	37
large gull sp	0	0	4	4	0	0	0	0	0	0	2	0
Kittiwake	0	0	0	0	0	2	0	2	0	0	0	0

Species	8 Nov	10Nov	23 Nov	30 Nov	6 Dec	16 Dec	5 Jan	17 Jan	6 Feb	17 Feb	7 Mar	28 Mar
Sandwich tern	0	0	0	0	0	0	0	0	0	0	0	4
Guillemot	0	0	0	4	7	16	13	0	0	0	0	0

Table 5. Survey area seabird population densities (birds per km^2) corrected for distance sampling and survey coverage, October 2016 - March 2017. *Note: as in Table 4 estimates based on 'in-transect' data only.*

Species	8 Nov	10Nov	23 Nov	30 Nov	6 Dec	16 Dec	5 Jan	17 Jan	6 Feb	17 Feb	7 Mar	28 Mar
Brent goose	0.20	0	0	0	0	0	0	0	0	0	0	0.12
Wigeon	0.03	0	0	0	0	0	0	0	0	0	0	0
Common Scoter	0.17	0.88	0.60	0	0.09	0.09	0.03	0	3.34	0	0	0
Velvet scoter	0	0	0	0	0	0	0.03	0	0	0	0	0
Red-throated diver	0.09	0.07	0.32	0.79	1.35	0.32	0.68	1.97	1.77	0.15	0.43	0.20
diver sp	0	0	0	0.08	0.12	0.03	0.06	0.09	0.28	0.06	0.02	0.78
Little grebe	0	0	0	0	0.03	0	0	0	0	0	0	0
Great Crested Grebe	0	0	0	0	0	0.03	0	0	0.03	0	0	0
Gannet	0	0.07	0	0	0	0	0	0	0.02	0	0	0
Cormorant	0.45	0.97	1.53	0.25	1.28	20.97	1.12	6.50	0.18	0.08	0.32	0.68
Peregrine	0.02	0	0	0	0	0	0	0	0.02	0	0.02	0
Great skua	0	0	0	0	0	0	0.02	0	0	0	0.02	0
Mediterranean gull	0	0.02	0	0	0	0	0	0	0	0	0	0
Common gull	0.23	0.20	0.43	0.17	0.10	0.17	0.15	1.17	0.67	0.85	0.18	0.03
Lesser black-backed gull	0.02	0	0	0	0	0	0	0	0	0	0	0.02
Herring gull	0.02	0.05	0.33	0.35	0.15	0.22	0.08	0.08	0.22	0.33	0.17	0.02
Great black-backed gull	0.52	0.47	0.90	2.37	0.60	1.60	0.22	0.33	0.10	0.12	0.42	0.30
large gull sp	0	0	0.03	0.03	0	0	0	0	0	0	0.02	0
Kittiwake	0	0	0	0	0	0.02	0	0.02	0	0	0	0
Sandwich tern	0	0	0	0	0	0	0	0	0	0	0	0.03
Guillemot	0	0	0	0.03	0.06	0.13	0.10	0	0	0	0	0

4.2 Key Species Distributions

The distribution of the key species that were present in notable numbers during the October 2016 - March 2017 surveys (divers, cormorant, common gull, herring gull and great black-backed gull) are shown in **Figures 3-7**.

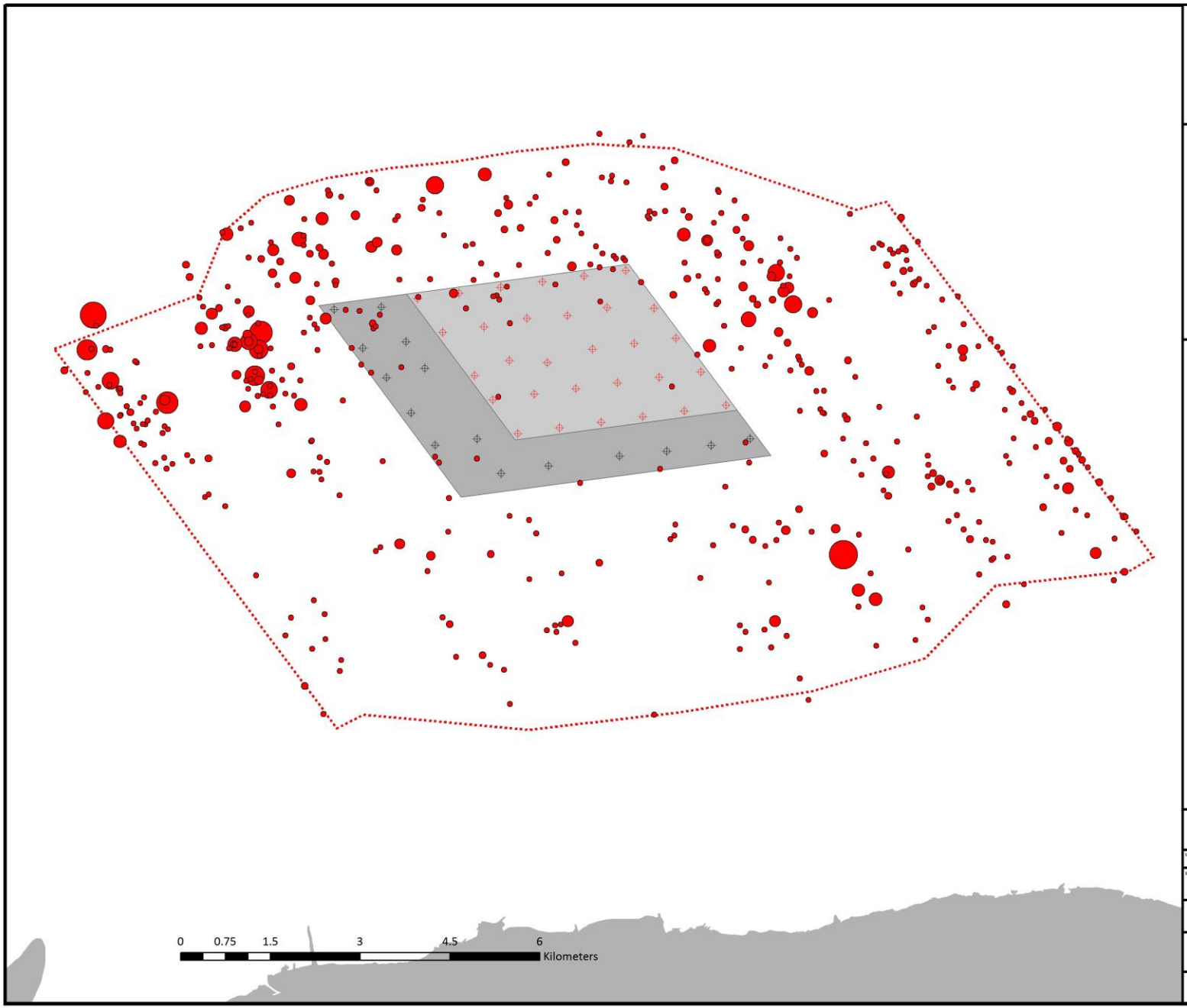
Divers (**Figure 3**) were widely distributed over the whole survey area, with the exception of the original Kentish Flats wind farm, from which they were largely absent (as found in previous post-construction surveys of that wind farm, Percival 2014, and in the 2014-15 pre-construction surveys, Percival and Ford 2015) and also from the KFE area too (as found in the previous post-construction surveys in 2015-16). Simple visual analysis of this mapping would suggest that the displacement observed previously from the Kentish Flats wind farm has also now been repeated at KFE (though further statistical analysis on this is presented below). As in previous surveys, these divers were predominantly red-throated divers (this was the only diver species identified in 2016-17).

Cormorants were widely distributed, including within the wind farm, with several larger flocks seen during the surveys, particularly in the southern part of the survey area (**Figure 4**).

All three gull species (**Figures 5-7**) had a similar widespread and generally even distribution across the survey area, as in previous years.

Further analysis of the spatial distribution of these birds in relation to the Kentish Flats and the KFE wind farm sites is presented in section 6 below.

One additional species of note was recorded during the 2016-17 surveys, peregrine. Though not a species usually associated with offshore habitats, there were four sightings of this species during the surveys, including two records of individuals perched on turbine bases. There were also two larger flocks of common scoter recorded than previously, one of 190 on 6/2/17 and one of 220 on 28/3/17, though both were seen on the western edge of the survey area (approximately 4km from the nearest wind turbine).



VATTENFALL

Kentish Flats Offshore Wind Farm Extension

FIGURE 3

Distribution and abundance of divers during winter 2016-17

KEY:

Number

- 1
- 5
- 10
- KFE turbines
- Kentish Flats turbines
- Survey area
- KFE wind farm
- Kentish Flats wind farm

ECOLOGY CONSULTING

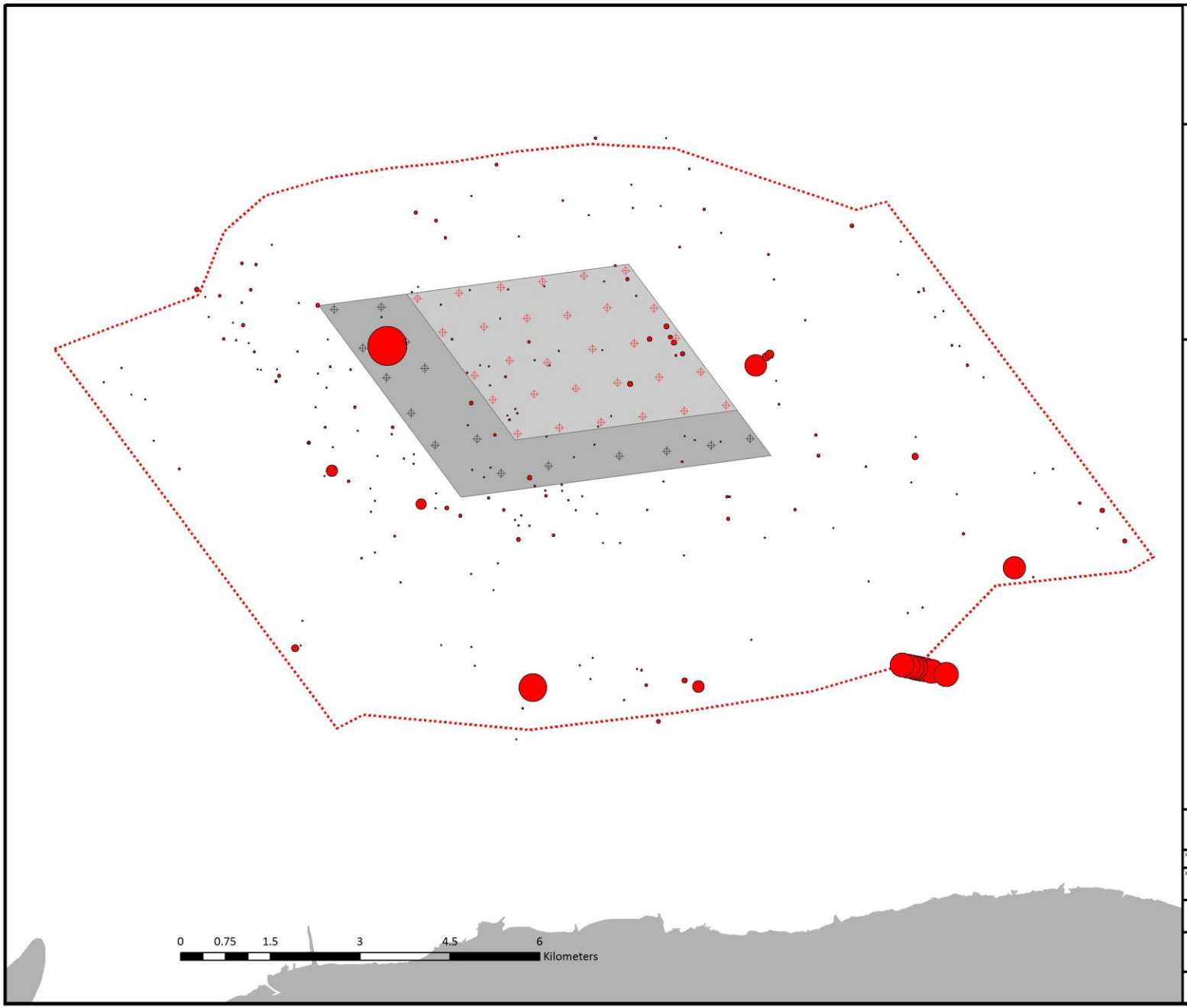
N

LAYOUT DWG N/A | T-LAYOUT NO. N/A

DRAWING NUMBER OFF2017-1

SCALE - 1:60,000 @ A3

KENTISH FLATS EXTENSION MONITORING 2016-17



VATTENFALL

Kentish Flats Offshore Wind Farm Extension

FIGURE 4

Distribution and abundance of Cormorants during winter 2016-17

KEY:

Number

1

10

1,000

KFE turbines

Kentish Flats turbines

Survey area

KFE wind farm

Kentish Flats wind farm

ECOLOGY CONSULTING

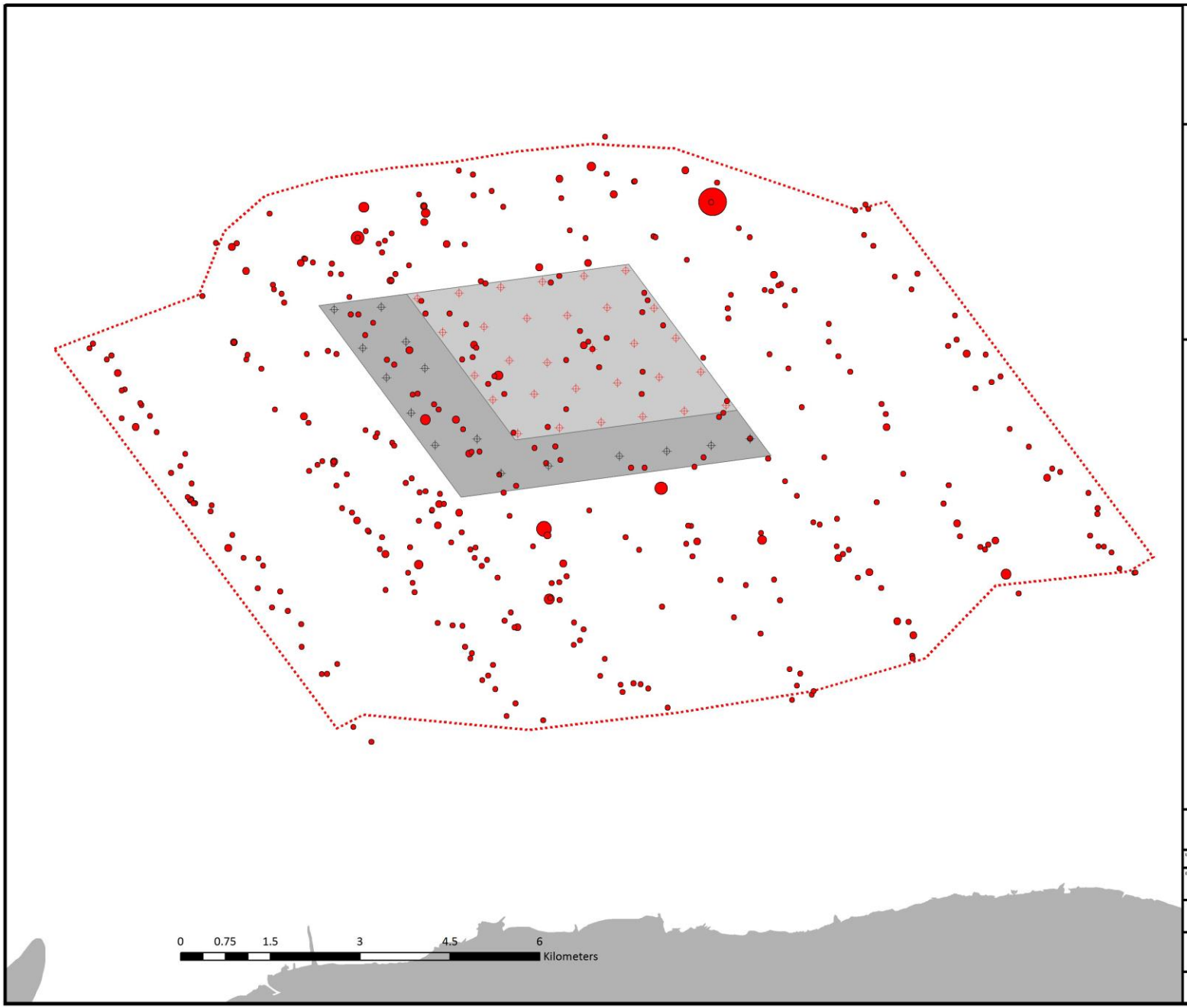
N

LAYOUT DWG N/A | T-LAYOUT NO. N/A

DRAWING NUMBER OFF2017-1

SCALE - 1:60,000 @ A3

KENTISH FLATS EXTENSION MONITORING 2016-17



VATTENFALL

Kentish Flats Offshore Wind Farm Extension

FIGURE 5

Distribution and abundance of Common Gulls during winter 2016-17

KEY:

Number

- 1
- 5
- 10
- KFE turbines
- Kentish Flats turbines
- Survey area
- KFE wind farm
- Kentish Flats wind farm

ECOLOGY CONSULTING

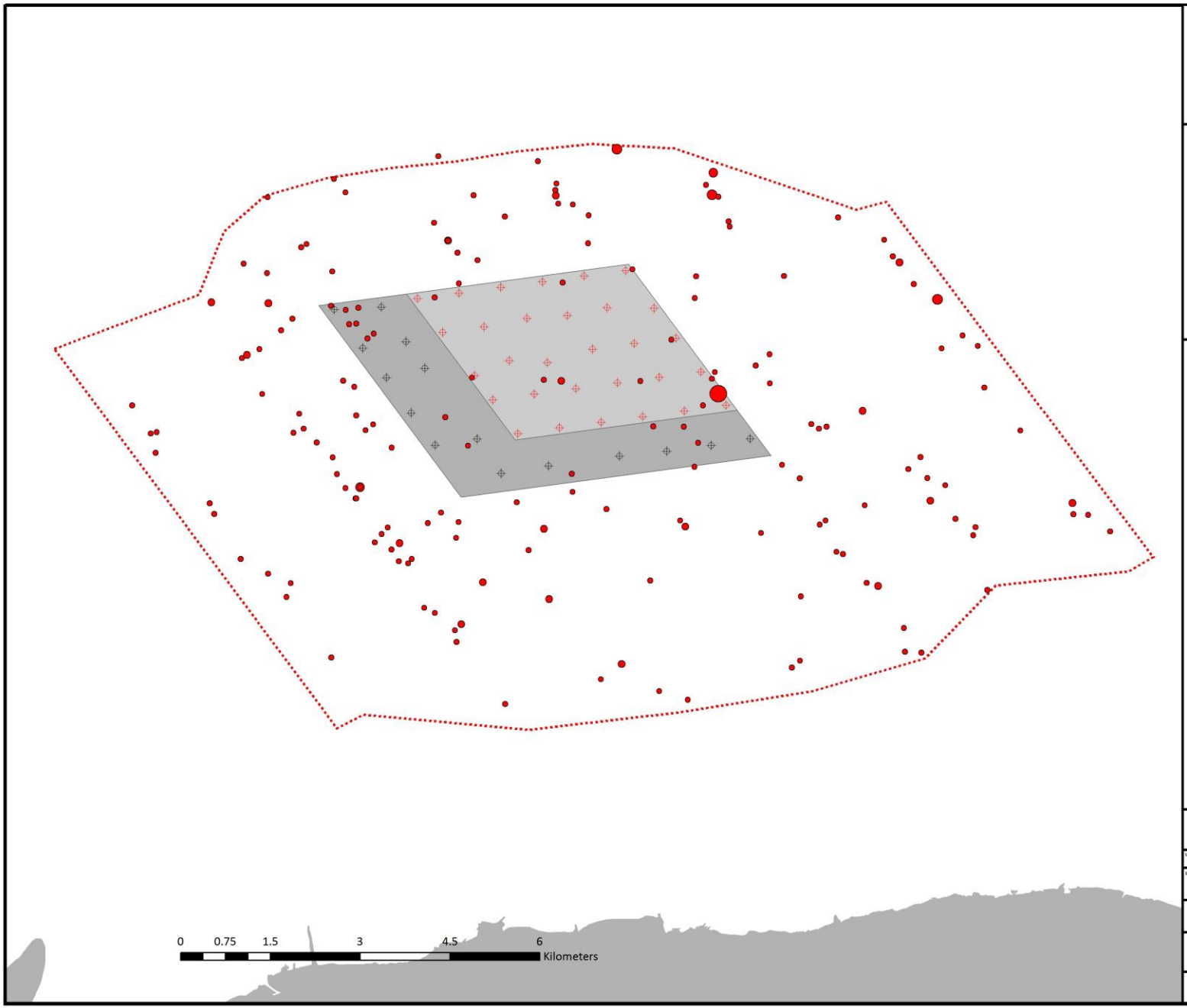
N

LAYOUT DWG N/A | T-LAYOUT NO. N/A

DRAWING NUMBER OFF2017-1

SCALE - 1:60,000 @ A3

KENTISH FLATS EXTENSION MONITORING 2016-17



VATTENFALL

Kentish Flats Offshore Wind Farm Extension

FIGURE 6

Distribution and abundance of Herring Gulls during winter 2016-17

KEY:

Number

- 1
- 5
- 10
- KFE turbines
- Kentish Flats turbines
- Survey area
- KFE wind farm
- Kentish Flats wind farm

ECOLOGY CONSULTING

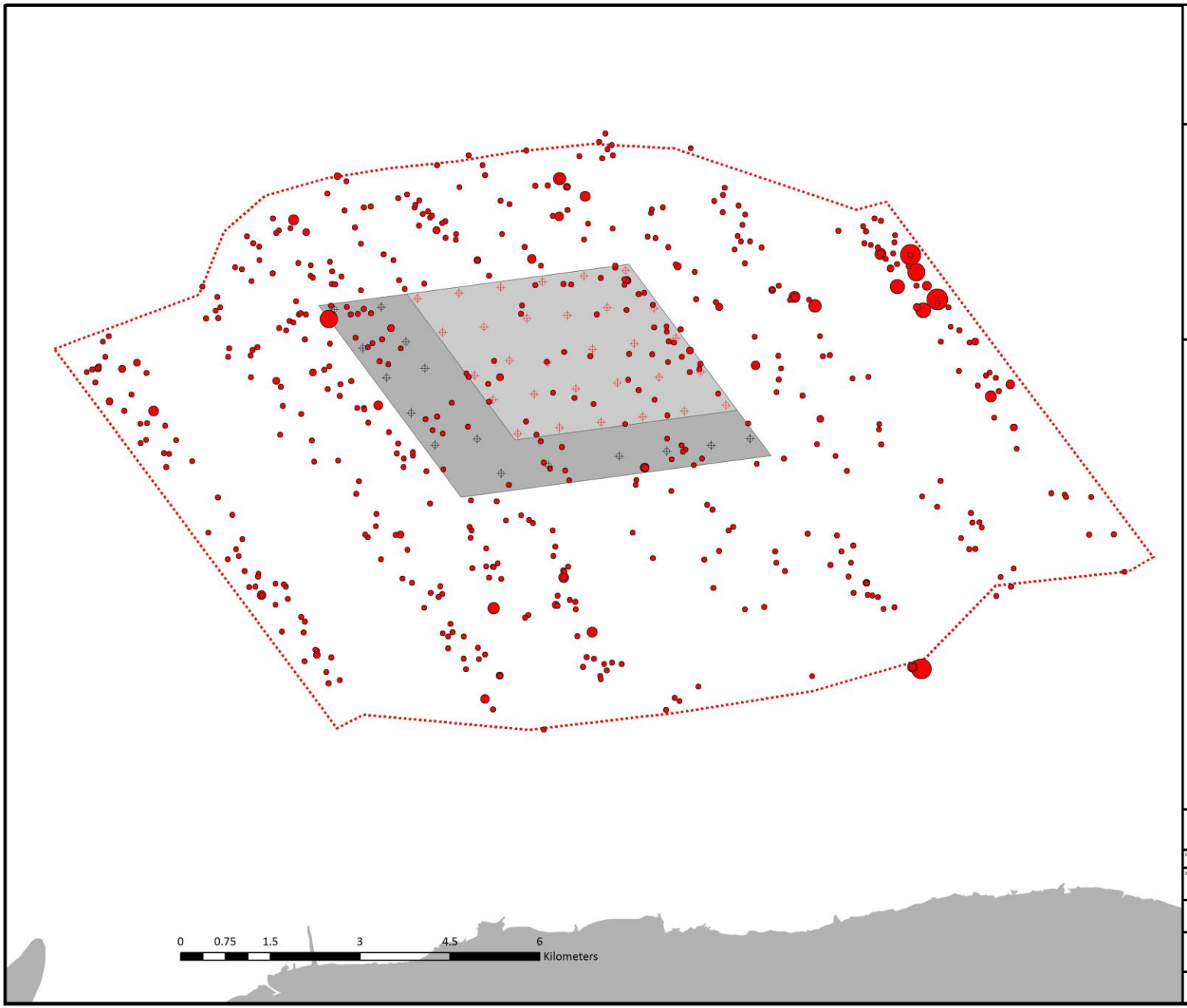
N

LAYOUT DWG N/A | T-LAYOUT NO. N/A

DRAWING NUMBER OFF2017-1

SCALE - 1:60,000 @ A3

KENTISH FLATS EXTENSION MONITORING 2016-17



VATTENFALL

Kentish Flats Offshore Wind Farm Extension

FIGURE 7

Distribution and abundance of GBB Gulls during winter 2016-17

KEY:

Number

- 1
- 5
- 10
- KFE turbines
- Kentish Flats turbines
- Survey area
- KFE wind farm
- Kentish Flats wind farm

ECOLOGY CONSULTING

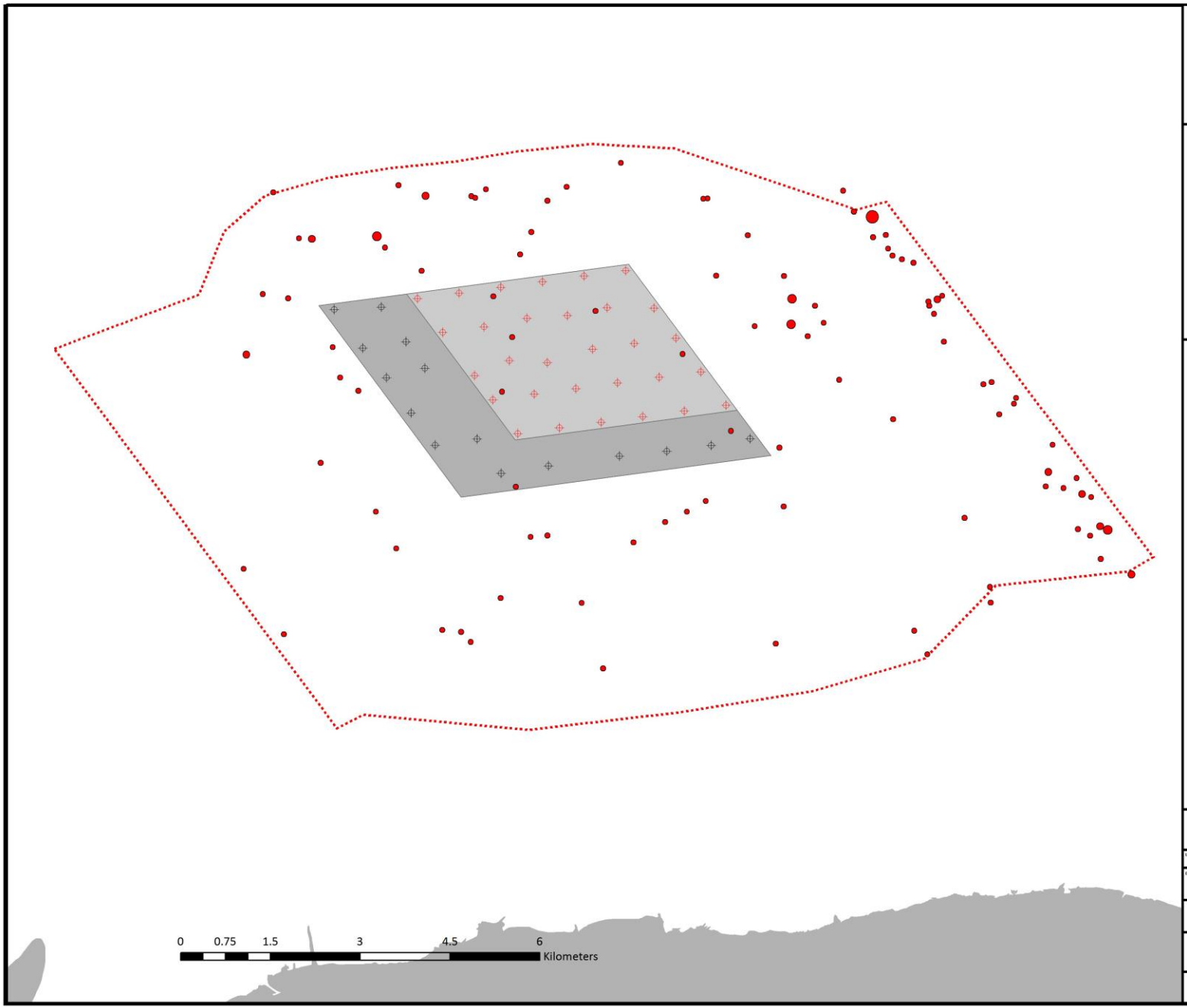
N

LAYOUT DWG N/A | T-LAYOUT NO. N/A

DRAWING NUMBER OFF2017-1

SCALE - 1:60,000 @ A3

KENTISH FLATS EXTENSION MONITORING 2016-17



VATTENFALL

Kentish Flats Offshore Wind Farm Extension

FIGURE 8

Distribution and abundance of grey seals during winter 2016-17

KEY:

Number

- 1
- 5
- 10
- KFE turbines
- Kentish Flats turbines
- Survey area
- KFE wind farm
- Kentish Flats wind farm

ECOLOGY CONSULTING

N

LAYOUT DWG N/A | T-LAYOUT NO. N/A

DRAWING NUMBER OFF2017-1

SCALE - 1:60,000 @ A3

KENTISH FLATS EXTENSION MONITORING 2016-17

4.3 Bird Flight Activity within the KFE collision risk zone

The bird flight activity within the KFE collision risk zone (taken as the KFE footprint, as now built plus a 200m buffer) is summarised in **Table 6**. This gives the mean count of birds seen flying within this zone ('in-transect'), the percentage of flocks observed at rotor height (again derived from the boat survey data), which are combined to give the estimated mean numbers flying at rotor height, for 2016-17 and for the two previous winters. The percentage of flying birds recorded at rotor height included all records of flying birds where height was recorded, in order to maximise the sample size. This overall percentage value was then applied to the number of flying birds in transect within the collision risk zone.

Table 6 also shows flight heights published by Johnston *et al*. (2014) in a review of data from 40 wind farm sites, for comparison.

Table 6. Bird numbers and flight behaviour within the KFE wind farm (as built) from the boat survey data, and the number flying at risk height.

Species	Mean density flying in wind farm 2014-15	Mean density flying in wind farm 2015-16	Mean density flying in wind farm 2016-17	% of flying birds at rotor height 2014-15	% of flying birds at rotor height 2015-16	% of flying birds at rotor height 2016-17	Johnston *et al*. 2014 % flights at rotor height
Red-throated diver	0.059	0.012	0.043	2.0%	5.6%	5.3%	6.2%
Unidentified diver sp	0.012	0	0	1.9%	-	-	-
Cormorant	0.024	0.166	0.064	4.6%	3.6%	4.5%	-
Common gull	0.142	0.107	0.114	25.6%	29.3%	27.9%	22%
Lesser black-backed gull	0.012	0	0	51.2%	-	-	28%
Herring gull	0.119	0.047	0.057	28.6%	28.8%	28.0%	32%
Great black-backed gull	0.261	0.154	0.171	47.0%	42.3%	46.1%	33%
Black-headed gull	0	0.036	0.007	8.1%	5.0%	6.9%	-
Kittiwake	0	0.012	0	27.8%	2.4%	-	15%
Unidentified large gull sp	0.012	0.012	0	0.0%	61.1%	-	-
Razorbill	0.012	0	0	0.0%	0.0%	-	2.7%
Peregrine	0	0	0.007	-	-	100%	-
Skylark	0.024	0	0	0.0%	0.0%	-	-
Starling	0.237	0.344	0.107	0.0%	0.0%	0.0%	-

Flight activity within the collision risk zone was generally low again for most species in 2016-17, including divers, herring gull and great black-backed gull.

Key species at risk of collision (i.e. those observed flying through the wind farm site at rotor height) comprised red-throated diver, cormorant, common gull, herring gull, great black-

backed gull, black-headed gull and kittiwake. Collision risk modelling was undertaken for these species and is presented below.

Unidentified species were allocated to species for collision modelling according to the proportions of identified birds of each main taxonomic group on each survey.

5 MARINE MAMMALS

The raw numbers of marine mammals recorded during each survey are shown in **Table 7**. As in previous surveys there were occasional sightings of harbour porpoise and common seal (in very low numbers), and regular sightings of grey seal (in higher numbers than in previous years; peaks of only 13 and 12 were recorded in the two previous winters' surveys). Peak counts in 2016-17 were 2 harbour porpoises, 1 common seal and 53 grey seals. The distribution of grey seals recorded during 2016-17 is shown in **Figure 8**. They were widely distributed across the survey area, but were more frequently encountered in the eastern part.

Table 7. Survey area marine mammal counts during each of the October 2016 - March 2017 surveys.

Species	8 Nov	10Nov	23 Nov	30 Nov	6 Dec	16 Dec	5 Jan	17 Jan	6 Feb	17 Feb	7 Mar	28 Mar
Common seal	0	0	1	1	0	0	0	0	0	0	0	0
Grey seal	3	6	4	12	17	53	3	4	9	9	0	1
Harbour porpoise	0	0	0	0	0	0	0	0	2	0	0	0

6 SPATIAL ANALYSIS OF KEY SPECIES DISTRIBUTIONS: DISTURBANCE EFFECTS

This section of the report focusses on the species for which there were sufficient numbers present in the impact zone of the wind farm in order to obtain meaningful results. This included red-throated diver, the species of primary conservation importance at this site (as identified in the ES), together with cormorant, common gull, herring gull and great black-backed gull.

The key questions addressed for these species by these spatial analyses were as follows:

- How have numbers changed within the KFE wind farm site since construction of the wind farm?
- How do these numbers compare with those in the wider survey area?
- Is there any evidence for any displacement beyond the KFE wind farm itself, and if so over what spatial extent did this occur?
- What are the cumulative displacement effects of KFE in combination with the original Kentish Flats wind farm?

Each of the above key species is discussed in turn.

Red-throated Diver

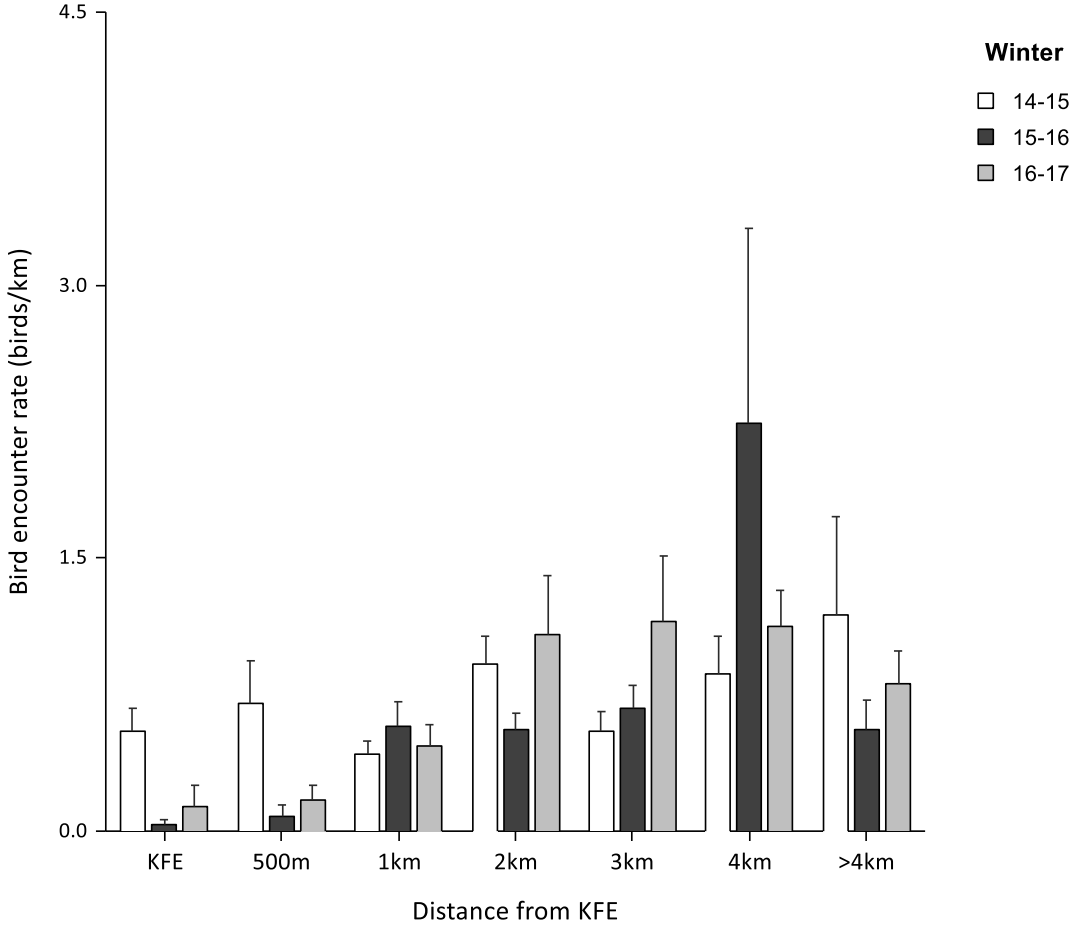
Divers were almost completely absent from the KFE in 2015-16 in the first winter after construction, whilst they had been recorded frequently (albeit in relatively low numbers) there in the previous winter prior to construction (Percival and Ford 2015). In 2016-17 (**Figure 3**) there were more records around the fringes of the wind farm than in the previous year. The mean encounter rate (number seen per km per survey) dropped from 0.55 in 2014-15 prior to construction, to 0.03 in the first post-construction winter, a reduction of 95% within the wind farm site. In 2016-17 the encounter rate increased to 0.13, equivalent to a reduction of 76% on the 2014-15 pre-construction baseline. It is clear therefore just looking at the raw data that there has been a substantial decline in diver numbers within the KFE site following construction of the wind farm, but the magnitude of that decline was less in the second year after construction than in the first.

There was a similarly low diver encounter rate within the original Kentish Flats wind farm in all three survey winters; 0.07 in 2014-15, zero in 2015-16 and 0.15 in 2015-16.

The data have been analysed to determine whether there is any evidence for any effects beyond the KFE wind farm itself, and if so over what spatial extent. Previous analysis of the original Kentish Flats wind farm reported in the KFE ES (Percival *et al*. 2011) found a proportionate reduction of 81% of diver numbers within the wind farm site, 53% within 500m and 29% within 1km, and a worst-case assessment of a decrease by 94% in the wind farm, 83% within 500m, 77% within 1km and 59% within 2km. The mean (and standard error) encounter rates in distance zones from KFE in 2014-15, 2015-16 and 2016-17 are shown in **Figure 9**. In order to distinguish between the effects of KFE and the Kentish Flats wind farm, these distance zones used in the analysis (see **Figure 2b**) have excluded the parts of the survey area in closer proximity to the original Kentish Flats wind farm from the analysis, so that in these Figures (and associated statistical analyses) it is KFE that is having the primary effect on these zones.

A test of the null hypothesis of no difference in diver encounter rate in 2016-17 between these distance zones was carried out using Kruskall-Wallis ANOVA. This analysis rejected that null hypothesis, indicating a statistically significant difference in diver encounter rate between the different zones (χ^2=35.3, 6df, p<0.001). Post-hoc Dunn's tests showed that the significant differences that contributed to this overall effect were between the KFE/500m buffer (which held statistically significantly fewer divers) and the other more distant zones. It is clear from this initial analysis that there has been a substantial reduction in diver numbers within the KFE site, with displacement apparent up to 500m outside the wind farm as well. Diver numbers outside this 500m zone seemed from this initial analysis to be little different between the three winters. A similar result was found in 2015-16 (χ^2=28.6, 6df, p<0.001).

***Figure 9**. Diver encounter rates in each of the KFE distance zones (excluding zones within and closer to the original Kentish Flats wind farm), in 2014-15 (before construction), and in 2015-16 and 2016-17 (after construction). Mean and standard error shown.*



Carrying out the same test for the 2014-15 data, prior to construction of the KFE, did not find any statistically significant difference in the diver encounter rate between the distance zones (χ^2=4.9, 6df, p=0.55). This further highlights that the differences observed in 2015-16 and 2016-17 (i.e. the reduced diver encounter rates within KFE and within a 500m buffer) were likely to have resulted from the presence of the wind farm. Given the location of KFE immediately adjacent to the southern and western edges of the original Kentish Flats wind farm, some reduction within the KFE zone may have been expected, but the separation from the original Kentish Flats turbines (median 700m, range 100-900m) was such that no significant depression in diver numbers was apparent in that zone in 2014-15.

Further analysis was undertaken of the change in diver encounter rate between the pre-construction (2014-15) and each post-construction year (2015-16 and 2016-17), testing null hypothesis of zero change in median diver encounter rate between these distance zones. Kruskall-Wallis ANOVA was again used. The 2015-16 analysis gave a clear rejection of that null hypothesis, indicating a statistically significant difference in the change in diver encounter rate between the different zones (2015-16; χ^2=16.6, 6df, p=0.01). Post-hoc Dunn's tests showed that the significant differences that contributed to this overall effect were between the KFE and 500m zones, which held statistically significantly greater reduction in diver encounter rate than the 1km, 3km and 4km zones (which did not differ significantly from each other). In 2016-17 the trend was consistent with the previous year's

results, but higher variability in the data meant that the result was not statistically significant (χ^2=10.7, 6df, p=0.099). These results are summarised in **Figure 10**, which gives the median change in diver encounter rate for each distance zone.

***Figure 10a**. Change in diver encounter rates in each of the KFE wind farms distance zones, between 2014-15 (prior to construction) and 2015-16 (first after construction).*

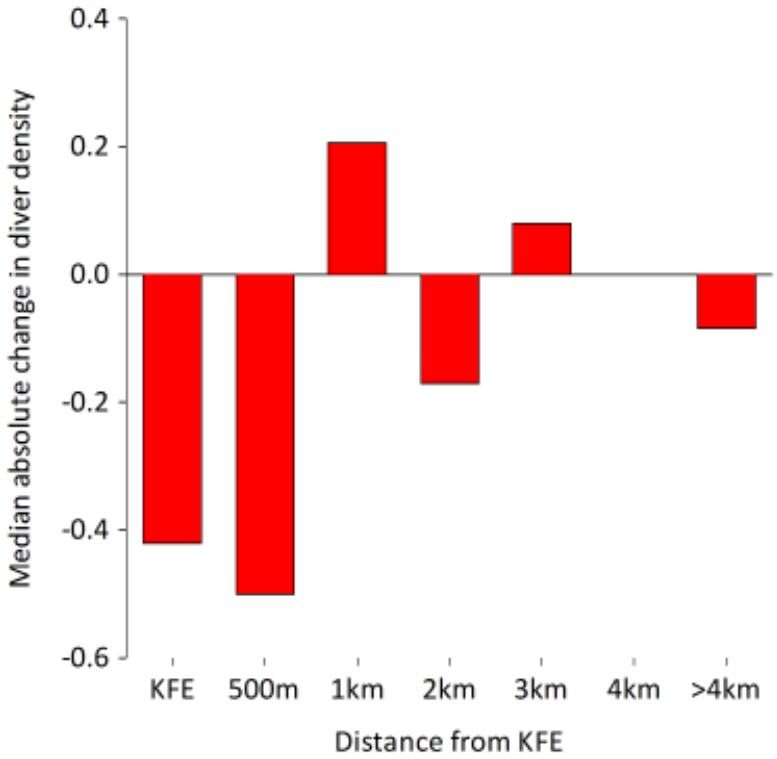
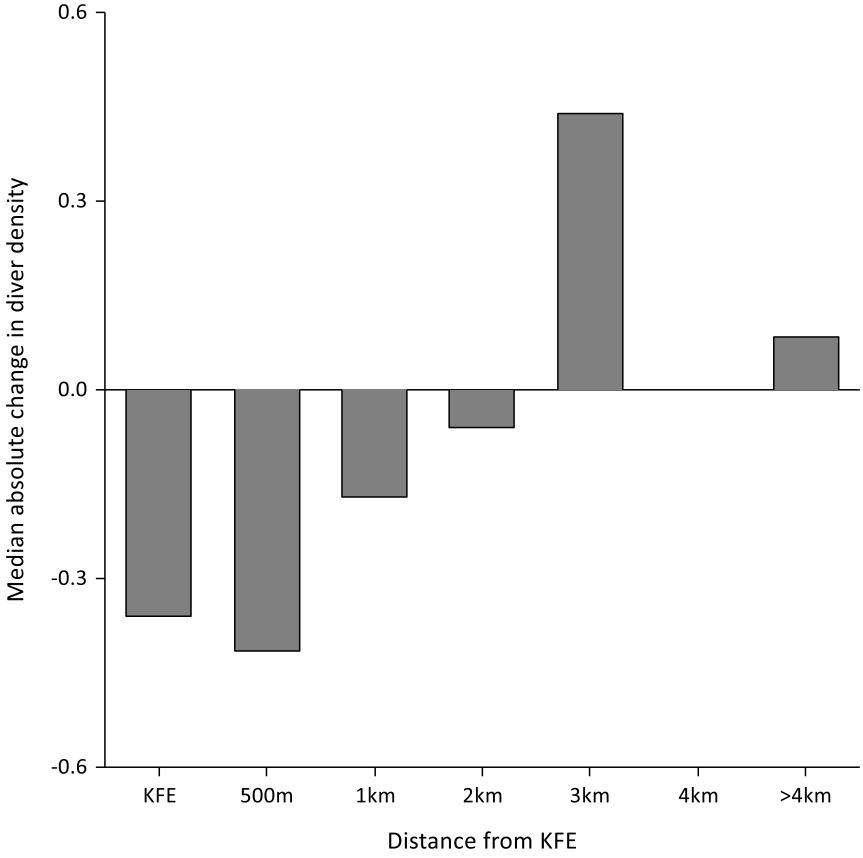


***Figure 10b**. Change in diver encounter rates in each of the KFE wind farms distance zones, between 2014-15 (prior to construction) and 2016-17 (second winter after construction).*



Cumulative Disturbance

The cumulative disturbance effect of KFE and the original Kentish Flats wind farm were explored by examining the diver encounter rates in distances zones around the two wind farms together and carrying out a gradient analysis using the 2016-17 data.

These results are summarised in **Figures 11a** (2015-16) and **11b** (2016-17), which give the mean (and standard error) diver encounter rate for each distance zone around the combined (KFE plus original Kentish Flats) wind farm for each winter. A test of the null hypothesis of no difference between these distance zones was carried out using Kruskall-Wallis ANOVA. This analysis rejected that null hypothesis in both years, indicating a statistically significant difference in diver encounter rate between the different zones (2015-16; χ^2=57.7, 6df, p<0.01: 2016-17; χ^2=28.3, 6df, p<0.01). Post-hoc Dunn's tests showed that the significant differences that contributed to this overall effect were between the combined wind farm (WF) and 500m zones in both years. The 3-4km distance zone from the turbines did support the highest diver encounter rate in 2015-16, though this was a result of a small number of larger flocks observed there in that winter. Diver densities were very similar across the 1km, 2km, 3km and >4km zones in 2015-16, and across all of the zones >500m from the wind farms in 2016-17.

***Figure 11a**. Diver encounter rates in each of the combined Kentish Flats and KFE wind farms distance zones, 2015-16 (after construction).*

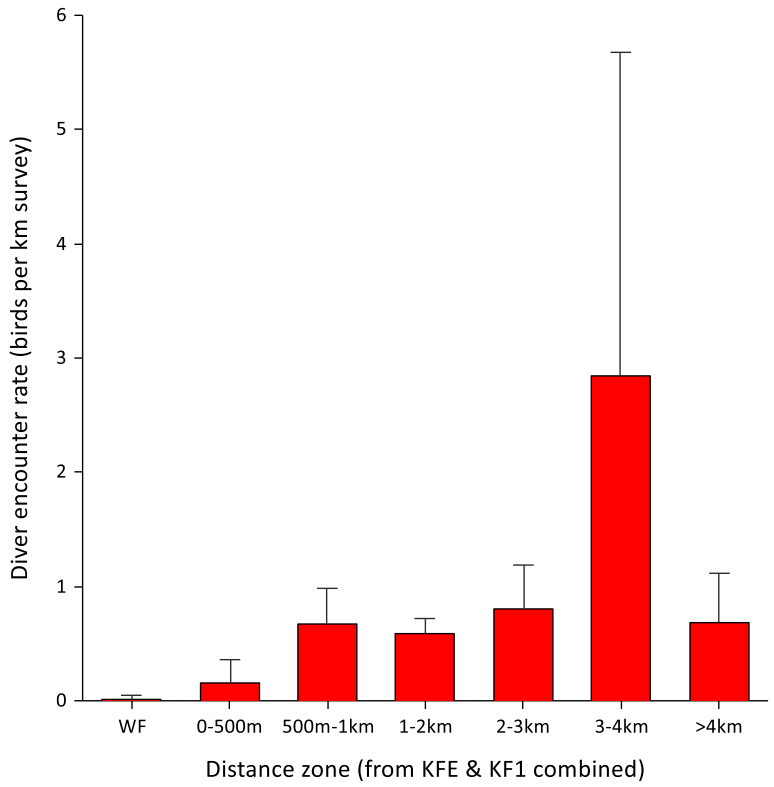
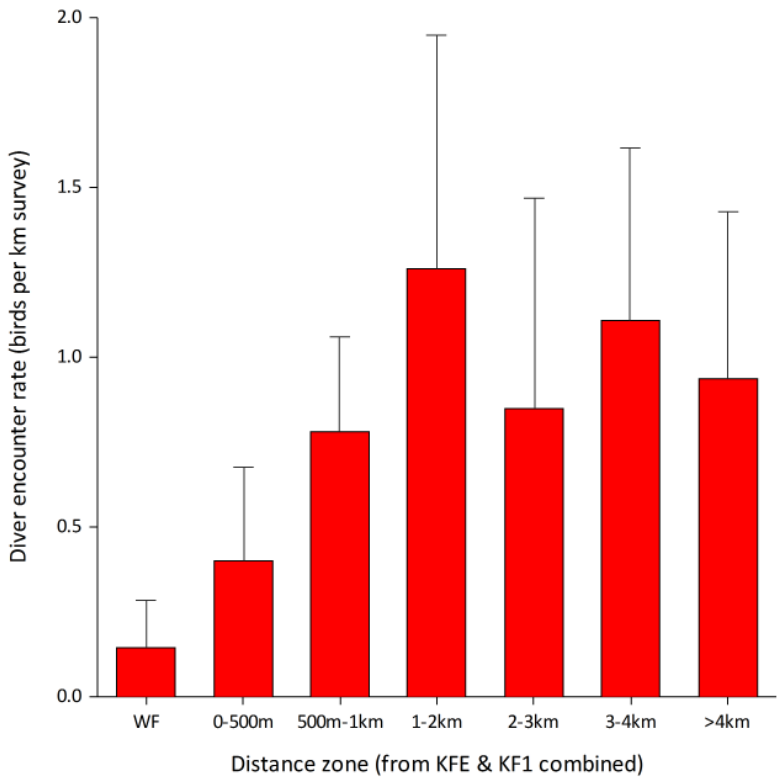


***Figure 11b**. Diver encounter rates in each of the combined Kentish Flats and KFE wind farms distance zones, 2016-17 (after construction).*



In order to further understand the effects of the wind farm(s) on the diver distribution and abundance, the changes in numbers and distribution were investigated in the context of the other factors affecting diver numbers. This followed the same approach as used in the KFE ES (Appendix 9.2), exploring the relationships between water depth, distance from main shipping lanes, proximity to the coast, and seabed sediment type/biotope and observed diver density. The results of the univariate analyses are shown in **Figures 12-15**. As previously, areas with shallower water did support higher diver abundance (**Figure 12**), but there was a less marked preference for sandier substrates in 2016-17 (**Figure 13**), though, as indicated by the larger standard error bars, there was high variability in the data.

Latitude and longitude were also used in the model to take into account any spatial correlation.

***Figure 12**. Diver encounter rate in 2015-16 and water depth within the KFE survey area.*

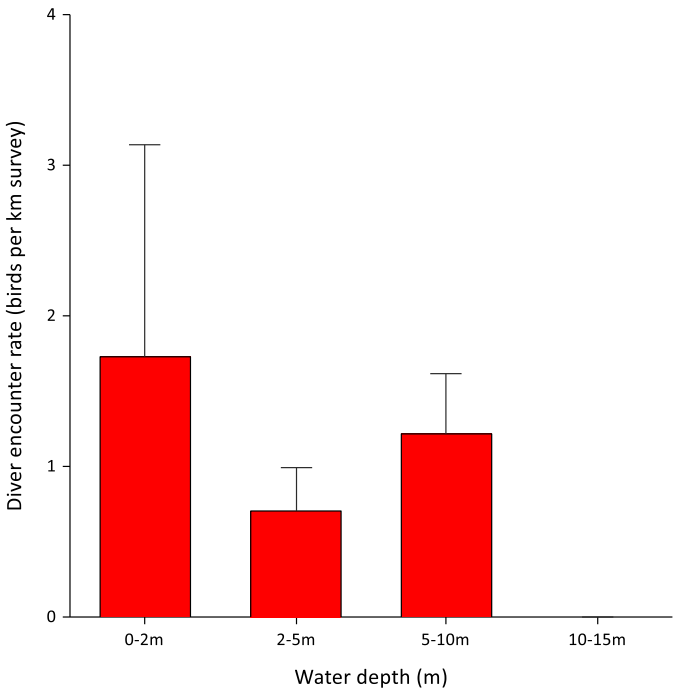
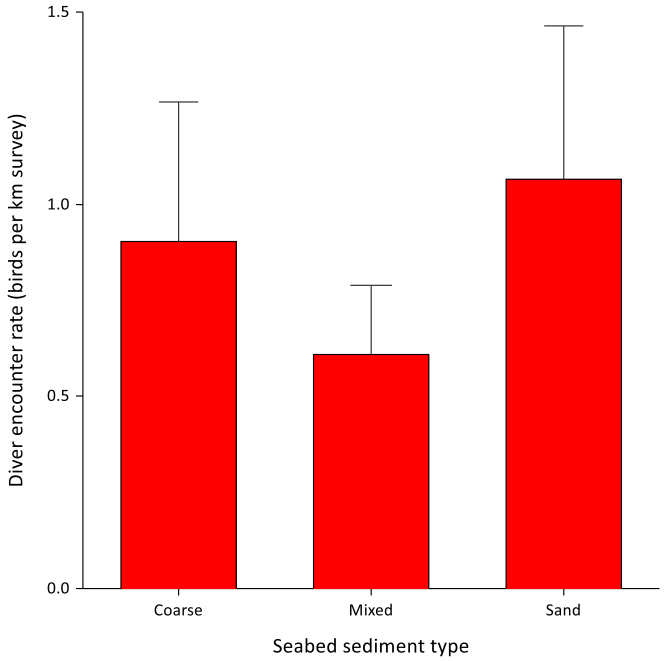


***Figure 13**. Diver encounter rate in 2015-16 and seabed sediment type within the KFE survey area.*



The relationship between distance from the shore and diver encounter rates was again weak and not statistically significant (Spearman rank correlation r_s= 0.13 respectively, p>0.05 in both cases), as in 2015-16. However, there was a statistically significant negative correlation between diver encounter rate in 2016-17 and distance from the main shipping channel, though this was a negative one (r_s= -0.32 p<0.001), indicating higher encounter rates closer to the main shipping channel. Scatter plots of the results are shown in **Figures 14 and 15** respectively. The three highest diver encounter rates have been omitted from these figures for clarity.

***Figure 14**. Diver encounter rate in 2016-17 and distance from the main shipping channel within the KFE survey area.*

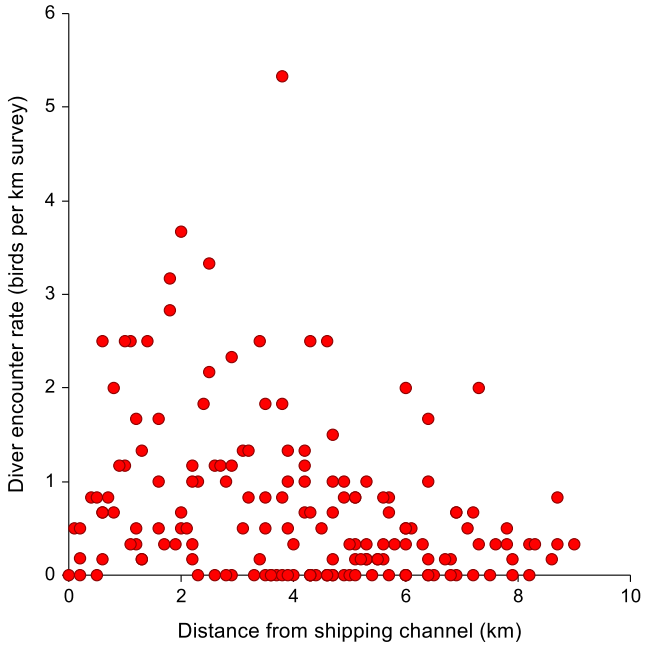
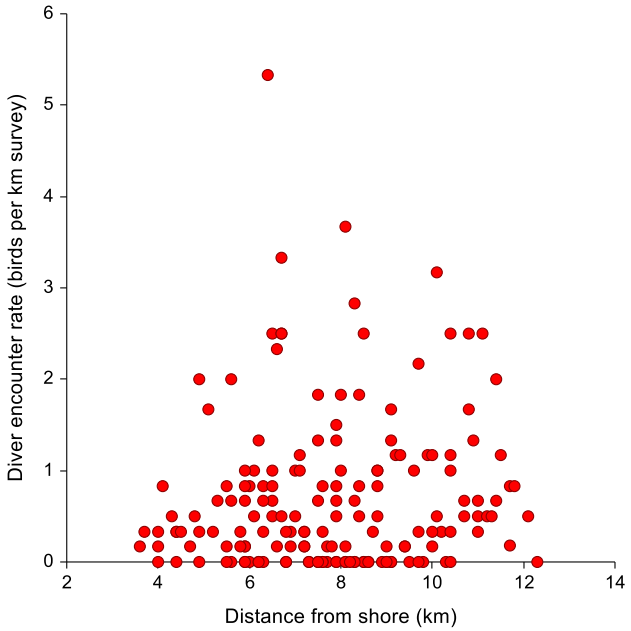


***Figure 15**. Diver encounter rate in 2016-17 and distance from the shore within the KFE survey area.*



The last stage of the assessment was to model diver density in relation to these environmental variables to provide further insight into the observed displacement effects. Generalised Least Squares (GLS) modelling of the diver encounter rate data was used initially for this, but it failed to detect any statistically significant difference in diver encounter rate between zones ($p>0.05$) even when just tested as single explanatory variable and allowing for data heterogeneity and spatial autocorrelation. Further

investigation of the data showed that this result was strongly affected by a small number of distant outliers (locations where a small number of larger diver flocks were seen). As an alternative approach, therefore, robust regression analysis was undertaken, as this is a statistical technique that is less sensitive to outliers (NCSS 2016). Sea depth class, seabed sediment type, latitude and longitude included in the analysis as well as the KFE distance zone, as for the 2015-16 analysis. This gave a similar result to the initial non-parametric analyses, with diver encounter rates significantly higher than KFE more than 500m from the wind farm. The full model results details are given in **Table 8**. This analysis provides further support to the initial conclusions reached from the non-parametric ANOVA, i.e. that the KFE distances zones more than 500m from the wind farm held statistically significantly more divers than the KFE site and its 500m buffer. The same conclusion was reached from the 2015-16 data.

Table 8. Results of the robust regression analysis of the 2016-17 diver encounter rates with sea depth, seabed sediment type, latitude, longitude and KFE distance zone.

Independent Variable	Regression coefficient	Standard error	Standardised coefficient	T-statistic	Probability level	Reject null H_o at 5%?
Intercept	-1975.7	266.2	0.00	-7.42	0.000	Yes
Depth 2-5m	-0.34	0.20	-0.19	-1.67	0.098	No
Depth 5-10m	-0.63	0.22	-0.31	-2.82	0.006	Yes
Latitude	38.42	5.17	0.79	7.43	0.000	Yes
Longitude	-0.53	0.91	-0.04	-0.58	0.561	No
Seabed mixed	0.08	0.14	0.04	0.55	0.581	No
Seabed sand	-0.07	0.17	-0.04	-0.42	0.678	No
Zone KFE 500m	0.27	0.24	0.09	1.13	0.263	No
Zone KFE 1km	0.46	0.20	0.22	2.28	0.025	Yes
Zone KFE 2km	0.89	0.20	0.53	4.53	0.000	Yes
Zone KFE 3km	1.43	0.24	0.55	5.99	0.000	Yes
Zone KFE 4km	1.51	0.22	0.76	6.99	0.000	Yes
Zone KFE >4km	1.60	0.25	0.71	6.52	0.000	Yes

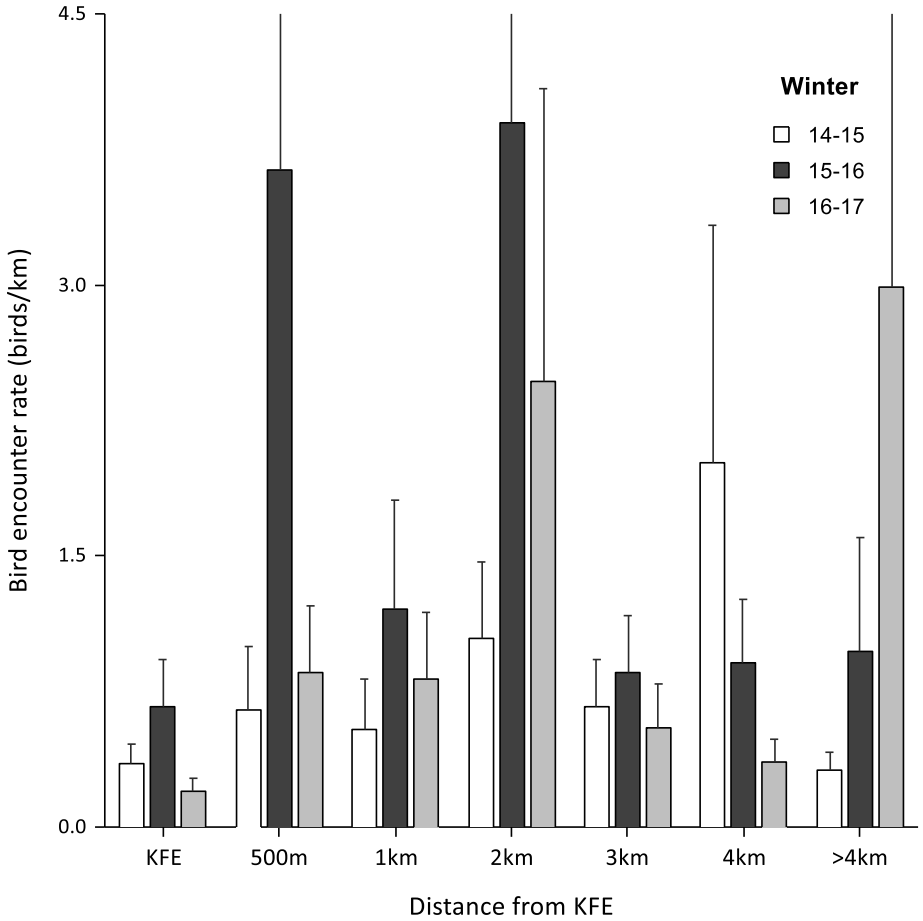
Cormorant

Cormorant numbers were high again over most of the survey area, as in the first winter after construction of KFE (**Figure 16**), particularly in the 1-2km zones and >4km zones. Similar results were found in the previous winter and for the original Kentish Flats wind farm.

The data have been analysed to determine whether there is any evidence for any effects of the KFE wind farm, and if so over what spatial extent. The mean (and standard error) encounter rates in distance zones from KFE are shown in **Figure 16**. In order to distinguish between the effects of KFE and the Kentish Flats wind farm, these bands have excluded the parts of the survey area in closer proximity to the original Kentish Flats wind farm from the analysis, so that in these Figures it is KFE that is having the primary effect on these zones.

A test of the null hypothesis of no difference in cormorant encounter rate between these distance zones was carried out using Kruskall-Wallis ANOVA. This analysis did not reject that null hypothesis, indicating no statistically significant difference in cormorant encounter rate between the different zones in 2016-17(χ^2=5.3, 6df, p=0.51). This adds further support to the conclusion that this species was not adversely affected by the KFE. A very similar result was found in 2015-16.

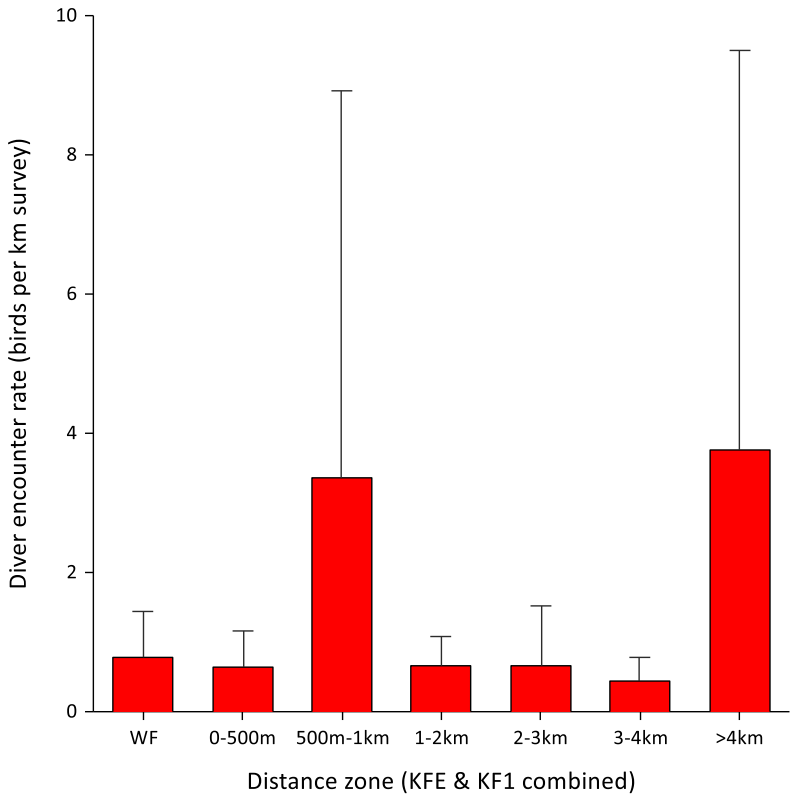
***Figure 16**. Cormorant encounter rates in each of the KFE distance zones, 2014-15 (before construction), and 2015-16 and 2016-17 (after construction).*



Carrying out the same test for the 2014-15 data, prior to construction of the KFE, also did not find any statistically significant difference in the cormorant encounter rate between the distance zones (χ^2=8.0, 6df, p=0.24).

The cumulative disturbance effect of KFE and the original Kentish Flats wind farm were explored by examining the cormorant encounter rates in distances zones around the two wind farms together and carrying out a gradient analysis using the 2016-17 data. These results are summarised in **Figure 17**, which gives the mean (and standard error) cormorant encounter rate for each distance zone around the combined (KFE plus the original Kentish Flats) wind farm. A test of the null hypothesis of no difference between these distance zones was carried out using Kruskall-Wallis ANOVA. No statistically significant difference in cormorant encounter rate between the different zones was found (χ^2=1.9, 6df, p=0.93), as in 2015-16.

***Figure 17**. Cormorant encounter rates in each of the combined Kentish Flats and KFE wind farms distance zones, 2016-17 (after construction).*



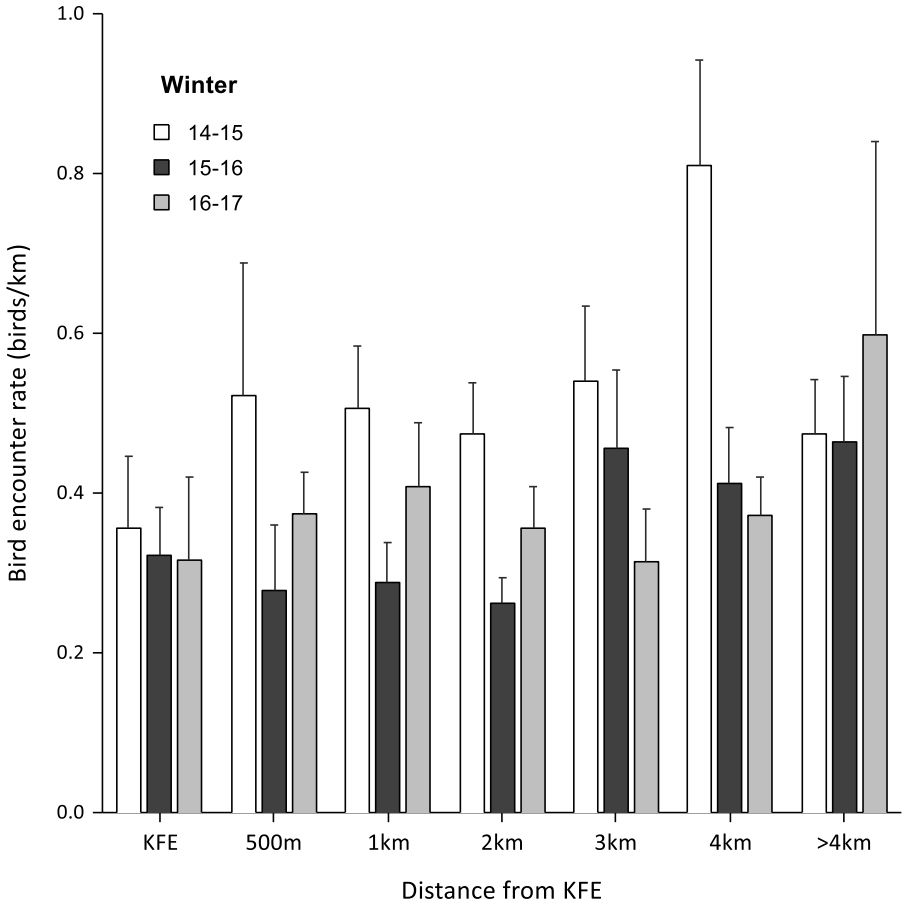
Common Gull

Common gull numbers decreased slightly over most of the survey area in 2015-16 after construction of KFE (**Figure 18**), but this decline occurred over the whole area, not just within KFE.

The data have been analysed to determine whether there is any evidence for any displacement effects of the KFE wind farm on this species, and if so over what spatial extent. The mean (and standard error) encounter rates in distance zones from KFE are shown in **Figure 18**. As for the previous species, in order to distinguish between the effects of KFE and the Kentish Flats wind farm, these bands have excluded the parts of the survey area in closer proximity to the original Kentish Flats wind farm from the analysis, so that in these Figures it is KFE that is having the primary effect on these zones.

A test of the null hypothesis of no difference in common gull encounter rate between the KFE distance zones was carried out using Kruskall-Wallis ANOVA. This analysis did not reject that null hypothesis, with no statistically significant difference in common gull encounter rate between the different zones (χ^2=3.1, 6df, p=0.80). This is in line with what would be expected if this species were not adversely affected by the KFE. A very similar result was found in the previous winter.

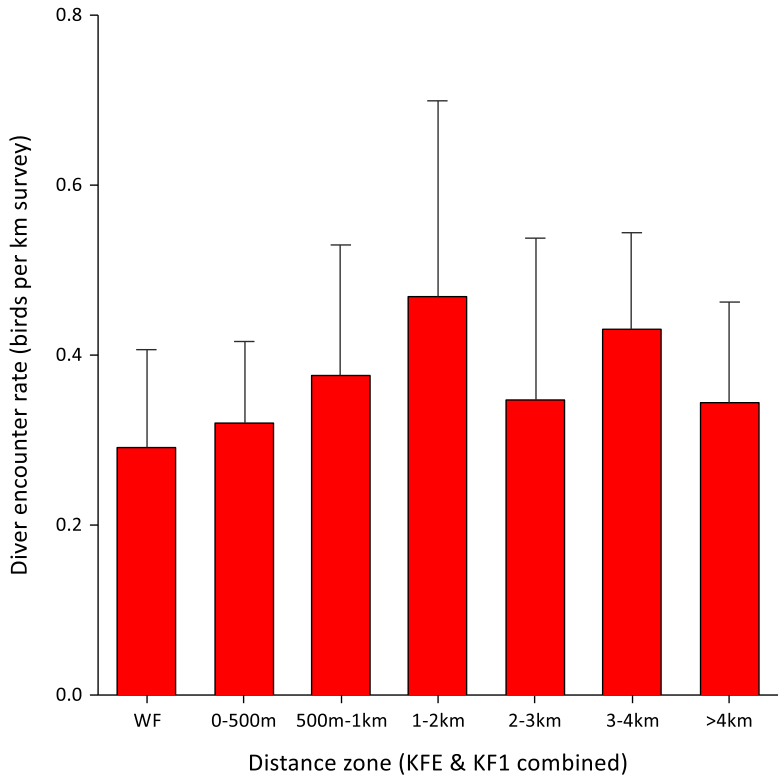
***Figure 18**. Common Gull encounter rates in each of the KFE distance zones, 2014-15 (before construction), and 2015-16 and 2016-17 (after construction).*



Carrying out the same test for the 2014-15 data, prior to construction of the KFE, there was no statistically significant difference in the common gull encounter rate between the distance zones (χ^2=9.4, 6df, p=0.15) during that winter either.

The cumulative disturbance effect of KFE and the original Kentish Flats wind farm were explored by examining the diver encounter rates in distances zones around the two wind farms together and carrying out a gradient analysis using the 2016-17 data. These results are summarised in **Figure 19**, which gives the mean (and standard error) diver encounter rate for each distance zone around the combined (KFE plus original Kentish Flats) wind farm. A test of the null hypothesis of no difference between these distance zones was carried out using Kruskall-Wallis ANOVA. This analysis did not reject that null hypothesis, with no statistically significant difference in common gull encounter rate between the different zones (χ^2=12.1, 6df, p=0.06), again in line with what would be expected if this species were not adversely affected by the wind farms in combination.

***Figure 19**. Common Gull encounter rates in each of the combined Kentish Flats and KFE wind farms distance zones, 2015-16 (after construction).*

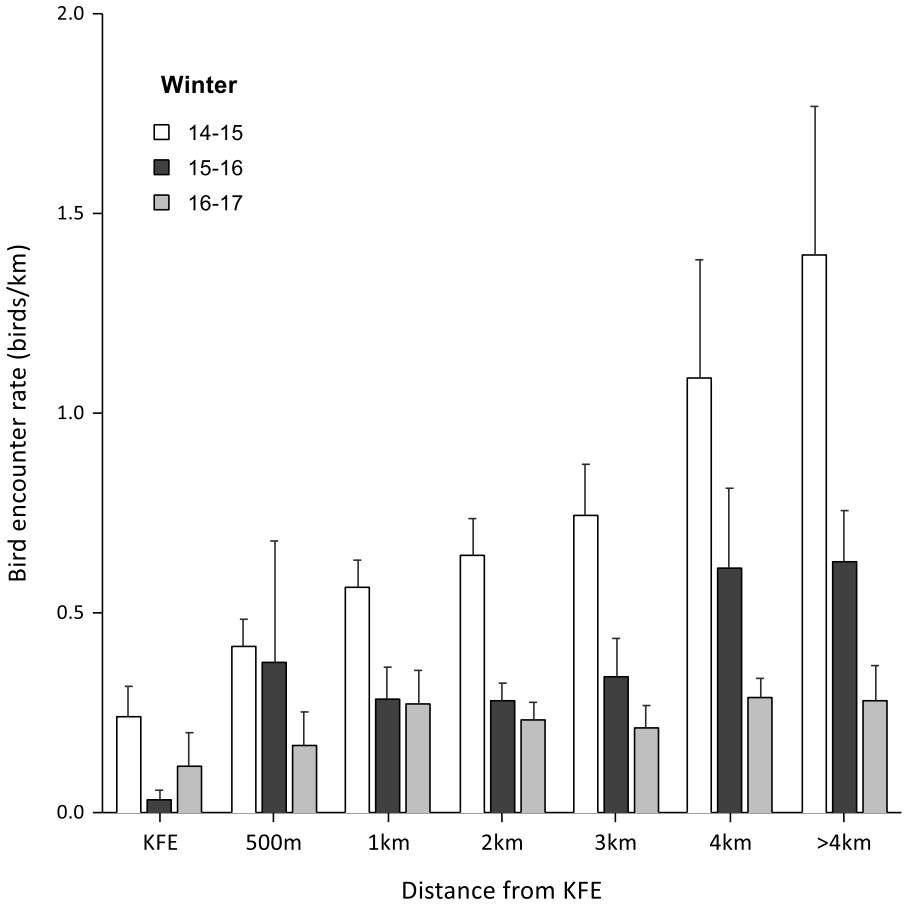


Herring Gull

Herring gull numbers decreased over much of the survey area in 2015-16 after construction of KFE and numbers were lower again in 2016-17 (**Figure 20**). The data have been analysed to determine whether there is any evidence for any displacement effects of the KFE wind farm on this species, and if so over what spatial extent. The mean (and standard error) encounter rates in distance zones from KFE are shown in **Figure 20**. As for the previous species, in order to distinguish between the effects of KFE and the Kentish Flats wind farm, these bands have excluded the parts of the survey area in closer proximity to the original Kentish Flats wind farm from the analysis, so that in these Figures it is KFE that is having the primary effect on these zones.

A test of the null hypothesis of no difference in herring gull encounter rate between the KFE distance zones was carried out using Kruskall-Wallis ANOVA. This analysis did not reject that null hypothesis, with no statistically significant difference in herring gull encounter rate between the different zones (χ^2=7.7, 6df, p=0.26), in line with what would be expected if this species were not adversely affected by the wind farms in combination. A different result had been found in 2015-16, when the KFE zone had held statistically significantly fewer herring gulls than the distance zones more than 1km from the wind farm. Numbers in the wind farm were again low in 2016-17 but high variability across the zones meant that in this case it was not statistically significant.

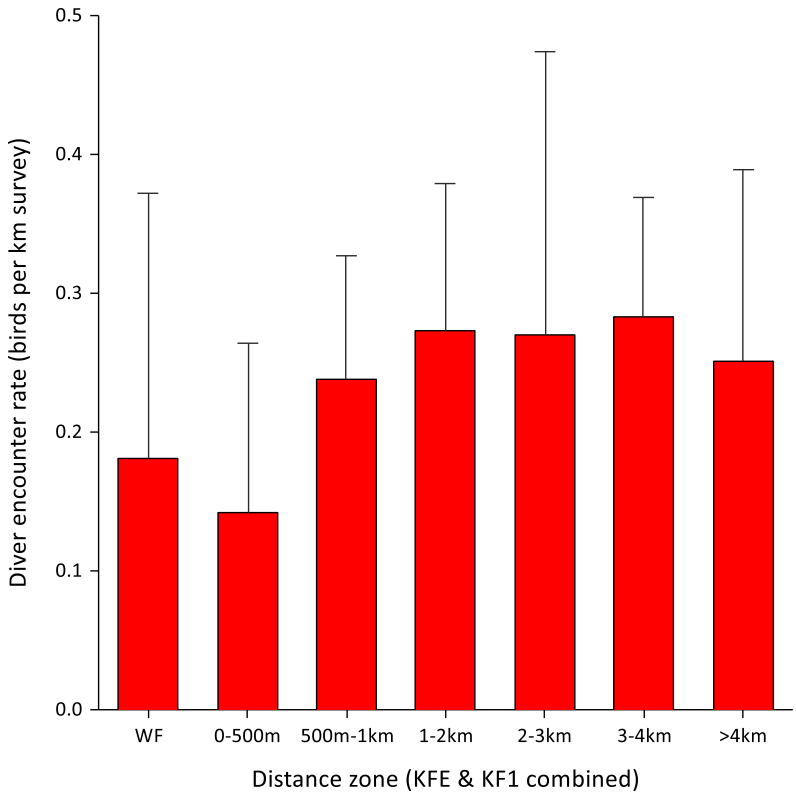
***Figure 20**. Herring Gull encounter rates in each of the KFE distance zones, 2014-15 (before construction) and 2015-16 (after construction).*



Carrying out the same test for the 2014-15 data, prior to construction of the KFE, there was a statistically significant difference in the herring gull encounter rate between the distance zones (χ^2=21.6, 6df, p=0.01), with a greater use of the distance zones more than 1km from the wind farm, suggesting that the observed differences in 2015-16 may not have been a result of the KFE.

The cumulative disturbance effect of KFE and the original Kentish Flats wind farm were explored by examining the herring gull encounter rates in distances zones around the two wind farms together and carrying out a gradient analysis using the 2016-17 data. These results are summarised in **Figure 21**, which gives the mean (and standard error) diver encounter rate for each distance zone around the combined (KFE plus original Kentish Flats) wind farm. A test of the null hypothesis of no difference between these distance zones was carried out using Kruskall-Wallis ANOVA. There was no statistically significant difference in herring gull encounter rate between the different zones (χ^2=11.5, 6df, p=0.07). In the previous winter the wind farms had held statistically significantly fewer herring gulls than the 2km, 3km, 4km and >4km zones.

***Figure 21**. Herring Gull encounter rates in each of the combined Kentish Flats and KFE wind farms distance zones, 2016-17 (after construction).*



Further analysis was undertaken of the change in herring gull encounter rate between the pre-construction (2014-15) and second post-construction year (2016-17), testing null hypothesis of equal change in herring gull encounter rate between these distance zones. Kruskall-Wallis ANOVA was again used. This analysis did not reject that null hypothesis, with no statistically significant difference in the change in median herring gull encounter rate between the different zones (χ^2=9.3, 6df, p=0.16). The same conclusion was reached using the previous winter's data. These results suggest again that the observed differences in herring gull numbers between the KFE distance zones may have resulted from other factors than displacement by the wind turbines. These results are summarised in **Figure 22a (2015-16) and 22b (2016-17)**, which gives the median change in herring gull encounter rate for each distance zone in each winter.

***Figure 22a**. Change in Herring Gull encounter rates in each of the KFE wind farms distance zones, between 2014-15 (prior to construction) and 2015-16 (after construction).*

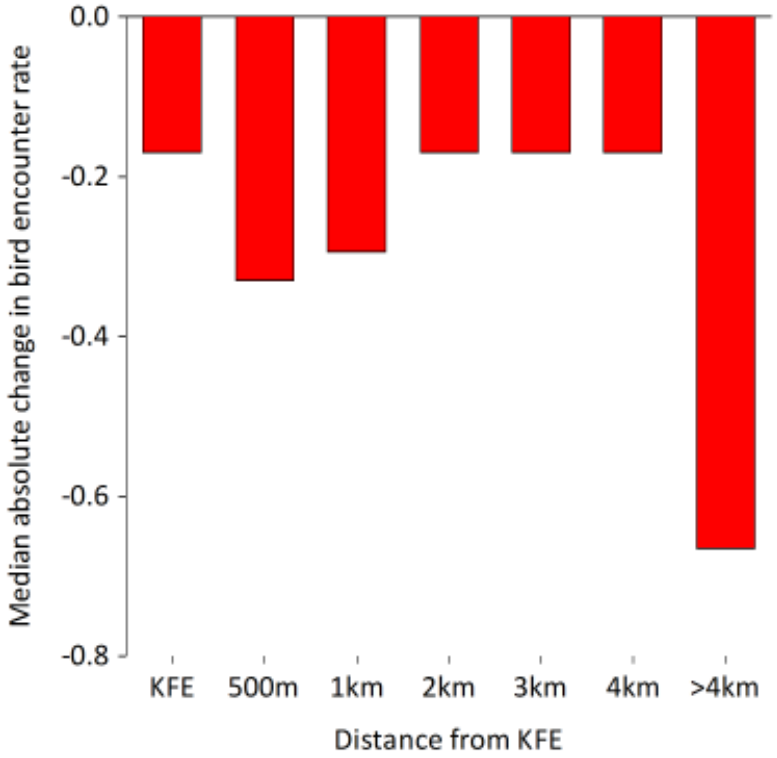
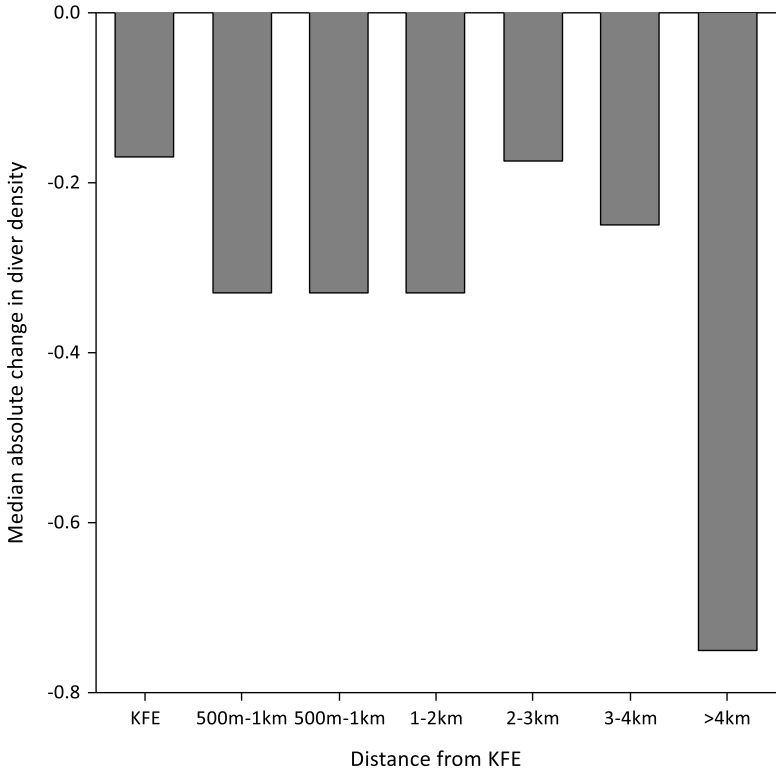


***Figure 22b**. Change in Herring Gull encounter rates in each of the KFE wind farms distance zones, between 2014-15 (prior to construction) and 2016-17 (after construction).*



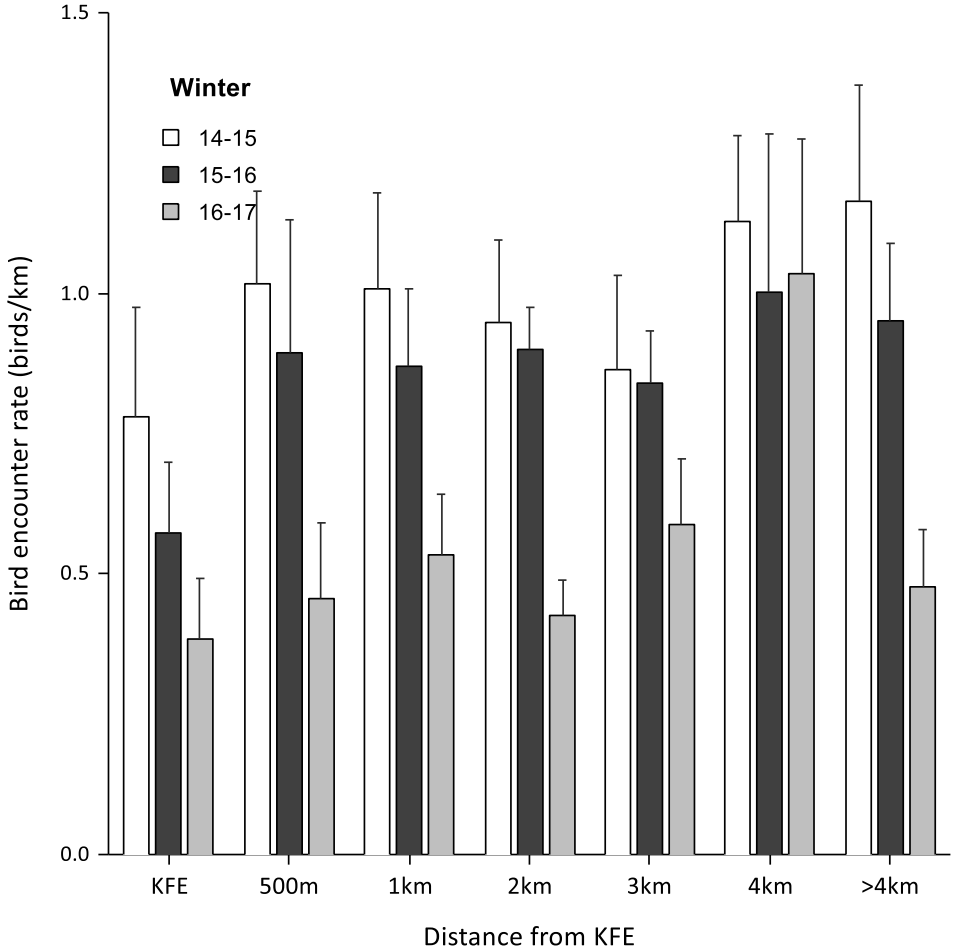
Great Black-backed Gull

Great black-backed gull numbers decreased slightly in 2015-16 after construction of KFE and again in 2016-17 (**Figure 23**), but this decline occurred over the whole area, not just within KFE.

The data have been analysed to determine whether there is any evidence for any displacement effects of the KFE wind farm on this species, and if so over what spatial extent. The mean (and standard error) encounter rates in distance zones from KFE are shown in **Figure 23**. As for the previous species, in order to distinguish between the effects of KFE and the Kentish Flats wind farm, these bands have excluded the parts of the survey area in closer proximity to the original Kentish Flats wind farm from the analysis, so that in these Figures it is KFE that is having the primary effect on these zones.

A test of the null hypothesis of no difference in great black-backed gull encounter rate between the KFE distance zones was carried out using Kruskall-Wallis ANOVA. This analysis did not reject that null hypothesis, with no statistically significant difference in great black-backed gull encounter rate between the different zones (χ^2=10.5, 6df, p=0.10). This is in line with what would be expected if this species were not adversely affected by the KFE. A very similar result was found in the previous winter.

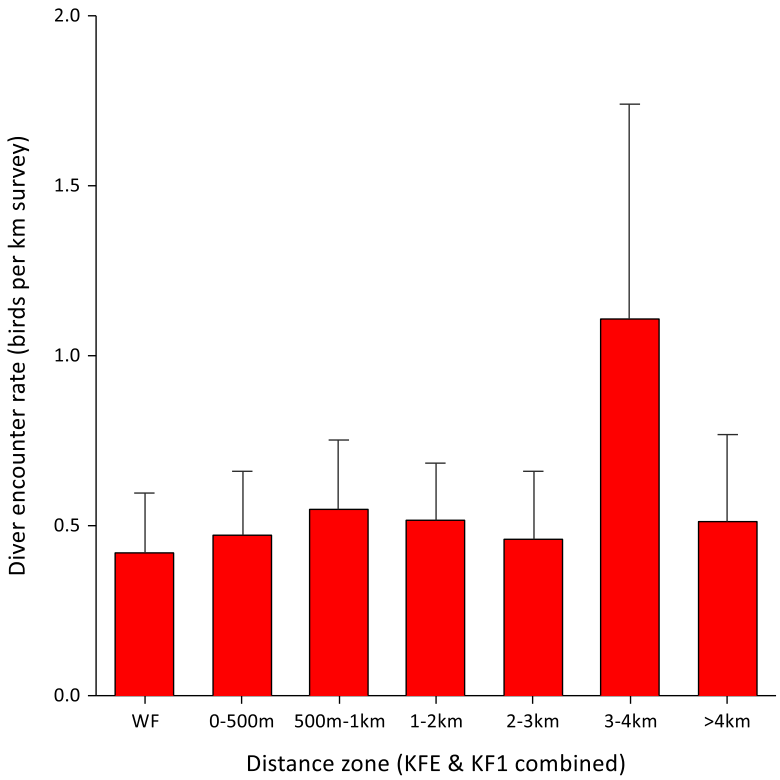
***Figure 23**. Great Black-backed Gull encounter rates in each of the KFE distance zones, 2014-15 (before construction), and 2015-16 and 2016-17 (after construction).*



Carrying out the same test for the 2014-15 data, prior to construction of the KFE, there was no statistically significant difference in the great black-backed gull encounter rate between the distance zones (χ^2=8.2, 6df, p=0.22) in that winter either.

The cumulative disturbance effect of KFE and the original Kentish Flats wind farm were explored by examining the diver encounter rates in distances zones around the two wind farms together and carrying out a gradient analysis using the 2016-17 data. These results are summarised in **Figure 24**, which gives the mean (and standard error) diver encounter rate for each distance zone around the combined (KFE plus original Kentish Flats) wind farm. A test of the null hypothesis of no difference between these distance zones was carried out using Kruskall-Wallis ANOVA. No statistically significant difference was found in great black-backed gull encounter rate between the different zones (χ^2=6.6, 6df, p=0.36). A similar (though more marginal) result was found in the previous winter.

***Figure 24**. Great Black-backed Gull encounter rates in each of the combined Kentish Flats and KFE wind farms (WF) distance zones, 2016-17 (after construction).*



Further examination of spatial extent of changes following construction of KFE was undertaken, by testing the change in great black-backed gull encounter rate between the pre-construction (2014-15) and the second post-construction years (2016-17), testing null hypothesis of equal change in great black-backed gull encounter rate between these distance zones. Kruskall-Wallis ANOVA was again used. This analysis did not reject that null hypothesis, with no statistically significant difference in the change in great black-backed gull encounter rate between the different zones (χ^2=5.6, 6df, p=0.47). A similar result was observed in 2015-16. This adds further support to the conclusion that this species was not adversely affected by the KFE. These results are summarised in **Figure 25a (2015-16) and**

25b (2016-17), which gives the median change in great black-backed gull encounter rate for each distance zone.

***Figure 25a**. Change in Great Black-backed Gull encounter rates in each of the KFE wind farms distance zones, between 2014-15 (prior to construction) and 2015-16 (after construction).*

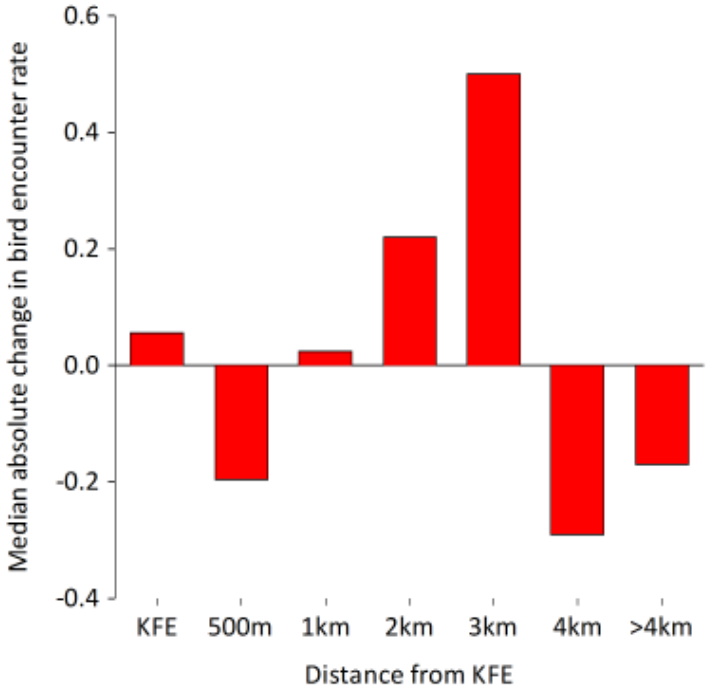
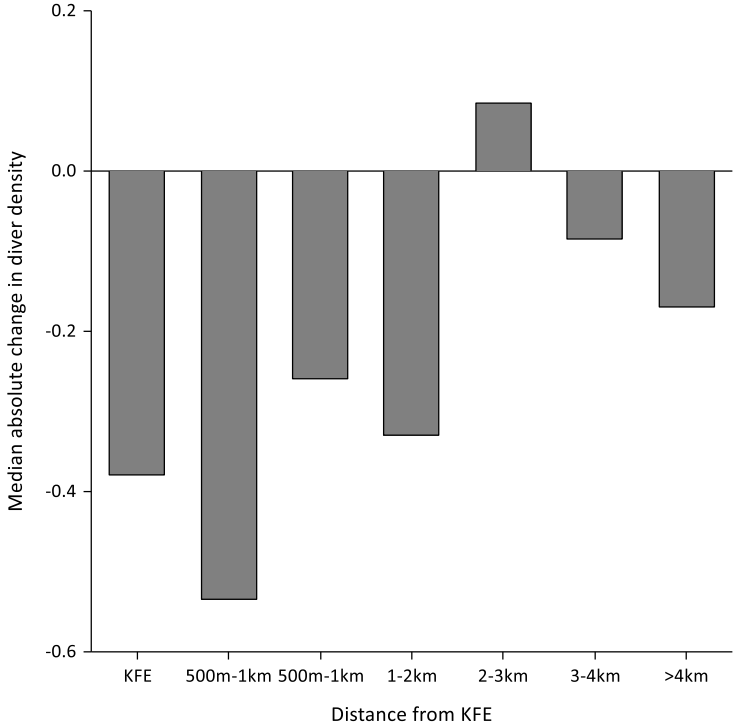


Figure 25b. *Change in Great Black-backed Gull encounter rates in each of the KFE wind farms distance zones, between 2014-15 (prior to construction) and 2016-17 (after construction).*



7 COLLISION RISK MODELLING

7.1 Collison Risk Modelling Methods

The risk of bird collision with the KFE wind turbines was identified as a potential impact in the project ES, though the conclusion was reached that this would not be significant for any bird species. Further analysis is presented here using more recent data to provide a further check on that conclusion.

Collision risk modelling has been undertaken for the key species that have been recorded flying through the collision risk zone at rotor height.

The collision risk model used in this assessment update is the same one as used for the ES assessment, developed by SNH and BWEA (Percival *et al*., 1999; Band, 2001, Band *et al*., 2007), and recently updated for specific use for offshore wind farm assessments (Band, 2012). Details of the model are given in these publications. The basic version of the collision risk model has been used, with site-specific flight height data.

The model runs as a two-stage process. Firstly, the risk is calculated making the assumption that flight patterns are unaffected by the presence of the wind turbines, i.e. that no avoidance action is taken. This is essentially a mechanistic calculation, with the collision risk calculated as the product of (i) the probability of a bird flying through the rotor swept area, and (ii) the probability of a bird colliding if it does so. This probability is then multiplied by the estimated numbers of bird movements through the wind farm rotors at the risk height (i.e. the height of the rotating rotor blades) in order to estimate the theoretical numbers at risk of collision if they take no avoiding action.

The second stage then incorporates the probability that the birds, rather than flying blindly into the turbines, will actually take a degree of avoiding action, as has been shown to occur in all studies of birds at existing wind farms. SNH has recommended a precautionary approach, using a value of 98% as an avoidance rate for all of the species modelled here (Urquhart, 2010), though with the recommended rate for divers recently updated to 99.5% (SNH 2016). Maclean *et al*. (2009) however recommended the use of more realistic rates (99%-99.9%) in their review for COWRIE. Results for a range of avoidance rates are presented here, as recommended by Band (2012).

The collision model requires data on bird body size and flight speed. Body sizes and baseline mortality rates were taken from Robinson (2005), and flight speeds from Alerstam *et al*. (2007). Bird flight heights were taken from the field data, but values from the SOSS-02 review project (Johnston *et al*. 2014) were also considered to make the collision predictions as robust as possible.

7.2 Collision Risk Modelling Results

Table 9 summarises the collision risk analysis for each of the key species (that were observed flying at rotor height within the collision risk zone) for the 15-turbine layout as built, based on the 2016-17 data over the winter (October-March). The Table gives the number of collisions predicted per year based on a range of avoidances rates (from the collision risk model), the magnitude of that effect and whether such an effect would be significant.

Table 9. Collision risk modelling predictions for the Kentish Flat Extension Offshore wind farm based on Oct 2016 – March 2017 baseline data: 15 x 3.3MW turbines.

Species	Predicted number of collisions per year applying the following avoidance rates:			Magnitude of effect	Likely significant effect?
	98%	99%	99.5%		
Red-throated diver	0.29	0.14	0.07	Negligible	No
Cormorant	0.51	0.26	0.13	Negligible	No
Common gull	4.84	2.42	1.21	Negligible	No
Herring gull	3.07	1.54	0.77	Negligible	No
Great black-backed gull	18.4	9.19	4.59	Low	No
Black-headed gull	0.13	0.07	0.03	Negligible	No

7.3 Comparison with previous collision modelling results

Table 10 compares the previous collision risk predictions presented in the ES (for an initial proposed 17-turbine layout) with that presented above for the 2016-17 data (for the finalised 15-turbine layout), and with the 2014-15 and 2015-16 data. The ES assessment was based primarily on applying a precautionary 98% avoidance rate for all species, but more recent publications have suggested that for many species this is overly precautionary. The results in Table 10 present the original collision risk predictions based on a 98% avoidance rate, and those on the recommended rates published by Cook *et al* (2014) (and for divers as currently recommended by SNH). For common gull and black-headed gull the

Cook *et al*. rate for kittiwake has been applied (99.2%). Table 12 includes all species for which peak use was recorded during the winter period (which was the only period surveyed in 2014-15, 2015-16 and 2016-17).

The updated collision risk predictions from 2016-17 are higher than the ES prediction for red-throated diver and great black-backed gull, but lower for gannet, cormorant, common gull, lesser black-backed gull, herring gull, black-headed gull and kittiwake. These differences are not sufficient to make any material differences to the conclusions reached in the previous assessment. For all species, the predicted collision risk would not be significant (as concluded in the ES).

Table 10. Comparison of the ES (based on the original 17T scheme) and 2014-15 Collision Risk Modelling Results (based on the wind farm as built) with those based on 2015-16 and 2016-17 survey data (as built).

Species	Collision risk applying avoidance rate of 98%				Cook *et al*. 2014 avoidance rate	Collision risk applying avoidance rate of Cook *et al* (2014) avoidance rate			
	ES (17T)	2014-15 (15T)	2015-16	2016-17		ES (17T)	2014-15 (15T)	2015-16	2016-17
Red-throated diver	0.1	0.2	0.1	0.3	99.5%[1]	0.03	0.05	0.03	0.07
Gannet	0.4	0	0	0	98.9%	0.2	0	0	0
Cormorant	5.8	0.2	1.1	0.5	-	-	-	-	-
Common gull	86.7	5.9	5.2	4.8	99.2%	34.7	2.4	2.1	1.9
Lesser black-backed gull	6.4	1.1	0	0	99.5%	1.6	0.3	0	0
Herring gull	8.7	6.3	2.5	3.1	99.5%	2.2	1.6	0.6	0.8
Great black-backed gull	1.2	26.7	13.0	18.4	99.5%	0.3	6.7	3.3	4.6
Black-headed gull	37.9	0	0.3	0.1	99.2%	15.2	0	0.1	0.05
Kittiwake	4.9	0.04	0	0	99.2%	2.0	0.02	0	0

8 SUMMARY AND CONCLUSION

Twelve further bird surveys of the KFE offshore wind farm site have been successfully completed during the October 2016 – March 2017 period, over the same survey area as covered in 2014-15 and 2015-16 (a larger one than that surveyed previously for the ES baseline).

Divers were identified in the ES as the primary ornithological sensitivity at this site: the wind farm lies within the Outer Thames Estuary SPA, for which red-throated diver is a qualifying feature. Numbers recorded in 2016-17 were similar to those found in the 2009-11 and 2014-15 baseline surveys, and in the first post-construction winter in 29015-16, though were higher than those from previous 2005-07 surveys. Overall, though, the survey area continued to hold only low numbers of divers in the context of the SPA population.

Numbers of other seabird species were broadly similar in 2016-17 to those recorded previously, though numbers of herring and great black-backed gulls were not as high as had been found in 2014-15.

[1] *As now recommended by SNH.*

There was strong evidence that red-throated divers had been displaced from KFE following construction, with a 76% reduction in encounter rate within KFE and a 76% reduction in the 500m buffer around that wind farm in 2016-17 compared with the 2014-15 pre-construction baseline. In the first post-construction winter (2015-16), a 95% reduction in encounter rate was found within KFE and a 88% reduction in the 500m buffer around that wind farm. There has therefore been a reduced displacement effect in the second post-construction winter in comparison with the first. Further post-construction surveys will test whether this apparent habituation to the wind farm is a continuing trend.

Previous analysis of the original Kentish Flats wind farm reported in the KFE ES (Percival *et al*. 2011) found a proportionate reduction of 81% of diver numbers within the wind farm site, 53% within 500m and 29% within 1km, and a worst-case assessment of a decrease by 94% in the wind farm, 83% within 500m, 77% within 1km and 59% within 2km. These values (particularly the worst case) should though be treated with caution, as the survey area at that time did not extend sufficiently far from the wind farm to be able to exclude the possibility of displacement across the whole survey area.

No statistically significant reduction was identified at KFE beyond 500m from the 2016-17 data, as had also been the case for the 2015-16 data. This will be investigated further as more post-construction data become available, to determine more precisely the extent of the disturbance effect on divers.

Other seabird species appeared, from the first winter's post-construction surveys, to be much less affected by the presence of the KFE. There was no evidence at all of any adverse effect on cormorants or common gulls.

Herring gull encounter rates in the wind farm were again low in 2016-17 but high variability across the zones meant that in this winter it was not statistically significant (it had been in 2015-16 but it was thought this was more likely that this is attributable to other factors than the wind farm). Great black-backed gulls, too, were not significantly affected by the presence of either of the two wind farms.

There were some minor differences in the predicted collision risks compared with those presented in the ES, but none of these were sufficiently to change the conclusion reached in the ES that there would not be any significant collision risk resulting from the KFE.

As noted previously, formal power analysis would not yield any meaningful result given the data distribution and particularly the presence of a small number of large outliers. The sample sizes currently available, though, have still enabled statistically significant effects of the wind farm to be identified. Also, from a practical point of view, the sample sizes in the key areas are already at the maximum possible - any further reduction in transect separation (to increase sample size) would a make it highly likely that divers would be displaced by the survey vessel between transects during the surveys.

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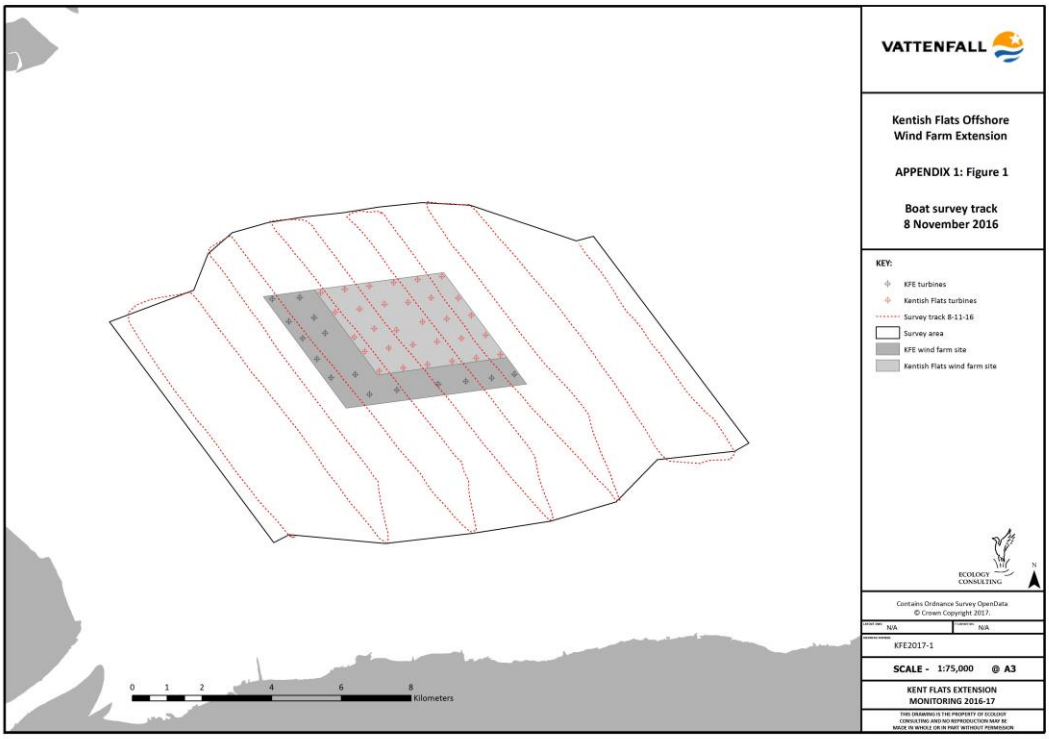
VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 1
Boat survey track
8 November 2016
KEY:
KFE turbines
Kentish Flats turbines
Survey track 8-11-16
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
N
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N/A
KFE2017-1
SCALE - 1:75,000 @ A3
KENT FLATS EXTENSION
MONITORING 2016-17
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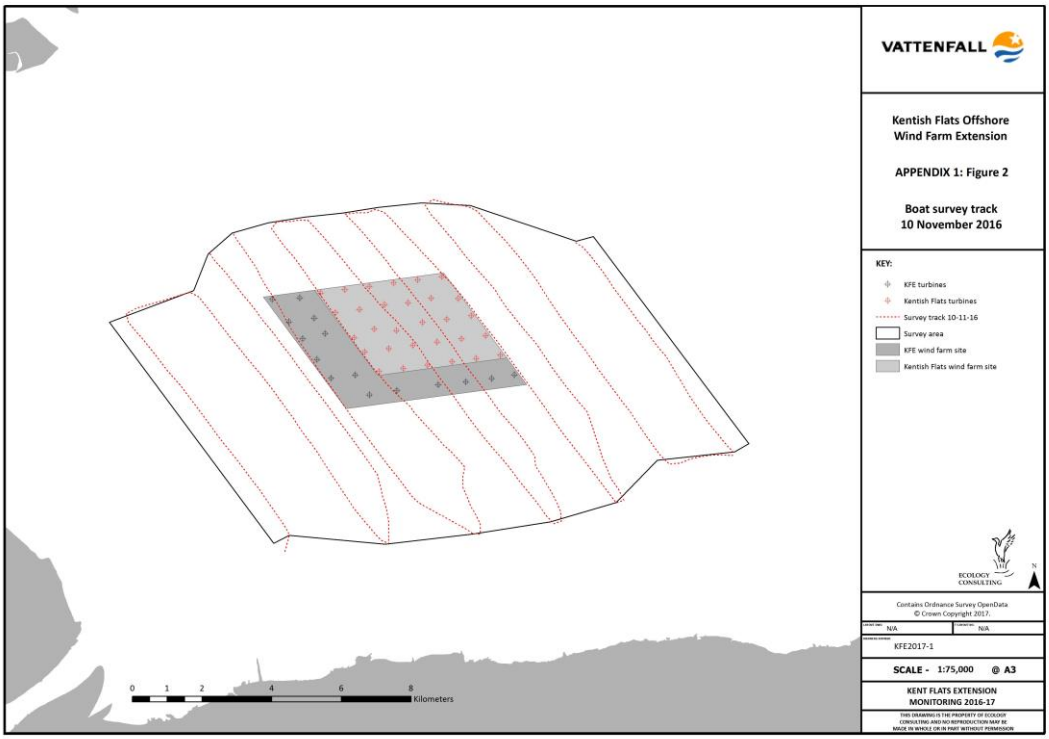
0 1 2 4 6 8
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 2
Boat survey track
10 November 2016
KEY:
KFE turbines
Kentish Flats turbines
Survey track 10-11-16
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
N
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KFE2017-1
SCALE - 1:75,000 @ A3
KENT FLATS EXTENSION
MONITORING 2016-17
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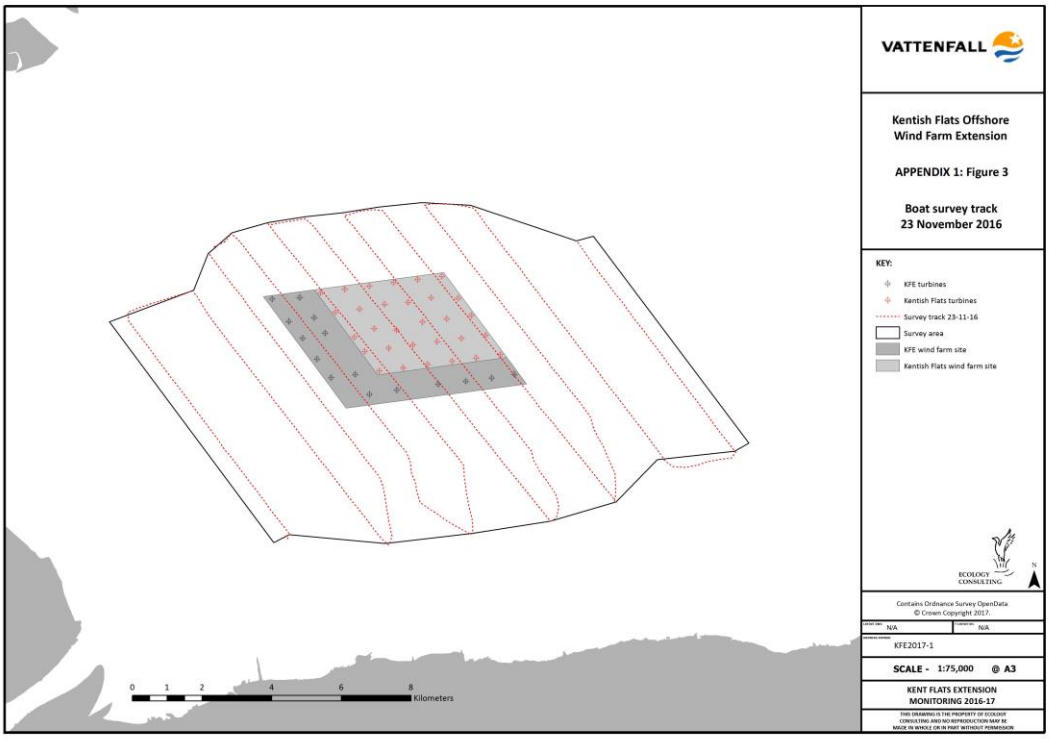
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 3
Boat survey track
23 November 2016
KEY:
KFE turbines
Kentish Flats turbines
Survey track 23-11-16
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
N
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KFE2017-1
SCALE - 1:75,000 @ A3
KENT FLATS EXTENSION
MONITORING 2016-17
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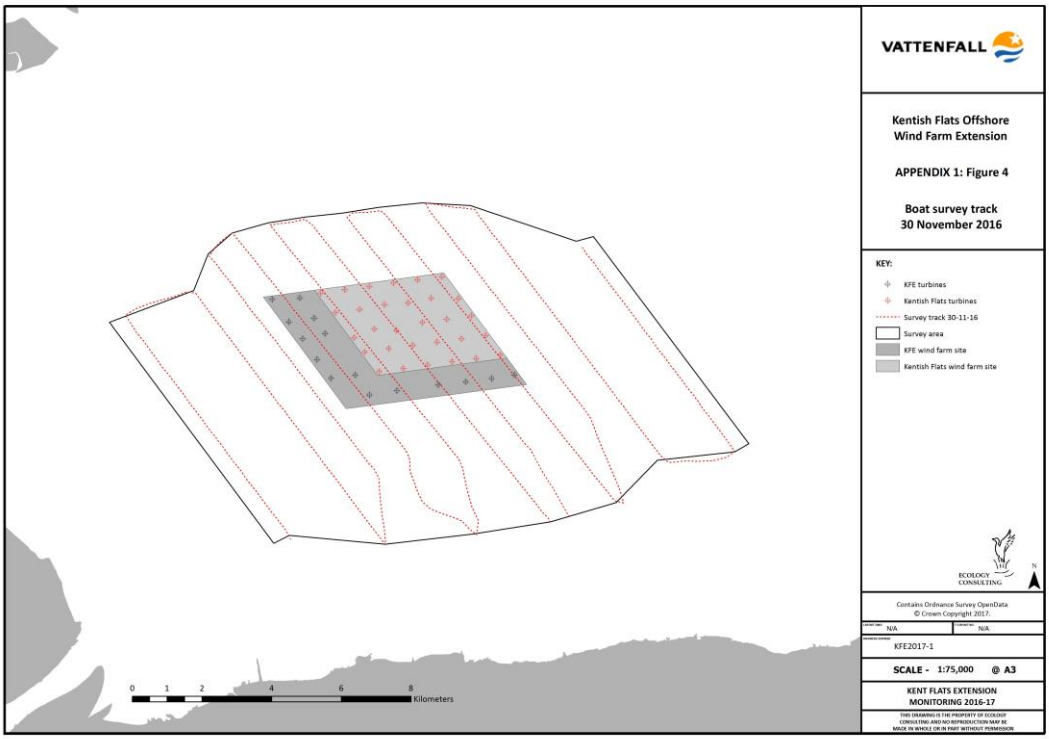
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 4
Boat survey track
30 November 2016
KEY:
KFE turbines
Kentish Flats turbines
Survey track 30-11-16
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
N
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KENT FLATS EXTENSION
MONITORING 2016-17
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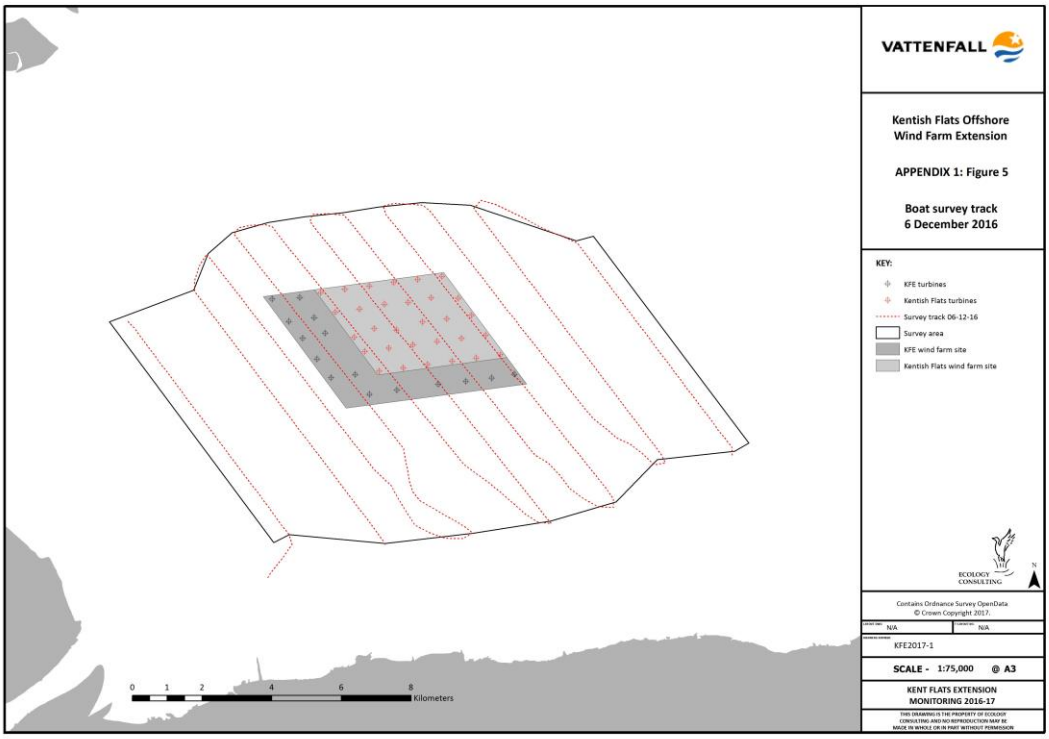
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 5
Boat survey track
6 December 2016
KEY:
KFE turbines
Kentish Flats turbines
Survey track 06-12-16
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
N
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KFE2017-1
SCALE - 1:75,000 @ A3
KENT FLATS EXTENSION
MONITORING 2016-17
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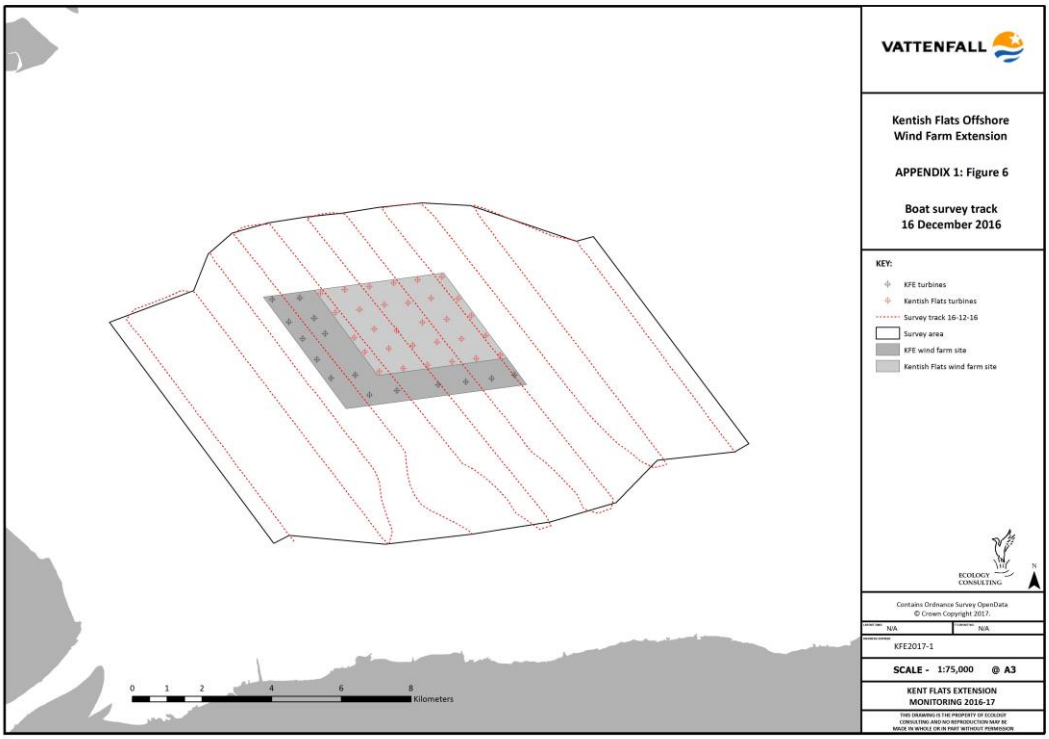
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 6
Boat survey track
16 December 2016
KEY:
KFE turbines
Kentish Flats turbines
Survey track 16-12-16
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
N
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KFE2017-1
SCALE - 1:75,000 @ A3
KENT FLATS EXTENSION
MONITORING 2016-17
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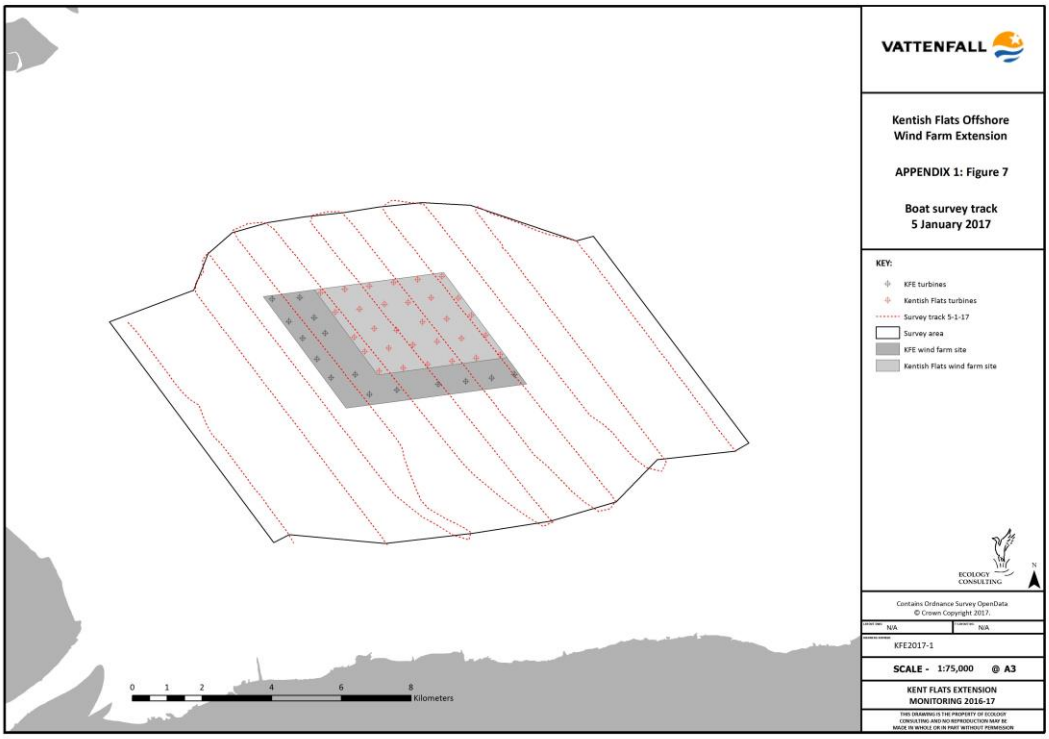
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 7
Boat survey track
5 January 2017
KEY:
KFE turbines
Kentish Flats turbines
Survey track 5-1-17
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
N
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SCALE - 1:75,000 @ A3
KENT FLATS EXTENSION
MONITORING 2016-17
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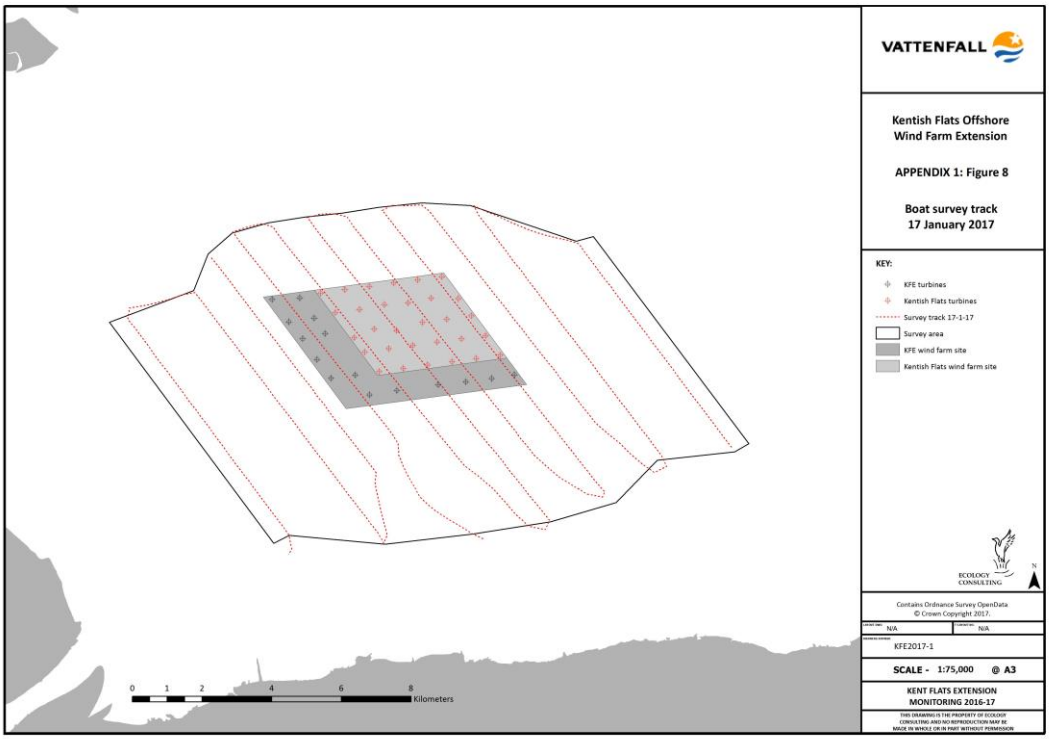
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 8
Boat survey track
17 January 2017
KEY:
KFE turbines
Kentish Flats turbines
Survey track 17-1-17
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
N
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KFE2017-1
SCALE - 1:75,000 @ A3
KENT FLATS EXTENSION
MONITORING 2016-17
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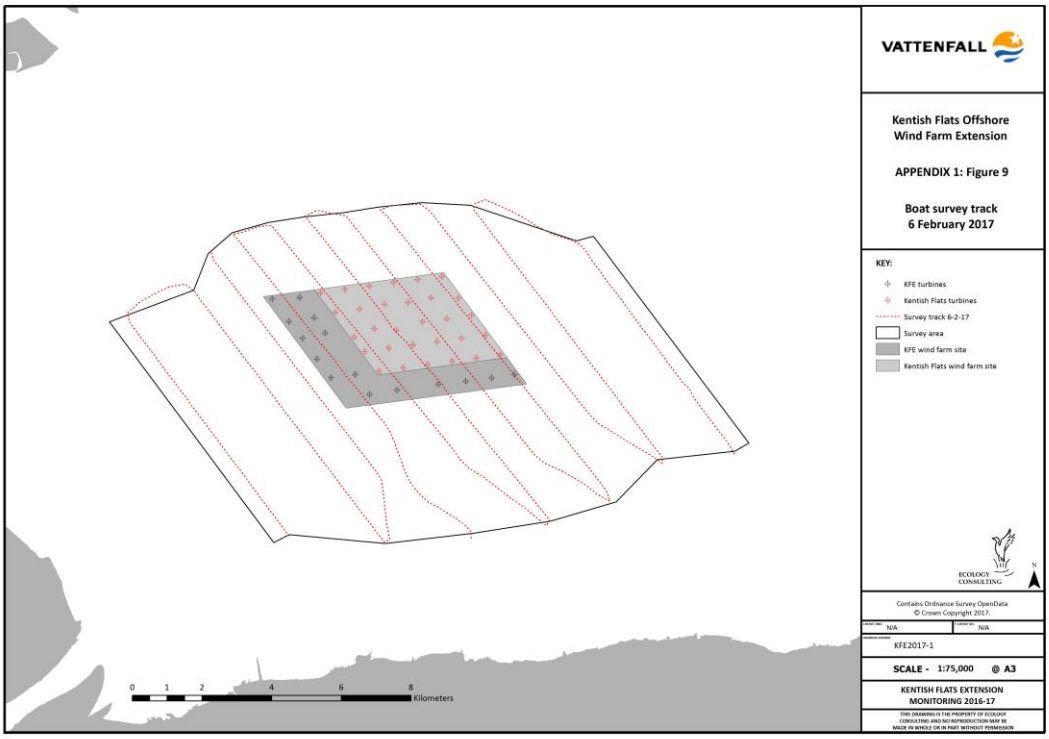
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 9
Boat survey track
6 February 2017
KEY:
KFE turbines
Kentish Flats turbines
Survey track 6-2-17
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
N
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SCALE - 1:75,000 @ A3
KENTISH FLATS EXTENSION
MONITORING 2016-17
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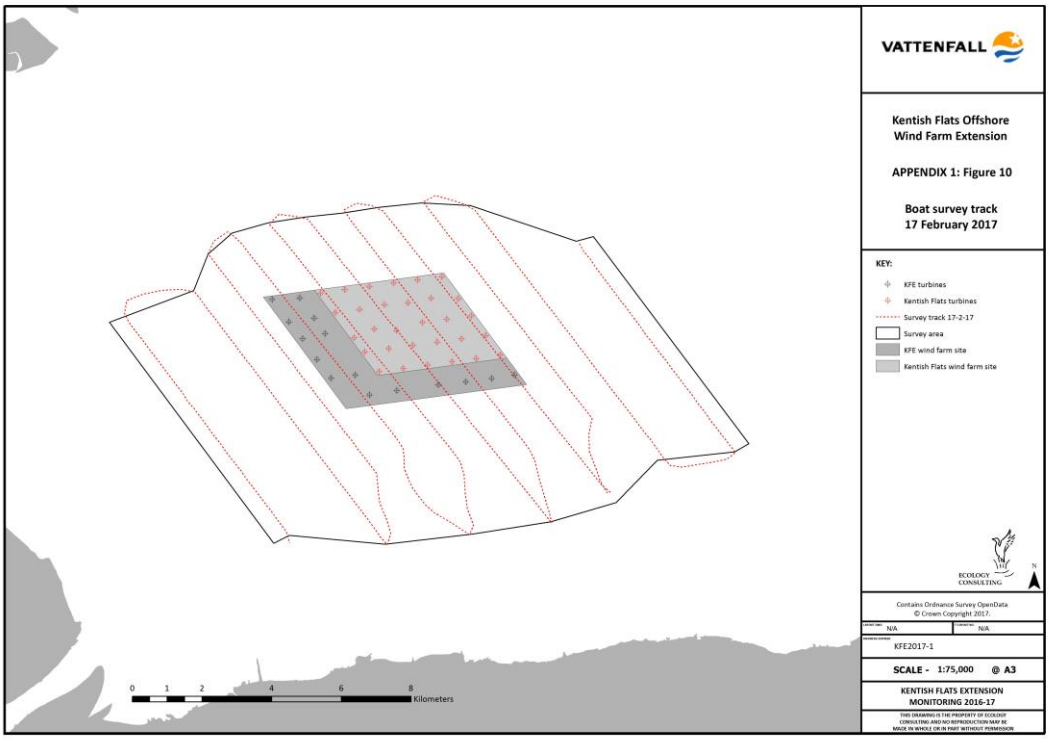
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 10
Boat survey track
17 February 2017
KEY:
KFE turbines
Kentish Flats turbines
Survey track 17-2-17
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
N
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SCALE - 1:75,000 @ A3
KENTISH FLATS EXTENSION
MONITORING 2016-17
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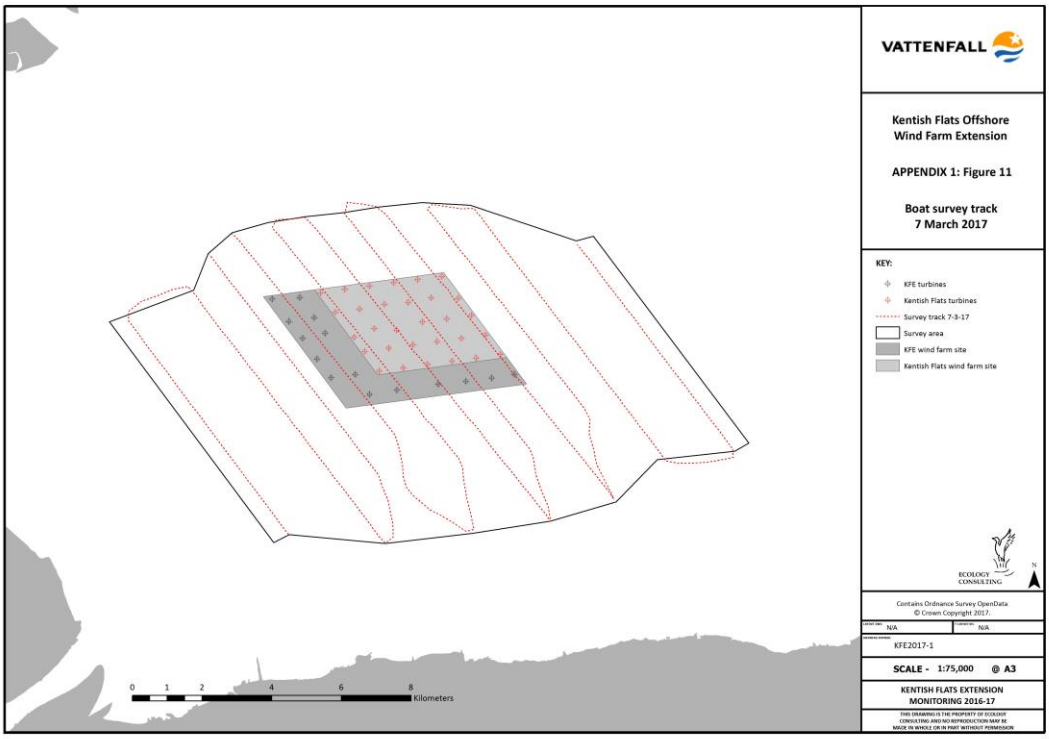
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 11
Boat survey track
7 March 2017
KEY:
KFE turbines
Kentish Flats turbines
Survey track 7-3-17
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
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KENTISH FLATS EXTENSION
MONITORING 2016-17
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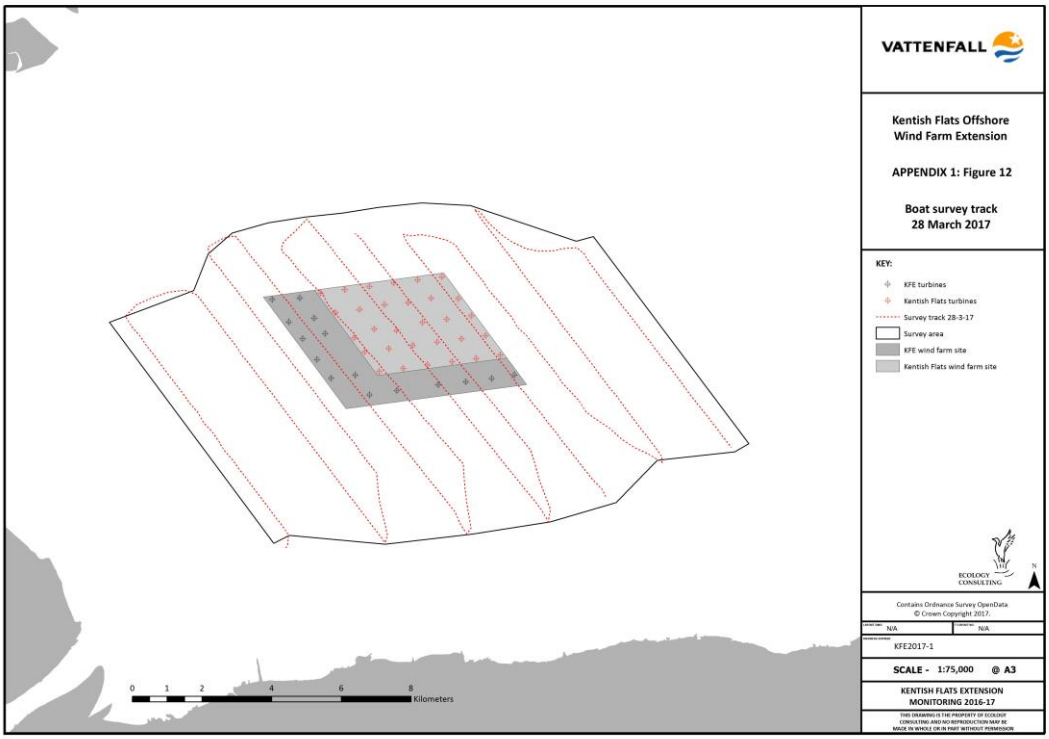
Kilometers


VATTENFALL
Kentish Flats Offshore
Wind Farm Extension
APPENDIX 1: Figure 12
Boat survey track
28 March 2017
KEY:
KFE turbines
Kentish Flats turbines
Survey track 28-3-17
Survey area
KFE wind farm site
Kentish Flats wind farm site
ECOLOGY CONSULTING
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SCALE - 1:75,000 @ A3
KENTISH FLATS EXTENSION
MONITORING 2016-17
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0 1 2 4 6 8
Kilometers