Appendix G

Marine Mammals and Megafauna Technical Report

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

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Natura Impact Statement

Appendix G: Marine Mammals and Megafauna Technical Report

MDR1520B
NIS – Appendix G
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Glossary

Term	Meaning
Cetacean	The order Cetacea includes whales, dolphins and porpoises and is collectively known as cetaceans.
Pinniped	Fin-footed group of marine mammals which are semi-aquatic. Pinnipeds comprise of the following families: Odobenidae (walrus); Otariidae (eared seals, sea lions, and fur seals); and Phocidae (earless seals). Pinnipeds are more broadly known as “seals”.
Small Cetacean Abundance in the North Sea and Adjacent Waters	Large scale surveys aimed at estimating the abundance of porpoises and other cetaceans in order to assess the impacts of by-catch. SCANS (1994), and SCANS II (2005) have been completed, some outputs from SCANS III were published in 2017.

Acronyms

Term	Meaning
AIC	Akaike Information Criterion
BSWP	Basking Shark Watch Project
CCW	Countryside Council for Wales
CF	Correction Factor
CGNS	Celtic and Greater North Seas
CIS	Celtic and Irish Seas
CITES	Convention on the International Trade in Endangered Species of Flora and Fauna
CMS	Convention on the Conservation of Migratory Species of Wild Animals
DAERA	Department of Agriculture, Environment and Rural Affairs
DEHLG	Department of the Environment, Heritage and Local Government
DPD	Dolphin Positive Days
DPH	Dolphin Positive Hours
DPM	Dolphin Positive Minutes
EEZ	Exclusive Economic Zone
ESAS	European Seabirds at Sea
ESW	Estimated Strip Width
GLM	Generalised Linear Models
IAMMWG	Inter-Agency Marine Mammal Working Group
IEF	Important Ecological Features
IWDG	Irish Whale and Dolphin Group
JNCC	Joint Nature Conservation Committee
LCL	Lower Confidence Limits
LIDAR	Light Detection and Ranging
MCS	Marine Conservation Society
MEMSG	Marine Environmental Monitoring Strandings Group
MLWT	Mean Low Water Tide
MMO	Marine Mammal Observers
MU	Management Units
NBDC	National Biodiversity Data Centre
NPWS	National Parks and Wildlife Service
NRW	Natural Resources Wales
NS	North Sea

PPD	Porpoise Positive Days
PPH	Porpoise Positive Hours
PPM	Porpoise Positive Minutes
QC	Quality Control
SAC	Special Area of Conservation
SAM	Static Acoustic Monitoring
SCANS	Small Cetacean Abundance in the North Sea
SCOS	Special Committee on Seals
SMRU	Sea Mammal Research Unit
UCL	Upper Confidence Limits
WS	West Scotland

Units

Unit	Description
cm	Centimetre (distance)
km	Kilometres
kHz	Kilohertz
NM	Nautical Mile (distance; equal to 1.852 km)

1 MARINE MAMMALS AND MEGAFAUNA TECHNICAL REPORT

1.1 Introduction

This Marine Mammals and Megafauna Technical Report provides a baseline characterisation of marine mammals and megafauna for the Oriel Wind Farm Project (hereafter referred to as the "the Project"). The offshore wind farm area is located in located in the Irish Sea, off the coast of County Louth (approximately 22 km east of Dundalk town centre and 18 km east of Blackrock). The closest wind turbine will be approximately 6 km from the closest shore on the Cooley Peninsula. The offshore cable corridor extends approximately 16 km southwest from the wind farm area to the landfall south of Dunany Point.

The baseline characterisation is informed by a detailed desktop study of the existing data resources pertaining to marine mammals and megafauna within the region. These data are useful in building a picture of the marine mammal and megafauna features in the area, particularly for those species which may not be easily captured by relatively short-term 'snap-shot' surveys. The desktop data also provide a useful historical perspective, i.e. indicating changes in species composition, distribution or abundance over time.

The baseline characterisation is also informed by site-specific surveys undertaken for the Project. Boat-based visual surveys of seabirds and marine mammals were previously conducted monthly between March and August 2006. Subsequently, additional surveys were conducted including: boat-based visual surveys from May 2018 to May 2020 (excluding February, March and April 2020 due to COVID restrictions); aerial surveys from April to September 2020; and Static Acoustic Monitoring (SAM) surveys from November 2019 to November 2020.

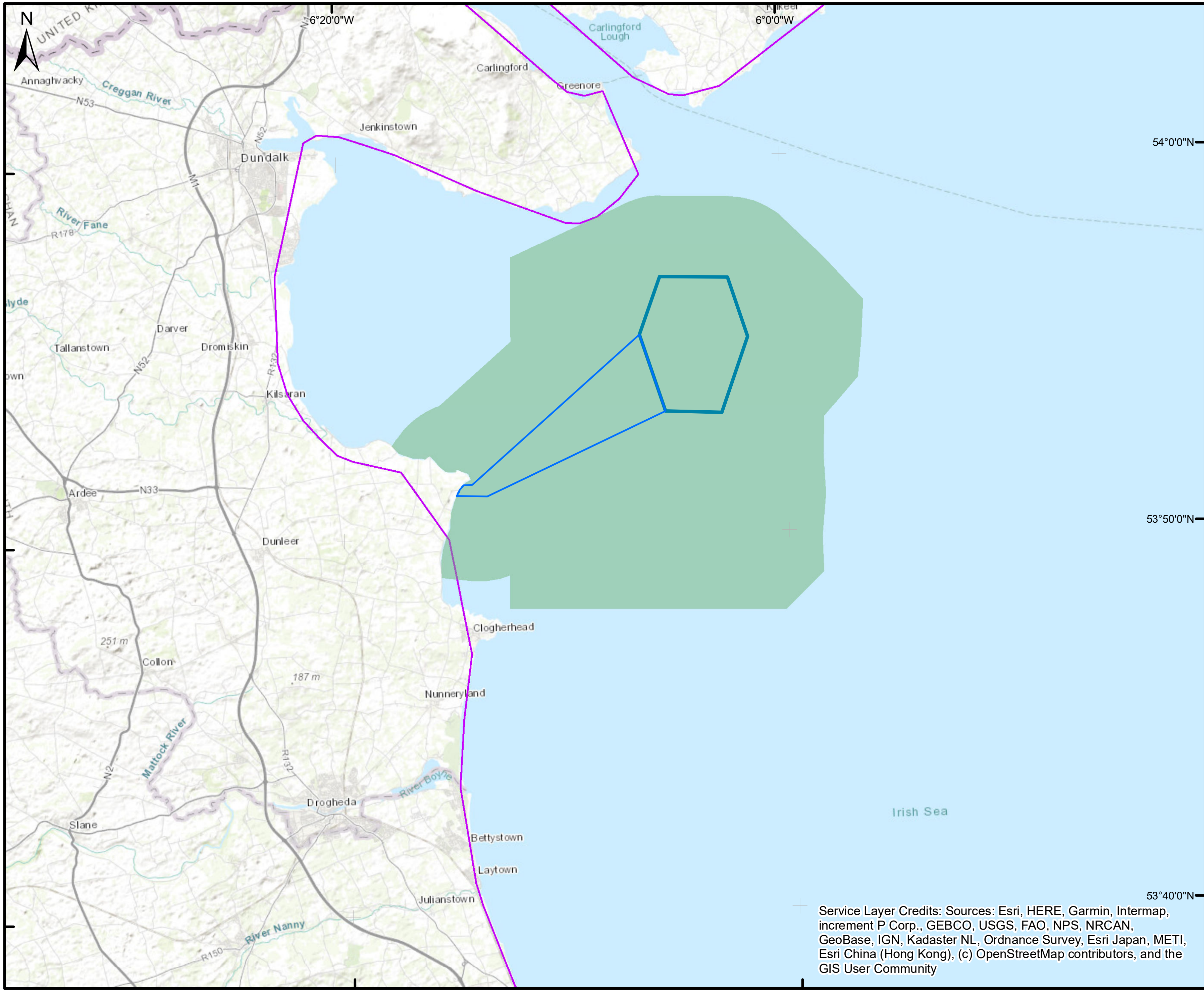
The aim of this Technical Report is to provide a baseline characterisation of marine mammal and megafauna ecological resources within a defined Marine Mammal and Megafauna Study Area (see section 1.2). Based on this characterisation, marine mammal and megafauna species have been categorised as Important Ecological Features (IEFs), based on their conservation and ecological importance, for consideration in the Natura Impact Statement (NIS).

1.2 Study area

Marine mammals, basking shark and leatherback turtle are spatially and temporally variable, therefore for the purposes of the Marine Mammal and Megafauna characterisation, two appropriate study areas were defined (**Figure 1-1**):

- **Marine Mammal and Megafauna Study Area (hereafter referred to as the 'Marine Megafauna Study Area'):** this is an area of 319.85 km^2 encompassing the offshore wind farm area and offshore cable corridor plus an appropriate buffer of varying extent (as illustrated in **Figure 1-1**) and is the area within which the site-specific marine mammal surveys were undertaken. The survey area was determined by the offshore wind farm area plus a minimum 4 km buffer (NatureScot, 2023; DCCAE, 2018) and the same area was carried forward for the most recent site-specific surveys in order to maintain consistency; and

- **Regional Marine Mammal and Megafauna Study Area (hereafter referred to as the 'Regional Marine Megafauna Study Area'):** marine mammals, basking shark and sea turtles are highly mobile and may range over large distances and therefore to provide a wider context, the desktop review will also consider ecology, distribution and abundance of these taxa within the wider Irish Sea. The Regional Marine Megafauna Study Area will also inform the assessment where the Zone of Influence (ZoI) for a given impact (e.g. subsea noise) may extend beyond the Project Marine Megafauna Study Area.



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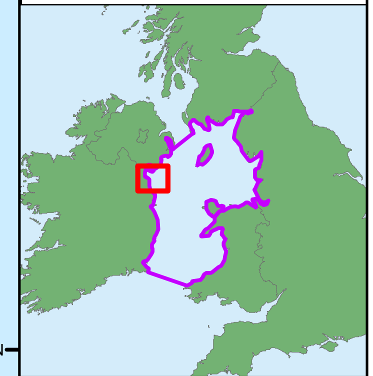
Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Marine Mammal and Megafauna Study Area
- Regional Marine Megafauna Study Area

Data Sources: Client.



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Project

Oriel Wind Farm Project

Title
Figure 1-1
Marine Megafauna Study Area and Regional Marine Megafauna Study Area

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1.3 Legislation

1.3.1 Legal framework – Ireland

The Wildlife Act (1976) and Wildlife (Amendment) Act (2000) provide protection for all cetaceans and their habitats up to 12 nautical miles (NM) from the coast of Ireland, including protection from disturbance and wilful interference. A number of marine mammal species are listed in Annex II of the Habitats Directive (Council Directive 92/43/EEC) as species whose conservation requires the designation of Special Areas of Conservation (SACs). In Ireland Annex II marine mammal species for which SACs are designated include harbour porpoise, grey seal, harbour seal and bottlenose dolphin. A summary of the SACs designated for marine mammal features within the Regional Marine Megafauna Study Area is provided in section 1.5.2.

All species listed under Annex IV of the Habitats Directive are European Protected Species (EPS). All cetacean species and some marine turtle species, including leatherback turtle are afforded strict protection wherever they occur within a Member State's territory, both inside and outside designated protected areas.

In the UK and Ireland all species of marine mammals, basking shark and marine turtles are listed under Appendix I and II of the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals (CMS)). All species of cetacean and basking shark are listed under Appendix II of the Convention on the International Trade in Endangered Species of Flora and Fauna (CITES) and leatherback turtle is listed under Appendix I of CITES. All species of cetacean and leatherback turtle are listed under Appendix II (strictly protected fauna species) of the Bern Convention and grey seal and harbour seal are listed under Appendix III (protected fauna species) of the Bern Convention. In Ireland, it is an offence to harm, deliberately disturb, possess or trade in any species of marine mammal, basking shark or marine turtle, whether alive or dead (Wildlife Act, 1976).

1.3.2 Legal framework – UK and Isle of Man

In the UK, all species of marine mammal, basking shark and marine turtles are protected under the Wildlife and Countryside Act (1981) and are also protected in Manx waters by the Isle of Man Wildlife Act (1990).

1.4 Methodology

1.4.1 Desktop study

Data was gathered for the Project Marine Megafauna Study Area and Regional Marine Megafauna Study Area through a review of existing data sources for the Irish Sea region. A summary of the key sources of information used for this baseline characterisation is provided in Table 1-1.

Table 1-1: Key sources of information.

Data	Description	Source
Harbour porpoise *Phocoena phocoena* surveys	Various surveys carried out by the Irish Whale and Dolphin Group (IWDG) using boat-based visual and aerial sampling techniques	Berrow *et al.* (2018; 2013; 2008)
Inshore surveys for cetaceans	Visual and acoustic surveys for cetacean carried out in two survey blocks in the north and south Irish Sea; the northern half of block A was in proximity to the Project	Berrow *et al.* (2011)
Irish Cetacean Review	Records of sightings and strandings throughout Irish waters	Berrow *et al.* (2010)
Basking Shark Watch 20-year Report (1987-2006)	Report presenting findings of 20 years of UK basking shark sightings and data analysis from the Basking Shark Watch Project (BSWP)	Bloomfield and Solandt (2008)
Aerial surveys of harbour seals in Ireland	An aerial survey of harbour seals in Ireland: Part 2: Galway Bay to Carlingford Lough (August – September 2012)	Duck and Morris (2013)

Data	Description	Source
	Thermal imaging surveys of seals in Ireland 2017 to 2018	Morris and Duck (2019)
SCANS II cetacean surveys	Small cetacean abundance in the North Sea (SCANS) surveys	Hammond *et al*. (2013)
SCANS III cetacean surveys	Small cetacean abundance in the North Sea (SCANS) surveys	Hammond *et al.* (2017)
	Estimates of cetacean abundance in European Atlantic waters from the Small Cetaceans in European Atlantic waters and the North Sea (SCANS) aerial and shipboard surveys	Hammond *et al.* (2021)
	Density surface modelling from SCANS III surveys	Lacey *et al.* (2022)
SCANS IV cetacean surveys	Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS IV aerial and shipboard surveys	Gilles *et al.* (2023)
Welsh Marine Mammal Atlas (2023)	Modelled Distribution and Abundance of Cetaceans and Seabirds in Wales and Surrounding Waters (2023) (Welsh Marine Mammal Atlas)	Evans and Waggitt (2023)
Management Units (MU) for marine mammals	Joint Nature Conservation Committee (JNCC) Management Units for all marine mammals in UK waters	Inter-Agency Marine Mammal Working Group (IAMMWG) (2013)
Management Units for cetaceans	Updated JNCC Management Units for cetaceans in UK waters	IAMMWG (2015; 2022)
	Review of Management Unit boundaries for cetaceans in UK waters (2023)	IAMMWG (2023)
Marine mammals in Ireland	Atlas of the marine mammals of Ireland 2010 to 2015	Lysaght and Marnell (2016)
Harbour and grey seal maps	Updated at-sea distribution maps (mean and upper/lower confidence intervals) based on telemetry data from UK tagged seals and sightings data from the Irish Sea. These updated maps were compared to previous at-sea distribution maps for the Irish Sea which were based upon a 2003 aerial survey of the Irish Sea.	Marine Scotland (2019a; 2019b) Russell *et al*., (2017) Jones *et al.* (2015)
Harbour and grey seal distribution maps	Habitat-based predictions of at-sea distribution for grey and harbour seal in the British Isles	Carter *et al*. (2020; 2022)
Biodiversity maps for Ireland	Marine mammal sightings and stranding records from dedicated surveys and from incidental observations.	National Biodiversity Data Centre (NBDC) online mapping tool (NBDC, 2020)
National Parks and Wildlife Service (NPWS) Marine Mammal and Sea Turtle Species Assessments	The Status of EU protected Habitats and Species in Ireland: Species Assessments (Volume III)	NPWS (2019)
Protected sites data	Internationally designated sites for the conservation of marine mammals in Irish waters	NPWS (2015, 2014a, 2014b, 2014c, 2013, 2011)
Marine turtle sightings records	Marine turtle Annual Reports of live and dead records in the UK and Republic of Ireland, Marine Environmental Monitoring	Penrose and Gander (2022 – 2001)
ObSERVE aerial data	Occurrence, distribution and abundance of cetaceans and seabirds in Irish waters based on aerial survey data (2015 – 2017)	Rogan *et al*. (2018a)

Data	Description	Source
Special Committee on Seals (SCOS) series	Scientific advice in relation to management of grey seal and harbour seal populations in the UK. Pup production and population trends are described which provide a picture of the health of seal populations around the UK and can be extrapolated to Ireland.	SCOS (reports date from 1990 up to 2022)
Marine mammals in Irish waters atlas	Distribution and relative abundance of marine mammals in Irish offshore waters	Wall *et al*. (2013)

1.4.2 Site-specific surveys

1.4.2.1 Overview

A summary of the surveys undertaken to inform the Marine Mammals and Megafauna baseline characterisation is outlined in Table 1-2 below. These surveys are described further in the following sections.

Table 1-2: Summary of site-specific survey data.

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
Oriel Wind Farm 2006 site-specific boat-based surveys	Marine Megafauna Study Area (see Figure 1-2)	Three surveys were conducted over a six-month period in 2006 (March/April; May/June; and July/August). 11 transects spaced 2 km apart were surveyed over a two-day period. Surveys were not conducted by dedicated Marine Mammal Observers (MMOs), but incidental marine mammal observations were recorded.	Aquafact Ltd.	March to August 2006	Oriel Windfarm Ltd. (2007)
Oriel Wind Farm 2018 to 2020 site-specific boat-based surveys	Marine Megafauna Study Area (see Figure 1-2)	Monthly boat-based surveys were completed from May 2018 to May 2020 (with the exception of February, March and April 2020 due to COVID restrictions). 11 transects spaced 2 km apart were surveyed over a two-day period each month. Surveys for the first three months were not conducted by dedicated MMOs. Surveys from August 2018 onwards were conducted by dedicated MMOs.	Galway Mayo Institute of Technology and IWDG on behalf of Aquafact Ltd.	May 2018 to May 2020	Aquafact Ltd. (2019; 2020)
Oriel Wind Farm 2020 site-specific aerial surveys	Marine Megafauna Study Area (see Figure 1-2)	Monthly digital aerial surveys of seabirds and marine mammals and megafauna along the 11 transects surveyed for the boat-based data (see above).	APEM	April 2020 to September 2020	APEM (2020) (see annex 2 of appendix H: Ornithological and Marine Megafauna Aerial Survey Results of Oriel Offshore Wind Farm)
Oriel Wind Farm 2019 to 2020 site-specific SAM surveys	Marine Megafauna Study Area and offshore cable corridor (see Figure 1-2)	SAM conducted using C-PODs at two locations within the offshore wind farm area and two locations within the offshore cable corridor. Duration of deployment differed between locations due to issues with equipment losses.	IWDG	November 2019 to November 2020	O'Brien *et al.* (2020) (see annex 1: Static Acoustic Monitoring Survey)

1.4.2.2 Boat-based visual surveys

Historical surveys (2006)

A total of three seasonal surveys of marine mammals were conducted alongside seabird surveys in 2006. The Survey Area comprised the offshore wind farm area for the Project plus an approximately 5 km buffer area. A total of 11 transects, spaced 2 km apart, were surveyed each season over a two-day period (Figure 1-2). Due to adverse weather conditions, the surveys during September/October 2006 seasons could not be completed. Successful marine mammal surveys were conducted on the following dates:

- March/April season: 19 and 20 April 2006;
- May/June season: 8 and 9 June 2006; and
- July/August season: 27 and 28 July 2006.

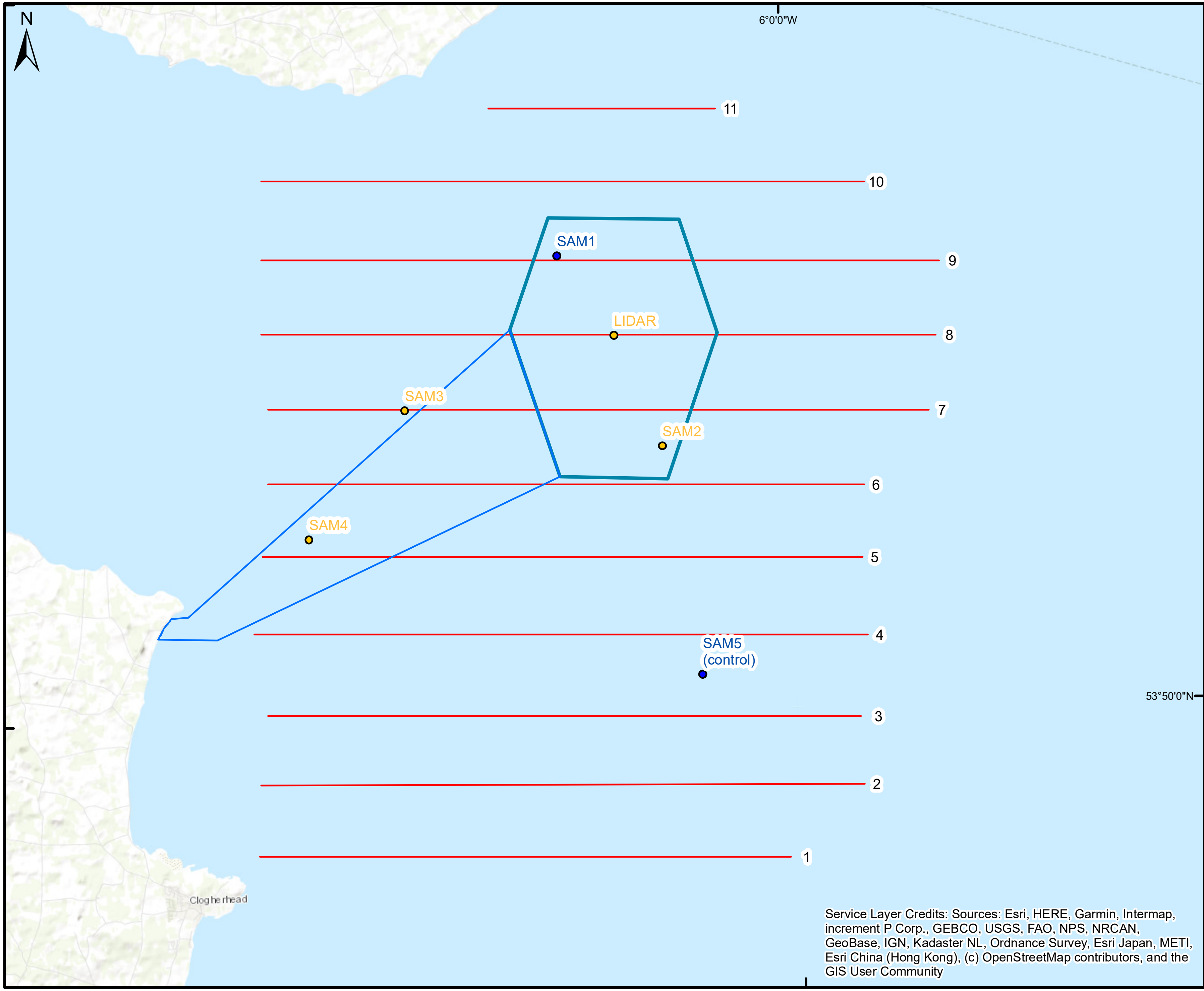
The standard JNCC survey protocol was followed (Walsh *et al.*, 1995). Marine mammals were recorded within a 90° arc over a transect width of 300 m to one side of the boat. Rare or conspicuous marine mammals were recorded beyond the 300 m transect as incidental observations and were excluded from further analyses. Environmental variables including wind force and direction, cloud cover, and sea state were recorded during each survey.

These surveys were not carried out by dedicated MMOs and did not record all observations beyond the 300 m transect. Therefore, it is possible that individuals may have been missed during the surveys, potentially resulting in an under-recording of the numbers of animals or species present. The data resulting from these surveys (as presented in Oriel Windfarm Ltd. (2007)) are therefore used to supplement the baseline characterisation but no additional data analysis has been conducted for the purposes of this report, and the data will not be carried forward for assessment purposes.

More recent surveys (2018 – 2020)

Monthly marine mammal and seabird surveys were conducted between May 2018 and May 2020. The Survey Area was designed to replicate the transects surveyed previously in 2006, following the same 11 transects, spaced 2 km apart (also shown in Figure 1-2). Surveys were conducted each month over a two-day period. All surveys were successfully completed in 2018, with the exception of November 2018, when one of the two survey days was missed due to adverse weather. However, the single survey day covered alternate transects over the Survey Area and therefore provides representative sampling coverage of the Survey Area. In 2019, all surveys were successfully completed with the exception of May 2019, September 2019 and November 2019. In 2020, European Seabirds at Sea (ESAS) census techniques (Camphuysen *et al*., 2004; Johansen *et al*., 2015) were employed. The surveys were conducted from the vessel '*Fastnet Petrel*', with a fixed platform height of 4.2 m above sea level (>5 m at eye height). Marine mammals were recorded within a 90° arc over a transect width of 300 m to one side of the boat. Environmental variables including wind force and direction, cloud cover, and sea state were recorded during each survey.

For the first three months of survey (May, June and July 2018) marine mammal sightings were recorded by one of the ESAS surveyors (certified as an MMO) as they occurred within the transect defined for the seabird survey (within 300 m of the trackline). Incidental observations were made for marine mammals outside the transect during these months. This approach is considered to result in under-recording and therefore, subsequently, the approach was adapted and the use of dedicated MMOs commenced in August 2018 and continued for all further surveys.



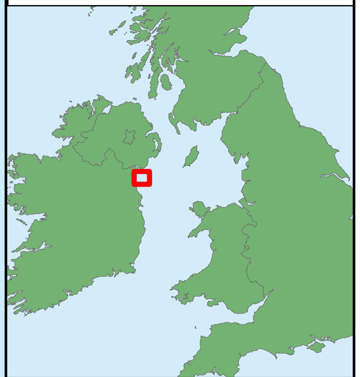
Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Bird & Mammal Boat-based Transect Line

Static Acoustic Monitoring (SAM) locations

- Long term deployments
- Loss of moorings/ equipment

Data Sources: Client.



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Project

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Title

Figure 1-2
Transects surveyed during the site-specific marine mammal boat-based surveys (2006 surveys and 2018 to 2020 surveys) and the 2020 aerial surveys and SAM locations monitored 2019 to 2020.

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1.4.2.3 SAM surveys

SAM was carried out between November 2019 and November 2020 to complement the boat-based visual surveys and describe the long-term presence of harbour porpoise within the Marine Megafauna Study Area. A detailed description of the approach and findings is presented in annex 1: Static Acoustic Monitoring Survey of this report. A total of 685 days of SAM data were collected at locations within the offshore wind farm area and offshore cable corridor using self-contained click detectors (C-PODs) (Figure 1-2). SAM was initially planned for a total of five sites, including a control location outside the offshore wind farm area but due to the loss of moorings and equipment this approach was revised. Subsequently, SAM data were available for two locations within the wind farm boundary (SAM2 and the floating Light Detection and Ranging (LIDAR) site) and two locations within the offshore cable corridor (SAM3 and SAM4) (Figure 1-2).

SAM was undertaken using fully-automated C-PODs which can detect echolocating animals such as porpoises, dolphins and other toothed whales withing a frequency range of 20 to 160 kHz. When a tonal click was detected, the C-POD recorded the time of occurrence, centre frequency, intensity, duration, bandwidth and frequency of the click. Click train recognition software (C-POD.exe) was then used to process the data. There were five species classification parameters but for this study the data collected was discriminated into two categories: 1) harbour porpoise and 2) dolphin species.

The range at which these devices can operate is context specific but a study in the Shannon Estuary showed average estimated detection distances of 441 m (harbour porpoise) and 798 m (bottlenose dolphin) (O'Brien *et al*., 2013). All C-POD equipment was calibrated twice – once in the laboratory under controlled conditions and subsequently in the field prior to deployment - to allow standardisation across units. C-PODs were then deployed on weighted mooring systems at each the selected locations for consecutive operational periods of three to four months. At the end of each period the systems were recovered, data downloaded and the systems re-deployed thus allowing the collection of continuous data over a one year period. Once deployed SAM are able to operate in all weather conditions thereby allowing the collection of a high quality (albeit small spatial scale) dataset over time.

1.4.2.4 Aerial digital surveys

Digital aerial surveys were undertaken by APEM between April and September 2020. A detailed description of the approach and findings is presented in annex 2 of appendix H: Ornithological and Marine Megafauna Aerial Survey Results of Oriel Offshore Wind Farm. The twin-engine aircraft was flown at an altitude of 395 m and a speed of 120 knots along the same 11 surveys lines that were delineated for the boat-based surveys. Data collected were 1.5 cm ground sample distance (GSD) digital still images using a GPS-linked bespoke flight management system to ensure the tracks were flown with a high degree of accuracy. The cameras covered a minimum of 25% of the sea surface of the survey area which was subsequently taken forward for analyses.

Weather conditions during all surveys were conducive to collecting and analysing imagery for the purpose of providing data on the identification, distribution and abundance of bird species and marine fauna within the survey area. Favourable conditions for surveying are defined as a cloud base of >518 m, visibility of >5 km, wind speed of <30 knots, and sea state of 4 (moderate) or less on the Beaufort scale.

Imagery was captured in raw format and post-processed to ensure optimal quality for the subsequent stage of image analysis, to extract information on marine fauna or other notable occurrences. When a survey was completed, the data were checked to ensure the number of lines and the number of images collected were correct, and that the quality of the imagery was acceptable. Once the image analysis was completed, further Quality Control (QC) processes take place (see section 3.2, annex 2 of appendix H: Ornithological and Marine Megafauna Aerial Survey Results of Oriel Offshore Wind Farm).

1.4.3 Analyses

1.4.3.1 Boat-based visual surveys

Historical boat-based surveys (2006)

For the purposes of this report, density estimates for harbour porpoise and minke whale were taken from Oriel Windfarm Ltd. (2007). No additional data analysis was conducted on the historical survey data for the purposes of this report, and this data was not carried forward for assessment purposes.

Boat-based surveys (May 2018 to May 2020)

Initially, encounter rates were calculated for all marine mammal and megafauna species sighted in the Survey Area during recent site-specific surveys. Encounter rates can be used as a basic index to make comparisons between 'relative abundance' of different species within an area or between areas and/or time periods; they are not a measure of density, and do not take into account the factors that affect detectability of different species in different survey environments. Encounter rates were calculated by dividing the number of observations by the amount of survey effort (length of transect observed).

Data taken from the transect surveys were used to calculate the density of marine mammals in any given season or month across the survey area using distance analyses (annex 2). Data were pooled across all months to inform the detection functions for each species and subsequently were truncated to 500 m as up to 90% of observations were within this distance. Sea state (categorical data) and group size (continuous data) were fitted as covariates to model the effect of these – in addition to distance - on detection probability. Exploratory analyses to determine goodness of fit of each detection function model were undertaken using standard approaches (e.g. Akaike Information Criterion (AIC), QQ plots etc).

Models were fitted to spatially explicit sightings data within a defined grid covering the Survey Area. These spatial abundance maps of marine mammals were made for each season (and month where appropriate) and models were developed to predict the abundance and density of marine mammals across the survey. Confidence interval maps were then produced for each spatial abundance map. The marine mammal survey data was analysed using the CReSS approach in a GEE framework with SALSA for model selection (Mackenzie *et al*., 2013). Several environmental variables were used as predictors of marine mammal density and distribution across the defined grid, covering the survey area. The following environmental covariates were used to predict the species' distributions:

- Bathymetry (depth in metres);
- X and Y coordinates; and
- Distance to coast (metres).

Using the MRSea package in R, the data was modelled using regression splines to best predict the density of marine mammals depending on these environmental variables.

Availability Bias

An equation modified by Mannocci *et al*. (2018) for marine mammal observations during shipboard surveys can be used to calculate availability bias using the data on surfacing and dive times of marine mammals:

$$g(0) \quad = \frac{E[s]}{E[s]+E[d]} + E[d]\frac{1-\exp\left(-\frac{1}{\mathrm{E[d]}} * \frac{r}{s}\right)}{E[s]+E[d]}$$

Where *E[s]* is the maximum time spent at or near the surface, *E[d]* is the mean dive duration, *r* is the maximum forward distance at which animals were expected to be detected (taken as 90^{th} percentile of radial distances), and *s* is the mean vessel speed (for Oriel = 5.9 ms^{-1}).

For harbour porpoise, the dive and surfacing times was taken from study looking at fine scale movements of harbour porpoise in the Danish North Sea (van Beest *et al*., 2018). GPS and dive recorder (V-tags) were used to record the diving behaviour of tagged individuals and the study estimated a mean dive duration of 53 s (min = 10.1 s, max = 250.0 s) and a mean surfacing time of 39 s (min = 2 s, max = 309 s). Taking a precautionary approach, the availability bias was calculated using the maximum dive duration (250.0 s) and the mean surfacing time (39 s). The value for 'r' in the equation above was based on the Estimated Strip Width in the Distance model (= 288 m for harbour porpoise). In this way an availability bias of 0.66 was calculated for harbour porpoise although with the caveat that this is not a precise measurement as it is acknowledged that a site-specific estimate would have been more robust.

The same equation above was applied to minke whale. A visual tracking study of minke whale in Iceland recorded the time sequence of individual minke whales in terms of the duration when they were on the surface in between both short and long dive sequences (McGarry *et al.*, 2020). Surfacing time was estimated as 58 s whilst dive duration was a mean of 73 s. With an Estimated Strip Width (ESW) of 291 the availability bias calculated for the tracking study of minke whales in Iceland was 0.72. As described for harbour porpoise this is not a precise measurement as it is acknowledged that a site-specific estimate would have been more robust.

A tracking study of three male grey seals in the Farne Islands (northeast England) found that the average proportion of time animals were submerged as they travelled was 84.3%, and this was slightly lower during short duration trips (83.4%) (Thompson *et al.,* 1991). Therefore, it follows that the average proportion of time a travelling grey seal would be available for detection ranges between 15.7% and 16.6%. Similarly, telemetry data from tags deployed by the Sea Mammal Research Unit (SMRU) on grey seals in the North Sea recorded 1,551 grey seal dives. These data were analysed for the Hornsea Three Offshore Wind Farm (to estimate detection probability) and showed that 60% of surfacing periods were between 15 and 45 seconds with an average of 40 seconds (Orsted, 2018). Dive durations varied between 20 and 496 seconds with an average of 216 seconds (Orsted, 2018). The average values reported from the telemetry data were used to estimate the proportion of time that grey seals were surfacing compared to diving to give an indication of the availability bias for the site-specific aerial surveys. The estimated availability was calculated as 15.6% and was therefore similar to the figures cited by Thompson *et al.,* (1991).

1.4.3.2 SAM surveys

Once processed the C-POD data were analysed to determine 'detection positive minutes' per day therefore generating a record of acoustic activity showing seasonal, diel and tidal occurrence of harbour porpoise (in porpoise positive minutes or PPM) and dolphin species (in dolphin positive minutes or DPM). Only 'high' and 'moderate' probability clicks were taken forward for trend analyses and further validation was performed by visual inspection of the click trains to determine the likelihood of false positives. This validation (on a 10% sample) showed that very few trains were false positives and therefore analyses of the data could proceed.

To assess fine scale use in detection positive minutes across the study area, the data were grouped according to the following environmental categories: season (spring, summer, autumn and winter), diel cycle (morning, day, evening and night-time), tidal state (ebb, flood, slack high, slack low) and tidal phase (spring, neap) (see section 3.1.4 of annex 1 for detailed classification).

A Generalised Linear Model (GLM) was fitted to the binomial data for the three sites where long-term data had been collected – SAM 2, 3 and 4 and the LIDAR site - using the programme R. The analyses investigated the influence of the different environmental categories (as factors) on DPM/PPM as the dependant variable. A series of post hoc tests were carried out to determine the best-fit model selection (see section 3.1.4 of annex 1 for further details of the tests). For SAM location 3, where three different deployments took place C-POD ID number was further included as a random factor to take into account potential variability between units.

1.4.3.3 Aerial digital surveys

For each monthly aerial digital survey of the Ornithology Study area, geo-referenced locations of marine fauna, contained within each individual digital still image, were used to generate raw counts. Marine fauna locations contained within the boundaries of the two areas – the survey area and the offshore wind farm area alone - were then extracted using QGIS, providing raw count data. These data are presented in annex 1 of appendix H: Offshore Ornithology Technical Report.

The raw counts were divided by the number of images collected to give the mean number of animals per image (i). Population estimates (N) for each survey month were then generated by multiplying the mean number of animals per image by the total number of images required to cover the entire study area (A):

$$N = i\,A$$

Non-parametric bootstrap methods were used for variance estimation. A variability statistic was generated by re-sampling 999 times with replacement from the raw count data. The statistic was evaluated from each of these 999 bootstrap samples and upper and lower 95% confidence intervals of these 999 values were taken as the variability of the statistic over the population (Efron and Tibshirani, 1993).

1.4.4 Assumptions and limitations

1.4.4.1 Boat-based surveys

The assumptions and limitations highlighted below are typical of difficulties encountered with undertaking field surveys of marine mammals using boat-based methods.

Survey approach

Marine mammal surveys are often conducted alongside seabird surveys as the survey protocol is similar for these two taxonomic groups. There are, however, some fundamental differences in the way observations are conducted which mean that the survey approach should ideally be adapted to address marine mammals separately, using a dedicated MMO rather than a single observer recording both seabirds and marine mammals. For example, a seabird observer will be viewing animals primarily in the air, with a smaller proportion noted on the surface of the sea. This contrasts with marine mammal surveys where all animals are sighted breaking the surface of the sea and therefore dedicated MMOs would observe the sea surface at all times. For the first three months of the 2018 to 2020 surveys, dedicated MMOs were not onboard the survey vessel. However, from August 2018 onwards, dedicated MMOs were onboard the survey vessel. In addition, seabird surveys are typically conducted over a fixed transect width of 300 m (i.e. ‘strip’ transects) and, as described previously (section 1.4.2.1), this means that a single observer would only make ‘incidental’ observations beyond the 300 m strip width. Marine mammal surveys, on the other hand, are more usefully conducted as line transects as these do not place a restriction on the distance that an animal can be recorded either side of the trackline (Buckland *et al.,* 2001).

Sea state

Sea state was recorded during the surveys and the results (presented in Table 1-4) show that sea state varied considerably between surveys over a range from 1.8 up to 4 and this can influence the detection probability of marine fauna during the surveys. Ideal conditions for marine mammal surveys are where sea states are 3 or less. Even then, at sea state 3 the probability of detecting a marine mammal can be significantly lower compared to sea states 0 or 1. For example, boat-based visual surveys of marine mammals in the Greater Wash for the Hornsea Project Three offshore wind farm estimated that detection probability decreased from 0.58 in sea state 1 to 0.22 in sea state 2 and 0.14 in sea state 3 (Orsted, 2018).

Species identification

Where possible marine fauna were identified to species level, although this was not achieved in all cases. In particular, it can be difficult to distinguish between different species of seal at sea and therefore, in these instances, the sighting was recorded as ‘seal species’. Since there were a number of sightings recorded as ‘seal species’, these unidentified seals were allocated to each species (grey seal *Halichoerus grypus* or harbour seal *Phoca vitulina*), based on the relative proportion that each species contributed to the overall number of identified seals present. In this way, all seal sightings could be used in the data analyses, which is important where the number of sightings in general is relatively low. For cetaceans, since only a small number of individuals were unidentified to species level these were removed from the analyses as their inclusion would not substantially affect the results.

Data availability

Surveys were not carried out in May 2019, September 2019 or November 2019 due to adverse weather conditions. Surveys planned to be carried out in February, March and April 2020 were not undertaken due to

COVID restrictions. However, an additional survey was carried out in May 2020 to replace the survey missed in May 2019. Analysis of seasonal trends is therefore affected by lack of data during these months. Furthermore, the presence of issuing data was accounted for by exploiting empirical relationships between abundance and other variables (depth and distance to coast) and exploiting commonalities between distributions in different months.

1.4.4.2 SAM surveys

Equipment losses/failure

The sampling design for the programme of SAM surveys included four locations within the offshore wind farm area and offshore cable corridor and one further location outside the offshore wind farm area as a control. However, there were multiple losses of equipment throughout the sampling campaign which meant that two of the five SAM locations had to be discounted due to data gaps and an additional location – the floating LIDAR within the offshore wind farm area – was included as a fourth location.

Spatial scale

C-PODs are able to provide continuous data for marine mammals that pass within close distances of the devices but the range over which these devices are able to record echolocation activity is limited to within approximately 400 m for harbour porpoise and approximated 700 m for dolphin species meaning that the spatial scale of the study is relatively small. However, due to the long-term deployment of the devices these data are considered to provide a good indication of the occupancy of the site, particularly with respect to harbour porpoise, which can be summarised by season, time of day and tidal cycle.

Species identification

The manufacturers click classification software can be reliably used to classify to species level for harbour porpoise but for dolphins it is not possible to differentiate between the species due to similarities in their click characteristics and overlap in frequency use. For this reason, all dolphin clicks could only be classified as ‘dolphin species’.

1.4.4.3 Aerial digital surveys

Weather Conditions

Weather conditions during the surveys were conducive to collection and analysis of imagery for the purpose of providing data on the identification, distribution and abundance of marine mammals within the study area. Several weather factors were assessed before a survey was commenced including, visibility, cloud cover, wind speed and sea state. Good enough weather conditions to survey were defined a cloud base of >518m, visibility of >5 km, wind speed of <30 knots, and sea state of 4 (moderate) or less on the Beaufort scale. For safety reasons, no surveying takes place in icy conditions. Good weather conditions were present for all surveys from April 2019 to March 2020. However, although all above the threshold to survey, weather conditions did vary between surveys, potentially making marine fauna more difficult to detect in some surveys compared to others.

Species Identification

Animals were identified as close to species level as possible. This was not possible from all of the images where marine mammals were present, meaning some sightings are grouped at a higher taxonomic level. Identification to species level can be difficult for some marine mammals such as seals, as it was not always possible to distinguish between species from aerial shots, particularly where an individual is submerged.

Bias in Data

Availability bias in the data (where an animal is underwater and therefore not available for detection) means that raw data counted from images is likely to be an underestimate of the total abundance of species. Availability bias can be corrected for using an estimate of the probability that an animal is on the surface at any randomly chosen instant. The resulting correction factor can then be used to estimate the total number of animals that may be present within the survey area. In the case of aerial digital surveys, animals are available for detection if they are on the surface or just below the surface (depth of detectability is dependent on water clarity).

Perception bias (where an animal is on the surface but the detection is missed) is less of a limiting factor since the high definition digital aerial survey captures all animals on the surface and the detection is not influenced by the ability of an observer to detect an animal.

Distribution of marine mammals

As raw counts of data were divided by the number of images taken, and then multiplied by the number of images required to cover the study area, this assumes an even distribution of marine mammals across the study area, of which, a relative sample was captured by the aerial survey. In reality, marine mammal distribution is patchy, and this method of sampling has the potential to underestimate or overestimate marine mammal abundance within the survey area. To account for this, a variance estimation was carried out using non-parametric bootstrap methods to generate 95% confidence intervals which could be used as the variability of the statistic over the population. A measure of precision of the data was also calculated using a Poisson estimator, producing a coefficient of variation for the marine mammal sightings.

Survey timings

Aerial data have been collected monthly between April 2020 and September 2020. Whilst this is a recent dataset of the study area, it represents a snapshot over a single survey day on each month. Changes in sightings rates may be influenced by environmental conditions but it has not been possible to explore this over such short (one day) time frames of data collection. Therefore, whilst differences in sightings rates between months may be due to seasonal changes, environmental conditions also have the potential to influence these results.

1.5 Baseline environment

1.5.1 Desktop study

Regional Marine Megafauna Study Area

Twenty-five species of cetacean and two species of pinniped have been recorded in Irish waters, evidenced from sightings or stranding records (Berrow *et al*., 2010; O'Brien *et al*., 2009)[1]. This high species richness is attributed to the suitability of the physical marine environment (bathymetry, seabed topography, salinity, temperature etc.) and the availability and distribution of prey species in Irish waters. The waters off the west and southwest coasts of Ireland support the greatest diversity and abundance of marine mammals in Irish waters.

Off the east coast of Ireland, in the western Irish Sea, the historical sightings and strandings records of cetaceans provide an overview of the species most likely to occur in the Irish Sea (Berrow *et al.,* 2010). Whilst some species are common and widespread throughout the Irish Sea (e.g. harbour porpoise *Phocoena phocoena*), other species are likely to be rare visitors to the region. A summary of the cetacean species recorded in the Irish Sea is provided in Table 1-3.

Table 1-3: Summary of cetacean species found in the Regional Marine Megafauna Study Area (Irish Sea). Sources: Berrow *et al.*, 2010 and www.biodiversitymap.ie.

Species	Occurrence in the Irish Sea	Description
Toothed whales, dolphins and porpoises		
Harbour porpoise *Phocoena phocoena*	Abundant	Abundant and widespread throughout Irish Sea; most frequently reported cetacean in Irish waters

[1] Following the sighting of a bowhead whale *Balaena mysticetus* in the Irish Sea in 2017 the total species count for Irish waters has increased from 24 to 25 (IWDG *pers. comm*).

Species	Occurrence in the Irish Sea	Description
Short-beaked common dolphin *Delphinus delphis*	Common	Occurs throughout the Irish Sea and second most frequently reported cetacean after harbour porpoise in Irish waters
Bottlenose dolphin *Tursiops truncatus*	Common	Occurs in both eastern and western Irish Sea near the coast and there is a semi-resident population at Cardigan Bay
Atlantic white-sided dolphin *Lagenorhynchus acutus*	Occasional	Largely restricted to cool waters of the North Atlantic; rarely recorded in the Irish Sea; 5 stranding records (1984-2006)
Striped dolphin *Stenella coeruleoalba*	Occasional	Small number of records from the Irish Sea and rarely sighted in inshore waters; largely distributed along south and west Ireland
Risso's dolphin *Grampeus griseus*	Common	Frequently recorded species in Irish Sea, particularly off coast of Co. Wexford and Wicklow
White-beaked dolphin *Lagenorhychus albirostris*	Rare	Sightings rare in all Irish waters; no sightings records for Irish Sea and only one stranding record
Killer whale *Orcinus orca*	Occasional	Occasionally sighted in Irish Sea (most recently 2011) but most sightings to southwest, west and north of Ireland
Sperm whale *Physeter macrocephalus*	Rare	Largely distributed off the western and along the northern coast of Ireland; single stranding record (1,766) on east coast
Beaked whales (Ziphidae)		
Northern bottlenose whale *Hyperoodon ampullatus*	Rare	Records of strandings on east coast of Ireland although none since 1954; sightings in inshore waters very rare.
Sowerby's beaked whale *Mesoplodon bidens*	Rare	Rarely recorded in Irish Sea; records of strandings on the southeast coast of Ireland; one in 2004.
Baleen whales		
Humpback whale *Megaptera novaeangliae*	Occasional	More commonly seen in the south and southwest of Ireland but occasional sightings on the east coast of Ireland.
Minke whale *Balaenoptera acutorostrata*	Common	Most frequently sighted baleen whale in Irish waters; occurs seasonally (spring/summer) in the Irish Sea
Fin whale *Balaenoptera physalus*	Rare	Occurs primarily in the south of Ireland but also along the west coast; rarely recorded in the Irish Sea
Blue whale *Balaenoptera musculus*	Rare	Migrates along the western seaboard of Ireland; single stranding record (early 1900) on the southeast coast of Ireland

Both species of pinniped, harbour seal *Phoca vitulina* and grey seal *Halichoerus grypus*, are native to Irish waters and have been recorded in the western Irish Sea. Terrestrial haul-out sites are scattered along the east coast of Ireland and are important locations for resting, moulting, breeding and pupping. Harbour seals favour inshore bays and islands, coves and estuaries, and on the east coast of Ireland there are strongholds at Carlingford Lough (County Louth) and Strangford Lough (County Down, Northern Ireland) (Lyons, 2004). The largest haul-out populations of grey seal on the east coast of Ireland are located at the Saltees and the Raven (both off County Wexford) (Lyons, 2004). Grey seal haul-out between tides, usually on rocks, uninhabited offshore islands and secluded beaches.

Basking shark *Cetorhinus maximus* is the largest fish seen off the Irish coast and migrates through Celtic and Irish waters during spring and summer. Basking shark has been recorded all around the coast of Ireland including the Irish Sea. The majority of sightings are around the south and southwest coasts of Ireland, however, there are a significant number of sightings records along the east coast of Ireland suggesting that the Irish Sea is also an important area for this species (www.maps.biodiversity.ie).

Historical records show that three species of marine turtle are likely to occur in Irish waters including leatherback (or 'leathery') turtle *Dermochelys coriacea*, loggerhead turtle *Caretta caretta* and Kemp's Ridley turtle *Lepidochelys kempii* (King and Berrow, 2009). Leatherback turtle is the most regularly reported turtle species around the coast of Ireland, accounting for just over 80% of all records (King and Berrow, 2009). Loggerhead turtle accounted for 5.6% of records and Kemp's Ridley turtle accounted for 0.9% of records.

Only single records have been found of hawksbill turtle *Eretmochelys imbricata* and green turtle *Chelonia mydas,* both on the south coast of Ireland, and these are thought to be rare vagrants to Irish waters (King and Berrow, 2009). The majority of sightings or strandings records are along the south and west coasts of Ireland, however, there are records of leatherback turtles along the east coast of Ireland suggesting that this species may be common within the Irish Sea.

Marine Megafauna Study Area

Existing data demonstrates that a number of cetacean species may occur within the vicinity of the Project. Harbour porpoise sightings were recorded frequently all along the east coast of Ireland during the ObSERVE aerial surveys, including the area around the Project, further corroborated by records from the NBDC (NBDC, 2024a). Harbour porpoise was the most frequently recorded cetacean species during the site-specific boat-based and aerial surveys and was recorded in every month of the year (see Table 1-5). Harbour porpoise was also recorded daily during the site-specific SAM surveys.

Other species of cetacean known to occur frequently in the Marine Megafauna Study Area include bottlenose dolphin, minke whale and short-beaked common dolphin (hereafter referred to as "common dolphin"). The presence of all three species were confirmed from existing records held by the NBDC which showed a number of sightings (in the last 10 years) around the Dundalk Bay area (NBDC, 2024).

Bottlenose dolphin is a wide-ranging species travelling distances of hundreds of kilometres around the coast of UK and Ireland (Nykanen *et al.*, 2019). It is therefore possible that animals within the Marine Megafauna Study Area may have originated from SACs designated for bottlenose dolphin in the eastern Irish Sea (i.e. Cardigan Bay SAC and Lleyn Peninsula and the Sarnau SAC; section 1.5.2). Existing records of bottlenose dolphin show the presence of this species in Dundalk Bay in spring, summer and autumn. No bottlenose dolphins were recorded during the boat-based, SAM or aerial site-specific surveys. There were unidentified dolphin species recorded during the SAM and aerial site-specific surveys, however, these were not confirmed to be bottlenose dolphins.

There is a seasonal pattern to the occurrence of minke whale in the Marine Megafauna Study Area with most sightings recorded during late summer/early autumn (NBDC, 2024b). Minke whale distribution is known to be closely linked to the distribution of key prey species. For example, in summer months this species is likely to make inshore movements over sandeel *Ammodytes* habitat whilst in autumn they disperse to pre-spawning herring *Clupea harengus* habitat (MacLeod *et al.*, 2004; Robinson *et al.,* 2009). During the site-specific surveys, a total of 30 minke whales were recorded during the boat-based survey and 1 minke whale was recorded during the aerial survey (Table 1-5, Table 1-17). An additional unidentified baleen whale was observed during the aerial survey, but this was not confirmed to be a minke whale.

Most existing records of common dolphin around Dundalk Bay are from the autumn months (NBDC, 2024c), corroborated by the recent site-specific boat-based surveys, which recorded large pods of common dolphin during August and September 2018 and a few individuals in December 2019 (see Table 1-5). Unidentified dolphin species were identified in the SAM surveys, however, the exact species could not be determined due to the overlap of sound frequency with other dolphin species (Table 1-14). Similarly, in the aerial surveys, over 40 dolphin/porpoise individuals were recorded, but could not be identified to species level (Table 1-16).

Risso's dolphin is frequently sighted in the Irish Sea, however, the majority of records for this species are south of the Marine Megafauna Study Area along the inshore waters of County Wexford and County Wicklow (Berrow *et al.,* 2010; NBDC, 2024d). Data from the ObSERVE surveys corroborates this finding, showing that Risso's dolphin regularly appears near the Saltee Islands (County Wexford), with no sightings recorded within the Marine Megafauna Study Area. Similarly, during the inshore boat-based visual and acoustic surveys of the Irish Sea in 2011, only harbour porpoise, minke whale and grey seal were recorded in 'Block A', within which the Marine Megafauna Study Area is located (Berrow *et al.,* 2011). Again, unidentified dolphin species were recorded during the SAM and aerial surveys, however, no individuals were confirmed to be Risso's dolphin. Risso's dolphin is therefore not considered to be a key species within the Marine Megafauna Study Area.

Grey seal has a wide distribution around the coast of Ireland and there are a considerable number of records for this species within the Marine Megafauna Study Area (NBDC, 2024e). The closest key haul-out sites for grey seal – measured as the shortest distance between the haul-out and the offshore wind farm area – are located 4.5 km to the north (near the mouth of Carlingford Lough) and 5.5 km to the south (near

Clogherhead) (see Figure 1-35 in section 1.6.5). Grey seals regularly travel between haul-out sites and offshore feeding areas and data from the recent boat-based and aerial surveys suggest that this species regularly occurs within the offshore wind farm area (see section 1.6.5).

Harbour seal, although less frequently recorded than grey seal, also has an Ireland-wide distribution and there are sightings records within the Marine Megafauna Study Area (NBDC, 2019f). The recent site-specific boat-based surveys also noted harbour seal within the Marine Megafauna Study Area, albeit in low numbers (see section 1.6.6). Site-specific aerial surveys also recorded phocids in the survey area that were not able to be identified down to species level. The closest key haul-out sites for harbour seal – measured as the shortest distance between the haul-out and the offshore wind farm area – are located 6.5 km to the north (just within the mouth of Carlingford Lough), 4.9 km to the south (near Clogherhead), and 17.8 km to the west (within the mouth of Dundalk Bay) (see Figure 1-35 in section 1.6.5). Harbour seals tend to forage within 50 km of haul-out sites (SCOS, 2015) therefore individuals from these haul-out sites may forage within the offshore wind farm area or transit the offshore wind farm area to foraging areas further afield.

Basking sharks were noted to the north of Dublin Bay during the inshore surveys of the western Irish Sea in July 2011 (Berrow *et al*., 2011). In addition, sighting records from the IWDG chondrichthyan database (within the last 10 years) suggest basking shark occurs in inshore areas around Dundalk Bay and in the vicinity of the offshore wind farm area. Basking sharks have also been tracked migrating through the Irish Sea, along the eastern coast of Ireland (Doherty *et al.,* 2017), migrating past the offshore wind farm area. Two basking sharks were recorded during the boat- based surveys, one in August 2018 and a second in August 2019. One unidentified shark was recorded during the ariel site-specific survey; however, this was not confirmed to be a basking shark.

The biodiversity maps of Ireland suggest that leatherback turtle may occur in the vicinity of the offshore wind farm area, supported by historical records gathered between 1971 and 2005 (King and Berrow, 2009; NBDC, 2024g). Of the 863 records of leatherback turtles around the coast of Ireland, only three (0.3%) were in the waters off County Louth (King and Berrow, 2009). There were no other turtle species recorded historically off the coast of County Louth and only two records of stranded loggerhead turtles (from 2004) and one record of Kemp's Ridley turtle (from 1968) to the south, around Dublin Bay, from the NBDC Biodiversity Maps Ireland database. During the site-specific surveys, one leatherback turtle was recorded during the aerial survey (Table 1-16).

Key marine mammal and megafauna receptors

The literature review described above has identified the following species as key receptors for the Project baseline, and which may be affected by activities associated with the Project. Additional information on each species is provided below in the species accounts (section 1.6):

- Cetaceans:
  - Harbour porpoise
  - Bottlenose dolphin
  - Short-beaked common dolphin
  - Minke whale
- Pinnipeds
  - Grey seal
  - Harbour seal
- Other megafauna
  - Basking shark
  - Leatherback turtle

1.5.2 Designated sites within the Regional Marine Megafauna Study Area

The following sections summarise the designated sites within the Regional Marine Megafauna Study Area which have marine mammals as notified qualifying interests. Figure 1-3 shows the location of designated sites in relation to the Project.

Rockabill to Dalkey Island SAC

The Rockabill to Dalkey Island SAC is located 30.5 km to the south of the offshore wind farm area and is designated for Annex I reef habitat and Annex II harbour porpoise (Figure 1-3). This site extends southwards, in a strip approximately 7 km wide and 40 km in length, from Rockabill, running adjacent to Howth Head, and crosses Dublin Bay to Frazer Bank in south Co. Dublin (NPWS, 2013, 2014a). The site encompasses Dalkey, Muglins and Rockabill islands.

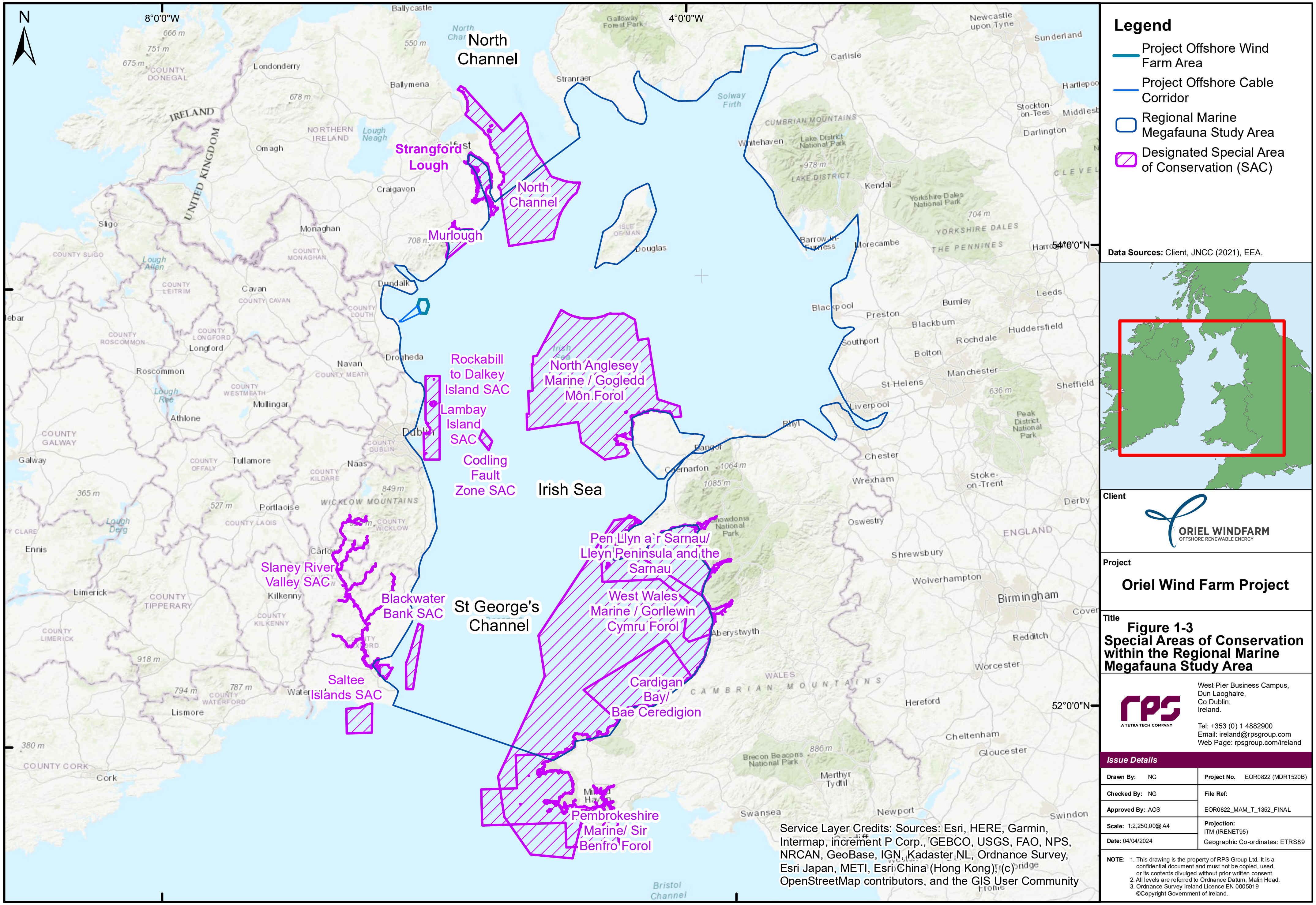
A range of habitats occur within this SAC, including sandy and muddy seabed, reefs, and sandbanks, which are key habitats for harbour porpoise. Harbour porpoise are known to inhabit shallow inshore sand and mud bank habitat and rocky reefs and are known to forage in areas of high tidal races (Pierpoint, 2008). Harbour porpoise occurs year-round within the SAC and at comparatively high group sizes (Department of Arts Heritage and the Gaeltacht, 2014). In addition, porpoises have been observed with calves at this SAC and effort-related sightings suggest that this species occurs here in relatively stable numbers across all seasons.

Grey seal and harbour seal are frequently reported in the SAC, although not as qualifying interests, as the SAC is in close proximity to the terrestrial haul-out sites for these species which are located on the coast of County Dublin (Figure 1-3).

Lambay Island SAC

Lambay Island SAC lies 43.1 km to the south of the offshore wind farm area and is within the boundaries of the Rockabill to Dalkey Island SAC (Figure 1-3) (NPWS, 2014b). Lambay Island is designated for the Annex I habitats Reefs and Vegetated Sea Cliffs and for Annex II species grey seal, harbour seal and harbour porpoise. Lambay Island SAC supports the principal breeding colony of grey seals on the east coast of Ireland. The 2024 SAC synopsis document gave a population estimate of 196 to 252 individual grey seals across all ages, whilst the count of harbour seal was given as 47 individuals (NPWS, 2024a). There are no quoted population estimates for harbour porpoise included in the site synopsis for this site.

A privately-owned inhabited island, this site comprises a low-lying western shore and steep cliffs to the north, south and east (NPWS, 2024). Offshore, the marine environment of the island has an extensive reef habitat. The intertidal shoreline, coves and caves around the island, provide ideal undisturbed haul-out sites for both grey and harbour seal.



Client: ORIEL WINDFARM — OFFSHORE RENEWABLE ENERGY

Project: **Oriel Wind Farm Project**

Title: **Figure 1-3 Special Areas of Conservation within the Regional Marine Megafauna Study Area**

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Issue Details

Drawn By:	NG	Project No.	EOR0822 (MDR1520B)
Checked By:	NG	File Ref:	
Approved By:	AOS		EOR0822_MAM_T_1352_FINAL
Scale:	1:2,250,000 @ A4	Projection:	ITM (IRENET95)
Date:	04/04/2024		Geographic Co-ordinates: ETRS89

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North Channel SAC

Covering approximately 85% of inshore waters in Northern Ireland, the North Channel SAC extends over a total area of 1,604 km^2 and lies 47.8 km to the north of the offshore wind farm area (Figure 1-3). This SAC is designated for harbour porpoise as a primary feature as it persistently supports high densities of harbour porpoise during the winter.

The water depths within the SAC range from mean low water springs at the coast to depths of around 150 m in the northern and eastern parts of the site. Near the coast, the waters are shallower with depths mostly between 10 and 40 m (DAERA and JNCC, 2017). A variety of habitats characterise the site with coarse sediments (sand/gravel) prevailing across large areas. Sandeels (Ammodytidae) – a key prey species of harbour porpoise – have a strong association with coarse sediments and therefore this may be a driver for high densities of harbour porpoise within this SAC.

SCANS II survey data (collected in July 2005) was used to derive a population estimate for this site of approximately 537 individuals (95% Confidence Interval (CI) = 276 to 1,046) for at least part of the year, noting that seasonal differences are likely to occur (DAERA and JNCC, 2017). Large groups of porpoises, numbering between 20 to 100 individuals have been recorded regularly between 1996 and 2014 in a narrow strip between Mew Island to Islandmagee (see Figure 1-17 in section 1.6.1). Although the SAC as a whole is designated for persistent high densities during winter months, this particular strip is also considered to be important during the summer months for harbour porpoise (DAERA and JNCC, 2017).

Murlough SAC

Murlough SAC encompasses the shallow waters of Dundrum Bay off the southeast coast of Northern Ireland (Figure 1-3). The habitat comprises extensive shallow sublittoral sandbanks and larger areas of intertidal mud and sandflat habitat. The beach at Ballykinler, which comprises dune habitat, is an important haul-out site for harbour seal and subsequently this species is listed as a selection feature for the Murlough SAC. The site, which lies 22 km from the offshore wind farm area, supports approximately 106 harbour seals (DAERA and JNCC, 2017).

North Anglesey Marine/ Gogledd Môn Forol SAC

Extending over an area of 3,249 km^2, the North Anglesey Marine SAC lies 55.9 km from the offshore wind farm area (Figure 1-3). The site is characterised by a mixture of hard substrate and sediments, including rock, coarse sediment, sand and mud. Water depths vary between Mean Low Water Tide (MLWT) and 100 m; away from the coast the depths largely fall within the range 40 to 50 m. This area has been designated for supporting persistently high densities of harbour porpoise during the summer months. It was estimated (based on the SCANS II survey data collected in July 2005) that the site supports approximately 1,084 individuals (95% CI = 557 to 2,111) for at least part of the year, as seasonal differences are likely to occur (JNCC and NRW, 2015a).

Codling Fault Zone SAC

Codling Fault Zone SAC is located 63 km south of the offshore wind farm area and has been selected for the presence of Submarine structures made by leaking gases and harbour porpoise. Structures made by leaking gases in the marine environment can form two described habitat types: Bubbling Reefs and Structures within Pockmarks. The habitat recognised in the Irish Sea conforms to the definition of bubbling reefs (NPWS, 2024b). The Codling Fault Zone has been documented to have in excess of 23 seep mounds generated as a result of currently active gas emissions from deep gas reserves. At this site, these features tend to form elongated structures, from 60-80 metres in width, raised a couple of metres proud of the surrounding seabed, which trace the movement of the strike/slip fault zone and can extend up to several hundred metres in length. A variety of fauna can be fund here including hydroids, anemones, crab, lobster, sponges, feather star, and fish species (NPWS, 2024b). There are no quoted population estimates for harbour porpoise included in the site synopsis for this site.

Strangford Lough SAC

The Strangford Lough SAC (Figure 1-3) is a is a multiple interest site selected for the presence of habitat types and/or species which are rare or threatened within a European context. The SAC covered the almost land-locked, Strangford Lough which is separated from the Irish Sea by the Ards Peninsula to the east and is bounded to the south by the Lecale coast. It is connected to the open sea by the Strangford Narrows, an 8 km long channel with a minimum width of 0.5 km. The Lough is 30 km long from head to mouth and up to 8 km wide (DAERA, 2017a). This SAC covers a total extent of 153.98 km^2 and is approximately 51 km from the offshore wind farm area. The site is designated for common seal however this is not a primary reason for the SACs selection (DAERA, 2017b). The SAC is considered to support a significant presence. The population was estimated at 210 at the time of designation in 2017 (DAERA, 2017a).

West Wales Marine/ Gorllewin Cymru Forol SAC

The West Wales Marine SAC covers a total area of 7,377 km^2 of Welsh inshore and UK offshore waters and lies approximately 136 km from the offshore wind farm area. Extending from the Lleyn Peninsula in north Wales to Pembrokeshire in southwest Wales, it reaches almost to the mid-line (UK Exclusive Economic Zone (EEZ)) between the Republic of Ireland and Wales. The site contains a mixture of hard substrate and sediments, including rock, coarse sediment, sand and mud, and depths range between MLWT and 100 m although much of the site incorporates shallow depths of ~40 m. This site has been designated for supporting persistently high densities of harbour porpoise during the summer months. It was estimated (based on the SCANS II survey data collected in July 2005) that the site supports approximately 2,506 individuals (95% CI = 1,410 to 4,455) for at least part of the year, as seasonal differences are likely to occur (JNCC and NRW, 2015b).

Cardigan Bay/ Bae Ceredigion SAC

Cardigan Bay is one of the largest bays in the British Isles, measuring over 100 km across its westernmost extent from the Lleyn Peninsula to St. David’s Head. A relatively shallow and gently sloping bay with depths reaching only 50 m in the outer parts of the bay towards St George’s Channel, the majority of Cardigan Bay has depths of less than 30 m. Cardigan Bay SAC extends over a total area of 960 km^2 and is located 196.4 km from the offshore wind farm area (Figure 1-3). This SAC is considered to be one of the most important areas for bottlenose dolphin in the UK and regularly supports a semi-resident population of this species (NRW, 2018). The boundary of this SAC was delineated to encompass habitat features, including reef and sandbank habitats, that were considered to be important to support the population of bottlenose dolphin as the primary designated interest.

Photo-identification studies show that many individuals are recorded every year for periods of five years or more whilst others return to the area after a gap of one or two years. This suggests a degree of site fidelity to Cardigan Bay. Recent estimates of the population size of bottlenose dolphin in Cardigan Bay indicate between 100 to 300 individuals occur regularly in this area and there is considerable variability between years. Calving takes place in Cardigan Bay from April to September and this region also serves as an important nursery ground for females and their calves. Recent analysis shows that nearly 30% of individuals have been identified in both Cardigan Bay SAC and Pen Llŷn a’r Sarnau SAC as well as north of the Llŷn Peninsula around the Isle of Anglesey, indicating large home ranges that probably extend to the northern Irish Sea and maybe beyond (NRW, 2018). Surveys show that the greatest numbers of bottlenose dolphin are recorded between July and October and only a few animals are seen between November and April, although some individuals are present in inshore waters most months of the year (NRW, 2018).

Cardigan Bay also supports a significant presence of grey seal as part of the southwest England and Wales Management Unit (SCOS, 2015). This population is not isolated as photo-identification studies have shown movement and exchanges with populations in southwest Scotland, southwest England and southeast Ireland (SCOS, 2013; Kiely *et al*., 2000). The abundance of grey seal found in southwest Wales (including Cardigan Bay) has been estimated historically as approximately 5,000 individuals (Baines *et al.,* 1995). The average number of grey seal pups born within Cardigan Bay between 1992 to 1994 was 66 pups per year, representing approximately 1.7% of the total recorded within west Wales. Pupping is greatest towards the southwestern end of the SAC and takes place throughout the site on open coast in suitable habitat (i.e. physically accessible, remote and/or undisturbed rocky coast beaches, coves and caves) (NRW, 2018). Pupping occurs in between August and November with the peak pupping period in September/October.

Blackwater Bank SAC

Blackwater Bank SAC is located 145.3 km south of the offshore wind farm area, spanning an area of approximately 12,407 ha. Blackwater Bank SAC consists of a series of sandbanks running roughly parallel to the coastline from Cahore Point, in the north, extending almost as far southwards as Rosslare, Co. Wexford. These banks are characterised predominantly by fine sand to medium sand with smaller percentages of very fine sand. High hydrodynamic activity and currents do not allow for the settling out of finer particles of organic and inorganic matter, making sediments quite mobile. Typical species recorded from the area include crustaceans, segmented worms and molluscs (NPWS, 2024c). There are no quoted population estimates for harbour porpoise included in the site synopsis for this site.

Lleyn Peninsula and the Sarnau/ Pen Llŷn a`r Sarnau SAC

The Lleyn Peninsula and the Sarnau SAC (Figure 1-3) has been designated for five Annex I marine habitat types as primary interest features and four further habitat types, and for three Annex II species as qualifying features. Located 139.3 km southeast of the offshore wind farm area, the site covers a total extent of 1,460 km^2 and comprises a diverse range of habitats which support a significant presence of grey seal and bottlenose dolphin as two of the qualifying species.

Grey seals present within this SAC are thought to be part of a wider north Wales population and, although it is possible this is a discrete breeding population, tracking studies show that individuals move between haul-out sites in the wider Irish Sea in east and southeast Ireland and southwest Wales (CCW (Countryside Council for Wales), 2009a). In 2002 the SAC population estimate of grey seals was given as 365 individuals, however, the number of grey seals present in the waters of north Wales was likely to be up to 1,100 individuals, based on summer/autumn counts. Most pupping takes place in the northwest of the SAC and around Bardsey Island (section 1.6.5) in remote and/or undisturbed rocky coastal beaches or coves and caves.

Bottlenose dolphins within Lleyn Peninsula and the Sarnau SAC are part of a wider population that ranges across waters of southwest UK and Ireland and includes the Cardigan Bay SAC population. The number of bottlenose dolphins that regularly use this SAC is not currently known. Between 1989 and 1998 there were about 90 sightings of bottlenose dolphins distributed throughout the whole site (CCW, 2009a). The number of bottlenose dolphin peaks between July and October and calving takes place in Cardigan Bay between April to September suggesting a seasonal inshore distribution.

Pembrokeshire Marine/ Sir Benfro Forol SAC

Pembrokeshire Marine SAC (Figure 1-3) is a multiple interest site selected for the presence of eight Annex I marine habitats and associated Annex II marine species. This SAC covers a total extent of 1,380.5 km^2 and is 219.3 km from the offshore wind farm area. Grey seal is one of the primary designated features of this SAC as it is considered to be one of the most important areas in the UK for this species (CCW, 2009b). The southwest Wales population is the most southerly in Europe of any significant size and supports around 4% of the UK population. Grey seals within this site do not form a discrete population but are part of the southwest Wales population which moves also throughout southwest England and southeast Ireland. As described above for Cardigan Bay, the population of grey seals within southwest Wales was estimated at 5,000 individuals (Baines *et al.*, 1995). Pup production occurs throughout the site on rocky coastal beaches, coves and caves in late summer/early autumn with approximately 980 pups produced each year, accounting for 75% of the southwest Wales population (CCW, 2009b).

1.5.3 Site-specific surveys

1.5.3.1 Boat-based visual surveys

Survey effort and environmental conditions

The total survey effort in each month of transect surveys was 166.8 km travelled across 11 transects, with the exception of November 2018 and October 2019, when, due to adverse weather conditions, the effort was reduced to 99.1 km travelled across six transects and 92.0 km travelled across six transects, respectively.

Environmental conditions varied across the months but, on the whole, the conditions were considered to be suitable for surveys of marine mammals (Table 1-4). However, sea state is known to be an important factor in the probability of detecting marine mammals during boat-based visual surveys (see section 1.4.4). During the boat-based surveys the sea states were, on average, below 3 for the majority of months. The exceptions to this were during May, October, November and December 2018, and July 2019, when the average sea state exceeded 3 during the surveys. Surveys conducted at these times may lead to an under-representation of the number of individuals or species (section 1.4.3).

Table 1-4: Summary of environmental conditions during the Project boat-based visual surveys of marine mammals and seabirds (May 2018 to May 2020).

Month	Average sea state (Beaufort scale)	Wind force (m/s)	Cloud cover (Okta)	Visibility
May 2018	3.3	4.0	7.2	Good
Jun 2018	2.3	1.9	3.4	Good
Jul 2018	1.8	2.5	4.2	Good
Aug 2018	2.9	2.6	5.2	Good
Sep 2018	1.8	2.3	5.5	Moderate to Good
Oct 2018	3.7	3.8	7.6	Moderate to Good
Nov 2018	4.0	4.0	7.0	Good
Dec 2018	3.2	3.3	7.0	Good
Jan 2019	2.7	2.7	7.3	Good
Feb 2019	2.4	2.2	2.9	Moderate to Good
Mar 2019	2.9	2.7	4.8	Very good
Apr 2019	2.0	2.3	3.5	Low to Good
Jun 2019	2.3	2.3	2.8	Good
Jul 2019	3.4	3.5	5.2	Good
Aug 2019	1.2	2.7	1.0	Good
Oct 2019	1.7	3.0	5.0	Good
Dec 2019	2.3	3.2	4.7	Good
Jan 2020	1.4	2.6	7.1	Very good
May 2020	1.4	2.9	6.3	Good
Averages:	2.7	4.9	4.9	Good

Marine mammal counts

Harbour porpoise was the most frequently recorded marine mammal species during the 2018/19 boat-based visual surveys. Minke whale and grey seal were also commonly sighted, albeit in lower numbers compared to harbour porpoise. Occasional sightings were also made of common dolphin, harbour seal and basking shark during the 2018/19 surveys. Minke whale and common dolphin sightings were highest in summer months; basking sharks were only sighted during August of both years; grey seal sightings were almost year-round, and harbour seal sightings were highest in the months of July to October. Table 1-5 shows a summary of counts of marine mammal and basking shark sightings recorded during Project boat-based surveys (May 2018 to December 2019) and Table 1-6 and Figure 1-4 shows encounter rates for sightings recorded during these surveys.

Table 1-5: Summary of counts of marine mammal and basking shark sightings during the Project boat-based visual surveys (May 2018 to May 2020).

Month	Harbour porpoise	Minke whale	Common dolphin	Grey seal	Harbour seal	Basking shark
May 2018	13	0	0	3	0	0
Jun 2018	5	4	0	2	0	0
Jul 2018	20	0	0	3	0	0
Aug 2018	114	4	30	4	1	1
Sep 2018	38	0	10	6	1	0
Oct 2018	53	4	0	0	1	0
Nov 2018	8	0	0	1	0	0
Dec 2018	61	0	3	5	0	0

Month	Harbour porpoise	Minke whale	Common dolphin	Grey seal	Harbour seal	Basking shark
Jan 2019	105	0	5	2	0	0
Feb 2019	36	0	0	3	0	0
Mar 2019	36	0	0	6	0	0
Apr 2019	54	0	0	2	0	0
Jun 2019	12	0	0	3	0	0
Jul 2019	3	1	0	0	2	0
Aug 2019	18	14	0	4	0	1
Oct 2019	9	3	0	2	0	0
Dec 2019	13	0	3	0	2	0
Jan 2020	70	0	0	6	1	0
May 2020	21	0	0	7	0	0
Sum Totals	689	30	51	59	8	2

Table 1-6: Summary of encounter rates (animals per km) of marine mammals and basking shark recorded during the Project boat-based visual surveys (May 2018 to May 2020).

Month	Harbour porpoise	Minke whale	Common dolphin	Grey seal	Harbour seal	Basking shark
May 2018	0.078	0	0	0.018	0	0
Jun 2018	0.030	0.024	0	0.012	0	0
Jul 2018	0.120	0	0	0.018	0	0
Aug 2018	0.683	0.024	0.180	0.024	0.006	0.006
Sep 2018	0.228	0.024	0.060	0.036	0.006	0
Oct 2018	0.318	0	0	0	0.006	0
Nov 2018	0.048	0	0	0.006	0	0
Dec 2018	0.366	0	0.018	0.030	0	0
Jan 2019	0.629	0	0.030	0.012	0	0
Feb 2019	0.216	0	0	0.018	0	0
Mar 2019	0.216	0	0	0.036	0	0
Apr 2019	0.324	0	0	0.012	0	0
Jun 2019	0.072	0	0	0.018	0	0
Jul 2019	0.018	0.006	0	0	0.012	0
Aug 2019	0.108	0.084	0	0.024	0	0.006
Oct 2019	0.054	0.018	0	0.022	0	0
Dec 2019	0.078	0	0.018	0	0.012	0
Jan 2020	0.420	0	0	0.036	0.006	0
May 2020	0.126	0	0	0.042	0	0

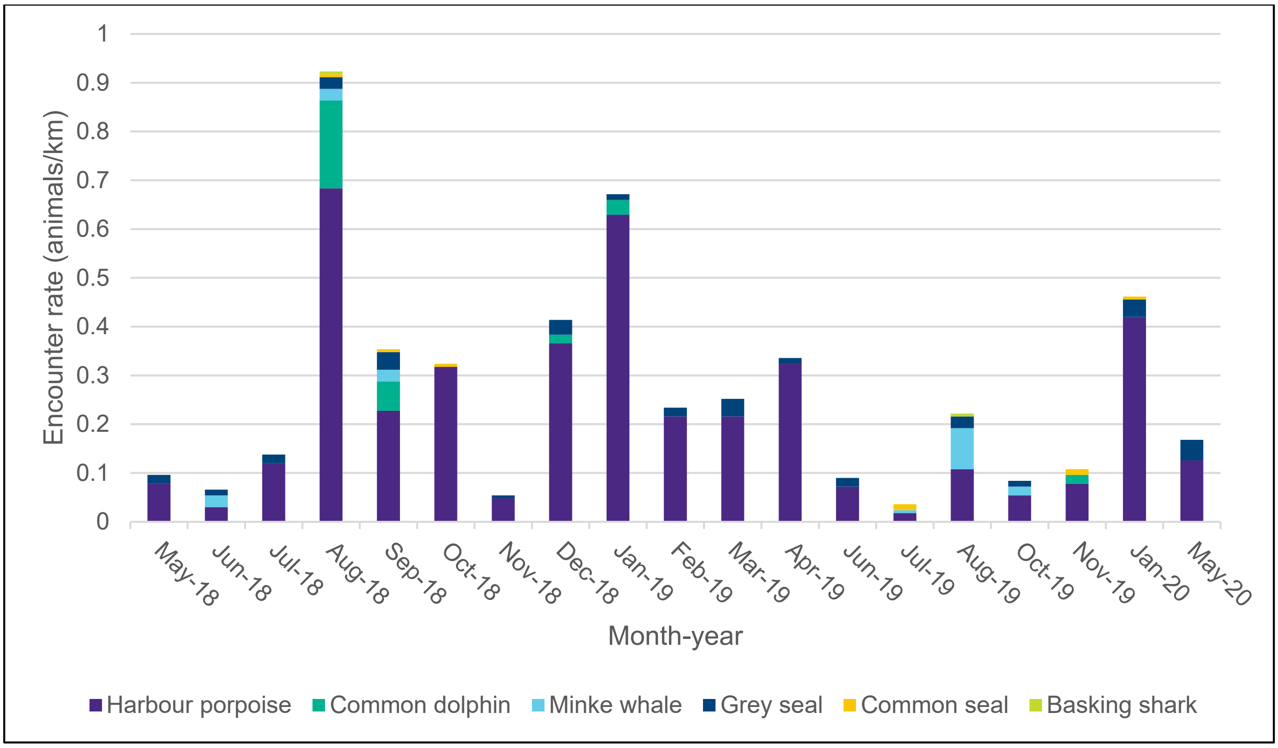


Figure 1-4: Encounter rate of species recorded during the boat-based visual surveys (May 2018-May 2020).

Distance Analysis

A summary of the results of distance models is provided in Table 1-7. Global Correction Factors (CFs) were derived from the surveyed transect distance for one side of the vessel (i.e. 500 m) divided by the ESW. The ESW represents the area under the detection function curve, or the distance to which the expected number of observations matches the observed numbers (Buckland *et al*., 2001).

Table 1-7: Distance Analysis Results Summary.

Species	Selected Model and Covariates	N obs	Detection Probability	ESW (±SE)	CF
Harbour Porpoise	Half normal detection function with group size and Sea state covariates	531	0.577	288.5 (±12)	1.78
Grey Seal	Half normal detection function with group size and Sea state covariates	55	0.40	200 (±45)	2.50
Minke Whale	Half normal detection function	22	0.582	291 (±48)	1.73

It can be seen from Table 1-7 that there was a decrease in detectability of all marine mammal species with distance, with the inclusion of sea state models for harbour porpoise and grey seal, illustrating the importance of environmental conditions on detectability (Table 1-7).

Spatial Abundance and Density Mapping

Harbour Porpoise

Abundance of harbour porpoise varied across months with highest numbers recorded in January and lowest numbers in July (Table 1-8). Mean group size was 2. Peak mean relative density was estimated as 0.88

animals per km^{-2}; corrected density was adjusted to 1.38 animals km^{-2} (Table 1-9; Figure 1-5). Average corrected density across all months was 0.57 (0.24 LCL: 1.71 UCL).

Table 1-8: Harbour porpoise modelled relative and availability bias corrected abundance estimates by month for the Survey Area including lower confidence limits (LCL) and upper confidence limits (UCL).

Period	Survey Area Estimate	Survey Area LCL	Survey Area UCL	Availability Bias Corrected Survey Area Estimate	Availability Bias Corrected Survey Area Estimate LCL	Availability Bias Corrected Survey Area Estimate UCL
January	324	193	544	491	292	824
February	118	41	406	179	62	615
March	179	75	488	271	114	739
April	206	68	680	312	103	1030
May	65	24	246	98	36	373
June	50	20	178	76	30	270
July	18	4	133	27	6	202
August	81	23	424	123	35	642
September	155	67	488	235	102	739
October	205	94	445	311	142	674
November	89	16	681	135	24	1032
December	160	84	300	242	127	455

Table 1-9: Harbour porpoise modelled relative and availability bias corrected density estimates by month for the Survey Area including lower confidence limits (LCL) and upper confidence limits (UCL).

Period	Survey Area Estimate	Survey Area LCL	Survey Area UCL	Availability Bias Corrected Survey Area Estimate	Availability Bias Corrected Survey Area Estimate LCL	Availability Bias Corrected Survey Area Estimate UCL
January	0.88	0.52	1.47	1.33	0.79	2.23
February	0.32	0.11	1.10	0.48	0.17	1.67
March	0.49	0.20	1.32	0.74	0.30	2.00
April	0.56	0.18	1.84	0.85	0.27	2.79
May	0.18	0.07	0.67	0.27	0.11	1.02
June	0.14	0.05	0.48	0.21	0.08	0.73
July	0.05	0.01	0.36	0.08	0.02	0.55
August	0.22	0.06	1.15	0.33	0.09	1.74
September	0.42	0.18	1.32	0.64	0.27	2.00
October	0.56	0.25	1.21	0.85	0.38	1.83
November	0.24	0.04	1.85	0.36	0.06	2.80
December	0.43	0.23	0.81	0.65	0.35	1.23
MEAN	0.37	0.16	1.13	0.57	0.24	1.71

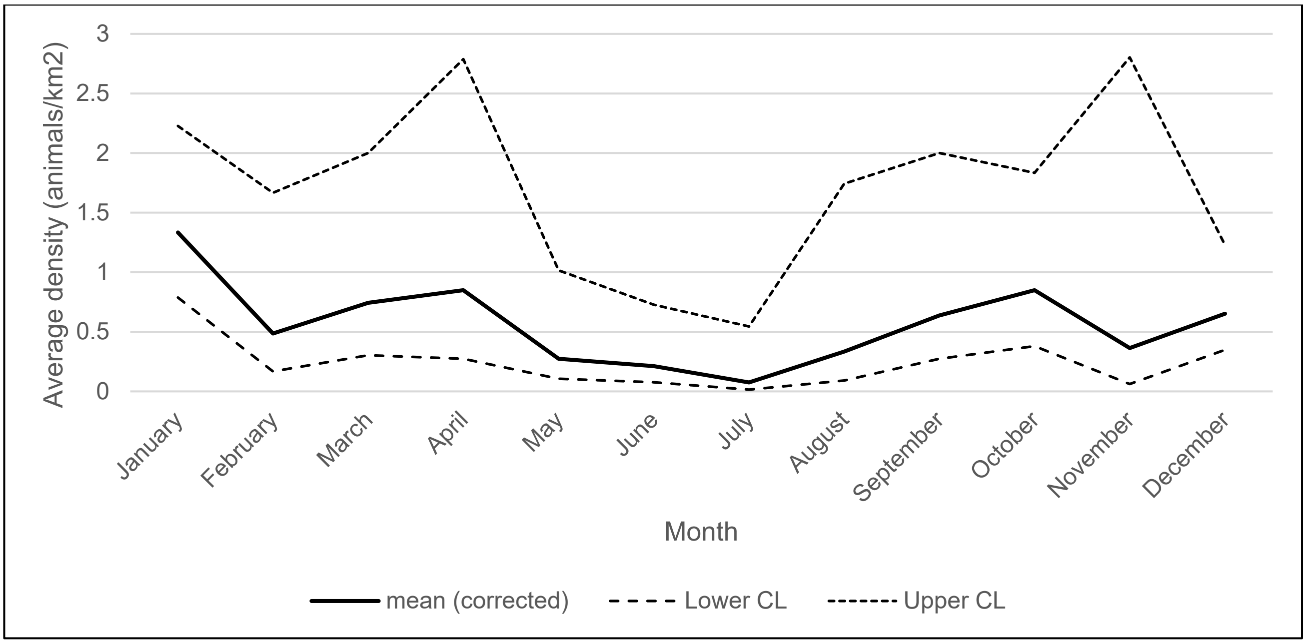


Figure 1-5: Mean density of harbour porpoise across the survey area by month.

Grey Seal

Abundance of grey seal varied across months with highest numbers recorded in March and lowest numbers in October (Table 1-10). There were no seals recorded in July. Mean group size was 1.04. The peak relative density of grey seal was estimated as 0.11 animals km^{-2}; corrected density was adjusted to 0.21 animals km^{-2} (Table 1-11 and Figure 1-6). Average corrected density across all months was 0.09 (0.03 LCL: 0.58 UCL).

Table 1-10: Grey seal modelled relative and availability bias corrected abundance estimates by month for the Survey Area including lower confidence limits (LCL) and upper confidence limits (UCL).

Period	Survey Area Estimate	Survey Area LCL (95%)	Survey Area UCL (95%)	Availability Bias Corrected Survey Area Estimate	Availability Bias Corrected Survey Area Estimate LCL	Availability Bias Corrected Survey Area Estimate UCL
January	21	7	89	39	13	164
February	11	4	78	20	7	144
March	42	12	181	77	22	333
April	7	3	29	13	6	53
May	37	10	194	68	18	357
June	12	2	122	22	4	224
July	0	0	0	0	0	0
August	18	4	175	33	7	322
September	26	8	97	48	15	178
October	5	0	227	9	0	418
November*	NA	NA	NA	NA	NA	NA
December	17	4	88	31	7	162

* - Due to incomplete survey coverage in this month, no estimate was possible.

Table 1-11: Grey seal modelled relative and availability bias corrected density estimates by month for the Oriel Survey Area. including lower confidence limits (LCL) and upper confidence limits (UCL).

Period	Survey Area Estimate	Survey Area LCL (95%)	Survey Area UCL (95%)	Availability Bias Corrected Survey Area Estimate	Availability Bias Corrected Survey Area Estimate LCL	Availability Bias Corrected Survey Area Estimate UCL
January	0.06	0.02	0.24	0.11	0.04	0.44
February	0.03	0.01	0.21	0.05	0.02	0.39
March	0.11	0.03	0.49	0.21	0.06	0.90
April	0.02	0.01	0.08	0.04	0.02	0.14
May	0.10	0.03	0.53	0.18	0.05	0.97
June	0.03	0.01	0.33	0.06	0.01	0.61
July	0.00	0.00	0.00	0.00	0.00	0.00
August	0.05	0.01	0.47	0.09	0.02	0.87
September	0.07	0.02	0.26	0.13	0.04	0.48
October	0.01	0.00	0.62	0.02	0.00	1.13
November*	NA	NA	NA	NA	NA	NA
December	0.05	0.01	0.24	0.08	0.02	0.44
MEAN	0.05	0.01	0.32	0.09	0.03	0.58

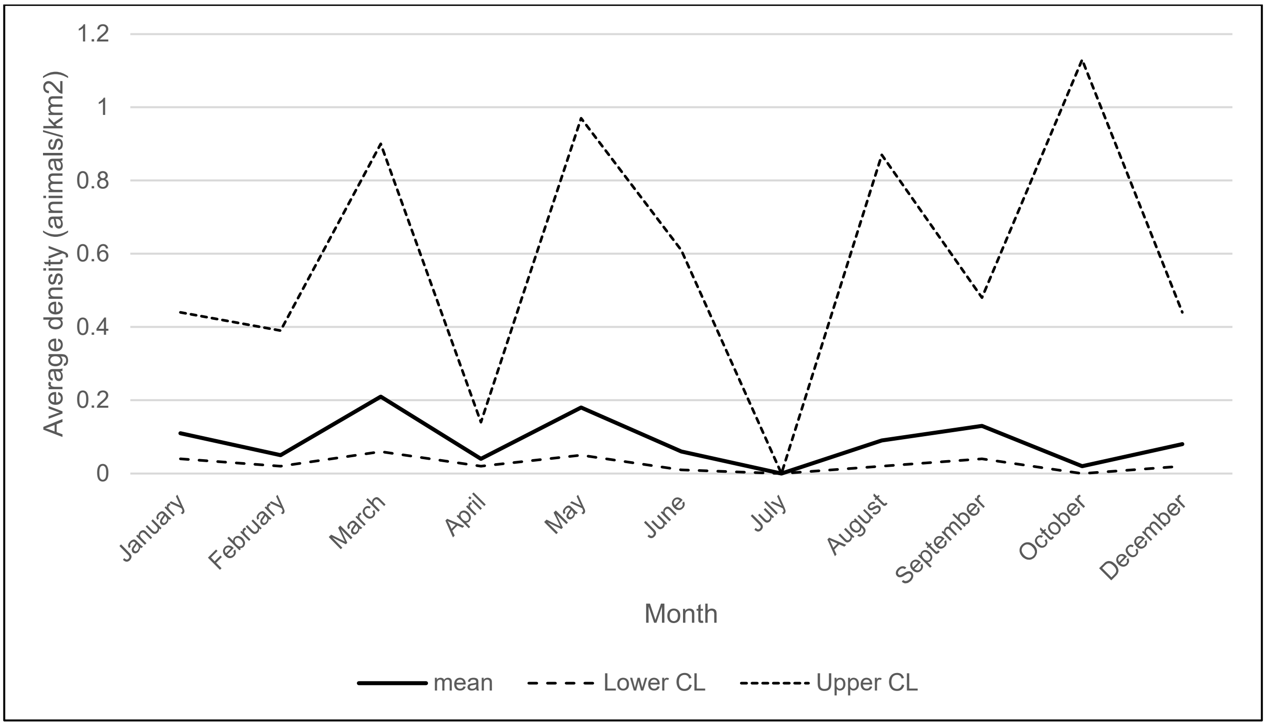


Figure 1-6: Mean density of grey seal across the survey area by month.

Minke Whale

Minke whale was recorded during late summer/early autumn with abundance peaking in August (Table 1-12). Mean group size was 1. The peak relative density of minke whale during August was estimated as 0.19 animals km^{-2}; since availability bias approached a value of one the corrected density was also 0.19 animals km^{-2} (Table 1-13). Average density across all months was 0.04 (0.00 LCL: 0.97 UCL).

Table 1-12: Minke whale modelled relative and availability bias corrected abundance estimates by month for the Survey Area including lower confidence limits (LCL) and upper confidence limits (UCL).

Period	Survey Area Estimate	Survey Area LCL	Survey Area UCL	Availability Bias Corrected Survey Area Estimate	Availability Bias Corrected Survey Area Estimate LCL	Availability Bias Corrected Survey Area Estimate UCL
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April*	NA	NA	NA	NA	NA	NA
May*	NA	NA	NA	NA	NA	NA
June*	NA	NA	NA	NA	NA	NA
July*	NA	NA	NA	NA	NA	NA
August	69	2	1349	96	3	1874
September	19	2	573	26	3	796
October	4	0	138	6	0	192
November	0	0	0	0	0	0
December	0	0	0	0	0	0

* - breeding season model did not converge due to low sample size. As such estimates for breeding season months were not able to be generated.

Table 1-13: Minke whale modelled relative and availability bias corrected density estimates by month for the Oriel Survey Area. including lower confidence limits (LCL) and upper confidence limits (UCL).

Period	Survey Area Estimate	Survey Area LCL	Survey Area UCL	Availability Bias Corrected Survey Area Estimate	Availability Bias Corrected Survey Area Estimate LCL	Availability Bias Corrected Survey Area Estimate UCL
January	0.00	0.00	0.00	0.00	0.00	0.00
February	0.00	0.00	0.00	0.00	0.00	0.00
March	0.00	0.00	0.00	0.00	0.00	0.00
April*	NA	NA	NA	NA	NA	NA
May*	NA	NA	NA	NA	NA	NA
June*	NA	NA	NA	NA	NA	NA
July*	NA	NA	NA	NA	NA	NA
August	0.19	0.01	3.66	0.26	0.01	5.08
September	0.05	0.01	1.55	0.07	0.01	2.15
October	0.01	0.00	0.37	0.01	0.00	0.51
November	0.00	0.00	0.00	0.00	0.00	0.00

December	0.00	0.00	0.00	0.00	0.00	0.00
MEAN	**0.03**	**0.00**	**0.70**	**0.04**	**0.00**	**0.97**

* - breeding season model did not converge due to low sample size. As such estimates for breeding season months were not able to be generated.

Density maps of all species by month can be seen in annex 3.

1.5.3.2 SAM surveys

Species discrimination of SAM data was carried out using the dedicated software into two categories:

1. NBHF, which represent harbour porpoise detections; and
2. Dolphin, which includes all dolphin detections.

It was not possible to differentiate between dolphin species with C-POD data due to similarities in their click characteristics, especially an overlap in frequency usage. Porpoises were the most frequently detected species, while confirmed dolphin detections were only found in two locations in small numbers (see annex 1: Static Acoustic Monitoring Survey, Figure 4.4 to Figure 4.9). A summary of the results can be seen in Table 1-14. Large gaps exist in the data set due to the loss of equipment at the site.

Table 1-14: Summary of results from Static Acoustic Monitoring (SAM) programme November 2019 November 2020 (135-268 days). (Porpoise Positive Minutes (PPM), Porpoise Positive Hours (PPH), Porpoise Positive Days (PPD), Dolphin Positive Hours (DPH), Dolphin Positive Days (DPD)).

Location	Effort (days)	Dates	PPH - %PPH	DPH - %DPH	PPD - %PPD	DPD - %DPD	Mean PPM/H	Mean PPM/D
2	103	11/08/2020-21/11/2020	2054 - 84%	54 - 2%	103 - 100%	30 - 29%	9.44	225
3	268	06/11/2019-19/03/2020 19/03/2020-18/04/2020 12/08/2020-21/11/2020	1661 - 26%	3 – 0%	264 - 99%	3 - 1%	1.08	26
4	135	06/11/2019-19/03/2020	1514 - 47%	0 - 0%	134 - 99%	0 - 0%	2.13	51
LIDAR	179	19/05/2020-12/08/2020 12/08/2020-13/11/2020	2008- 47%	29 - 1%	161 – 90%	23 - 13%	2.96	71

Generalized linear models (GLMs) were carried out for the three sites (sites 2, 3 and 4) to assess significant difference between monitoring locations. Modelling was conducted for porpoise detections (PPH), but not for dolphin detections due to the limited presence reported in the datasets. Results were examined across temporal classes (season, diet, tidal cycle and tidal phase). The model results can be seen below. Further details of the models and the Tukey test can be found in annex 1.

At SAM 2, season was found to have a significant influence of detection rate ($Chi^2 = 239.3$, $p < 0.001$; Figure 4.10 in annex 1). Diel cycle also influences porpoise presence ($Chi^2 = 54.3$ $p < 0.001$), with most detected at night, followed by evening and morning; least detections occurred during the day. No effect of tidal parameters (cycle or phase) were observed at this site over the deployment duration. A summary of the model results is shown in Table 1-15.

At SAM 3, season was again found to have a significant influence of detection, however, contrary to site 2, more detections occurred in winter and spring than in autumn ($Chi^2 = 33.9$, $p < 0.001$; Figure 4.11 in annex 1). Diel cycle also had a significant effect ($Chi^2 = 532.1$, $p < 0.001$), with again a higher detection rate at night, lower during morning and evening, and minimal during the day. At this location, porpoises seemed to be present more often during slack-high tides than flood or slack high waters ($Chi^2 = 20.9$, $p < 0.001$). Tidal phase was a significant factor for the model ($Chi^2 = 6.2$, $p = 0.045$), although no clear differences across levels were identified following the Tukey test. A summary of the model results is shown in Table 1-15.

At SAM 4, season was again found to have a significant influence of detection, with more porpoises recorded in the winter months ($Chi^2 = 24.2$, $p < 0.001$, Figure 4.12 in annex 1). Detection rate was significantly higher during the morning and night compared to the day and evening ($Chi^2 = 19.6$, $p = 0.0002$). At this location, slack low waters and flood periods had higher presence than ebb periods ($Chi^2 = 19.9$, $p = 0.0002$). Tidal phase had no significant impact on porpoise detections at this location, even though the factor was included in the best model ($Chi^2 = 4.6$, $p = 0.097$). A summary of the model results is shown in Table 1-15.

At the LIDAR site, contrary to what was observed in other locations, porpoise presence was lowest at night, compared to the day and evening ($Chi^2 = 13.6$, $p= 0.0035$; Figure 4.13 in annex 1). There was a clear decrease in detection rate between summer and autumn ($Chi^2 = 55.6$, $p < 0.001$). Tidal cycle did not influence detections, but a higher PPH probability coincided with spring tides ($Chi^2 = 15.8$, $p = 0.0004$). A summary of the model results is shown in Table 1-15.

Table 1-15: Summary of overall predictors significance across datasets from the Oriel Sites; SAM 2, SAM 3, SAM 4 and LIDAR (Wald Chi^2 test).

Predictor	SAM 2	SAM 3	SAM 4	LIDAR
Season	***	***	***	***
Diel cycle	***	***	***	**
Tidal cycle	X	***	***	X
Tidal phase	X	*	.	***

Wald X^2 test – Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. X indicates that the predictor wasn't included in the final model (lowest AIC)

1.5.3.3 Aerial digital surveys

A total of 80 marine mammals were recorded in the Survey Area across all surveys. Details of the species recorded can be seen in Table 1-16, and the mean density estimate for each species in the survey area is presented in Table 1-17. Mean uncorrected density estimates were calculated for each species across all months of the survey. Density estimates by month for each species can be found in the original report (annex 2 of appendix H: Ornithological and Marine Megafauna Aerial Survey Results of Oriel Offshore Wind Farm). Figure 1-7 to Figure 1-14 show the distribution of the recorded marine mammals.

Table 1-16: Raw counts of marine megafauna species recorded during all surveys.

Species	Submerged	Surfaced	Total
Grey Seal	3	1	4
Phocids	9	9	18
Dolphin Species	2	1	3
Harbour Porpoise	3	3	6
Dolphin/Porpoise	40	5	45
Common Minke Whale	1	-	1
Baleen Whale Species	1	-	1
Marine Mammal Species	2	-	2
Total Marine Mammals	**61**	**19**	**80**
Shark Species	1	-	1

Leatherback Turtle	-	1	1

Table 1-17: Density estimates for marine megafauna species in the survey area.

Species	Density estimate
Grey Seal	0.0067
Phocids	0.022
Dolphin Species	0.0033
Harbour Porpoise	0.0067
Dolphin/Porpoise	0.062
Common Minke Whale	0.0017
Baleen Whale Species	0.0017
Marine Mammal Species	0.0017
Shark Species	0.0017
Leatherback Turtle	0.0017

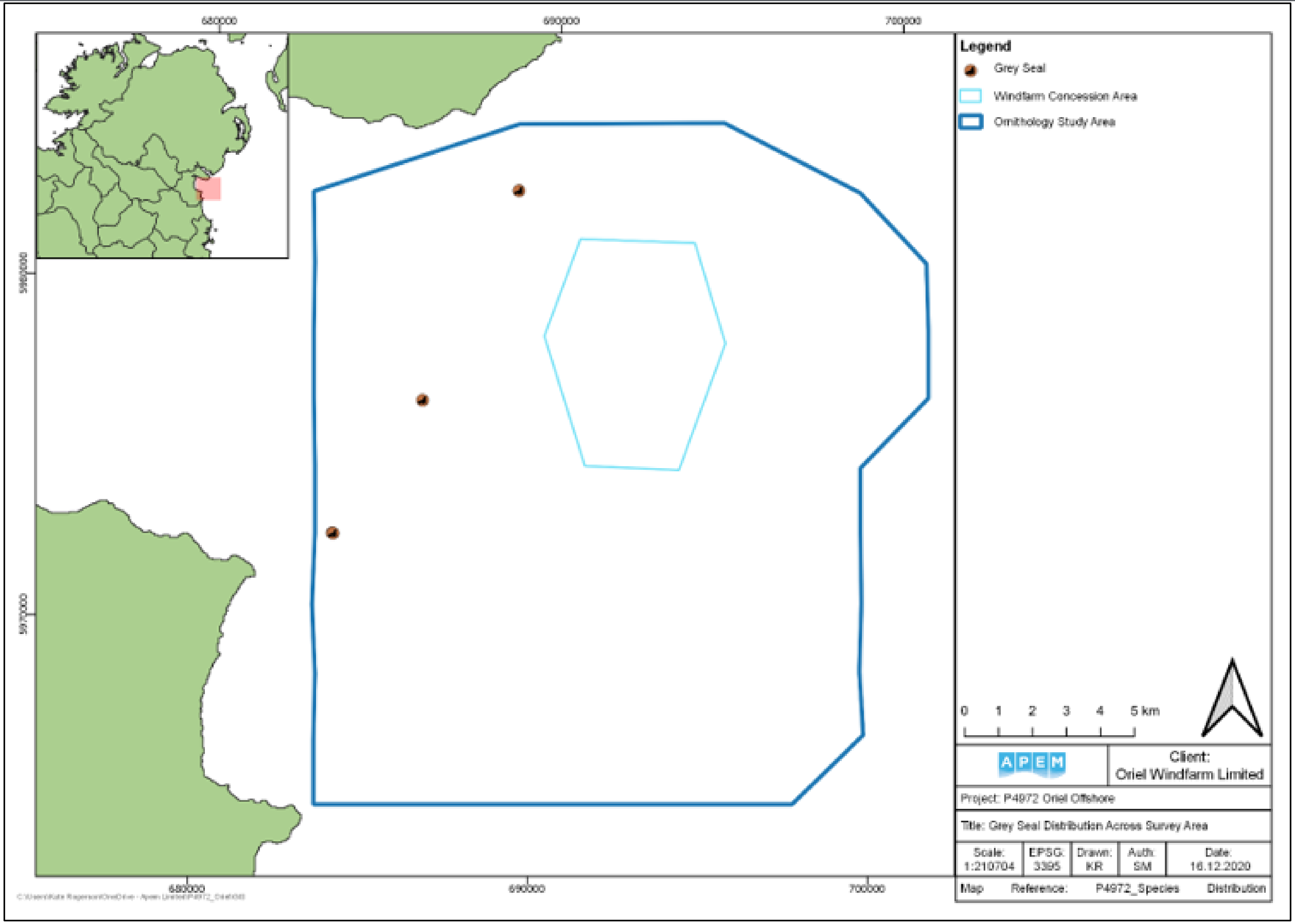


Figure 1-7: Distribution of grey seal recorded across the Marine Megafauna Study Area.

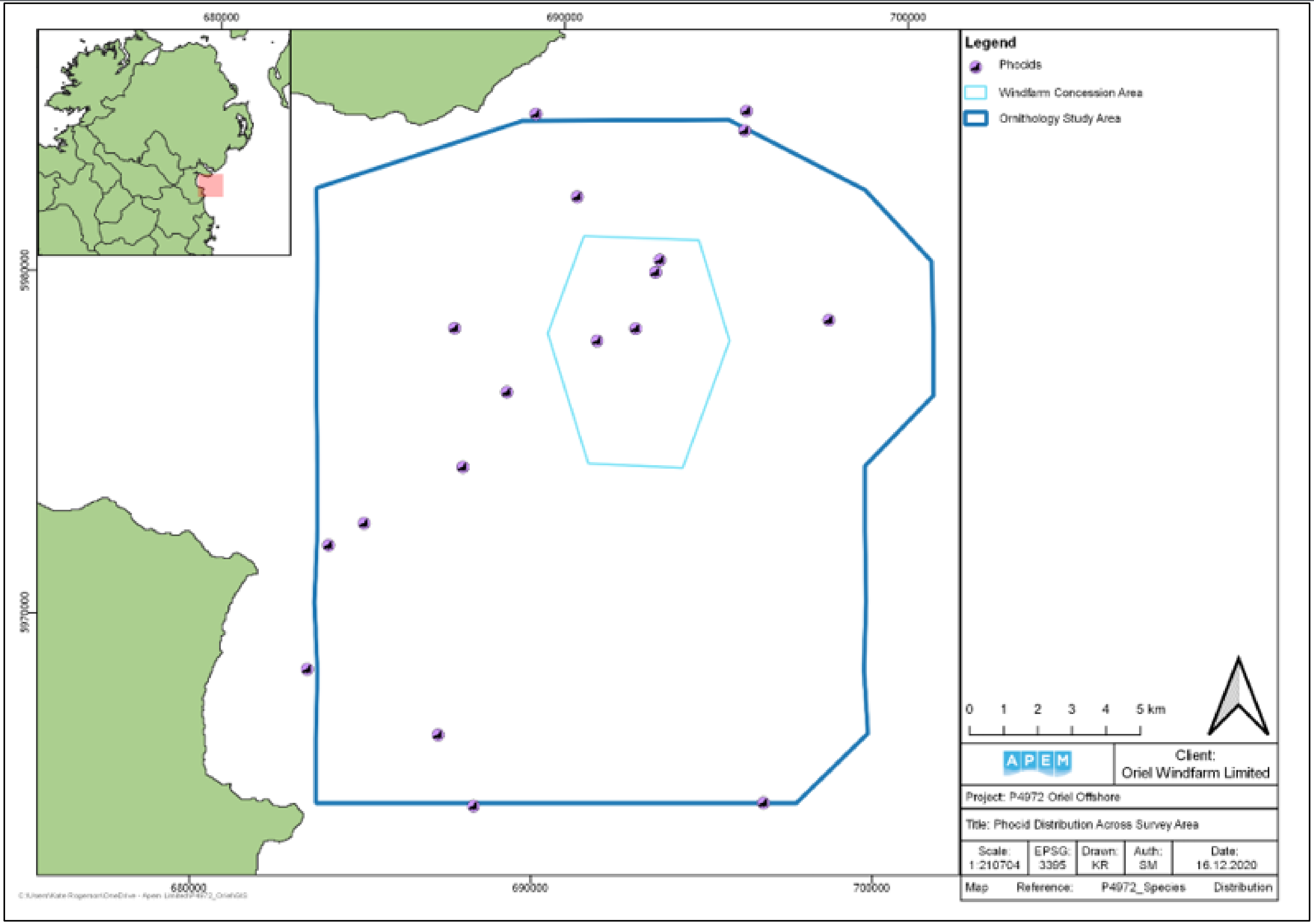


Figure 1-8: Distribution of phocids recorded across the Marine Megafauna Study Area.

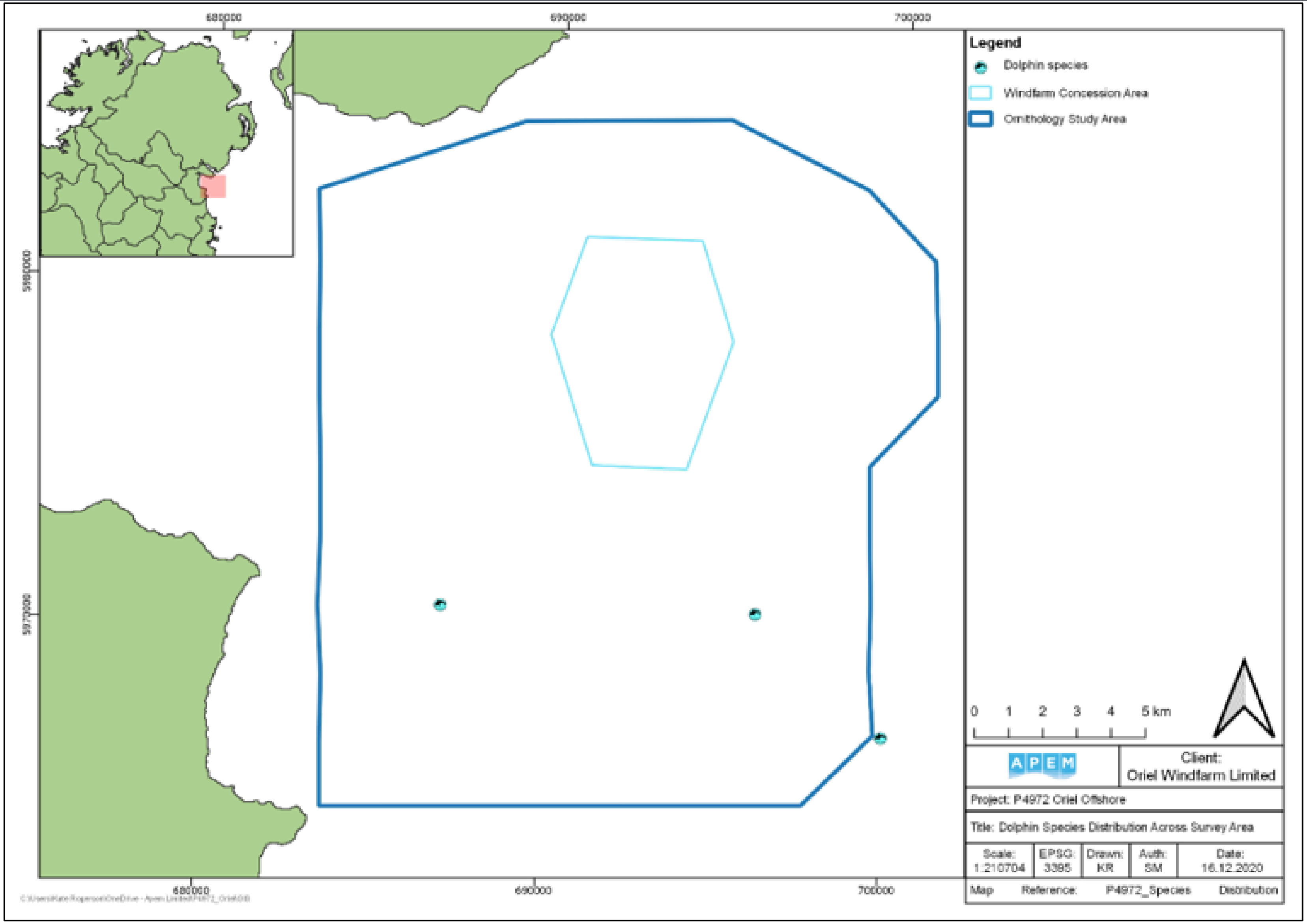


Figure 1-9: Location of unidentified dolphin species recorded in the Marine Megafauna Study Area.

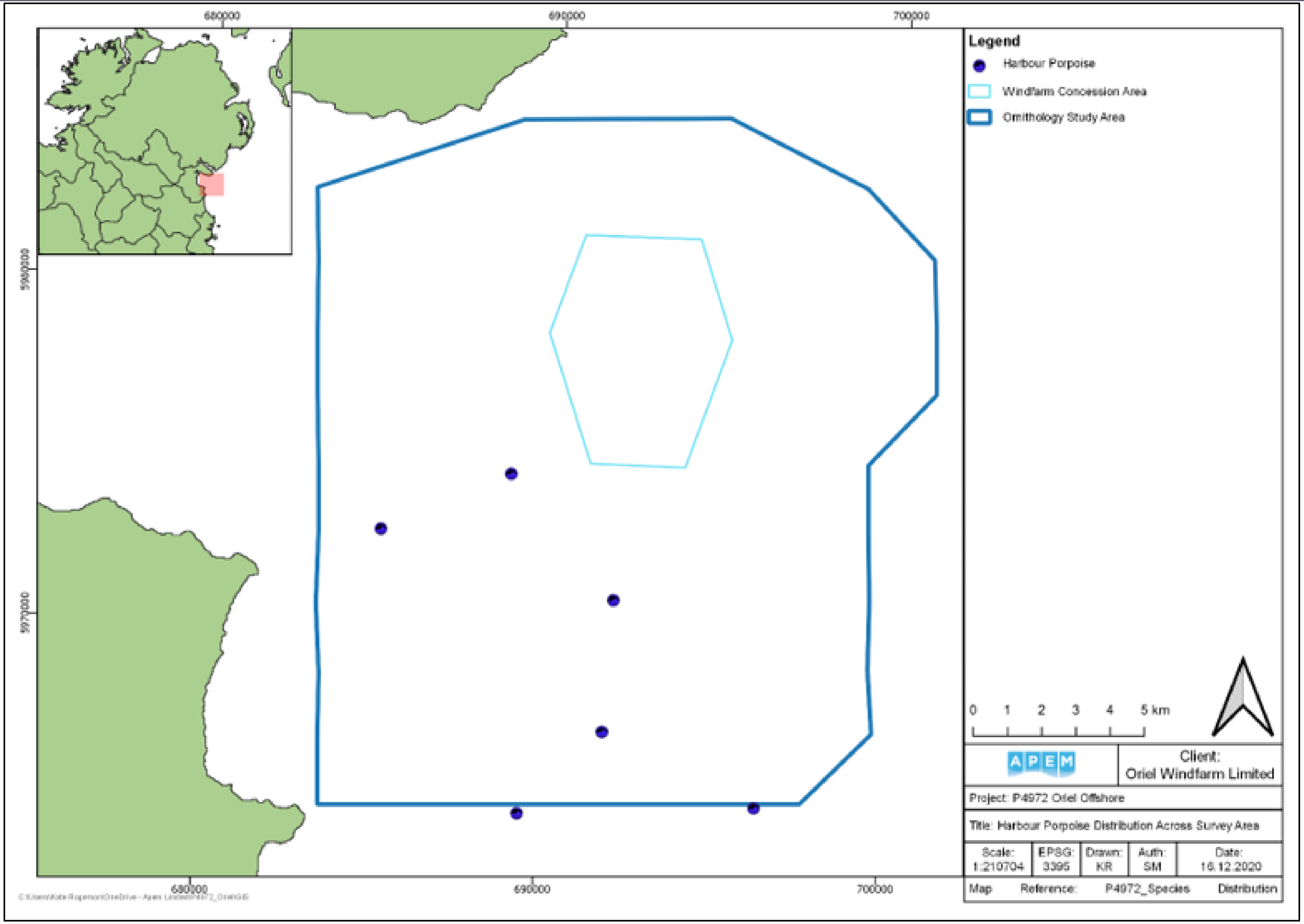


Figure 1-10: Location of harbour porpoise recorded in the Marine Megafauna Study Area.

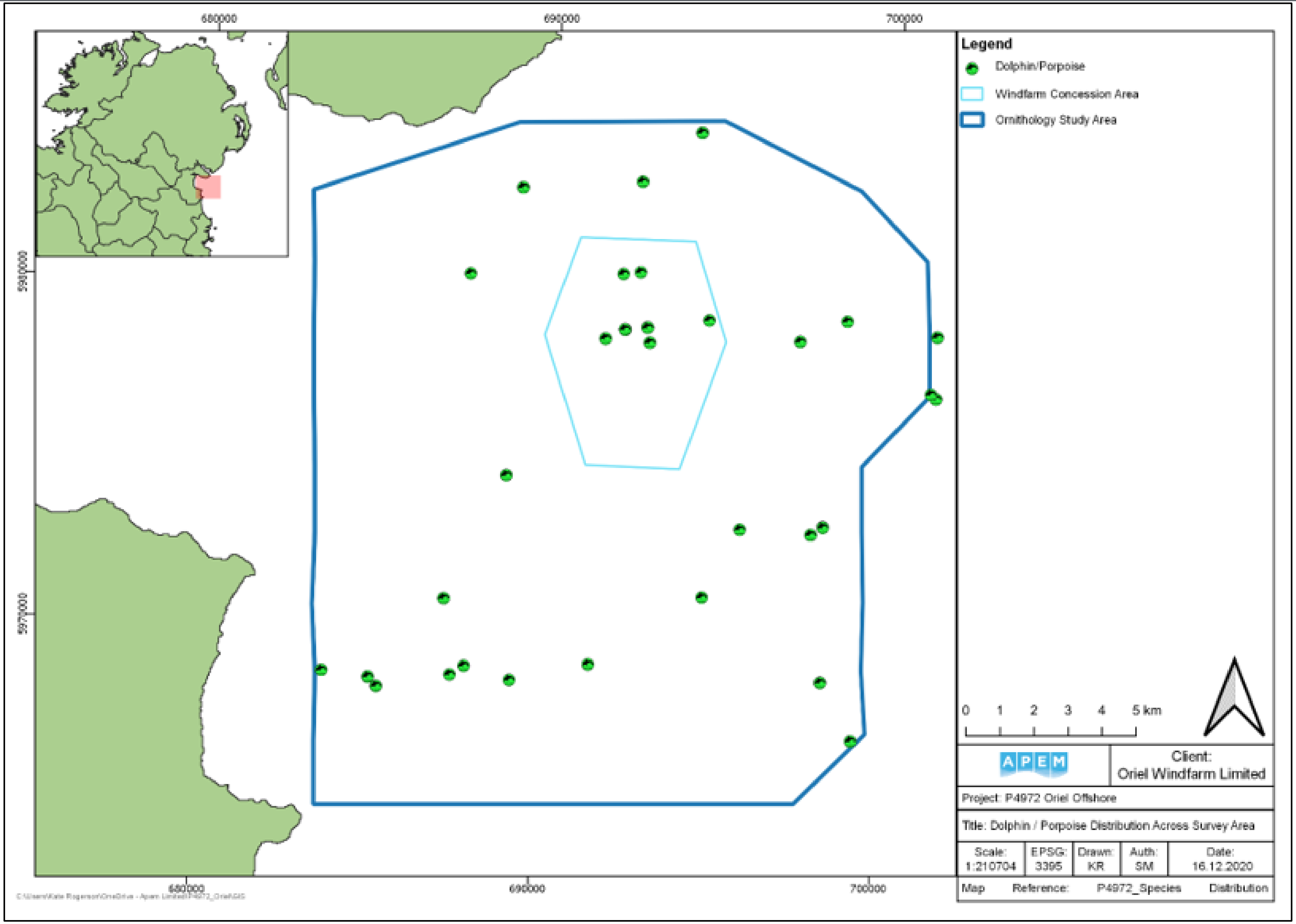


Figure 1-11: Location of dolphin / porpoise recorded in the Marine Megafauna Study Area.

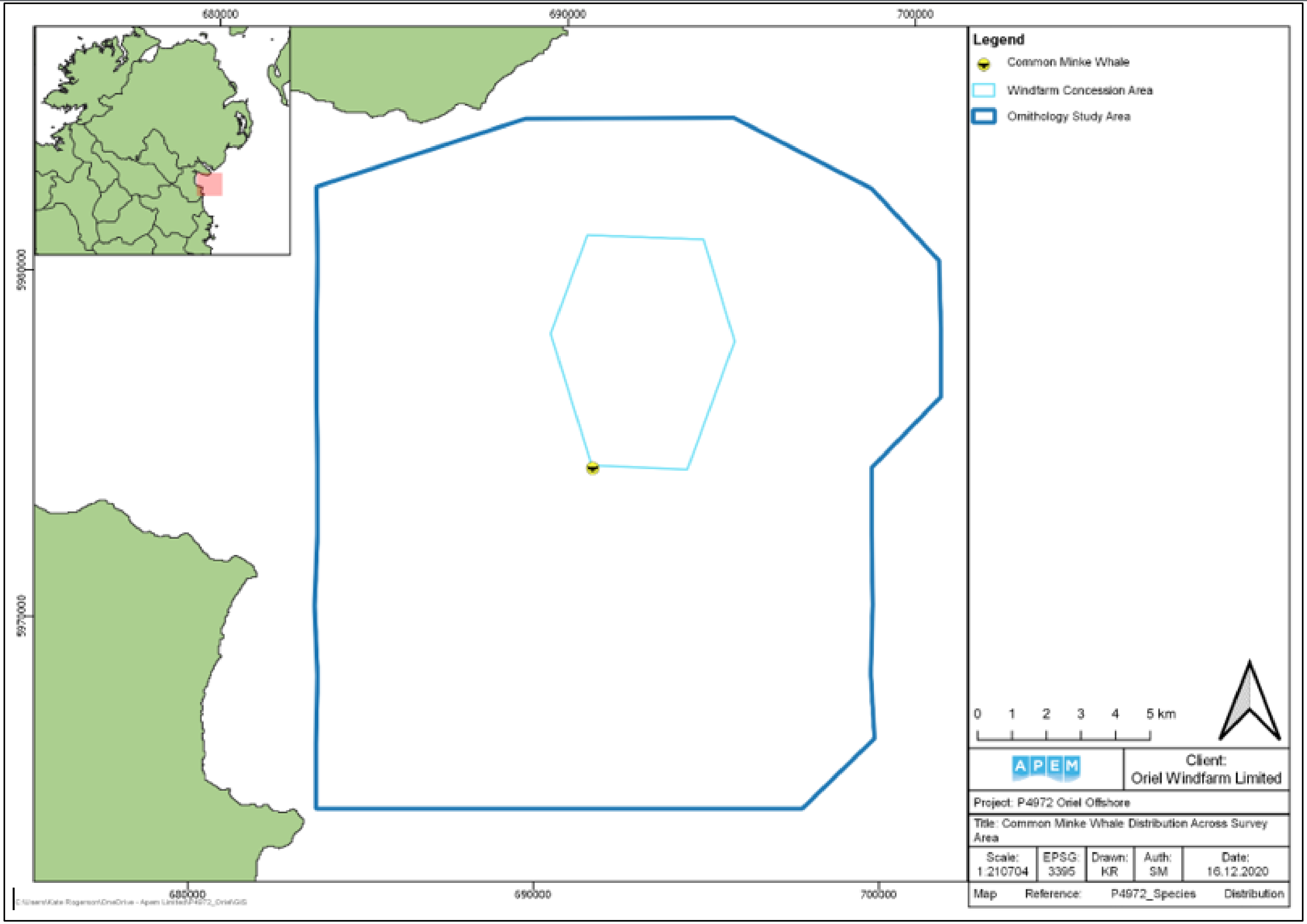


Figure 1-12: Location of common minke whale recorded in Marine Megafauna Study Area.

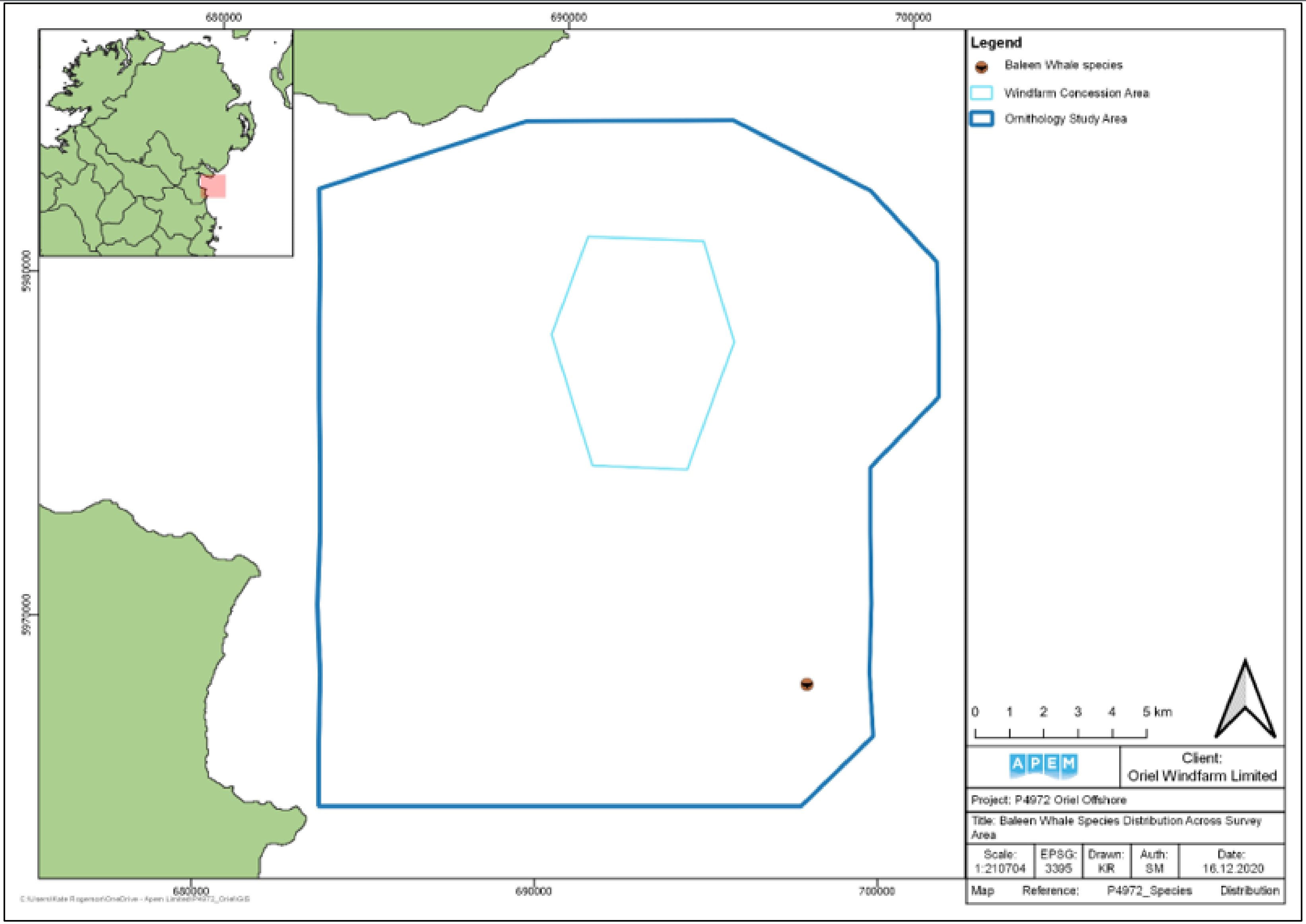


Figure 1-13: Location of unidentified baleen whale recorded in the Marine Megafauna Study Area.

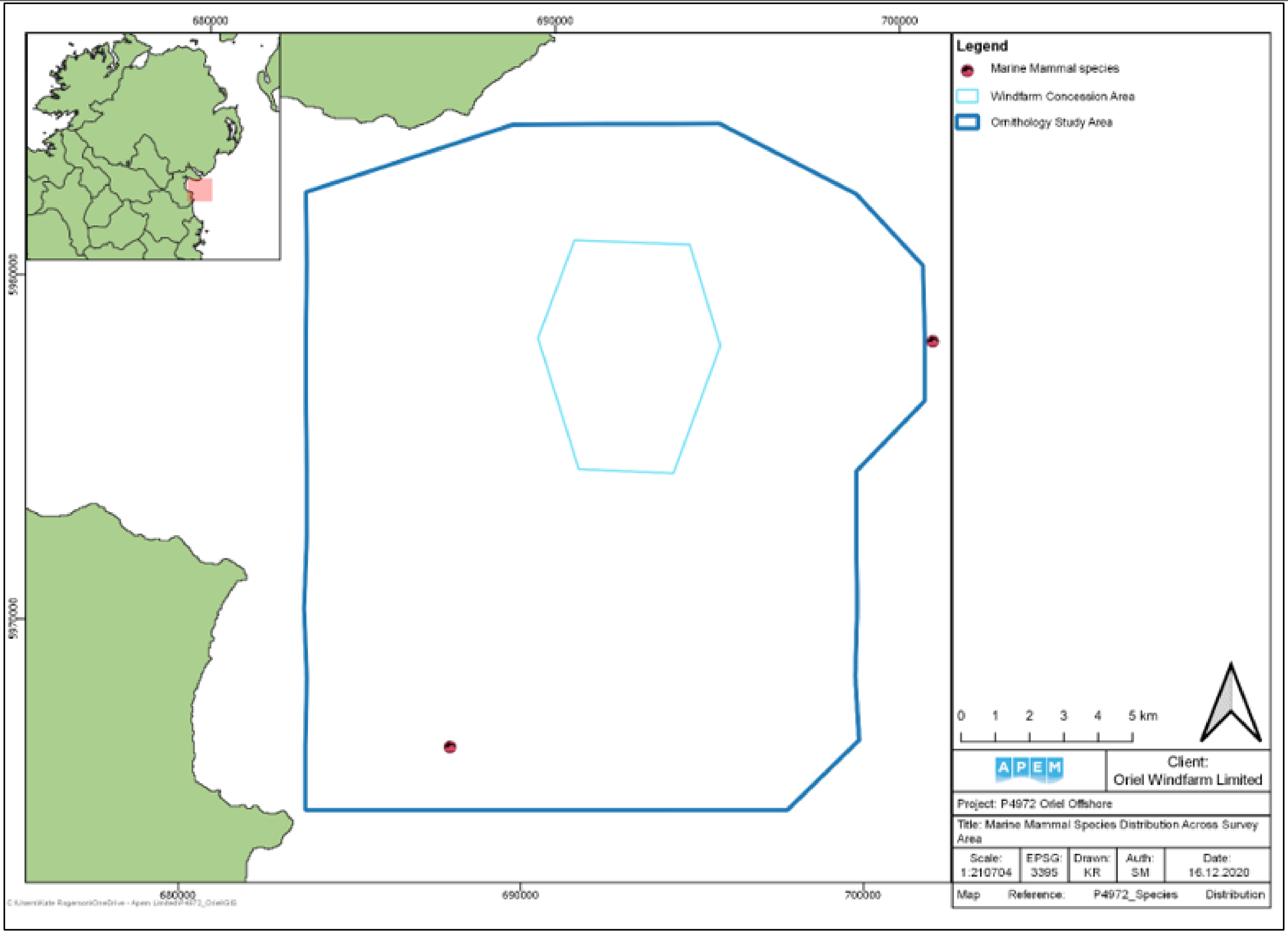


Figure 1-14: Location of unidentified marine mammal species recorded in the Marine Megafauna Study Area.

1.6 Species accounts

1.6.1 Harbour porpoise

Ecology

Porpoises comprise a group of relatively small-bodied Odontoceti (toothed) cetaceans within the family Phocoenidae. The harbour porpoise is one of the smallest cetacean species, reaching a maximum length of 1.9 m. On average females grow to a length of 1.6 m whilst males reach 1.45 m in length (Lockyer, 1995). Although the recorded longevity is 24 years, most individuals do not live past 12 years of age (Lockyer, 2003). Porpoises in the Celtic and Irish Seas MU have been shown to be significantly larger in their maximum length, asymptotic length and average length at 50% maturity compared to porpoises in the North Sea MU, in a study by Murphy *et al.* (2020).

Often living in cool waters, harbour porpoise has a higher metabolic rate than dolphins and therefore needs to feed more frequently and consume more prey per unit body weight, in order to maintain their body temperature and other energy needs (Rojano-Doñate *et al.,* 2018). For this reason, porpoise may be highly susceptible to changes in the abundance of prey species or disturbance from foraging areas. Harbour porpoise feed on a wide variety of fish and generally focus on the most abundant local species. The predominant prey type appears to be bottom-dwelling fish such as sandeels Ammodytidae, although shoaling fish such as mackerel *Scomber scombrus* and herring *Clupea harengus* are also taken (Santos and Pierce, 2003; Pierce *et al*., 2007). O'Brien *et al*. (2009) reported that for harbour porpoises stranded and by-caught in the Irish Sea, gadoids and clupeids comprised 95% of their stomach contents.

Harbour porpoise regularly forage around tidal races, overfalls, and upwelling zones during the ebb phase of the tide (Pierpoint, 2008). O'Brien *et al*., (2009) highlighted that maximum tidal current is the best environmental explanation of persistent harbour porpoise abundance, although in contrast to other studies, they found that densities were higher in areas of low current. Although harbour porpoise generally hunt alone or in small groups, this species is often seen in larger aggregations of fifty or more individuals, either associated with food concentrations or seasonal migrations. Within these loose aggregations, segregation may occur, with females travelling with their calves and yearlings, and immature animals of each sex being segregated into groups.

The age at sexual maturation for the harbour porpoise is approximately three to four years and reproduction is strongly seasonal with mating occurring between June and August (Lockyer, 1995). Gestation is 10 to 11 months and there is a peak in birth rate around the British Isles during the months of June to July (Boyd *et al.*, 1999).

A range of threats to harbour porpoise around the UK have been identified, with bycatch in fishing gears considered the greatest (Calderan and Leaper, 2019). Harbour porpoise is particularly vulnerable to getting caught in bottom-set gill nets as a result of their feeding behaviour. Other threats include prey depletion, pollution that may affect the health of individuals, as well as acoustic and physical disturbance (Evans and Prior, 2012). These threats are considered likely to continue or increase in future. They are also susceptible to bottlenose dolphin attack and some studies have shown distributions of the two species show relatively little overlap (Pesante *et al.,* 2008; Simon *et al.,* 2010). Where an overlap does exist, there is likely to be aggression between the two species (Norrman *et al.,* 2015). Nuuttila *et al*. (2017) showed fine-scale temporal partitioning between the species occurring at three levels: seasonal variation (porpoise detections peaking in winter, bottlenose dolphin in summer), diel variation (porpoise detections higher at night, dolphins highest shortly after sunrise) and tidal variation (peak dolphin detections occurring during ebb at the middle of the tidal cycle and before low tide, harbour porpoise detections were highest at slack water, during and after high water with a secondary peak recorded during and after low water).

Distribution, occurrence and seasonality

Harbour porpoise is one of the most frequently recorded cetacean species in Irish waters and is predominately distributed in coastal waters and waters of the continental shelf and slope (e.g. Berrow *et al*., 2010; Wall *et al*., 2013). The natural range of harbour porpoise in Irish waters is a small component of the species' wider North Atlantic range (NPWS, 2019). The most recent SCANS survey data (SCANS IV, conducted in summer 2022) showed widespread sightings across the Irish Sea (Gilles *et al.,* 2023), with significantly fewer sightings south of the Irish landmass. Historically, the observed distribution of harbour porpoise from the SCANS III survey in 2016 (Hammond *et al.,* 2021), ObSERVE surveys around Ireland from 2015 to 2017 (Rogan *et al*., 2018) and the SCANS II survey in 2005 (Hammond *et al.*, 2013) was similar to that observed in SCANS IV. These observations were corroborated by data collated by both the NBDC (historical sightings up to 2017), and by the National Parks and Wildlife Service (NPWS) (sightings between 2013 and 2018) (NPWS, 2019) which showed widespread distribution of harbour porpoise in the Irish Sea, with a prominent distribution in coastal waters and those overlying the continental shelf and continental slope.

Evidence from multi-annual surveillance programmes (e.g. Ó Cadhla *et al*., 2004; Berrow *et al*., 2010; Wall *et al*., 2013; Rogan *et al*., 2018a) demonstrated that, whilst harbour porpoise occurred widely in Irish waters throughout the year, there was a seasonal spike in records in July, and dip in December. It was noted, however, that this may be linked to increased observer effort in summer months (Rogan *et al*., 2018a).

During historic site-specific boat-based surveys in 2006, harbour porpoise was recorded in the Survey Area during each of the three surveys in April, June and July. Harbour porpoise was also recorded during each month of the more recent boat-based surveys undertaken between May 2018 and May 2020, with sightings noted throughout the survey area, including the offshore wind farm area (Figure 1-16). During the SAM surveys, harbour porpoise were recorded during 100%, 99%, 99% and 90% of survey days respectively, for a total of 662 days observed out of 685 days surveyed (Table 1-14). A total of six harbour porpoise were identified down to species level on the aerial surveys primarily in the southern half of the survey area (Table 1-16; Figure 1-10). Another 45 porpoise/dolphin were identified throughout the surveys area but could not be identified down to species level (Figure 1-11; Table 1-16).

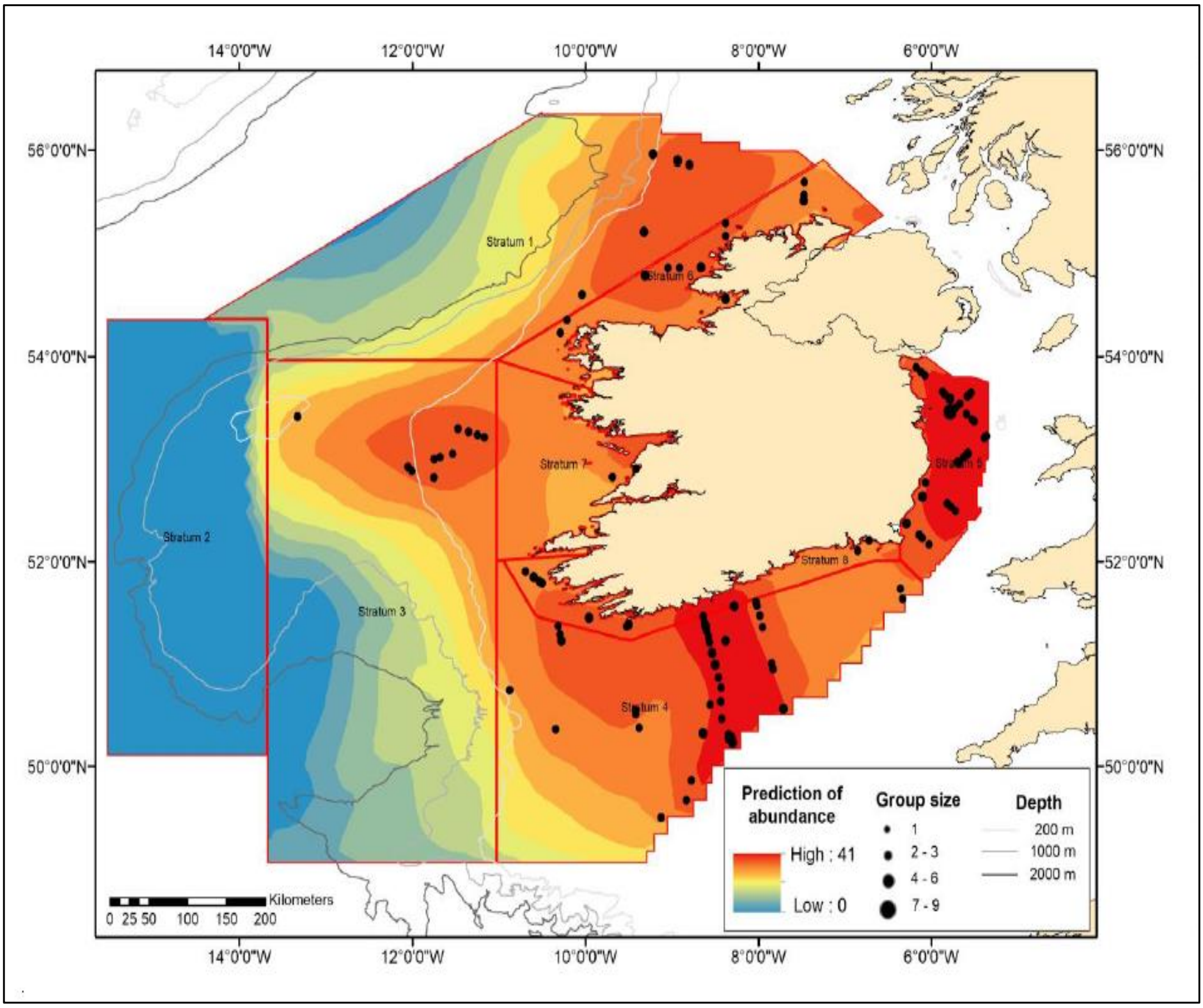
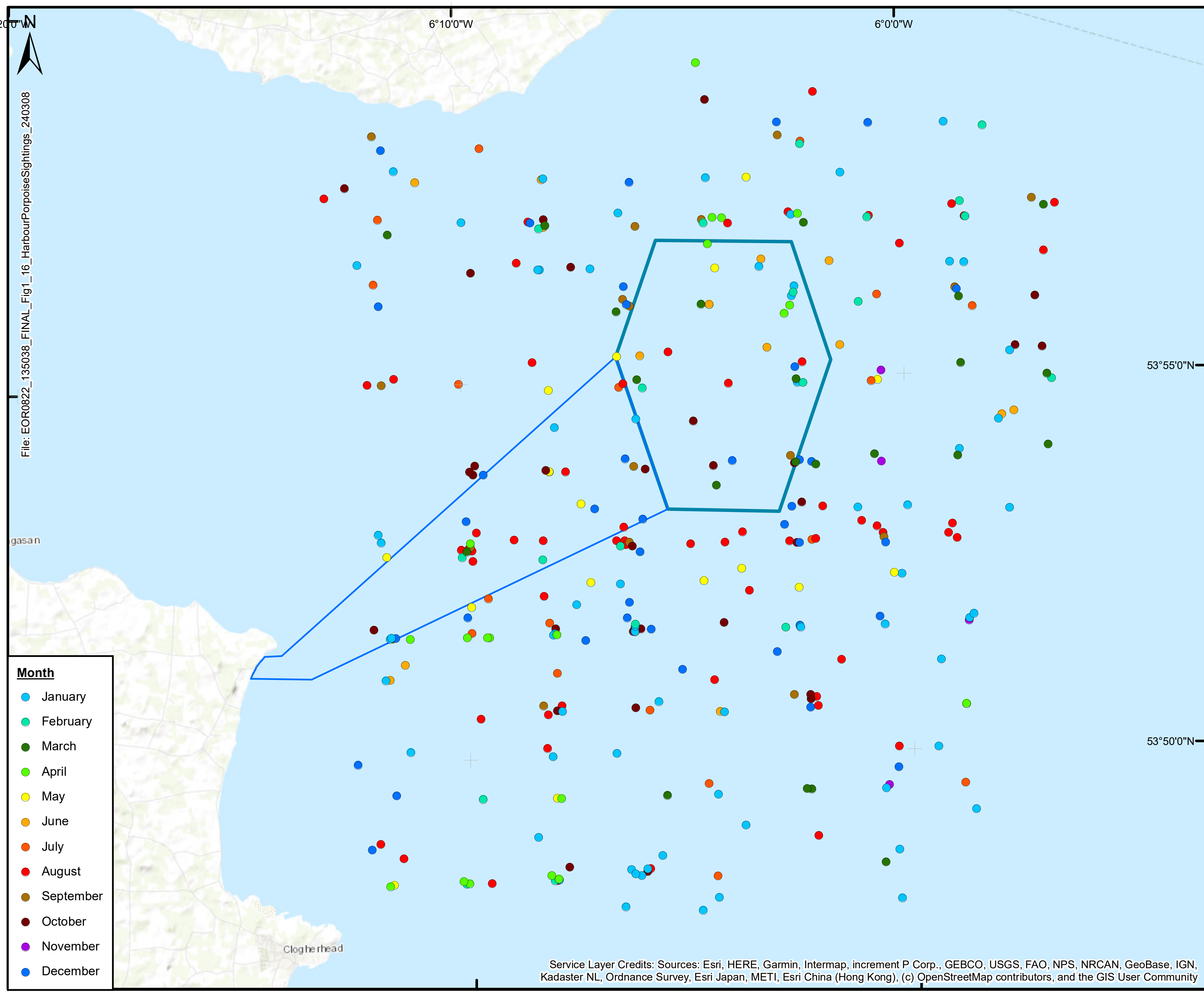


Figure 1-15: Predicted summer distribution of harbour porpoise in 2016 from the ObSERVE aerial surveys. The scale of abundance is a relative estimate and therefore does not represent absolute numbers of harbour porpoise (Rogan *et al.,* 2018a).

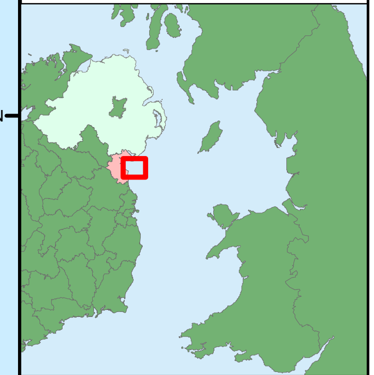


Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources: Client, RPS.



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Title **Figure 1-16**
Harbour porpoise sightings from site-specific surveys (2018 - 2020)

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Density/abundance

Analyses of the ObSERVE data found that the western Irish Sea and Celtic Sea had consistently the highest summer densities/abundance of harbour porpoise compared to other regions surveyed around Ireland. Corrected design-based estimates of density and abundance for harbour porpoise in the western Irish Sea show that maximum densities can reach 1.046 animals per km^2 in this stratum. Mean abundance estimates gave a maximum of 11,625 harbour porpoise in the Irish Sea survey area (95% CI = 8,725 to 15,486). Model-based estimates were also produced using a set of environmental variables to investigate the effect on the derived density and abundance figures. The models produced very similar, albeit slightly lower values compared to the design-based estimates, and therefore represent less conservative estimates.

SCANS II surveys estimated the average density in Block O (covering the Irish Sea) (see Figure 1-17) as 0.3353 animals per km^2 (CV = 35; 95% CI = 0.1759 to 0.6850), with a mean group size of 1.37 (95% CI = 1.21 to 1.58) (Hammond *et al*., 2013). The total abundance in Block O was estimated as 15,230 animals (CV = 35; 95% CI = 7,988 to 31,111) corrected for group size. Block O was subsequently divided into the western Irish Sea (Block E) and eastern Irish Sea (Block F) for the SCANS III surveys (Hammond *et al.*, 2017) (see Figure 1-18). SCANS III data (see Figure 1-18) estimated the densities in these two blocks as 0.239 (Block E) and 0.086 (Block F) animals per km^2, suggesting that the eastern Irish Sea supports lower densities than the western Irish Sea. Similarly, abundance estimates for the eastern Irish Sea are lower compared to the west (although the area of this block is smaller), with N (number of animals) = 8,320 (CV = 0.28; 95% CI = 4,643 to 14,354) for Block E and N = 1,056 (CV = 0.38; 95% CI = 342 to 2,010) for Block F. Combining the numbers for each Block gives a total abundance estimate for the Irish Sea of 9,376 harbour porpoise. The most recent SCANS IV surveys (Gilles *et al.,* 2023) estimated the densities as 0.280 (Block CS-D, overlapping with Block E of SCANS III) and 0.515 (Block CS-E, overlapping with Block F of SCANS III) animals per km^2 supporting the view that the eastern Irish Sea supports greater densities of harbour porpoise.

Although a primary aim of SCANS III survey data was to provide robust large-scale estimates of cetacean abundance (Hammond *et al.,* 2021), SCANS III data was also used to provide information on summer distribution by modelling the data in relation to spatially linked environmental features to generate density surface maps. Lacey *et al.* (2022) presented density surface model (DSM) data for those cetacean species for which sufficient data were obtained during SCANS III, which includes harbour porpoise, bottlenose dolphin, short-beaked common dolphin and minke whale. The cetacean data used in the analysis were the same as those used to obtain design-based estimates of abundance in Hammond *et al.* (2021). SCANS III DSM data (Lacey *et al.*, 2022) gave a mean density of 0.278 animals per km^2 and a maximum of 0.388 animals per km^2 for the Marine Megafauna Study Area (see Figure 1-20).

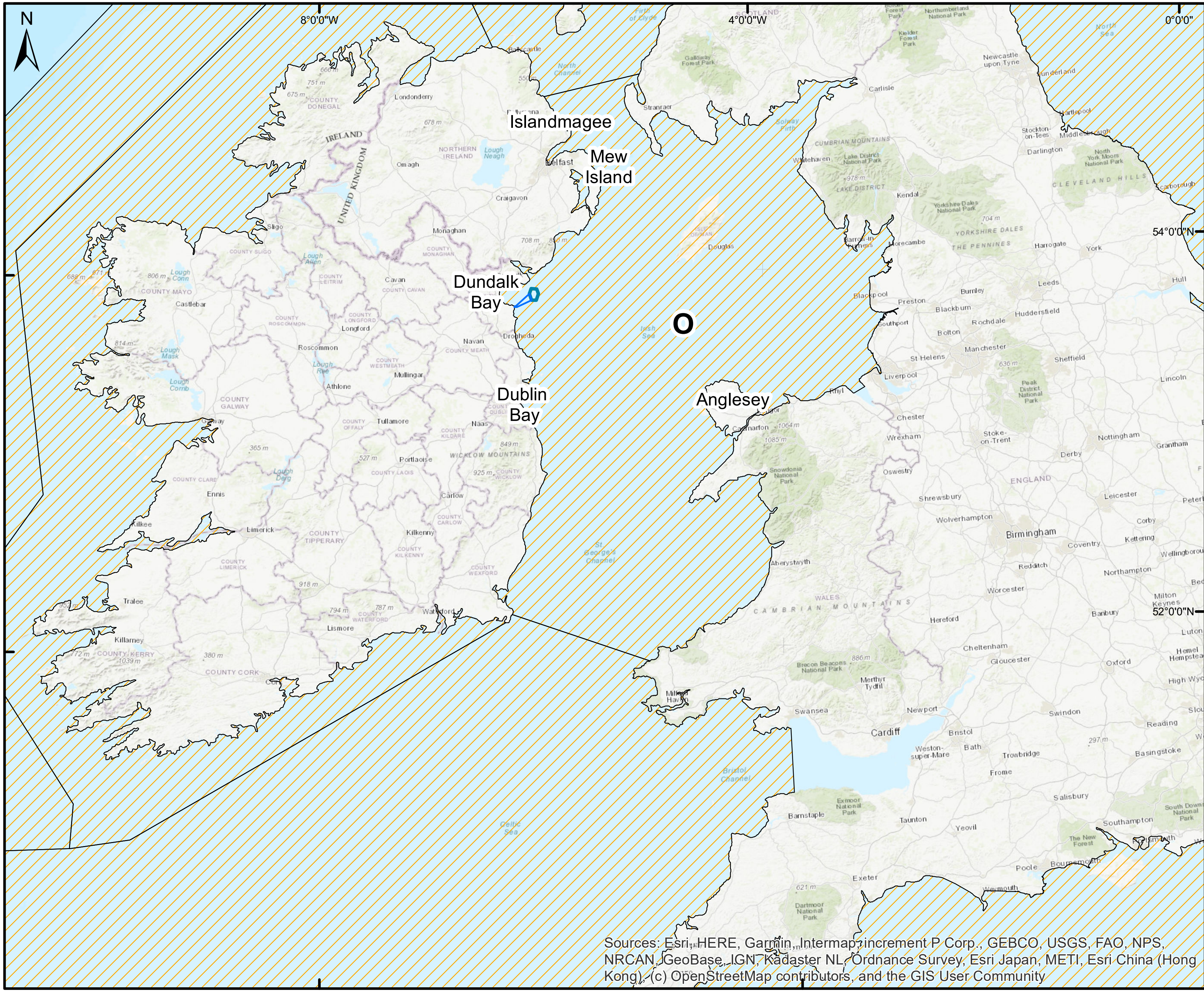
Commissioned by NRW in 2020, the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023) maps marine species distribution and abundance using habitat-based modelling. Modelled densities were provided at 2.5 km^2 resolution for those species sufficiently common enough to allow robust modelling, which included harbour porpoise, bottlenose dolphin, short-beaked common dolphin and minke whale. The average density for the Marine Megafauna Study Area from the annual composite maps was calculated as 0.224 animals per km^2 (see Figure 1-21)

Density estimates were calculated from historical (2006) site-specific surveys across the Survey Area. During the historical surveys (2006), the highest densities of harbour porpoise were found during the period March to April, with the southeast region of the Survey Area supporting slightly higher densities compared to the rest of the surveyed area (1.6 to 2.0 individuals per km^2).

During boat-based site-specific surveys (May 2018 to May 2020) a total of 689 harbour porpoise were recorded with peak counts of 114 in August 2018 and 105 in January 2019. Encounter rates were estimated across the Survey Area using the site-specific boat-based data. The highest encounter rates occurred in August 2018 (0.683 animals per km) and January 2019 (0.629 animals per km) and the lowest encounter rates occurred in July 2019 (0.018 per animals km) (see Table 1-6). Modelled density estimates from the recent boat-based site-specific data found that on average the corrected density of harbour porpoise was 0.57 animals per km^2 with a mean monthly peak of 1.33 animals per km^2. The relative density estimate from the aerial surveys for harbour porpoise was 0.0067 across the Survey Area and 0.062 for unidentified dolphin/porpoise species (Table 1-17). Comparison of the data from recent boat-based site-specific surveys (2018/20) and historical surveys (2006) implies that seasonal trends are low, if not absent, for harbour porpoise presence in the Survey Area, corroborating the theory that the Irish Sea is an important area for harbour porpoise during the summer and winter months.

As a precautionary approach a density range of 0.280 (SCANS IV Block CS-D) to 1.33 (site-specific surveys) animals per km^2 has been applied to the assessment.

In most of the eastern North Atlantic, harbour porpoise is generally considered to behave as a ‘continuous’ biological population that extends from the French coast from the Bay of Biscay, northwards to the arctic waters of Norway and Iceland (JNCC, 2015). The IAMMWG for practical management purposes, however, has identified three Management Units (MU) as appropriate for harbour porpoise: North Sea (NS), West Scotland (WS) and Celtic and Irish Seas (CIS). The Regional Marine Megafauna Study Area falls within the CIS MU which extends from the northwest coast of France to the northwest coast of the Republic of Ireland and east from the southwest coast of Scotland, including the entirety of Irish waters (see Figure 1-19). The total harbour porpoise abundance for the CIS MU was estimated as 62,517 animals (95% CI = 48,324 to 80,877) (IAMMWG, 2023).



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- SCANS II Survey Blocks

Data Sources:

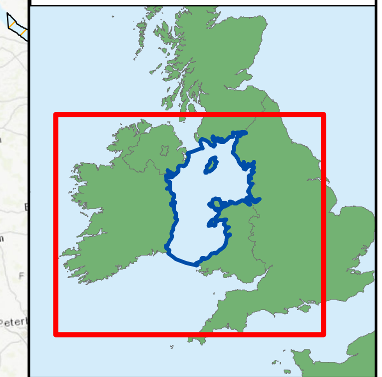


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Figure 1-17

SCANS II Survey Blocks (2006)

(Hammond *et al.*, 2013)

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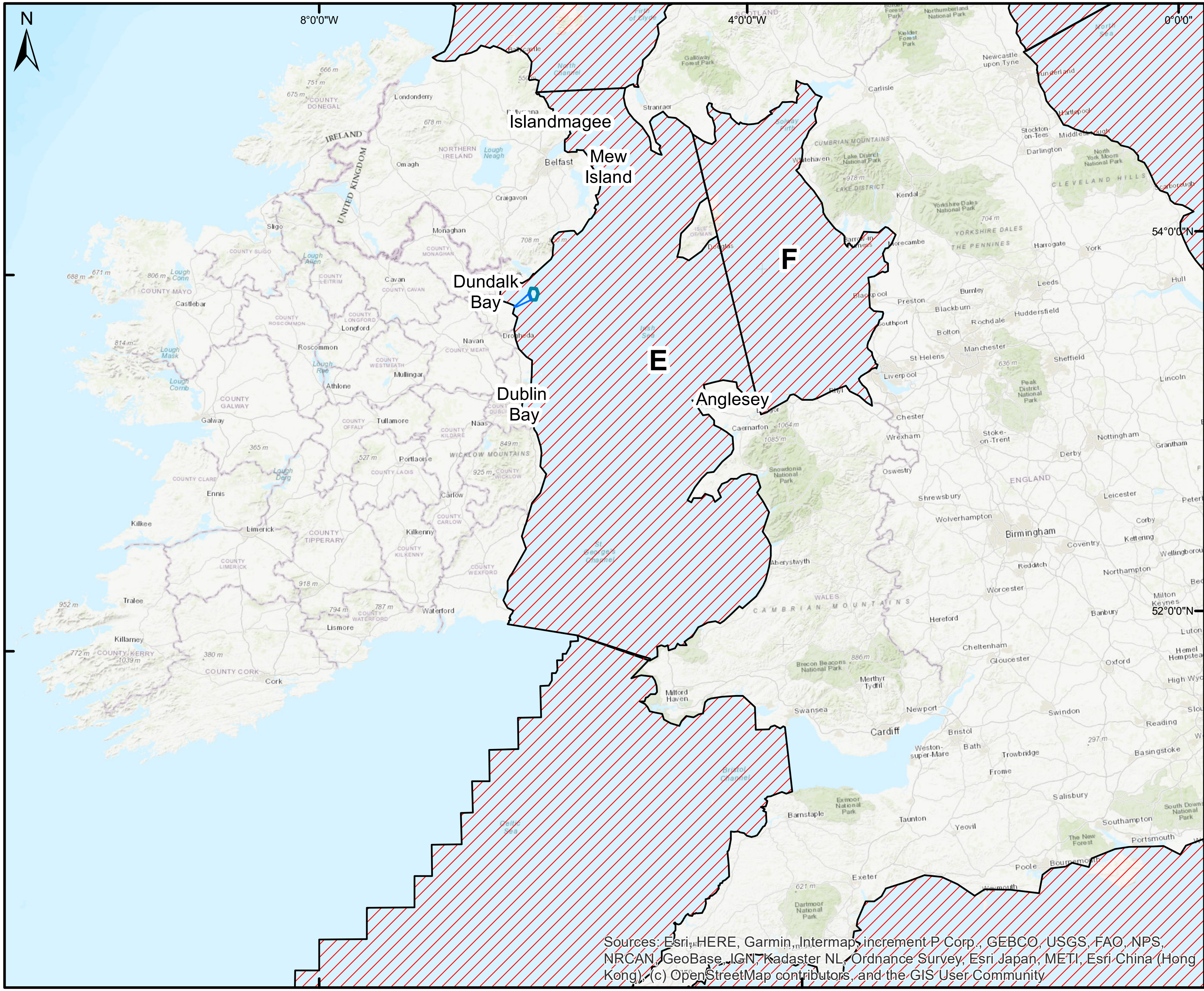

Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- SCANS III Suvery Blocks

Data Sources:

Client

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Figure 1-18

SCANS III Survey Blocks (2016)

(Hammoond *et al.*, 2021)

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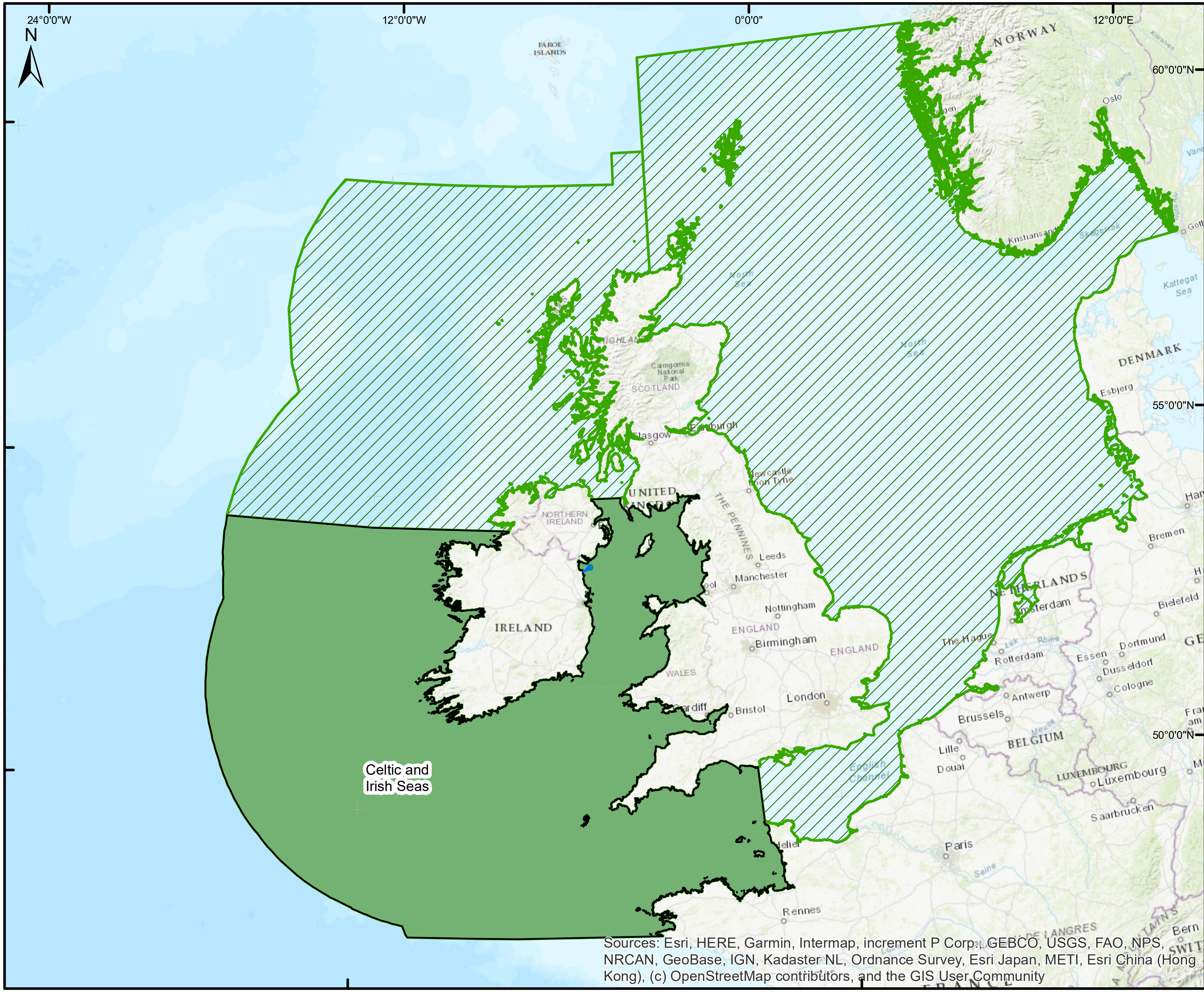

Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Celtic and Irish Seas Management Unit
- Harbour Porpoise Management Units

Data Sources: IAMMWG (2023)

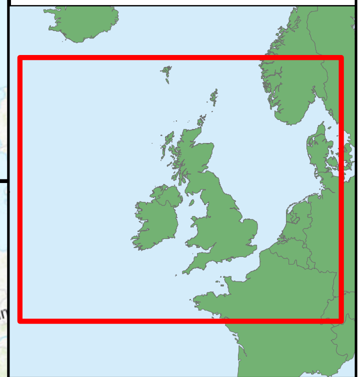

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Figure 1-19
Harbour porpoise CIS Management Unit (IAMMWG, 2023)

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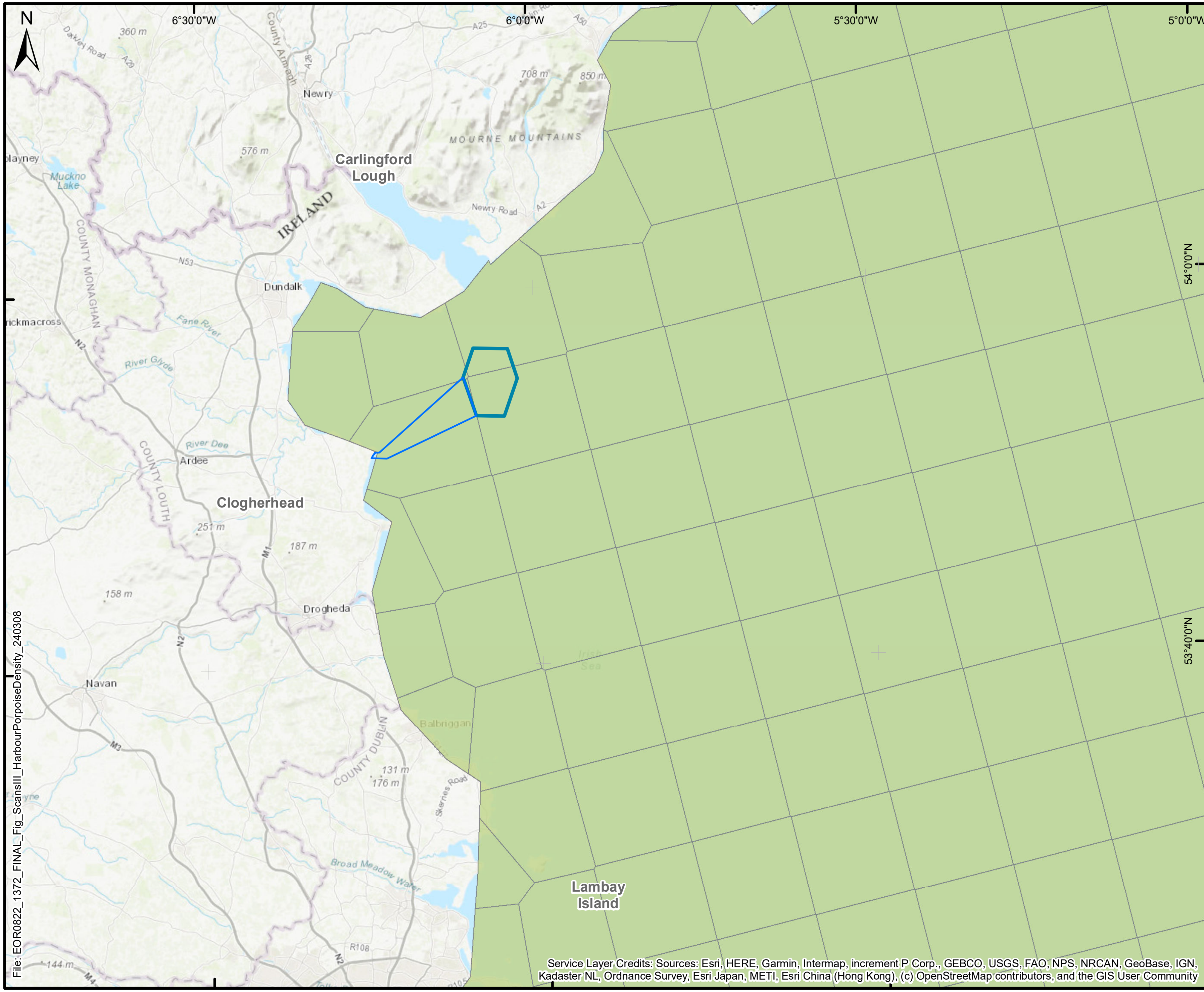

Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Density - Animals per km2 (SCANS-III)

- 0.200001 - 0.300000

Data Sources: Client, Scans-III

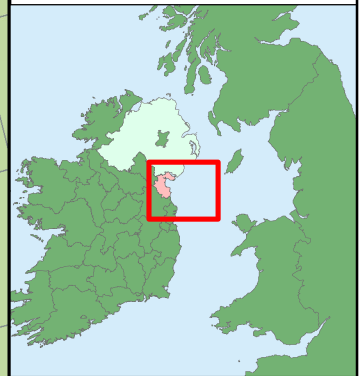

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Figure 1-20
Density surface maps from SCANS III data for harbour porpoise (Lacey *et al.*, 2022).

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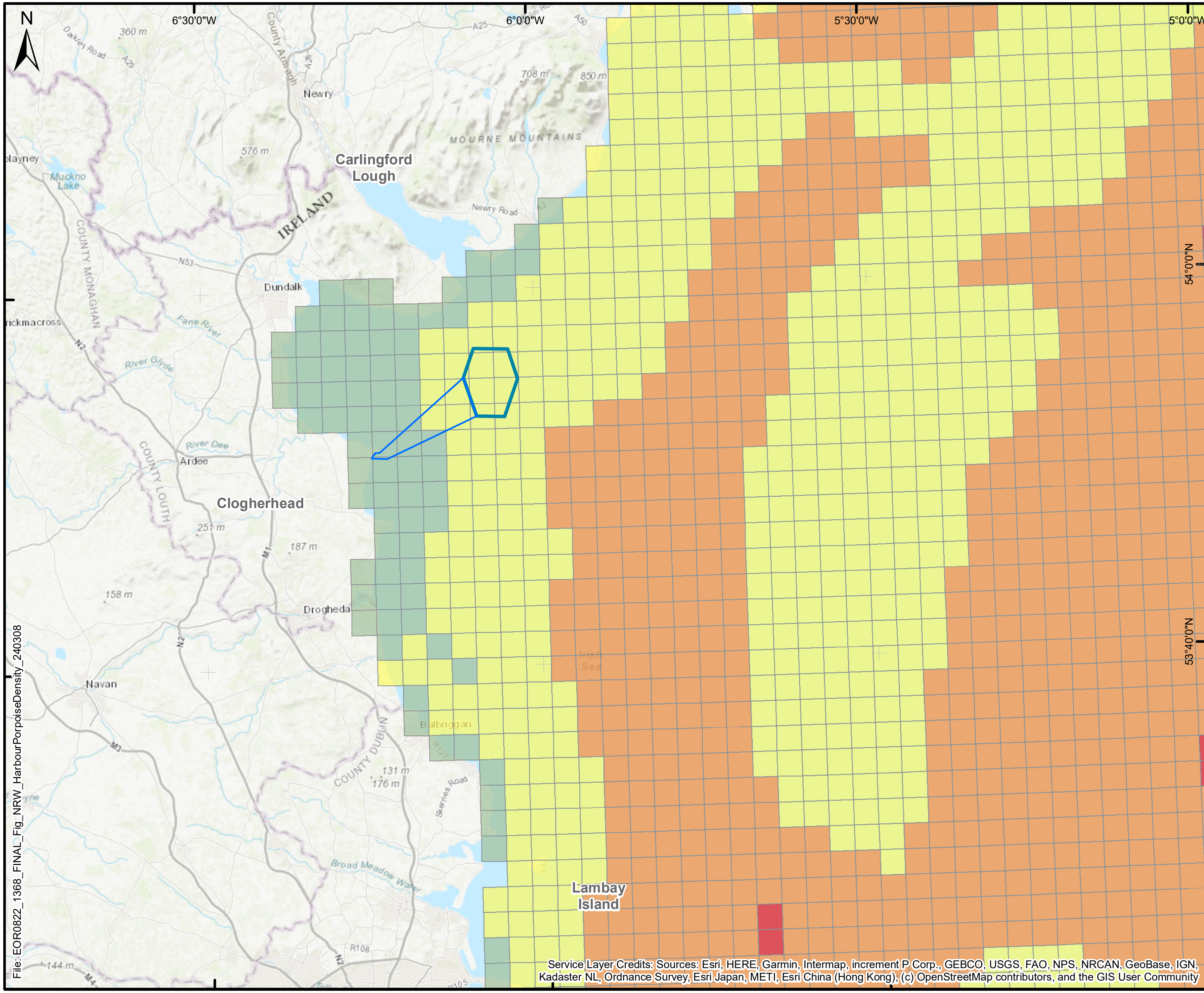


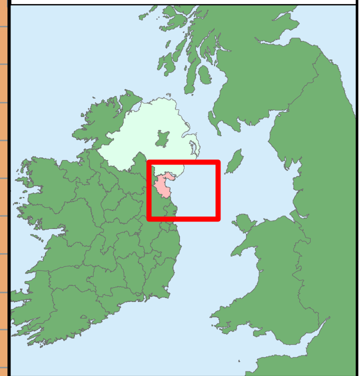
Legend

- Offshore Wind Farm
- Offshore Cable Corridor

Maximum density of animals per km^2

- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5

Data Sources: Client, NRW



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title

Figure 1-21
Harbour porpoise annual composite modelled densities (measured as the maximum density per cell across months) from the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023).

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1.6.2 Bottlenose dolphin

Ecology

Bottlenose dolphin is a member of the family Delphinidae, oceanic dolphins found in temperate and tropical waters worldwide. The largest of the beaked dolphins, this species ranges in size from 1.9 to 3.8 m and can live, on average, between 20 to 30 years. On average, males reach sexual maturity at 10 to 12 years and females at 5 to 10 years. Mating occurs during the summer months, with gestation taking 12 months and calves suckling for 18 to 24 months. Females generally reproduce every three to six years (Mitcheson, 2008).

There is variation in the patterns of habitat use of bottlenose dolphin, even within a population, and generally the distribution of this species is influenced by factors such as tidal state, weather conditions, resource availability, life cycle stage, or season (Hastie *et al*., 2004). Typical prey items in UK waters include cod *Gadus morhua*, saithe *Pollachius virens*, whiting *Merlangius merlangus*, salmon *Salmo salar* and haddock *Melanogrammus aeglefinus* (Santos *et al*., 2001). Investigations of the feeding habits of bottlenose dolphin in Irish waters reported that this species preys on salmon, garfish *Belone belone*, and eels *Anguilla anguilla* in estuarine environments, whilst pollock, whiting and saithe have been identified from the stomach contents of stranded animals (O'Brien *et al.,* 2009).

Bottlenose dolphin are frequently seen in groups rather than individually, although group size in coastal populations may be smaller than offshore populations, however very little is known about offshore populations (Rogan *et al*., 2018a). Mean group size across the ObSERVE survey areas ranged between 4.4 to 8.3 individuals (Rogan *et al.,* 2018a). Berrow *et al.* (2013) suggests that an offshore ecotype of bottlenose dolphins may exist in Irish waters with different habitat preferences compared to inshore populations. Offshore bottlenose dolphins appear to inhabit continental slope habitat in contrast to inshore dolphins, which prefer coastal and estuarine habitats.

Distribution, occurrence and seasonality

Bottlenose dolphin are found throughout the world's tropical and temperate marine waters and are regularly recorded in Irish coastal and offshore waters (NPWS, 2019) and in all seasons (Berrow *et al.*, 2018; Rogan *et al.*, 2018a). The distribution of sightings indicates a preference for waters overlying the continental shelf and the continental slope plus adjacent deeper ocean waters and topographical basins (NPWS, 2019), but bottlenose dolphin are also encountered in enclosed bays and in close proximity to the Irish coast (Oudejans *et al.*, 2010; Wall *et al.*, 2013; Rogan *et al.*, 2018b). Some communities of bottlenose dolphin show a level of residency in (quite) discrete coastal areas (DEHLG, 2009). Cardigan Bay, in the eastern Irish Sea, is an important area for bottlenose dolphin, and is occupied by a semi-resident population of approximately 300 individuals which use this area to reproduce, nurture and feed young (NRW, 2018). The number of animals in this region tends to increase throughout the summer and peak in late September/October. Animals from this population are likely to venture throughout the Irish Sea and therefore may occur in the western Irish Sea within which the Project is located.

During the ObSERVE aerial surveys (2015 to 2017), bottlenose dolphin was the most frequently sighted cetacean species in Irish EEZ waters, with more than twice as many sightings during winter compared to summer (Figure 1-22) (Rogan *et al.,* 2018a). Bottlenose dolphin were recorded in oceanic, neritic, and coastal waters, however, there were very few sightings in the western Irish Sea (Stratum 5) compared to other regions within the Irish EEZ. This suggests that the west and southwest of Ireland are more important in terms of the distribution of this species. This trend is corroborated by other continuing and widespread records of bottlenose dolphins in Irish waters, particularly to the south, west and north of Ireland (e.g. Ó Cadhla *et al.*, 2004; Berrow *et al.*, 2010; Wall *et al.*, 2013; Berrow *et al.*, 2018, collated by NPWS, 2019). The 2016 SCANS III survey also reported very few sightings of bottlenose dolphin in the Irish Sea; the few sightings in the Irish Sea that were reported, were largely located in the north west. The 2022 SCANS IV survey however (Gilles *et al.,* 2023) showed widespread sightings across the Irish Sea, with high density areas of bottlenose dolphin in the north western Irish Sea, and lower sighting numbers in the south western Irish Sea, and very few sightings in the eastern Irish Sea. Whilst far greater sighting numbers were reported in the 2022 SCANS IV survey compared to the 2016 SCANS III survey, the trend of highest sighting numbers in the north west of the Irish Sea was reported in both surveys.

During the historical SCANS II survey in 2006 (Hammond *et al.,* 2013), and the more recent site-specific surveys (2018 to 2020), no bottlenose dolphins were recorded in the Survey Area. During the SAM surveys, specific dolphin species could not be identified, however, unidentified dolphin species were recorded on 29%, 1%, 0%, and 13% of days per survey respectively. This resulted in dolphins being recorded on 56 days out of 685 days surveyed (Table 1-14). There were three unidentified dolphin species and 45 unidentified dolphin/porpoise species recorded on the aerial surveys which could potentially be bottlenose dolphins (Table 1-16).

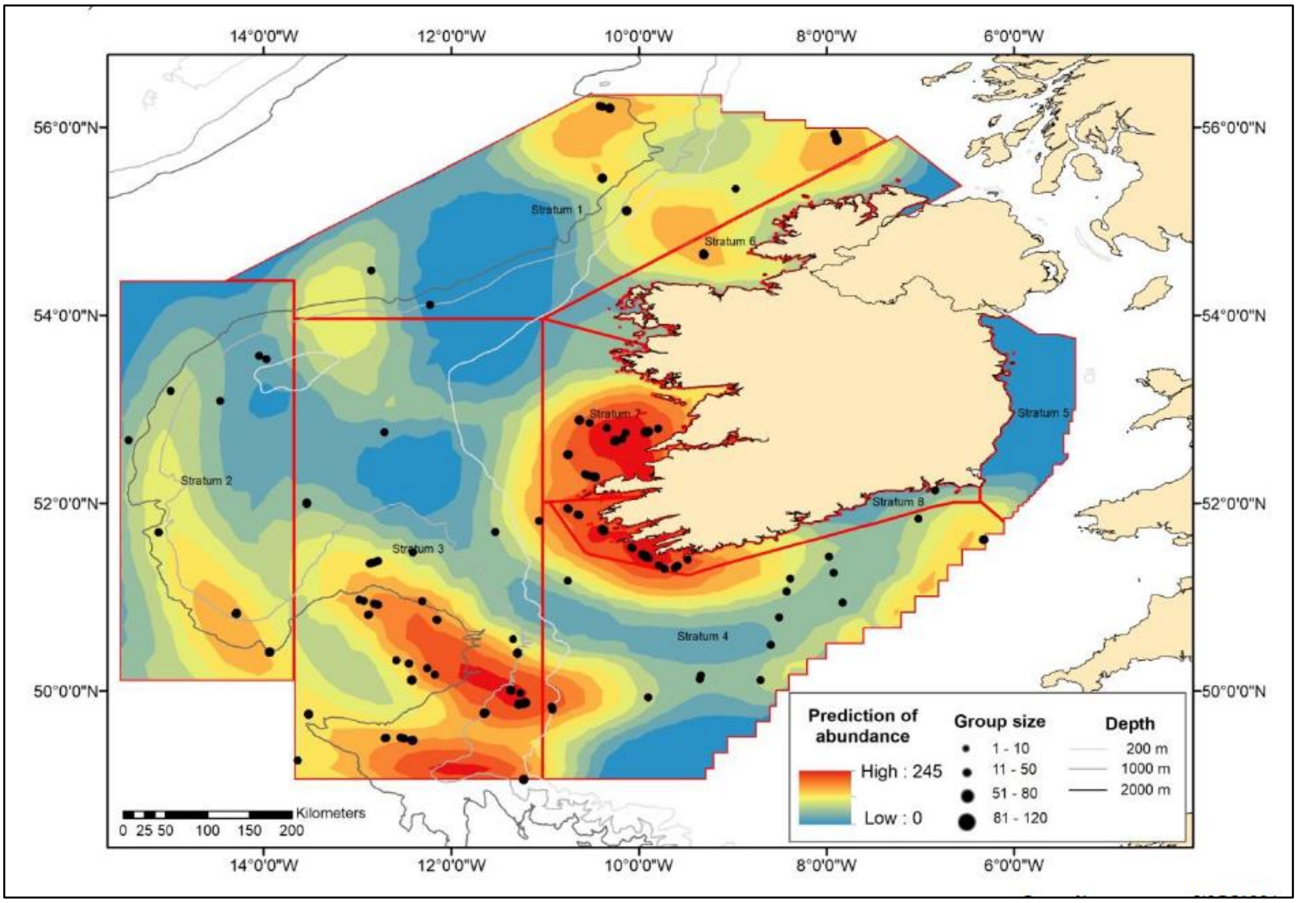


Figure 1-22: Predicted summer distribution of bottlenose dolphin in 2016 from the ObSERVE aerial surveys. The scale of abundance is a relative estimate and therefore does not represent absolute numbers of bottlenose dolphin (Rogan *et al*., 2018a).

Density/abundance

The low number of sightings during the ObSERVE surveys translated into very low density and abundance estimates of bottlenose dolphin in the western Irish Sea. The average density across Stratum 5 was estimated as 0.036 animals per km^2 and abundance was calculated as 401 animals (95% CI = 76 to 2,105) (Rogan *et al.,* 2018b).

Figures estimated using the SCANS II data for Block O (Irish Sea) (see Figure 1-17) identified lower numbers than the ObSERVE surveys. Design-based estimates found that the density of bottlenose dolphin in Block O was 0.0052 (95% CI = 0.0014 to 0.0199) animals per km^2, with a mean group size of 2.71. The abundance of bottlenose dolphin within Block O was estimated as 235 animals (95% CI = 61 to 902) (Hammond *et al.,* 2013).

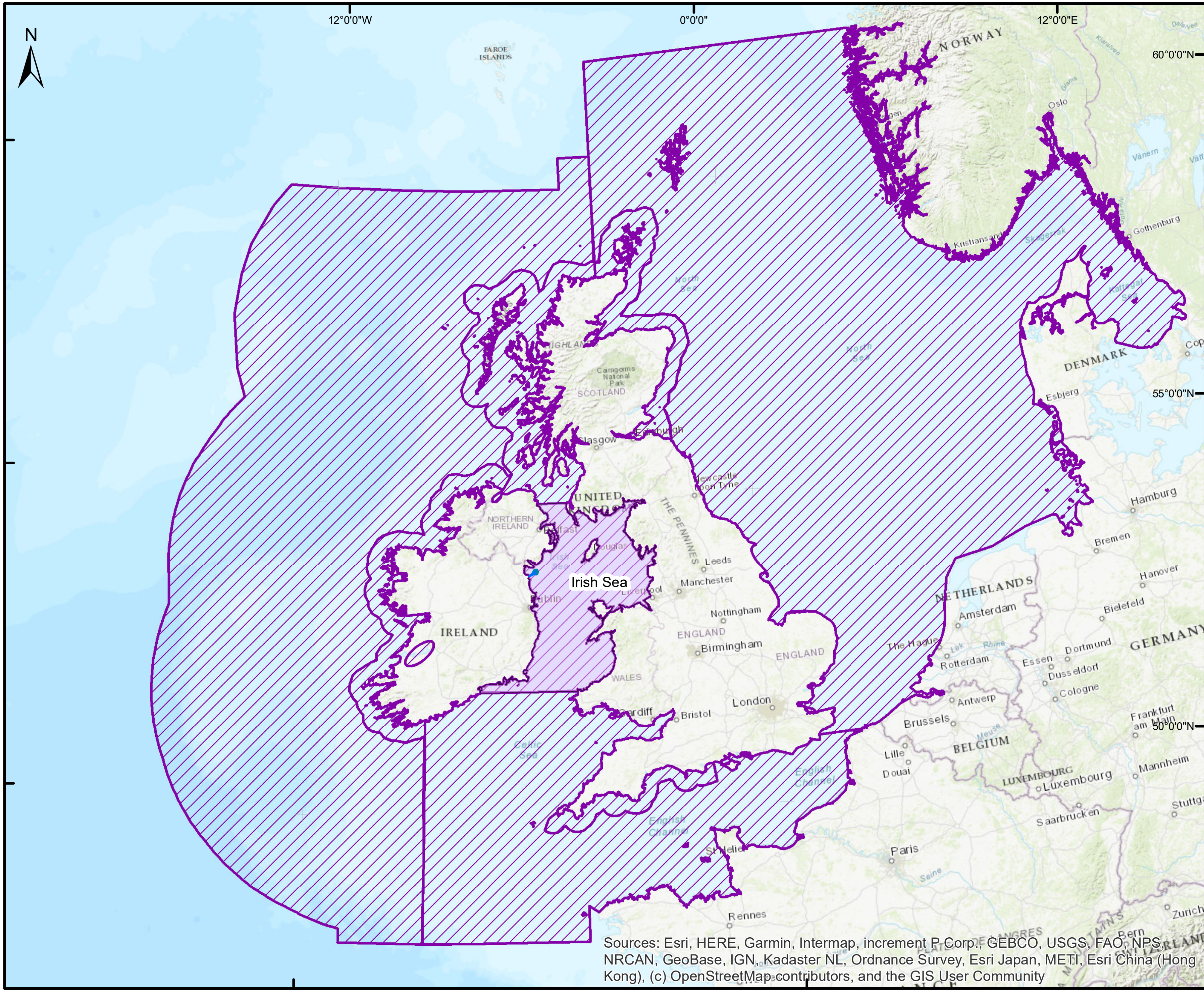
Data from the SCANS III surveys also recorded low numbers of bottlenose dolphins within the Irish Sea (Block E) and estimated a density of 0.008 animals per km^2 for this species. Abundance was calculated as 288 (CV = 0.57; 95% CI = 0 to 664) animals in Block E, with a mean group size of 1.5 estimated (Hammond *et al.,* 2017). The most recent SCANS IV surveys (Gilles *et al.,* 2023) estimated the density in Block CS-D as 0.235 animals per km^2. Abundance estimates were given as 8,199 for Block CS-D (CV = 0.353; 95% CI = 3,595 to 15,158) and 127 for Block CS-E (CV = 0.700; 95% CI = 3 to 153), resulting in an abundance estimate of 8,326 animals for the Irish Sea). SCANS III DSM data (Lacey *et al.*, 2022) gave a mean density of 0.046 animals per km^2 and a maximum of 0.129 animals per km^2 for the Marine Megafauna Study Area (see Figure 1-24). It is suggested in the SCANS IV report that differences in distribution and abundance estimates for bottlenose dolphin between SCANS campaigns may reflect a response to interannual spatial variation in prey availability.

The average density for the Marine Megafauna Study Area from the Welsh Marine Mammal Atlas annual composite maps was calculated as 0.0005 animals per km^2 (Evans and Waggitt, 2023) (see Figure 1-25).

As a precautionary approach a density range of 0.046 animals per km^2 (SCANS III Block E DSM; Lacey *et al.,* 2022) to 0.235 animals per km^2 (SCANS IV; Gilles *et al.,* 2023) will be applied to the assessment.

Bottlenose dolphin were not recorded during the historic (2006) or latest (2018 to 2020) boat-based surveys for the Project and therefore density and abundance estimates were not available from these site-specific datasets. During the aerial surveys a total density of unidentified dolphin species was 0.0033 and unidentified dolphin/porpoise species was 0.062 (Table 1-17).

The IAMMWG has identified seven MUs as appropriate for bottlenose dolphin. The Marine Megafauna Study Area falls within the Irish Sea (IS) MU, which occurs to the east of Ireland, from southwest Scotland to the northern coast of Pembrokeshire (Figure 1-23). The total bottlenose dolphin abundance for the IS MU was estimated as 293 animals (95% CI = 108 to 793) (IAMMWG, 2023), which will be applied to the assessment where the density of 0.046 (SCANS III Block E DSM; Lacey *et al.,* 2022) is applied. Since the SCANS IV density data is an order of magnitude larger compared to SCANS III density estimates, and noting that the Irish Sea MU was derived from SCANS III data, this means that the population estimate of 293 animals is not in proportion to the larger SCANS IV densities. Instead, for SCANS IV data an abundance estimate was derived for the Irish Sea by summing the SCANS IV blocks that fell within this region. Thus, an abundance of 8,326 animals has been estimated as the Irish Sea population and was used as the reference population where the SCANS IV densities have been applied to the quantitative the assessment (SCANS IV; Gilles *et al.,* 2023).



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Irish Seas Management Unit
- Bottlenose Dolphin Management Units

Data Sources: IAMMWG (2023)

Client

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Figure 1-23
Bottlenose dolphin IS Management Unit (IAMMWG, 2023)

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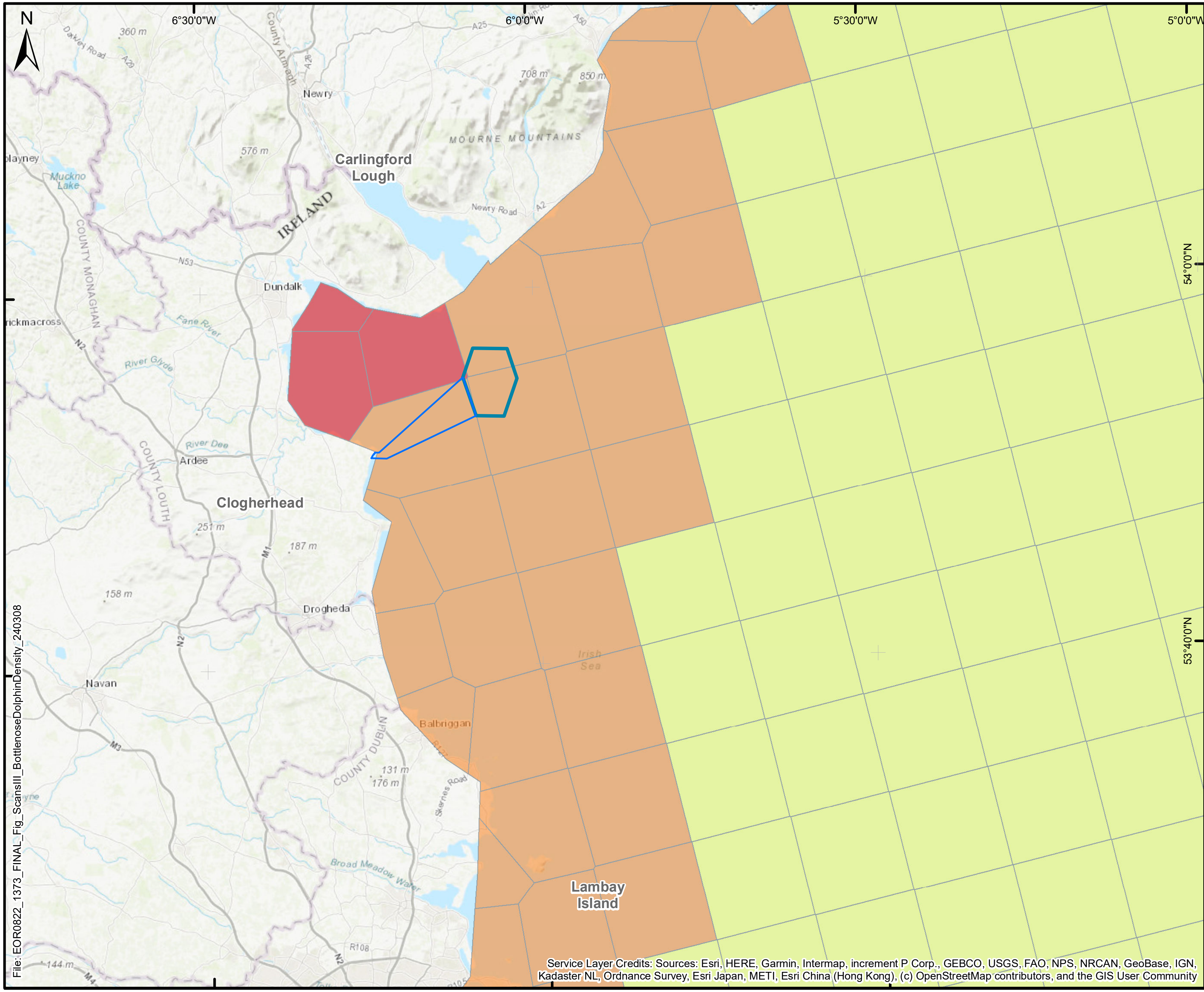


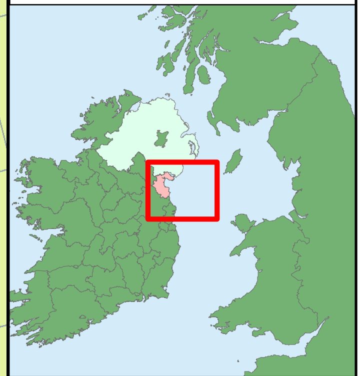
Legend

- Offshore Wind Farm
- Offshore Cable Corridor

Density - Animals per km^2 (SCANS-III)

- 0.02 - 0.03
- 0.03 - 0.04
- 0.04 - 0.42

Data Sources: Client, Scans-III



Client

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Title

Figure 1-24

Density surface maps from SCANS III data for bottlenose dolphin (Lacey *et al.*, 2022).

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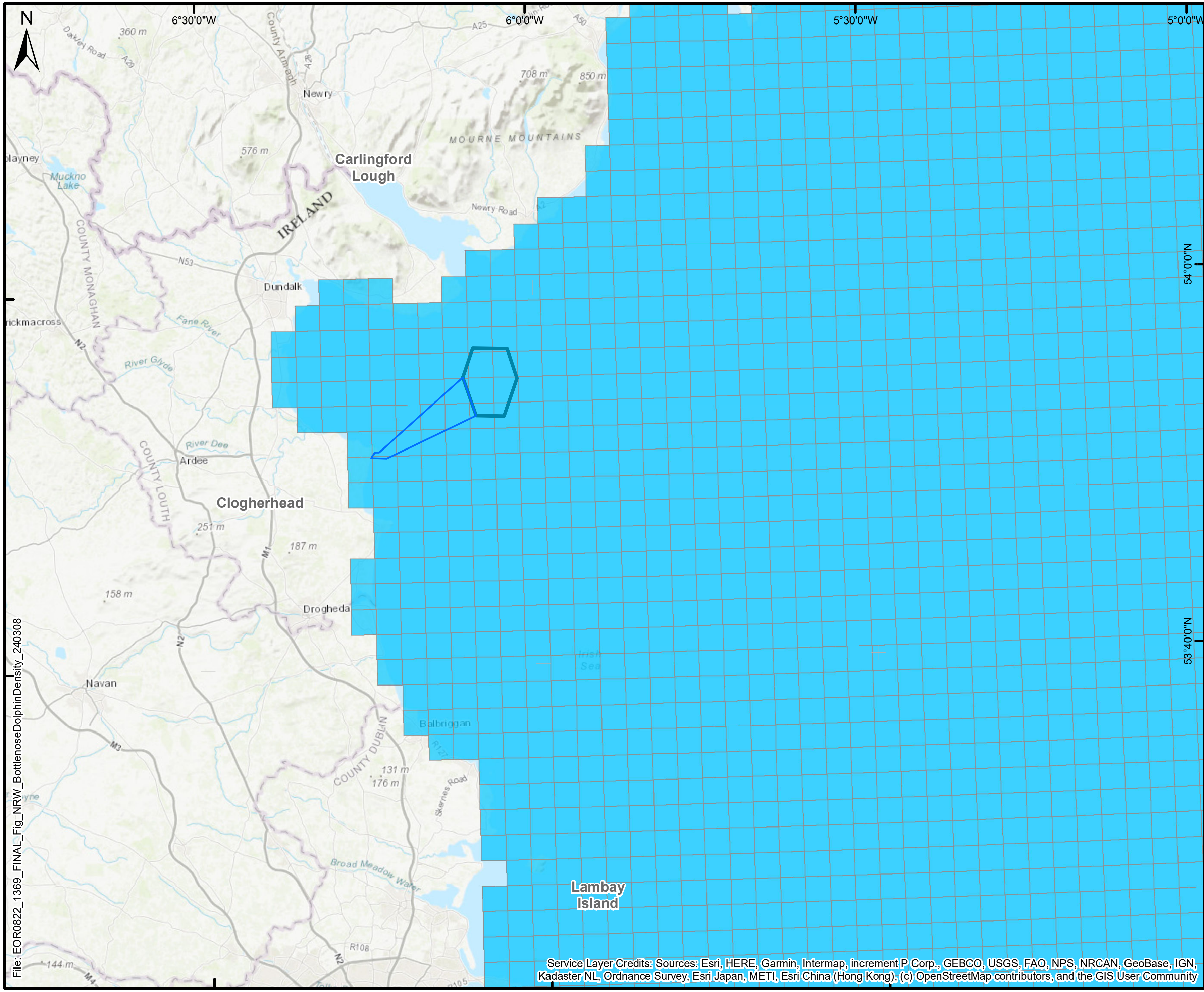


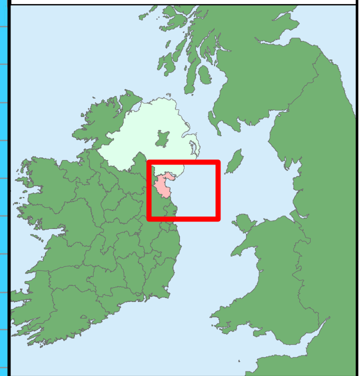
Legend

- Offshore Wind Farm
- Offshore Cable Corridor

Maximum density of animals per km^2

- 0.00 - 0.05

Data Sources: Client, NRW



Client

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Project

Oriel Wind Farm Project

Title

Figure 1-25
Bottlenose dolphin annual composite modelled densities (measured as the maximum density per cell across months) from the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023)."

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Date: 08/03/2024	

1.6.3 Short-beaked common dolphin

Ecology

The short-beaked common dolphin (common dolphin) is a small cetacean species found in both neritic and pelagic environments, and has a varied diet which includes mackerel, herring, cod, hake, whiting, sandeel and other schooling species (Seawatch Foundation, 2012a). Often travelling in large groups, this species hunts cooperatively, working together to drive prey into a bait-ball. In the UK, group size is usually up to 30 individuals, although animals are also often seen alone or in pairs (Seawatch Foundation, 2012a).

Adult common dolphins typically grow to a length of 2.1 to 2.4 m and with a long, slender shape they are capable of swimming at great speed and are often known to bow-ride alongside vessels. Females become sexually mature at approximately six years old and males at five to seven years. There are two calving peaks for common dolphin, spring and autumn, and gestation lasts for 11 months. Calves nurse for around 19 months, and after a four-month resting period, the female will mate again. Other females in a social group may assist in looking after the calf whilst the mother feeds.

Distribution, occurrence and seasonality

Common dolphins are found throughout the Atlantic seaboard of Europe, in the Western Channel and Irish Sea. This species commonly inhabits continental shelf waters and occurs along the shelf edge and in deep water, and is the second most frequently reported cetacean, after harbour porpoise, within Irish waters (Berrow *et al.,* 2010).

The distribution of common dolphin around Irish waters is primarily to the west and south of Ireland, although there are some stranding records from the east coast of Ireland (Berrow *et al.*, 2010). The 2006 SCANS II survey (Hammond *et al.,* 2013) and 2016 SCANS III survey (Hammond *et al.,* 2021) did not record any common dolphins in the western Irish Sea, and similarly there were no sightings of common dolphin during the ObSERVE aerial surveys (conducted from 2015 to 2017) (Rogan *et al.,* 2018a) or the inshore cetacean surveys in this region (Berrow *et al.,* 2011). The SCANS IV 2022 surveys did record common dolphin in the western Irish Sea, the first of the SCANS surveys to sight common dolphin in this area (Gilles *et al.,* 2023). Evidence collated from multi-annual surveillance programmes indicate that whilst common dolphins do occur widely in Irish waters, the species' presence is much less pronounced in the western Irish Sea (NPWS, 2019; NBDC, 2024c) (Figure 1-26). For example, data from IWDG suggests that the southern Irish Sea is likely to be a key area for common dolphin within the Irish Sea (Berrow *et al.*, 2010). Records from ferries show a notable increase in numbers in the southern Irish Sea in the autumn and a peak in inshore records during the month of August, and suggests that there may be an eastward movement along the south coast during autumn and winter (Berrow *et al.*, 2010).

During the historic site-specific surveys in 2006, common dolphin was not recorded in the Survey Area. In more recent site-specific surveys (May 2018 to May 2020), common dolphin was recorded in five of the nineteen survey months, in August, September and December of 2018, January and December of 2019 in the south, southwest and west of the Survey Area, but was not recorded within the offshore wind farm area (Figure 1-27). During the SAM surveys, specific dolphin species could not be identified, however, unidentified dolphin species were recorded on 29%, 1%, 0%, and 13% of days per survey respectively. This resulted in dolphins being recorded on 56 days out of 685 days surveyed (Table 1-14). There were 3 unidentified dolphin species and 45 unidentified dolphin/porpoise species recorded on the aerial surveys which could potentially be short-beaked common dolphins (Table 1-16).

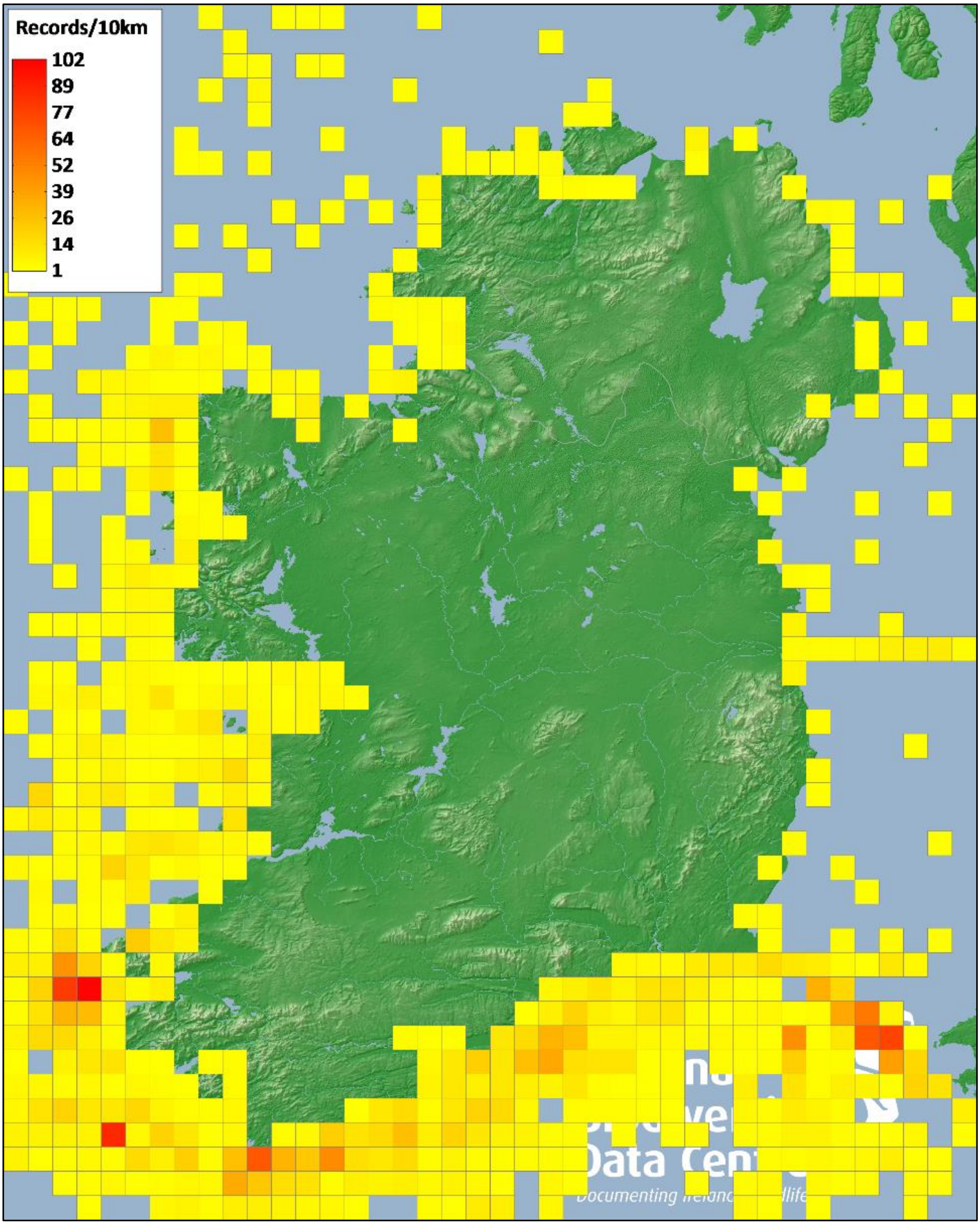
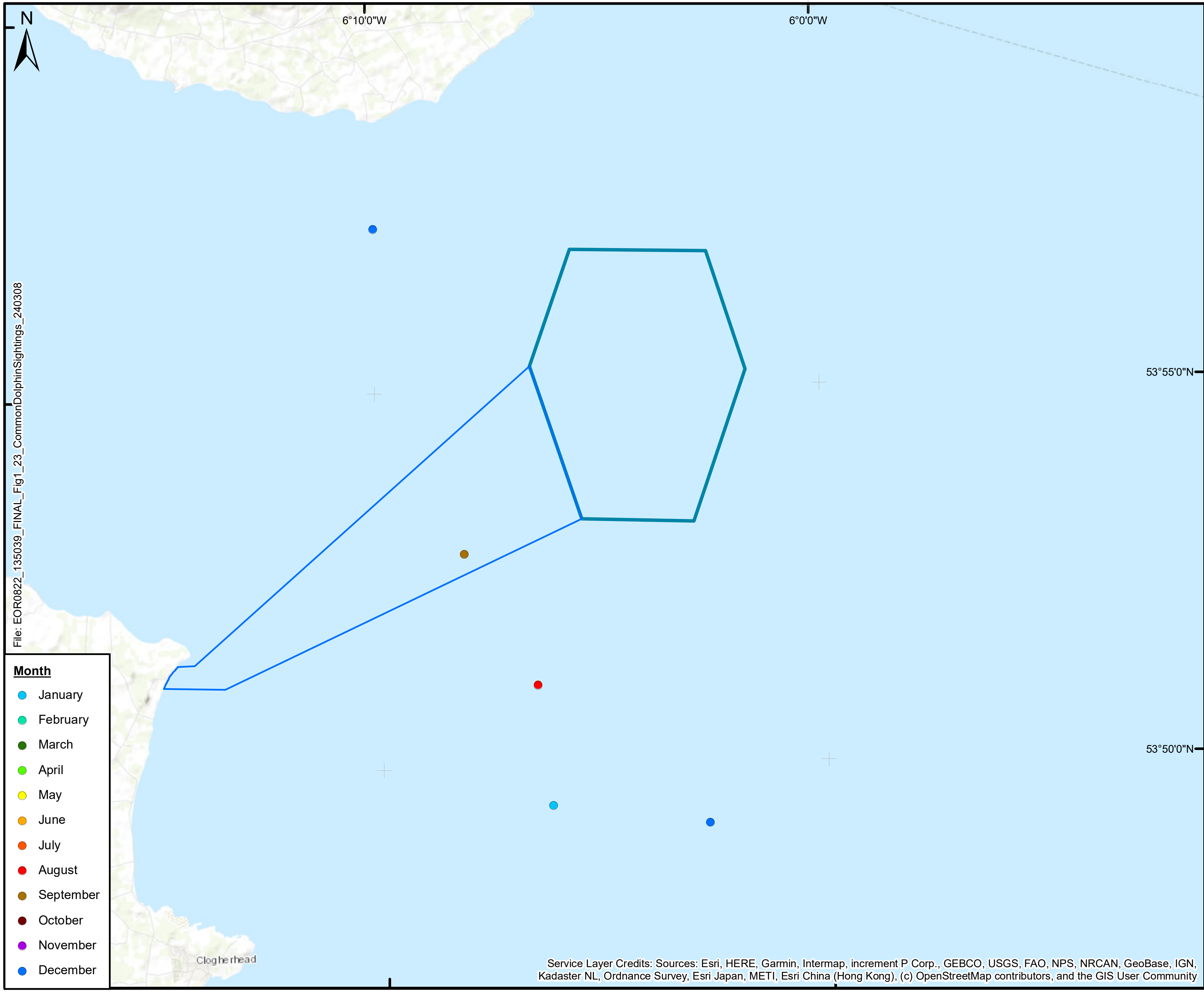


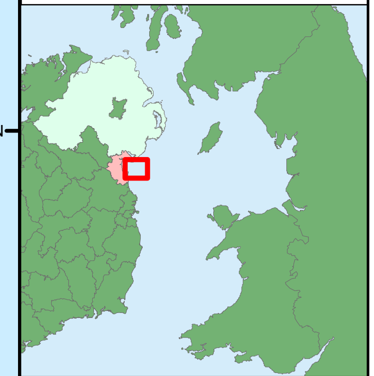
Figure 1-26: Short-beaked common dolphin records – distribution of the number of records (animals per 10x10 km grid cell) (1986 to 2016) (NBDC, 2024c).



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Data Sources: Client, RPS.



Client

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Title

Figure 1-27
Common dolphin sightings from site-specific surveys (2018 - 2020)

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Density/abundance

Common dolphin was not recorded during the ObSERVE surveys, therefore density and abundance estimates were not available from these datasets (Rogan *et al.,* 2018a).

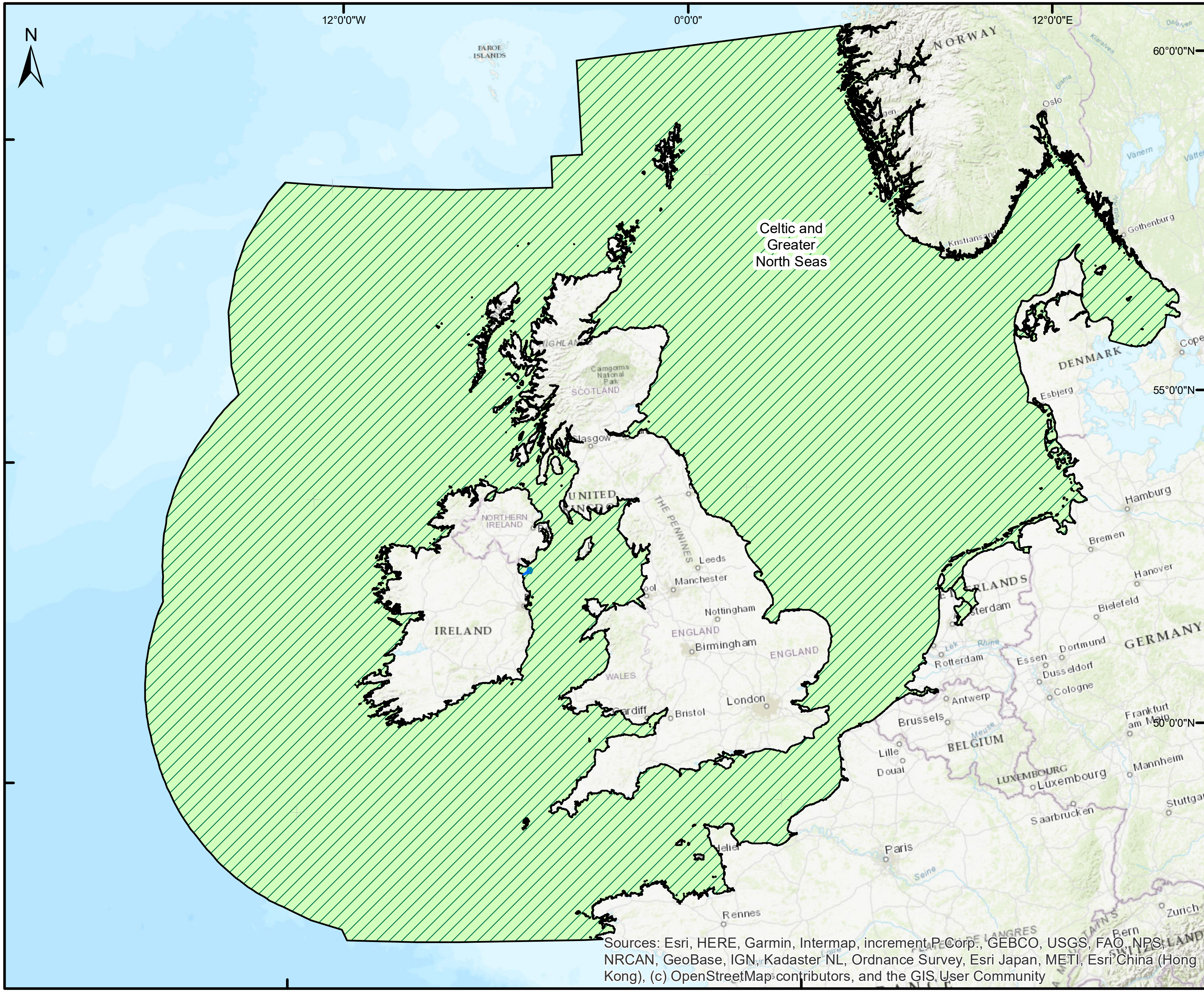
Design-based estimates using SCANS II data for Block O (Irish Sea) (Figure 1-17) found that the density of common dolphin was 0.008 animals per km^2 (95% CI = 0.0022 to 0.0301) and abundance was calculated as 366 animals (CV = 72%; 95% CI = 98 to 1,368) (Hammond *et al*., 2013). Sightings within this block were in the southern part of the Irish Sea and not in proximity to the Project. There were no sightings of common dolphin recorded in Block E (western Irish Sea) during the SCANS III surveys (Hammond *et al.,* 2017). Based on SCANS III DSM data (Lacey *et al.,* 2022), established from sightings across the SCANS III survey blocks, it was possible to identify a mean density of 0.033 animals per km^2 and a maximum of 0.103 animals per km^2 for the Marine Megafauna Study Area (see Figure 1-29). The most recent SCANS IV surveys (Gilles *et al.,* 2023) estimated the density in Block CS-D as 0.027 animals per km^2.

The average density for the Marine Megafauna Study Area from the Welsh Marine Mammal Atlas annual composite maps was calculated as 0.00005 animals per km^2 (Evans and Waggitt, 2023) (see Figure 1-30).

During recent site-specific surveys (May 2018 to May 2020) more than 51 common dolphin were recorded over five sightings, including one sighting of 30+ animals, and one sighting of ten animals. Encounter rates were estimated across the Survey Area using these data. For months where common dolphin was sighted, the highest encounter rate occurred in August 2018 (0.181 animals per km) and the lowest in December 2018 and 2019 (0.018 animals per km). In 14 of the 19 survey months, the encounter rate was 0 animals per km where no common dolphin were recorded (see Table 1-6). During the aerial surveys a total density of unidentified dolphin species was 0.0033 and unidentified dolphin/porpoise species was 0.062 (Table 1-17). There were insufficient data to generate modelled density estimates from the recent site-specific boat-based data. Therefore, a precautionary density of 0.008 animals per km^2 (SCANS II, Block O) was carried forward to the impact assessment.

As a precautionary approach a density of 0.027 animals per km^2 (SCANS IV; Gilles *et al.,* 2023) will be applied to the assessment.

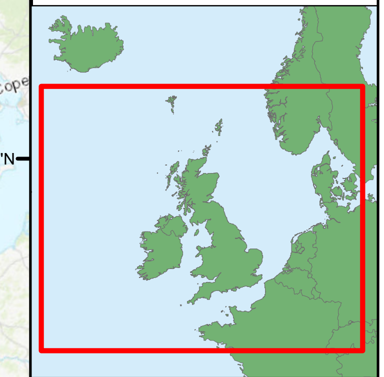
The IAMMWG has identified a single MU as appropriate for common dolphin, the Celtic and Greater North Seas (CGNS) MU, which extends from the north of the Shetland Isles, to the west of the Irish landmass, and east to mainland Europe (see Figure 1-28). The Marine Megafauna Study Area falls within the CGNS MU. The total common dolphin abundance for the CGNS MU was estimated as 102,656 (CI = 58,932 to 178,822) (IAMMWG, 2023).



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Common Dolphins Management Units
- Celtic and Greater North Sea Management Unit

Data Sources: IAMMWG (2023)



Client

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Title

Figure 1-28
CGNS Manangement Unit for common dolphin and minke whale (IAMMWG, 2023)

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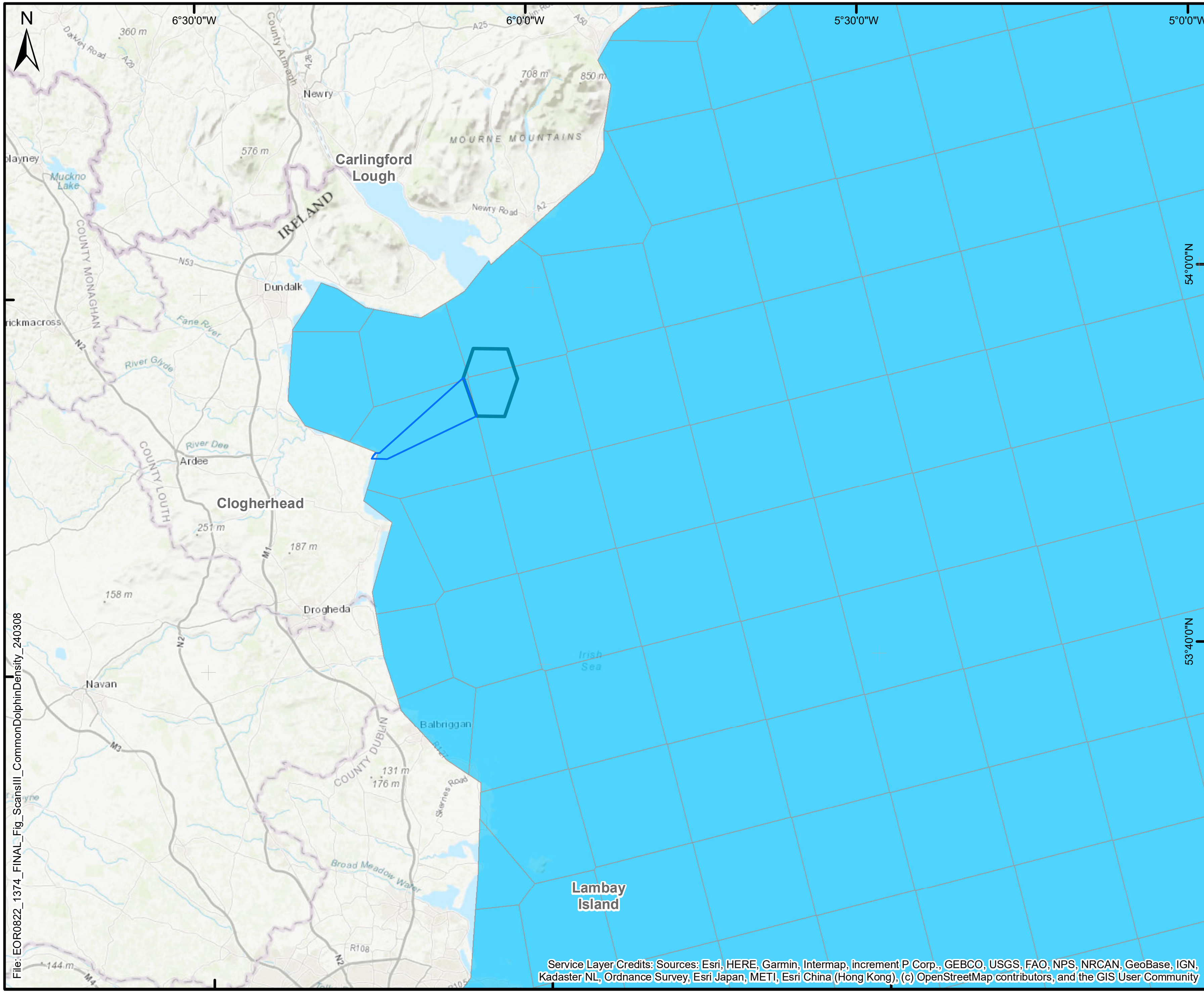


File: EOR0822_1374_FINAL_Fig_ScansIII_CommonDolphinDensity_240308

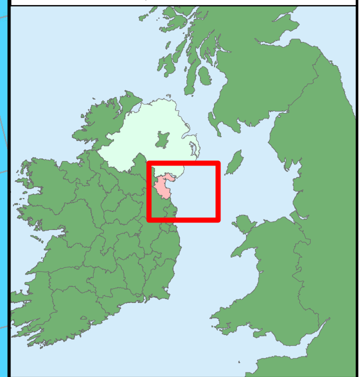
Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Density - Animals per km^2 (SCANS-III)

- 0.0 - 0.1

Data Sources: Client, Scans-III



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title **Figure 1-29**

Density surface maps from SCANS-III data for common dolphin (Lacey *et al.*, 2022)

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Scale: 1:500,000 @ A4	Projection: ITM (IRENET95) Geographic Co-ordinates: ETRS89
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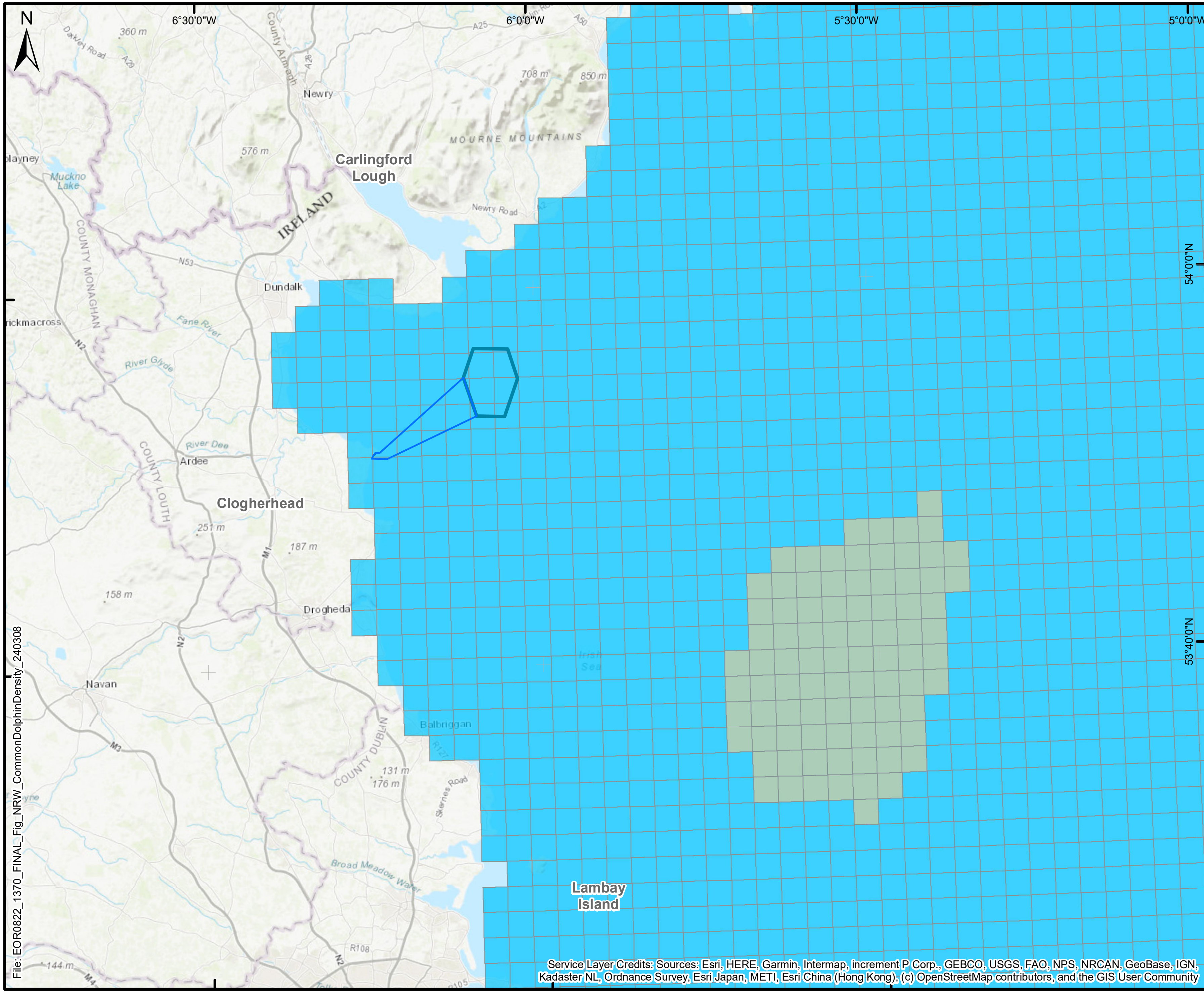


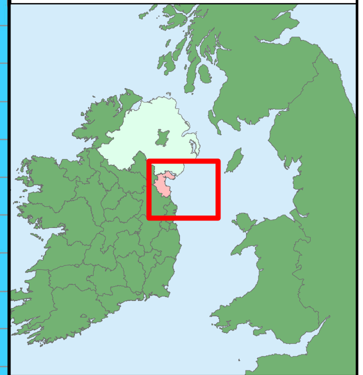
Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Maximum density of animals per km^2

- 0.0 - 0.1
- 0.1 - 0.2

Data Sources: Client, NRW



Client

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Project

Oriel Wind Farm Project

Title **Figure 1-30**
Short-beaked common dolphin annual composite modelled densities (measured as the maximum density per cell across months) from the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023).

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1.6.4 Minke whale

Ecology

Minke whale is the most frequently sighted mysticete species in UK and Irish waters, and although they are most commonly seen alone or in pairs, when feeding they sometimes aggregate into larger groups of up to 10 to 15 individuals (Reid *et al.,* 2003). Mostly inhabiting continental shelf waters, this species occurs in depths of less than 200 m and can often be seen close to land. In the eastern North Atlantic, minke whale feed on a wide variety of prey species including herring, cod, capelin, haddock, saithe and sandeel Ammodytidae (Haug *et al.,*1995), however, studies in UK waters have shown that their diet comprises mainly sandeels (~ two-thirds by weight) and clupeids (herring and sprat *Sprattus sprattus* (Pierce *et al.,* 2004).

The smallest of the baleen whales, male minke whales achieve lengths of 7 to 9.8 m, whilst females are typically 7.5 to 11 m (Seawatch Foundation, 2012b). Sexual maturity occurs in females from the age of 6 to 8 years and males at 5 to 8 years. In the northern hemisphere, mating occurs between October to March and the gestation period lasts approximately 10 months, with the peak birth period between December and January (Seawatch Foundation, 2012b). Calves usually nurse for a period of four to six months.

Distribution, occurrence and seasonality

Minke whale is extensively distributed throughout the northern hemisphere in tropical, temperate and polar seas. High densities are known to occur in relatively cool waters over the Atlantic continental shelf (< 200 m). (Reid *et al.,* 2003; Hammond *et al.,* 2013). Minke whale is the most frequently recorded baleen whale (or mysticete) in British shelf waters (Evans *et al.,* 2003) and has been observed all around Ireland's coast and offshore in deep ocean basins as well as over the continental shelf and slope (Berrow *et al.*, 2010).

Minke whale have a temporal distribution, exhibiting seasonal migrations from polar feeding grounds to warm tropical breeding grounds, and are mainly sighted in Irish waters in summer months, with few sightings in winter (Baines and Evans, 2012). The IWDG cetacean sightings review found that the number of sightings around Irish waters started to increase in April and May, peaking in August, and tapering off in late autumn and early winter (Berrow *et al.*, 2010). This pattern is also reflected in the Irish Sea where animals appear in the eastern Irish Sea in April to June (Berrow *et al.*, 2010). The coastal distribution in summer months and lower or lack of coastal sightings in winter suggests a seasonal offshore to inshore movement. Data from the ObSERVE aerial surveys of Irish waters found a high use of coastal waters during the summer months, particularly in the southwest of Ireland and Irish Sea and the predicted distribution suggests that the Irish Sea appeared to be unsuitable for minke whale in winter (Figure 1-31) (Rogan *et al.,* 2018a).

The species has a largely offshore distribution and is most abundant off the southwest coast of Ireland and localised patches in the Irish Sea. Highest densities in the Irish Sea occur in the Celtic Deep and in lower concentrations northwards towards the Isle of Man and Dublin Bay (Baines and Evans, 2012; Hammond *et al.,* 2013). During boat-based surveys of the Irish Sea, observations of minke whale were made in the northern inshore block (Block A) only, which encompasses Dublin Bay and waters to the north, in which the Marine Megafauna Study Area is located (Berrow *et al.,* 2011). During SCANS II survey in 2006, there were few sightings in the Irish Sea, with highest density sightings to the south of the Irish landmass, towards the Celtic Deep. This trend in distribution is corroborated by the SCANS III survey in 2016 (Hammond *et al,,* 2013) and the SCANS IV survey in 2022 (Gilles *et al,* 2023); whilst minke whale were sighted in SCANS III Block E and SCANS IV Block CS-D (in which the Project is located) sighting numbers across the Irish Sea in general were low.

During the historic site-specific surveys in 2006, minke whale was observed in the Marine Megafauna Study Area in July and August only. In the more recent site-specific boat-based surveys (May 2018 to May 2020), minke whale was recorded in six of nineteen months; in June, August and September of 2018 and July, August and October of 2019 (Table 1-5). Minke whale were sighted throughout the Survey Area but sightings were concentrated in the southeast of the Survey Area, with one sighting within the offshore wind farm area (Figure 1-32). One minke whale was identified in the aerial surveys, as well as one unidentified baleen whale which could also be a minke whale (Table 1-16).

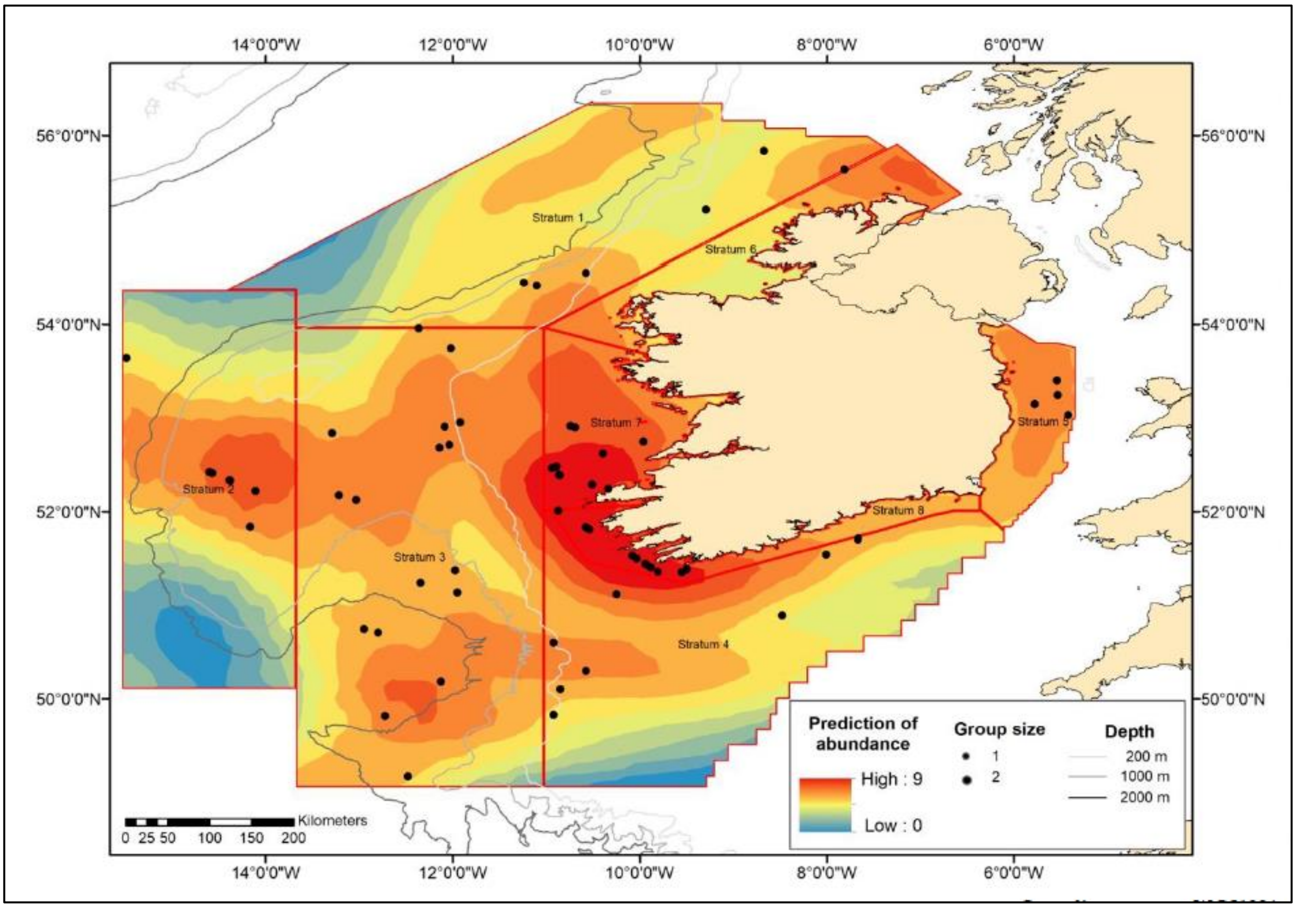
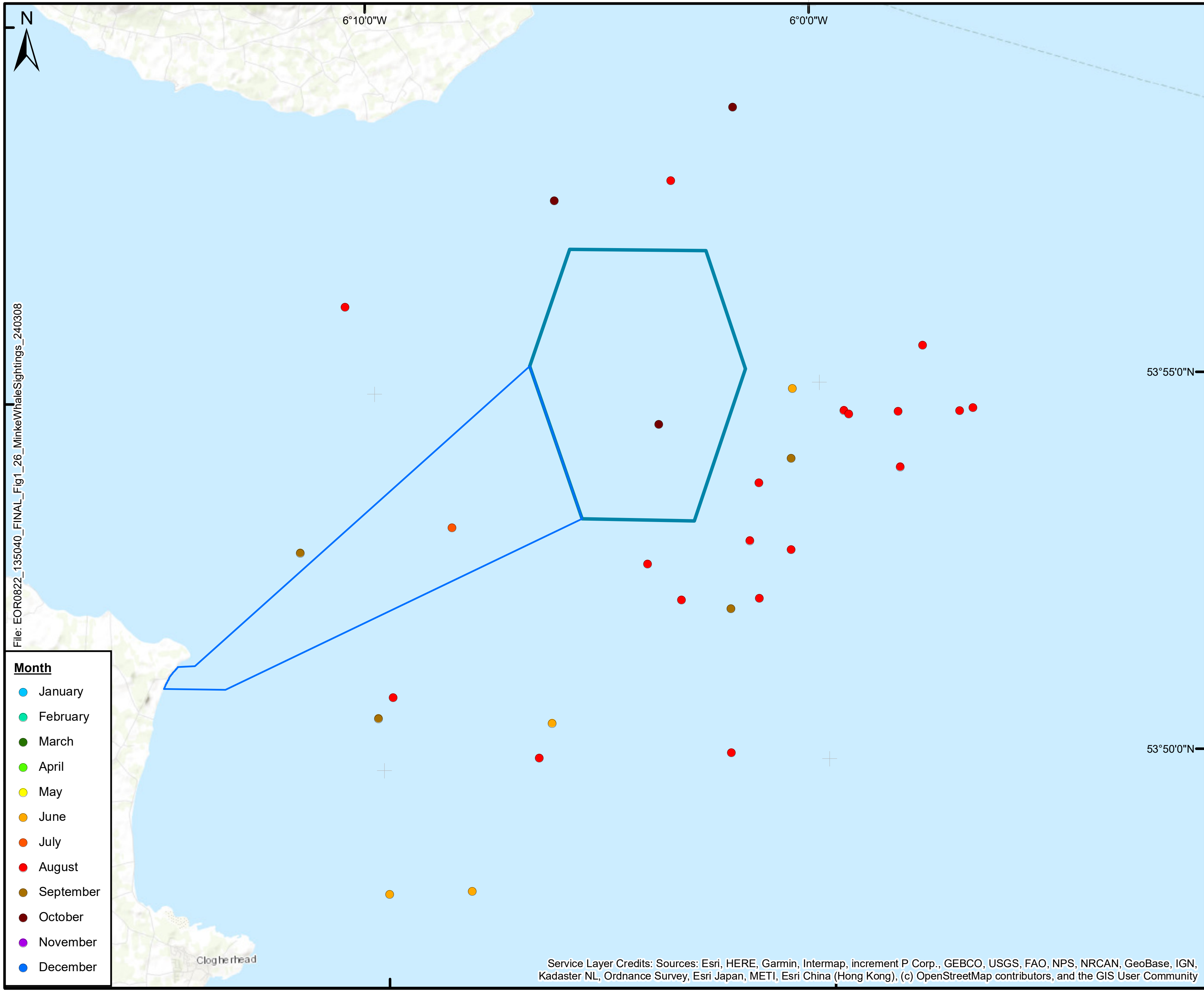


Figure 1-31: Predicted summer distribution of minke whale in 2016 from the ObSERVE aerial surveys. The scale of abundance is a relative estimate and therefore does not represent absolute numbers of minke whale (Rogan *et al*., 2018).



Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources: Client, RPS.

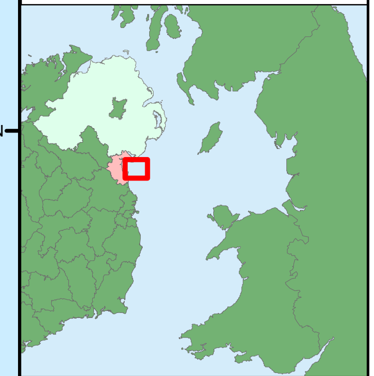


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Figure 1-32
Minke whale sightings from site-specific surveys (2018 - 2020)

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Density/abundance

Corrected design-based estimates for abundance and density of minke whale from the ObSERVE surveys for the western Irish Sea showed that densities reached 0.014 animals per km^2 and the abundance was 495 animals (95% CI: 221 to 1,105).

Estimates for SCANS II Block O (Figure 1-17) were calculated as 0.0236 animals per km^2 (95% CI = 0.0052 to 0.1071) for density, and 1,073 animals (CV = 89; 95% CI = 237 to 4,862) for abundance (Hammond *et al.,* 2013). Sightings of minke whale in Block O were in the west of the Irish sea just north of Dublin Bay, in the east Irish Sea near the Isle of Man, and in the south Irish Sea in St George's Channel (Figure 1-17).

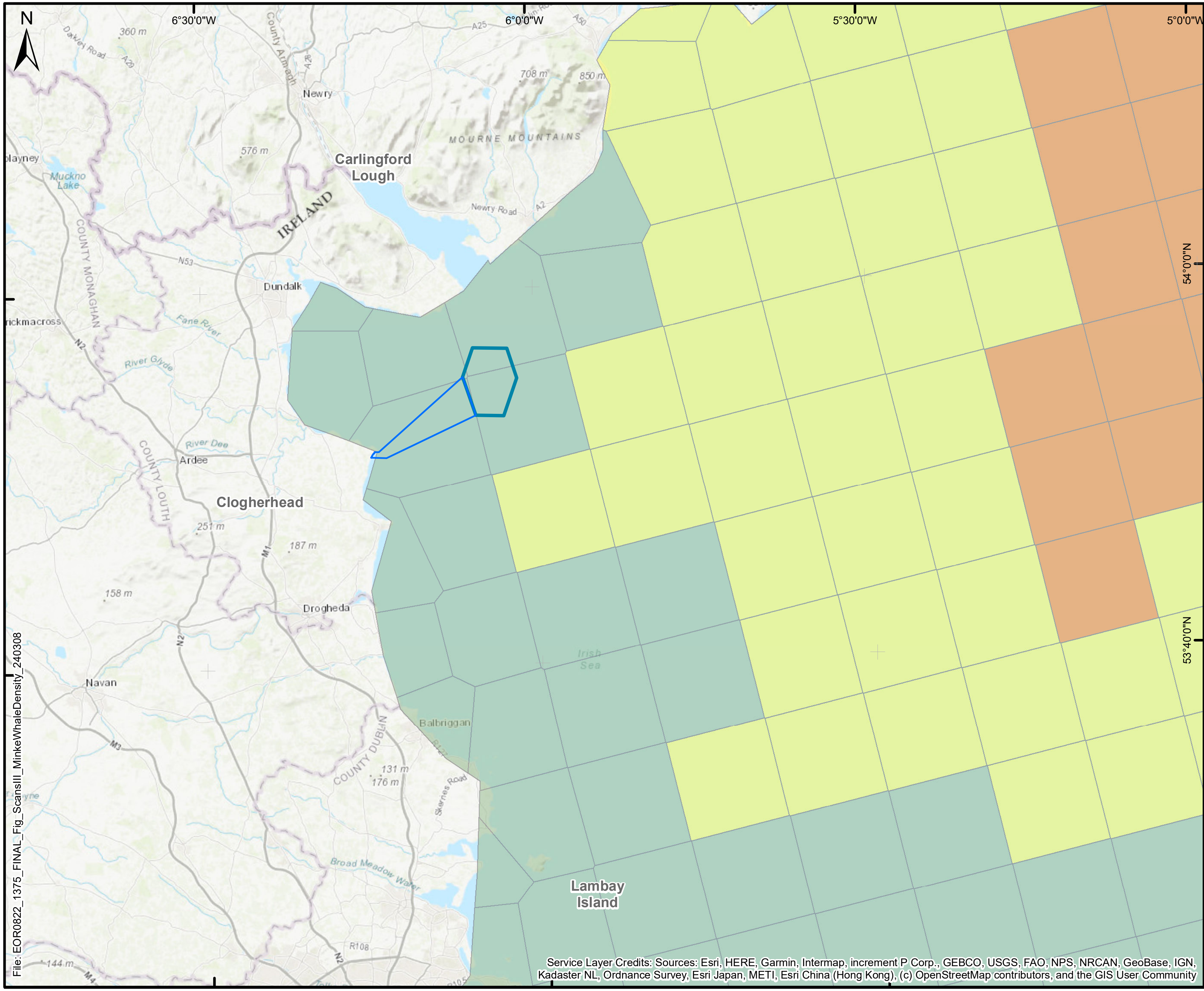
In SCANS III Block E (see Figure 1-18), the density estimate was similar to that estimated using the ObSERVE aerial data, with 0.017 animals per km^2 calculated for this block. The total abundance for Block E was estimated as 603 animals (CV = 0.62; 95% CI = 134 to 1,753). A precautionary density of 0.017 animals per km^2 (SCANS III, Block E) will be applied to the assessment. SCANS III DSM data (Lacey *et al.*, 2022) gave a mean density of 0.019 animals per km^2 and a maximum of 0.035 animals per km^2 for the Marine Megafauna Study Area (see Figure 1-33) The most recent SCANS IV surveys (Gilles *et al.,* 2023) estimated the density in Block CS-D as 0.0137 animals per km^2.

The average density for the Marine Megafauna Study Area from the Welsh Marine Mammal Atlas annual composite maps was calculated as 0.003 animals per km^2 (Evans and Waggitt, 2023) (see Figure 1-34).

During the recent boat-based site-specific surveys (May 2018 to May 2020) a total of 30 minke whale was recorded. Encounter rates were estimated across the Survey Area using the boat-based site-specific data. For those months in which minke whale were recorded the highest encounter rate occurred in August 2019 (0.084 animals per km) with the lowest in July 2019. In 13 of the 19 survey months, the encounter rate was 0 animals per km. Modelled density estimates using these data found that, on average, there were 0.04 animals per km^2 with a monthly mean peak of 0.26 animals per km^2 (Table 1-13). The density of minke whales observed during the aerial surveys was 0.0017 across the Survey Area. The density for unidentified baleen whale species was also 0.0017 (Table 1-17).

As a precautionary approach a density range of 0.014 animals per km^2 (SCANS IV; Gilles *et al.,* 2023) to 0.26 animals per km^2 (site-specific surveys) will be applied to the assessment.

The IAMMWG has identified a single MU as appropriate for minke whale, the CGNS MU, which extends from the north of the Shetland Isles, to the west of the Irish landmass, and east to mainland Europe (Figure 1-28). The Marine Megafauna Study Area falls within the CGNS MU. The total minke whale abundance for the CGNS MU was estimated as 20,118 animals (95% CI = 14,061 to 28,786) (IAMMWG, 2023).



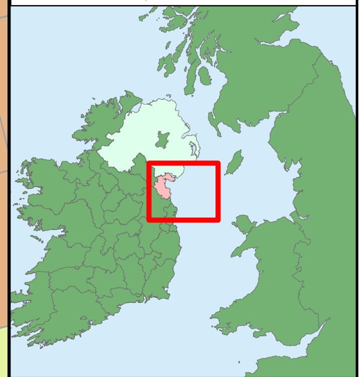
Legend

- Offshore Wind Farm
- Offshore Cable Corridor

Density - Animals per km2 (SCANS-III)

- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.04

Data Sources: Client, Scans-III



Client

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Figure 1-33
Density surface maps from SCANS-III data for minke whale (Lacey *et al*., 2022)

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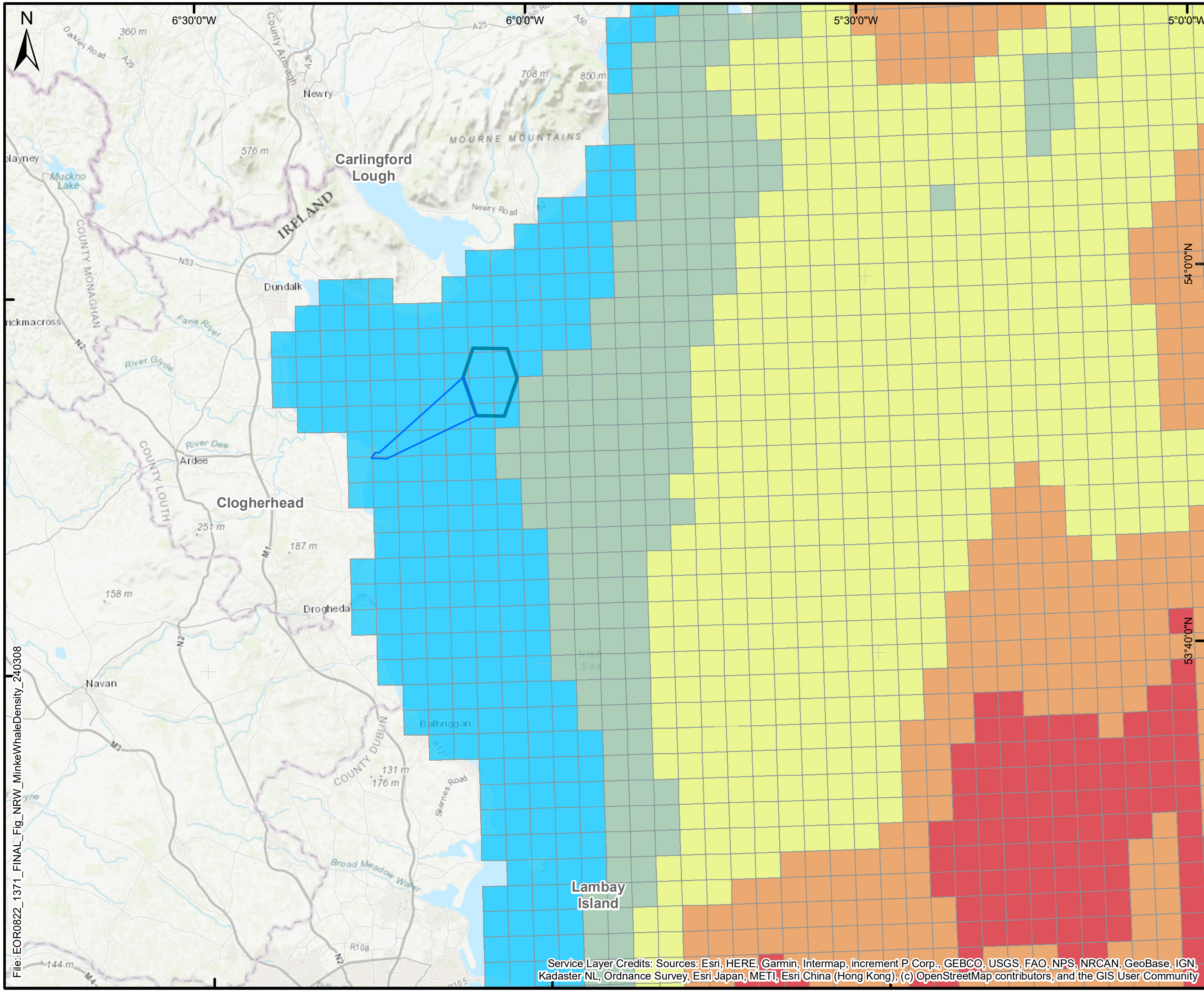


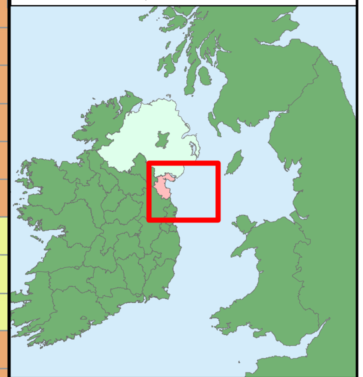
Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Maximum density of animals per km²

- 0.000 - 0.005
- 0.005 - 0.010
- 0.010 - 0.015
- 0.015 - 0.020
- 0.020 - 0.026

Data Sources: Client, NRW



Client

ORIEL WINDFARM
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Title **Figure 1-34**
Minke whale annual composite modelled densities (measured as the maximum density per cell across months) from the Welsh Marine Mammal Atlas (Evans and Waggitt, 2023).

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1.6.5 Grey seal

Ecology

Grey seal is the larger of the two pinniped species which occur around the Irish coast. Grey seals gather in colonies on land (known as haul-outs) where they breed, rest, moult and engage in social activity (Bonner, 1990). Breeding occurs in late August to December and the annual moult between November to April (Kiely *et al.,* 2000). Preferred haul-out locations around the coast of Ireland include uninhabited islands, isolated main beaches, rocky skerries and sea caves (O'Cadhla *et al.*, 2007).

Grey seals can live for over 20 to 30 years, with females tending to live longer than males (SCOS, 2015). Sexual maturity is reached at approximately ten years in males, and five years in females (SCOS, 2015). Gestation occurs over 10 to 11 months. Female grey seals tend to return to the same breeding site at which they were born in order to give birth and pupping tends to take place between August and November (SCOS, 2018) in the UK and Ireland. Grey seal give birth to a single, white-coated pup which are weaned over a period of 17 to 23 days (SCOS, 2018), with the pups leaving the breeding site for the sea after approximately one month. Following this, the female comes into oestrus and mating occurs, after which adult grey seal return to sea to forage and build up fat reserves. Just before weaning the pups shed their white natal coat (lanugo) and develop their first adult coat. Moult occurs in stages at the colony with juvenile seal moulting first, followed by adults.

A study of grey seal diet in Irish waters found that the Gadidae family (true cod) was the most important prey group of grey seals, with *Trisopterus* spp. (small cod species) accounting for the highest abundance and biomass in prey composition (Gosch, 2017). Other important gadoids, in terms of the second largest contribution to prey biomass, included haddock and pollack. Sandeels occurred frequently and in high abundances in their diet although only contributed to a small proportion (5.4% of the biomass) (Gosch, 2017). Hammond and Wilson (2016) also highlighted sandeels as an important prey item for grey seals in Scottish waters where they account for approximately 50% of the diet. Gosch (2017) highlighted that there are significant regional and temporal differences in the diet of grey seal. Seals in shallow waters show a preference for demersal and groundfish species such as cephalopods and flatfish, whilst seals foraging in deeper waters, over sandy substrates, will target pelagic and bentho-pelagic species such as blue whiting and sandeels (Gosch, 2017). The muddy sediments within the vicinity of the Project support a large *Nephrops* fishery, and associated predators and fish assemblages, such as gadoids, flatfish and elasmobranchs. It is therefore likely that species such as cod, haddock, pollack, and flatfish such as flounder *Platichthys flesus* and plaice *Pleuronectes platessa*, would be key prey items in this area.

Grey seals tend to forage in the open sea, returning to land regularly to haul-out. Foraging trips can be wide-ranging; tracking data from Carter *et al.,* 2022 showed a maximum foraging range of 448 km. However, tracking studies have shown that most foraging is likely to occur within 100 km of a haul-out site (SCOS, 2018). Foraging trips can last anywhere between 1 and 30 days. Movements of grey seal between haul-out sites in the North Sea and haul-out sites in the Outer Hebrides have been recorded as well as movements from sites in Wales and northwest France, to the Inner Hebrides (SCOS, 2020). Grey seal swim at an average of 1-2 ms^{-1} (Gallon *et al.*, 2007) and dive to depths of up to 100 m (SCOS, 2015), though they have been recorded at much greater depths.

Distribution, occurrence and seasonality

Globally, there are three hotspots of grey seal abundance; one in eastern Canada and northeast USA; a second smaller population in the Baltic Sea; and the third along the coast of the UK and Ireland (38% of the world's grey seals breed in the UK) (SCOS, 2017). Grey seal in Ireland are generally considered part of a larger population or meta-population that also inhabits adjacent jurisdictions (i.e. the UK and France at least) (NPWS, 2019).

Data from NBDC shows that grey seal occur all around the coast of Ireland, including records from the County Louth coast, adjacent to the Project[2]. The distribution around Ireland is concentrated along the Atlantic seaboard with more isolated regional concentrations off the coast of Wexford, Dublin, the Skerries, Clogherhead, Dundalk Bay and Carlingford Lough (Figure 1-36) (O'Cadhla *et al.,* 2007; Duck and Morris,

[2] http://marine.gov.scot/information/seal-usage-maps

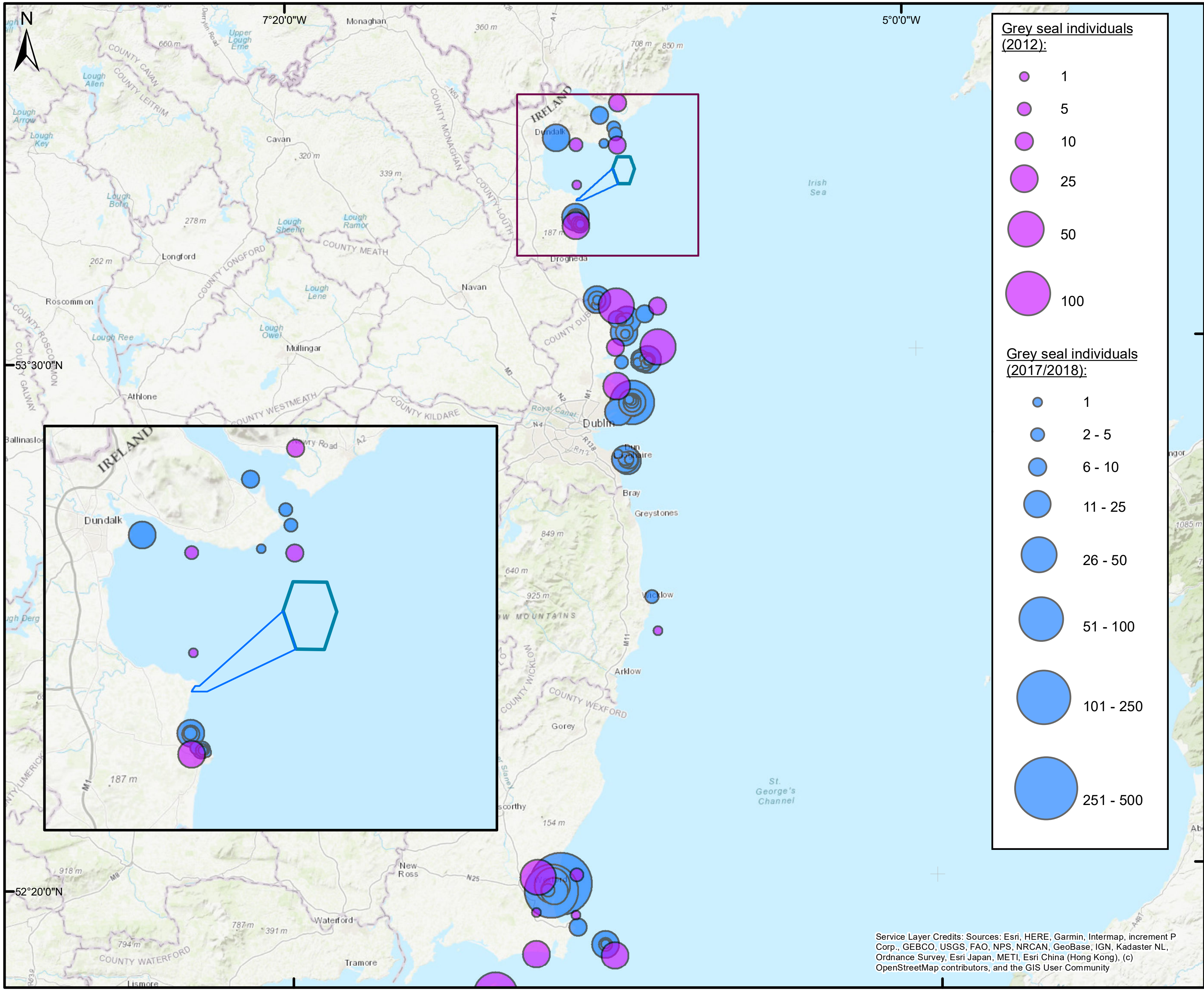
2013; Morris and Duck, 2019). Although pup production tends to be lower off the east coast of the mainland compared to the west coast (due to lower availability of suitable habitat), (Duck and Morris, 2013)., there has been a 87% increase in grey seal pups counted between 2012 and 2018 in the east coast survey blocks suggesting that numbers of grey seals are increasing at a relatively high rate in the Irish Sea (Morris and Duck, 2019).

Information on grey seal distribution is provided in the SMRU grey seal usage maps published by Marine Scotland (MS). These maps are based on seals tagged in UK waters and therefore may under-represent seals in Ireland, however they indicate that grey seal occur regularly in the Irish Sea, particularly to the north, between Dublin Bay and Dundalk Bay, and to the south in County Wexford (see Figure 1-36to Figure 1-38). The distribution shown in Figure 1-36 is similar to that mapped by Jones *et al*. (2015) which used data from seals originating from Irish colonies, indicating that the SMRU seal at-sea usage maps provide a good representation of seal distribution and occurrence in the western Irish Sea. Jones *et al*. (2015) however did not identify the Isle of Man as a stronghold for grey seal, whereas the SMRU data shows mean values of >100 animals per 5 x 5 km grid cell for the southwest coast of the Isle of Man. The data from Jones *et al*. (2015) was not mapped here as there were considered to be some limitations with the modelling in this study (Mark Jessopp, University College Cork, pers. comm.).

Telemetry studies from Carter *et al.* (2020) include tagging deployments from Ramsey and Skomer Islands, Bardsey Island and the Dee Estuary and shows that seals hauling out at one SAC during the foraging season may comprise breeding stock from another (Carter *et al.,* 2020). The most recent UK-wide study of at-sea distribution for grey seal by Carter *et al.,* (2022) demonstrated areas of relatively high use around Lambay Island and north towards the Project, and further south in Co. Wexford. Finer scale seasonal movements were also identified, with seals transitioning between sites within the Irish Sea, but not leaving Wales. This confirms at-sea usage maps by Carter *et al.* (2020) which highlighted some higher densities observed in the east of the Irish Sea compared to the west Irish Sea (see Figure 1-40).

Data from the 2012 and 2018 aerial surveys of seals showed that there are a number of grey seal haul-outs within foraging distance of the Project (Morris and Duck, 2013; Duck and Morris, 2019; Figure 1-35). From the most recent data, the closest haul-out site to the north of the Project is near to the mouth of Carlingford Lough (4.5 km from the offshore wind farm area; 6.5 km from the offshore cable corridor) (Morris and Duck, 2019). To the south, there are several recorded haul-out sites around Clogherhead (13.3 km from the offshore wind farm area; ~4.1 km from the offshore cable corridor) (Morris and Duck, 2019; Figure 1-35). In Dundalk Bay, to the west of the Project, the grey seal haul-out was recorded at 15.5 km from the offshore wind farm area and 14.8 km from the offshore cable corridor (Morris and Duck, 2019). Grey seals can range over large distances and are likely to move up and down the east coast of Ireland. For example, telemetry data from 19 individuals tagged in 2013/14 from colonies at Raven Point, Wexford demonstrated that animals were moving north as far as the Isle of Man (Cronin *et al.*, 2016) (see Figure 1-36). The offshore wind farm area is 43.1 km from Lambay Island SAC, therefore it is likely that grey seals from this SAC may venture northwards and may potentially occur in the waters around the Project; Lambay Island SAC supports the principal breeding colony of grey seal on the east coast of Ireland (NPWS, 2014c).

In the recent site-specific surveys (May 2018 to May 2020), grey seal was recorded in every month other than October 2018, July 2019 and December 2019, and a total of 59 animals were recorded (Table 1-5). Counts of grey seal were similar throughout the survey period, ranging between one and seven animals for each survey month and sightings were distributed throughout the Survey Area and offshore wind farm area (Figure 1-39). During the aerial site surveys, a total of four grey seals and another 18 unidentified phocids were recorded (Table 1-16).



Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources: Client, Marine Scotland.

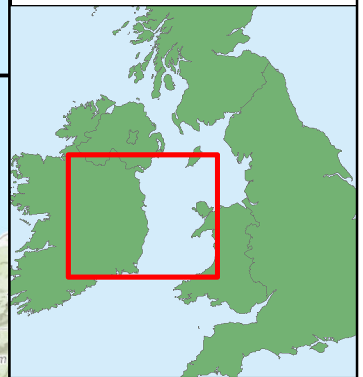


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Figure 1-35
Distribution of grey seal haul outs in the western Irish Sea recorded in 2012 (Duck and Morris, 2013) and 2017/18 (Morris and Duck, 2019)

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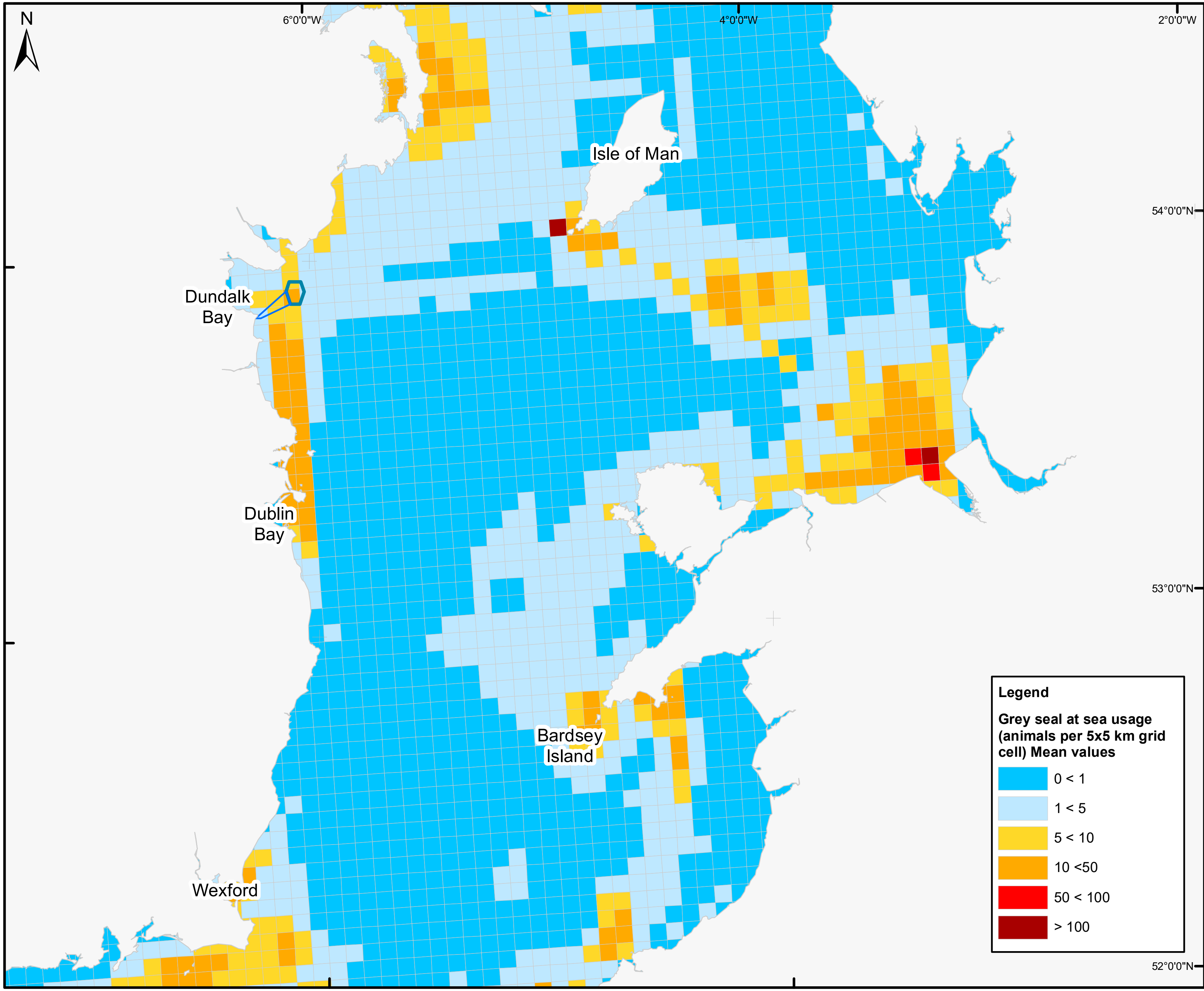

Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources:

Client

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Title

Figure 1-36
Grey seal at-sea usage (animals per 5x5 km grid cell) Mean values

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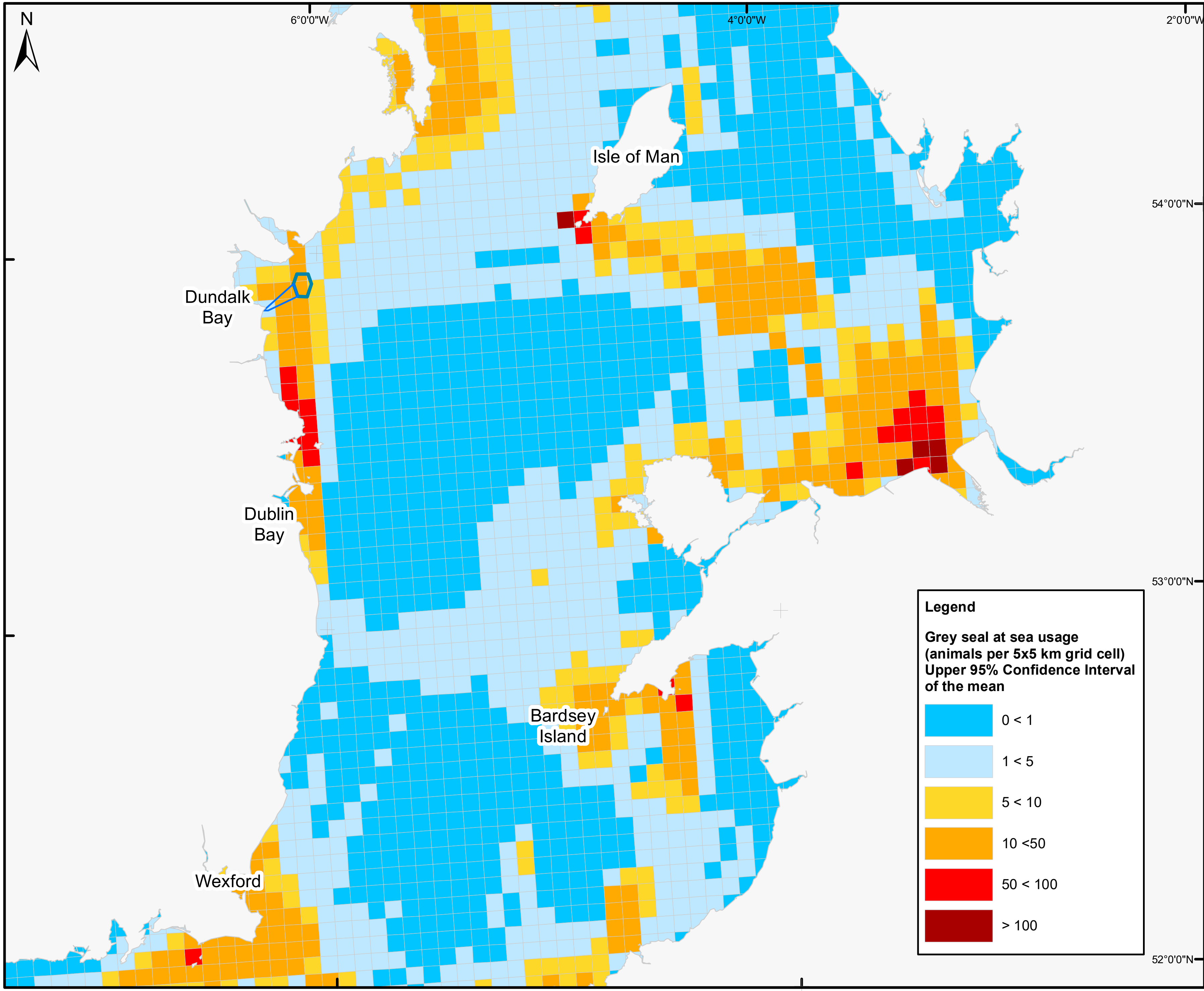

Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources:

Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title **Figure 1-37**
Grey seal at-sea usage (animals per 5x5 km grid cell) Upper 95% Confidence Interval (CI) of the mean

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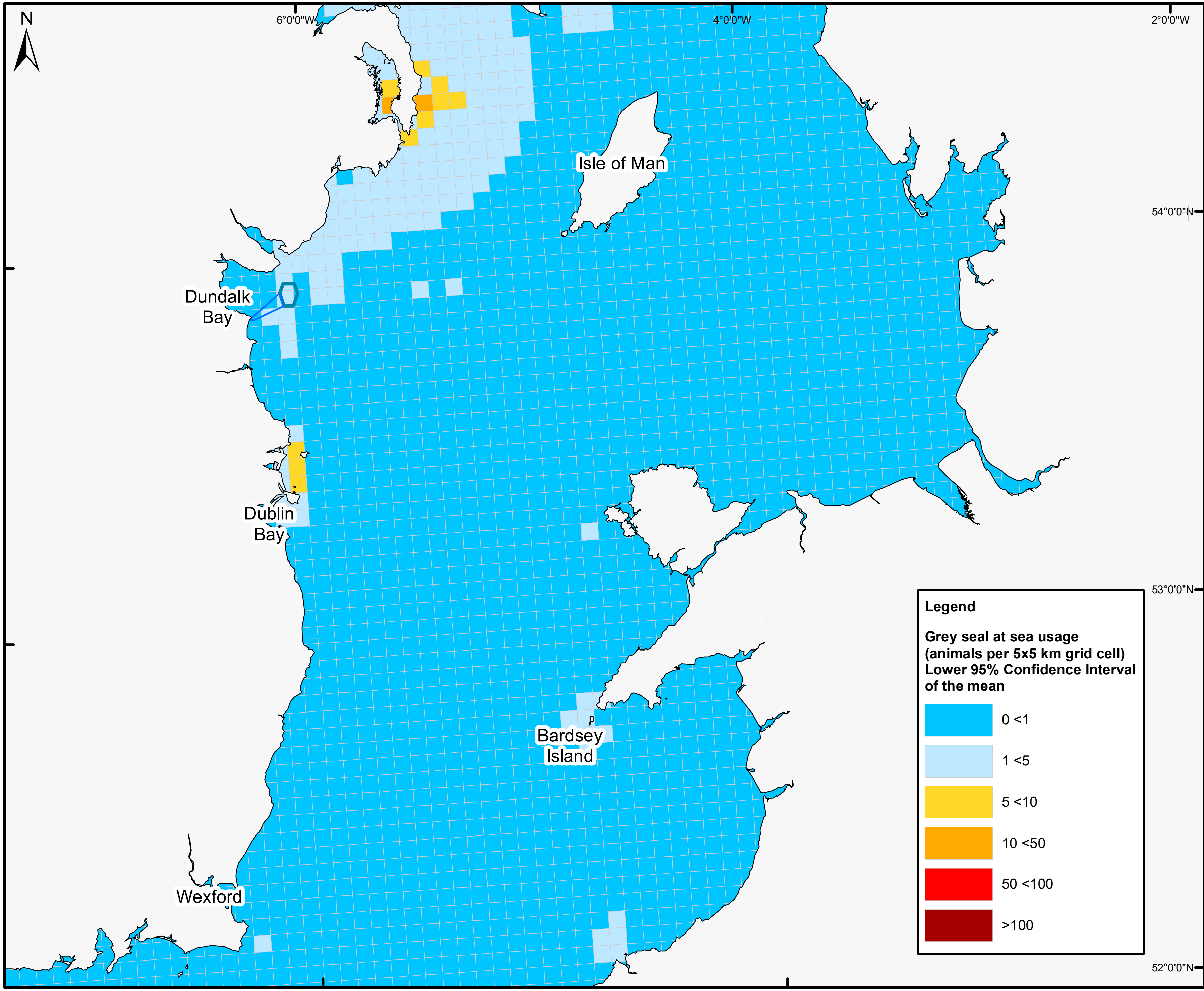

Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources:

Client

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OFFSHORE RENEWABLE ENERGY

Project

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Title

Figure 1-38
SMRU Grey seal at-sea usage (animals per 5x5 km grid cell) Lower 95%Confidence Interval (CI) of the mean

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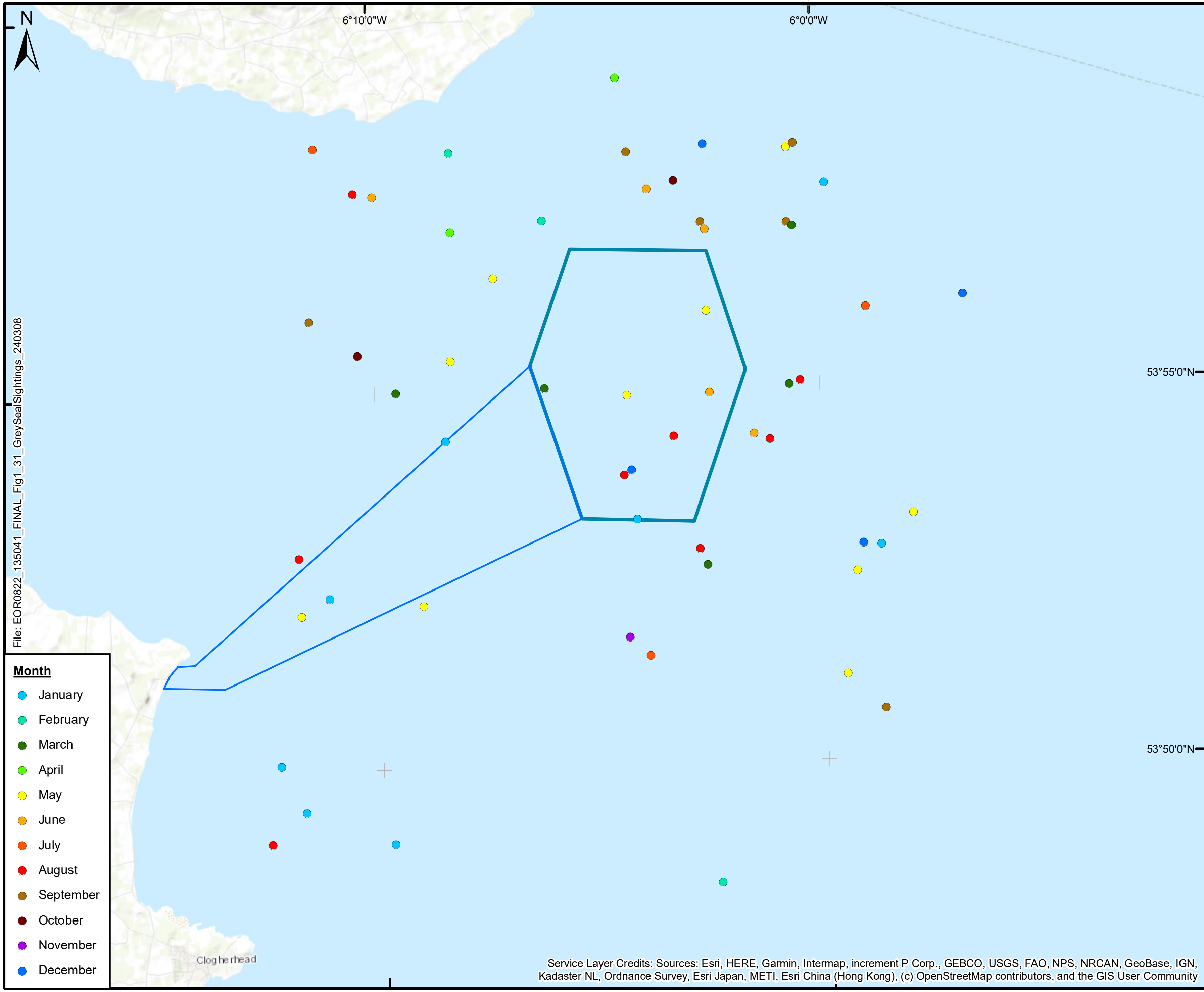

Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources: Client, RPS.

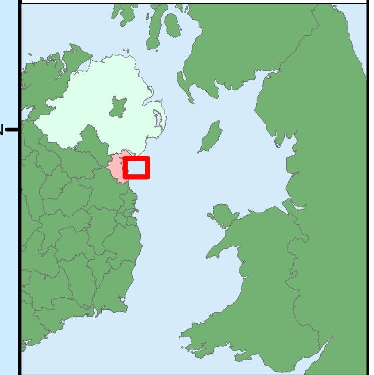

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Figure 1-39
Grey seal sightings from site-specific surveys (2018 - 2020)

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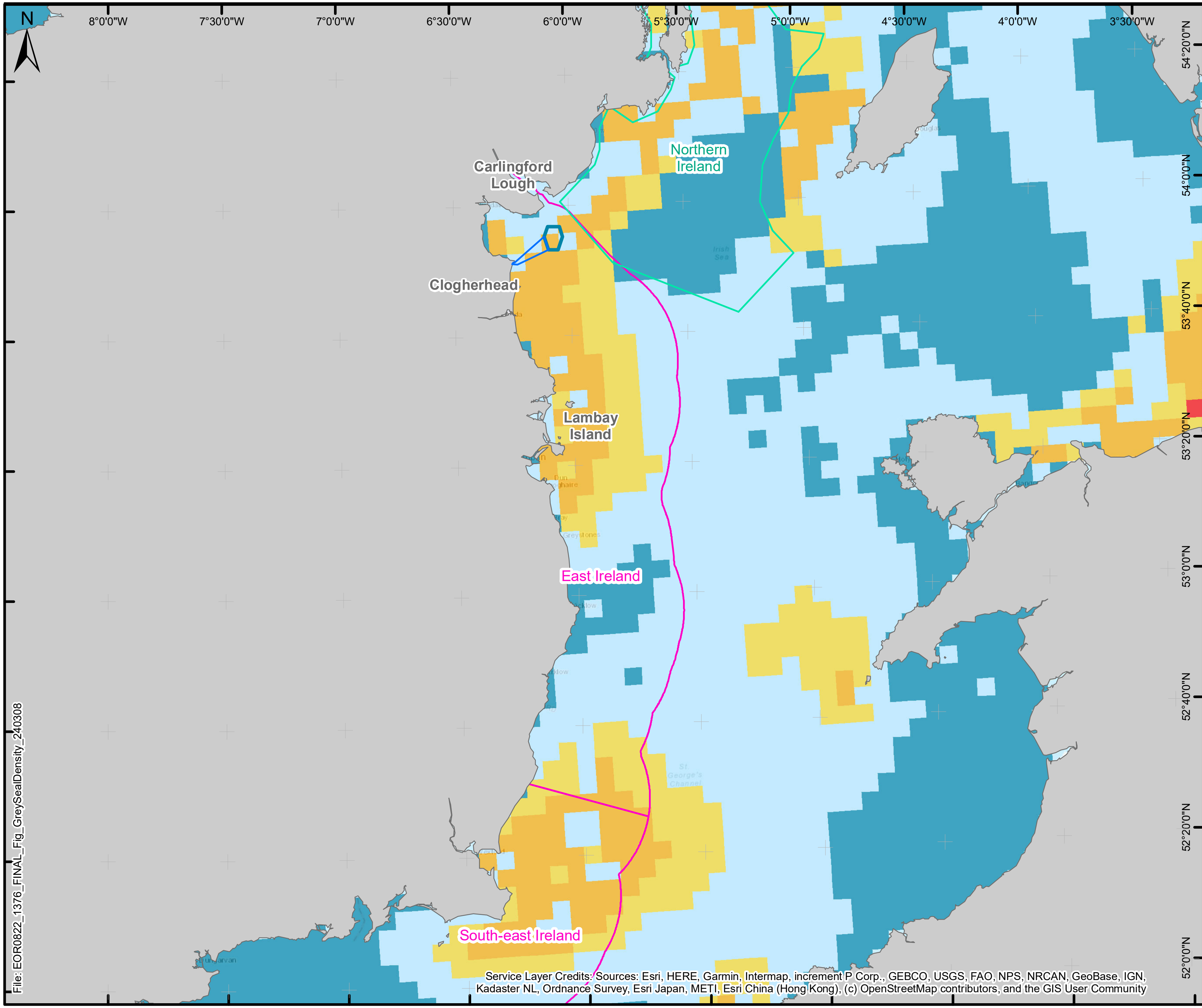

Client

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Title **Figure 1-40**

Distribution and predicted number of grey seal in 5km x 5km grid cells (mean) in the vicinity of the Oriel Wind Farm Project (Carter *et al.*, 2022)

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Density/abundance

The SMRU grey seal at-sea density map predicted that densities of animals will be relatively high along the coast from Carlingford Lough south to Dublin Bay, in comparison to the rest of the coast of eastern Ireland (Figure 1-36 to Figure 1-38). Mean abundance values in the Marine Megafauna Study Area were estimated at between 5 to < 50 animals per 5 x 5 km grid cell, equating to a density of 0.2 to < 2.0 animals per km^2. The highest mean abundance values within specific grid cells overlapping the Marine Megafauna Study Area was 10.09 animals per 5 x 5 km grid cell equating to a density of 0.40 animals per km^2 (upper confidence limit 1.26 animals per km^2). Slightly higher densities (0.59 animals per km^2) were mapped to the south of the Marine Megafauna Study Area and may overlap the maximum zone of influence during piling.

Within the Marine Megafauna Study Area, the average value (of the mean at sea usage) from Carter *et al*., 2022 was estimated at 9.29 animals per 5 x 5 km grid cell, equating to a density of 0.372 animals per km^2.

A total of 1,574 grey seal pups were estimated from around the coast of the Republic of Ireland during the 2005 breeding season (O'Cadhla *et al.*, 2007). This equated to a total population estimate of grey seals in Irish Waters of 5,509 to 7,083 animals (O'Cadhla *et al.,* 2007). Using additional moult haul-out data collected in 2007, O'Cadhla and Strong (2007) estimated a total of 5,343 grey seals across all Irish haul-out sites and therefore suggested that this figure should represent a minimum population estimate.

Aerial survey counts of the west, southwest, south and east of Ireland by SMRU in 2012 counted 48 grey seals in County Louth (Carlingford Lough to Dublin Bay) and 172 grey seals in County Dublin (Dublin Bay to Lambay Island) of a total of 2,964 grey seals counted across all Irish survey blocks (Duck and Morris, 2013). In 2018 the numbers increased with counts of 83 in County Louth, 335 in County Dublin and 3,698 across all Irish survey blocks (Morris and Duck, 2019). The 2017/18 aerial thermal-imaging August surveys in Ireland estimated a total of 418 grey seals across Irish haul-outs in the East Ireland survey region, and 556 grey seals across Irish haul-outs in the South East Ireland survey region (Morris and Duck, 2019). SCOS (2020) counts estimated a total of 505 grey seals across Northern Ireland haul-outs. Correcting these for the proportion of the population that are estimated to be hauled-out during the survey period (25.15% based on SCOS, 2021) gave corrected population estimates of 1,662 (East Ireland), 2,211 (South East Ireland) and 2,008 (Northern Ireland) animals, totalling 5,882 animals (termed the Grey Seal Reference Population (GSRP) from this point onwards).

During the recent site-specific boat-based surveys (May 2018 to May 2020) a total of 59 grey seal were recorded (Figure 1-39). Encounter rates were estimated across the Survey Area using the site-specific boat-based data and the highest encounter rate occurred in May 2020 (0.042 animals per km). In three of the seventeen survey months, the encounter rate was 0 animals per km. Modelled density estimates from these surveys estimated a mean of 0.09 animals per km^2 and a monthly peak of 0.21 animals per km^2. Density calculated from the aerial surveys showed a grey seal density of 0.0067 and a phocid density of 0.022 across the Survey Area (Table 1-17). For the purposes of the assessment the site-specific boat-based density estimates were considered to be robust and, taking a precautionary approach, a range of 0.09 to 0.21 animals per km^2 was carried forward.

1.6.6 Harbour seal

Ecology

Harbour (common) seal is the smaller of the two species of pinniped that breed in the UK and Ireland, typically weighing between 80 to 100 kg (SCOS, 2018). Female harbour seal become sexually mature at three to five years of age and gestation lasts between 10.5 to 11 months (Thompson and Härkönen, 2008). Harbour seal are long-lived animals with individuals estimated to live to between 20 and 30 years (SCOS, 2018).

Harbour seal breed in small groups scattered along the coastline. Pups are born in June and July having moulted their white coats prior to birth. This allows harbour seal pups to swim within a few hours of birth (SCOS, 2018). During lactation females spend much of their time in the water with their pups, and although they will forage during this period, distances travelled at this time are more restricted than during other periods (Thompson and Härkönen, 2008). Following the spring/summer breeding and nursing season, the annual moult of harbour seals in Ireland occurs from late July through August.

Harbour seal are generalist feeders and their diet varies both seasonally, and from region to region (Hammond and Wilson, 2016). Analyses of seal scat in Ireland has demonstrated that a wide variety of prey items are exploited by harbour seal (Hammond and Wilson, 2016). These includes species from the surface, mid-water and benthic habitats including sandeels, whitefish, herring, sprat, common octopus, and squid *Loligo* spp. (SCOS, 2010). Gadoid fish (whiting, pollack and haddock) are key prey species of harbour seal with pouting *Trisopterus luscus* contributing to the largest proportion of diet by weight (Kavanagh *et al.,* 2010). As stated in section 1.6.5, the muddy sediments in the vicinity of the Project support a large *Nephrops* fishery, and associated predators and fish assemblages, such as gadoids, flatfish and elasmobranchs. It is therefore likely that species such as cod, haddock and pollack,, would be key prey items in this area.

Tagging studies of harbour seal in the UK have revealed differing maximum foraging ranges. SCOS (2018) reports that harbour seal persist in discrete metapopulations and tend to forage within 40 to 50 km around their haul-out sites, but most foraging trips tend to be within shorter ranges. Harbour seal have a smaller maximum foraging range of 273 km, than grey seal (448 km) (Carter *et al.,* 2022). Harbour seal, an income breeder, undertakes foraging trips during lactation, in contrast to grey seal which are capital breeders and tend to stay with the pups until they are weaned (Bonner, 1972). Since harbour seal females need to regularly return to their pups at the haul-out site they may be more limited in foraging distance. Carter *et al.* (2022) found during their study, that distance to haul-out site was the primary driver of distribution for harbour seal in all regions. Because of the constraint on their foraging range, particularly during the breeding season, harbour seal may be particularly vulnerable to changes in prey abundance or disturbance events from human activities (Bailey *et al*., 2014).

Distribution, occurrence and seasonality

Harbour seals inhabit the Northern Hemisphere from warm temperate and subtropical waters to northern polar regions. Data collated by NPWS (NPWS, 2019) show a widespread occurrence around much of the Irish coastline, including many enclosed bays and several island and skerries.

Areas of particular importance for harbour seal in Irish waters are the west of Ireland (particularly Galway Bay) and the northwest coast of Ireland (Cronin *et al.,* 2004). Data from the 2012 and 2018 aerial surveys of seal showed that there are a number of haul-out sites within close proximity to the Project area (Figure 1-41). The most recent data recorded the closest haul-out sites offshore wind farm area near the mouth of Carlingford Lough (7.9 km to the north of the offshore wind farm area; 10.6 km from the offshore cable corridor), Clogherhead (13.3 km to the south of the offshore wind farm area; 4.1 km from the offshore cable corridor) and Dundalk Bay (15.5 km to the west of the offshore wind farm area; 14.8 km from the offshore cable corridor) (Morris and Duck, 2019; Figure 1-41). Lambay Island, 43.1 km to the south of the offshore wind farm area, is also an important site for harbour seal (section 1.5.2).

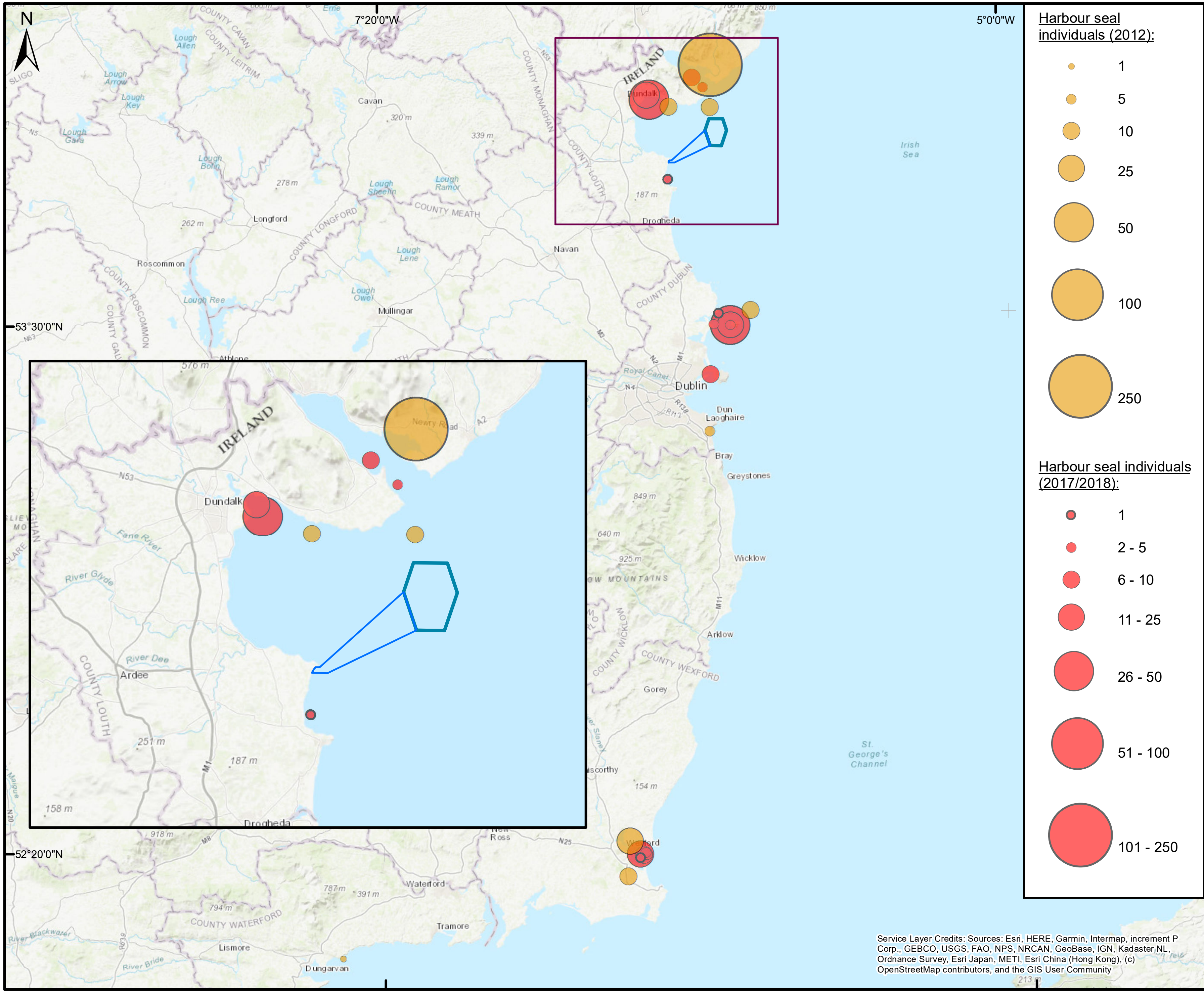
Information on harbour seal distribution is provided in the SMRU harbour seal at-sea usage maps published by Marine Scotland[3] (Figure 1-42- to Figure 1-44). As stated previously, these maps are based on seals tagged in UK waters and therefore may under-represent the seals in Ireland, however, they indicate that harbour seal is most likely to occur in the northwest Irish Sea, with smaller colonies in north County Dublin and off the southwest coast (County Wexford). The distribution and density are corroborated by data presented in Jones *et al.* (2015), suggesting that the SMRU seal at-sea usage maps provide a good representation of seal distribution and occurrence in the western Irish Sea.

The most recent UK-wide study of at-sea distribution for harbour seal by Carter *et al.* (2022) demonstrated areas of relatively high use north of the Project from Carlingford Lough to Strangford Lough compared to the rest of the western Irish Sea (see Figure 1-46).

During the recent site-specific surveys (May 2018 to May 2020), harbour seal was recorded in six out of nineteen months of surveys, in August, September and October 2018, July and December 2019, and January 2020, and eight animals were recorded in total. Four sightings were located outside the offshore wind farm area, three within the offshore wind farm area, and one sighting in the offshore cable corridor (Figure 1-45). Aerial surveys did not record any harbour seal specifically, however, there were 18 unidentified phocids recorded (Table 1-16). It is likely that any harbour seal recorded during site-specific

[3] http://marine.gov.scot/information/seal-usage-maps

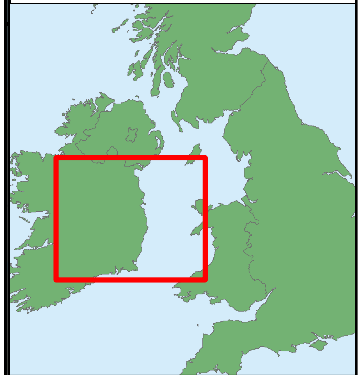
surveys originate from colonies either to the north of the offshore wind farm area at Carlingford Lough, or from the south around Dublin Bay or Lambay Island SAC.



Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Data Sources: Client, Marine Scotland.



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Title

Figure 1-41

Distribution of harbour seal haul outs in the western Irish Sea recorded in 2012 (Duck and Morris, 2013) and 2017/18 (Morris and Duck, 2019)

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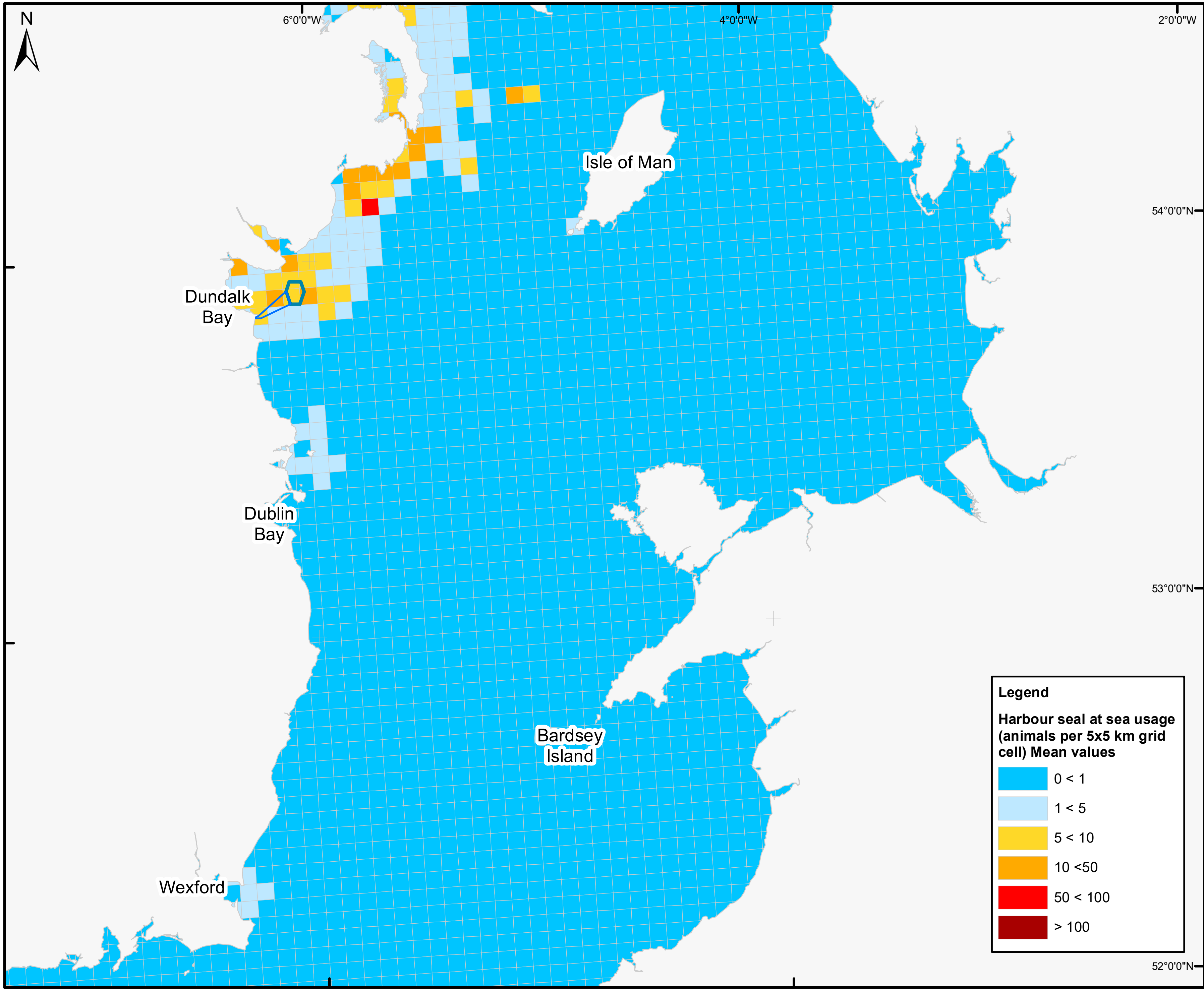

Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources:

Client

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Title

Figure 1-42
SMRU Harbour seal at-sea usage (animals per 5x5 km grid cell) mean values

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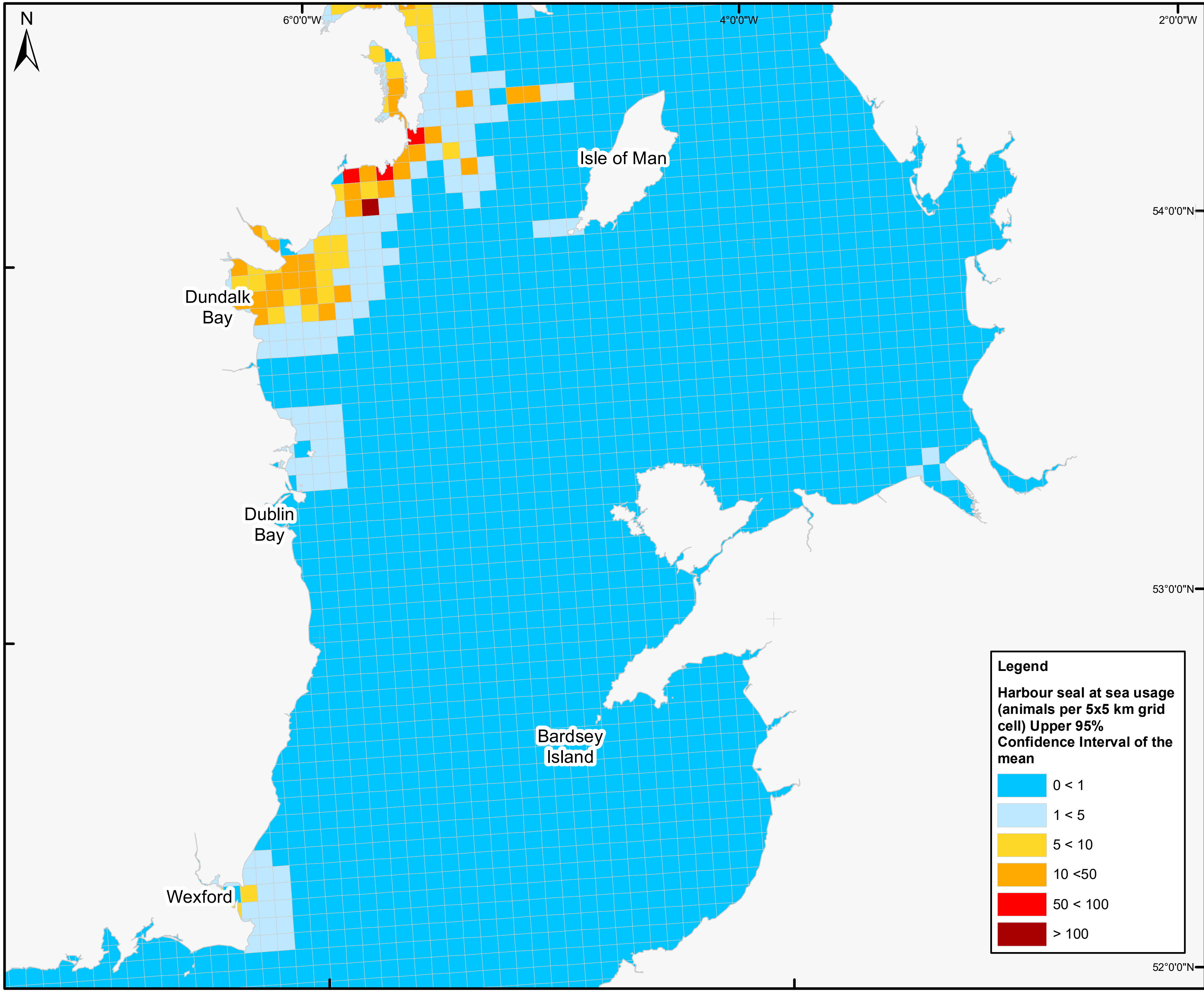

Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources:

Client

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Title **Figure 1-43**
Harbour seal at-sea usage (animals per 5x5 km grid cell) Upper 95% Confidence Interval (CI) of the mean

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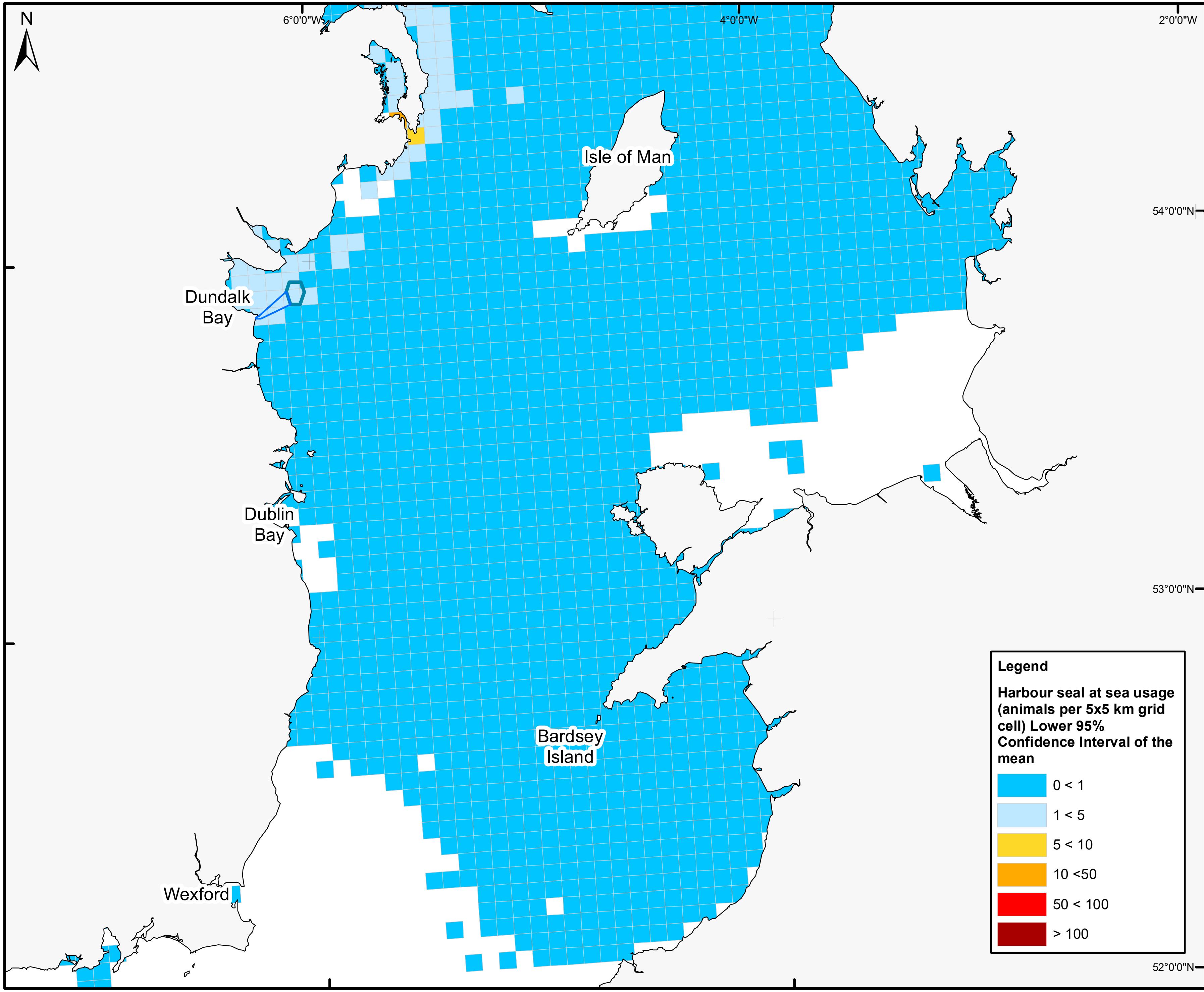

Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources:

Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title **Figure 1-44**

SMRU Harbour seal at-sea usage (animals per 5x5 km grid cell) Lower 95% Confidence Interval (CI) of the mean

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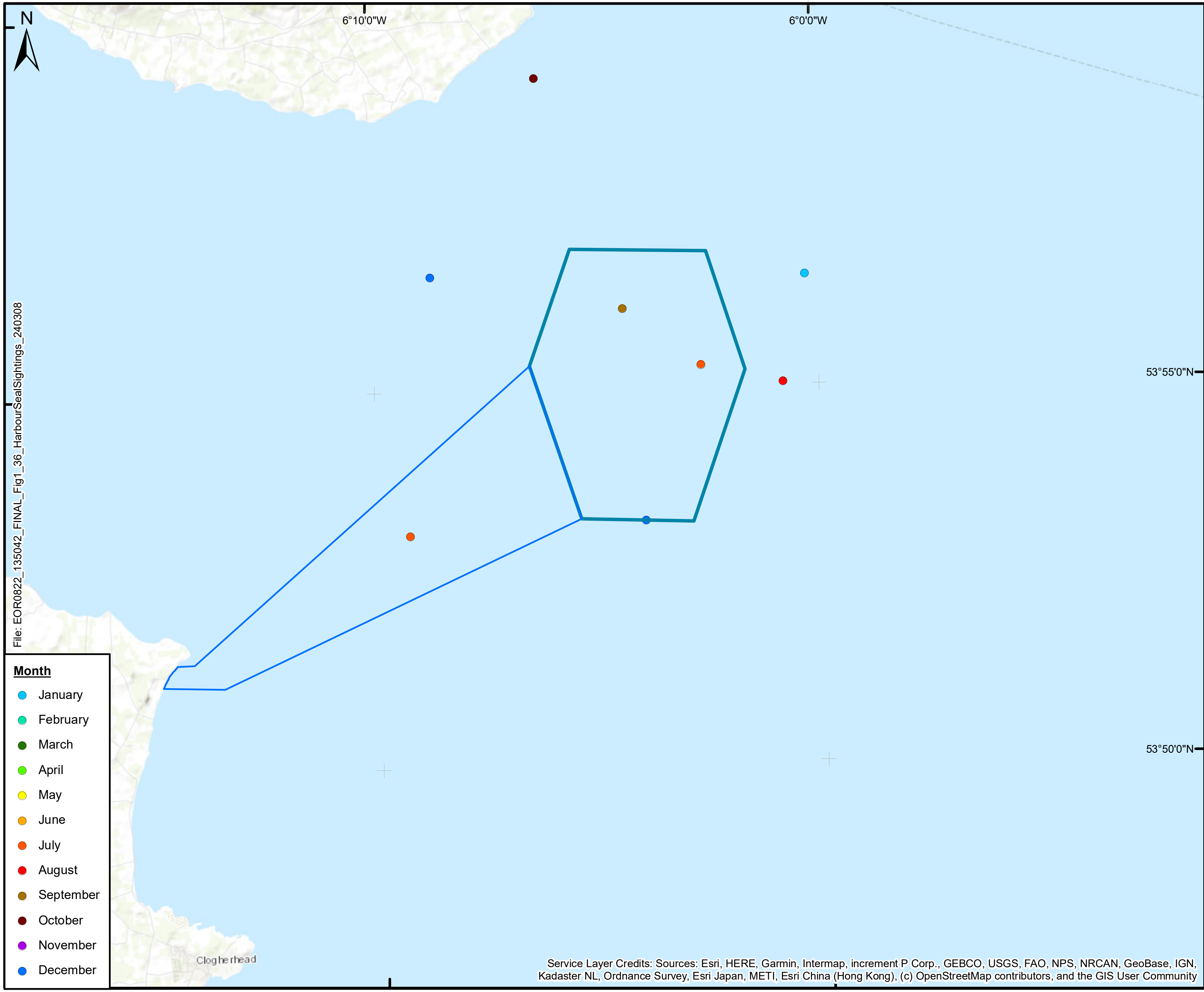
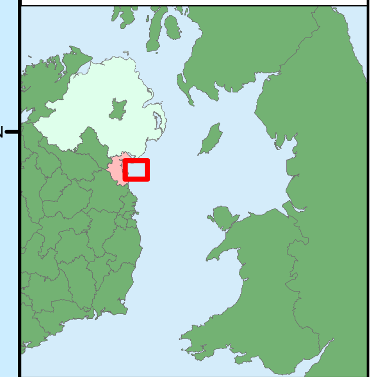


Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Data Sources: Client, RPS.



Client

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Figure 1-45 Harbour seal sightings from site-specific surveys (2018 - 2020)

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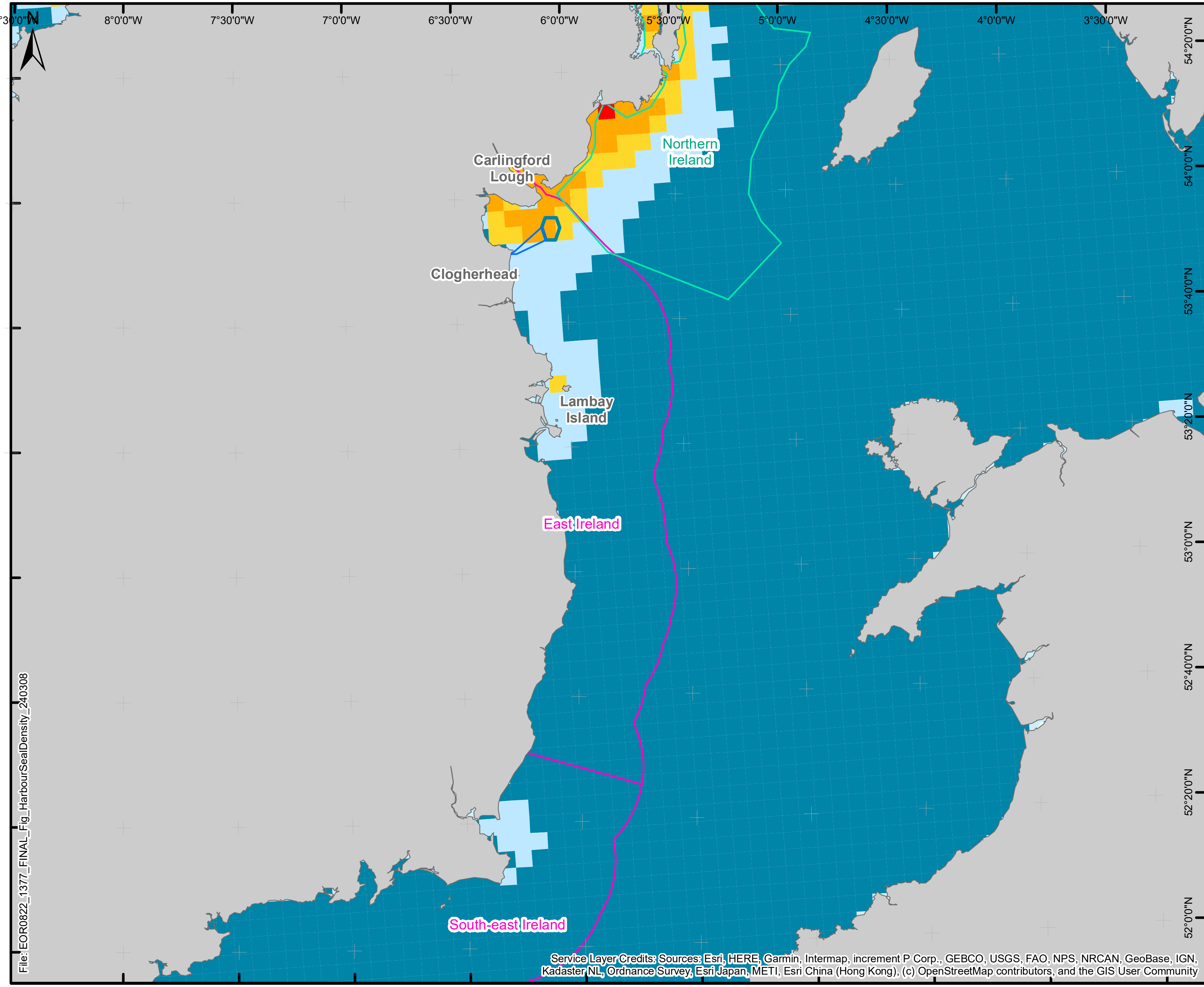


Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

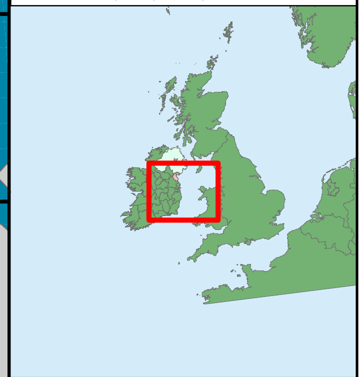
Harbour seal at sea usage (animals per 5x5 km grid cell) Mean values (Based on Carter *et. al.* 2022)

- >0 to 1
- >1 to 5
- >5 to 10
- >10 to 50
- >50 to 100

Seal Management Unit

- From SCOS, 2020: Northern Ireland
- From Morris and Duck, 2019: East Ireland, South East Ireland

Data Sources: Client, Cater *et al.*, 2022, Morris and Duck., 2019, SCOS., 2020



Client

ORIEL WINDFARM
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Project

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Title

Figure 1-46

Distribution and predicted number of harbour seal in 5km x 5km grid cells (mean) in the vicinity of the Oriel Wind Farm Project (Carter *at al.*, 2022)

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Density/abundance

The SMRU harbour seal at-sea density map predicted that densities of animals will be relatively high around the offshore wind farm area, in comparison to the rest of the east coast of Ireland (Figure 1-42 to Figure 1-44). Mean abundance values in the Marine Megafauna Study Area are estimated at between 1 to <50 animals per 5 x 5 km grid cell, equating to a density of 0.04 to <2.0 animals per km^2. The highest mean abundance values within specific grid cells overlapping the Marine Megafauna Study Area was 12.09 animals per 5 x 5 km grid cell equating to a density of 0.48 animals per km^2 (upper confidence limit 1.14 animals per km^2). Slightly higher densities (0.61 animals per km^2) were mapped to the north of the Marine Megafauna Study Area near the coast (most likely reflecting at-sea movements of animals near to main haul-outs) and may overlap the maximum zone of influence during piling. The range of density values within the zone of influence was mapped as 0.01 to 0.061 animals per km^2.

Within the Marine Megafauna Study Area, the average value (of the mean at sea usage) from Carter *et al*., 2022 was estimated at 6.98 animals per 5 x 5 km grid cell, equating to a density of 0.280 animals per km^2.

Aerial survey counts of west, southwest, south and east of Ireland by SMRU in 2017/8 counted 61 harbour seals in County Louth (Carlingford Lough to Dundalk Bay) representing 4.2% of the total number of harbour seals (4,007) counted across all survey areas (Morris and Duck, 2018). For the Louth region of Ireland, the counts of 61 animals in 2018 were the same as those counted in 2012 but represented an overall decrease of 31.5% from the counts undertaken in 2003, when 89 harbour seals were recorded (Duck and Morris, 2013; Morris and Duck, 2019). However, overall, the population around Ireland has remained fairly stable over this whole period. At Lambay Island SAC, which lies 43.1 km to the south of the offshore wind farm area a count of 60 individuals was made in 2017/18 (Morris and Duck, 2018) which is an increase from the count of 47 from the 2014 SAC site synopsis (NPWS, 2024). Harbour seal haul-out counts during the 2017/18 aerial thermal-imaging surveys in Ireland estimated a total of 131 animals across haul-outs in the East Ireland survey region and 34 animals across haul-outs in the South East Ireland survey region (Morris and Duck, 2019). Correcting this for the proportion of the population that are estimated to be hauled-out during the survey period (72% based on Lonergan *et al*., 2013) gave minimum harbour seal population estimates of 182 (East Ireland) and 48 (South East Ireland) animals. SCOS (2021) gave a minimum population estimate of 1,405 animals across haul-outs in Northern Ireland (derived from a count of 1,012 harbour seals across haul-out sites and corrected as above (Lonergan *et al*., 2013). The minimum population estimate for all three regions is therefore given as 1,635 harbour seal (termed the Harbour Seal Reference Population (HSRP) from this point onwards).

During the recent site-specific surveys (May 2018 to May 2020) a total of eight harbour seal was recorded (Figure 1-45). There were insufficient data to estimate densities from these surveys. Density of unidentified phocids from the aerial surveys was 0.022 across the Survey Area. Due to the absence of robust site-specific density estimates the densities carried forward for assessment were 0.01 to 0.61 animals per km^2 based on the SMRU at-sea densities described above.

1.6.7 Basking shark

Ecology

The basking shark is a large, filter-feeding species that is predominately solitary but may also occur in aggregations where there is dense zooplankton abundance (Speedie, 1999). The basking shark's unique feeding strategy dominates all aspects of its ecology and life history; the basking shark is an obligate ram filter feeder whereby the flow of water across gill rakers within the mouth is controlled by swimming speed (Sims, 2000; Sims, 2008). There is evidence that basking sharks exhibit fine scale surface foraging, responding to gradients in zooplankton density (Sims and Quayle, 1998). Basking sharks feed on a number of zooplankton species, however the dominant zooplankton species found in areas of surface-feeding basking sharks is the copepod *Clanus helgolandicus* (Sims, 2008). Mating has not been observed in basking sharks and most likely occurs in deep water with courtship-like behaviour as the precursor, particularly where individuals aggregate in food-rich waters (Sims, 2008). Individuals are thought to pair and mate in early summer (Sims, 2008) and gestation has been estimated over a range of 12 to 36 months (Parker and Stott, 1965; Compagno, 1984; Sims, 2008; 2015). As an ovoviviparous species, basking sharks bear live young, hatched from eggs within the uterus of the female. Basking sharks are a slow-growing species with late maturation at 12 to 20 years of age (or over 6 m in length; Bloomfield and Solandt, 2008) and a relatively low fecundity (producing litters of around six pups; Sund, 1943). These characteristics suggest that basking shark would be vulnerable to environmental changes and the population would be slow to recover from any major losses. With a long history of exploitation, this species is listed on the IUCN Red List globally as vulnerable (Fowler, 2009) and on the Ireland Red List for cartilaginous fish as Endangered (Clarke *et al*., 2016).

Distribution, occurrence and seasonality

Basking sharks are the largest fish in European waters and migrate through Celtic and Irish Seas during spring and summer. Migration routes cover large distances from North Africa up to Scotland, using both the continental shelf and oceanic habitats in the upper 50-200 m of the water column (Doherty *et al.,* 2017). Distribution has been shown to be influenced by a range of environmental conditions (Austin *et al*., 2019); surface sightings of basking sharks are typically reported where sea surface temperatures range between 15 and 17.5°C (Cotton *et al.,* 2005; Skomal *et al*., 2004) where thermal fronts are present (Sims and Quayle, 1998; Jeewoonarain *et al*., 2000) and where zooplankton is in its greatest abundance (Sims and Quayle, 1998; Sims, 1999). Twenty-eight basking sharks tagged off Scotland and the Isle of Man in the summer showed an average migration distance of 1,057 km with movements starting in October (Doherty *et al.*, 2017). Some remained in Irish and UK waters, including the Irish Sea but moved further offshore, whilst others migrated as far as the Bay of Biscay and as far south as North Africa. The tagging data also demonstrated that several sharks in this study migrated through the Irish Sea. In addition, 17 basking sharks that migrated outside UK waters returned to the Celtic and Irish Seas in March-June (Doherty *et al.*, 2017). In summary, 51% of basking sharks tracked in this study entered the EEZ of Ireland, including the Irish Sea indicating that this is an important area for overwintering that links foraging grounds in the waters off the west coast of the UK and Ireland to the southern migration destinations (Doherty *et al.*, 2017).

The Marine Conservation Society (MCS) Basking Shark Watch Project (BSWP) has identified hotspots in southwest England, the Isle of Man (80 km east of the offshore wind farm area), and Scotland (Figure 1-47). Data presented in the 20-year report (Bloomfield and Solandt, 2008) show that the Isle of Man has a clear distinction between areas of low basking shark density in the north, east and west of the island and areas of high basking shark density to the south and southwest coast of the island, where the Dublin front meets the southwest of the island (Figure 1-48). Nirarbyl Bay, to the southwest is an area where frequent reports of courtship have been observed, and high mean size ranges from Manx waters may indicate that it is an area where sharks congregate to feed and breed. Size data suggests that Scotland and the Isle of Man may attract a larger population of breeding adults than southwest England (Bloomfield and Solandt, 2008). In addition, many young basking sharks are seen in Manx waters (Howe, 2018). Based on public sightings data, more small basking sharks of 1.5 m to 2 m are seen in the waters off the Isle of Man than are recorded in the whole of the rest of the British Isles (Hall *et al.,* 2009); sharks of this size are thought to be newly born.

During the recent site-specific surveys (May 2018 to May 2020), basking shark was recorded in two out of nineteen months of surveys, in August 2018 and August 2019, with two animals recorded in total. One sighting was located on the southwest border of the offshore wind farm area and the second sighting was located in the far south of the Survey Area (Figure 1-49). During the aerial survey, one shark was recorded, however, it was unable to be identified down to species level (Table 1-16).

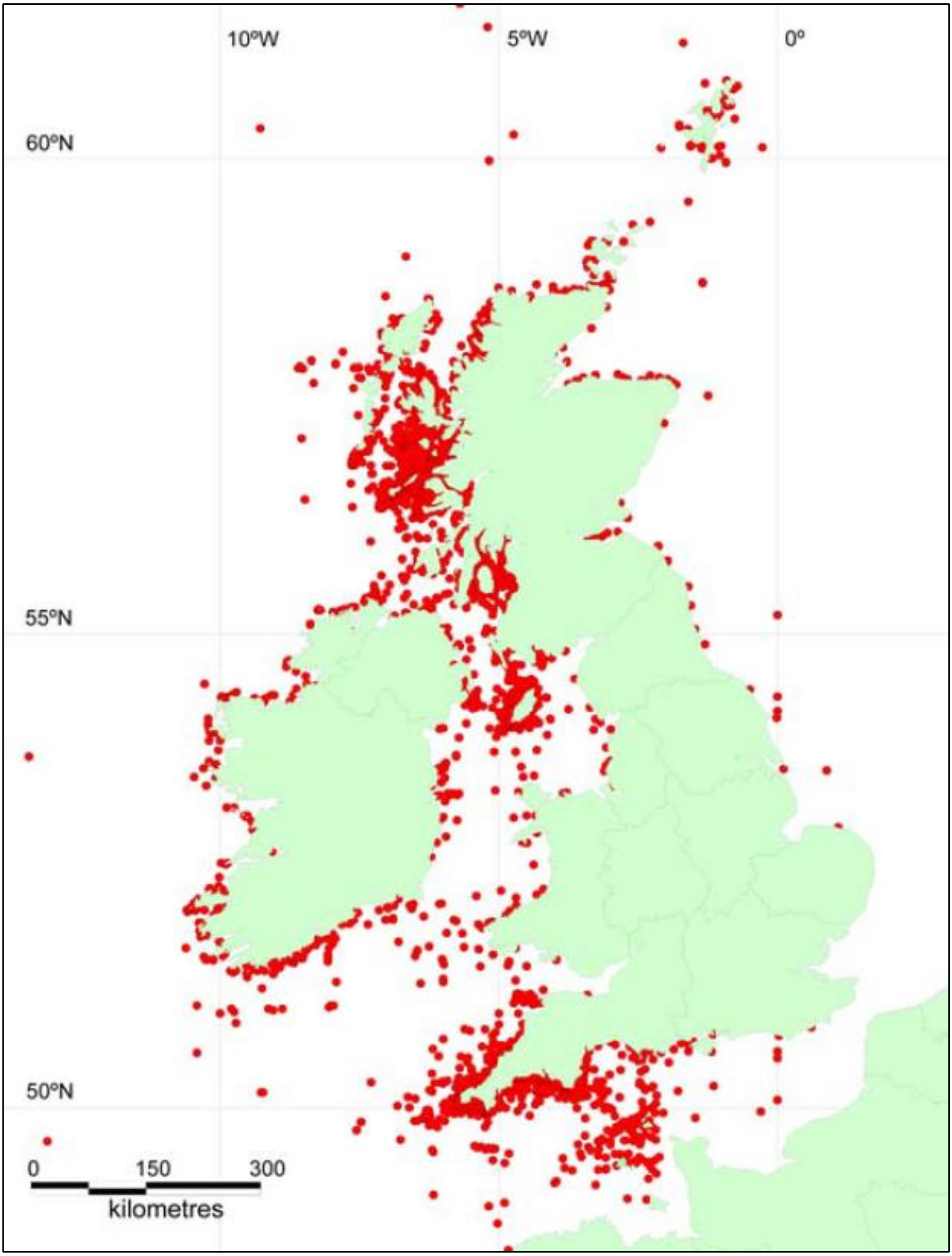


Figure 1-47: Distribution of basking shark sightings around the UK and Ireland, 1987 – 2006 (individual sightings are plotted as single red dots) (from Bloomfield and Solandt, 2008).

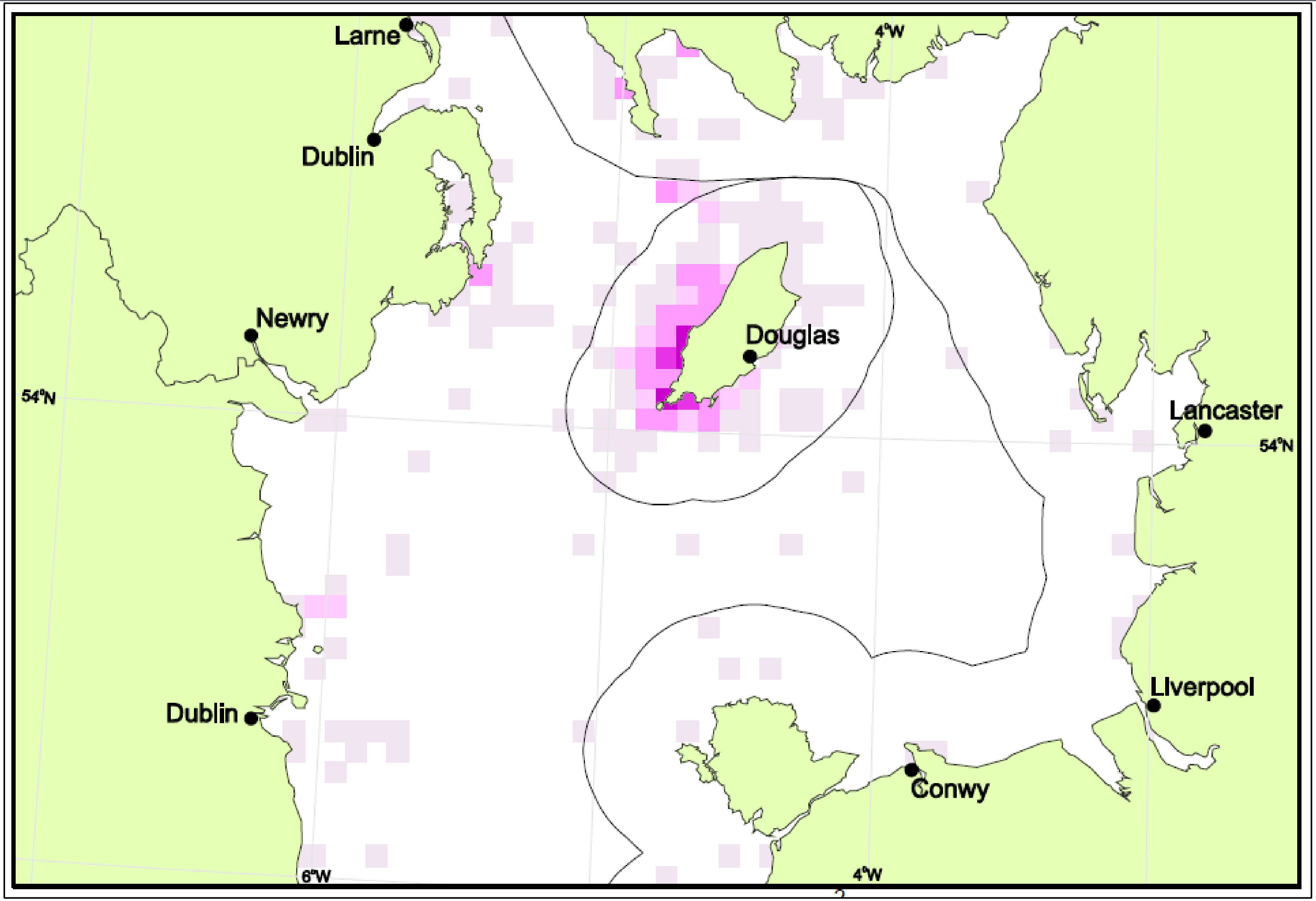
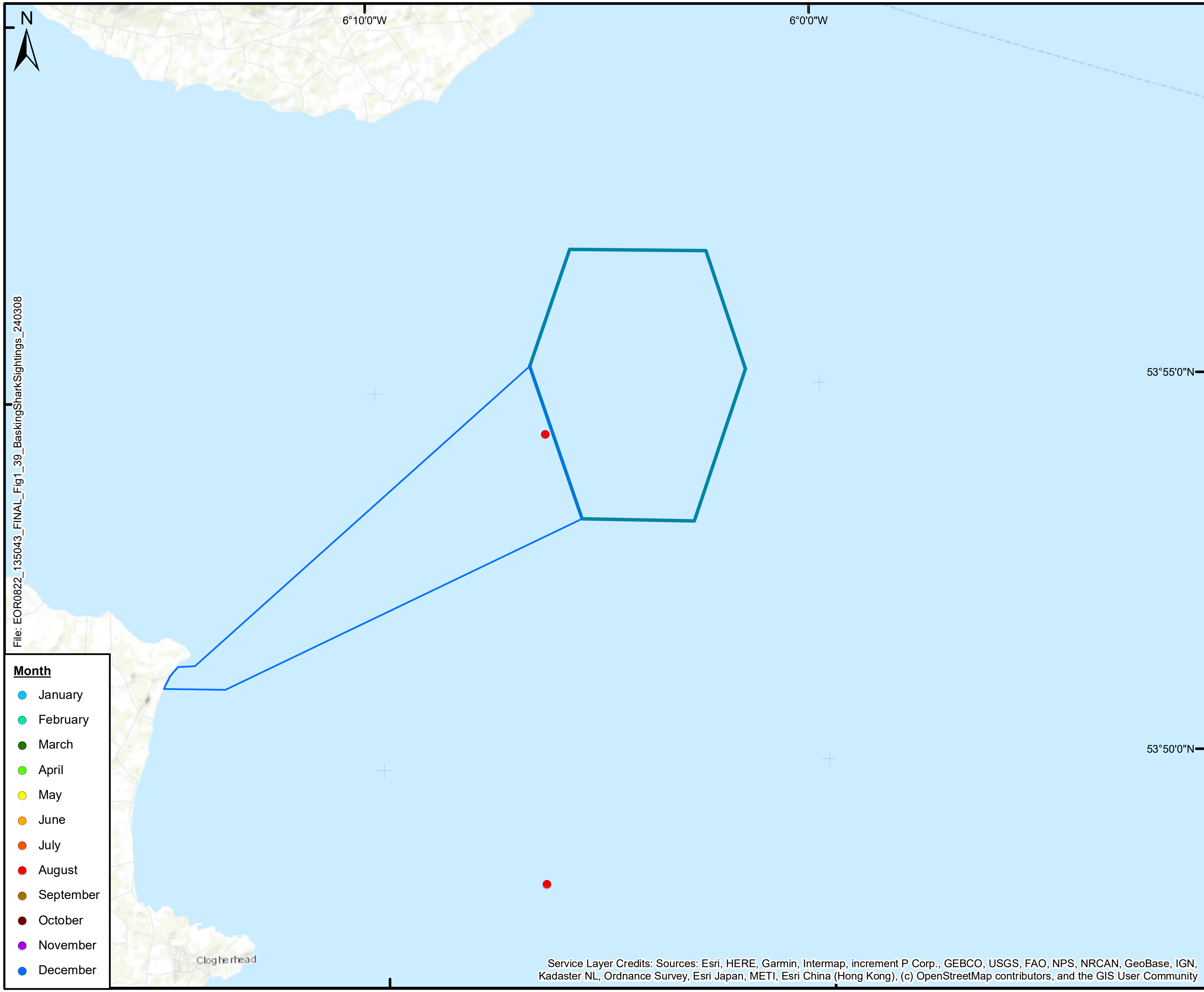


Figure 1-48: Basking shark sightings around the Isle of Man, 1987 – 2006 (lightest shades are 1-10 sightings; then 11-50; 51-100; the darkest squares represent densities of 100+ sightings) (from Bloomfield and Solandt, 2008).

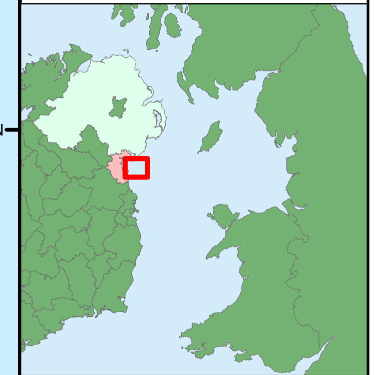


Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Data Sources: Client, RPS.



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title

Figure 1-49
Basking shark sightings from site-specific surveys (2018 - 2020)

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Issue Details

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Density/abundance

A study looking at photo-identification and mark-recapture methodology to assess basking shark populations in the northeast Atlantic identified that the low rate and temporal patterning of re-sightings support the view that local basking shark populations are temporary, dynamic groupings of individuals drawn from a much larger population than was previously supposed. Reliable estimates for the long-term regional population were not possible, due to low re-sighting numbers, however, a closed-population estimate was generated for an area between the islands of Mull, Coll and Tiree (50 km in diameter, ~250 km north of the offshore wind farm area), highlighted as a key area for surface sightings of basking sharks (Speedie *et al.,* 2009; Witt *et al.,* 2012). The estimates presented for a 6-9 day period in 2010 were 985 (95% CI = 494 to 1,683) and in 2011 were 201 (95% CI = 143 to 340) (Gore *et al.,* 2016). Whilst this area is located ~ 250 km from the offshore wind farm area, tagging studies have shown that those basking sharks which migrated past the offshore wind farm area also passed through this site (between the Islands of Mull, Coll and Tiree) (Doherty *et al.,* 2017).

During the recent site-specific surveys (May 2018 to May 2020) two basking sharks were recorded (Figure 1-49). Encounter rates were estimated across the offshore wind farm area using the site-specific boat-based data. In the two months that basking sharks were recorded (August 2018 and August 2019), the encounter rate was 0.006 animals per km. During the site-specific aerial survey, one shark species was identified, giving a density of 0.0017 animals per kilometre across the survey area (Table 1-17). This, however, was not confirmed to be a basking shark.

1.6.8 Leatherback turtle

Ecology

The leatherback is the largest of all turtle species, reaching a length of up to 2.2 m and averaging 360 kg in weight. As an endothermic species, with body temperatures up to 8°C warmer than the sea water temperature, they are adapted to survive in colder temperate waters and therefore commonly occur in the waters around the UK and Ireland (King and Berrow, 2009). Leatherback turtle is a specialist feeder on jellyfish (Cnidaria, particularly *Rhizostoma* in the east Atlantic, including the Irish Sea) (Hays *et al.,* 2006; Houghton *et al.,* 2006). They are able to dive to great depths (>1,000 m) to exploit deep water species and their distribution is likely to be driven by the distribution of jellyfish, salps and other gelatinous organisms on which they feed (Bjorndal, 1997). A survey of jellyfish in the Irish sea between July and October identified hotspots of jellyfish density around Rosslare harbour (southeast coast of Ireland), Carmarthen Bay (southwest coast of Wales) and Tremedoc Bay (west coast of Wales) (Houghton *et al.*, 2006).

Leatherback turtles nest in tropical breeding sites and make large-scale migrations to preferred feeding grounds, including those in temperate waters. The breeding sites of leatherback turtles inhabiting Irish waters is unknown but satellite telemetry data of two adult turtles show movement from southwest Ireland to west Africa and the northwest coast of south America (Doyle *et al.,* 2008).

Distribution, occurrence and seasonality

A highly migratory species, the leatherback turtle has a worldwide distribution and the Atlantic Ocean in particular is considered a stronghold for this species. Leatherback turtle is distributed all around the coast of Ireland and occurs in both the eastern and western Irish Sea. Recent studies have shown that after nesting in the tropics the majority of leatherbacks head north towards cooler temperate waters; some of these head north towards the northeast Atlantic and Irish waters (Doyle *et al.,* 2008).

There are records of leatherback turtle throughout the year around the coast of Ireland, although the majority (~90%) are from the summer months between June and September, peaking in August (Penrose and Gander, 2018) with winter records mainly along the west coast of Ireland (King and Berrow, 2009). The records suggest a strong seasonality for this species with most individuals occurring in inshore Irish waters during the summer months, most likely driven by an increase in the abundance of jellyfish during the summer. Whilst most sightings records are from near the coast, or strandings, they can also be encountered offshore, and it is likely that offshore areas consist of important foraging grounds for this species (NPWS, 2019).

All sightings (N = 3) for leatherback turtle during the ObSERVE surveys occurred during summer months, sighted at the southern tip of the survey effort in stratum 4, southwest of St George's Channel (Figure 1-50). The distribution of leatherback turtle records from 1938 to 2018, as collated by the NBDC, are shown in Figure 1-51.

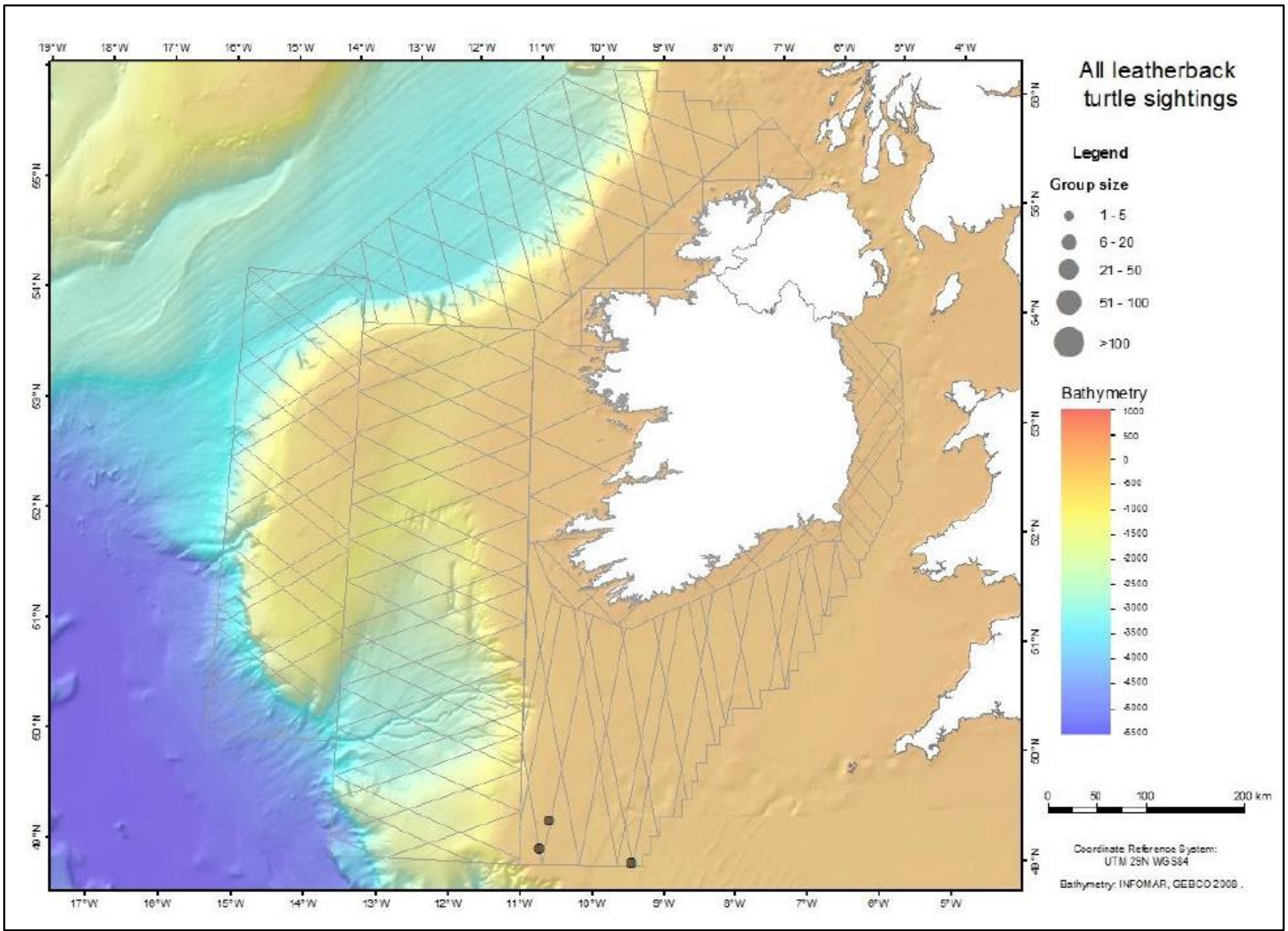

Figure 1-50: Sightings of leatherback turtles during the ObSERVE surveys. Grey lines indicate the survey tracklines along which sightings were made. Circles are proportional to the number of individuals in each sighting (Rogan *et al*., 2018).

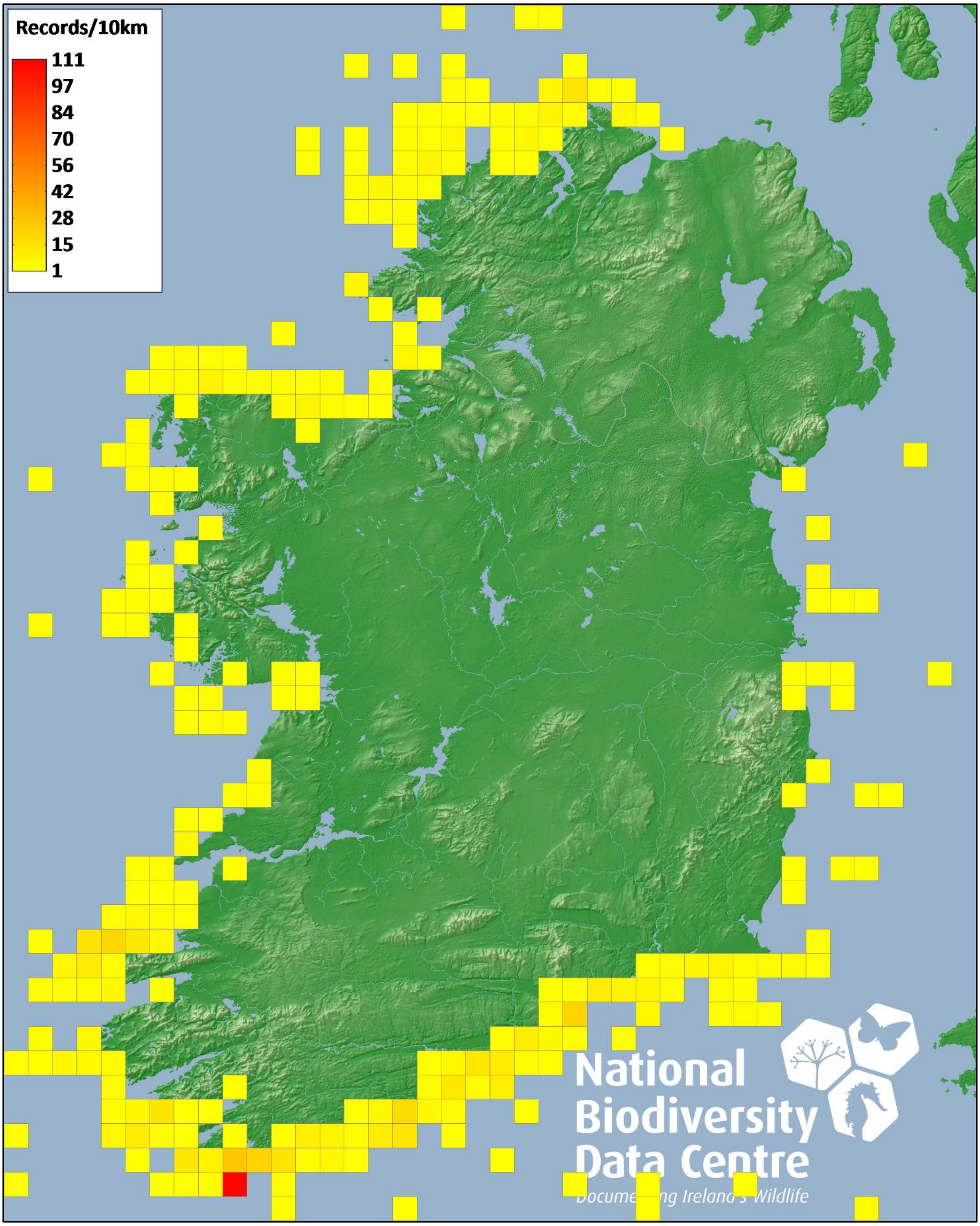

Figure 1-51: Leatherback turtle records – distribution of the number of records (animals per 10x10 km grid cell) (1938 to 2018) (NBDC, 2024g).

Density/abundance

Providing abundance and density estimates for leatherback turtles in Irish waters is difficult for a number of reasons; primarily the area in question is large and the animal's numbers may be extremely low (Houghton *et al.,* 2006). Aerial surveys conducted in 2003 to 2006 estimated a density of 0.06 animals per 100 km^2 (unpublished data; reported in Doyle *et al.,* 2008). However, there is a great deal of uncertainty regarding the actual number of leatherback turtles that pass through or use Irish waters each year. The length of time that individuals remain resident in Irish waters and the amount of time they spend at the surface are key parameters in determining reliable abundance estimates; yet these data are scares (Doyle *et al.*, 2008). Two satellite tagged leatherback turtles found that in total animals spent 54% and 71% of time diving, but that there were spatial difference in diving behaviour related to mesoscale features (e.g. rich feeding site) (Doyle *et al.* 2008). Subject to these uncertainties, an approximation of the abundance of leatherback turtles in Irish waters has been estimated in the low thousands, which may be equivalent to 2 to 5% of the Atlantic population (Doyle, 2007).

The ObSERVE survey only recorded three turtles throughout Irish waters, indicating that numbers may be lower than was previously thought. The ObSERVE surveys, however, were designed for bird and cetacean observations, flying at an altitude of roughly 100 m greater (180 m compared to 80 to 100 m) than has been used for sea turtle-specific aerial surveys (Witt *et al.,* 2009) and therefore may not have been appropriate for accurate identification of sea turtles.

In 2018 a total of 17 leatherback turtles (eight live, nine dead) were reported to the Marine Environmental Monitoring Strandings Group (MEMSG). The closest live report to the offshore wind farm area was on the south coast of Ireland, and the nearest dead report was off the north coast of Cornwall, in the UK (Penrose and Gander, 2018). Between 2010 and 2018 a total of 180 live sightings of leatherback turtles were recorded in Irish waters, a decrease of 33% from the previous 8-year period (2001 to 2009) (Annual Reports 2001 to 2018, summarised in Penrose and Gander, 2018). No leatherback turtles were sighted in the 2006 site-specific surveys or the 2018/19 boat-based surveys and one individual was sighted during the recent aerial site-specific survey (Table 1-16). The lack of sea turtle sightings during these surveys is not unexpected, given that the surveys were designed for marine mammals and birds, which present, relatively, more obvious sightings cues than the surfacing of a turtle.

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ANNEX 1: STATIC ACOUSTIC MONITORING SURVEY

Static Acoustic Monitoring (SAM) at the Proposed Windfarm Site at Oriel

Mooring deployments - Oriel Windfarm © Simon Berrow/IWDG

IWDG Consulting

Final Report to Oriel Windfarm Limited

Static Acoustic Monitoring (SAM) at the Proposed Windfarm Site at Oriel

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Contents

Contents

1 Executive Summary

Static Acoustic Monitoring (SAM) was carried out between 2019 and 2020 to complement boat-based visual surveys and describe the long-term presence of harbour porpoise off Co Louth within the site of a proposed offshore windfarm. Between November 2019 and November 2020 a total of 685 days of SAM data were collected across the site. Large data gaps exist due to the multiple losses of equipment and moorings experienced over the monitoring period.

SAM using self-contained click detectors (C-PODs) was conducted at four sites. SAM datasets were then used to explore the temporal presence of harbour porpoises within their detection range. Generalized linear mixed-effect models were used to associate porpoise presence with factors such as season, diel, tidal cycles and phases. Results showed porpoises to be present on average 99% of days monitored. Harbour porpoises were the most frequently detected species with dolphins rarely detected. Of a total of 592 days of SAM data collected across all sites, most were obtained at SAM 3. At this site harbour porpoises were recorded on 99% of days with a mean of 1.08 detections per hour. This was followed by SAM 4 with 135 days of data during which porpoises were also recorded on 99% of days, with a mean of 4.21 detections per hour and at SAM 2 where porpoises were recorded on 100% of the 103 days monitored and returned the number of detections with a mean of 9.44 detections per hour. At the floating LIDAR site, a total of 179 days were monitored with porpoise detections on 90% of days and a mean of 2.96 detections per hour. Dolphins were recorded on 29% of days at SAM 2 but the overall number of detections were low, with detections on 1% of days at SAM 3 and no dolphins recorded at the other sites. Results across all days monitored show porpoises to be present on average over 99% of days monitored. Season appeared to influence porpoise presence differently across sites, with winter and summer overall important periods for porpoise presence. The effect of diel cycle also varied across location, although night, morning and/or evening phases often yielded more detections than day phases (except at the LIDAR site). Tidal cycle and tidal phase only affected detection rate at some locations, where slack low water coincided with increased detections.

Although the Irish Sea is recognised as an important area for harbour porpoise there was little previous dedicated survey effort for marine mammals at this site. The results presented here, combined with the results from dedicated boat-based visual surveys (Berrow and O’Brien 2020) provide an excellent assessment of the marine mammal community potentially exposed to the windfarm development. These data will help to inform planning and any mitigation required.

2 Introduction

Static Acoustic Monitoring (SAM) involves the detection and recording of cetacean vocalizations or echolocation clicks and is a very valuable tool for the exploration of fine scale habitat use by the various odontocete species. SAM is especially useful for monitoring small vocal cetaceans since it can be carried out without the interference of weather conditions or daylight restrictions and, most importantly, does not negatively impact upon the animals. In order to evaluate the importance of an area, it is fundamental that the presence of small cetaceans at a site is fully understood and this requires monitoring over time scales of at least years. An evaluation of a site must be underpinned through scientific research from dedicated survey effort. Visual monitoring of cetaceans can provide numbers for density and abundance estimation but will be biased due to factors such as observer effect and unfavourable sea conditions. Therefore, a complete dataset cannot be gathered, necessitating the requirement of SAM. Through SAM, informative datasets, robust enough to detect distinctive trends in presence across a range of factors, can be achieved much more rapidly than visual means. Small cetaceans rely on sound production through the use of echolocation signals for foraging, orientation and communication. Dolphins have the ability to echolocate across a wide range of frequencies (200Hz to 150kHz, Evans, 1973). Harbour porpoise signals are characterised as being narrow-band, high frequency clicks peaking between 110 and 150kHz, while the average click has a duration of 2µs with a mean source level of 150dB re 1µPa @ 1m (Møhl and Andersen 1973; Goodson and Sturtivant, 1996; Au *et al.,* 1999; Carlström, 2005; Villadsgaard *et al.,* 2007; Verfuß *et al.,* 2007). The reliance on sound by these animals, coupled with the fact they seem to continuously, or regularly echolocate, makes SAM a very valuable tool for determining the presence of dolphins and porpoise and assessing their fine scale habitat use. The main advantage of SAM is that it can provide information on harbour porpoises that can go undetected visually for up to 95% of the time (Read & Westgate, 1995). Patterns of cetacean presence have been described over seasonal scales (Canning *et al*., 2008, Bolt *et al*., 2009; Simon *et al*., 2010; Gilles *et al*., 2011; O'Brien *et al.,* 2013), diel cycle (Carlström, 2005; Todd *et al*., 2009; O'Brien *et al.,* 2013) and tidal patterns (Marubini *et al*., 2009; O'Brien *et al.,* 2013). In order to evaluate the importance of an area, it is fundamental that the presence of small cetaceans at a site is fully understood and this requires monitoring over varying time scales depending on monitoring methods. The Irish Whale and Dolphin Group (IWDG) were contracted by Aquafact to undertake Static Acoustic Monitoring using C-PODs for 12 months at the proposed windfarm site off Oriel, Co Louth. The site was defined by Parkwind and covered an area east of Dundalk bordered by Clogherhead to the south, Carlingford Lough to the north out east to the 50m contour. SAM was carried out from November 2019 to November 2020. The aims of the SAM were to:

i) Provide data on the seasonal occurrence of porpoises and dolphins within the site,
ii) Provide data on small cetaceans during times when no visual surveys are taking place
iii) Allow for comparisons of this site to other areas when long-term SAM has taken place.

3 Methodology

3.1.1 Study area

The Oriel Windfarm project is located in the Irish Sea off the coast of Co. Louth, East of Dundalk Bay. Following an extensive review of sites in the Irish Sea, the Oriel location was chosen as a suitable site to develop an offshore windfarm (www.orielwindfarm.ie). SAM was initially planned for a total of five sites, including a control, but after the loss of moorings and equipment this had to be revised. The longer-term SAMs were at locations SAM 2, 3 and 4 and the floating LIDAR site (Figure 3.1).

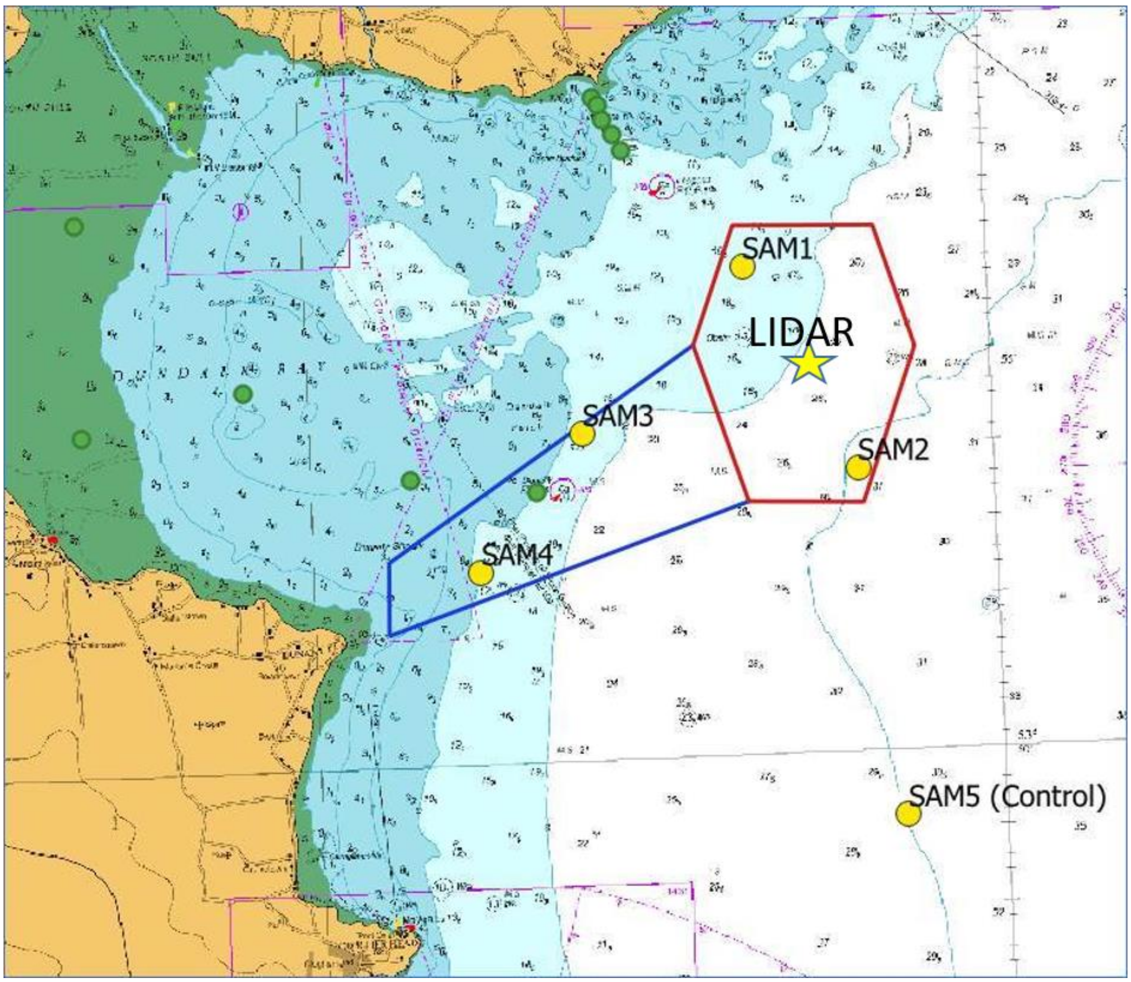

Figure 3.1: Original location of all SAM moorings.

3.1.2 C-PODs

The C-POD is a fully automated, static acoustic monitoring system which can detect porpoises, dolphins and other toothed whales by recognising echolocation click trains these animals make in order to detect their prey, orientate themselves and interact with one another (Figure 3.2). These units are designed and manufactured by Chelonia Ltd and they are the only commercially available instruments with click train recognition software which produces fully automated, accurate data on the behaviour and identification of odontocetes (see www.chelonia.co.uk). A single C-POD can monitor both porpoise and dolphins simultaneously through identifying characteristic click parameters which can be assigned to either harbour porpoise or dolphin species. Once deployed at sea, C-PODs operate in a passive mode and are constantly listening for tonal clicks within a frequency range of 20 to 160 kHz. When a tonal click is detected, the C-POD records the time of occurrence, centre frequency, intensity, duration, bandwidth and frequency of the click. Internally, the C-POD is equipped with a Secure Digital (SD) flash card, and all data are stored on this card. Dedicated software, C-POD.exe, provided by the manufacturer, and is used to process the data from the SD card when connected to a PC via a card-reader. This allows for the extraction of data files under pre-determined parameters as set by the user. Additionally, the C-POD also records temperature over its deployment duration. It must be noted that the C-POD does not record actual sound files, only information about the tonal clicks it detects.

Figure 3.2: C-POD unit by Chelonia Ltd

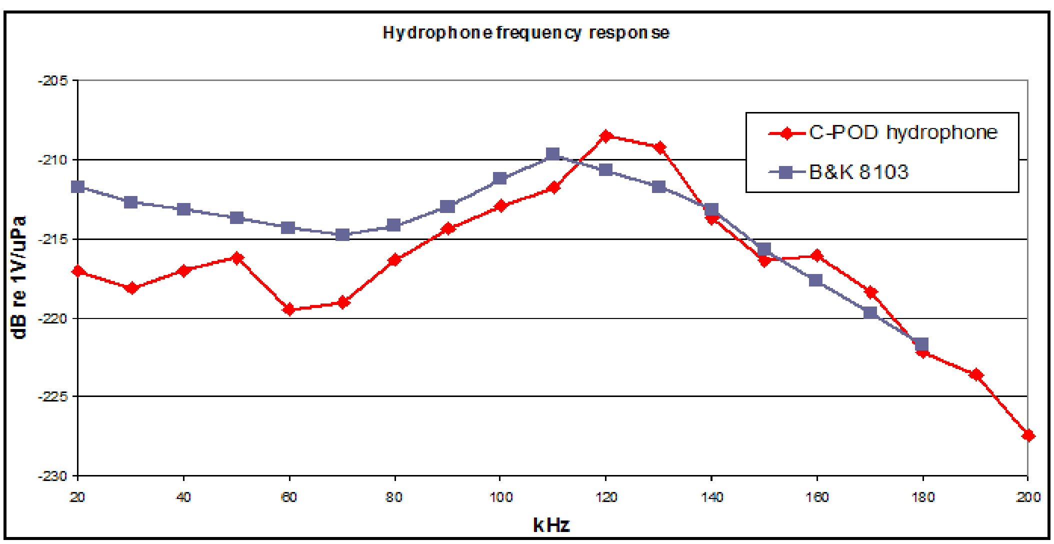

Figure 3.3: Threshold for detection across various frequency bands between 20 and 200 kHz for the C-POD (note 1Pa p-p is the SI unit for pressure and correctly represents the threshold) © Chelonia Ltd.

The C-POD detector is a sound pressure level detector with a threshold of 1Pa peak to peak at 130 kHz, with the frequency response shown below (Figure 3.2, 3.3, www.chelonia.co.uk). An estimated detection distance of 797.6m ±61m (75% of groups recorded<400m) for C-PODs and bottlenose dolphins was generated in the Shannon Estuary, while distances estimates of 441m ±42m (92% <400m) were generated for the harbour porpoise in Galway Bay (O'Brien *et al,* 2013).

Through the C-POD.exe software (example Figure 3.4), data can be viewed, analysed and exported. Additionally, the software can be used to change settings of individual SD cards. The software includes automatic click train detection, which is continually evolving as Chelonia Ltd receives more feedback from their clients. C-POD.exe can be run on any version of Windows and requires an external USB card reader, which reads the SD card into the directory. Version 2.044 (October, 2014) was used for all analyses. C-POD.exe software allows the user to extract click trains under five classification parameters but only the porpoise like category was used for this analysis of the long-term dataset.

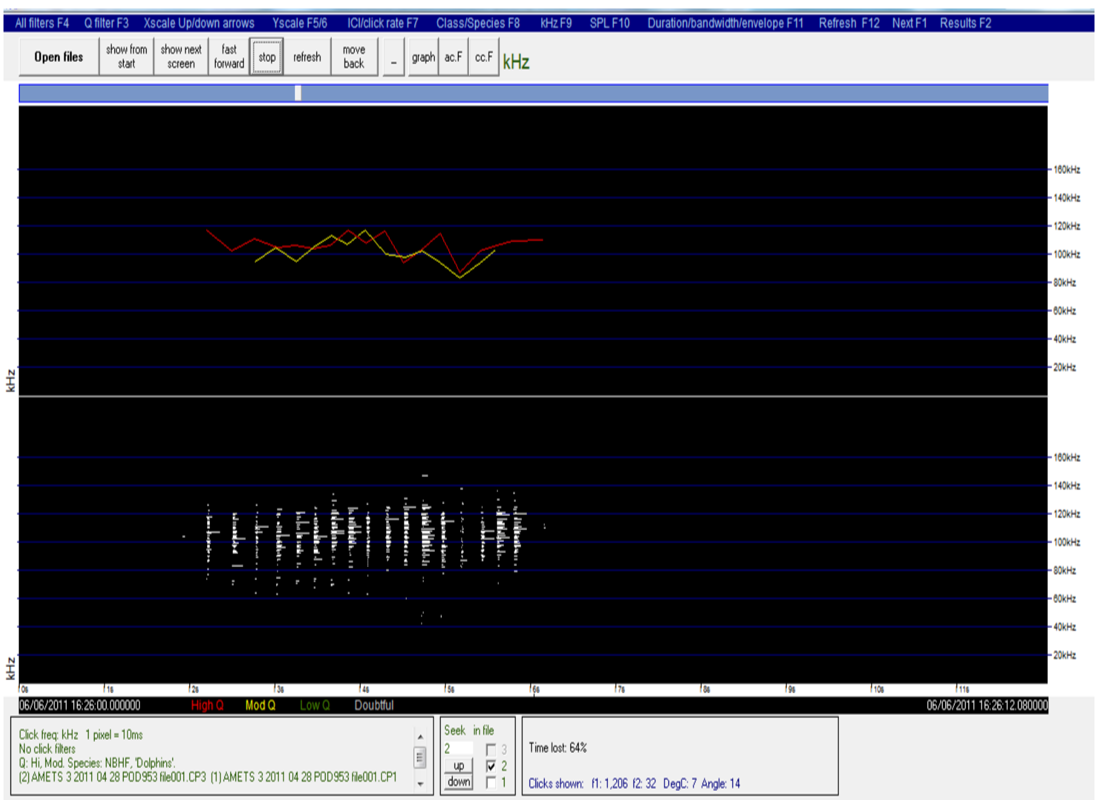

Figure 3.4: Screen grab of C-POD.exe, showing a harbour porpoise click train ((i) porpoise-like, but other categories include (ii) dolphins, iii) other train sources, iv) unclassed, v) boat sonars)

SAM once deployed is independent of weather conditions and thus ensures high quality data is collected but only at a small spatial scale. C-PODs can be deployed on a mooring for 3-4 months before recovery and downloading of data. Data was recovered and analysed three to four times a year. This data was analysed as detection positive minutes (DPM) to generate an acoustic index of activity. This technique provides large datasets to enable changes in activity to be identified at high resolutions. DPM's provide high quality data on seasonal, diel and tidal occurrence. Data was compared across sites, provide opportunities for assessing cetacean activity at the MRE Test site prior to the deployment of any devices.

3.1.3 C-POD calibration

Calibration of equipment is important in order to compare results across units. Chelonia LTD, the manufacturers of C-PODs, calibrates all units to a standard prior to dispatch. These calibrations are carried out in the lab under controlled conditions and thus Chelonia highly recommend that further calibrations are carried out in the field prior to their employment in monitoring programmes instead of further tank tests (Nick Tregenza *pers comms*). All C-PODs deployed during this present study were calibrated during field trials in the Shannon Estuary by the IWDG.

Field calibrations are important where projects employ several units aimed at comparing detections across a number of sites. If units of differing sensitivities are used, then these data do not truly reflect the activity at a site. For example, a low detection rate may be attributed to a less sensitive C-POD, with a lower detection threshold, which in turn leads to a lower detection range, while the opposite holds for a very sensitive unit. It is fundamental that differences between units are determined prior to their deployment as part of any project, to allow for the generation of correction factors which can be applied to the resulting data. Field trials should be carried out in high density areas in order to determine the detection function (O'Brien *et al.* 2013). The field calibration of new units should be carried out in conjunction with a reference C-POD, where a single unit is used solely for calibrations and is deemed a reference. This allows for the incidence where new units are acquired over the course of a project to be calibrated with the reference. All units used for SAM were deployed in the Shannon Estuary prior to deployment for up to 28 days to allow enough time to establish if sensitivity would be a confounding factor between units before been deployed as part of the present study.

Upon recovery of the units, data were extracted under two categories, 1) Narrow Band High Frequency (NBHF) (porpoise band) and 2) Other (dolphin band) using the C-POD.exe software (Version3.0.0.030, November 2019, October, 2014). These data were in the form of Excel.xlsx files using C-POD.exe software and analysed as Detection Positive Minutes (DPM) across hourly segments. Statistical analyses were carried out using the program R (R Development Core Team, 2011). All combinations of C-POD pairs were modelled using an orthogonal regression of DPM across hourly segments. This was compared to a null model, assuming no variation in C-POD detections, a = 0 and b = 1, and used to assess C-POD performance. An error margin of ±20% DPM per hour was plotted along the null model to distinguish between an acceptable level of variation in C-POD performance and problematic variation due to faulty or highly sensitive units (Tregenza pers comm.). From these graphs it is possible to determine successful or unsuccessful C-POD combinations. The mean intercept and gradient values of the orthogonal model for each C-POD pair were extracted and used to create centipede plots where, deviation from 0 on the horizontal axis, of mean intercept values and deviation from 1 on the horizontal axis, of mean gradient values indicated deviations from the null model. This was also used to identify if only one or two POD combinations were unsuccessful and also the extent of variability within the intercept and gradient values. Results were then used to highlight poor performing units or very sensitive units, if they existed and a correction factor can be generated and applied to the data.

3.1.4 SAM Data Analyses

All C-POD data were analysed using only high and moderate probability clicks. Both dolphin and porpoise detections were extracted as detection positive minutes per day (DPM), and both were statistically analysed for trends. As recommended by the manufacturers, a validation overview was carried out on the data, where 10% of all detected trains were visually inspected on cpod.exe to verify they were in fact of harbour porpoise origin. Of this 10% very few trains were classified as false positives, and therefore analysis of the porpoise detections proceeded with the classification of hourly variables into the following categories; season (spring, summer, autumn and winter), diel cycle (morning, day, evening and night-time), tidal state (ebb, flood, slack high, slack low) and tidal phase (spring, neap). The term *PPM* represents the number of minutes in a day or an hour that harbour porpoises were acoustically detected and *DPM* represent the number of dolphin minutes. Seasonal categorisations were assigned according to the seasons; spring (February, March April), summer (May, June, July) autumn (August, September, October) and winter (November, December, January). Data files in the format porpoise minutes per hour (*PPM/h*) and dolphin minutes per hour (*DPM/h*) were classified into **morning, day, evening and night-time** categories, using local times of sunrise and sunset times, which were obtained from the U.S. Naval Observatory (www.aa.usno.navy.mil/data/docs/RS). Hourly data segments were further categorised into each of the four tidal states, where three hours were assigned to each state (one hour either side of the hour). Files were further split to correspond with tidal phase (spring and neap cycles) using admiralty data (WXTide 32) where two days either side of the highest tidal height was deemed spring, and two days either side of the least difference in tidal height between high and low tide was deemed neap, all other days were classified as transitional.

All data were analysed using the programme R. A GLM was fitted to the binomial data using the glm() function. For site 3 where three different deployment took place, C-POD ID number was further included as a random factor to take into account potential variability between units, using the glmer() function in the lme4 package. Akaike's information criterion (AIC) and a histogram of fitted residuals were used as diagnostic tools for model selection. Hosmer and Lemeshow goodness of fit (GOF) test was used to check that model fitted values didn't differ significantly from observed values. Wald chi-squared tests were computed for each variable and predicted proportions of Porpoise positive hours (PPH) were extracted across all levels using the HH package and displayed as box plots. A series of post hoc tests using a Tukey approach for pairwise comparison of means (lsmeans() R packages 'lsmeans' & 'multcomp') was conducted to locate significant differences. The cld() function (R packages 'multcomp') was used to group levels of each factor based on significant differences. Levels labelled with a common letter on the boxplots are not significantly differing from each other. R is a language and environment for statistical computing and graphics. It is free software, available at http://www.r-project.org/index.html. The software compiles and runs on a wide range of UNIX platforms, Windows and MacOS. R provides a wide variety of linear and nonlinear modelling, classical statistical tests, time-series analysis, classification, clustering and graphical techniques (R Development Core Team, 2020). R is designed around a true computer language, similar to the S language. The effective programming language includes conditionals, loops, user-defined recursive functions and input and output facilities.

3.1.5 Moorings

Two mooring types were used over the project duration (Figure 3.5a and 3.5b). Heavy weight mooring were established with 250kg of clumped chain and surface markers while Acoustic Release Arrays were also established. Equipment loss was experienced with both mooring types. Moorings were established with a foreshore licence from the Department of Housing, Planning and Local Government (FS 006840).

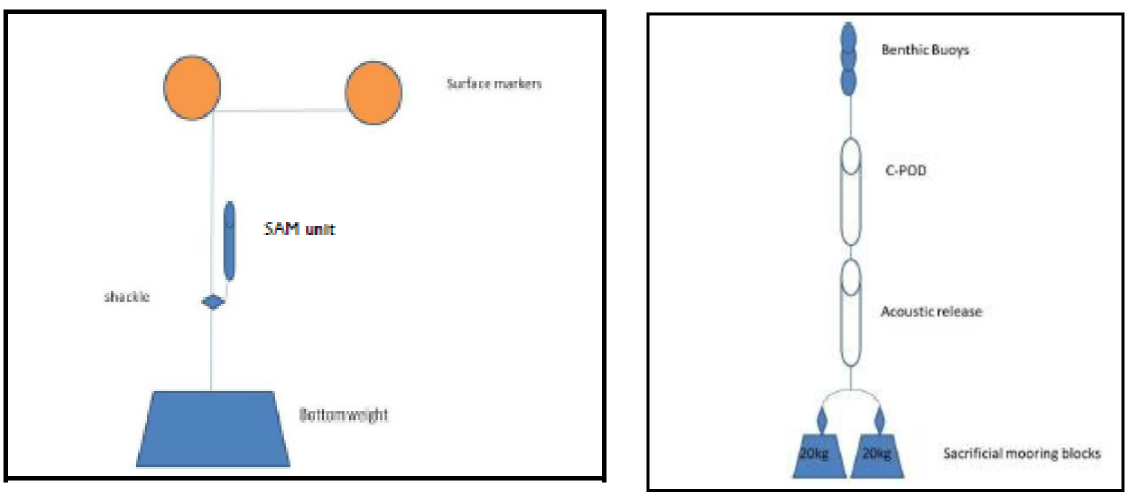

Figure 3.5a. CPOD deployed off heavy mooring, 3.5b. Acoustic Release system for deploying C-PODs.

4 Results

4.1.1 C-POD Calibrations

All units used during the present project were calibrated in the Shannon Estuary across three calibration trials in June and December 2019 and April 2020. Results from these trials are presented below (Figures 4.1-4.3) and show that there were some discrepancies between units. Further exploration into individual unit performance showed that C-POD performance was however within the acceptable error margin of ±20% DPM per hour (Figures 4.1-4.3) and therefore no correction factor was needed to be applied to the data to make them comparable (O'Brien *et al*. 2013). During analysis of the long-term dataset, differences in sensitivities between units is accounted for by inserting the C-POD number as a random factor when running the generalized linear mixed-effect models (GLMMs) and additionally all C-PODs were deployed randomly between sites over the duration of the study. C-PODs are constantly monitored to ensure they are performing as expected and not unit caused concern over the duration of this project.

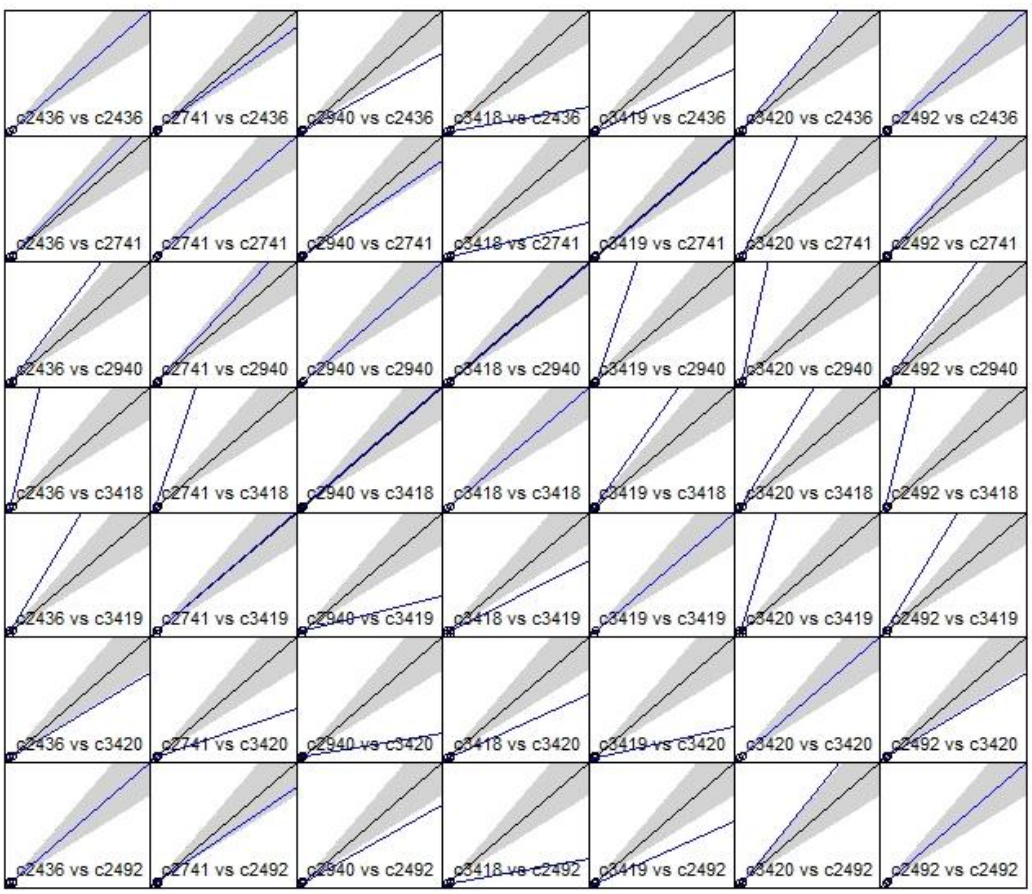

Figure 4.1: Orthogonal regression plot of C-POD comparisons in calibration trial (June-July 2019), in blue, with a null model where each unit performs exactly the same, in black and an acceptable error margin of ±20%, in grey from Calibration trials, June-July 2019.

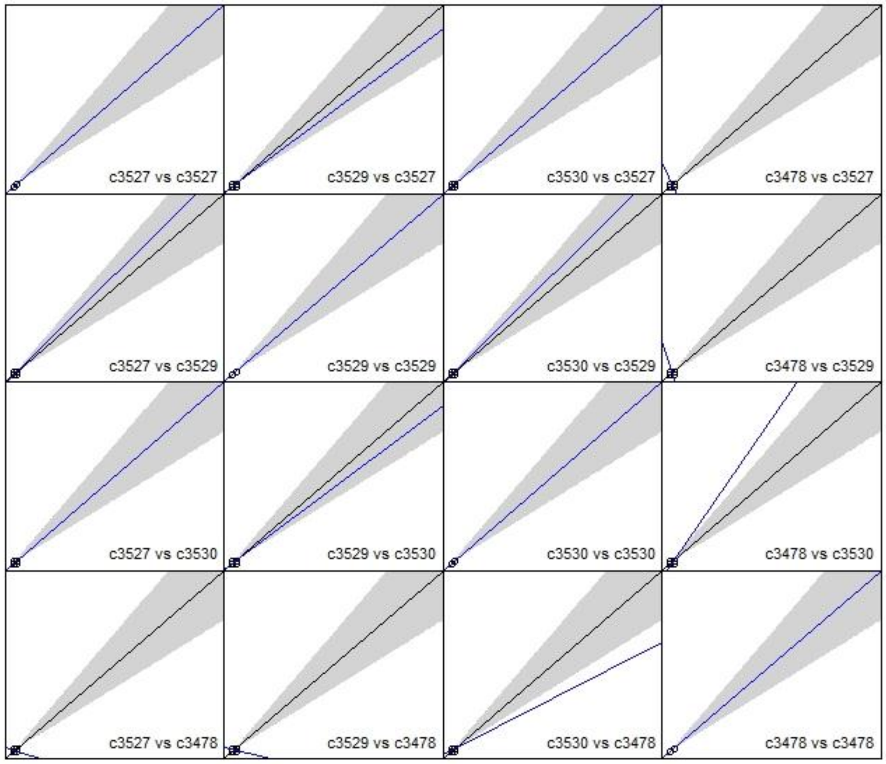

Figure 4.2: Orthogonal regression plot of C-POD comparisons in calibration trial 2, with a null model where each unit performs exactly the same, in black and an acceptable error margin of ±20%, in grey from Calibration trials, December 2019.

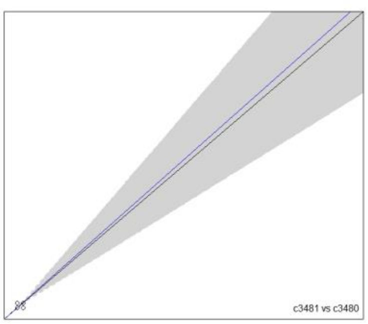

Figure 4.3: Orthogonal regression plot of C-POD comparisons in calibration trial 3, with a null model where each unit performs exactly the same, in black and an acceptable error margin of ±20%, in grey from Calibration trials, April 2020

4.1.2 Overview of SAM results

Species discrimination of SAM data was carried out using the dedicated software into two categories;

1) NBHF, which represent harbour porpoise detections and

2) Dolphin, which includes all dolphin detections.

It is not possible to differentiate between dolphin species with C-POD data due to similarities in their click characteristics and especially an overlap in frequency use. Results from this short deployment showed that porpoises were the most frequently detected species (Figures 4.4-4.7), while confirmed dolphin detections were only found in two locations during this deployment, in small numbers (Figures 4.8-4.9).

Figure 4.4-4.7: Number of Harbour Porpoise positive detections minutes (PPM) per day recorded across all locations (Lidar, SAM2, SAM3 and SAM4).

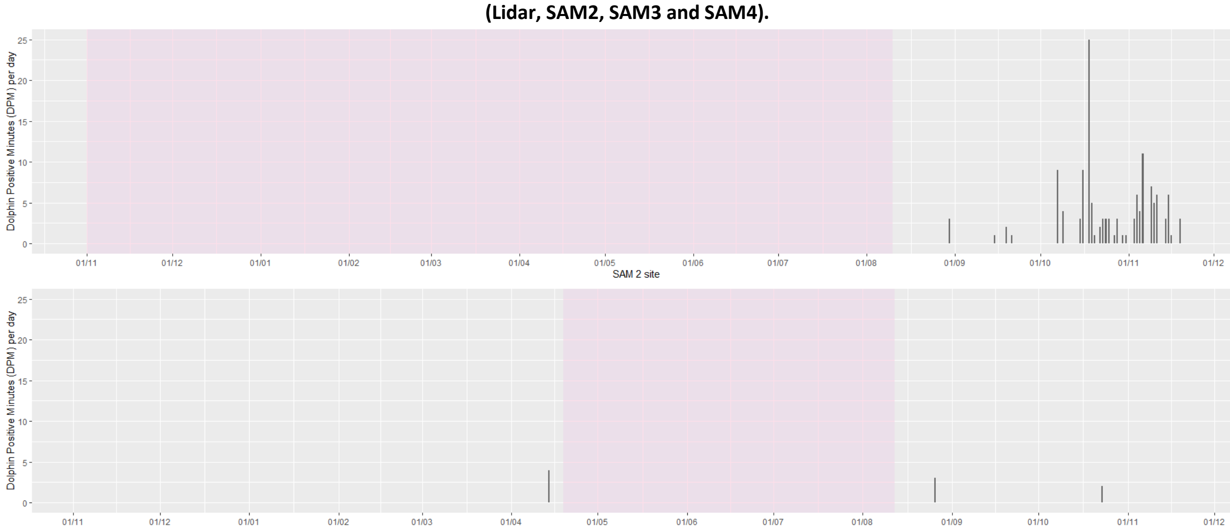

Figure 4.8-4.9: Number of Dolphin detections per day recorded across SAM2 and SAM3 locations.

Harbour porpoises were the most frequently detected marine mammal species (see Table 4.1, Porpoise Positive Minutes (PPM), Porpoise Positive Hours (PPH), Porpoise Positive Days (PPD)) with dolphins rarely detected (Table 4.1, Dolphin Positive Hours (DPH), Dolphin Positive Days (DPD)) (Table 4.1). Large gaps exist in the dataset due to the repeated loss of equipment at the site.

Most data were obtained from SAM 3, and porpoises were recorded at the site on 99% of days with a mean of 1.08 detections per hour. At SAM 4, 135 days of data were obtained and porpoises also recorded on 99% of days with a mean of 2.13 detections per hour and SAM 2 porpoises were recorded on 100% of 103 days monitored with a highest mean of 9.44 detections per hour. At the LIDAR site, a total of 179 days were monitored with porpoise detections on 90% of days and a mean of 2.96 detections per hour. Dolphins were recorded on 29% of days at SAM 2 but the overall number of detections were low, while at the remaining sites were never recorded with the exception of SAM 3 where detections were recorded on 1% of days.

Table 4.1: Summary of results from Static Acoustic Monitoring (SAM) programme November 2019-November 2020 (135-268 days).

Location	Effort (days)	Dates	PPH - %PPH	DPH - %DPH	PPD - %PPD	DPD - %DPD	Mean PPM/H	Mean PPM/D
2	103	11/08/2020 – 21/11/2020	2054 - 84%	54 - 2%	103 - 100%	30 - 29%	9.44	225
3	268	06/11/2019 –19/03/2020 19/03/2020 –18/04/2020 12/08/2020 –21/11/2020	1661 - 26%	3 – 0%	264 - 99%	3 - 1%	1.08	26
4	135	06/11/2019 – 19/03/2020	1514 - 47%	0 - 0%	134 - 99%	0 - 0%	2.13	51
LIDAR	179	19/05/2020 –12/08/2020 12/08/2020 – 13/11/2020	2008- 47%	29 - 1%	161 – 90%	23 - 13%	2.96	71

4.1.3 Generalized linear model (GLM) analyses

Generalized linear models (GLM) were carried out for the 3 sites (SAM 2, 3 and 4) where multiple deployments took place - to assess significant differences between monitoring locations, allowing for a detailed but preliminary assessment of fine scale use of the proposed Oriel Windfarm. Modelling was conducted for porpoise detections (PPH) but not for dolphins detections given the very limited presence reported in the datasets. Results were examined across temporal classes (season, diel, tidal cycle and tidal phase). Using the box plots below, results can be explained more easily. Tables 4.10-4.12 present the statistical significance of each factor at each site, and the differing levels within each variable.

4.1.3.1 SAM 2

At SAM 2, season was found to have a significant influence on detection rate (Wald test for “Season”: $Chi^2 = 239.3$, $p < 0.001$; Figure 4.10), with more porpoises being reported in autumn than in winter. Diel cycle also influenced porpoise presence (Wald test for “Diel”: $Chi^2 = 54.3$ $p < 0.001$), detected most often at night, followed by evening and morning, with least detections occurring during the day. No effect of tidal parameters (cycle or phase) were observed at this site over the deployment duration.

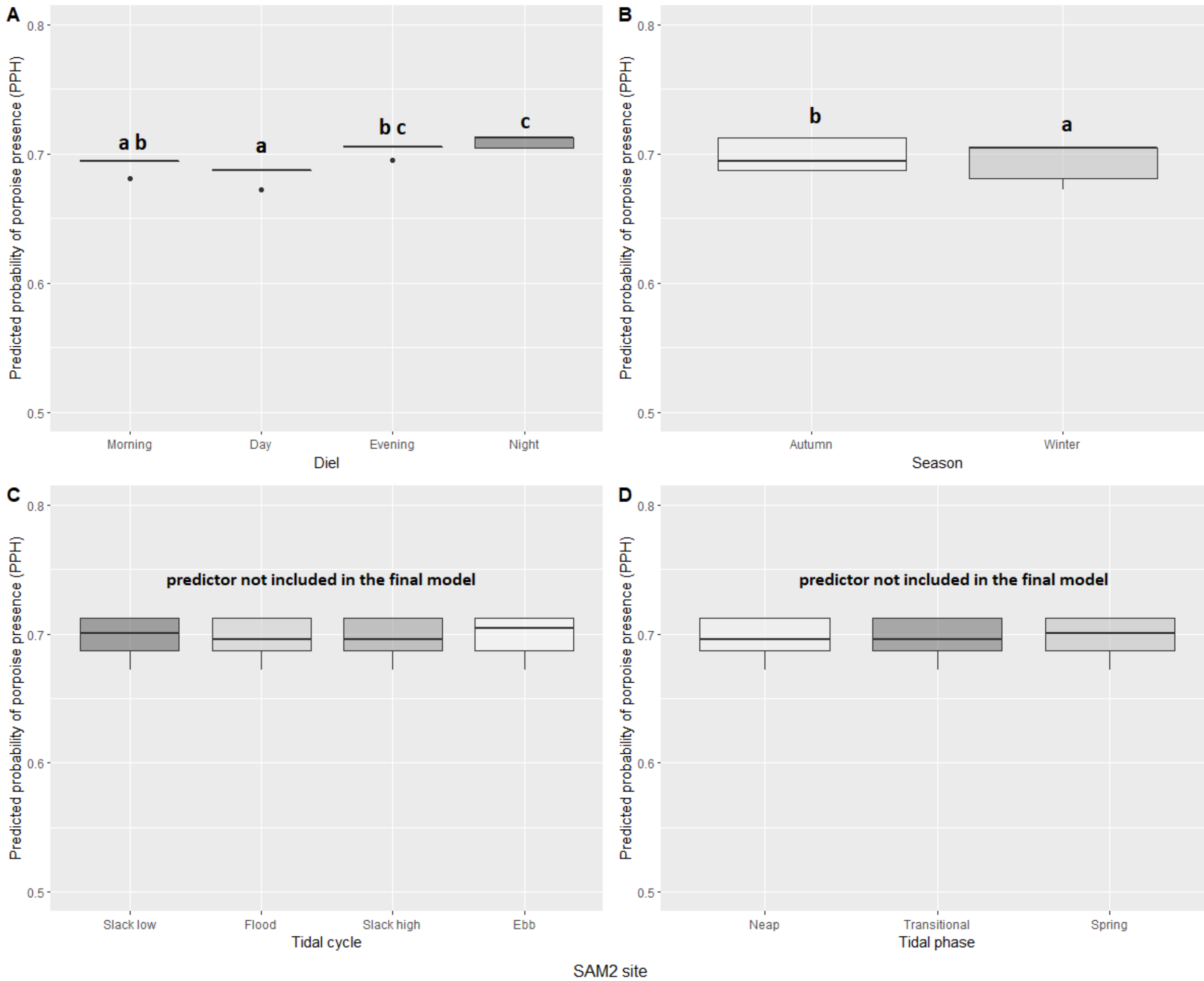

Figure 4.10 Predicted proportion of Harbour porpoise (NBHF) detection positive hours, in the narrow band high frequency channel at the SAM2 Site, across the variables of season, diel, tidal phase, and tidal cycle. Letters indicate groups of significant differences: levels sharing a letter are not statistically different from each other.

4.1.3.2 SAM 3:

At site 3, contrary to site 2, more detections occurred in winter and spring than in autumn (Wald test for “Season”: Chi² = 33.9, p < 0.001; Figure 4.11). Diel cycle also had a significant effect (Wald test for “Diel”: Chi² = 532.1, p < 0.001), with again a higher detection rate at night, lower during morning and evening, and minimal during the day. At this location, porpoises seemed to be present more often during slack-high tides than flood or slack high waters (Wald test for “Tidal cycle”: Chi² = 20.9, p < 0.001). Tidal phase was a significant factor in the model (Wald test for “Tidal phase”: Chi² = 6.2, p = 0.045), although no clear differences across levels were identified following the Tukey test.

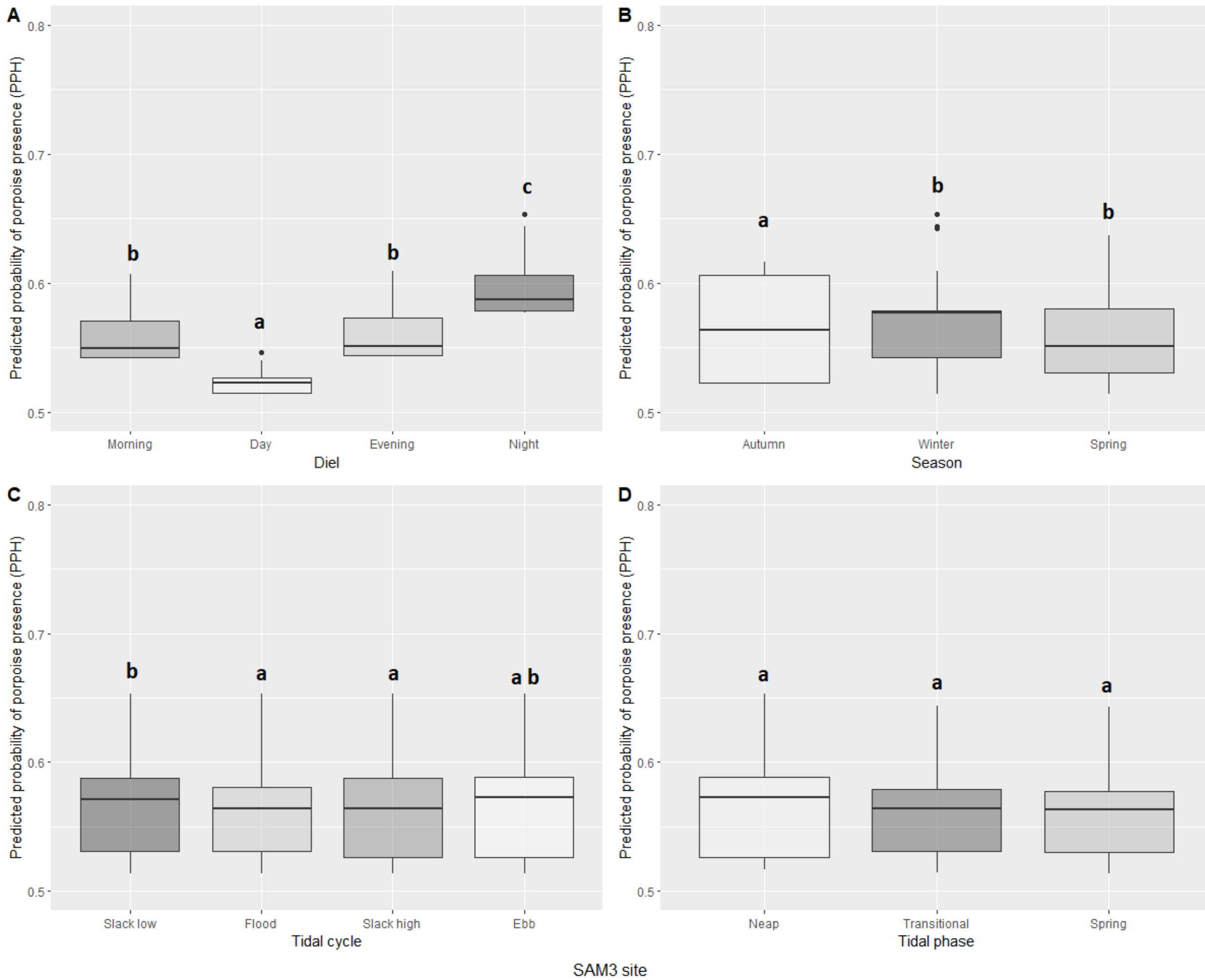

Figure 4.11. Predicted proportion of Harbour porpoise (NBHF) detection positive hours, in the narrow band high frequency channel at the SAM3 Site, across the variables of season, diel, tidal phase, and tidal cycle. Letters indicate groups of significant differences: levels sharing a letter are not statistically different from each other.

4.1.3.3 SAM 4

Significantly more porpoise detections were recorded during the winter months compared to spring months (Wald test for “Season”: Chi^2 = 24.2, $p < 0.001$, Figure 4.12). Detection rate was significantly higher during morning than during the day and evening, and also higher during the night than during the evening (Wald test for “Diel”: Chi^2 = 19.6, p = 0.0002, see Table 4.2 for detailed pairwise comparisons). At this location, slack low waters again, but also flood periods had higher presence than ebb periods (Wald test for “Tidal cycle”: Chi^2 = 19.9, p = 0.0002). Tidal phase had no significant impact on porpoise detections at this location over the deployment period, even though the factor was included in the best model (Wald test for “Tidal phase”: Chi^2 = 4.6, p = 0.097).

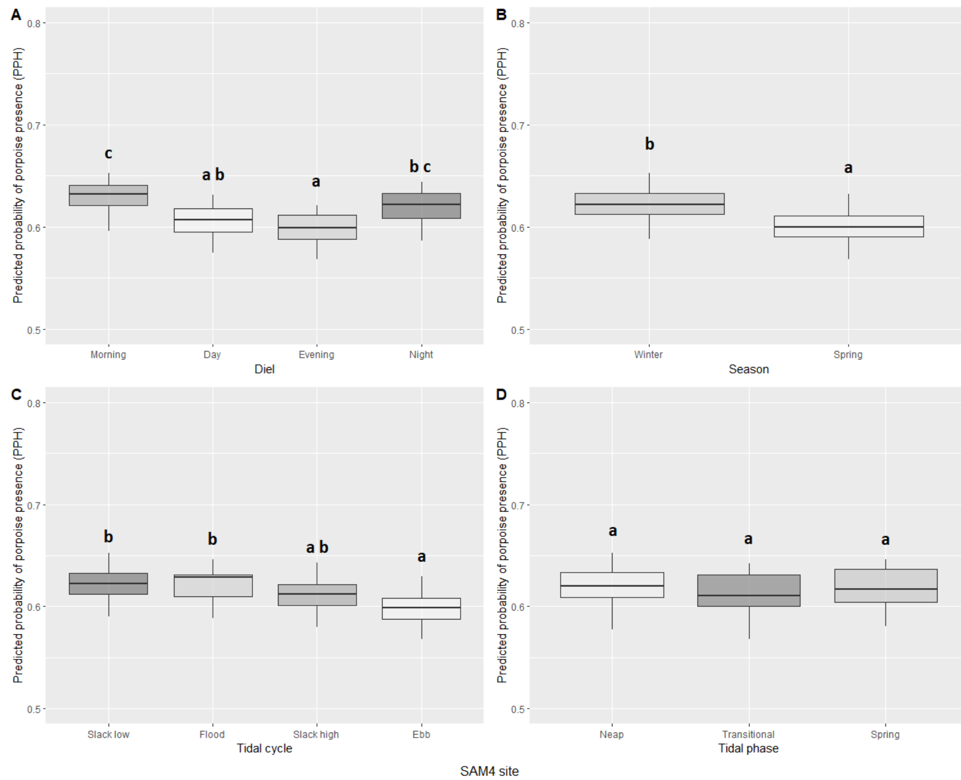

Figure 4.12. Predicted proportion of porpoise detection positive hours, in the narrow band high frequency channel at the control location of the SAM4 Site, across the variables of season, diel, tidal phase, and tidal cycle. Letters indicate groups of significant differences: levels sharing a letter are not statistically different from each other.

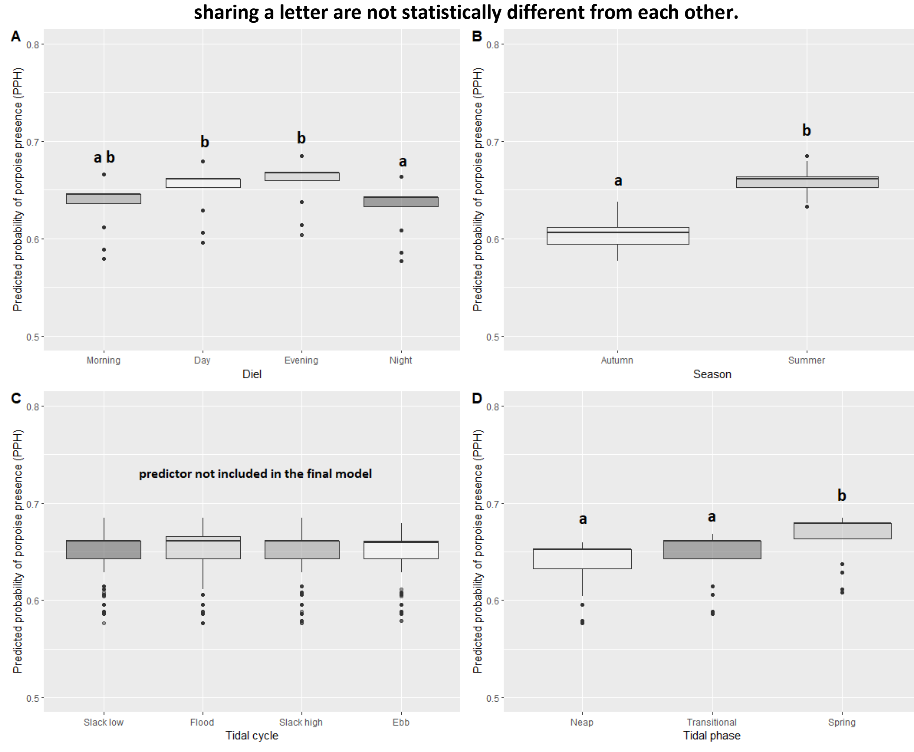

Figure 4.13. Predicted proportion of porpoise detection positive hours, in the narrow band high frequency channel at the control location of the LIDAR Site, across the variables of season, diel, tidal phase, and tidal cycle. Letters indicate groups of significant differences: levels sharing a letter are not statistically different from each other.

Table 4.2: Summary of overall predictors significance across datasets from the Oriel Sites; SAM2, SAM3, SAM4 and LIDAR (Wald Chi² test)

	SAM2	SAM3	SAM4	LIDAR
Season	***	***	***	***
Diel cycle	***	***	***	**
Tidal cycle	x	***	***	x
Tidal phase	x	*	.	***

Wald χ² test - Significance codes: 0 '*' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. X indicates that the predictor wasn't included in the final model (lowest AIC)**

Table 4.3: Summary of Tukey test results used to locate significant differences between levels of each factors, across datasets from the Oriel Sites; SAM2, SAM3, SAM and LIDAR. Each pairwise comparison of least mean squares (LMS) (i.e each p-value) isn't presented for clarity, but have been used to build groups (a, b, c) within each factor. Levels sharing a common group (low case letter) do not statistically differ from each other (i.e Tukey adjusted p-value >0.05).

	SAM2		**SAM3**		**SAM4**		**LIDAR**	
	LMS	Group	LMS	Group	LMS	Group	LMS	Group
Season								
Winter	1.38 ± 0.1211	a	-0.976 ± 0.291	b	0.0135 ± 0.0539	b		
Spring	x		-0.957 ± .,292	b	-0.3611 ± 0.0672	a		
Summer	x		x		x		0.648 ± 0.0646	b
Autumn	1.75 ± 0.0722	b	-1.628 ± 0.3	a	x		-0.334 ± 0.1277	a
Diel cycle								
Morning	1.33 ± 0.1493	ab	-1.097 ± 0.296	b	0.0964 ± 0.1035	c	-0.0131 ± 0.1396	ab
Day	1.12 ± 0.0935	a	-2.307 ± 0.295	a	-0.2918 ± 0.477	ab	0.2826 ± 0.0817	b
Evening	1.73 ± 0.17	bc	-1.069 ± 0.296	b	-0.4282 ± 0.1050	a	0.4258 ± 0.1461	b
Night	2.08 ± 0.1086	c	-0.275 ± 0.287	c	-0.0715 ± 0.0559	bc	-0.0656 ± 0.1170	a
Tidal cycle								
Slack low	x		-0.982 ± 0.291	b	-0.0128 ± 0.0782	b	x	
Flood	x		-1.242 ± 0.290	a	-0.0481 ± 0.0723	b	x	
Slack high	x		-1.369 ± 0.292	a	-0.1997 ± 0.0795	ab	x	
Ebb	x		-1.155 ± 0.292	ab	-0.4346 ± 0.0836	a	x	
Tidal phase								
Neap	x		-1.06 ± 0.292	a	-0.0816 ± 0.0827	a	-0.0889 ± 0.1191	a
Spring	x		-1.27 ± 0.292	a	-0.1678 0.0836	a	0.4793 ± 0.1176	b
Transitional	x		-1.24 ± 0.287	a	-0.2720 ± 0.0532	a	0.0819 ± 0.0822	a

Results are averaged over the levels of other predictors in each model. Results are given on the logit (not the response) scale. Confidence level used: 0.95. Results are given on the log odds ratio (not the response) scale. P value adjustment: Tukey method for comparing a family of 2-4 estimates. Significance level used: alpha = 0.05. Groups are based on these p-values.

4.1.3.4 SAM LIDAR

At the LIDAR site, contrary to what was observed in other locations, porpoise presence was lowest at night, compared to the day and evening (Wald test for "Diel": Chi² = 13.6, p= 0.0035). There was a clear decrease in detection rate between summer and autumn (Wald test for "Season": Chi² = 55.6, p < 0.001). Tidal cycle did not influence detections but a higher PPH probability coincided with spring tides Wald test for "Tidal phase": Chi^2 = 15.8, p = 0.0004).

4.1.3.5 SUMMARY

In summary, results across all days monitored at each of the sites show porpoises to be present on average over 99% of days monitored. Season appeared to influence porpoise presence differently across sites, with winter and summer seemingly important periods, with more porpoise detections recorded. The effect of diel cycle also varied across location, although night, morning and/or evening phases often yielded more detection than day phases (except at the LIDAR site). Tidal cycle and Tidal phase only affected detection rate in some locations, where slack low water coincided with increased detections.

5 Discussion

Cetaceans live in an acoustic world and increasingly attempts have been made to develop acoustic monitoring techniques rather than relying on visual methods, where efficacy is dependent on light, weather conditions and sea-state, especially for species such as the elusive harbour porpoise. The reliance on sound by these animals is extremely important and therefore SAM is a very valuable tool for their determining presence and assessing fine scale habitat use by various odontocete species. The main advantage of SAM is that it can provide information on species that can go undetected visually for up 95% of the time (harbour porpoise; Read & Westgate, 1995). Patterns of cetacean presence have been described over seasonal scales (Canning *et al*., 2008, Bolt *et al*., 2009; Simon *et al*., 2010; Gilles *et al*., 2011; O'Brien *et al.* 2013) diel cycle (Carlström, 2005; Todd *et al*., 2009; O'Brien *et al.* 2013) and tidal patterns (Marubini *et al*., 2009; O'Brien *et al.* 2013). Although SAM can provide a much more complex account of cetacean activity at a site in comparison to visual monitoring, it fails to inform on the numbers present and hence the need for visual surveys. It is clear from the present report that SAM shows harbour porpoises to be present throughout the year with an increase in activity or numbers during winter and autumn Detections were highest across all locations during these months, but differences between locations occurred with diel and tidal cycles showing their use of a site is quite complex even at a small spatial scale.

The aim of the present study was to produce a robust assessment of the marine mammal community at the proposed Oriel Windfarm site and their use of the site. We have also produced a baseline dataset of cetacean occurrence across a 12 month period from November 2019 and November 2020. Large gaps exist in the dataset due to missing equipment on a number of occasions. A total of six deployments were lost over the duration of the project from different mooring types, including acoustic release arrays and heavy weight moorings. Two CPODs were washed up, one in Scotland (incl. an acoustic release) and one in Baltray, Co Louth and both recovered, with 3 units lost permanently.

Table 5.1: Monitoring results from SAM across Ireland

County	Site	Total days	DPD %	Total PPM	%DPM	Mean DPM/day	Mean DPM/hr	Reference
Louth	SAM 2	103	100	23,112	*	225	9.44	*Present study*
Louth	SAM 3	268	99	6381	*	26	1.08	*Present study*
Louth	SAM 4	135	99	6839	*	51	2.13	*Present study*
Louth	LIDAR	179	90	10,000	*	71	2.96	*Present study*
Dublin	Loughshinny	189	100	26,281	9.6	137	5.8	O'Brien *et al.* (2015)
Galway	Spiddal	572	89	27,902	3.4	48.8	2	O'Brien *et al.* (2013)
Kerry	Inishtooskert	264	80	3930	1.04	14.9	0.6	O'Brien *et al.* (2013)
Kerry	Wild Bank	289	80	2097	0.51	7.3	0.3	O'Brien *et al.* (2013)
Kerry	The Gob	52	49	3015	4.1	58	2.4	O'Brien *et al.* (2013)

From the data presented here, it is clear that the all sites monitored are important areas for harbour porpoises, with porpoises recorded on a daily basis across all sites monitored. However, looking at trends this presence differs between locations. Regarding season, autumn was the most significant season across three of the four sites, with night-time hours also yielding more detections at three of the four sites. This highlights the need for SAM as without it perhaps we are missing much of this activity during visual surveys. The states of the tide had a significant effect at two of the four sites, while tidal phase only had an effect at the inshore LIDAR site with more detections recorded during spring tides.

These results are similar to those found in other inshore areas, and comparing detections it can be seen these are important areas off Co. Louth even with the many data gaps that exist. Mean detection positive minutes per day from Co. Louth are higher than some important sites around the country, for example the Blasket Islands SAC in Co. Kerry, which is one of three designated areas for the species (Table 5.1).

5.1.1 Conclusion

In conclusion, SAM does not provide information on the numbers of animals using a site but gives an insight into habitat use across time which could not be determined from visual monitoring alone. Clearly, this area of Co. Louth is an important area for harbour porpoises. As harbour porpoises are listed on Annex II of the Habitats Directive, this species is entitled to strict habitat protection, and extreme care must be taken to ensure any development does not degrade this habitat or cause undue disturbance. These SAM results will serve to inform protocols of best practice for the area thus ensure small cetaceans are not negatively impacted upon. Mitigation measures should take into account the potential acoustic disturbance of marine mammals at the site and any associated noise input or long-term potential disturbance should be reviewed in order to minimise displacement and to prevent habitat exclusion or hearing impacts such Temporary Threshold Shift (TTS).

6 Acknowledgements

We would like to thank Fastnet Shipping Ltd and skippers Nicky Fortune and Walter Rankin and crew for providing an excellent vessel and building moorings these deployments and Eoin Grimes at Irish Commercial Charter Boats for the final SAM recovery. This survey project was contracted by Parkwind through Aquafact and we would particularly like to thank Brendan O'Connor of Aquafact and Richard Church of Parkwind for their support throughout.

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ANNEX 2: BOAT-BASED DATA ANALYSES REPORT

ORIEL WIND FARM PROJECT

Annex 2: Marine Mammal Boat-Based Survey Data Analyses Report

MDR1520B
NIS Appendix G
Annex 2
A1 C01
March 2024

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1 INTRODUCTION

Oriel Windfarm Limited has commissioned RPS to undertake analysis of boat based survey data collected for the Oriel Wind Farm Project (the Project) plus a minimum 5 km buffer area (hereafter referred to as the Survey Area; Figure 1-1) to provide information on the abundance, distribution, and behaviour of marine mammals.

The offshore wind farm area is located in the Irish Sea, off the coast of County Louth (approximately 22 km east of Dundalk town centre and 18 km east of Blackrock). The closest wind turbine will be approximately 6 km from the closest shore on the Cooley Peninsula. The offshore cable corridor extends approximately 16 km southwest from the wind farm area to the landfall south of Dunany Point.

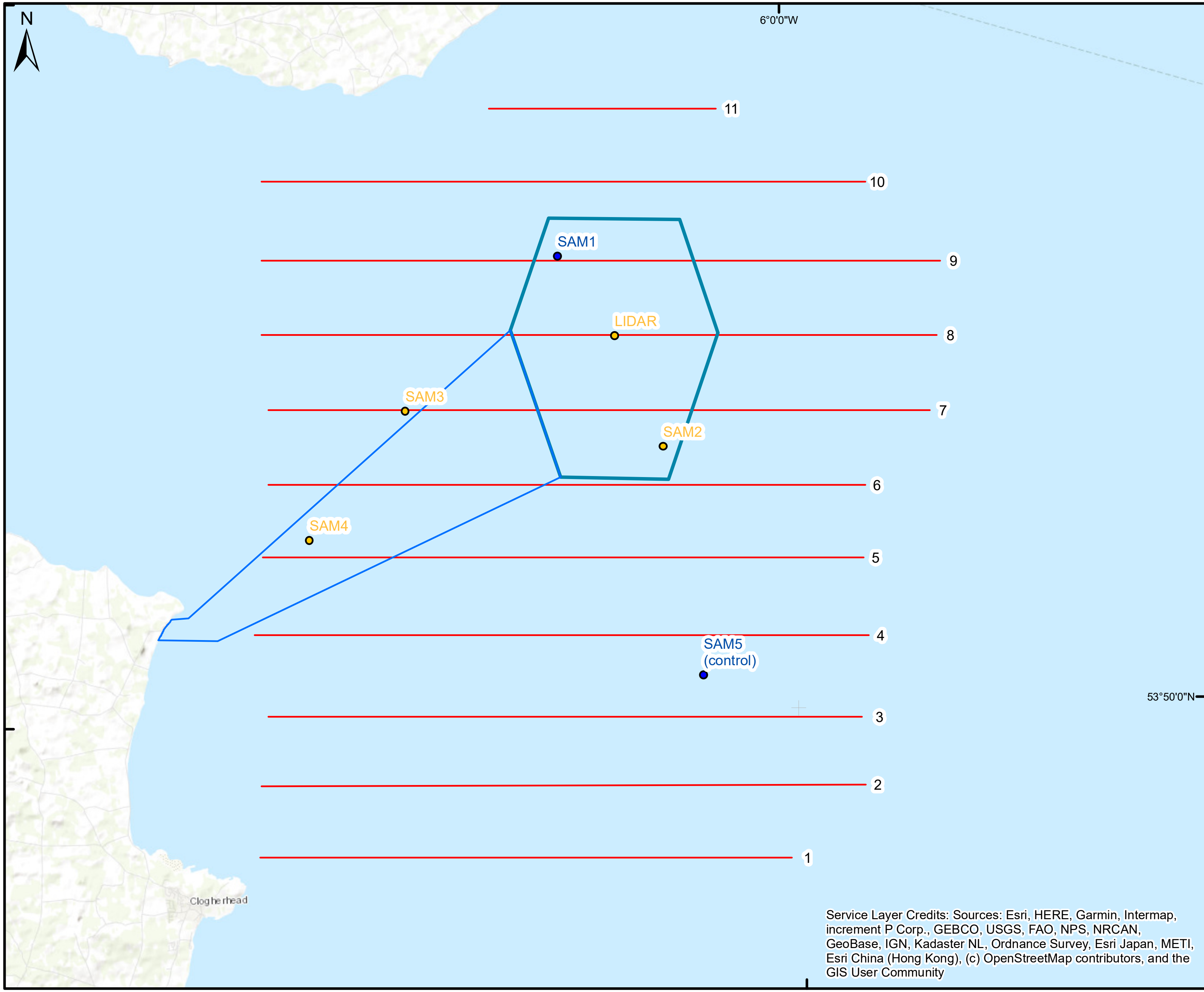
1.1 Aims and objectives

This report aims to present an analysis of baseline marine mammal boat-based survey data for the Survey Area. This has been undertaken for the following key species: Harbour Porpoise, Grey Seal and Minke Whale.

The objectives of this analysis of boat-based survey data were to:

1. Produce abundance estimates for each species by calendar month and/or season;
2. Produce spatial abundance maps of each species within the season and/ or month (where appropriate); and
3. Produce spatial abundance confidence interval maps for each map produced above.

This report describes the results of the objectives described above for the key species.



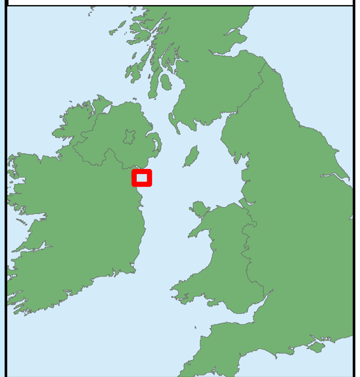
Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor
- Bird & Mammal Boat-based Transect Line

Static Acoustic Monitoring (SAM) locations

- Long term deployments
- Loss of moorings/ equipment

Data Sources: Client.



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

Oriel Wind Farm Project

Title

Figure 1-1

Survey Area and boat based survey transects.

RPS
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Issue Details

Drawn By: NG	**Project No.** EOR0822 (MDR1520B)
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Approved By: AOS	
Scale: 1:130,000 @ A4	**Projection:** ITM (IRENET95) Geographic Co-ordinates: ETRS89
Date: 08/03/2024	

2 METHODS

2.1 Data

Full details of data collection methods are in the survey reports provided in appendix A.1 of this report. Boat based ornithological surveys followed standard survey methods based on the methodological principles established by COWRIE (Camphuysen *et al.,* 2004) and the European Seabirds at Sea team (ESAS) method (see Tasker *et al.,* 1984, Webb & Durinck, 1992).

Surveys were undertaken between May 2018 and May 2020. A summary of the available survey data and the periods of survey are presented in Table 2-1 and Table 2-2 below.

Table 2-1: Grey seal data summary and ecological period grouping.

Ecological Period	Period Months	2018	2019	2020	No. Surveys	No. Years
Pupping (grey seal)	Aug-Oct	III	II*		5	2
Non-pupping (grey seal)	Nov – Jul	IIII*I	IIIIIII	II	14	3

* - Incomplete surveys – not all transects completed.

Table 2-2: Cetacean data summary and ecological period grouping

Ecological Period	Period Months	2018	2019	2020	No. Surveys	No. Years
Breeding season (cetaceans)	Apr-Jul	III	III	I	7	3
Non-breeding season (cetaceans)	Aug-Mar	IIII*I	III*III	I	12	3

* - Incomplete surveys – not all transects completed.

2.2 Distance analysis

Surveying animals by eye carries the potential for decreases in detectability with distance, resulting in negatively biased population estimates (e.g. Skov *et al.,* 1995, Ronconi & Burger, 2009). This is especially likely for relatively small species, such as Harbour Porpoise. Detection is also likely to change according to sea state amongst other factors. Distance analysis can be used to analyse variations in the detectability of birds and correct density estimates accordingly. Buckland *et al.* (2001) define the central concept of Distance analysis as the modelling of the detection function, g(x), which is the probability of detecting an object (a marine mammal or group of marine mammals), given that it is at distance x from a transect line or point (see Buckland *et al.,* 2001, 2004).

Distance correction analysis makes several important assumptions about the nature of the data: 1) the distribution of marine mammals is random with respect to the transect line, 2) marine mammals are non-aggregated and are evenly distributed across all distance bands and 3) all marine mammals on the surface and transect line at distance 0 are detected (Thomas *et al.,* 2010). It was also assumed that marine mammals were identified and located prior to any response (flushing, swimming or diving) to the vessel, which might violate the assumptions of Distance correction (Buckland *et al.,* 2001).

Models were fitted using various key functions (uniform, half-normal, hazard-rate or gamma), with or without adjustment terms (e.g. cosine, simple polynomial or hermite polynomial). Sea state and group size were also investigated as model covariates in determining detection probability with sea state fitted as a categorical variable and group size as continuous. Data collected in sea state 5 and above were omitted due to small sample sizes and the noted difficulties in sampling above sea state 4 (Hammond *et al.,* 2002[1]). Goodness of fit of potential detection functions was assessed using Akaike Information Criterion (AIC) values, Cramer-von mises tests and visual inspection of QQ plots and fitted detection functions. These together have been used to identify the 'best' model to assess the goodness of fit in the following sections.

Distance analysis was undertaken with all data pooled within each species to maximise the data informing the detection functions and produce a single detection function for each species. Data were truncated to 500 m as ~90% of all observations for each species were within 500 m of the transect. The effect of this on detection probability.

2.3 Spatial abundance mapping

The methods described in this section were used to meet the following analyses objectives:

- Spatial abundance maps of each species within the season and / or month (where appropriate);
- Spatial abundance confidence interval maps for each map produced above; and
- Densities (and associated error) estimated from spatial abundance maps.

Where possible, the marine mammal survey data was analysed using the CReSS approach in a GEE framework with Spatially Adaptive Local Smoothing Algorithm (SALSA) for model selection (Mackenzie *et al.*, 2013). Environmental data was used to predict the density and distribution of species across a defined grid covering the Survey Area. The following environmental covariates were used to predict the species' distributions:

- Bathymetry (Depth in metres);
- X and Y coordinates; and
- Distance to coast (metres).

The CReSS modelling technique was developed to deal with spatial smoothing in geographically complex regions (i.e. coastal waters); it has been further developed as part of the MRSea (Scott-Hayward, 2017) R package specifically to deal with data collected for offshore wind farm projects. The modelling technique allowed both spatially auto-correlated and zero-inflated data to be modelled in a robust method. The confidence intervals generated using CReSS incorporate both the uncertainty in the detection function fitting (where applicable) and in the spatial model fitting process (Mackenzie *et al.,* 2013). Using a CReSS modelling method also enabled any spatial auto-correlation within the dataset to be incorporated providing more robust confidence intervals. Autocorrelation Function (ACF) plots allowed detection of spatial autocorrelation, and an appropriate blocking structure was specified within the model to account for any autocorrelation detected. This method was appropriate for analysing zero-inflated count data through specification of an appropriate family (quasipoisson) within the modelling process. The MRSea package in R allowed the data to be modelled using regression splines and CReSS smoothing with SALSA for model selection.

Data were collected along transect lines over the entire survey area, but in some months, some transects were not surveyed resulting in partial spatial coverage (i.e. May 2020 and November 2019). The presence of these missing data means that standard methods for analysing surveys through transforming point data to a smoothed surface (e.g. kernel density estimation) could not be used. As such, we used SALSA; (Walker *et al.,* 2010) within the R package MRSea (Scott-Hayward, 2017). This approach allows for the presence of

[1] Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Jorgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F. and Oien, N. 2002. Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. Journal of Applied Ecology 39(2): 361-376.

missing data by exploiting empirical relationships between abundance and other variables (depth and distance to coast) and exploiting commonalities between distributions in different months.

Due to small numbers of observations in many months information was pooled across months within broad ecologically relevant periods (see Table 2-1 and Table 2-2) and models fitted to each of these broad periods for each species of interest with sufficient observations for model convergence (~80). Since there are likely to be differences between spatial distributions across species between breeding and non-breeding seasons, we only pooled information across months within each of these periods, and not between periods as far as practicable within the limits of sample size. Two separate models based on season were fit to each species to allow for differences in the relationships of distance to coast and/or depth, and different levels of smoothness depending on the time of year.

Crucially, these assumptions do not imply that the distribution of marine mammals across the study area needs to be the same. The degree of smoothing for each species and season was determined within the MRSea software using tenfold cross validation where possible. In some cases, the cross validation approach led to unreliable estimates of the upper 95% confidence limit due to external edge effects. In this case the results are presented using QAIC for model fitting. Within each of the models, separate maps with associated 95% lower and upper confidence intervals were produced for each species and month, where possible.

Availability bias

As marine mammals spend a large proportion of time underwater, there will be periods when they are not detectable at the surface. This may lead to an under-estimate of their abundance during surveys, known as availability bias.

Abundance estimation covers the range of techniques by which the size of a population of marine mammals can be estimated. Such population size estimates are often referred to as “absolute” abundance estimates (the density of animals present per unit area). When it is difficult to estimate absolute abundance with an acceptably low bias, relative abundance (number of animals) indices are often used instead. These indices that are believed to be proportional to population size, apart from stochastic variation, allowing trends in the population in space and/or time to be assessed.

There are two main approaches to account for availability bias either by using double platform surveys (for example Borchers *et al.*, 2002) which is logistically difficult to achieve and relatively expensive or by using known data on time spent underwater to apply correction factors to abundance estimates (for example Barlow *et al.*, 1988). Ideally correction factors for availability bias should be applied on a site-specific basis as there may be geographic variation in the estimates, however, in the absence of such data availability bias has been provided based on telemetry studies for harbour porpoise and grey seal. This is explained in appendix G: Marine Mammal and Megafauna Technical Report section 1.4.3.

3 RESULTS

3.1 Distance analysis

A summary of the results of distance correction models is provided in Table 3-1 with fitted detection functions and plots of detection distance against sea state presented in appendix A.2. Global Correction Factors (CFs) were derived from the surveyed transect distance for one side of the vessel (i.e. 500 m) divided by the Estimated Strip Width (ESW). The ESW represents the area under the detection function curve, or the distance to which the expected number of observations matches the observed numbers (Buckland *et al.,* 2001).

Table 3-1: Distance analysis results summary.

Species	Selected Model and Covariates	N obs	Detection Probability	ESW (±SE)	CF
Harbour Porpoise	Half normal detection function with size and Sea state covariates	531	0.577	288.5 (±12)	1.78
Grey Seal	Half normal detection function with size and Sea state covariates	55	0.40	200 (±45)	2.50
Minke Whale	Half normal detection function	22	0.582	291 (±48)	1.73

It can be seen from Table 3-1 that there was a decrease in detectability of all marine mammal species with distance, with the inclusion of sea state models for Harbour Porpoise and grey seal, illustrating the importance of environmental conditions on detectability (Table 3-1).

3.2 Spatial abundance and density mapping

To prepare for the GEE-CReSS analyses, a grid of abutting cells based on the transect routes and environmental covariates was constructed to cover the entire survey area. All variables except X and Y co-ordinate were included in the one-dimensional SALSA model selection method (Walker *et al.,* 2011) and automatic model simplification using non-significant p-values was carried out. An appropriate blocking structure using transect ID was included as there was evidence of autocorrelation.

CReSS was used to fit the spatial density surface and GEEs were used to provide realistic model-based estimates. The GEE-CReSS grid knot locations are included in appendix A.2. An interaction with month was included to allow the density surface to vary between months. Following predictions, bootstrapping was used to generate 95% confidence intervals for each grid cell to allow for an assessment of uncertainty. The bootstrapping procedure incorporated any autocorrelation specified within the prediction model following the CReSS method.

CReSS was used to fit the spatial density surface and GEEs were used to provide realistic model- based estimates. Following predictions, bootstrapping was used to generate 95% confidence intervals for each grid cell to allow for an assessment of uncertainty. The bootstrapping procedure incorporated any autocorrelation specified within the prediction model following the CReSS method.

3.2.1 Harbour Porpoise

There were 330 observations of 689 Harbour Porpoise recorded over the survey period. Mean group size was 2.

Model derived spatial abundance and density estimates

During initial data exploration and model fitting for Harbour Porpoise a high co-linearity/ correlation between bathymetry and distance to coast was identified resulting in a prohibitively high Variance Inflation Factor (VIF) for these parameters. The variance inflation factor is the quotient of the variance in a model with multiple terms by the variance of a model with one term alone. It quantifies the severity of multi-collinearity and the effect it will have on parameter estimates and in particular, the confidence we have in them. Because of this distance to coast was removed from the model. The following refined environmental and spatial covariates were used in the MRSea CReSS analysis for Harbour Porpoise:

- Bathymetry (depth in metres);
- Month (as a factor); and
- X and Y coordinates.

The initial one-dimensional SALSA model fitting for Harbour Porpoise failed to identify a suitable spline parameter for the inclusion of depth during the non-breeding season, as such depth was excluded as a linear parameter in the 2D spatial modelling step for the non-breeding season model (Aug-Mar) as opposed to a smoothed parameter. Depth was however included as a smoothed parameter in the breeding season model.

CReSS was used to fit the spatial density surface and GEEs were used to provide realistic model- based estimates.

Table 3-2 below presents the Harbour Porpoise modelled abundance estimates for the Survey Area by Season and Table 3-3 shows the modelled density estimates for this area. Figure 3-1 shows the monthly variation in densities of Harbour Porpoise across the Survey Area.

Table 3-2: Harbour Porpoise modelled relative (number) abundance estimates by month for the Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	17	10	30
February	16	7	39
March	12	5	29
April	19	5	54
May	6	3	14
June	5	2	12
July	1	0	7
August	5	1	44
September	17	8	27
October	12	5	24
November	2	0	28
December	16	9	31

Table 3-3: Harbour Porpoise modelled relative density (n/km²) estimates by month for the Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	0.61	0.36	1.08
February	0.58	0.25	1.41
March	0.43	0.18	1.05
April	0.69	0.18	1.95
May	0.22	0.11	0.51
June	0.18	0.07	0.43
July	0.04	0.00	0.25
August	0.18	0.04	1.59
September	0.61	0.29	0.97
October	0.43	0.18	0.87
November	0.07	0.00	1.01
December	0.58	0.32	1.12

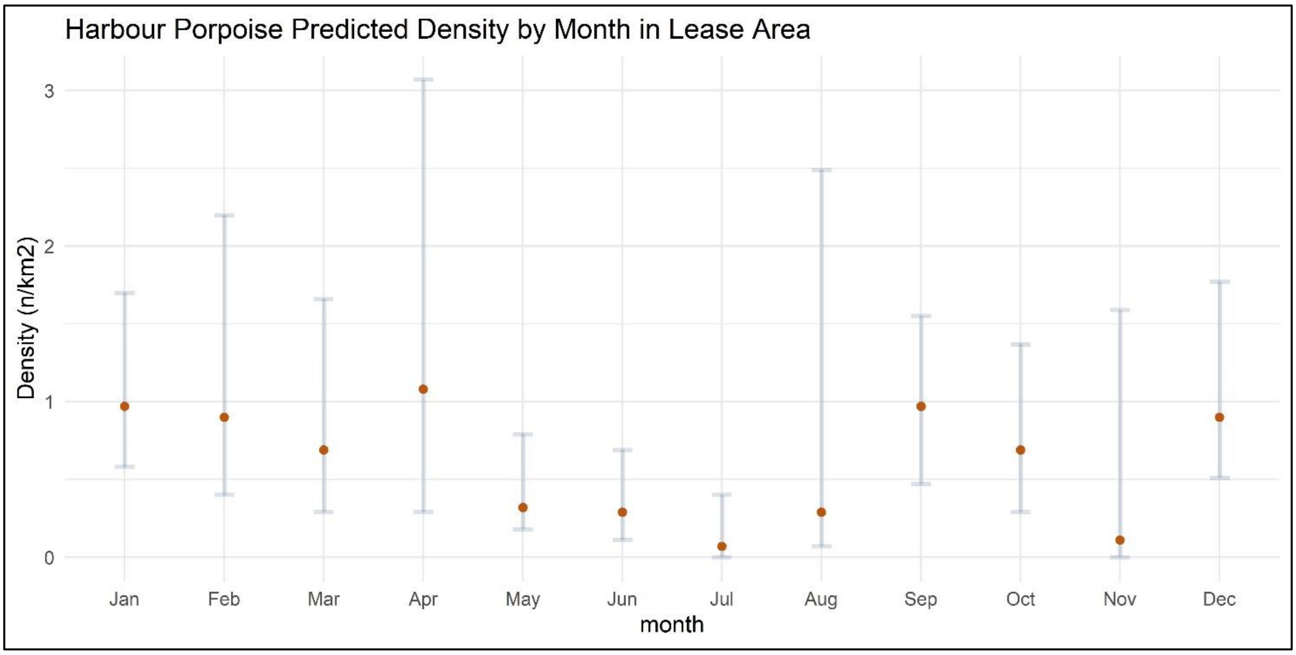

Figure 3-1: Predicted Harbour Porpoise availability bias corrected density in the Survey Area.

Table 3-4 below presents the Harbour Porpoise modelled abundance estimates for the Survey Area by Season and Table 3-5 shows the modelled density estimates for this area. Figure 3-2 shows the monthly variation in densities of Harbour Porpoise across the Survey Area.

Table 3-4: Harbour Porpoise modelled relative abundance (number) estimates by month for the Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	324	193	544
February	118	41	406
March	179	75	488
April	206	68	680
May	65	24	246
June	50	20	178
July	18	4	133
August	81	23	424
September	155	67	488
October	205	94	445
November	89	16	681
December	160	84	300

Table 3-5: Harbour Porpoise modelled relative density (n/km^2) estimates by month for the Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	0.88	0.52	1.47
February	0.32	0.11	1.10
March	0.49	0.20	1.32
April	0.56	0.18	1.84
May	0.18	0.07	0.67
June	0.14	0.05	0.48
July	0.05	0.01	0.36
August	0.22	0.06	1.15
September	0.42	0.18	1.32
October	0.56	0.25	1.21
November	0.24	0.04	1.85
December	0.43	0.23	0.81

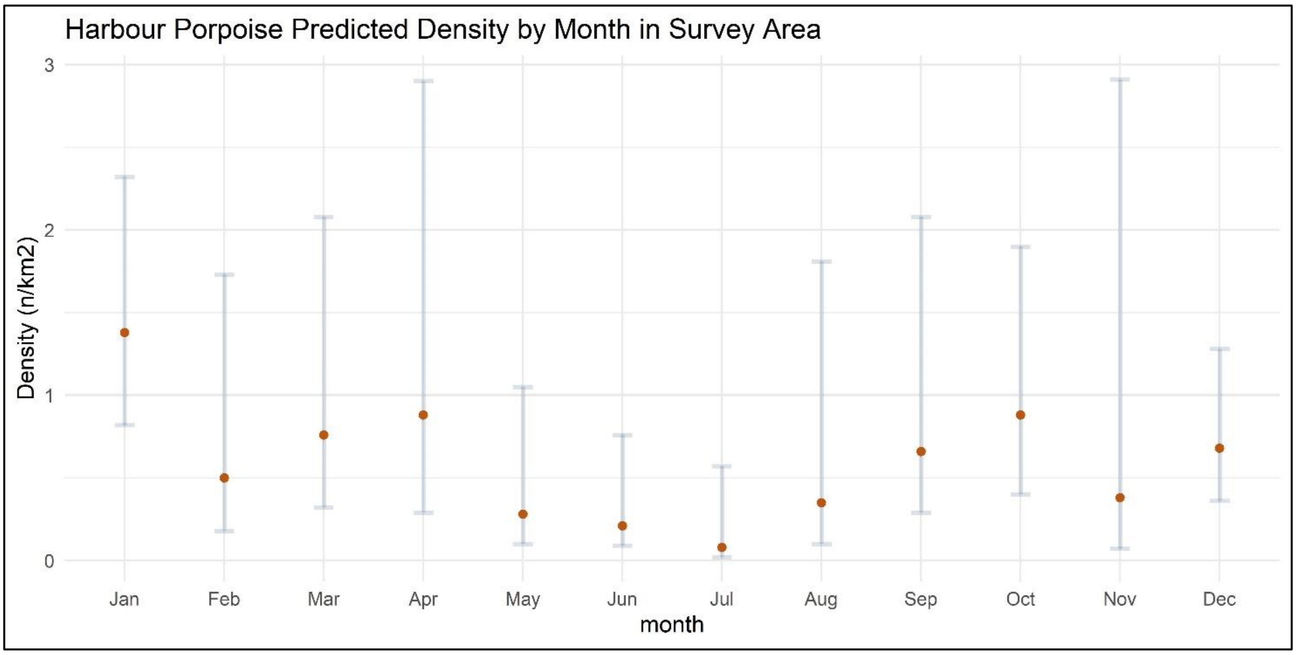

Figure 3-2: Predicted Harbour Porpoise availability bias corrected density in Survey Area.

3.2.2 Grey Seal

There were 56 observations of a total of 59 individual Grey Seal recorded over the survey period. Mean group size was 1.04.

Model derived spatial abundance and density estimates

During initial data exploration and model fitting a high co-linearity/ correlation between Bathymetry and distance to coast was identified resulting in a prohibitively high VIF for these parameters. Because of this distance to coast was removed from the model. The following refined environmental and spatial covariates were used in the MRSea CReSS analysis for Grey Seal:

- Bathymetry;
- Month (as a factor); and
- X and Y coordinates.

CReSS was used to fit the spatial density surface and GEEs were used to provide realistic model-based estimates. Table 3-6 and Table 3-7 below presents the Grey Seal modelled abundance and density estimates within the Survey Area respectively. Figure 3-3 shows the monthly variation in densities of Grey Seal across the Survey Area.

Table 3-6: Grey Seal modelled relative abundance (number) estimates by month for the Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	0	0	3
February	0	0	5
March	12	3	41
April	0	0	1
May	1	0	7
June	2	0	25
July	0	0	0
August	1	0	7
September	2	1	4
October	0	0	5
November	0	0	0
December	1	0	8

Table 3-7: Grey Seal modelled relative density (n/km^2) estimates by month for the Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	0.00	0.00	0.11
February	0.00	0.00	0.18
March	0.43	0.11	1.48
April	0.00	0.00	0.04
May	0.04	0.00	0.25
June	0.07	0.00	0.90
July	0.00	0.00	0.00
August	0.04	0.00	0.25
September	0.07	0.04	0.14
October	0.00	0.00	0.18
November	0.00	0.00	0.00
December	0.04	0.00	0.29

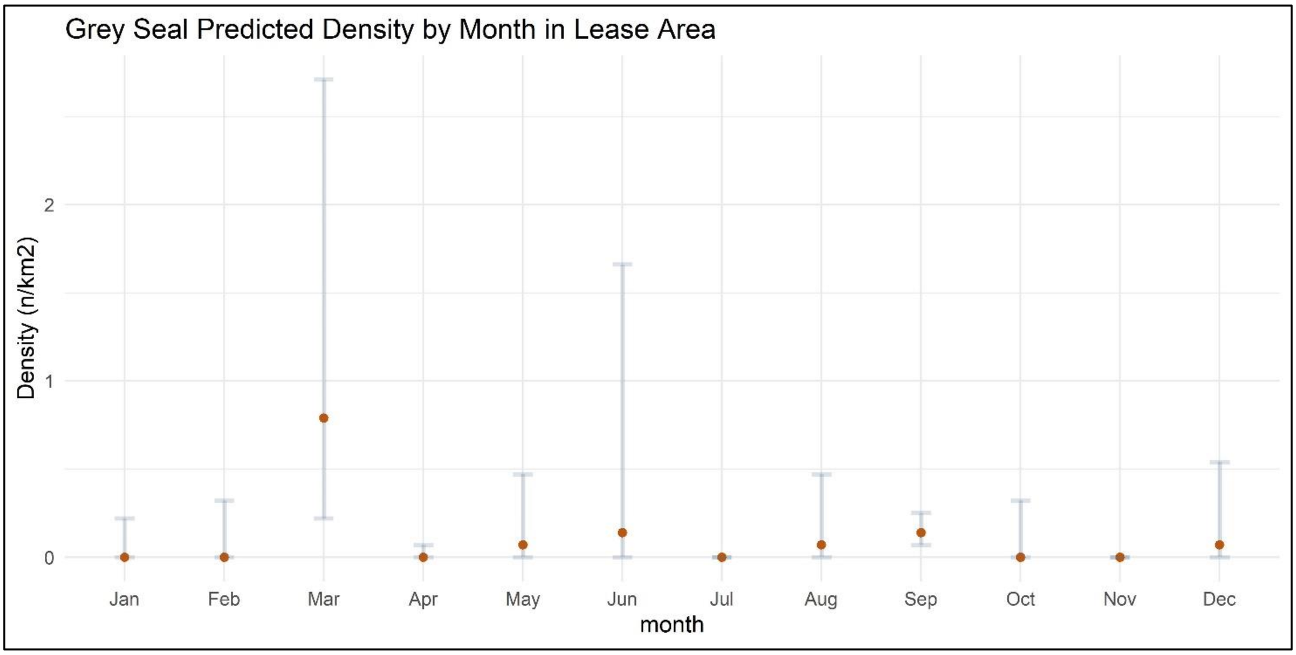

Figure 3-3: Predicted Grey Seal availability bias corrected density in the Survey Area.

Table 3-8 and Table 3-9 below presents the Grey Seal modelled abundance and density estimates respectively within the Survey Area. Figure 3-4 shows the monthly variation in densities of Grey Seal across the Survey Area.

Table 3-8: Grey Seal modelled relative abundance (number) estimates by month for the Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	21	7	89
February	11	4	78
March	42	12	181
April	7	3	29
May	37	10	194
June	12	2	122
July	0	0	0
August	18	4	175
September	26	8	97
October	5	0	227
November*	NA	NA	NA
December	17	4	88

* - Due to incomplete survey coverage in this month, no estimate was possible.

Table 3-9: Grey Seal modelled relative density (n/km^2) estimates by month for the Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	0.06	0.02	0.24
February	0.03	0.01	0.21
March	0.11	0.03	0.49
April	0.02	0.01	0.08
May	0.10	0.03	0.53
June	0.03	0.01	0.33
July	0.00	0.00	0.00
August	0.05	0.01	0.47
September	0.07	0.02	0.26
October	0.01	0.00	0.62
November*	NA	NA	NA
December	0.05	0.01	0.24

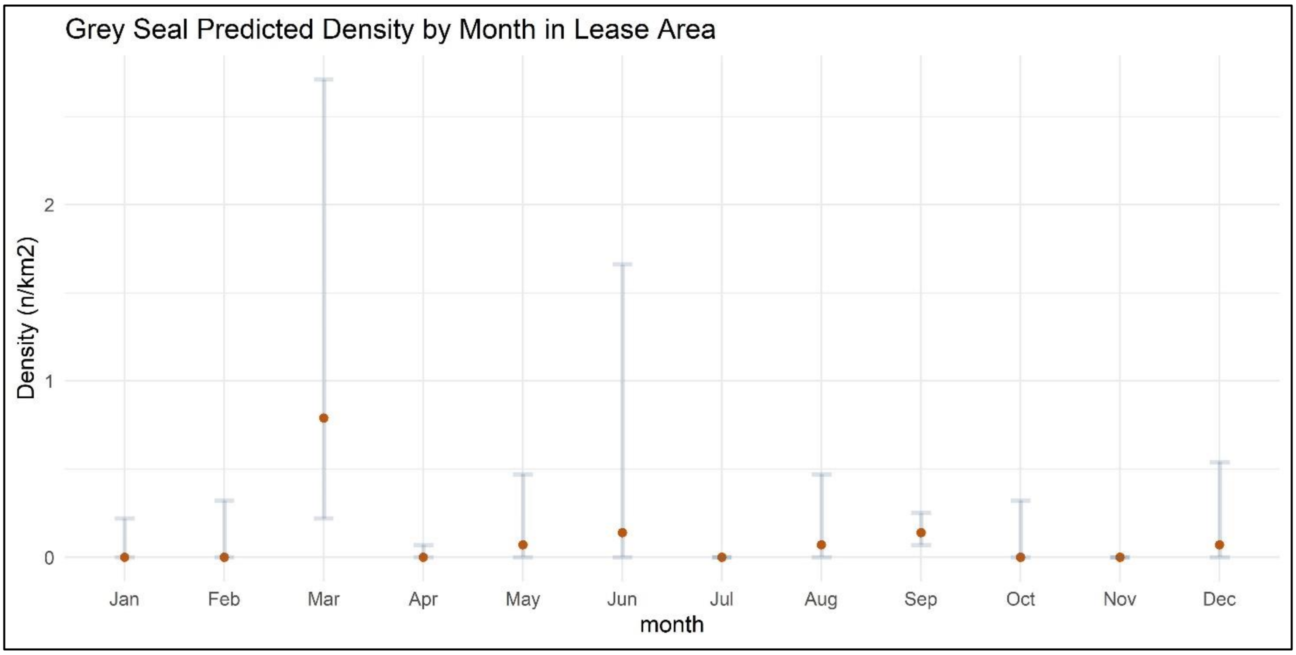

Figure 3-4: Predicted Grey Seal availability bias corrected density in the Survey Area.

3.2.3 Minke Whale

There are 27 observations of 30 individual Minke Whale recorded over the survey period. Mean group size was 1.

Model derived spatial abundance and density estimates

During initial data exploration and model fitting a high co-linearity/ correlation between Bathymetry and distance to coast was identified resulting in a prohibitively high VIF for these parameters. Because of this distance to coast was removed from the model. The following environmental and spatial covariates were used in the MRSea CReSS modelling for Minke Whale:

- Bathymetry (in metres);
- Month (as a factor); and
- X and Y coordinates

CReSS was used to fit the spatial density surface and GEEs were used to provide realistic model- based estimates. The breeding season model (months April to July) failed to converge and as such we were unable to generate monthly estimates for this period.

Table 3-10 and Table 3-11 below presents the Minke Whale modelled abundance and density estimates respectively for the Survey Area. Figure 3-5 shows the monthly variation in densities of Minke Whale across the Survey Area.

Table 3-10: Minke Whale modelled monthly abundance (number) estimates for the Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	0	0	0
February	0	0	0
March	0	0	0
April*	NA	NA	NA
May*	NA	NA	NA
June*	NA	NA	NA
July*	NA	NA	NA
August	3	0	51
September	0	<1	95
October	1	0	31
November	0	0	0
December	0	0	0

* - breeding season model did not converge due to low sample size. As such estimates for breeding season months were not able to be generated.

Table 3-11: Minke Whale modelled monthly density (n/km²) estimates for the Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	0.00	0.00	0.00
February	0.00	0.00	0.00
March	0.00	0.00	0.00
April*	NA	NA	NA
May*	NA	NA	NA
June*	NA	NA	NA
July*	NA	NA	NA
August	0.11	0.00	1.84
September	0.00	0.00	3.43
October	0.04	0.00	1.12
November	0.00	0.00	0.00
December	0.00	0.00	0.00

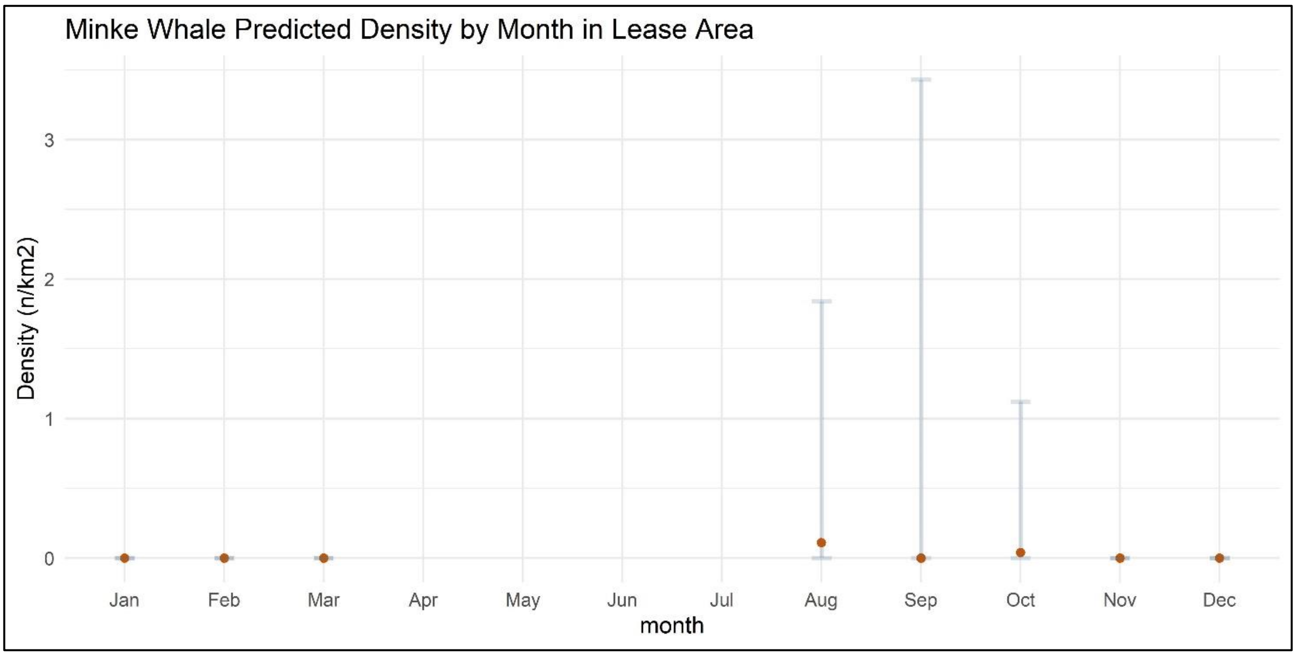

Figure 3-5: Predicted Minke Whale density in Survey Area.

Table 3-12 and Table 3-13 below presents the Minke Whale modelled abundance and density estimates respectively for the Survey Area. Figure 3-6 shows the monthly variation in densities of Minke Whale across the Survey Area.

Table 3-12: Minke Whale modelled abundance (numbers) estimates for Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	0	0	0
February	0	0	0
March	0	0	0
April*	NA	NA	NA
May*	NA	NA	NA
June*	NA	NA	NA
July*	NA	NA	NA
August	69	2	1349
September	19	2	573
October	4	0	138
November	0	0	0
December	0	0	0

* - Breeding season model did not converge due to low sample size. As such estimates for breeding season months were not able to be generated.

Table 3-13: Minke Whale modelled density (n/km^2) estimates for Survey Area.

Month	Estimate	LCL (95%)	UCL (95%)
January	0.00	0.00	0.00
February	0.00	0.00	0.00
March	0.00	0.00	0.00
April*	NA	NA	NA
May*	NA	NA	NA
June*	NA	NA	NA
July*	NA	NA	NA
August	0.19	0.01	3.66
September	0.05	0.01	1.55
October	0.01	0.00	0.37
November	0.00	0.00	0.00
December	0.00	0.00	0.00

* - Breeding season model did not converge due to low sample size. As such estimates for breeding season months were not able to be generated.

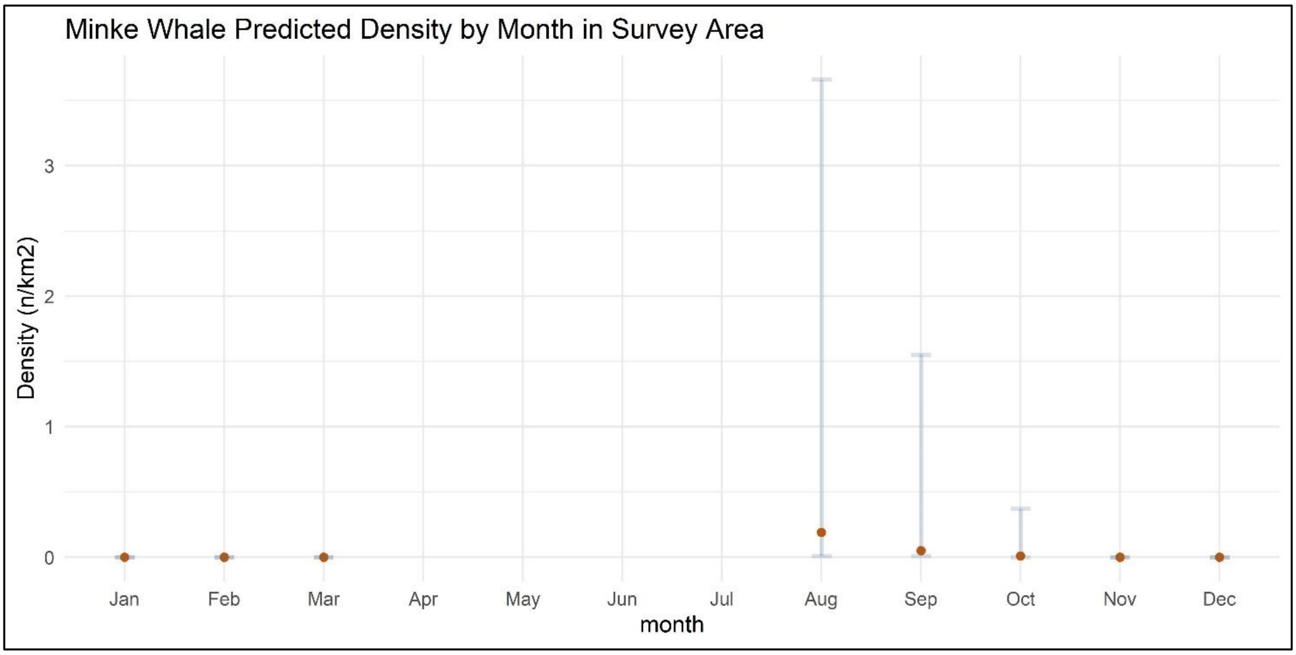

Figure 3-6: Predicted Minke Whale density in Survey Area.

4 SUMMARY

This data report provides a description of the abundance and densities of key marine mammal species within the Survey Area specifically. Sufficient data were available for analyses for the following species: Harbour Porpoise, Grey Seal and Minke Whale.

Sightings data for these key marine mammal species recorded during the boat-based surveys together with environmental covariates were analysed in MRSea to provide estimates of the abundance and densities of marine mammals monthly. Geo-referenced data were subsequently generated to produce spatially explicit plots of the marine mammals and these are presented in appendix G: Marine Mammal and Megafauna Technical Report.

Abundance and density estimates generated by the model provide an estimate of the relative densities of the marine mammal species but do not account for availability bias. Further information on this is provided in of the appendix G: Marine Mammal and Megafauna Technical Report, section 1.4.4.

A.1 Baseline survey reports

Where distances to European sites are quoted in this document, the reader should instead refer to those quoted in the Natura Impact Statement (NIS).

Aquafact Ltd.

Oriel Wind Farm

Seabird and Marine Mammal Surveys

Baseline Ecology Report

May 2018 – April 2019

November 2019

INIS Environmental Consultants Ltd.

Suite 11,
Shannon Commercial Properties,
Information Age Park,
Ennis,
County Clare
Ireland.

Inis

Quality Assurance

The findings outlined within this report and the data we have provided are to our knowledge true and express our bona fide professional opinions. This report has been prepared and provided in accordance with the Chartered Institute of Ecology and Environmental Management (CIEEM) Code of Professional Conduct. Where pertinent, CIEEM Guidelines used in the preparation of this report include the *Guidelines for Ecological Report Writing* (CIEEM, 2017), *Guidelines for Preliminary Ecological Appraisals* (CIEEM, 2015) and *Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine*, (CIEEM, 2018). CIEEM Guidelines include model formats for Preliminary Ecological Appraisal and Ecological Impact Assessment. Also, where pertinent, evaluations presented herein take cognisance of recommended Guidance from the EPA such as *Draft Guidelines on the information to be contained in Environmental Impact Assessment Reports* (EPA, 2017), and in respect of European Sites, *Managing Natura 2000 sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC* (European Commission, 2018).

Additional non-statutory Guidance referenced in the preparation of this report includes *Guidance on EIS and NIS preparation for Offshore Renewable Energy Projects* (DCCAE, 2017); *Guidance on Marine Baseline Ecological Assessments & Monitoring Activities for Offshore Renewable Energy Projects: Part 1 April 2018* (DCCAE, 2018a), and *Guidance on Marine Baseline Ecological Assessments & Monitoring Activities for Offshore Renewable Energy Projects: Part 2 April 2018* (DCCAE, 2018b)

Due cognisance has been given at all times to the provisions of the *Wildlife Act (1976),* the *Wildlife (Amendment) Act (2000),* the *European Union (Natural Habitats) Regulations (SI 378/2005)*, the *European Communities (Birds and Natural Habitats) Regulations (2011),* EU Regulation on Invasive Alien Species under *EU Regulation 1143/2014*, the *EU Birds Directive 2009/147/EC* and the *EU Habitats Directive 92/43/EEC.*

No method of assessment can completely remove the possibility of obtaining partially imprecise or incomplete information. In line with Best Practice, any limitation to the methods applied or constraints however are clearly identified within the main body of this document.

Version	Date		Name	Signature
1	10/05/19	Report prepared by:	Dr. Alex Copland BSc PhD	
1	10/05/19	Report checked by:	Chris Cullen DFE, HND Eng. ACIEEM.	
1	10/05/19	Report approved by:	Howard Williams CEnv, MCIEEM CBiol MRSB MIFM	
Title		Oriel Windfarm Seabird and Marine Mammal Surveys: Baseline Ecology Report (May 2018 – April 2019)		

Version	Date		Name	Signature
2	14/05/19	Report prepared by:	Dr. Alex Copland BSc PhD	
2	14/05/19	Report checked by:	Chris Cullen DFE, HND Eng. ACIEEM.	
2	14/05/19	Report approved by:	Howard Williams CEnv, MCIEEM CBiol MRSB MIFM	
Title		Oriel Windfarm Seabird and Marine Mammal Surveys: Baseline Ecology Report (May 2018 – April 2019)		
Reason for Change		Client Comments		

Version	Date		Name	Signature
3	12/11/19	**Report prepared by:**	Joao Martins MSc MIENVSC	
3	13/11/19	**Report checked by:**	Jennifer Pearson MSc ACIEEM	
3	13/11/19	**Report signed off by:**	Chris Cullen DFE, HND Eng. ACIEEM	
Title		Oriel Windfarm Seabird and Marine Mammal Surveys: Baseline Ecology Report (May 2018 – April 2019)		
Reason for Change		Client Comments – Figure corrections.		

Notice

This report was produced by INIS Environmental Consultants Ltd (INIS) on behalf of Aquafact Ltd. for the specific purpose of assessing the bird and mammal usage on marine areas offshore of Co. Louth with all reasonable skill, care and due diligence within the terms of the contract with the client, incorporating our terms and conditions and taking account of the resources devoted to it by agreement with the client.

This report may not be used by any person other than Aquafact Ltd., the client, without the client's express permission. In any event, INIS accepts no liability for any costs, liabilities or losses arising as a result of the use of or reliance upon the contents of this report by any person other than the client.

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Table of Contents

SUMMARY

This report outlines the results and findings of baseline bird and marine mammal surveys in respect of a marine renewable energy site located near Clogher Head. Inis Environmental Consultants (IEC) have been commissioned to carry out these surveys on behalf of Aquafact Ltd (Aquafact).

Based on data collected to date (May 2018 to April 2019 inclusive), it is our professional opinion that no substantial ecological (bird or marine mammal) constraints have been recorded during the surveys described herein. However, the current dataset is relatively small and further surveys and extended analysis to ensure a final robust baseline dataset (i.e. fully compliant with Best Practice) which allows for a complete and lacuna-free assessment in respect of the EIA Directive and Habitats Directive (should it be required) are recommended.

- Current survey effort should continue (2019) to ensure that baseline data is robust in respect of seasonality and also adherence to Best Practice (in particular with regard to birds offshore);
- For the baseline surveys of any potential offshore windfarm development, the approach used in the UK and elsewhere in Europe, involves undertaking at minimum 24 monthly surveys of the proposed windfarm site that collect at least 10% coverage of the proposed footprint with at least a 4 km buffer is followed.
- Within the Irish context recent non-statutory Guidance recommends a minimum of 3 years of baseline data be collected in respect of birds (DCCAE, 2018) if no previous data is available for the area, and 2 years baseline data if previous data is available and/or the sensitivity of the site is low. For Marine mammals, similarly, 3 years is recommended with two years considered "*an absolute minimum where data is lacking*".
- Recent advice on the lifespan of ecological survey data suggests datasets >3 years old are unlikely to be valid, subject to review by a professional ecologist, with regard to the distribution of mobile species whose distribution within a development site may be subject to change (CIEEM, 2019).
- We therefore recommend that the surveys be completed for a further 24-month period at minimum unless statutory consultation offers written advice to the contrary, ensuring a total of 3 years of up-to-date baseline data is at hand to inform any impact assessment requirements. This is the most risk-averse approach given the methods and quality of any available desktop data (e.g. Observe data (Jessop *et al.,* 2018)) may not be comparable to current methods.

It is also recommended that further liaison takes place with Irish regulatory authorities to ensure that the continuing survey approach and data analysis is acceptable. Despite a standard survey approach existing for offshore wind developments in some countries, ongoing liaison with Regulatory Bodies and Stakeholders is an important part of the process. Given that the offshore wind industry is relatively new to Ireland, this process is particularly important, and a written record of consultation on e.g. survey effort, identification of constraints, efficacy of data examination in respect of key receptors is required.

It is strongly recommended that surveys (bird and marine mammal) continue for the requisite Best Practice period to ensure an up-to-date robust baseline dataset is available for the future consideration of likely significant effects, when and where required, in addition to ensuring compliance with recent ECJU judgements such as on e.g. the level and sufficiency of baseline data required to inform the consideration of ex-situ effects on European Sites.

1. INTRODUCTION

Inis Environmental Consultants (IEC) have been commissioned to carry out baseline bird and marine mammal surveys in relation to the Oriel Windfarm Licence area in the Irish Sea off Clogher Head, Co. Louth. This report summarises the results for the period May 2018 to April 2019 inclusive.

1.1 Limitations

There are a number of limitations inherent to field-based surveying in the marine environment and the analysis of complex, ecological data. These are indicated below and have been considered in the presentation of results and in the discussion sections.

1.1.1 Survey limitations

These particularly relate to availability of suitable weather and sea conditions for completing surveys, with good visibility and little wind or rain of paramount importance. As such, when undertaking and completing fieldwork, careful consideration and planning is made to ensure optimal weather conditions during survey periods.

For the boat-based seabird surveys, qualified ESAS surveyors are required as well as an appropriate survey vessel. There are a limited number of ESAS qualified and appropriately experienced ecologists available in Ireland to undertake this work. Surveys schedules therefore needed to consider the availability of the survey vessel and a team of surveyors as well as optimal weather conditions.

Throughout the survey period reported here, only one survey day was missed (in November 2018) which was largely due to weather constraints. As a result, the survey visit undertaken in November covered alternate transects throughout the survey area to achieve representative sampling coverage across the whole site. The absence of partial data from one month has been taken into account in the presentation of the results.

1.1.2 Data limitations

With large sets of complex ecological data, there can be many methods of presentation, interpretation and analysis. The data presented within this report have been tailored to meet the needs of the client. The data presented in the results section are therefore based on approaches used in previous reports of seabirds at the Oriel Windfarm area (Aquafact, 2009), and are described in the Methods section. However, other approaches to data presentation and analysis have been used in other studies of seabirds at sea, and these may offer greater ecological refinement and allow alternative interpretation of the data presented. Alternative approaches to analysis are considered further in the Discussion section.

1.2 Statement of Authority

The following staff at IEC worked on this report.

Mr Howard Williams MCIEEM CEnv CBiol MRSB MIFM is Lead Ecologist with Inis and has more than 20 years' experience as a professional ecologist, specialising in birds.

Following his degree, he worked as a biologist for the ESB for three years (1997-2000). Mr Williams has completed in excess of 500 separate ecology assessments in Ireland and the UK since 2000. Mr Williams is a full member of the Chartered Institute of Ecology and Environmental Management (CIEEM). He is a Chartered Environmentalist (CEnv) with the Society for the Environment (Soc Env) and a Chartered Biologist (CBiol) with the Society of Biology. He is also a full member of the Institute of Fisheries Management. Mr Williams is principal ecologist with INIS Environmental Consultants Ltd and currently project manager on all INIS projects in the Republic of Ireland and the UK.

Mr. Chris Cullen Dip. Eng. Dip. Ecol. ACIEEM is a Senior Ecologist with INIS and has more than 10 years' experience as a professional ecologist, specialising in birds.

Chris is an Associate Member of the Chartered Institute of Ecology and Environmental Management. He holds a Higher National Diploma in Engineering and a further Diploma in Field Ecology. Chris has a broad range of experience within the environmental sector. He is a specialist in Ornithological survey and assessment and has experience at a professional and voluntary level of a wide range of bird survey techniques. He is interested in wintering wildfowl and has been a contributor to IWeBS and Low Tide count studies across the south of Ireland. He has conducted specific research on the diet of wintering raptors such as Short-eared Owl and Hen Harrier. Chris has been a co-recipient of the BTO Boddy and Sparrow prize in respect of research on the roosting of Barn Swallows.

He also has experience in Project Management, Appropriate Assessment (Case law), Expert Witness testimony, Legal review, Due Diligence, Cumulative Impact Assessment, Habitat Mapping, Mitigation Development, EIA, Collision Risk Modelling, Biomonitoring, Education, and Public Speaking. Over the last number of years Chris has been involved in a number of significant SID Projects and has overseen Ecology requirements from Scoping Stage through planning and oral hearing. Chris has had a number of papers published in peer reviewed publications such as Irish Birds, The Irish Naturalists Journal, The Proceedings of the Royal Irish Academy, Ringing and Migration and In Practice. Chris has also been a named author on additional papers published in journals such as Ibis.

Dr. Alex Copland BSc PhD.

Dr. Copland is Senior Ecologist with INIS and has over 20 years of bird survey experience. He is proficient in experimental design and data analysis and has been working on bird populations on in Ireland for over 12 years. He has managed several large-scale, multi-disciplinary conservation projects, including research and conservation work for species of conservation concern, the design and delivery of practical conservation actions with a range of stakeholders and end-users, education and interpretation on the interface between people and the environment and the development of co-ordinated, strategic plans for birds and biodiversity in Ireland, where he has worked with NGOs and industry as well as public officials, and the EU, where he has worked with EU-level NGOs as well as EU institutions (EU Commission and EU Parliament).

He has written numerous scientific papers, developed and contributed to evidence-based position papers, visions and strategies on birds and habitats in Ireland. He has supervised the successful completion of research theses for several post-graduate students, including doctoral candidates. He lectures to both undergraduate and post-graduate students at UCD, as well as being a collaborative researcher with both UCD and UCC. He also sits on the Editorial Panel of the scientific journal, *Irish Birds*.

2. METHODS

2.1 Survey Area

The survey area comprises an area of open marine habitats north-east of Clogher Head in the Irish Sea (see Figure 2.1).

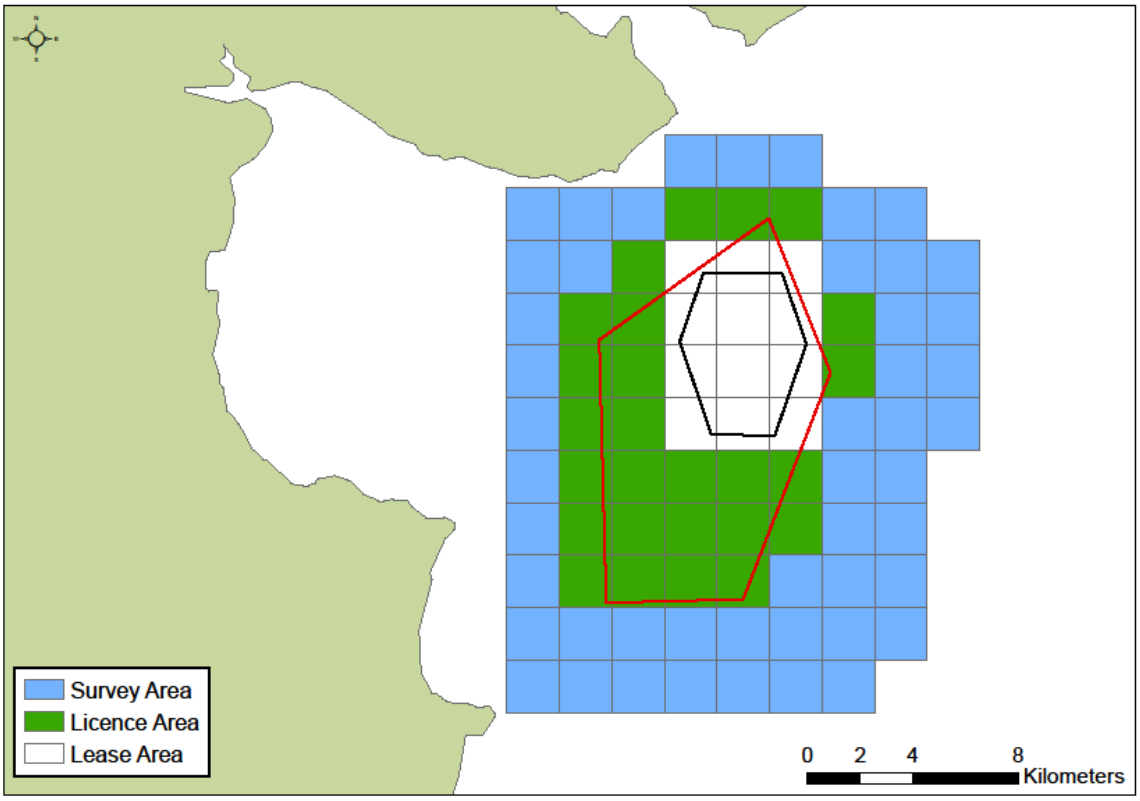

Figure 2.1 Survey area, transect route (horizontal grid lines), 2km square grid and survey zones for the Oriel Wind farm Survey Area

2.1.1 Transects routes

Following recommendations from Best Practice guidelines for surveying (Camphuysen *et al*., 2004), line-transects spaced across the survey area, a minimum of 0.5 nm apart up to a maximum spacing of 2nm were used. For this survey, transect spacing of 2km was used (see Figure 2.1; transect lines are the horizontal lines in the grid, numbered from 1 (in the south) to 11 (in the north); the top three squares therefore relate to transect 11).

2.1.2 Weather conditions

Weather and sea conditions were recorded for all survey visits, and Best Practice requirements were strictly adhered to for both seabirds at sea and marine mammal surveying.

2.2 Avian (Seabirds at Sea) Surveys

Standardised seabirds at sea census techniques were used for the bird survey work described here (Camphuysen *et al*., 2004; Johansen *et al.*, 2014). These are described in brief below.

2.2.1 Field survey methods

Surveys incorporate three elements of data collection. The transect surveys birds perpendicular to the direction of travel on one side of the boat, out to 300m. A scan surveys an arc of 90° from directly in front to one side, recording all birds within a quadrat with sides 300m to the front and side of the observer. Also, a "snapshot" is used for flying birds, whereby all birds are recorded every minute within the 300m quadrat. Each bird record from the transects survey is allocated to five distance bands:

- A: 0-50m
- B: 50-100m
- C: 100-200m
- D: 200-300m
- E: 300m+

For all bird sightings, the following details are recorded (where feasible):

- Species
- Sex, age and plumage characteristics (dependent upon species)
- Behaviour
- Flight height (if flying) with direction

Surveys should only be conducted in suitable weather conditions (less than sea state 5), from a ship deck height of 5-25m (5m for this study), travelling between 5 and 15 knots (typically 10-11 knots for the work described here).

For each survey visit, two trained ESAS surveyors were used: one to observe birds and one to scribe and make notes.

2.2.2 Data interpretation and analysis

All abundance data were recorded on field sheets and these were transferred to Excel. Abundance data from the transect surveys only were allocated to 2km section of each transect (in line with previous surveys undertaken (Aquafact, 2009) to create a 2km x 2km grid within the survey area (See Figure 2.1). As the boat moved at a constant speed along each transect, and the start and finish times and transect length were recorded, the individual location of each bird could be plotted using the time of the sighting. These were calculated and mapped using ArcGIS (version 10.4.1).

The survey grids were allocated to one of three zones: Lease Area, Licence Area and Survey Area (See Figure 2.1). All squares which touched the identified Lease area were allocated to that Zone. All squares outside of the Lease area but were wholly or partially within the Licence area were allocated to the Licence area, and the remaining squares were allocated to the Survey area.

Density estimates were derived from data using the approach adopted in previous work at the Oriel Wind farm site (Aquafact, 2009). Only birds within 200m of the transect line (e.g. Distance Bands A, B and C). For each 2km section of the transect route, the number of birds occurring in these distance bands were noted, and the multiplication factor from Stone *et al.,* (1995) applied. As these data cover an area of 0.4km^2 (2km x 200m) these were then multiplied by 2.5 to generate density estimates of birds/km^2.

2.3 Marine Mammal Surveys

Marine mammal sightings were undertaken using certified MMO's following a similar approach to the recording methodology for the seabird surveys (Berrow *et al*., 2014), with the same transect routes used. For Marine mammals, all animals are recorded, with the distance to each sighting noted. Furthermore, the survey extends to an 180° arc in front of the ship.

Recorded data per sighting includes the age and sex of the individual (where possible), the distance from the vessel where the animal was observed and the behaviour, bearing and direction of travel. Additional observations of species of interest such as Basking Shark and Pinniped species were also noted.

We note that dedicated Marine Mammal Observation (MMO) studies did not commence until August 2018. Prior to August (i.e. May, June and July 2018) marine mammals were recorded as they occurred 'in transect' and out with, where possible, by the ESAS surveyors (one of whom was also a certified MMO).

3 BIRD SURVEY RESULTS

Bird data are presented below on a species-by-species basis to assist in interpretation of the data collection. The collective occurrence of species is considered in the Discussion (Section 5).

For all species, monthly data for bird recorded on the fixed transects (i.e. within 300m of one side of the boat) are indicated, and it is these records that are used in populating the abundance maps (see Section 2.2 for a description of how these abundance maps are derived from the raw survey data). Additional observations of birds recorded during surveys, but not allocated to the transect, are also indicated within the “All records” column, which includes all bird observed (whether present on the transect or recorded incidentally).

A separate sub-section of maps shows density estimates for selected species, derived from abundance maps (see Section 2.2. for a description of how the density estimates were derived from the abundance data).

3.1 Common Scoter

Common Scoter are scarce breeders in Ireland with c.40 pairs estimated (Hunt *et al.*, 2013), and are Red-listed as Birds of high conservation concern due to long-term (25-year) population declines (Colhoun & Cummins, 2013). They favour large inland waterbodies with tree or shrub-covered islands to nest. In winter they flock in large numbers in offshore habitats, often over shallow (<20m), sandy substrates where they dive for small benthic bivalve molluscs on (or within the upper few centimetres) of the substratum (Fox, 2003; Kaiser *et al*., 2006).

3.1.1 Common Scoter Abundance

Data from fieldwork indicates that Common Scoter are present in varying numbers in the survey area throughout the year (see Table 3.1.1) with a maximum of 880 records (including a flock of 850 individuals) in May 2018 and no birds recorded in July 2018, September 2018 or April 2019

Common Scoter were recorded occasionally on transects during the fieldwork period (see Figures 3.1.1 to 3.1.5), with a maximum of 106 in January 2019 (see Figure 3.1.5). Birds were all typically recorded in the north-western corner of the survey area except for one flock of eight birds on the sea at the southern edge of the survey area in November 2018 (Figure 3.1.4). No birds were recorded from transect sections within the Lease area during surveys, and only one flock (consisting of ten individuals in flight) was recorded on a transect section at the north-western corner of the Licence area in May 2018 (Figure 3.1.1).

Table 3.1.1 Common Scoter records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	10	880
June 2018	4	8
July 2018	0	0
August 2018	0	42
September 2018	0	0
October 2018	2	31
November 2018	8	49
December 2018	0	43
January 2019	106	247
February 2019	0	39
March 2019	50	86
April 2019	0	5
TOTAL	**180**	**1430**

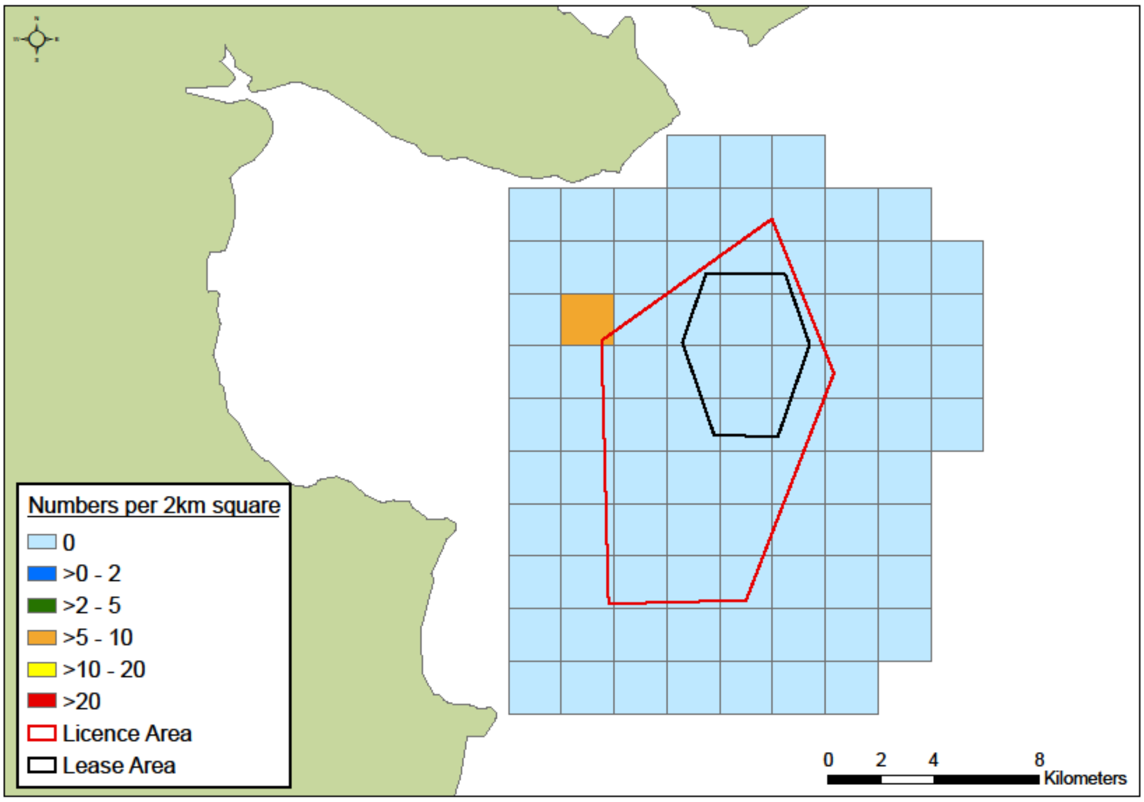

Figure 3.1.1 Common Scoter survey results May 2018.

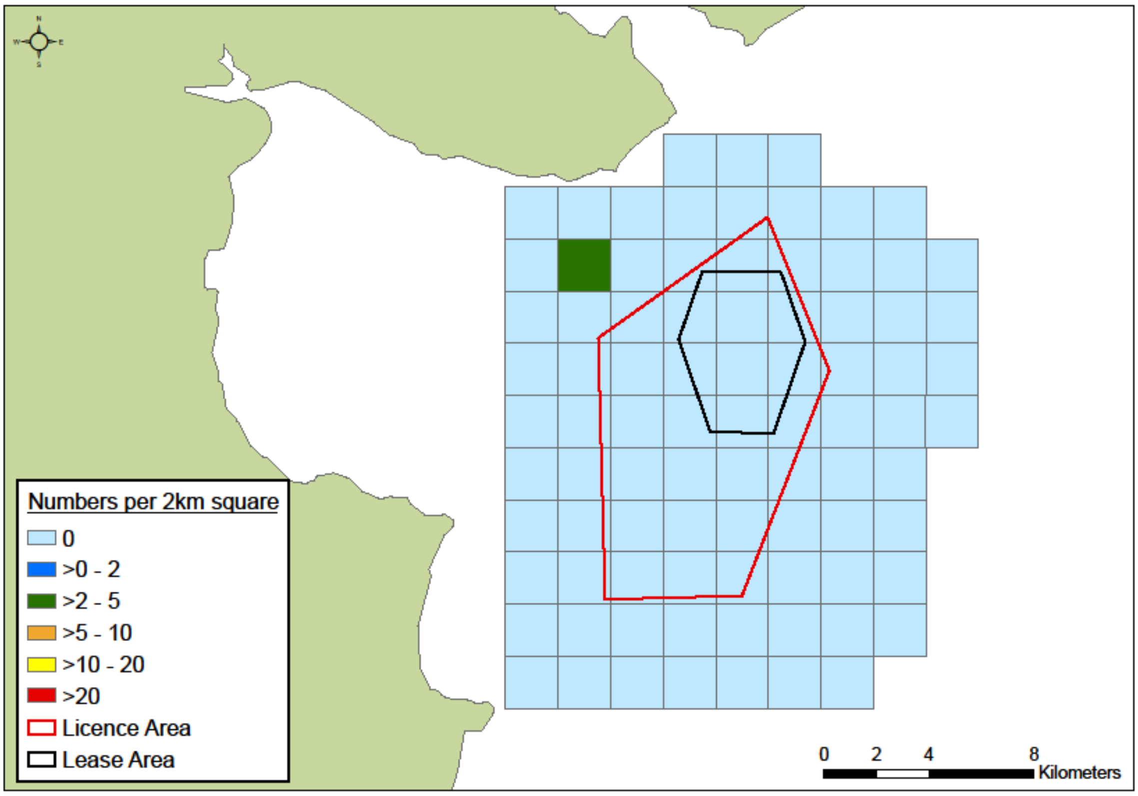

Figure 3.1.2 Common Scoter survey results June 2018.

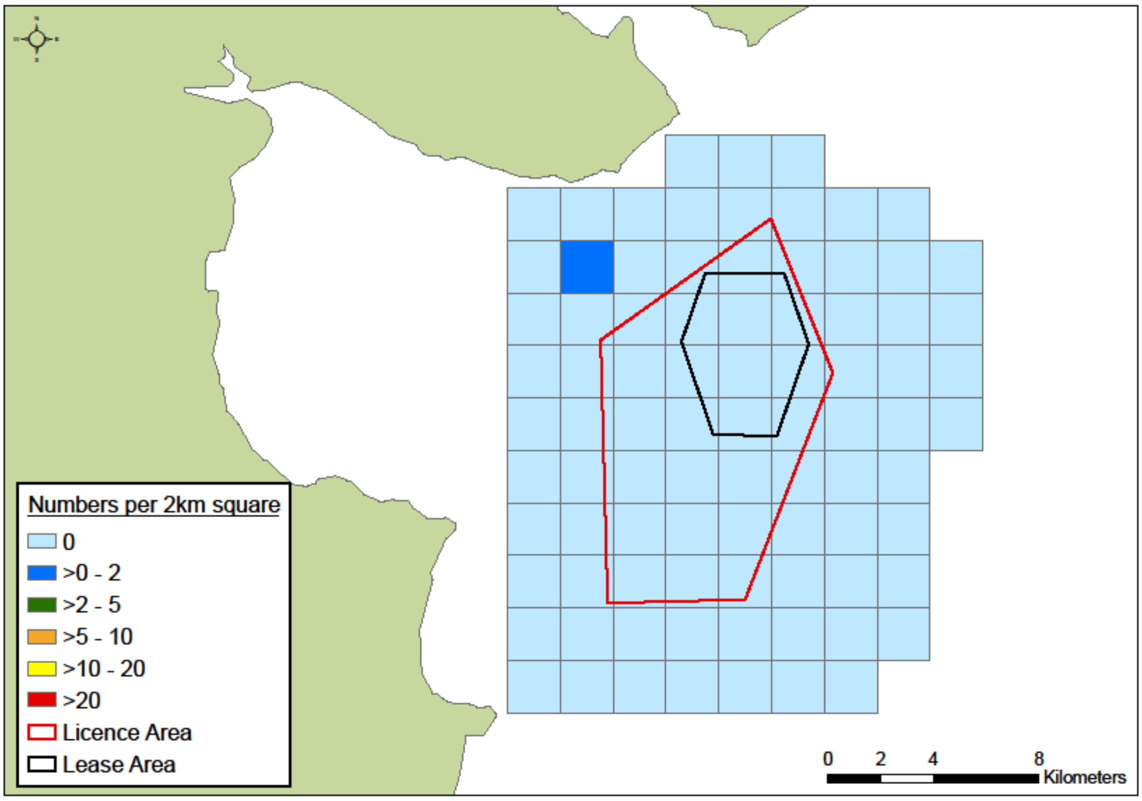

Figure 3.1.3 Common Scoter survey results October 2018.

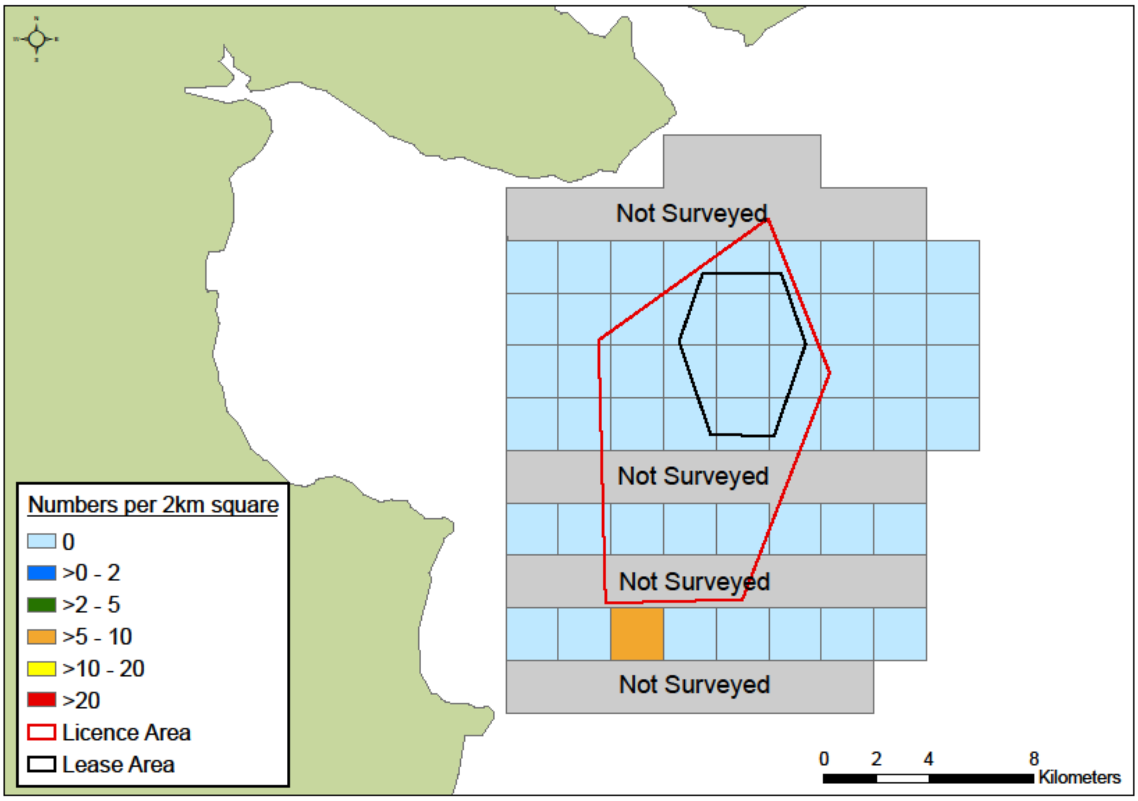

Figure 3.1.4 Common Scoter survey results November 2018.

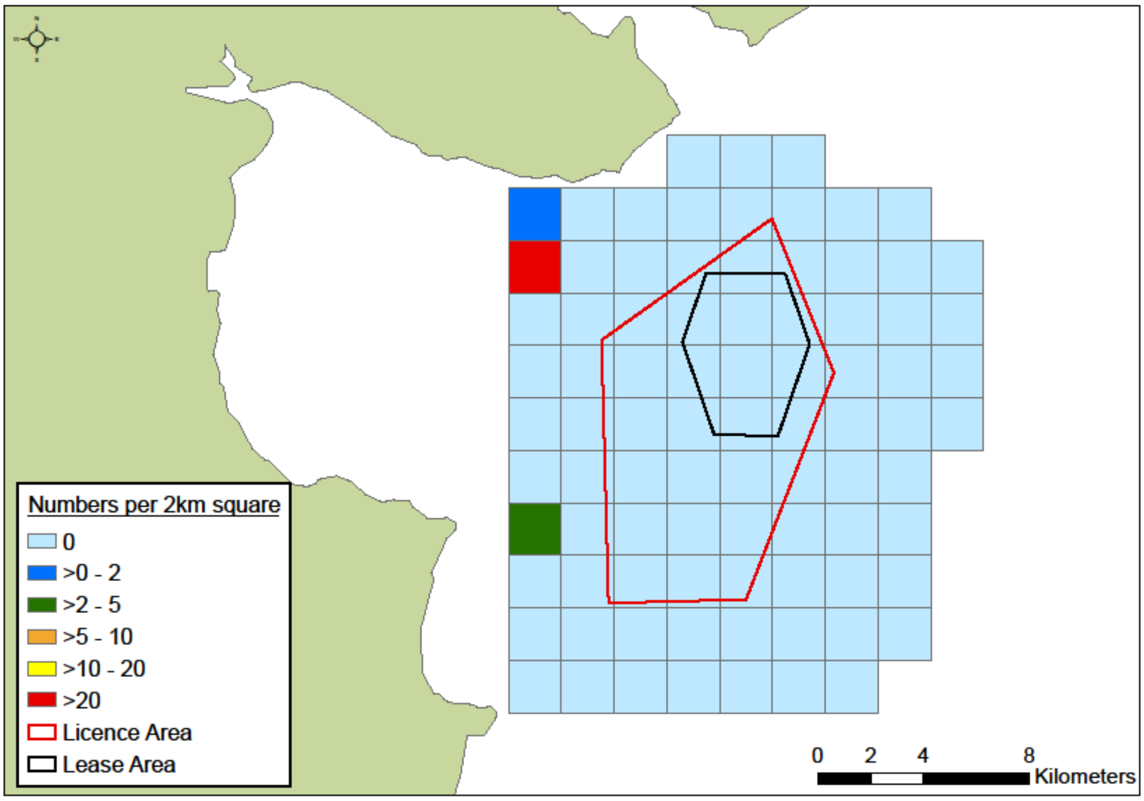

Figure 3.1.5 Common Scoter survey results January 2019

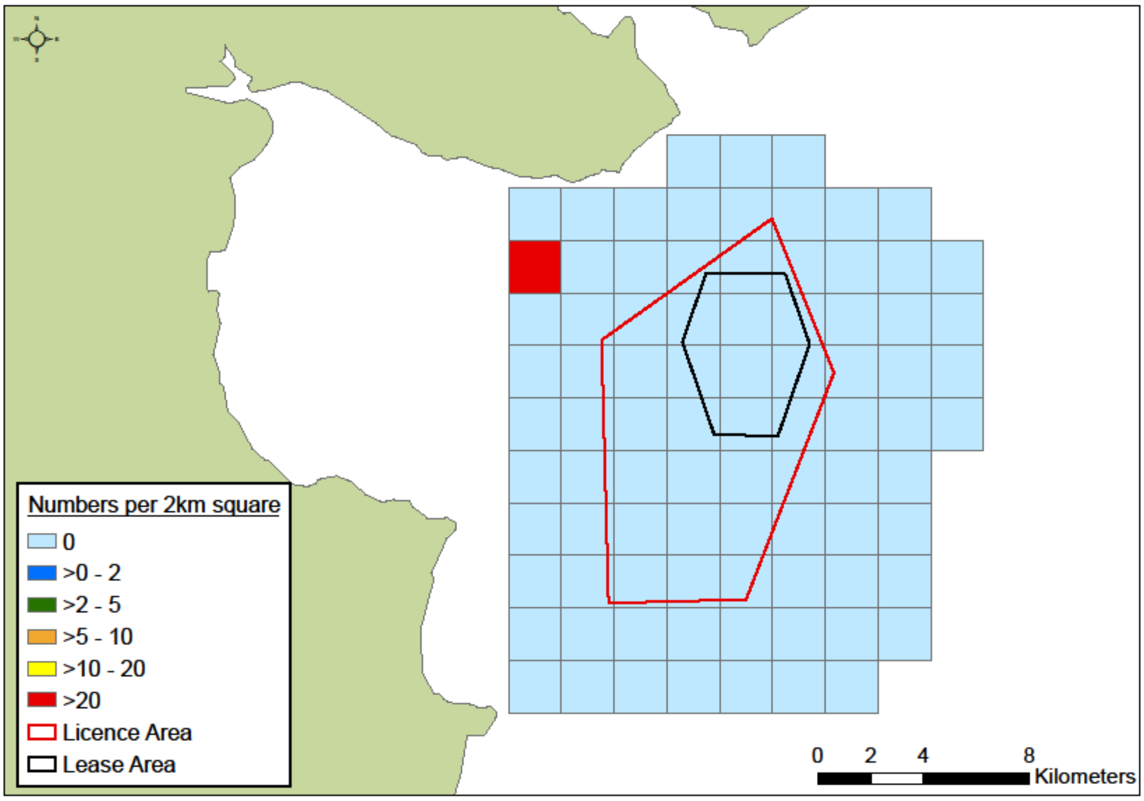

Figure 3.1.6 Common Scoter survey results March 2019.

3.1.2 Common Scoter Density

As only one record of Common Scoter was of birds on the sea within 200m of the transect route (the flock of eight birds recorded in November 2018), density estimates were not derived.

3.2 Red-breasted Merganser

Red-breasted Merganser breed on sheltered rivers and lakes in the north and west of Ireland (Balmer *et al.*, 2013). Numbers in Ireland increase in winter with the influx of birds from northern and eastern breeding areas (Stone *et al.*, 1995) and are predominantly found in shallow coastal marine habitats as well as offshore, where the predominantly feed on small fish (Crowe, 2005). They are Green-listed in Ireland (Colhoun & Cummins, 2013), although (Non-significant) declines have been recorded in wintering populations in recent years (Crowe & Holt, 2013).

3.2.1 Red-breasted Merganser Abundance

Red-breasted Merganser were recorded in January (four birds) and February (14 birds) within the survey area (Table 3.2.1), but were only recorded on transects in February 2019, when three birds were observed in the north-western corner of the survey area (Figure 3.2.1). No Red-breasted Merganser were recorded in the Lease or Licence Areas during transect surveys.

Table 3.2.1 Red-breasted Merganser records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	0
June 2018	0	0
July 2018	0	0
August 2018	0	0
September 2018	0	0
October 2018	0	0
November 2018	0	0
December 2018	0	0
January 2019	0	4
February 2019	3	14
March 2019	0	0
April 2019	0	0
TOTAL	**3**	**18**

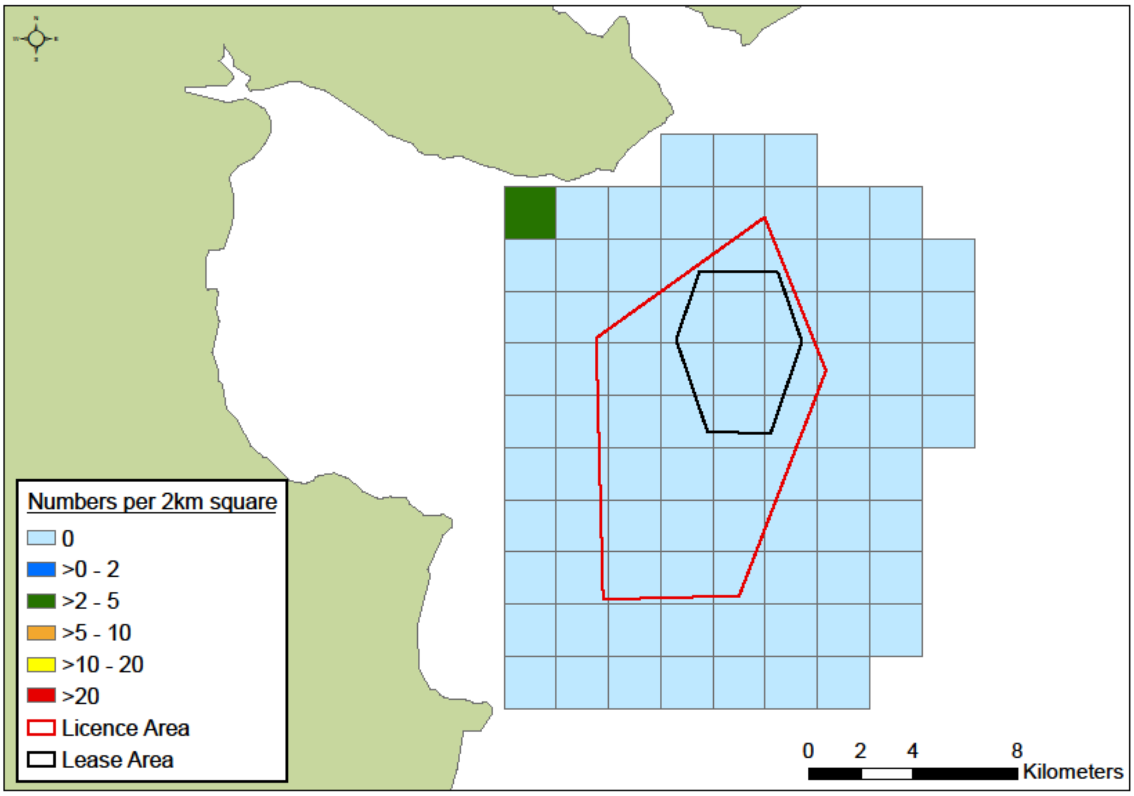

Figure 3.2.1 Red-breasted Merganser survey results February 2019

3.2.2 Red-breasted Merganser Density

Red-breasted Merganser do not have correction factors indicated in Stone *et al.,* (1995) and occurred once during transect surveys; no density estimates have therefore been calculated for this species.

3.3 Red-throated Diver

Red-throated Diver are very rare breeders in Ireland, with approximately six breeding pairs in Co. Donegal (Newton, 2016). Larger numbers winter in coastal areas around Ireland, where they typically favour shallow bays with sandy substrates to forage for flatfish (Crowe, 2005). They are Amber-listed in Ireland (Colhoun & Cummins, 2013) as a rare breeding species and due to their status as a Species of European Conservation Concern.

3.3.1 Red-throated Diver Abundance

A total of 64 Red-throated Divers were recorded within the survey area during the survey period, with records in all months except for the summer (breeding) months of June and July (Table 3.3.1). A slight increase of records in the post-breeding period in August (Table 3.3.1) may reflect passage birds from north-western breeding areas (Crowe, 2005). The main peak in numbers observed in the winter period (December to February), with a maximum of 18 birds on the transects in February 2019, when a total of 27 birds were recorded from the whole survey area.

A total of five Red-throated Diver records came from the Lease area (Table 3.3.2), comprising one bird in January 2019 (Figure 3.3.6) and four birds in February 2019 (Figure 3.3.7). A total of 12 birds were observed within the Licence area during survey visits, comprising single birds in each of September 2018 (Figure 3.3.2), October 2018 (Figure 3.3.3), November 2018 (Figure 3.3.4) and January 2019 (Figure 3.3.6), with two birds in the Licence area in December 2018 (Figure 3.3.5) and April 2019 (Figure 3.3.9), and three birds present in March 2019 (Figure 3.3.8). Overall, 7.8% of birds recorded were in the lease area, 18.8% were in the Licence area and 73.4% of Red-throated Diver records were in the Survey area.

Table 3.3.1 Red-throated Diver records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	2
June 2018	0	0
July 2018	0	0
August 2018	6	7
September 2018	2	4
October 2018	5	5
November 2018	3	4
December 2018	5	12
January 2019	9	12
February 2019	18	27
March 2019	6	9
April 2019	10	10
TOTAL	**64**	**92**

Table 3.3.2 Red-throated Diver records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	0	-	0	-	0	-
June 2018	0	-	0	-	0	-
July 2018	0	-	0	-	0	-
August 2018	6	100	0	0	0	0
September 2018	1	50.0	1	50.0	0	0
October 2018	4	80.0	1	20.0	0	0
November 2018	2	66.6	1	33.3	0	0
December 2018	3	60.0	2	40.0	0	0
January 2019	7	77.8	1	11.1	1	11.1
February 2019	13	72.2	1	5.6	4	22.2
March 2019	3	50.0	3	50.0	0	0
April 2019	8	80.0	2	20.0	0	0
TOTAL	47	73.4	12	18.8	5	7.8

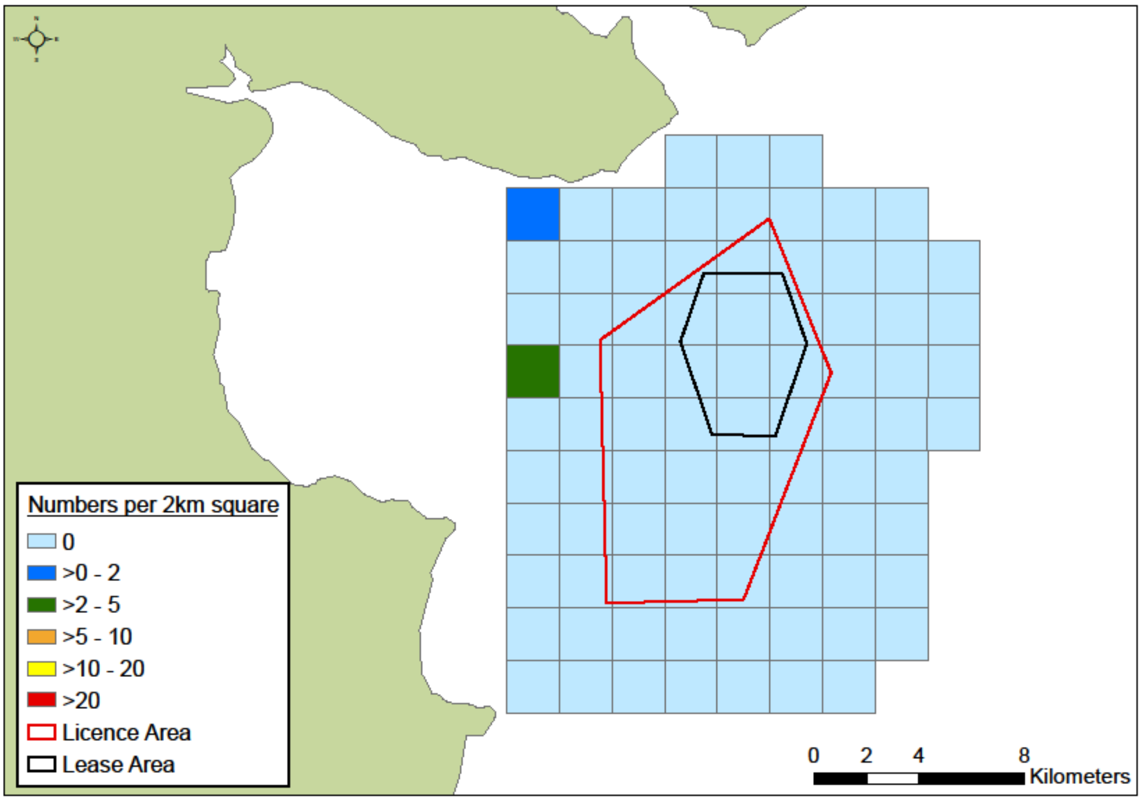

Figure 3.3.1 Red-throated Diver survey results August 2018.

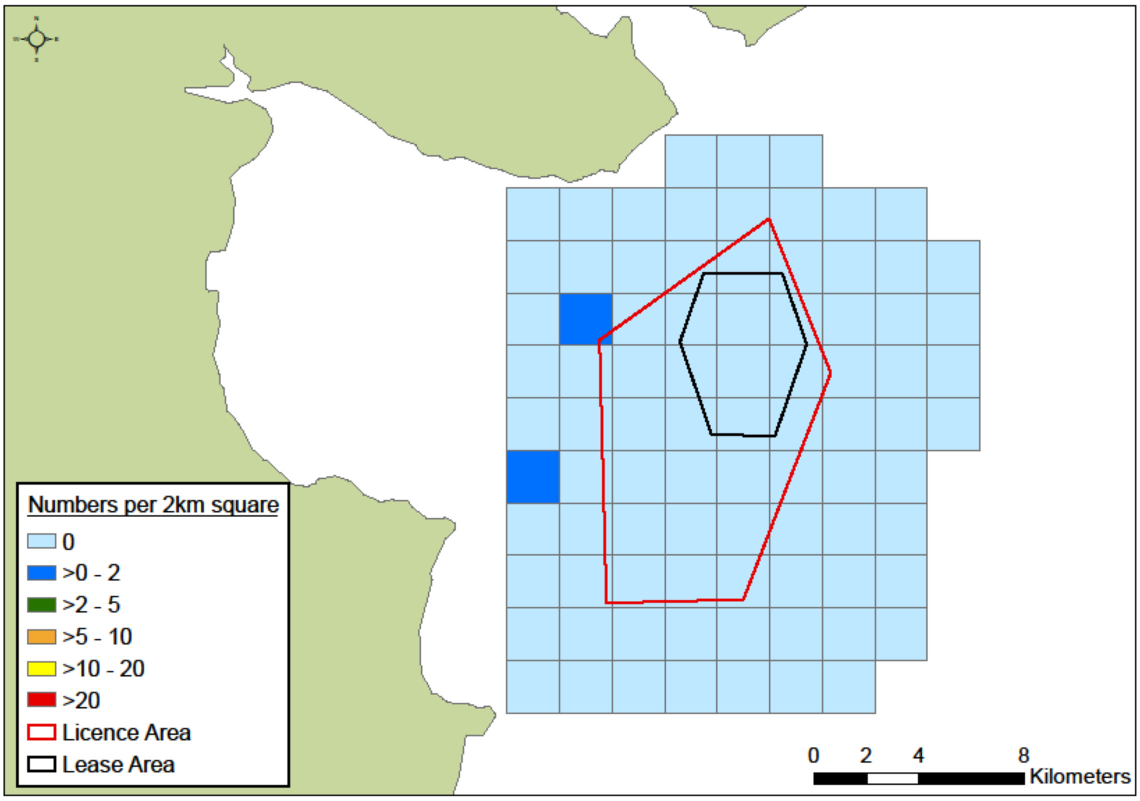

Figure 3.3.2 Red-throated Diver survey results September 2018.

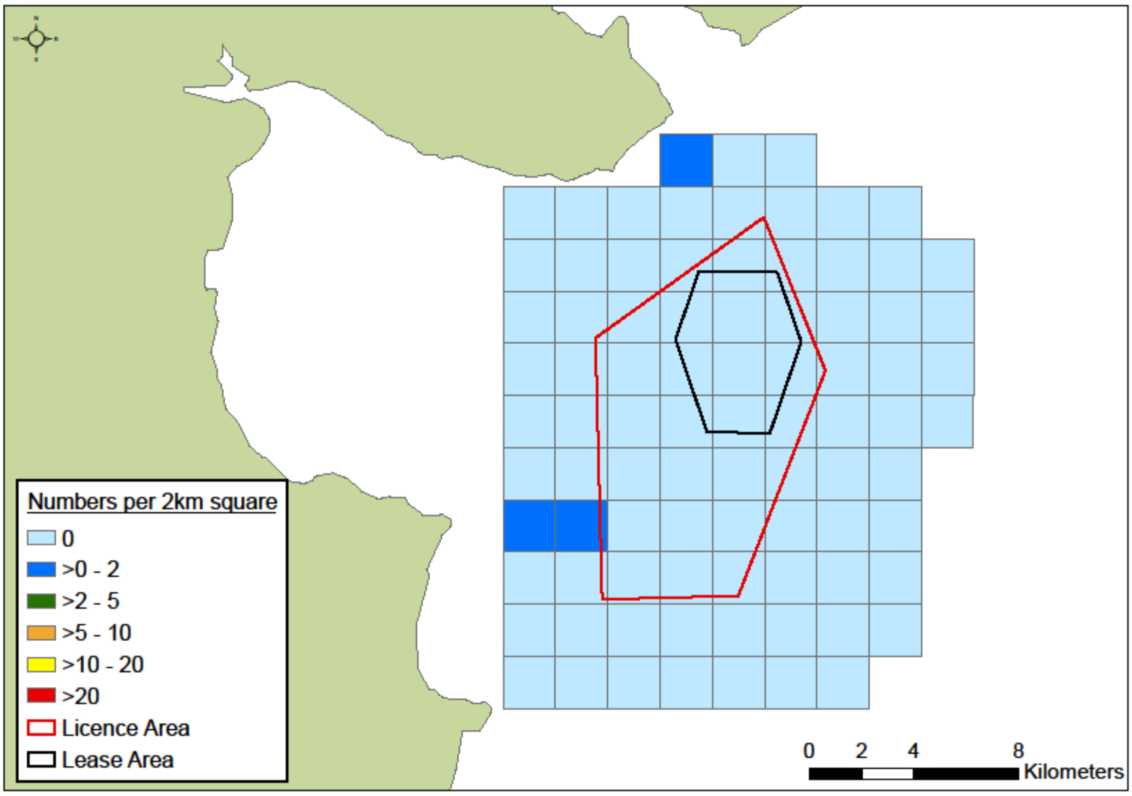

Figure 3.3.3 Red-throated Diver survey results October 2018.

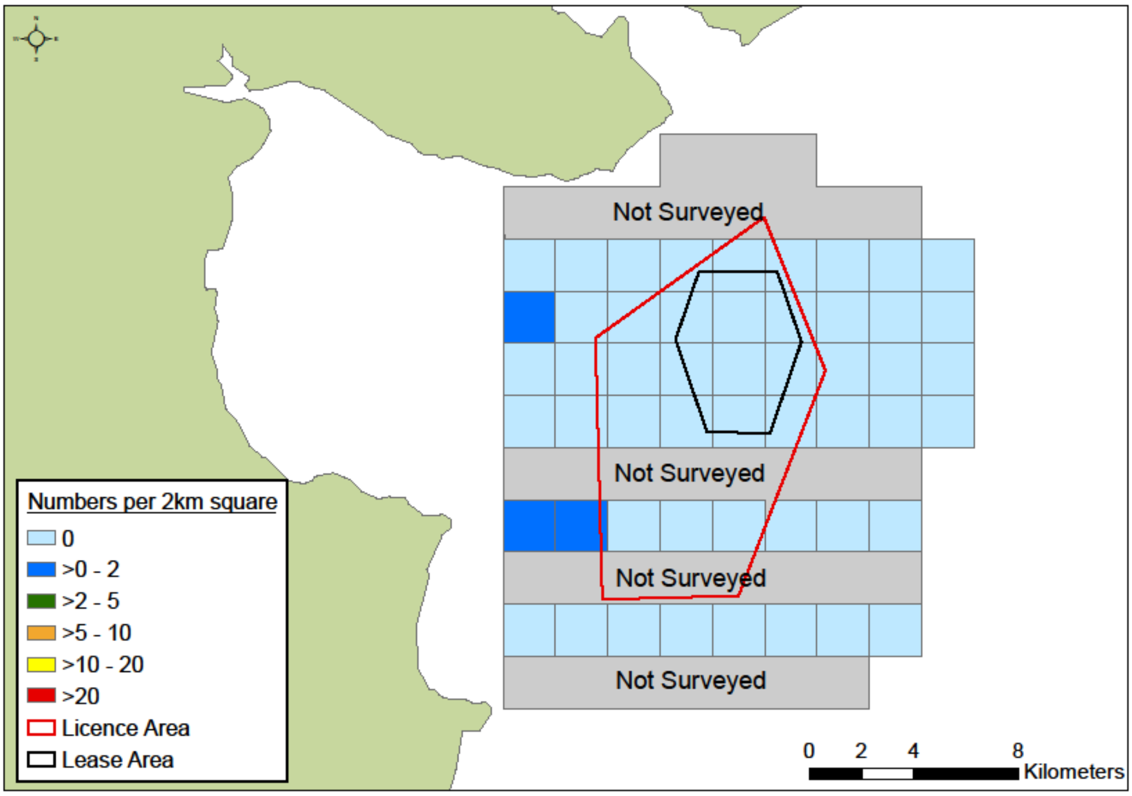

Figure 3.3.4 Red-throated Diver survey results November 2018.

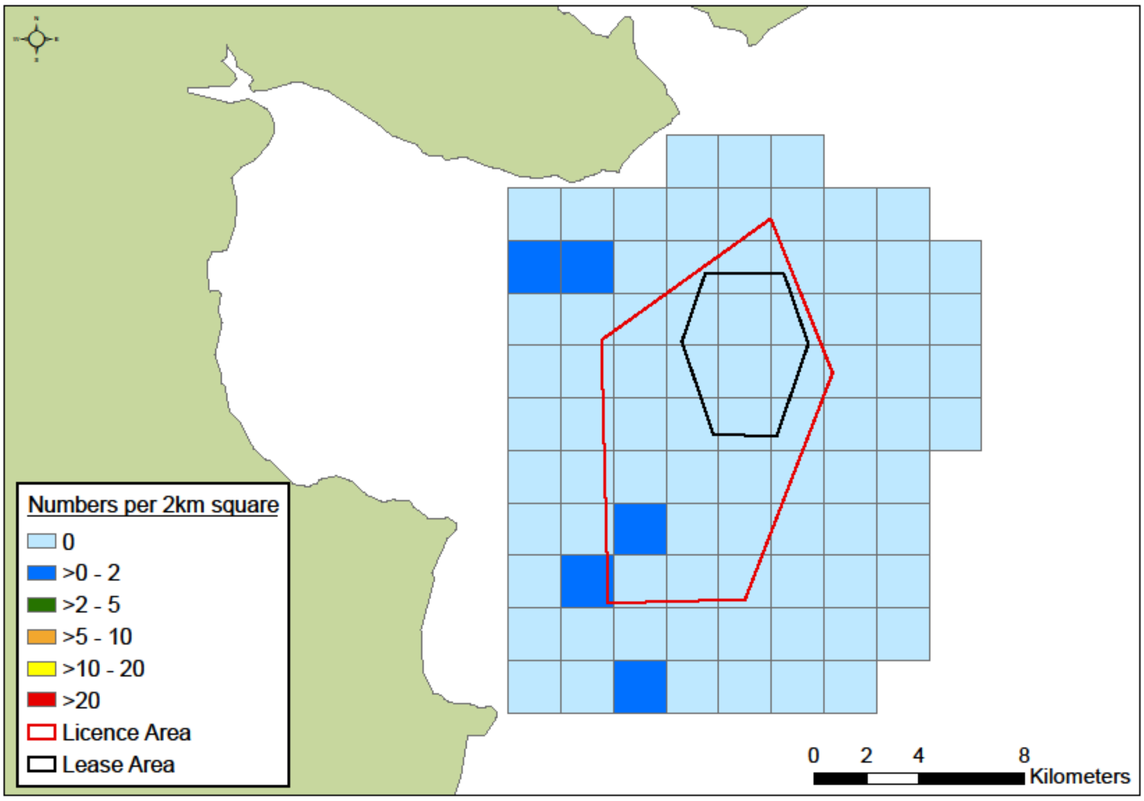

Figure 3.3.5 Red-throated Diver survey results December 2018.

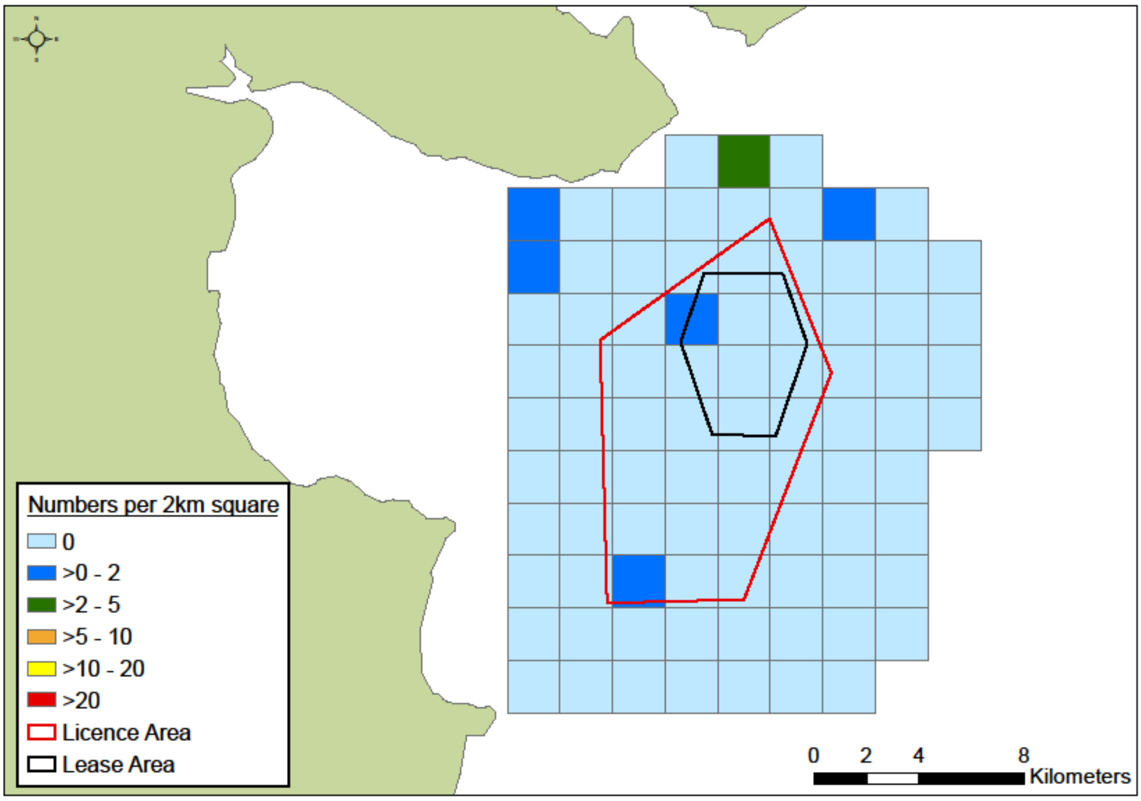

Figure 3.3.6 Red-throated Diver survey results January 2019.

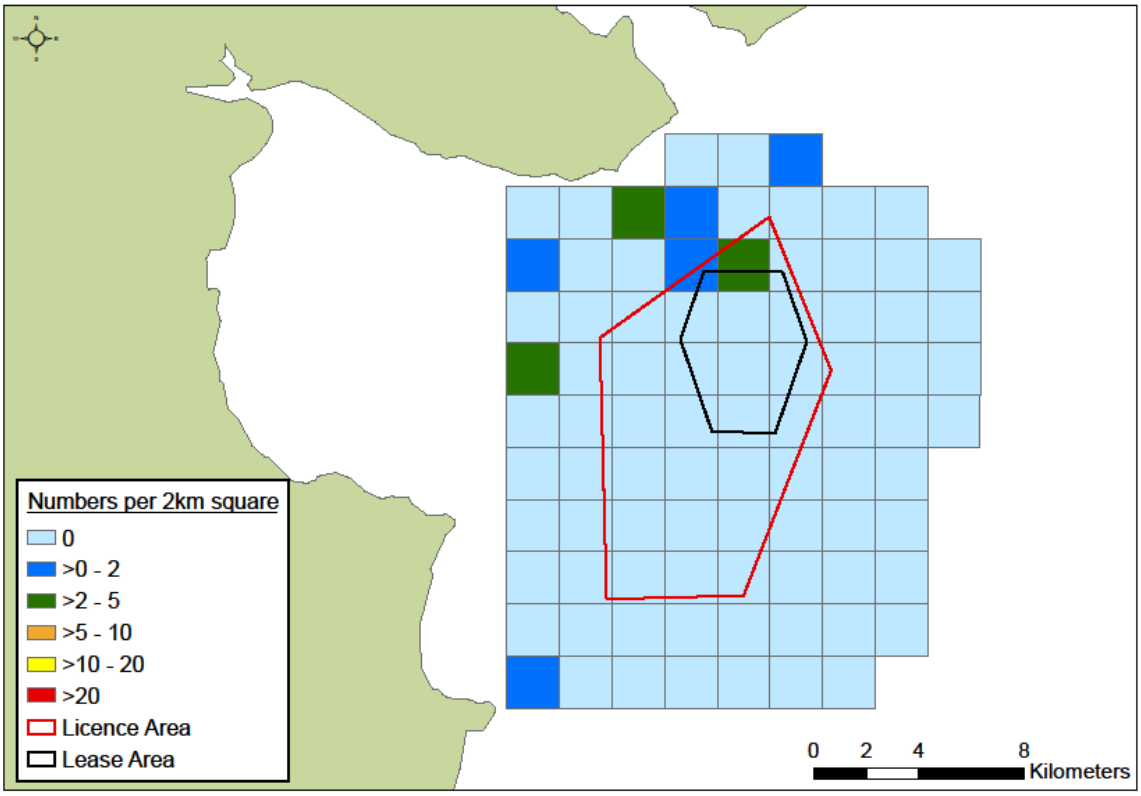

Figure 3.3.7 Red-throated Diver survey results February 2019.

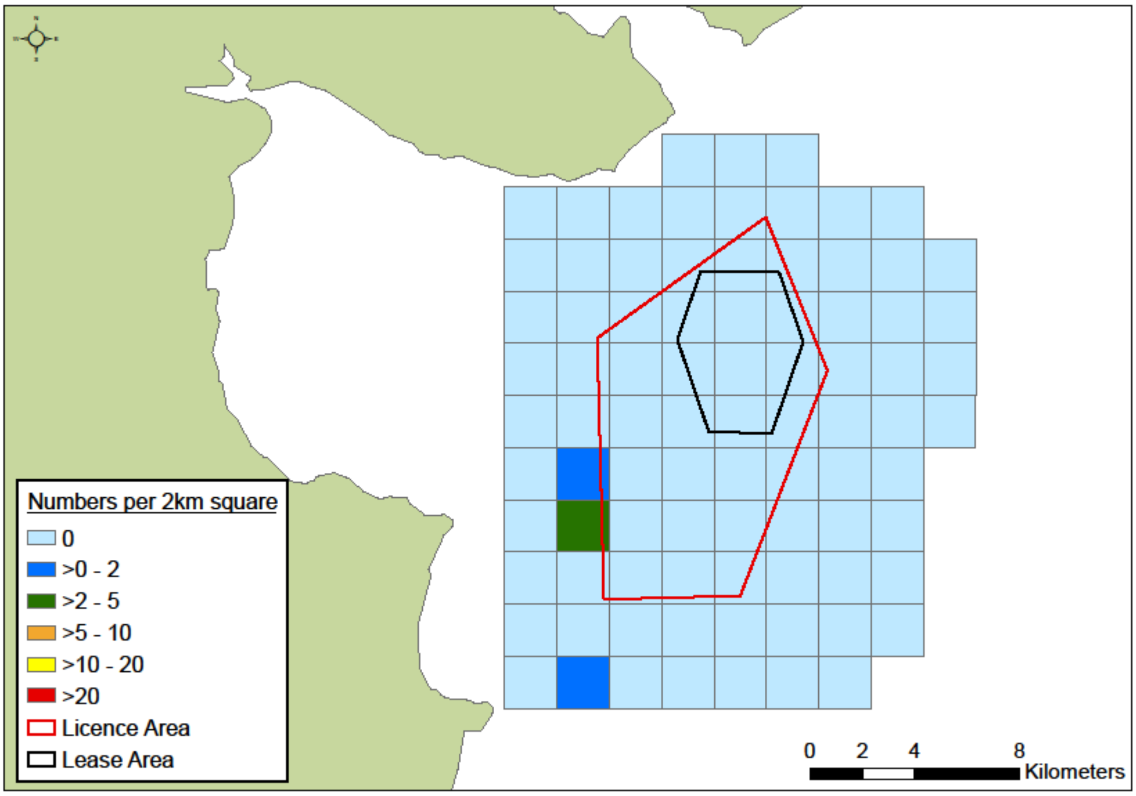

Figure 3.3.8 Red-throated Diver survey results March 2019.

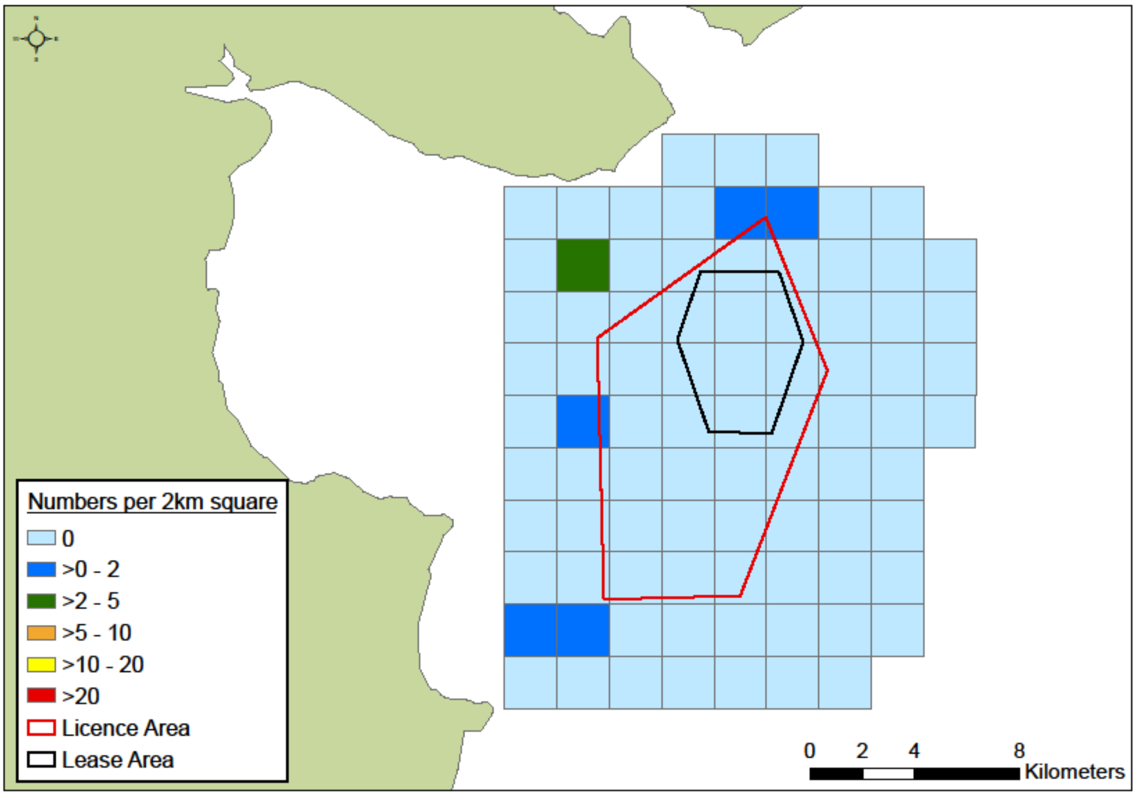

Figure 3.3.9 Red-throated Diver survey results April 2019

3.3.2 Red-throated Diver Density

The derived density estimates for Red-throated Diver records obtained from transects is shown in Figures 3.3.10 to 3.3.18. As expected from the abundance data, densities for this species are low across the survey area, with a highest derived density of just 0.10 birds/km^2 in February. Density estimates from the western Irish Sea (Jessop *et al.*, 2018) for all divers is given as between 0.01 and 0.98 divers/km^2 (note that all divers were combined for that study; see section 3.4.3 below).

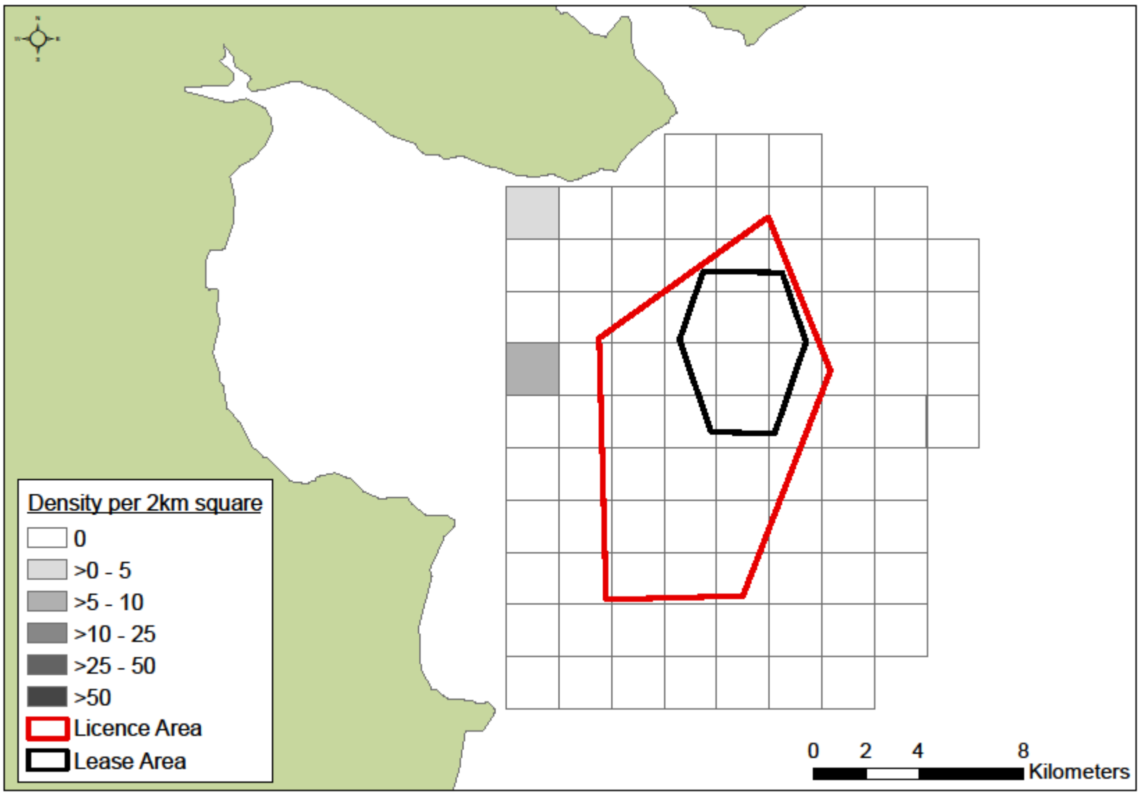

Figure 3.3.10 Red-throated Diver density estimates August 2018

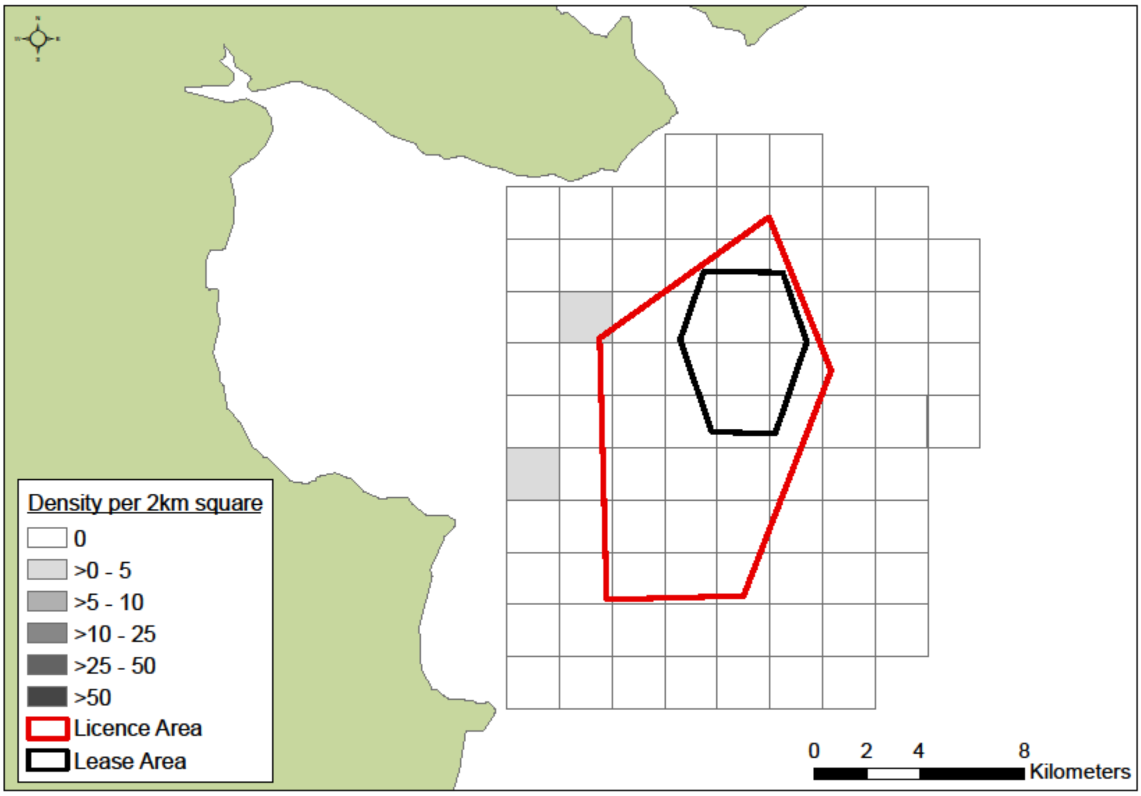

Figure 3.3.11 Red-throated Diver density estimates September 2018

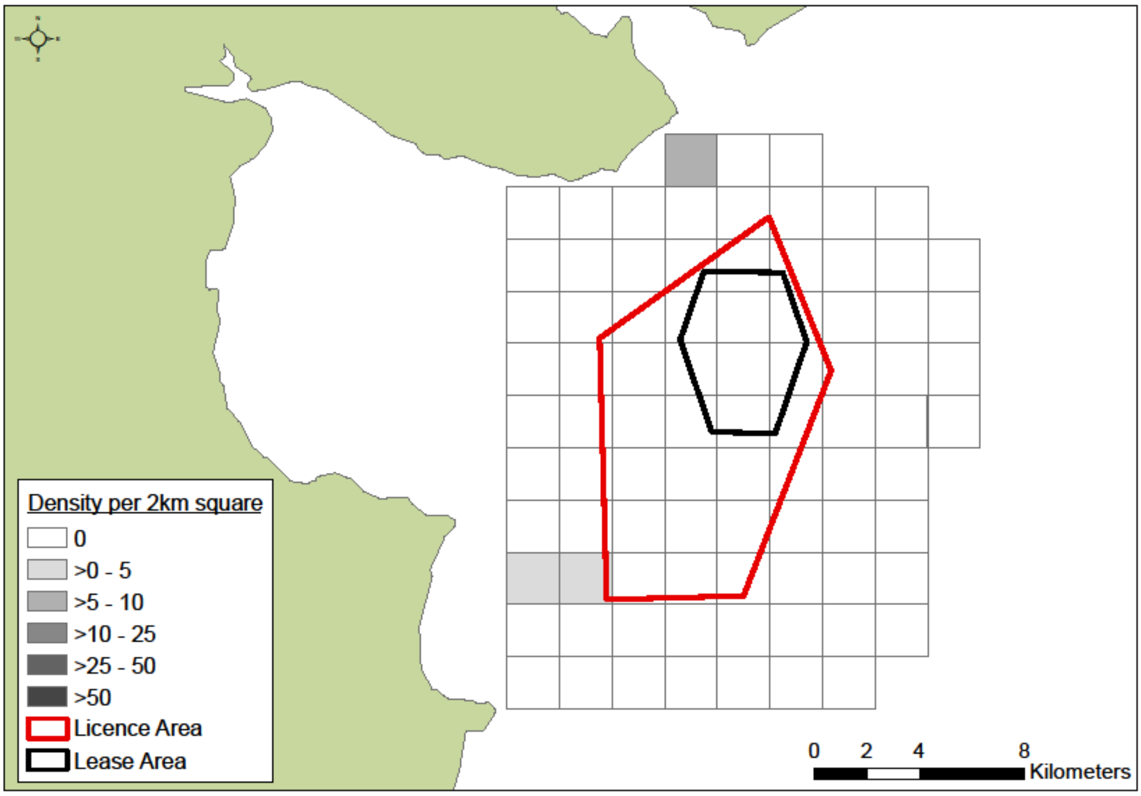

Figure 3.3.12 Red-throated Diver density estimates October 2018

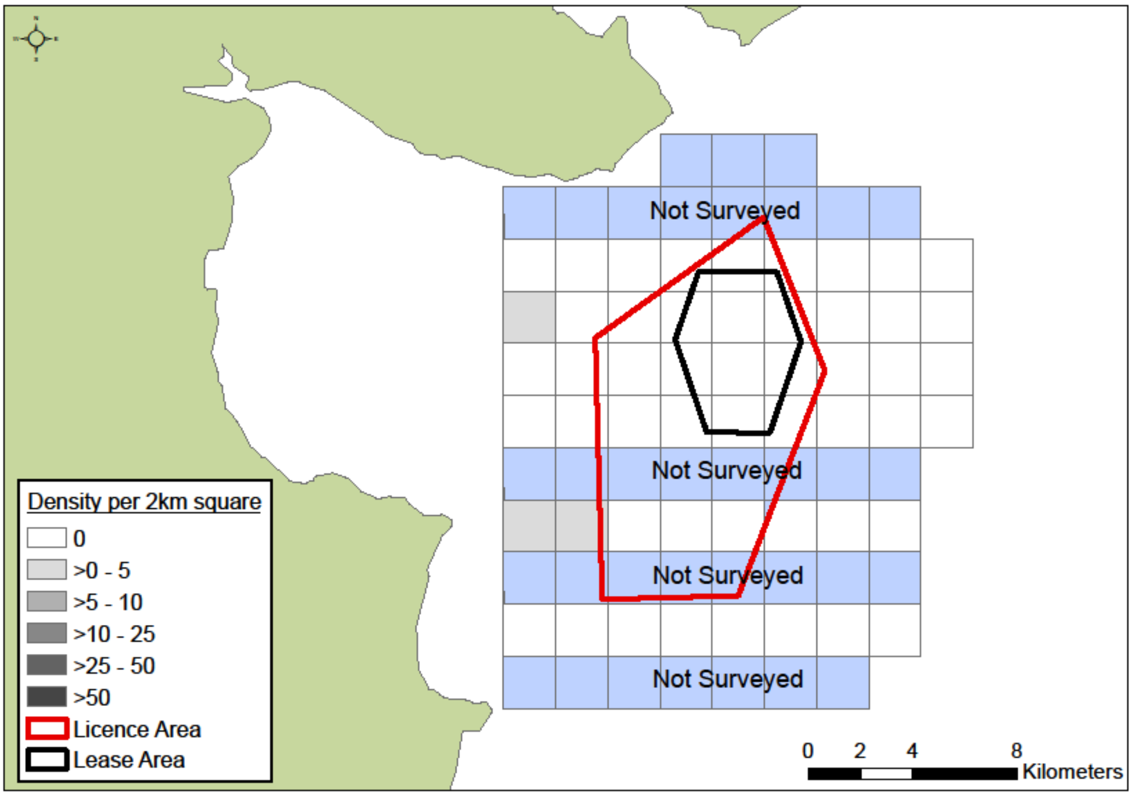

Figure 3.3.13 Red-throated Diver density estimates November 2018

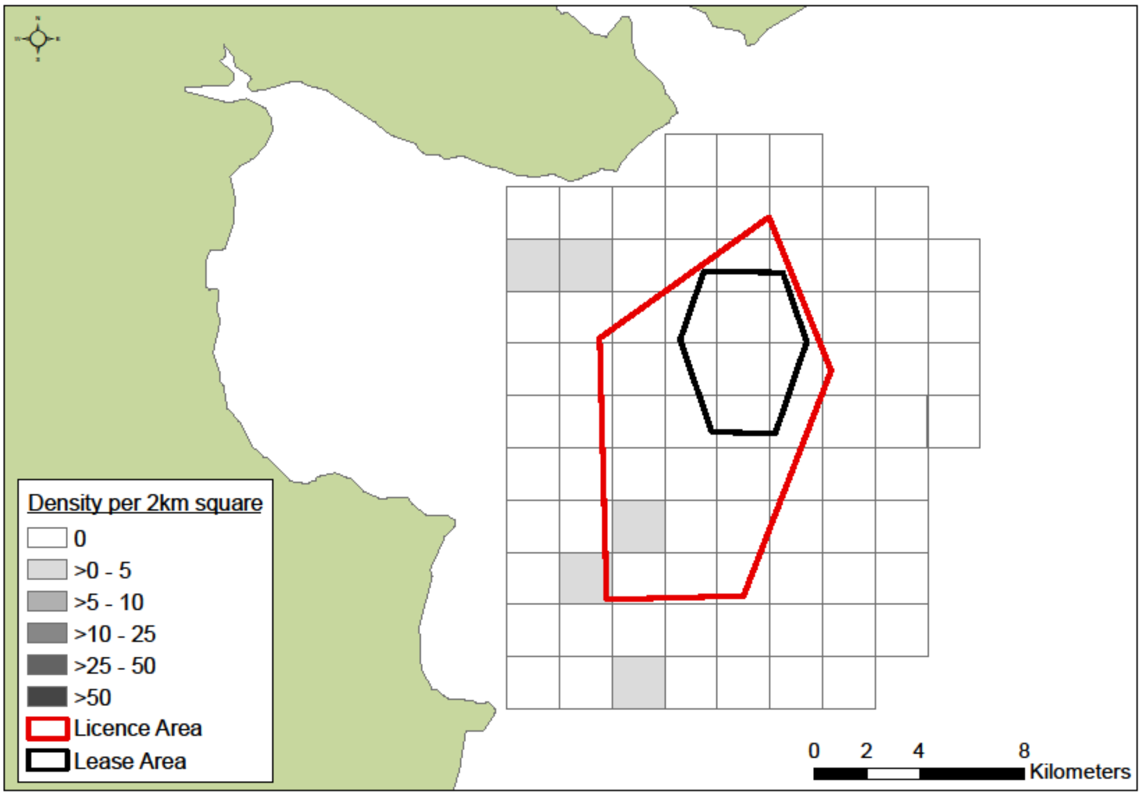

Figure 3.3.14 Red-throated Diver density estimates December 2018

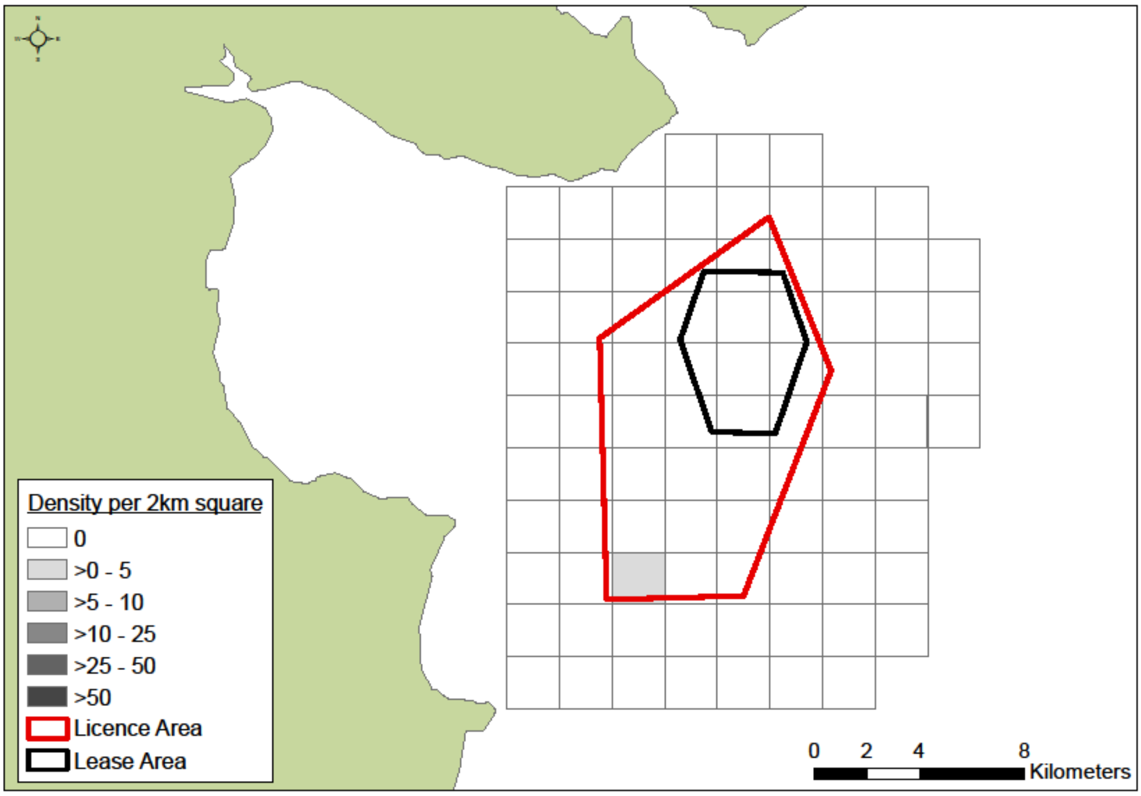

Figure 3.3.15 Red-throated Diver density estimates January 2019

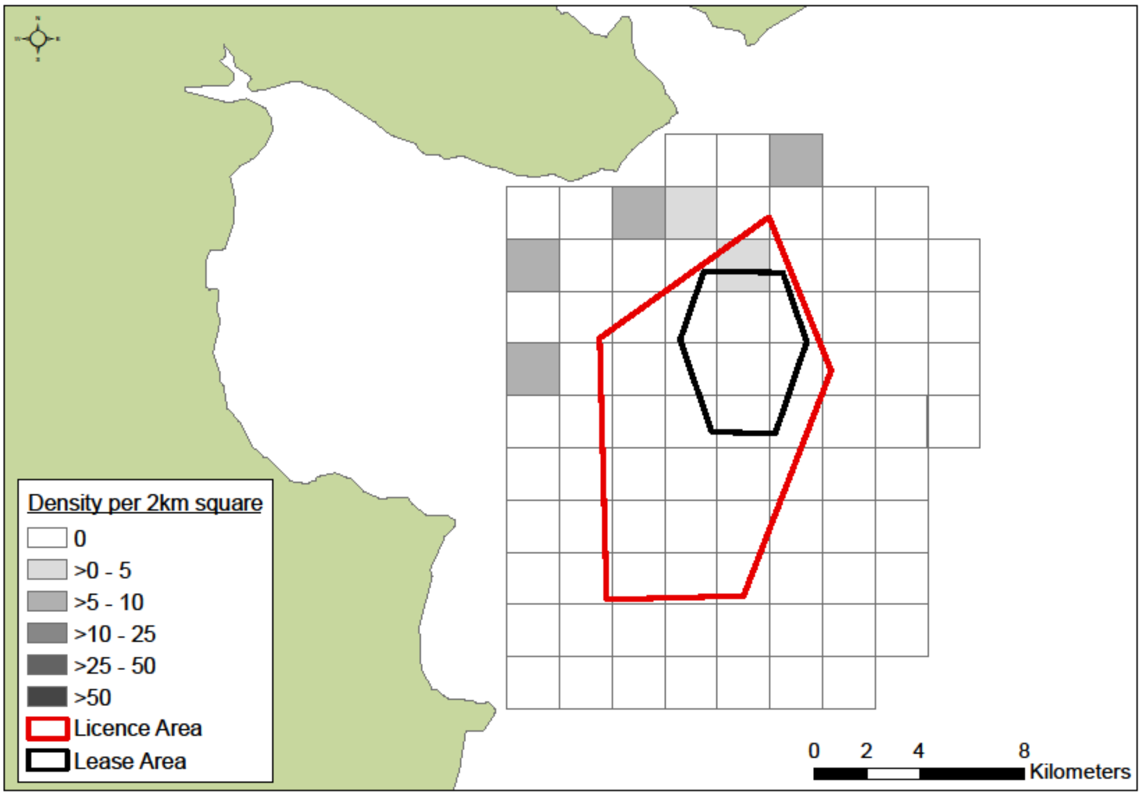

Figure 3.3.16 Red-throated Diver density estimates February 2019

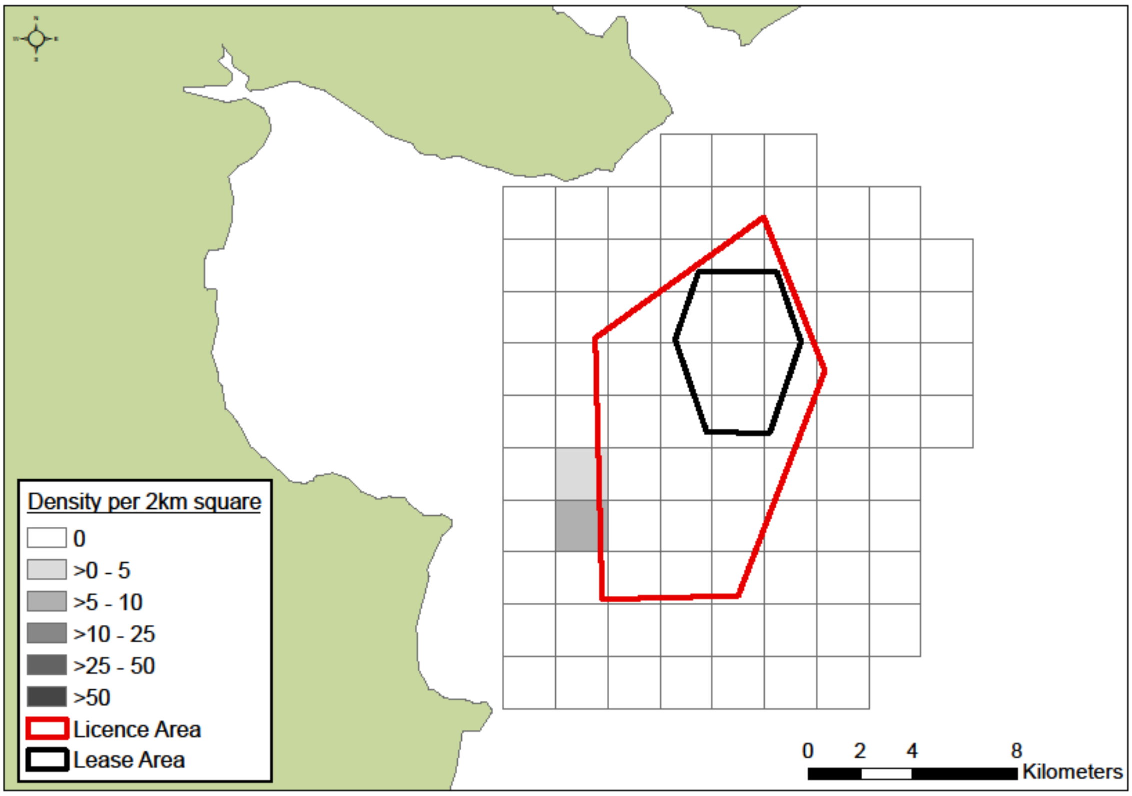

Figure 3.3.17 Red-throated Diver density estimates March 2019

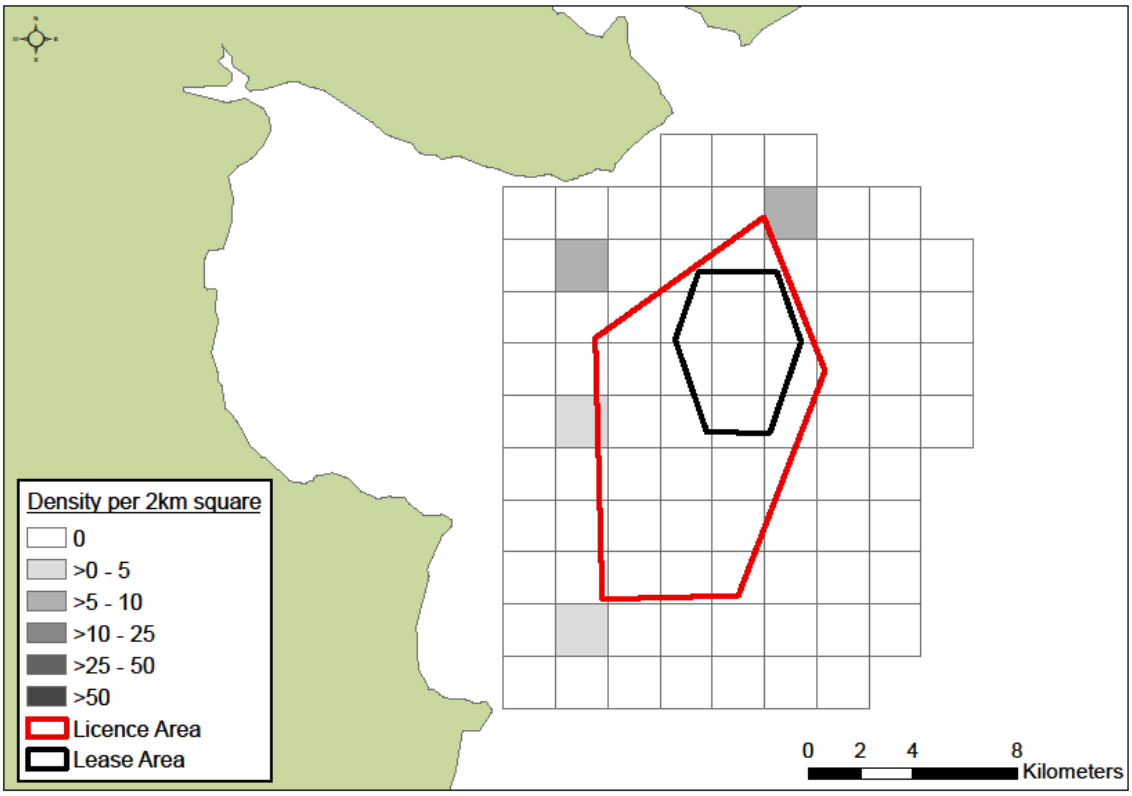

Figure 3.3.18 Red-throated Diver density estimates April 2019

3.4 Great Northern Diver

Great Northern Divers are winter visitors to Ireland, mainly occurring between September and April in offshore areas (Crowe, 2005; Stone *et al.*, 1995). They are able to feed in deeper water than Red-throated Diver, so are commoner further off the coast and using deeper bays and inlets (Hutchinson, 1989). They are Amber-listed in Ireland (Colhoun & Cummins, 2013) due to the international importance of the wintering population.

3.4.1 Great Northern Diver Abundance

Great Northern Divers were recorded in all months except June and July 2018 (Table 3.4.1), with peak occurrence in January 2019 (see Figure 3.4.7), comprising 76 birds observed in the survey area and 61 recorded from transects and May 2018 (Figure 3.4.1) when 49 birds were recorded from transects and 83 were observed in the survey area. However, high numbers were also recorded in other months, including October 2018 (Figure 3.4.4) with 60 on the transect survey and 63 across the survey area and April 2019, with 53 on transects and 68 in the survey area (Figure 3.4.10).

Table 3.4.1 Great Northern Diver records from boat surveys in Oriel Windfarm survey area, showing transects record and total observations.

Month	Transect records	All records
May 2018	49	83
June 2018	9	9
July 2018	0	0
August 2018	0	1
September 2018	2	2
October 2018	60	63
November 2018	20	25
December 2018	30	38
January 2019	61	76
February 2019	21	24
March 2019	31	55
April 2019	53	68
TOTAL	**336**	**444**

The large occurrence in May 2018 is notable, as this species tends to vacate Irish water from April (Crowe, 2005; Stone *et al.*, 1995). The reasons for this may be related to wet weather events in spring 2018 (Met Éireann, 2018) delaying the departure of birds to more exposed marine areas and more northerly summer areas, as well as the early survey date in that month (surveys were undertaken on 4 May 2018).

Throughout the winter, birds were typically found towards the northern and western parts of the survey area, although birds were recorded along the whole of the southern side of the survey area in

January 2019 (Figure 3.4.7). This local re-distribution may reflect local weather conditions affecting prey availability in these areas (Crowe, 2005).

As noted, Great Northern Divers exhibit a greater tolerance for deeper waters that other diver species, and are therefore more likely to be recorded further offshore. This is reflected by the greater proportion of birds found within the Lease and Licence Areas (Table 3.4.2). Within the Lease area, a total of 68 individual were observed from transects, representing 20.2% of all individuals recorded across the survey area as a whole. By contrast, a total of 116 individuals were recorded within the Licence area (34.6% of the total) and 110 Great Northern Divers in the remaining survey area, representing 45.2% of all Great Northern Divers recorded from transects.

Table 3.4.2 Great Northern Diver records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	14	28.6	22	44.9	13	26.5
June 2018	1	11.1	4	44.4	4	44.4
July 2018	0	-	0	-	0	-
August 2018	0	-	0	-	0	-
September 2018	1	50.0	1	50.0	0	0
October 2018	16	26.7	29	48.3	15	25.0
November 2018	17	85.0	2	10.0	1	5.0
December 2018	10	33.3	14	46.7	6	20.0
January 2019	38	62.3	16	26.2	7	11.5
February 2019	13	61.9	6	28.6	2	9.5
March 2019	18	58.1	6	19.3	7	22.6
April 2019	24	45.3	16	30.2	13	24.6
TOTAL	**152**	**45.2**	**116**	**34.6**	**68**	**20.2**

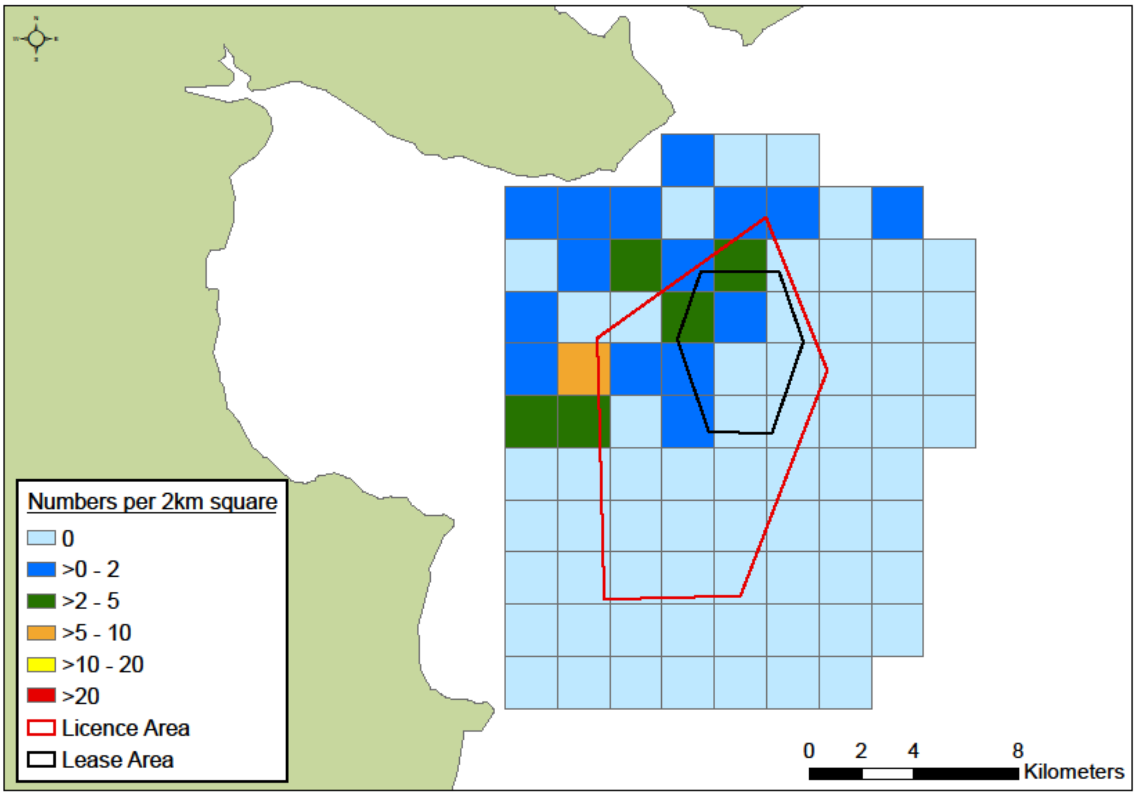

Figure 3.4.1 Great Northern Diver survey results May 2018.

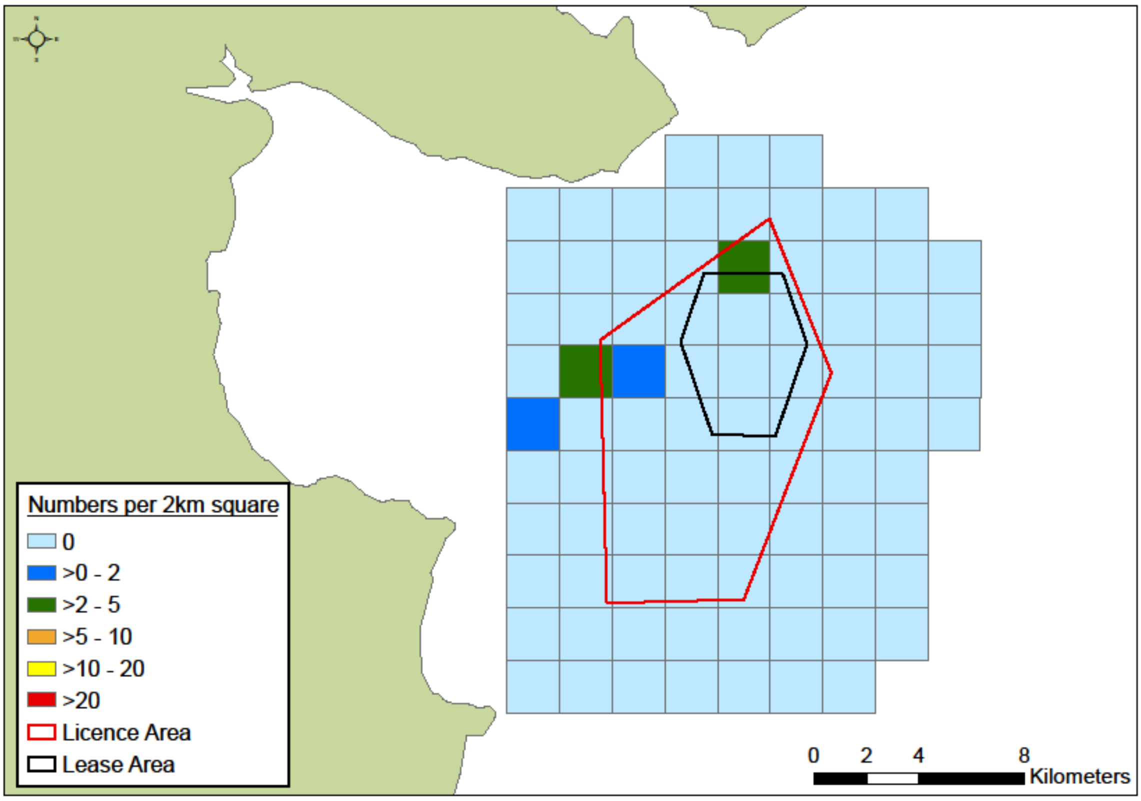

Figure 3.4.2 Great Northern Diver survey results June 2018.

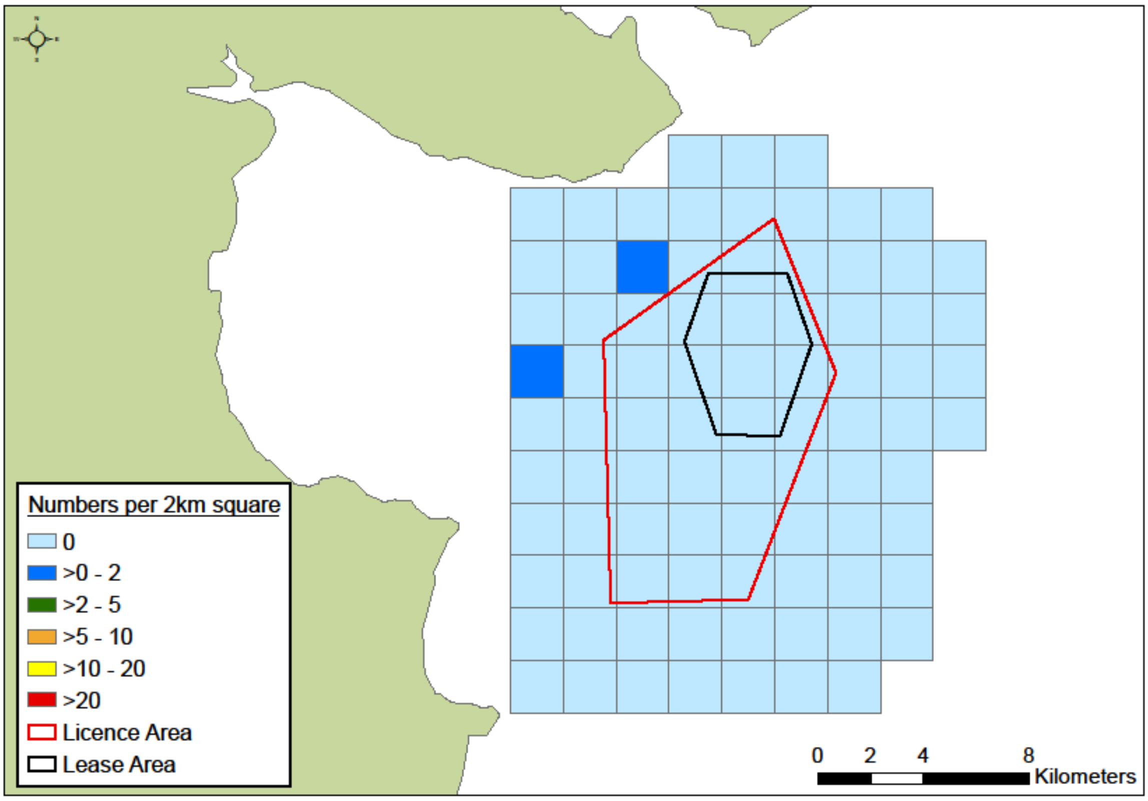

Figure 3.4.3 Great Northern Diver survey results September 2018.

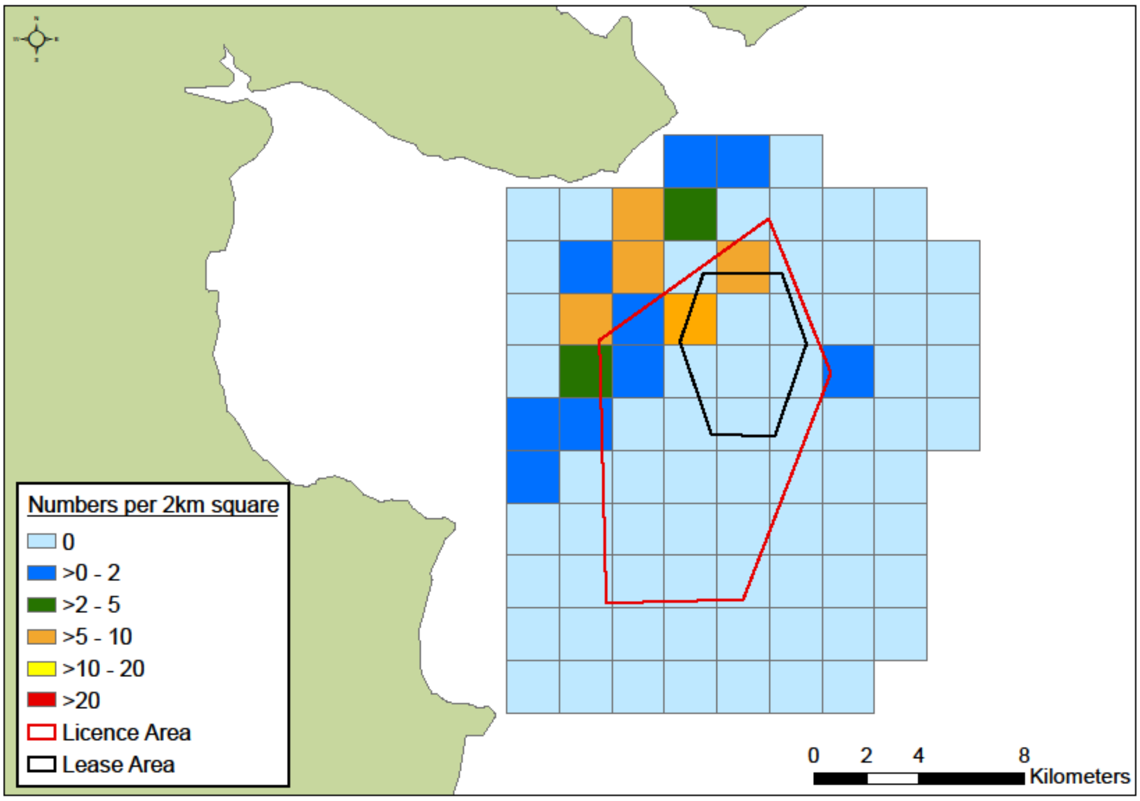

Figure 3.4.4 Great Northern Diver survey results October 2018.

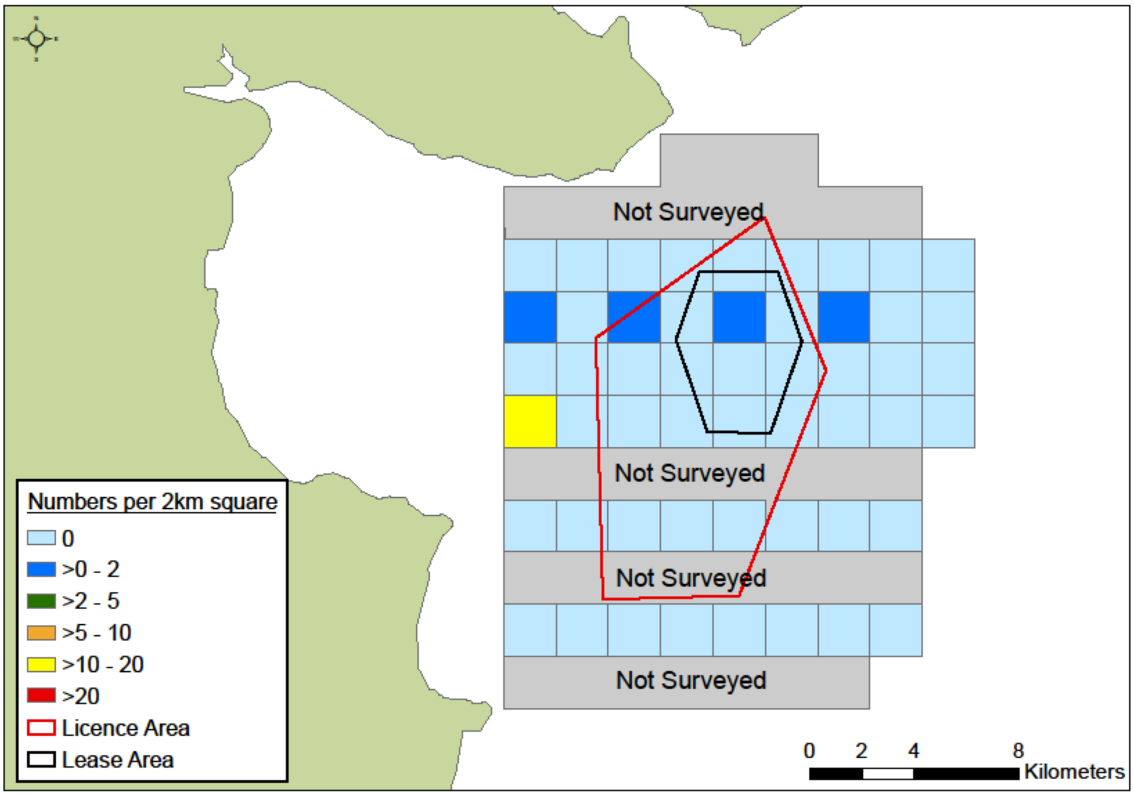

Figure 3.4.5 Great Northern Diver survey results November 2018.

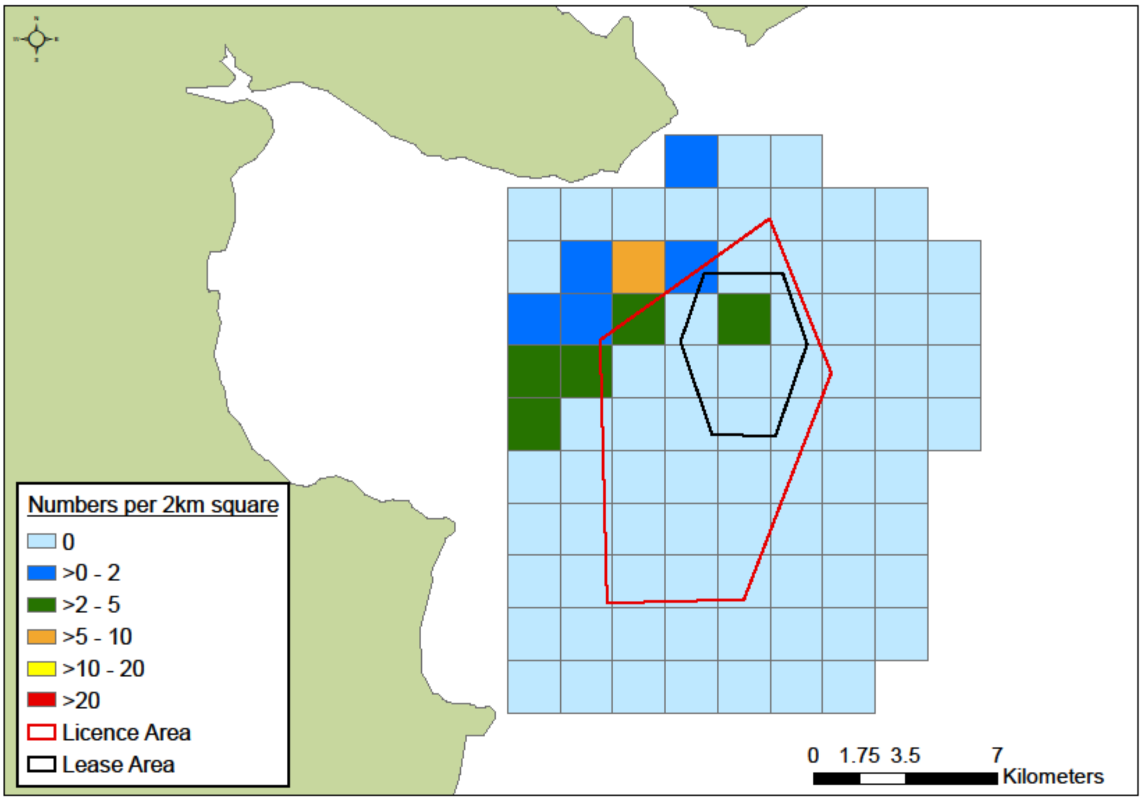

Figure 3.4.6 Great Northern Diver survey results December 2018.

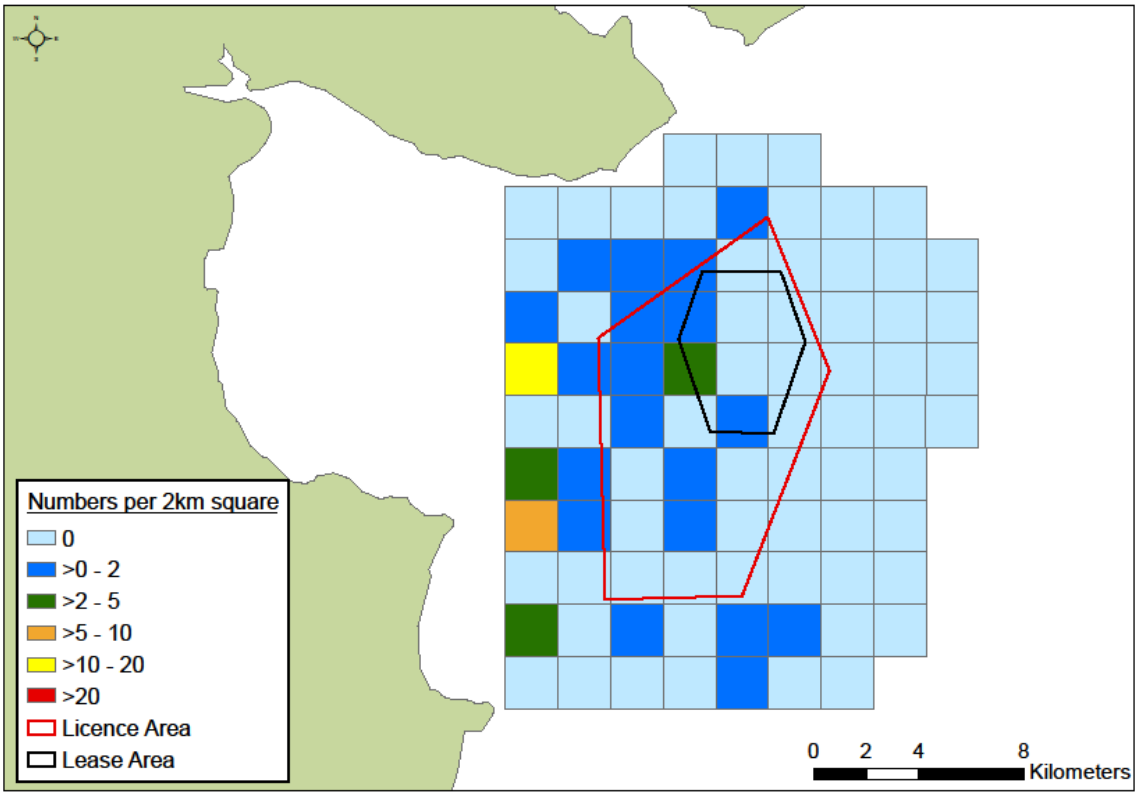

Figure 3.4.7 Great Northern Diver survey results January 2019.

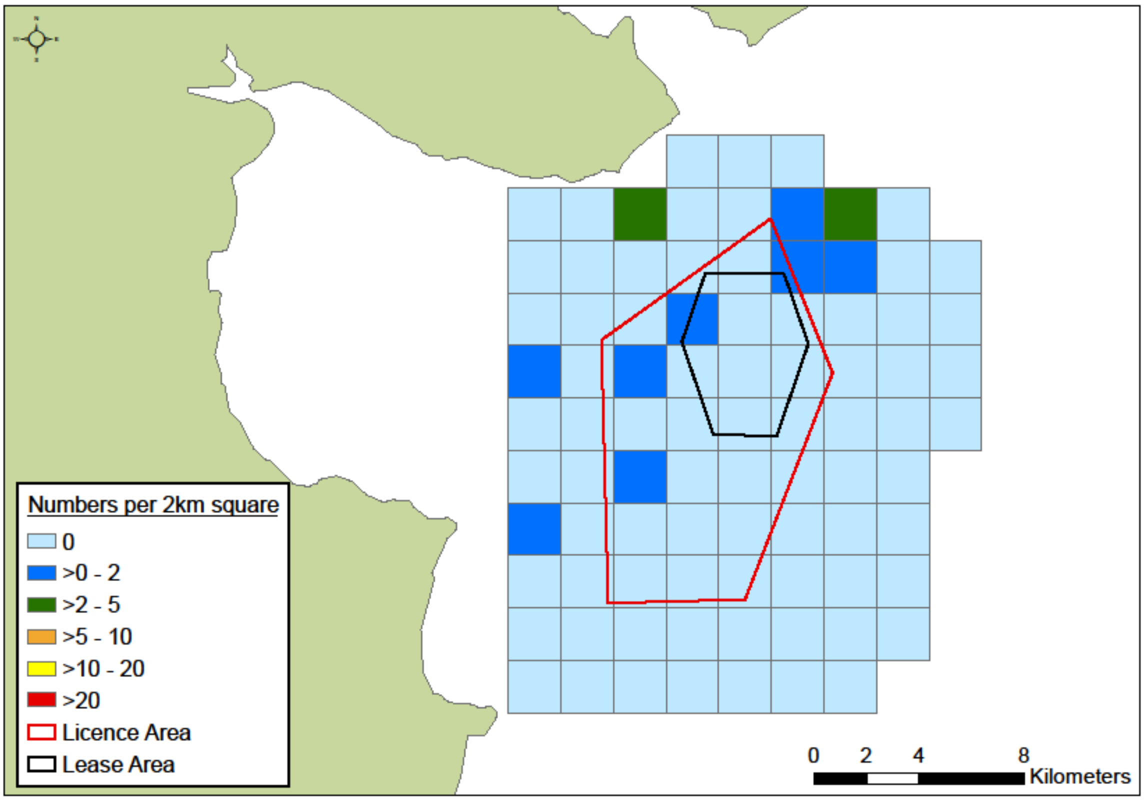

Figure 3.4.8 Great Northern Diver survey results February 2019.

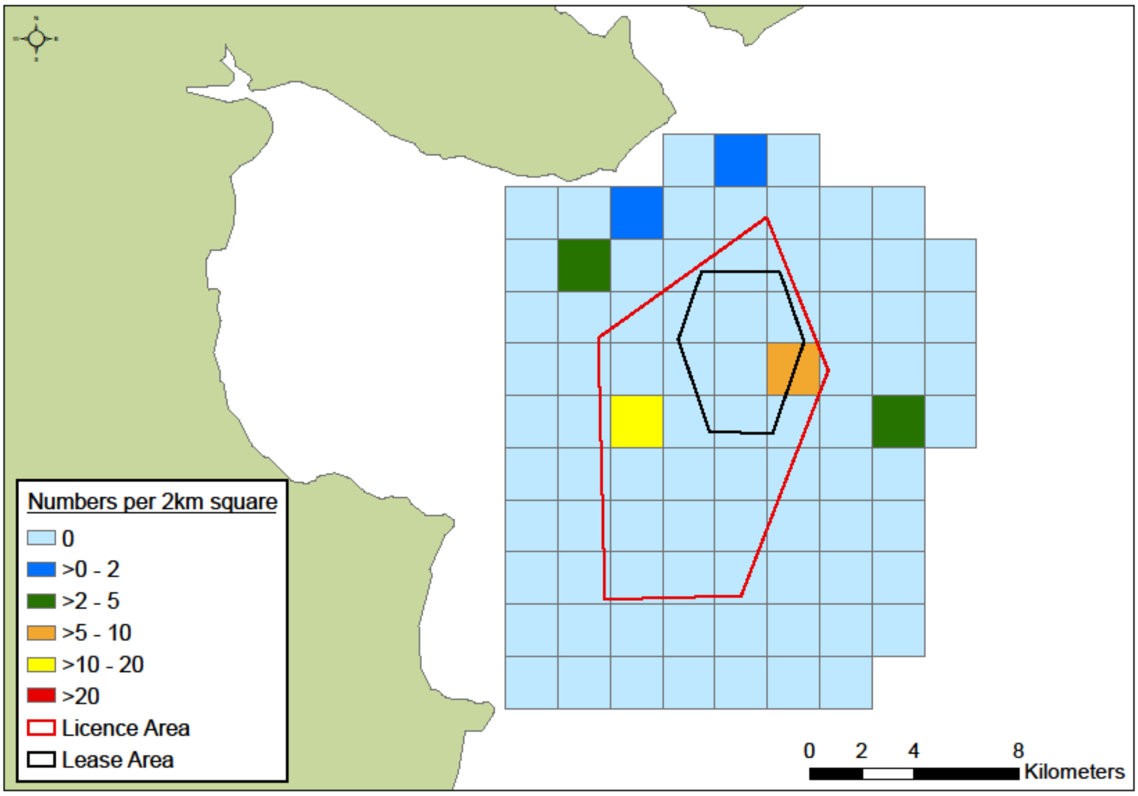

Figure 3.4.9 Great Northern Diver survey results March 2019.

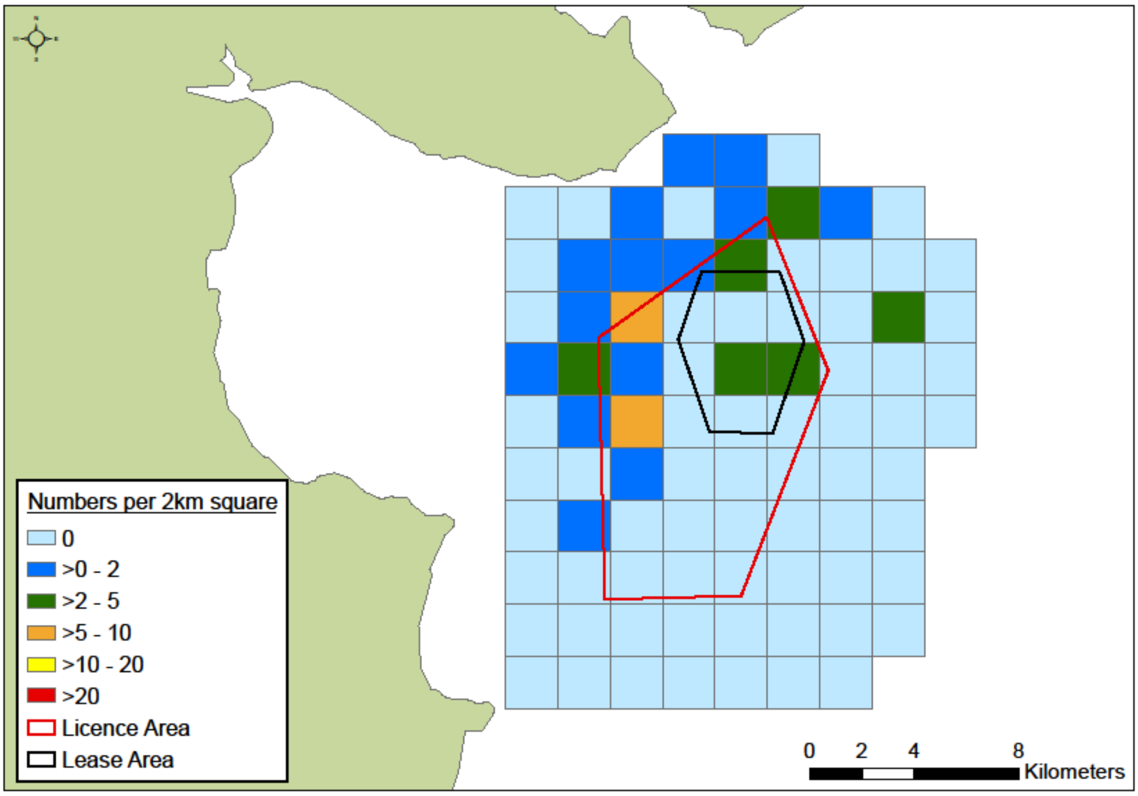

Figure 3.4.10 Great Northern Diver survey results April 2019.

3.4.2 Great Northern Diver Density

Great Northern Diver densities derived from transect surveys are shown in Figures 3.4.11 to 3.4.20. The highest density observed was of 0.44 birds/km^2 during October.

3.4.3 Diver Density Estimates

If all diver records are combined (i.e. Red-throated Diver and Great Northern Diver) then a collective maximum density estimate of 0.49 divers/km^2 during October is obtained. This tallies with the seasonality observed in the western Irish Sea estimates (Jessop *et al.,* 2018) when highest for divers' densities occurred in Autumn (0.97 divers/ km^2).

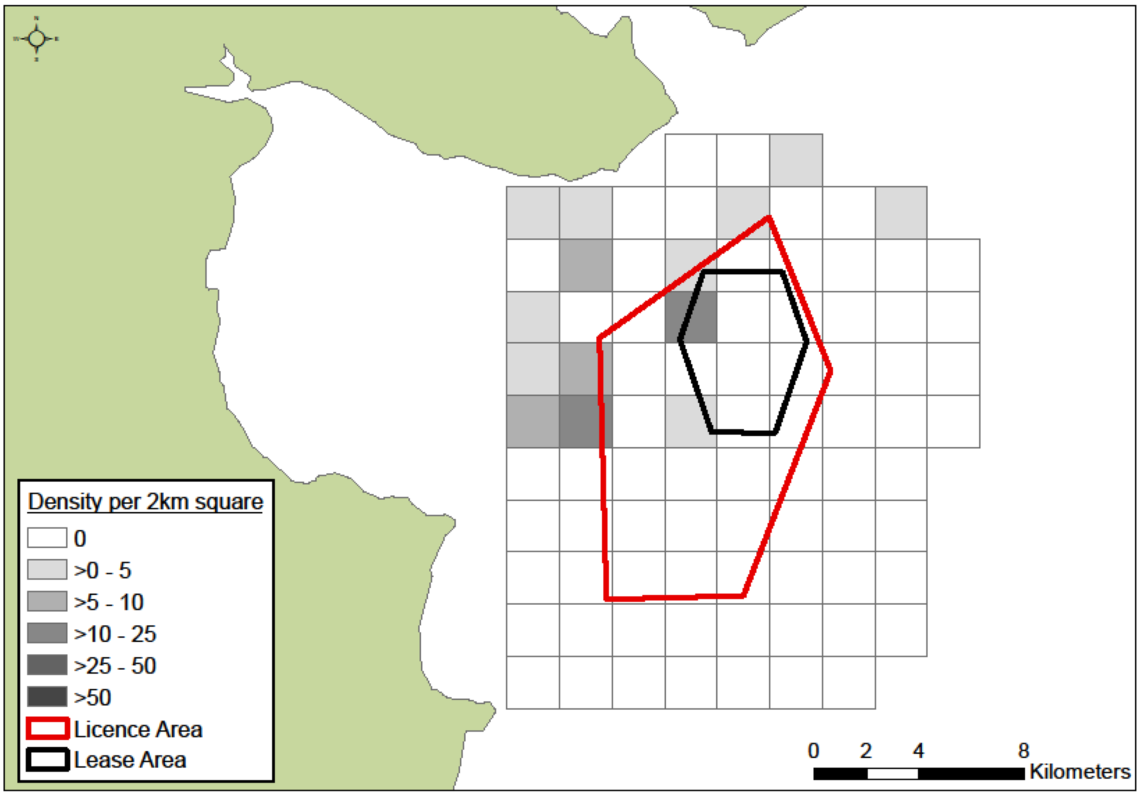

Figure 3.4.11 Great Northern Diver density estimates May 2018.

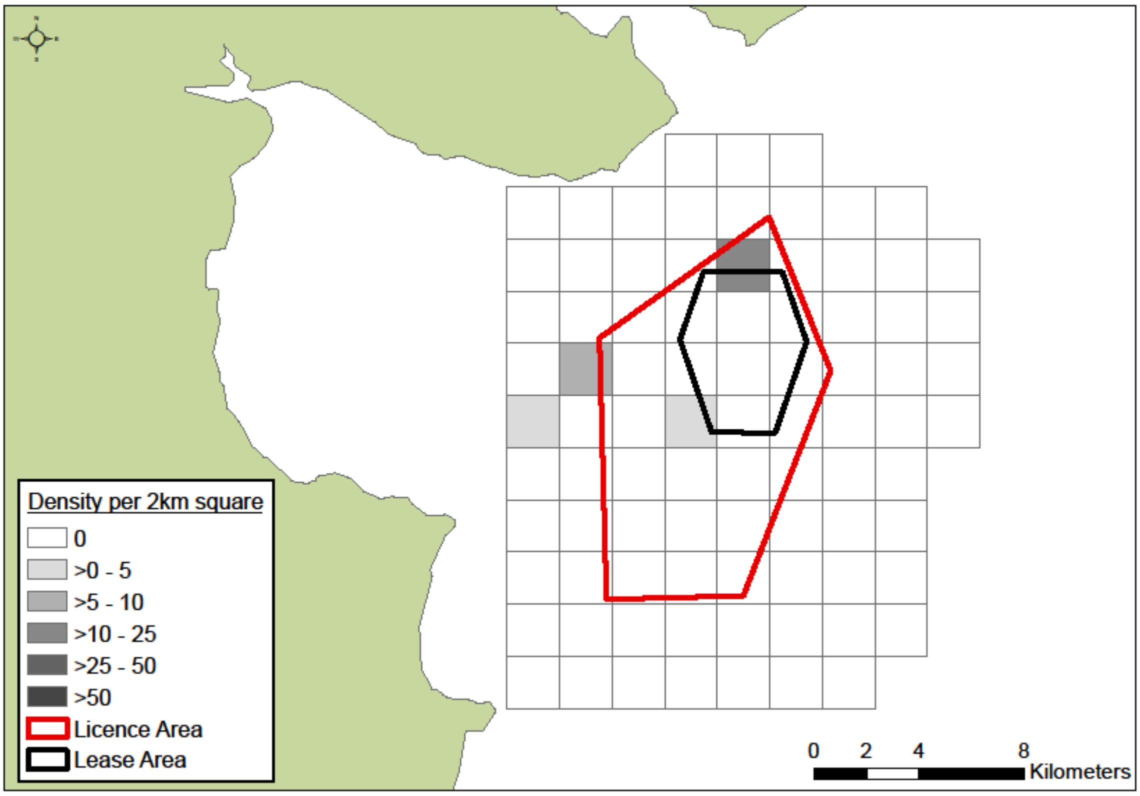

Figure 3.4.12 Great Northern Diver density estimates June 2018.

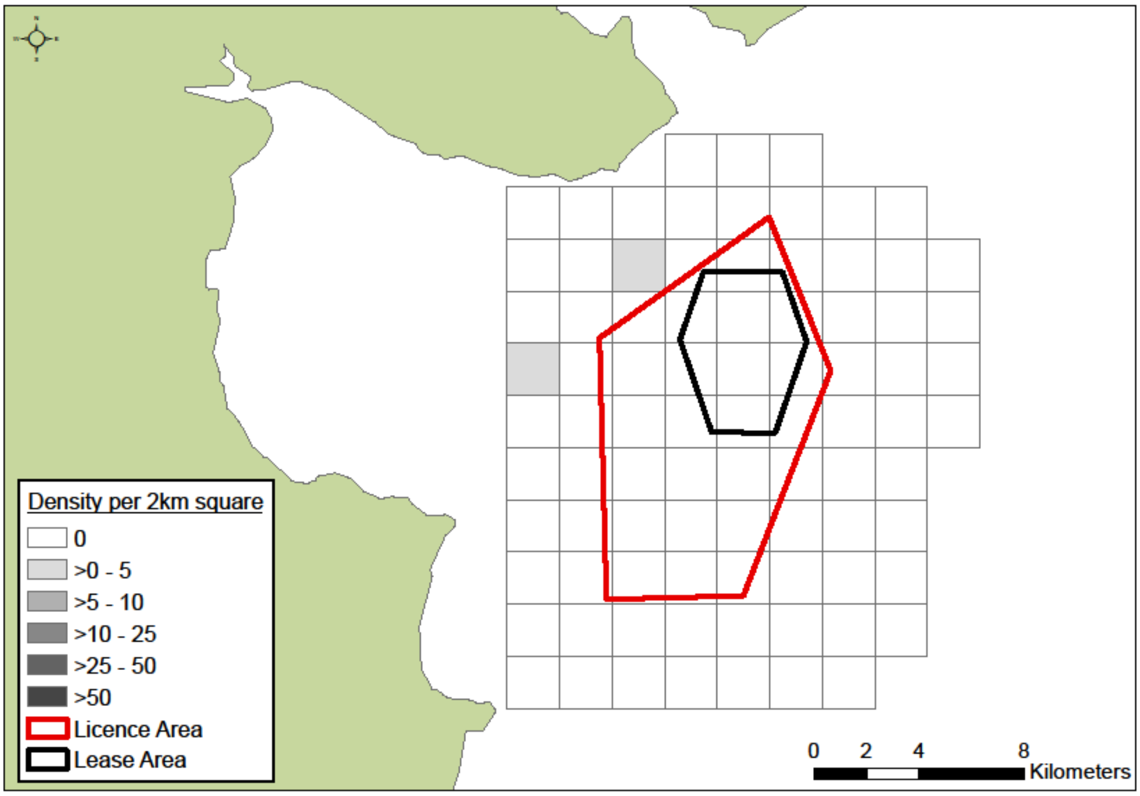

Figure 3.4.13 Great Northern Diver density estimates September 2018.

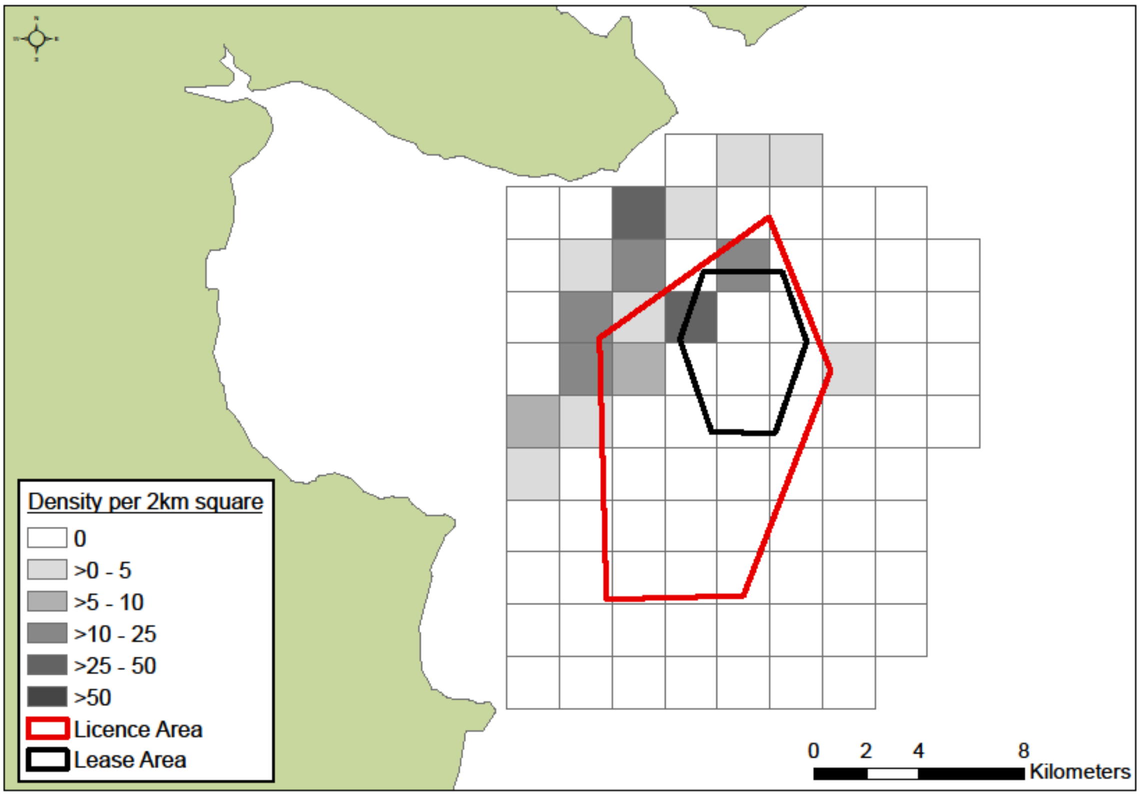

Figure 3.4.14 Great Northern Diver density estimates October 2018.

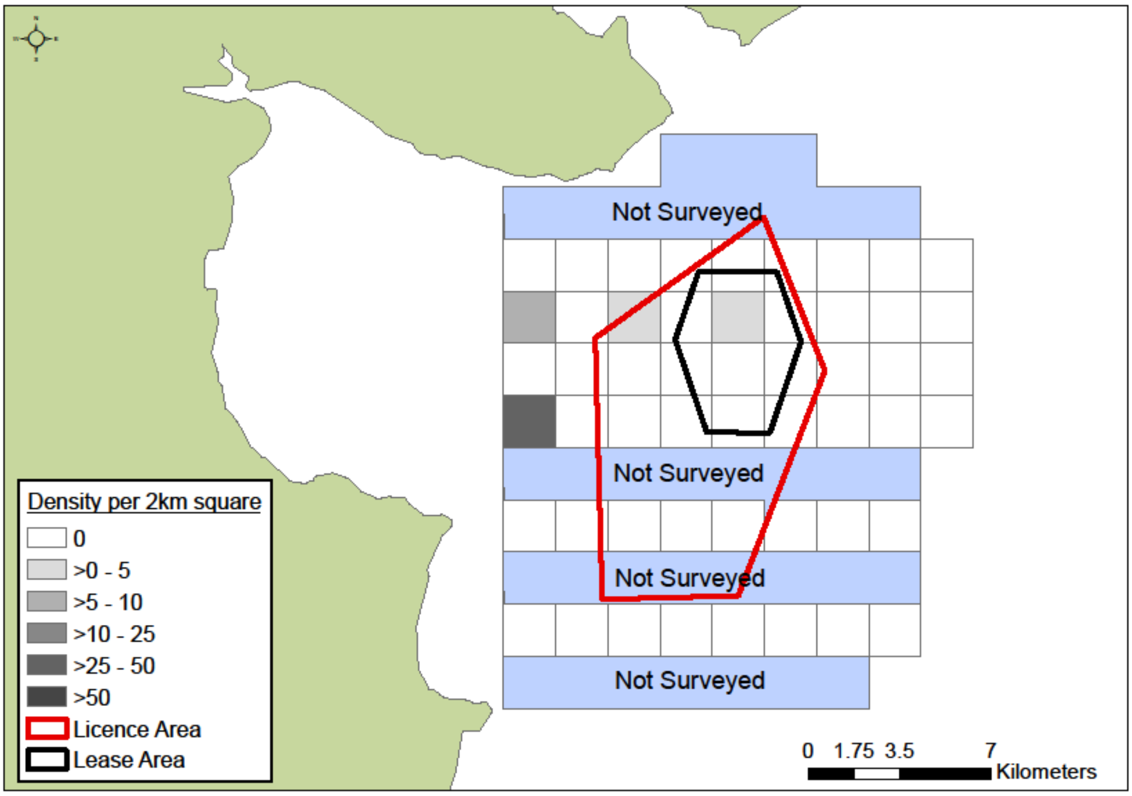

Figure 3.4.15 Great Northern Diver density estimates November 2018.

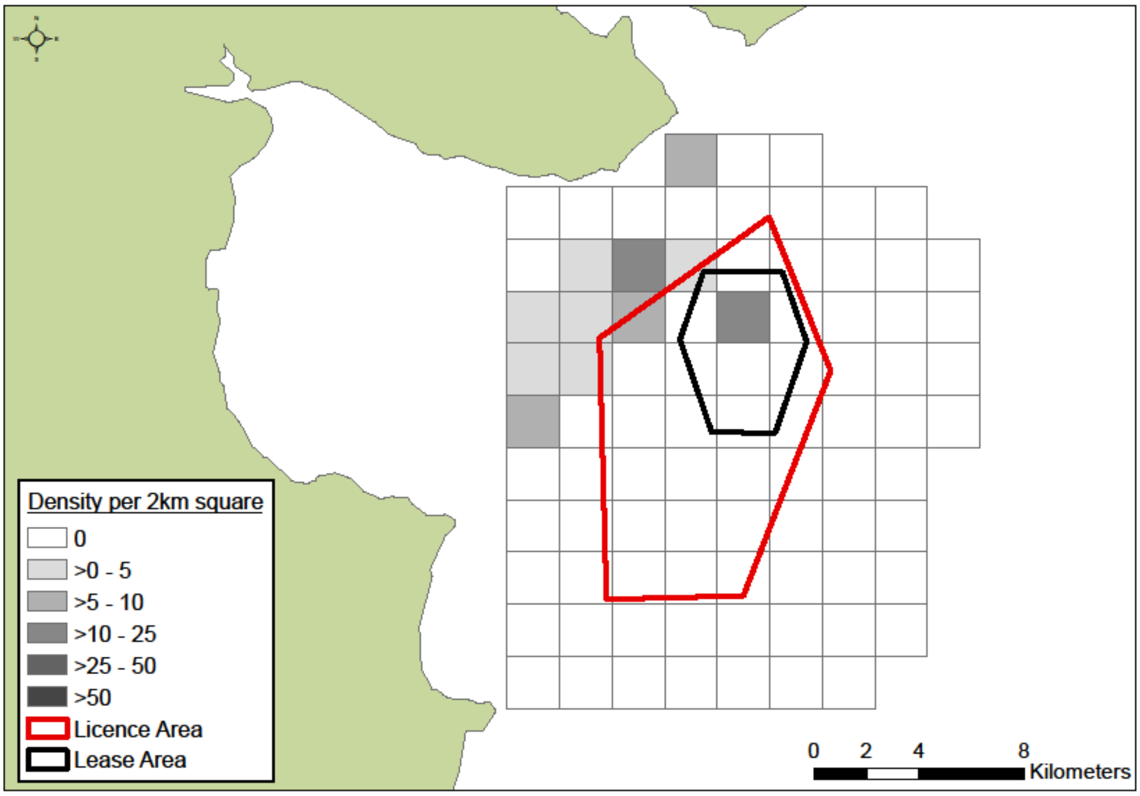

Figure 3.4.16 Great Northern Diver density estimates December 2018.

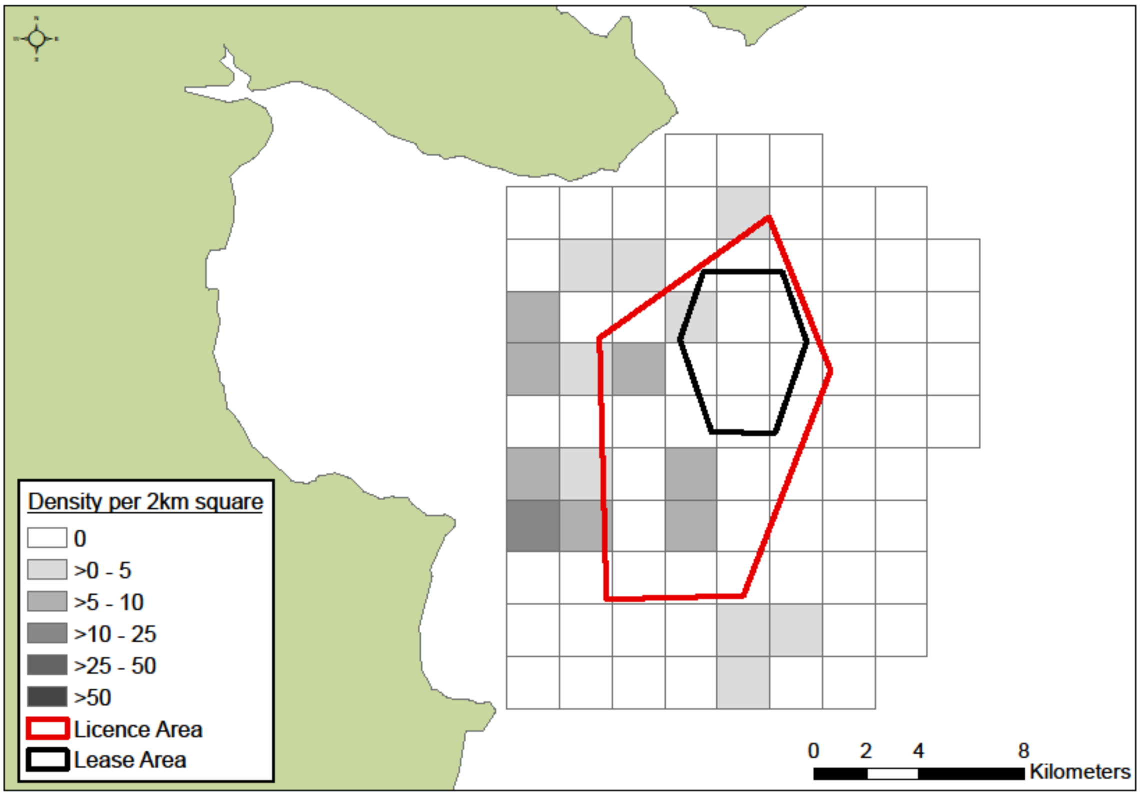

Figure 3.4.17 Great Northern Diver density estimates January 2019.

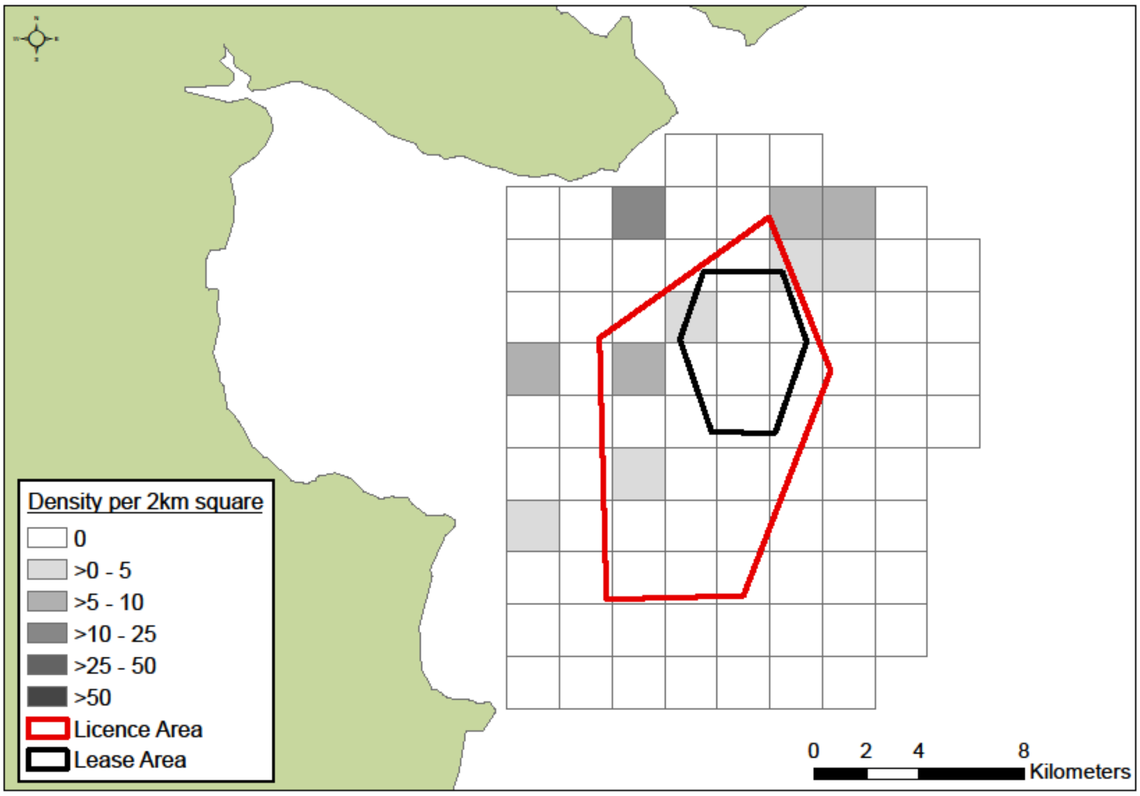

Figure 3.4.18 Great Northern Diver density estimates February 2019.

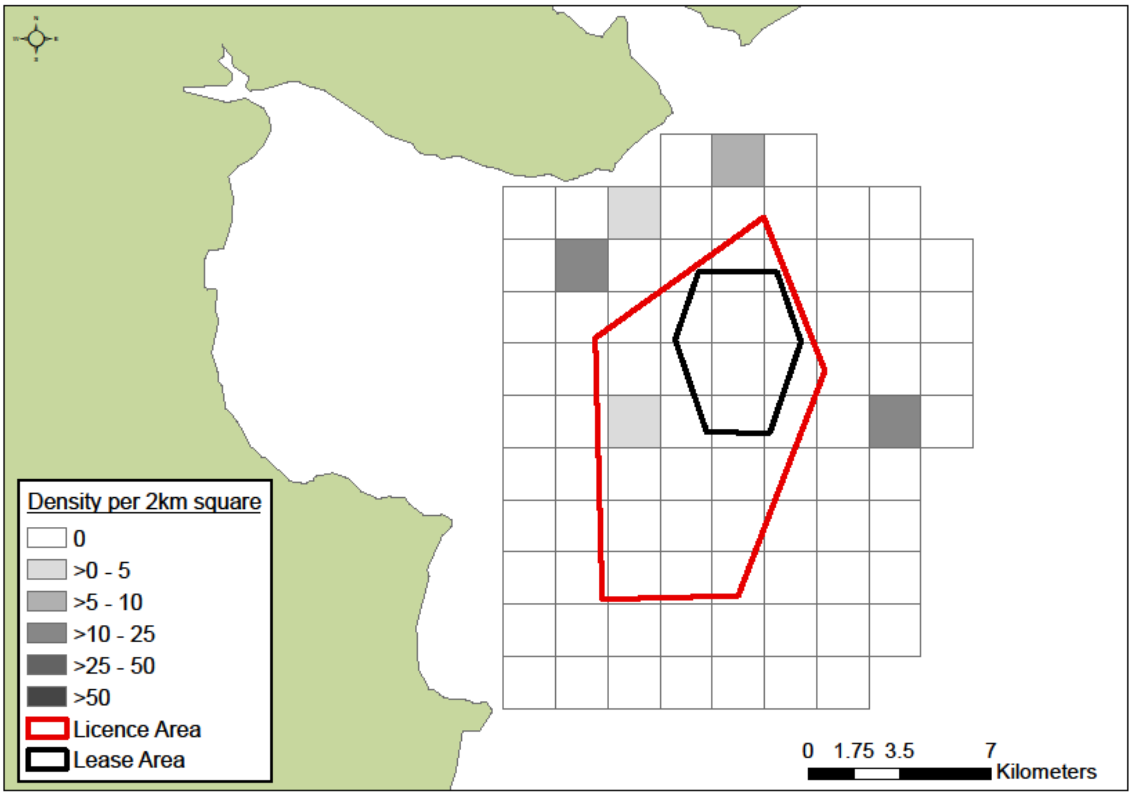

Figure 3.4.19 Great Northern Diver density estimates March 2019.

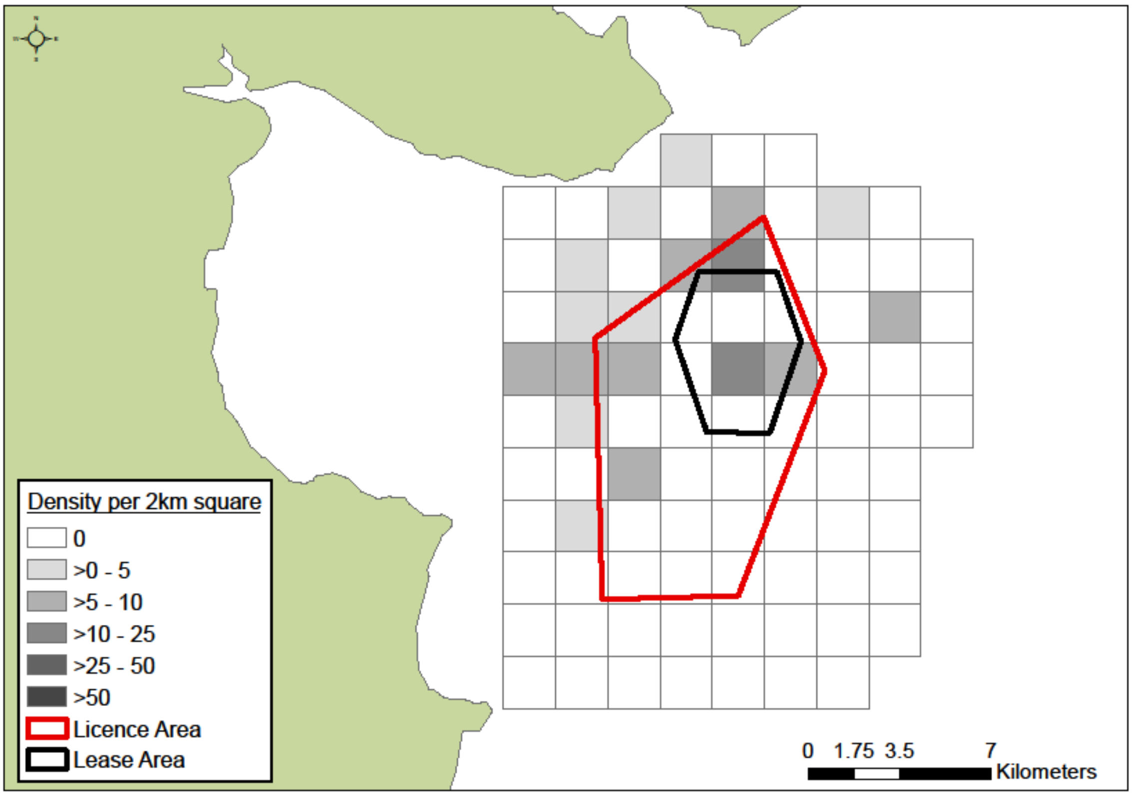

Figure 3.4.20 Great Northern Diver density estimates April 2019.

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3.5 Fulmar

Fulmar are widespread breeding species around Irish coasts (Balmer *et al.*, 2013), with an increasing population observed in recent years (Mitchell *et al.*, 2004) and are Green-listed in Ireland (Colhoun & Cummins, 2013). They forage almost exclusively at sea on small fish and crustaceans and scavenge on commercial fishing discards (Phillips *et al.*, 1999).

3.5.1 Fulmar Abundance

Fulmar were recorded in five of the twelve months of surveying (Table 3.5.1), with peak counts occurring in July 2018 (See Figure 3.5.2), with 18 birds recorded on transects from a total of 20 bird observed across the survey area. The summer timing of records (June to September 2018; see Figures 3.5.1 – 3.5.4) reflects birds returning to breeding colonies around the Irish Sea (although there are no breeding sites immediately adjacent to the survey area (Balmer *et al.,* 2013)).

A single Fulmar was recorded in the Lease area in July 2018 (see Figure 3.5.2). Two Fulmars were recorded in the Licence area in June 2018 (See Figure 3.5.1), with single birds recorded in the Lease area in both July 2018 (Figure 3.5.2) and August 2018 (Figure 3.5.3).

Table 3.5.1 Fulmar records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	0
June 2018	3	6
July 2018	18	20
August 2018	2	11
September 2018	2	5
October 2018	0	0
November 2018	0	0
December 2018	0	0
January 2019	0	0
February 2019	6	6
March 2019	0	0
April 2019	0	0
TOTAL	**31**	**48**

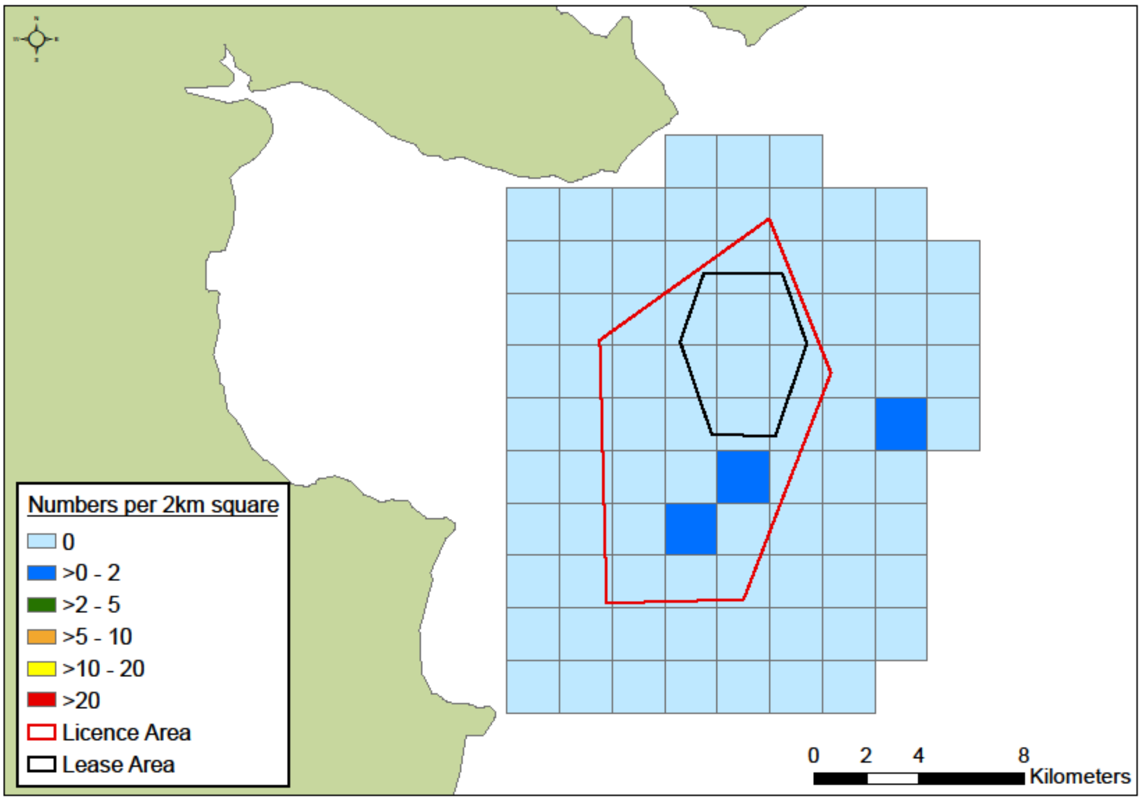

Figure 3.5.1 Fulmar survey results June 2018.

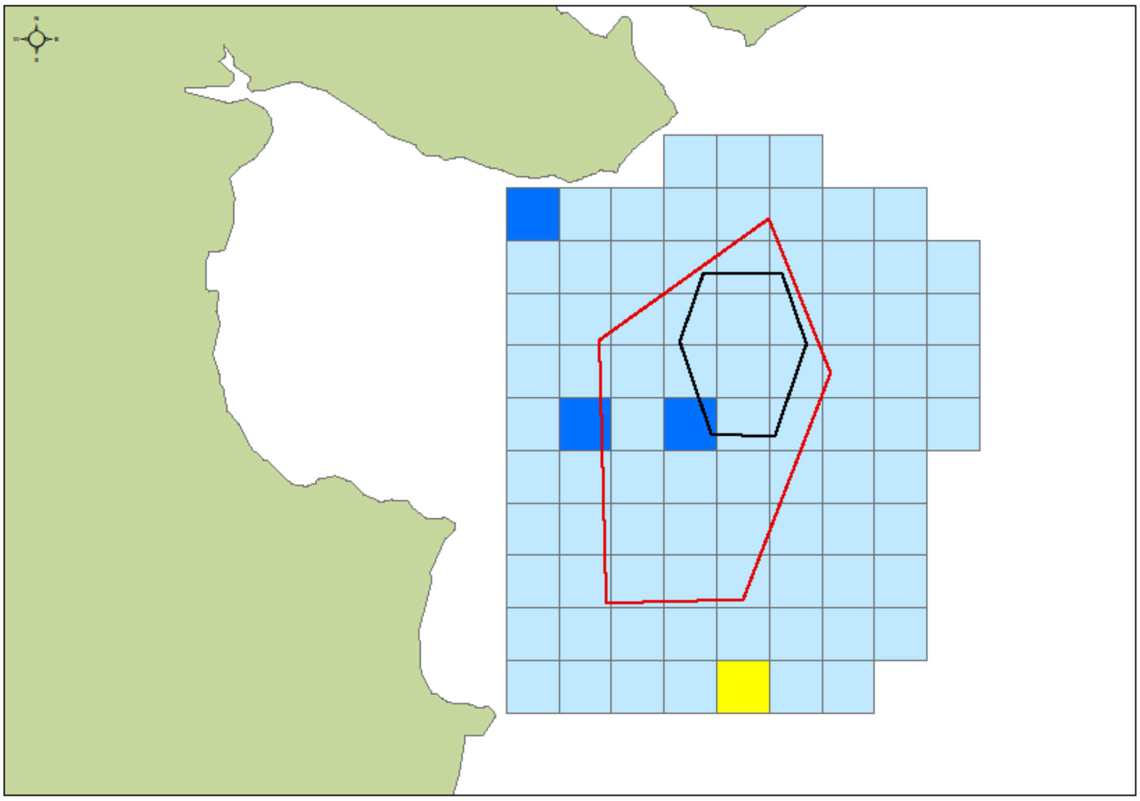

Figure 3.5.2 Fulmar survey results July 2018.

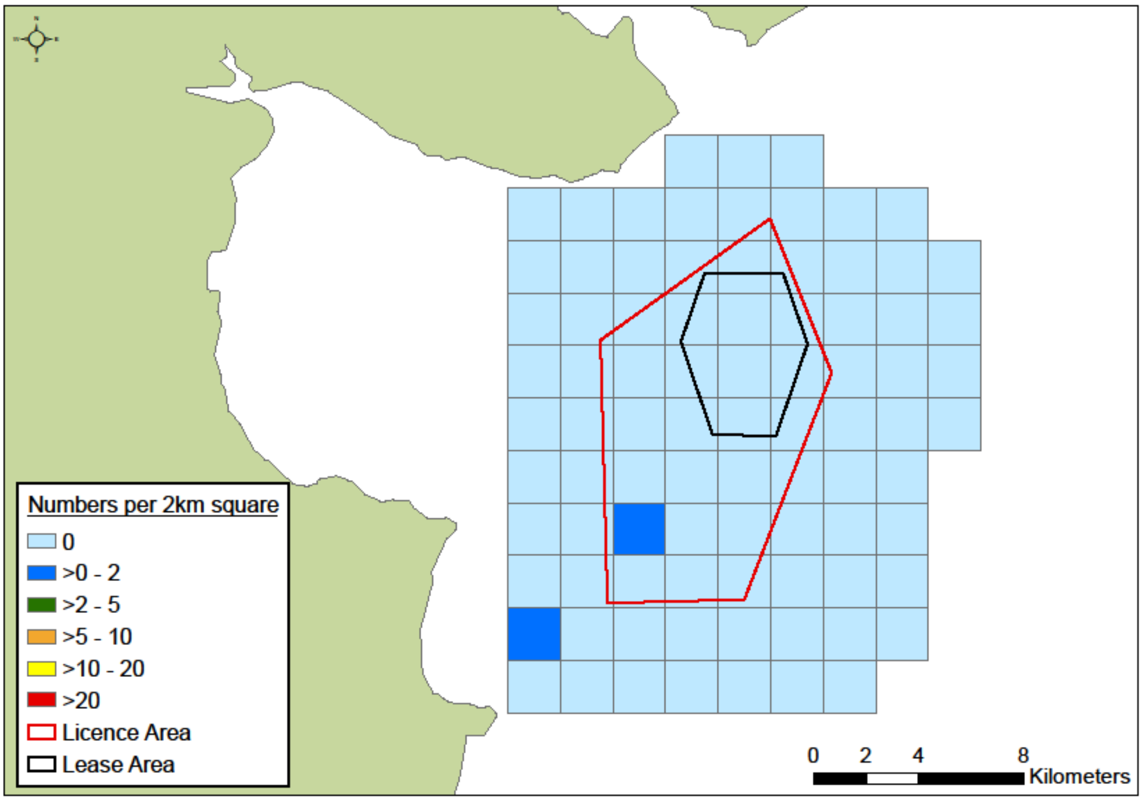

Figure 3.5.3 Fulmar survey results August 2018.

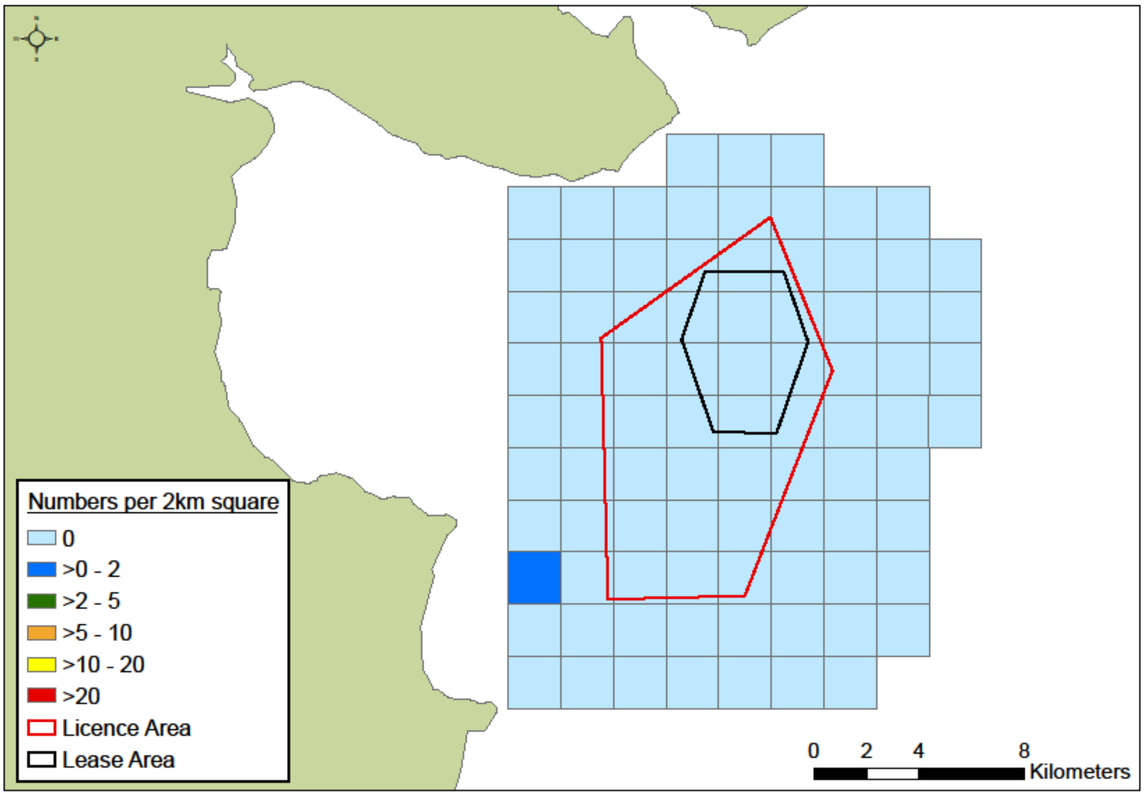

Figure 3.5.4 Fulmar survey results September 2018.

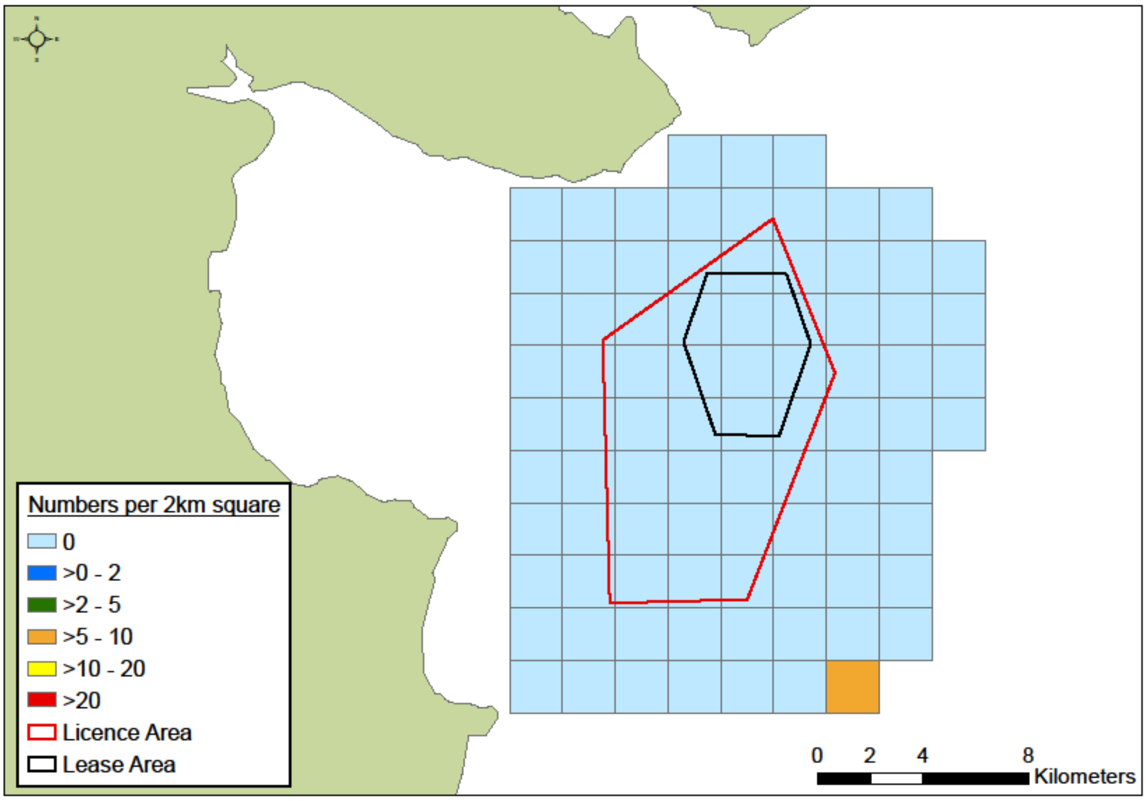

Figure 3.5.5 Fulmar survey results February 2019.

3.5.2 Fulmar Density

The monthly density estimates for Fulmar, as derived from the transect survey data, are presented in Figures 3.5.6 to 3.5.9. Highest densities were observed in July 2018, when the overall derived estimate was 0.13 birds/km^2.

Note that these density estimates are derived from a very small number of observed individuals (20 birds in total), so need to be treated with caution. The density estimates presented here are substantially lower than those derived for the western Irish Sea (Jessop *et al*., 2018), with a maximum of 1.52 Fulmar/ km^2 were estimated. The lower densities in the Oriel windfarm survey area may be due to low breeding densities on the adjacent coastline. However, the seasonality of Fulmar occurrence in the Irish Sea, with higher numbers in the post-breeding season (autumn) is reflected in both sets of data.

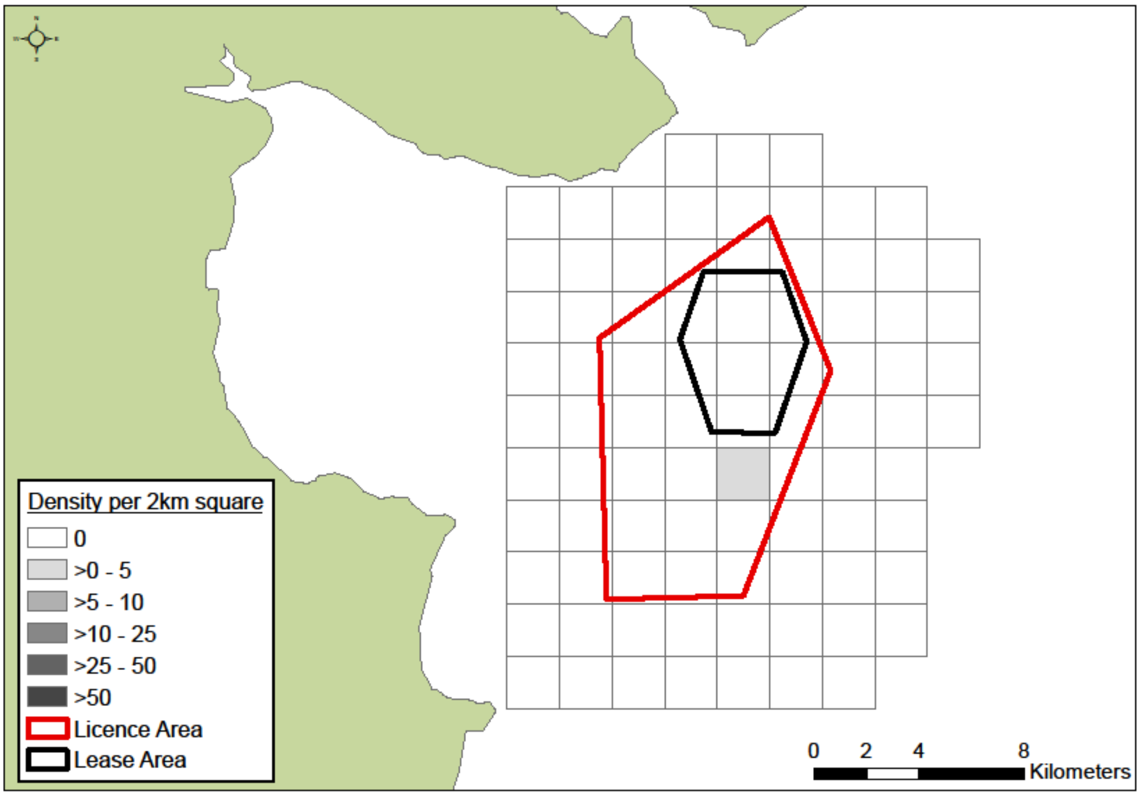

Figure 3.5.6 Fulmar density estimates June 2018.

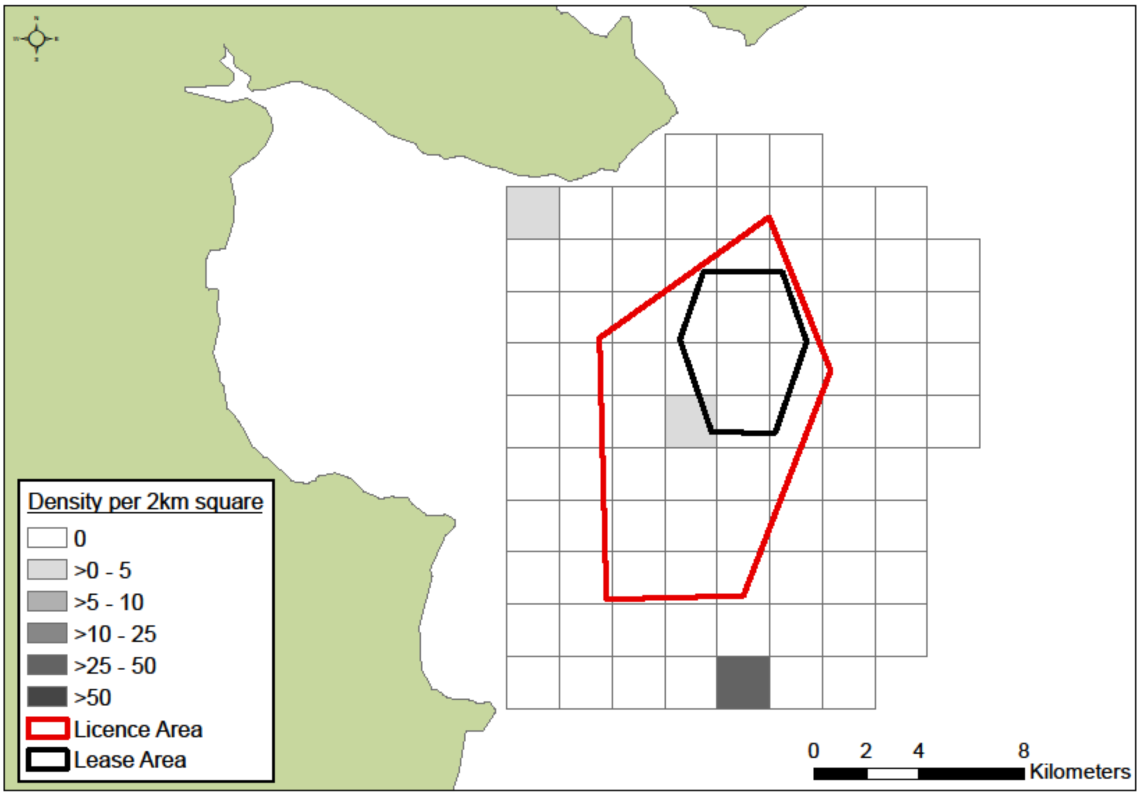

Figure 3.5.7 Fulmar density estimates July 2018.

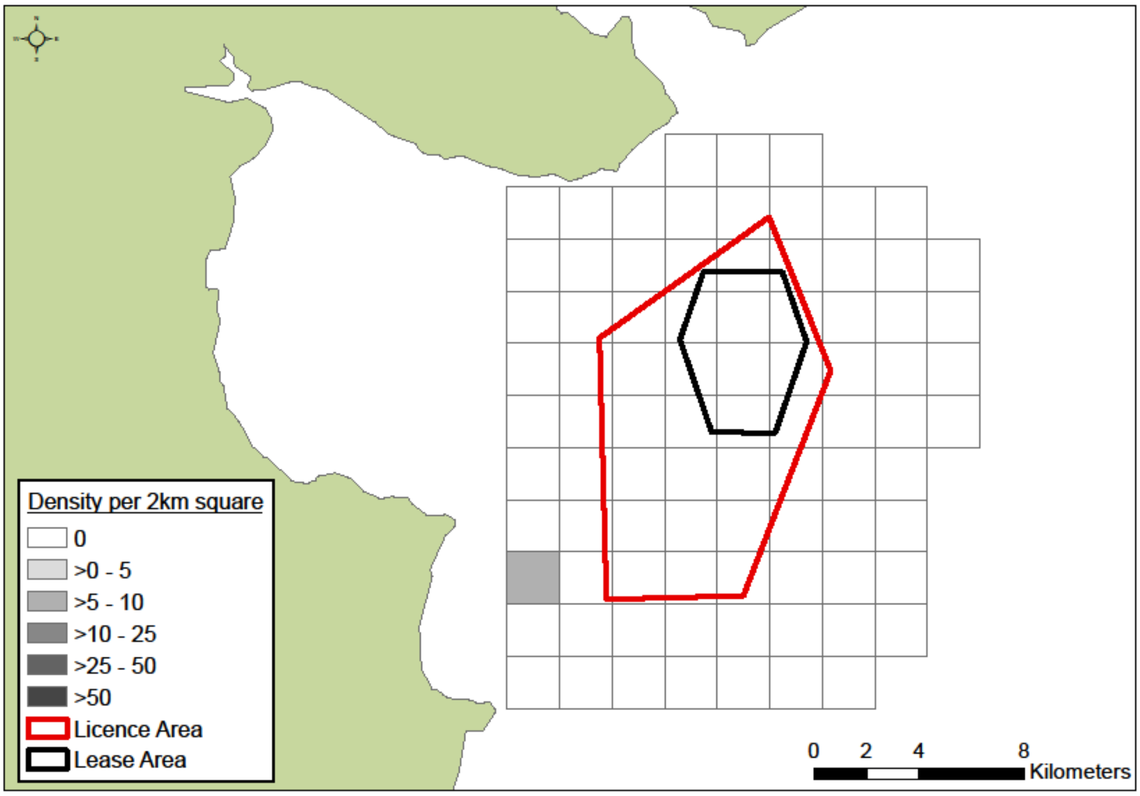

Figure 3.5.8 Fulmar density estimates September 2018.

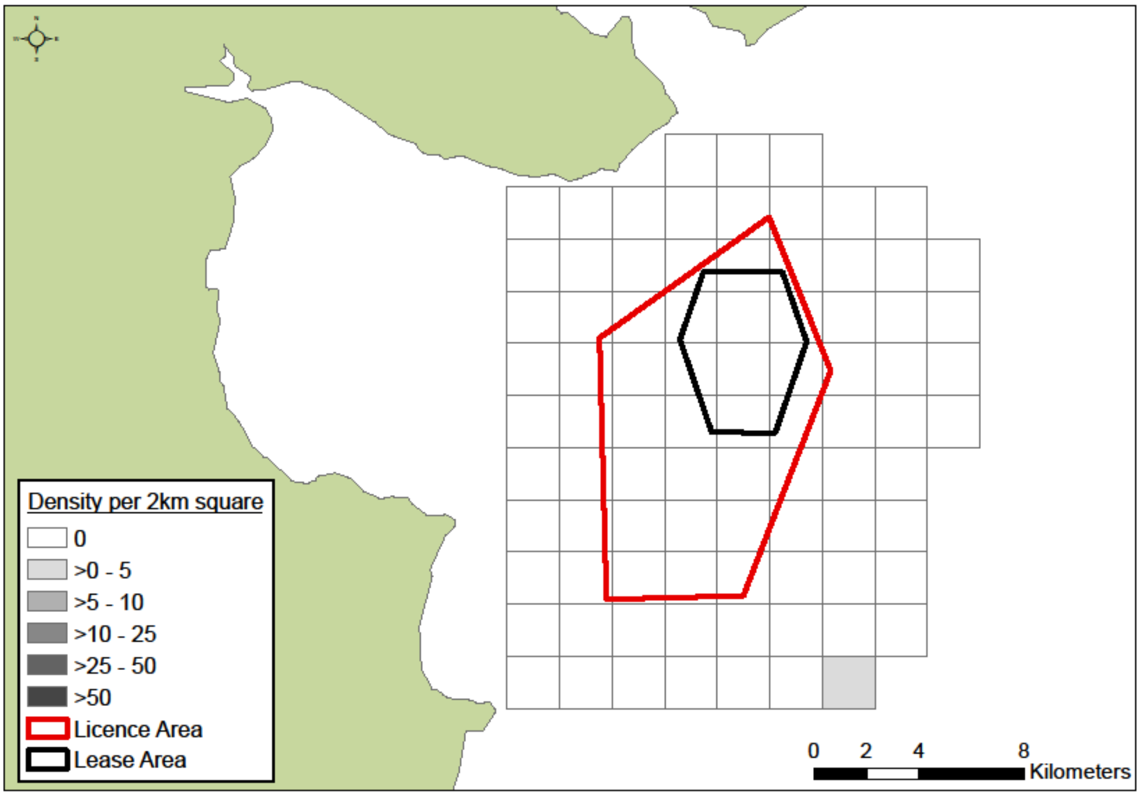

Figure 3.5.9 Fulmar density estimates February 2019.

3.6 Manx Shearwater

Manx Shearwaters are summer visitors to the Irish Sea (Stone *et al.*, 1995) where their breeding is localised to a small number of (often very large) colonies (Mitchell *et al.*, 2004). Although two of these colonies (Copeland Islands, Co. Down and Lambay Island, Co. Dublin) are located north and south of the survey area (Balmer *et al.*, 2013), it is likely that birds foraging in the Irish Sea may travel from as far afield as Scotland (Rhum) or Wales (Skomer/Skokhom) as well as other Irish Sea colonies (Stone *et al.*, 1994). They are Amber-listed in Ireland due to more than 50% the Irish population occurring at fewer than ten sites (Colhoun & Cummins, 2013). The feed on small fish, crustaceans and plankton from the sea, diving into the first few metres of water (Stone *et al.*, 1994).

3.6.1 Manx Shearwater Abundance

As expected, Manx Shearwaters were only recorded in the survey area (and on the transects) during the summer (April-September) period (Table 3.6.1). Peak counts occurred towards the end of the nesting season, with 1,593 birds observed in the survey area in August 2018, which includes 990 bird recorded on transects and 1,419 observations in September 2018, including 957 records from the transect surveys.

Table 3.6.1 Manx Shearwater records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	7	31
June 2018	150	404
July 2018	285	630
August 2018	990	1,593
September 2018	957	1,419
October 2018	0	0
November 2018	0	0
December 2018	0	0
January 2019	0	0
February 2019	0	0
March 2019	0	2
April 2019	1	4
TOTAL	**2,390**	**4,083**

A total of 322 Manx Shearwaters were recorded within the Lease area during transect surveys (representing 13.5% of all individuals recorded), with 553 (23.1%) in the Licence area and 1,515 (63.4%) in the remainder of the survey area (Table 3.6.2). This pattern of occurrence reflects the fact that Manx Shearwater were typically recorded further offshore, away from coastal areas towards the north-west and western edges of the survey area (see Figures 3.6.1 to 3.6.5).

Table 3.6.2 Manx Shearwater records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	0	0	7	100	0	0
June 2018	91	60.7	2	1.3	57	38.0
July 2018	168	58.9	116	40.7	1	0.4
August 2018	693	70.0	149	15.1	148	14.9
September 2018	562	58.7	279	29.2	116	12.1
October 2018	0	-	0	-	0	-
November 2018	0	-	0	-	0	-
December 2018	0	-	0	-	0	-
January 2019	0	-	0	-	0	-
February 2019	0	-	0	-	0	-
March 2019	0	-	0	-	0	-
April 2019	1	100	0	0	0	0
TOTAL	1,515	63.4	553	23.1	322	13.5

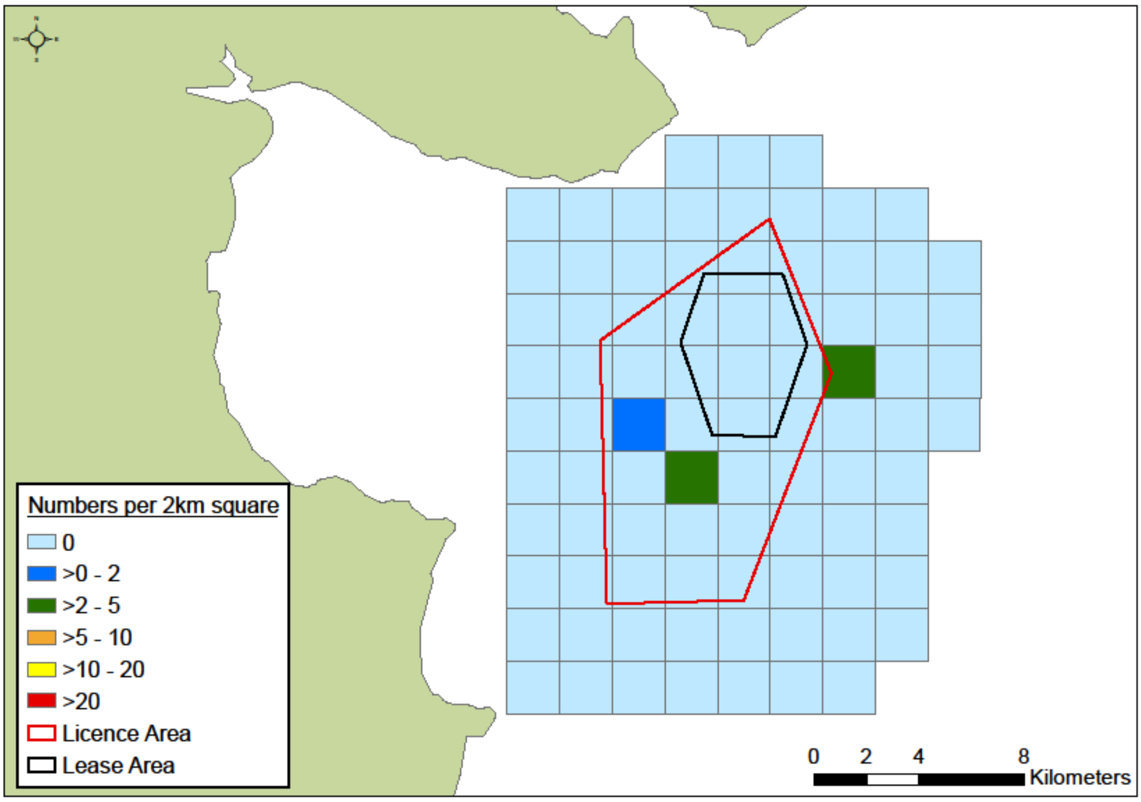

Figure 3.6.1 Manx Shearwater survey results May 2018.

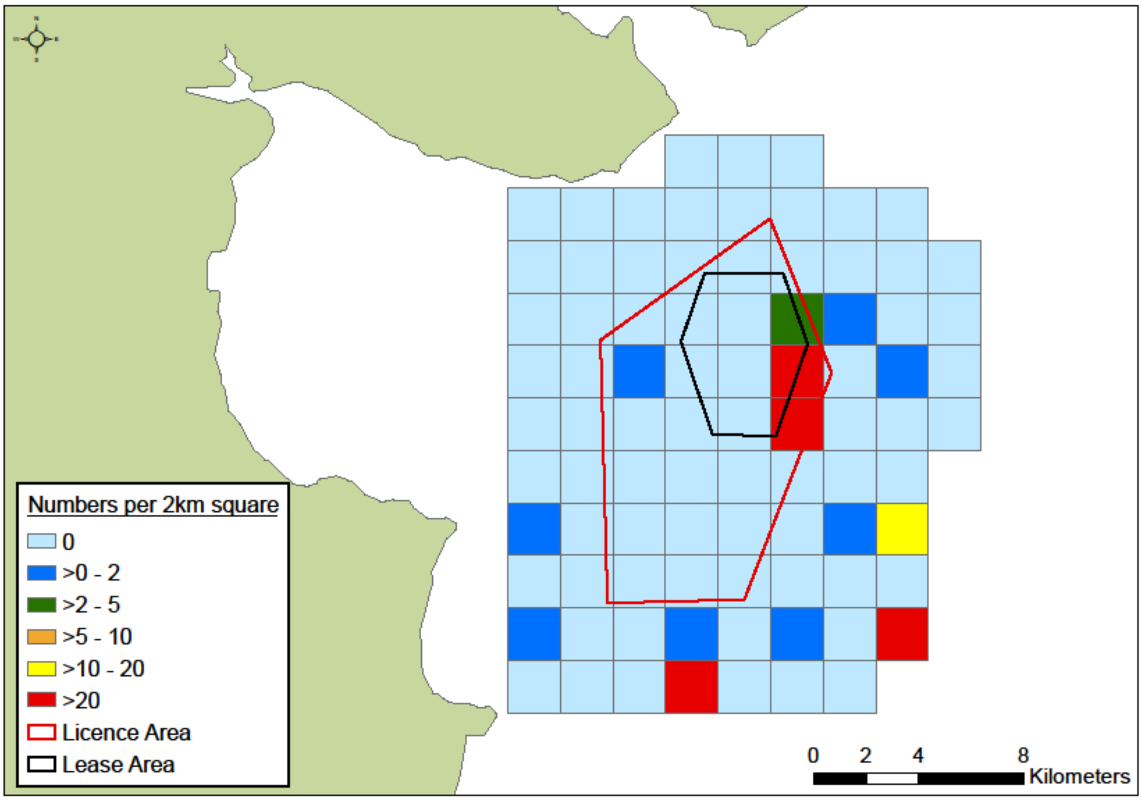

Figure 3.6.2 Manx Shearwater survey results June 2018.

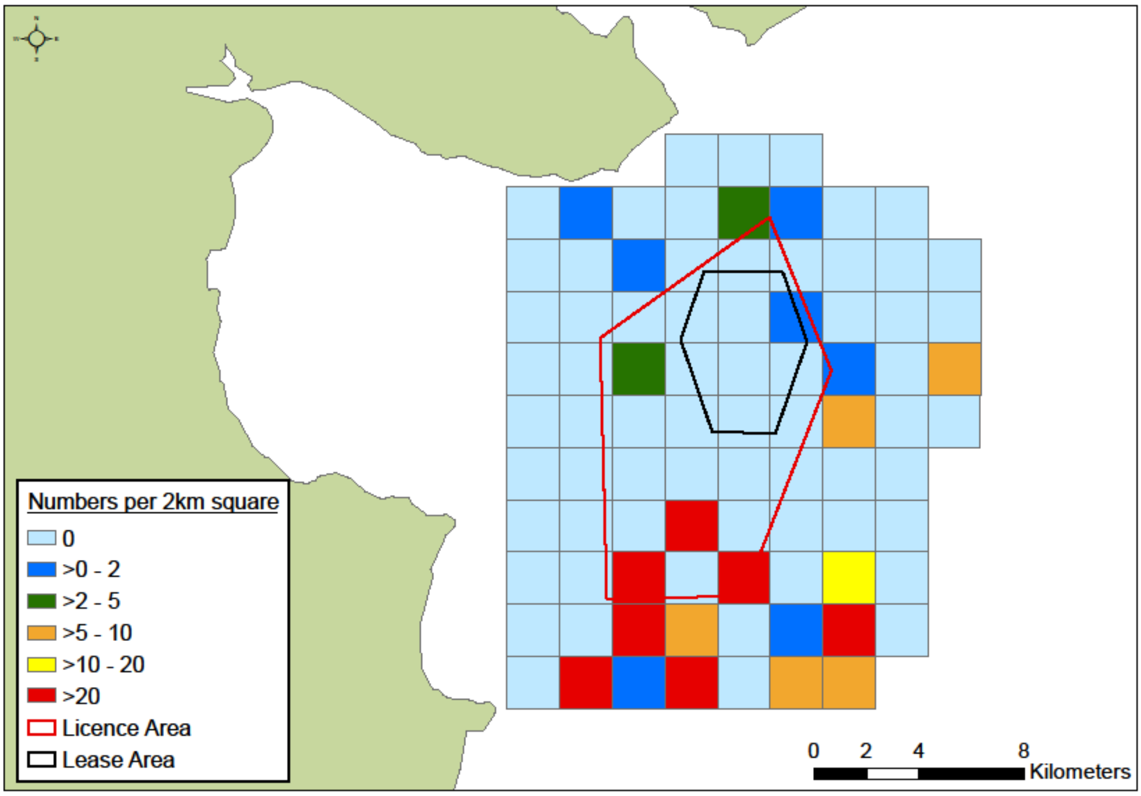

Figure 3.6.3 Manx Shearwater survey results July 2018.

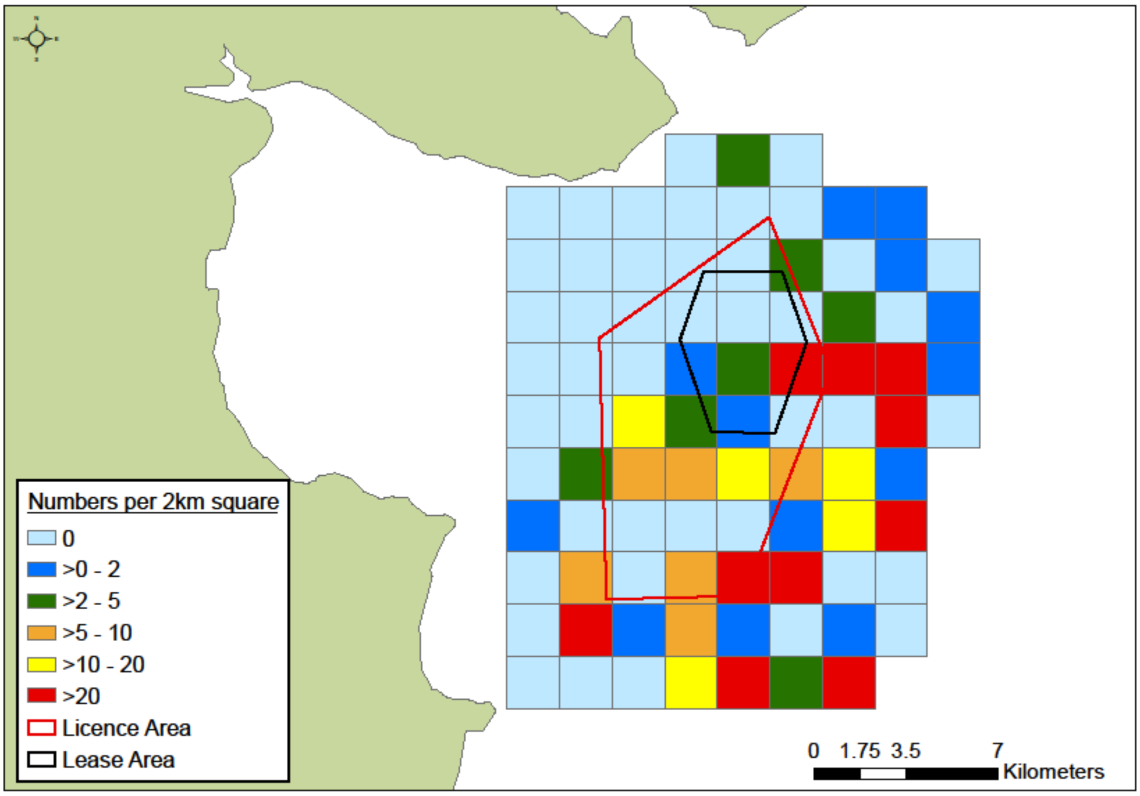

Figure 3.6.4 Manx Shearwater survey results August 2018.

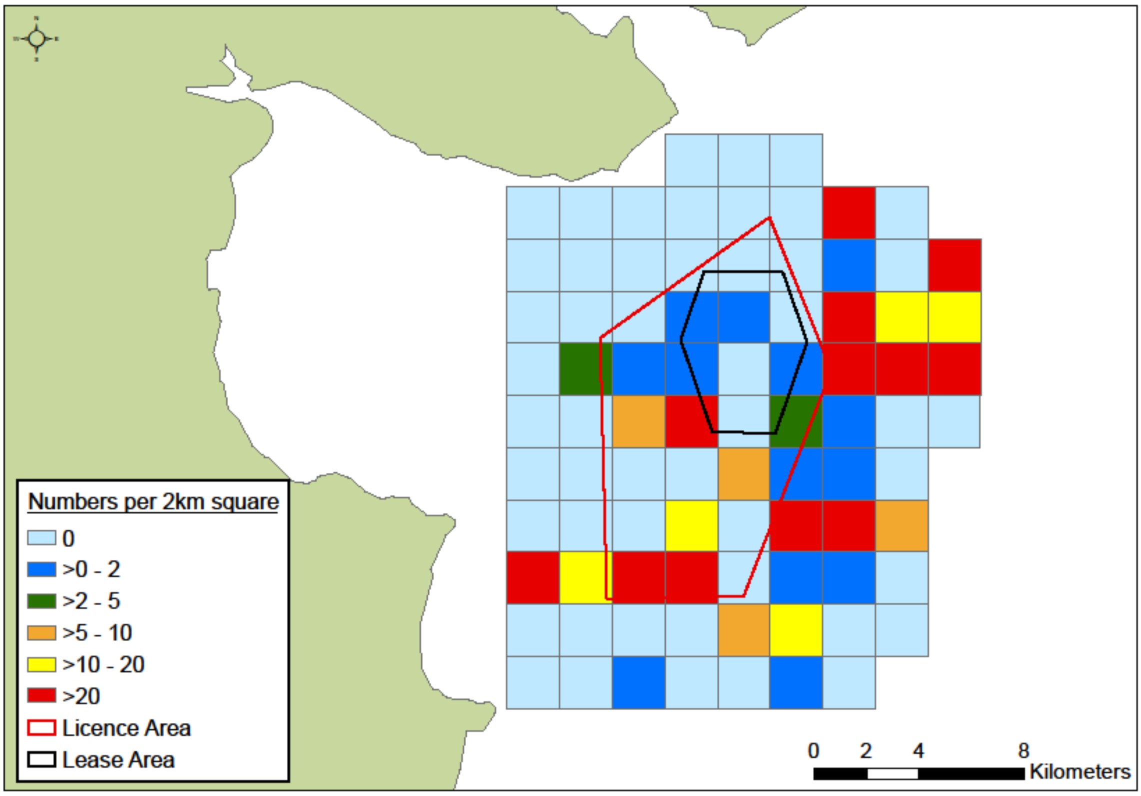

Figure 3.6.5 Manx Shearwater survey results September 2018.

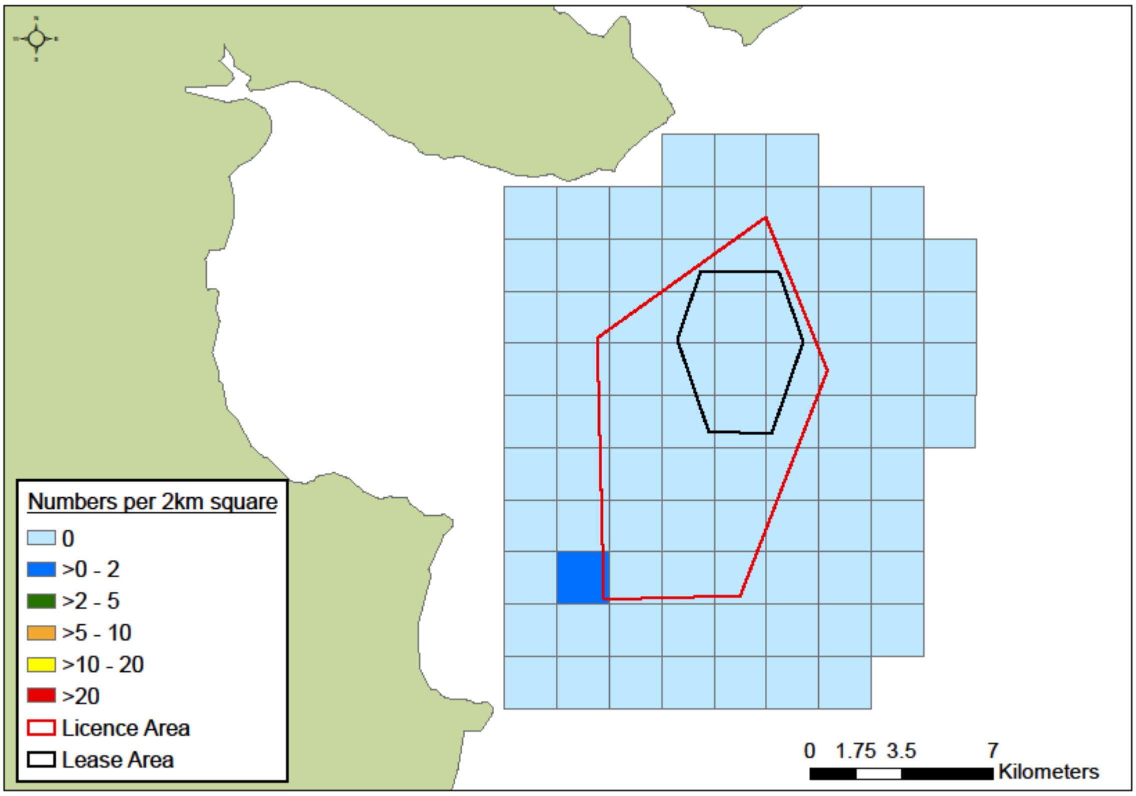

Figure 3.6.6 Manx Shearwater survey results April 2019.

3.6.2 Manx Shearwater Density

Derived monthly density estimates for Manx Shearwater are shown in Figures 3.6.7 to 3.6.12. Peak density was recorded in August, with a derived density estimate of 5.82 birds/km^2. This is high in comparison with the density estimates provides in Jessop *et al*., (2018) for the western Irish Sea of 3.37 birds/km^2 for summer and 1.15 bird/km^2 for Autumn.

The reasons for this increased density are not clear. It is possible that the Oriel Windfarm survey area in the north-western corner of the western Irish Sea survey area may have higher concentrations of Manx Shearwater than elsewhere within that survey area, although such a preference is not clearly indicated within that data (Jessop *et al.*, 2018).

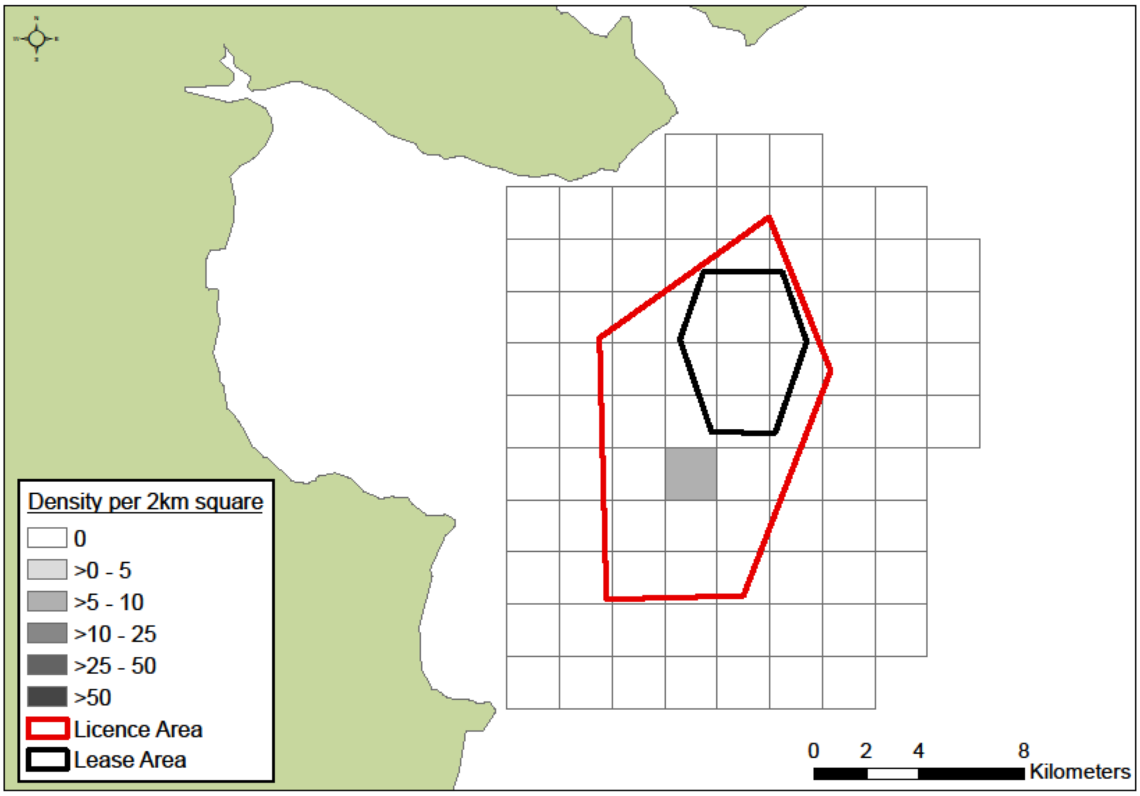

Figure 3.6.7 Manx Shearwater density estimates May 2018.

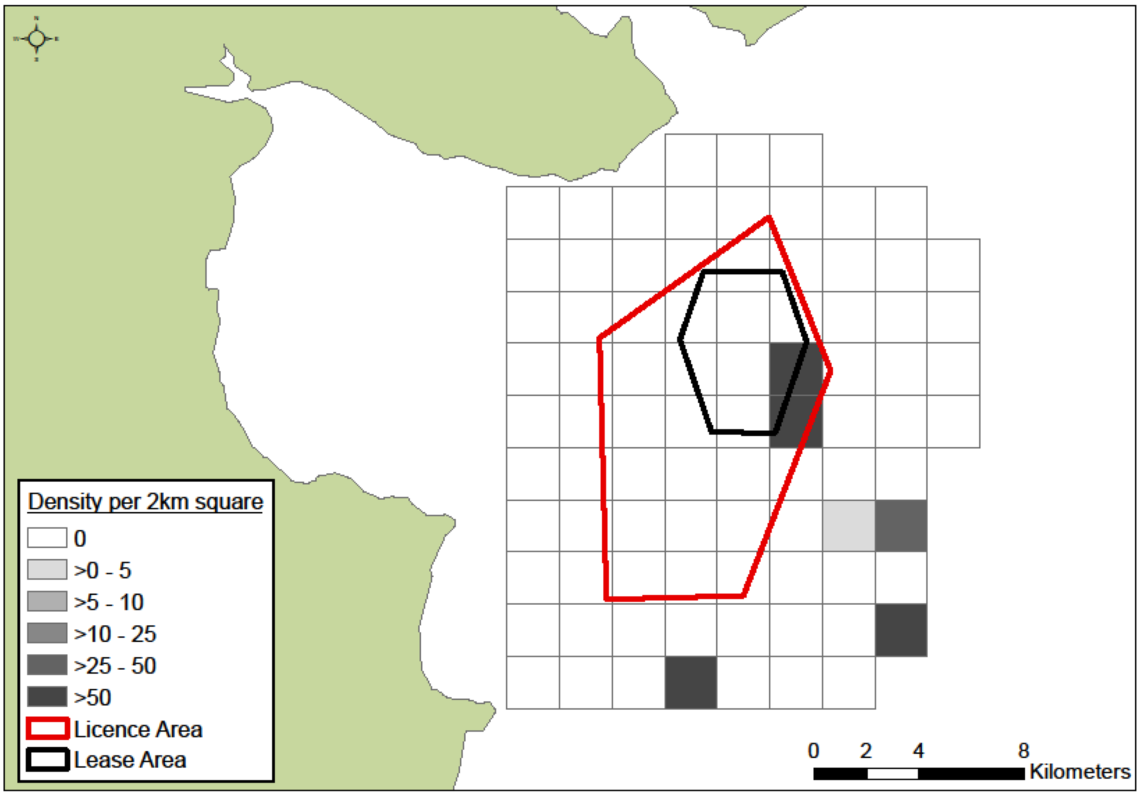

Figure 3.6.8 Manx Shearwater density estimates June 2018.

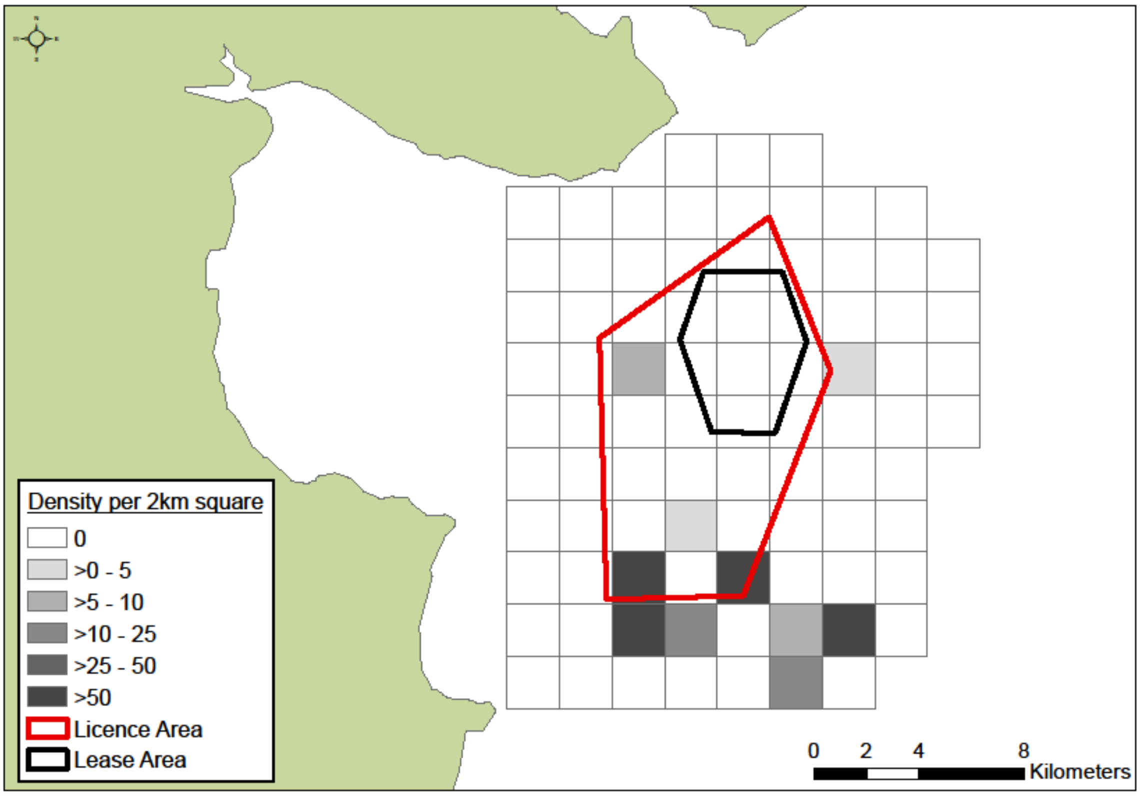

Figure 3.6.9 Manx Shearwater density estimates July 2018.

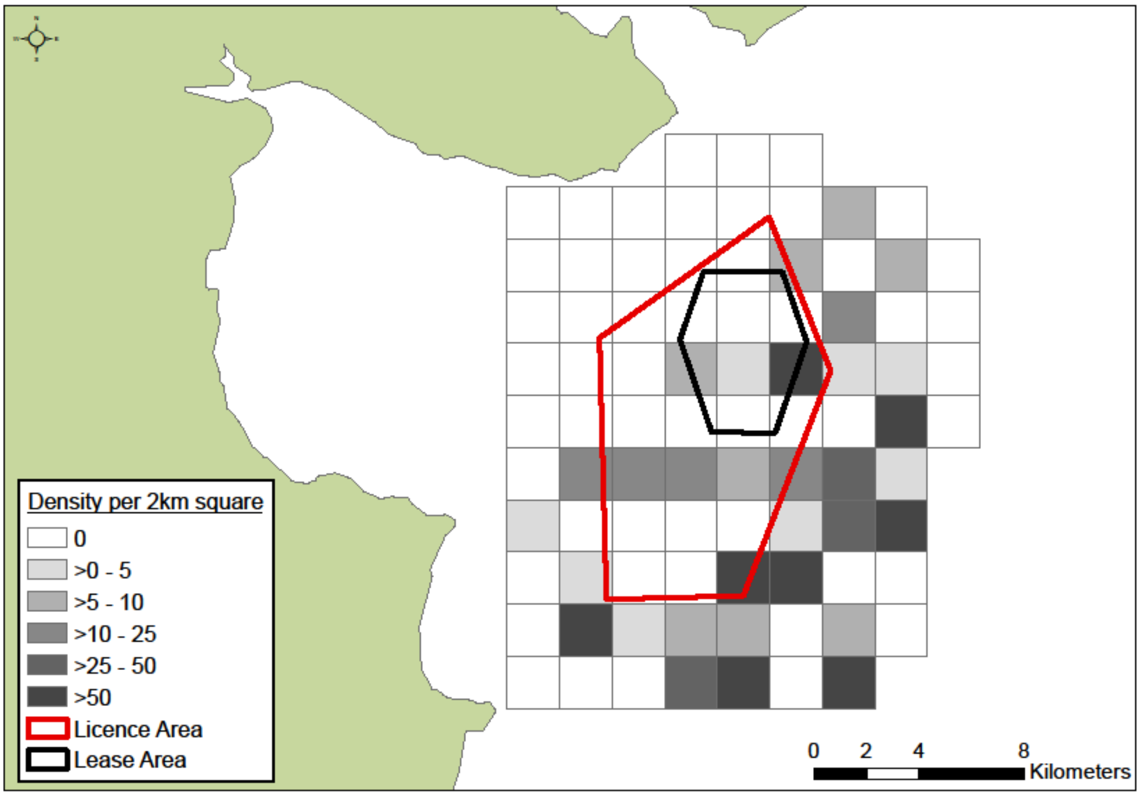

Figure 3.6.10 Manx Shearwater density estimates August 2018.

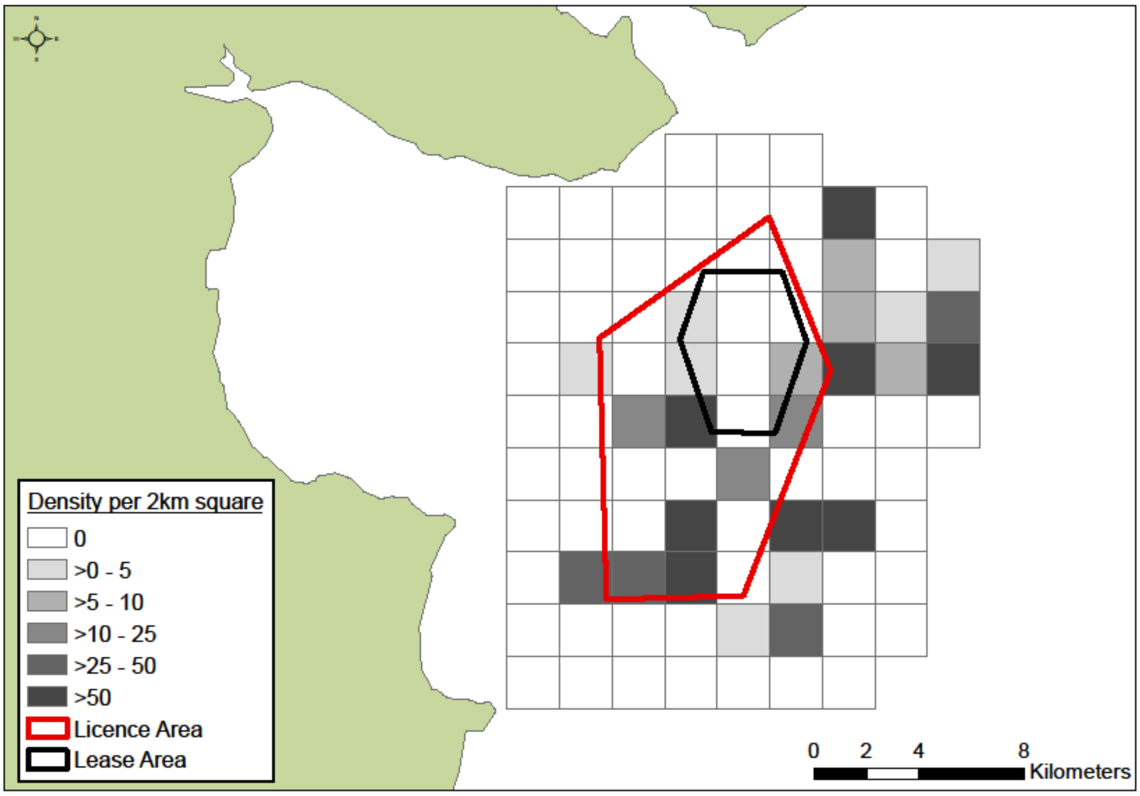

Figure 3.6.11 Manx Shearwater density estimates September 2018.

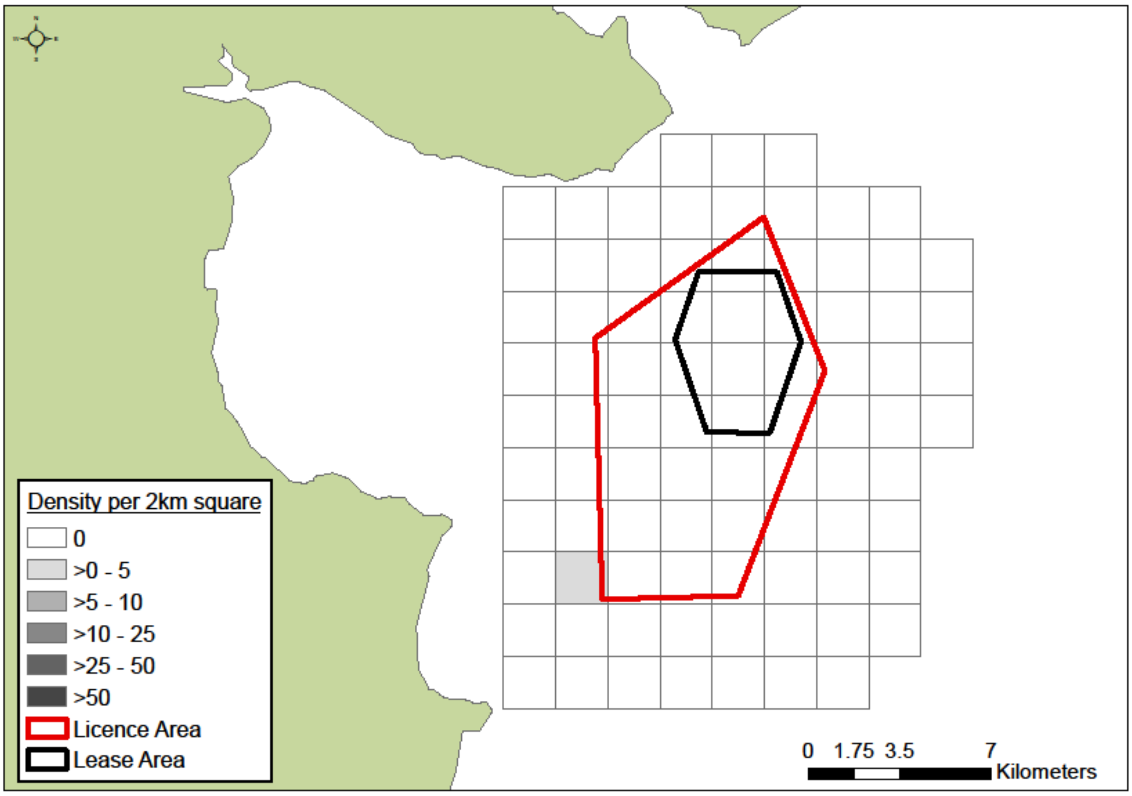

Figure 3.6.12 Manx Shearwater density estimates April 2019.

3.7 Gannet

Gannets are found around the Irish coastline throughout the year (Balmer *et al.*, 2013), although they tend to be scarcer during winter when they disperse away from breeding colonies (Tasker *et al*., 1985; Stone *et al.*, 1995). They are Amber-listed in Ireland as more than 50% of the breeding population are found at fewer than ten sites (Colhoun & Cummins, 2013). They feed by plunge-diving to a depth of c.35m (Brierley & Fernandez, 2001), where they feed on a variety of prey species (Lewis, *et al.*, 2003).

3.7.1 Gannet Abundance

The greatest abundances recorded for Gannet were in September 2018 with a maximum of 119 birds recorded on transects with a total of 247 observed within the whole survey area (Table 3.7.1). This peak coincides with the end of the breeding season when adults and juveniles are dispersing from breeding colonies.

Table 3.7.1 Gannet records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	2	12
June 2018	27	80
July 2018	17	66
August 2018	62	199
September 2018	119	247
October 2018	23	99
November 2018	0	0
December 2018	2	4
January 2019	0	3
February 2019	1	3
March 2019	3	20
April 2019	8	33
TOTAL	**264**	**766**

Out of the 264 Gannets recorded during transect surveys, 122 individuals (46.2% of the total number recorded) were present in the survey area (Table 3.7.2). A further 87 birds (33.0% of the total) were present within the Licence area and 55 Gannets (20.8% of all individuals recorded) were present in the Lease area.

Outside the peak recording period (May-June 2018 and November 2018-April 2019; Figures 3.7.1, 3.7.2 & 3.7.7 to 3.7.10), Gannets were typically recorded further offshore (i.e., away from the west and north-west parts of the survey area). However, during the peak recording months of July 2018 to October 2018, birds were widespread throughout the survey area (see Figures 3.7.3 to 3.7.6).

Table 3.7.2 Gannet records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	1	50.0	1	50.0	0	0
June 2018	24	88.9	2	7.4	1	3.7
July 2018	10	58.8	5	29.4	2	11.8
August 2018	30	48.4	20	32.3	12	19.4
September 2018	42	35.3	48	40.3	29	24.4
October 2018	5	21.7	11	47.8	7	30.4
November 2018	0	-	0	-	0	-
December 2018	2	100	0	0	0	0
January 2019	0	-	0	-	0	-
February 2019	1	100	0	0	0	0
March 2019	1	33.3	0	0	2	66.7
April 2019	6	75.0	0	0	2	25.0
TOTAL	**122**	**46.2**	**87**	**33.0**	**55**	**20.8**

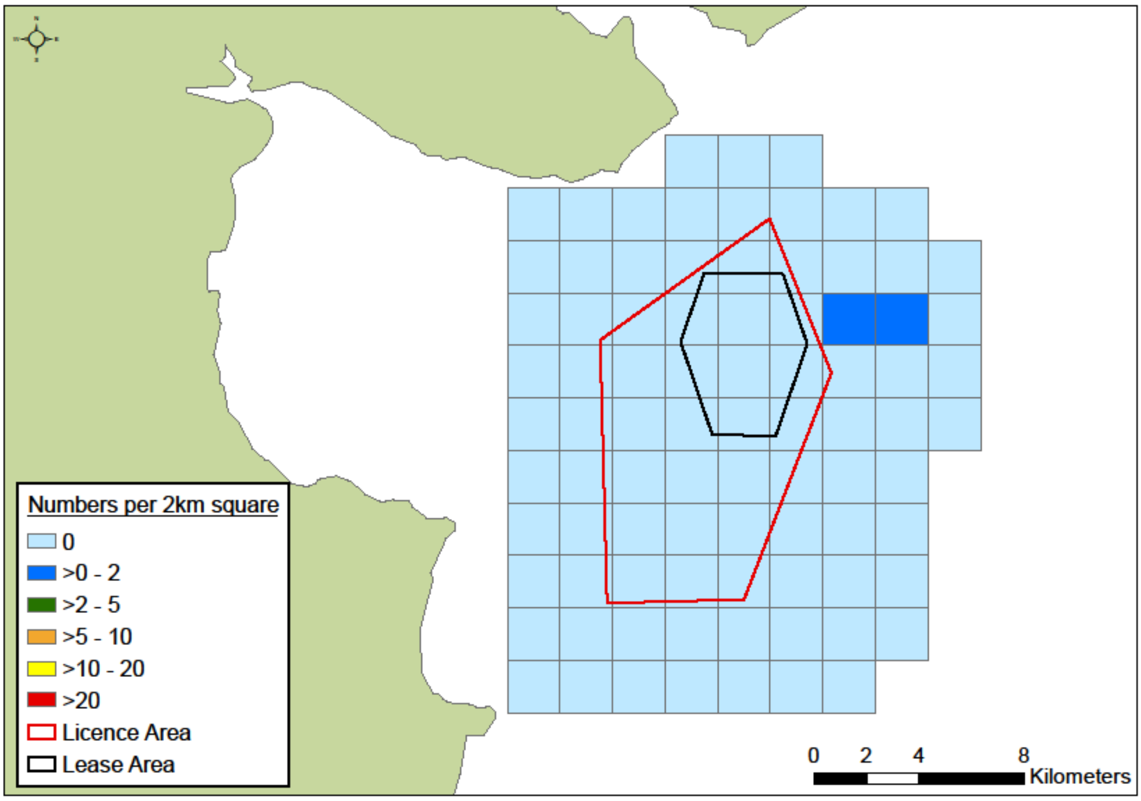

Figure 3.7.1 Gannet survey results May 2018.

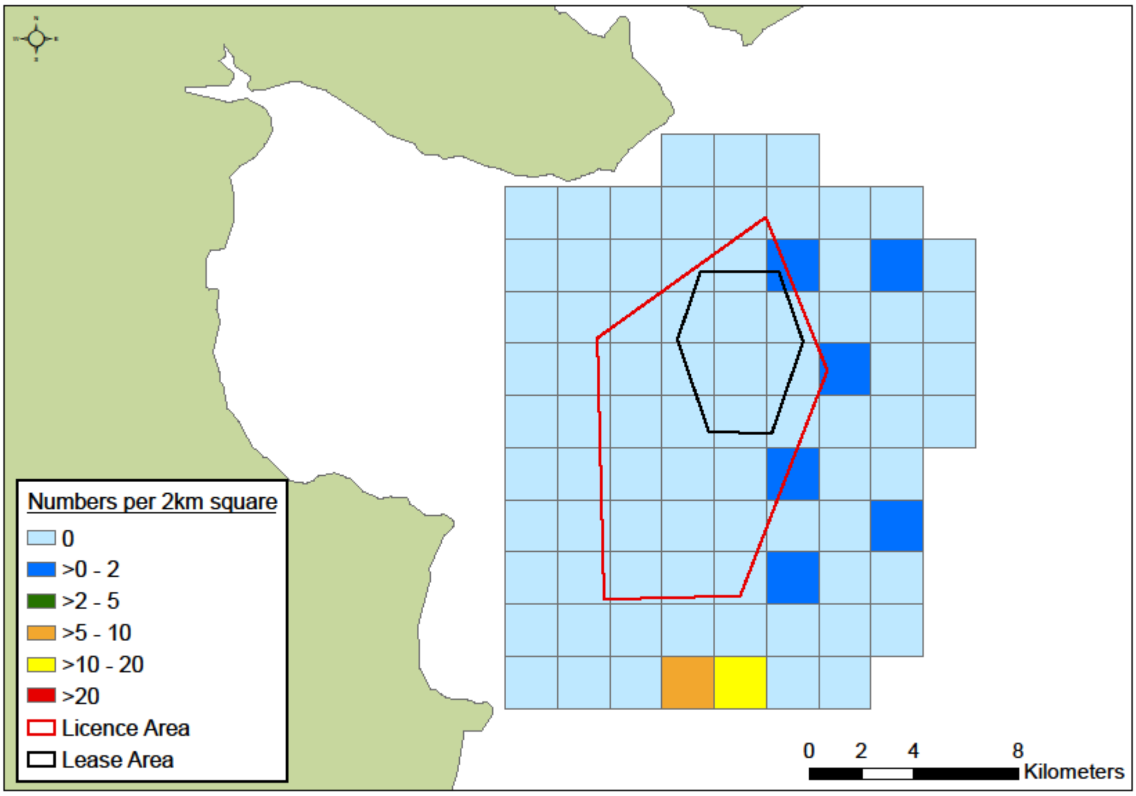

Figure 3.7.2 Gannet survey results June 2018.

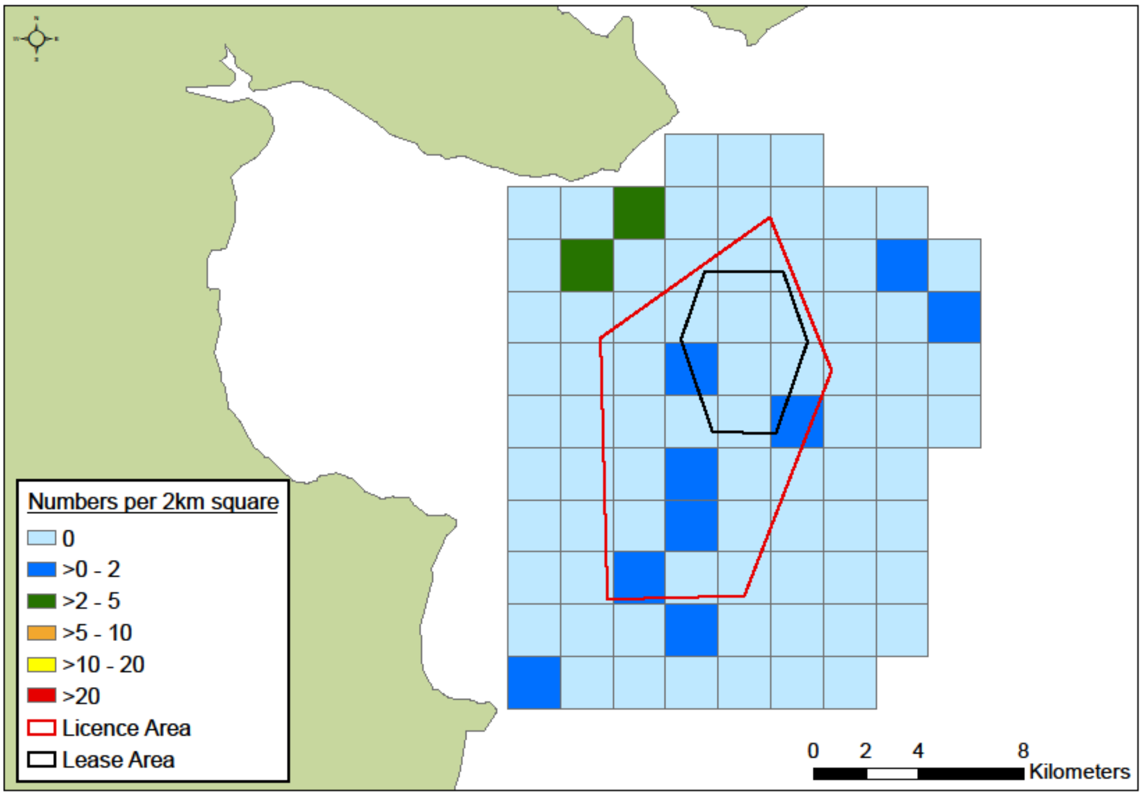

Figure 3.7.3 Gannet survey results July 2018.

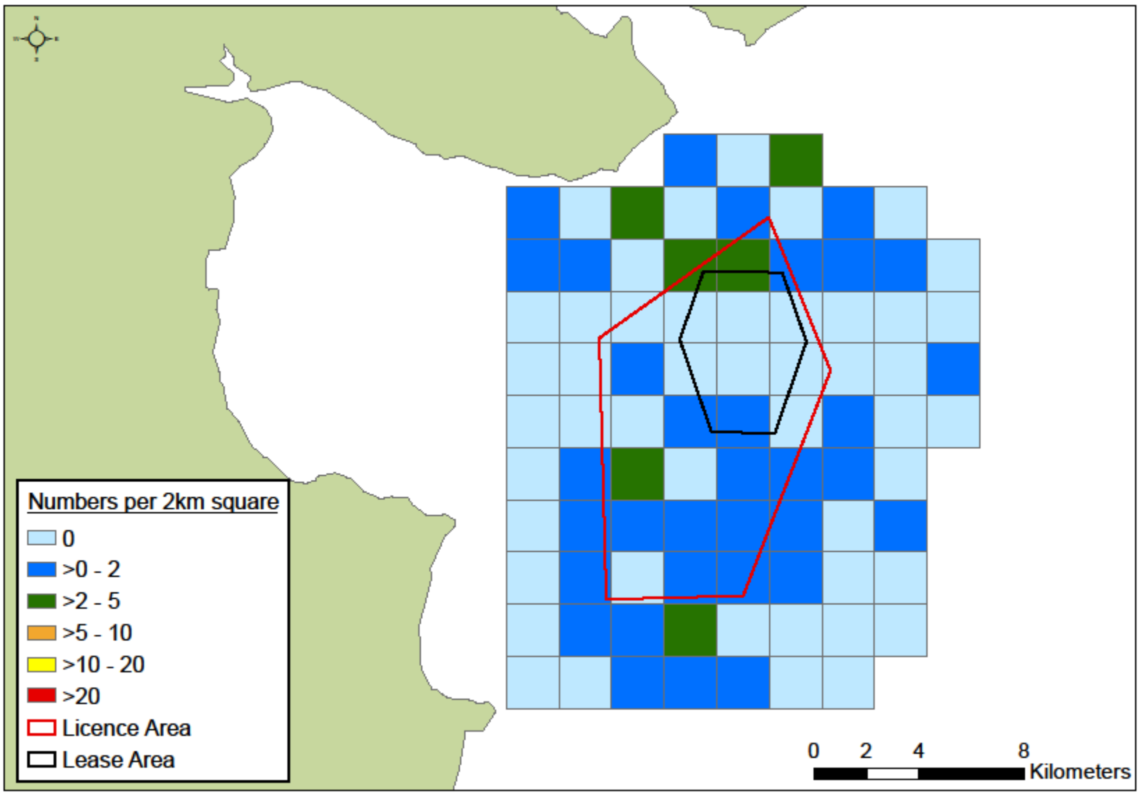

Figure 3.7.4 Gannet survey results August 2018.

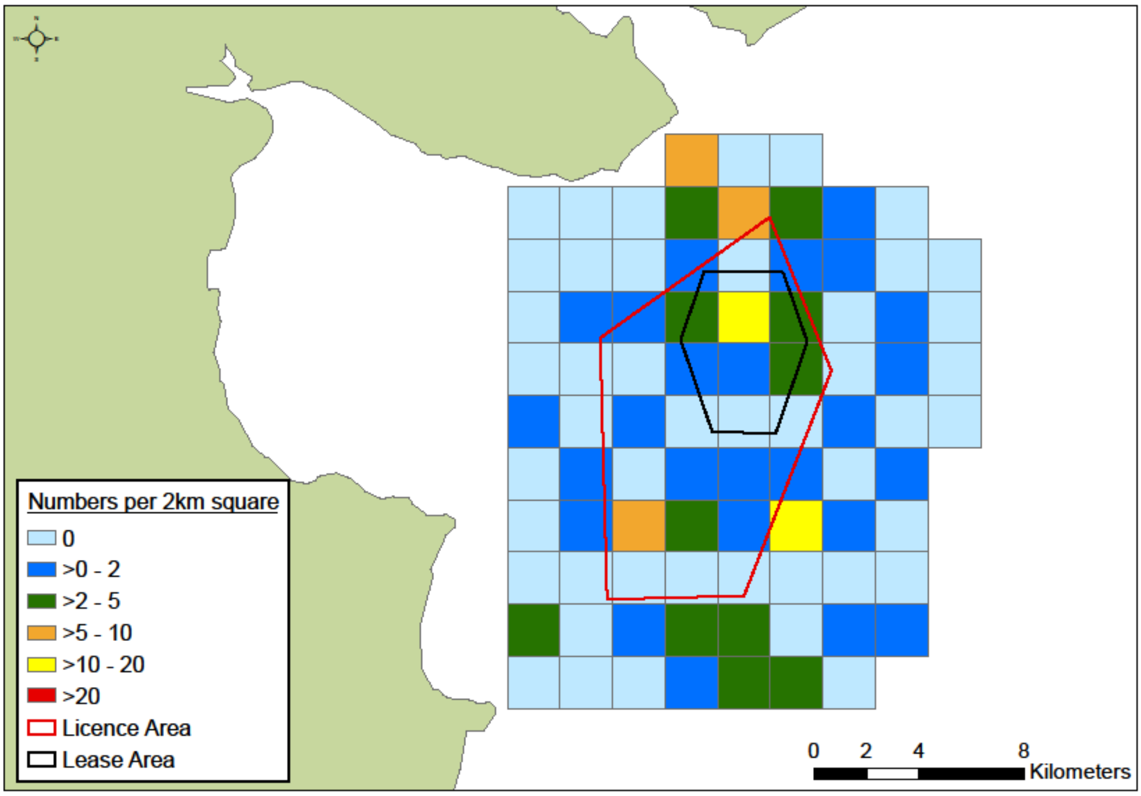

Figure 3.7.5 Gannet survey results September 2018.

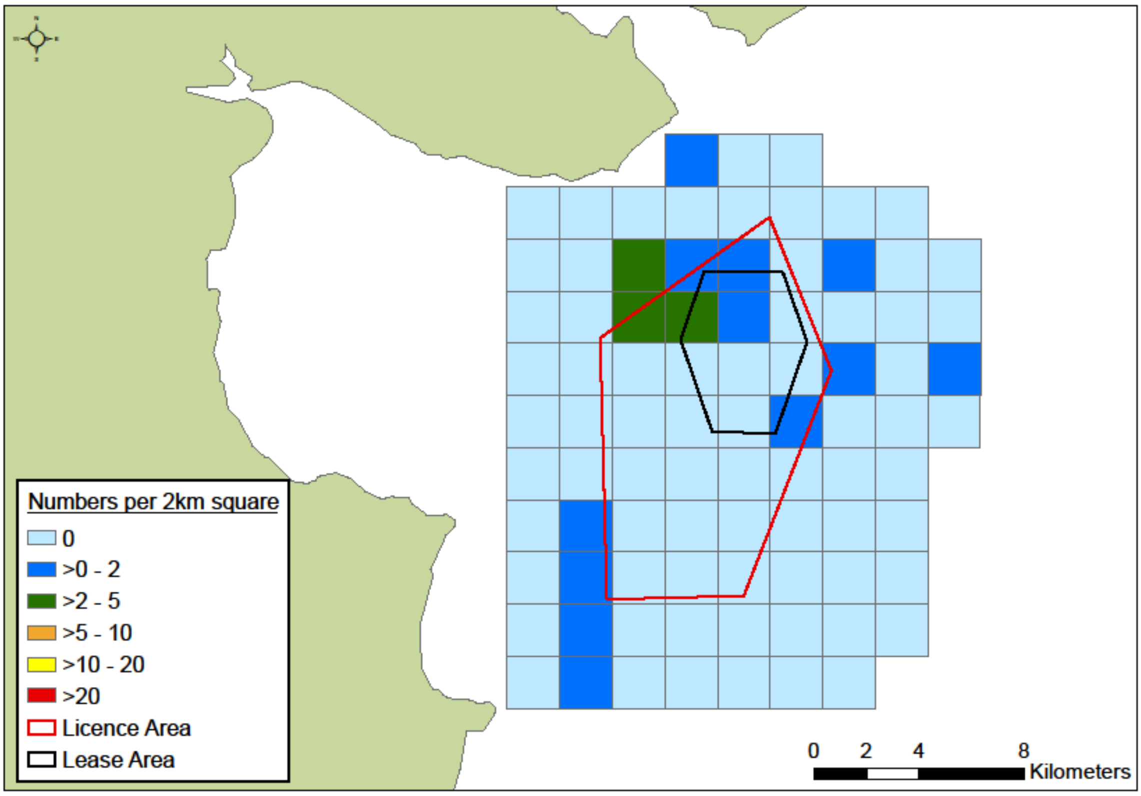

Figure 3.7.6 Gannet survey results October 2018.

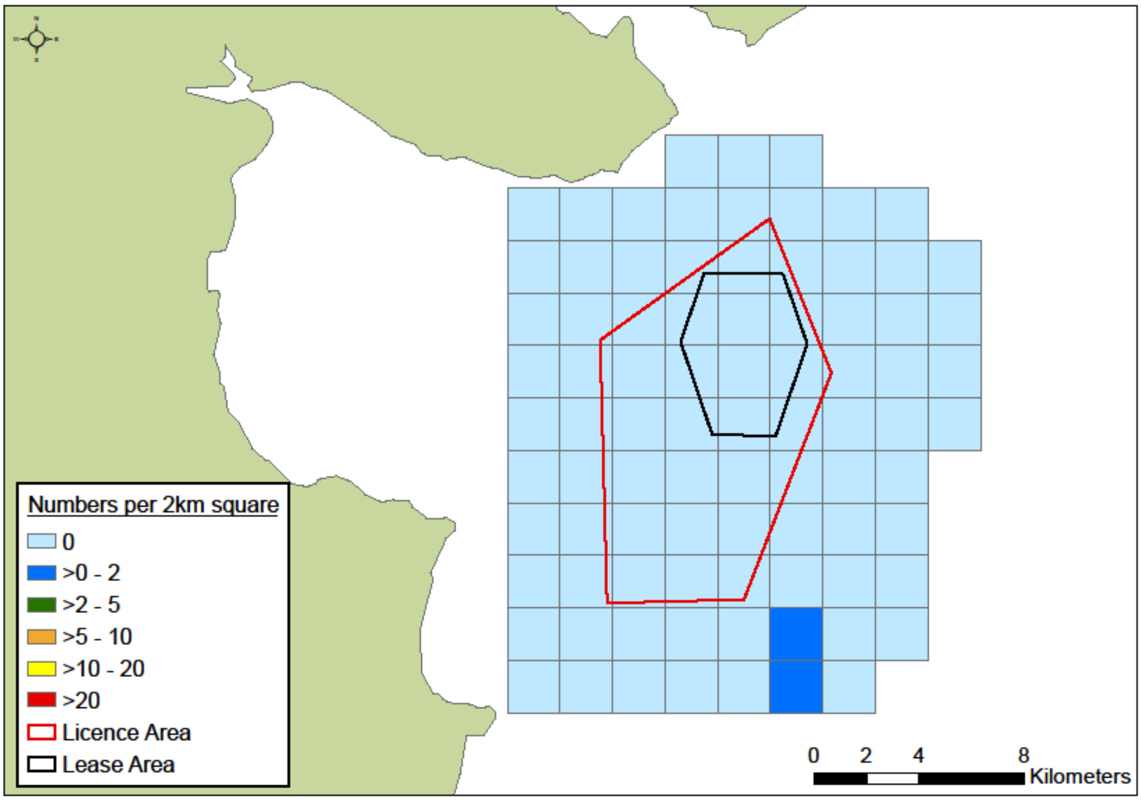

Figure 3.7.7 Gannet survey results December 2018.

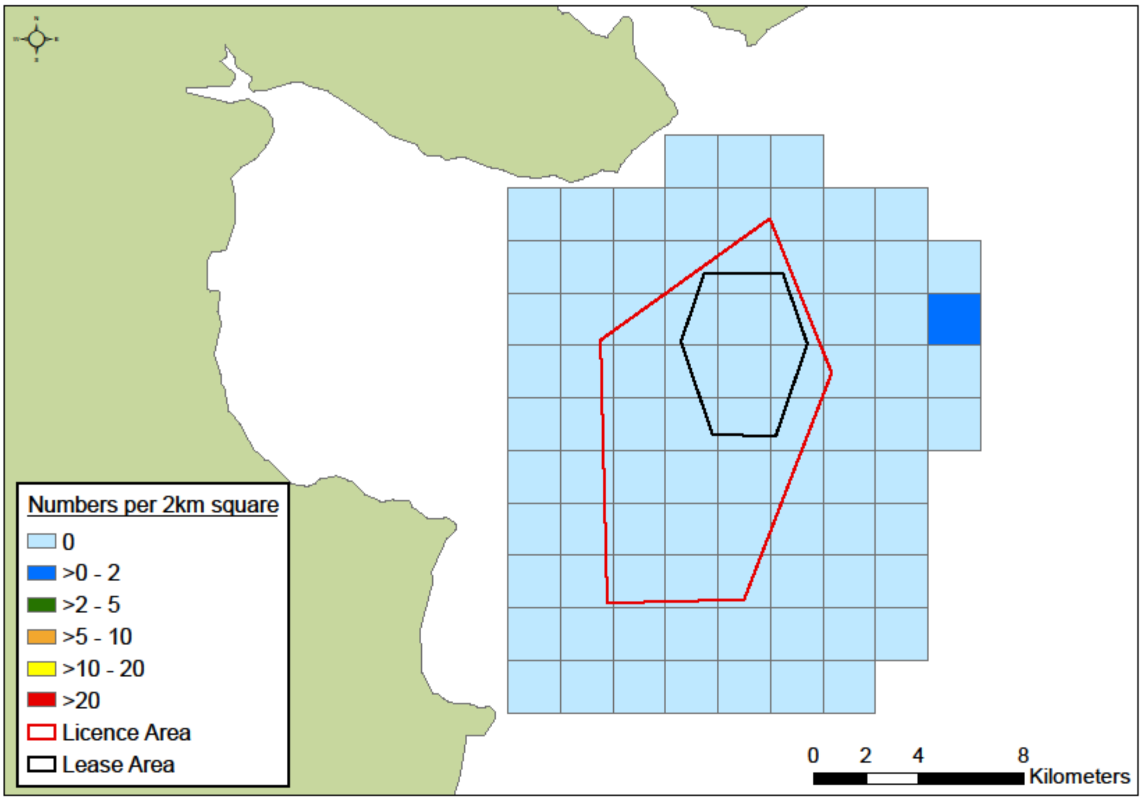

Figure 3.7.8 Gannet survey results February 2019.

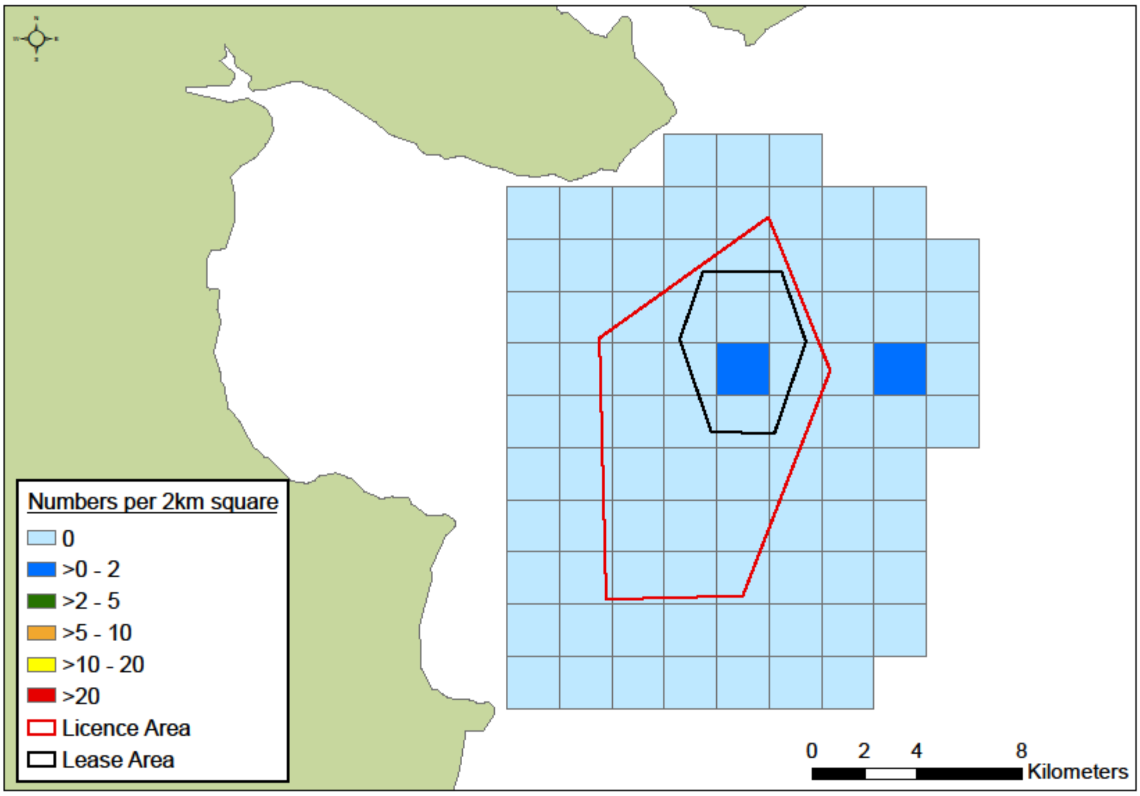

Figure 3.7.9 Gannet survey results March 2019.

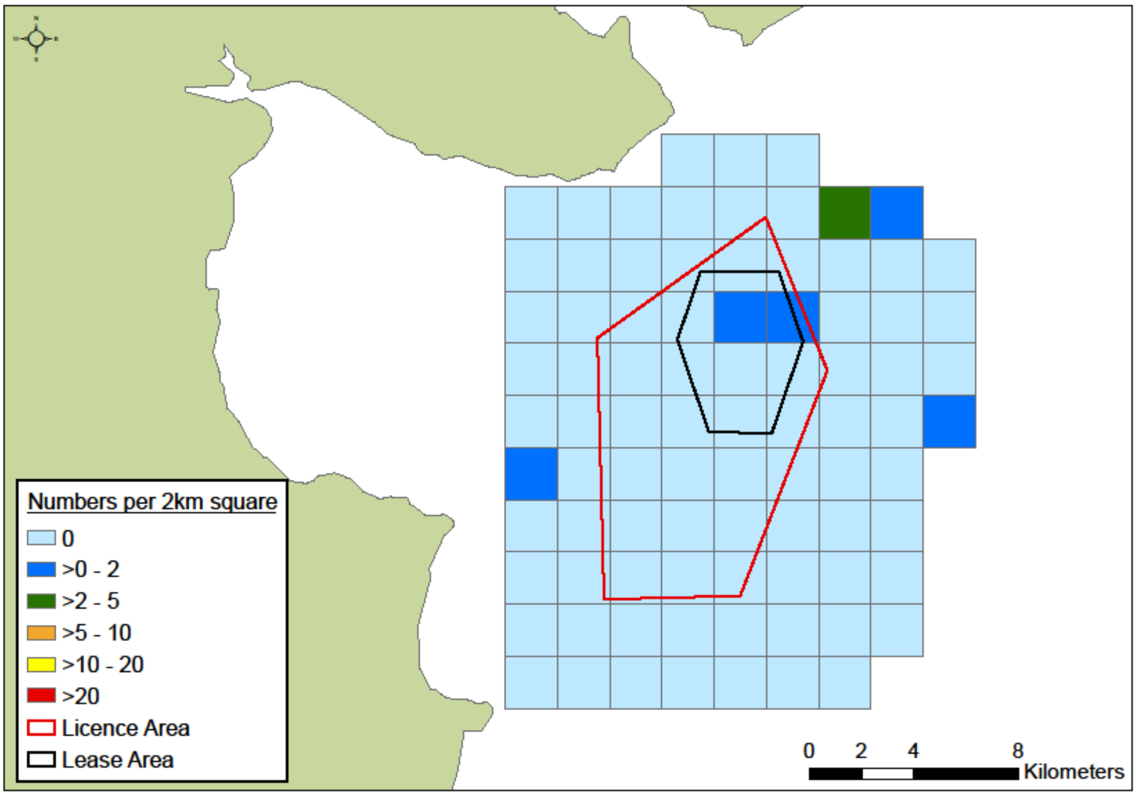

Figure 3.7.10 Gannet survey results April 2019.

3.7.2 Gannet Density

Gannet densities, as derived from the monthly transect survey data, are mapped in Figures 3.7.11 to 3.7.15. Peak density estimates occurred in September, with a derived density estimate of 0.52 birds/ km^2. This approximates well with the density estimates indicated for the western Irish Sea (Jessop *et al*., 2018) of 0.88 birds/km^2 (for autumn).

Both studies observed similar seasonal variation, with very low densities in the winter period (no wintering birds met the criteria for deriving density estimated in this study, with a density estimate of 0.03 birds km^2 in Jessop *et al.,* (2018)).

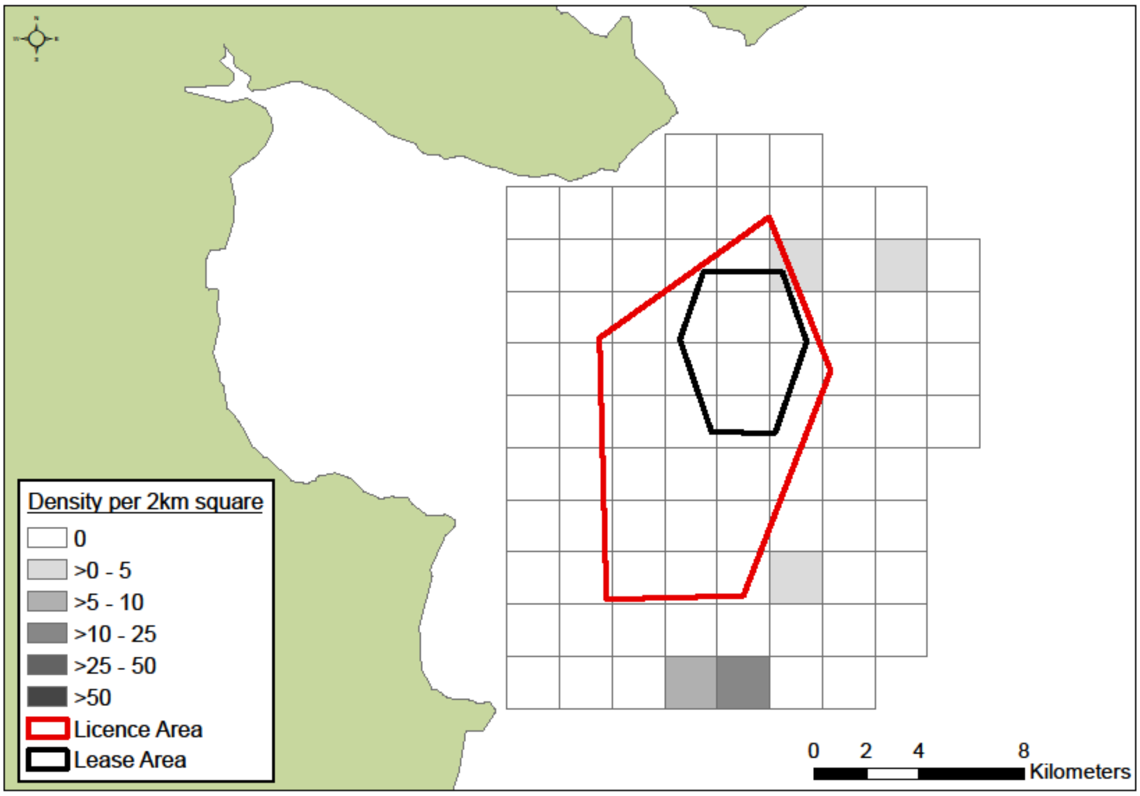

Figure 3.7.11 Gannet density estimates June 2018.

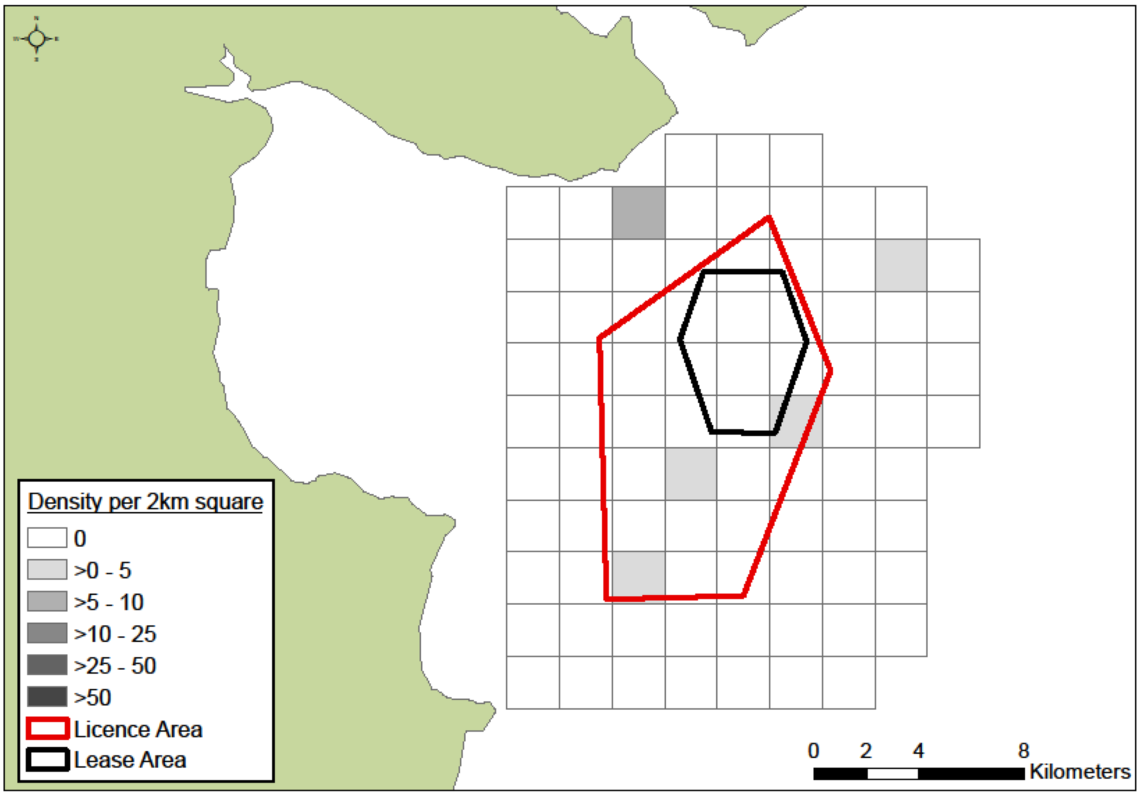

Figure 3.7.12 Gannet density estimates July 2018.

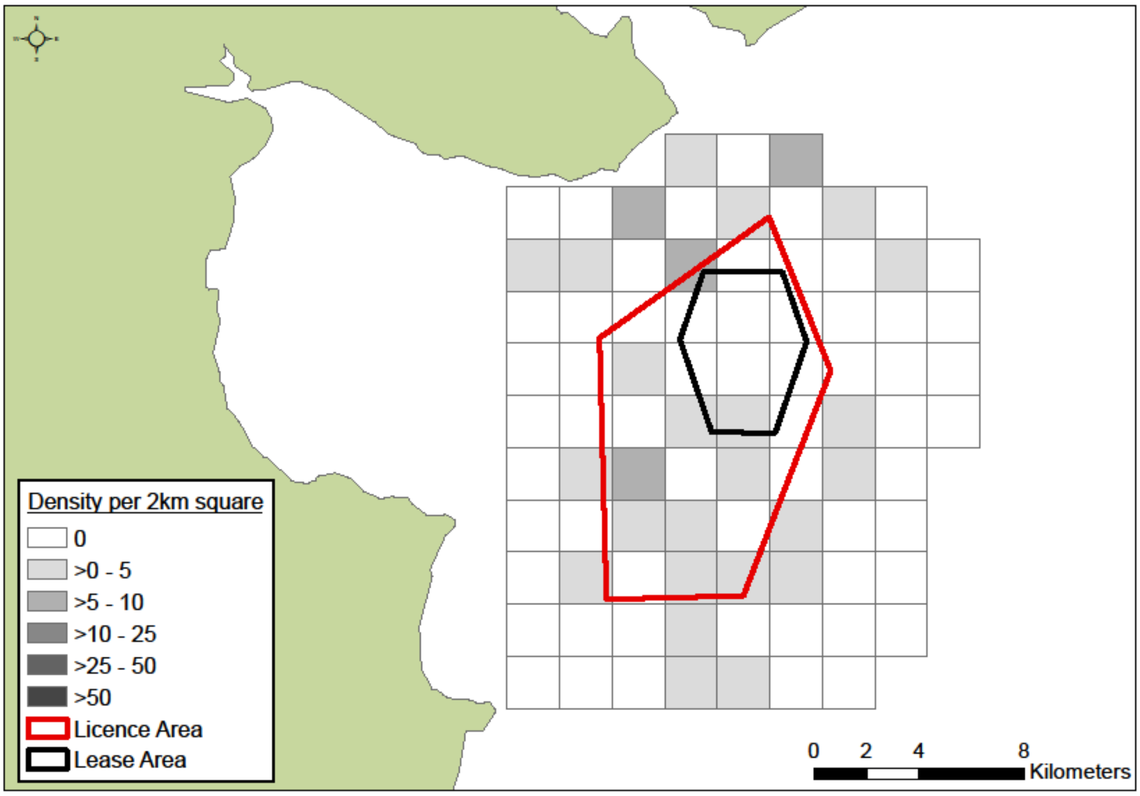

Figure 3.7.13 Gannet density estimates August 2018.

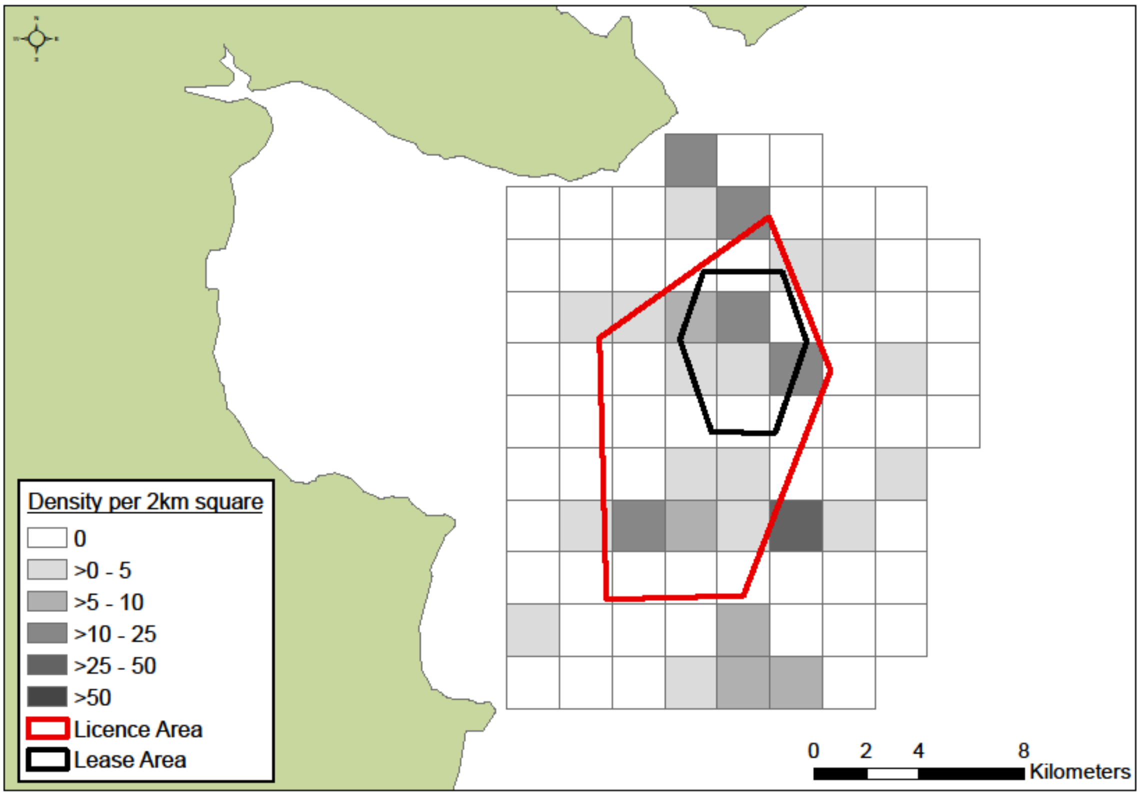

Figure 3.7.14 Gannet density estimates September 2018.

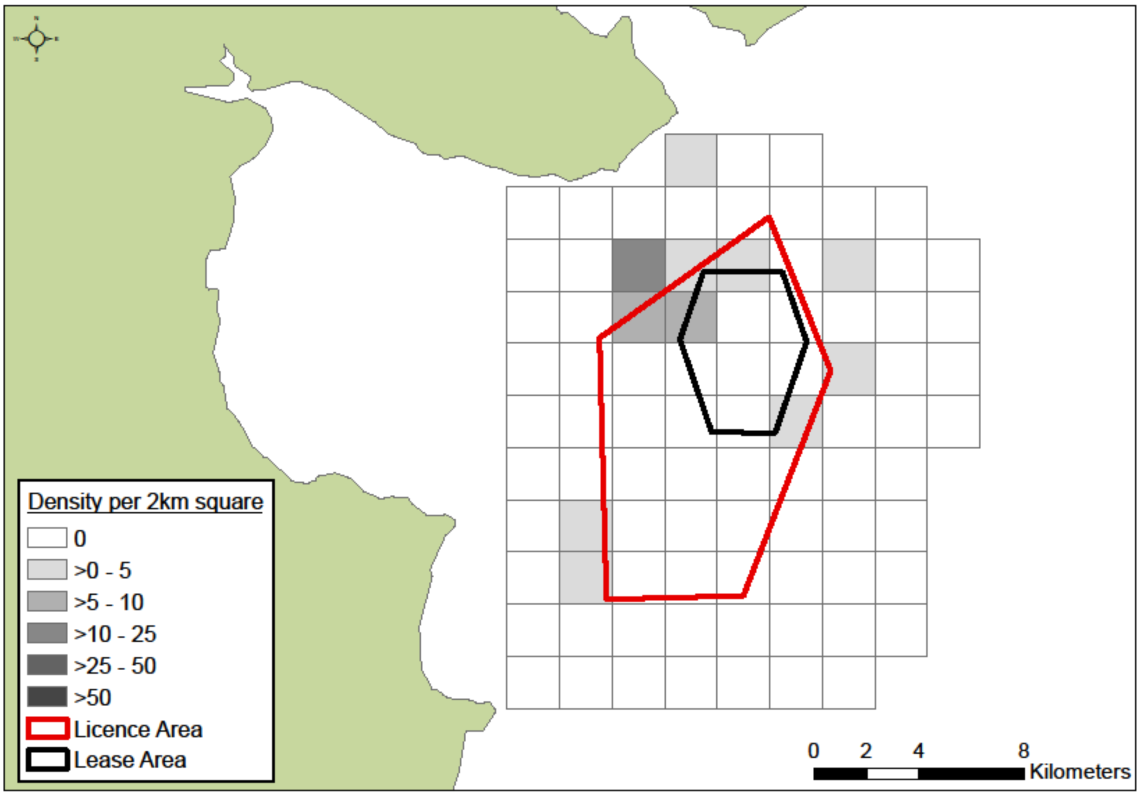

Figure 3.7.15 Gannet density estimates October 2018.

3.8 Shag

Shags are widely dispersed around Ireland throughout the year (Stone *et al.*, 1995), although they tend to be more thinly scattered away from breeding colonies (rocky sea cliffs) with few breeding in close proximity to the Oriel Windfarm survey area (Balmer *et al*., 2013). Shags are Amber-listed in Ireland, due to over 50% of the breeding population concentrated in ten or fewer locations (Colhoun & Cummins, 2013). They typically forage on sand eels and other bottom-living fish over both sandy and rocky substrates, up to 40m in depth (Harris & Wanless, 1993; Watanuki *et al*., 2008).

3.8.1 Shag Abundance

Shags were recorded in all months apart from in the survey area apart from March 2019 (Table 3.8.1). Number fluctuated throughout the survey months, with larger numbers in the post-breeding dispersal and winter periods from October 2018 through to February 2019 (the low count in November 2018 in Table 3.8.1 may be explained by the reduced survey effort in that month). The peak count on the transects was 24 birds recorded in October 2018 (when 35 bird were observed across the whole survey area) followed by December 2018 (when 23 birds were recorded on the transects from a peak tally of 59 birds observed within the surveys area as a whole).

Table 3.8.1 Shag records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	10	12
June 2018	0	2
July 2018	1	3
August 2018	13	17
September 2018	0	7
October 2018	24	35
November 2018	5	7
December 2018	23	59
January 2019	20	25
February 2019	17	23
March 2019	0	0
April 2019	0	1
TOTAL	**113**	**191**

Of the 113 Shags recorded from transects within the survey area, 24.8% of them (accounting for 28 individuals) were present within the Lease area (see Table 3.8.2). A further 31 individuals (27.4% of the total number) were in the Licence area with the remaining 54 Shags (47.8% of the total) recorded within the Survey Area. As might be expected from a species that predominantly forages on the bottom, the majority of birds recorded from transects were in the western and north-western parts of the survey area (see Figures 3.8.1 to 3.8.8), although birds were also recorded further offshore.

Table 3.8.2 Shag records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	4	40.0	5	50.0	1	10.0
June 2018	0	-	0	-	0	-
July 2018	1	100	0	0	0	0
August 2018	7	53.8	2	15.4	4	30.8
September 2018	0	-	0	-	0	-
October 2018	23	95.8	1	4.2	0	0
November 2018	3	60.0	1	20.0	1	20.0
December 2018	6	26.1	10	43.5	7	30.4
January 2019	4	20.0	6	30.0	10	50.0
February 2019	6	35.3	6	35.3	5	29.4
March 2019	0	-	0	-	0	-
April 2019	0	-	0	-	0	-
TOTAL	**54**	**47.8**	**31**	**27.4**	**28**	**24.8**

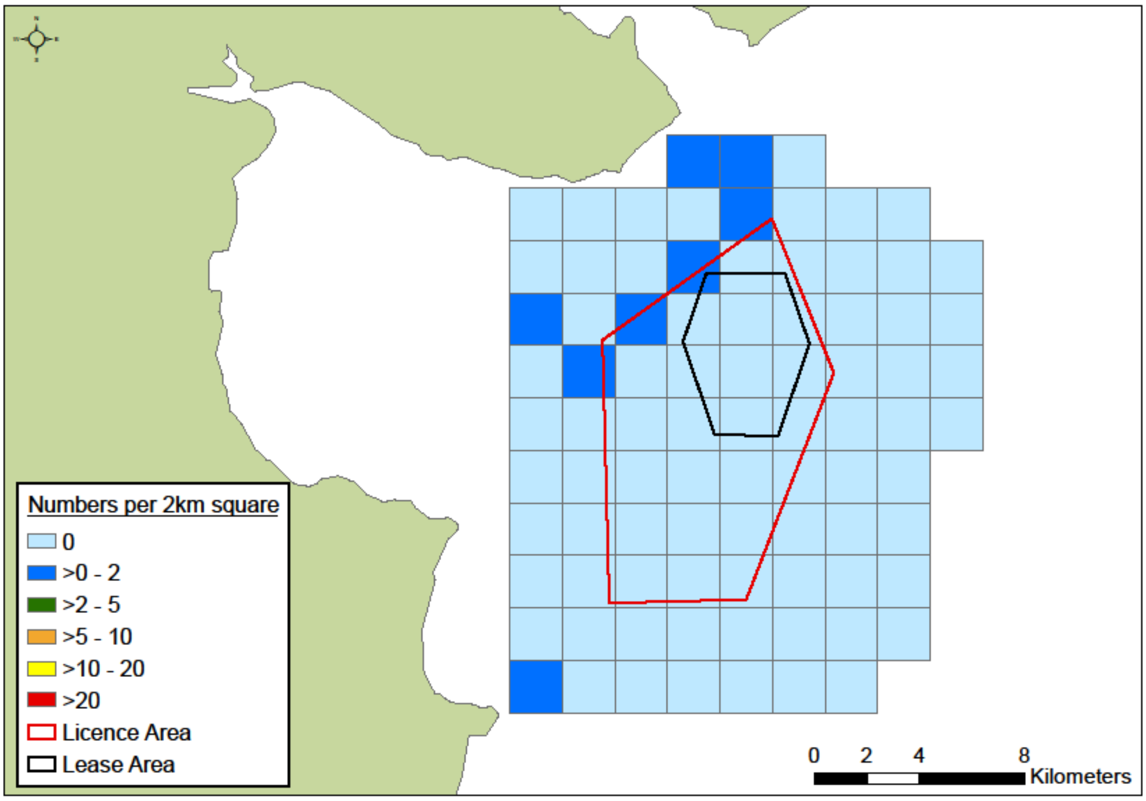

Figure 3.8.1 Shag survey results May 2018.

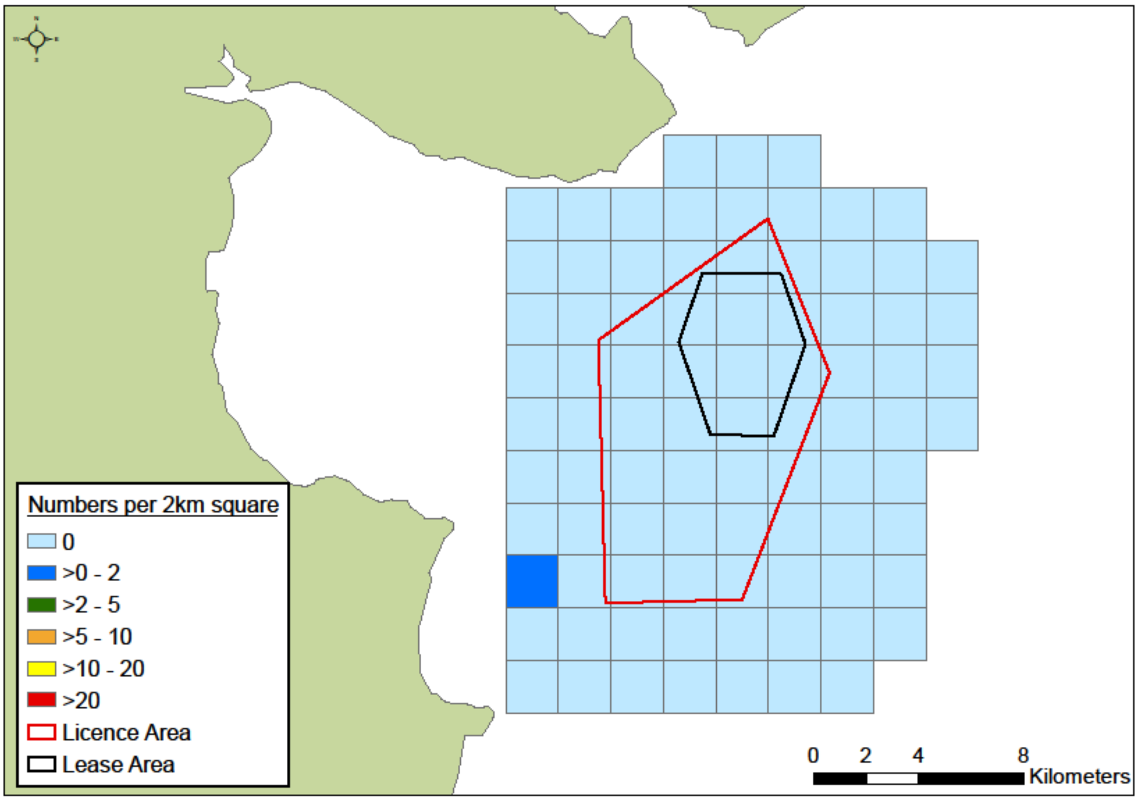

Figure 3.8.2 Shag survey results July 2018.

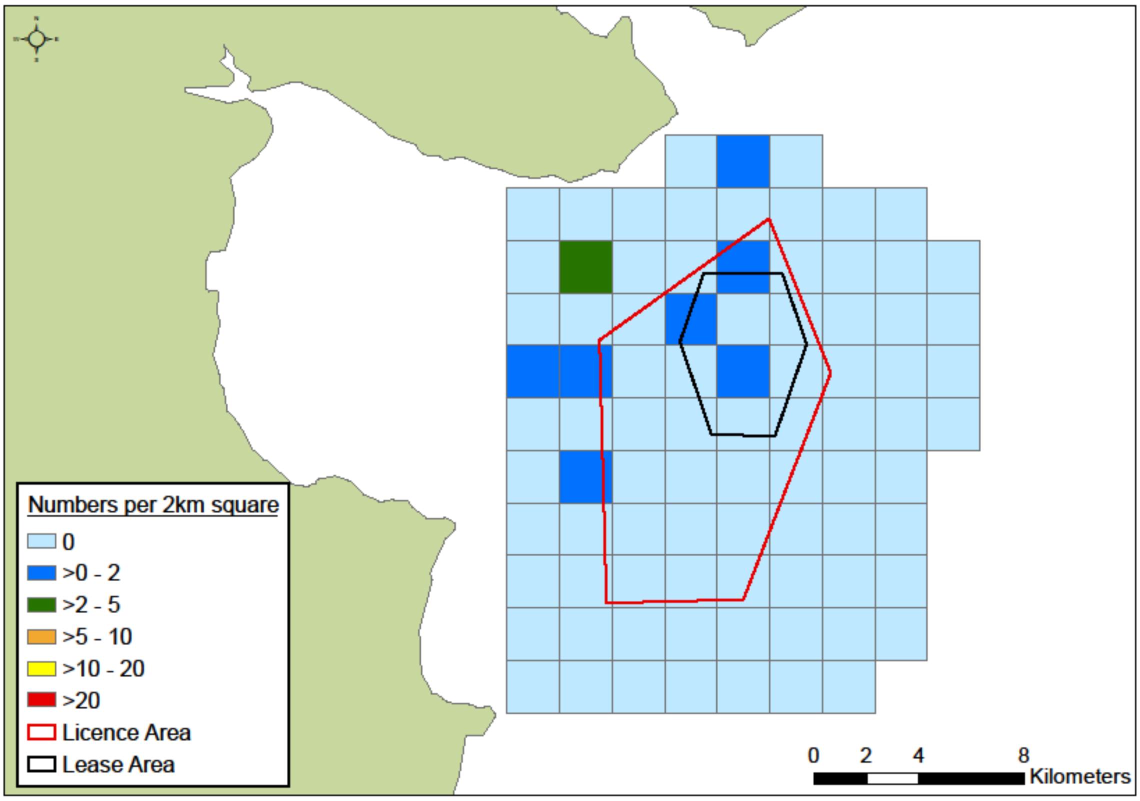

Figure 3.8.3 Shag survey results August 2018.

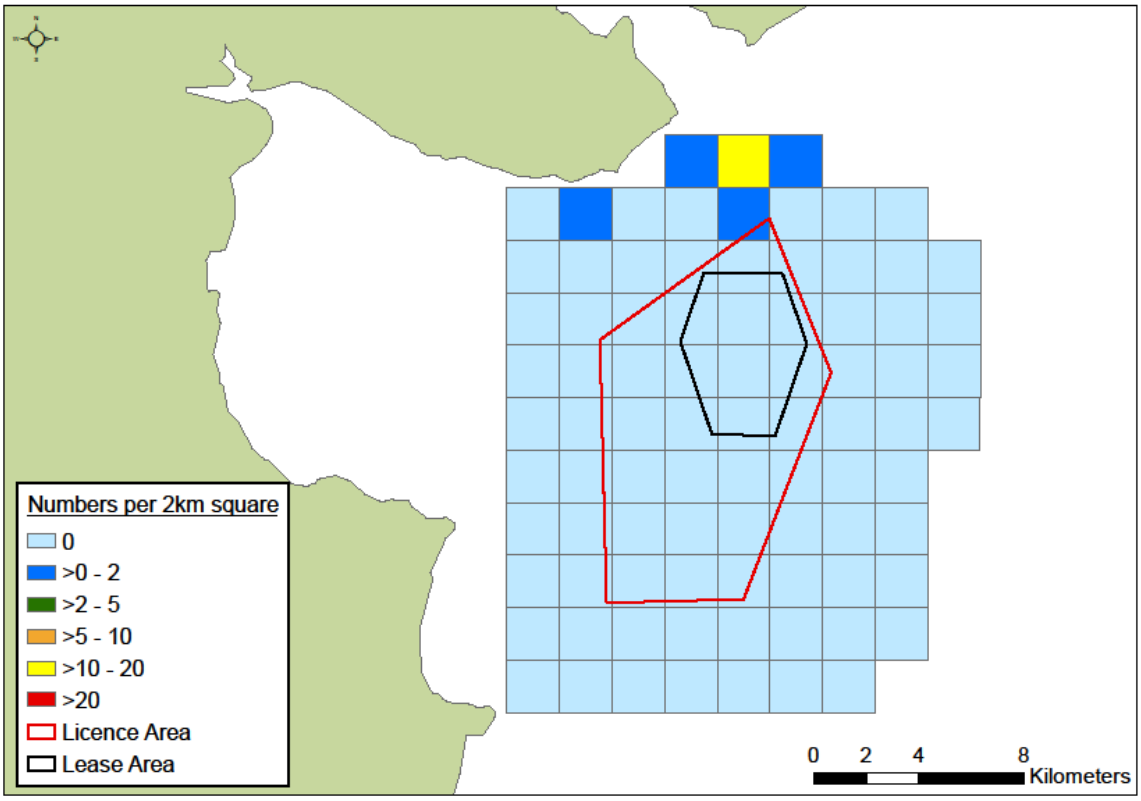

Figure 3.8.4 Shag survey results October 2018.

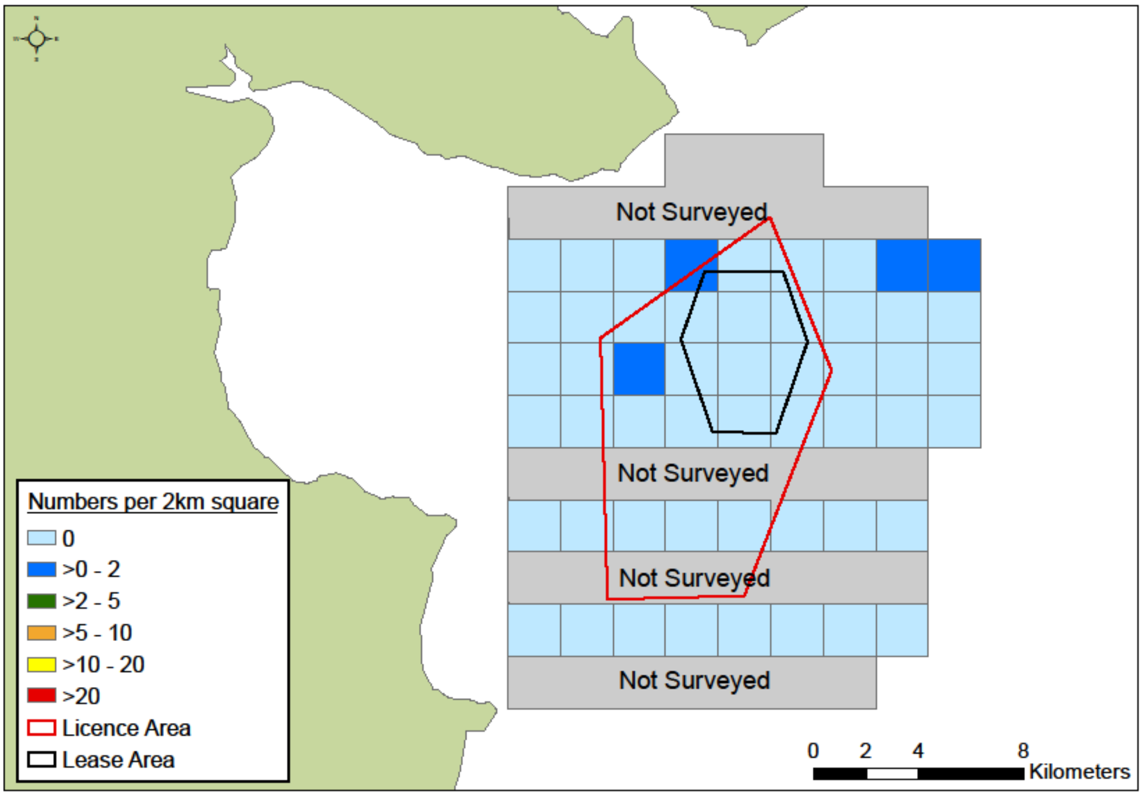

Figure 3.8.5 Shag survey results November 2018.

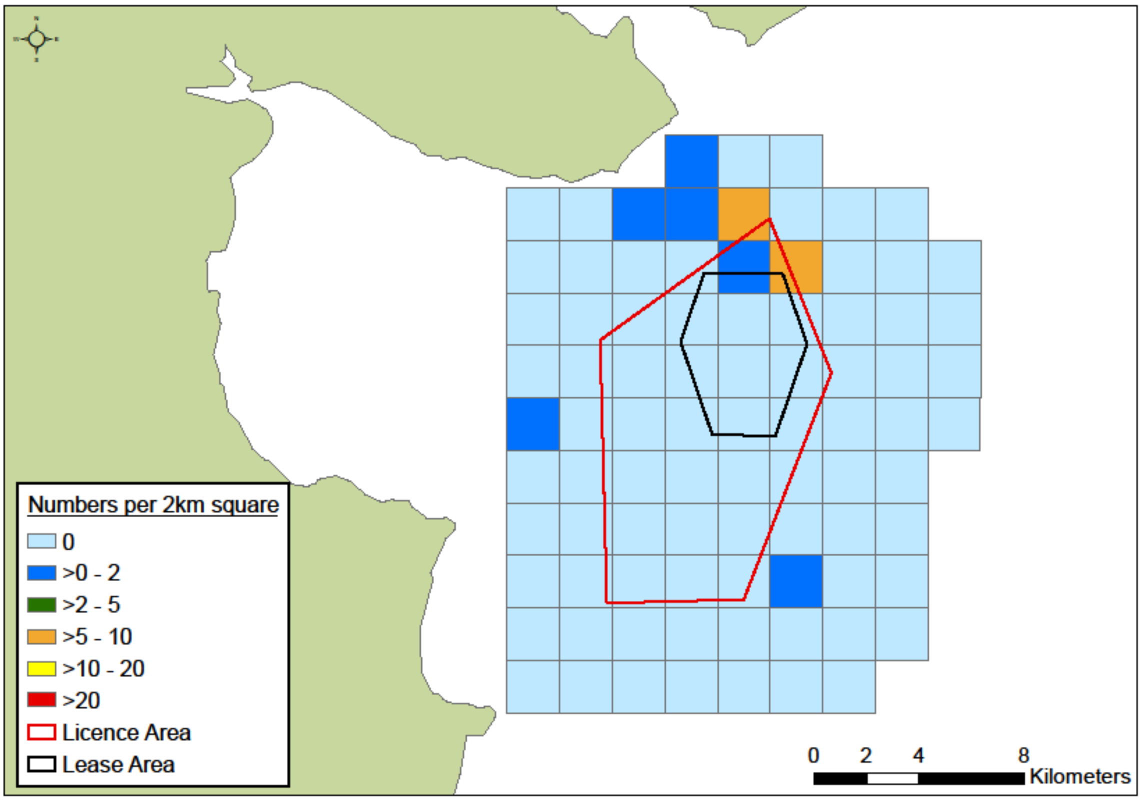

Figure 3.8.6 Shag survey results December 2018.

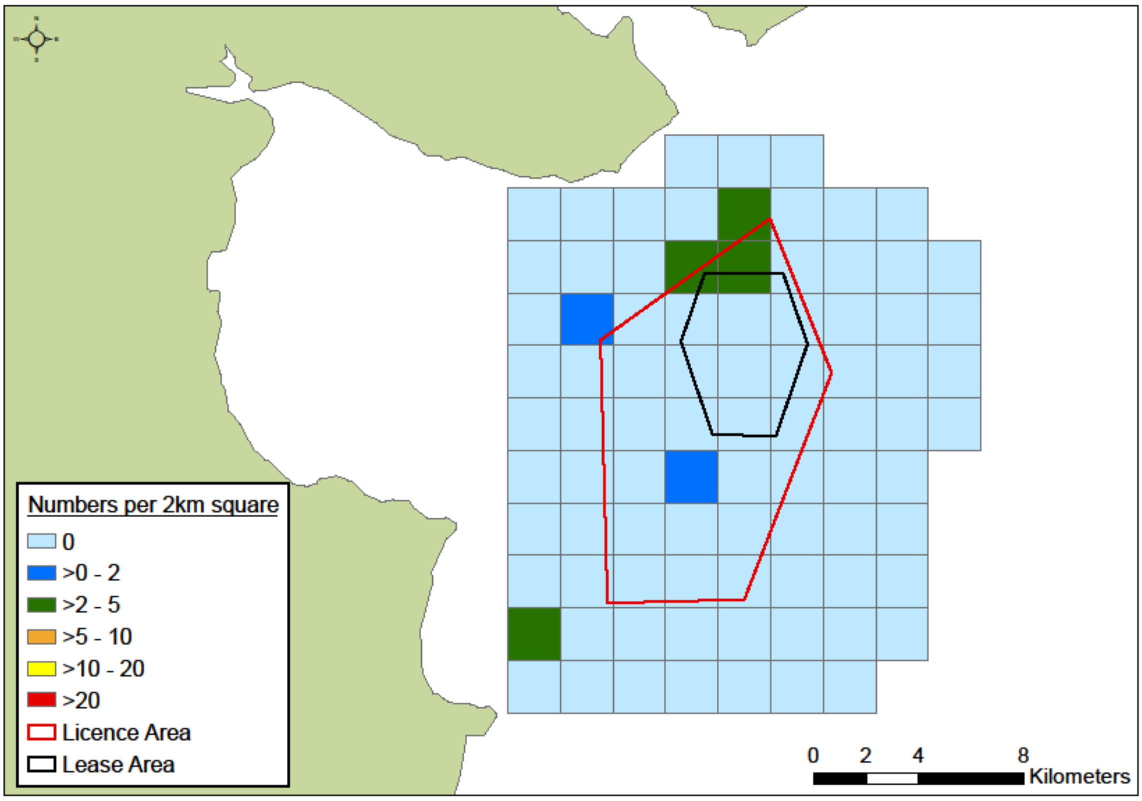

Figure 3.8.7 Shag survey results January 2019.

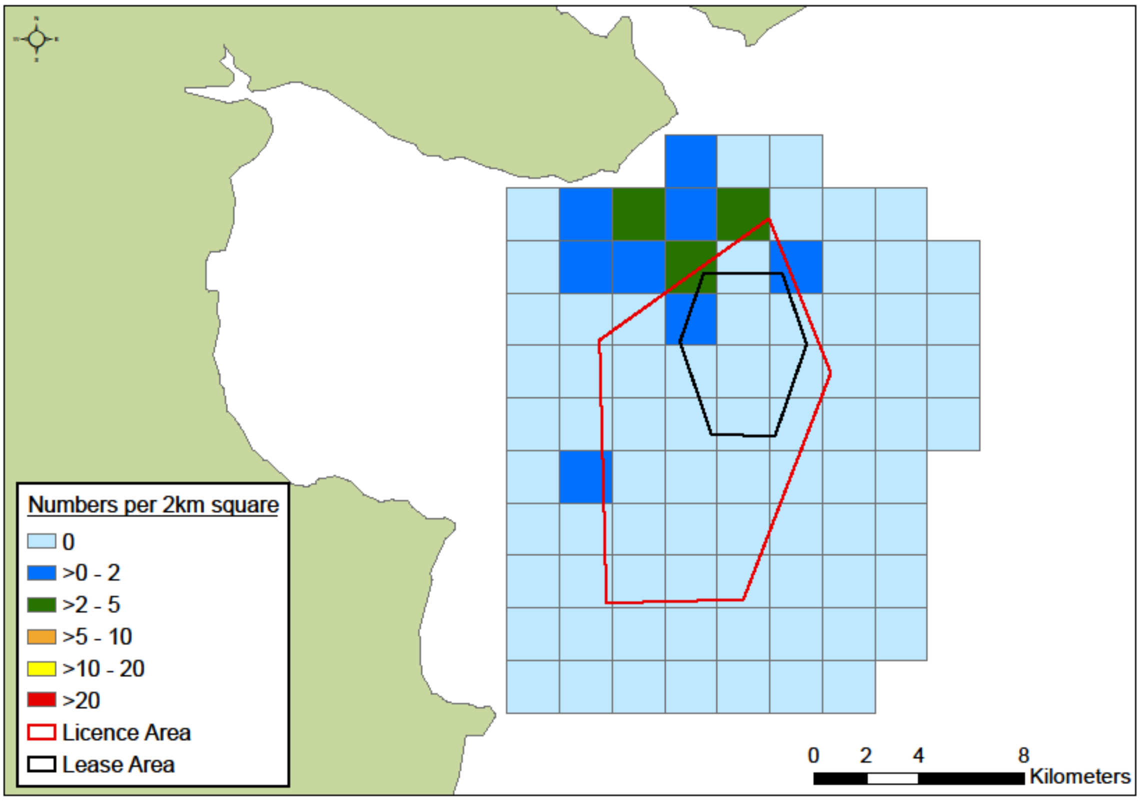

Figure 3.8.8 Shag survey results February 2019.

3.8.2 Shag Density

Monthly Shag density estimates are shown in Figures 3.8.9 to 3.8.16. Peak densities derived from the transect survey data are indicated in October 2018, with 0.19 birds/km^2.

Density estimates for the western Irish Sea (Jessop *et al*., 2018) were derived from a combination of both Shag and Cormorant data; this approach for comparative purposes is also adopted here (see Section 3.9.3).

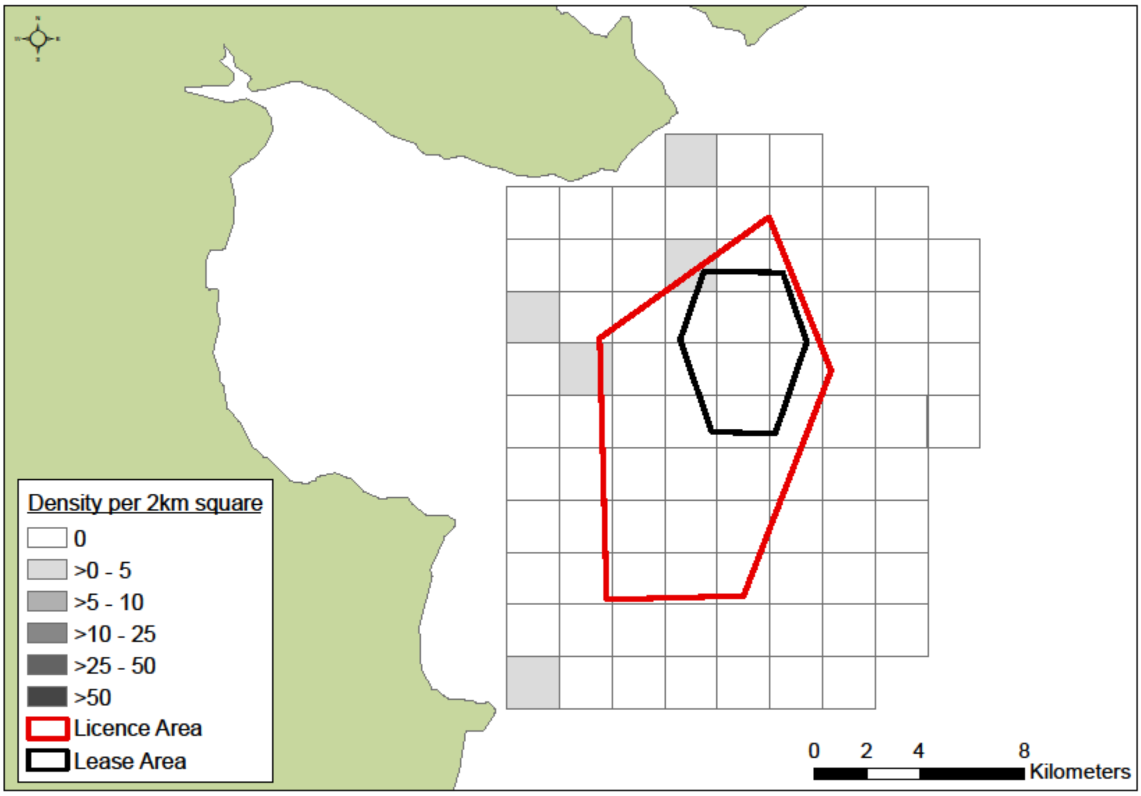

Figure 3.8.9 Shag density estimates May 2018.

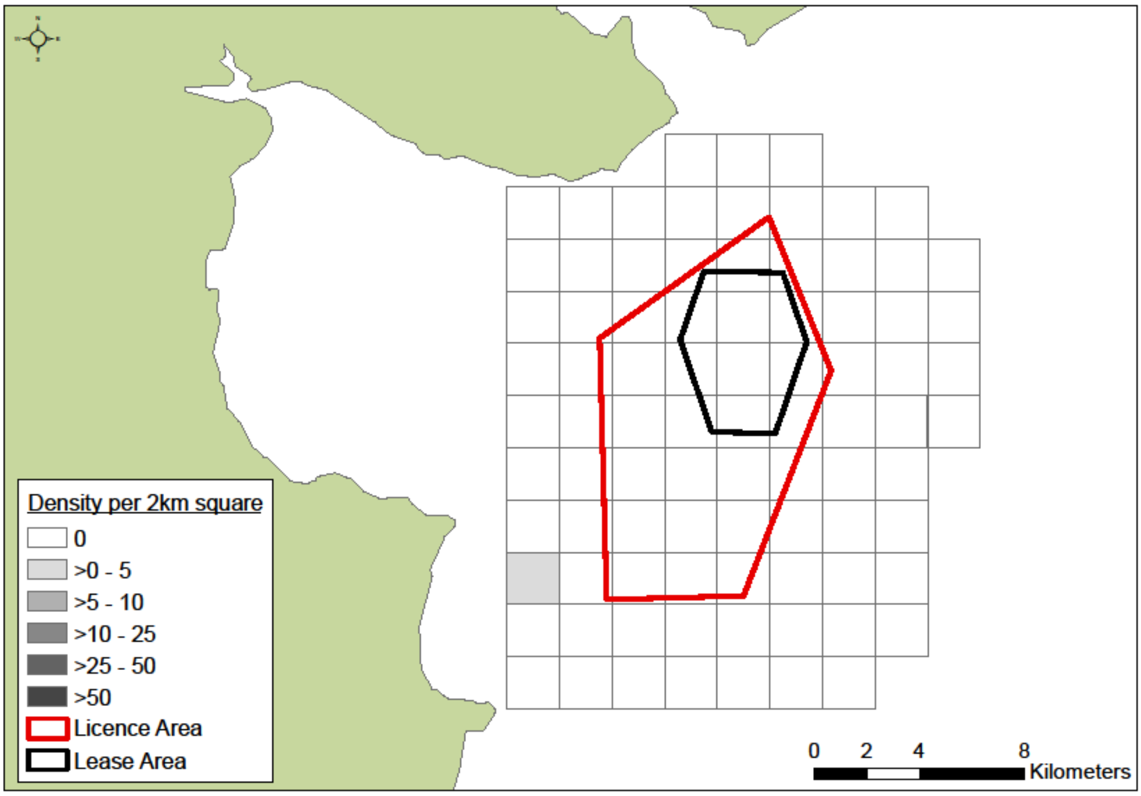

Figure 3.8.10 Shag density estimates July 2018.

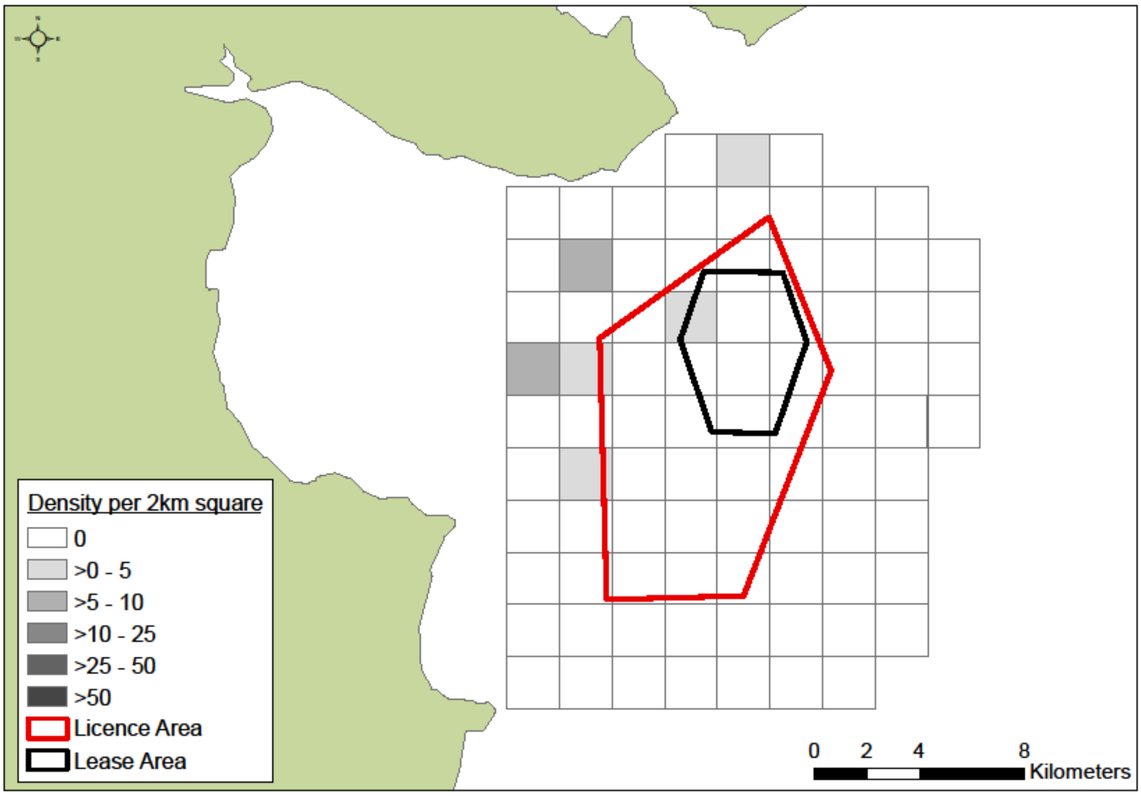

Figure 3.8.11 Shag density estimates August 2018.

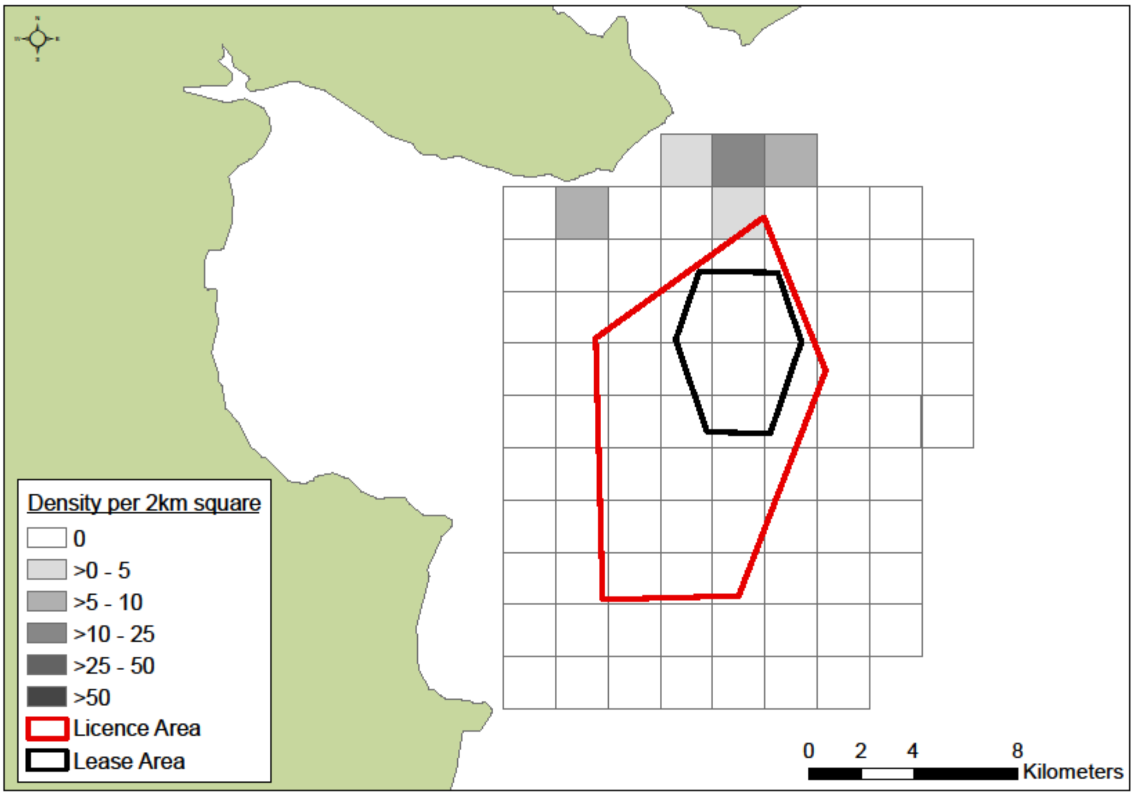

Figure 3.8.12 Shag density estimates October 2018.

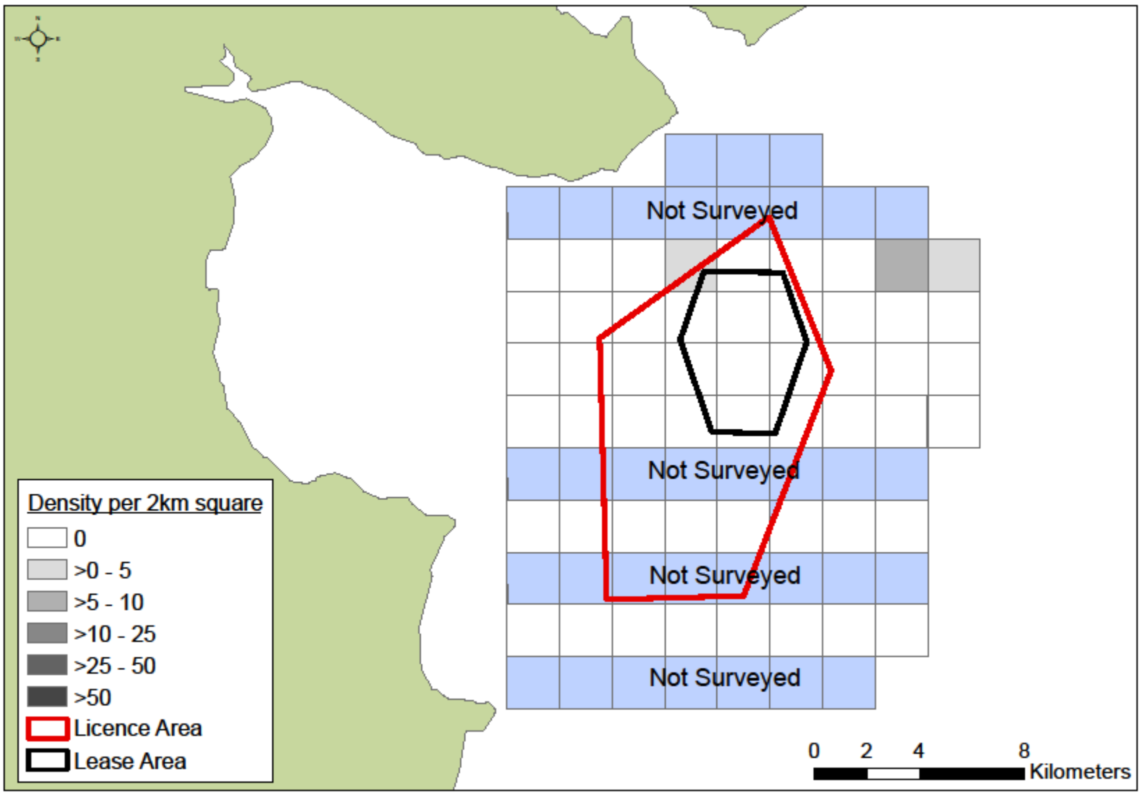

Figure 3.8.13 Shag density estimates November 2018.

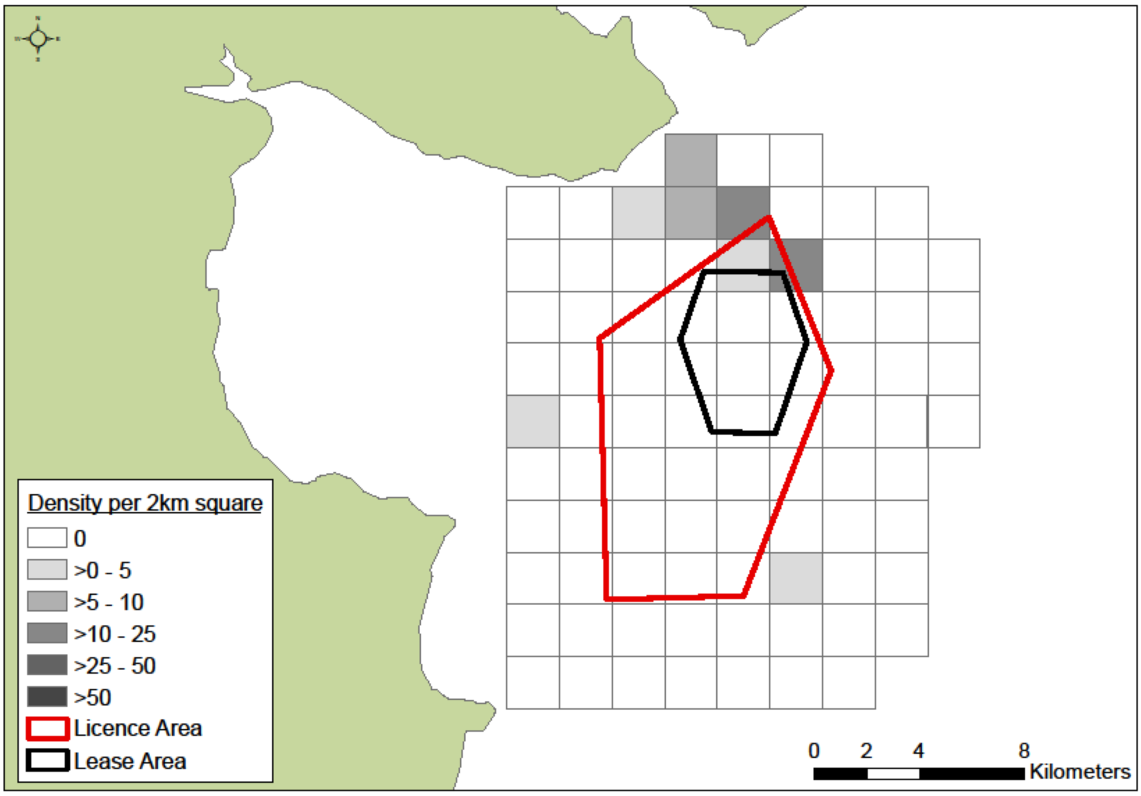

Figure 3.8.14 Shag density estimates December 2018.

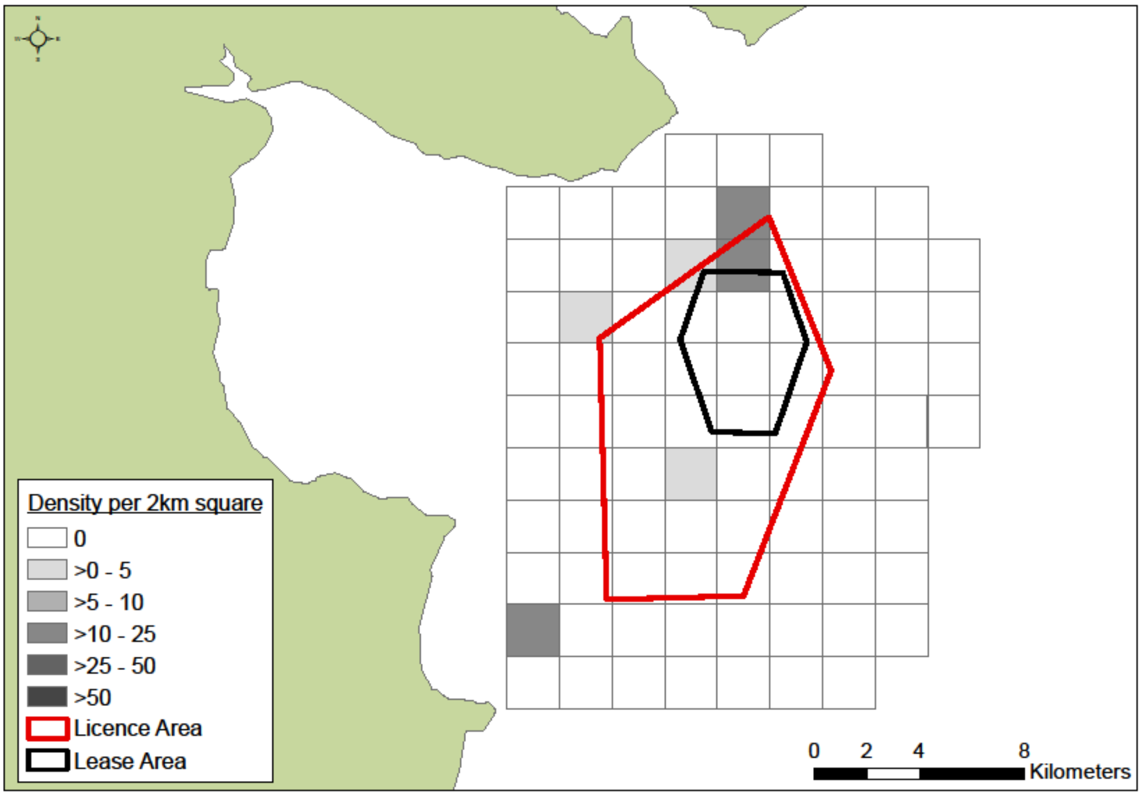

Figure 3.8.15 Shag density estimates January 2019.

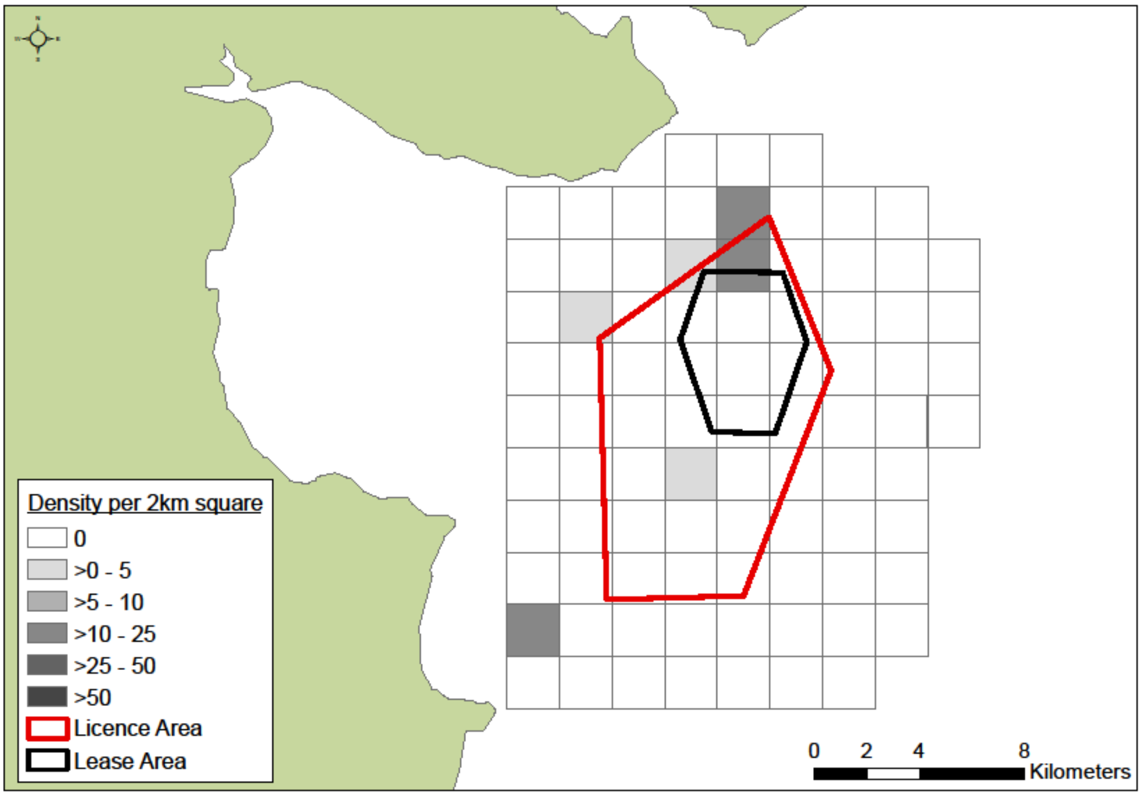

Figure 3.8.16 Shag density estimates February 2019.

3.9 Cormorant

Cormorant occupy more terrestrial and inland habitats than Shag (Balmer *et al*., 2013; Mitchell *et al*., 2004), nesting in trees (usually (but not exclusively) those of the European race *sinesis*) as well as coastal islands and stacks (typically of the British race *carbo*). Cormorants are Amber-listed in Ireland (Colhoun & Cummins, 2013) due to a moderate decline in the breeding population. They typically feed on fish (West *et al*., 1975) from the sea and substrate (Barret *et al*., 2007).

3.9.1 Cormorant Abundance

Cormorants were recorded within the survey area in all months that fieldwork took place, except for September 2018 (Table 3.9.1). However, the number of observations were generally very low, and birds were only recorded on the transects in seven out of the twelve months. The peak count on the transects in October 2018 included one group of 11 individuals flying through the survey area (Figure 3.9.4). Apart from this, two individuals were observed during transect surveys in close proximity on the sea in February 2019 (Figure 3.9.6) and the remaining transect records were of single birds. This scarcity of records is reflected in the observations from the whole survey area, which included a group of five birds flying together in August 2018 and another group of four birds flying together in March 2019, with the remaining records consisting of solitary birds, typically flying within the survey area.

Table 3.9.1 Cormorant records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	1	4
June 2018	1	1
July 2018	0	1
August 2018	1	9
September 2018	0	0
October 2018	12	18
November 2018	0	1
December 2018	3	4
January 2019	0	2
February 2019	2	3
March 2019	0	8
April 2019	1	3
TOTAL	**20**	**51**

Due to Cormorant favouring shallower water over which to hunt, they were typically observed closer to coastal areas along the western and north-western sides of the survey area (see Figures 3.9.1 to 3.9.6).

A single Cormorant was recorded within the Lease area in October 2018 (Figure 3.9.4); the remaining birds were recorded in the Survey area (i.e. there were no records in the Licence area).

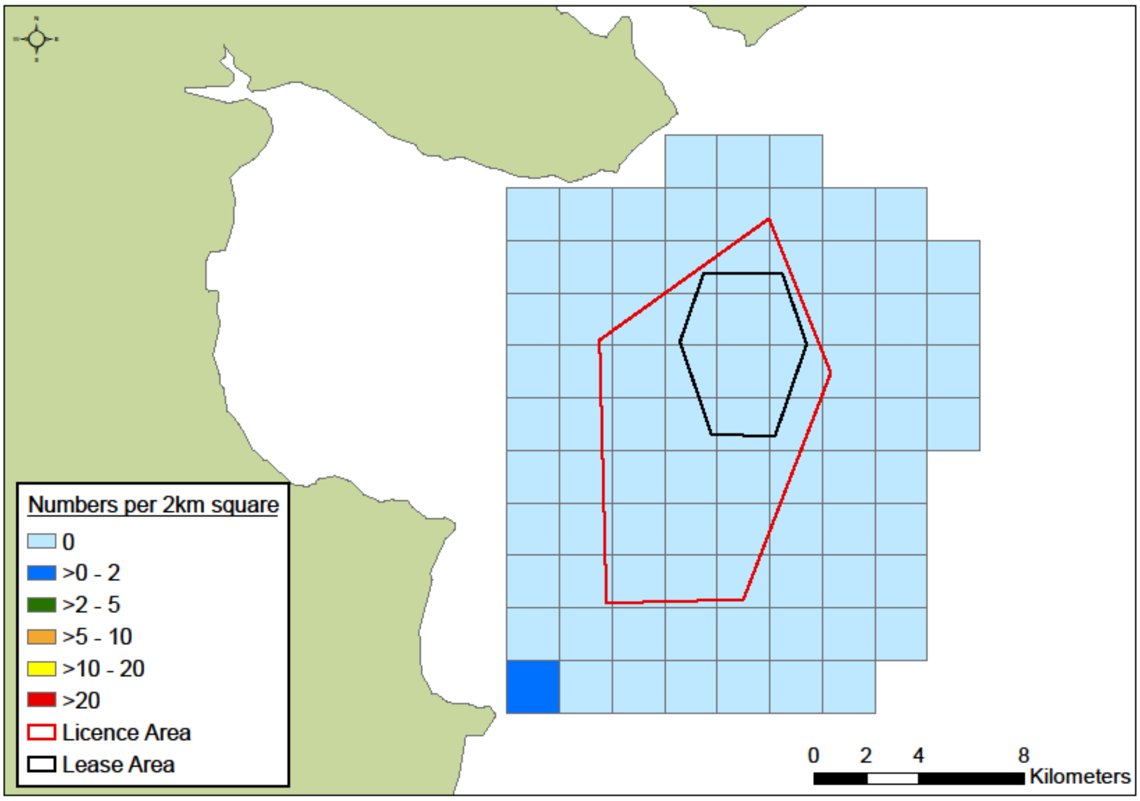

Figure 3.9.1 Cormorant survey results May 2018.

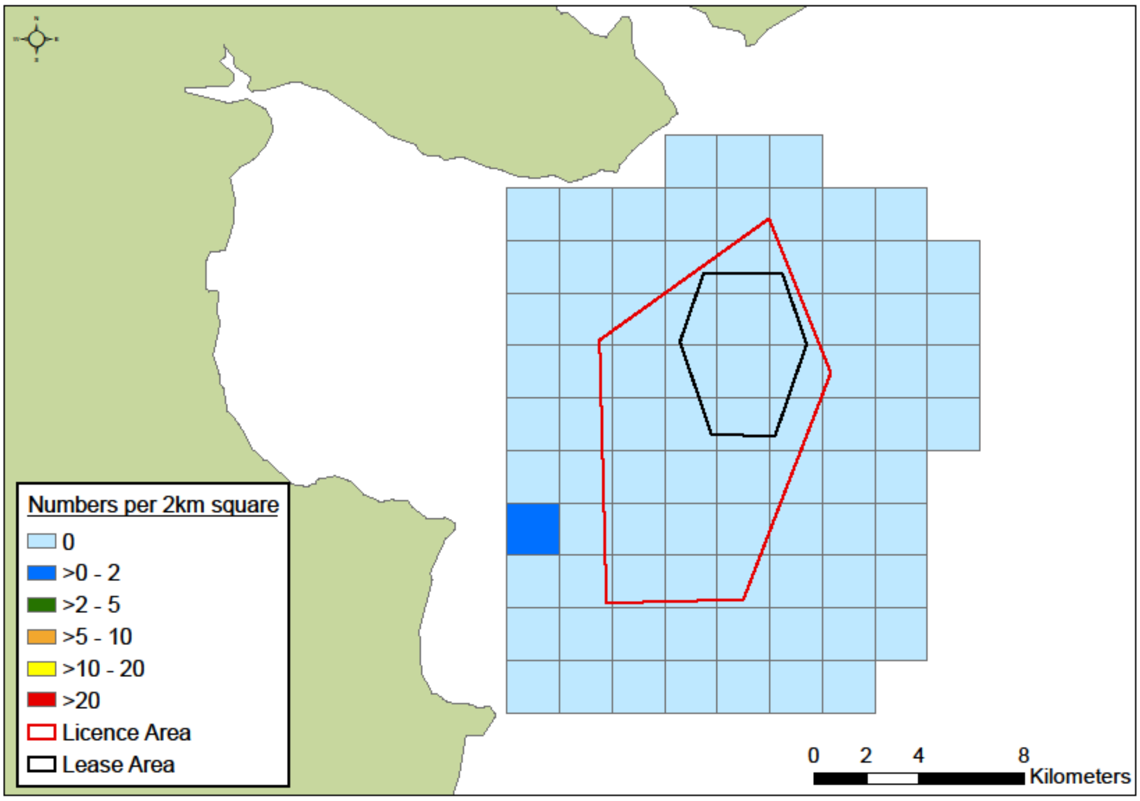

Figure 3.9.2 Cormorant survey results June 2018.

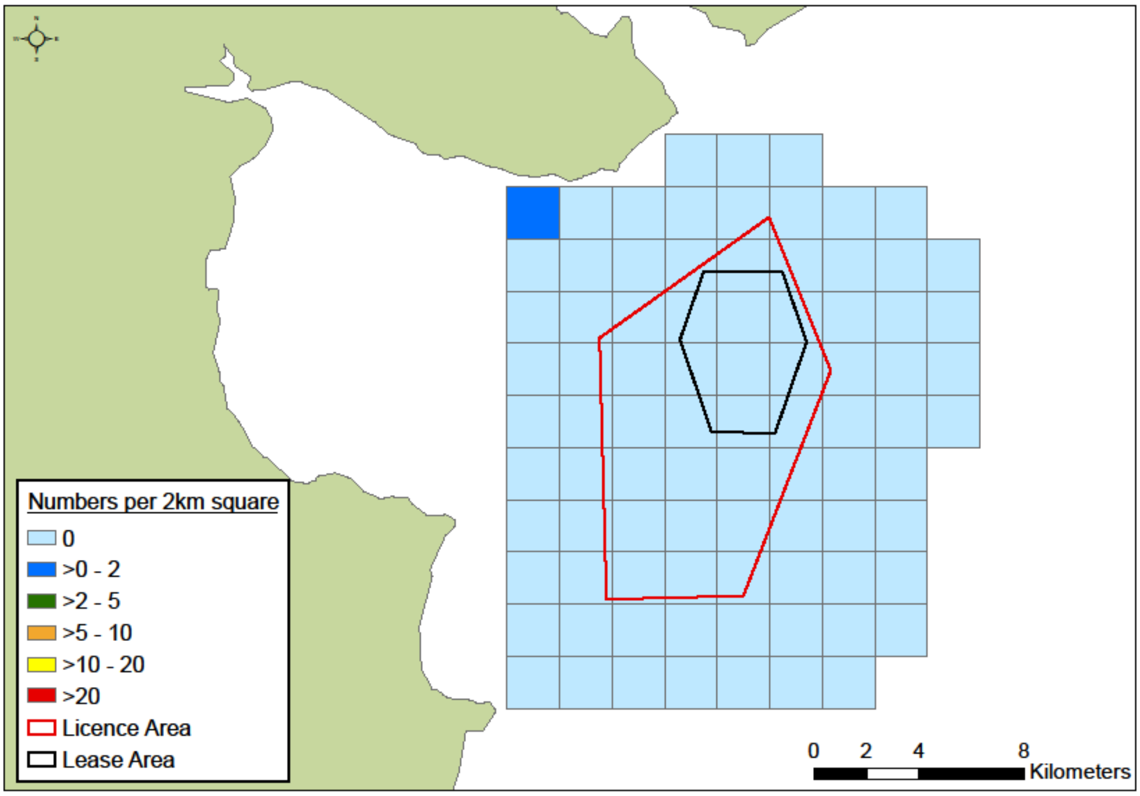

Figure 3.9.3 Cormorant survey results August 2018.

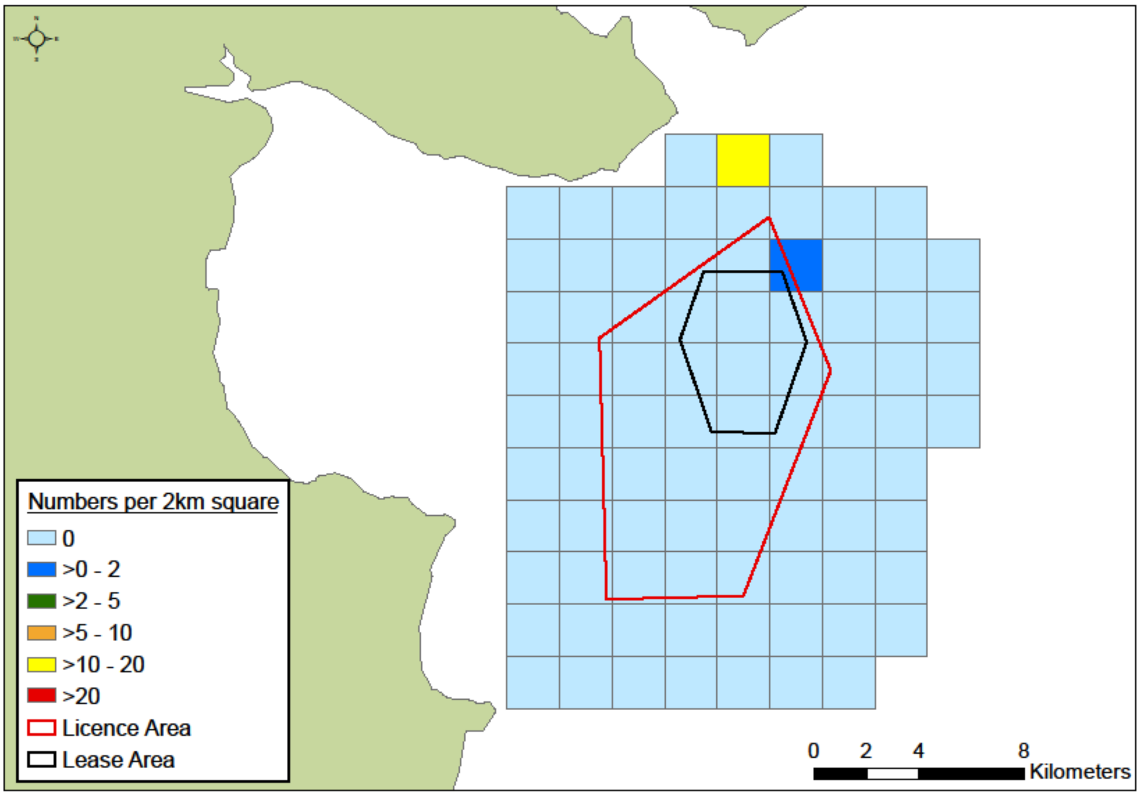

Figure 3.9.4 Cormorant survey results October 2018.

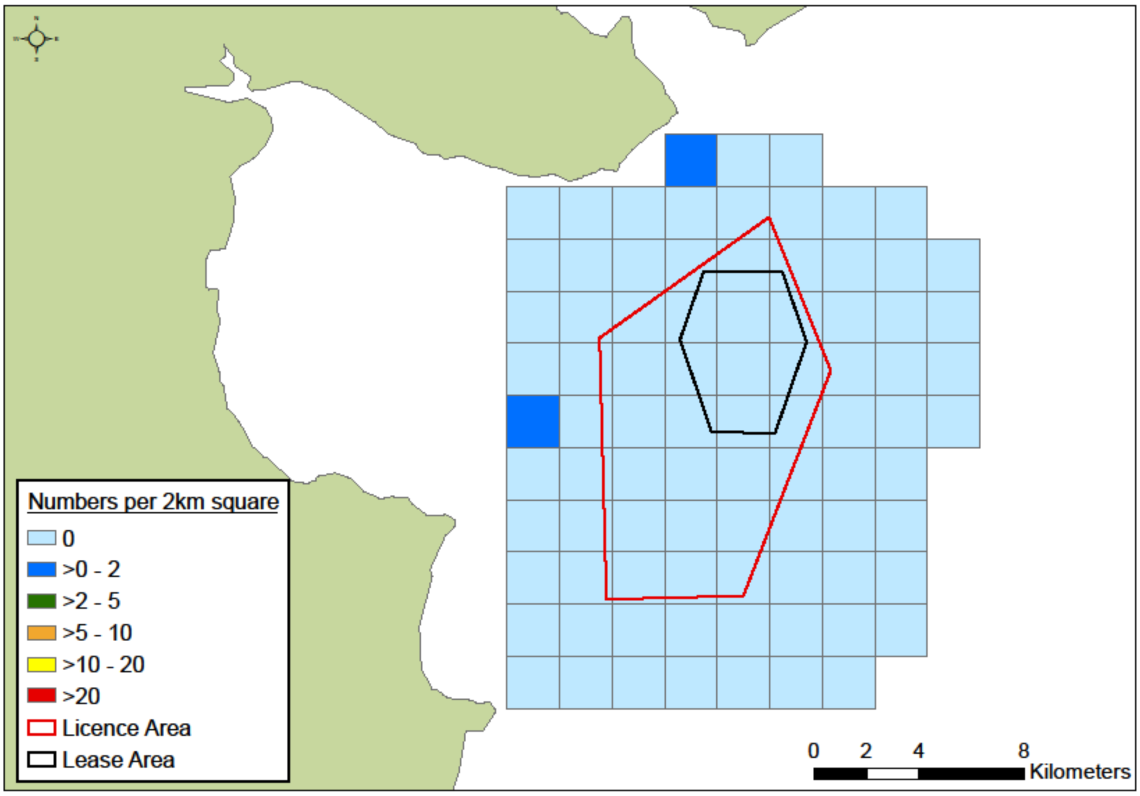

Figure 3.9.5 Cormorant survey results December 2018.

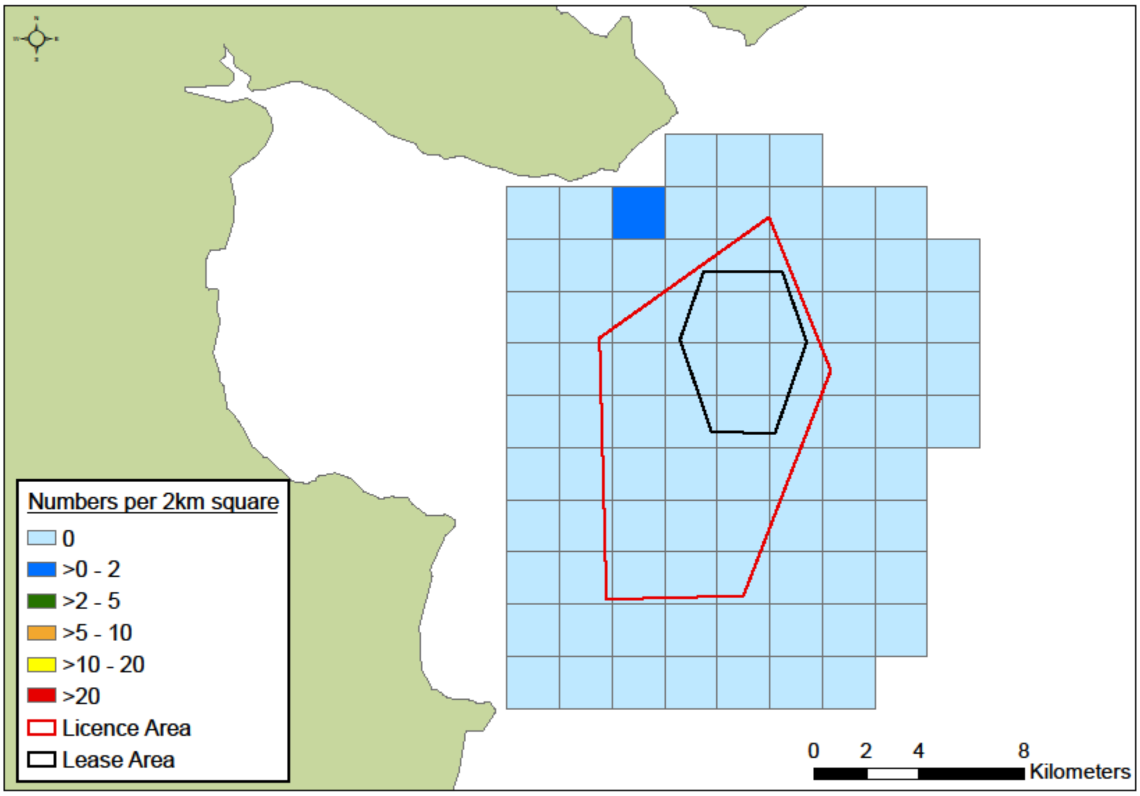

Figure 3.9.6 Cormorant survey results February 2019.

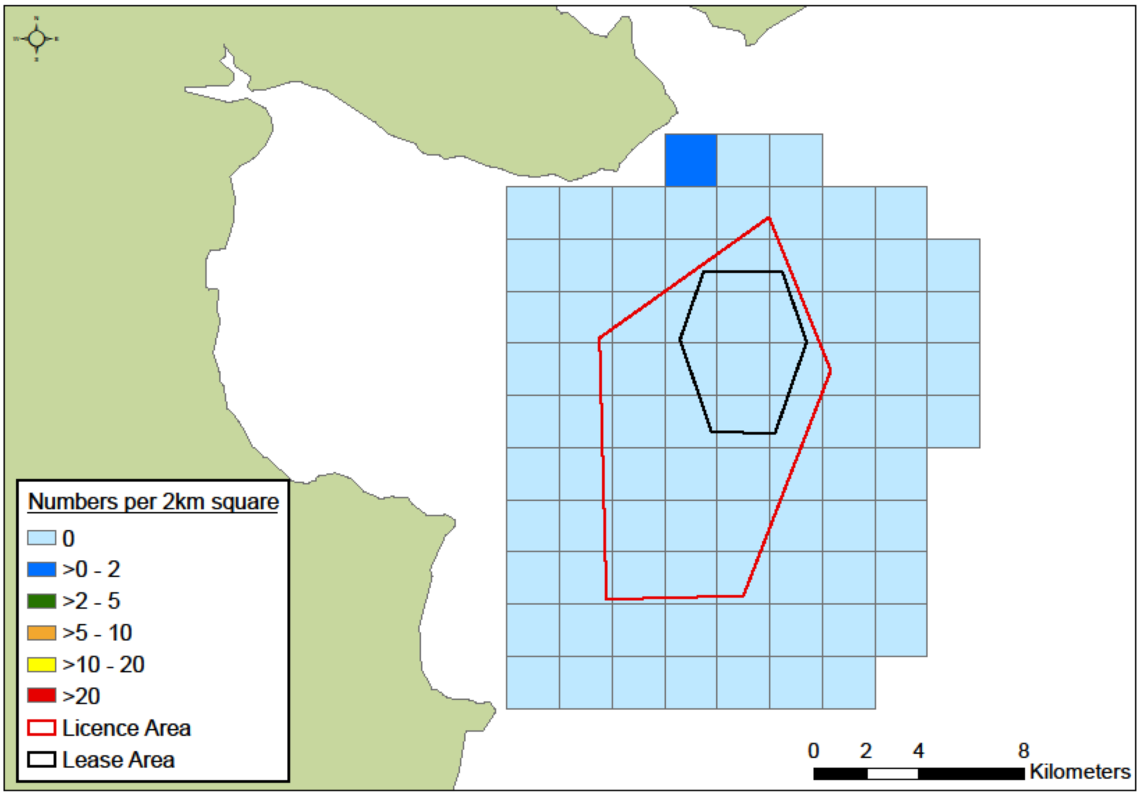

Figure 3.9.7 Cormorant survey results April 2019

3.9.2 Cormorant Density

Cormorant density estimates as derived from the monthly transect surveys are shown in Figures 3.9.8 to 3.9.12). As noted, few Cormorant were seen during the survey, and only six birds have been used to derive these density estimates, so they must be treated with caution. Peak density estimates were derived for December of 0.02 birds/km^2.

3.9.3 Shag/Cormorant Density Estimates

When combined, the highest derived density estimates for Shag and Cormorant using the transect survey data is 0.20 birds/km^2. This compares with similar levels observed in the western Irish Sea (Jessop *et al*., 2018) of between 0.14 birds/km^2 and 0.31birds/km^2.

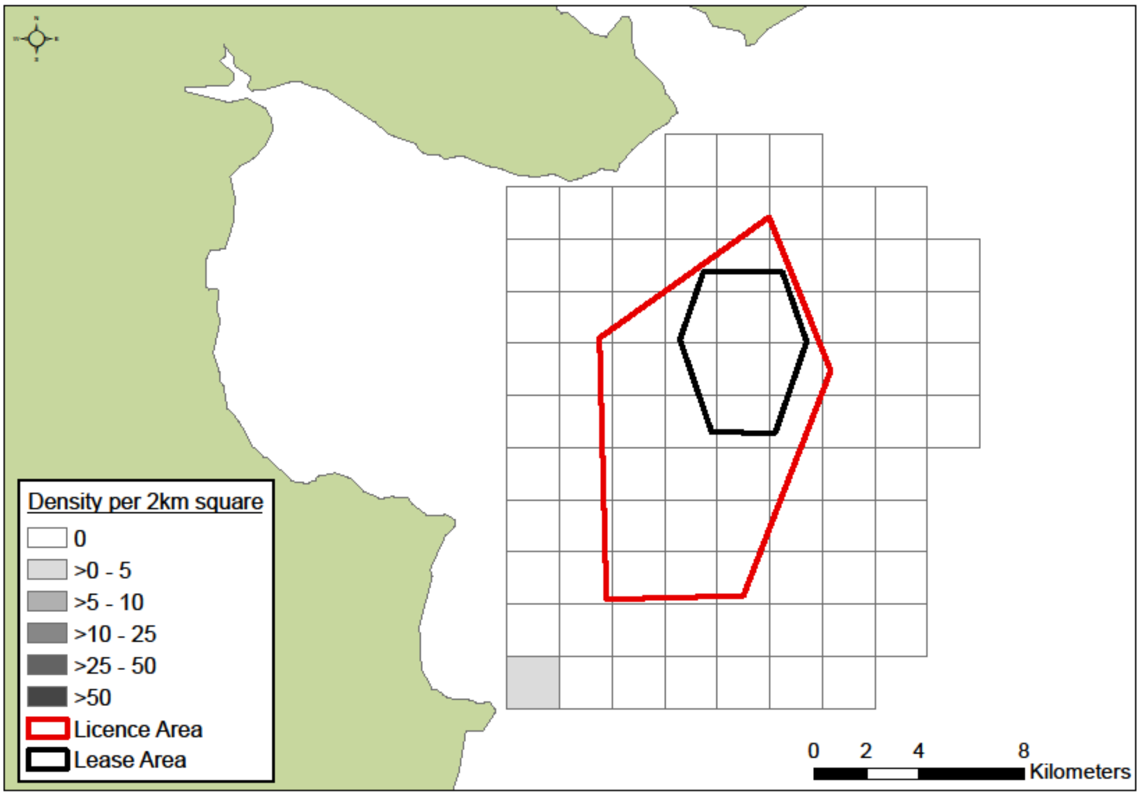

Figure 3.9.8 Cormorant density estimates May 2018.

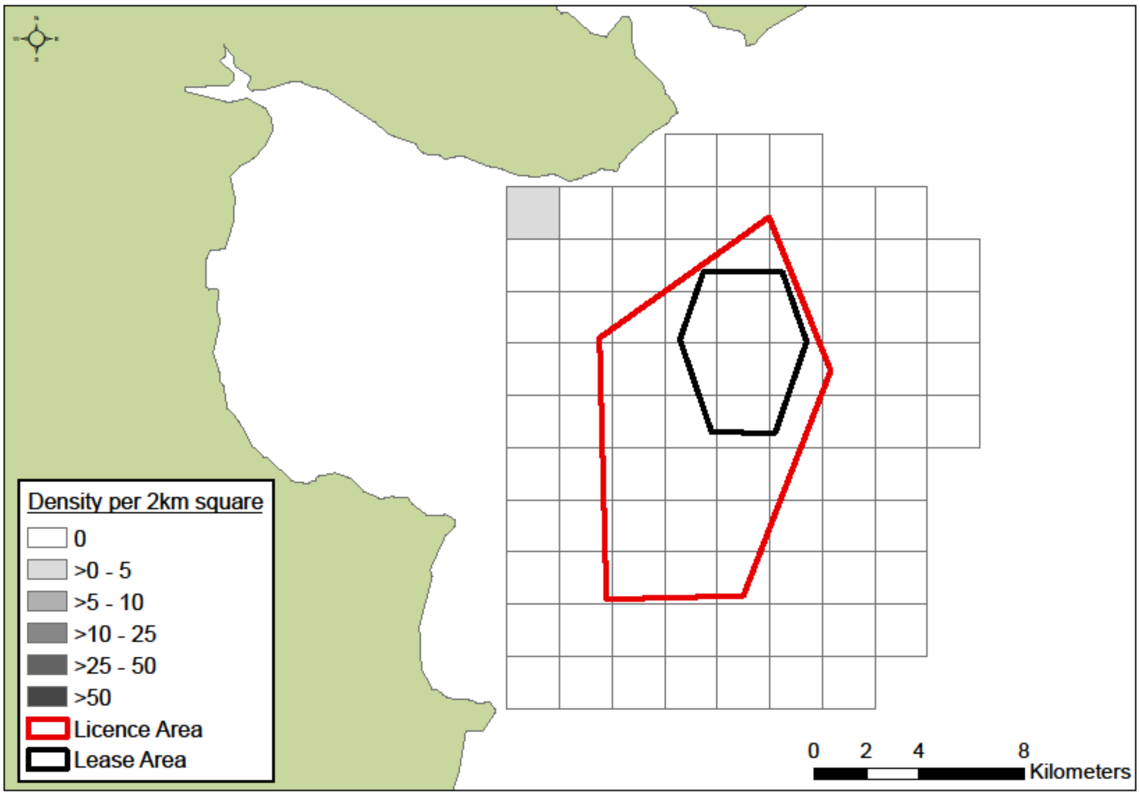

Figure 3.9.9 Cormorant density estimates August 2018.

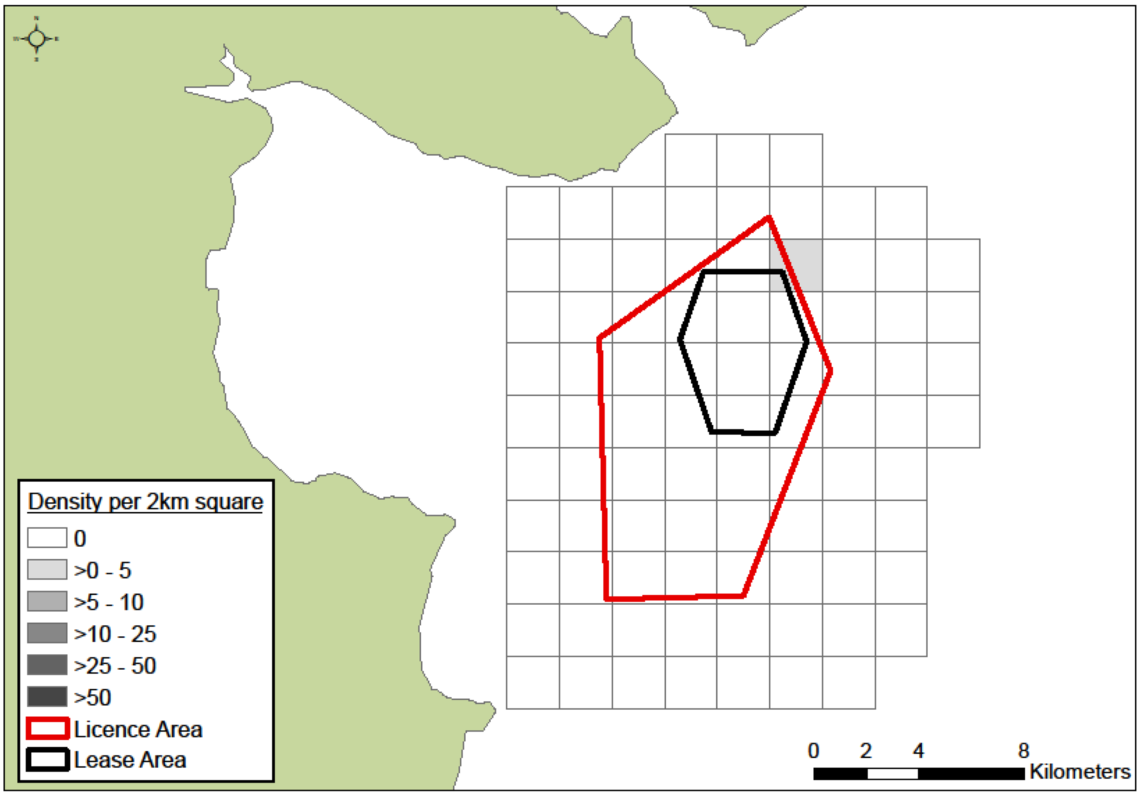

Figure 3.9.10 Cormorant density estimates October 2018.

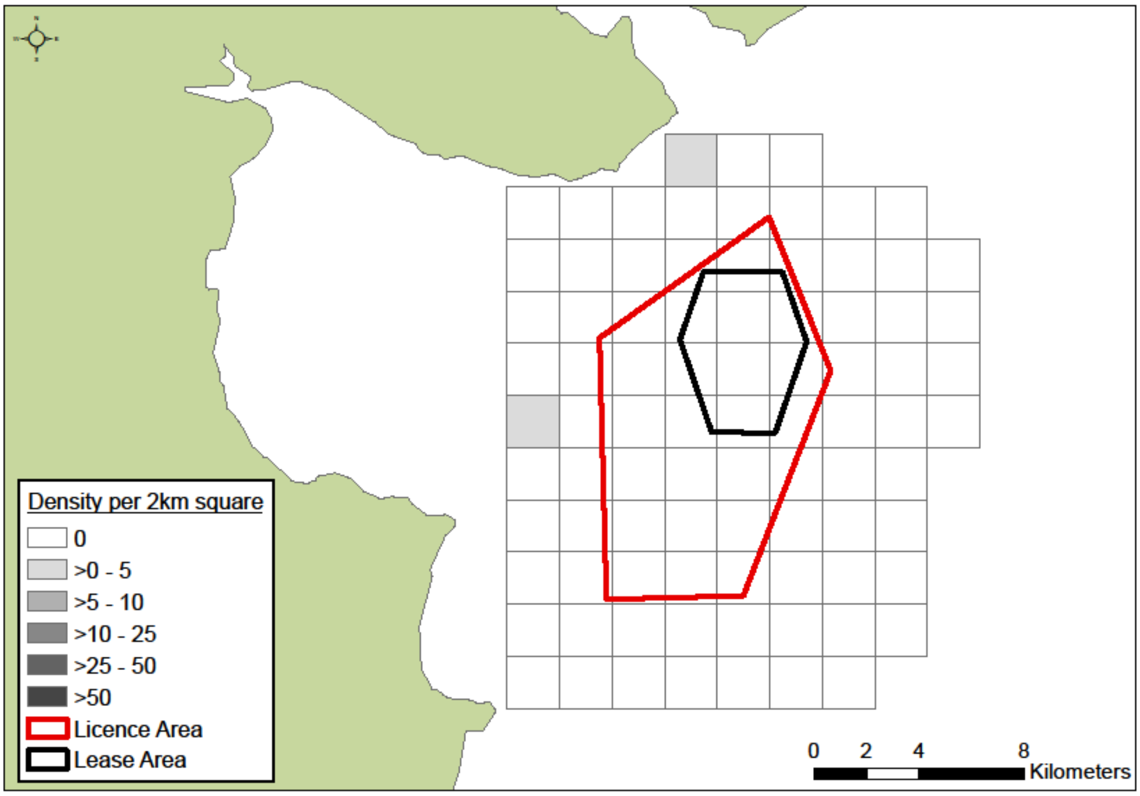

Figure 3.9.11 Cormorant density estimates December 2018.

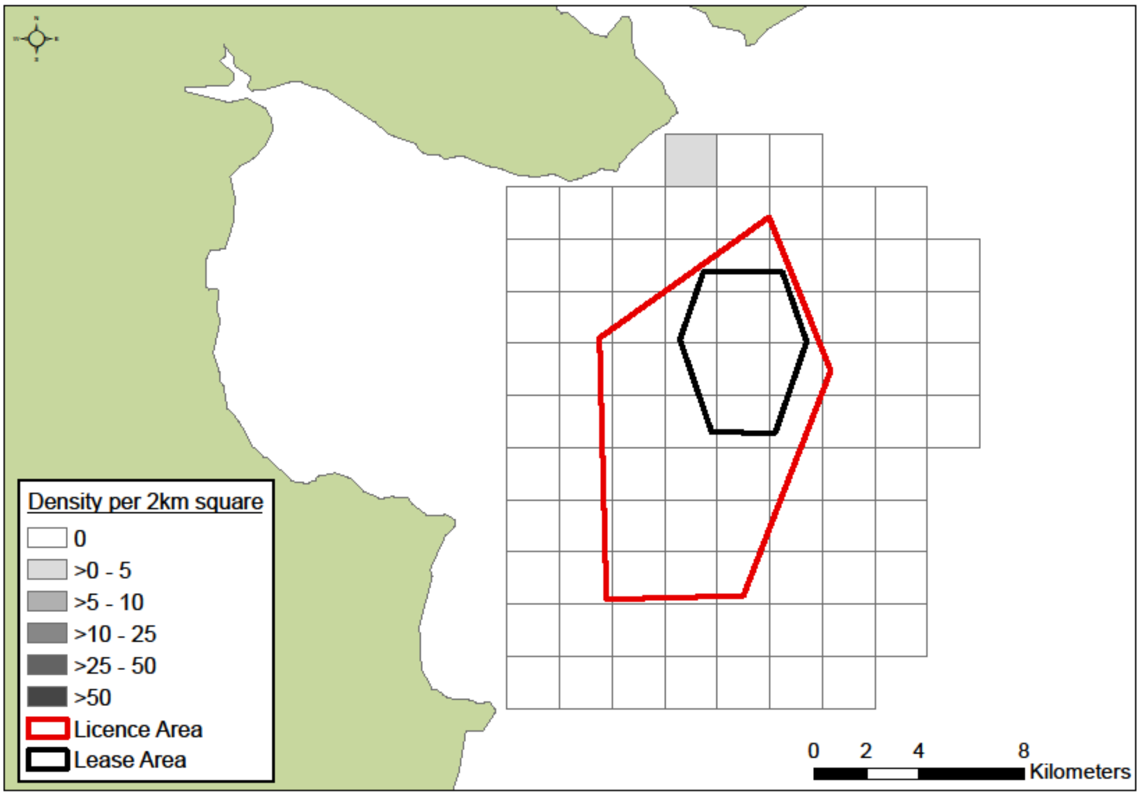

Figure 3.9.12 Cormorant density estimates April 2019.

3.10 Kittiwake

Kittiwake have a scattered breeding distribution around the Irish coast, occurring at colonies at sea cliffs (Balmer *et al.*, 2013). However, they are one of the commonest seabirds, with a distribution throughout the Irish Sea (Mitchell *et al*., 2004; Stone *et al.*, 1995). Kittiwakes in the Irish Sea typically forage on small fish (Chivers *et al.*, 2012a), which they catch on the surface of the sea (Chivers *et al.*, 2012b). Kittiwakes are Amber-listed in Ireland (Colhoun & Cummins, 2013) due to a moderate decline in the breeding populations.

3.10.1 Kittiwake Abundance

Kittiwake were recorded in all months of fieldwork (Table 3.10.1), with peak counts occurring in October 2018 (See Figure 3.10.6), with 125 birds recorded on transects from a total of 238 bird observed across the survey area. These are likely birds dispersing away from breeding areas, with the larger numbers reflecting both juveniles and fledged young. The reduced number of records in the summer (June to September 2018; see Figures 3.10.2 – 3.10.5) reflect birds preferring to be closer to breeding colonies, none of which are immediately adjacent to the survey area (Balmer *et al.,* 2013). Birds were widely spread through the whole survey area with no particular pattern to the observation (see Figures 3.10.1 to 3.10.12).

Table 3.10.1 Kittiwake records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	23	48
June 2018	17	65
July 2018	6	13
August 2018	7	18
September 2018	24	45
October 2018	125	238
November 2018	14	70
December 2018	17	87
January 2019	18	45
February 2019	85	146
March 2019	45	62
April 2019	1	3
TOTAL	**382**	**839**

14.9% of all Kittiwake records (representing 57 individuals) from the transect surveys were located in the Lease area (see Table 3.10.2), with 17.8% of records (68 individuals) in the Licence area and 67.3% of records (257 individuals) in the remaining Survey area.

Table 3.10.2 Kittiwake records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	10	43.5	9	39.1	4	17.4
June 2018	16	94.1	0	0	1	5.9
July 2018	5	83.3	1	16.7	0	0
August 2018	4	57.1	1	14.3	2	28.6
September 2018	10	41.7	13	54.2	1	4.2
October 2018	97	77.6	7	5.6	21	16.8
November 2018	13	92.9	1	7.1	0	0
December 2018	7	41.2	6	35.3	4	23.5
January 2019	12	66.7	4	22.2	2	11.1
February 2019	56	65.9	11	12.9	18	21.2
March 2019	27	60.0	14	31.1	4	8.9
April 2019	0	0	1	100	0	0
TOTAL	**257**	**67.3**	**68**	**17.8**	**57**	**14.9**

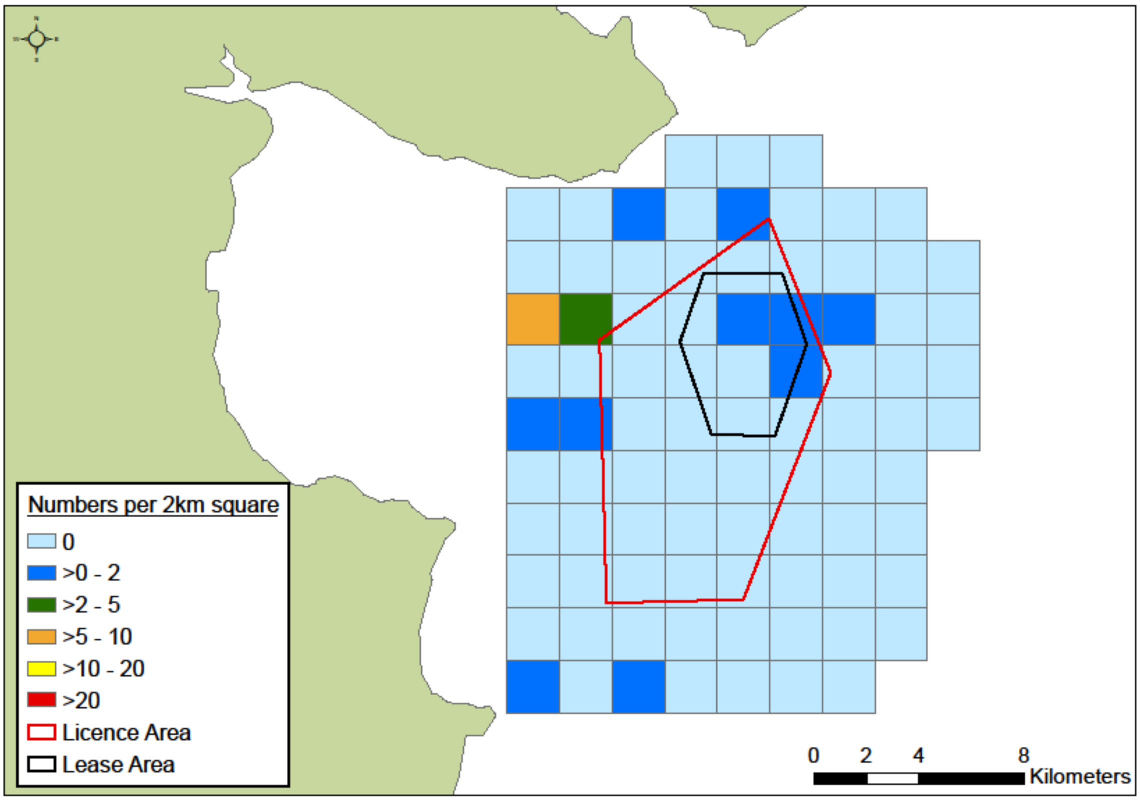

Figure 3.10.1 Kittiwake survey results May 2018

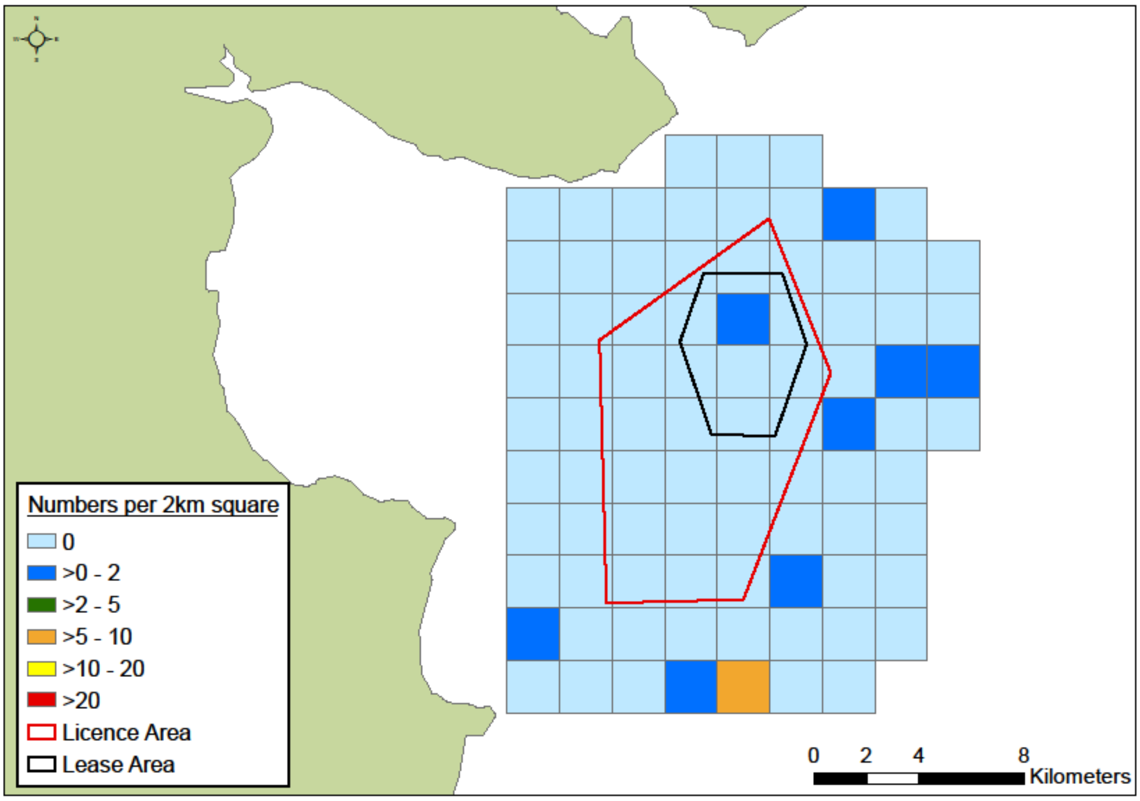

Figure 3.10.2 Kittiwake survey results June 2018

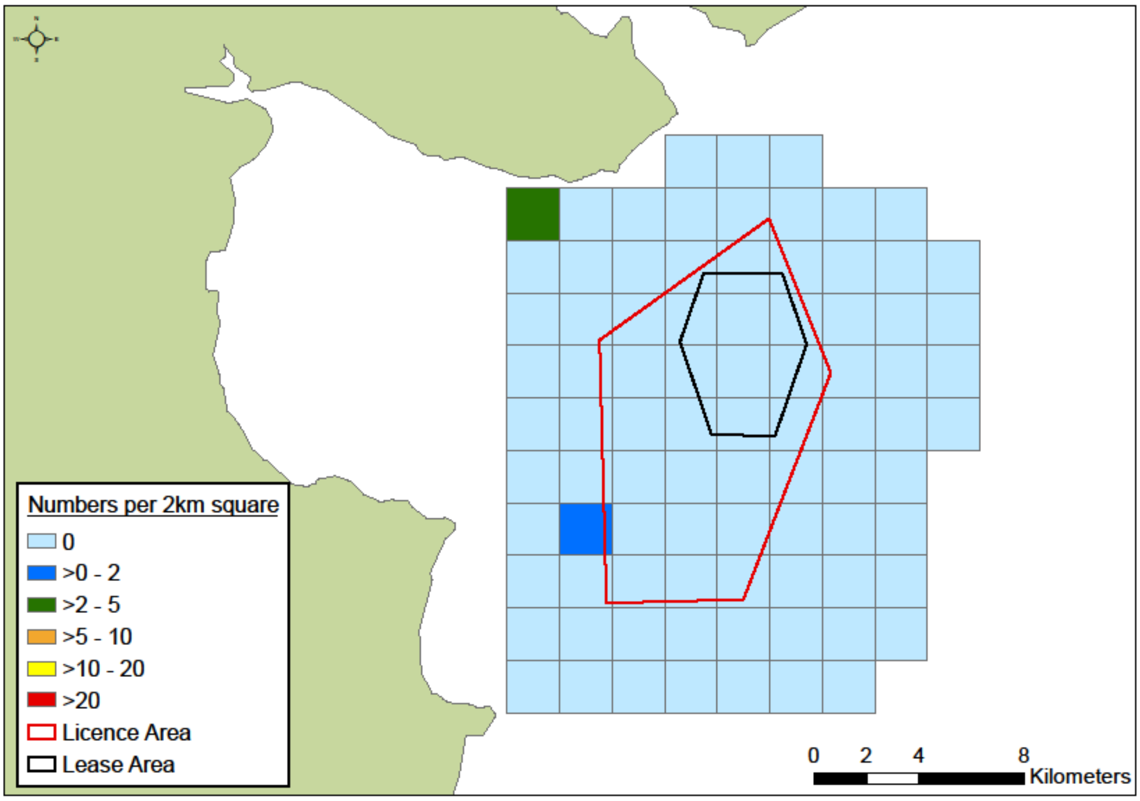

Figure 3.10.3 Kittiwake survey results July 2018

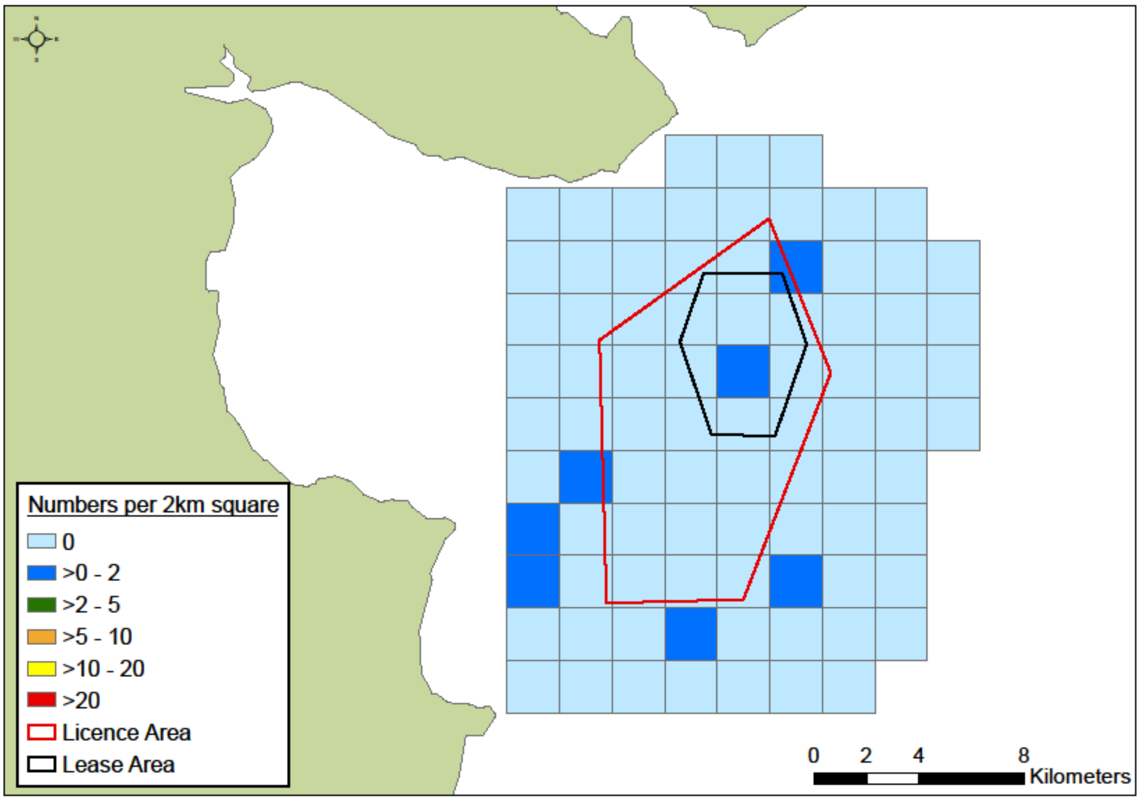

Figure 3.10.4 Kittiwake survey results August 2018

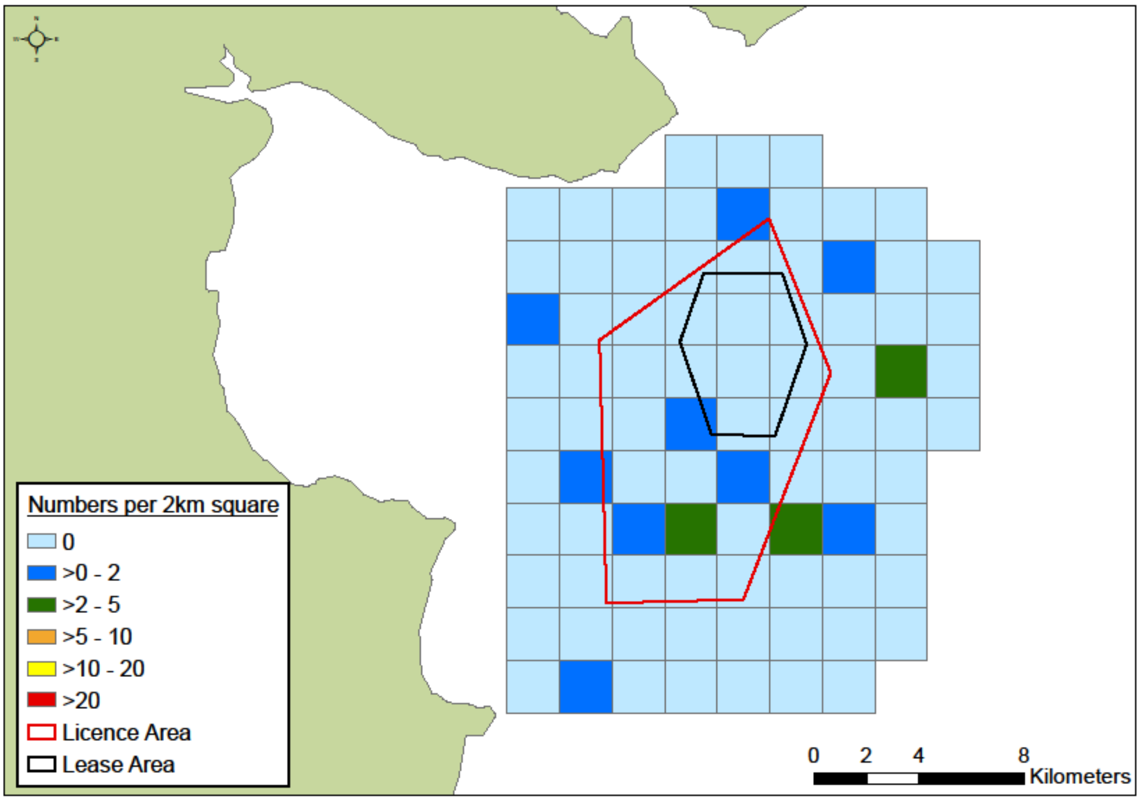

Figure 3.10.5 Kittiwake survey results September 2018

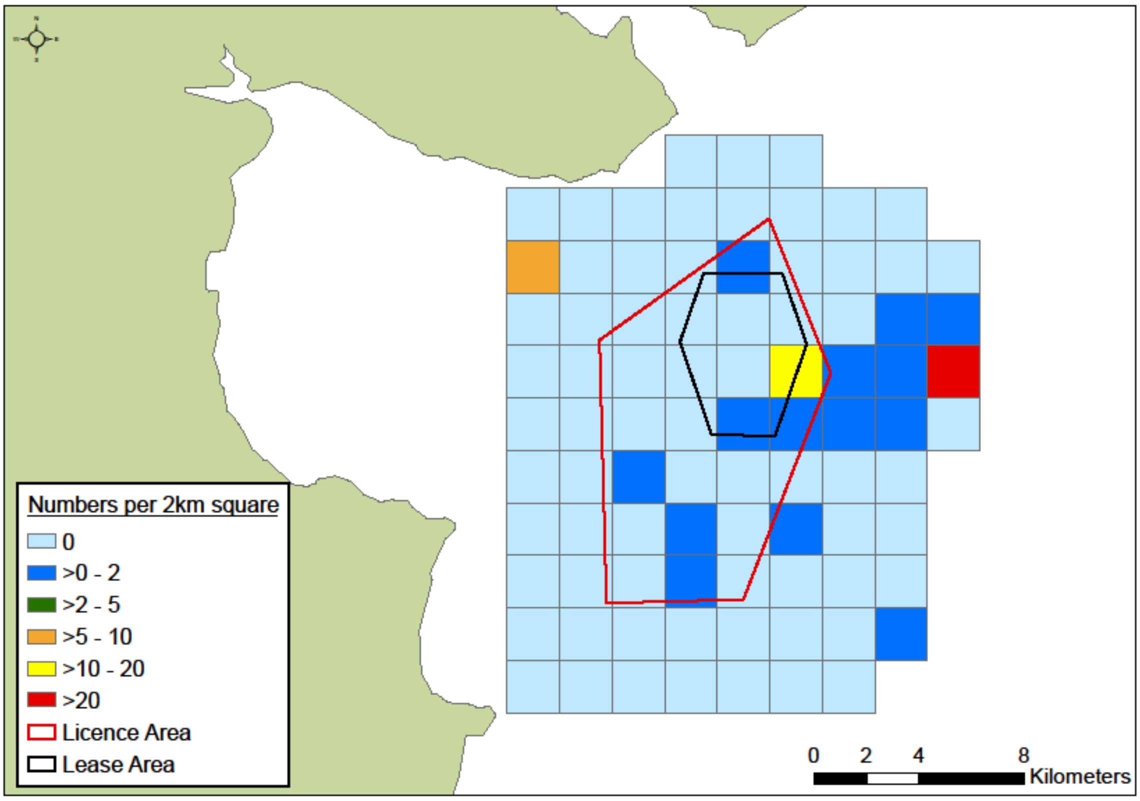

Figure 3.10.6 Kittiwake survey results October 2018

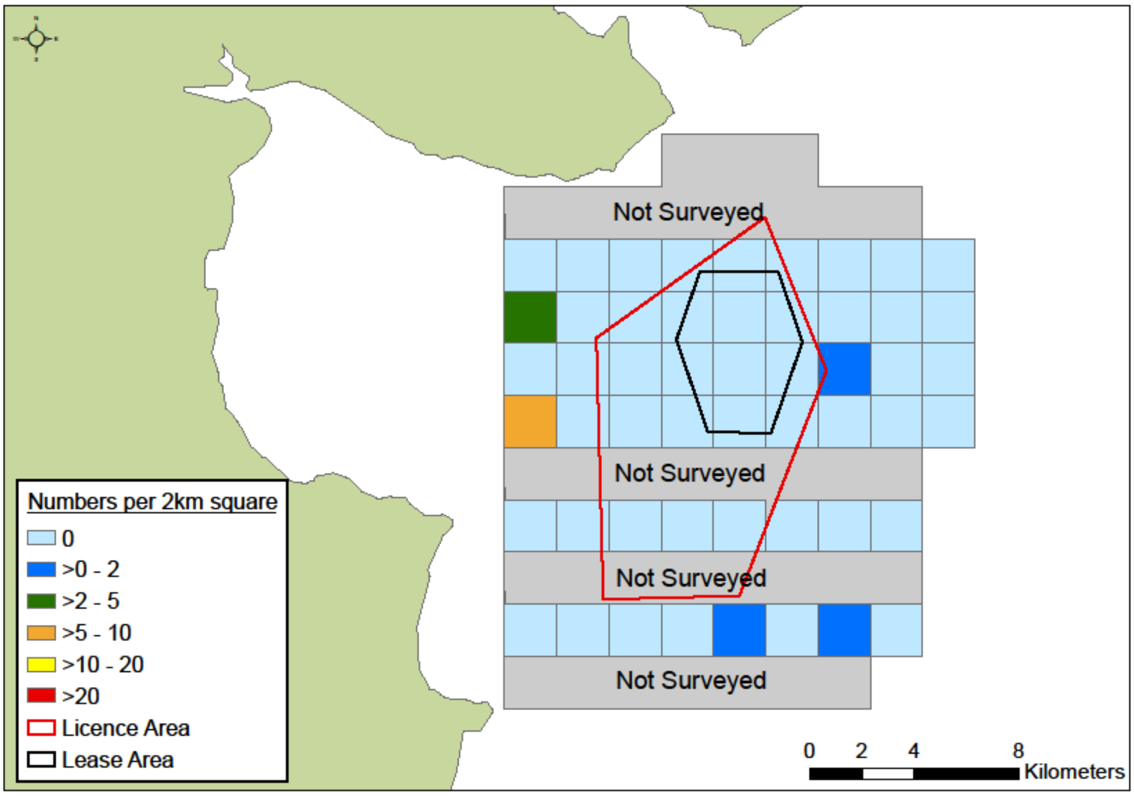

Figure 3.10.7 Kittiwake survey results November 2018

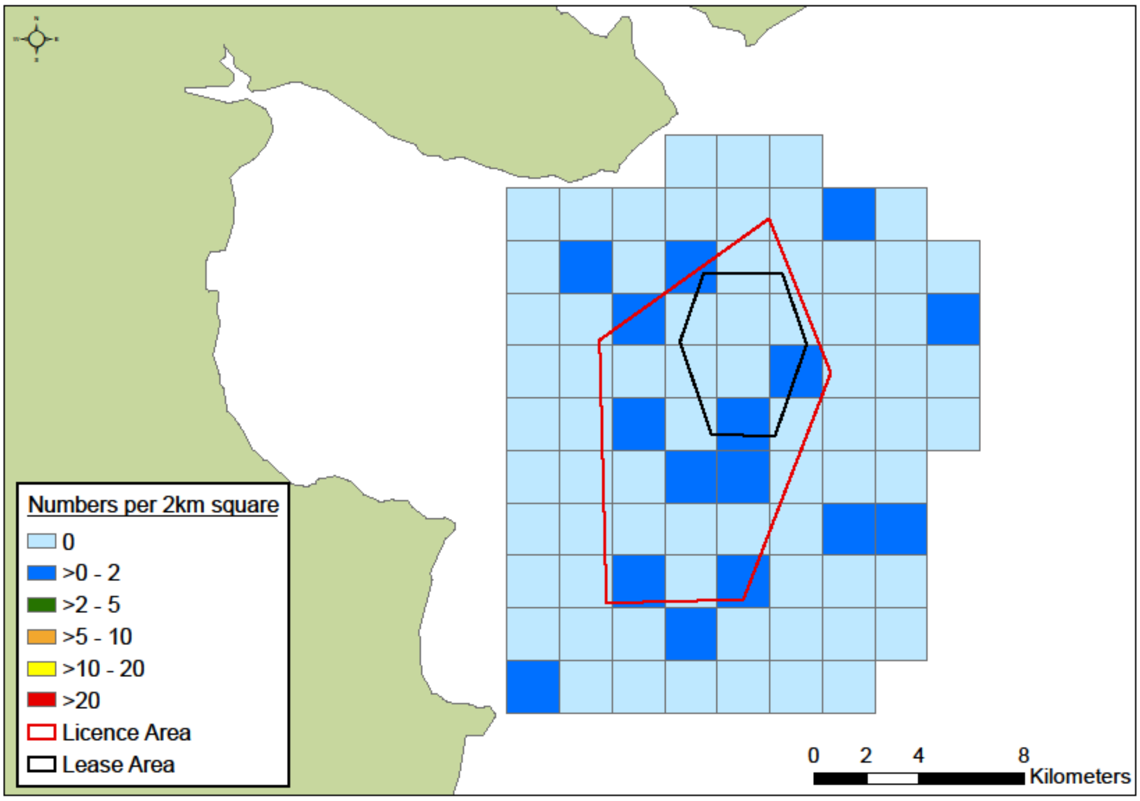

Figure 3.10.8 Kittiwake survey results December 2018

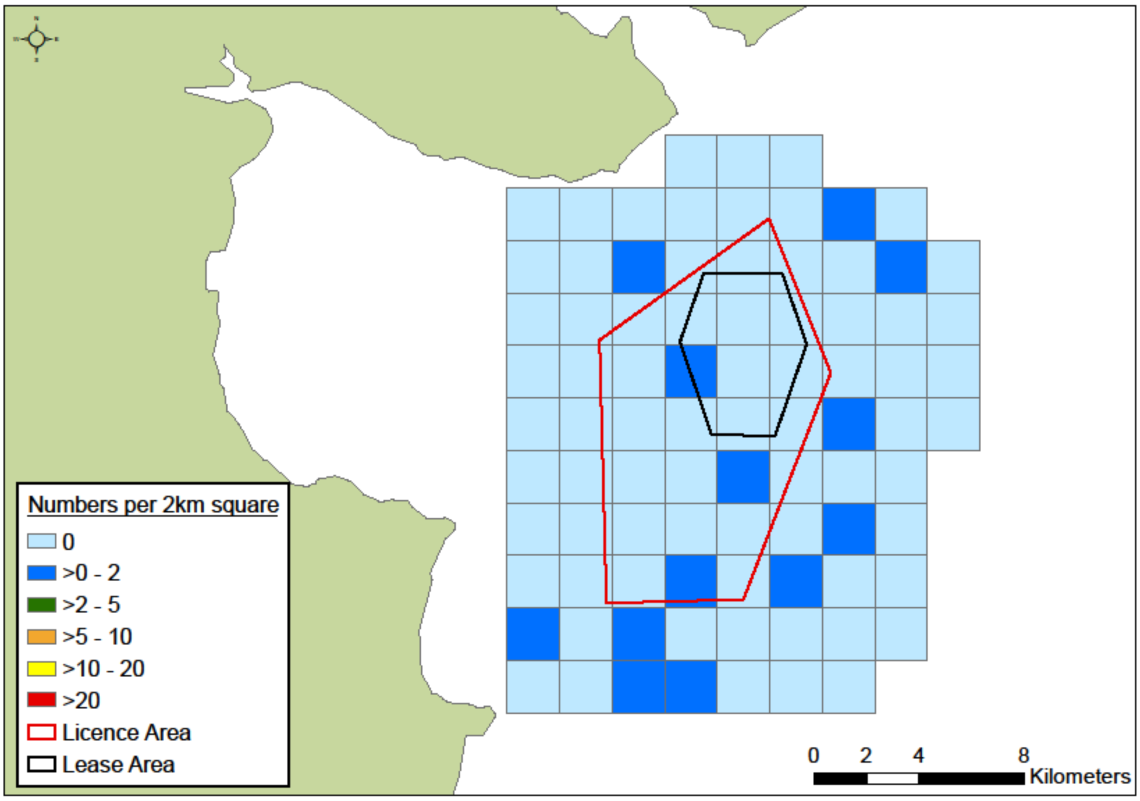

Figure 3.10.9 Kittiwake survey results January 2019

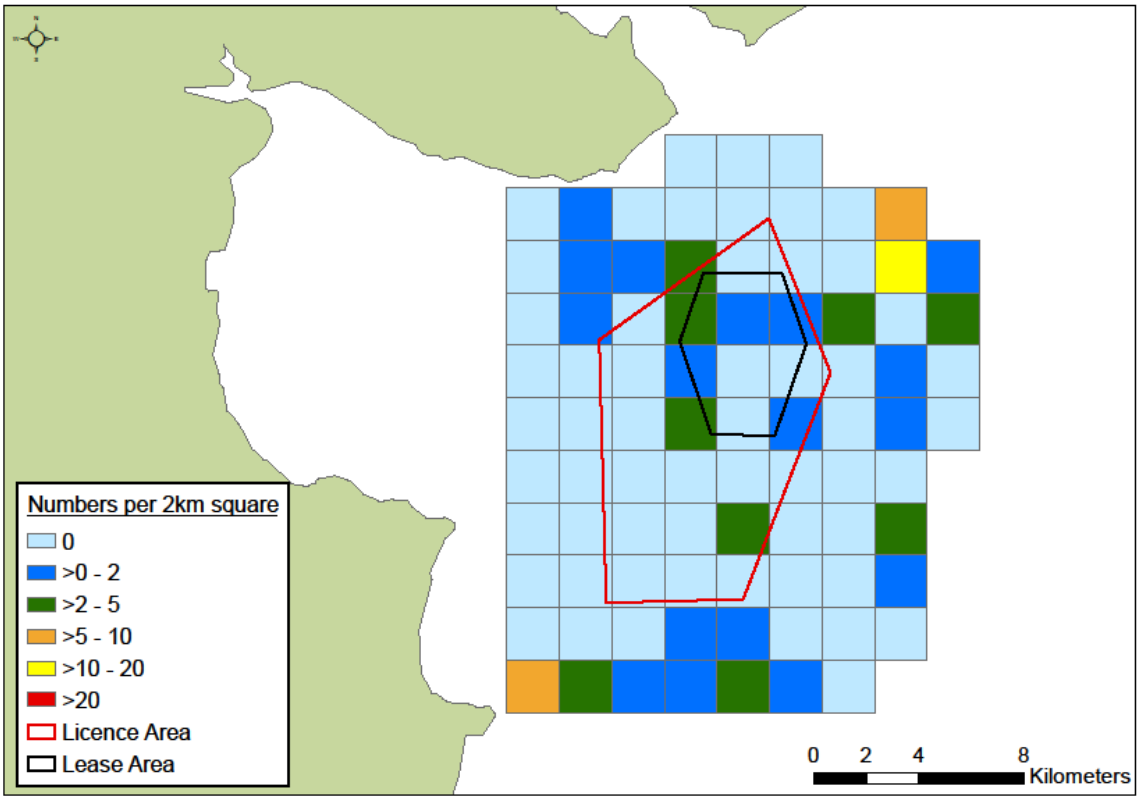

Figure 3.10.10 Kittiwake survey results February 2019

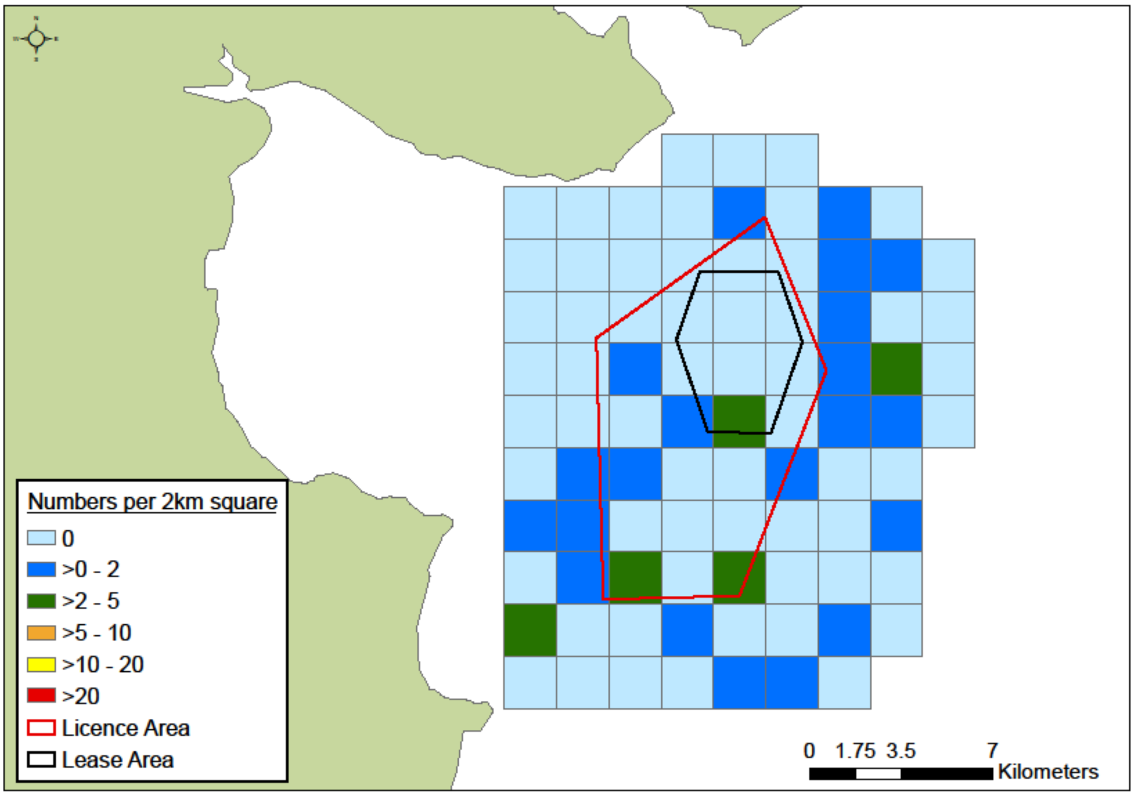

Figure 3.10.11 Kittiwake survey results March 2019

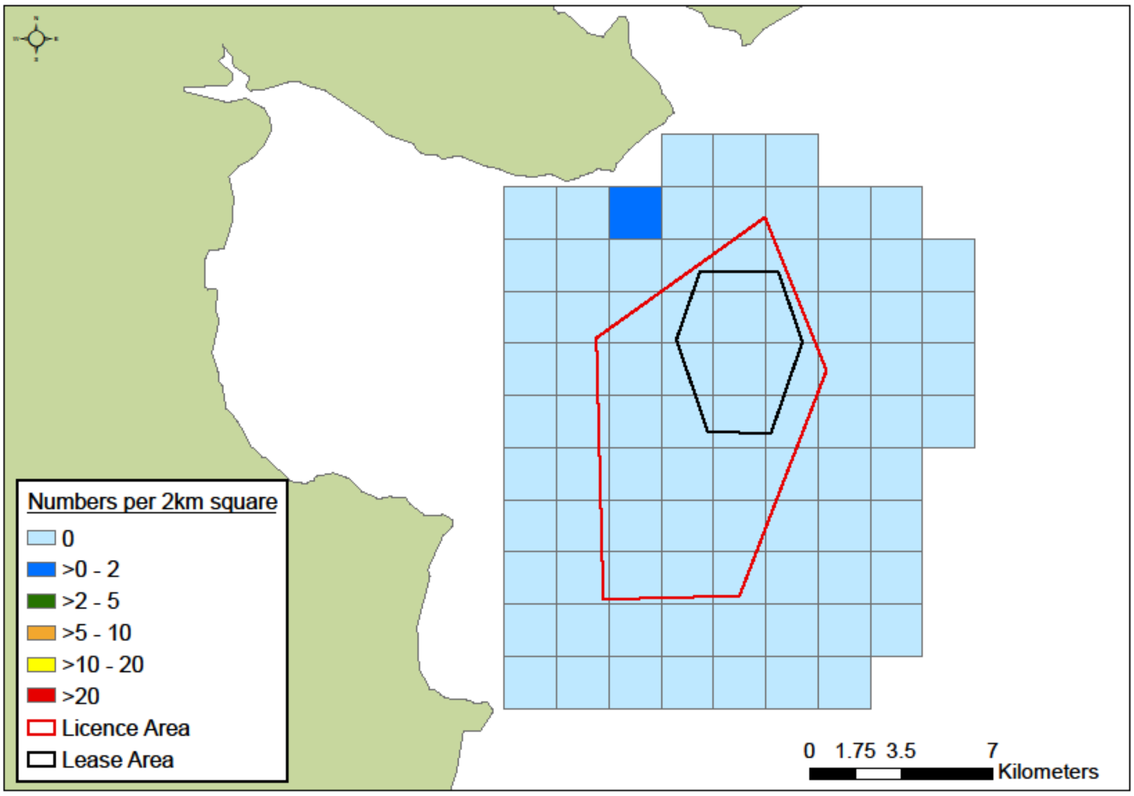

Figure 3.10.12 Kittiwake survey results April 2019

3.10.2 Kittiwake Density

Kittiwake densities, estimated from the abundance data from the survey transects, are indicated in Figures 3.10.13 to 3.10.23. Estimated densities peaked in February 2019, with a derived estimate of 0.58 birds/km^2. This compares to 0.57 birds/km^2 for the western Irish Sea (Jessop *et al.*, 2018) in Summer and Winter, but is lower than the peak densities recorded in summer (1.47 birds/km^2), indicating that higher densities are more likely to be found closer to breeding areas.

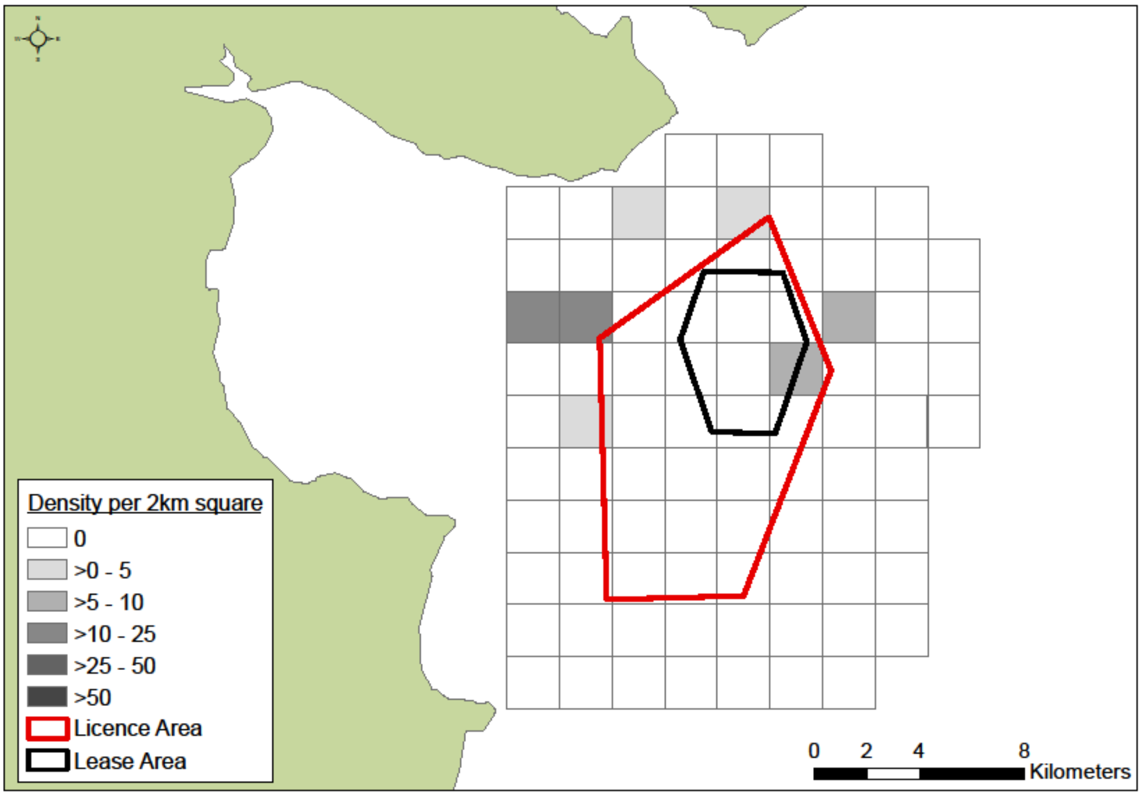

Figure 3.10.13 Kittiwake density estimates May 2018.

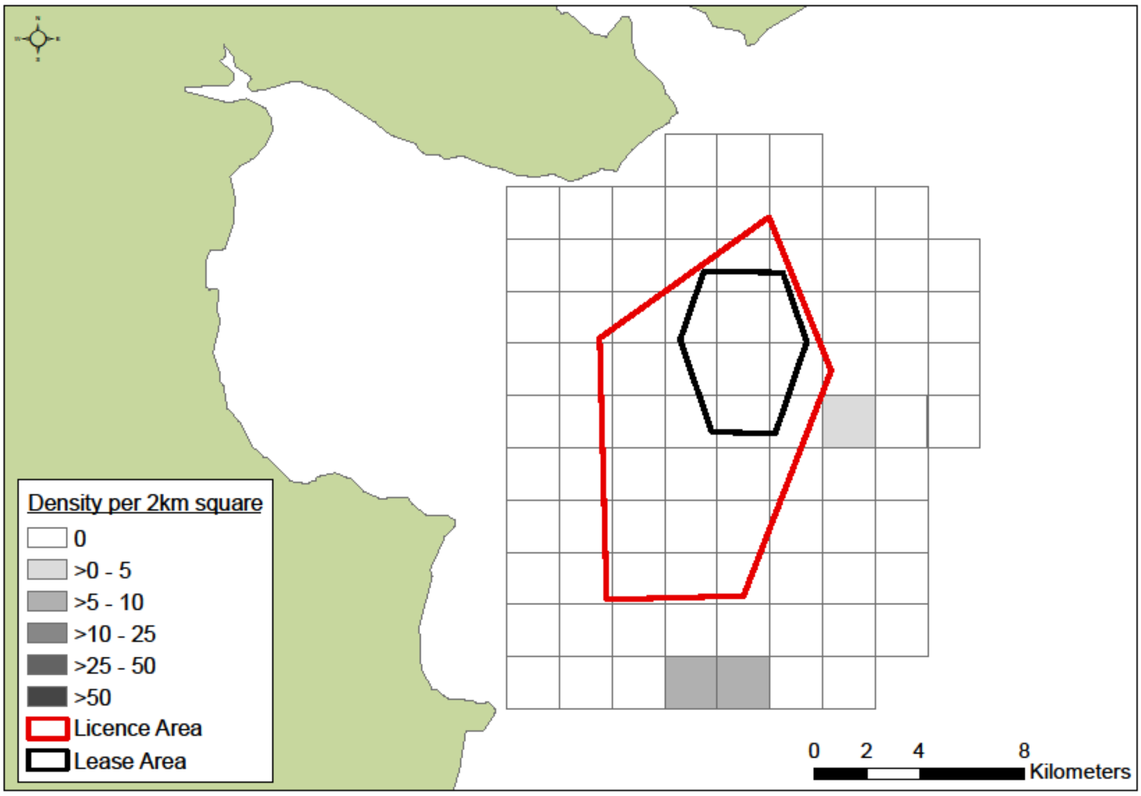

Figure 3.10.14 Kittiwake density estimates June 2018.

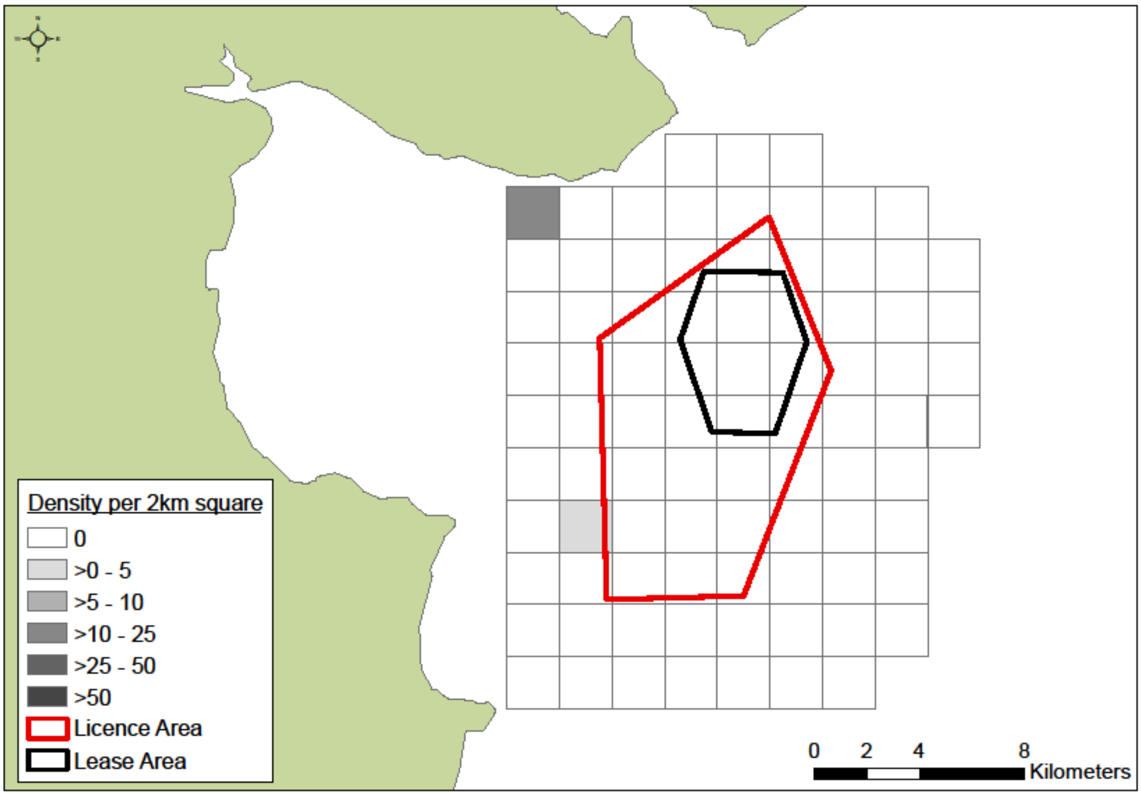

Figure 3.10.15 Kittiwake density estimates July 2018.

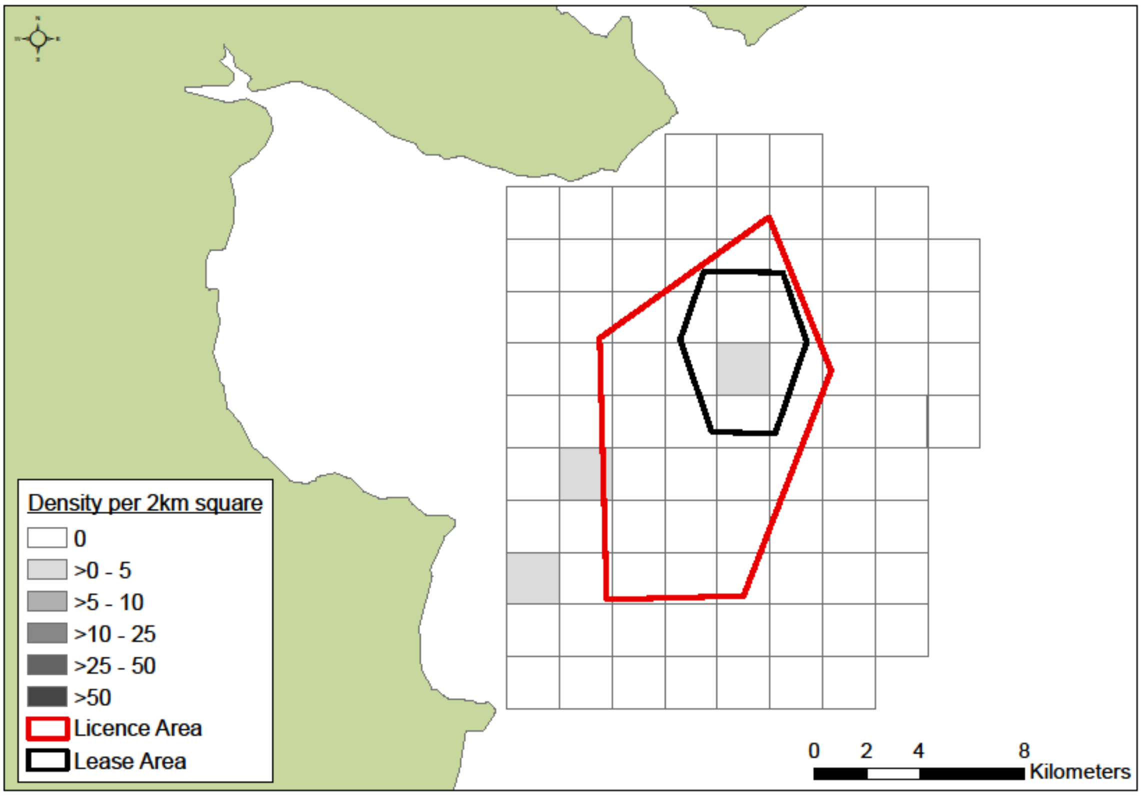

Figure 3.10.16 Kittiwake density estimates August 2018.

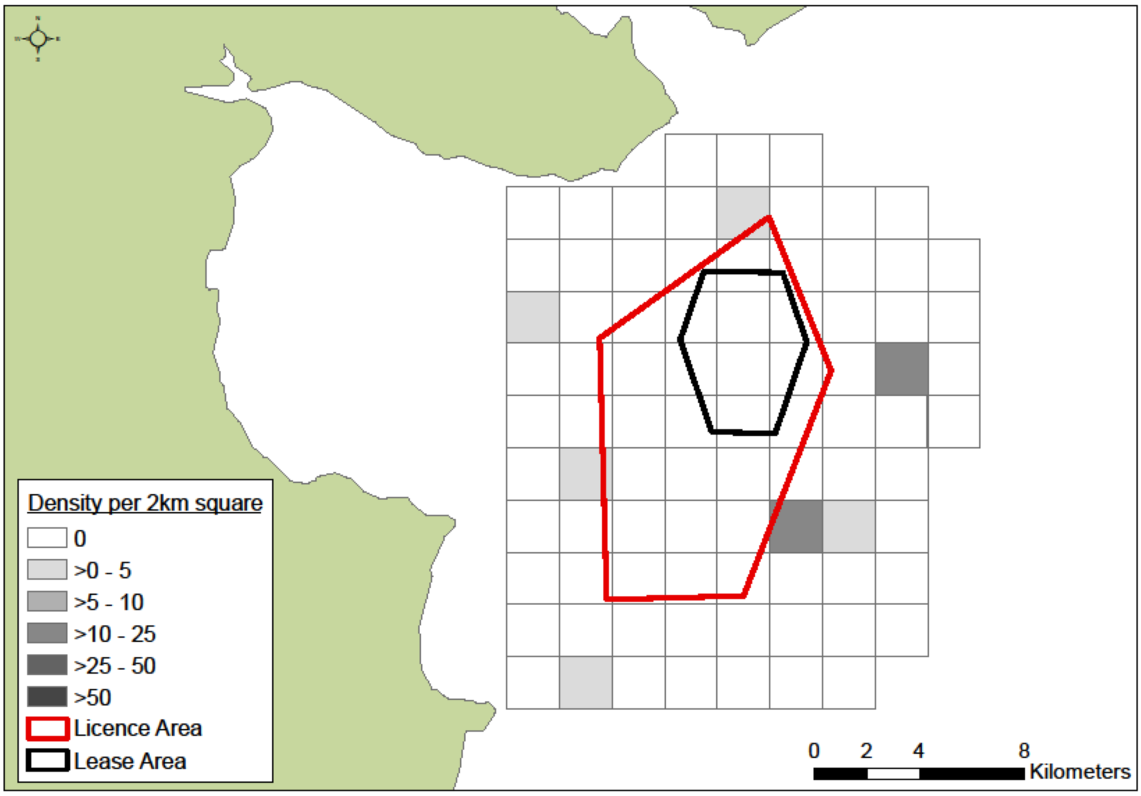

Figure 3.10.17 Kittiwake density estimates September 2018.

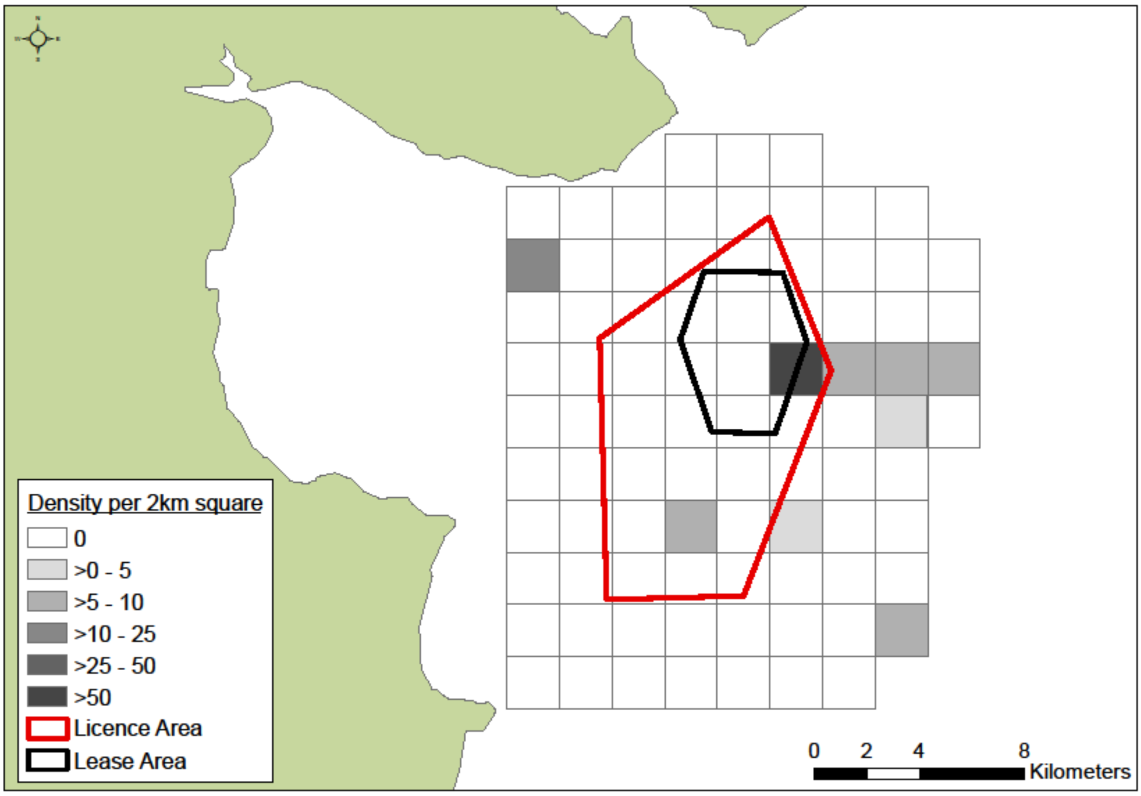

Figure 3.10.18 Kittiwake density estimates October 2018.

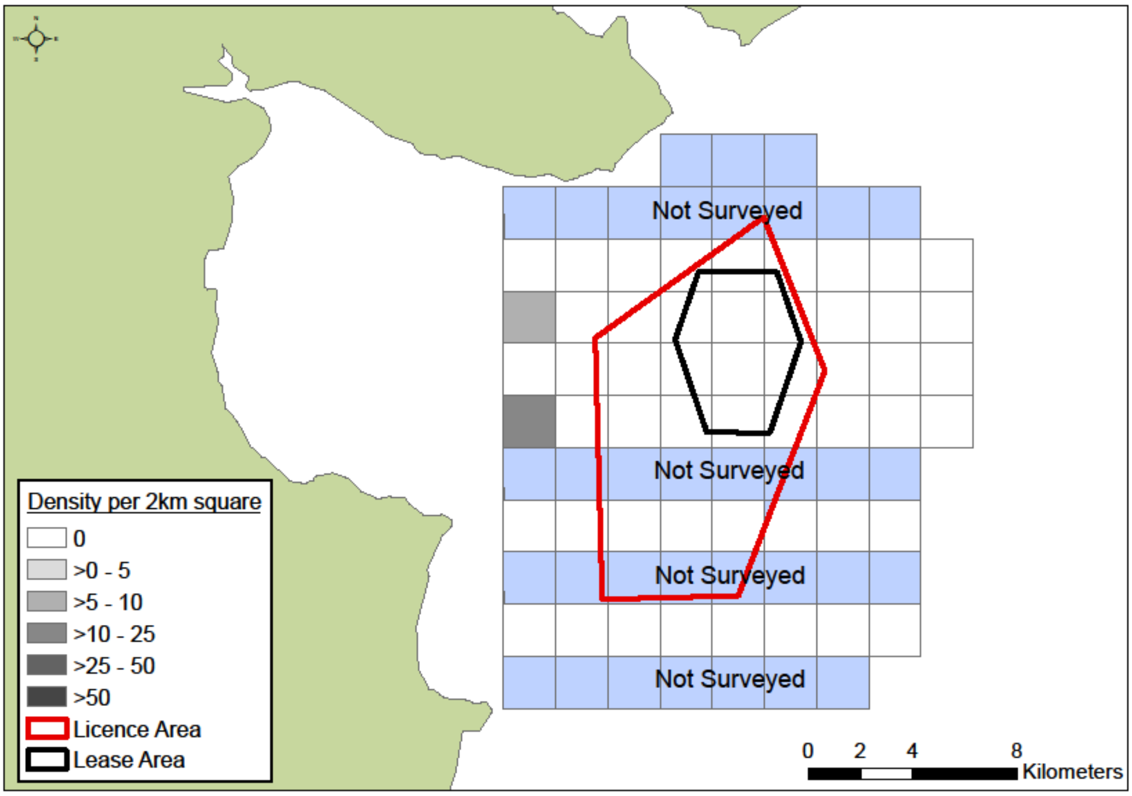

Figure 3.10.19 Kittiwake density estimates November 2018.

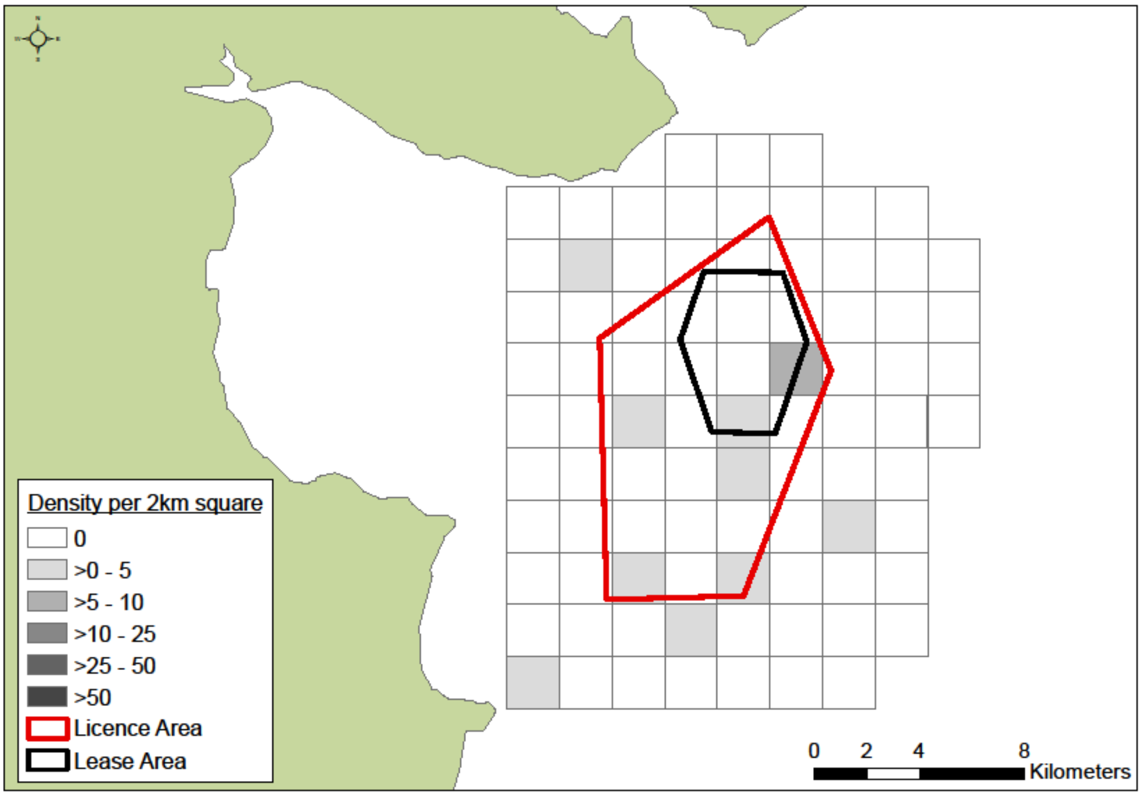

Figure 3.10.20 Kittiwake density estimates December 2018.

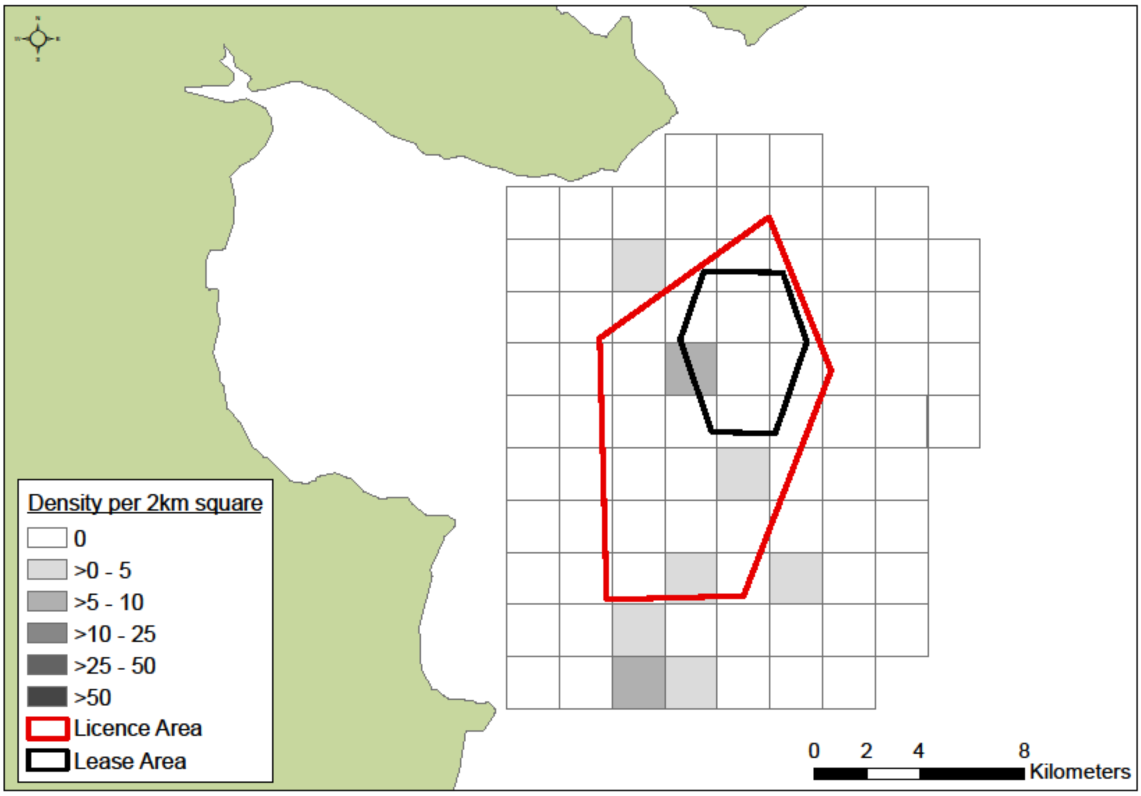

Figure 3.10.21 Kittiwake density estimates January 2019.

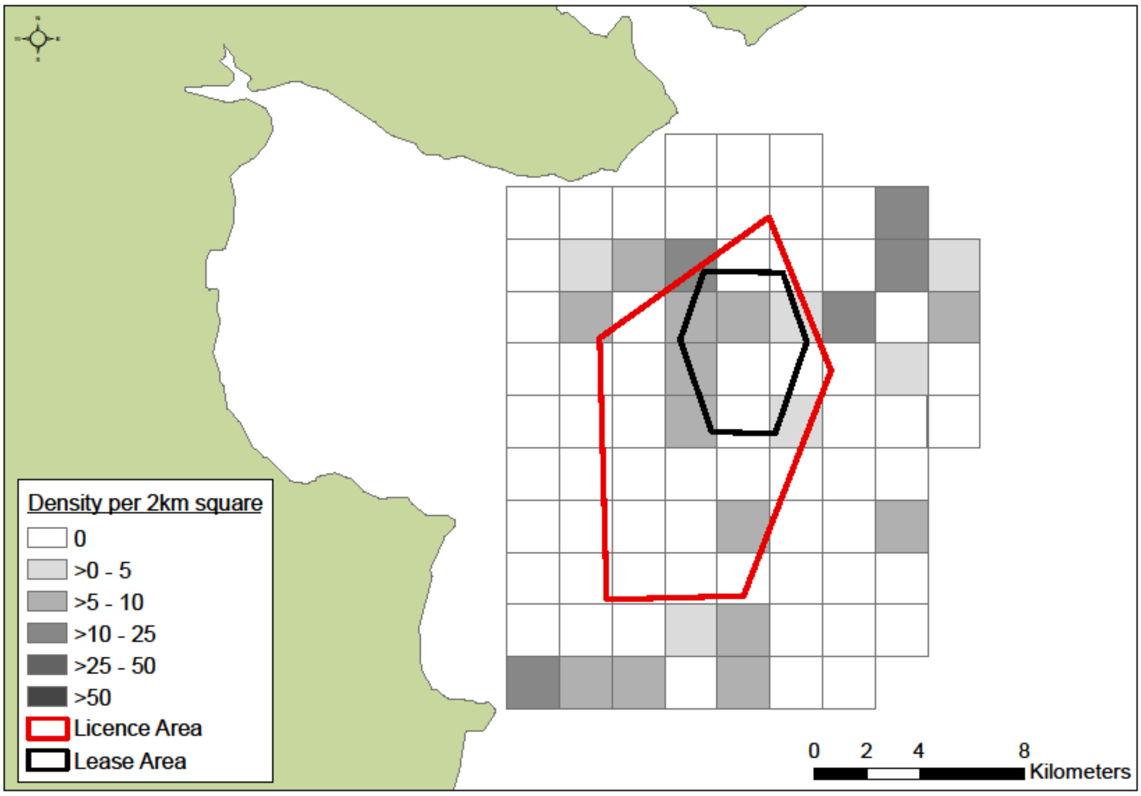

Figure 3.10.22 Kittiwake density estimates February 2019.

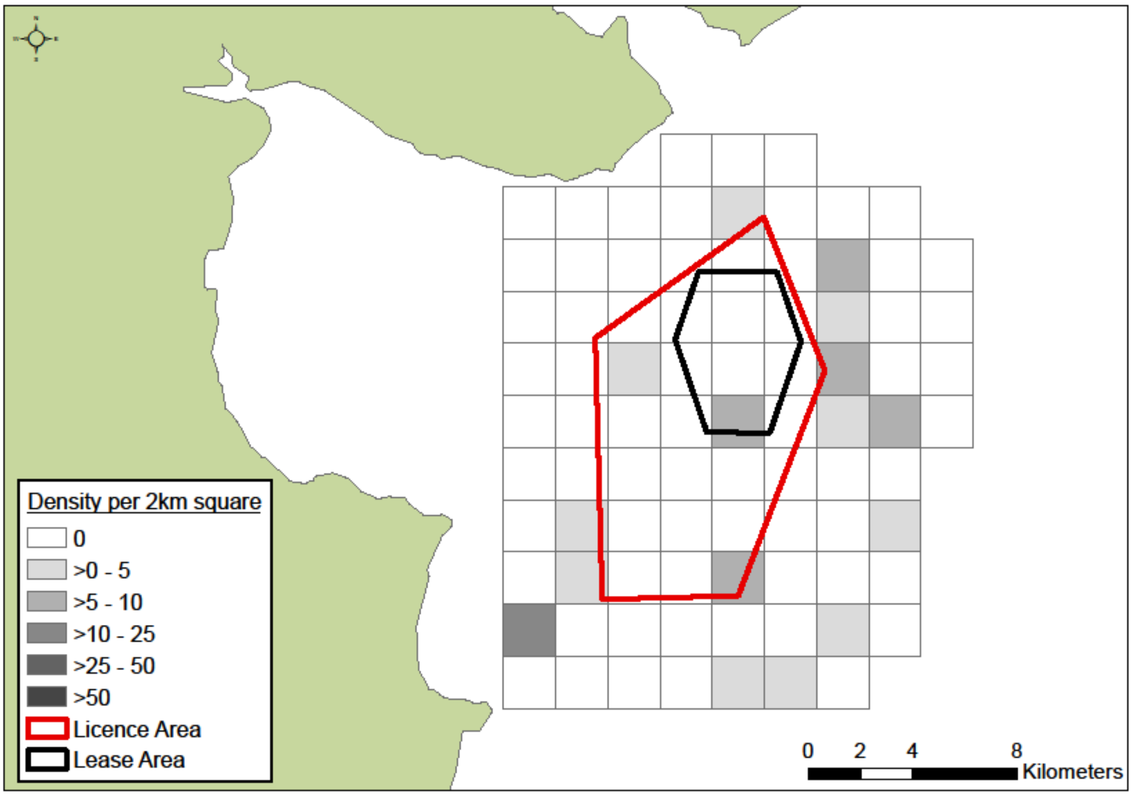

Figure 3.10.23 Kittiwake density estimates March 2019.

3.11 Black-headed Gull

Black-headed Gulls are less reliant on marine and coastal habitats than other gull species, with 44% breeding inland in Britain and Ireland (Mitchell *et al.*, 2004). Nevertheless, they are widespread in coastal and marine habitats around Ireland and the Irish Sea (Balmer *et al.*, 2013; Stone *et al*., 1995). Black-headed Gulls have a wide and varied diet, and in marine habitats typically scavenge food from the sea surface (Camphuysen *et al*., 2006). They are Red-listed and a species of high conservation concern in Ireland due to long-term declines in their breeding population and breeding range over the past 20 to 25 years (Colhoun & Cummins, 2013).

3.11.1 Black-headed Gull Abundance

As a predominantly terrestrial and coastal gull species, only 19 birds were observed in total within the survey area, of which 5 were recorded on transects (Table 3.11.1). On the transects, birds were only recorded in three months (October 2018 (Figure 3.11.1), January 2019 (Figure 3.11.2) and March 2019 (Figure 3.11.3)) with July the only other month that birds were observed within the survey area but not recorded on transects.

Table 3.11.1 Black-headed Gull records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	0
June 2018	0	0
July 2018	0	2
August 2018	0	0
September 2018	0	0
October 2018	1	10
November 2018	0	0
December 2018	0	0
January 2019	3	4
February 2019	0	0
March 2019	1	3
April 2019	0	0
TOTAL	**5**	**19**

Of the five Black-headed Gulls recorded on transects, one was in the Lease area and four in the wider Survey area (see Table 3.11.2), with no records from the Licence area.

Table 3.11.2 Black-headed Gull records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	0	-	0	-	0	-
June 2018	0	-	0	-	0	-
July 2018	0	-	0	-	0	-
August 2018	0	-	0	-	0	-
September 2018	0	-	0	-	0	-
October 2018	0	0	0	0	1	100
November 2018	0	-	0	-	0	-
December 2018	0	-	0	-	0	-
January 2019	3	100	0	0	0	0
February 2019	0	-	0	-	0	-
March 2019	1	100	0	0	0	0
April 2019	0	-	0	-	0	-
TOTAL	**4**	**80.0**	**0**	**0**	**1**	**20.0**

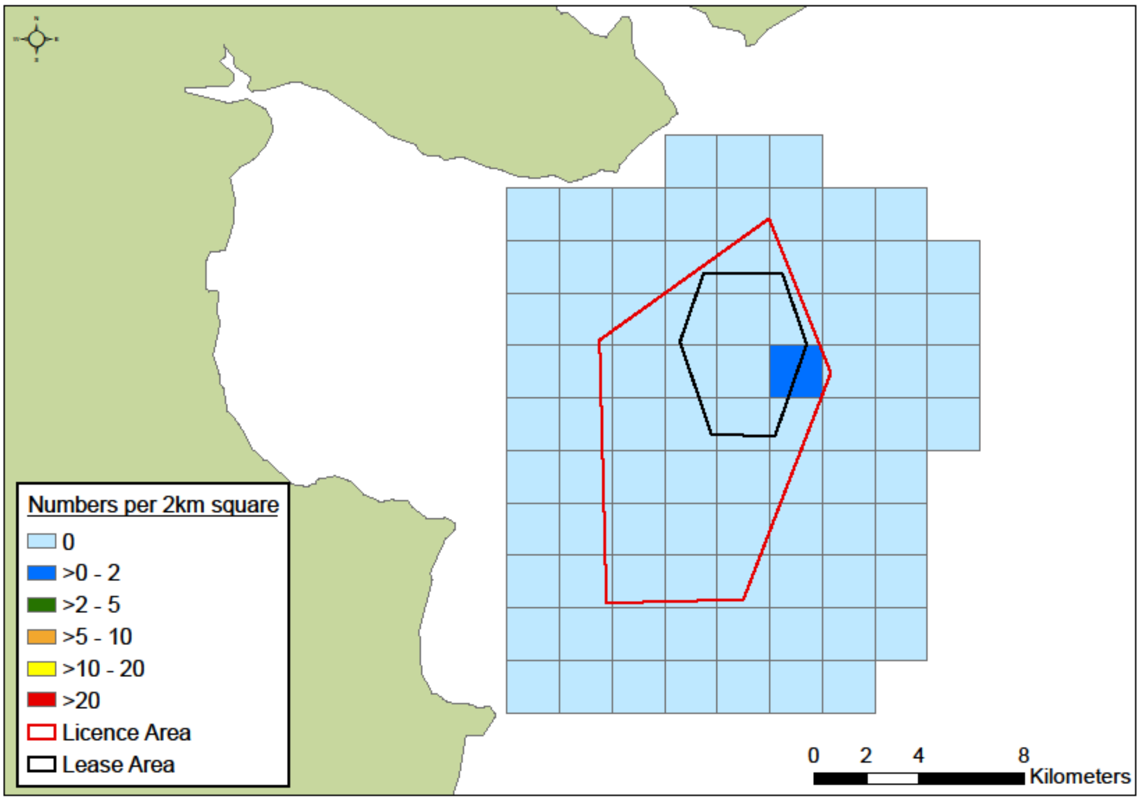

Figure 3.11.1 Black-headed Gull survey results October 2018

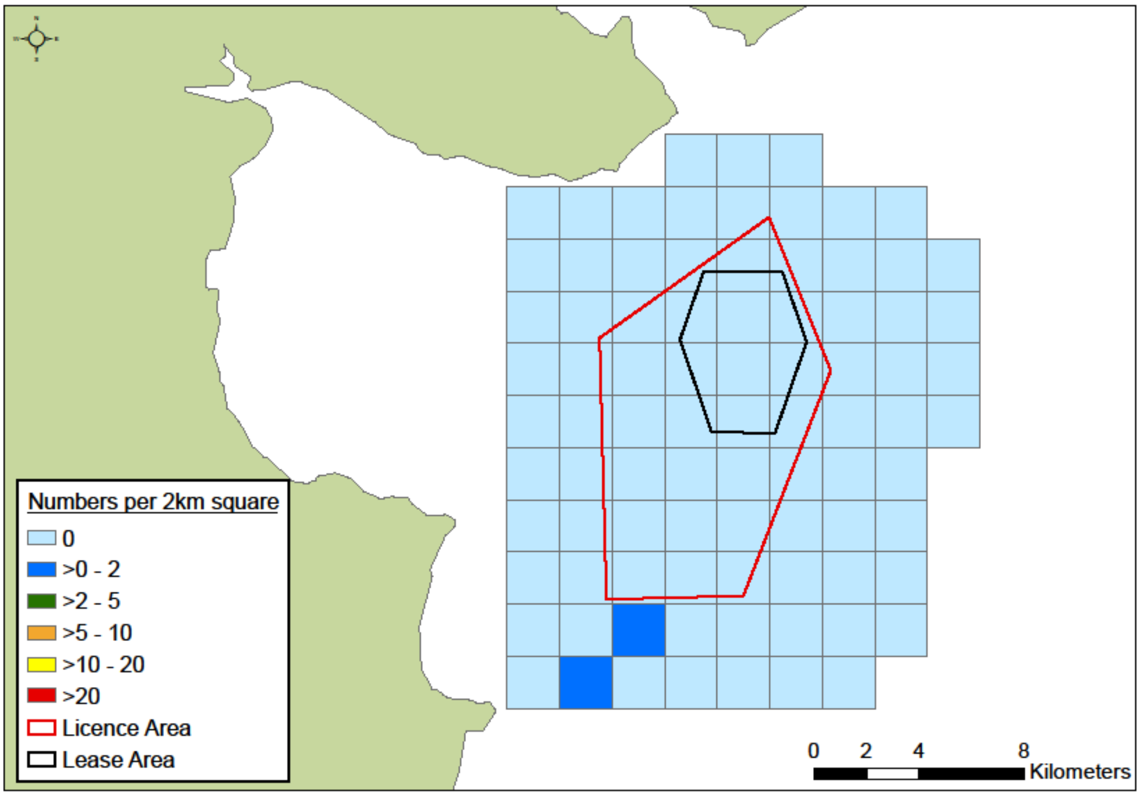

Figure 3.11.2 Black-headed Gull survey results January 2019

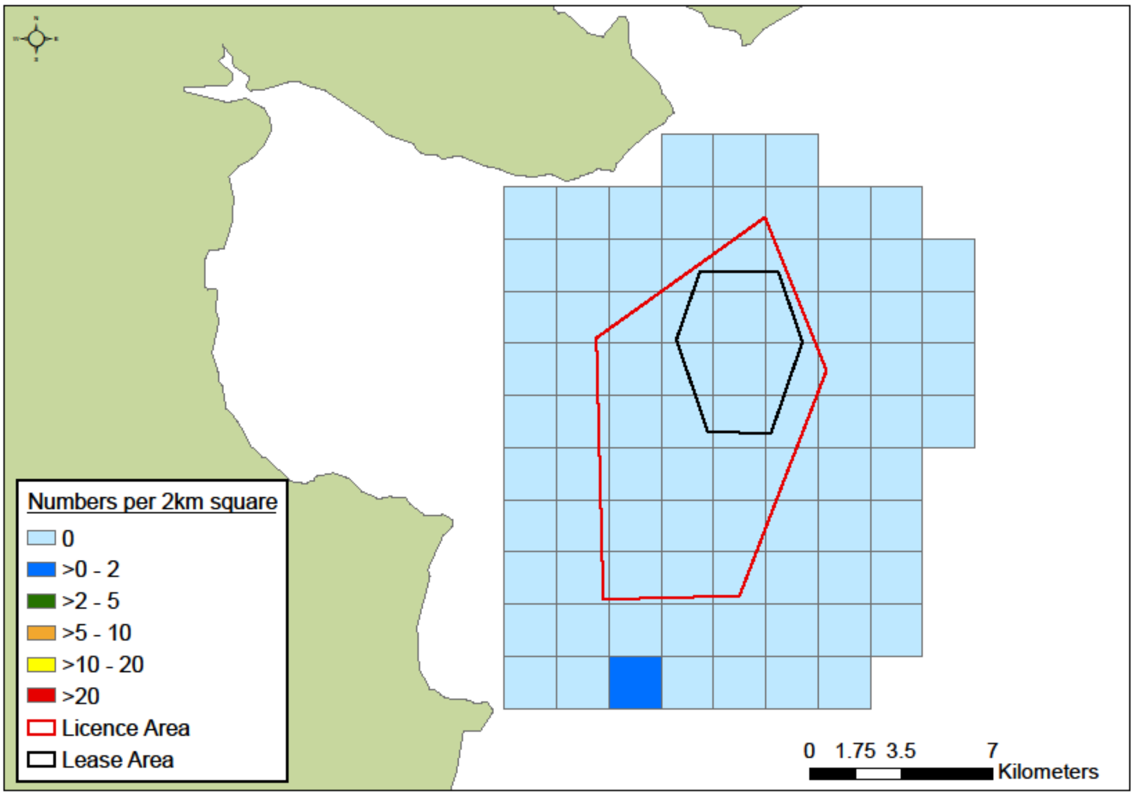

Figure 3.11.3 Black-headed Gull survey results March 2019

3.11.2 Black-headed Gull Density

With such few records, the derived density estimates for Black-headed Gull are very low (see Figures 3.11.4 to 3.11.6). These estimates are based on just three individuals (one in each of the thre months) so need to be treated with caution. The overall abundance estimate for the survey area as a whole is 0.01 birds/km^2. This si very substantialy lower than the estimates of 0.10 birds/km^2 to 0.17 birds/km^2 indicated for the western Irish Sea (Jessop *et al.*, 2018). However, that study included areas closer to shore where densities are likley to be very substantially higher than the mainly offshore areas covered in the Oriel Windfarm survey area.

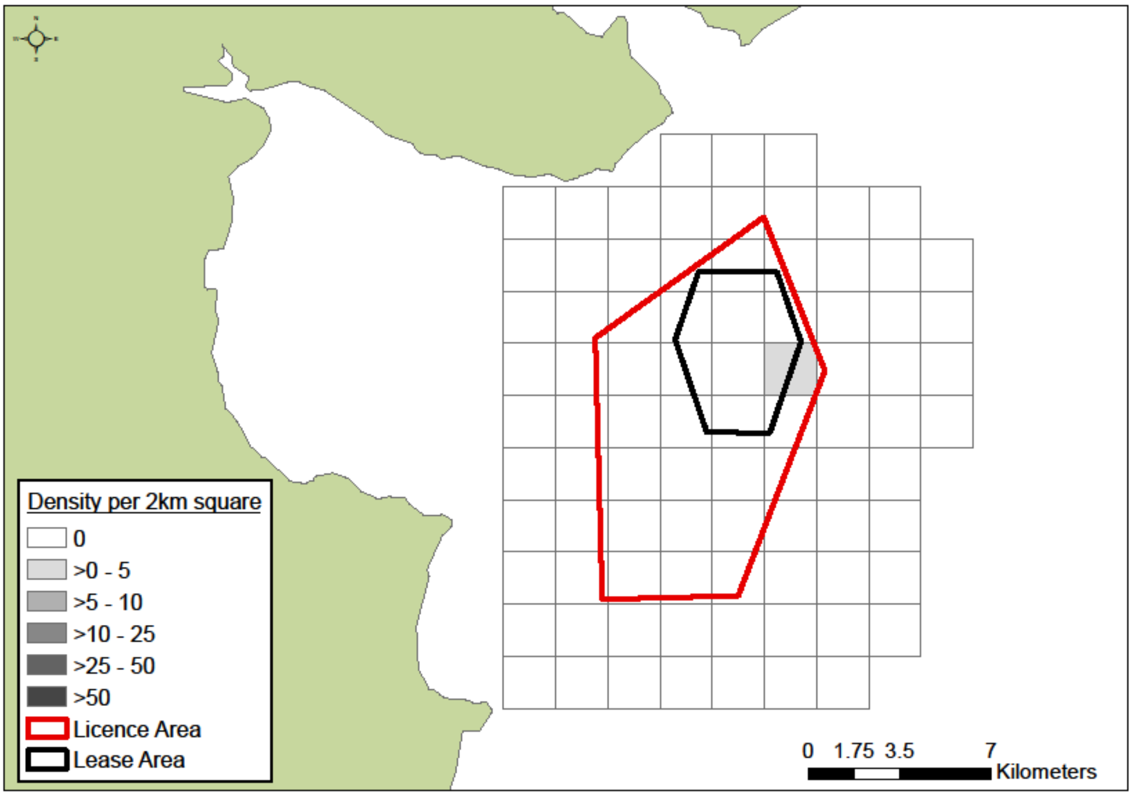

Figure 3.11.4 Black-headed Gull density estimates October 2018.

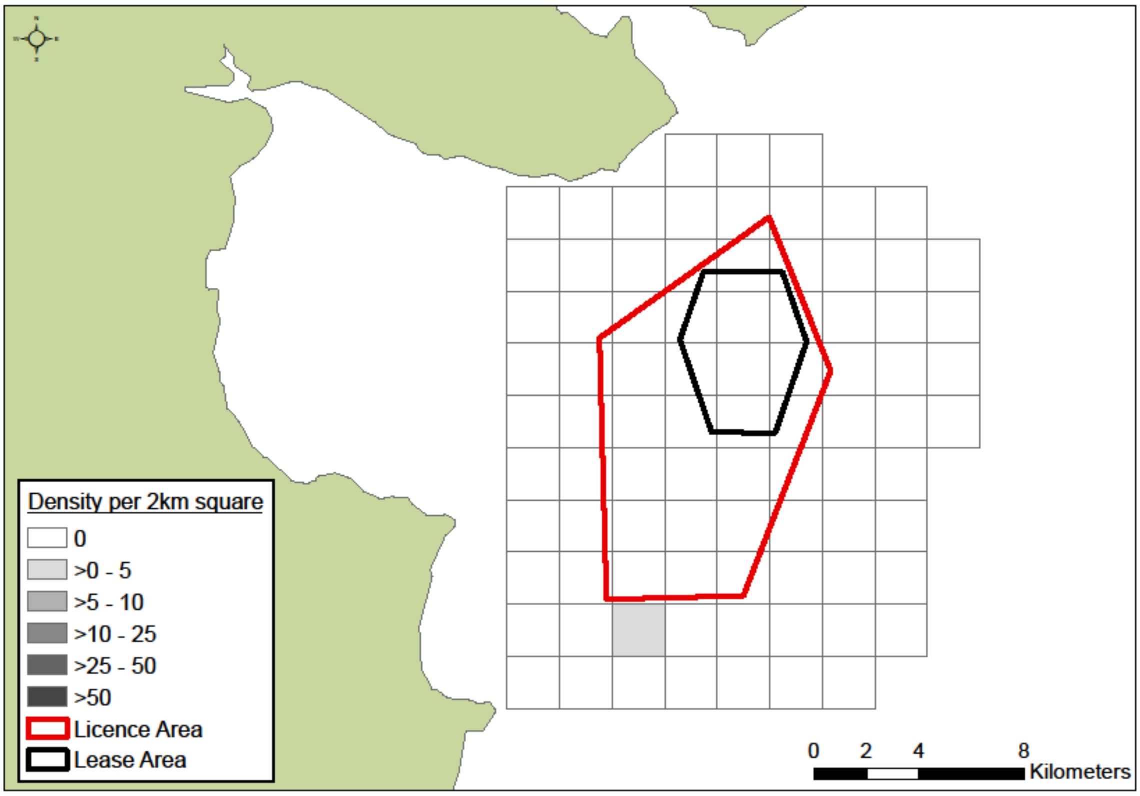

Figure 3.11.5 Black-headed Gull density estimates January 2019.

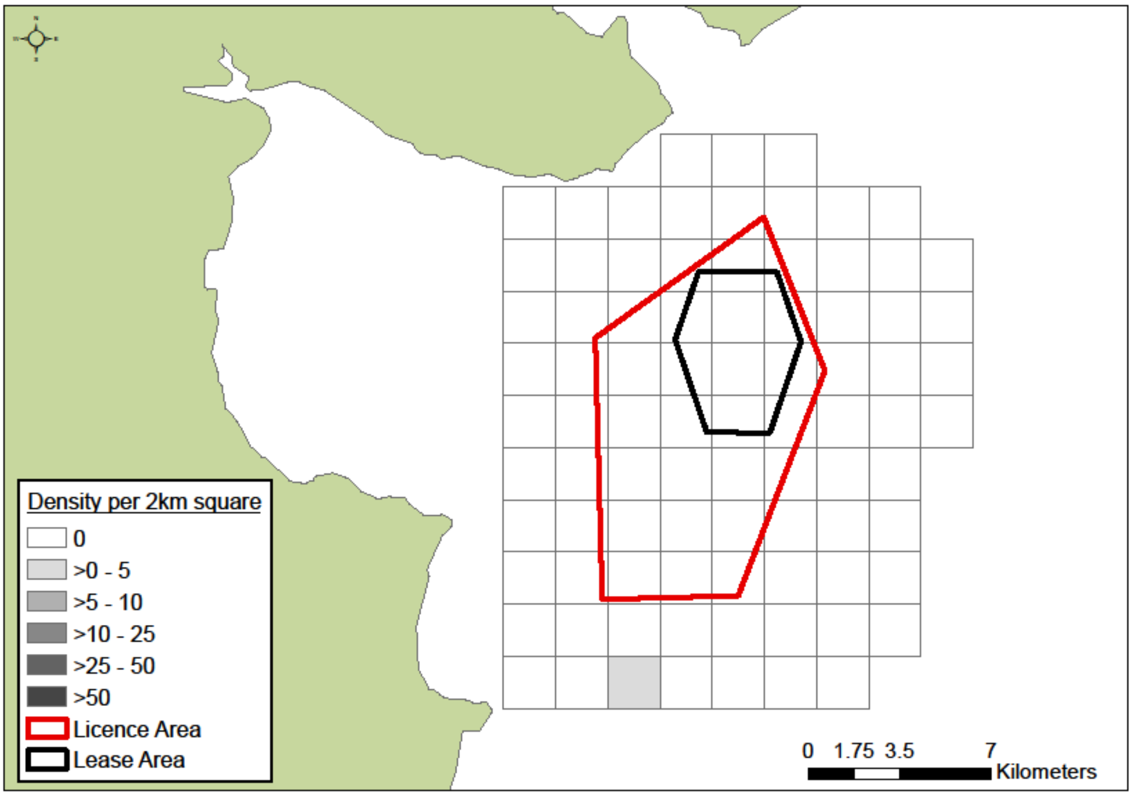

Figure 3.11.6 Black-headed Gull density estimates March 2019

3.12 Common Gull

Common Gull also breed inland, with 57% of pairs in non-coastal habitats (Mitchell *et al.*, 2004), and a largely north-west occurrence for the Irish population, with few birds occurring around coasts adjacent to the survey area (Balmer *et al*., 2013). However, they are more common in marine habitats outside of the breeding season (Stone *et al*., 1995), including the east coast of Ireland (Balmer *et al.*, 2013). As with Black-headed Gull, Common Gulls typically scavenge food from the sea surface (Kubetzki & Garthe, 2003). They are Amber-listed in Ireland due to a moderate decline in their breeding range, and due to being a Species of European Conservation Concern (Colhoun & Cummins, 2013).

3.12.1 Common Gull Abundance

Common Gulls were observed in the survey area in nine out of the twelve months that surveys took place, with birds recorded on transects in eight of those months (Table 3.12.1). They were largely absent during the breeding season (May to September), with only twelve birds recorded in July 2018 (see Figure 3.12.1) which could have been failed or non-breeders. The peak count on the transects surveys was in April 2019 (Figure 3.12.8), with 43 individuals recorded, although this included three moderate groups of between five and seven individuals.

Table 3.12.1 Common Gull records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	0
June 2018	0	0
July 2018	12	26
August 2018	0	3
September 2018	0	0
October 2018	13	75
November 2018	3	18
December 2018	20	57
January 2019	22	45
February 2019	31	64
March 2019	8	26
April 2019	43	59
TOTAL	**152**	**373**

Common Gulls were recorded widely across the survey are as a whole, with no particular pattern to their occurrence (see Figures 3.12.1 to 3.12.8). 16.4% of all records from transects, amounting to 25 individuals) were in the Lease Area (Table 3.12.2), with 45 individuals (29.6% of the total) in the Licence area and 82 individuals (53.9% of the total) in the remining Survey area.

Table 3.12.2 Common Gull records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	0	-	0	-	0	-
June 2018	0	-	0	-	0	-
July 2018	7	58.3	5	41.7	0	0
August 2018	0	-	0	-	0	-
September 2018	0	-	0	-	0	-
October 2018	7	53.8	6	46.2	0	0
November 2018	3	100	0	0	0	0
December 2018	6	30.0	11	55.0	3	15.0
January 2019	6	27.3	11	50.0	5	22.7
February 2019	19	61.3	11	35.5	1	3.2
March 2019	6	75.0	1	12.5	1	12.5
April 2019	28	65.1	0	0	15	34.9
TOTAL	**82**	**53.9**	**45**	**29.6**	**25**	**16.4**

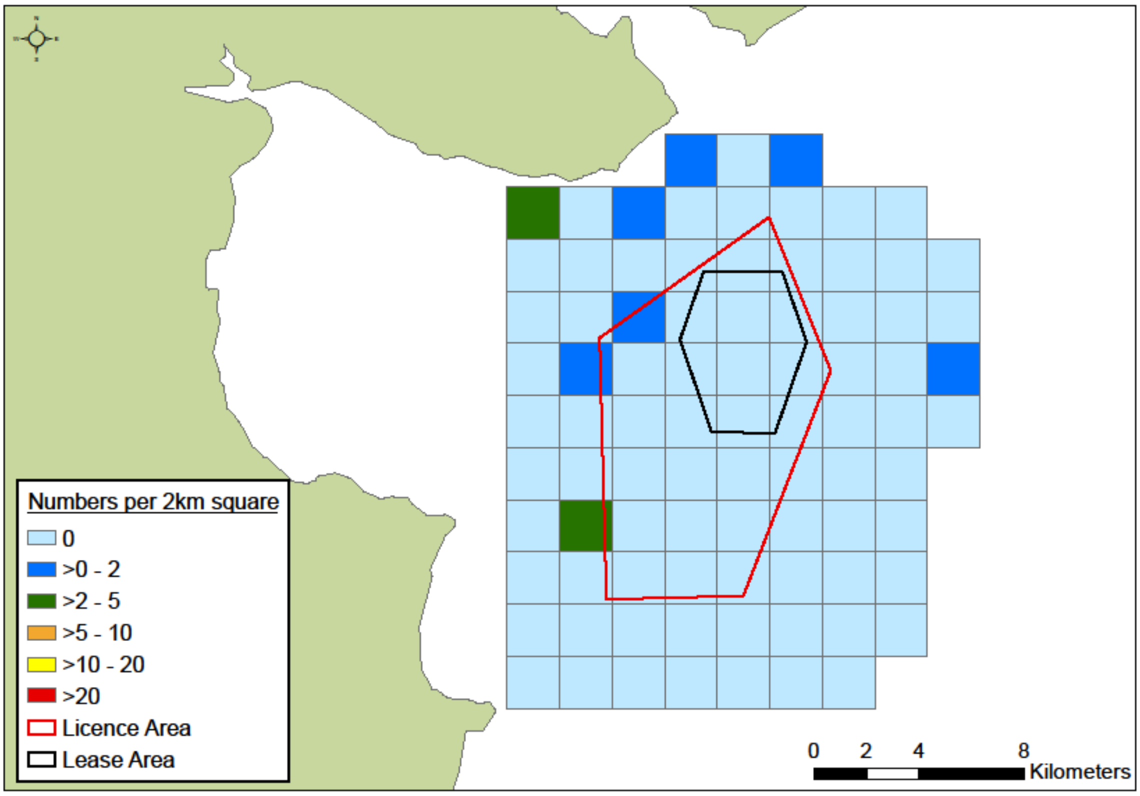

Figure 3.12.1 Common Gull survey results July 2018

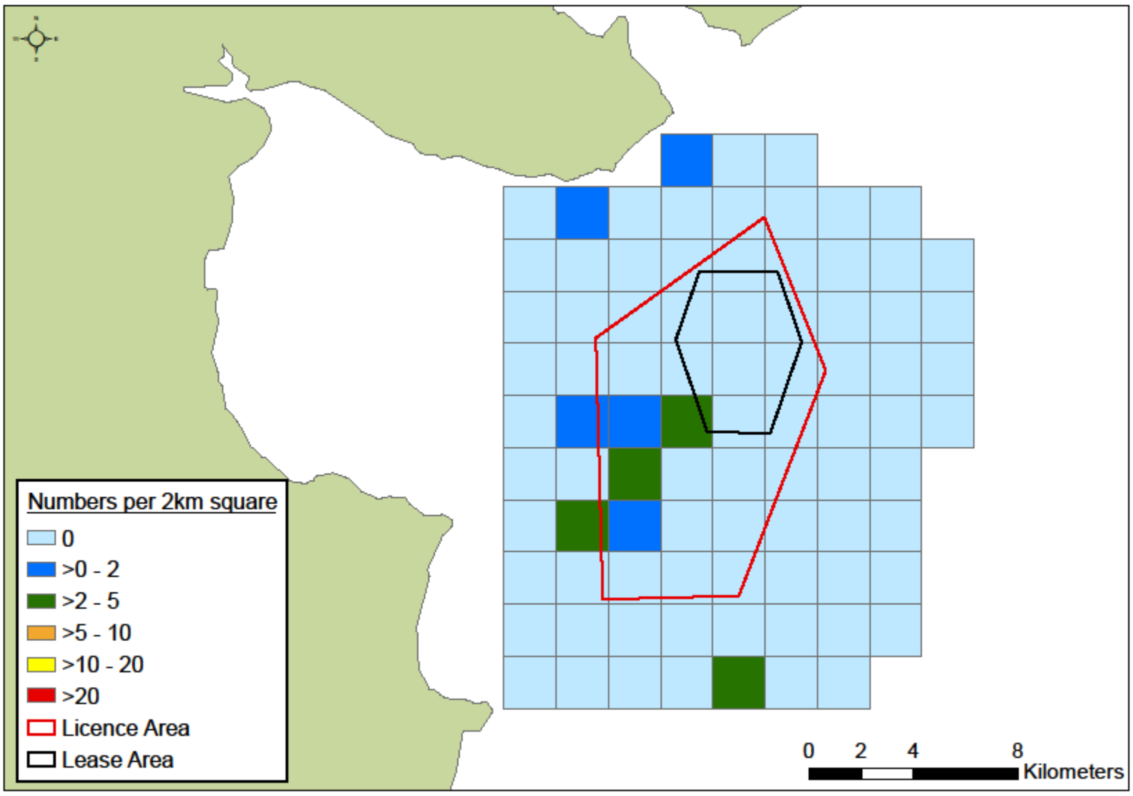

Figure 3.12.2 Common Gull survey results October 2018

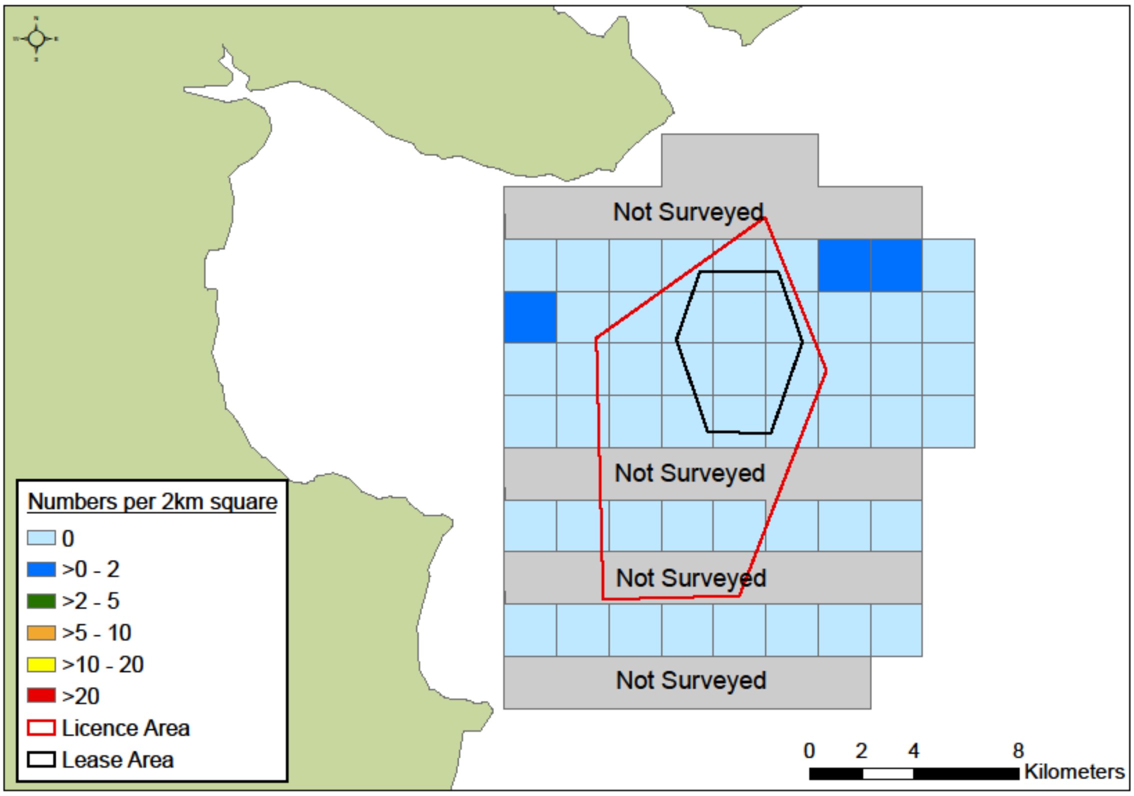

Figure 3.12.3 Common Gull survey results November 2018

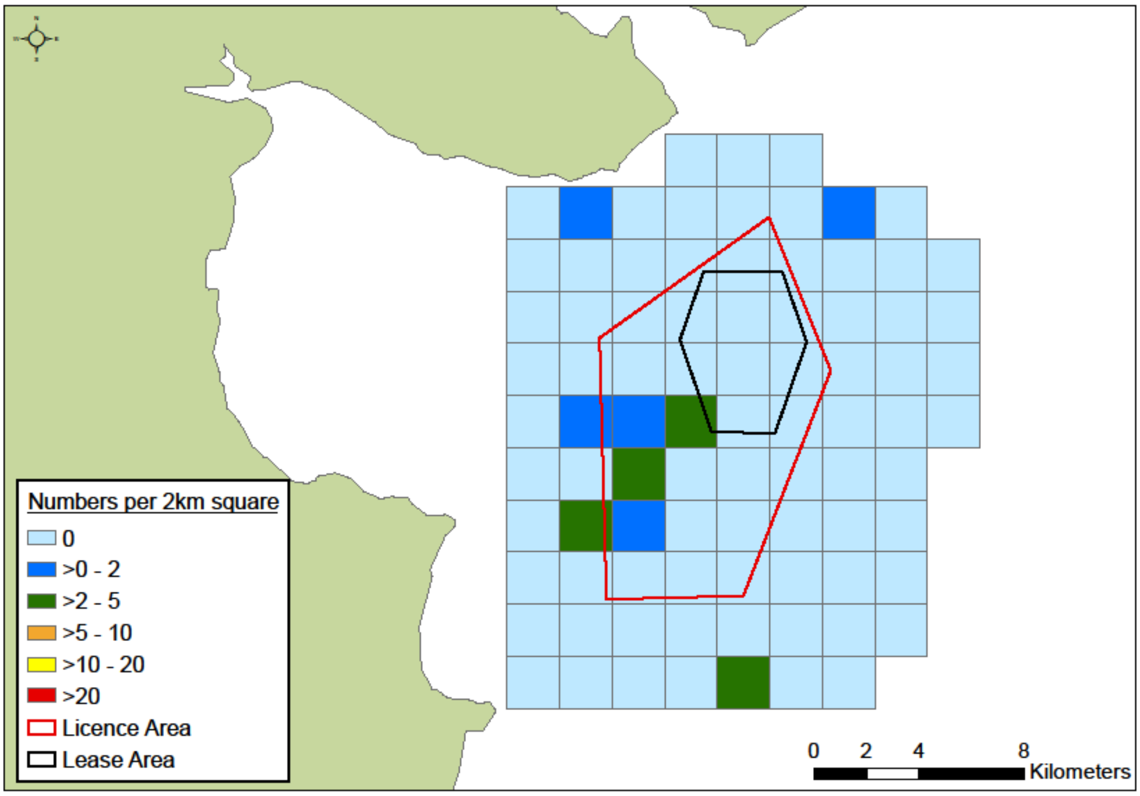

Figure 3.12.4 Common Gull survey results December 2018

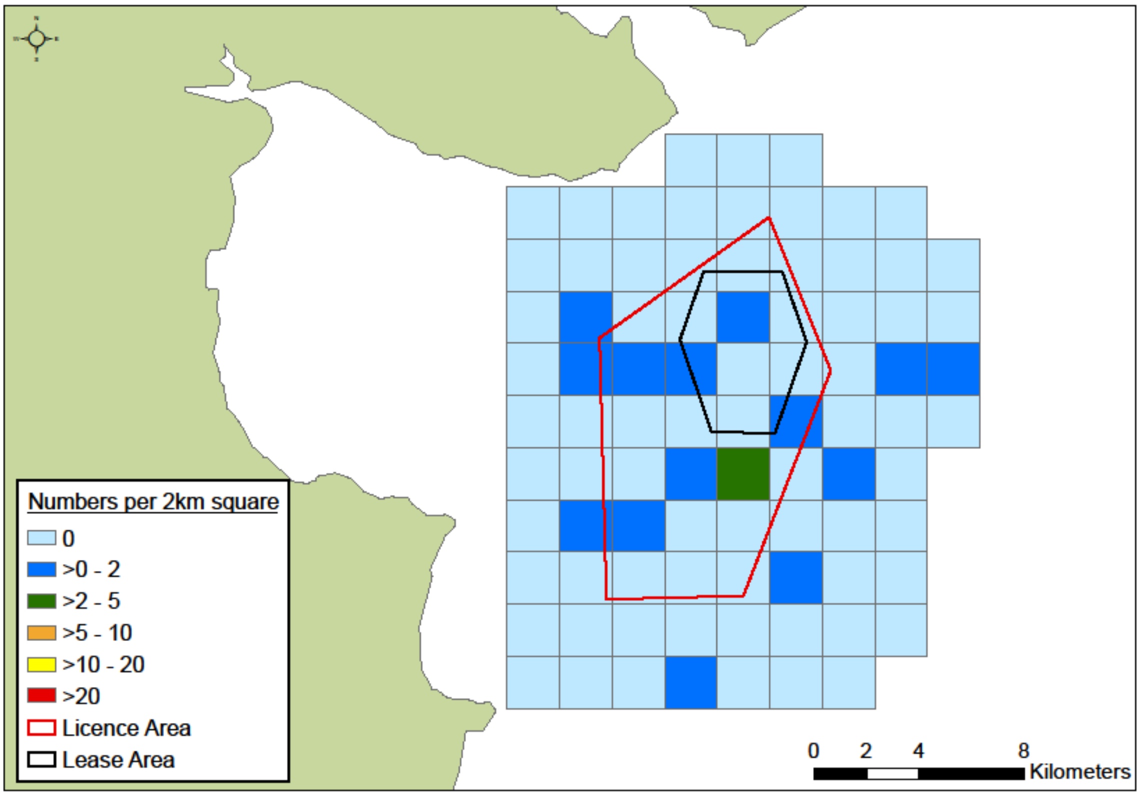

Figure 3.12.5 Common Gull survey results January 2019

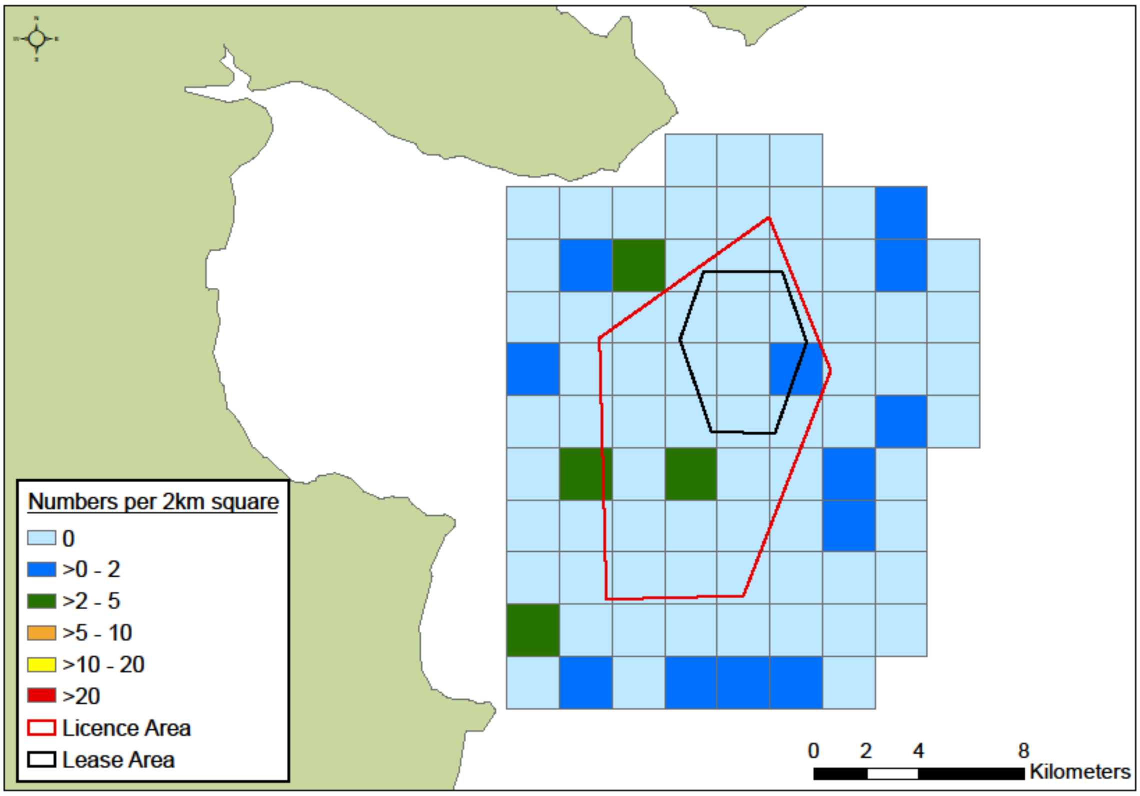

Figure 3.12.6 Common Gull survey results February 2019

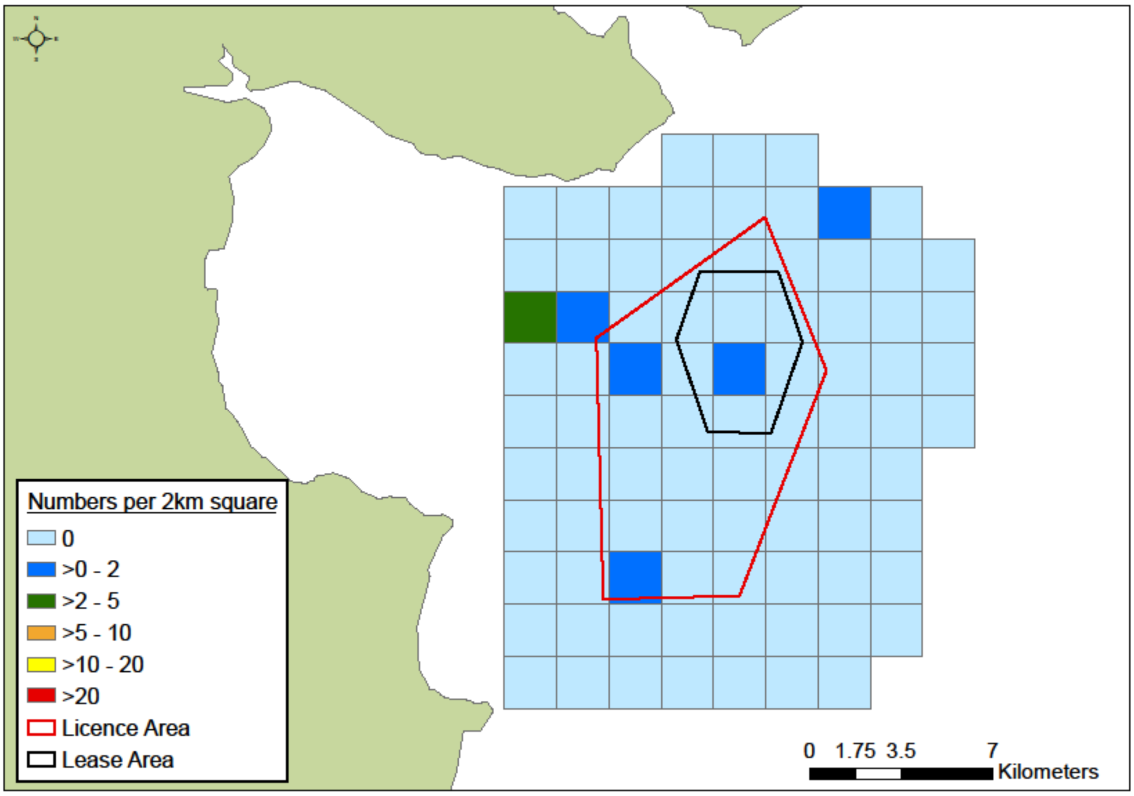

Figure 3.12.7 Common Gull survey results March 2019

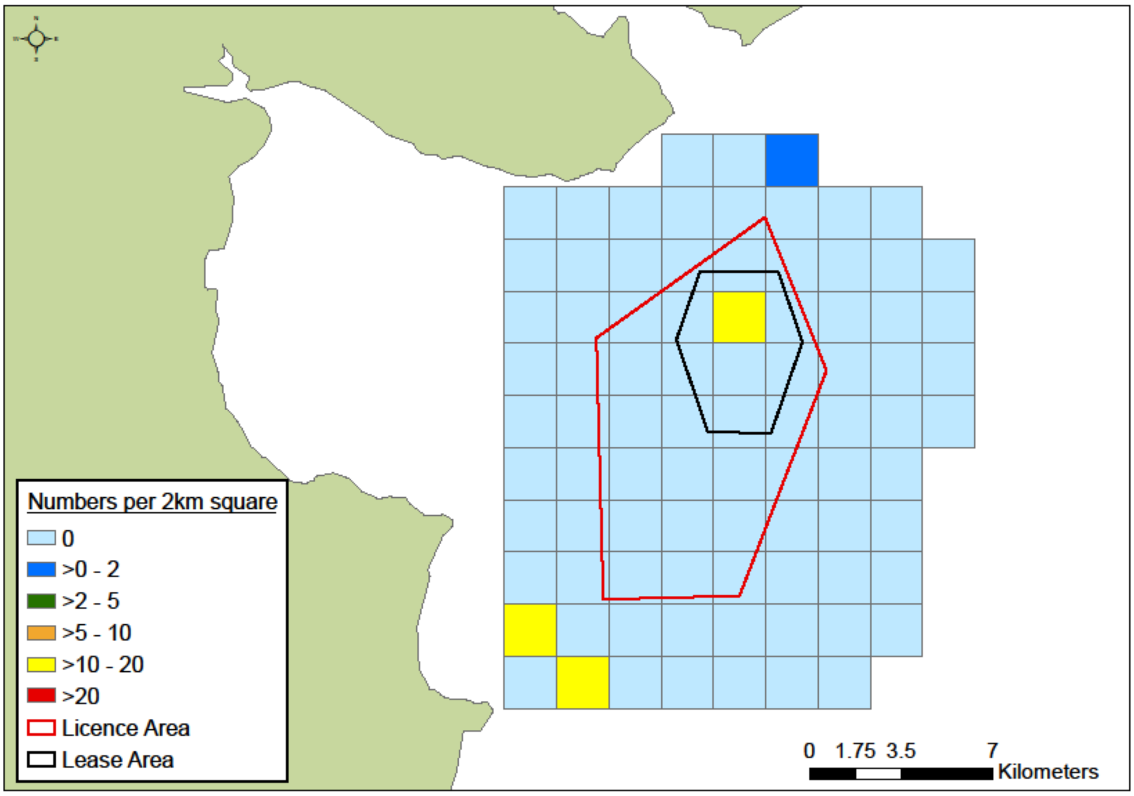

Figure 3.12.8 Common Gull survey results April 2019

3.12.2 Common Gull Density

Density estimates for Common Gull, derived from the monthly transects surveys, are shown in Figures 3.12.9 to 3.12.16. The peak density was in April when an estimated 0.18 birds/km^2 across the survey area was derived. For comparative purposes in the western Irish Sea, Jessop *et al*., (2018) combined estimates for Common Gull with Herring Gull (See Section 3.14.3).

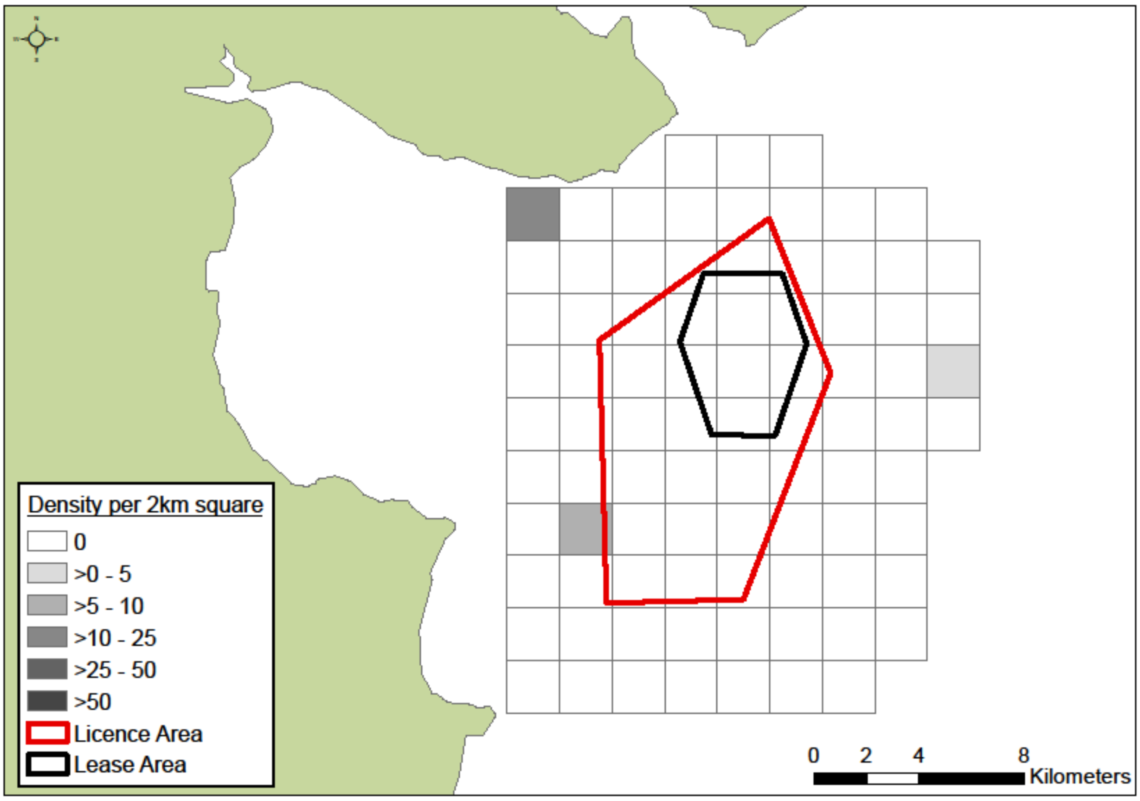

Figure 3.12.9 Common Gull density estimates July 2018

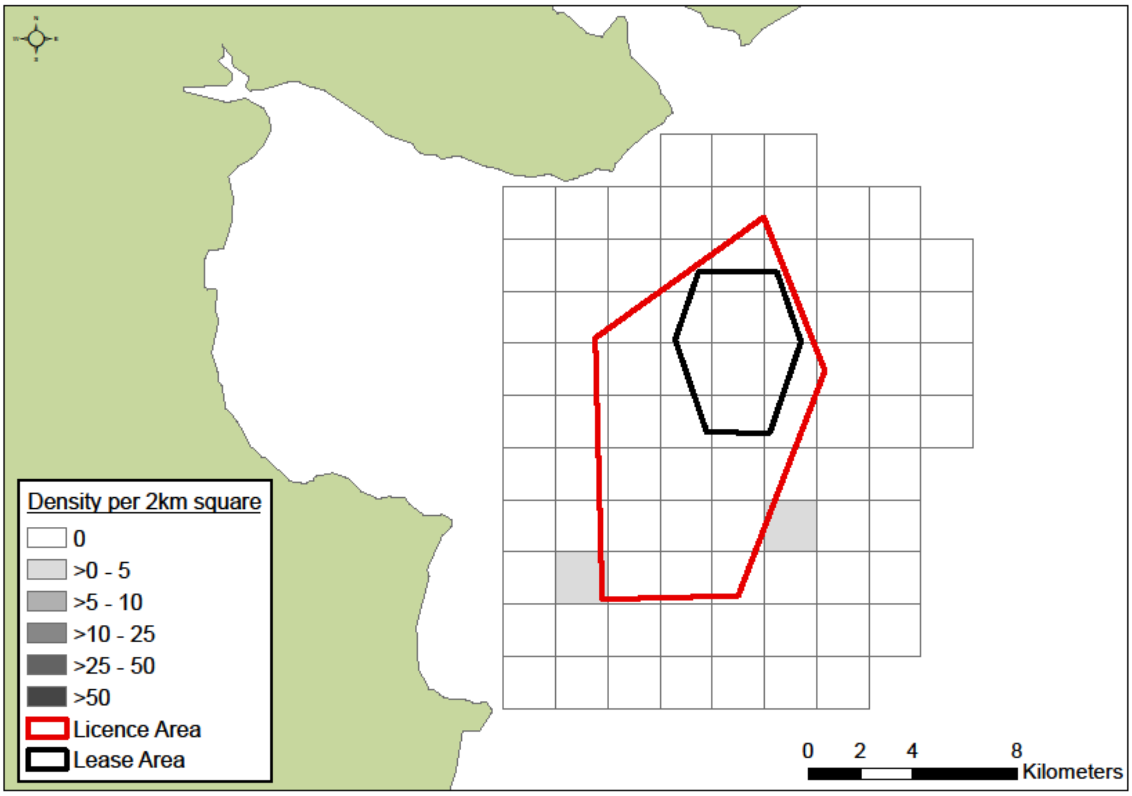

Figure 3.12.10 Common Gull density estimates October 2018

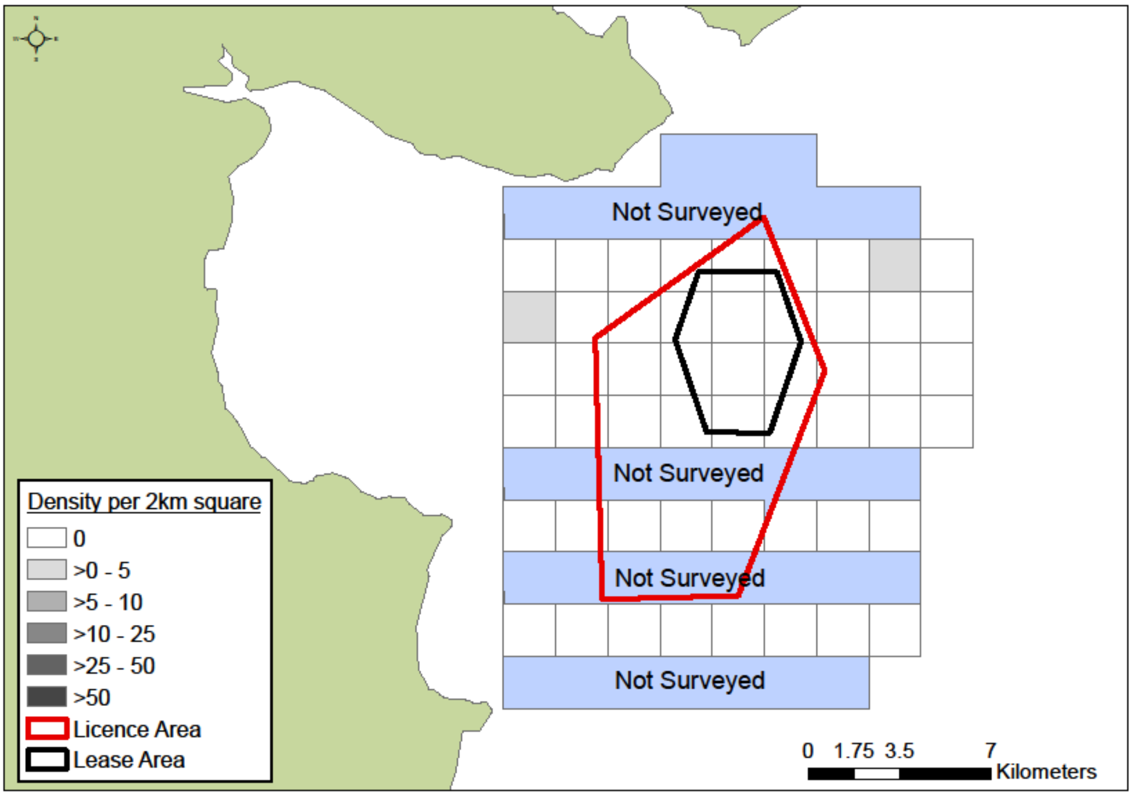

Figure 3.12.11 Common Gull density estimates November 2018

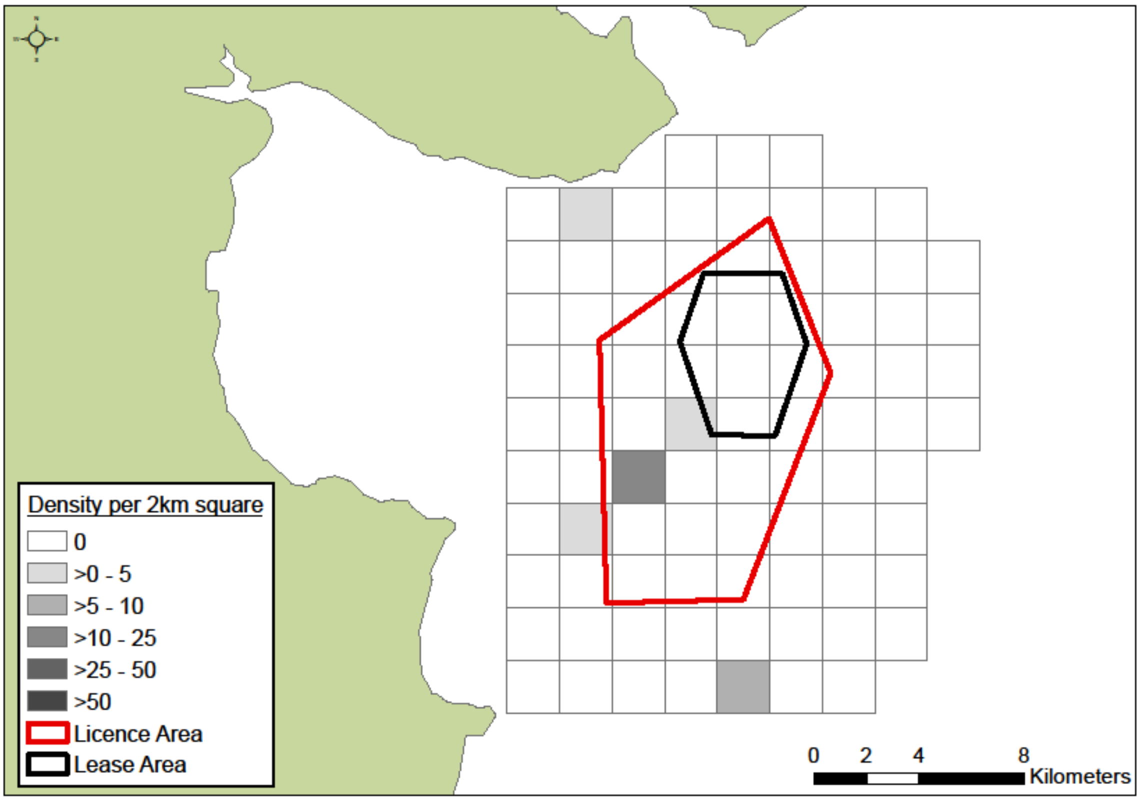

Figure 3.12.12 Common Gull density estimates December 2018

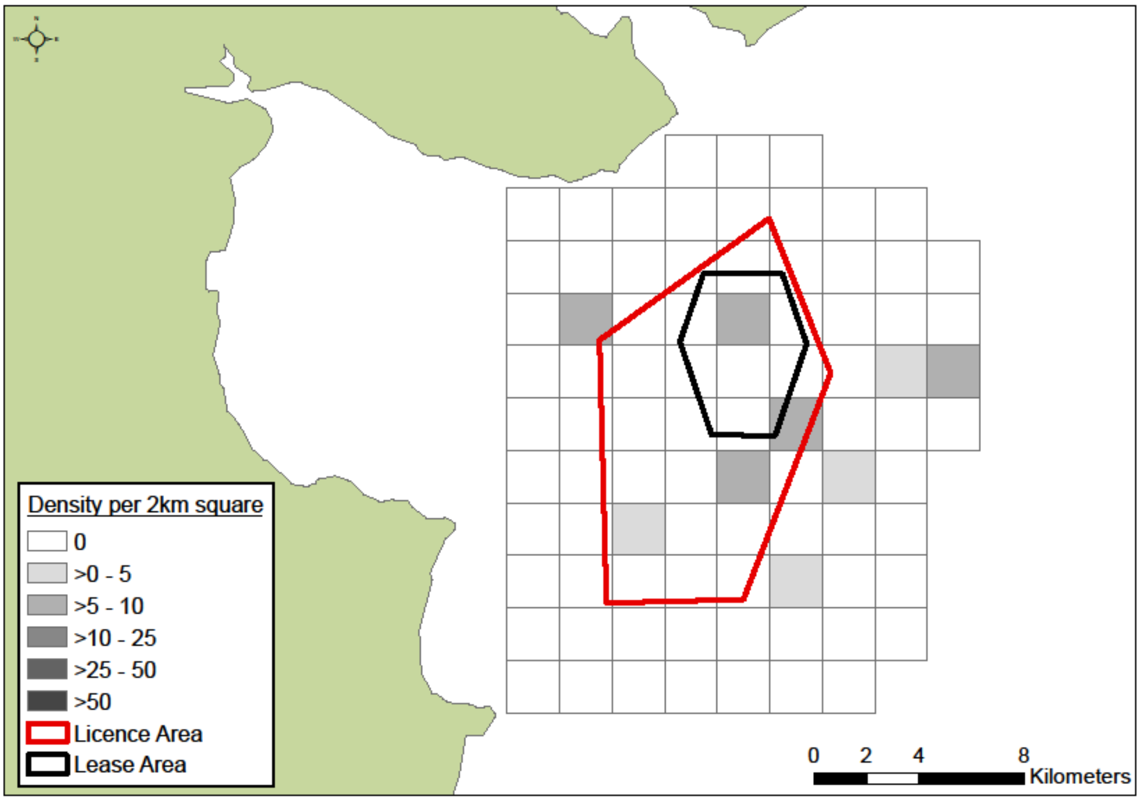

Figure 3.12.13 Common Gull density estimates January 2019

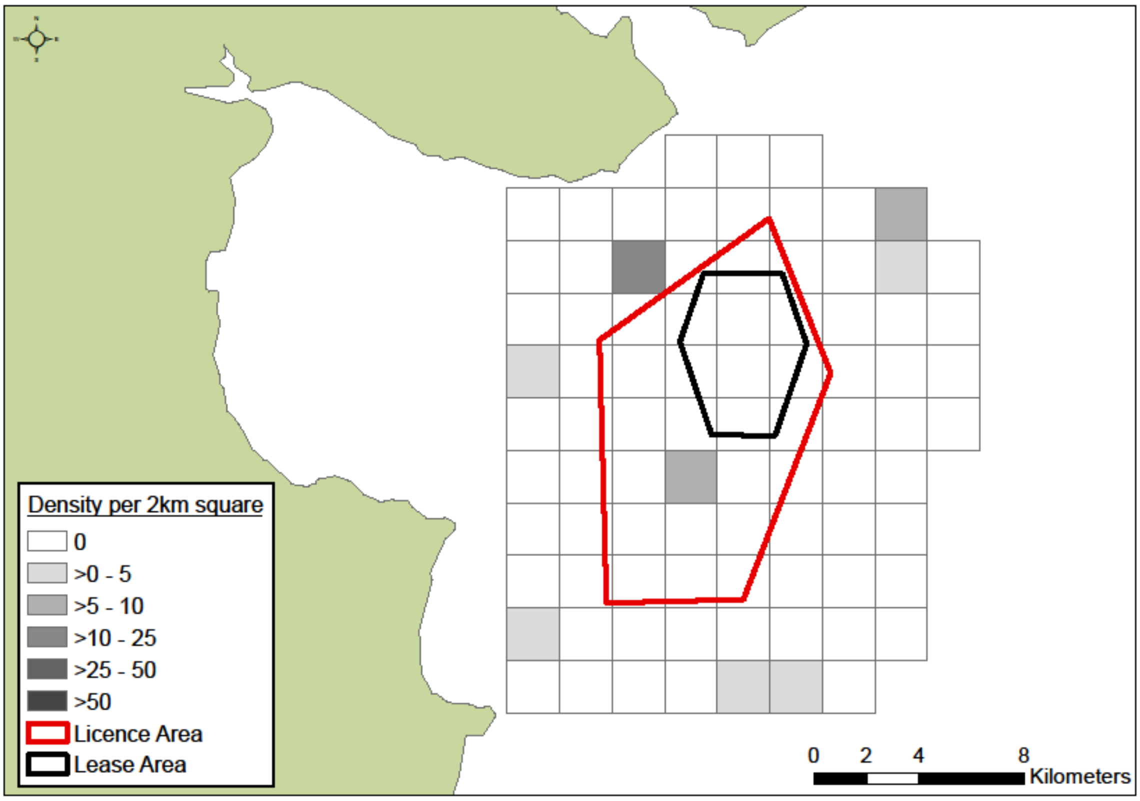

Figure 3.12.14 Common Gull density estimates February 2019

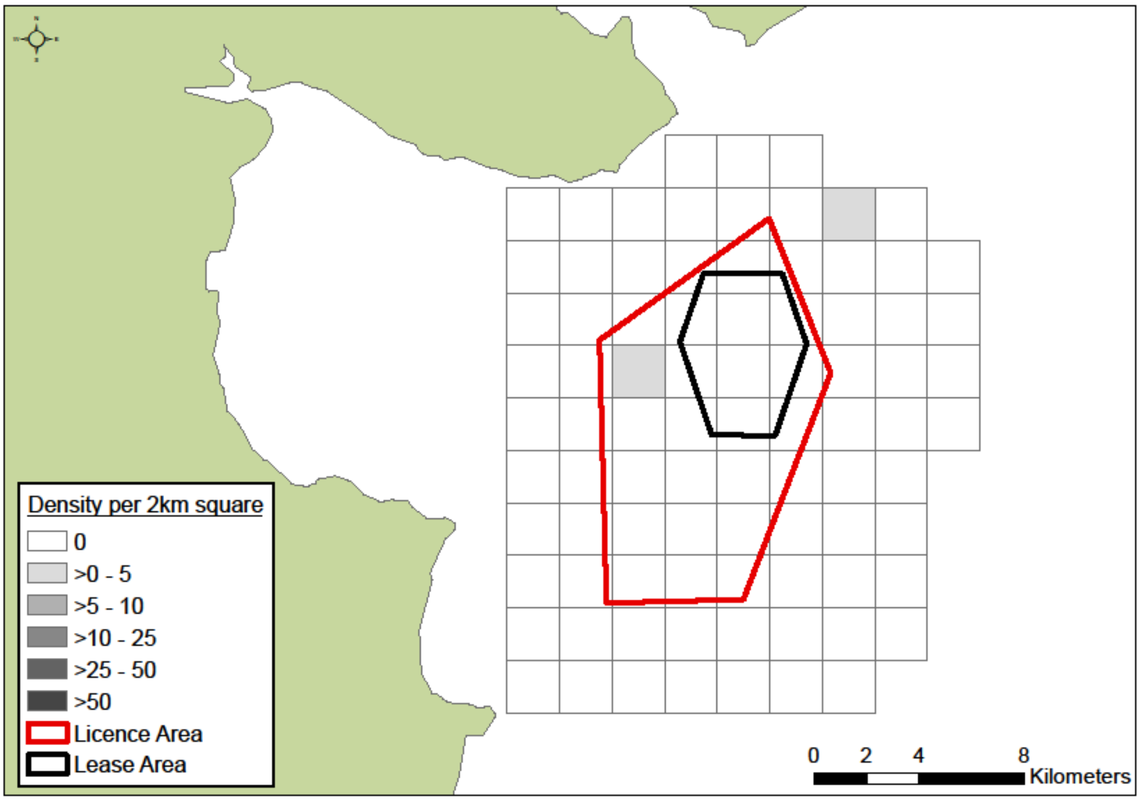

Figure 3.12.15 Common Gull density estimates March 2019

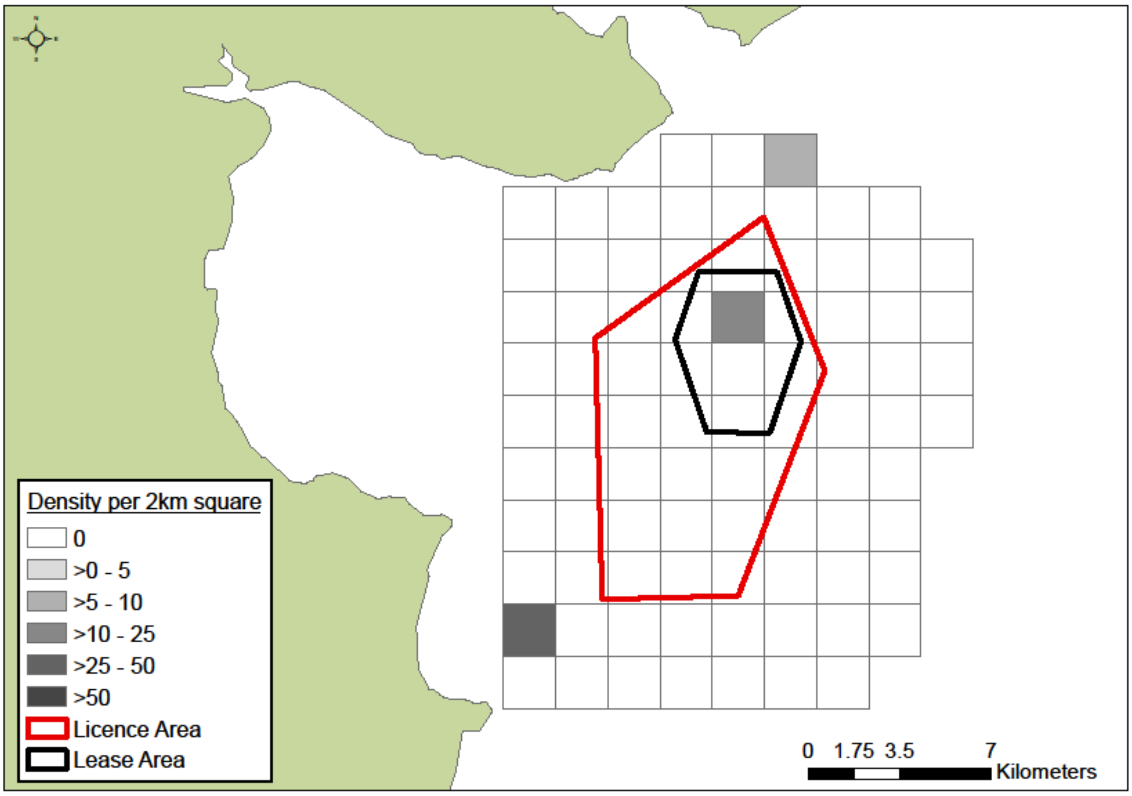

Figure 3.12.16 Common Gull density estimates April 2019

3.13 Great Black-backed Gull

Great Black-backed Gull have a coastal distribution in Ireland (Balmer *et al*., 2013) and are found in the Irish Sea (Stone *et al*., 1995). They are typically predatory, feeding predominantly on fish and small seabirds (such as auks), as well as eggs, chicks, mammals, crabs and other shellfish (Buckley, 1990; Veitch *et al*., 2016). Great Black-backed Gull are Amber-listed in Ireland due to moderate declines in their population and range in the past 20 to 25 years (Colhoun & Cummins, 2013).

3.13.1 Great Black-backed Gull Abundance

Great Black-backed Gulls were recorded in all months from survey transects (see Figure 3.13.1), with peak counts in April 2019, when 74 individuals were recorded on transects out of 126 individuals observed within the survey area as a whole. Numbers were typically lower during the breeding season (May to July; Figures 3.13.1 to 3.13.3) but little seasonality was apparent.

Table 3.13.1 Great Black-backed Gull records from boat surveys in Oriel Windfarm survey area, showing transects record and total observations.

Month	Transect records	All records
May 2018	6	43
June 2018	1	8
July 2018	7	27
August 2018	18	96
September 2018	19	77
October 2018	10	44
November 2018	6	40
December 2018	14	57
January 2019	9	80
February 2019	17	41
March 2019	21	55
April 2019	74	126
TOTAL	**202**	**694**

Out of the 202 Great Black-backed Gulls recorded on transects, 10 individuals (5.0% of the total number recorded) were in the Lease area, compared to 24 individuals (11.9%) in the Licence Area and 168 individuals (83.2%) in the remaining Survey area (Table 3.13.2).

Table 3.13.2 Great Black-backed Gull records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	6	100	0	0	0	0
June 2018	0	0	0	0	1	100
July 2018	4	57.1	3	42.9	0	0
August 2018	15	83.3	2	11.1	1	5.6
September 2018	17	89.5	1	5.3	1	5.3
October 2018	7	70.0	2	20.0	1	10.0
November 2018	4	66.7	1	16.7	1	16.7
December 2018	12	85.7	1	7.1	1	7.1
January 2019	6	66.7	2	22.2	1	11.1
February 2019	12	70.6	5	29.4	0	0
March 2019	12	57.1	7	33.3	2	9.5
April 2019	73	98.6	0	0	1	1.4
TOTAL	**168**	**83.2**	**24**	**11.9**	**10**	**5.0**

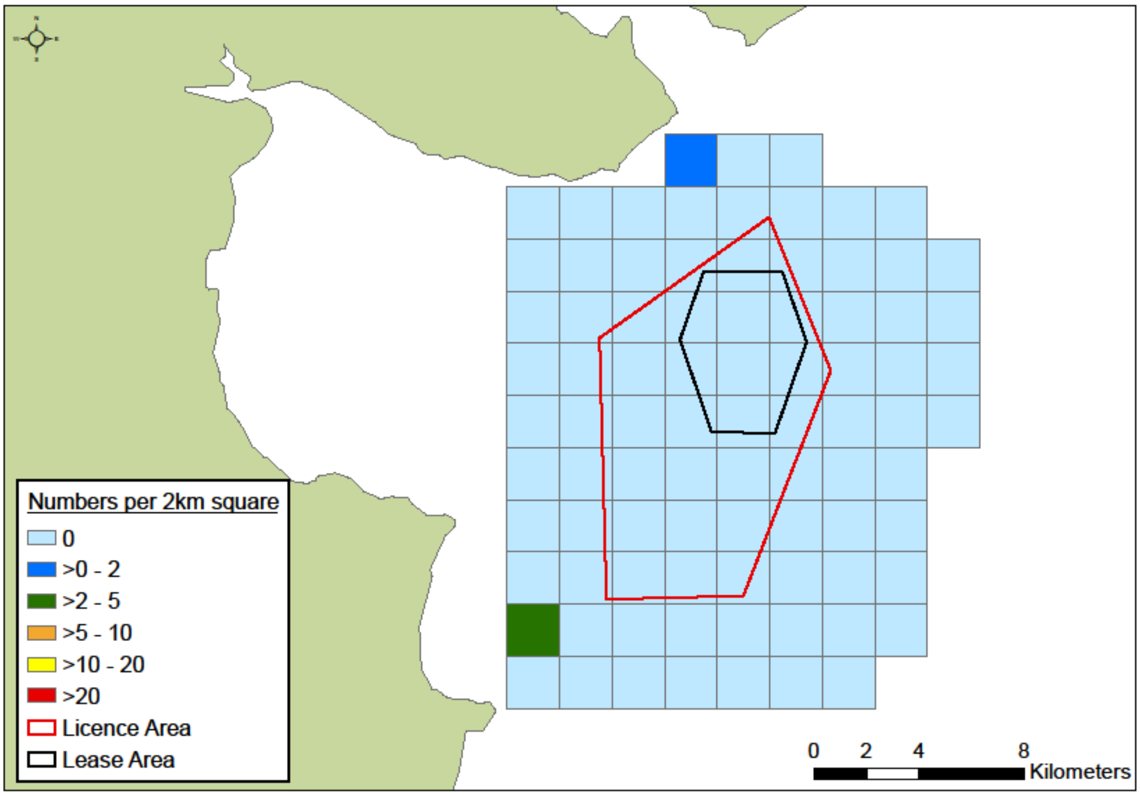

Figure 3.13.1 Great Black-backed Gull survey results May 2018

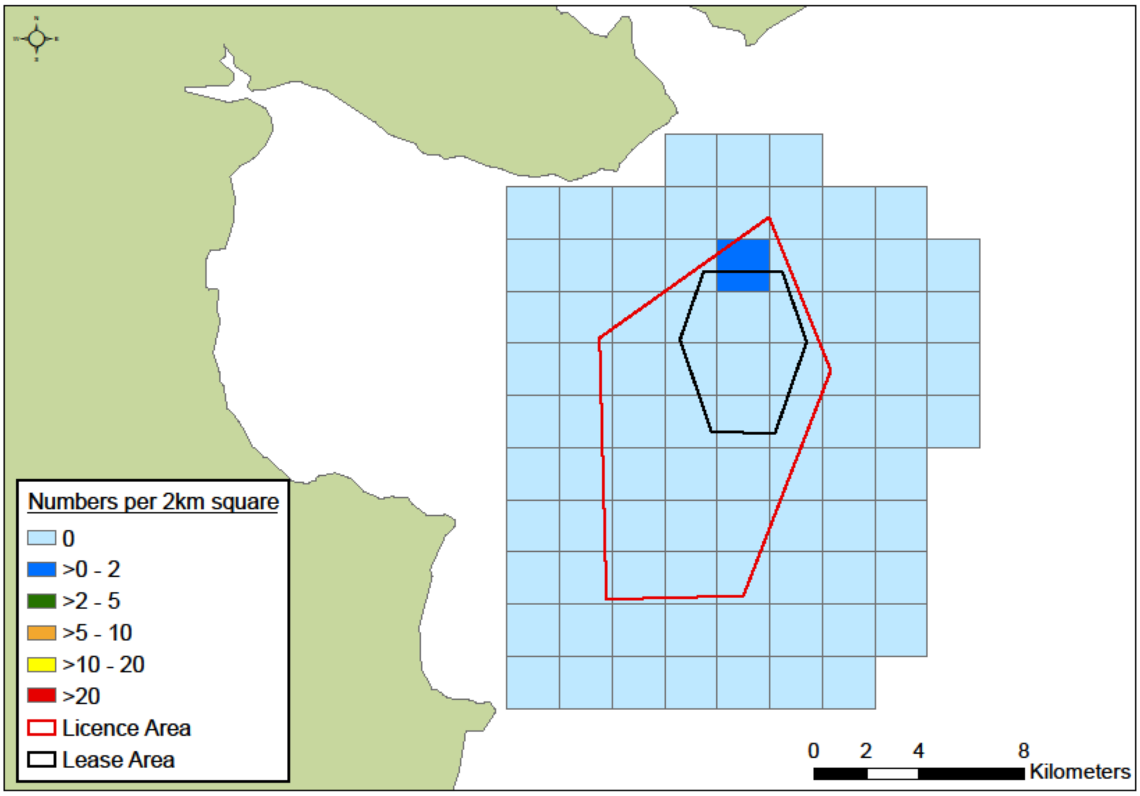

Figure 3.13.2 Great Black-backed Gull survey results June 2018

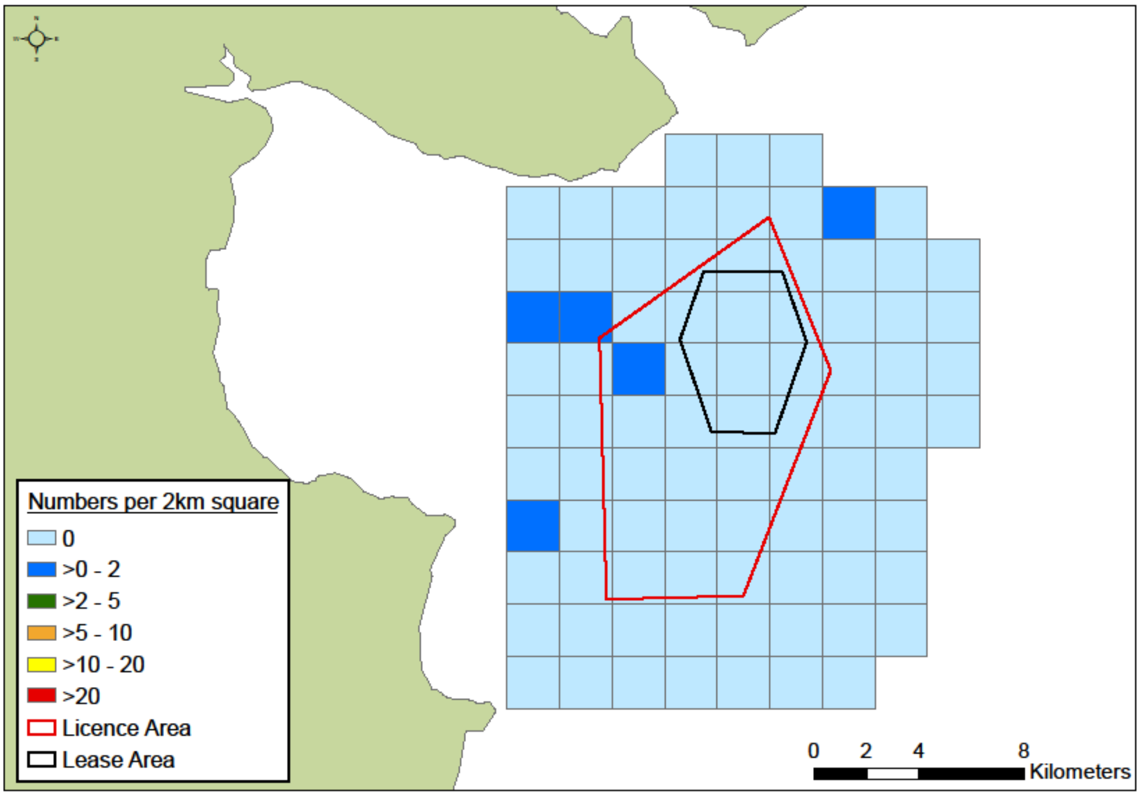

Figure 3.13.3 Great Black-backed Gull survey results July 2018

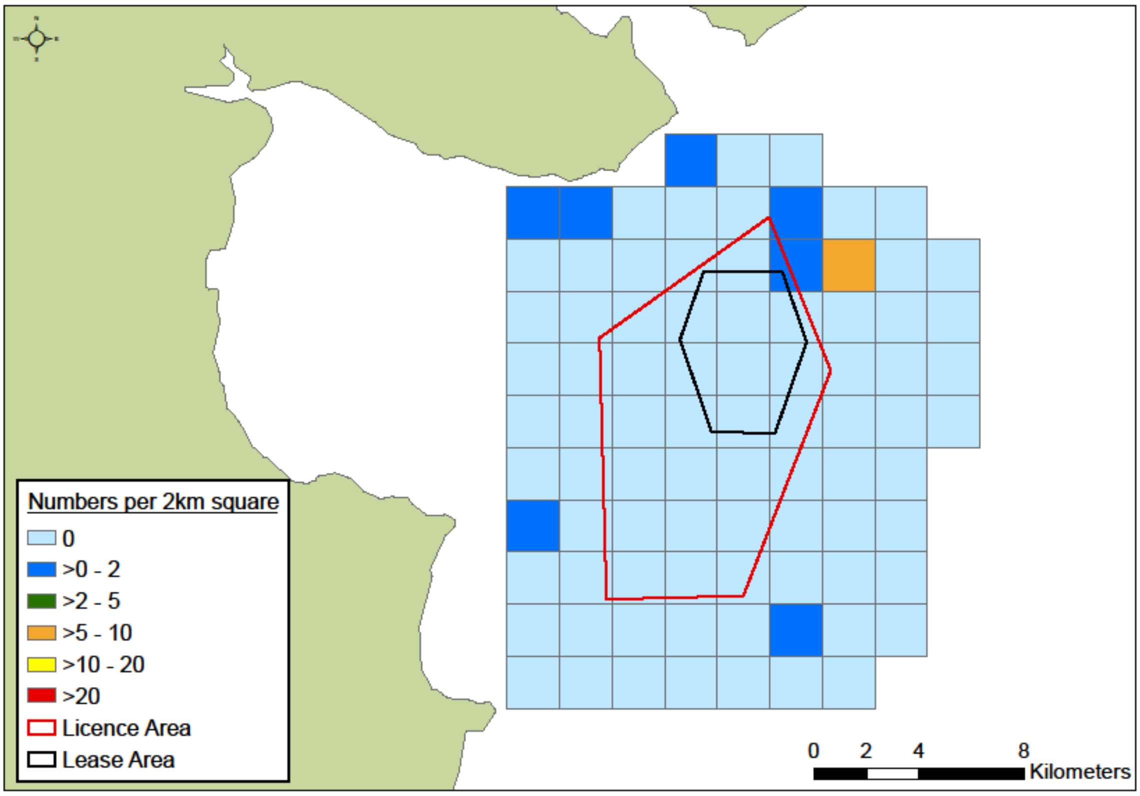

Figure 3.13.4 Great Black-backed Gull survey results August 2018

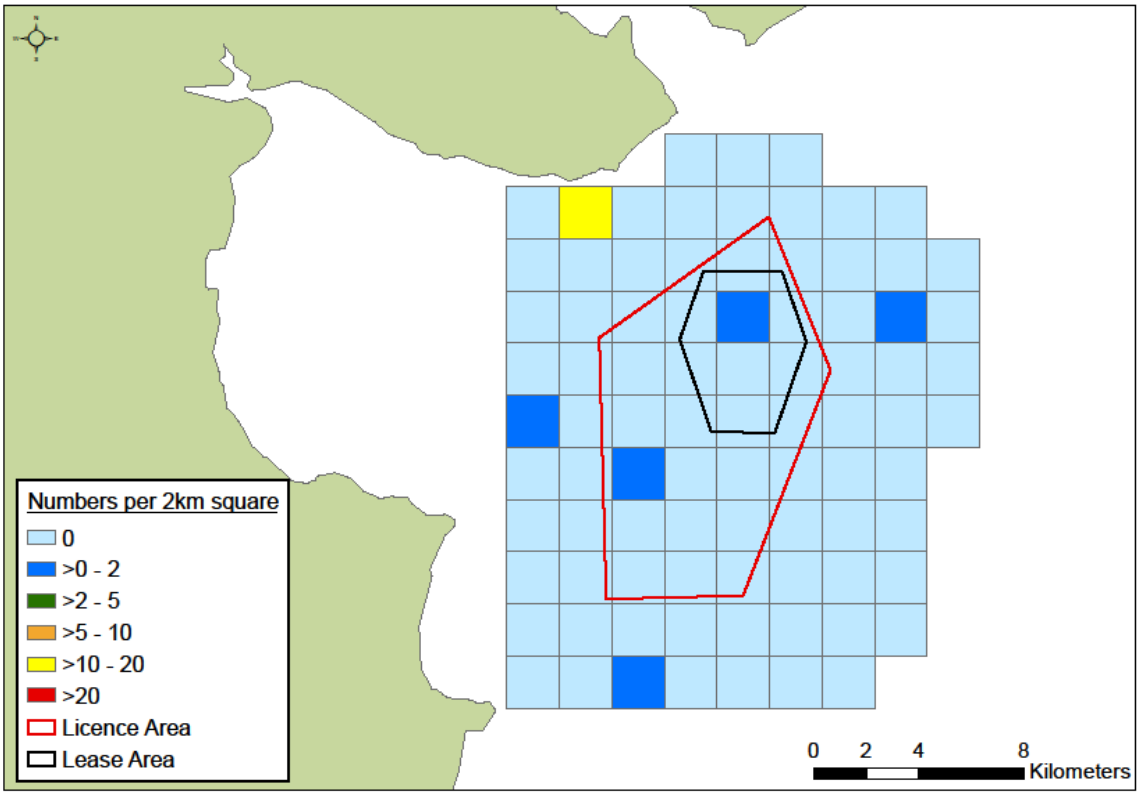

Figure 3.13.5 Great Black-backed Gull survey results September 2018

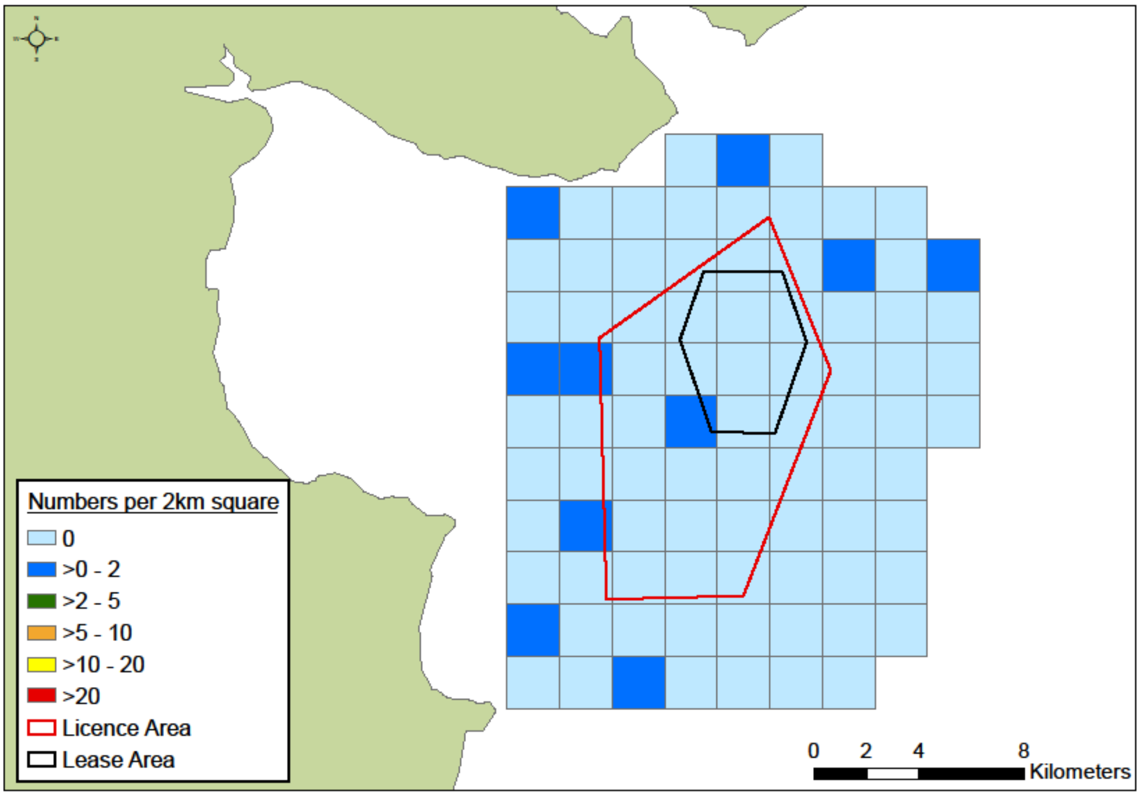

Figure 3.13.6 Great Black-backed Gull survey results October 2018

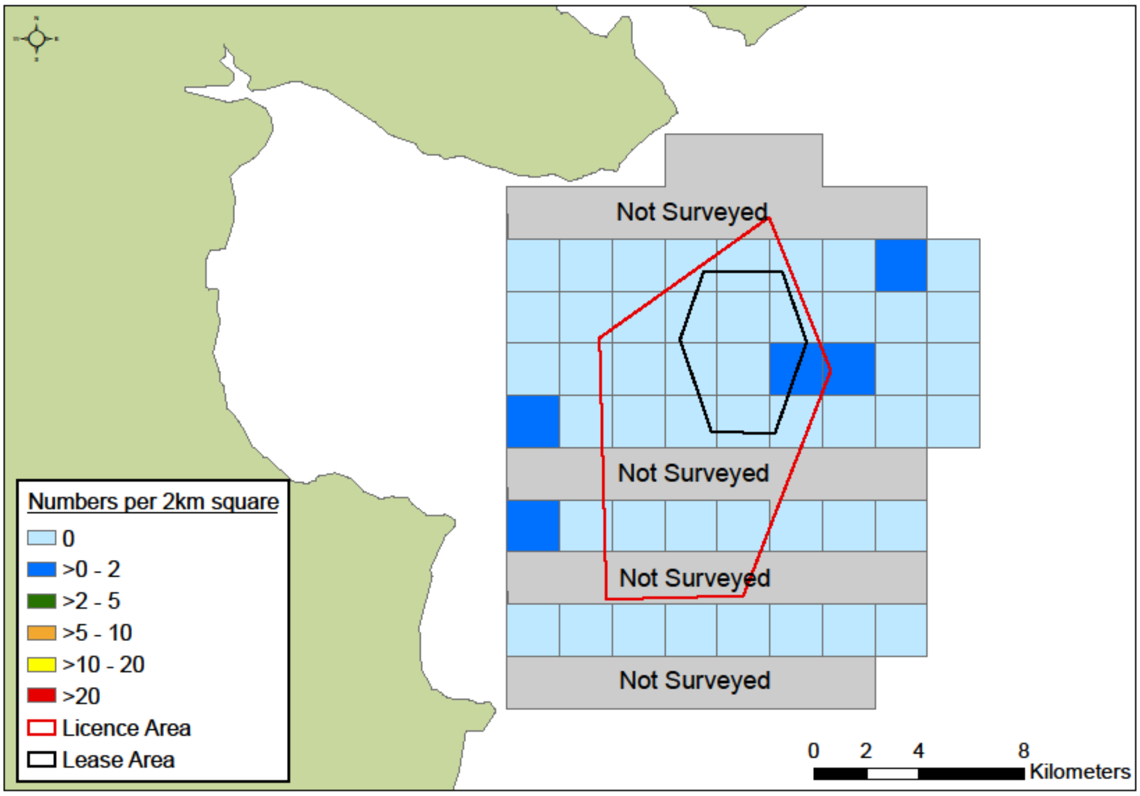

Figure 3.13.7 Great Black-backed Gull survey results November 2018

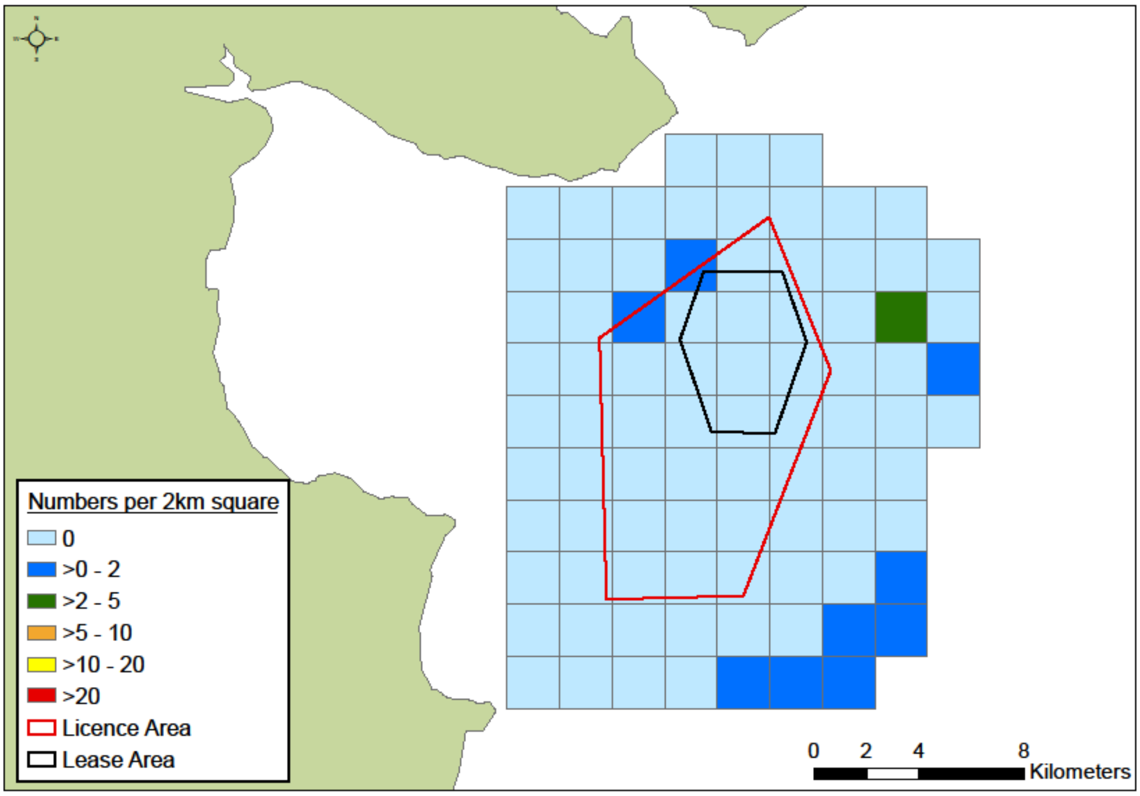

Figure 3.13.8 Great Black-backed Gull survey results December 2018

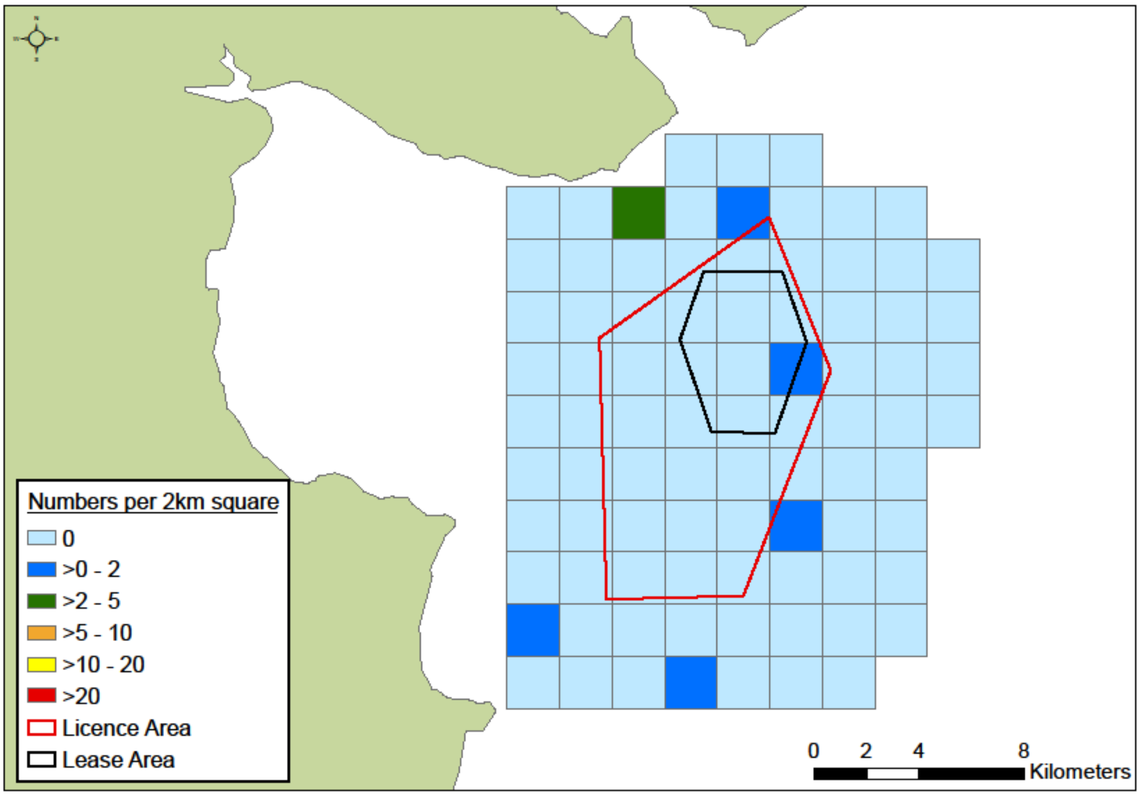

Figure 3.13.9 Great Black-backed Gull survey results January 2019

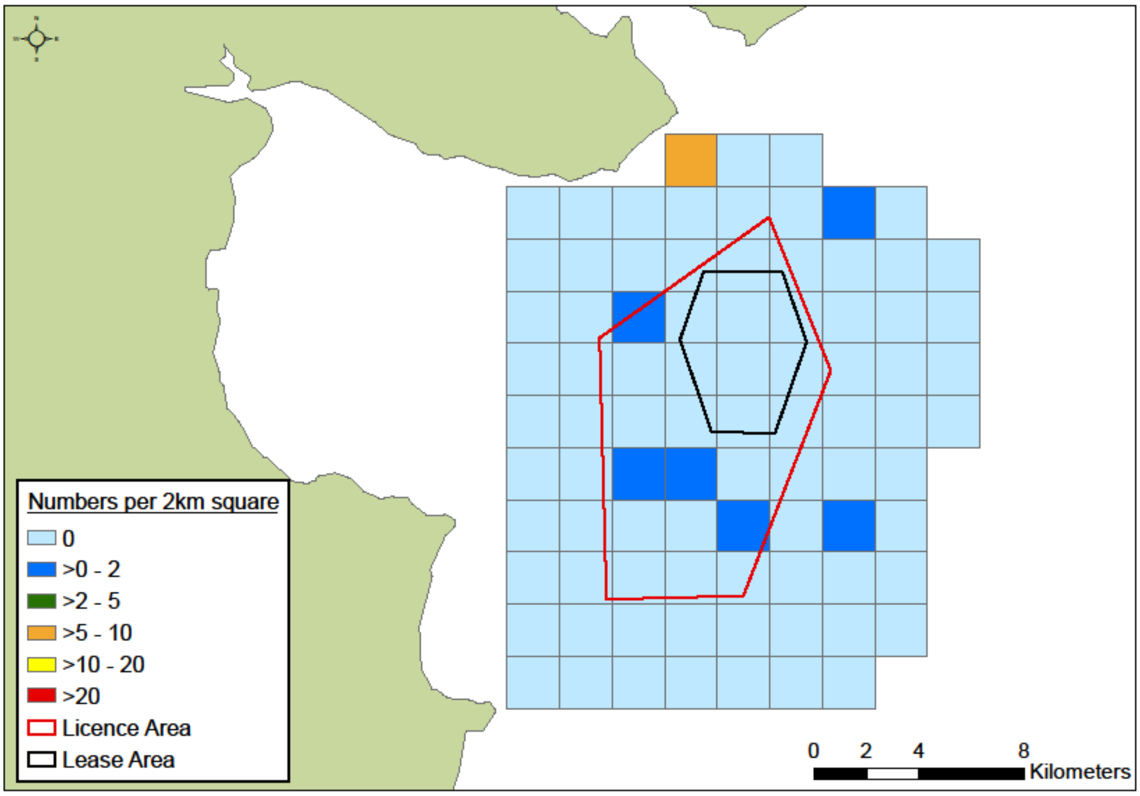

Figure 3.13.10 Great Black-backed Gull survey results February 2019

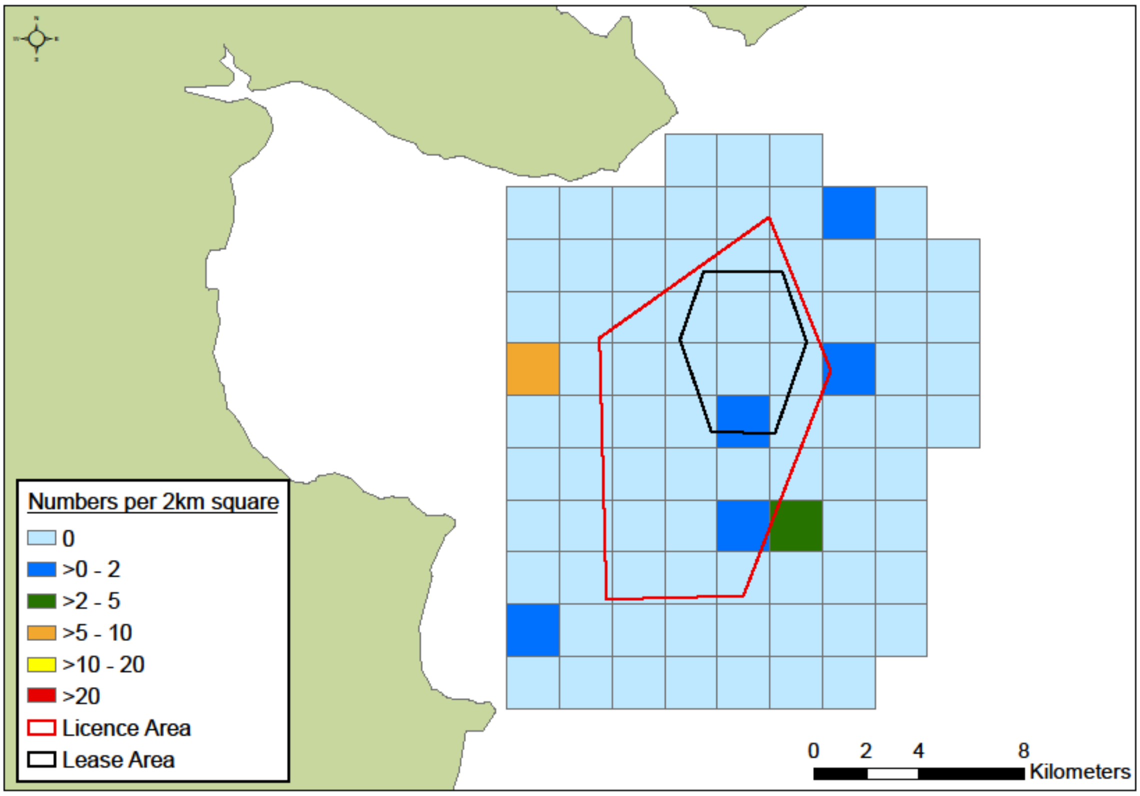

Figure 3.13.11 Great Black-backed Gull survey results March 2019

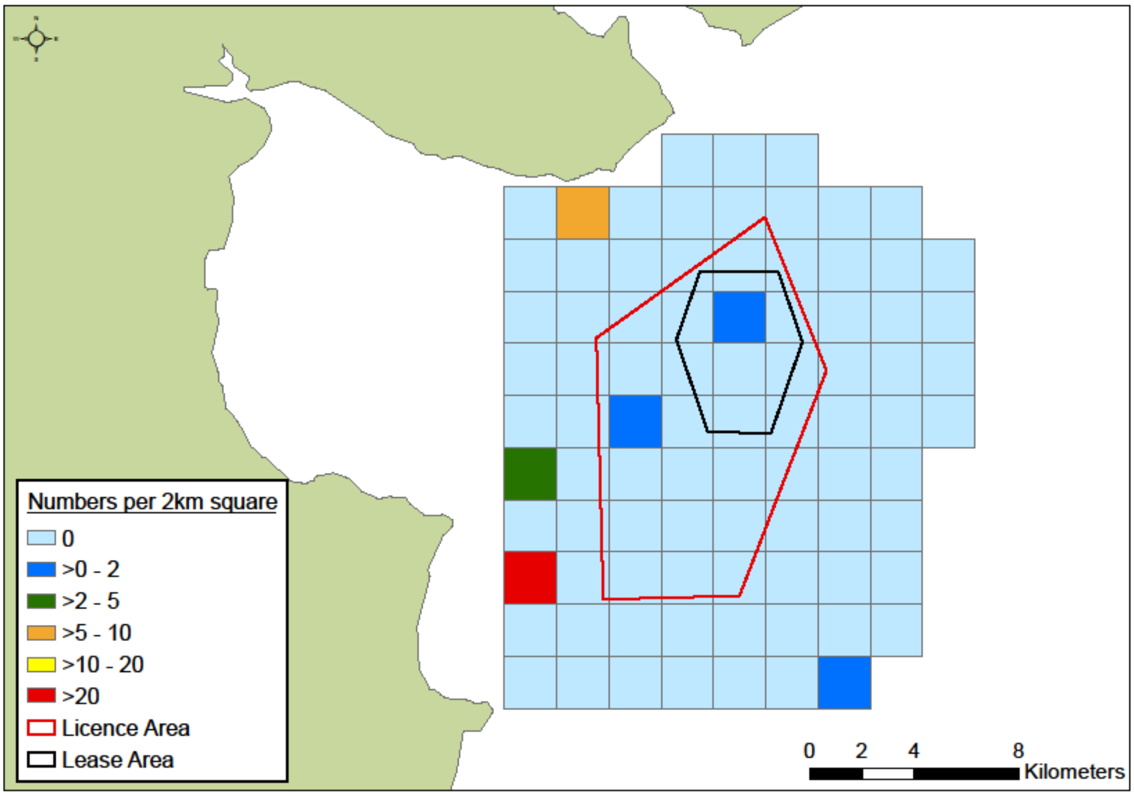

Figure 3.13.12 Great Black-backed Gull survey results April 2019

3.13.2 Great Black-backed Gull Density

Density estimates, derived from the monthly abundance data collected from transects, is shown in Figures 3.13.13 to 3.13.22. Peak density was recorded in September 2018, with a density estimate of 0.13 birds/km^2. This is a similar density estimate to that derived for the western Irish Sea (Jessop *et al*., 2018), which had a peak density of 0.24 birds/km^2 in Autumn.

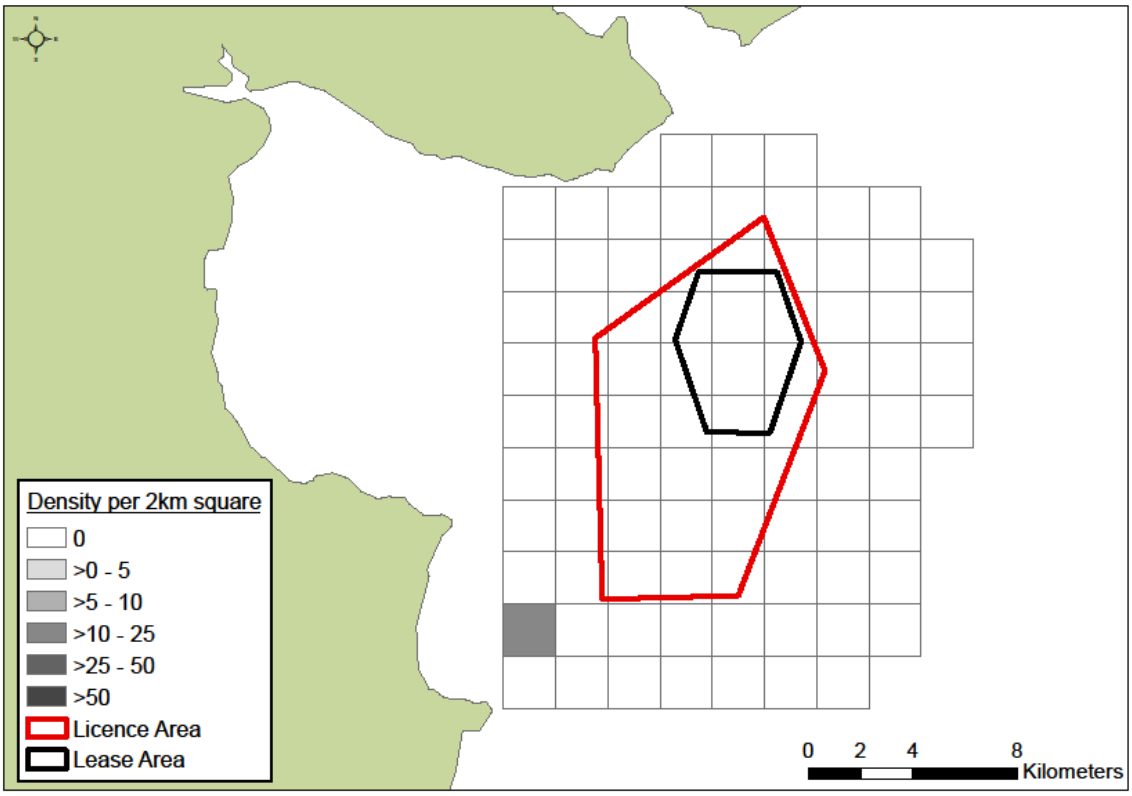

Figure 3.13.13 Great Black-backed Gull density estimates May 2018

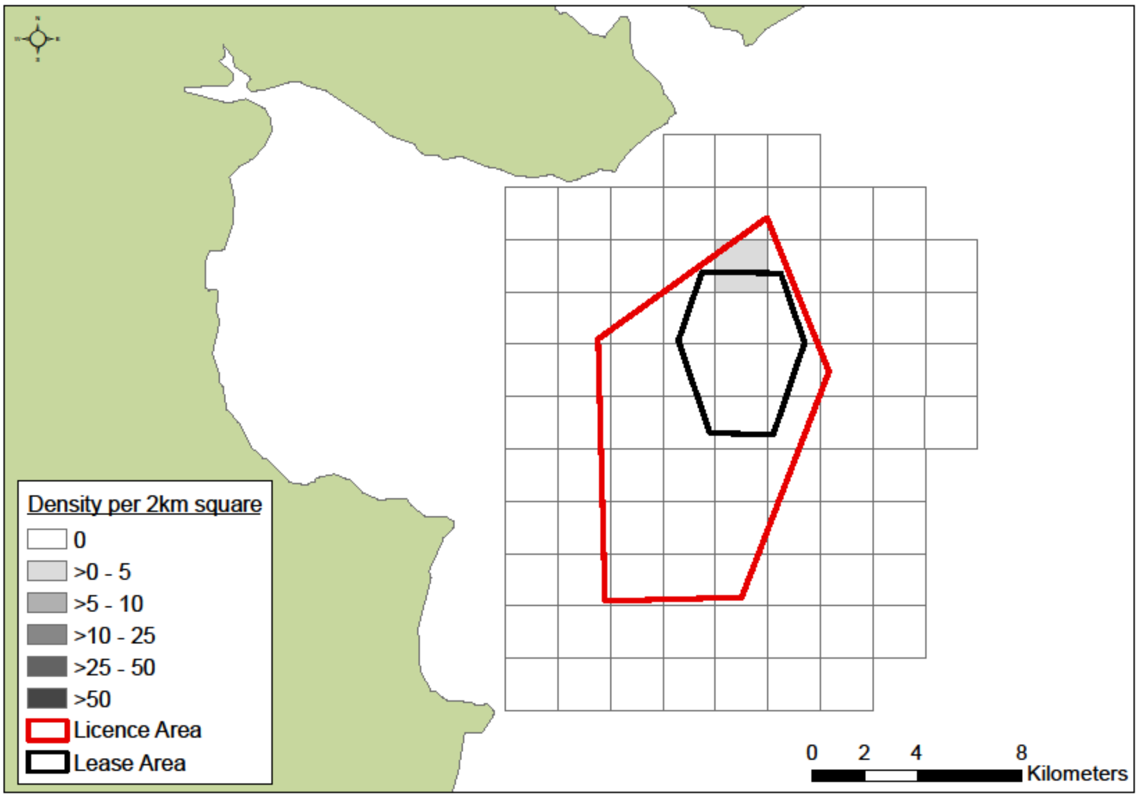

Figure 3.13.14 Great Black-backed Gull density estimates June 2018

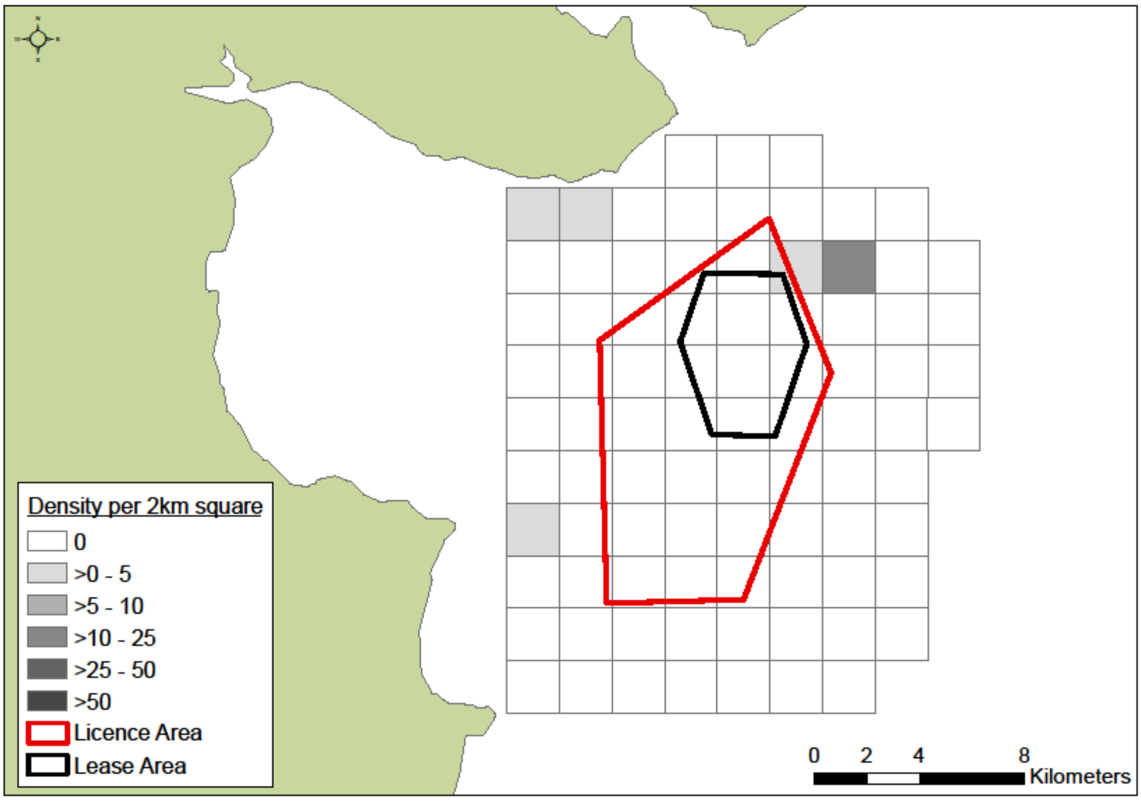

Figure 3.13.15 Great Black-backed Gull density estimates August 2018

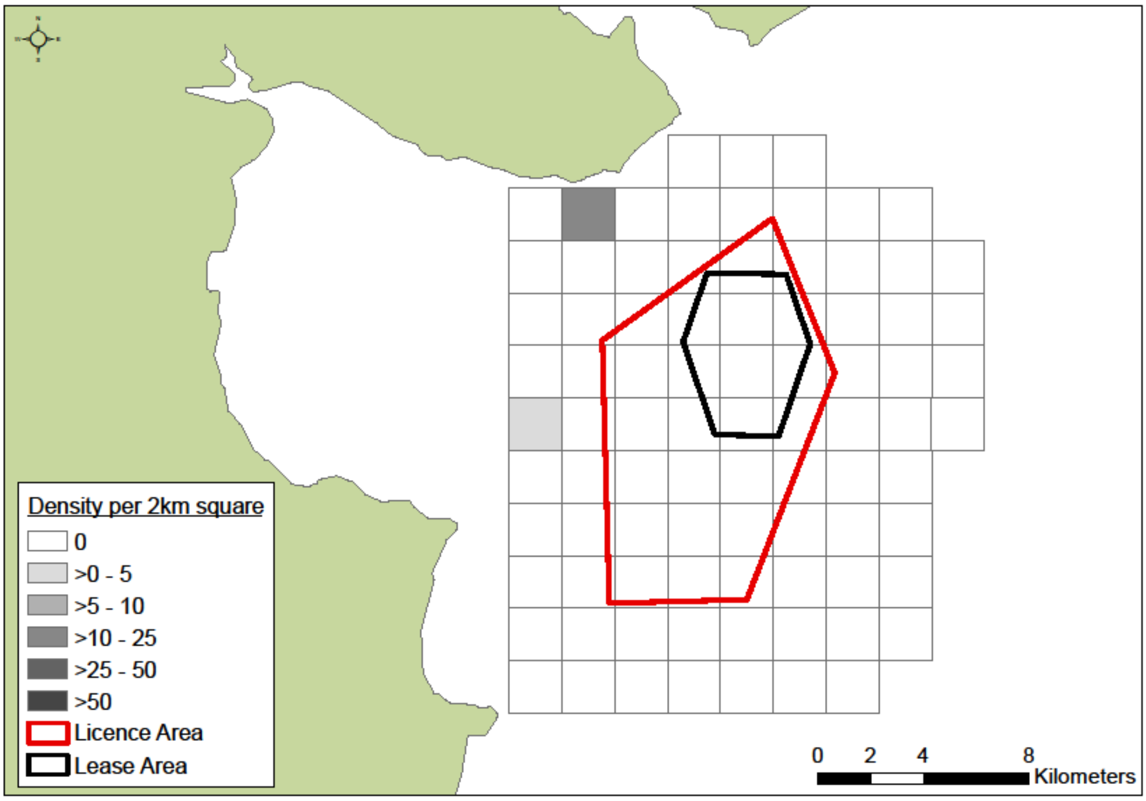

Figure 3.13.16 Great Black-backed Gull density estimates September 2018

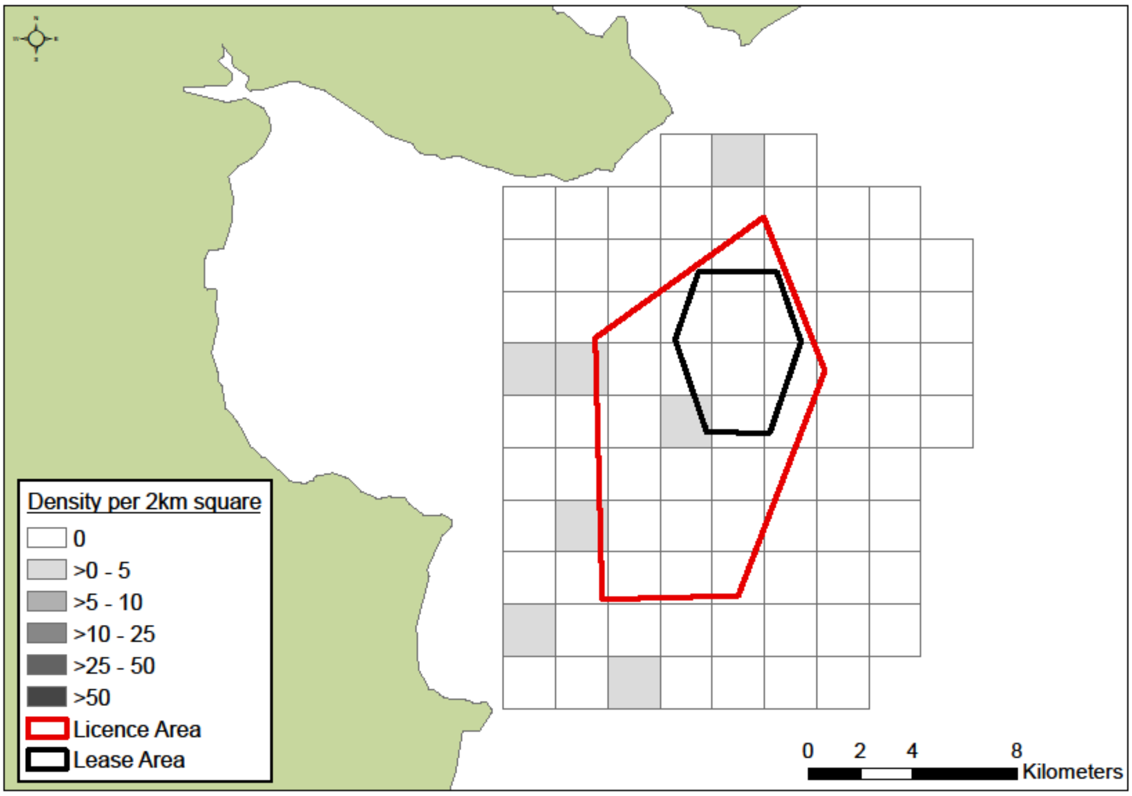

Figure 3.13.17 Great Black-backed Gull density estimates October 2018

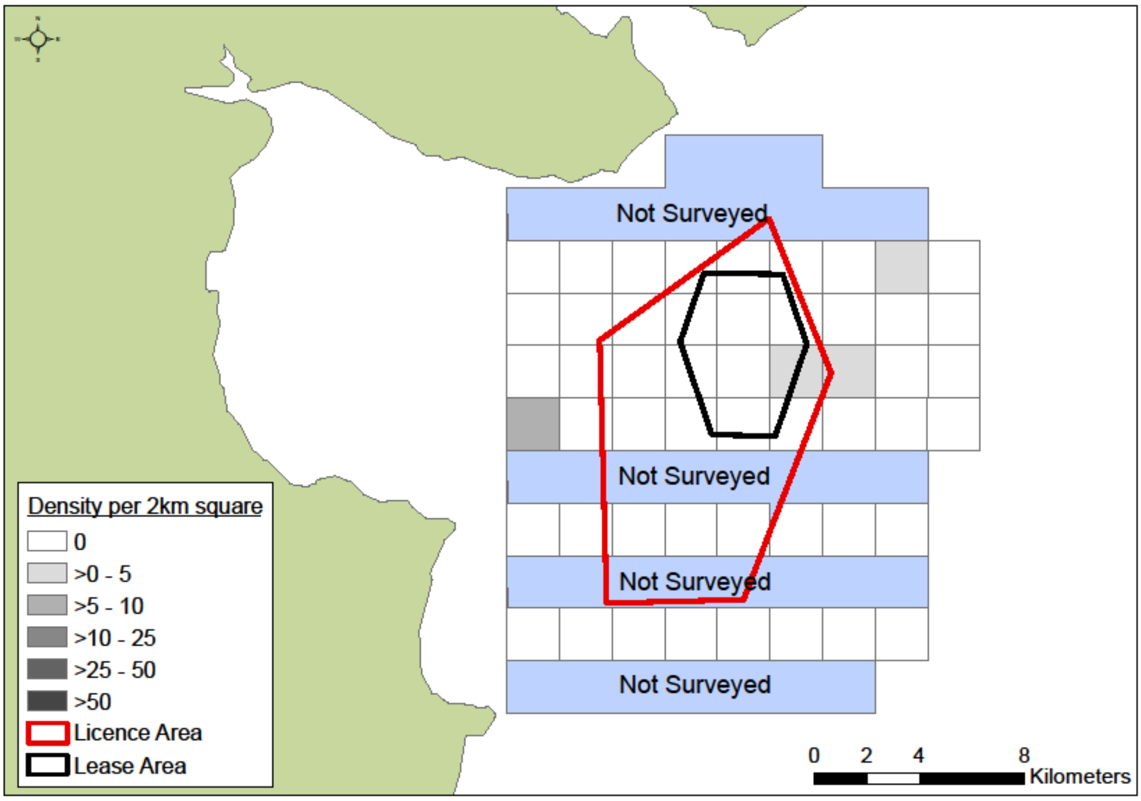

Figure 3.13.18 Great Black-backed Gull density estimates November 2018

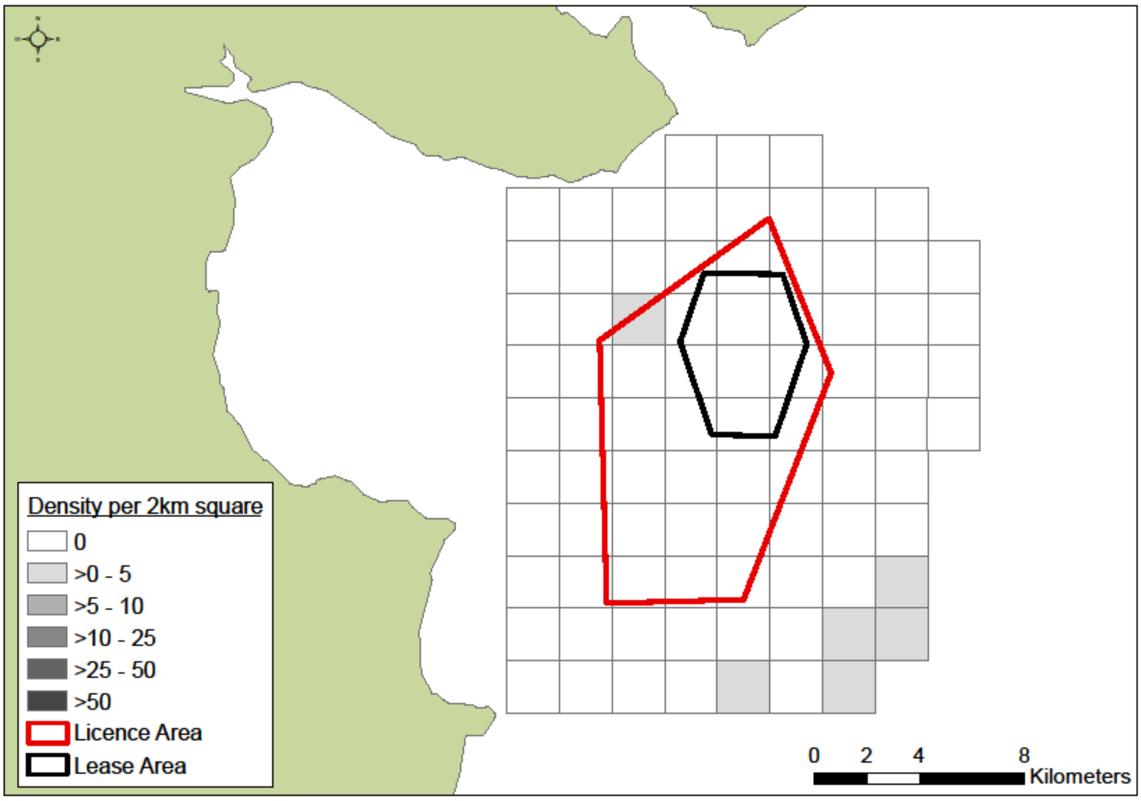

Figure 3.13.19 Great Black-backed Gull density estimates December 2018

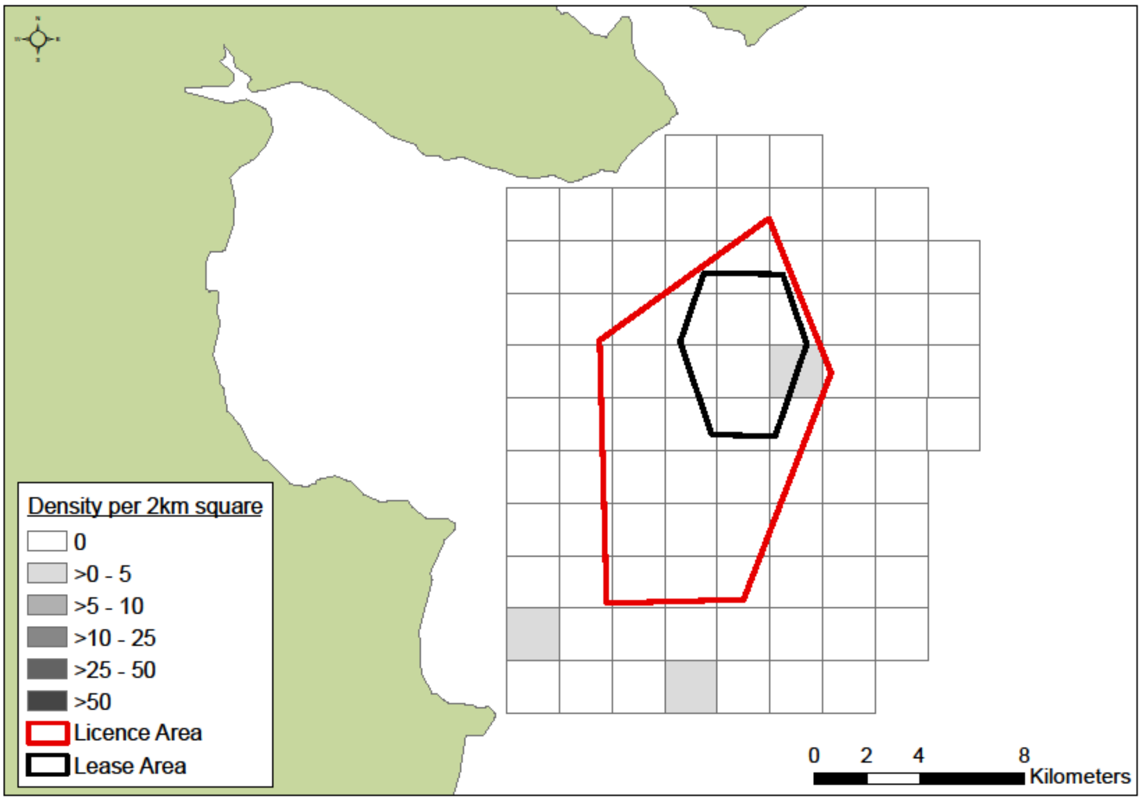

Figure 3.13.20 Great Black-backed Gull density estimates January 2019

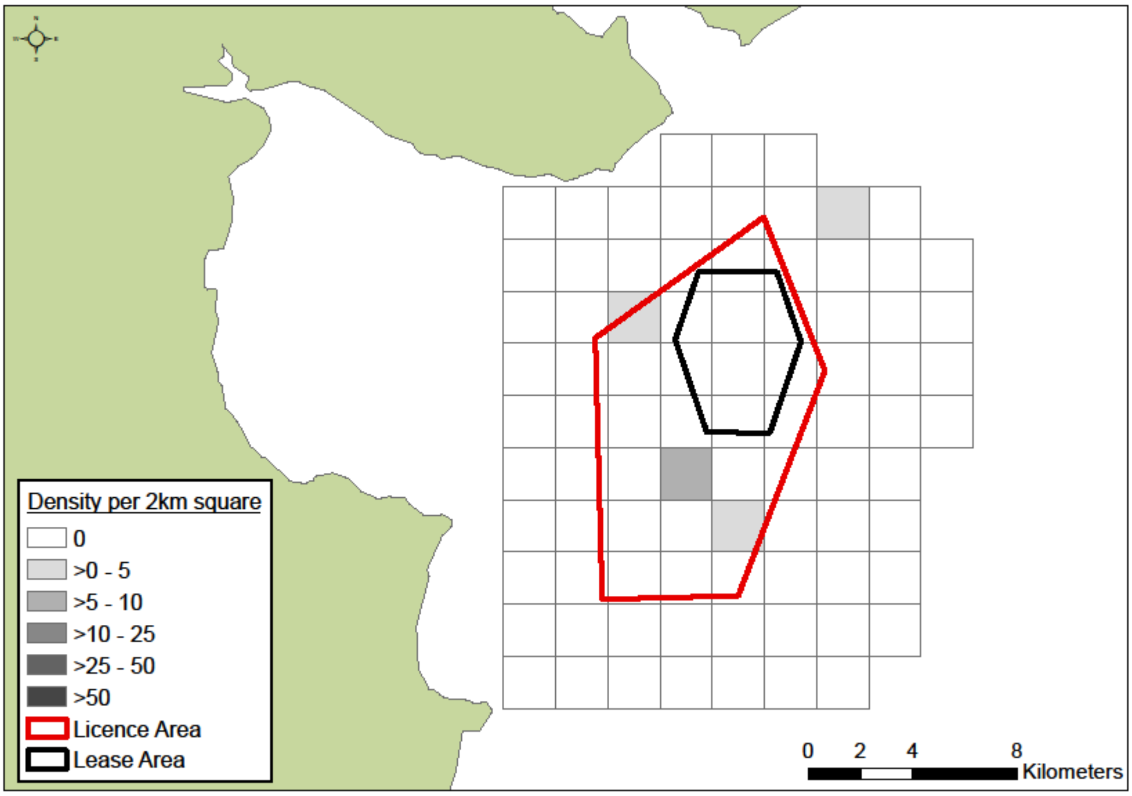

Figure 3.13.21 Great Black-backed Gull density estimates February 2019

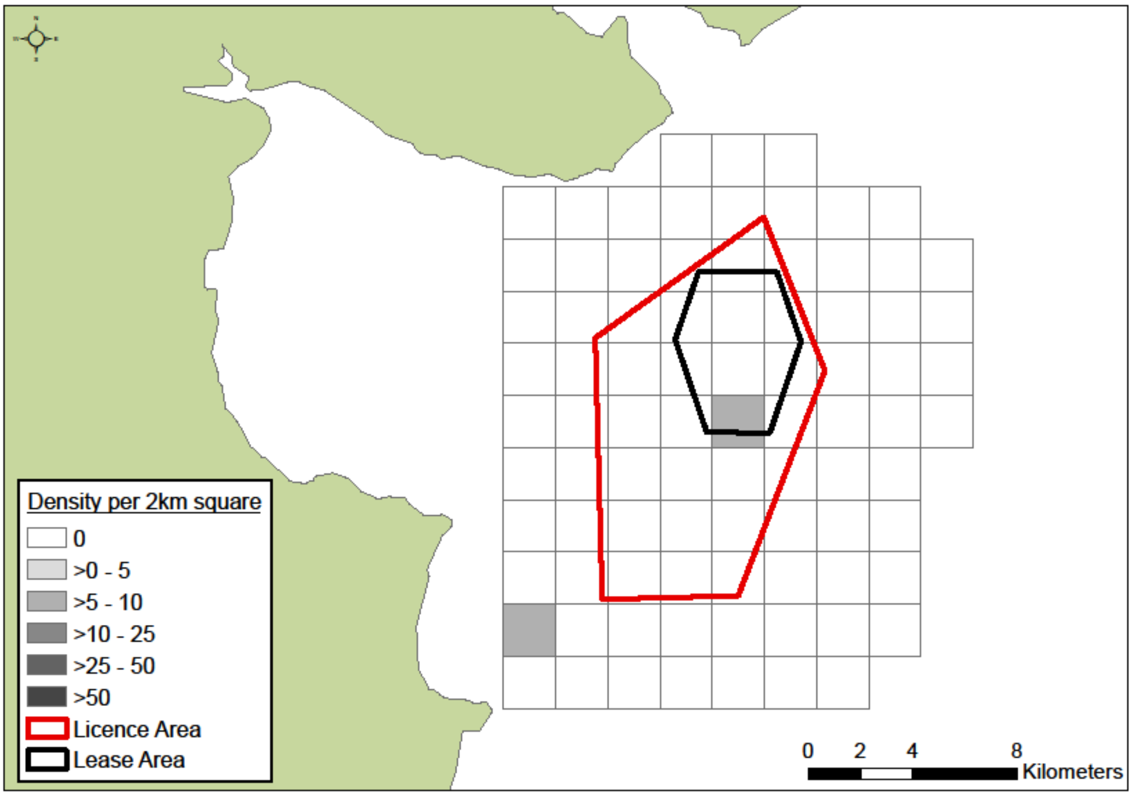

Figure 3.13.22 Great Black-backed Gull density estimates March 2019

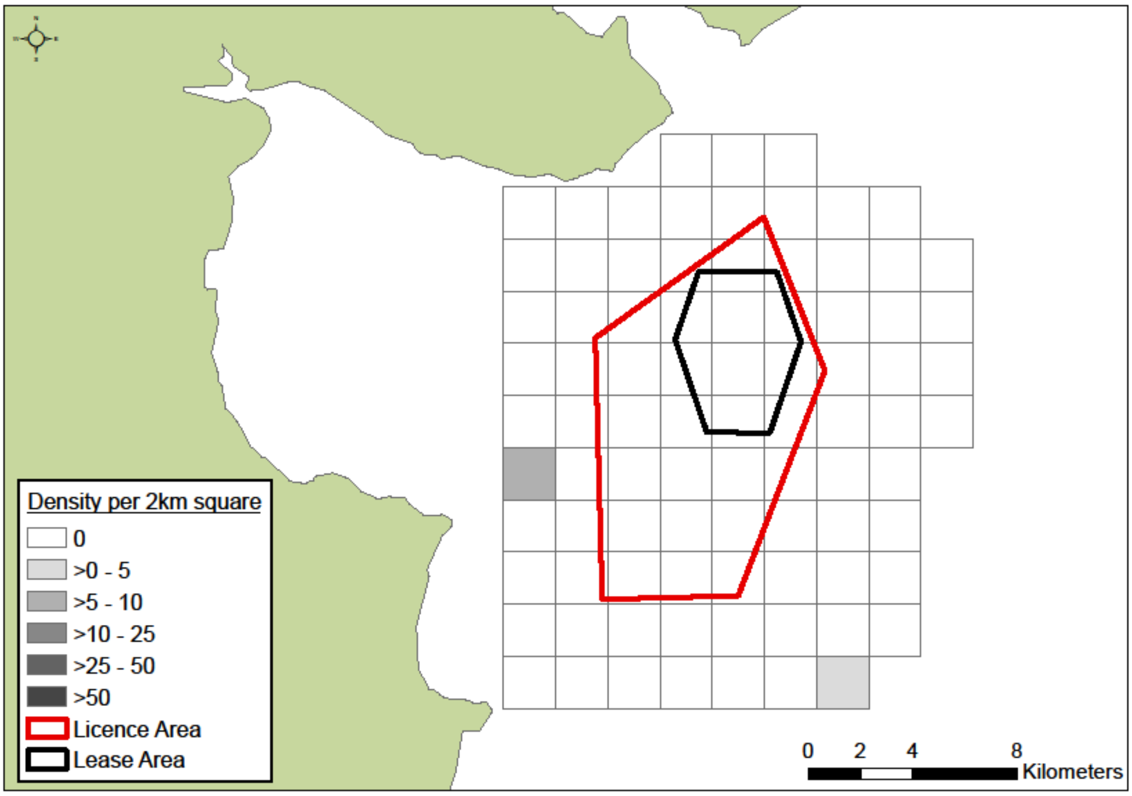

Figure 3.13.23 Great Black-backed Gull density estimates April 2019

3.14 Herring Gull

Herring Gull have a largely coastal distribution in Ireland, although they do move inland in winter (Balmer *et al.*, 2013), and have started breeding on buildings and rooftops (as opposed to coastal cliff sites) in recent years (Mitchell *et al.*, 2004). As with most larger gulls, Herring gulls are predatory, foraging on seabird eggs and chicks, as well as in intertidal area and scavenging from fishery discards and other human waste, particularly in urban areas (Kubetzki & Garthe, 2003; Mitchell *et al.*, 2004). Herring Gulls are Red-listed in Ireland due to long-term declines in their breeding population and breeding range over the past 20 to 25 years (Colhoun & Cummins, 2013).

3.14.1 Herring Gull Abundance

Herring Gull were present within the recording area in every month that surveys took place but were only recorded on transects in nine of the twelve months (Table 3.14.1). Numbers on transects were low during the breeding season (April to September), reflecting the absence of local breeding birds, but increased slightly through the winter, with peak counts in late winter early spring, particularly February to March, when the peak count of 17 birds on the transects was made (March 2019; Figure 3.14.9).

Table 3.14.1 Herring Gull records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	14
June 2018	4	51
July 2018	2	20
August 2018	2	17
September 2018	0	18
October 2018	10	75
November 2018	6	21
December 2018	5	69
January 2019	3	47
February 2019	17	33
March 2019	15	48
April 2019	0	20
TOTAL	64	433

Although records were scattered across the survey area as a whole (Figures 3.14.1 to 3.14.9) only a single bird was recorded in the Lease Area in June 2018 (Table 3.14.2; Figure 3.14.1). A total of 19 birds (29.7% of the total observations from transects) were recorded in the Licence area, with the remaining 44 birds (68.7% of the total number) present in the remaining survey area.

Table 3.14.2 Herring Gull records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	0	-	0	-	0	-
June 2018	3	75.0	0	0	1	25.0
July 2018	2	100	0	0	0	0
August 2018	0	0	2	100	0	0
September 2018	0	-	0	-	0	-
October 2018	8	80.0	2	20.0	0	0
November 2018	5	83.3	1	16.7	0	0
December 2018	0	0	5	100	0	0
January 2019	2	66.7	1	33.3	0	0
February 2019	17	100	0	0	0	0
March 2019	7	46.7	8	53.3	0	0
April 2019	0	-	0	-	0	-
TOTAL	44	68.7	19	29.7	1	1.6

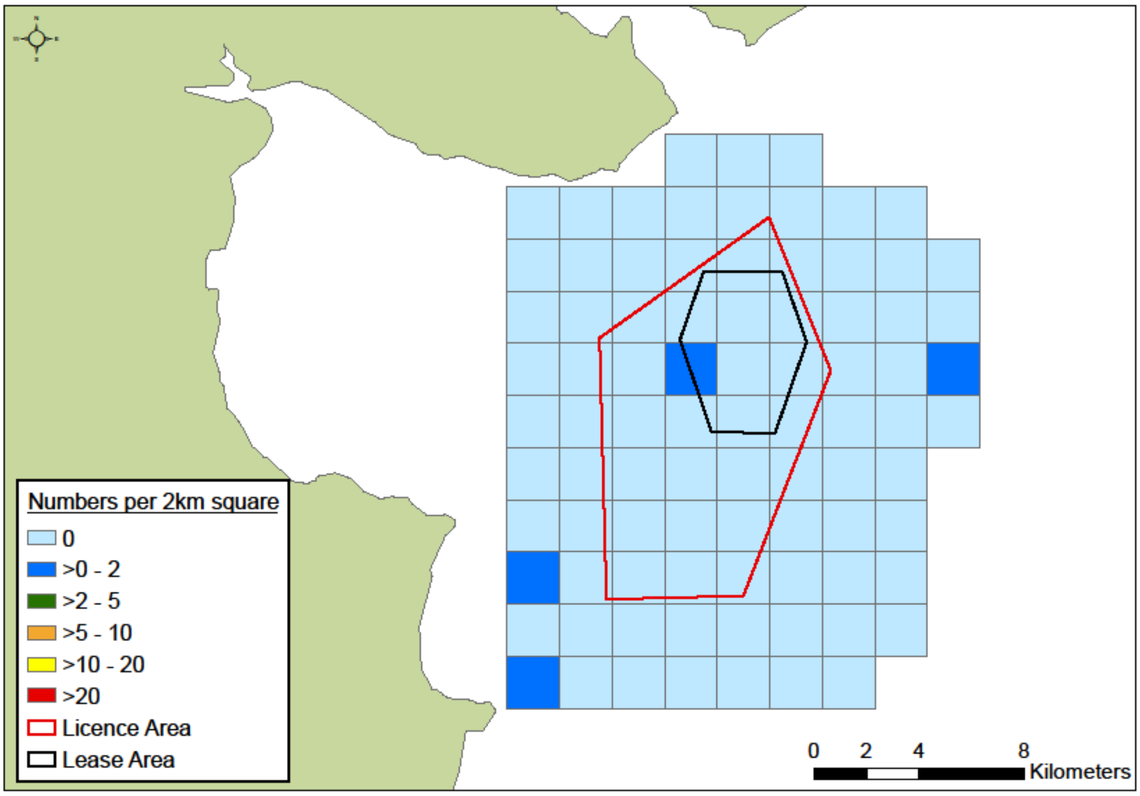

Figure 3.14.1 Herring Gull survey results June 2018

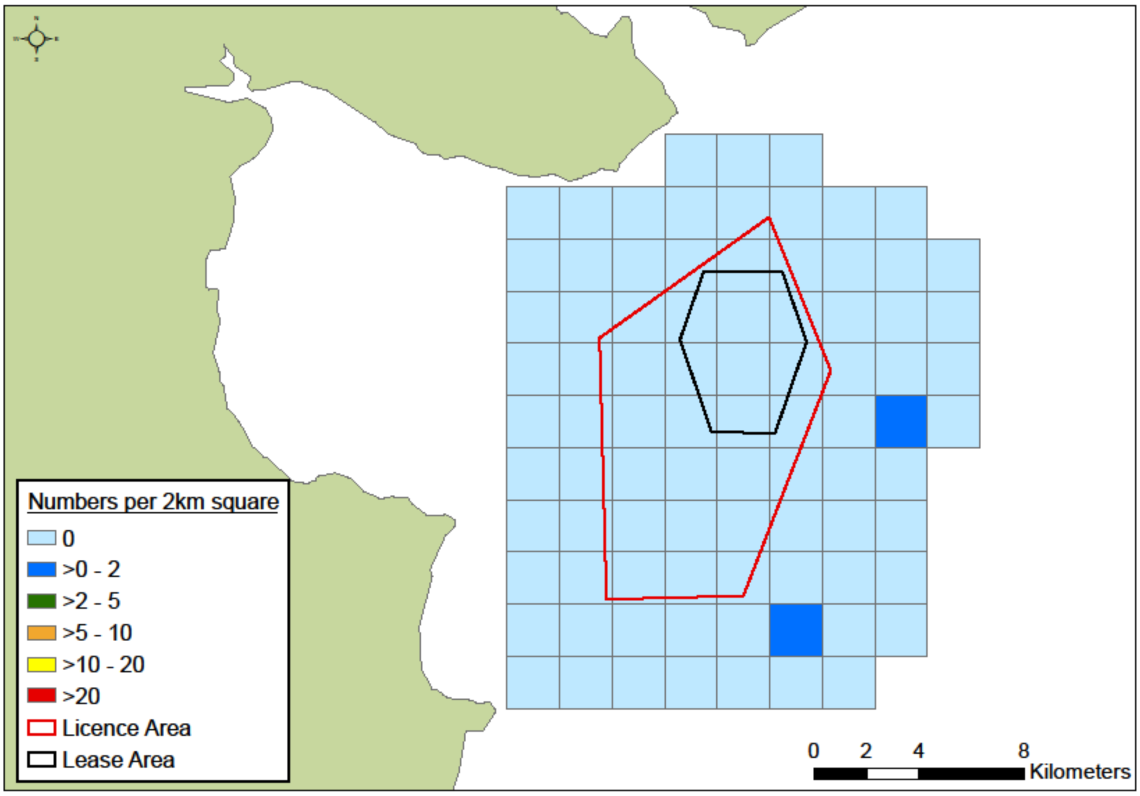

Figure 3.14.2 Herring Gull survey results July 2018

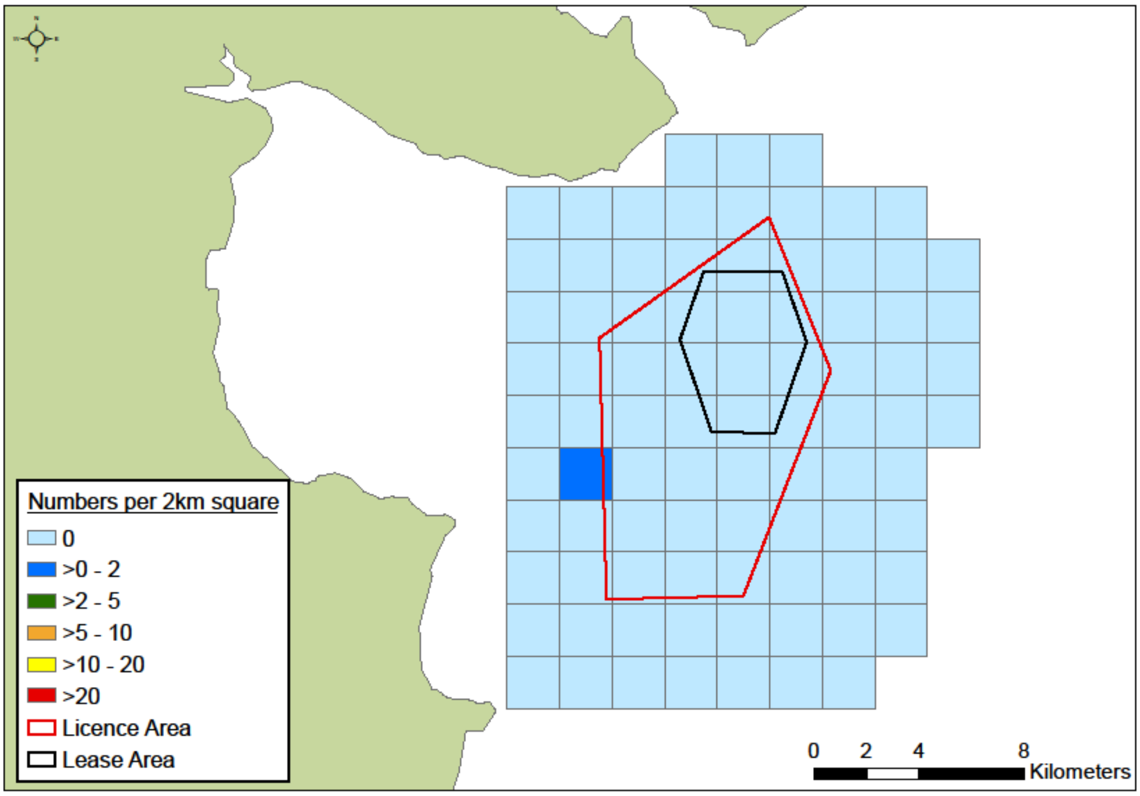

Figure 3.14.3 Herring Gull survey results August 2018

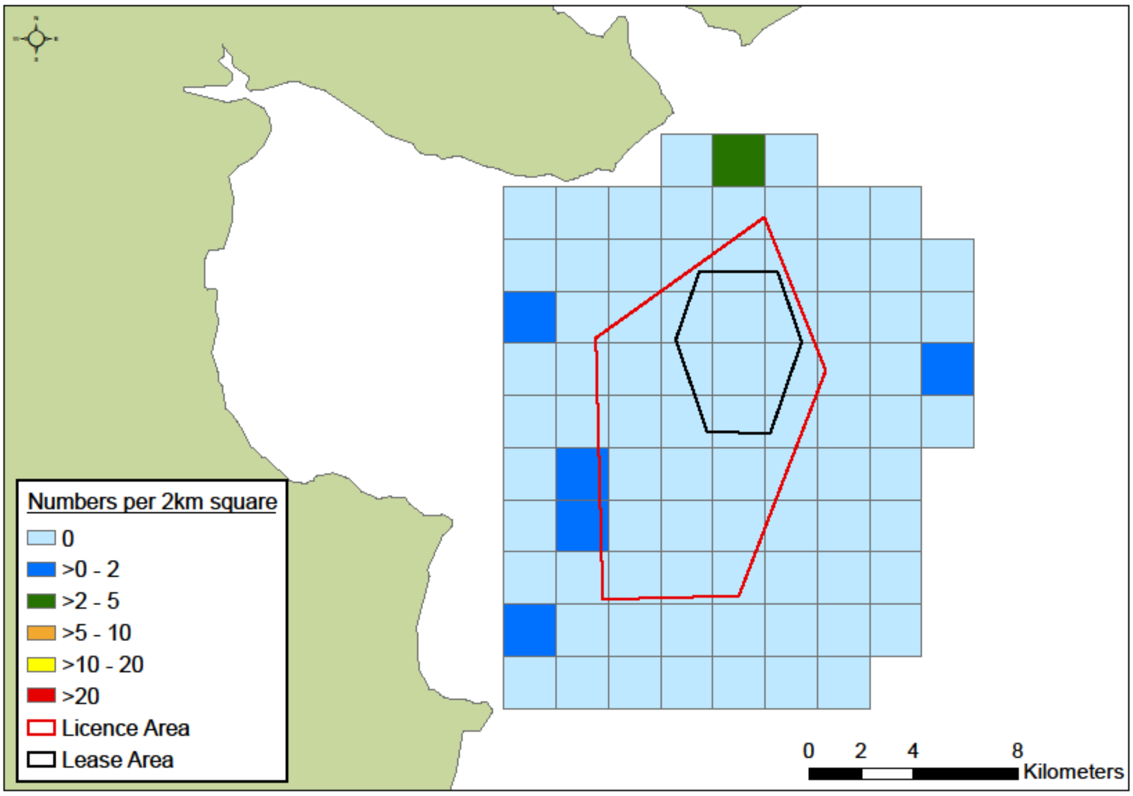

Figure 3.14.4 Herring Gull survey results October 2018

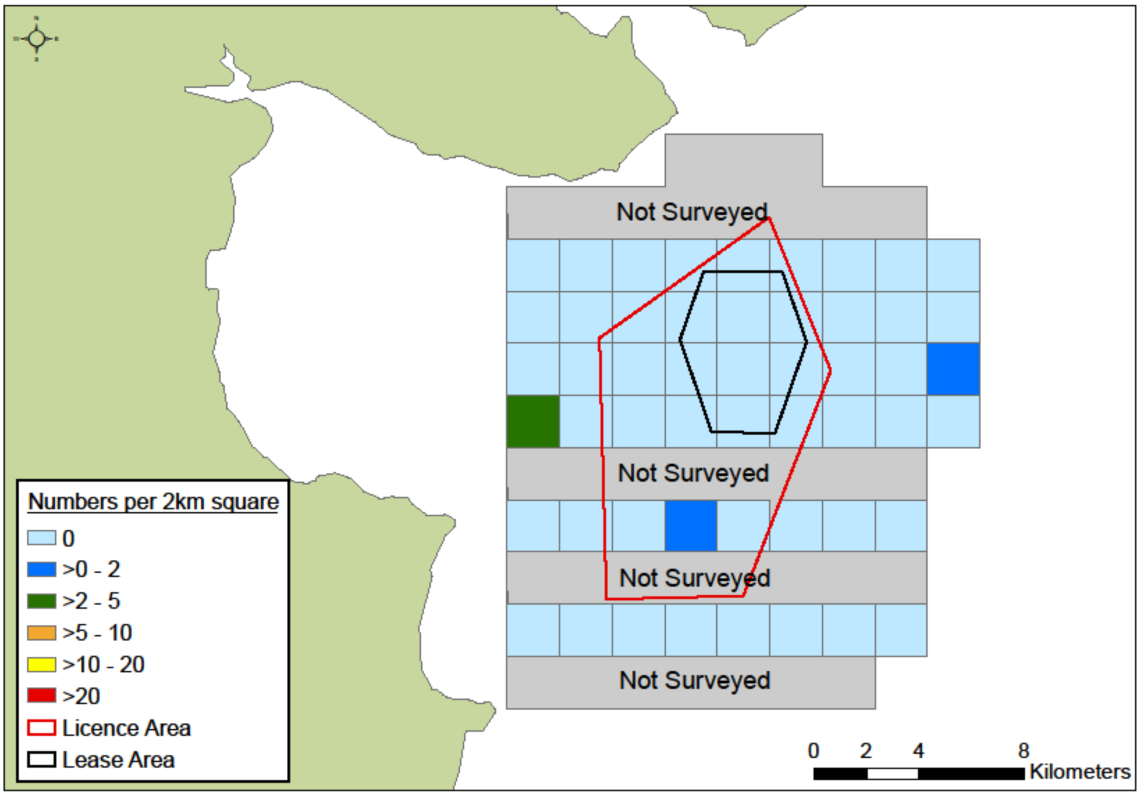

Figure 3.14.5 Herring Gull survey results November 2018

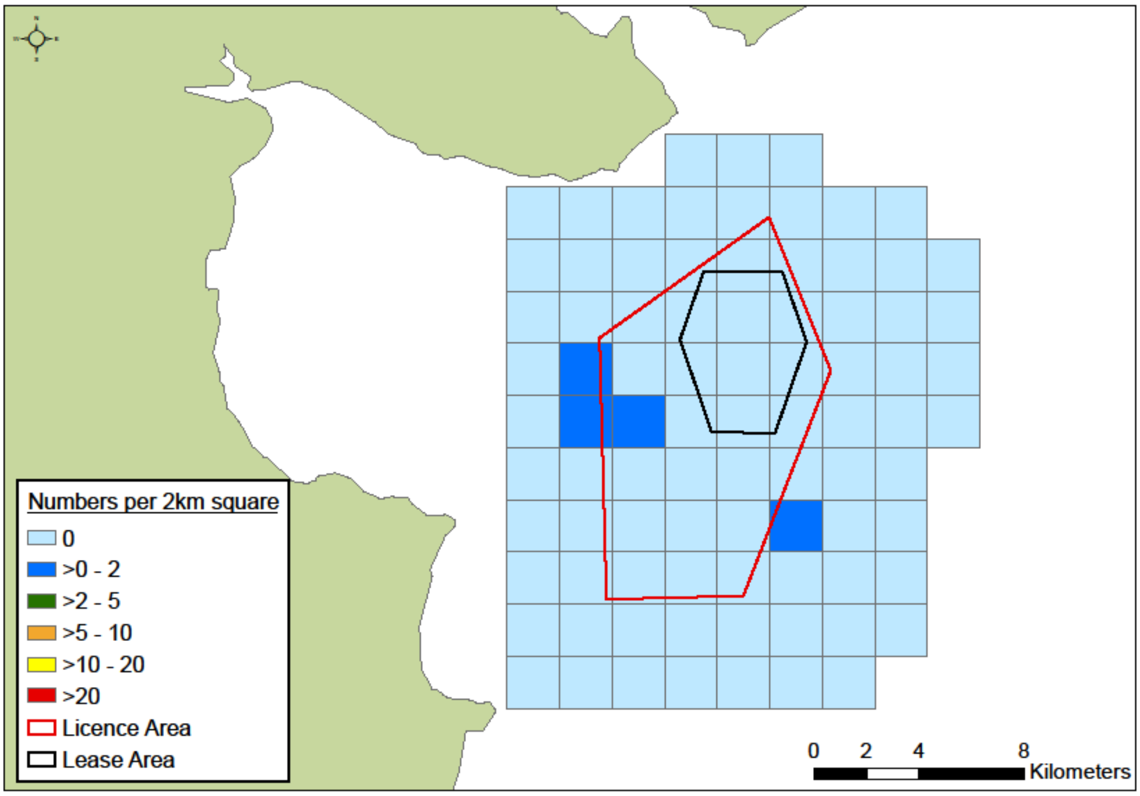

Figure 3.14.6 Herring Gull survey results December 2018

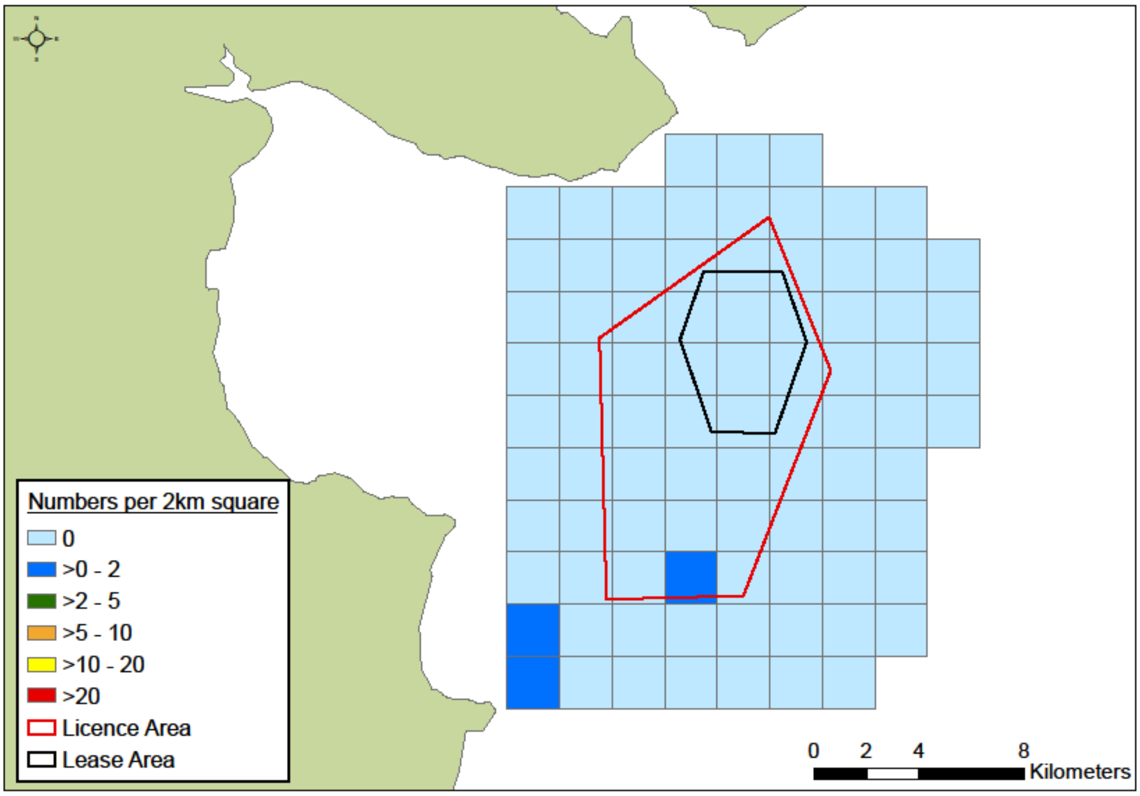

Figure 3.14.7 Herring Gull survey results January 2019

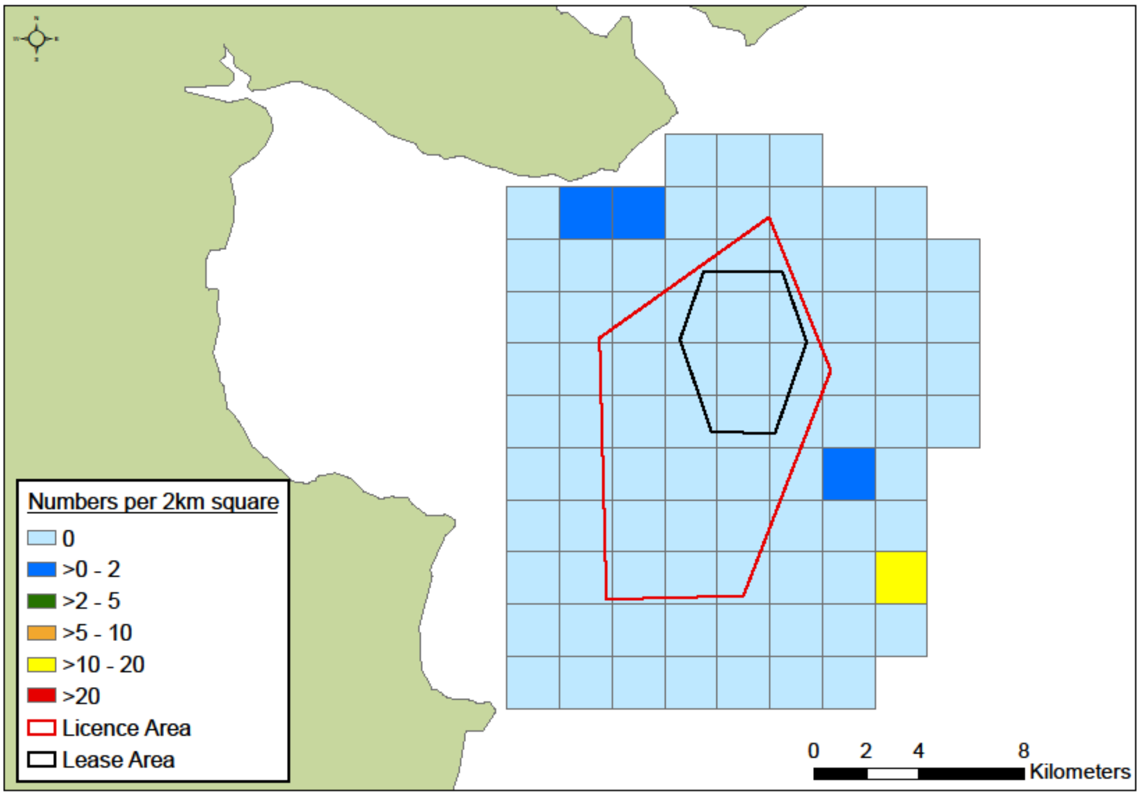

Figure 3.14.8 Herring Gull survey results February 2019

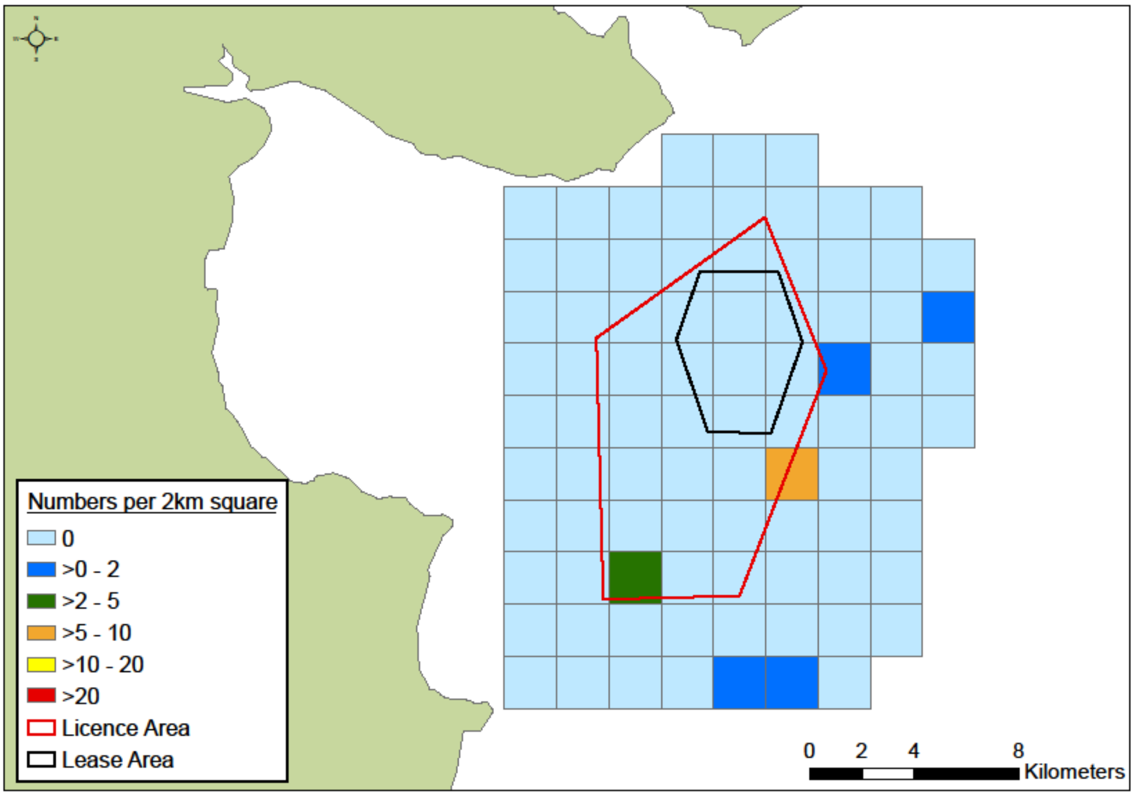

Figure 3.14.9 Herring Gull survey results March 2019

3.14.2 Herring Gull Density

Density estimates for Herring Gull were derived from the monthly abundance data for six of the months that surveys took place (Figures 3.14.10 to 3.14.15). Peak densities were estimated from the November data (noting that this is a reduced dataset with a limited number of transects surveyed; see Figure 3.14.12) of 0.06 birds/km^2. It is also important to note the small number of bird observations used to calculate these estimates (just four individuals in November; with a total of 14 individuals across all survey months).

3.14.3 Common/Herring Gull Density Estimates

To facilitate comparison with the western Irish Sea data, density estimates for Common Gull and herring Gull have been combined. A maximum density for the two species was estimated as 0.18 birds/km^2. This is substantially lower than the estimates indicated within Jessop *et al.,* (2018), where estimates ranged from 0.75 birds/km^2 (summer) to a peak of 3.82 birds/km^2 (autumn) with the winter estimate of 1.76 birds/km^2 (winter) in between. The reason for the low densities observed in the Oriel Windfarm survey area may be related to the absence of local breeding sites.

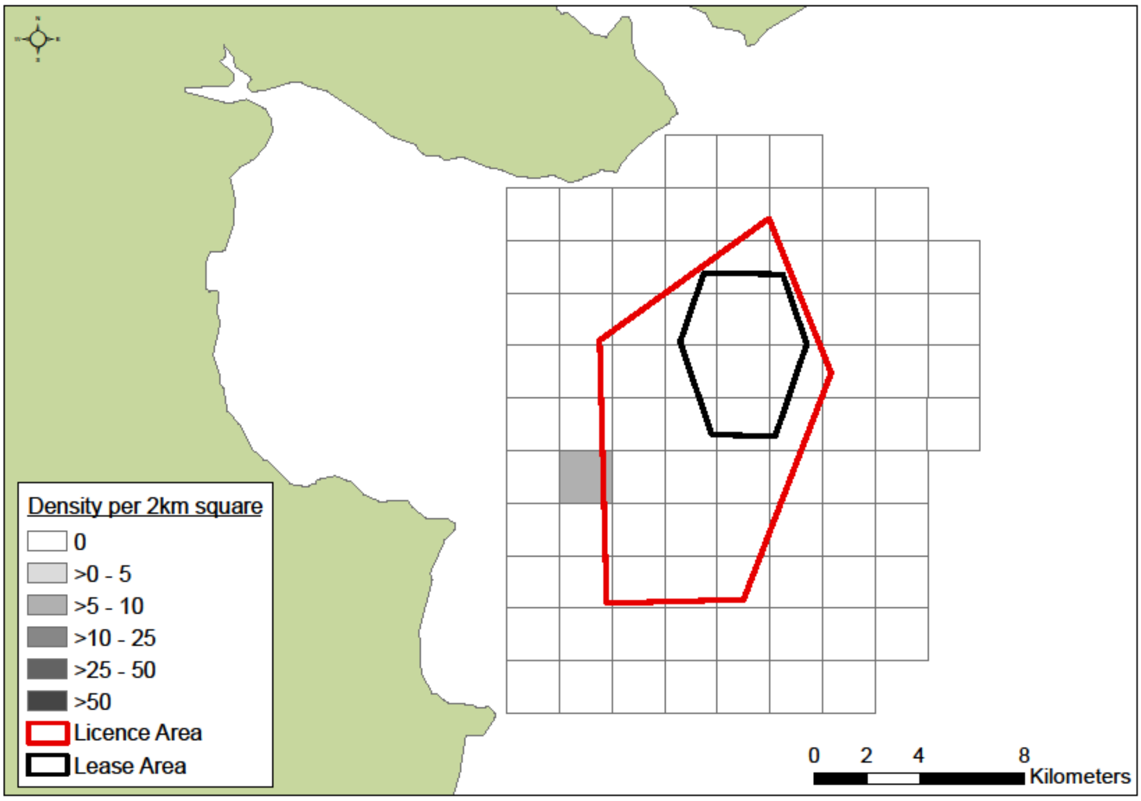

Figure 3.14.10 Herring Gull density estimates August 2018

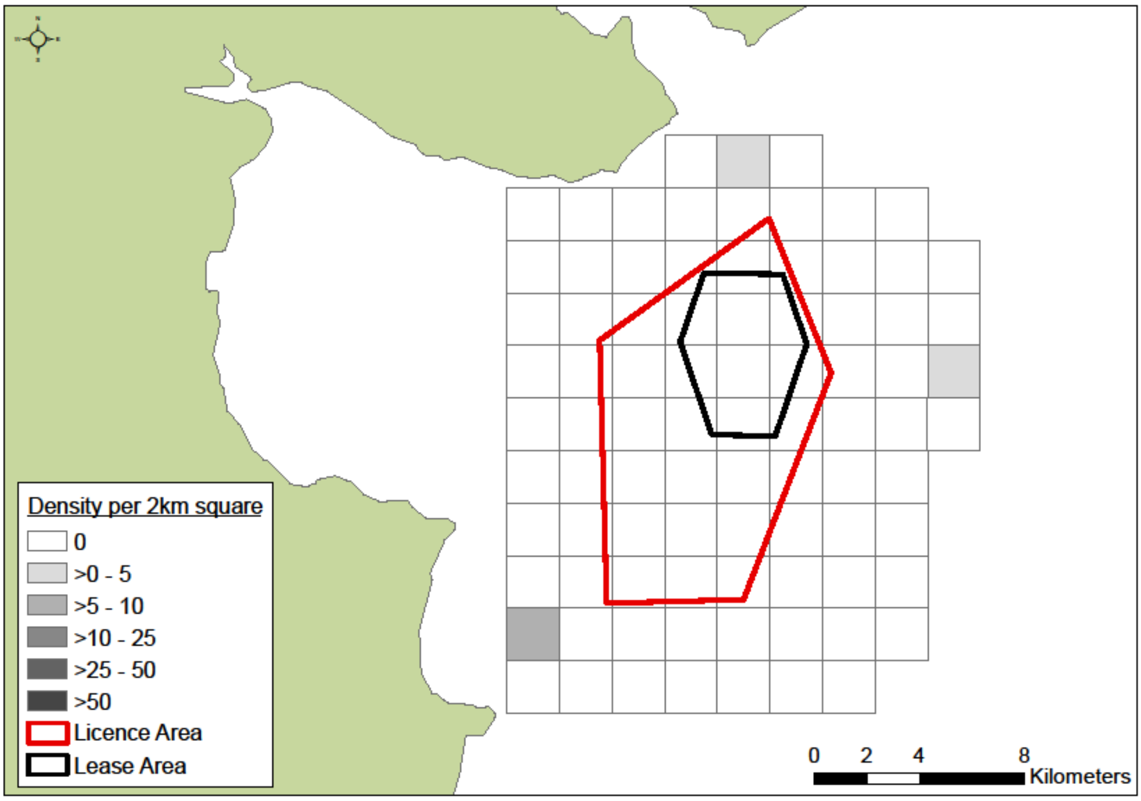

Figure 3.14.11 Herring Gull density estimates October 2018

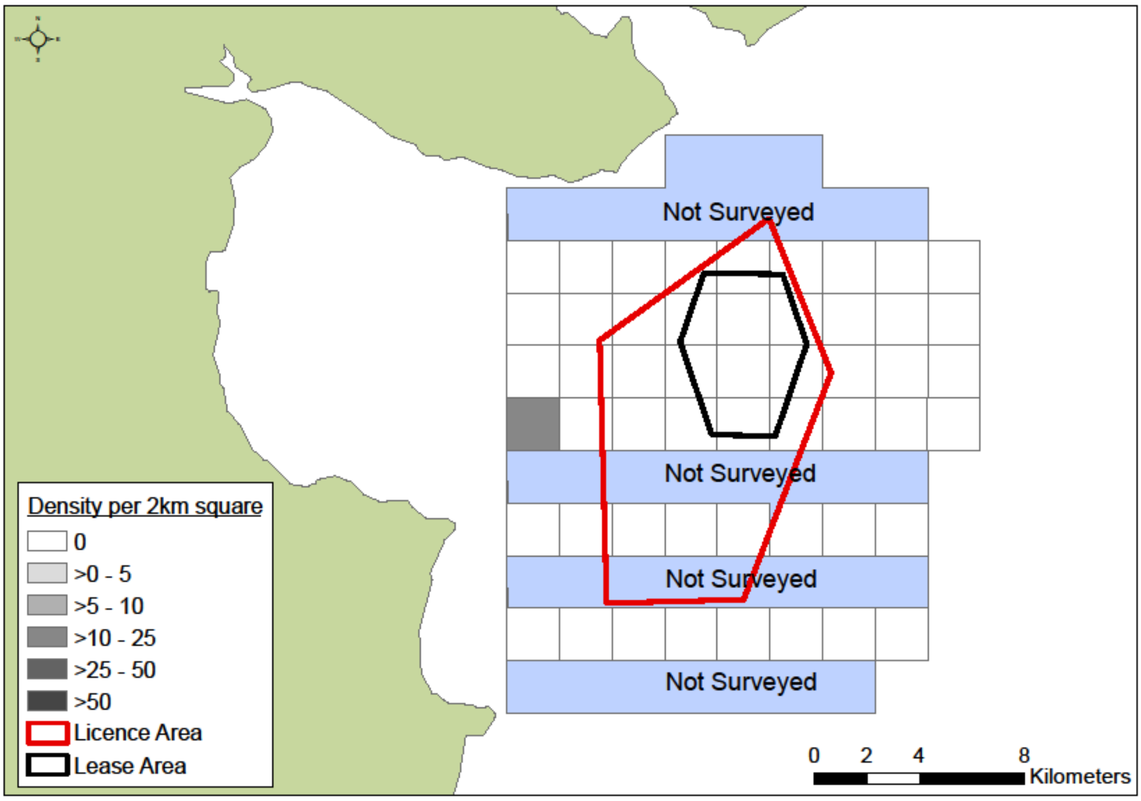

Figure 3.14.12 Herring Gull density estimates November 2018

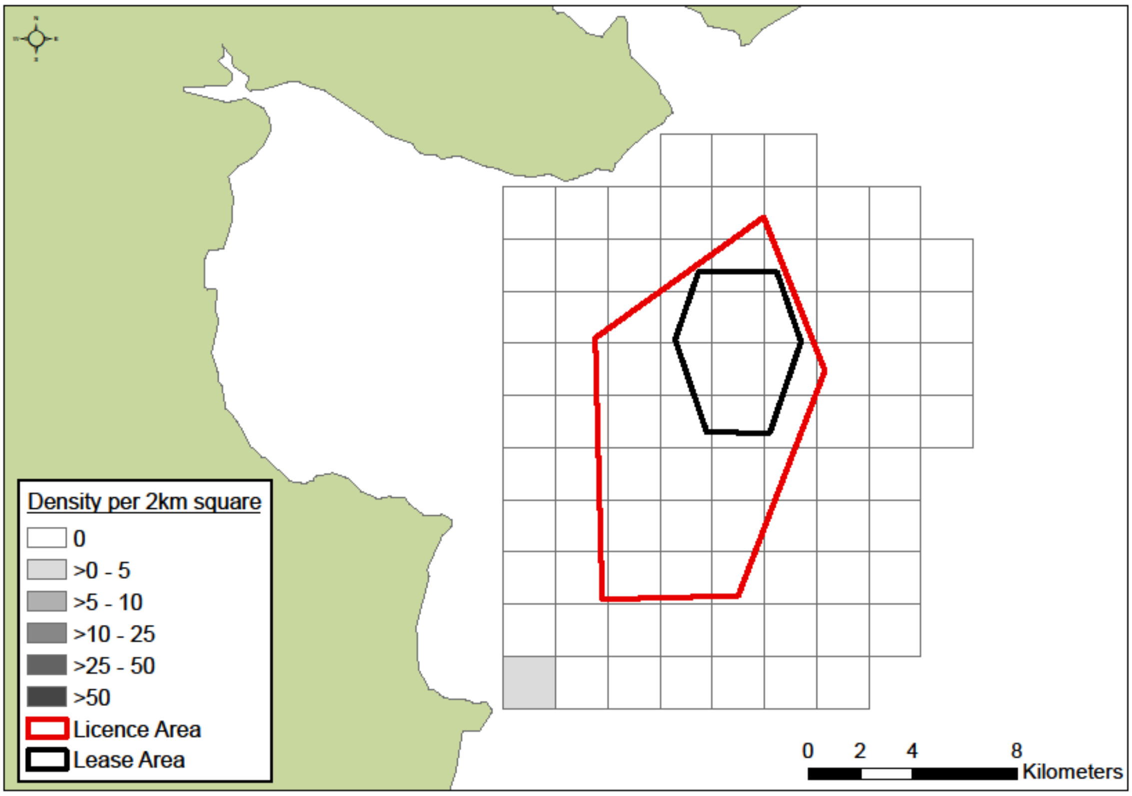

Figure 3.14.13 Herring Gull density estimates January 2019

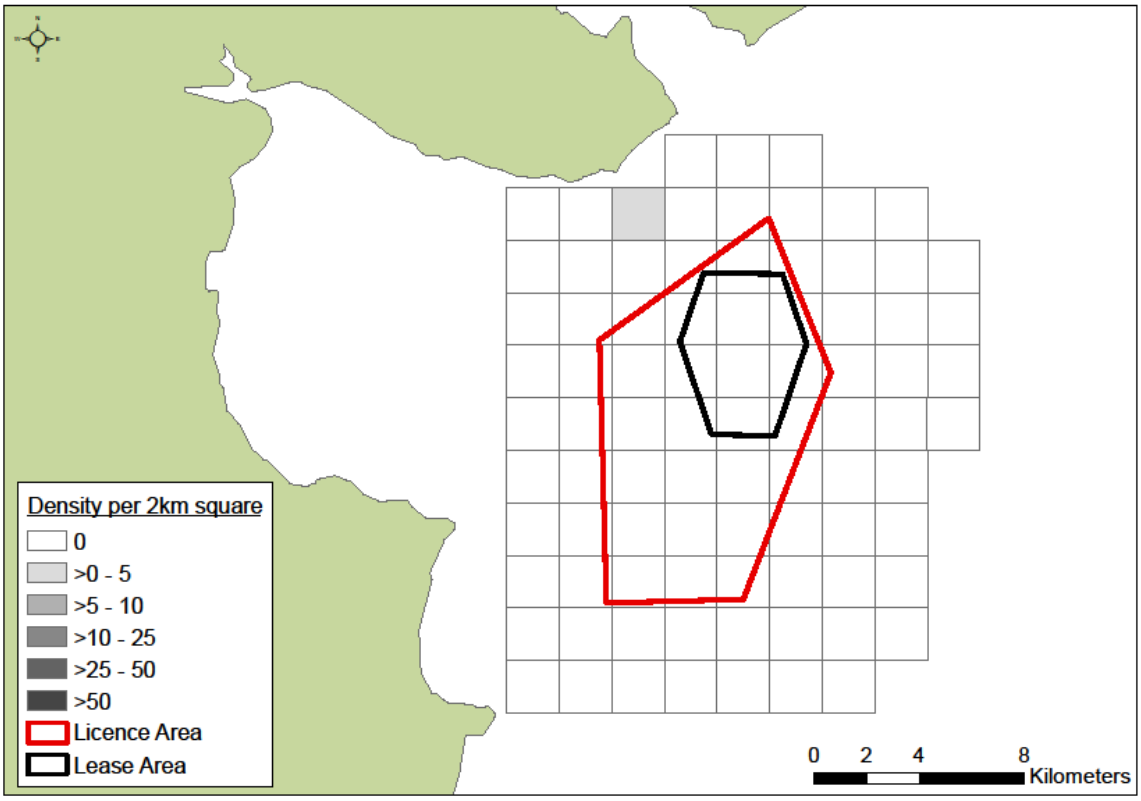

Figure 3.14.14 Herring Gull density estimates February 2019

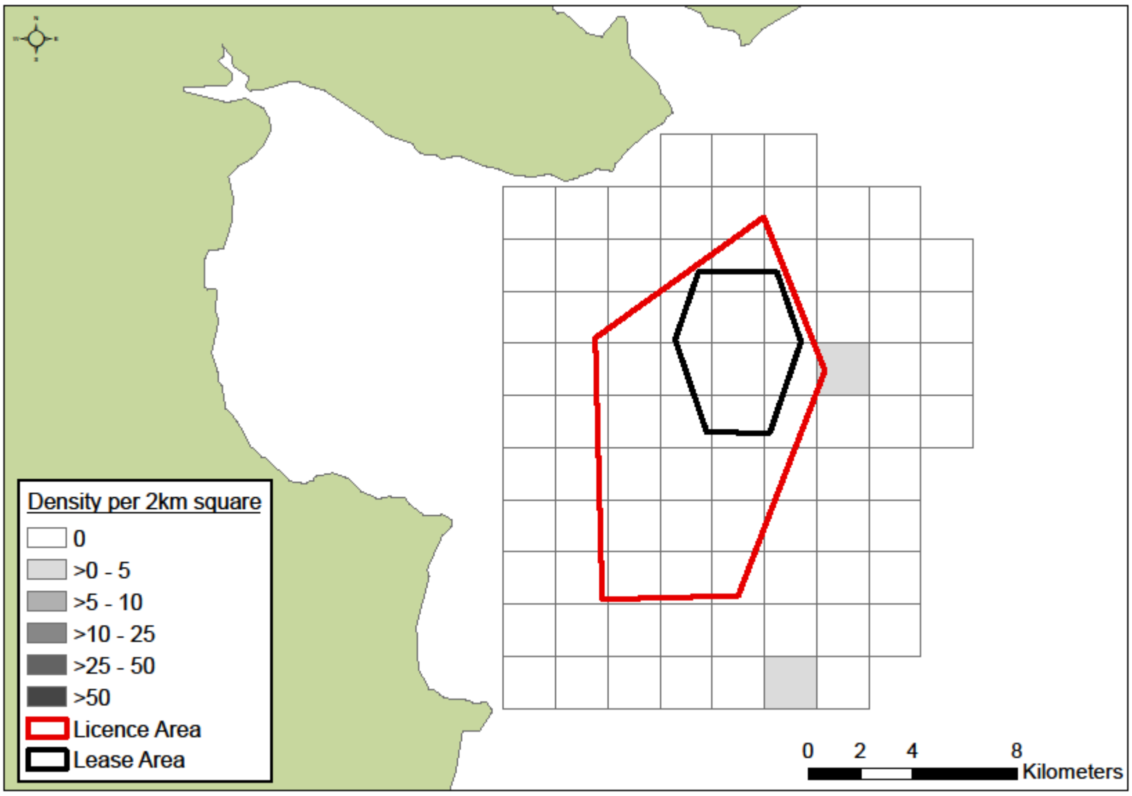

Figure 3.14.15 Herring Gull density estimates March 2019

3.15 Lesser Black-backed Gull

The majority of Lesser Black-backed Gulls nest on inland lakes in the west of Ireland, although a few nest on buildings around the Dublin area (Balmer *et al*., 2013; Mitchell *et al*., 2004). Lesser Black-backed Gulls are considered to forage in more marine habitats than other gull species (Kubetzki & Garthe, 2003), but they typically migrate out of north-west European water in winter (Stone *et* al., 1995).Lesser Black-backed Gulls are Amber-listed in Ireland due to a moderate decline in their breeding range over the past 20 years, and that the breeding population is localised, with over half the breeding population occurring at ten or fewer sites (Colhoun & Cummins, 2013).

3.15.1 Lesser Black-backed Gull Abundance

Lesser Black-backed Gulls were observed in the survey area in seven of the twelve survey months, typically in very small numbers (see Table 3.15.1) and only recorded from transects in two months (June 2018; Figure 3.15.1) and April 2019 (Figure 3.15.2). It is likely that the April and possibly June birds may have been migrants from southern wintering areas towards more northerly breeding sites in Scotland or Northern Ireland.

Table 3.15.1 Lesser Black-backed Gull records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	4
June 2018	5	20
July 2018	0	8
August 2018	0	5
September 2018	0	2
October 2018	0	0
November 2018	0	0
December 2018	0	0
January 2019	0	0
February 2019	0	1
March 2019	0	0
April 2019	2	3
TOTAL	**7**	**43**

Of the seven birds observed, three were recorded in the Lease area (two in June 2018 and one in April 2019), one in the Licence area (in June 2018) and three in the remaining Survey area (two in June 2018 and one in April 2019.

3.15.2 Lesser Black-backed Gull Density

With just two usable records, no density estimates for Lesser Black-backed Gull have been derived.

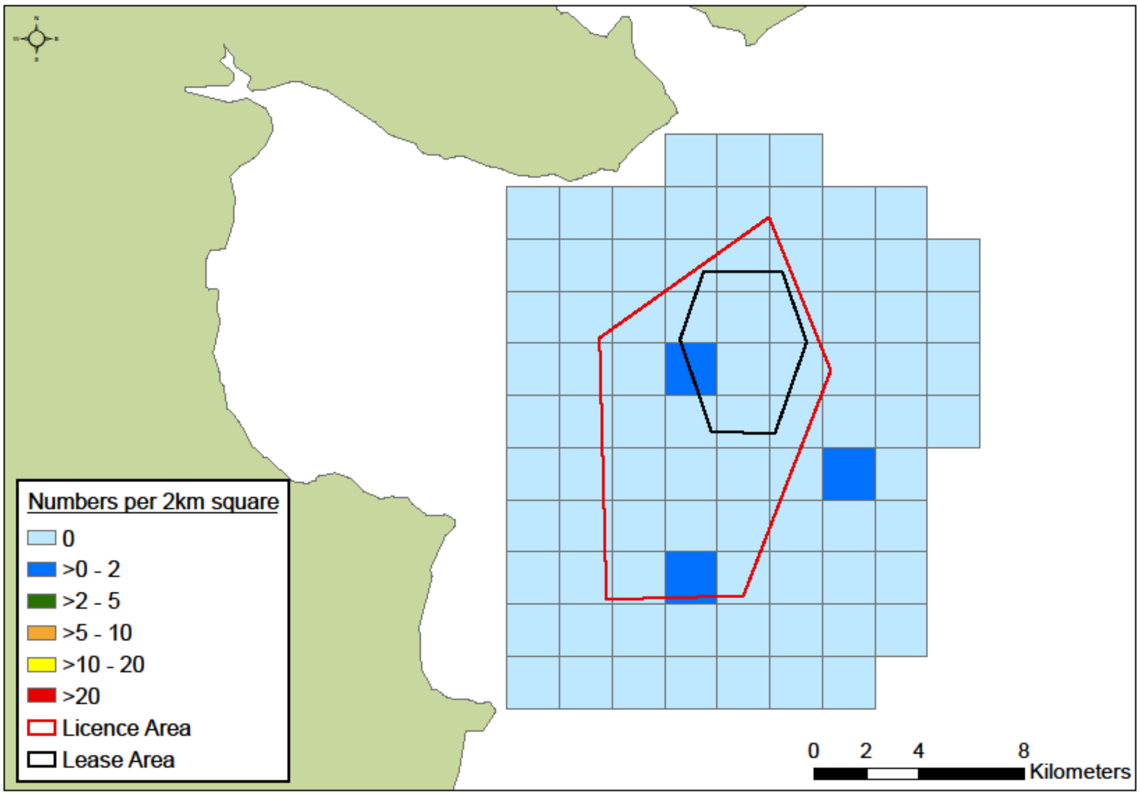

Figure 3.15.1 Lesser Black-backed Gull survey results June 2018

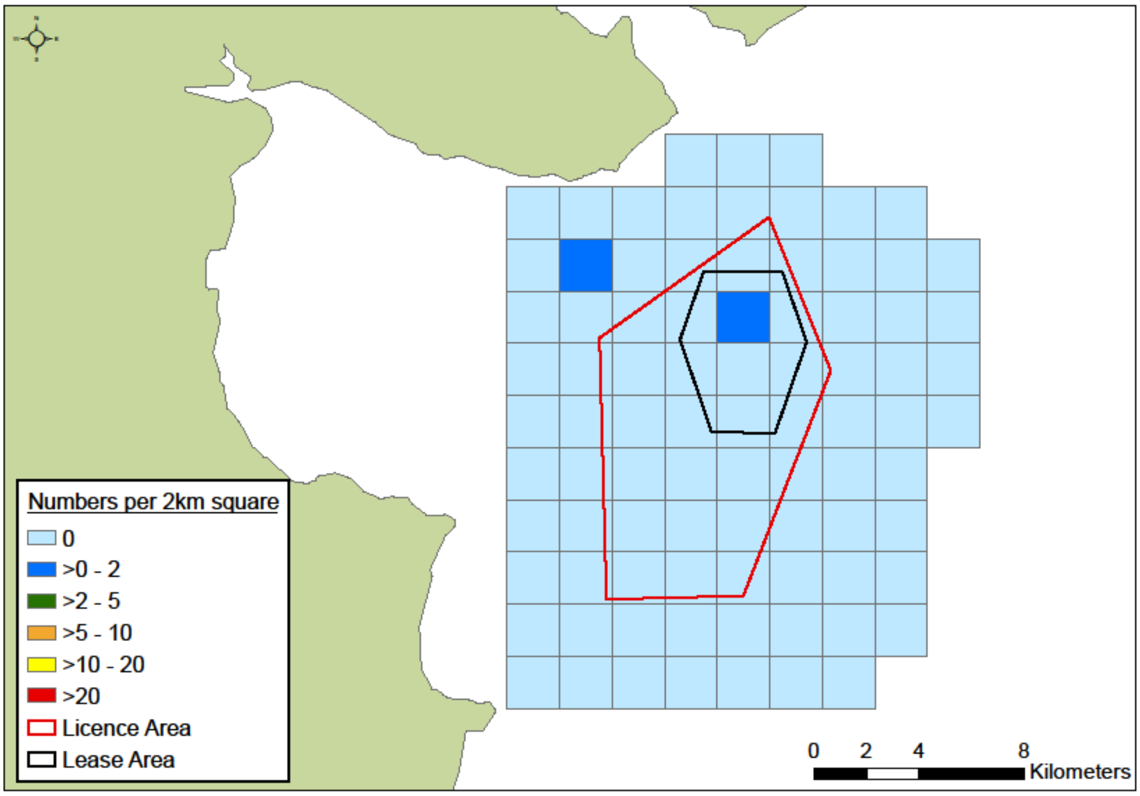

Figure 3.15.2 Lesser Black-backed Gull survey results April 2019

3.16 Common Tern

Common Terns are summer visitors to Ireland, where the breed locally throughout the country, with breeding colonies located along the east coast of Ireland north and south of the Oriel Windfarm survey area (Balmer *et al*., 2013). Common Tern are Amber-listed in Ireland due to moderate short- and long-term declines in breeding range and the localised nature of the breeding population, with over 50% of the population found at ten sites or fewer.

3.16.1 Common Tern Abundance

Common Terns were only recorded from transects in two months of survey (see Table 3.16.1): August 2018 (Figure 3.16.1) and September 2018 (Figure 3.16.2), although birds were also observed in the wider survey area in May 2018. All three transects records were of birds flying through the Licence area, and likely refer to post-breeding dispersal.

Table 3.16.1 Common Tern records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	1
June 2018	0	0
July 2018	0	0
August 2018	1	9
September 2018	2	21
October 2018	0	0
November 2018	0	0
December 2018	0	0
January 2019	0	0
February 2019	0	0
March 2019	0	0
April 2019	0	0
TOTAL	**3**	**31**

3.16.2 Common Tern Density

With no records of birds on the sea within 200m of the transect route, density estimates were not derived.

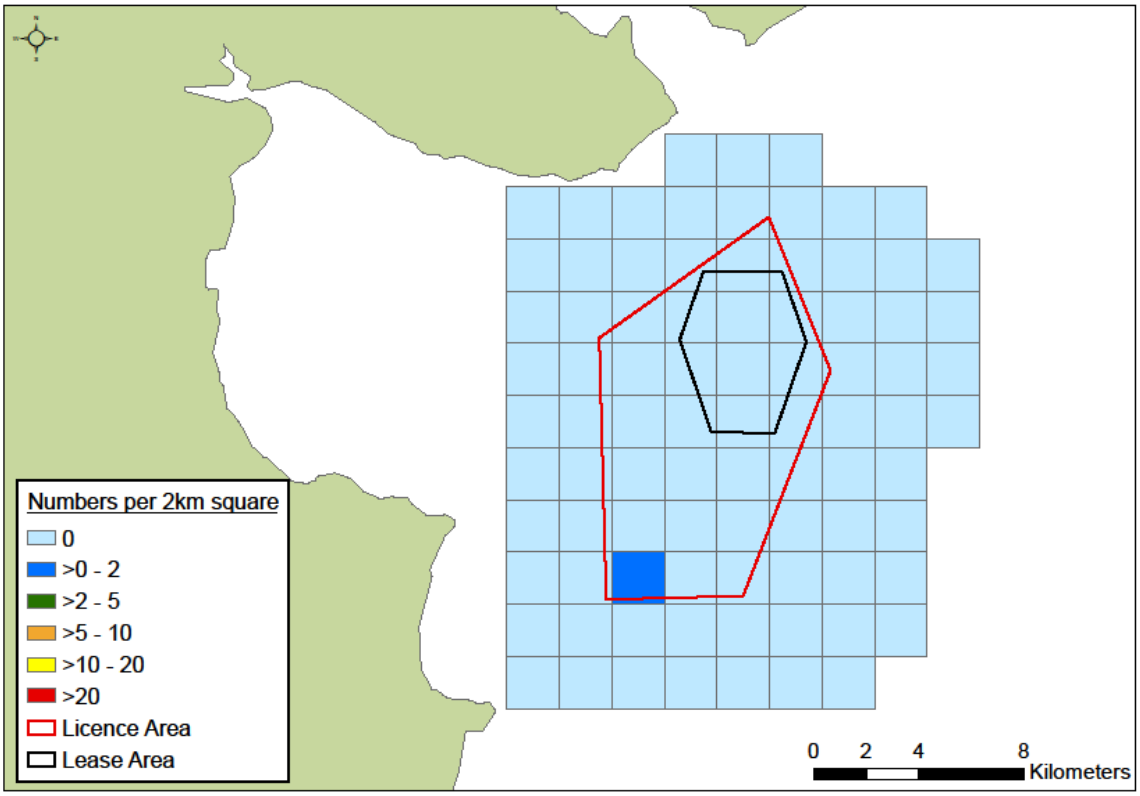

Figure 3.16.1 Common Tern survey results August 2018

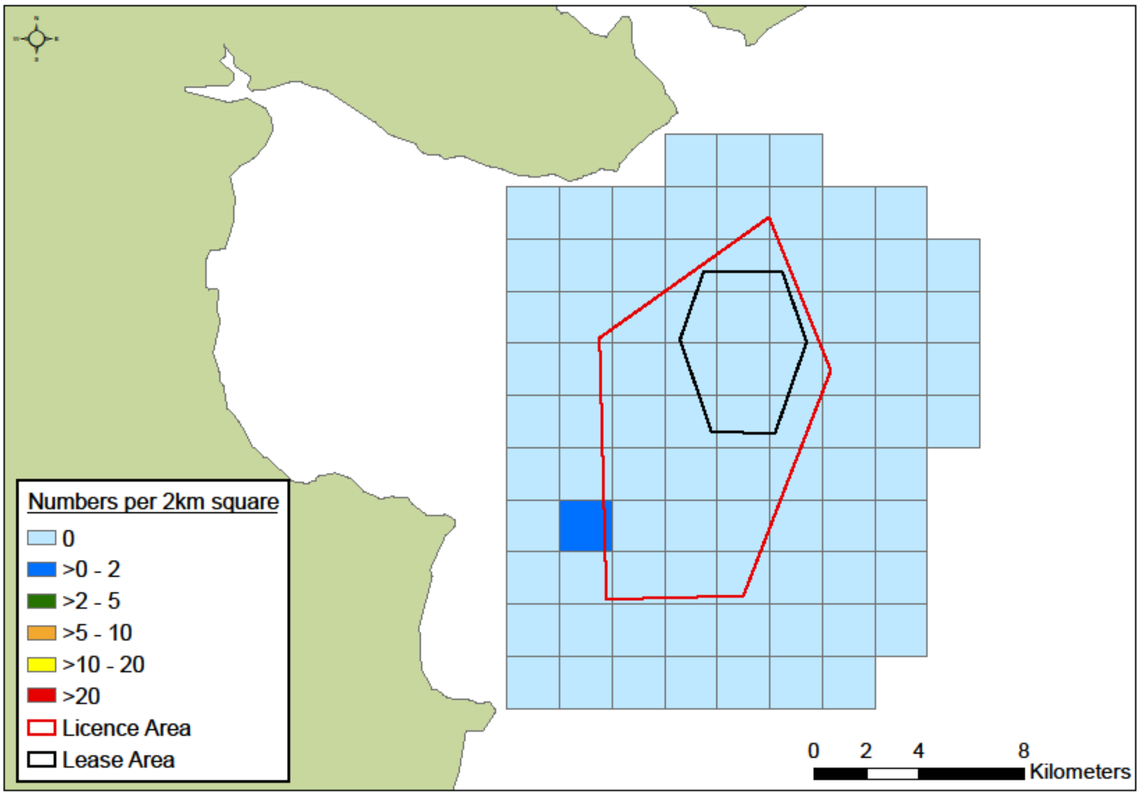

Figure 3.16.2 Common Tern survey results September 2018

3.17 Great Skua

A small population of Great Skua has recently been discovered breeding in Ireland, and approximately eight breeding pairs at four to five sites are known (Newton, 2016; Balmer *et al*., 2013). Great Skuas are kleptoparasites, stealing food from other seabirds, as well as scavenging from fishing discards and predating eggs, chicks and other seabirds (Mitchell *et al*., 2004). Due to their status as a rare breeder, coupled with the localised nature of the breeding population in Ireland, Great Skua are Amber-listed (Colhoun & Cummins, 2013).

3.17.1 Great Skua Abundance

Only a single Great Skua was recorded during monthly transect survey in August 2018 (Table 3.17.1; Figure 3.17.1). However, additional observations were made within the survey area, comprising a further seven birds in June 2018 (one individual), September 2018 (two), October 2018 (two), December 2018 (one) and April 2019 (one).

Table 3.17.1 Great Skua records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	0
June 2018	0	1
July 2018	0	0
August 2018	1	1
September 2018	0	2
October 2018	0	2
November 2018	0	0
December 2018	0	1
January 2019	0	0
February 2019	0	0
March 2019	0	0
April 2019	0	1
TOTAL	**1**	**8**

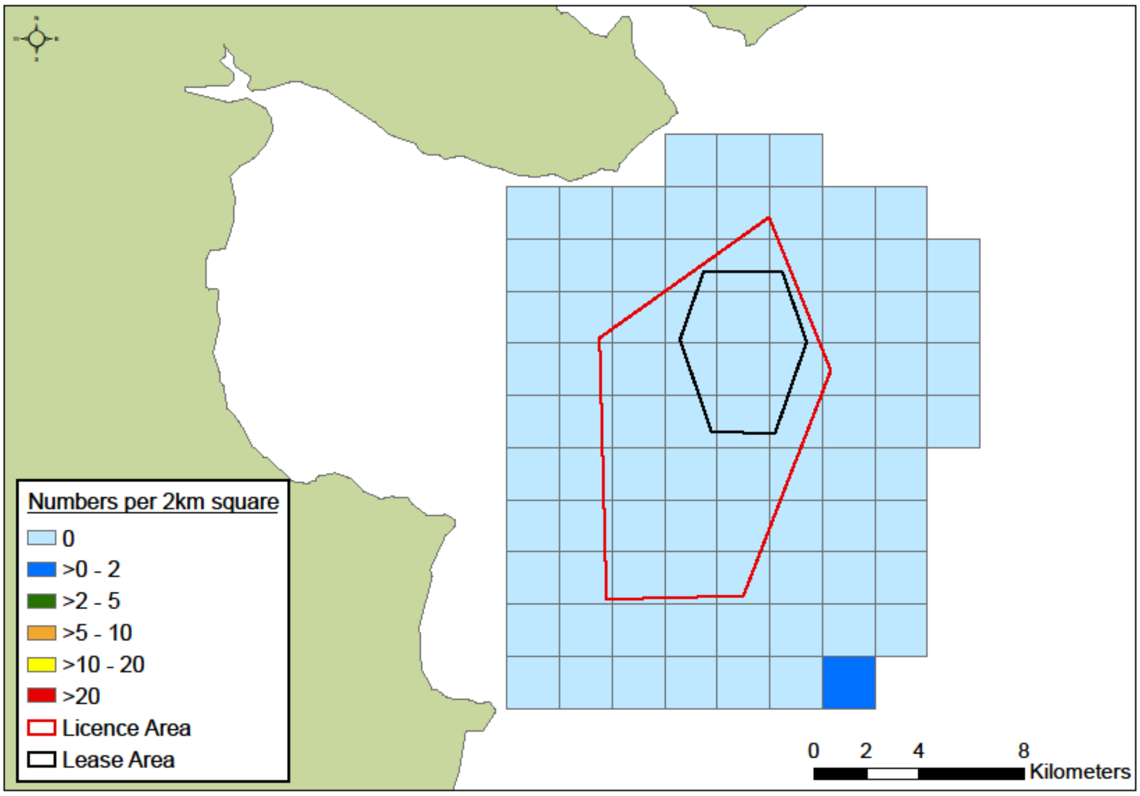

Figure 3.17.1 Great Skua survey results August 2018

3.17.2 Great Skua Density

With only a single record of a Great Skua on the sea within 200m of the transect route, no density estimate was derived for this species.

3.18 Guillemot

Guillemot are the commonest seabird in Ireland with an all-Ireland total estimated at 236,654 birds (Mitchell *et al.*, 2004). They breed on sea cliff colonies where suitable habitat exists around Ireland, with breeding confirmed south of the Oriel Windfarm survey area on the east coast of Ireland (Balmer *et al.*, 2013). Guillemot dive for prey, which typically comprise small fish such as sand eels and sprats (Mitchell *et al.*, 2004). Guillemot are Amber-listed in Ireland due to over 50% of the breeding population occurring at ten sites or fewer (Colhoun & Cummins, 2013).

3.18.1 Guillemot Abundance

Guillemot were the commonest bird recorded on transects, with a total of 5,000 individuals over the twelve months of surveys (see Table 3.18.1). Peak counts occurred in August 2018 (1,274 individuals; Figure 3.18.4) and September (1,640 individuals; Figure 3.18.5), representing the post-fledging dispersal of adults and juveniles.

Table 3.18.1 Guillemot records from boat surveys in Oriel Windfarm survey area, showing transects record and total observations.

Month	Transect records	All records
May 2018	228	277
June 2018	388	461
July 2018	247	299
August 2018	1,274	1,342
September 2018	1,640	1,655
October 2018	117	214
November 2018	44	64
December 2018	181	199
January 2019	115	201
February 2019	184	201
March 2019	179	245
April 2019	403	451
TOTAL	**5,000**	**5,609**

As a species that forages in marine waters, they were widespread across the whole survey area(see Figures 3.18.1 to 3.19.12). Of the 5,000 birds recorded, 1,028 (representing 20.6% of the total) were recorded in the Lease area, with 1,453 birds (29.1%) in the Licence area and 2,519 (50.4%) in the remaining survey area (Table 3.18.2).

Table 3.18.2 Guillemot records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	104	45.6	83	36.4	41	18.0
June 2018	219	56.4	90	23.2	79	20.4
July 2018	132	53.4	79	32.0	36	14.6
August 2018	533	41.8	464	36.4	277	21.7
September 2018	905	55.2	297	18.1	438	26.7
October 2018	54	46.2	40	34.2	23	19.7
November 2018	26	59.1	15	34.1	3	6.8
December 2018	96	53.0	65	35.9	20	11.0
January 2019	69	60.0	30	26.1	16	13.9
February 2019	107	58.2	58	31.5	19	10.3
March 2019	107	59.8	40	22.3	32	17.9
April 2019	167	41.4	192	47.6	44	10.9
TOTAL	**2,519**	**50.4**	**1,453**	**29.1**	**1,028**	**20.6**

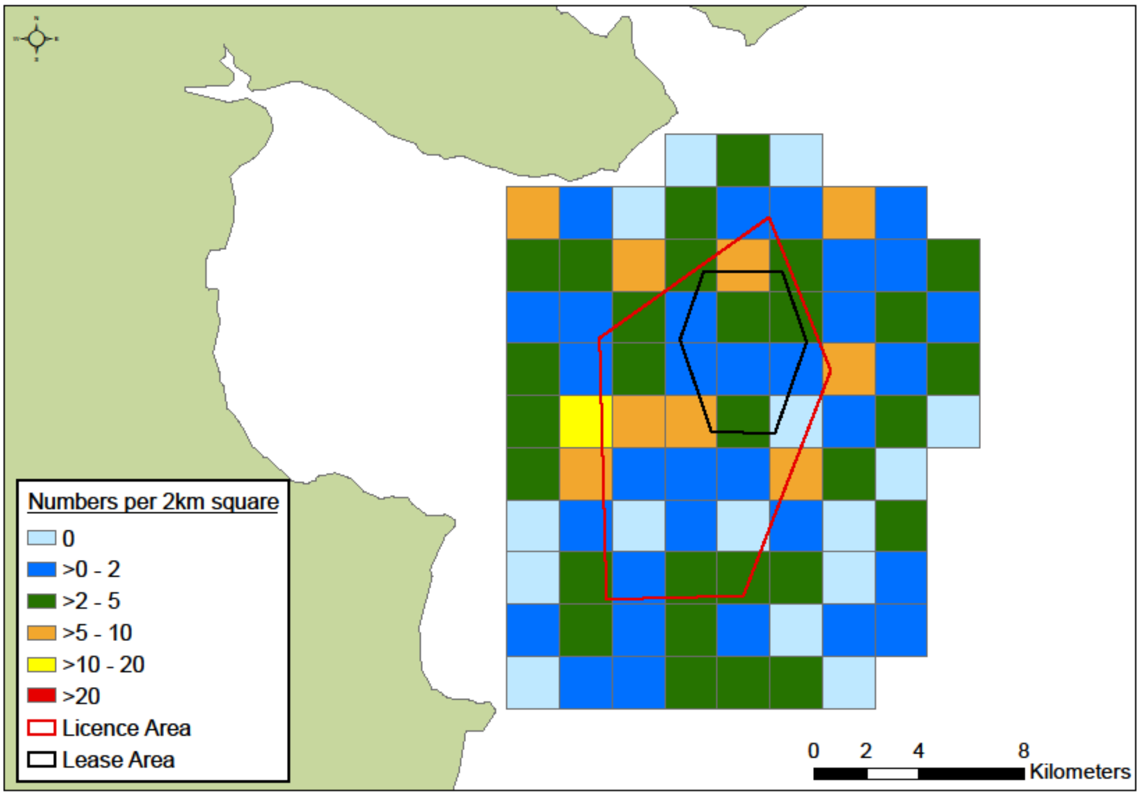

Figure 3.18.1 Guillemot survey results May 2018

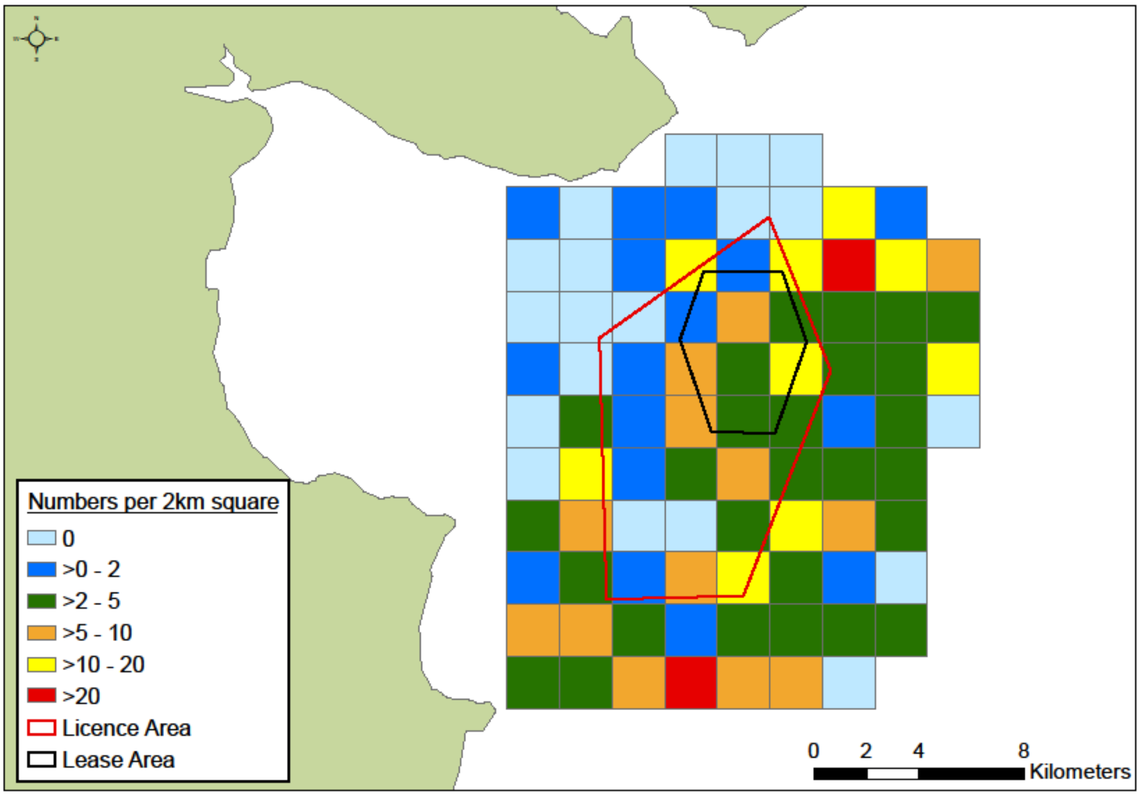

Figure 3.18.2 Guillemot survey results June 2018

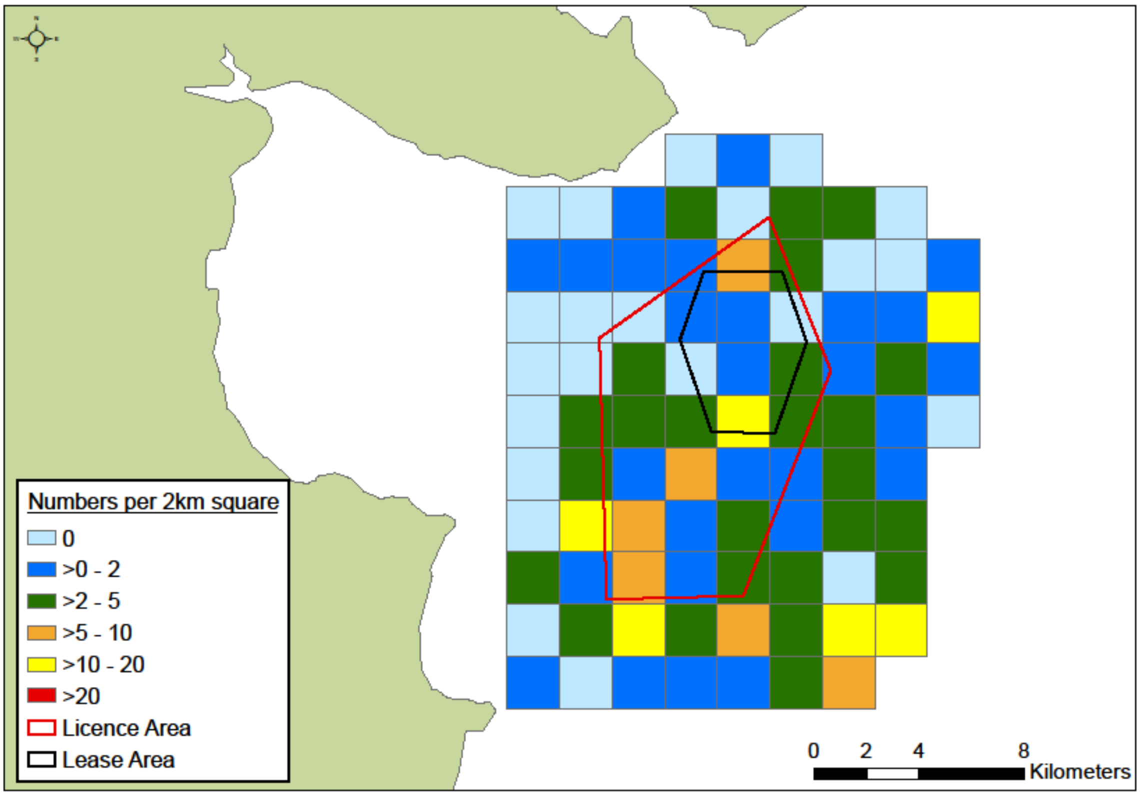

Figure 3.18.3 Guillemot survey results July 2018

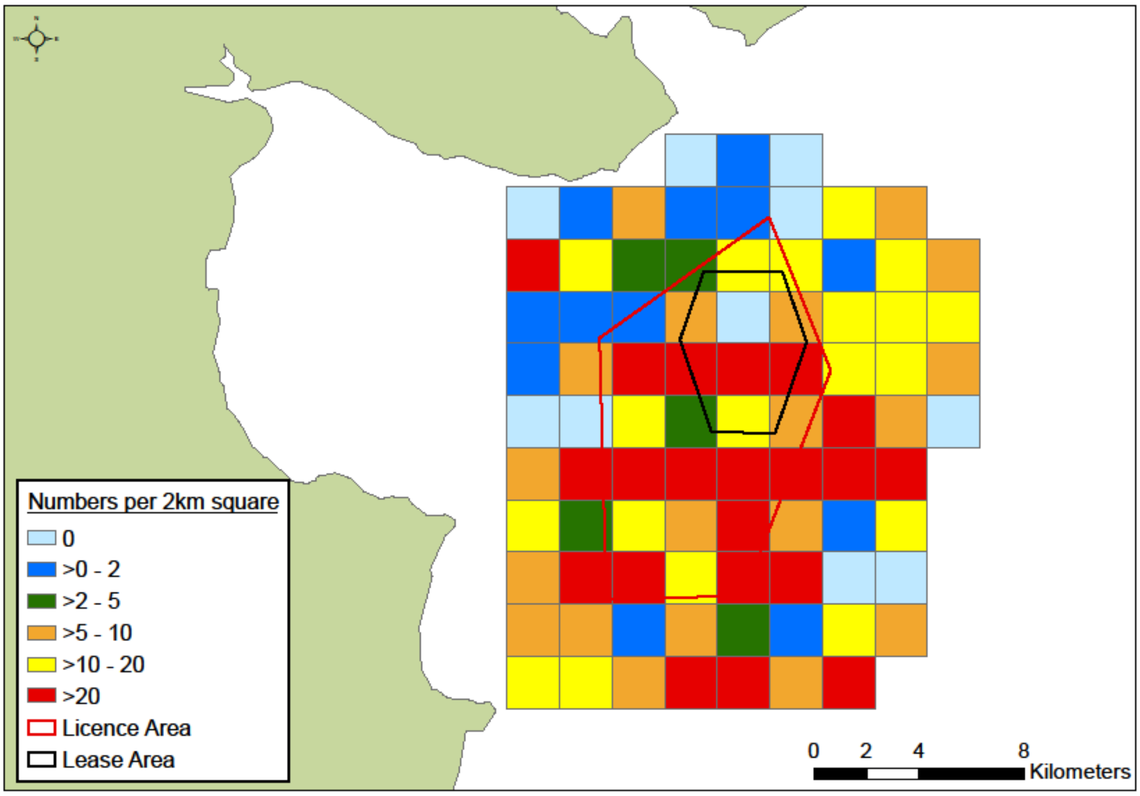

Figure 3.18.4 Guillemot survey results August 2018

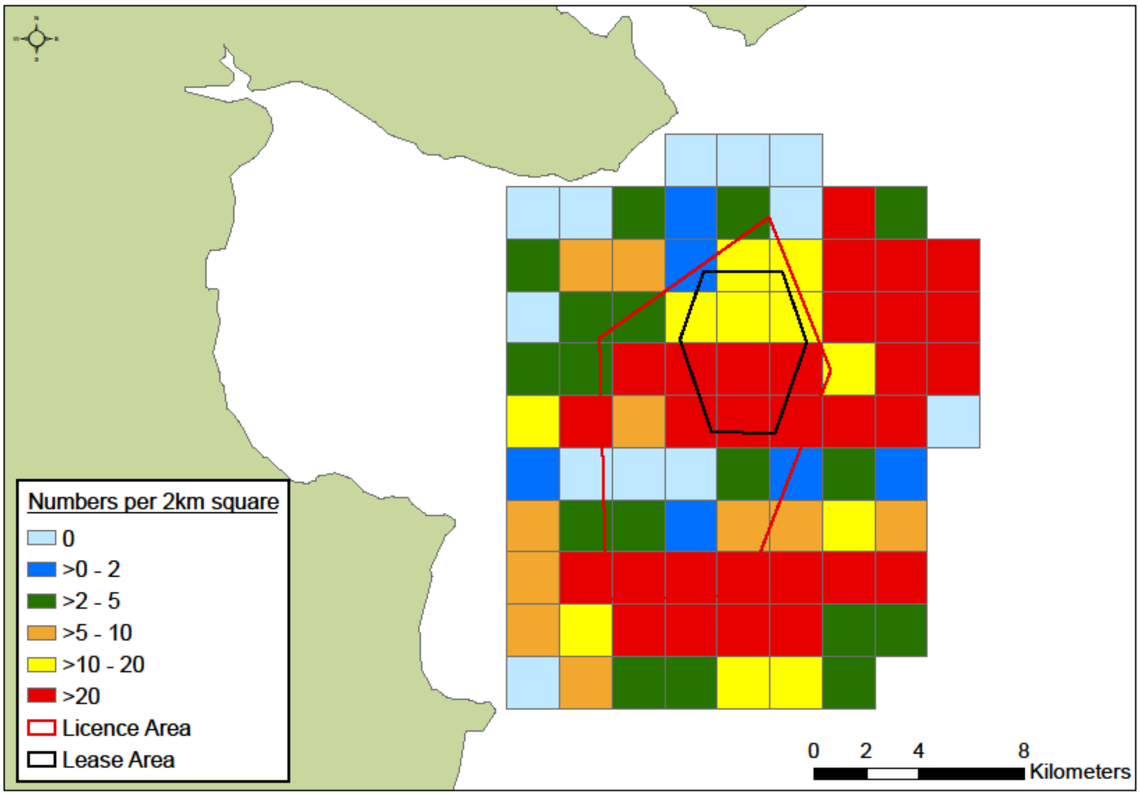

Figure 3.18.5 Guillemot survey results September 2018

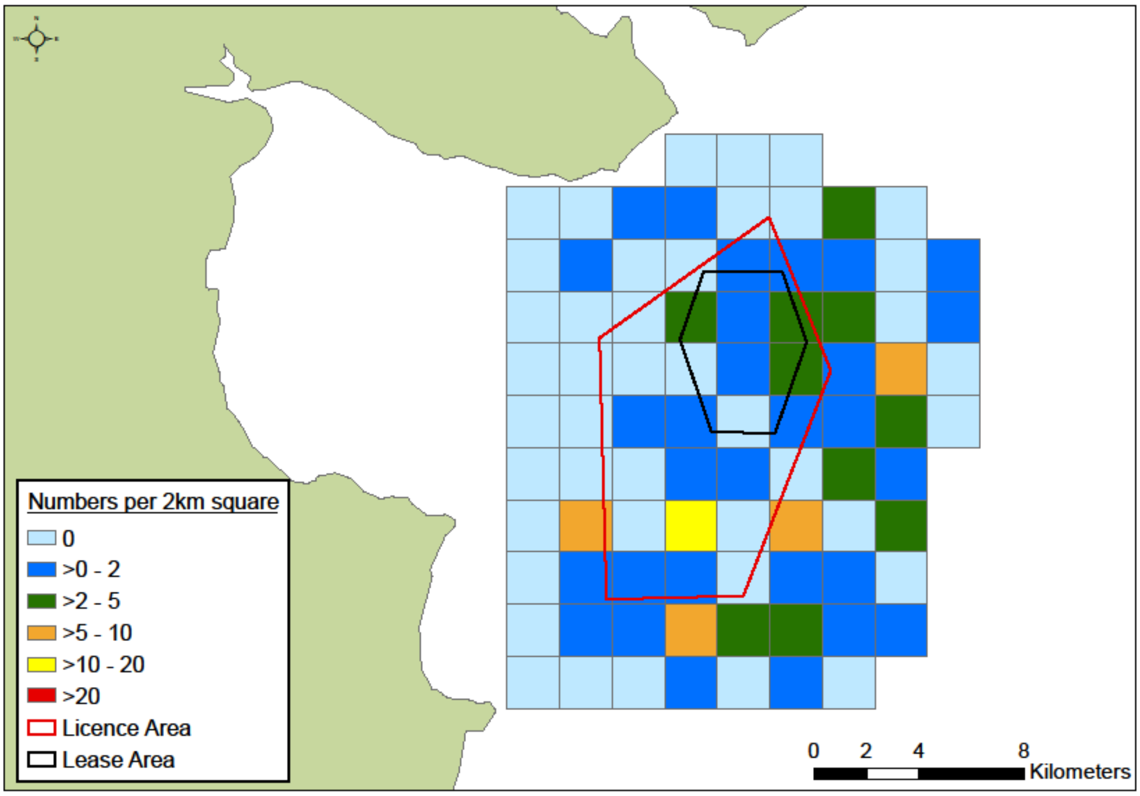

Figure 3.18.6 Guillemot survey results October 2018

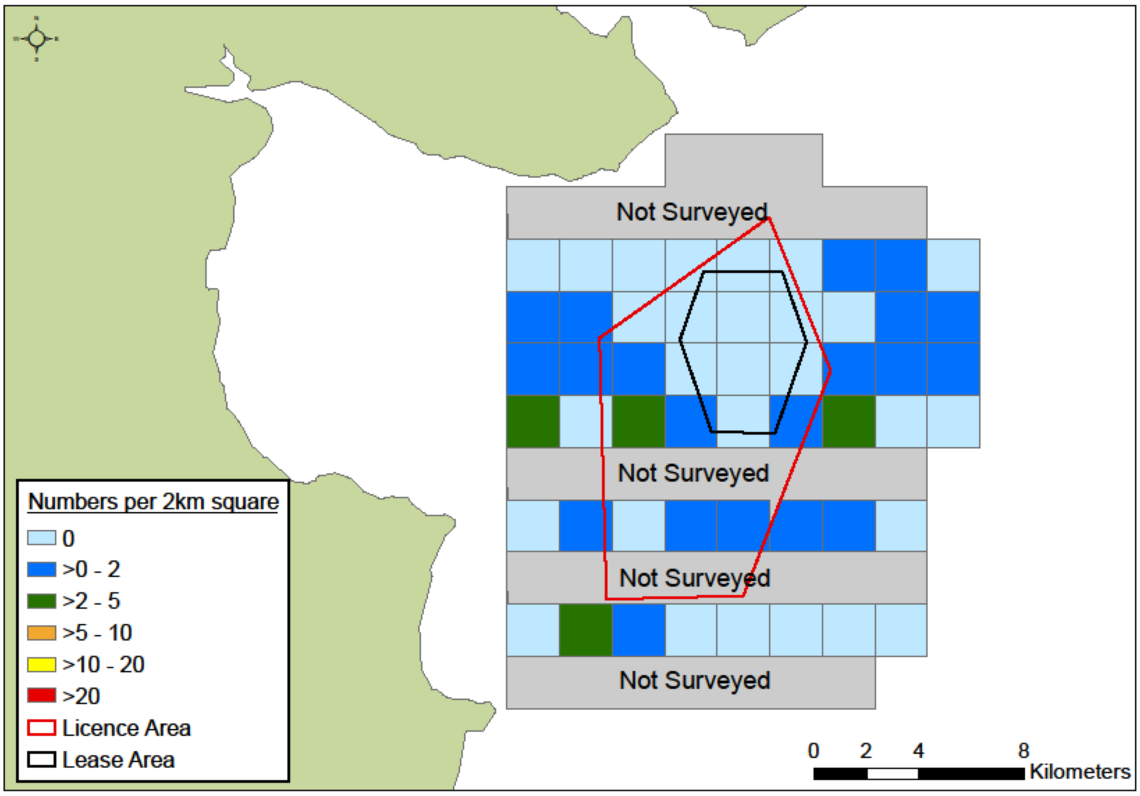

Figure 3.18.7 Guillemot survey results November 2018

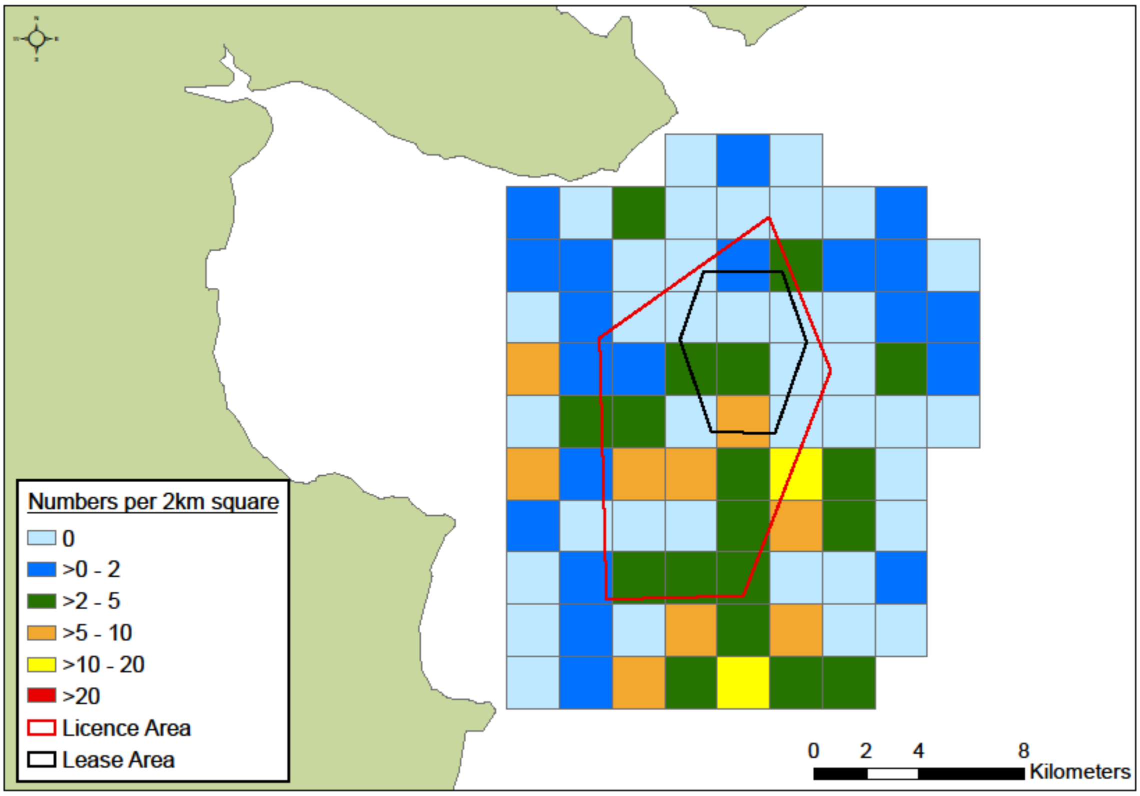

Figure 3.18.8 Guillemot survey results December 2018

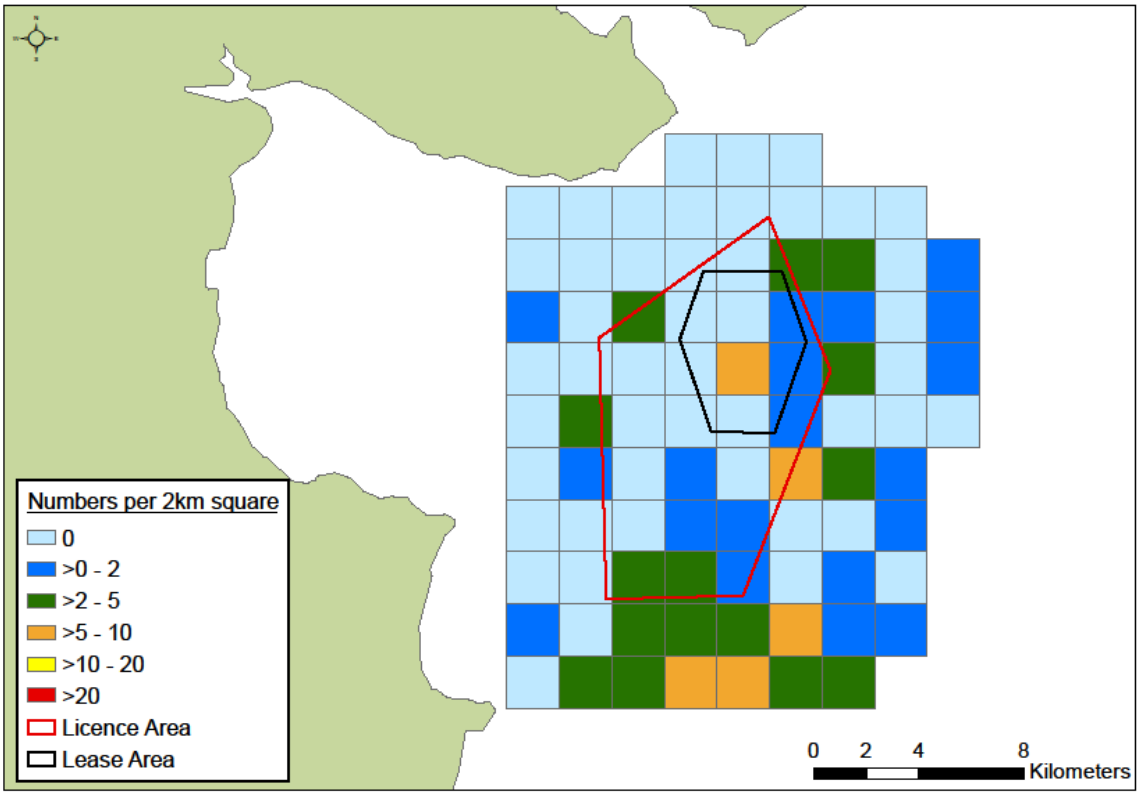

Figure 3.18.9 Guillemot survey results January 2019

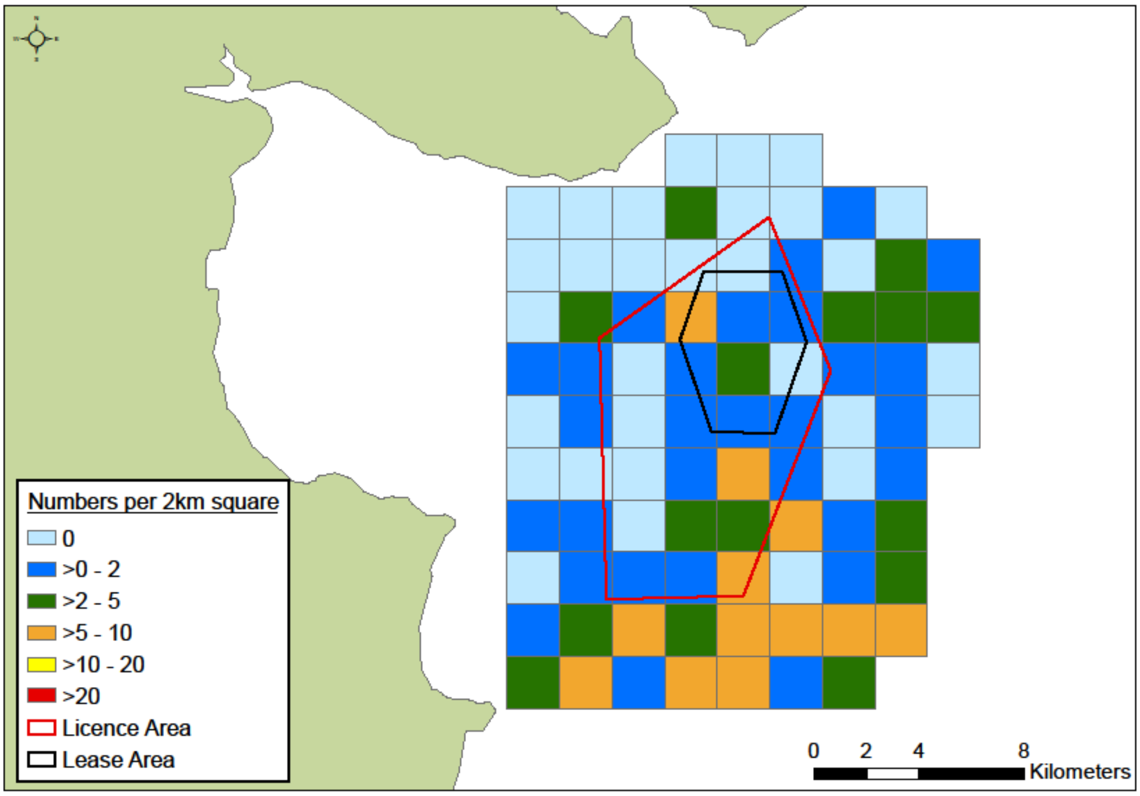

Figure 3.18.10 Guillemot survey results February 2019

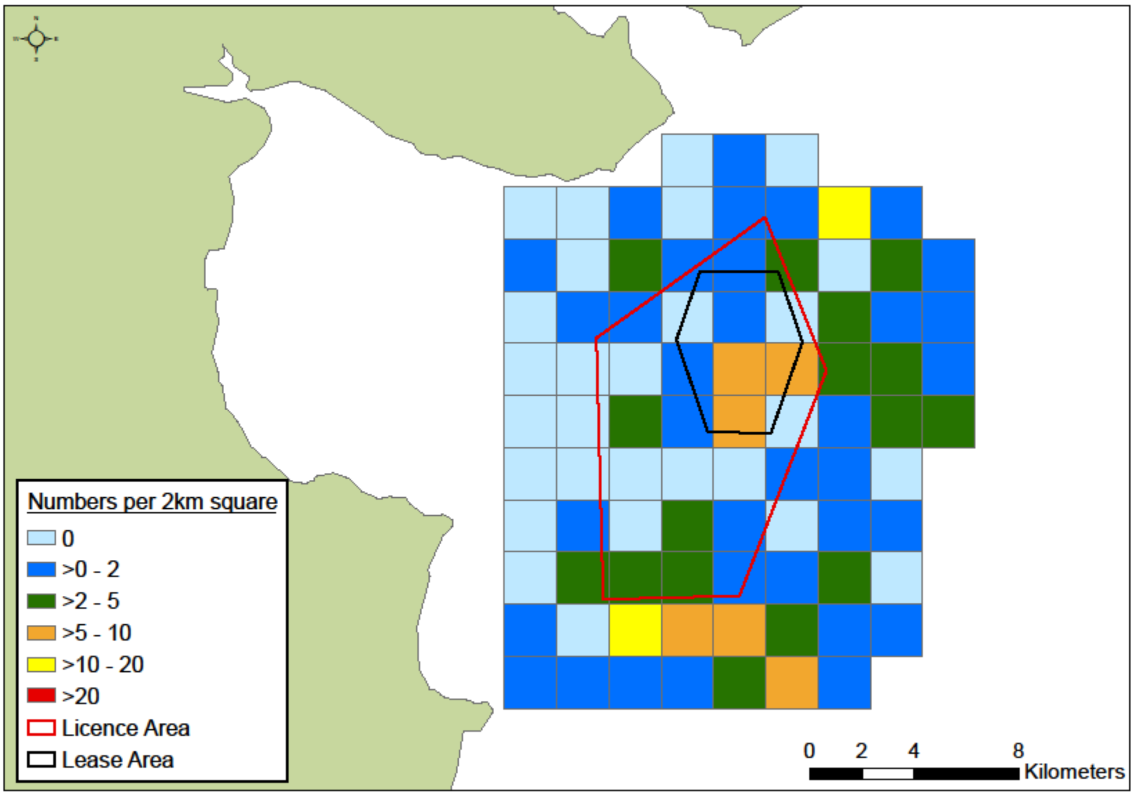

Figure 3.18.11 Guillemot survey results March 2019

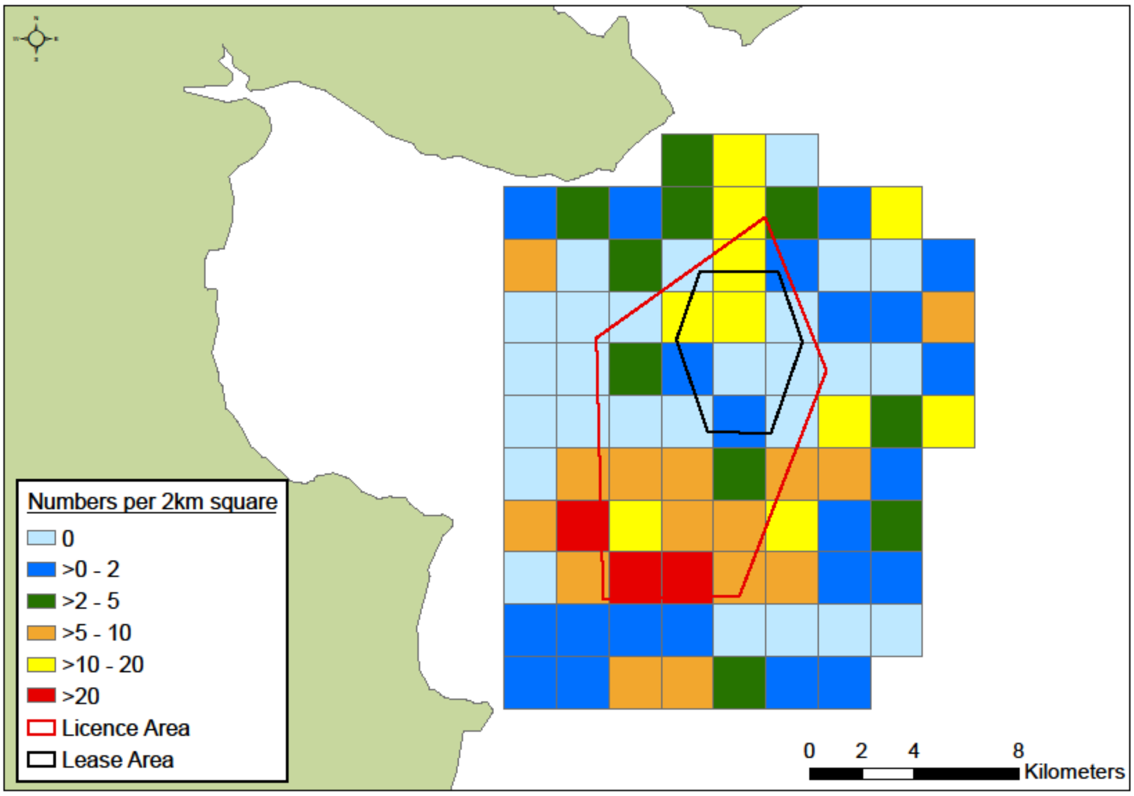

Figure 3.18.12 Guillemot survey results April 2019

3.18.2 Guillemot Density

The derived density estimates for Guillemot, using data from the transects surveys, are shown on a month-by-month basis in Figures 3.18.13 to 3.18.24. The peak derived density estimate was in September, when 11.65 birds/km^2 were observed.

Density estimates for the western Irish Sea (Jessop *et al*., 2018) were derived from a combination of both Guillemot and Razorbill data; this approach for comparative purposes is also adopted here (see Section 3.20.2).

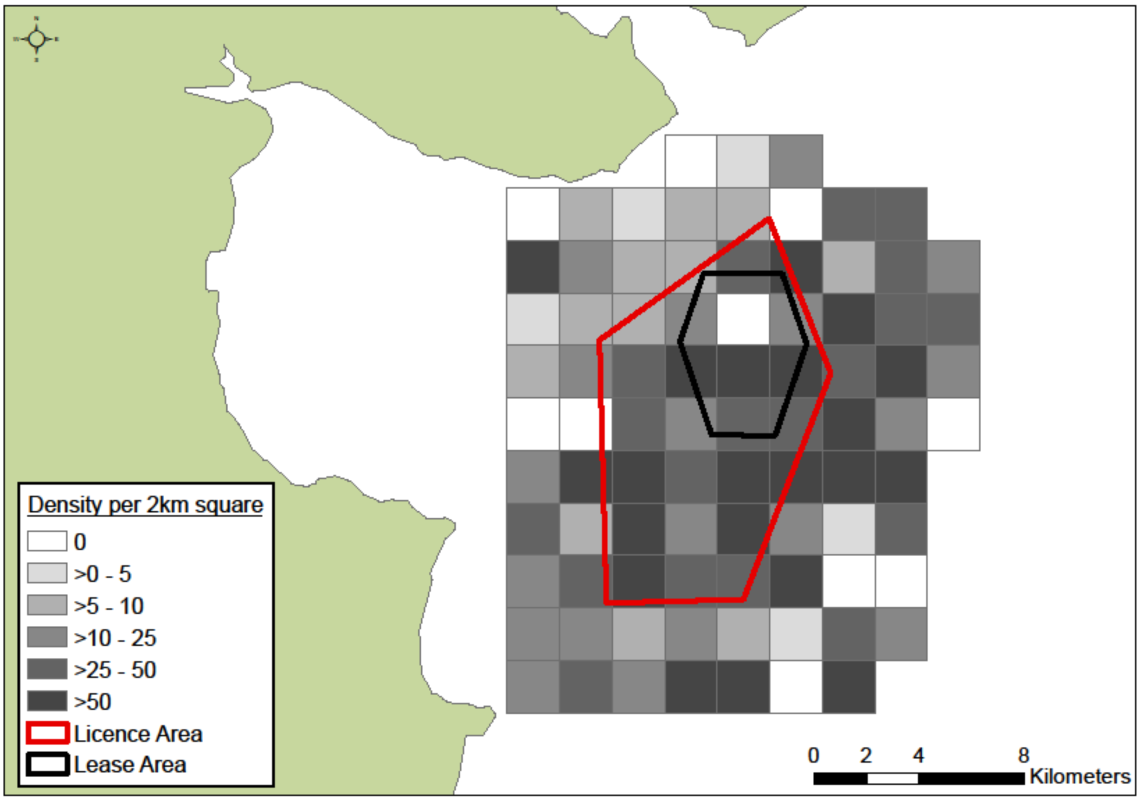

Figure 3.18.13 Guillemot density estimates May 2018

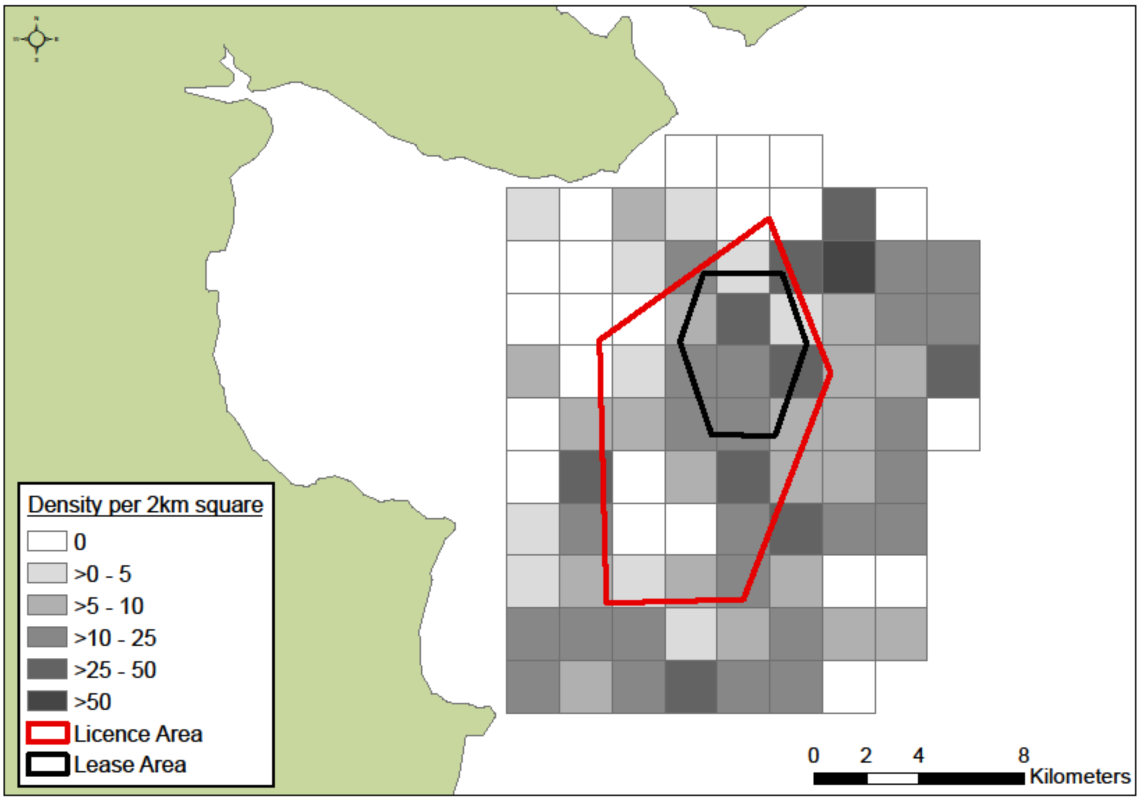

Figure 3.18.14 Guillemot density estimates June 2018

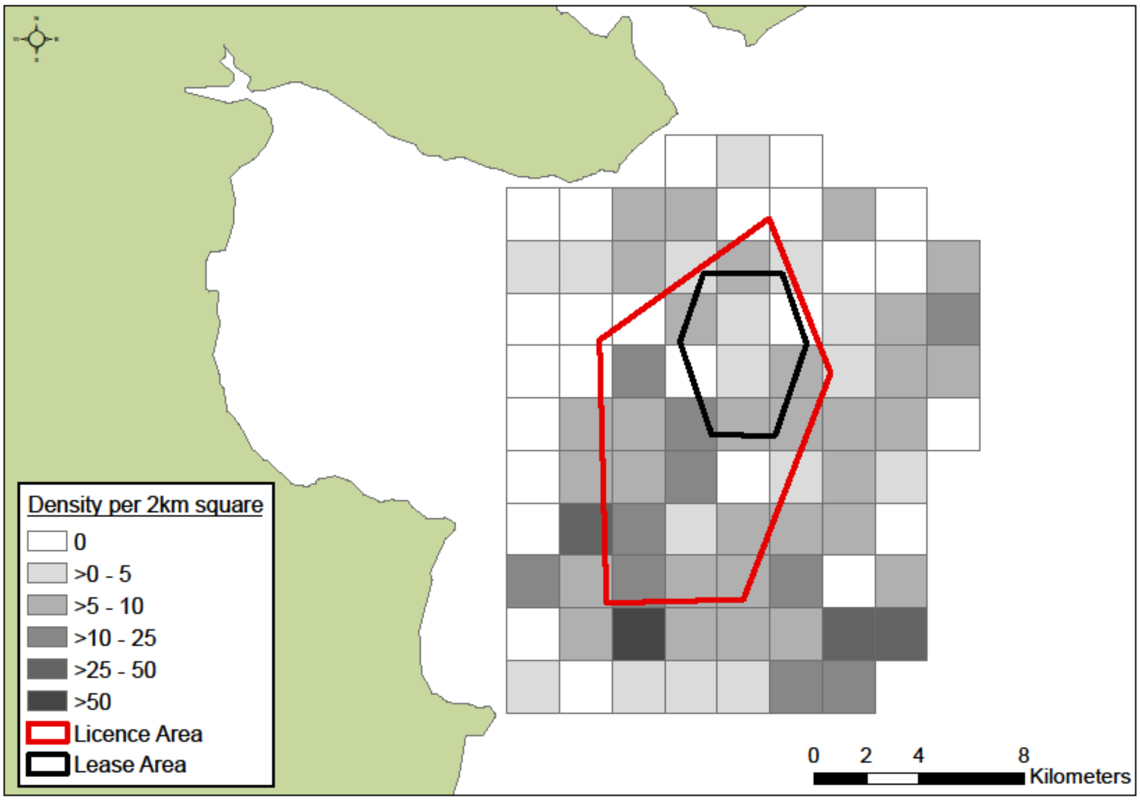

Figure 3.18.15 Guillemot density estimates July 2018

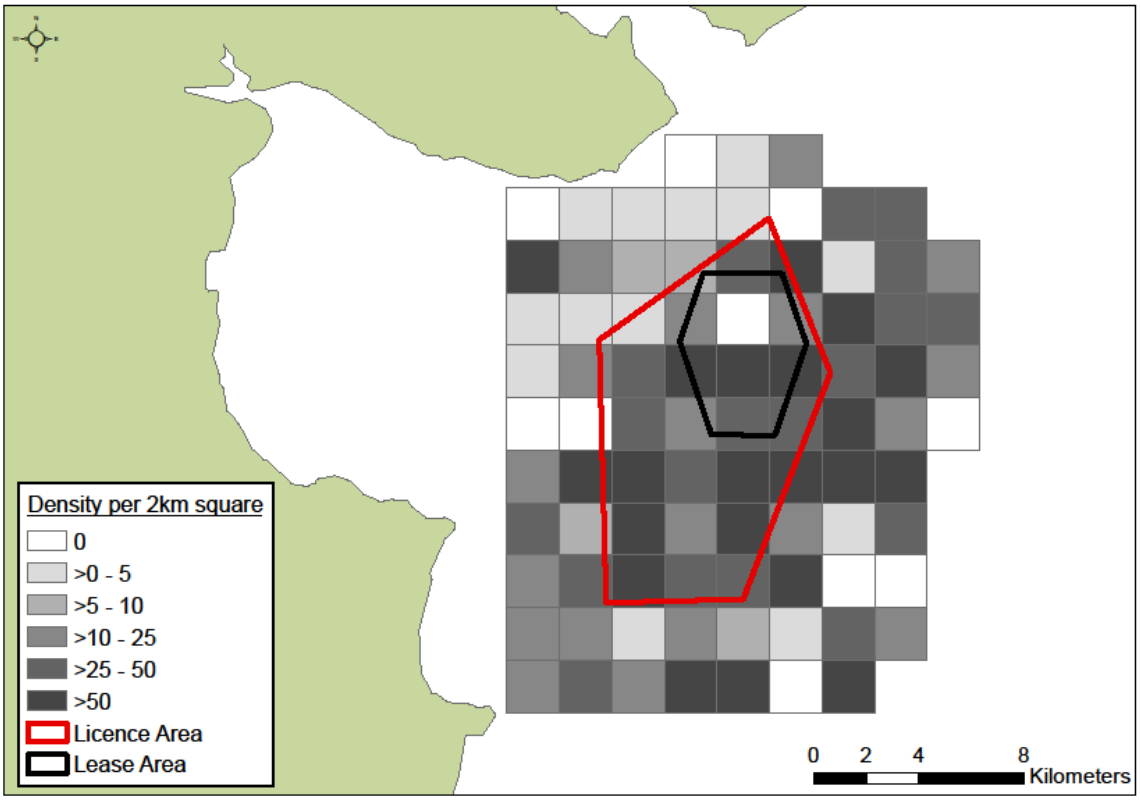

Figure 3.18.16 Guillemot density estimates August 2018

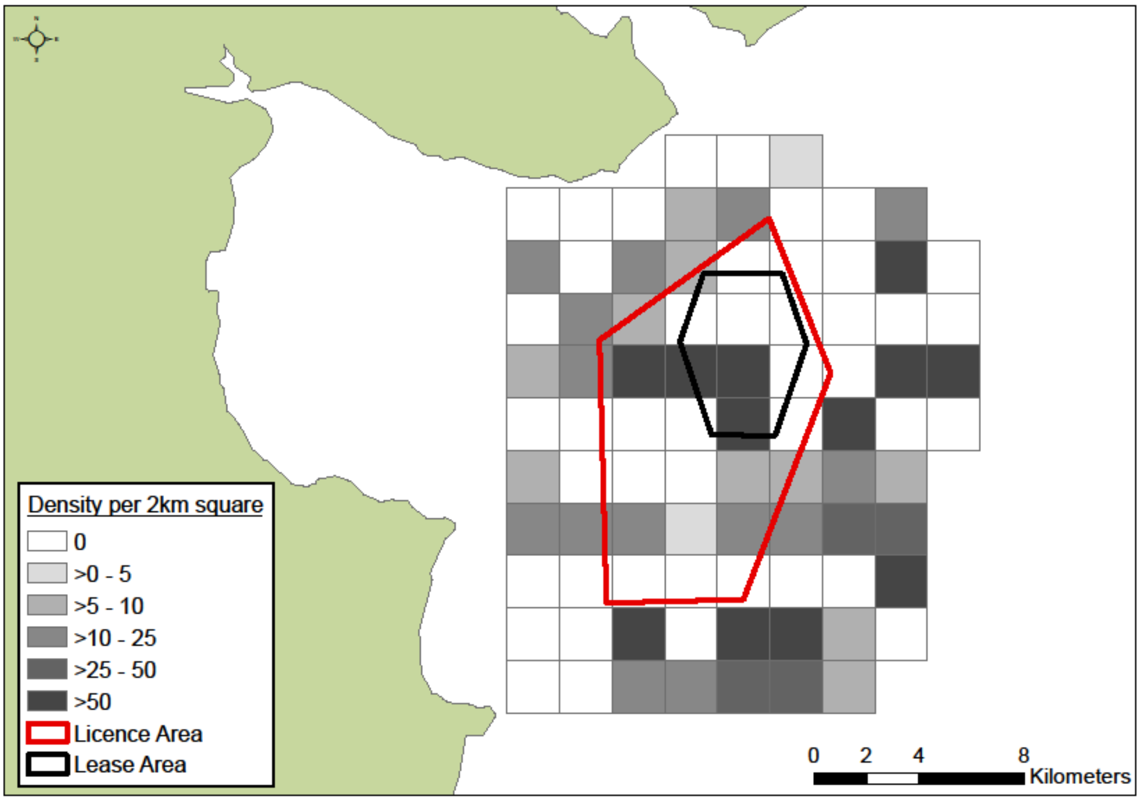

Figure 3.18.17 Guillemot density estimates September 2018

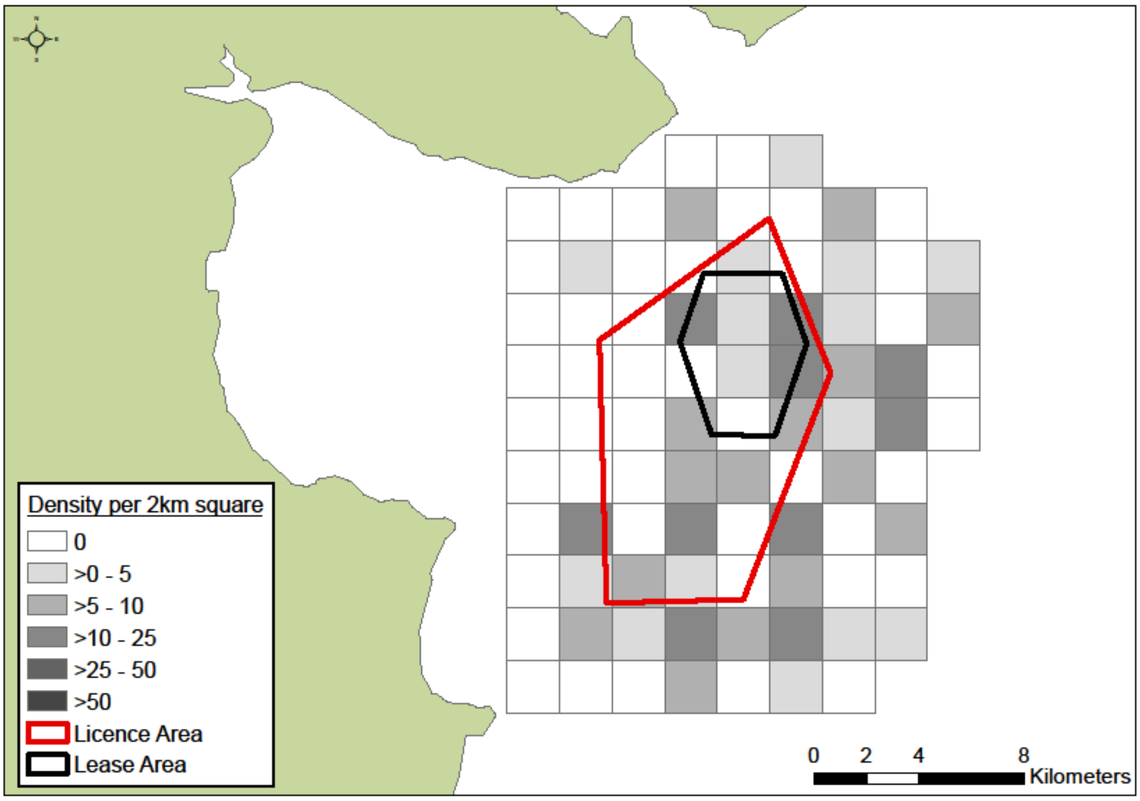

Figure 3.18.18 Guillemot density estimates October 2018

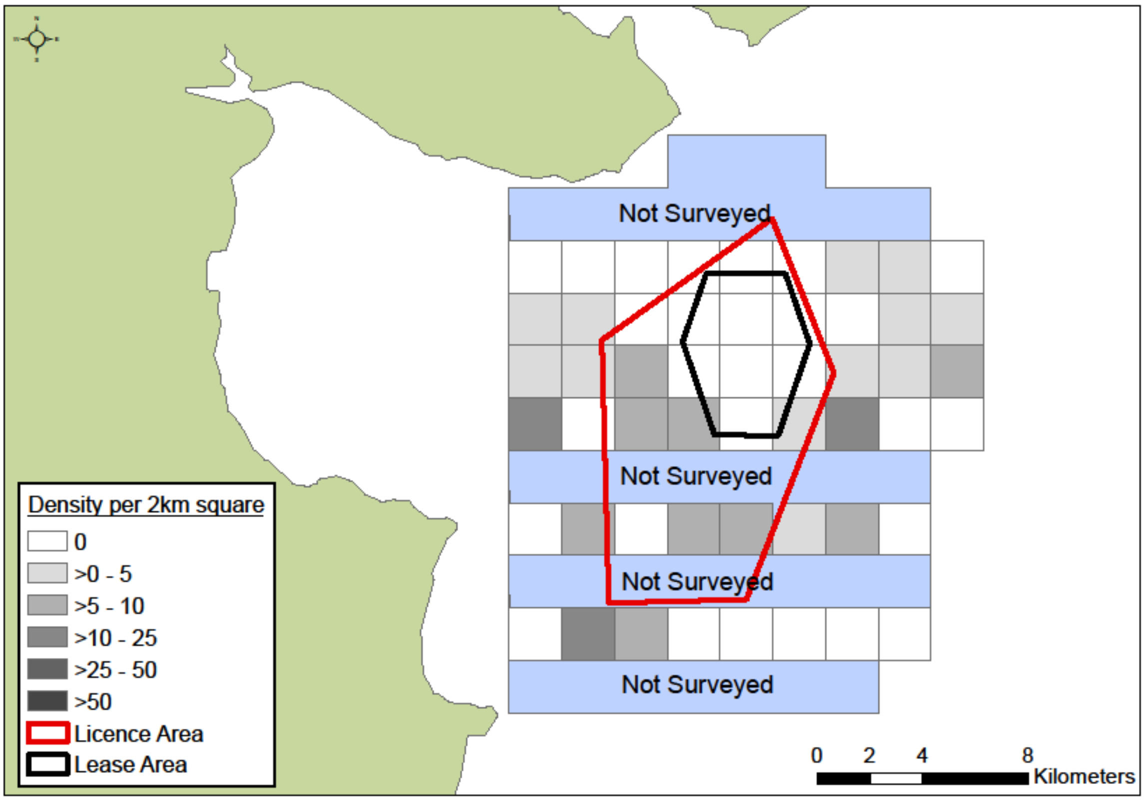

Figure 3.18.19 Guillemot density estimates November 2018

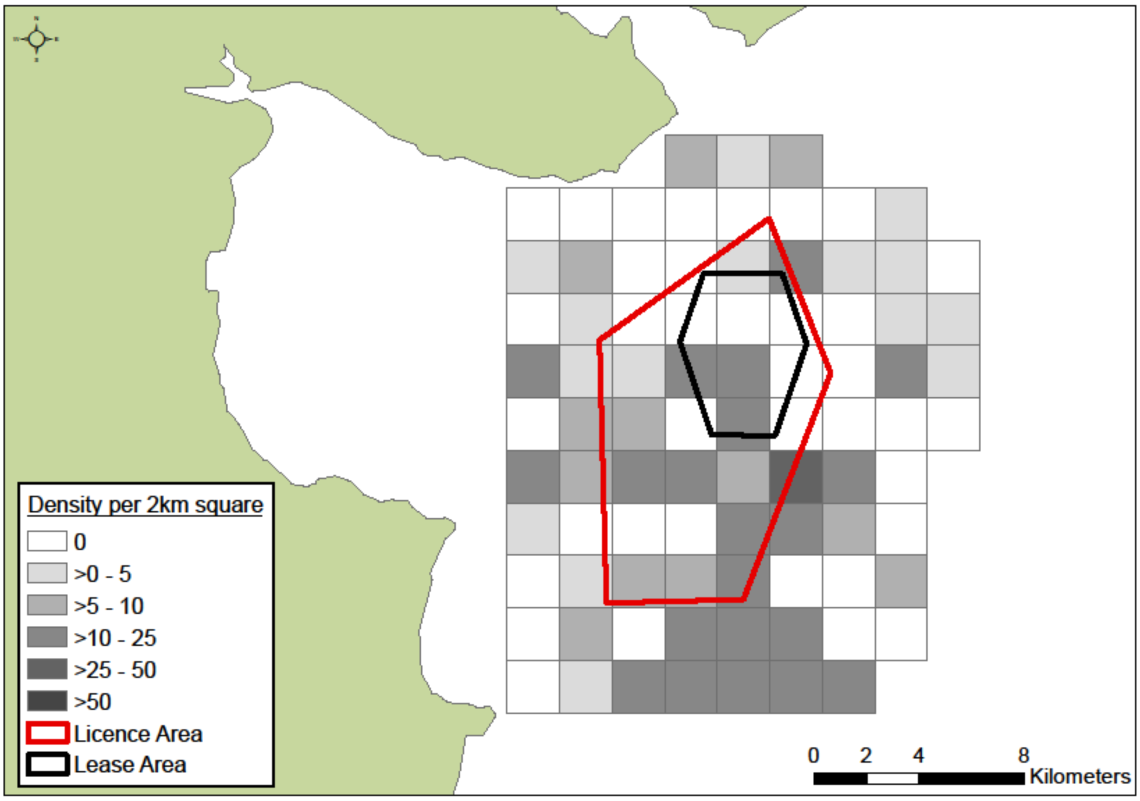

Figure 3.18.20 Guillemot density estimates December 2018

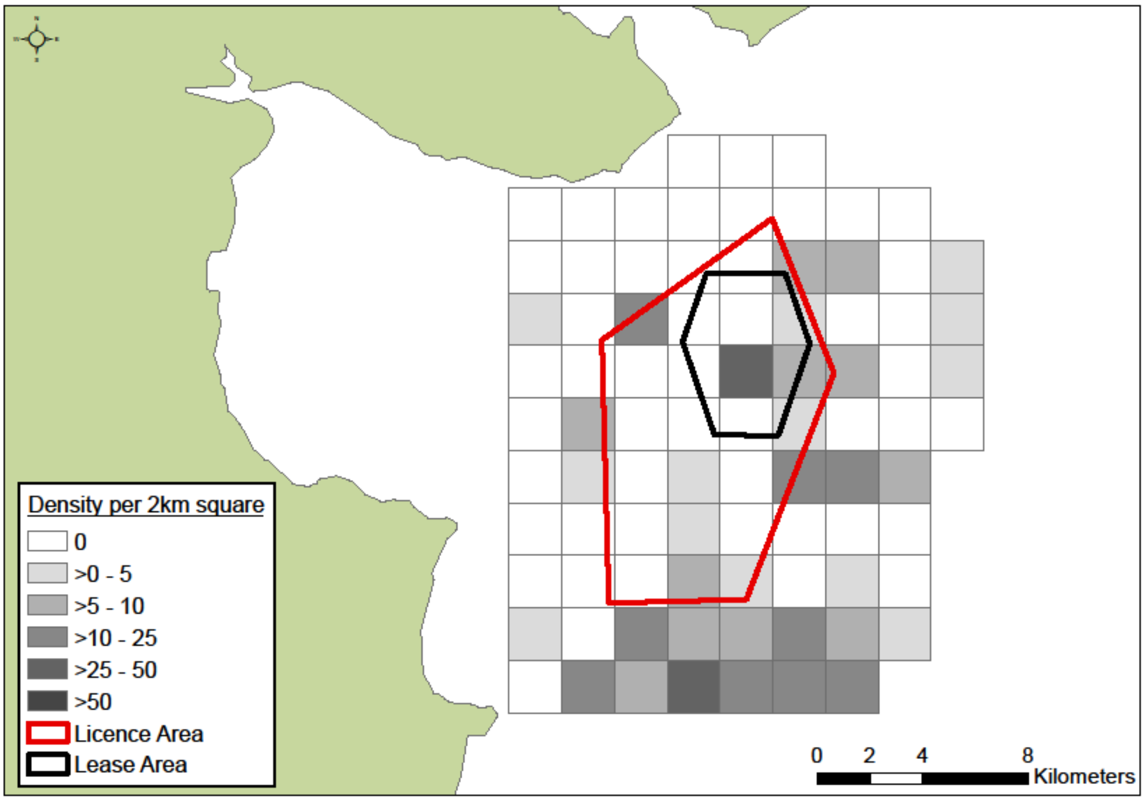

Figure 3.18.21 Guillemot density estimates January 2019

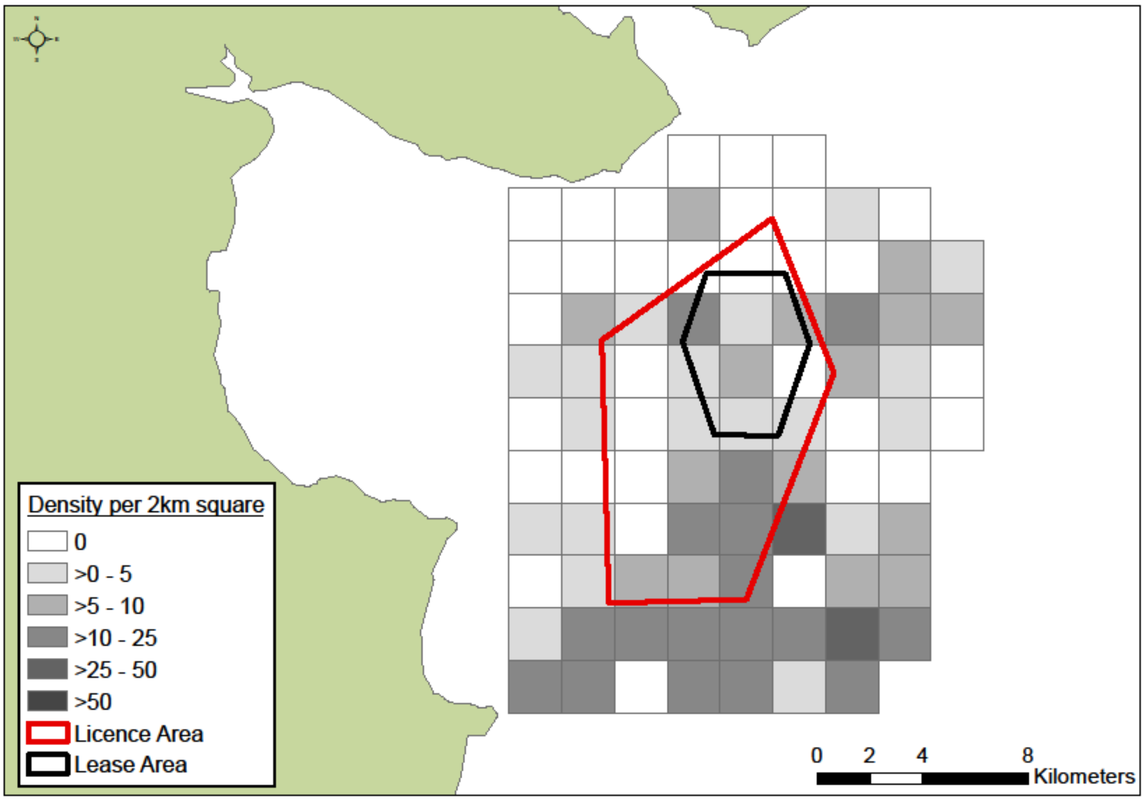

Figure 3.18.22 Guillemot density estimates February 2019

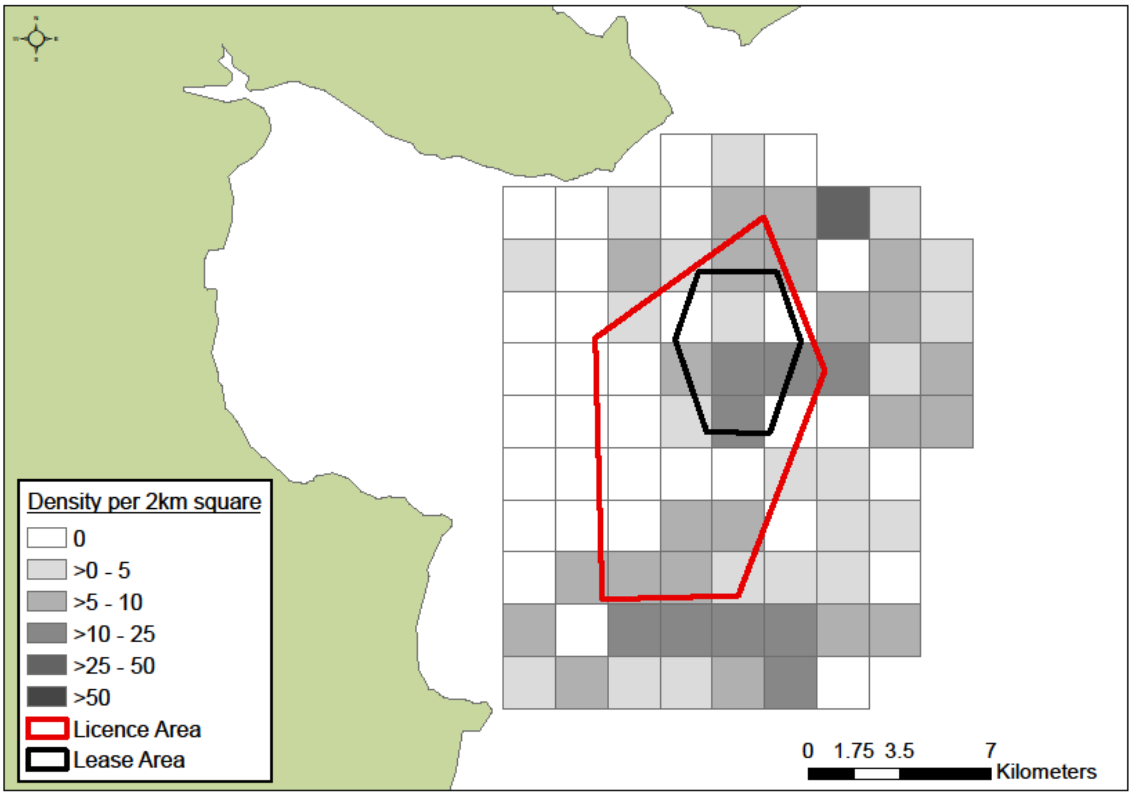

Figure 3.18.23 Guillemot density estimates March 2019

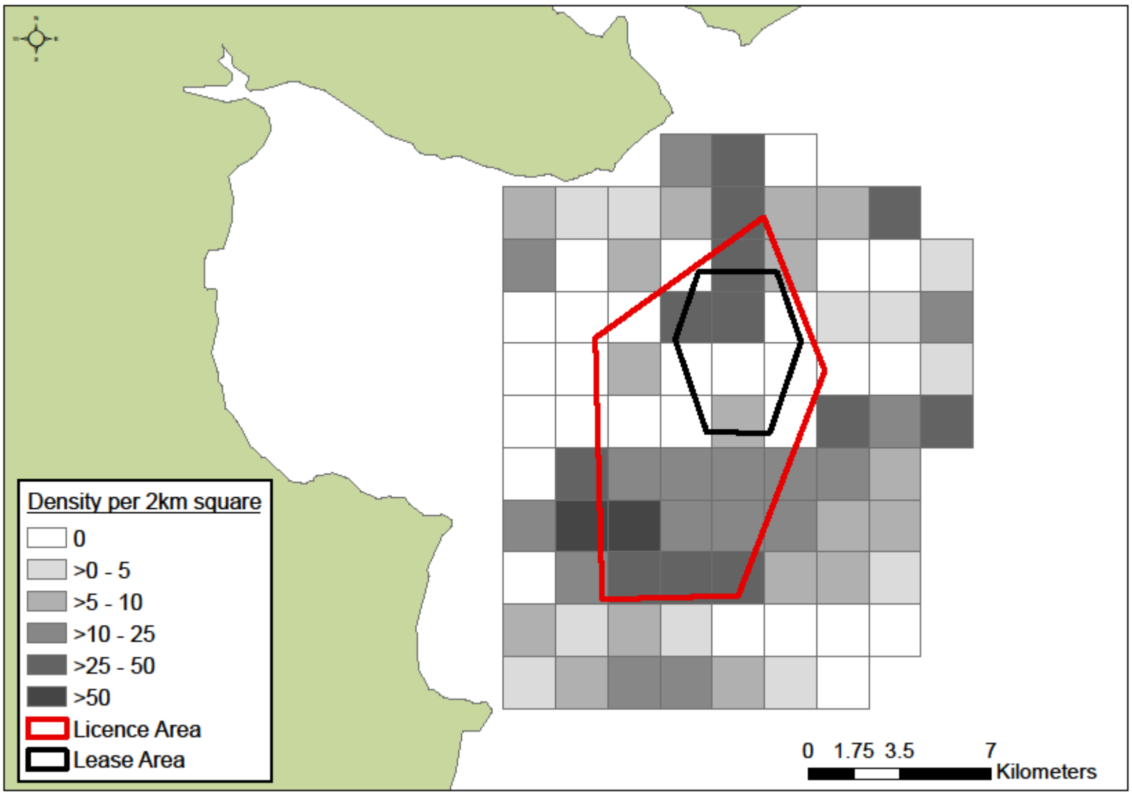

Figure 3.18.24 Guillemot density estimates April 2019

3.19 Razorbill

Razorbill breed in very similar habitats to Guillemot (sea cliffs) and consequently are typically found in the same areas in Ireland (Balmer *et al*., 2013). They typically feed on slightly larger fish than Guillemot, with a preference for sprats over sand eels (Ouwehand *et al*., 2004). Razorbill are Amber-listed in Ireland due to over 50% of the breeding population occurring at ten sites or fewer (Colhoun & Cummins, 2013).

3.19.1 Razorbill Abundance

Razorbills were recorded in each month of surveying, with a peak count in October 2018 of 224 birds on the transects out of a total of 439 individuals observed (Table 3.19.1; Figure 3.19.6). This peak likely equates to post-breeding dispersal of adults and juveniles. Numbers during the breeding season (April to July) were typically low as there are no breeding colonies immediately adjacent to the Oriel Windfarm survey area.

Table 3.19.1 Razorbill records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	10	15
June 2018	4	10
July 2018	2	5
August 2018	138	140
September 2018	63	65
October 2018	224	439
November 2018	28	39
December 2018	105	111
January 2019	191	219
February 2019	98	108
March 2019	44	51
April 2019	4	7
TOTAL	**911**	**1,209**

Most birds were recorded in offshore areas, away from the more coastal part in the west and north-west of the survey area (see Figures 3.19.1 to 3.19.12). The distribution of birds between the three survey zones was similar to that for Guillemot, with 14.1% of records in the Lease area, 27.4% of records in the Licence area and the remaining 58.5% of individuals recorded from the remaining survey area (Figure 3.19.2).

Table 3.19.2 Razorbill records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	5	50.0	0	0	5	50.0
June 2018	1	25.0	2	50.0	1	25.0
July 2018	2	100	0	0	0	0
August 2018	54	39.1	73	52.9	11	8.0
September 2018	41	65.1	11	17.5	11	17.5
October 2018	156	69.6	52	23.2	16	7.1
November 2018	28	100	0	0	0	0
December 2018	34	32.4	50	47.6	21	20.0
January 2019	137	71.7	26	13.6	28	14.7
February 2019	53	54.1	15	15.3	30	30.6
March 2019	21	47.7	18	40.9	5	11.4
April 2019	1	25.0	3	75.0	0	0
TOTAL	**533**	**58.5**	**250**	**27.4**	**128**	**14.1**

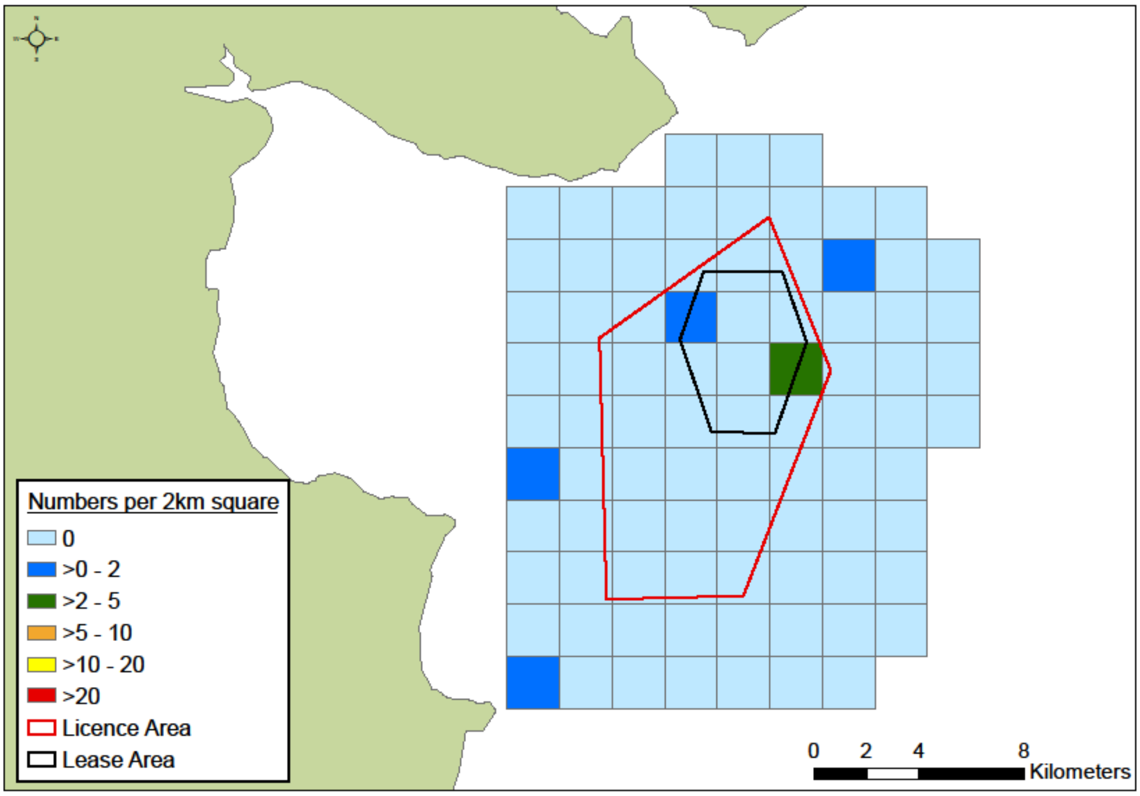

Figure 3.19.1 Razorbill survey results May 2018

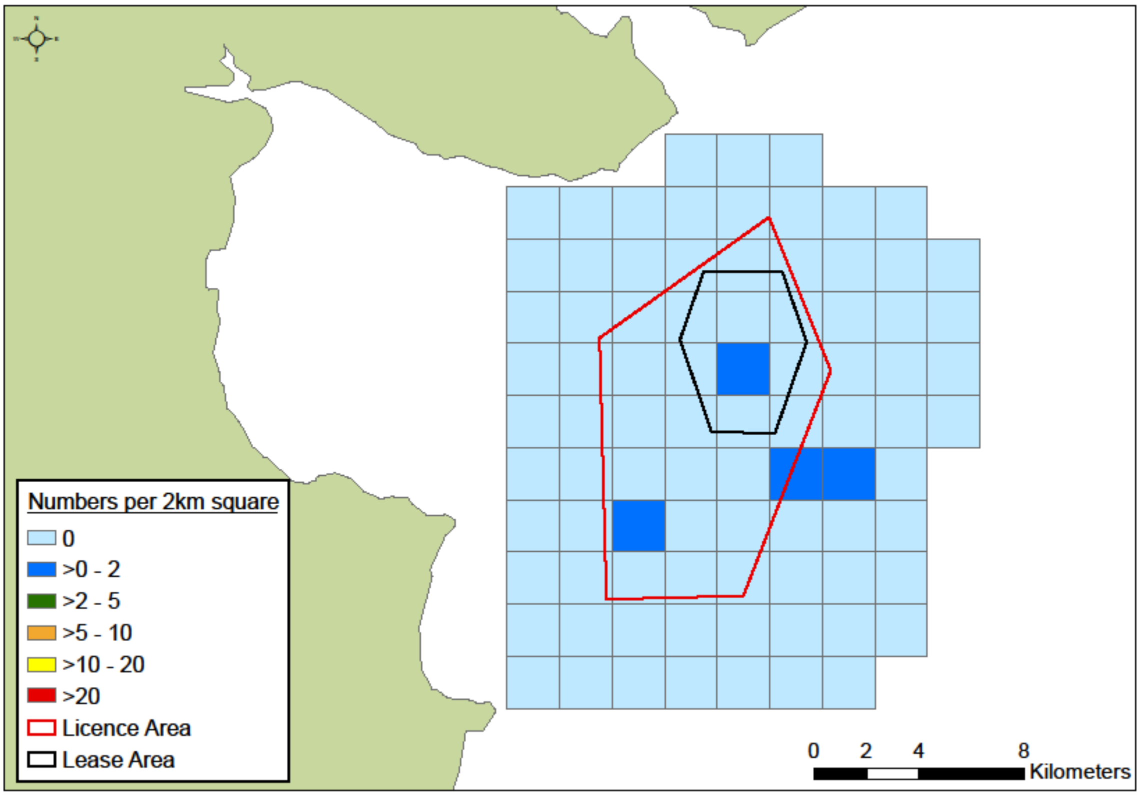

Figure 3.19.2 Razorbill survey results June 2018

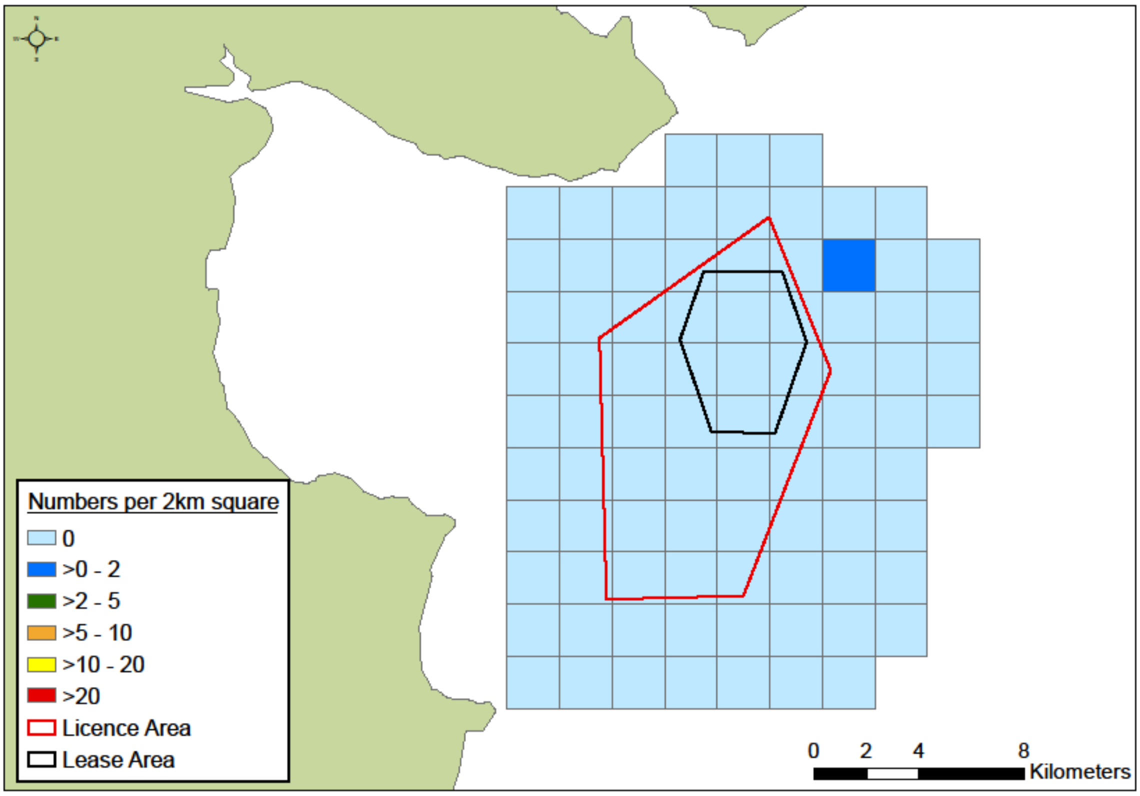

Figure 3.19.3 Razorbill survey results July 2018

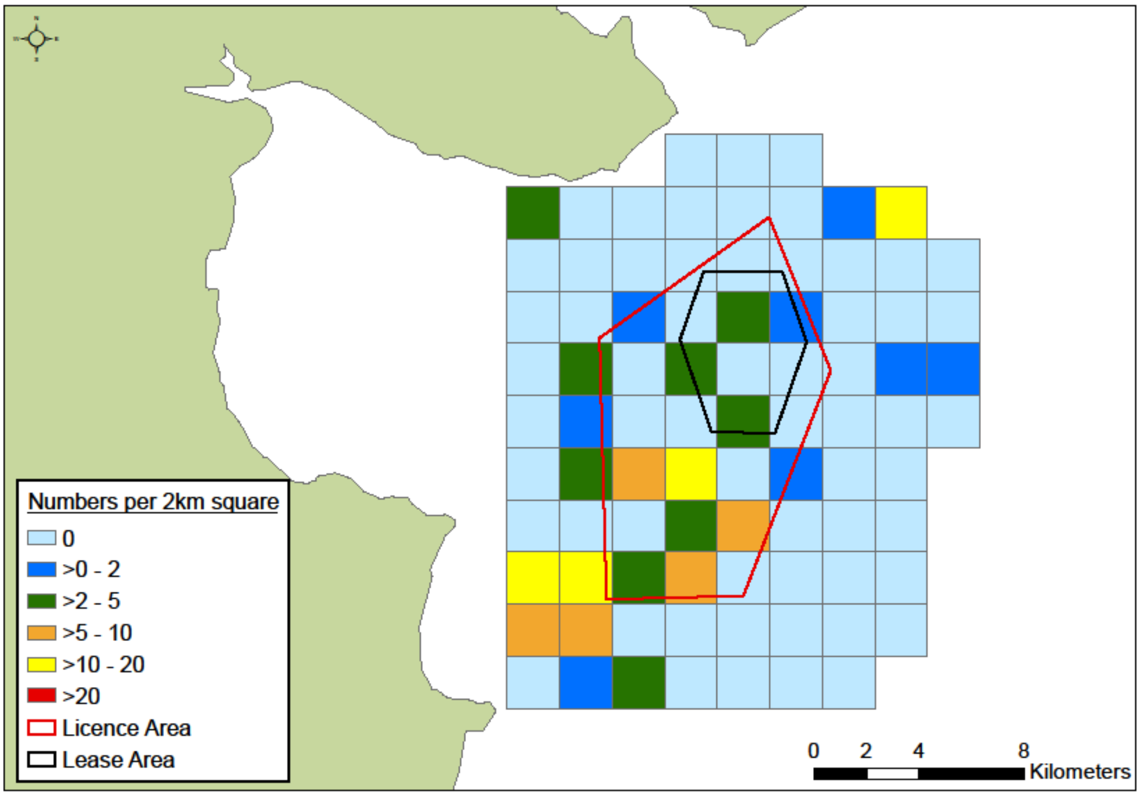

Figure 3.19.4 Razorbill survey results August 2018

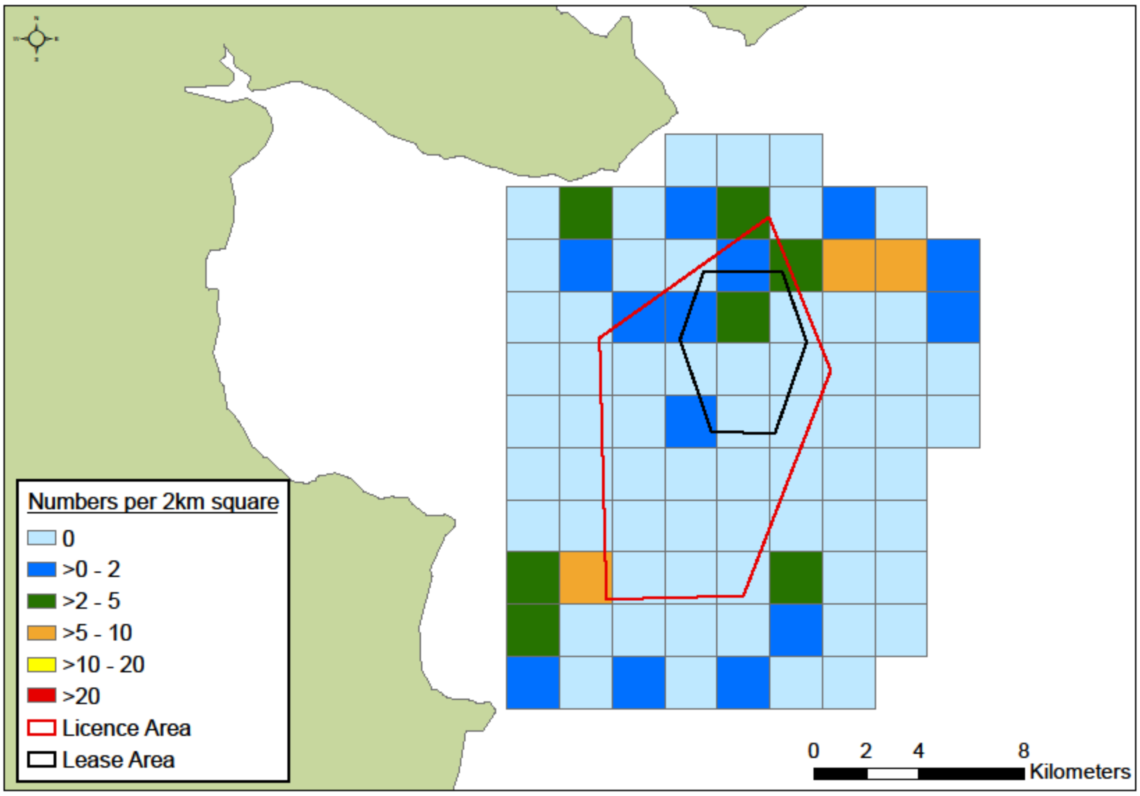

Figure 3.19.5 Razorbill survey results September 2018

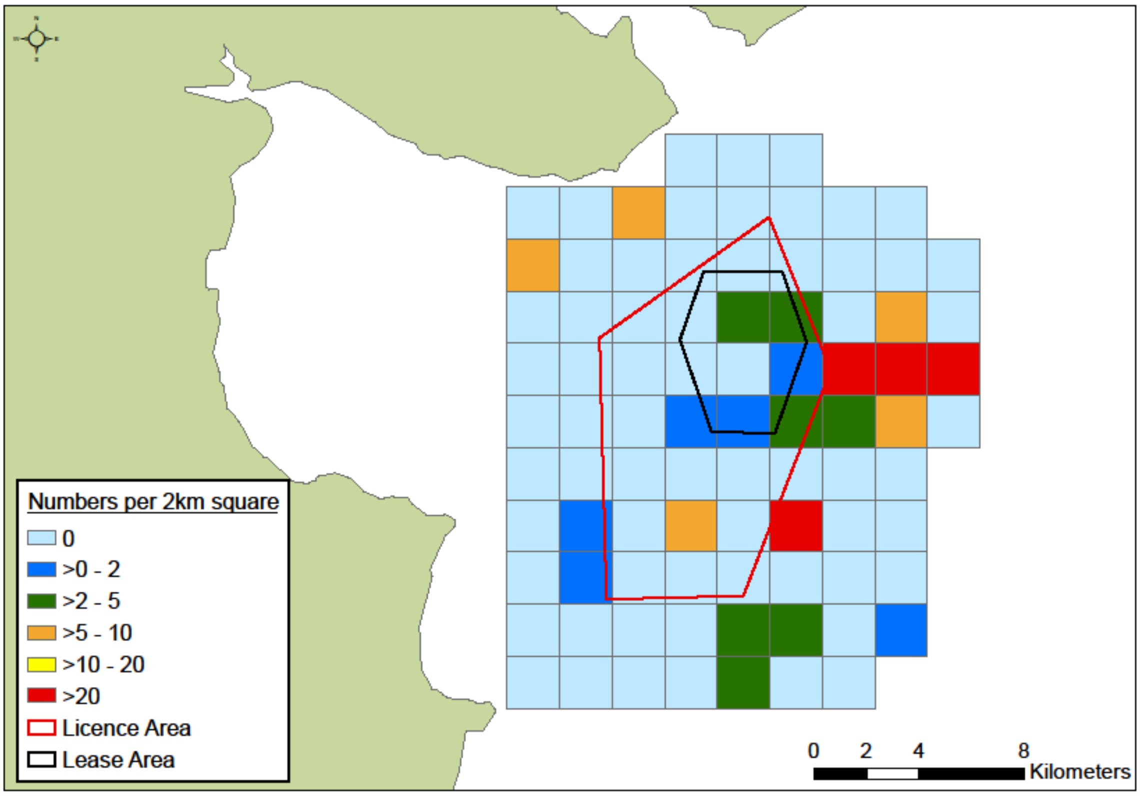

Figure 3.19.6 Razorbill survey results October 2018

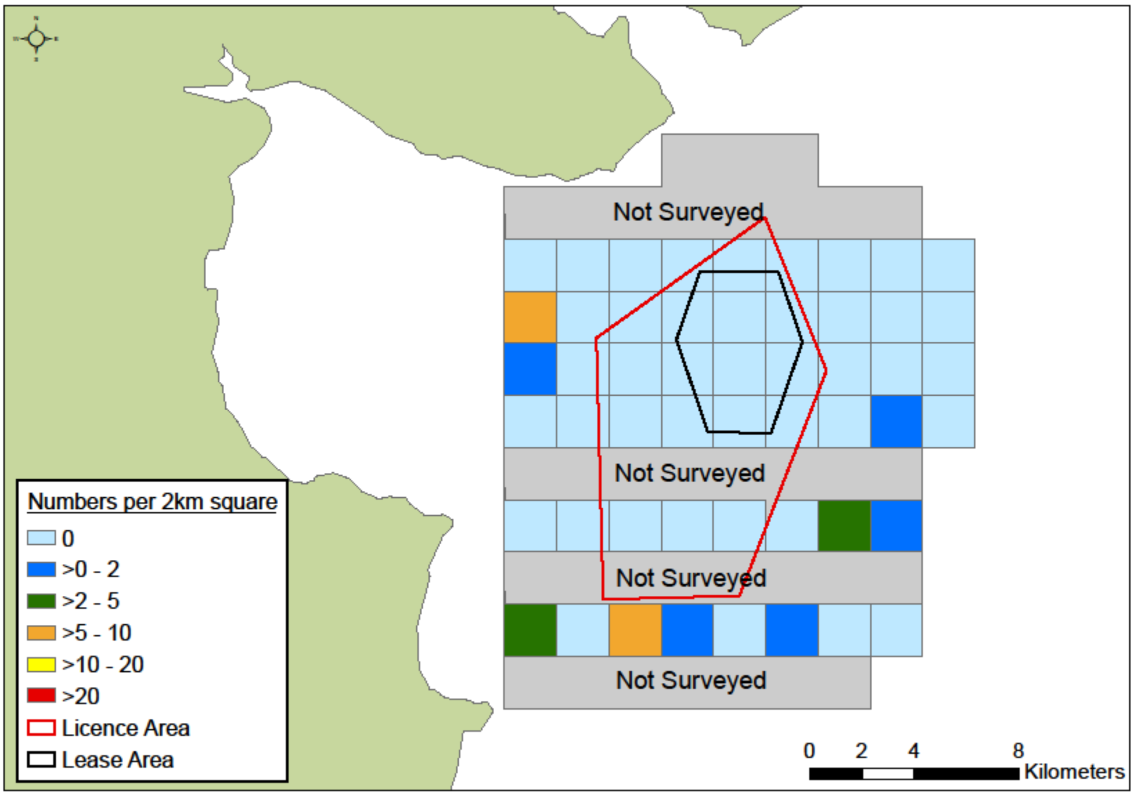

Figure 3.19.7 Razorbill survey results November 2018

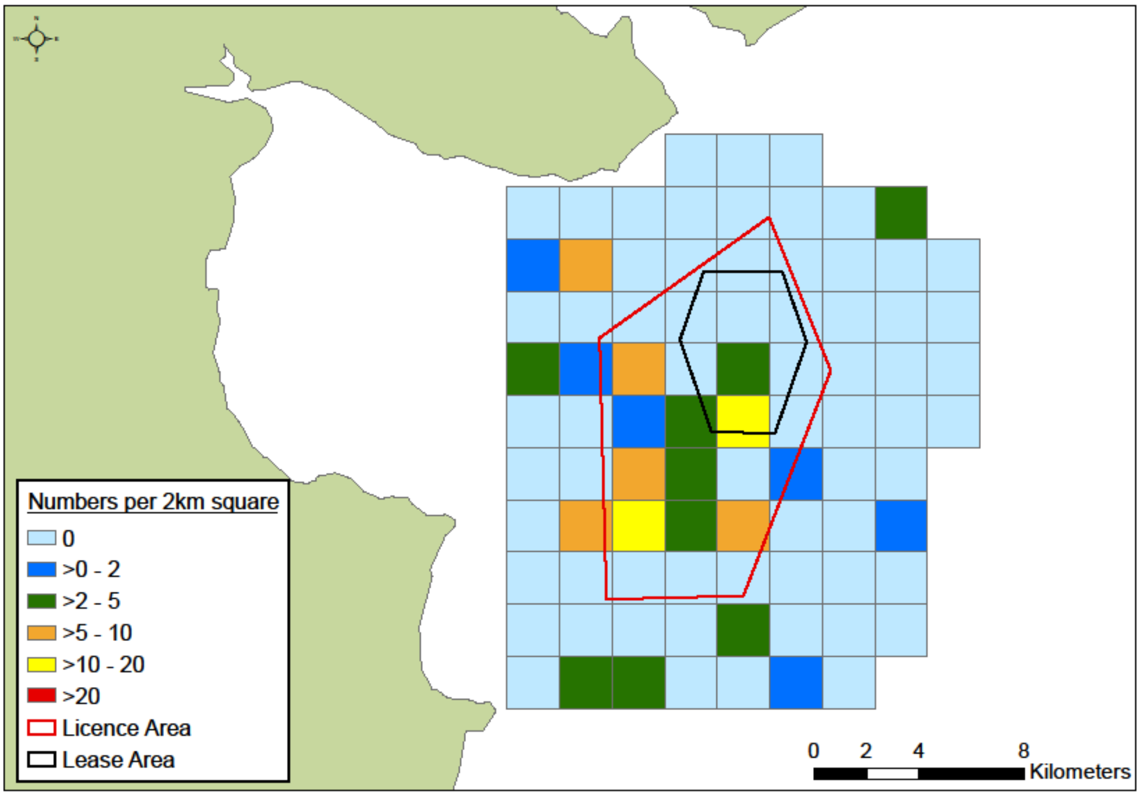

Figure 3.19.8 Razorbill survey results December 2018

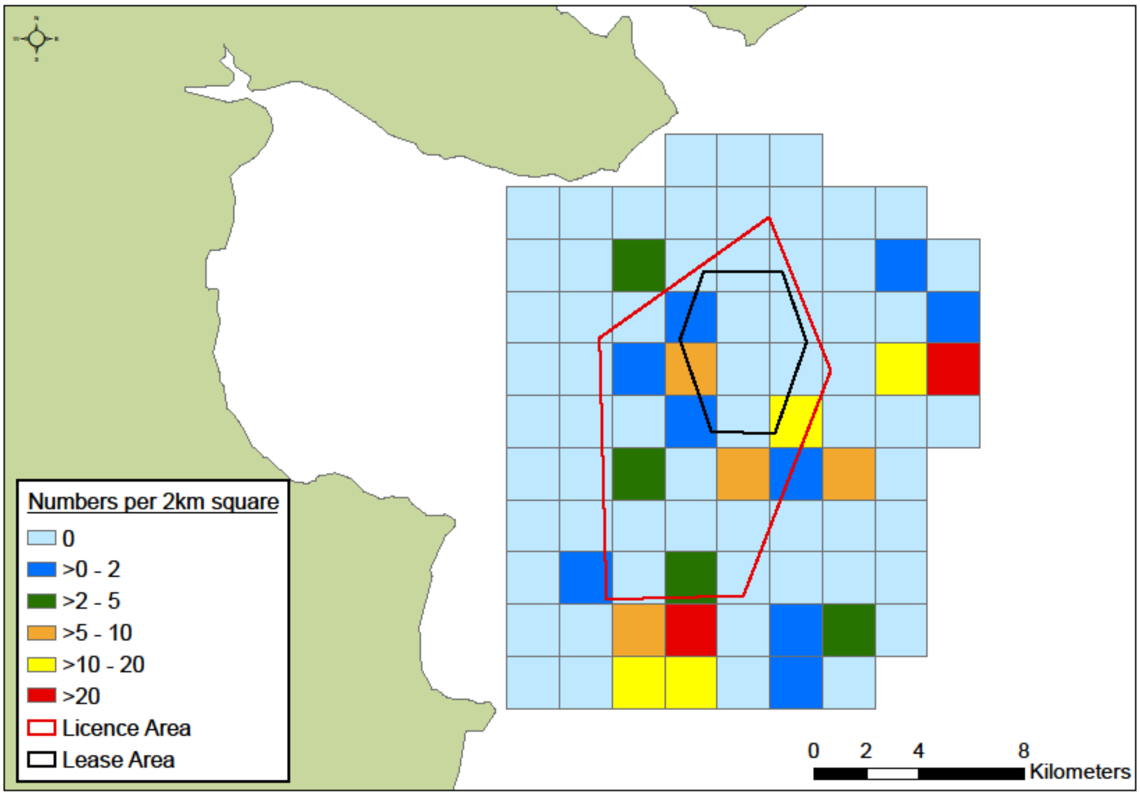

Figure 3.19.9 Razorbill survey results January 2019

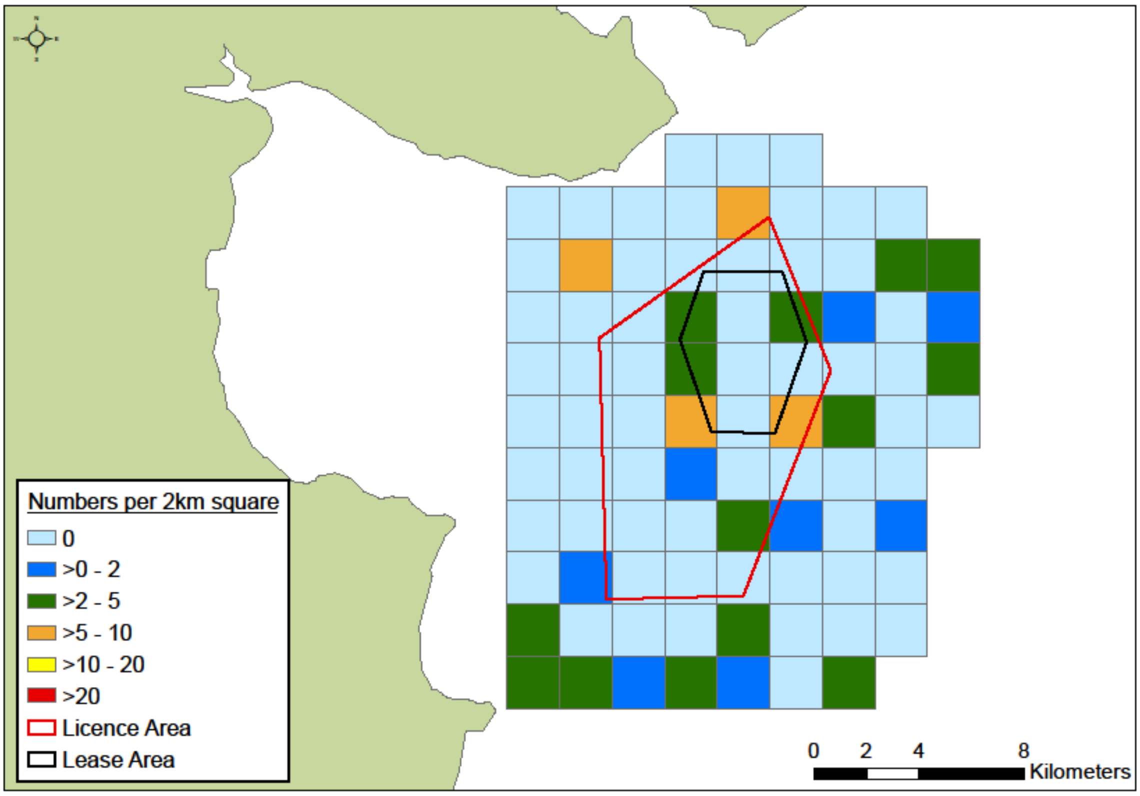

Figure 3.19.10 Razorbill survey results February 2019

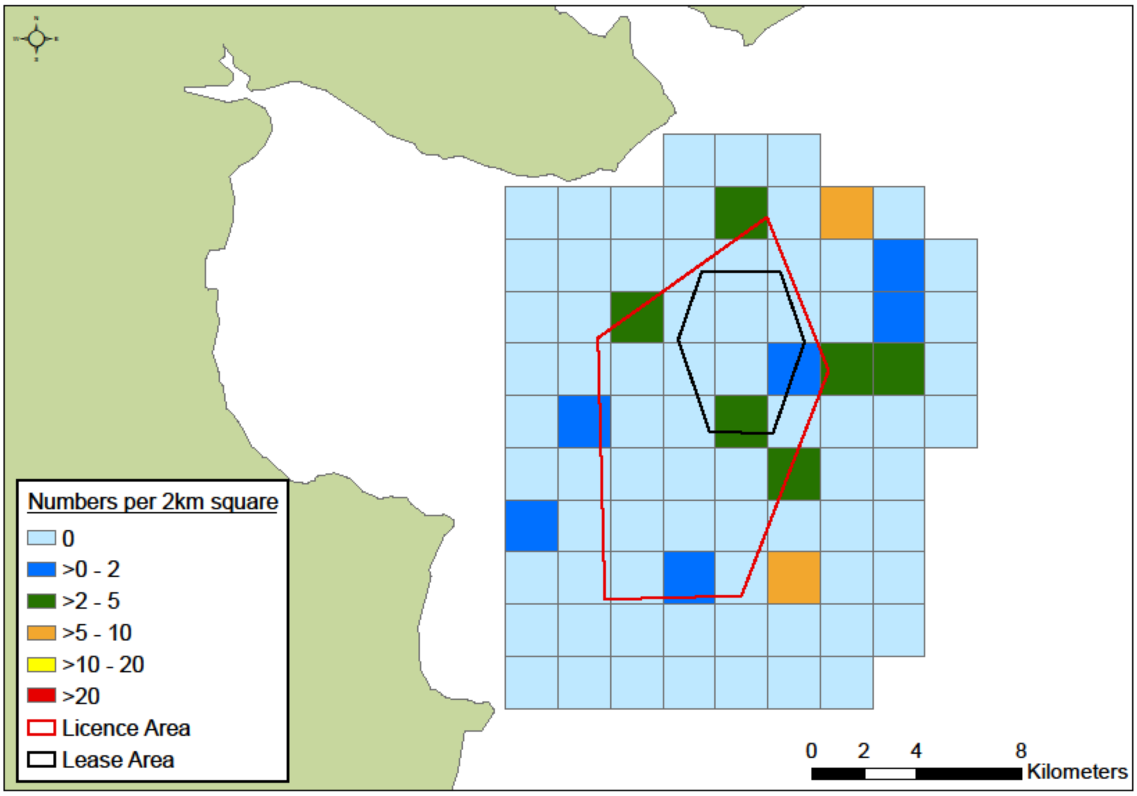

Figure 3.19.11 Razorbill survey results March 2019

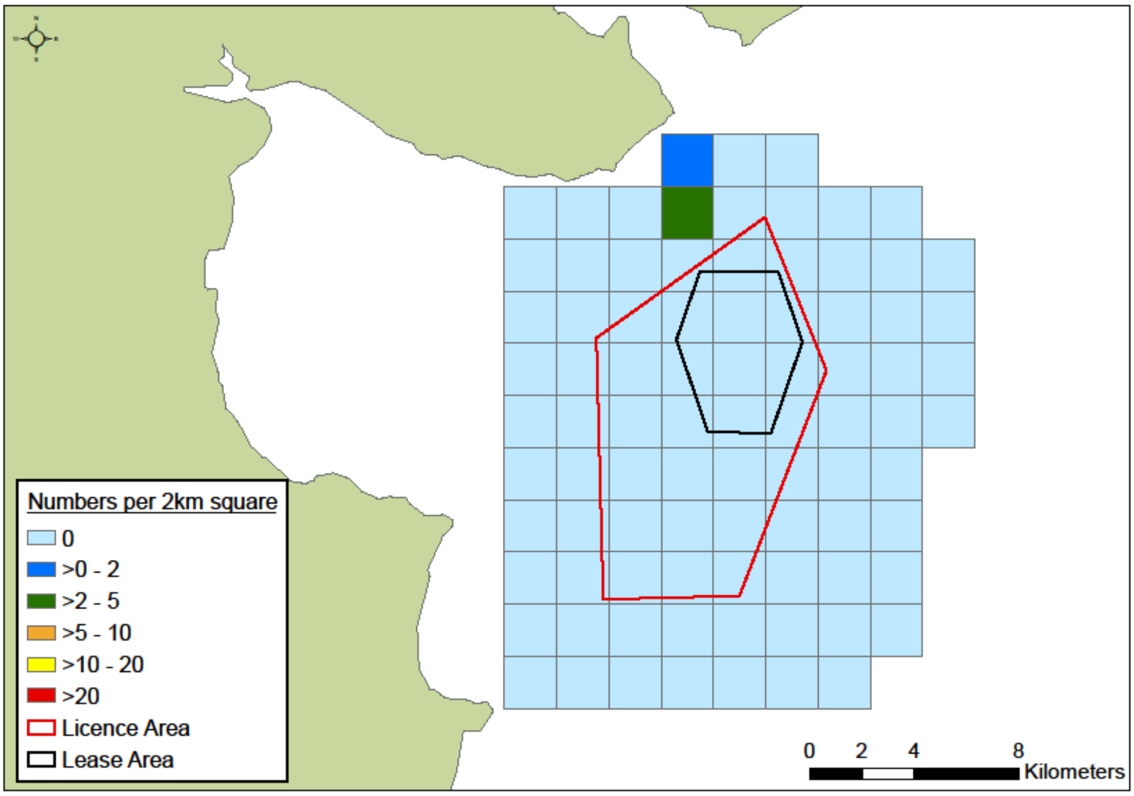

Figure 3.19.12 Razorbill survey results April 2019

3.19.2 Razorbill Density

The monthly estimates for Razorbills within the survey area, derived from the abundance data collected on the transect surveys, are shown in Figures 3.19.13 to 3.19.23. The peak density estimate derived from these data was 1.74 birds/km^2 in October 2018.

Density estimates for the western Irish Sea (Jessop *et al*., 2018) were derived from a combination of both Guillemot and Razorbill data; this approach for comparative purposes is also adopted here (see Section 3.20.2).

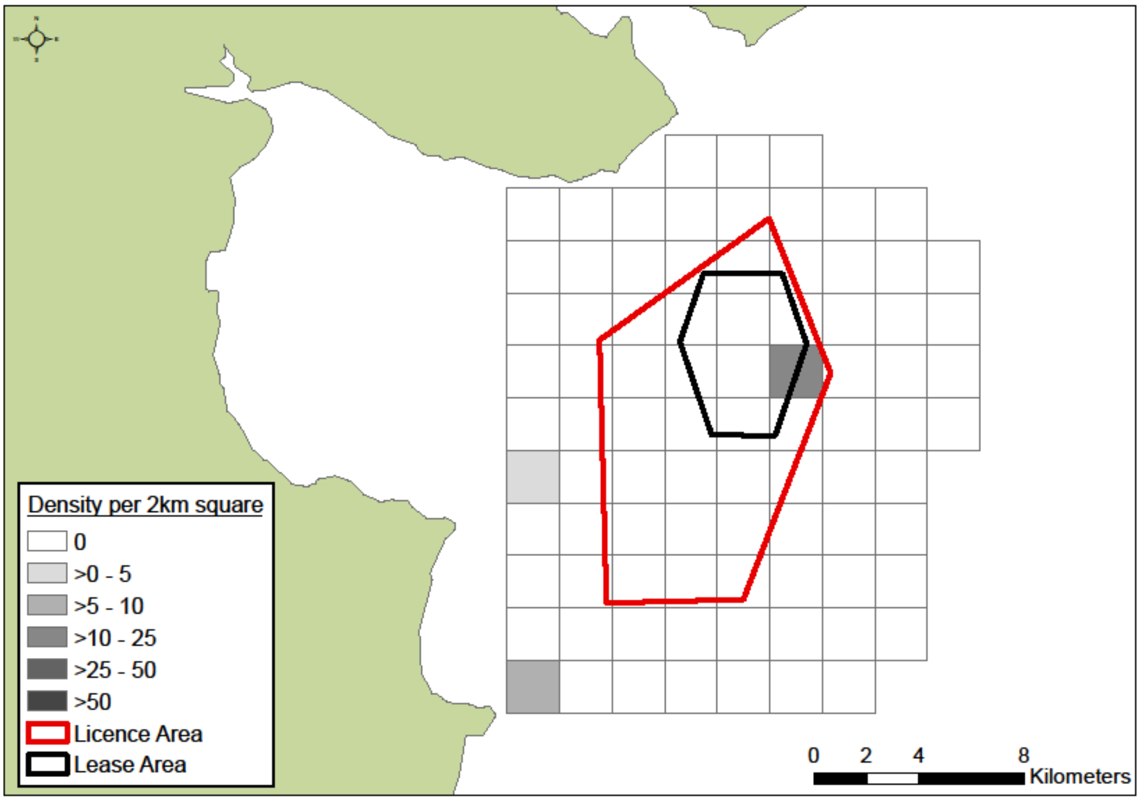

Figure 3.19.13 Razorbill density estimates May 2018

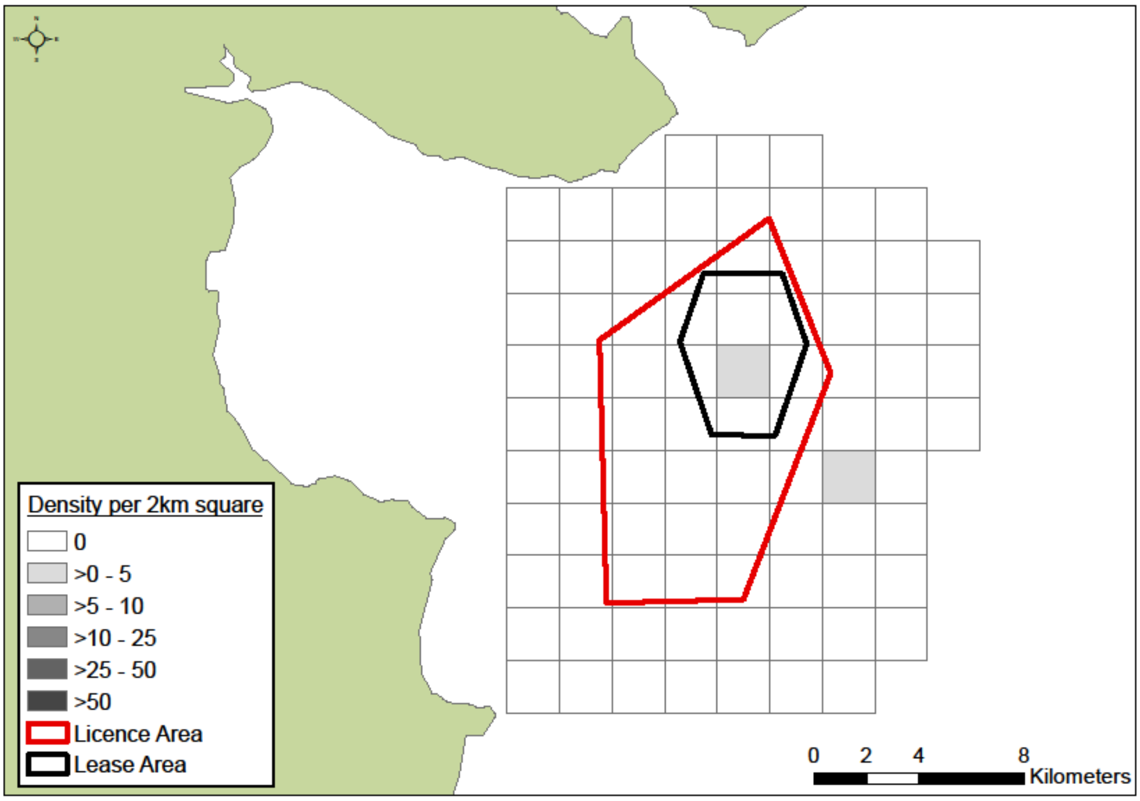

Figure 3.19.14 Razorbill density estimates June 2018

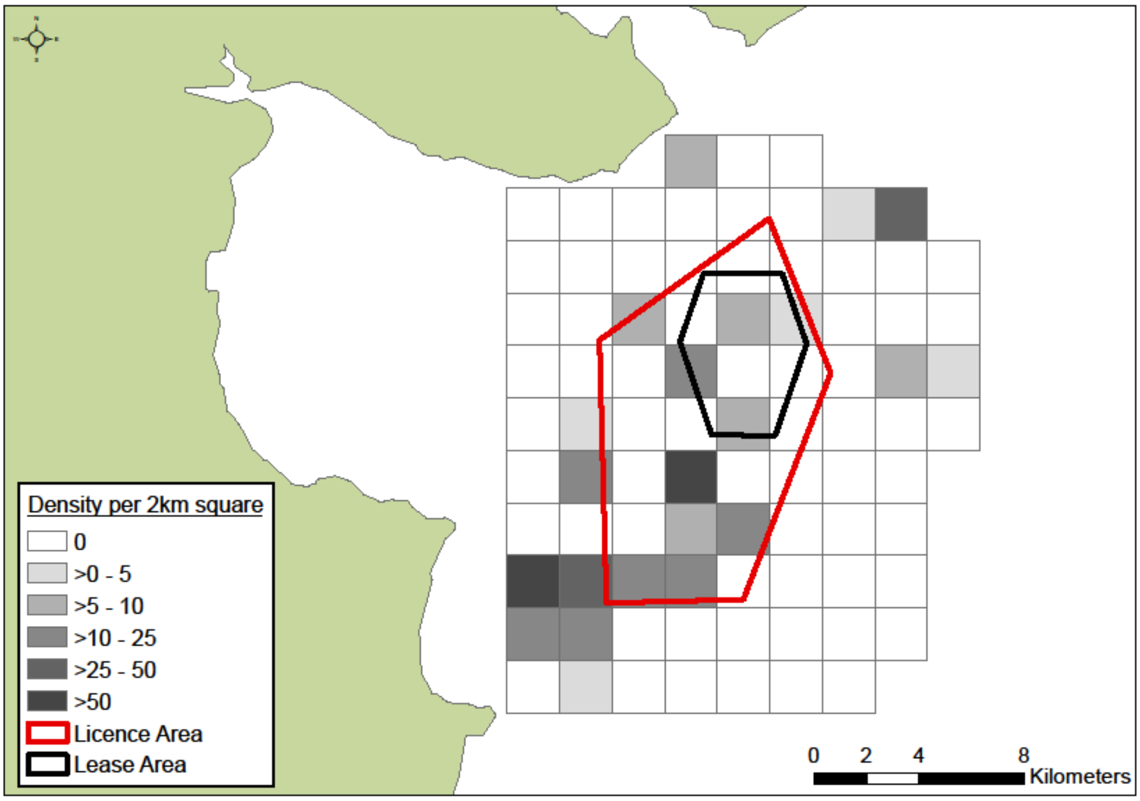

Figure 3.19.15 Razorbill density estimates August 2018

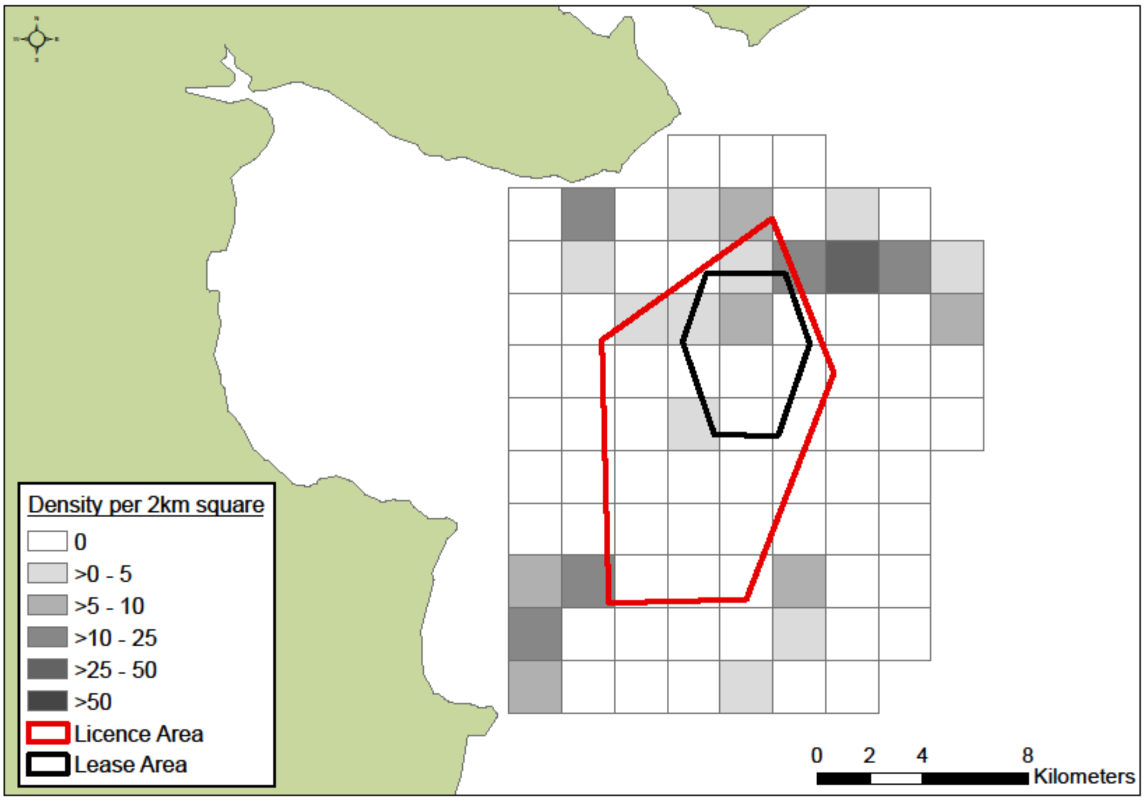

Figure 3.19.16 Razorbill density estimates September 2018

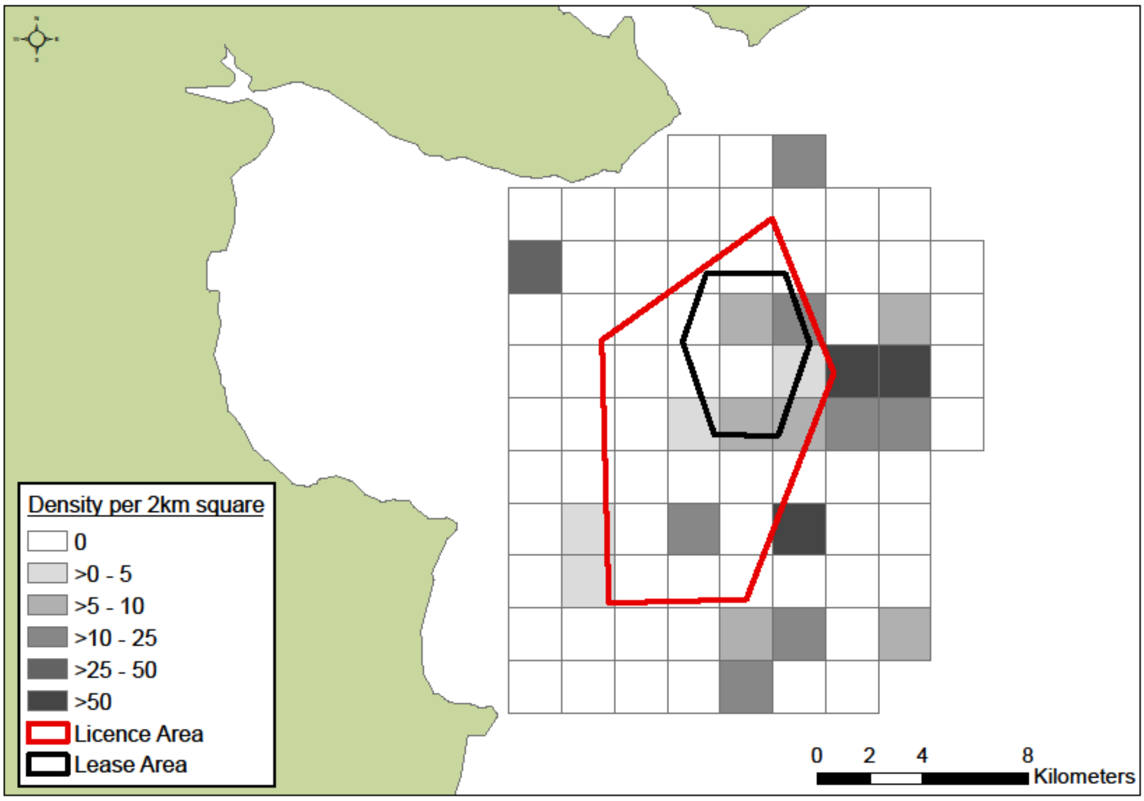

Figure 3.19.17 Razorbill density estimates October 2018

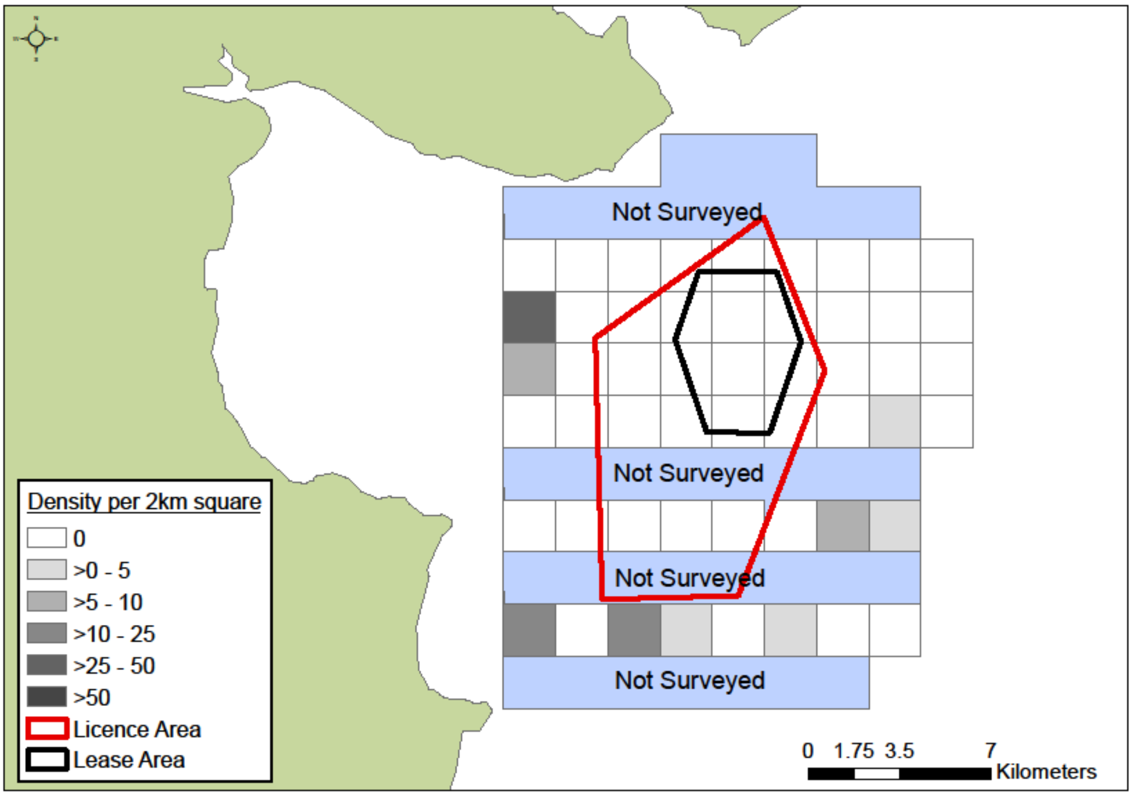

Figure 3.19.18 Razorbill density estimates November 2018

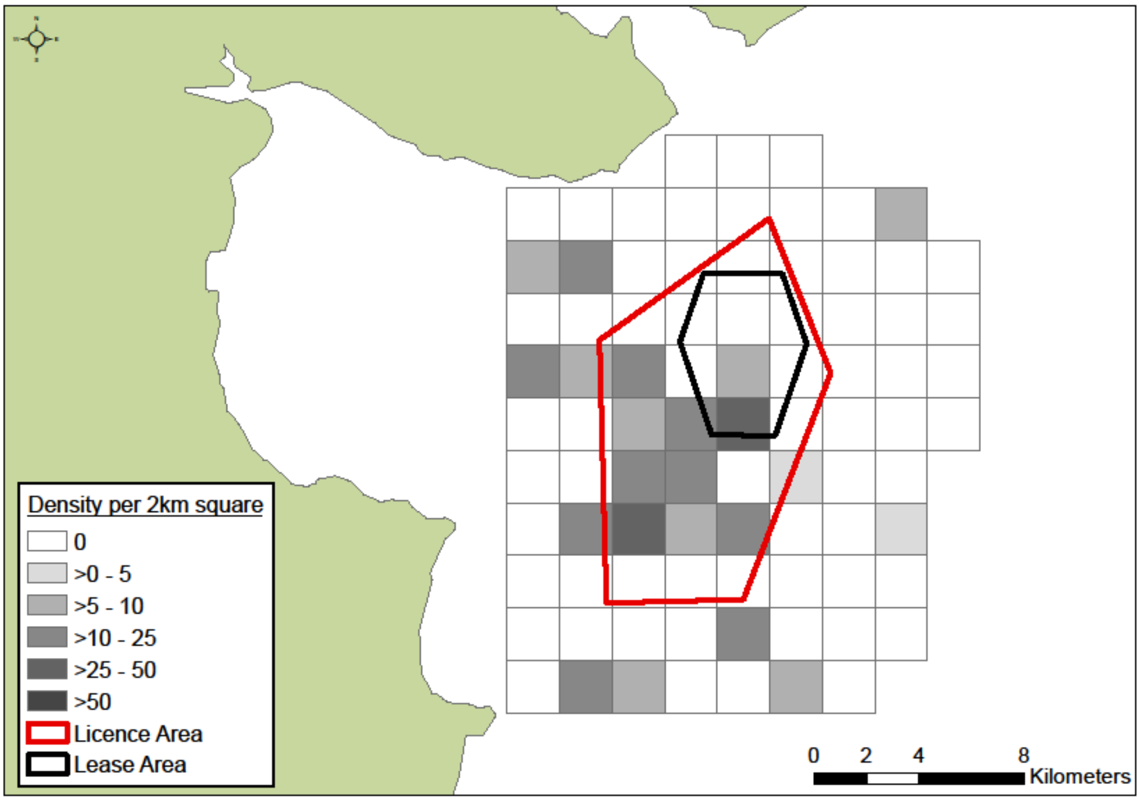

Figure 3.19.19 Razorbill density estimates December 2018

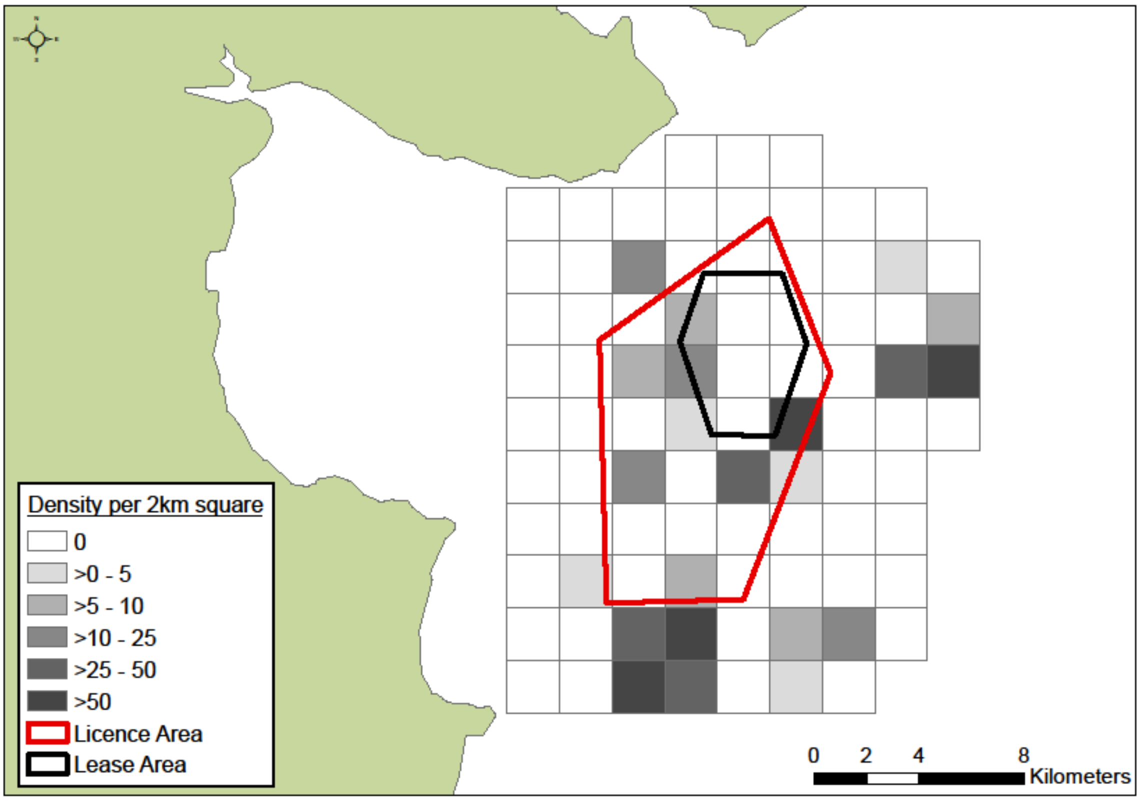

Figure 3.19.20 Razorbill density estimates January 2019

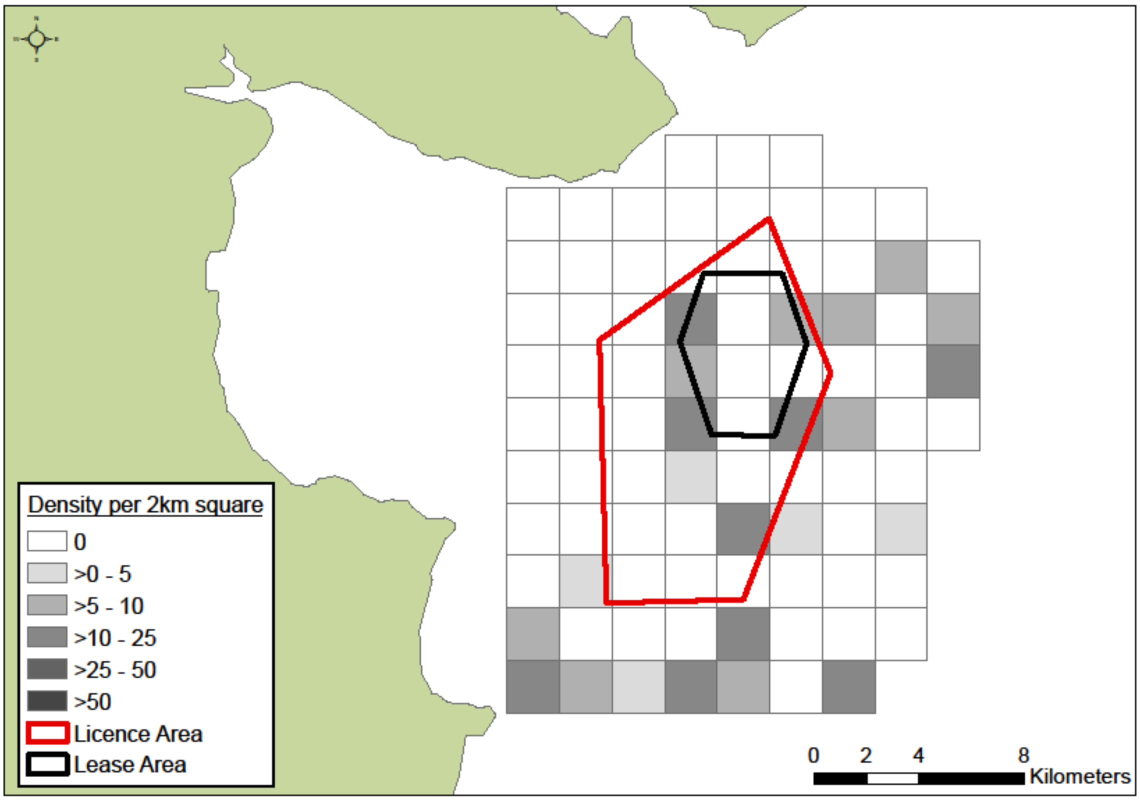

Figure 3.19.21 Razorbill density estimates February 2019

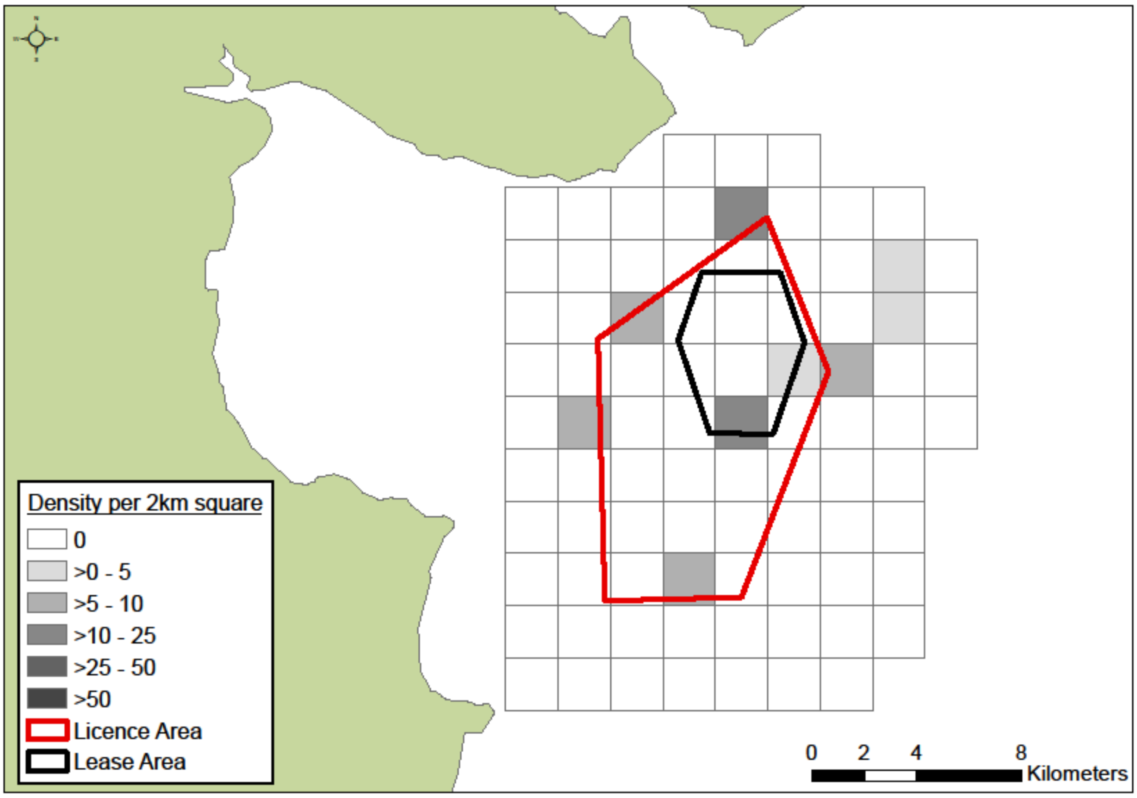

Figure 3.19.22 Razorbill density estimates March 2019

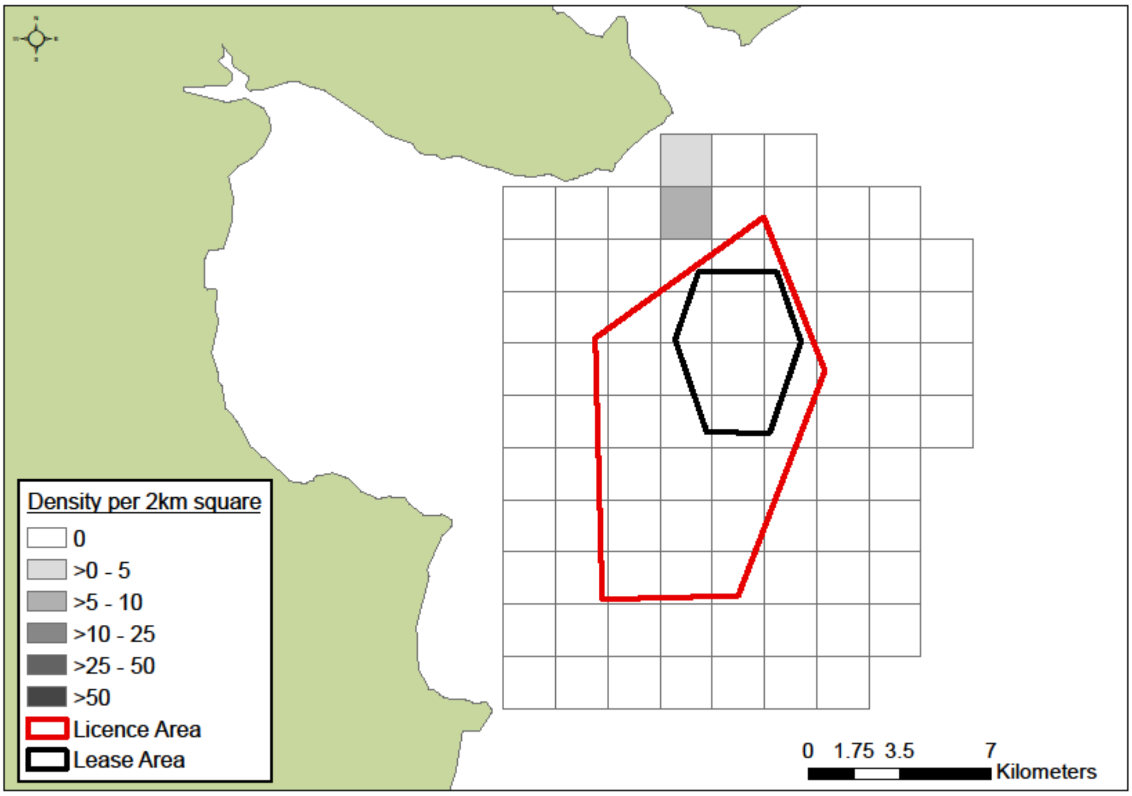

Figure 3.19.23 Razorbill density estimates April 2019

3.20 Guillemot/Razorbill

In some cases, it was not possible to separate Guillemot from Razorbill. Such unidentified auks are included here for completeness.

3.20.1 Guillemot/Razorbill Abundance

The total number of birds categorised as Guillemot or Razorbill that were recorded from the transect surveys were five individuals (see Table 3.20.1). These included three birds in January 2019 (Figure 3.20.1), and single birds in March 2019 (Figure 3.20.2) and April 2019 (Figure 3.20.3).

Table 3.20.1 Guillemot/Razorbill records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	2
June 2018	0	0
July 2018	0	0
August 2018	0	19
September 2018	0	0
October 2018	0	0
November 2018	0	1
December 2018	0	0
January 2019	3	3
February 2019	0	0
March 2019	1	6
April 2019	1	1
TOTAL	**5**	**32**

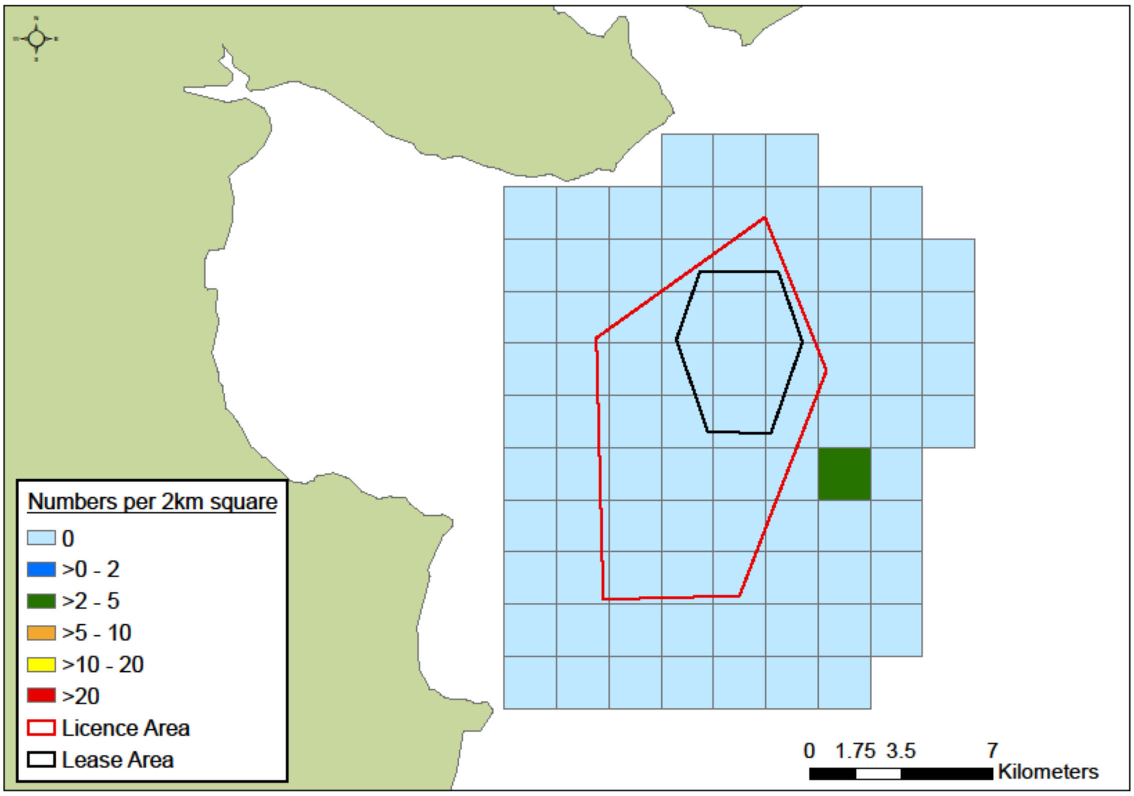

Figure 3.20.1 Guillemot/Razorbill survey results January 2019

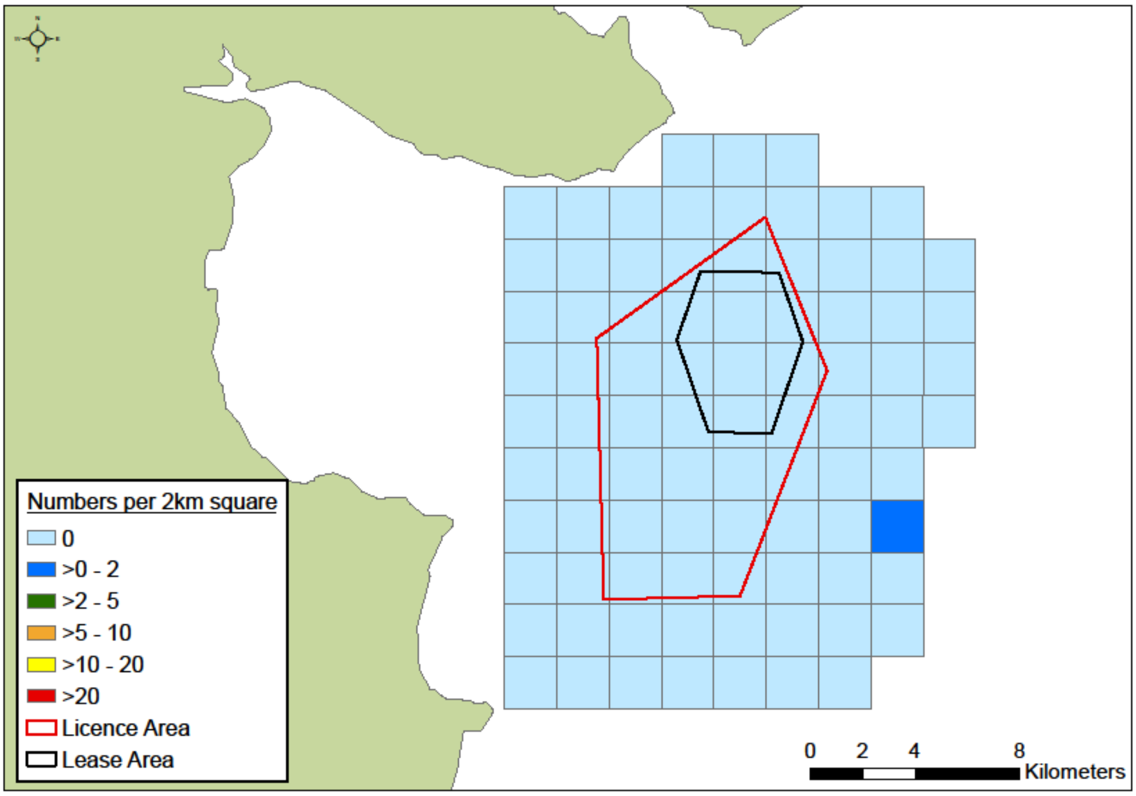

Figure 3.20.2 Guillemot/Razorbill survey results March 2019

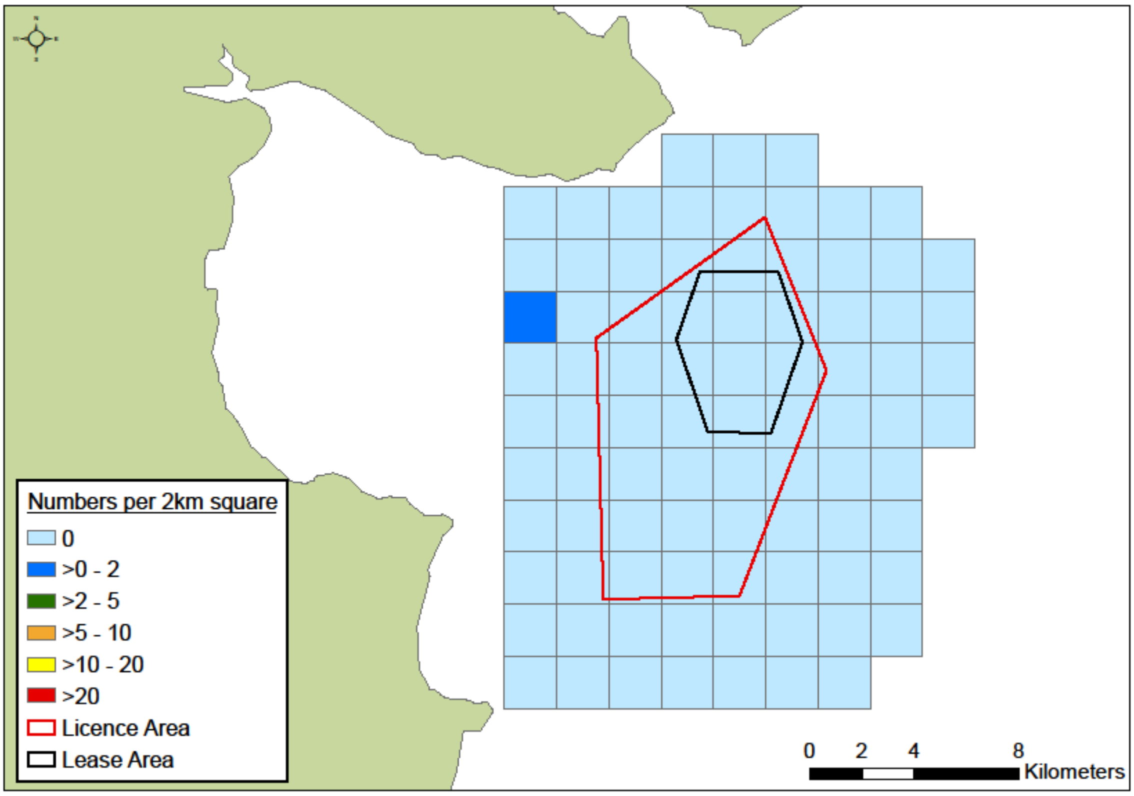

Figure 3.20.3 Guillemot/Razorbill survey results April 2019

3.20.2 Guillemot/Razorbill Density Estimates

When combined, the highest derived density estimates for Guillemot and Razorbill using the transect survey data is 12.18 birds/km^2. This compares with similar levels observed in the western Irish Sea (Jessop *et al*., 2018) of 17.40 birds/km^2 in Autumn. Similar seasonality is also shown between the two data sets, with lower densities in summer and winter.

3.21 Black Guillemot

Black Guillemot breed around the coastline of Ireland, including areas adjacent to the Oriel Windfarm Survey Area (Balmer *et al*., 2013). They feed primarily on sand eels, although also take other small fish and crustaceans (Ewins, 1990). Black Guillemots are Amber-listed in Ireland as they are a species of European Conservation Concern (Colhoun & Cummins, 2013).

3.21.1 Black Guillemot Abundance

Black Guillemots were recorded in all survey months (Table 3.21.1) with a peak observed on the transect data in August 2018 (when 50 individuals were recorded; Figure 3.21.4). The peak month for observation in the survey area as a whole was in January 2019, with 82 bird counted. Nevertheless, the numbers were fairly constant throughout the survey period, indicating little movement of birds to or from breeding or wintering areas.

Table 3.21.1 Black Guillemot records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	6	16
June 2018	4	9
July 2018	11	16
August 2018	50	52
September 2018	30	32
October 2018	14	37
November 2018	26	34
December 2018	17	37
January 2019	42	82
February 2019	37	47
March 2019	13	28
April 2019	44	46
TOTAL	**294**	**436**

Black Guillemot were typically observed in areas closer to the shore in the north-west corner of the survey area (Figures 3.21.1 to 3.21.12). This likely reflects proximity to breeding sites (Balmer *et al*., 2013). As a result, very few birds were recorded in the Lease area (just three individuals, or 1.0% of all bird counted), compared to 80 birds (27.2% of the individual total) in the Licence area and 211 individuals (71.8% of the total) in the survey area (Table 3.21.2).

Table 3.21.2 Black Guillemot records in the three Oriel Windfarm survey zones.

Month	Survey Area		Licence Area		Lease Area	
	No.	%	No.	%	No.	%
May 2018	4	66.7	1	16.7	1	16.7
June 2018	3	75.0	1	25.0	0	0
July 2018	10	90.9	1	9.1	0	0
August 2018	43	86.0	7	14.0	0	0
September 2018	20	67.7	10	33.3	0	0
October 2018	9	64.3	3	21.4	2	14.3
November 2018	14	53.8	12	46.2	0	0
December 2018	12	70.6	5	29.4	0	0
January 2019	23	54.8	19	45.2	0	0
February 2019	19	51.4	18	48.6	0	0
March 2019	11	84.6	2	15.4	0	0
April 2019	43	97.7	1	2.3	0	0
TOTAL	211	71.8	80	27.2	3	1.0

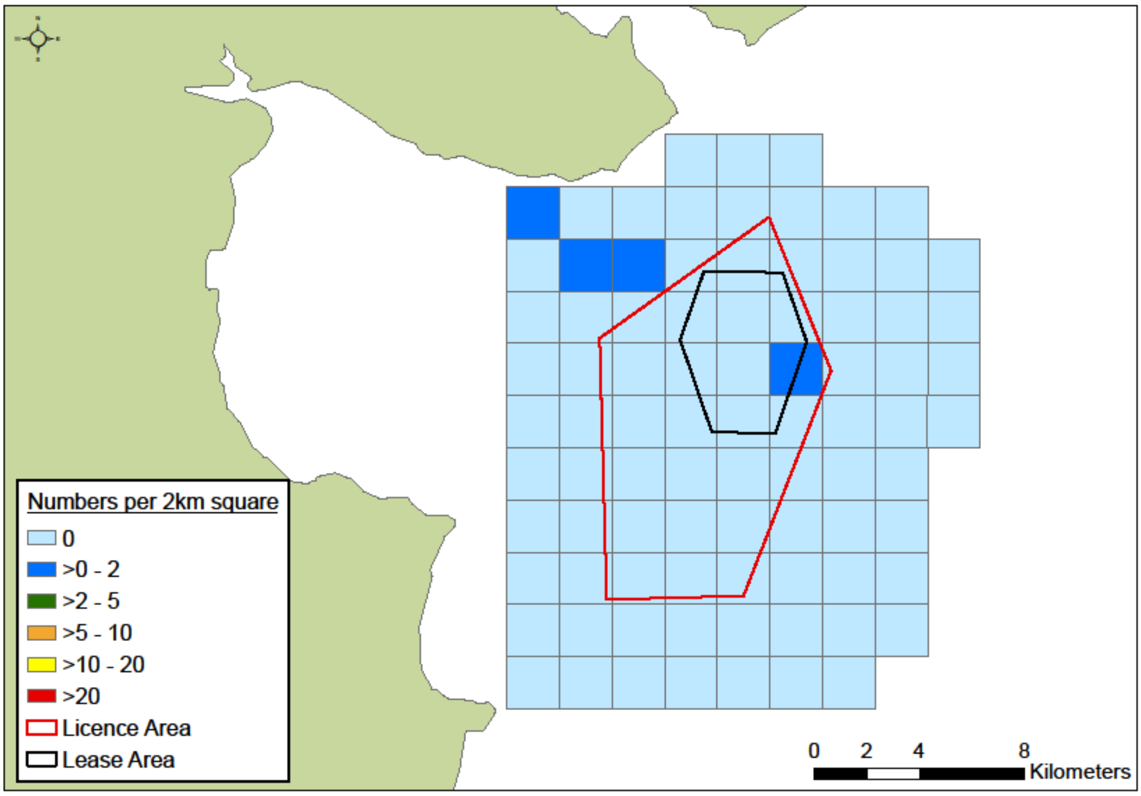

Figure 3.21.1 Black Guillemot survey results May 2018

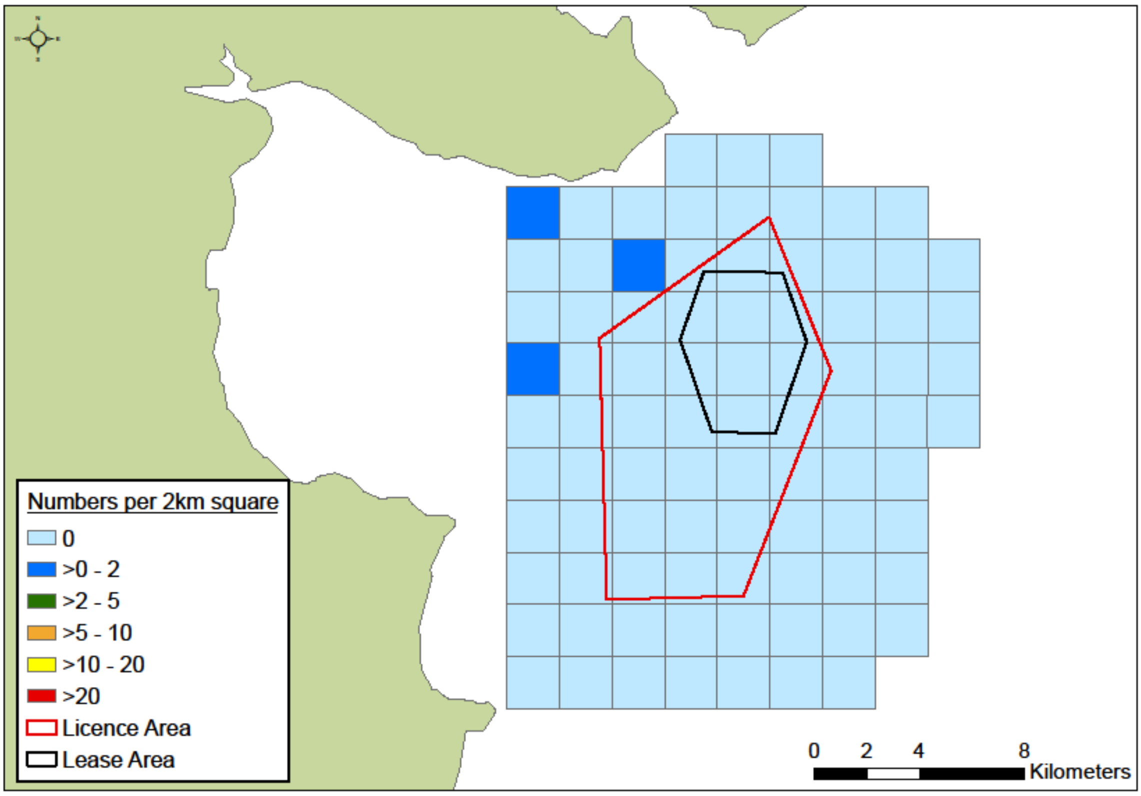

Figure 3.21.2 Black Guillemot survey results June 2018

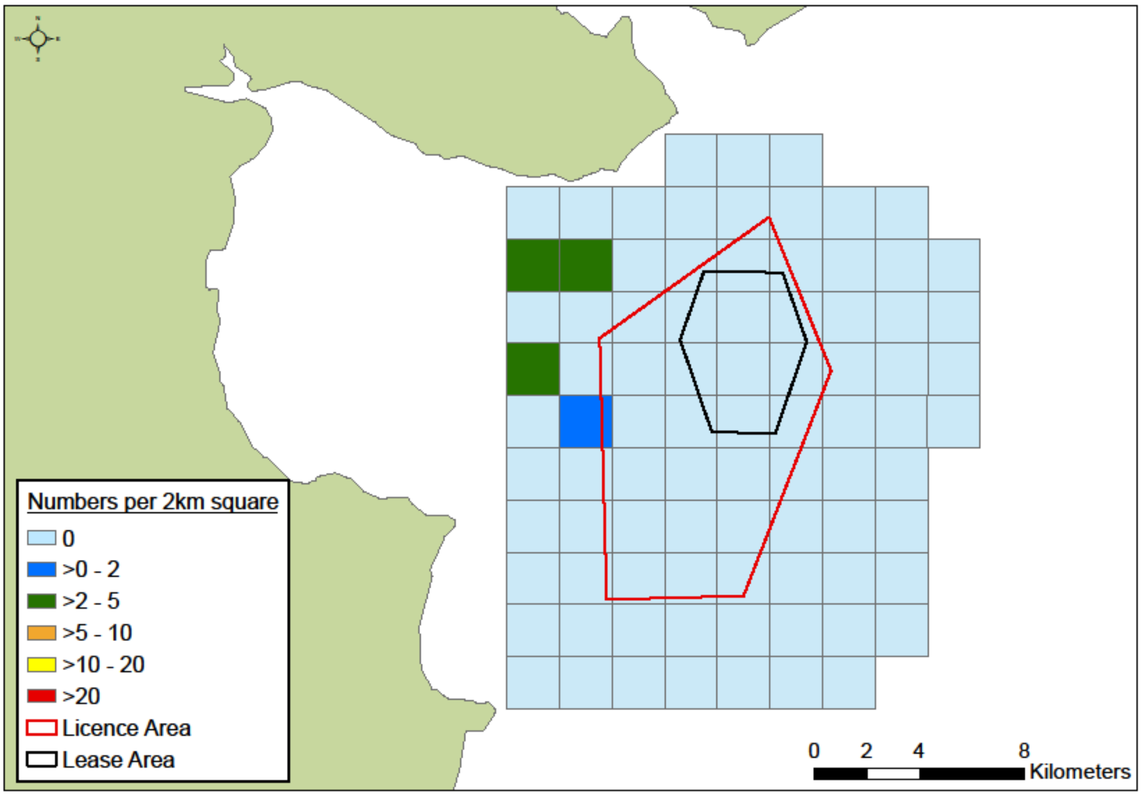

Figure 3.21.3 Black Guillemot survey results July 2018

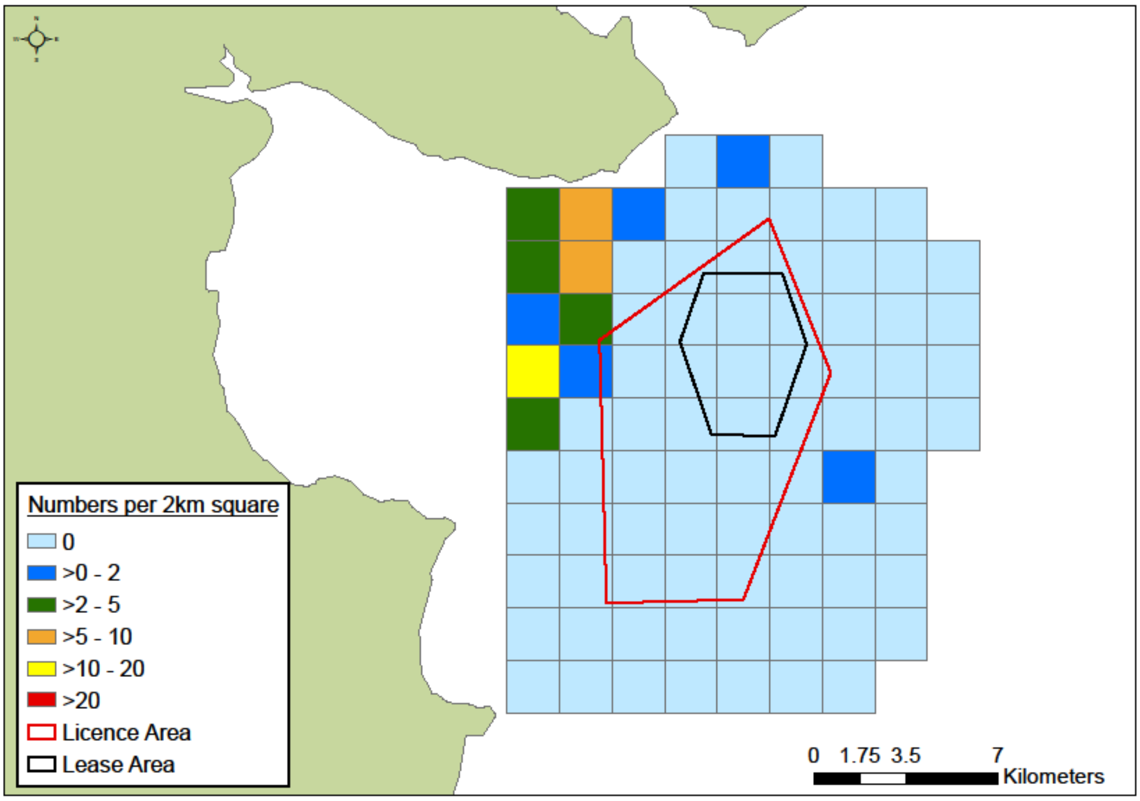

Figure 3.21.4 Black Guillemot survey results August 2018

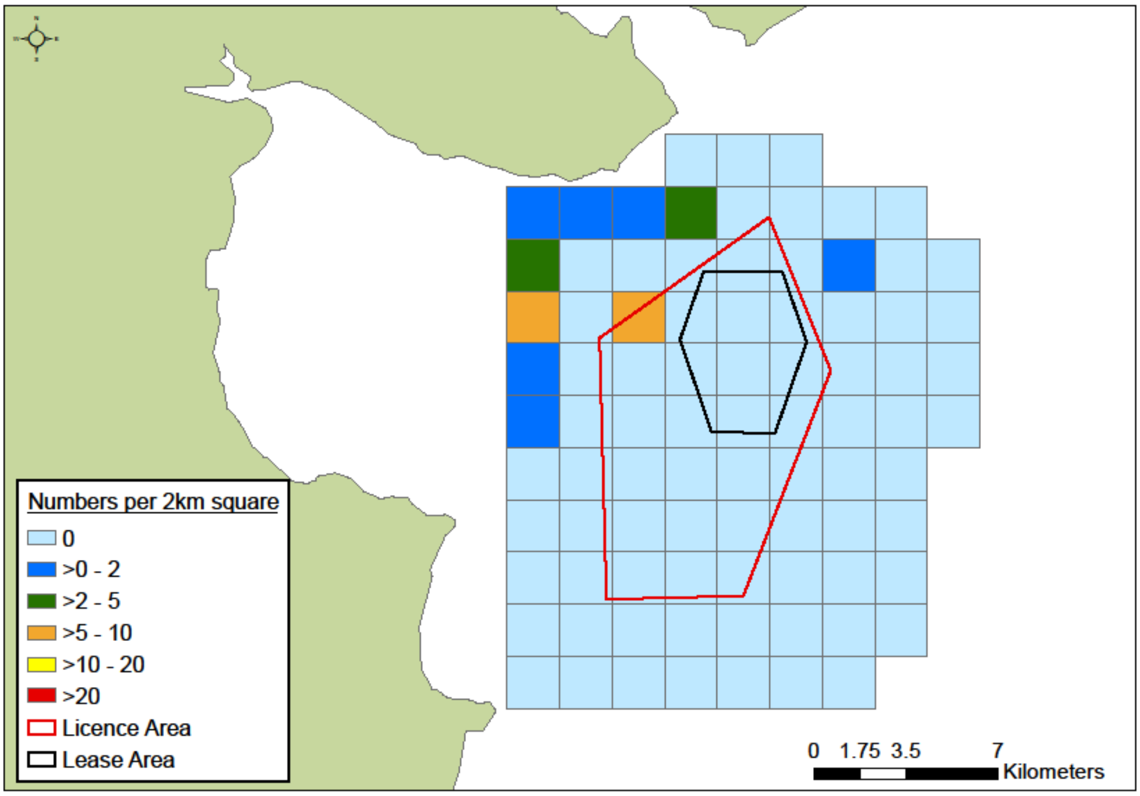

Figure 3.21.5 Black Guillemot survey results September 2018

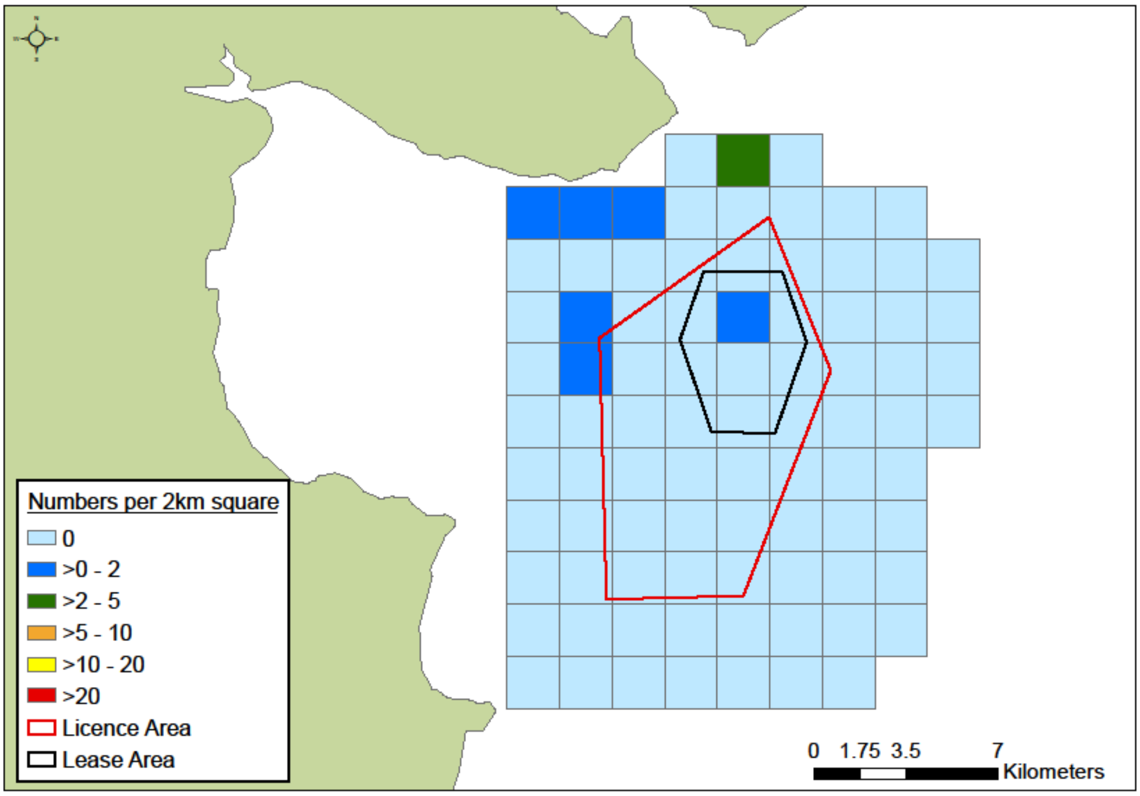

Figure 3.21.6 Black Guillemot survey results October 2018

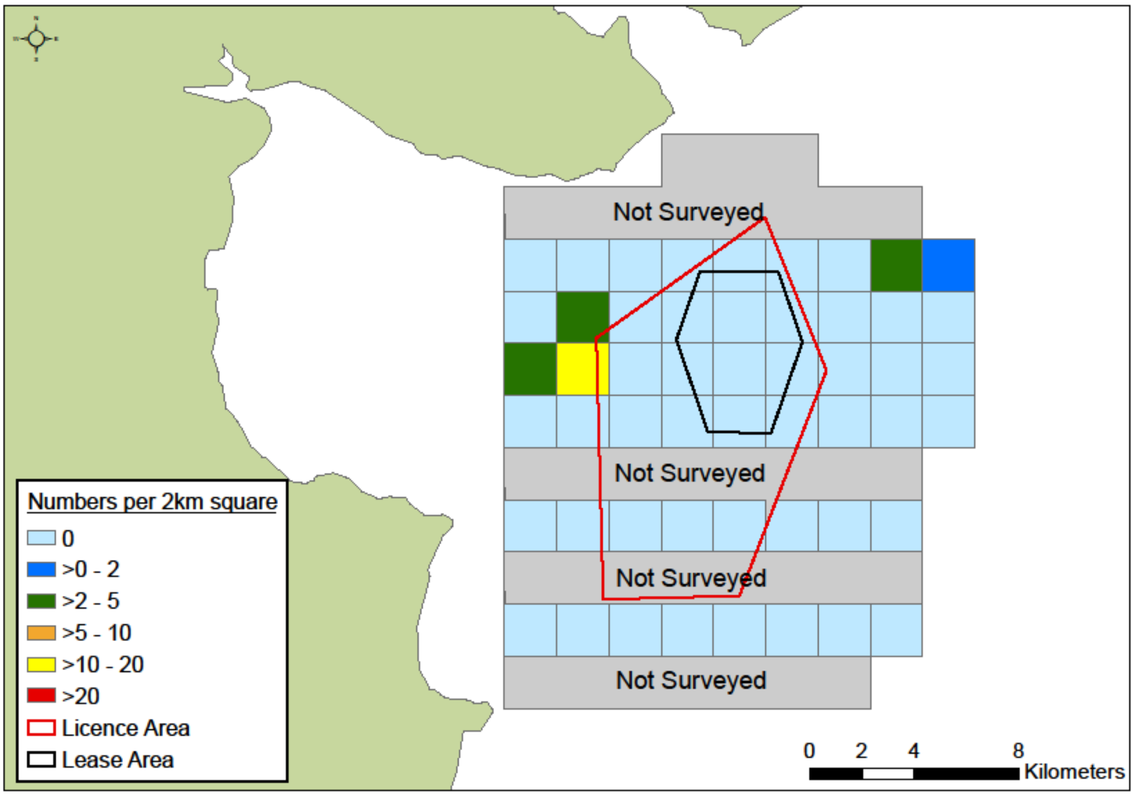

Figure 3.21.7 Black Guillemot survey results November 2018

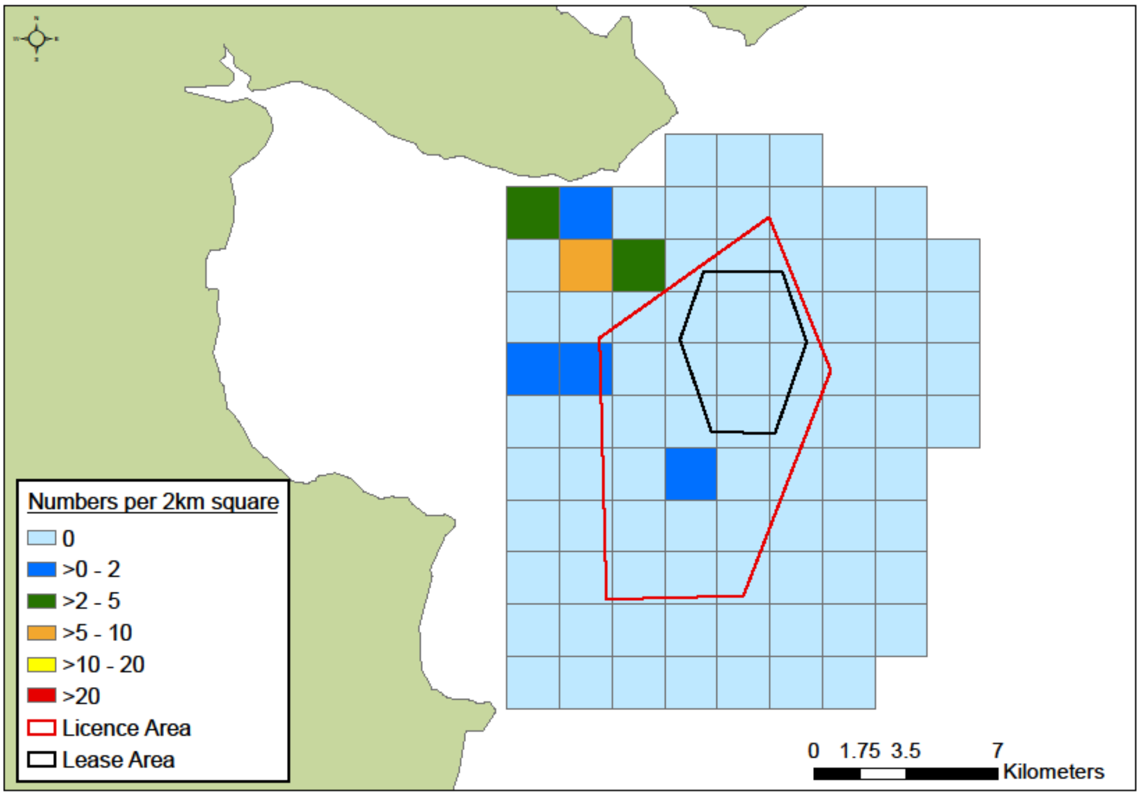

Figure 3.21.8 Black Guillemot survey results December 2018

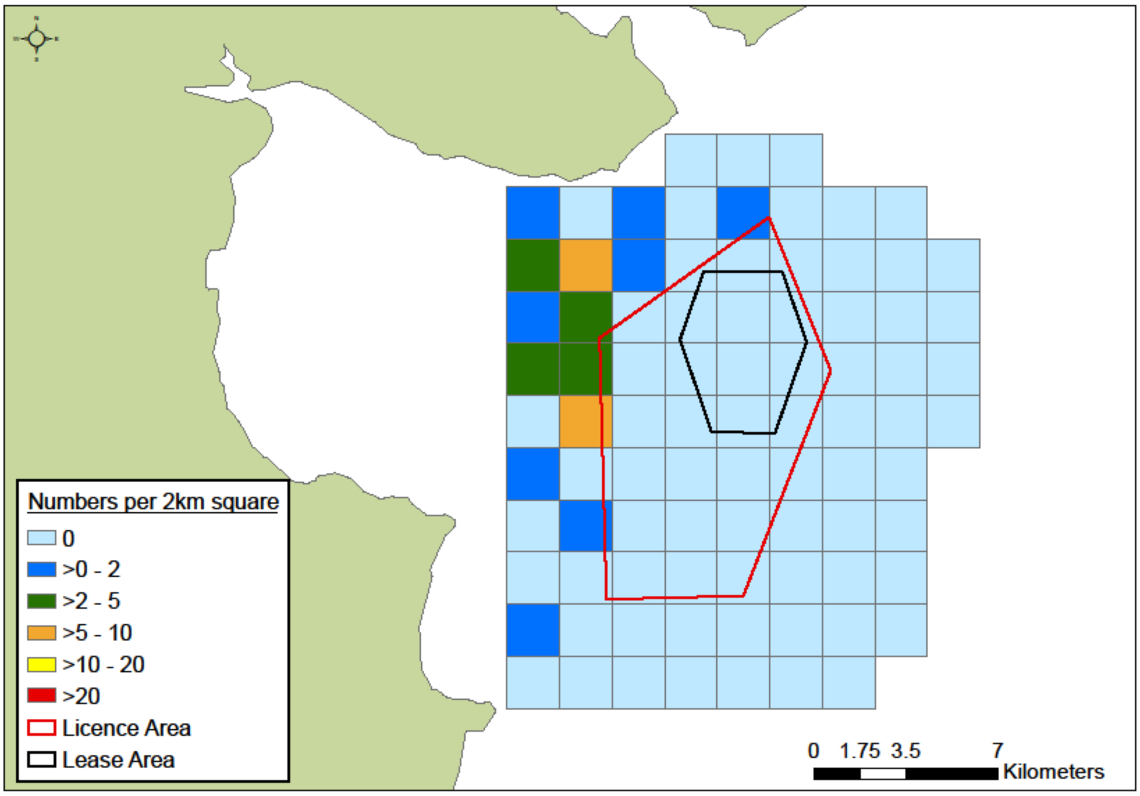

Figure 3.21.9 Black Guillemot survey results January 2019

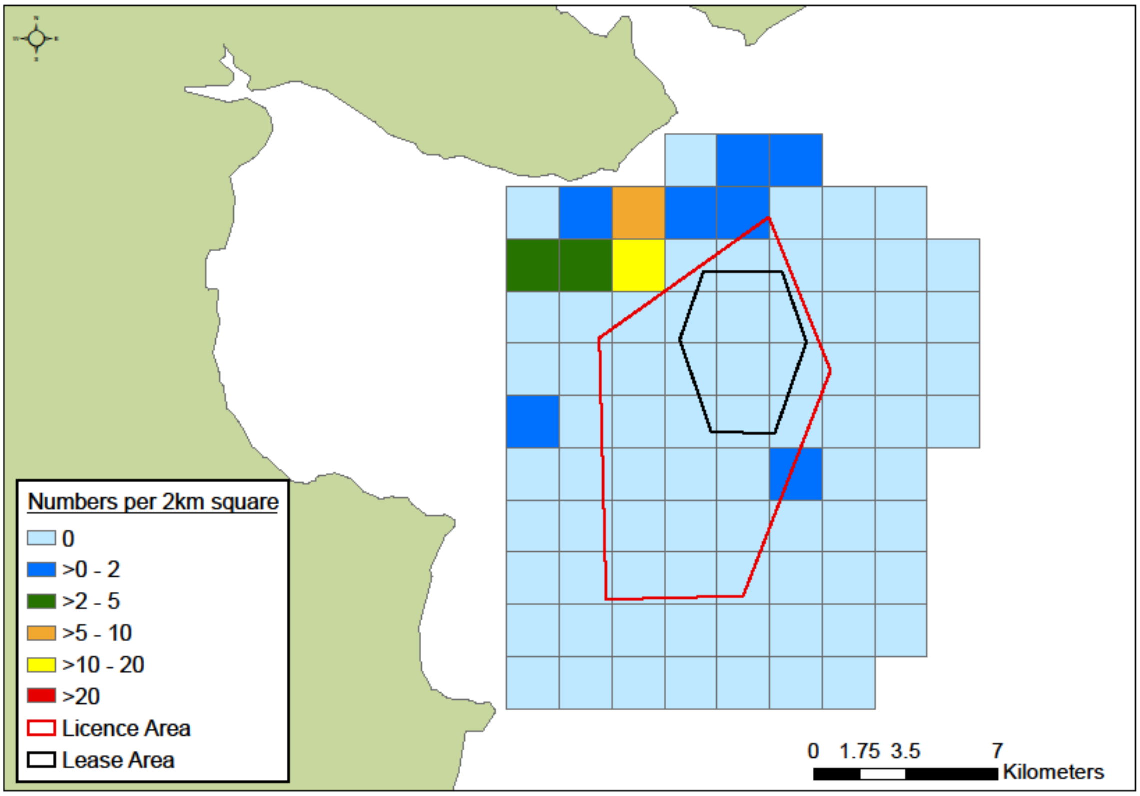

Figure 3.21.10 Black Guillemot survey results February 2019

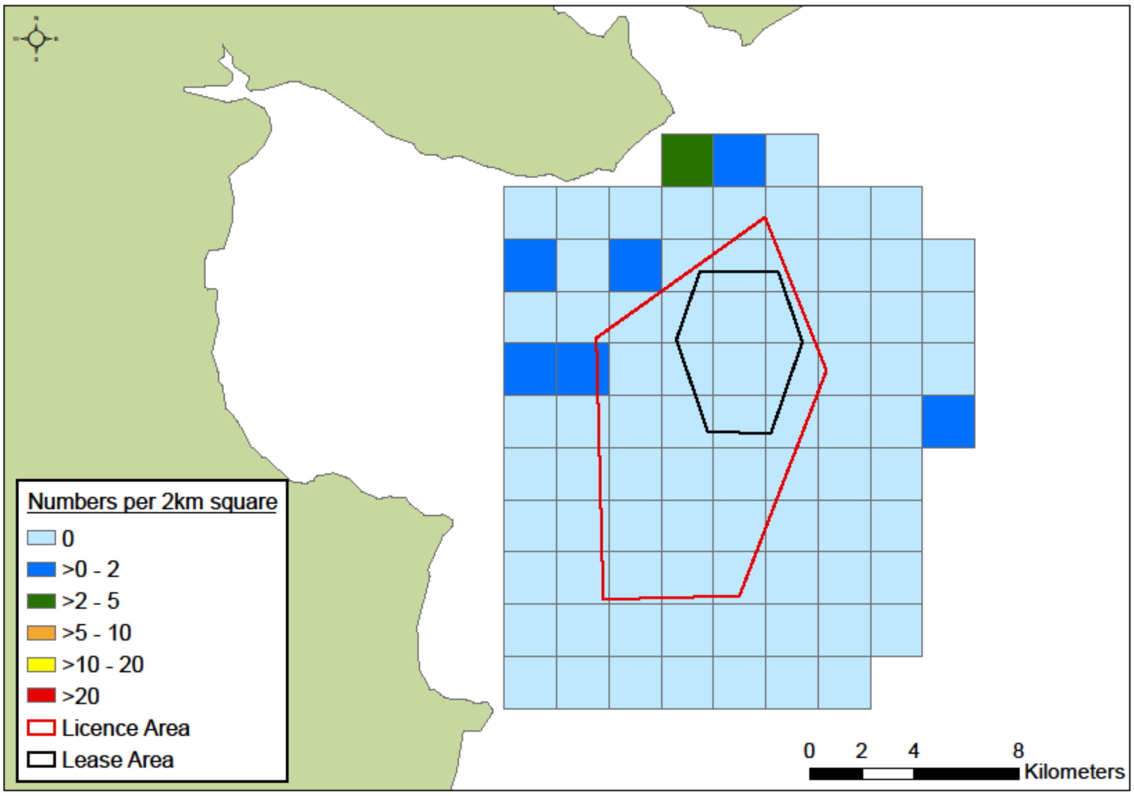

Figure 3.21.11 Black Guillemot survey results March 2019

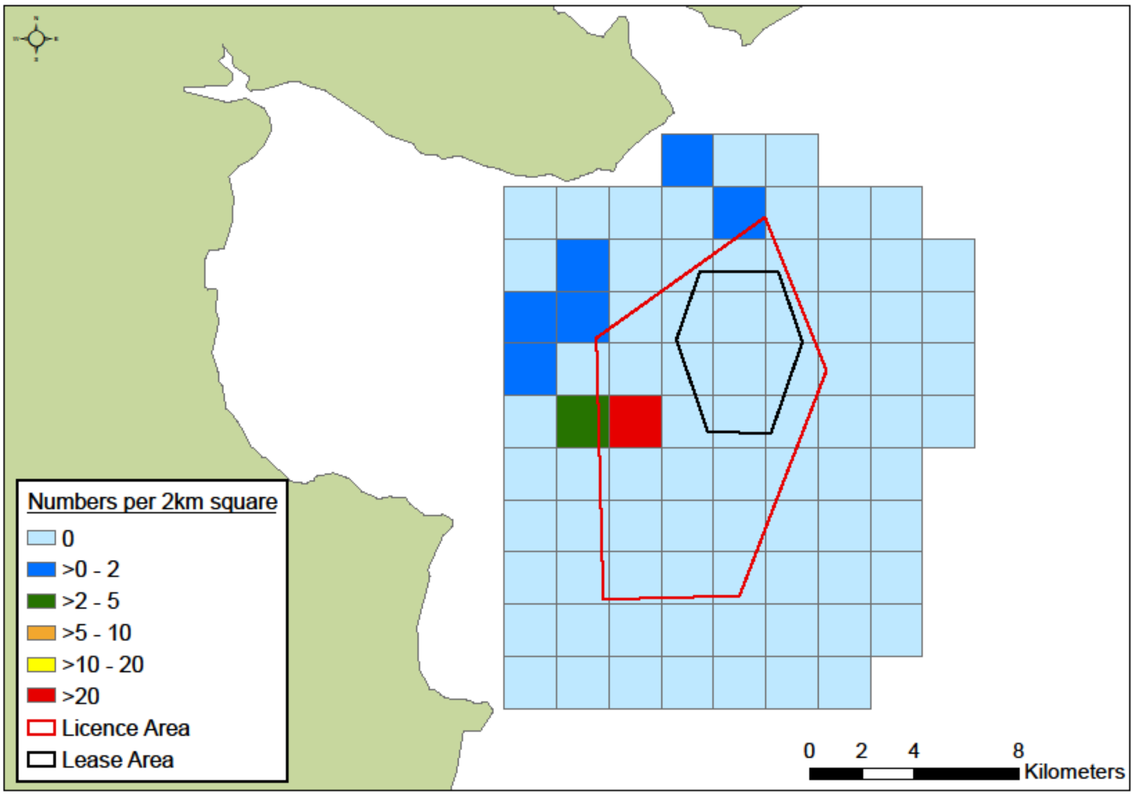

Figure 3.21.12 Black Guillemot survey results April 2019

3.21.2 Black Guillemot Density

Black Guillemot do not have correction factors indicated in Stone *et al.,* (1995) therefore no density estimates have been calculated for this species.

3.22 Puffin

Puffins are very localised breeders around the Irish coast, although a small number breed on the east coast of the country to the south of the survey area (Balmer *et al*., 2013). As with other auks, they typically feed on small fish (Mitchell *et al*., 2004). They are Amber-listed in Ireland as they are a species of European Conservation Concern (Colhoun & Cummins, 2013).

3.22.1 Puffin Abundance

Puffin were only recorded in two months of the survey period, with two birds each in June 2018 and July 2018 (Table 3.22.1; Figures 3.22.1 and 3.22.2). The two June records occurred within the Lease area (Figure 3.22.1), whilst the two July records were in the Licence area (Figure 3.22.2)

Table 3.22.1 Puffin records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
May 2018	0	0
June 2018	2	5
July 2018	2	1
August 2018	0	0
September 2018	0	0
October 2018	0	0
November 2018	0	0
December 2018	0	0
January 2019	0	0
February 2019	0	0
March 2019	0	0
April 2019	0	0
TOTAL	**4**	**6**

3.22.2 Puffin Density

With only one record of Puffin on the sea within 200m of the transect route (a single bird recorded in June 2018); density estimates were not derived.

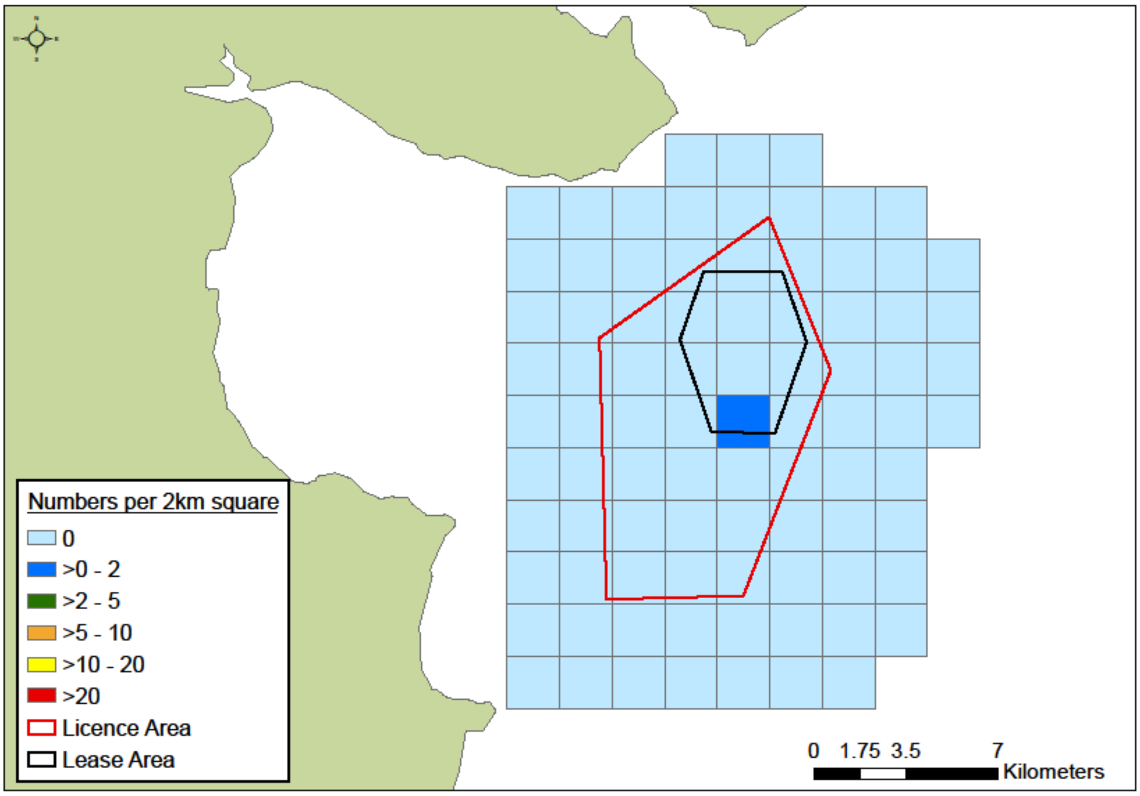

Figure 3.22.1 Puffin survey results June 2018

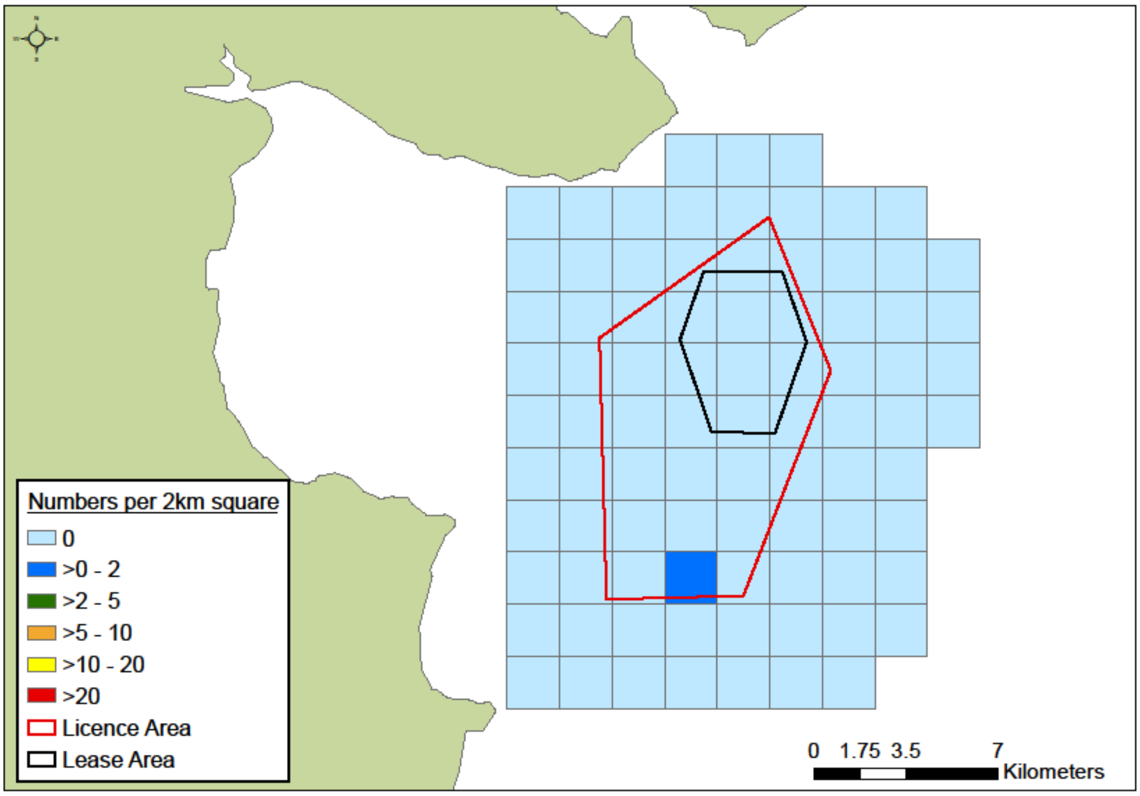

Figure 3.22.1 Puffin survey results July 2018

3.23 Additional Species

A number of additional, non-seabird species were recorded during the bird survey within the Oriel Windfarm survey area. Although these may be regarded as incidental to the site, their presence indicates that this area is used by birds on passage and migration along the east coast of Ireland, and between Ireland and Britain. Two species (Dunlin and Meadow Pipit) were recorded during transect surveys, and abundance maps have been produced for these species. The remaining species observed during fieldwork have been summarised.

3.23.1 Dunlin Abundance

Dunlin are a wading bird, that are very scarce breeders in Ireland but winter in substantial numbers around the Irish coast (Balmer *et al*., 2013). A single flock of ten birds was recorded in May 2018 (Figure 3.23.1).

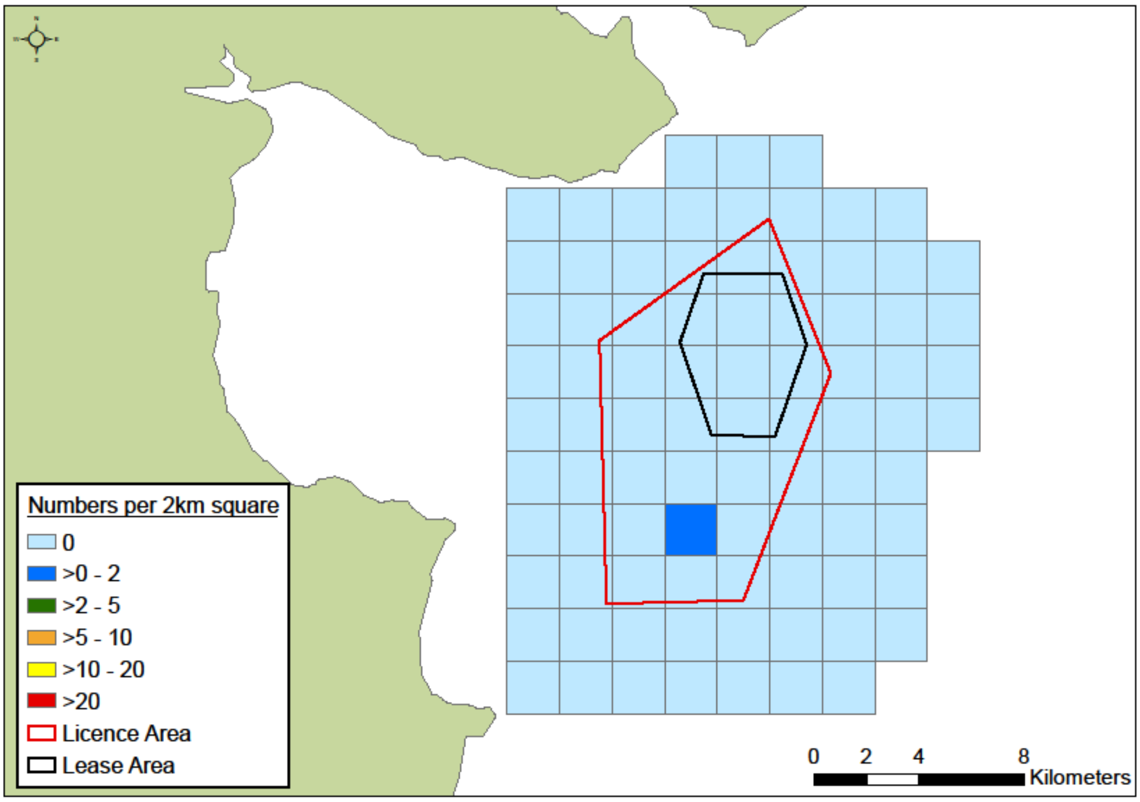

Figure 3.23.1 Dunlin survey results May 2018

3.23.2 Meadow Pipit

Meadow Pipit is a small passerine species that breeds and winters throughout Ireland (Balmer *et al.*, 2013). The wintering population in Ireland is likely to be bolstered by migrants from more northerly breeding areas.

Three birds were recorded from transects in March 2019 (Table 3.23.1). These were all flying north-west, and likely refer to migrants leaving Ireland for more northerly breeding grounds.

Table 3.23.1 Meadow Pipit records from boat surveys in Oriel Windfarm survey area, showing transect records and total observations.

Month	Transect records	All records
March 2019	3	11
April 2019	0	1
TOTAL	**3**	**12**

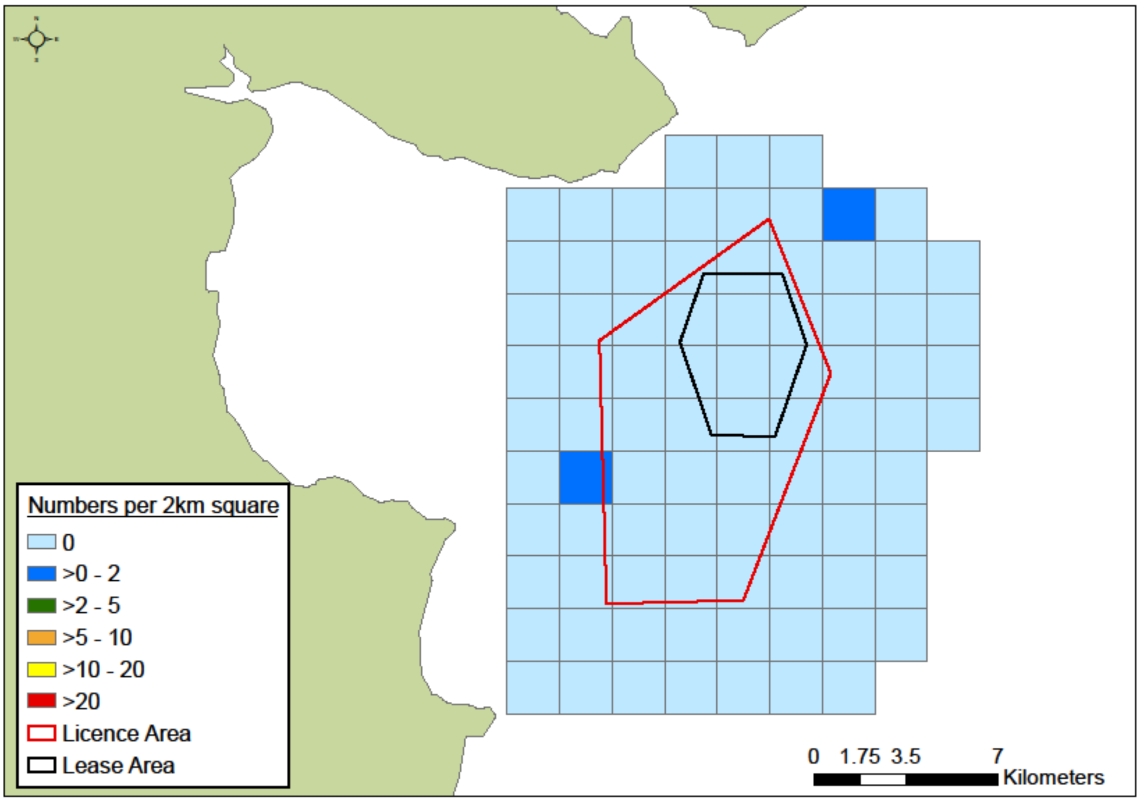

Figure 3.23.1 Meadow Pipit survey results March 2019

3.23.3 Non-transect species

All species observed within the survey area, but not recorded on transects, are summarised in Table 3.23.2. In the majority of cases, these records likely refer to bird migrating (Pale-bellied Brent Goose, Turnstone, Sanderling, Swift, Swallow and Starling) or refer to scarce seabirds foraging or on passage within the survey area (Sandwich, Roseate and Arctic Tern and Arctic and Pomarine Skua).

Table 3.23.2 Species observed during fieldwork but not recorded on transects

Species	Month	No. observed	Notes
Pale-bellied Brent Goose	Nov-18	4	A group of four flying south on 26 November 2018
	Jan-19	2	Two birds observed flying north on 11 January 2019
Grey Heron	Feb-19	1	A single bird flying south on 27 February 2019
Turnstone	May-18	1	A single bird flying north on 4 May 2018 with a flock of Sanderling (below) and a flock of ten Dunlin
Sanderling	May-18	10	A flock of ten Sanderling flying north on 4 May 2018 with a flock of ten Dunlin and a single Turnstone
Sandwich Tern	May-18	2	Two birds flying west on 4 May 2018
	Jul-18	1	One bird flying north on 7 July 2018
	Aug-18	2	Two birds flying west on 30 August 2018
		2	Two birds flying north on 31 August 2018
Roseate Tern	Jul-18	4	Four bird milling/feeding on 7 July 2018
Arctic Tern	Jun-18	1	One bird flying north-west on 8 June 2018
		1	One bird milling/feeding on 9 June 2018
	Jul-18	1	One bird flying south on 6 July 2018
		2	Two birds flying south-west on 6 July 2018
		6	Six birds flying east on 7 July 2018
		2	Two birds flying west on 7 July 2018
Pomarine Skua	Oct-18	1	One bird flying west on 21 October 2018
Arctic Skua	May-18	1	One bird milling/feeding on 4 May 2018
	Aug-18	1	One bird flying south-east on 30 August 2018
		1	One bird flying south on 31-August
Swift	Jul-18	1	One bird flying north-west on 7 July 2018
Swallow	May-18	6	Six individual birds flying west on 4 May 2018
		1	One bird flying north-east on 4 May 2018
		1	One bird flying south-west on 4 May 2018
	Sep-18	8	A flock of eight birds flying south on 1 September 2018
	Apr-19	2	Two individual birds flying south-west on 20 April 2019
		1	One bird flying south-west on 21 April 2019
Starling	Oct-18	27	A flock of 27 birds flying north on 20 October 2018
		1	One bird flying north-west on 21 October 2018
	Dec-18	28	A flock of 28 birds flying west on 4 December 2018

4. MARINE MAMMAL SURVEY RESULTS

Marine Mammal data are presented below on a species-by-species basis to assist in interpretation of the data collection. The collective occurrence of species is considered in the Discussion (Section 5).

4.1 Harbour Porpoise

The Harbour Porpoise *Phocoena* is Irelands smallest whale. It is generally regarded as an elusive species and does not engage as readily in the following of vessels nor do they breach clear of the water as frequently as other whales.

The Harbour Porpoise has been recorded off all Irish coasts, including over the continental shelf, but it is thought to be most abundant off the southwest coast (O'Brien, 2016). Harbour Porpoise occur at highest densities in the Irish Sea, with highest abundances in the central Irish Sea. Three areas of important habitat for Harbour Porpoise in Ireland have been designated as Special Areas of Conservation; including one on the east coast (Rockabill to Dalkey Island, County Dublin.).

4.1.1 Harbour Porpoise Abundance

A total of 543 Harbour Porpoises were recorded during fieldwork (see Table 4.1.1), with peak counts of 114 individuals in August 2018 (Figure 4.1.4) and 105 animals in January 2019 (Figure 4.1.9). However, animals were recorded in each month of surveying (see Figures 4.1.1 to 4.1.12). Most Harbour Porpoise records for Ireland are in the summer months (O'Brien, 2016), but it is commented that this may be linked to increased observer activity at this time.

Table 4.1.1 Harbour Porpoise records from boat surveys in Oriel Windfarm survey area

Month	Number sighted
May 2018	13
June 2018	5
July 2018	20
August 2018	114
September 2018	38
October 2018	53
November 2018	8
December 2018	61
January 2019	105
February 2019	36
March 2019	36
April 2019	54
TOTAL	**543**

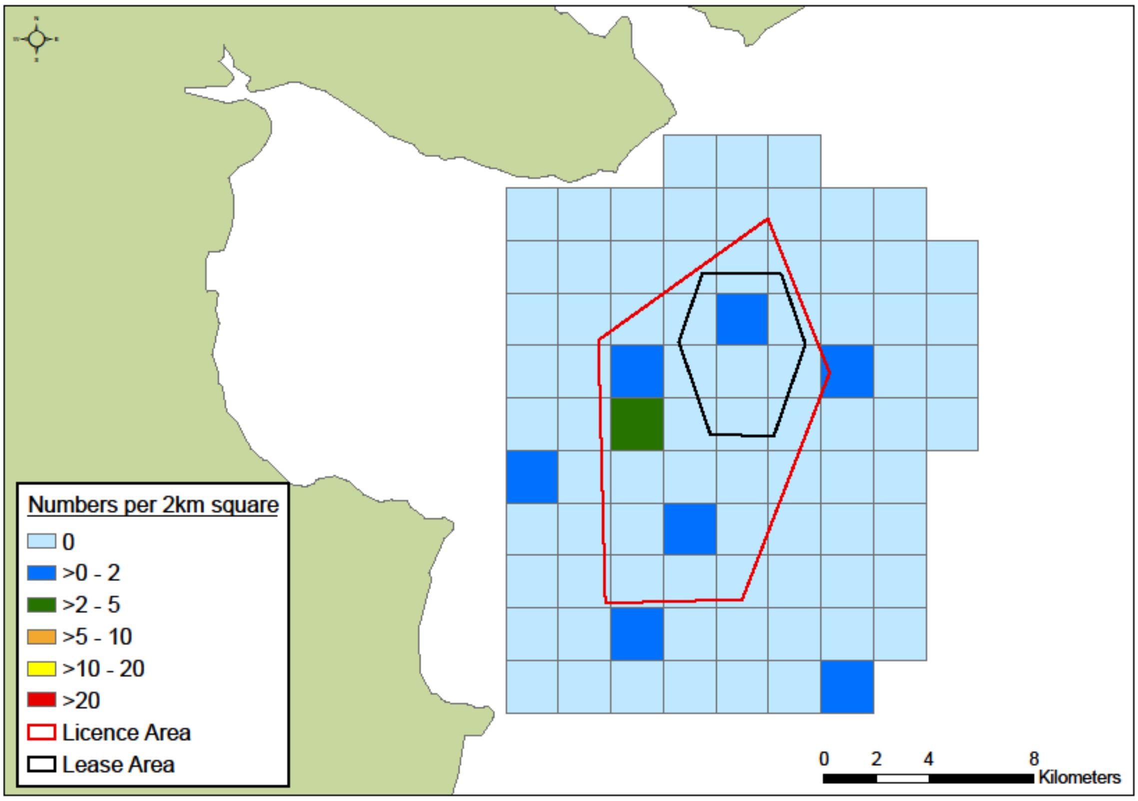

Figure 4.1.1 Harbour Porpoise survey results May 2018

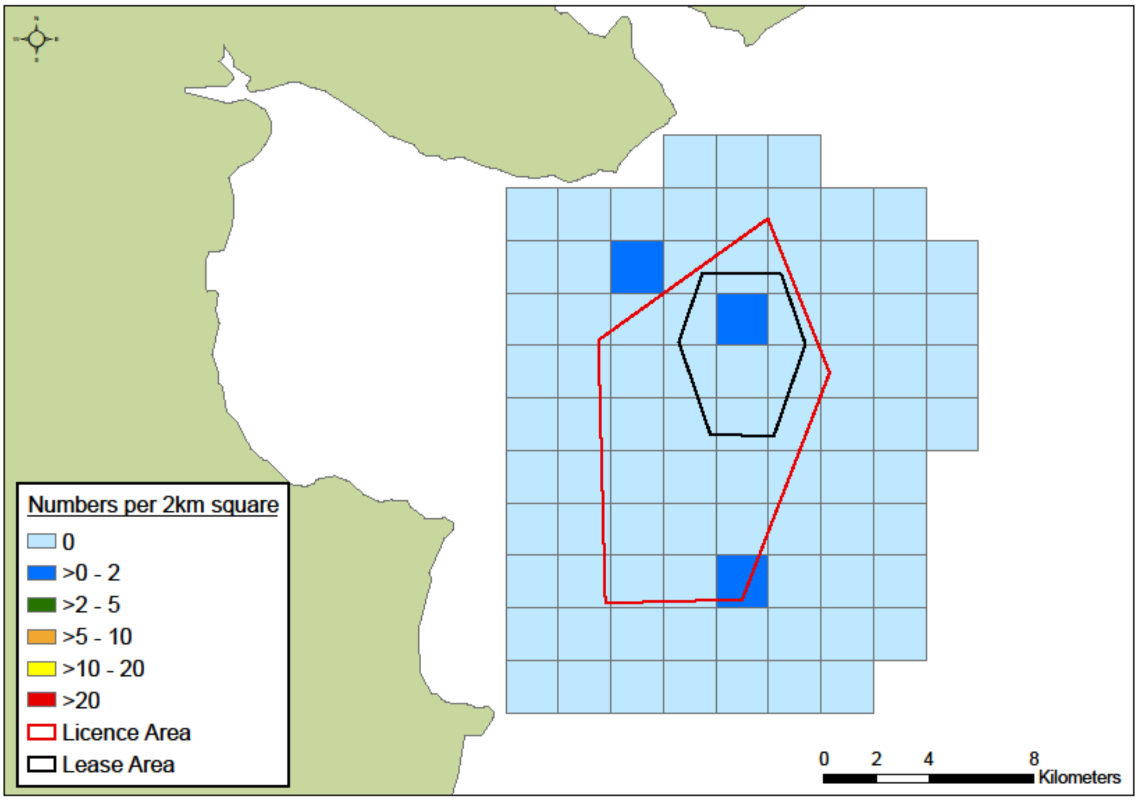

Figure 4.1.2 Harbour Porpoise survey results June 2018

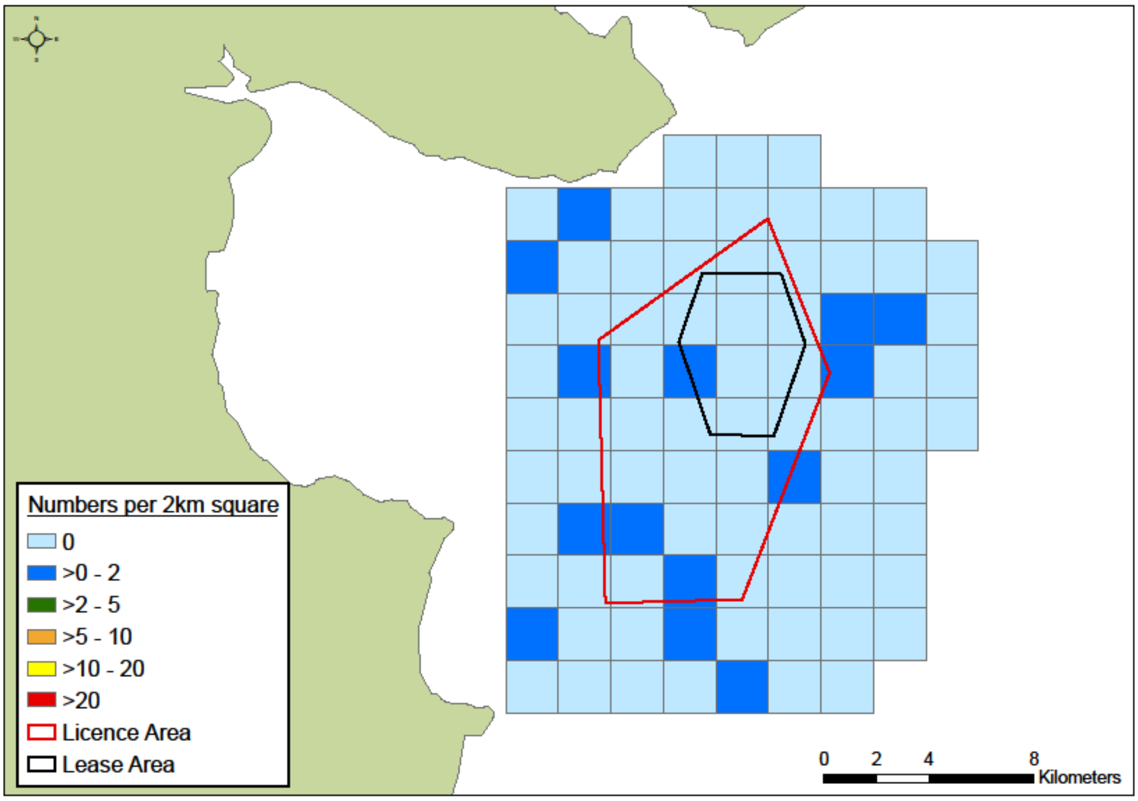

Figure 4.1.3 Harbour Porpoise survey results July 2018

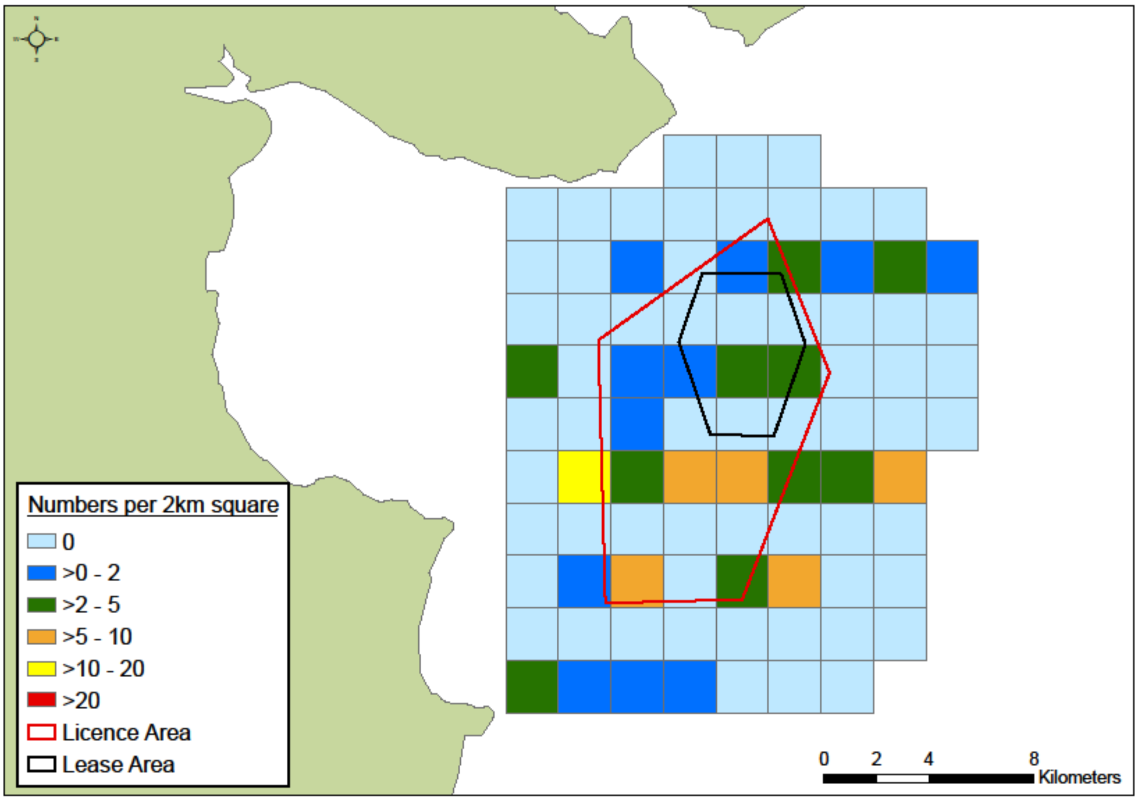

Figure 4.1.4 Harbour Porpoise survey results August 2018

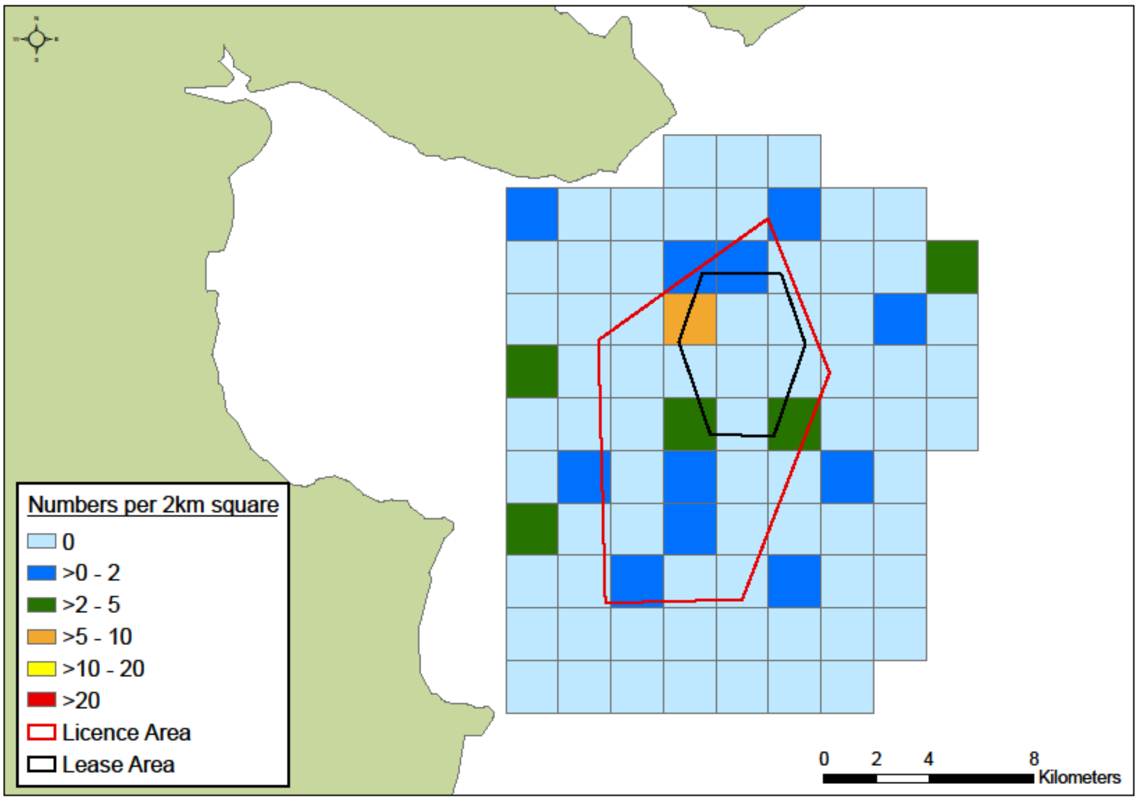

Figure 4.1.5 Harbour Porpoise survey results September 2018

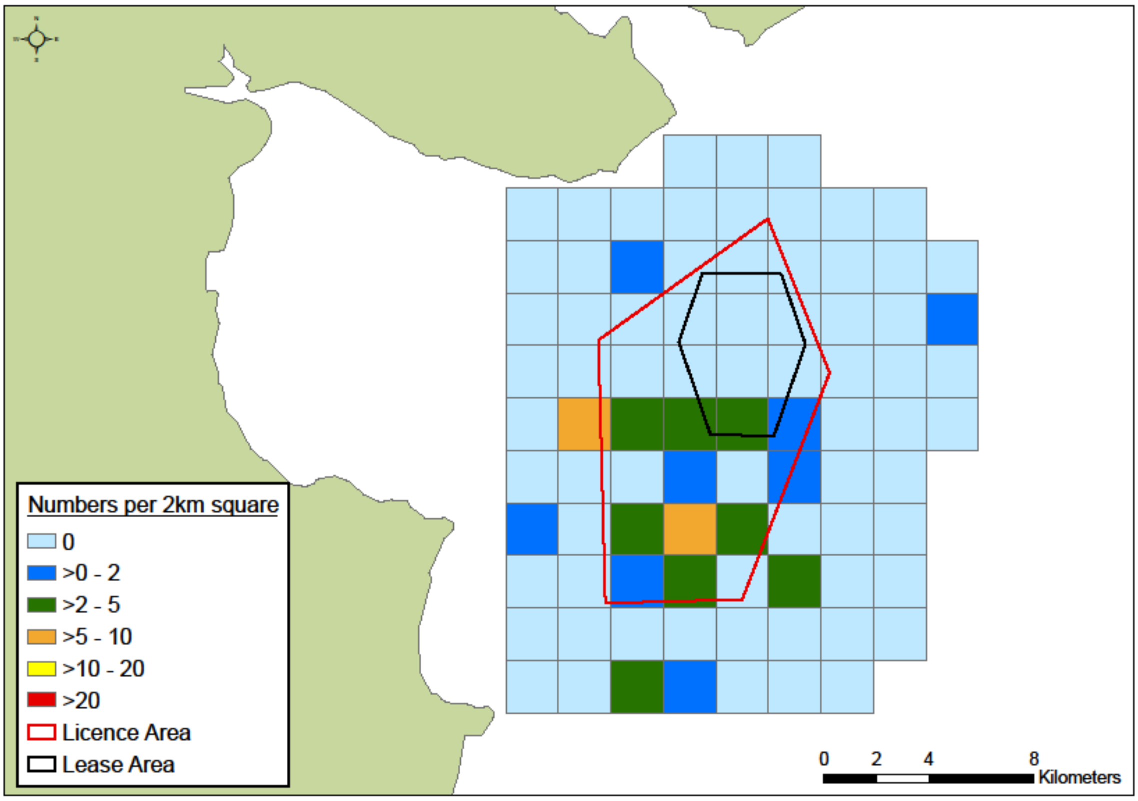

Figure 4.1.6 Harbour Porpoise survey results October 2018

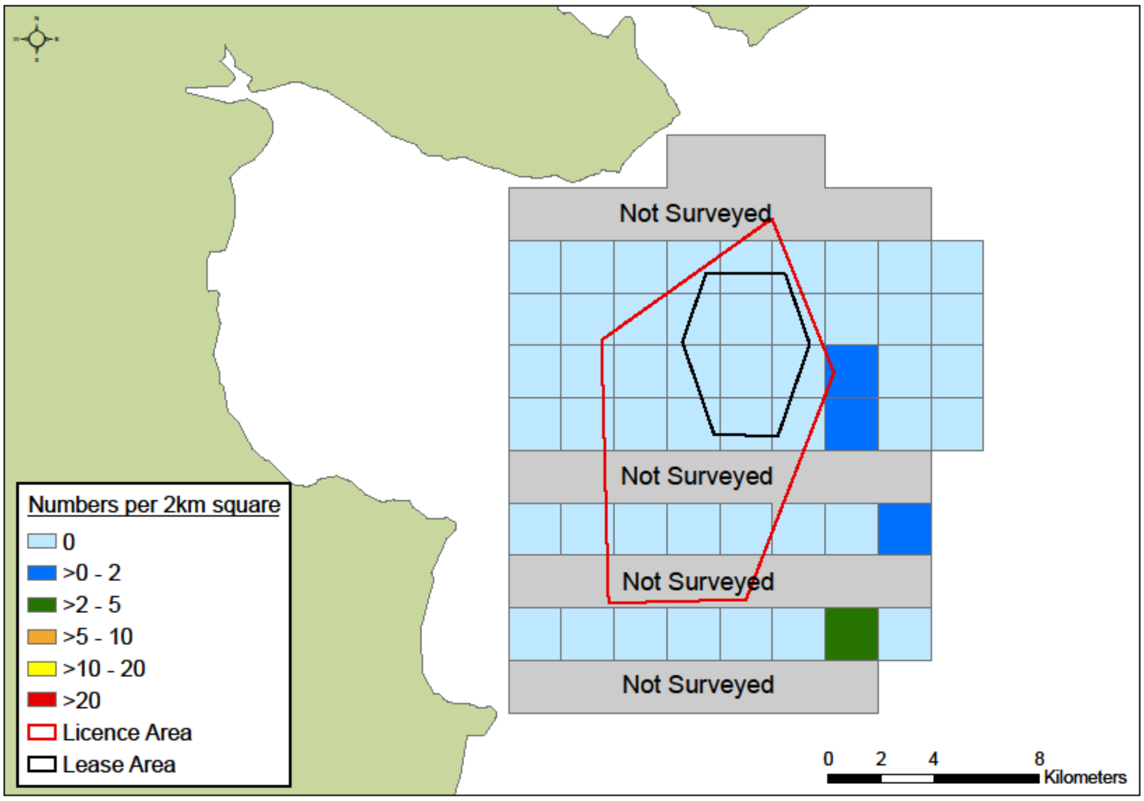

Figure 4.1.7 Harbour Porpoise survey results November 2018

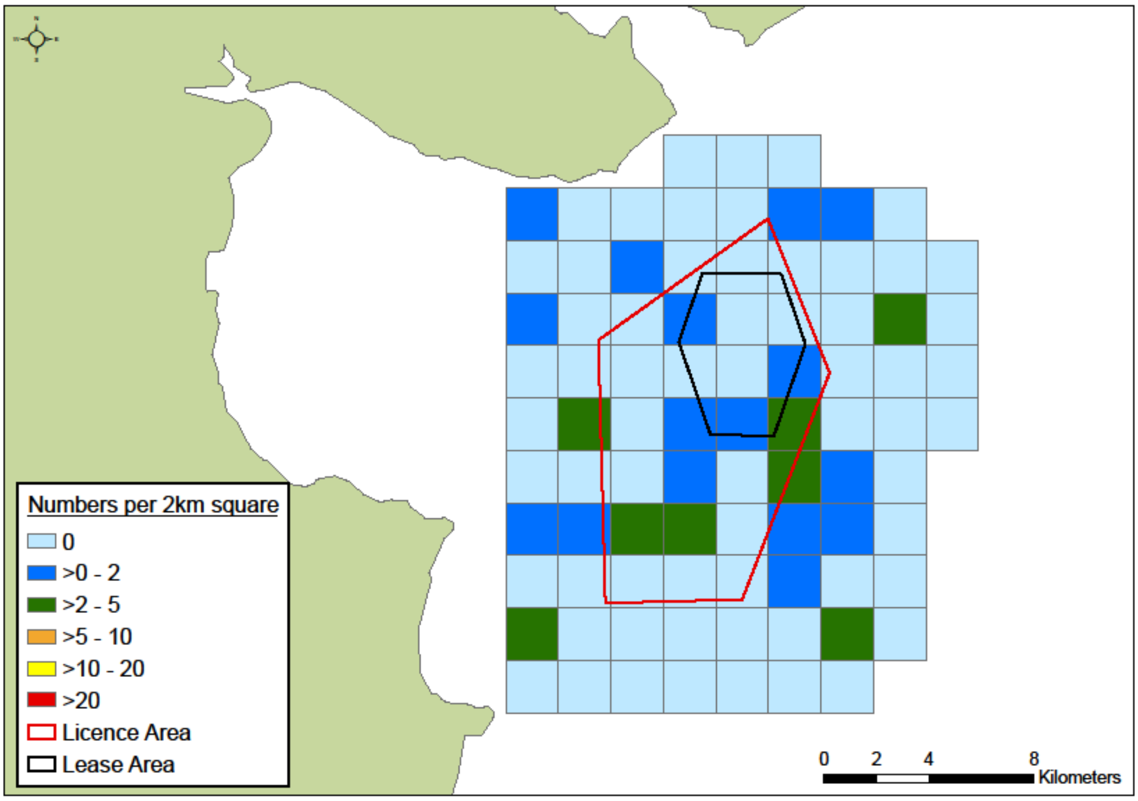

Figure 4.1.8 Harbour Porpoise survey results December 2018

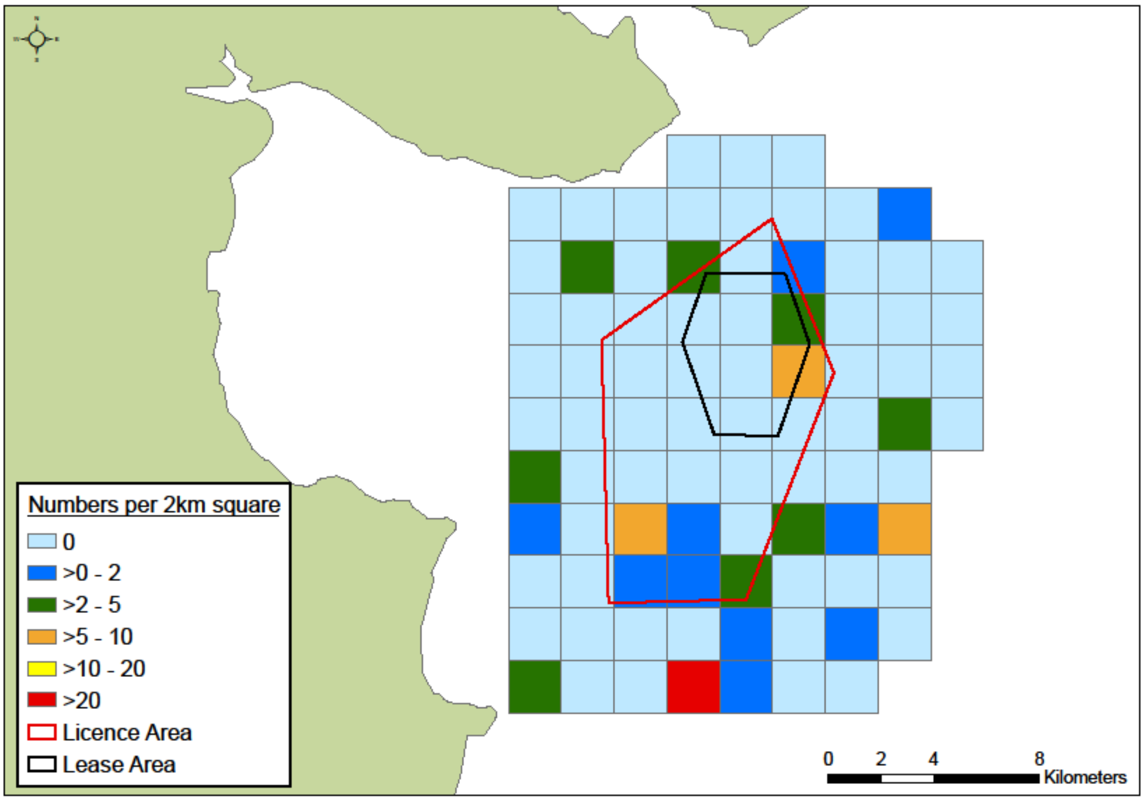

Figure 4.1.9 Harbour Porpoise survey results January 2019

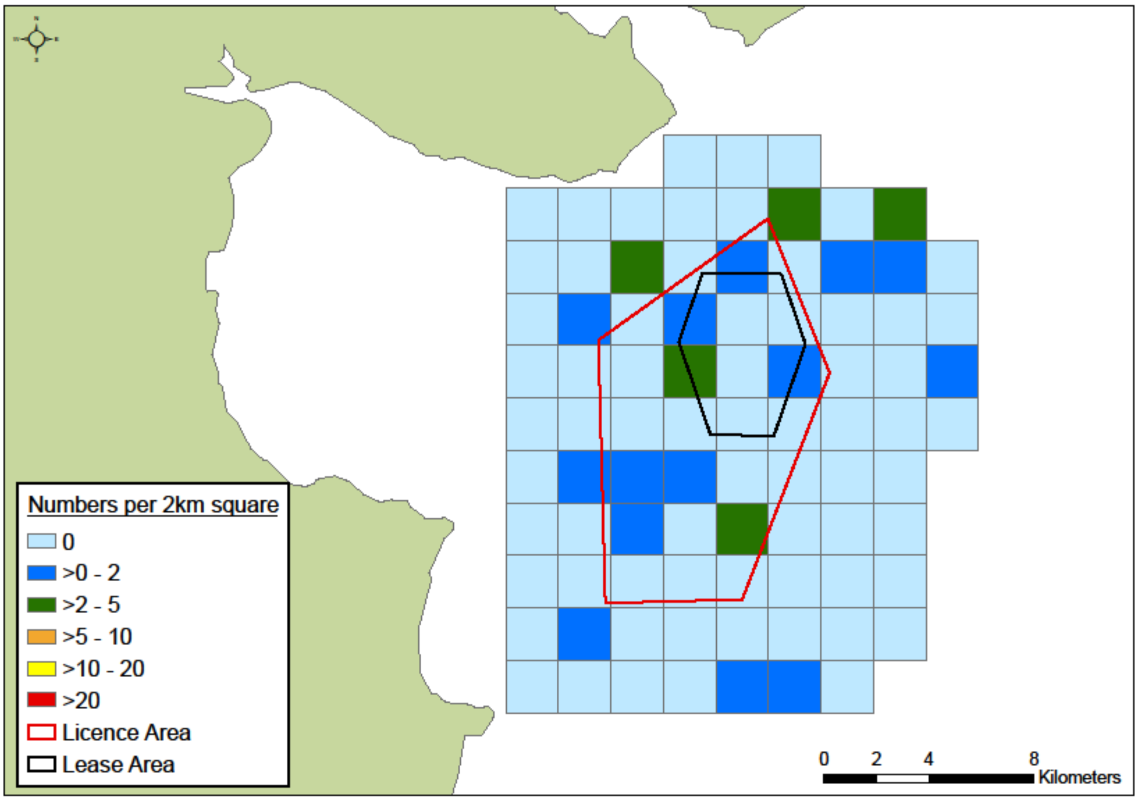

Figure 4.1.10 Harbour Porpoise survey results February 2019

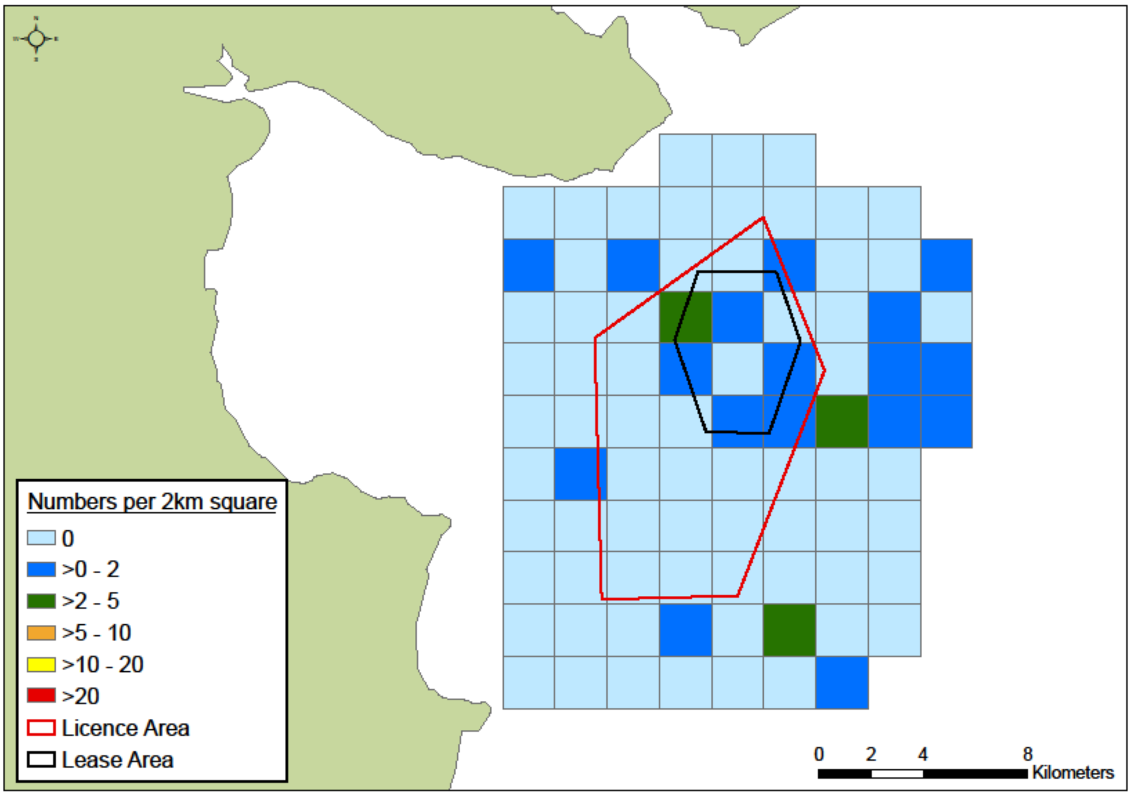

Figure 4.1.11 Harbour Porpoise survey results March 2019

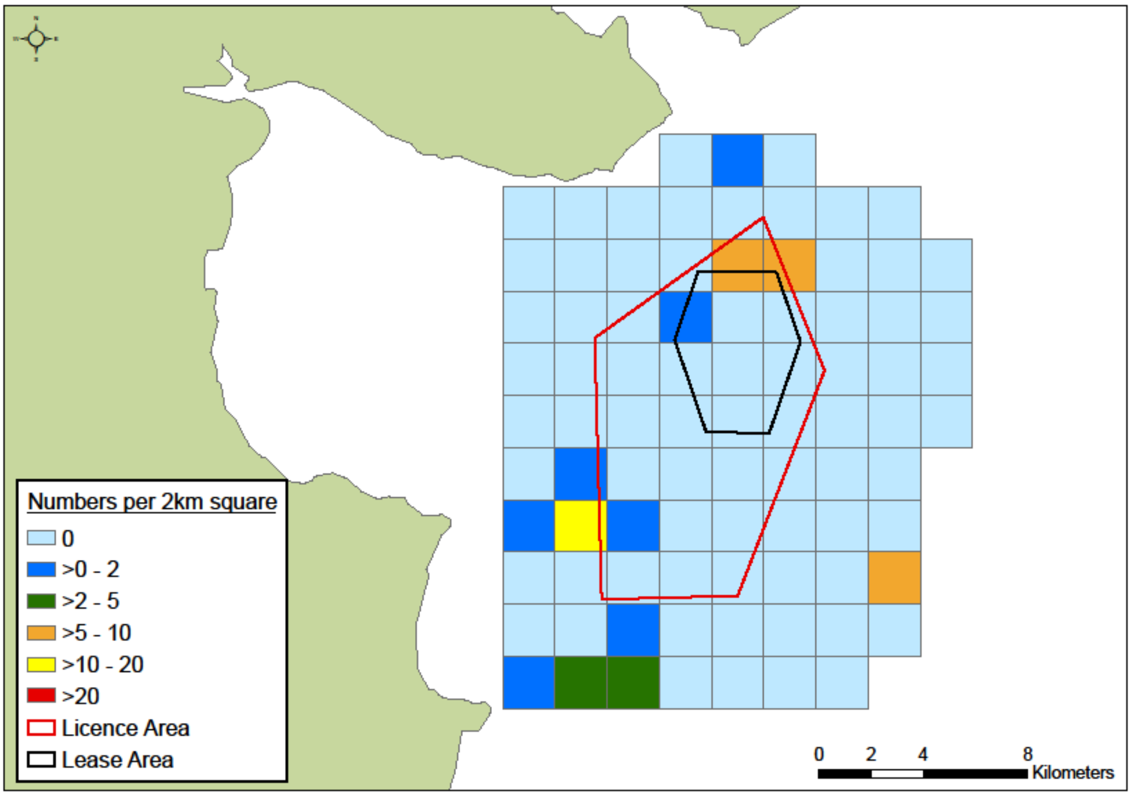

Figure 4.1.12 Harbour Porpoise survey results April 2019

4.2 Minke Whale

The Minke Whale *Balaenoptera acutorostrata* is a rorqual whale which grows to a maximum length of ca.10m in the North Atlantic. They are the most abundant species of baleen whale and are found virtually worldwide. Within the Irish context, they are Ireland most frequently observed baleen whale and prefer the shallow waters (<200m) over the Irish shelf (Berrow *et al.,* 2010). The highest relative abundance of Minke Whales is recorded off the south and southwest coast in the autumn and western Irish Sea in the Spring (Whooley,2016).

4.2.1 Minke Whale Abundance

Minke Whale were seen in three months of the survey (Table 4.2.1), with four sightings of single individuals each in June 2018 (Figure 4.2.1), August 2018 (Figure 4.2.2) and September (Figure 4.2.3).

Table 4.2.1 Minke Whale records from boat surveys in Oriel Windfarm survey area

Month	Number sighted
May 2018	0
June 2018	4
July 2018	0
August 2018	4
September 2018	0
October 2018	4
November 2018	0
December 2018	0
January 2019	0
February 2019	0
March 2019	0
April 2019	0
TOTAL	**12**

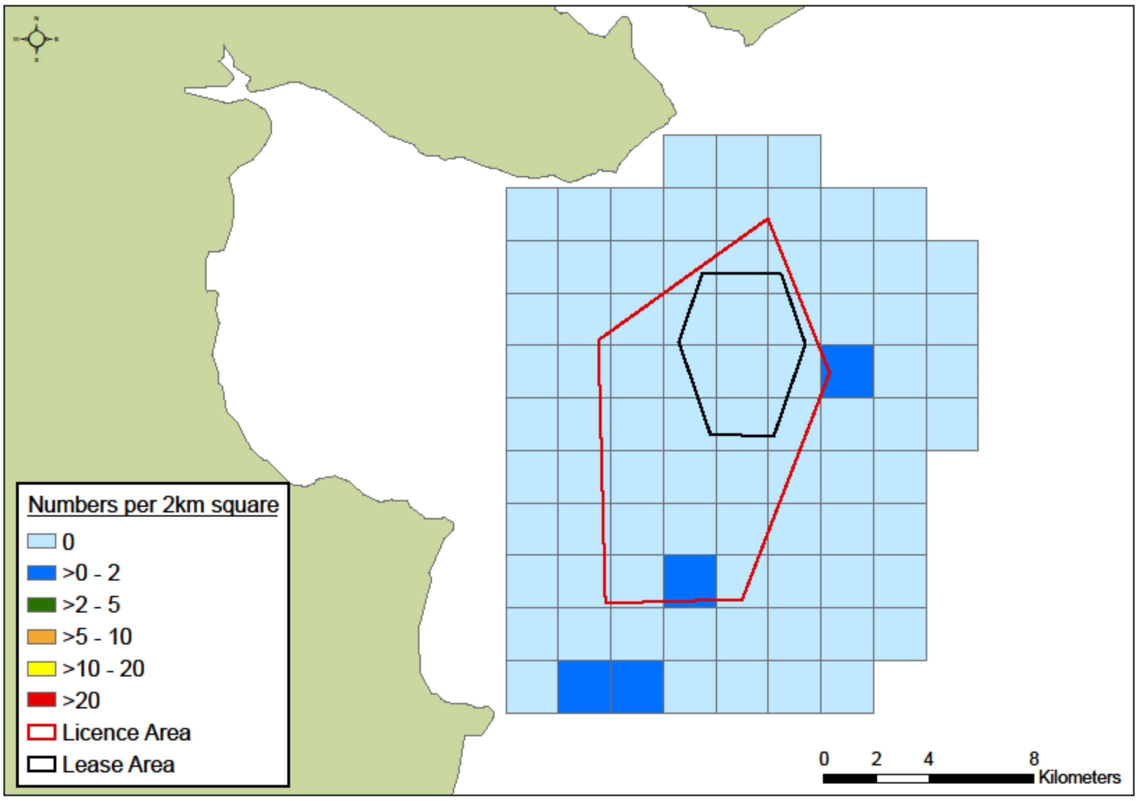

Figure 4.2.1 Minke Whale survey results June 2018.

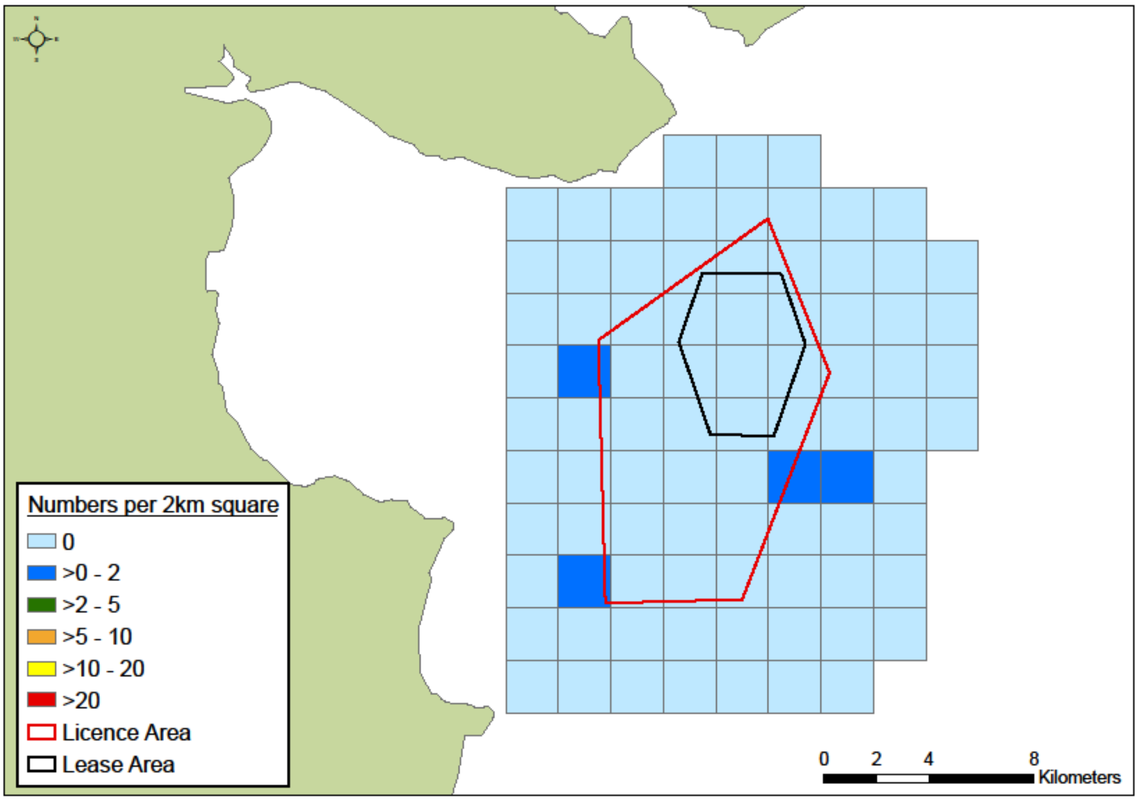

Figure 4.2.2 Minke Whale survey results August 2018.

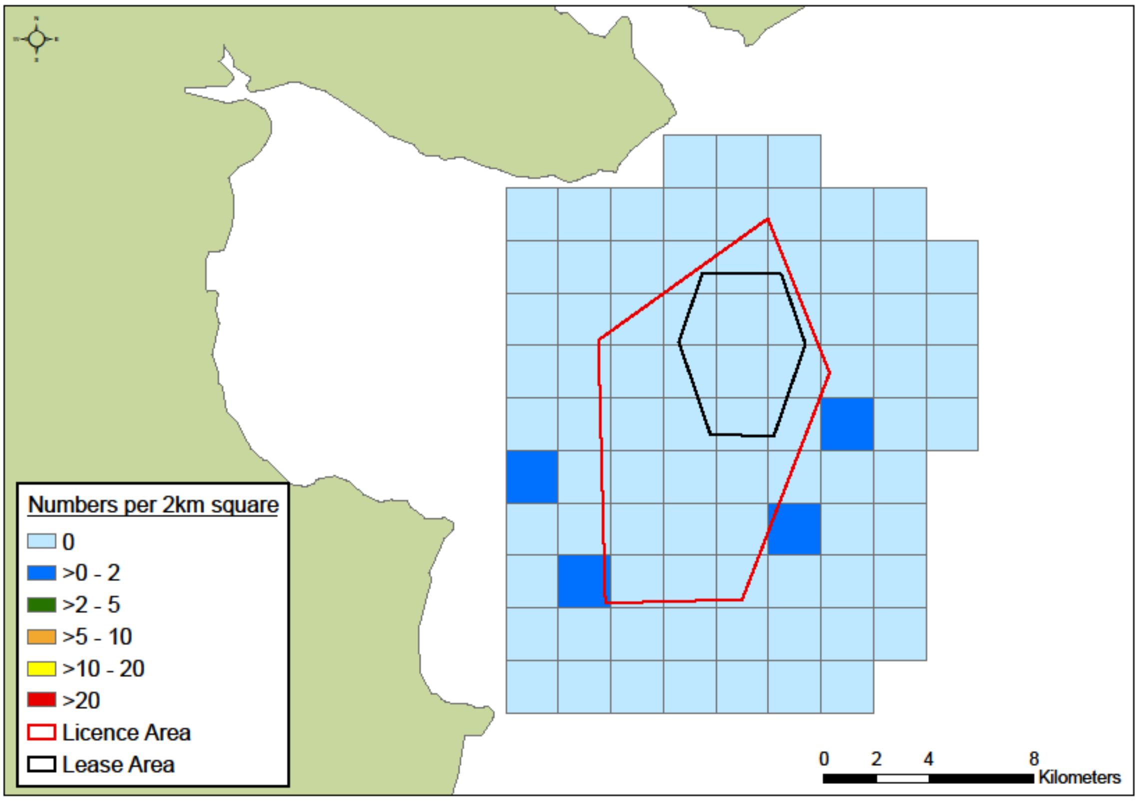

Figure 4.2.3 Minke Whale survey results September 2018.

4.3 Grey Seal

Grey Seals are widely recorded around Irish coasts and coastal waters (Cronin, 2016), and are visible throughout the year, although larger numbers are typically seen during the mating season (September to December) and during moult (January to March).

4.3.1 Grey Seal Abundance

A total of 37 Grey Seals were recorded, with animals observed in every month apart from October (Table 4.3.1). The peak count of six animals was had in September 2018 (Figure 4.3.5) and March 2019 (Figure 4.3.10), but there was little difference between monthly surveys (See Figures 4.3.1 to 4.3.11).

Table 4.3.1 Grey Seal records from boat surveys in Oriel Windfarm survey area

Month	Number sighted
May 2018	3
June 2018	2
July 2018	3
August 2018	4
September 2018	6
October 2018	0
November 2018	1
December 2018	5
January 2019	2
February 2019	3
March 2019	6
April 2019	2
TOTAL	**37**

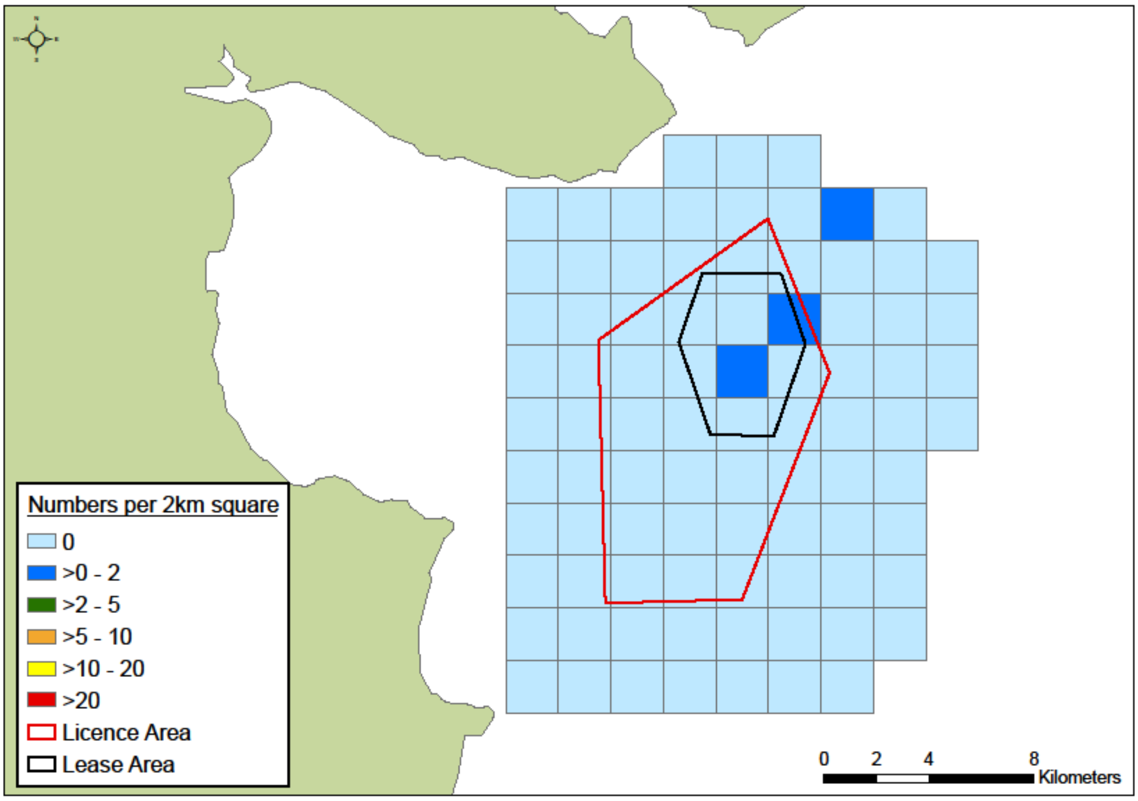

Figure 4.3.1 Grey Seal survey results May 2018.

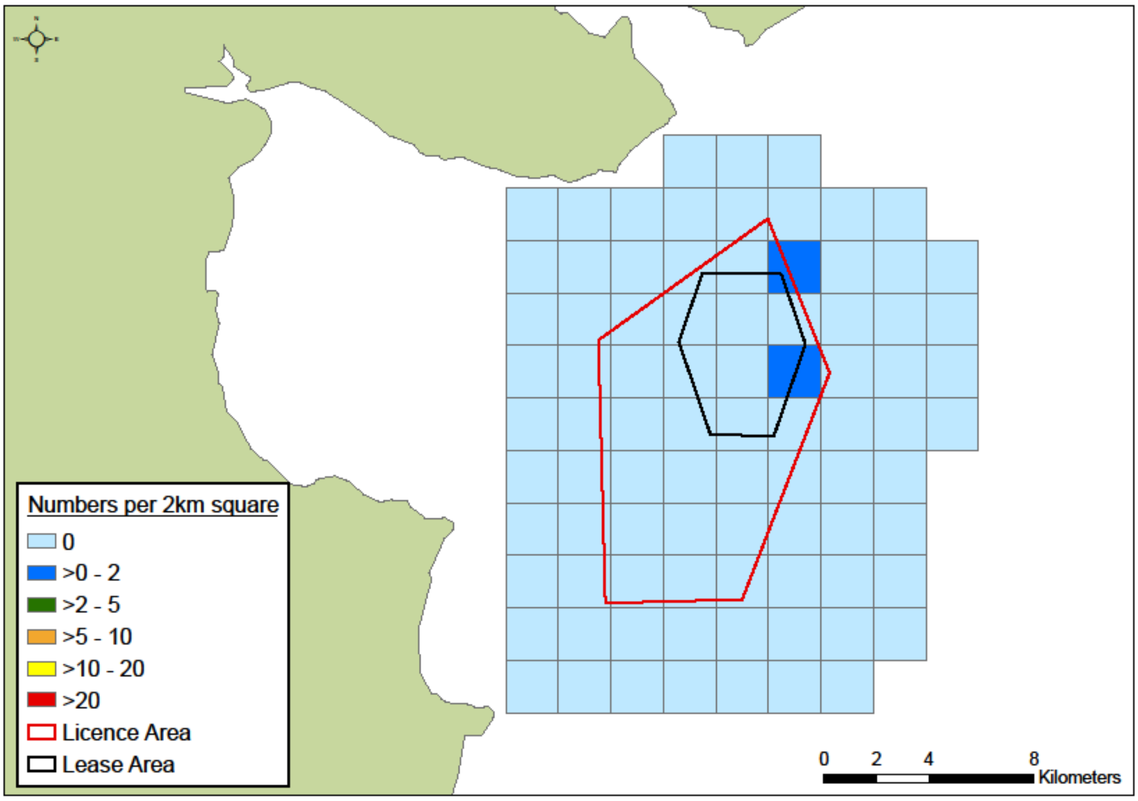

Figure 4.3.2 Grey Seal survey results June 2018.

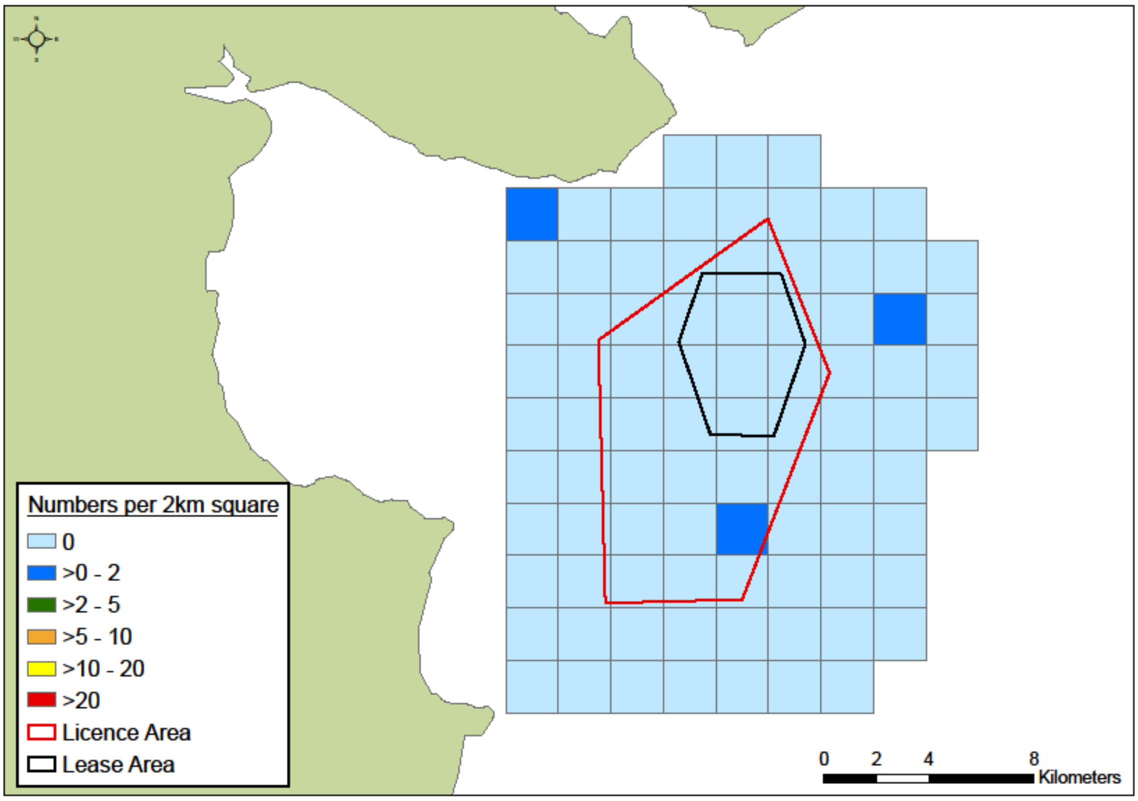

Figure 4.3.3 Grey Seal survey results July 2018.

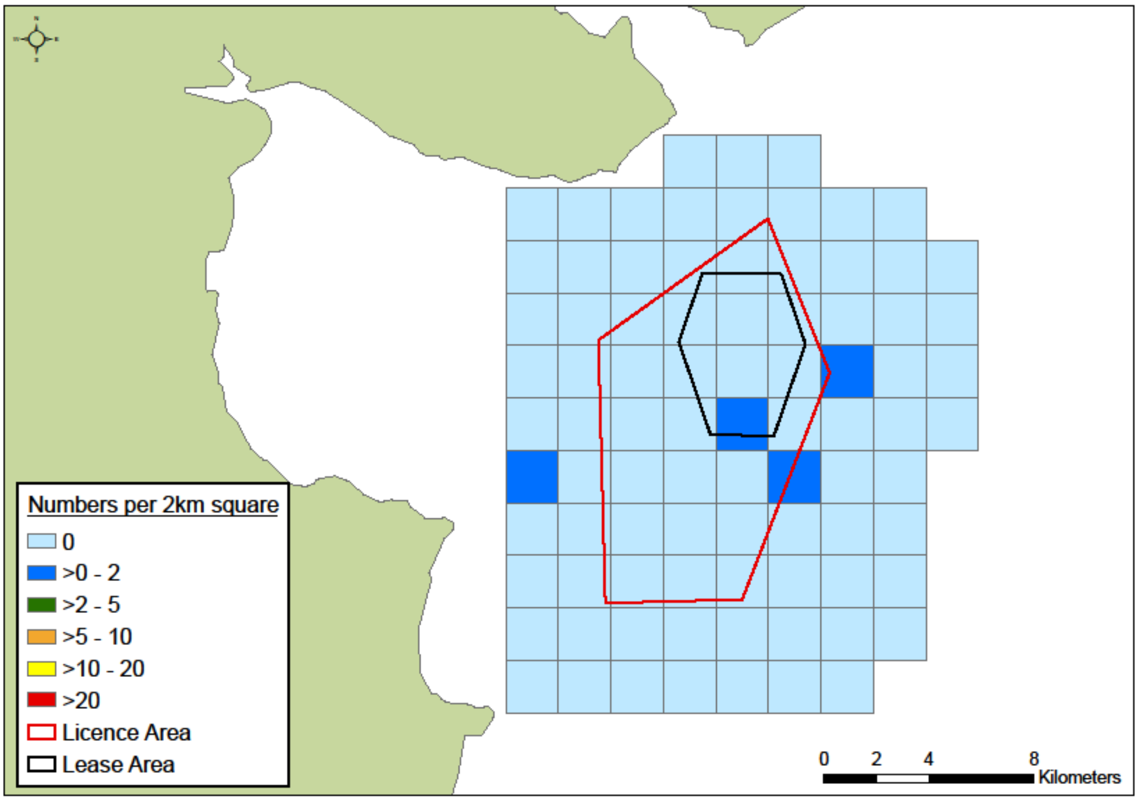

Figure 4.3.4 Grey Seal survey results August 2018.

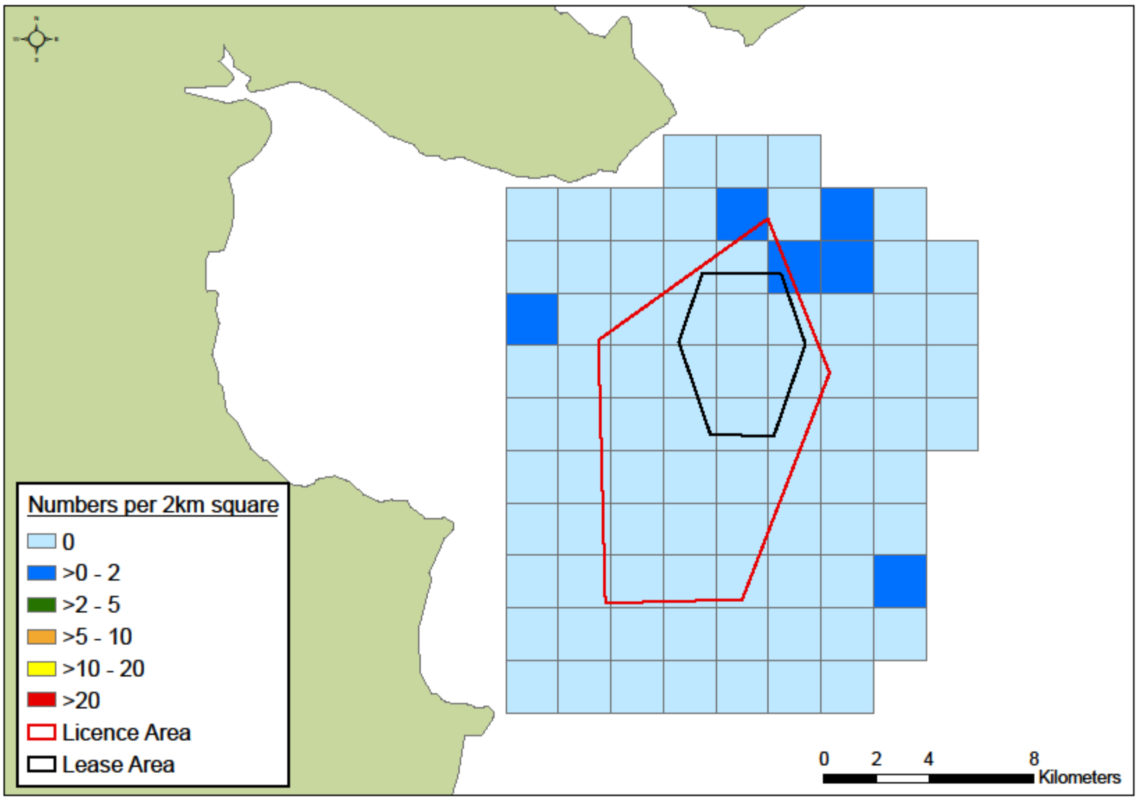

Figure 4.3.5 Grey Seal survey results September 2018.

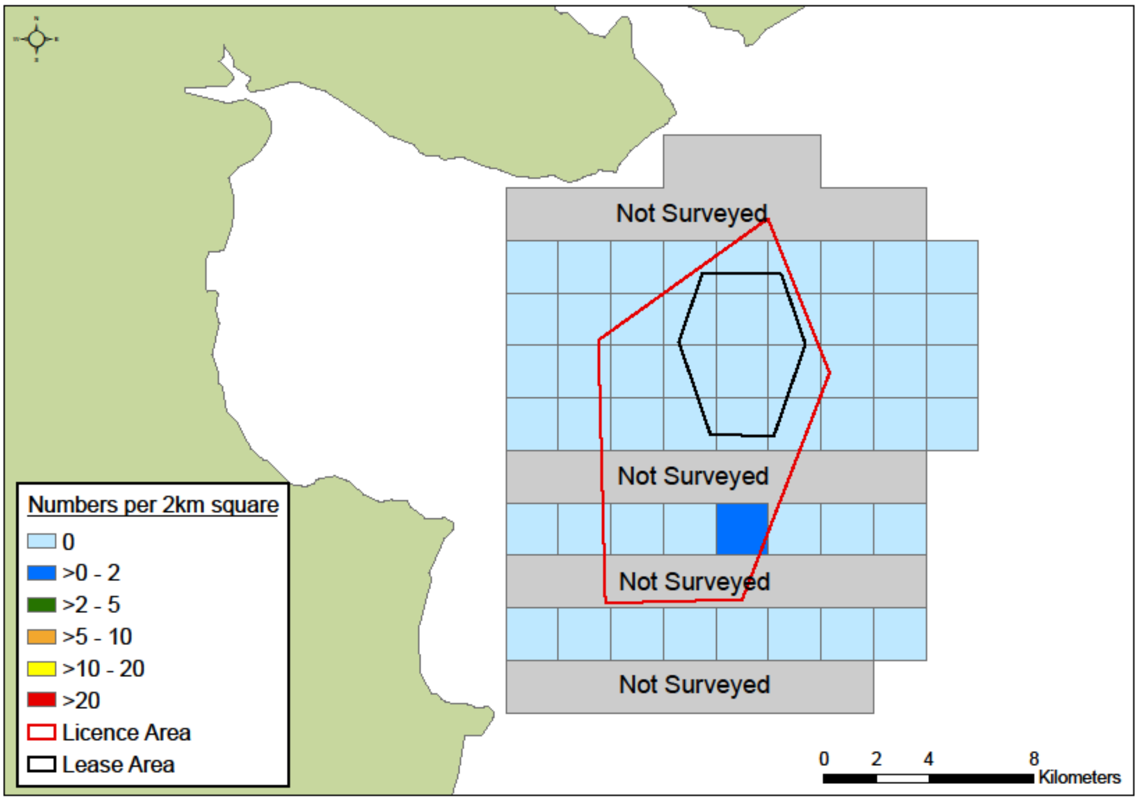

Figure 4.3.6 Grey Seal survey results November 2018.

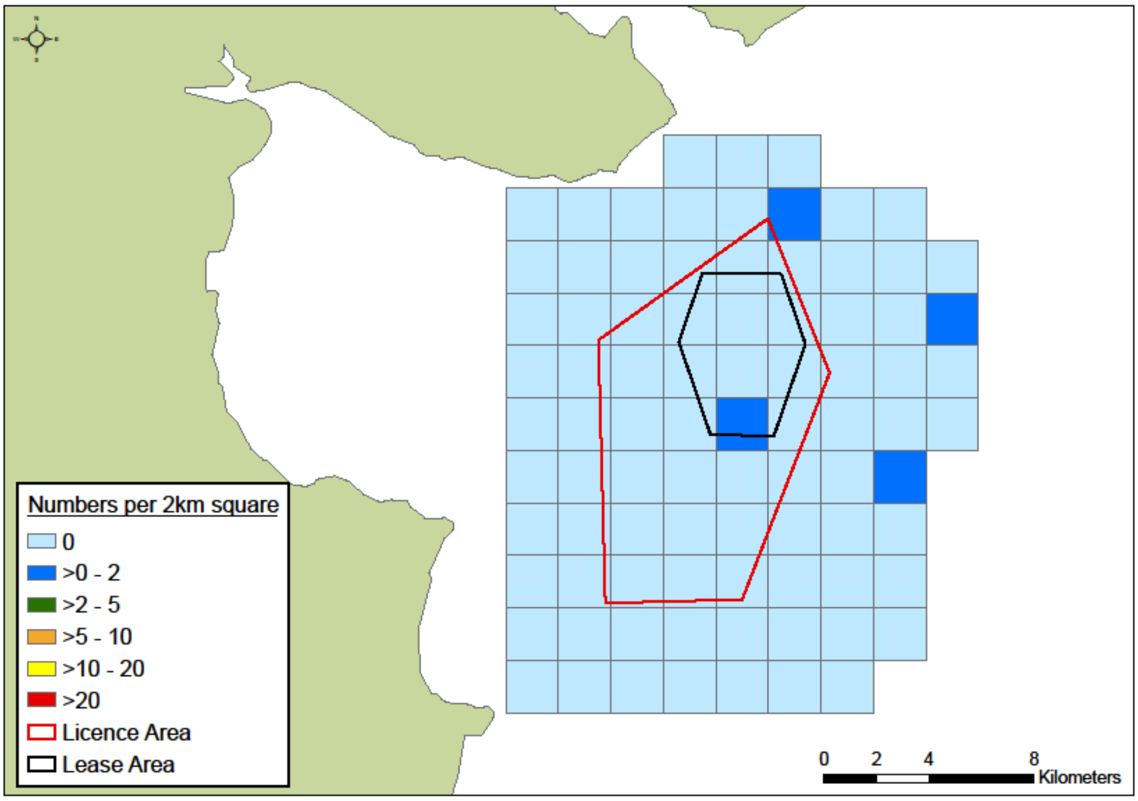

Figure 4.3.7 Grey Seal survey results December 2018.

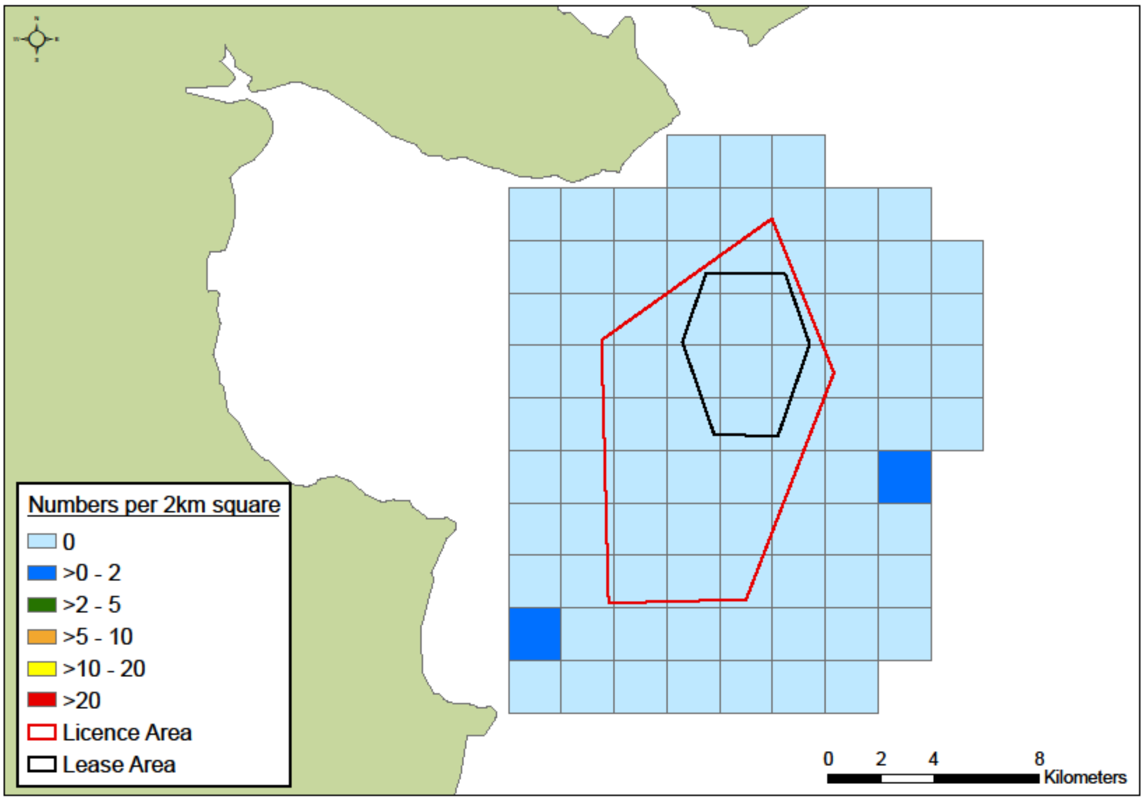

Figure 4.3.8 Grey Seal survey results January 2018.

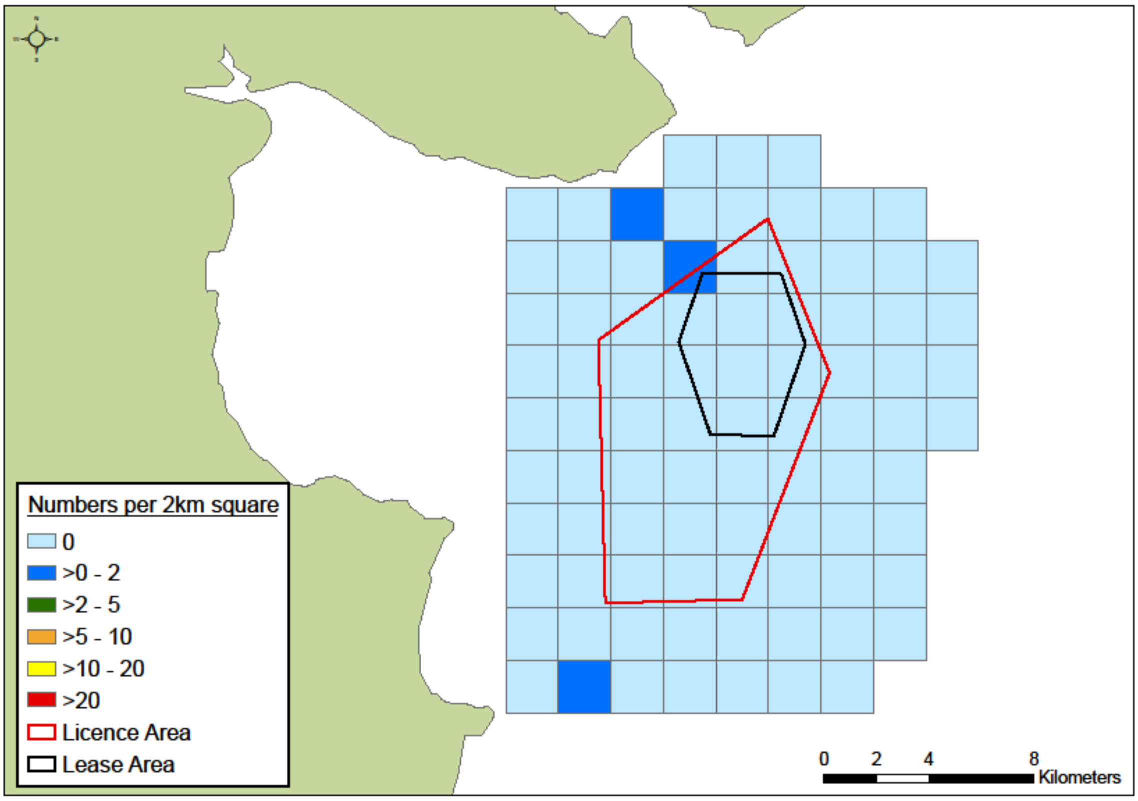

Figure 4.3.9 Grey Seal survey results Ferbruary 2018.

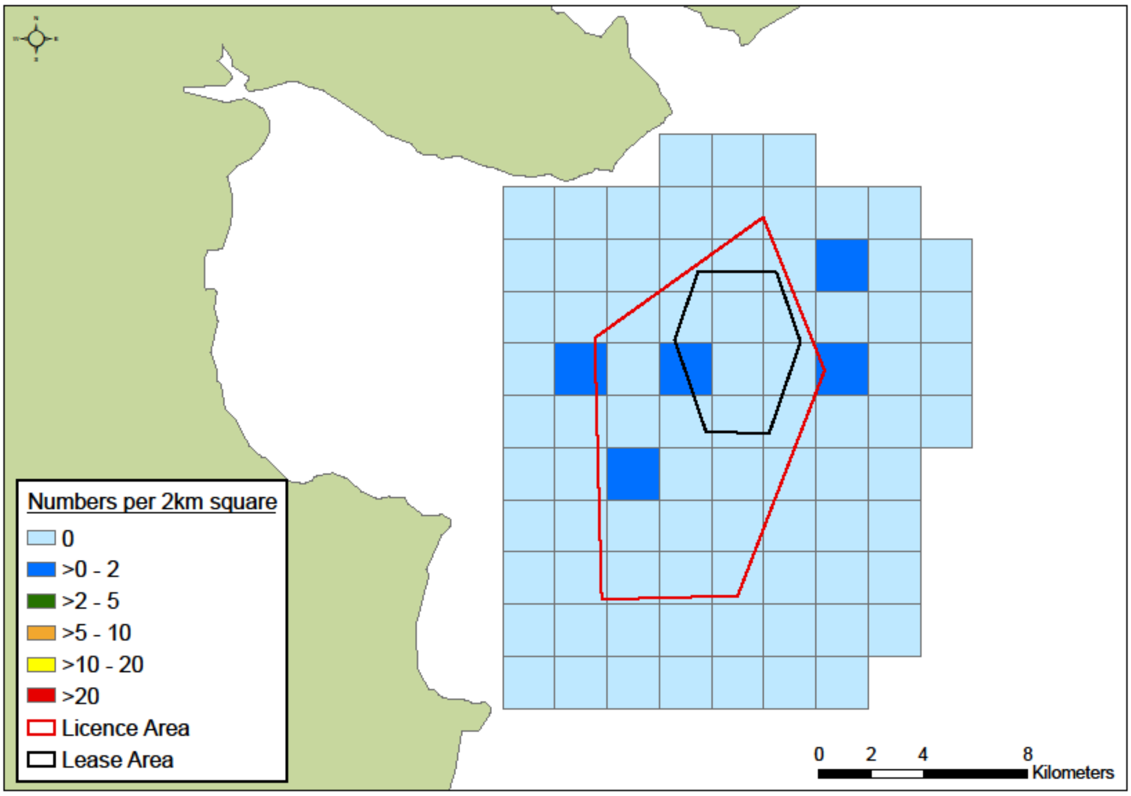

Figure 4.3.10 Grey Seal survey results March 2018.

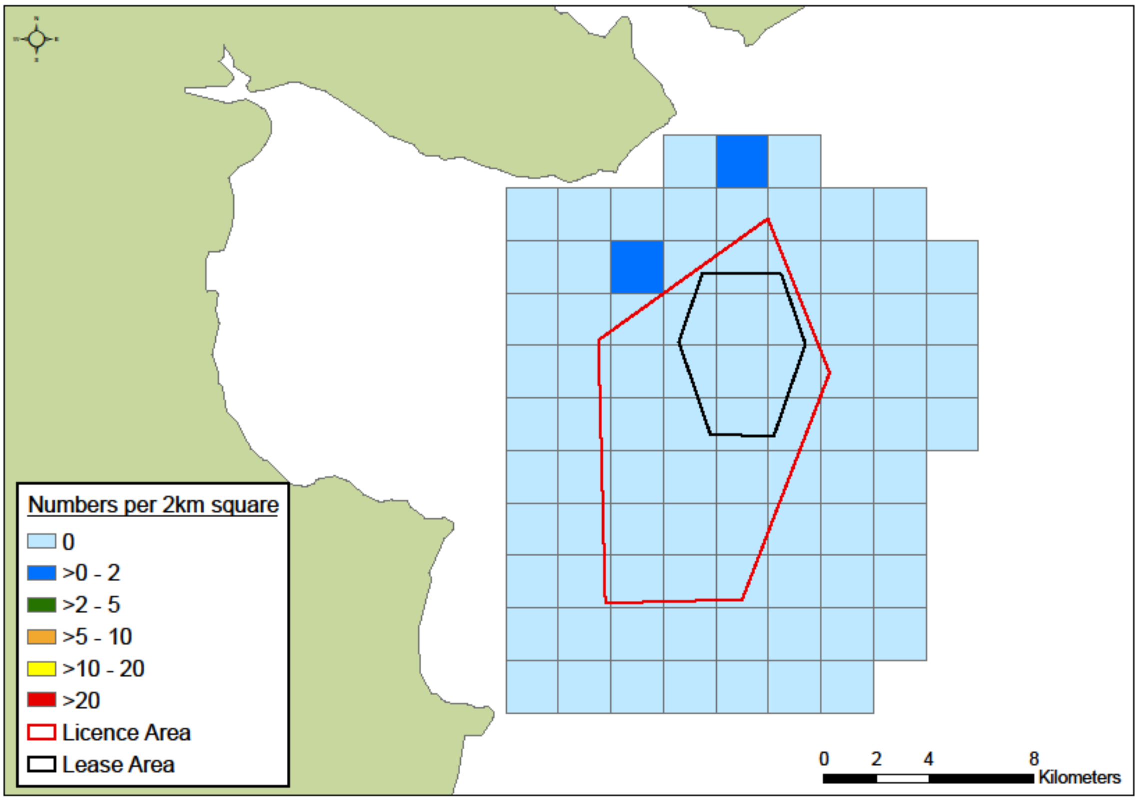

Figure 4.3.11 Grey Seal survey results April 2018.

4.4 Additional Species

A number of other mammals and Basking Shark were also noted. These were scarcely recorded (less than five sightings in total) during fieldwork but are reported here for completeness.

4.4.1 Common Dolphin

The Common Dolphin *Delpninus delphis* is one of the most frequently observed dolphins in Irish waters, being sighted in all sea areas, where they often occur in gregarious groups of up to 1000+ individuals (Rogan, 2016). Common Dolphin is a largely oceanic species however they occasionally visit coastal, shallow waters and it has been suggested that seasonal inshore and offshore movements associated with reproduction and prey distribution are likely.

A large school of Common Dolphin (30+) was recorded in August 2018, with a smaller group of 10 animals recorded in September 2018. Smaller groups of three (in December 2018) and five (January 2019) were also recorded.

4.4.2 Harbour (Common) Seal

Harbour Seal are widespread around Ireland, with greater concentration on the west and south coasts (Ó Cadhla, 2016). There were three sightings of Harbour Seal during fieldwork, with single records of lone animals in August 2018, September 2018 and October 2018. This coincides with their pup-rearing and moulting period of May to September (Ó Cadhla, 2016).

4.4.3 Basking Shark

Basking Shark is the largest fish in the North Atlantic. They are regularly sighted off the Irish coast between April and August, feeding on plankton. A single Basking Shark was recorded in August 2018 in the Oriel Windfarm survey area.

5. DISCUSSION

With a single year of survey data, it is difficult to determine firm conclusions from the data on the importance of the marine study area. Nevertheless, from the data available, some patterns appear to be emerging in relation to the usage of the site by the target species and species groups. In addition to exploring the available data, comments on potential data gaps are presented for consideration.

5.1 Overview of Bird Data

Table 5.1.1 shows the total numbers of birds recorded for each species encountered on the transects and also observed during fieldwork within the survey area (i.e. recorded during the scan and snapshot surveying). Note that these figures show the summed totals for each month for all transects. They should not be taken as absolute numbers of birds using the area, as some birds may be recorded on more than one month or even on more than one transect during a single survey day. Nevertheless, these data offer an indication to relative abundances within the Oriel Windfarm survey area.

Table 5.1.1 Total numbers of birds recorded during the monthly surveys.

Month	Transect records	All records
Common Scoter	180	1,430
Red-breasted Merganser	3	18
Red-throated Diver	64	92
Great Northern Diver	336	444
Fulmar	31	48
Manx Shearwater	2,390	4,083
Gannet	264	766
Shag	113	191
Cormorant	20	51
Kittiwake	382	839
Black-headed Gull	5	19
Common Gull	152	373
Great Black-backed Gull	202	694
Herring Gull	64	433
Lesser Black-backed Gull	7	43
Common Tern	3	31
Great Skua	1	8
Guillemot	5,000	5,609
Razorbill	911	1,209
Guillemot/Razorbill	5	32
Black Guillemot	294	436
Puffin	4	6
TOTAL (21 species)	**10,431**	**16,855**

The commonest species recorded from transects was Guillemot, comprising nearly half of all the bird records (5,000 Guillemot records out of a total of 10,431 birds sighted). The second most commonly recorded species was Manx Shearwater (2,340 individuals sighted), followed by Razorbill (911 individuals), Kittiwake (382 individuals) and Great Northern Diver (336 individuals). Three species had numbers in excess of 200 recorded (Black Guillemot (294), Gannet (264) and Great Black-backed Gull (202), with records for three other species numbering in excess of 100 (Common Scoter (180), Common Gull (152) and Shag (113). Four species had between 10 and 100 individual birds recorded from transects (Red-throated Diver and Herring Gull (both with 64 individuals sighted), Fulmar (31) and Cormorant (20). The remaining six species had less than ten individuals recorded, including Lesser Black-backed Gull (7), Black-headed Gull (5), Puffin (4), Red-breasted Merganser and Common Tern (both had three Individuals sighted) and Great Skua, with just one bird recorded from transect surveys.

5.2 Bird Flight Heights

Table 5.2.1 shows the numbers of birds recorded in flight height bands exceeding 20m. These records are taken from all fieldwork (i.e. transects, scan and snapshot surveying). The final column shows the proportion for each species recorded at that flight height out of the total number of birds recorded from all fieldwork within the Oriel Windfarm survey area.

The majority of birds recorded flying at heights over 20m are gulls. Herring Gull were most likely to be encountered flying over 20m, with a total of 83 individuals (representing 19.2% of all Herring Gulls recorded) present in the height bands as indicated with Great Black-backed Gull the next most commonly encountered species flying over 20m, with 77 birds (11.1% of all Great Black-backed Gulls recorded) flying over this height.

Gannet were the third most likely species to be recorded flying at heights exceeding 20m, although less than one-tenth (9.7%) of the total number of birds observed were flying above this height. Similarly, Kittiwake and Common Gull, with 42 and 24 individuals respectively flying at heights over 20m recorded, had a low proportion of birds flying at this height, with 5.0% in these height bands for Kittiwake and 6.4% for Common Gull. Although relatively scarcely recorded flying in over 20m with eight individuals recorded, this nevertheless represented 18.6 of all Lesser Black-backed Gull records flying over this height.

Of the other species recorded flying over 20m, all were relatively scarcely encountered flying at this altitude, with six Guillemot (0.1% of all Guillemots recorded) flying at this height, and single individuals of Red-throated Diver, Arctic Tern and Razorbill recorded flying over 20m.

Overall, a total 317 individual birds (covering all species) were recorded flying over 20m out of a total count of 16,855 birds recorded; i.e. 1.9% of all birds recorded in the Oriel Windfarm survey area were recorded flying over 20m. Most of these are gulls, which show some levels of micro-avoidance of turbines (Thaxter *et al*., 2018) even though they may actually be attracted into the wind farm area (Dierschke *et al*., 2016). Gannet, the only non-gull species regularly recorded flying above 20m, shows macro-avoidance of wind farms as a whole (Venermen *et al*., 2015).

Table 5.2.1 Numbers of birds recorded in flight heights exceeding 20m during surveys.

Flight Height	Species	No.	Proportion (%) of all records
50m+	Common Gull	1	0.27
	Great Black-backed Gull	1	0.14
	Herring Gull	12	2.77
40-50m	Gannet	3	0.39
	Common Gull	1	0.27
	Great Black-backed Gull	4	0.58
	Herring Gull	1	0.23
	Lesser Black-backed Gull	1	2.33
30-40m	Gannet	11	1.44
	Kittiwake	5	0.60
	Common Gull	2	0.54
	Great Black-backed Gull	18	2.59
	Herring Gull	21	4.85
	Lesser Black-backed Gull	1	2.33
20-30m	Red-throated Diver	1	1.09
	Gannet	60	7.83
	Kittiwake	37	4.41
	Common Gull	20	5.36
	Great Black-backed Gull	54	7.78
	Herring Gull	49	11.32
	Lesser Black-backed Gull	6	13.95
	Arctic Tern	1	7.69
	Guillemot	6	0.11
	Razorbill	1	0.08

It is notable from these data that the commonest species recorded (Guillemot, Manx Shearwater and Razorbill) all occur most frequently at heights below any likely rotor envelope, subject to confirmation of final turbine design. Nevertheless, it may be appropriate that Collision Risk Modelling (CRM) is undertaken on these data to fully evaluate likely impacts, as local factors may affect collision risk (Everaert, 2014).

5.3 Survey Context and Coverage

Within the Irish context recent non-statutory Guidance recommends a minimum of 3 years of baseline data be collected in respect of birds (DCCAE, 2018) if no previous data is available for the area, and 2 years baseline data if previous data is available and/or the sensitivity of the site is low. For Marine mammals, similarly, 3 years is recommended with two years considered "*an absolute minimum where data is lacking*".

The benefit of 24-36 monthly surveys is that by providing at least two years of data an understanding of species fluctuations and movements between seasons and between years is gathered. As seabirds are known to fluctuate in their density and distribution year-to-year based on various environmental and anthropogenic factors (Maclean *et al*., 2013), it is therefore important to capture any trends, patterns, or anomalies appropriately with more than one year of data (Joint SNCB Interim Displacement Advice Note, 2017). Such an approach of collecting and maintaining up-to-date ecological data is also recommended as Best Practice (CIEEM, 2019).

Additional data would also be useful in performing more robust calculations about the occurrence of species in the area, particularly in relation to the determination of density estimates. Although density estimates presented here largely agree with those presented from other studies (e.g. Jessop *et al*., 2018; Stone *et al*., 1995), improved modelling of densities using Distance sampling would be preferred, improving the value of the data presented and the conclusions that could be drawn about the occurrence of the species encountered in a wider context, including the western Irish Sea (Jessop *et al*., 2018) or north-eastern Europe's marine waters (Stone *et al.*, 1995).

Aerial surveys are suitable for both birds and marine mammals; however, owing to the utilisation of nearby areas by large numbers of Harbour Porpoise, INIS suggests that static Passive Acoustic Monitoring (PAM) in and around the development site be considered to provide extra species-specific detail. Part of the nearby Rockabill to Dalkey Islands candidate SAC, for which Harbour Porpoise are a permanent feature of interest, lies less than 20km from the proposed development area. Previous work conducted prior to, during, and post-construction of a windfarm in the German North Sea, suggested that Harbour Porpoise showed strong avoidance to pile-driving noise up to 20 km of the noise source (Dähne *et al*., 2013). Consequently, thorough surveys to accurately determine porpoise densities in the proposed development area may be necessary. An objection to a previous development (Dublin Array) was lodged by the Irish Whale and Dolphin Group (IWDG) owing to surveying not being carried out in line with Best Practice.

Therefore, to assess whether the noise created during piling could deter or harm marine mammals detailed noise recording before and especially during construction should be considered at Oriel. However, it is important to note that all survey methods have limitations. For PAM surveys, the method detects the volume of noise produced by marine mammals but this does not necessarily indicate how many individuals are present as PAM is limited in its ability to detect and separate between individuals. Thus, a single very noisy and mobile individual could give the impression of being several individuals. Continued boat-based surveys are therefore still required.

In the UK, Germany and USA, more often than not a buffer of 4 km has been found to be appropriate for baseline studies, but a few sites have determined the appropriate size of the buffer based on the species of concern in the area, such as auks, divers, or scoters. These species in particular are known to be displaced from anthropogenic activity, such as vessel traffic, by more than 4 km (Joint SNCB Interim Displacement Advice Note, 2017; Schwemmer *et al.*, 2011). Baseline surveys of a proposed windfarm site have had 10 km buffers where the species of concern was Puffin, or an irregular buffer of up to 15 km to incorporate habitat of Red-throated Divers and auks. In Germany, it is necessary to survey an area of 2,000 km^2 irrespective of the size of the proposed offshore windfarm site (Aumüller *et al*., 2013). For this reason, many offshore windfarm companies develop sites in a consortium and therefore combine surveys to improve efficiency.

Once an offshore windfarm site has been granted permission to build, post-consent surveys are undertaken to monitor the effect of the activities of the windfarm development on the density and distribution of key seabirds and / or marine mammals. There is no standard approach for post-consent survey in the UK as it very much depends on the key species predicted to be affected in the Environmental Statement. Post construction requirements are defined for birds and marine mammals/Basking Sharks in Irish Guidance (DCCAE, 2018), however similarly to the UK and elsewhere, the final scale of monitoring will be dependent on receptors likely to be affected by the eventual development.

Post-consent surveys for seabirds are tailored specifically to meet the aims and objectives of an Ornithological Monitoring Plan (OMP) that describes the work necessary to test the predictions in the Environmental Statement or EIAR. The aims and objectives are agreed with the relevant Regulatory Bodies and are designed to collect information appropriately from the key species. It is good practice to undertake a power analysis prior to delivering the surveys required by the OMP. This ensures that the surveys cover a suitable area and are sufficiently frequent to detect a pre-defined level of change in the key species potentially resulting from construction of the development. For example, London Array on The Thames conducted one survey per month from November to February for two years pre-construction, two years during construction, and three years post-construction. The surveys collected 10% coverage at 2 cm ground sampling resolution (GSD). A Final Monitoring Report reports on the analysis of the surveys conducted throughout the monitoring period and describes whether the pre-construction Environmental Statement predictions to the key species were correct or not.

6. CONCLUSION

It is strongly recommended that surveys (bird and marine mammal) continue for the requisite Best Practice period to ensure a robust baseline dataset is available for the future consideration of likely significant effects, in addition to ensuring compliance with recent ECJU judgements such as on e.g. the level and sufficiency of baseline data required to inform the consideration of ex-situ effects on European Sites.

IEC would strongly recommend that the baseline surveys be completed for a further 24-month period which involves monthly surveys of the proposed windfarm site that collect at least 10% coverage of the proposed footprint with at least a 4 km buffer. This is the most risk-averse approach given the methods and quality of any available data (e.g. Observe data (Jessop *et al.,* 2018)) may not match current methods, and given the age of previously collected data. Consultation should be maintained with the relevant statutory bodies on an ongoing basis to fully determine whether any deviation from 36 months of survey is acceptable, and to seek comment on the efficacy of data examination and analysis being undertaken. Despite a standard survey approach existing for offshore wind developments in some countries, liaison with Regulatory Bodies and Stakeholders early is an important part of the process. Given that the offshore wind industry is relatively new to Ireland, this process is particularly important.

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Visual Surveys for Marine Mammals at the Proposed Windfarm Site at Oriel

Site surveys off the Proposed Oriel Windfarm © Simon Berrow/IWDG

IWDG Consulting

Final Report to Oriel Windfarm Limited

Visual Surveys for Marine Mammals at the Proposed Windfarm Site at Oriel

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Executive Summary

In order to describe the marine mammal community off Oriel, Co Louth within the site of a proposed offshore windfarm boat-based visual surveys were carried out. Dedicated single platform line-transect surveys were carried out each month, when sea conditions were suitable, according to a standardised design.

A total of 1081km of track-line was surveyed during 12 days between June 2019 and May 2020. Over one-half (62.2%) was surveyed in sea-state ≤2 and 87.1% in sea-state ≤3. No visual surveys were carried out in September, and November 2019 and between February and April, due to no suitable weather windows being available and latterly restrictions associated with Covid-19. Five of the seven surveys (71%) were full surveys carried out over two days but on two occasions (2 October and 19 May 2020) only one day was available resulting in 6 and 8 of the 11 track-lines being surveyed. On one occasion (17-18 July 2019) conditions were poor for the whole survey and data are to be treated with caution. On the 1 December conditions were poor but improved on the second day (2 December) and the number of track-lines surveyed each day were modified to maximise survey effort in favourable sea-states. The distribution and relative abundance of all marine mammals encountered, as well as other ETP (Endangered, Threatened or Protected) species of interest (basking sharks) were recorded. Distance sampling was used to produce a detection function based on the observed distribution of harbour porpoise and minke whale sightings, when the number of sightings per survey was >10. This enables estimates of absolute abundance to be made. Overall density estimates were also generated for harbour porpoise using all the data from all surveys combined and stratified by sea-state.

A total of 140 on-effort sightings were recorded of at least five marine mammal species (Table 3). This included one sighting of a single basking shark. One cetacean sighting and one seal sighting could not be identified to species level. Most sightings (67.6% of those sightings identified to species level) were of harbour porpoise which were recorded during every survey. Most sightings were of individuals but larger group sizes were recorded in January and May 2020. Calves were recorded on two occasions, one in a group of 2 in January 2020 and one in a group of three in May 2020. Juveniles were recorded more frequently on six occasions, all in January. The next most frequently recorded species was grey seal (16.2%) recorded on five of the seven surveys and minke whale (13.2%), recorded on three of the seven surveys. Common seals were recorded on three surveys and accounted for only 2.2% of all sightings. Individual minke whales were recorded on 18 occasions, with 14 of these on survey 3 on 1-2 August 2019. They were also recorded on the July and October surveys. They occurred throughout the survey area with a tendency to be a little offshore. Marine mammals were distributed throughout the survey area, with a small tendency for more sightings towards the north and middle of the survey area, with fewer sightings to the south.

Density estimates were calculated for harbour porpoise from five surveys (surveys 1, 3, 5, 6 and 7) to run the DISTANCE model and for all survey days combined. Harbour porpoise density ranged from 0.18 porpoise per km^2 to 0.64 per km^2, and was 0.22 overall (Table 7). The estimate from survey 6 (0.65 porpoise per km^2) resulting in an abundance of 205±35 reflects the peak in abundance during January, which may be associated with a historical herring spawning ground (Mourne Spawning Ground) within the site (Dickey-Collas et al. 2001). The overall estimate from the pooled data is considered the most robust as it accounts for seasonal variation and provides a good average abundance estimate. The density of 0.22 porpoises per km^2 resulted in an overall abundance of 71±21 (CV=0.30) with 95% Confidence Interval of 36-140. Density and abundance estimates were also calculated with increasing sea-state. Density estimates ranged from 0.69 porpoises per km^2 (sea-state 0) to 0.27 porpoises per km^2 (sea-state ≤4). The most robust estimates are for sea-state ≤1, and sea-state ≤2, as the sample sizes were high (52-85 individuals). This resulted in an abundance estimate of 118±26 to 140±34 harbour porpoise in the survey area. A density estimate was calculated for minke whales from data obtained during survey 3 on 1-2 August 2019 as there were 14 sightings of individual minke whales. This resulted in a density of 0.01±0.02 minke whales per km^2, which gives an abundance estimate of 3±0.6 (95% CI 2-5 individuals) with a CV of 0.20.

Although the Irish Sea is recognised as an important area for harbour porpoise there is limited historical survey data for the area. Most relevant data was collected to the south off north County Dublin. Density estimates here

were much higher than within the survey area suggesting that although the site provides important habitats for harbour porpoise as they were recorded throughout the survey period, the site is not as important as protected sites to the south. The presence of harbour porpoise and seals throughout the year and minke whales in the summer and autumn, provides important site-specific data in which to inform industry on the distribution and abundance of marine mammals in the site of the proposed offshore windfarm.

1.0 Introduction

The Irish Whale and Dolphin Group (IWDG) were contracted by Aquafact to undertake baseline marine mammal surveys of the proposed windfarm site off Oriel, Co Louth. The site was defined by Oriel Windfarm Limited and covered an area east of Dundalk bordered by Clogherhead to the south, Carlingford Lough to the north out east to the 50m contour. Marine mammal surveys were to be carried out in association with seabird surveys being undertaken by the Galway-Mayo Institute of Technology (GMIT) and survey design and fieldwork was agreed collectively to provide the best possible outputs.

The aims of the marine mammal surveys were to:

i) Provide a species list of marine mammal species that occur in the survey area;
ii) Provide data on the seasonal occurrence of these species within the site; and
iii) Provide density and abundance data of species within the site.

The IWDG were contracted to carry out monthly boat-based surveys from June 2019 to May 2020. Surveys were to be carried out over two contiguous days each month in sea-state ≤3, but ideally sea-state ≤2. This report provides the final deliverable by the IWDG on the boat-based surveys for marine mammals in the proposed windfarm site at Oriel.

2.0 Methodology

Dedicated marine mammal surveys were carried out to describe the marine mammal community, its distribution and abundance and derive density estimates. The survey site and line-transect survey design is shown in Figure 1. The area surveyed was 320 km^2. Marine mammal surveys were concurrent with seabird surveys.

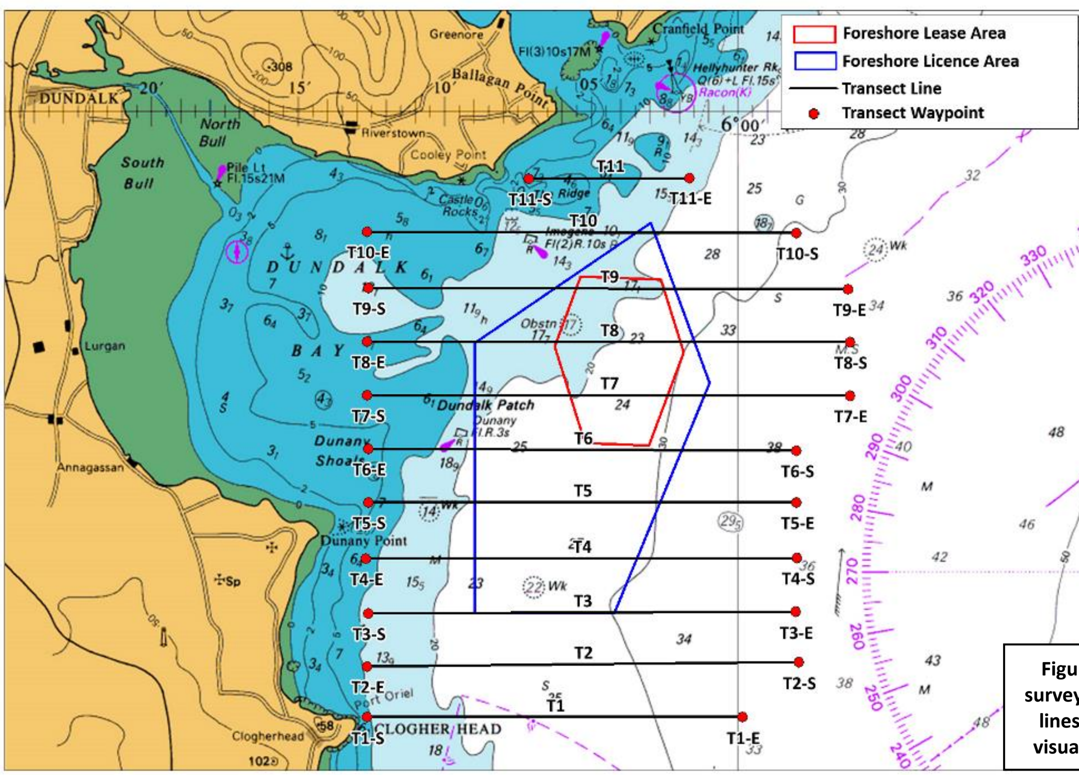


Figure 1. Location of survey area and transect lines surveyed during visual surveys off Oriel

2.1 Survey platform

The vessel used for each survey was the *MV Fastnet Petrel*, provided by Fastnet Shipping Ltd. *MV Fastnet Petrel* is an 18M DNV Classed Windfarm Service and Survey Support Vessel (Figure 2). The vessel proved to be excellent, providing fast passage to the start of each track-line, stability and an observation platform height of 4m above the waterline.

Figure 2. *MV Fastnet Petrel* used for line-transect surveys off Oriel

2.2 Survey methodology

Conventional single platform line-transect surveys were carried out within the boundaries of the site along the pre-determined track-lines (Figure 1). Transect lines were designed to try and obtain full coverage of the licensed area. Track-lines were evenly spaced 2.0km apart and provided by Aquafact and Oriel Windfarm Limited. The same track-lines were maintained through surveys in 2006-08 and 2018 onwards for consistency. These were provided to the IWDG, GMIT Seabird Team and were chosen to provide equal coverage of the area. Lines were surveyed from north to south and south to north depending on prevailing weather conditions. Two days were required to survey all 11 track-lines. Surveys were to be carried out in Beaufort force/sea-state 2 or less. Low swell (<1m) and in good light conditions with visibility of 6 km or more.

The survey vessel travelled at a speed of 15-16 km hr^{-1} (10-12 knots), which was 2-3 times the average speed of the most abundant species likely to be recorded in the survey area (harbour porpoise and dolphins) as recommended by Dawson *et al.* (2008). One primary observer was positioned on each bridge wing, which provided a platform height above sea-level of around 4m. The starboard bridge wing was shared with the seabird team. Primary observers watched with the naked eye from dead ahead to 90^{o} to port or starboard depending on which side of the vessel they were stationed. All sightings were recorded. Calves/juveniles were defined as individual's ≤ half the length of the accompanying animal (adult) and in very close proximity to it. Small animals seen alone were also classified as juveniles. Sightings off-effort while transiting between track-lines or to the study site were also recorded but not included in the analysis of abundance and density.

During each transect the position of the survey vessel was tracked continuously through a GPS receiver connected to a laptop computer, while survey effort data including environmental conditions (sea-state, wind strength and direction, glare, etc.) were recorded every 15 minutes using LOGGER software (© IFAW). One person operated LOGGER and communicated with the primary observers via VHF radios. During good weather conditions, LOGGER was positioned behind the wheel house at the same height as the primary observers and during poorer weather in the cabin, situated immediately below the wheel house. When a sighting was made the position of the vessel was recorded immediately and the angle of the sighting from the track of the vessel and the estimated radial distance of the sighted animal(s) from the vessel were recorded. The angle was recorded to the nearest degree using an angle board attached to the vessel immediately in front of each observer. Accurate distance estimation is important for distance sampling. Personal measuring sticks (Heinemann 1981) were used by each primary observer to assist in distance estimation.

2.3 Density and abundance estimation

Distance sampling was used to derive a density estimate and to calculate a corresponding abundance estimate for the whole area. The software programme DISTANCE (Version 6, University of St Andrews, Scotland) was used for calculating the detection function, which is the probability of detecting an object on the vessel's track-line. The detection function is used to calculate the density of animals on the track-line of the vessel. In this survey we assumed that all animals on the track-line were observed, i.e., that g(0) = 1, given the strict operational and environmental conditions under which surveys took place. The DISTANCE software allows the user to select a number of models in order to identify the most appropriate one for the data. It also allows truncation of sighting outliers when estimating variance in group size and testing for evasive movement prior to detection.

To calculate density we used "survey" as the sample regime with sightings as the sampling observation. Estimates of density and thus abundance were calculated if there were ten or more sightings of a species recorded during each survey. Buckland *et al.* (2001) recommended the minimum number of observations required for robust estimates to be around 40-60 records. We pooled all data from all surveys to derive an overall density estimate, which was necessary in order to meet this criteria to use the DISTANCE software model. We also used "sea-state" as the sample regime with sightings as the sampling observations for all surveys combined to stratify the effect of sea-state on sightings. When pooling data we had to assume that each survey was representative of the natural occurrence of marine mammals within the study area and there were no significant changes in distribution within the site between surveys nor any significant immigration into, or emigration out of, the site. Clearly, although this is not the case over the 10month study period, pooled estimates provide an overall abundance estimate in the site which can be used for risk assessments.

We fitted the data to a number of models available in the DISTANCE software. We found that a Half-Normal model with cosine adjustments best fitted the data according to the Akaike Information Criterion delivered by the model. The recorded data were grouped into equal distance intervals of the size and number depending on the species of interest and prevailing sea conditions. Porpoise data were truncated at between 300-500m depending on the survey and minke whale data at 700m. The DISTANCE model determines the influence of cluster size on variability by using a size-bias regression method with the log(n) of cluster size plotted against the corresponding estimated detection function g(x).

A Chi-squared test associated with the estimation of each detection function was calculated by the DISTANCE model. If found to be statistically significant it indicated that the detection function was a good fit and that the corresponding estimates were robust. The proportions of the variability accounted for by the encounter rates, detection probability and group size (cluster size) are presented with each detection function. Variability associated with the encounter rate reflects the number of sightings on each track-line. The detection probability reflects how far the sightings were from the track-line and cluster size reflects the range of estimated group sizes recorded on each survey.

2.4 Mapping cetacean survey and encounter data

Maps of the study area and associated survey data were created in Irish Grid (TM65_Irish Grid) with ArcMap 10.2 while maps of the prescribed survey area were obtained from Aquafact. Data concerning transects, effort, sightings, abundance and density were stored in a single MS Access database, which was queried and processed via GIS to produce distribution maps.

3.0 Results

It was planned to carry out dedicated visual surveys each month for 12 months from June 2019 to May 2020. Visual surveys for marine mammals have to be carried out in favourable sea-states, which were considered to be sea-state ≤3, but ideally sea-state ≤2 as the ability to detect small cetaceans, such as harbour porpoise, declines considerably above sea-state 2. These conditions were not always available, especially during winter months and a total of only seven surveys were carried out over a 12 month period (Table 1). No visual surveys were carried out in September and November 2019 and February to April 2020 due to no suitable weather windows being available and latterly restrictions associated with Covid-19.

Table 1. Overall environmental conditions during surveys off Oriel from June 2019 to May 2020

Date	Swell (m)	Visibility (km)	Wind strength (knots)	Wind direction	Cloud Cover	Precipitation
19-20 June 2019	0	11-15km	7	270°	3/8	None
17-18 July 2019	0	5-10km	15	195°	4/8	CL/None
1-2 August 2019	0	16-25km	9	209°	1/8	None
2 October 2019	0	21-25km	11	270°	6/8	None
1-2 December 2020	0	21-25km	12	305°	6/8	None
20-21 January 2020	0	16-20km	7	290	7/8	None
19 May 2020	0	11-15km	6	180°	6/8	None

On five of the seven surveys (71%) were full surveys carried out over two days but on two occasions (2 October and 19 May 2020) only one day was available resulting in 6 and 8 of the 11 track-lines being surveyed. On one occasion (17-18 July 2019) conditions were poor for the whole survey and data are to be treated with caution. On the 1 December conditions were poor but improved on the second day (2 December) and the number of track-lines surveyed each day were modified to maximise survey effort in favourable sea-states. Environmental conditions during the seven surveys carried out were favourable for the majority of survey effort (Table 2).

Table 2. Sightings data during surveys off Oriel from June 2019 to May 2020

Sample Day	Date	Total effort (km)	Sea-state (% of total survey time)					Total No. sightings	Total No. animals
			0	1	2	3	4		
1	19-20 June 2019	175.0	5.1	16.6	38.2	32.7	7.4	14	15
2	17-18 July 2019	174.7	0.0	0.0	1.1	43.7	55.2	6	6
3	1-2 August 2019	170.3	3.5	68.3	20.6	7.6	0.0	35	39
4	2 October 2019	92.5	0.0	25.9	60.2	13.8	0.0	13	14
5	1-2 December 2020	167.0	0.0	3.0	48.3	40.7	18.0	14	20
6	20-21 January 2020	168.0	8.9	51.2	14.9	25.0	0.0	41	77
7	19 May 2020	133.9	17.2	45.9	37.0	0.0	0.0	17	28
Total		**1081.4**						**140**	**199**

A total of 1081 km of track lines were surveyed in sea conditions up to sea-state 4 over 12 days. Of this a total of 672 km of track line (62.2%) was sampled in sea-state ≤2 and 889.0 km of track-line (87.1%) in sea-state ≤3 or less (Table 2.2). Sea conditions were very good for five of the seven surveys, with sea-state ≤1 predominating for three surveys (surveys 3, 6 and 7).

3.1 Marine mammal sightings

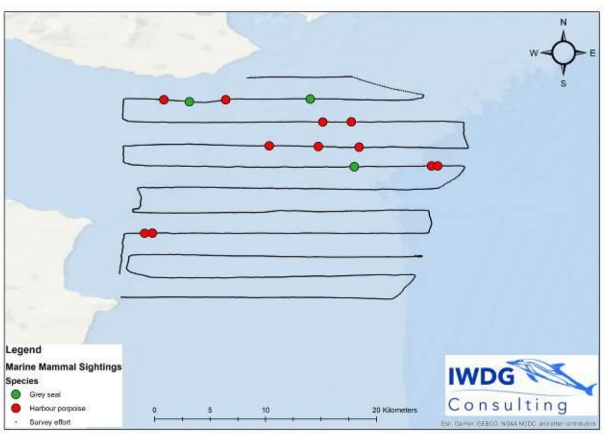
A total of 140 on-effort sightings were recorded of at least five marine mammal species (Table 3). This included one sighting of a single basking shark. One cetacean sighting and one seal sighting could not be identified to species level. Most sightings (67.6% of those sightings identified to species level) were of harbour porpoise which were recorded during every survey. The next most frequently recorded species was grey seal (16.2%) recorded on five of the seven surveys and minke whale (13.2%), recorded on three of the seven surveys. Common seals were recorded on three surveys and accounted for only 2.2% of all sightings (Table 3).

Table 3. Number of sightings (individuals) of marine mammals during surveys off Oriel from June 2019 to May 2020
HP = Harbour porpoise, CD – Common dolphin, MW = Minke whale, GS = Grey seal, CS = Common seal

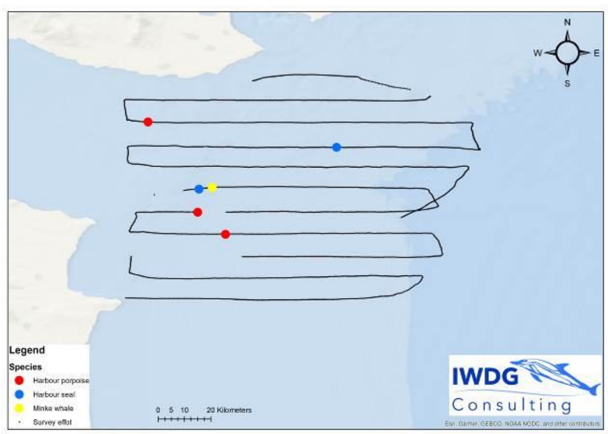
Date	HP	CD	MW	GS	CS	Others
19-20 June 2019	11(12)	-	-	3(3)	-	
17-18 July 2019	3(3)	-	1(1)	-	1(1)	
1-2 August 2019	15(19)	-	14(14)	4(4)	-	1 basking shark, 1 cetacean sp.
2 October 2019	8(9)	-	3(3)	2(2)	-	
1-2 December 2020	11(15)	1(3)	-	-	1(1)	1 seal sp.
20-21 January 2020	34(70)	-	-	6(6)	1(1)	
19 May 2020	10(21)	-	-	7(7)	-	

3.2 Marine mammal distribution

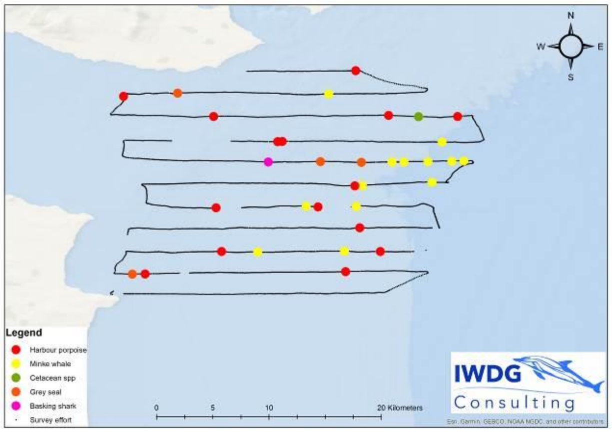
The distribution of each sighting during each survey is shown in Figure 3a-g. Marine mammals were distributed throughout the survey area, with a small tendency for more sightings towards the north and middle of the survey area, with fewer sightings to the south.



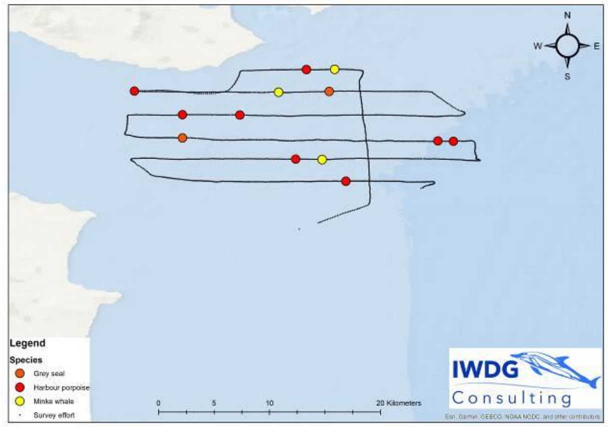
3a. 19-20 June 2019



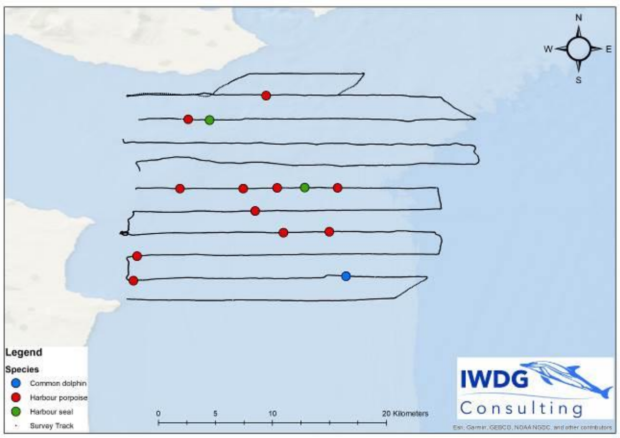
3b. 17-18 July 2019



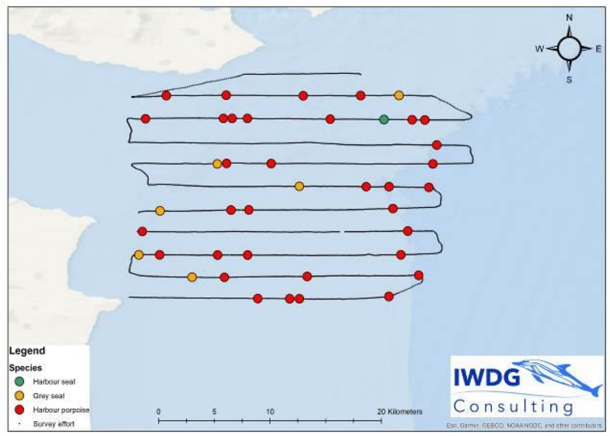
3c. 1-2 Aug 2019



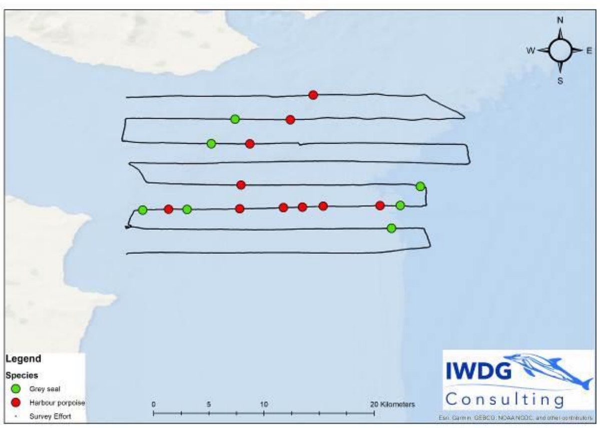
3d. 2 October 2019



1-2 December 2020



3f. 20-21 January 2020



3g. 19 May 2020

Figure 3a-f. Distribution of all marin mammal sightings by survey (1-7) off Oriel from June 2019 to May 2020

3.2.1 Harbour porpoise (*Phocoena phocoena*)

Harbour porpoise were the most frequently recorded species accounting for 67.6% of all sightings identified to species level and 76.4% of all individuals counted and were recorded on all surveys. They occurred throughout the survey area (Figure 4). Most sightings were of single individuals but larger group sizes were recorded in January and May 2020 (Table 7).

Calves were recorded on two occasions, one in a group of 2 in January 2020 and one in a group of three in May 2020 (Table 4). Juveniles were recorded more frequently on six occasions, all in January. Single individuals were recorded in groups of 2 on one occasion, groups of three on three occasions and groups of four individuals on two occasions. The adult to calf ratio was 1.4% and juveniles 4.3%. Harbour porpoise calves are born during summer and typically wean over the winter and the presence of calves during spring and juveniles over winter is consistent with this pattern. Harbour porpoise are widespread and abundant in the Irish Sea with some of the highest densities in Ireland recorded off north County Dublin (Berrow et al. 2014). The area off Oriel certainly provides good habitats for this species and their continued presence was to be expected.

Table 4. Number of adults, juvenile and calves recorded for harbour porpoise off Oriel from June 2019 to May 2020

Sample Day	Date	Group Composition			
		Total	Ad	Juv	Calf
1	19-20 June 2019	12	12	0	0
2	17-18 July 2019	3	3	0	0
3	1-2 August 2019	19	19	0	0
4	2 October 2019	9	9	0	0
5	1-2 December 2020	15	15	0	0
6	20-21 January 2020	70	63	6	1
7	19 May 2020	21	20	0	1
Total		**149**	**141**	**6**	**2**

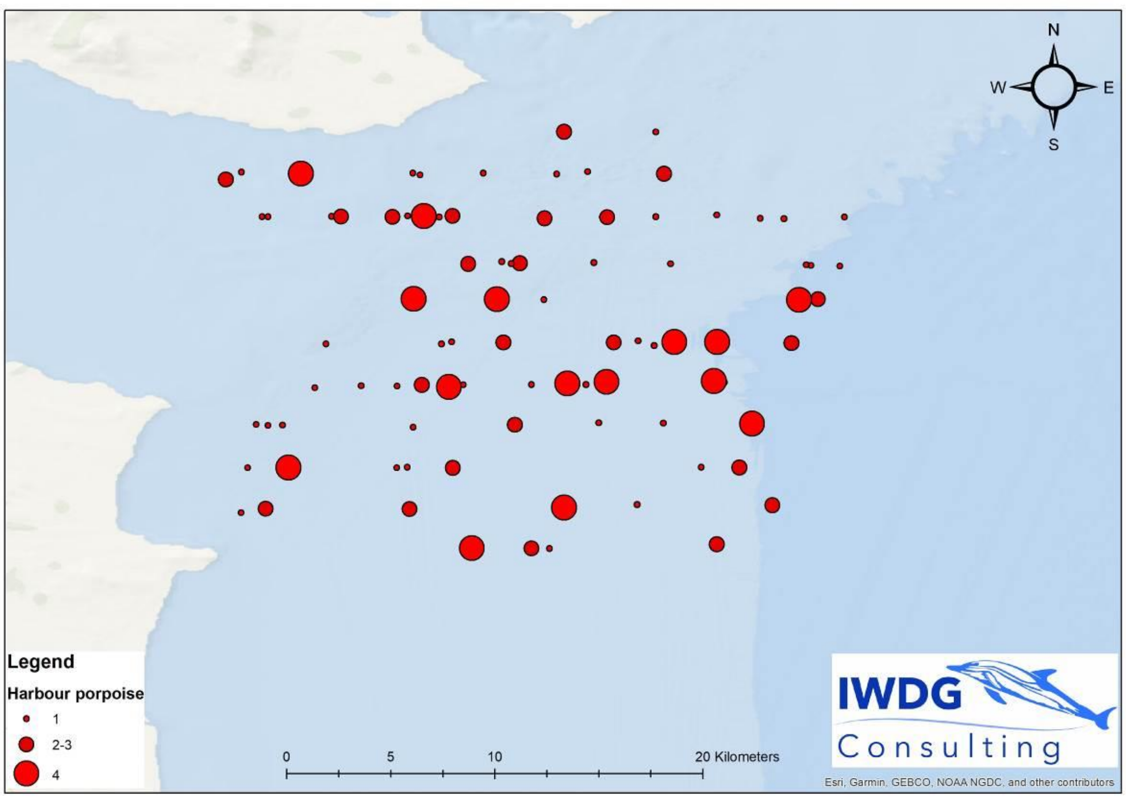


Figure 4. Distribution and group size of harbour porpoise sightings off Oriel from June 2019 to May 2020

3.2.2 Minke whale (*Balaenoptera acutorostrata)*

Individual minke whales were recorded on 18 occasions, with 14 of these on survey 3 on 1-2 August 2019. They were also recorded on the July and October surveys. They occurred throughout the survey area with a tendency to be a little offshore (Figure 6). Minke whales are seasonally abundant in Irish coast waters, typically recorded from May through to October (Berrow et al. 2010) but also occur in the winter offshore in large numbers (Rogan et al. 2019). Rogan et al. (2019) did not record any minke whales in the Irish Sea during winter.
There are few abundance estimates available for small inshore areas in Ireland thus that density estimate calculated from data collected in August 2019 is useful and provides an estimate of the number of whales exposed to the proposed windfarm during construction and operation.

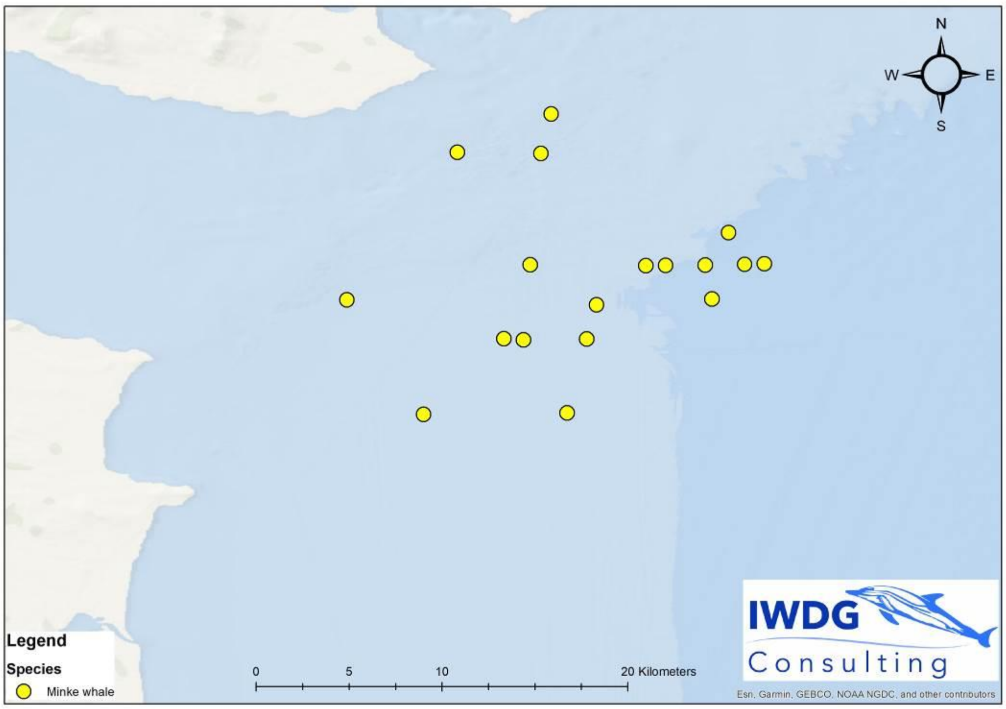


Figure 5. Distribution of minke whale sightings off Oriel from June 2019 to May 2020

3.2.3 Common dolphin (*Delphinus delphis*)

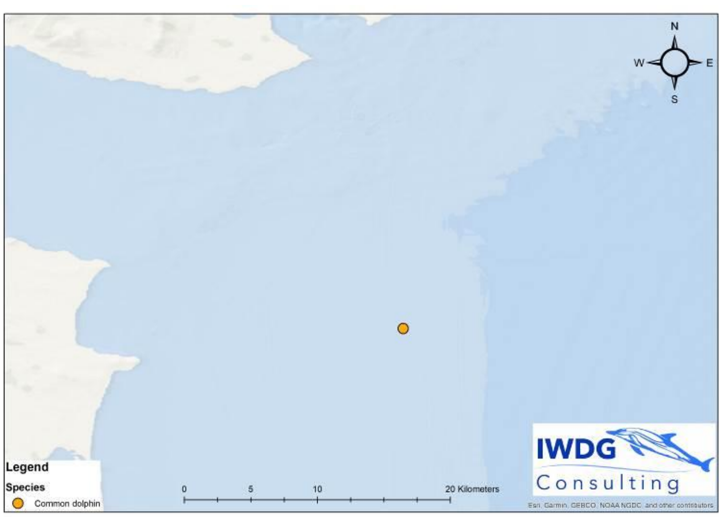


Figure 6. Distribution of the common dolphin sighting off Oriel from June 2019 to May 2020

Only one group of three common dolphins were recorded on 2 December 2019 (Figure 4). Common dolphins are thought to be most abundant in the Irish Sea in the autumn entering from the south and moving north (Wall et al. 2013) so this single sighting is consistent with the suspected distribution. Rogan et al. (2019) did not record any common dolphins in the Irish Sea during summer or winter, in two consecutive years (2015 and 2016) during the ObSERVE Aerial survey.

3.2.4 Grey (*Halichoerus grypus*) and common seal (*Phoca vitulina*)

Grey seals were the second most frequently recorded species accounting for 16.2% of sightings and 11.3% of individuals recorded. They were recorded on five of the seven surveys and in all seasons sampled and in consistent numbers per survey. All sightings were of individual animals. Only three sightings of common or harbour seals were recorded, one each in July, December and January, all of single individuals (Table 3) and one in November, again of single individuals. Seals were distributed throughout the study area with a tendency to be more inshore (Figure 7). Common seals were recorded in the northern half of the study area.

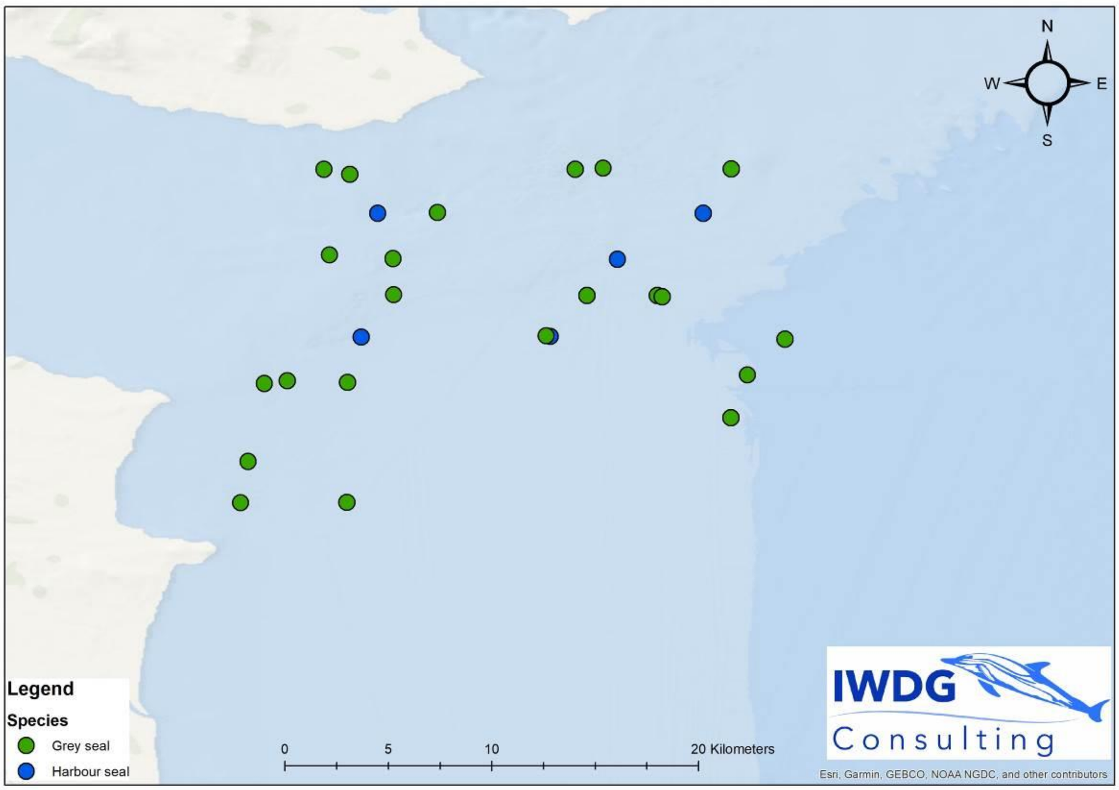


Figure 7. Distribution of grey and common (harbour) seal sightings off Oriel from June 2019 to May 2020

During an aerial survey of common seals carried out during August and September 2012, Duck and Morris (2013) counted 40 on 31 August 2012 in Carlingford Lough making it the single most important site for this species on the east coast of Ireland and 90 in total between Carlingford and north Dublin. Grey seals were also frequently recorded, with 48 counted between Carlingford and Dunany Point and 172 from Lambay Island to Dublin Bay. These counts showed a 14-31% decline in harbour seals since 2003 and an increase of between 18-23% in grey seals (Duck and Morris 2013). We might have expected to record more common seals in the survey area as the site is close to Carlingford. Common seals are not as mobile as grey seals, typically foraging within 10km of their haul-out site (Thompson et al. 1998).

3.2.5 Other Endangered, Threatened or Protected (ETP) species

A single sighting of a basking shark *Cetorhinus maximus* was recorded on survey 3 on 1 August.

3.3 Density and abundance estimation

Density estimates were calculated if there were sufficient sightings during each survey (≥10). All data from every survey were then pooled to derive an overall detection function for harbour porpoise. Porpoise data was then stratified by sea-state to explore the effect of sea-state on sightings and derive the best density and abundance estimates. Chi-squared values delivered by the model are presented, and the results from the models with a poor fit should be treated with caution. The Effective Strip Width gives an idea of the actual area surveyed and typically increases with decreasing sea-state and thus increased detectability of the species recorded.

3.3.1 Harbour porpoise

Sufficient harbour porpoise sightings were made during five surveys (surveys 1, 3, 5, 6 and 7; Table 6) to run the DISTANCE model and for all survey days combined. The goodness of fit for surveys 1, 6 and 7 were good but poor for survey 5. The Effective Strip Width was also variable between surveys (Table 6). Most variability on surveys 1 and 3 was attributed to the detection probability rather than cluster size since group size was consistent. Group size increased and was more variable on surveys 6 and 7, resulting in more variability associated with this parameter (Table 6). Overall, most variability was attributed to encounter rate (89.3%), which is shown in the large variation in the number of sightings per survey (Table 6).

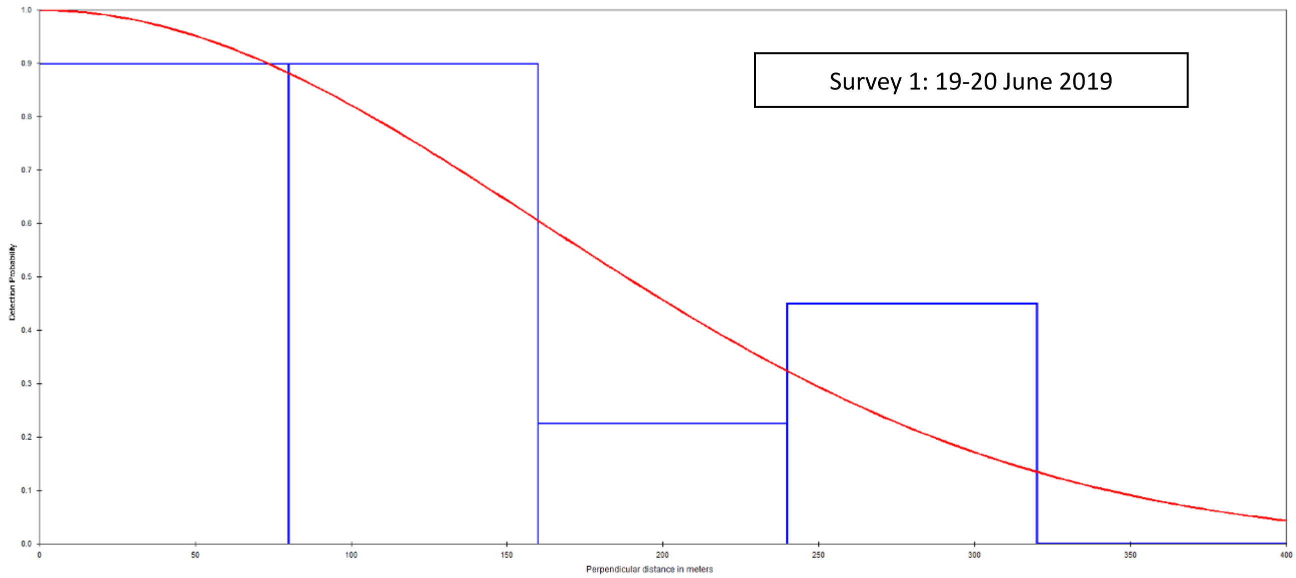
Table 6. Model data used in the harbour porpoise abundance and density estimation process for each survey off Oriel

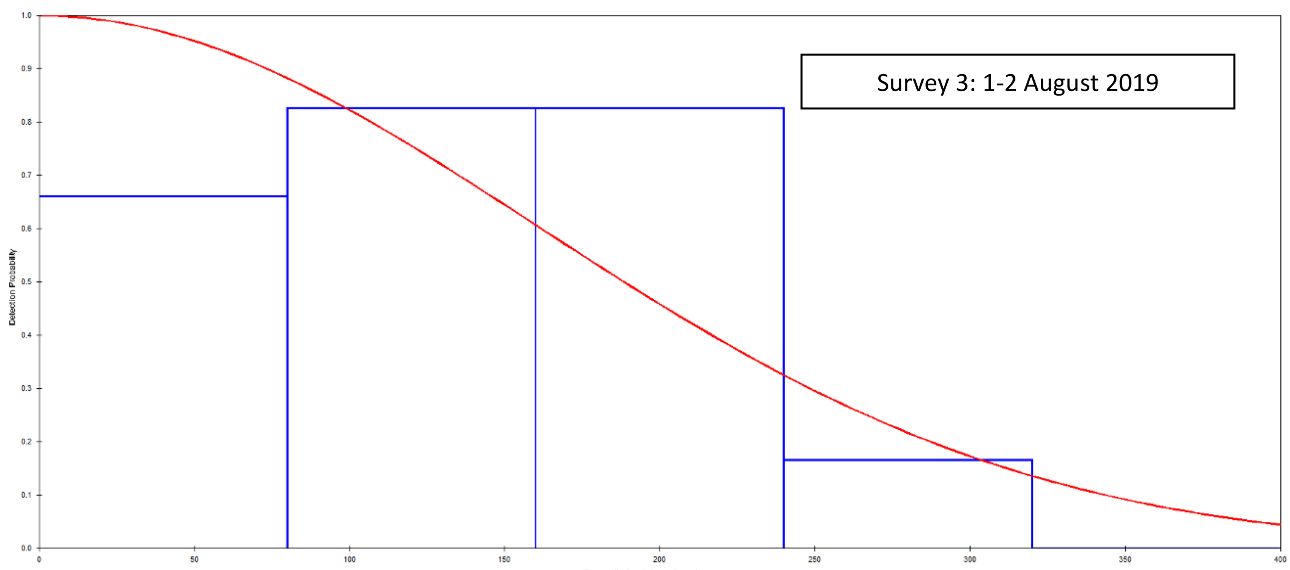
Survey	Sample size	Chi^2 P value	Effective Strip Half-Width (m)	Mean Group Size ±SE	Variability (D)		
					Detection	Encounter	Cluster
Survey 1	11	0.66	197	1.10±0.01	91.9	-	8.1
Survey 3	15	0.31	198	1.06±0.12	94.9	-	15.1
Survey 5	11	0.19	303	1.37±0.15	79.9	-	20.1
Survey 6	**34**	**0.67**	**328**	**2.06±0.17**	**69.1**	**-**	**30.9**
Survey 7	10	0.66	457	2.22±0.36	65.3	-	34.7
Overall	**92**	**0.69**	**283**	**1.62±0.09**	**7.7**	**89.3**	**3.1**

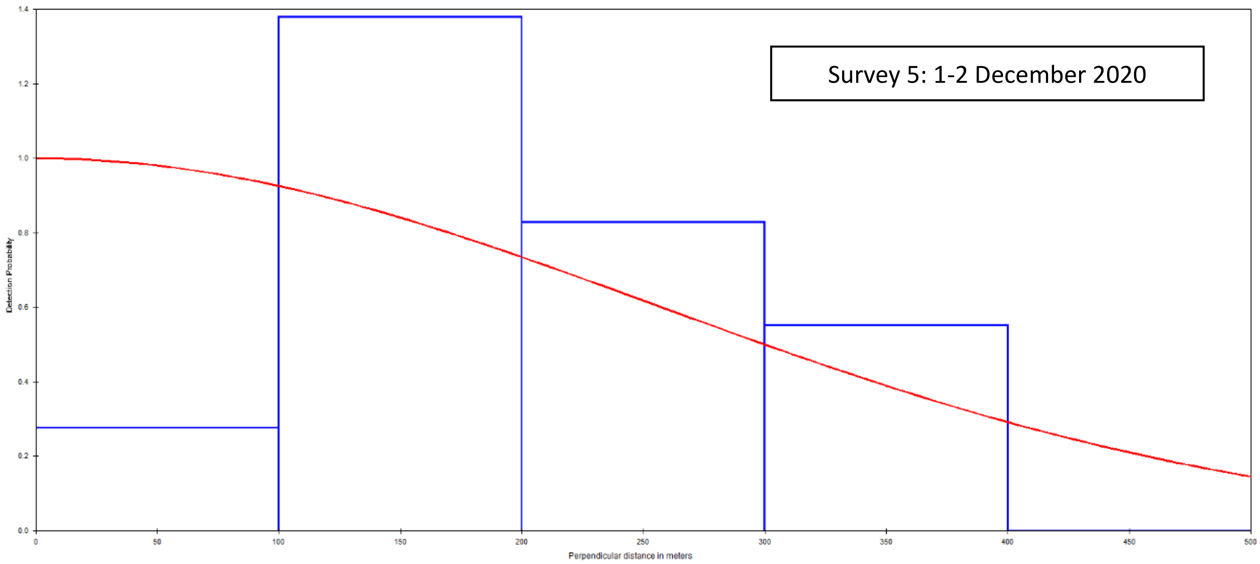
Table 7. Estimated density, abundance (N) and group sizes of harbour porpoise recorded during each survey off Oriel
The best estimates are highlighted in **bold** font

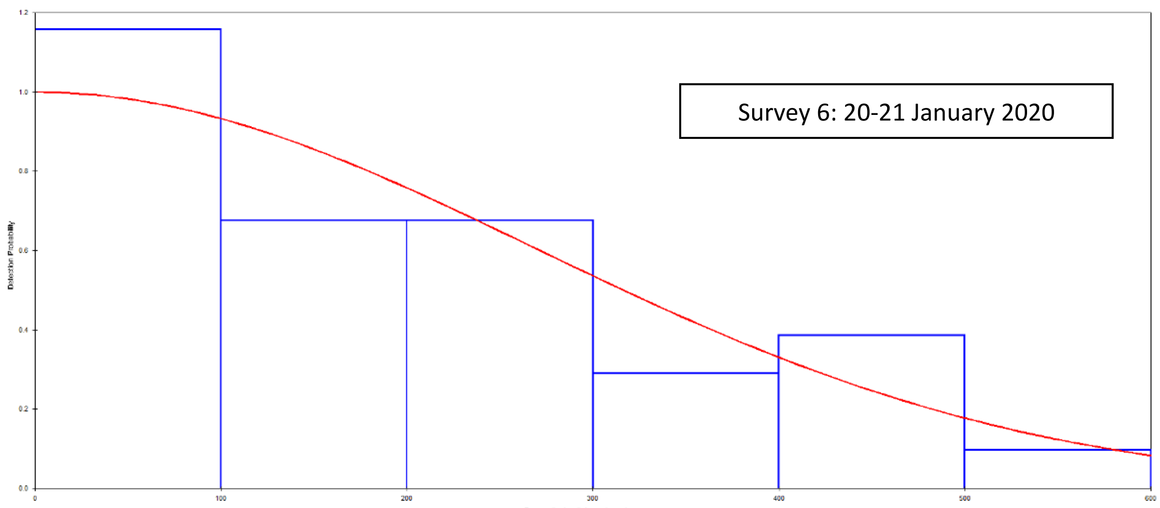
Survey Day	N (95% CI)	SE	CV	Density (per km^2)	Mean Group Size (95% CI)
Survey 1	58 (34-100)	15	0.25	0.18±0.05	1.09 (1.00-1.31)
Survey 3	76 (47-121)	17	0.23	0.24±0.05	1.27 (1.04-1.55)
Survey 5	45 (24-84)	13	0.29	0.14±0.04	1.36 (1.00-1.74)
Survey 6	**205 (145-288)**	**35**	**0.17**	**0.64±0.11**	**2.06 (1.74-2.43)**
Survey 7	59 (25-138)	24	0.41	0.19±0.07	2.22 (1.52-3.24)
Overall	**71 (36-140)**	**21**	**0.30**	**0.22±0.07**	**1.62 (1.45-1.92)**

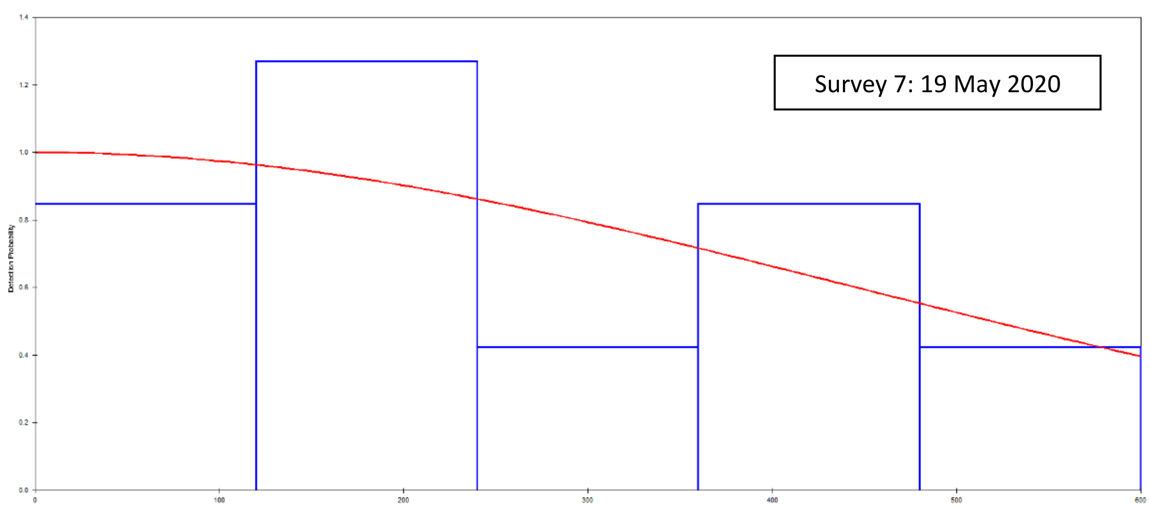
Harbour porpoise density ranged from 0.14porpoise per km^2 to 0.64 per km^2, and was 0.22 overall (Table 7). The estimate from survey 6 (0.65 porpoise per km^2) resulting in an abundance of 205±35 reflects the peak in abundance during January, which may be associated with a traditional herring spawning ground within the site (Dickey-Collas et al. 2001). The overall estimate from the pooled data is considered the most robust as it accounts for seasonal variation and provides a good average abundance estimate. The density of 0.22 porpoises per km^2 resulted in an overall abundance of 71±21 (CV=0.30) with 95% Confidence Interval of 36-140 (Table 7).






Survey 5: 1-2 December 2020
Detection Probability
Perpendicular distance in meters


Survey 6: 20-21 January 2020
Detection Probability
Perpendicular distance in meters


Survey 7: 19 May 2020
Detection Probability
Perpendicular distance in meters

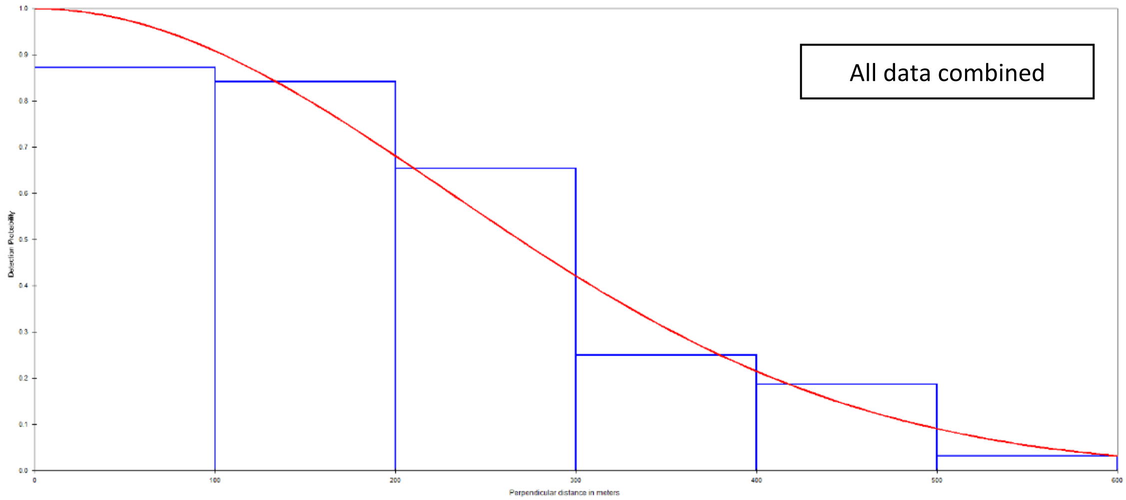


Figure 8. Detection function plots for harbour porpoise off Oriel

Density and abundance estimates were also calculated with increasing sea-state, and are shown in Tables 8 and 9. Detection functions for harbour porpoise are also presented in Figure 9. As sea-state increased the density estimate declined. This is to be expected as more porpoises will go undetected at higher sea-states resulting in false negatives and an under-estimation of actual density.

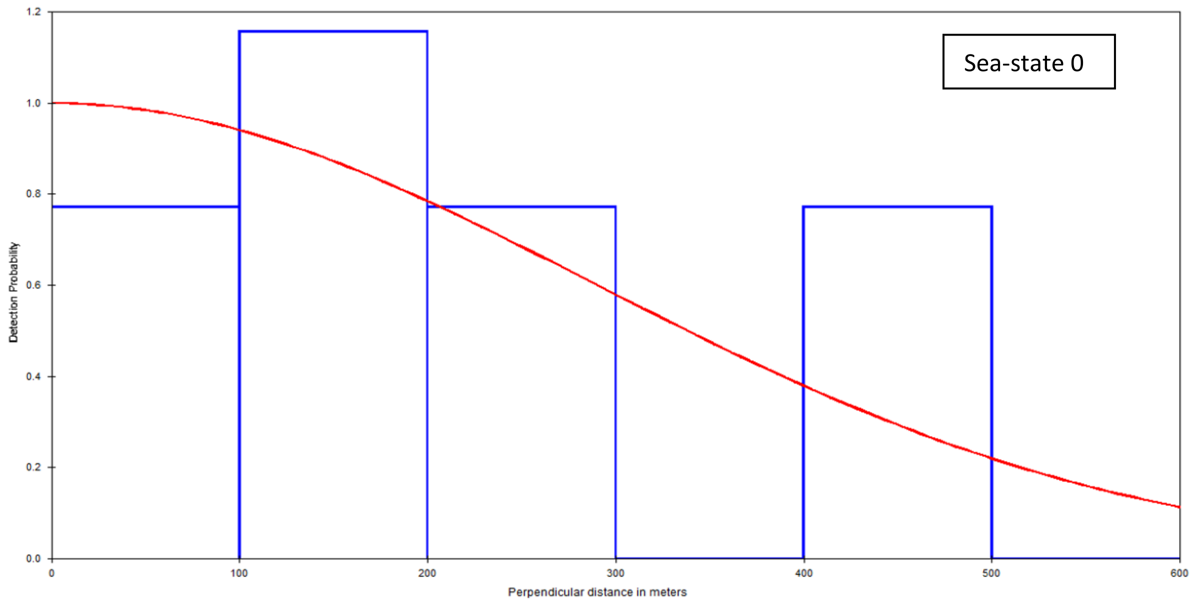
Table 8. Model data used in the harbour porpoise abundance and density estimation process in increasing sea-state for each survey off Oriel

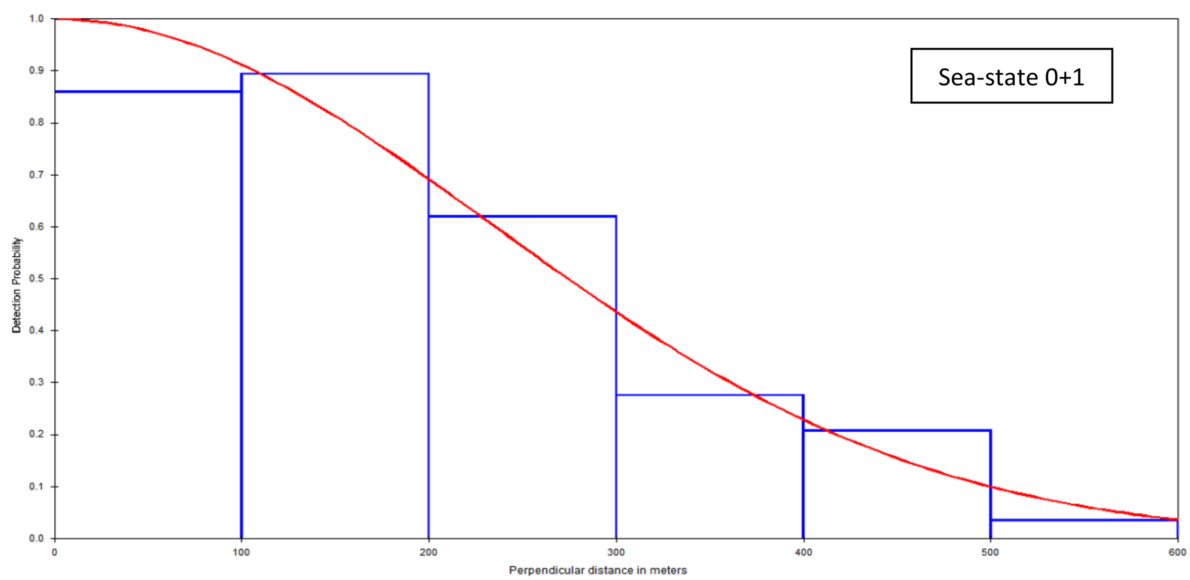
Survey	Sample size	Chi^2 P value	Effective Strip Half-Width (m)	Mean Group Size ±SE	Variability (D)		
					Detection	Encounter	Cluster
0	10	0.79	346	2.45±0.34	54.4	14.7	30.9
0+1	**52**	**0.86**	**273**	**1.70±0.13**	**19.5**	**71.2**	**9.3**
0+1+2	**85**	**0.78**	**288**	**1.64±0.09**	**15.3**	**78.6**	**6.1**
All sea-states (≤4)	92	0.69	283	1.62±0.09	10.8	84.9	4.3

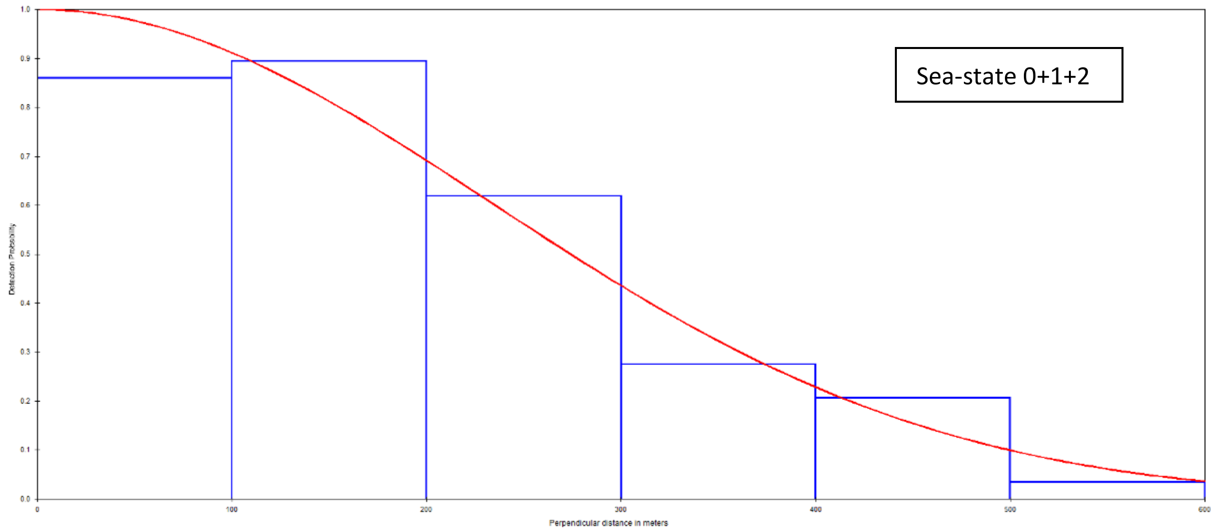
Density estimates ranged from 0.69 porpoises per km^2 (sea-state 0) to 0.27 porpoises per km^2 (sea-state ≤4). There was only 53km of effort in sea-state 0 with 10 sightings which are too few to trust model outputs. The most robust estimates are for sea-state ≤1, and sea-state ≤2, (Table 8) as the sample sizes were high (52-85 individuals). The chi-squared values are high, suggesting a reasonable good fit of the detection function with low CVs (0.22-0.25) (Table 9). This resulted in an abundance estimate of 118±26 to 140±34 harbour porpoise in the survey area.

Table 9. Estimated density, abundance (N) and group sizes of harbour porpoise recorded during each survey off Oriel
The best estimates are highlighted in **bold** font

Sea-state	N (95% CI)	SE	CV	Density (per km^2)	Mean Group Size (95% CI)
0	224 (101-494)	87	0.39	0.69	2.44 (1.78-3.36)
0+1	**140 (83-235**	**34**	**0.25**	**0.44**	**1.71 (1.46-1.99)**
0+1+2	**118 (75-187)**	**26**	**0.22**	**0.37**	**1.64 (1.46-1.84)**
All sea-states (≤4)	88 (53-146)	22	0.25	0.27	1.62 (1.46-1.82)







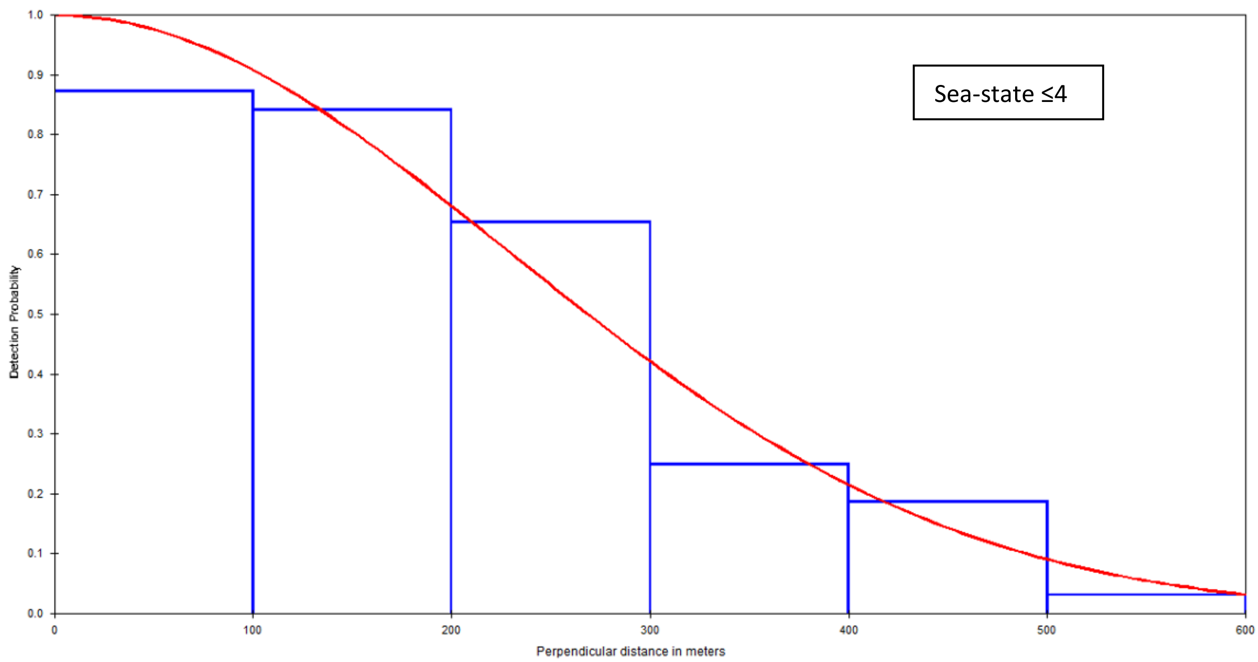


Figure 9. Detection function plots for harbour porpoise off Oriel in increasing sea-states

3.3.2 Minke whale

A density estimate was calculated for minke whales from data obtained during survey 3 on 1-2 August 2019 as there were 14 sightings of individual minke whales. The detection function is shown in Figure 10 and is a good fit (P=0.71). The Effective Strip Width was estimated at 259m which resulted in a density of 0.01±0.02 minke whales per km^2. This gives an abundance estimate of 3±0.6 (95% CI 2-5 individuals) with a CV of 0.20.

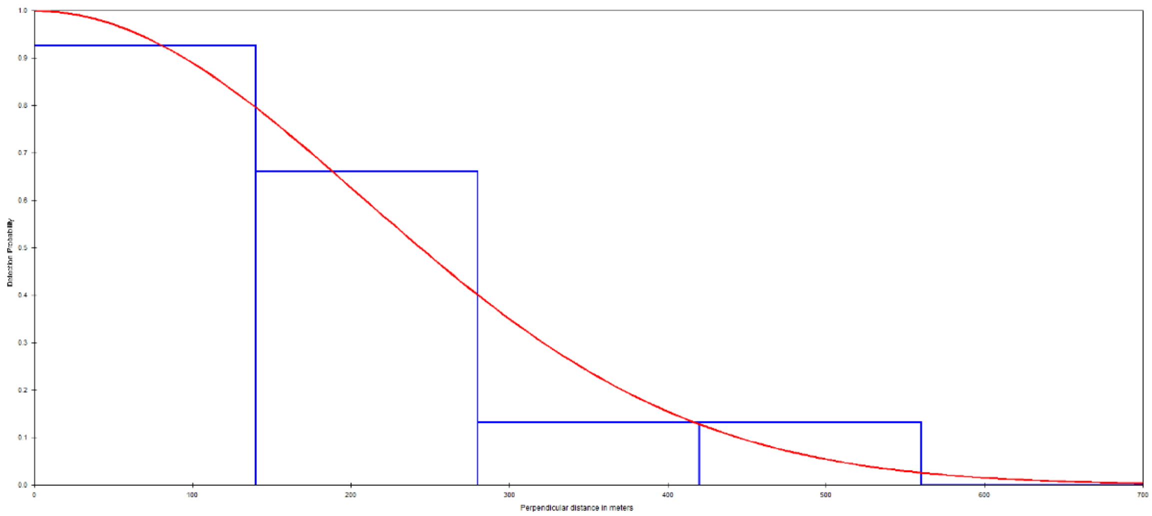


Figure 10. Detection function plots for minke whale during survey 3 off Oriel

4.0 Discussion

The Irish Sea is recognised as an important habitat for a range of marine mammals (Berrow 2010; Wall et al. 2013. The regular presence of harbour porpoise and seasonal occurrence of minke whales were to be expected, as well as grey seals. Although marine mammal species diversity is less than recorded off the south and west coasts of Ireland, abundance of species such as harbour porpoises are higher in the Irish Sea than elsewhere (Berrow et al. 2014). Minke whales are also frequently recorded in the Irish Sea during the summer (Berrow et al. 2010; Wall et al. 2013). We might have expected to record bottlenose dolphins in the study area as they are frequently observed off the east coast (Berrow et al. 2010). They are highly mobile and individuals recorded off the east coast are considered part of the inshore population which uses all Irish coastal waters (O'Brien et al. 2009). They typically pass through sites on the east coast, rarely staying for long in an area. Other species such as Risso's dolphin, killer and humpback whales have also been recorded although not frequently (Berrow et al. 2010; Wall et al. 2013). The western Irish Sea front is a well-known feature (Simpson et al. 2009) that runs to the east of the study area. High productivity leading to increased marine predators including seabirds have been reported (Begg et al. 1997). This feature varies in its position and zone of influence and the effect of this front on marine mammals should not be ignored.

Overall marine mammals were observed throughout the study area (Figure 11). Clearly harbour porpoise and grey seals occur at the site, with both groups having different sensitivities to potential impacts. Minke whales occur seasonally during the summer and autumn and are more sensitive to low frequency sounds, which they use for communication and navigation.

As is to be expected harbour porpoise were by far the most frequently recorded cetacean species observed on every survey. They occur all year round at the study site, with increases in the winter. Porpoise abundance is likely to be more consistent throughout the year but with offshore movements in early spring (March-April) though to be associated with calving (Berrow et al. 2010).

Although both resident seal species breeding in Ireland were recorded in the study site, most sightings were of grey seals which occurred in every month of survey. Although grey seals are highly mobile and welsh Scottish breeding seals also use Irish waters to forage an important breeding site for grey seals occur on the Saltee Islands, to the east of the study area. Clearly the study area is an important foraging area for seals and were recorded throughout the site.

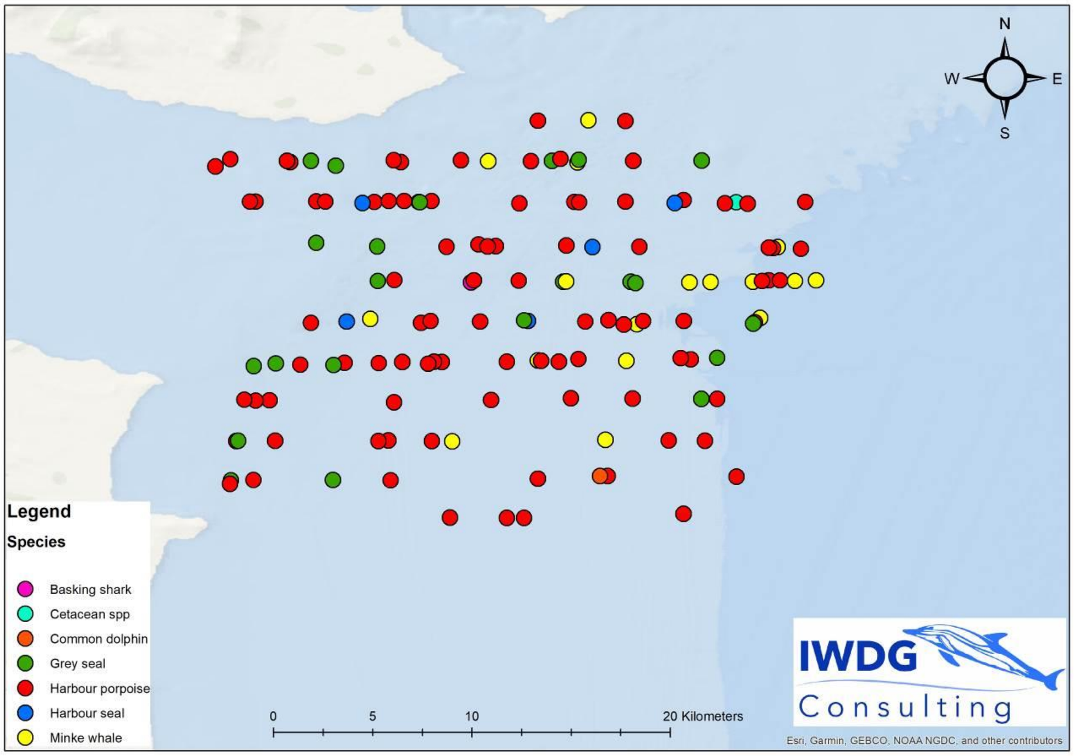


Figure 11. Distribution of all marine mammal sightings off Oriel

All marine mammals are protected in Ireland through national and EU legislation. All species occur on Annex IV of the EU Habitats directive and are entitled to strict protection while harbour porpoise, is listed on Annex II which require the designation of Special Areas of Conservation. The proposed windfarm site at Oriel is 47.8km from the North Channel SAC which list harbour porpoise as a primary reason for selection of the site and the Rockabill to Dalkey Island SAC, which is around 50 km to the south. The boundary of Strangford Lough SAC, which is designated to protect common (harbour seals) lies approximately 50km to the northeast of the site. Murlough SAC, which lists common (harbour) seal as present as a qualifying feature but not a primary reason for site selection, lies around 35km to the northwest. All marine mammals are highly mobile and all individuals occurring at the site are part of a much wider population. No population structuring at a local scale has been recognised or is expected and thus risk assessments should consider connectivity between this site and other sites, including other offshore windfarm sites.

4.1. Abundance estimates

Distance sampling was used to estimate absolute abundance. The use of distance sampling and modelling to derive density and abundance estimates in Ireland using a single observation platform has been discussed by Berrow et al. (2014). Statistical interpretation using distance sampling rests on several assumptions (Buckland et al. 2001). These include the assumption that objects are spatially distributed according to some stochastic process. If transect lines are randomly placed within the study area we can safely assume that target objects are uniformly distributed with respect to track-line in any given direction. Density and abundance estimates presented here for harbour porpoise and common dolphin are a minimum as g(0) is not = 1, meaning animals on the track-line are missed and not included in the estimates however without a double-platform survey the proportion missed cannot be quantified but for harbour porpoise could be up to 30-40%. These assumptions are sometimes violated but this technique has been widely used in Ireland allowing comparisons in density estimates within and between sites to assess periods or areas of greater importance for cetacean species. However, density and abundance estimates presented here for harbour porpoise can be used in risk assessments to determine the number of individuals exposed to potentially negative impacts during construction and operation.

Abundance estimates of marine mammals from the North Irish Sea are scarce. Berrow et al. (2014) derived a density estimates of 1.19 harbour porpoise per km^2 in Dublin Bay (CV=0.24) and 2.03 harbour porpoise per km^2 in North County Dublin (CV=0.22) to the east of the study area during summer 2008. These were the two of the highest density estimates of eight sites sampled by Berrow et al. (2014). Dedicated site surveys of the Rockabill to Dalkey Island SAC funded by the NPWS and conducted during the summer (June to September) returned density estimates of 1.59 porpoises per km^2 in 2011 (Berrow *et al.* 2011) of 1.44±0.09 porpoises per km^2 (CV = 0.06) in 2013 (Berrow and O'Brien, 2013) and 1.55±0.17 porpoises per km^2 (CV=0.10). Density estimates of between 0.22 and 0.27 porpoises per km^2 in the present study are very low compared to densities recorded further south, but it should be remembered these surveys were carried out between June and May and in a range of sea-states, while the NPWS surveys were carried out in optimal conditions. Monthly dedicated boat-based surveys, using the same methodology as the present study, were carried out between April 2015 and January 2017 off Portmarnock, Co Dublin to the south of the present survey area. Density estimates varied between 0.97 and 2.29 porpoises per km^2 with a mean density estimate of 1.32 harbour porpoise per km^2 (Meade et al. 2017), which is again much higher than reported off Oriel. Even the highest density estimate (0.69 harbour porpoise per km^2) is below the minimum of the range of estimates further south.

5.0 Acknowledgements

We would like to thank Fastnet Shipping Ltd and skippers Nicky Fortune and Walter Rankin and their crew for providing an excellent vessel and contributing to the success of these surveys. This survey project was contracted by Parkwind through Aquafact and we would particularly like to thank Caroline Roche and Brendan O'Connor of Aquafact and Richard Church of Parkwind for their support throughout.

6.0 References

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A.2 Fitted detection Functions and Sea state plots

Harbour Porpoise

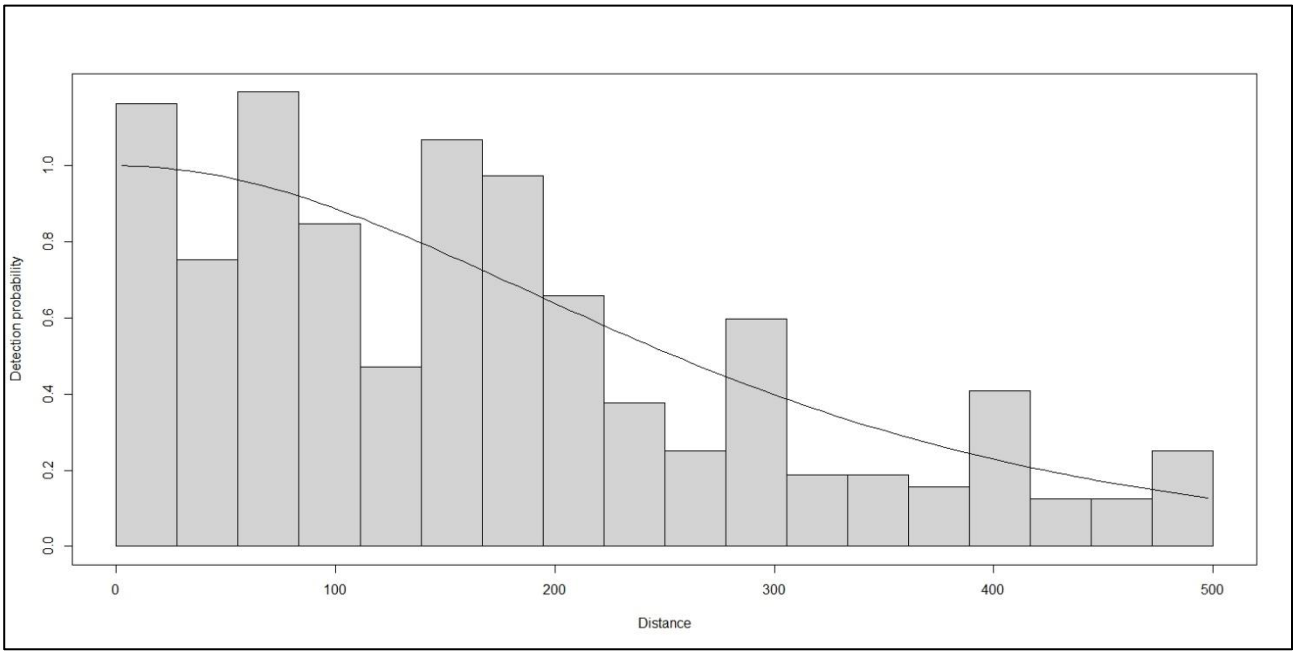


Figure A-1: Harbour Porpoise fitted detection function.

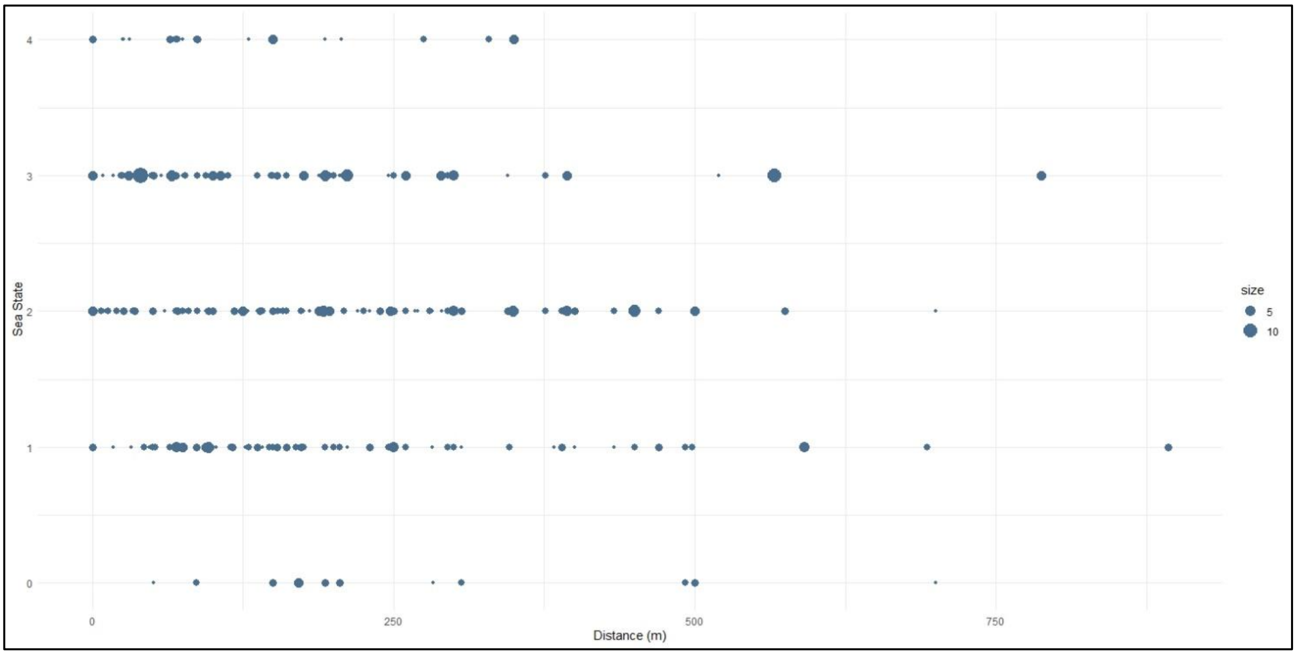


Figure A-2: Harbour Porpoise observations sea state vs detection distance.

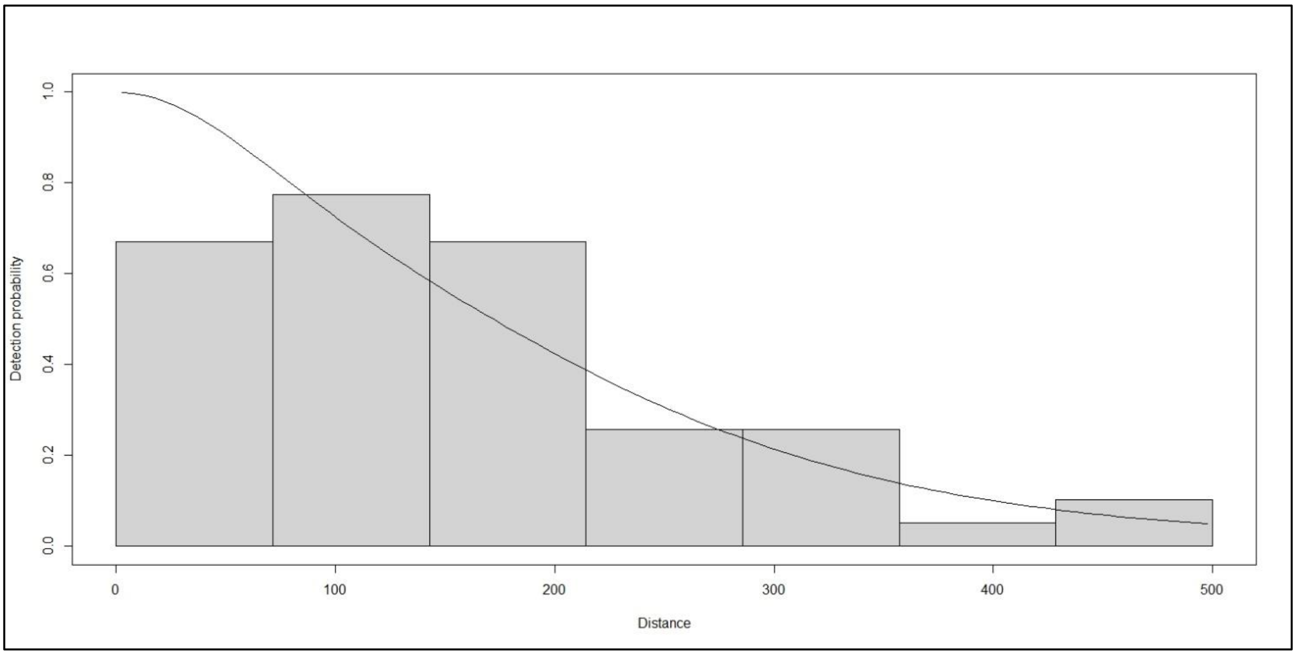


Figure A-3: Harbour Porpoise fitted detection function.

Grey Seal

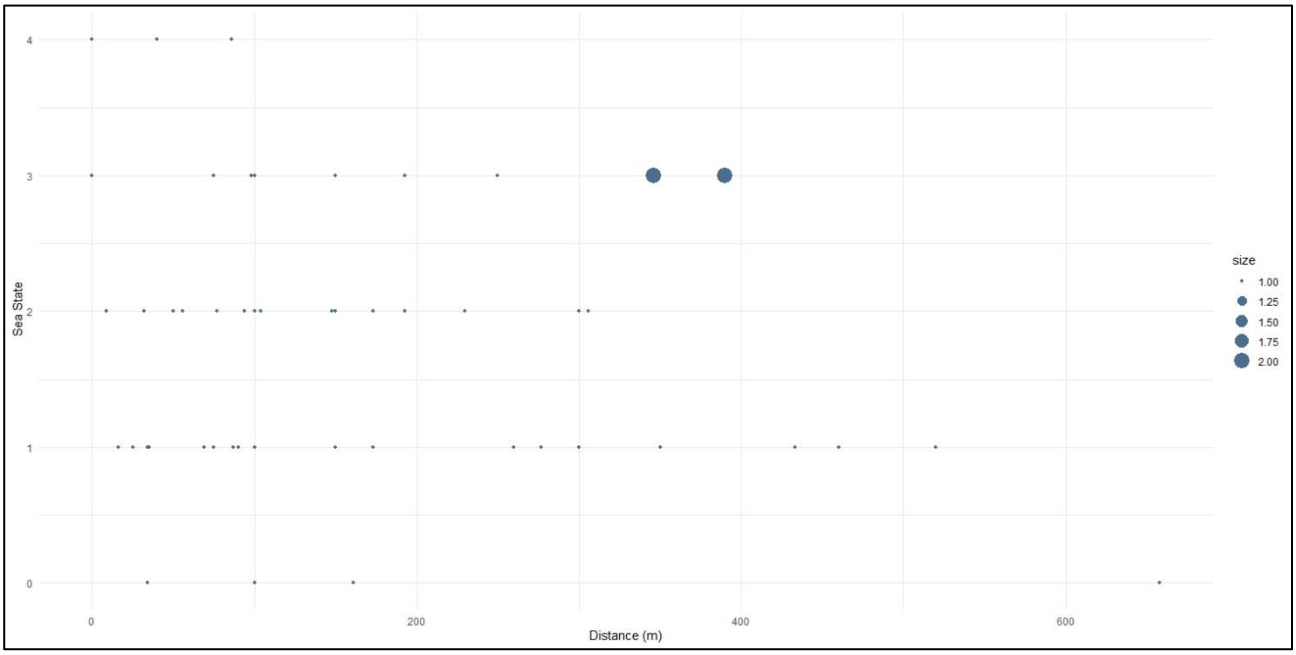


Figure A-4: Grey Seal observations sea state vs detection distance.

Minke Whale

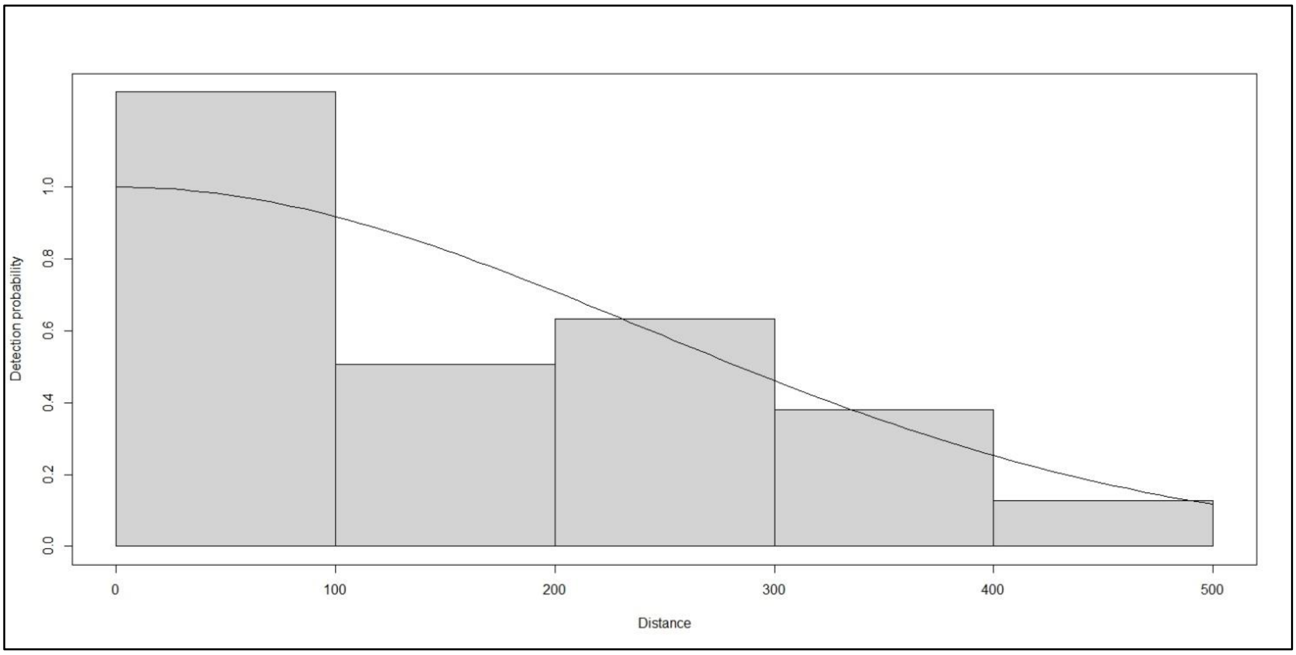


Figure A-5: Minke Whale fitted detection function.

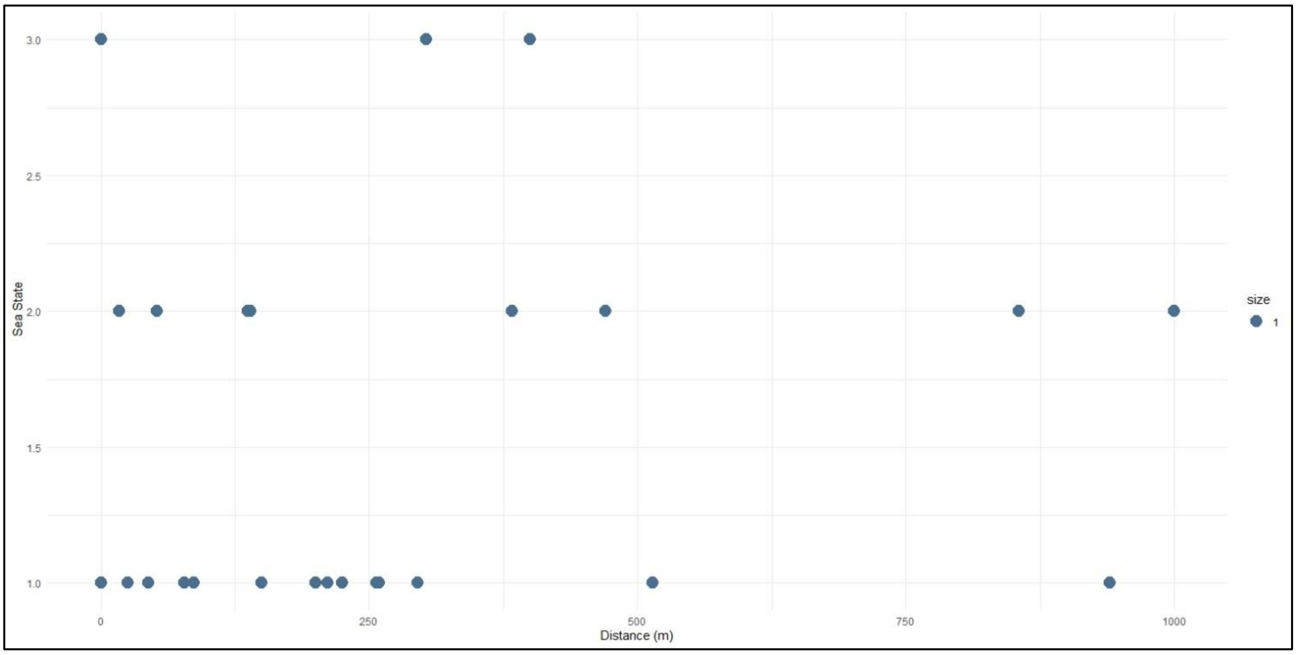
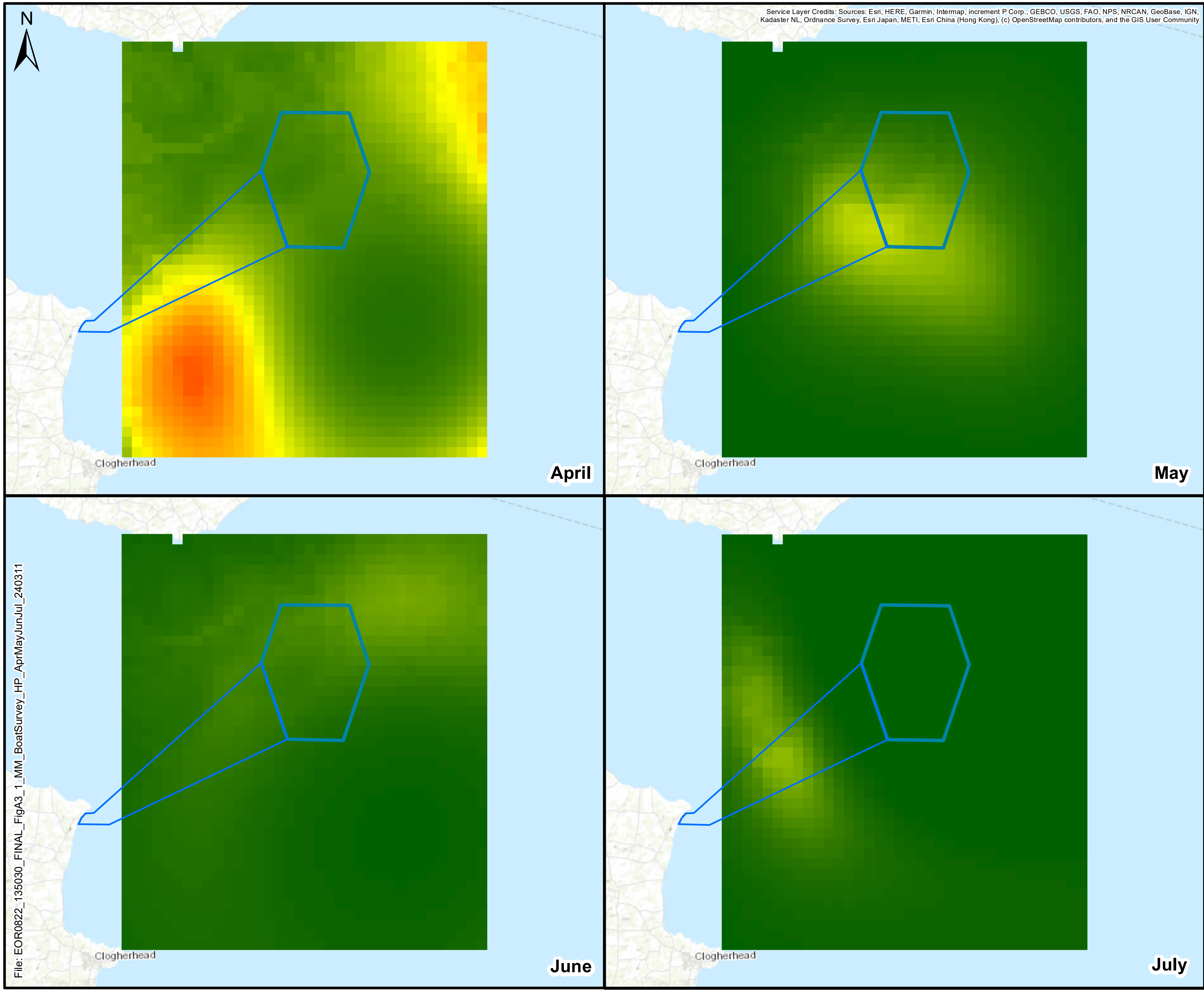


Figure A-6: Minke Whale observations sea state vs detection distance.

ANNEX 3: SPECIES DISTRIBUTION MAPS



Legend

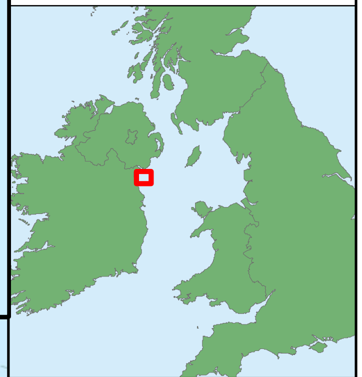
Offshore Wind Farm Area

Offshore Cable Corridor

Mean Density Estimate Value

0.5
0.4
0.3
0.2
0.1
0

Data Sources: Client,



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Title

Figure A.3-1
Species distribution maps of mean harbour porpoise density in April, May, June and July

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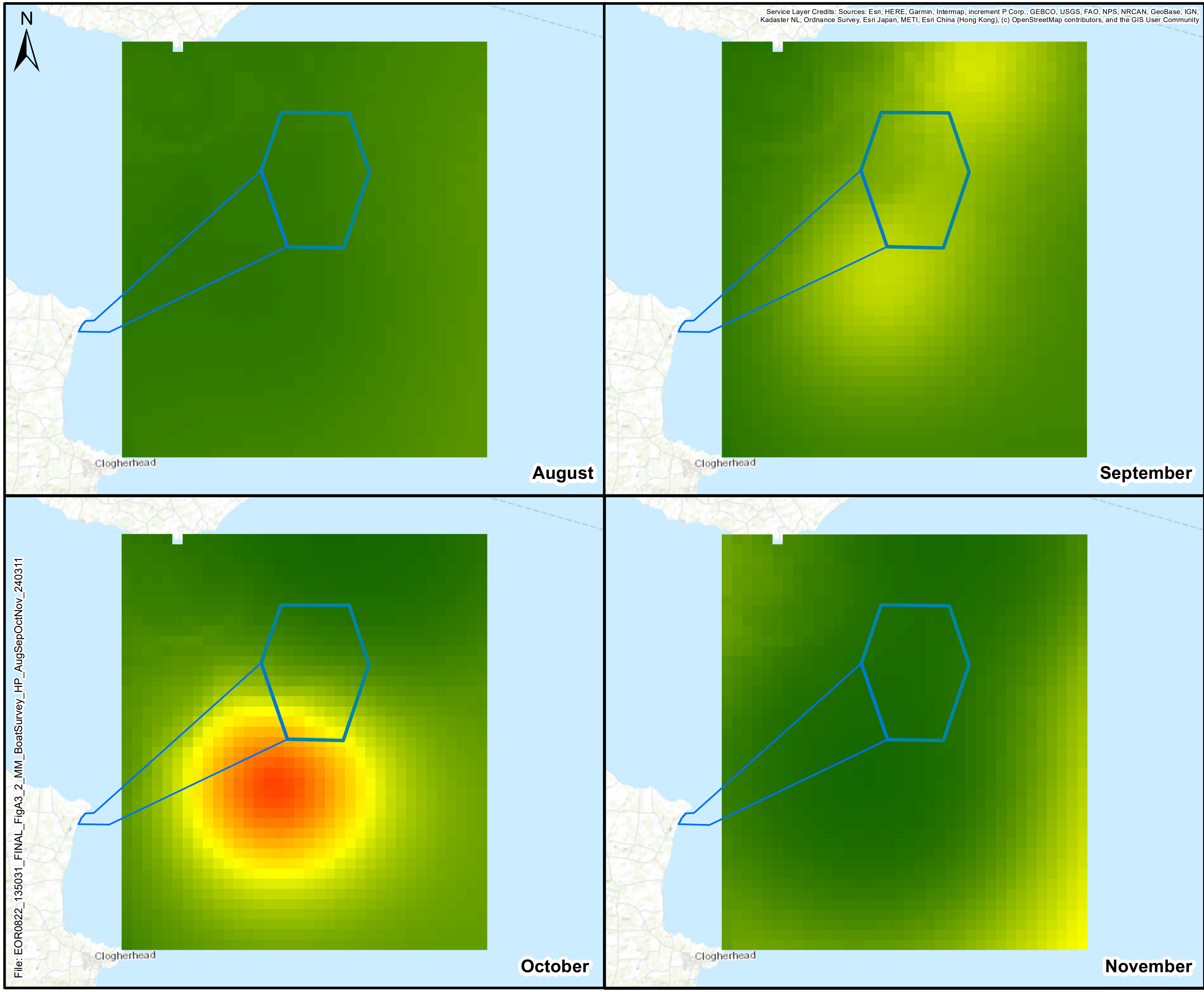

Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Mean Density Estimate Value

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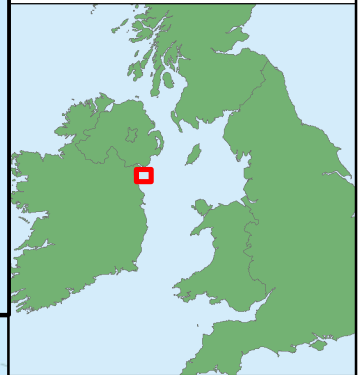
0.4
0.3
0.2
0.1
0

Data Sources: Client,



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Title Figure A.3-2
Species distribution maps of mean harbour porpoise density in August, September, October and November

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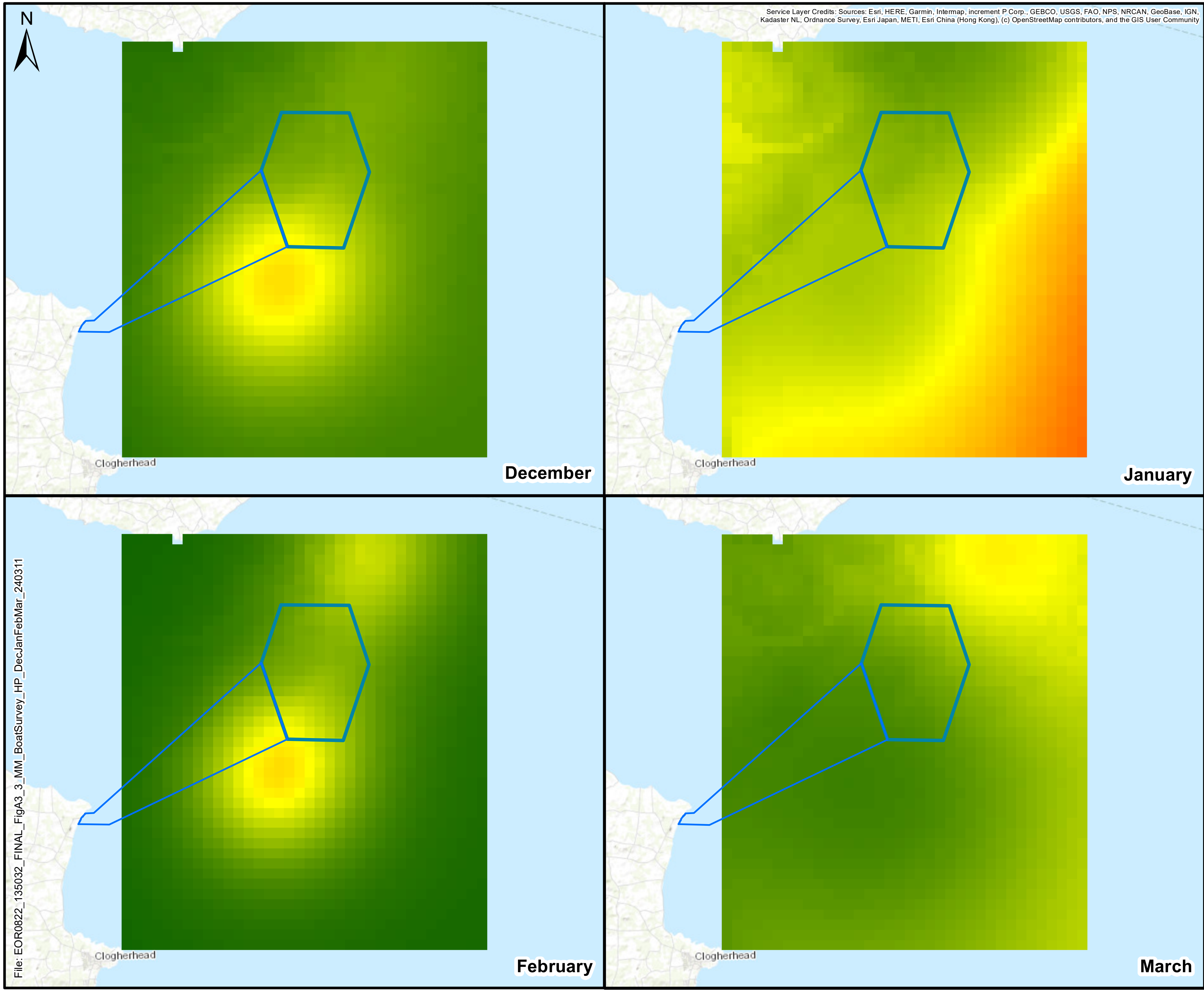

Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Mean Density Estimate Value

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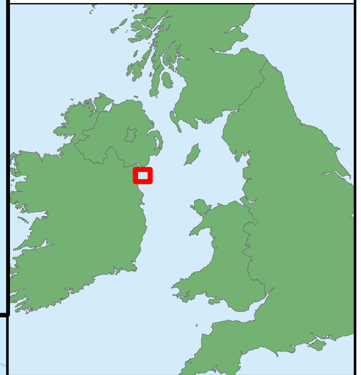
0.4
0.3
0.2
0.1
0

Data Sources: Client,



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Title

Figure A.3-3
Species distribution maps of mean harbour porpoise density in December, January, February and March

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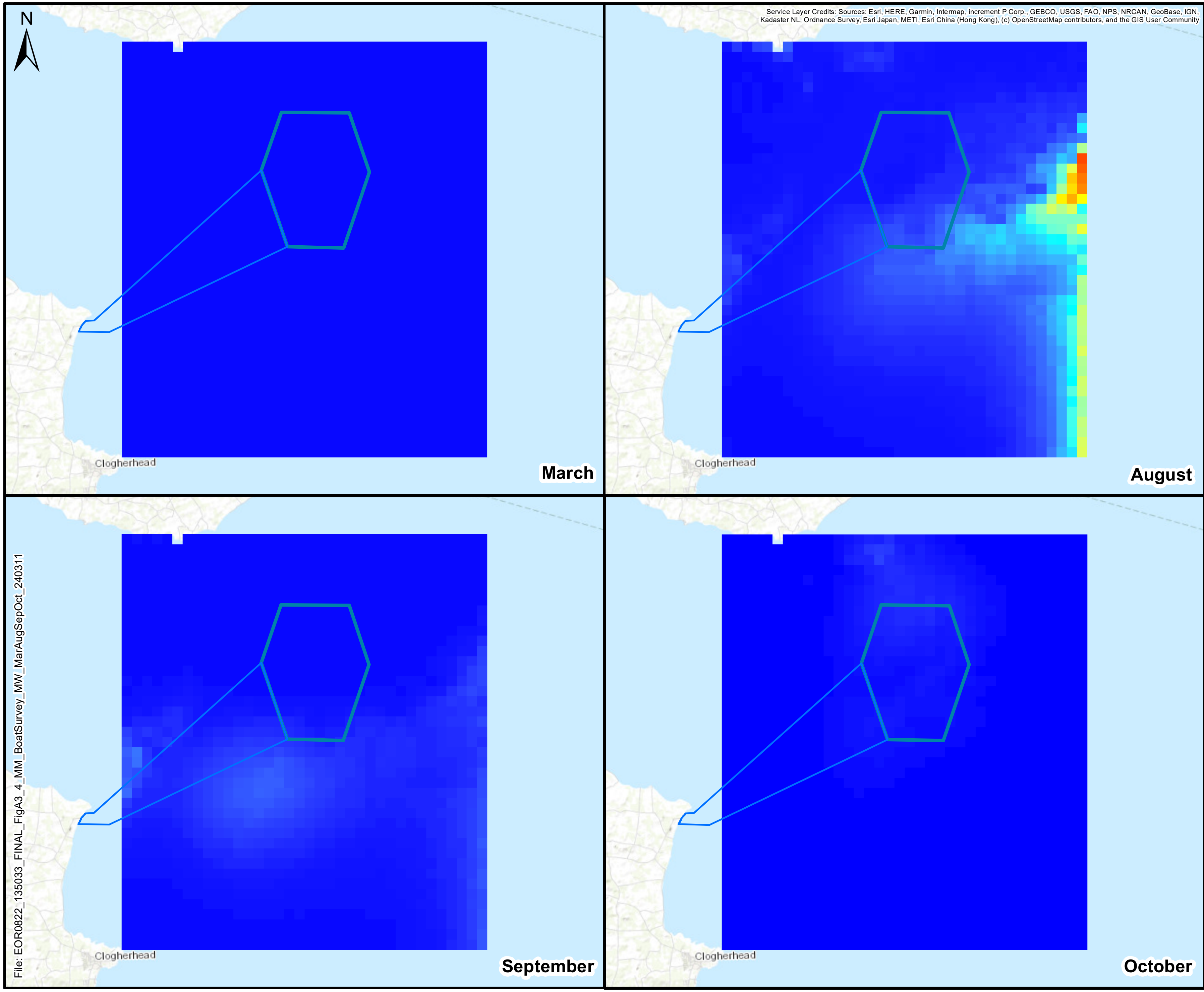

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Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Mean Density Estimate Value

0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

Data Sources: Client,

Client

ORIEL WINDFARM
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Project

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Title **Figure A.3-4**
Species distribution maps of mean minke whale density in March, August, September and October

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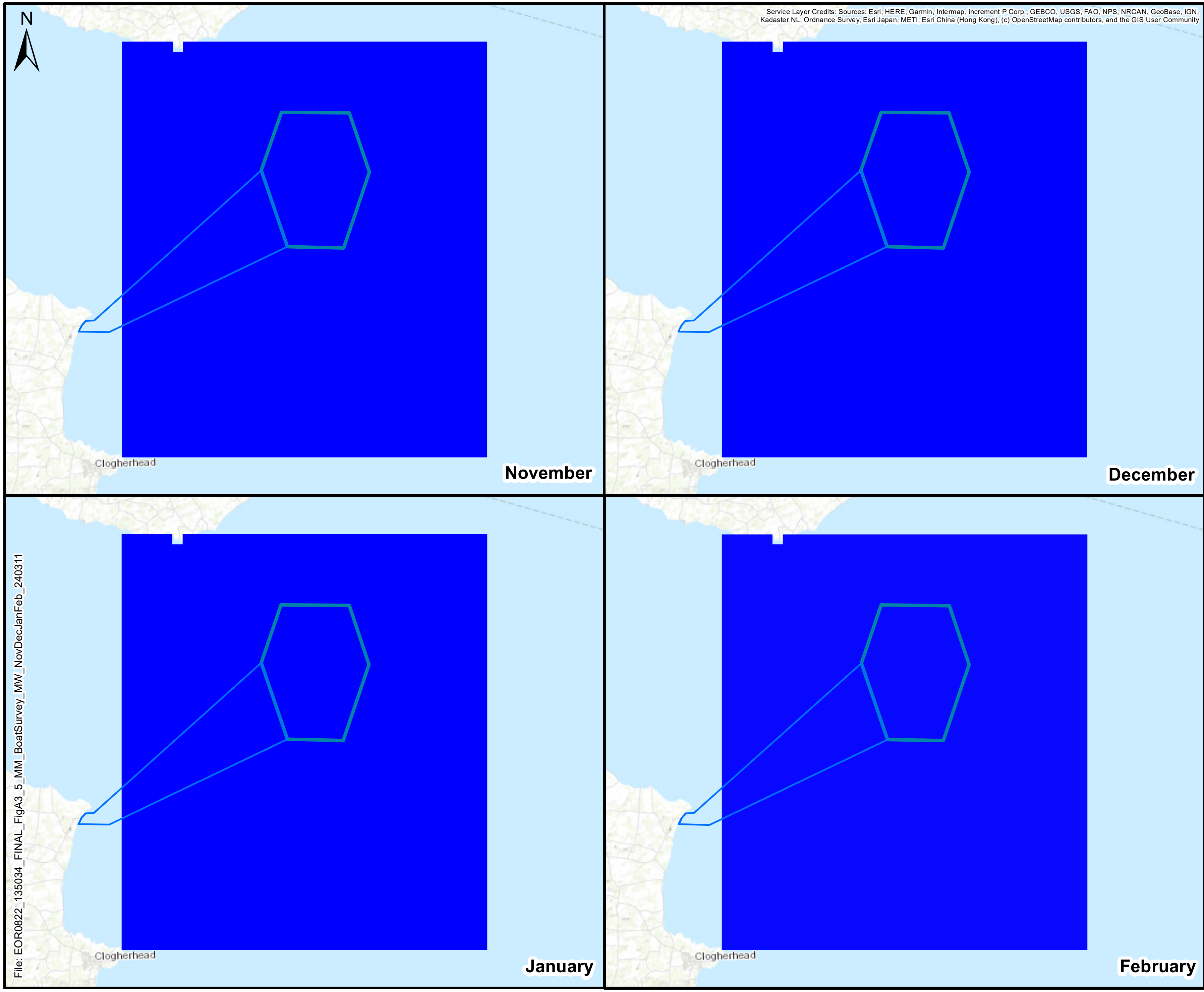

Legend

Offshore Wind Farm Area

Offshore Cable Corridor

Mean Density Estimate Value

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0.6
0.5
0.4
0.3
0.2
0.1
0

Data Sources: Client,

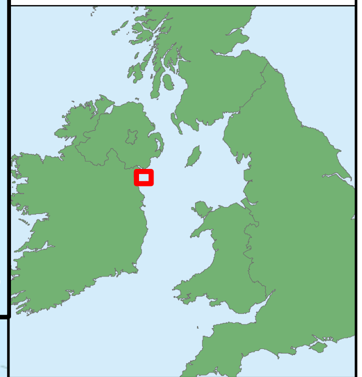

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Figure A.3-5
Species distribution maps of mean minke whale density in November, December, January and February

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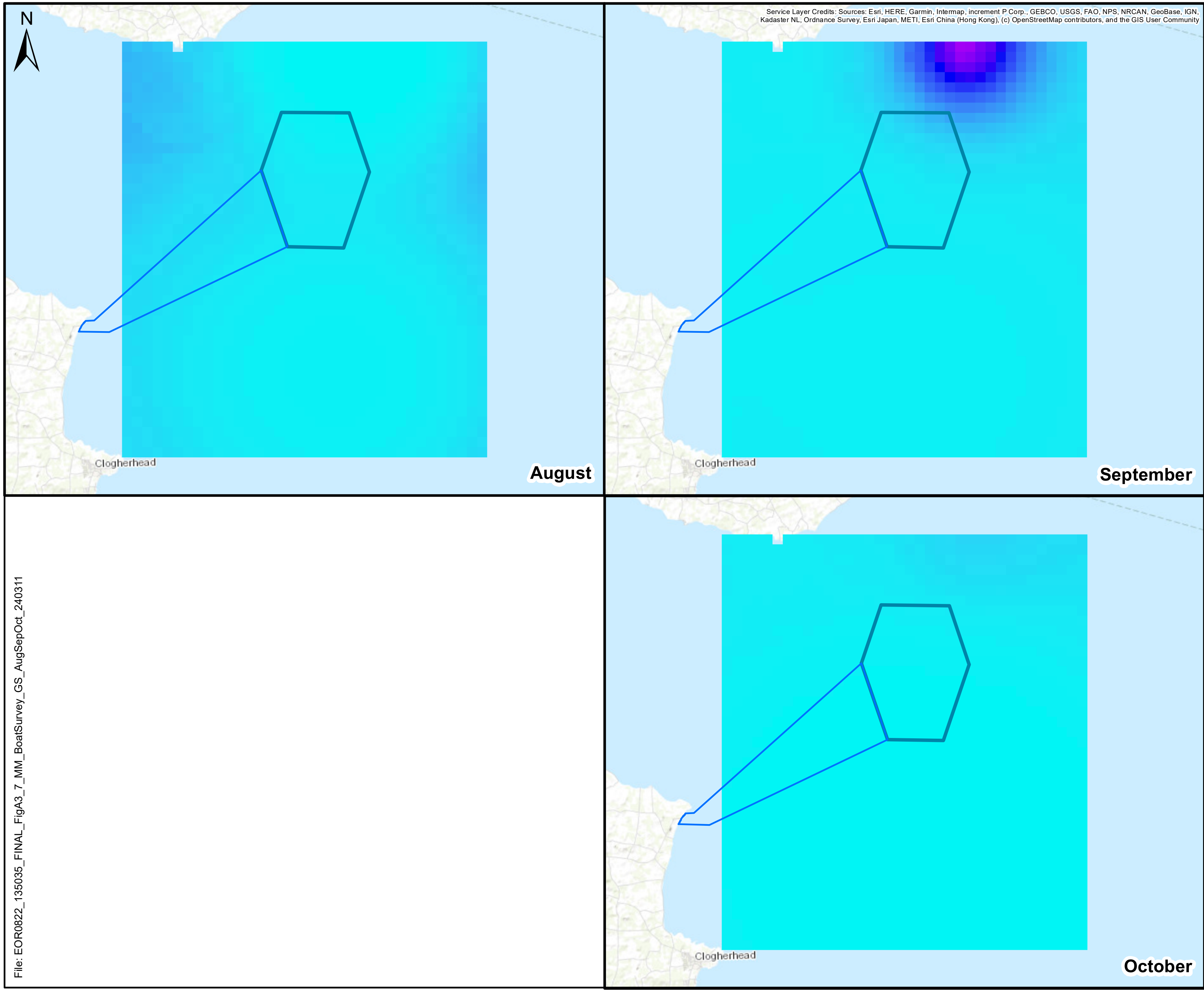

File: EOR0822_135035_FINAL_FigA3_7_MM_BoatSurvey_GS_AugSepOct_240311

Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Mean Density Estimate Value

0.4
0.3
0.2
0.1
0

Data Sources: Client,

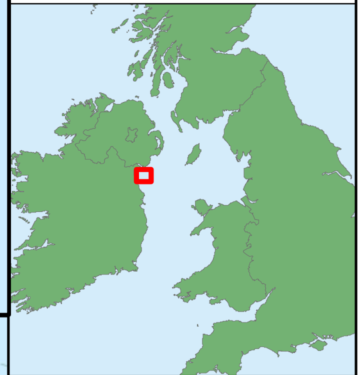

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Figure A.3-7
Species distribution maps of grey seal density in August, September and October

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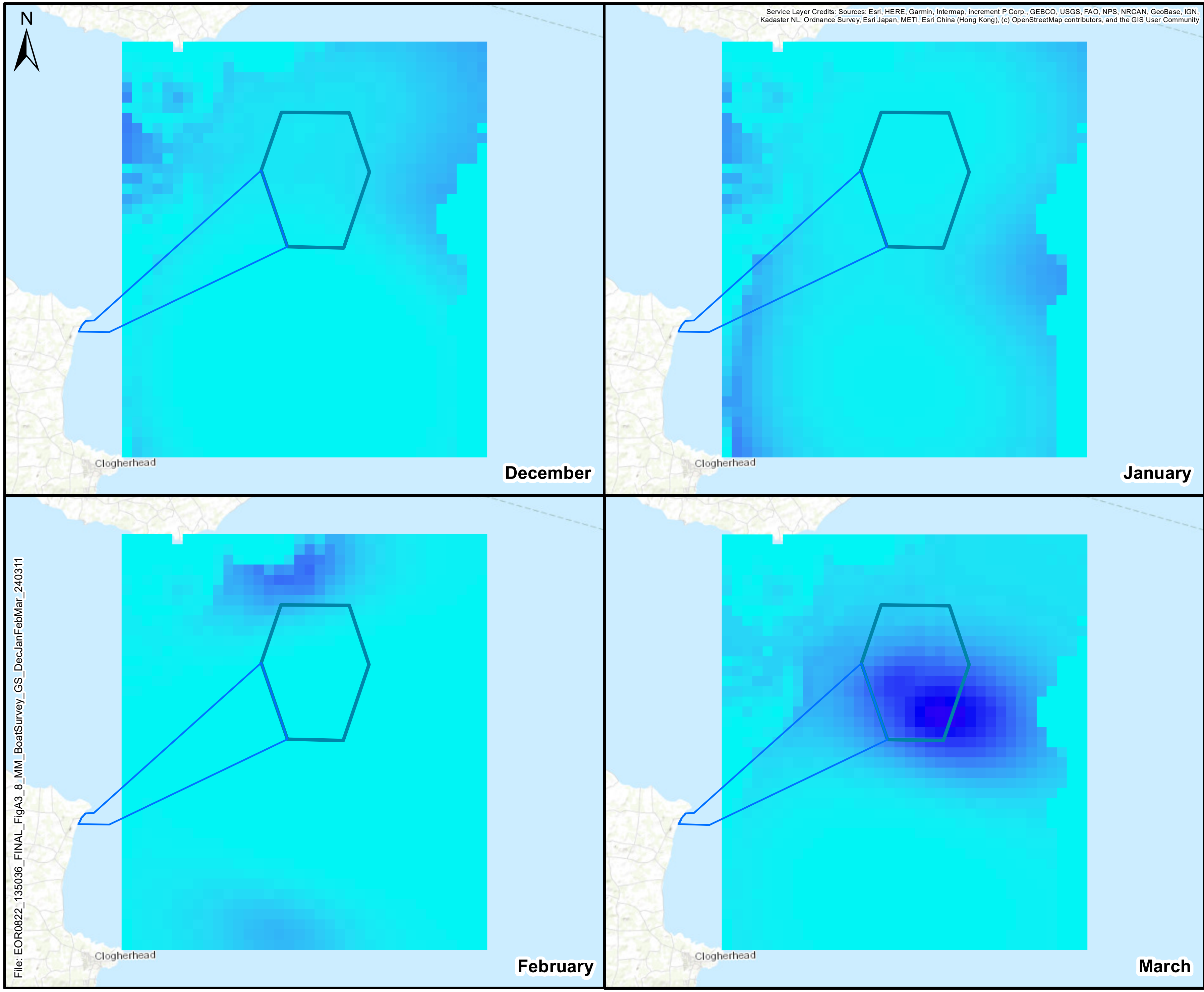

File: EOR0822_135036_FINAL_FigA3_8_MM_BoatSurvey_GS_DecJanFebMar_240311

Legend

- Offshore Wind Farm Area
- Offshore Cable Corridor

Mean Density Estimate Value

0.4
0.3
0.2
0.1
0

Data Sources: Client,

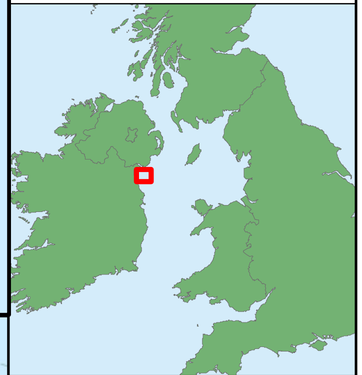

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Figure A.3-8
Species distribution maps of grey seal density in December, January, February and March

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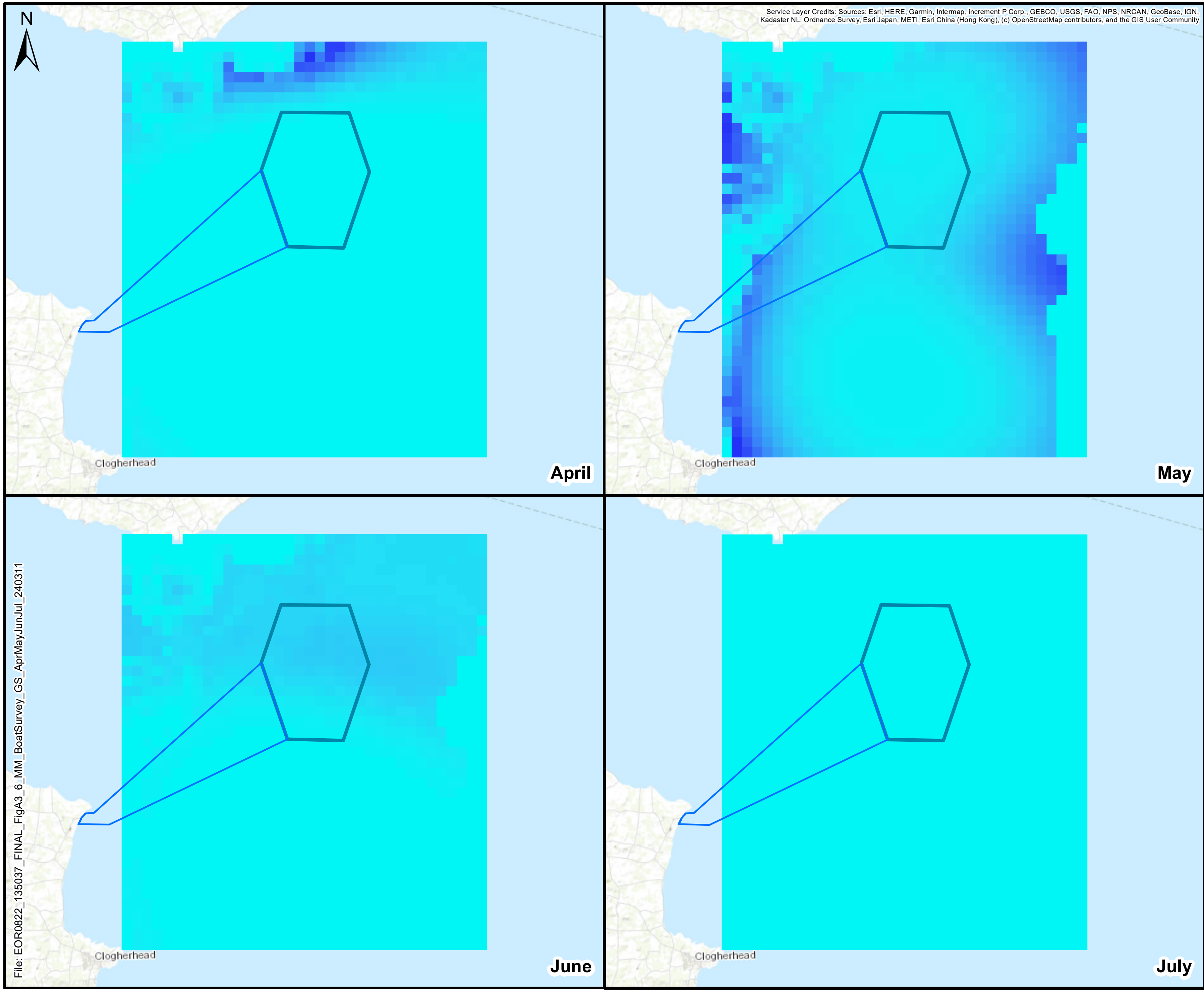

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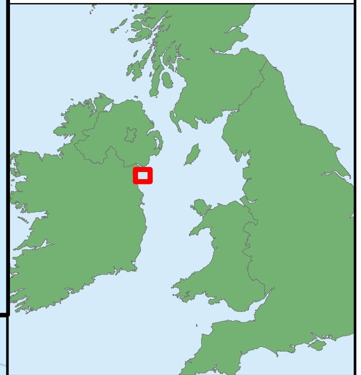
Offshore Wind Farm Area

Offshore Cable Corridor

Mean Density Estimate Value

0.4
0.3
0.2
0.1
0

Data Sources: Client,



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Project

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Title

Figure A.3-6
Species distribution maps of grey seal density in April, May, June and July

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