E.ON Climate & Renewables

Analysis of Marine Ecology Monitoring Plan Data from the Robin Rigg Offshore Wind Farm, Scotland

(Operational Year 2)

Technical Report

Chapter 5: Birds

Report: 1012206

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Robin Rigg Offshore Wind Farm, Scotland: Analysis of MEMP Ecological Data (Operational year 2) Chapter 5: Birds

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5. ORNITHOLOGICAL MONITORING AT ROBIN RIGG

The remit of the Marine Environment Monitoring Plan (hereafter referred to as the MEMP) for the Robin Rigg offshore wind farm development was to record any changes to the physical and ecological environment that may be caused by the construction and operation of the wind farm, complying with condition 6.4 of Section 36 Consent conditions. The programme concentrated on areas where there was uncertainty on the effects of the wind farm and where those effects may cause potential impacts on the marine ecology. This included benthos, fish, birds and marine mammals.

5.1. Introduction

This chapter contains a summary of the bird data available for analysis to Natural Power Consultants (NPC) and represents an update on previous reports to include data collected during operational year two. All data collected during construction of the Robin Rigg wind farm was undertaken as part of the requirements for the MEMP and agreed by the RRMG.

5.1.1. Predicted impacts from the Environmental Statement

The Environmental Statement (hereafter referred to as the ES) assessed the potential impacts on birds by impact type. This document concluded the following:

Loss of habitat for feeding and roosting

Direct loss of habitat resulting from the development will be of such a small scale that it will not be significant in terms of its impact on bird habitat (and their foods).

Collision risk

Generally, the collision risk model predictions were very low, even though unrealistic worst case assumptions were made. For most species, the magnitude of risk was less than 1% above annual baseline mortality rate (See Table 5.1). The one species that exceeded this value was the red-throated diver, with a predicted annual collision mortality rate of 22.8%. It was felt this high value was due to a combination of a small population within the study area and it being a long-lived species.

Table 5.1: Worst case collision risk predictions for key species at the Robin Rigg offshore wind farm as presented in the Environmental Statement.

Species	Predicted annual collision with wind farm (worst case)	Annual mortality rate	Collision mortality as % of overall annual mortality
Common scoter	3.4	23%	0.3%
Red-throated diver	3.3	10%	22.8%
Oystercatcher	10.9	7%	0.4%
Barnacle goose	11	10%	0.5%

The overall collision risks predicted from the Robin Rigg development are detailed in Table 5.2 below.

Table 5.2: Summary of collision risks from the Robin Rigg offshore wind farm as predicted in the Environmental Statement.

Species	**Sensitivity of local population**	**Magnitude of effect**	**Significance**	**Significant impact?**
Common scoter	High	Negligible	Very low	No
Red-throated diver	High	Low	Low	No
Migrant waterfowl	Very high	Negligible	Low	No
Other seabirds	Medium	Low/negligible	Low/very low	No
Migrant land birds	Low	Negligible	Very low	No

Habitat loss

Overall, no significant disturbance impacts were predicted. At most, disturbance would affect regionally, rather than nationally important numbers and it was concluded that the development area does not provide particularly important resources for the bird populations discussed.

For the two species known to occur in internationally important numbers, red-throated diver and common scoter, displacement zones of 5 km and 3 km respectively were predicted as being needed to affect nationally important numbers. Studies at existing wind farms (at the time) found small-scale disturbance with the maximum distance reported as 800 m (Pedersen & Poulsen, 1991), suggesting that disturbance to species of concern around Robin Rigg would be unlikely. A summary of species sensitivities and magnitudes of impacts can be found in Table 5.3.

Table 5.3: Summary of disturbance assessment from the Robin Rigg development, as predicted in the Environmental Statement. The magnitude of impact is that which would arise if birds were displaced from an area 1 km around the wind farm and what disturbance zone would be needed to result in a significant impact.

Species	Sensitivity of local population	Buffer width (for national importance)	Magnitude of effect	Significance	Significant impact?
Common scoter	High	3 km	Low	Low	No
Red-throated diver	High	>5 km	Low	Low	No
Manx shearwater	Medium		Negligible	Very low	No
Storm petrel	Medium		Negligible	Very low	No
Gannet	Medium		Negligible	Very low	No
Cormorant	Medium		Low	Low	No
Scaup	Medium		Low	Low	No
Kittiwake	Medium		Low	Low	No
Guillemot	Medium		Low	Low	No
Razorbill	Medium		Low	Low	No
Other seabirds	Low		Low	Very low	No

5.1.2. Solway bird populations

The Solway Firth is an important area for a wide range of diverse bird species, with a number of areas protected under national and international law (see Appendix 3 Table 1) for a full list of sites and protected species). The Robin Rigg Environmental Statement (ES) reports a number of these bird species as being present within the Solway Firth in nationally important numbers. This included common scaup, scoter; divers (red-throated, black-throated and great northern); Manx shearwater; cormorant; gannet; kittiwake and guillemot. These species, in addition to razorbill, herring gull and great black-backed gull, are the main focus of this analysis, which will compare observed patterns with predictions provided in the ES predictions as well as allowing a detailed assessment of the efficacy of the MEMP.

Scaup

Scaup are mainly present in the UK during the winter, with the majority arriving in late October and leaving again in February. Most individuals winter in marine coastal areas where they typically feed on molluscs such as mussels and tend to congregate in large flocks. Strong links have been found between wintering birds in the UK and breeding populations in Iceland (Wernham *et al*., 2008) but the limited tagging data available suggest that birds observed in the UK disperse to a wide range of sites in northwest Europe (Wernham *et al*., 2008).

Common scoter

Common scoter breeds on inland waters, near moorland lochs or on wooded islets. Only a few breeding sites are known in Scotland, they mostly breed in Scandinavia. They feed predominantly on molluscs, in particular the blue mussel. They are also known to eat cockles, clams, small fish and plant material. Some birds will overwinter near their breeding grounds while others migrate to transitional sites to moult. Moulting occurs between July and October, rendering the birds flightless for 3-4 weeks. Common scoter are listed on Schedule 1 of the Wildlife and Countryside Act, are listed on the IUCN Red List of threatened species and a UK Priority BAP species.

Common scoters were recorded throughout the wider ES study area, with the highest numbers recorded in August/September (pre-moult) and May/June. Observations were primarily in the north-western edge of the study area.

Divers

Three species of diver (red-throated, black-throated and great northern) have been recorded in the survey area, primarily during the winter and spring. Of these, 90% were identified as red-throated divers and so analysis has focussed on this species. These birds breed around shallow pools on upland moors and bogs, travelling to the coast to feed. Breeding red-throated divers are distributed throughout the north and west of Scotland, with almost half of the Scottish population breeding in Shetland. Outside of the breeding season, they can be found around the coast, in shallow sandy bays. They develop their breeding plumage between February and April, moulting after breeding has finished. All three species of diver feed predominantly on marine fishes such as cod, herring, sandeel and sprat. The red-throated (and great northern) diver is listed on Annex 1 of the Birds Directive, Schedule 1 of the Wildlife and Countryside Act and are Amber listed Birds of Conservation Concern (Eaton *et al*., 2009).

Diver distribution was scattered throughout the study area for the ES, although there was a tendency for red-throated divers to occur in shallow waters of between 5-10 m.

Manx shearwater

The Manx shearwater is the commonest shearwater observed around Britain. The breeding population in Great Britain and Ireland is approximately 332,300 pairs (estimated from AOS data), breeding in 40 colonies in the west of the UK (Mitchell *et al*., 2004). However, this estimate is based on a survey that overlooked 14 further potential colonies so this may be an underestimate. The populations of Great Britain and Ireland form approximately 68-91% and 7-18%, respectively, of the global population of 340,000-410,000 pairs.

Manx shearwater prefer the open ocean except when nesting, burrowing on flat or sloping land close to the sea and only approaching land after dark. The nearest breeding grounds are on Sanda, Argyll and the Calf of Man (Mitchell *et al*., 2004). Manx shearwaters feed at the sea-surface, either making plunge dives from a height of 1-2m, or making shallow, wing-propelled dives to catch prey items. They feed on fish such as herring, sardine and sprat plus sometimes squid (Snow & Perrins, 1998). They are a long distance migrant, travelling between breeding grounds in the spring to their wintering grounds in South America from July. Manx shearwater are considered to be of conservation concern under the Birds Directive and are Amber listed Birds of Conservation Concern (Eaton *et al*., 2009).

Survey work for the ES only recorded Manx shearwater during the summer months with no birds observed after August. They were observed predominantly over deeper waters to the south and west of the study area.

Gannet

The breeding population of northern gannet in Great Britain and Ireland is approximately 259,500 pairs breeding in 21 colonies (Mitchell *et al*., 2004). This forms approximately 67% of the global population of 390,000 pairs, of which approximately 312,300 breed in Europe (Mitchell *et al*., 2004).

Gannet are Amber Listed Birds of Conservation Concern (Eaton *et al*., 2009) and a qualifying feature of the Scare Rocks Site of Special Scientific Interest (SSSI). The nearest Special Protected Area (SPA) for gannets to the Solway Firth is Ailsa Craig, roughly 100 km to the north of the Solway Firth. Satellite telemetry studies of the Bass Rock colony found maximum foraging distances during the breeding season of up to 540 km (Hamer *et al*., 2007) suggesting that the Solway Firth is well within the maximum foraging range of birds from this colony.

Gannets live on the open ocean for most of the year, first visiting nest sites from January with breeding beginning around April. Most British breeding colonies occur in the north and west, including the one at Scare Rock in Luce Bay (SSSI) where 2,394 nests were counted in 2003-2004 (Mitchell *et al*., 2004).

The gannet is a pelagic feeder, foraging primarily on lipid-rich pelagic fish up to 30 cm in length such as mackerel, herring and sandeel (Snow & Perrins, 1998; Hamer *et al*., 2007), but also forages extensively for fishery discards. Many birds are present in British waters throughout the year, although young will leave their colonies during August/September to head to the African coast.

The majority of gannets recorded as part of the ES were done so during the summer, with only sporadic sightings between October and March. They were fairly evenly distributed throughout the study area, apart from the shallower waters to the north-west.

Cormorant

Cormorants are primarily associated with rocky coasts and estuaries, although are sometimes found by inland lakes and rivers, particularly during the winter. Coastal breeding sites are found on cliffs, stacks and rocky islets. Cormorants are Amber Listed Birds of Conservation Concern (Eaton *et al*., 2009) and are listed as a qualifying feature for the SSSI between Abbey Burn Foot to Balcary Point and Upper Solway Flats SPA. Breeding occurs during the spring with birds moving away from breeding colonies once the young have fledged. They feed on fish such as plaice, flounder, cod and spat.

During the survey work for the ES, the highest numbers of cormorants were recorded during the summer with the greatest numbers recorded in the north-western part of the study area.

Kittiwake

The breeding population of black-legged kittiwake in Great Britain and Ireland is approximately 416,000 breeding pairs (estimated from surveys of apparently occupied nests (AON), Seabird 2000) distributed all around the coastline, with the largest populations being found in the north-east. The highest concentration is found in Scotland, where 68% of AON were located (Mitchell *et al*., 2004).

During the spring and summer, kittiwakes can be seen around rocky coasts, nesting on tall sea cliffs. They leave their breeding colonies in July/August, heading out to sea were they remain for the rest of the year, often beyond the continental shelf. They feed on fish species such as capelin, herring, sprat and sand eel and have been known to take crustaceans such as shrimps. Kittiwake are Amber Listed Birds of Conservation Concern (Eaton *et al*., 2009) and breeding kittiwake are listed as qualifying features for the SSSI's between Abbey Burn Foot and Balcary Point, at St Bees Head and Mull of Galloway.

Highest numbers recorded for the ES occurred during the spring and summer, with numbers dropping through the winter. Their distribution was not associated with any particular areas through the study area.

Herring gull

The breeding population of herring gulls in Great Britain and Ireland is approximately 149,177 pairs (based on AON data from Seabird 2000). This species is absent only from the coastline of small parts of the east coasts of England and Ireland (Mitchell *et al*., 2004). The Great Britain and Ireland populations of herring gull form approximately 12-13% and 0.5-0.6%, respectively, of the global population of 1,100,000-1,200,000 pairs (Mitchell *et al*., 2004).

Herring gulls are opportunistic feeders, taking a range of fish, crabs, insects, young birds and garbage. They usually nest in colonies on sea cliffs or in sand dunes but will also nest on building roofs. After nesting, adults and juveniles mostly only travel short distances to favourite feeding grounds although some will migrate to southern Europe and the Mediterranean. Population levels may increase in the winter with the arrival of birds from Iceland and Scandinavia.

Herring gulls are Amber Listed Birds of Conservation Concern (Eaton *et al*., 2009) and a UK BAP Priority Species. Breeding herring gulls are a qualifying feature of the St Bees Head SSSI.

Great black-backed gull

The breeding population of great black-backed gulls in Great Britain and Ireland is approximately 19,700 pairs (based on AON data from Seabird 2000), largely concentrated in the west of the region and in the Scottish Northern Isles (Mitchell *et al*., 2004). The Great Britain and Ireland populations of great black-backed gull form approximately 8-10% and 1%, respectively, of the global population of 170,000-180,000 pairs, of which 100,000-110,000 breeds in Europe (Mitchell *et al*., 2004).

They breed in colonies, usually on cliff tops, islands and estuaries but also on moor-land. Breeding begins in March or April with eggs laid between April and late June. They have a broad diet, taking fish, crustaceans, young birds and even garbage, which they will either catch for themselves or steal from others. Great black-backed gulls are Amber Listed Birds of Conservation Concern (Eaton *et al*., 2009) and breeding birds are a qualifying feature of the Borgue coast SSSI.

Guillemot

The breeding population of common guillemots in Great Britain and Ireland is approximately one million pairs, breeding all around the coastline, particularly in the north and west. These are concentrated in Scotland where approximately 75% of individuals are found (Mitchell *et al*., 2004). The population of Great Britain and Ireland forms approximately 14% of the global population of an estimated 7,300,000 pairs, and 35% of the approximately 2,800,000 pairs which breed in Europe (Mitchell *et al*., 2004).

Guillemots spend most of the year at sea, only coming to land to breed between May and August. Many adults remain within a few hundred kilometres of the colonies throughout the year, dispersing rather than migrating. At some colonies, adults continue to visit their nest sites in late autumn/winter once they have completed the main moult, during which they are flightless (Harris & Wanless, 1990; Harris & Swann, 2002). Chicks leave the nest without being able to fly, remaining on the sea surface for a further 8-10 weeks, accompanied by the adult male who continues to feed it. The breeding population of common guillemots in Great Britain and Ireland is approximately one million pairs, breeding all around the coastline, particularly in the north and west. These are concentrated in Scotland where approximately 75% of individuals are found (Mitchell *et al*., 2004). The main prey of guillemots is sandeel and clupeids (i.e. herring), with small gadoids (i.e. cod and whiting) also important at some colonies (Cramp & Simmons, 1985).

Guillemots are Amber Listed Birds of Conservation Concern (Eaton *et al*., 2009) and breeding birds are listed as qualifying features at the SSSI's between Abbey Burn Foot and Balcary Point, St Bees head and at Scare Rocks.

The ES surveys recorded peak numbers of guillemots during the spring and early summer, with a decline in numbers from July onwards when nest sites were abandoned. They were observed throughout the study area with concentrations in the relatively deeper waters of the south-western region, close to nesting colonies.

Razorbill

The total population of razorbill in Great Britain and Ireland is estimated at approximately 110,000 breeding pairs distributed around rocky coastlines throughout the region (Mitchell *et al*., 2004). The Great Britain and Ireland populations of razorbill form approximately 17.5-18% and 5.4-5.6%, respectively, of the global population of 610,000-630,000 pairs and 20.8% and 6.6% of the breeding Northwest Europe population (Mitchell *et al*., 2004).

Razorbills breed mainly on small ledges or in cracks of rocky cliffs and in associated screes, and on boulder-fields. They are usually associated with colonies of other seabirds, and small numbers scattered among large concentrations of common guillemots and black-legged kittiwakes can easily be overlooked. Razorbill 'nest' sites are usually hidden from view, but the presence of a colony is clearly indicated by the attendance of off-duty birds standing close by. Egg-laying usually begins in late April, early May with a peak in mid-May. Razorbills have a diet chiefly consisting of fish with some invertebrates (Snow & Perrins, 1998). Studies on the Isle of May showed that sandeels are the main prey fed to razorbill chicks (Harris & Wanless, 1986).

Razorbill are Amber Listed Birds of Conservation Concern (Eaton *et al*., 2009) and breeding birds are listed as qualifying features at the SSSI's between Abbey Burn Foot and Balcary Point, St Bees head and the Mull of Galloway.

5.2. Survey methods

Ecology Consulting completed the assessment of potential impacts of the development on birds from 2001 onwards as part of the ecological impact assessment (EIA) process and continued to conduct boat-based surveys required under the MEMP. The schedule of surveying is described below.

EIA baseline surveys

- Boat-based surveys consisting of ten transects were conducted on a bi-monthly basis between May 2001 and April 2002 (with exception of May and October 2001 when only one survey was completed).
- Each transect was about 18 km in length with 2 km intervals between.

MEMP monitoring

- Monthly boat-based surveys were conducted in April/May 2003 and bi-monthly surveys between January and September 2004 with an additional survey performed in July 2007, just prior to construction commencing.
- Construction phase surveys began in January 2008 and continued on a bi-monthly basis until the end of the construction phase in February 2010. Surveys were completed in all months of the construction phase except November 2009.
- During post-construction, one survey per month is to be carried out for five years with review after three to establish if further surveys still required.

5.2.1. Timetable

A summary of when data have been collected can be found in Table 5.4 below:

Table 5.4: Summary of when bird surveys were conducted. Birds = survey undertaken; Light blue = baseline/EIA period; Orange = pre-construction; Purple = construction; Green = operation.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001					Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds
2002	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds
2003				Birds	Birds							
2004	Birds	Birds	Birds		Birds		Birds	Birds	Birds			
2005												
2006												
2007							Birds					
2008	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds
2009	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds		Birds
2010	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds
2011	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds
2012	Birds	Birds										

5.3. Analytical Methods

The analytical methodology has been determined by the data available to Natural Power Consultants, collected as part of the MEMP before, during and after construction.

The approach to analysis has been developed after reviewing the requirements of the MEMP, Food and Environment Protection Act (FEPA) licensing requirements and the recent Centre for Environment, Fisheries and Aquaculture Science (CEFAS) document, “Strategic review of offshore wind farm monitoring data associated with FEPA licence conditions”[1].

As part of this process, consultation with Marine Scotland and Scottish Natural Heritage (SNH) identified key questions and concerns for specific focus. Data analysis was specifically tailored to the predictions made in the EIA and addresses the licence monitoring conditions. The analysis has focused on key areas highlighted by the Robin Rigg Management Group (RRMG) and where data was available and appropriate, on addressing the uncertainties outlined in the aims of the MEMP.

Specific key questions identified by E.ON (with NPC) and the RRMG for the data analysis relate to:

- Disturbance/displacement of specific species;
- Changes in patterns of abundance and distribution relating to the wind farm; and
- Comparing observed patterns with predicted impacts/sensitivities from the EIA process.

Analysis of the ornithological data has been undertaken by the NPC Ecology & Hydrology Department. Questions have been investigated as fully as possible within limits imposed by the nature of the data, the survey program the survey methodology and the rigour and consistency of the data collected by 3rd party consultants .

The analysis presented here represents an update to that presented in Report 035_R_NPC_EON_4: Analysis of MEMP ecological data – operational year one; incorporating data collected during operational year two. A total of five years of bird data are to be collected with a review after three at which point conclusions on the impacts of the development of birds in the Solway Firth will be made.

5.3.1. Data collection

All surveys consisted of boat-based visual surveys conducted monthly or bimonthly, depending on phase (see Table 5.5 in section 5.2.1). A number of vessels have been used through the project (see Table 5.5), with viewing platforms ranging from 3.5 - 4.5 m above sea level. Although slightly below the recommended 5 m, it was considered these vessels gave suitable viewing platforms without restricting the size or location of the survey area (larger vessels would not be able to navigate the shallower areas of the Firth, thus reducing the potential survey area).

Table 5.5: Summary of vessels used to bird data between 2004 and 2012, including height of viewing platform above sea level.

Vessel	Viewing Platform Height (m)	No survey days
Solway Protector	4.5	101
Tiger	4.5	18
Catch Me II	4.5	2
Talisman of Wight	3.5	8
Pilgrim	4	5
Maid Good	4.5	31

The survey methodology consists of 10 parallel transects, each about 18 km in length and spaced 2 km apart (see Figure 5.1). The distance between transects was chosen to ensure good sampling of the

[1] Walker, R. & Judd, Adrian. 2010. Strategic Review of offshore wind farm monitoring data associated with FEPA licence conditions. CEFAS, SMRU Ltd, FERA on behalf of DEFRA & MMO.

study area for all species while minimising the likelihood that birds displaced from once transect would be counted on the neighbouring transect. To allow comparison between phases, the same methodology was used for all surveys. Tidal conditions at the time of the survey dictate whether or not the entire survey is covered in a single day or over two days. Access to some parts of the survey area can be restricted at low tide.

Two observers work simultaneously, each observing a 90° angle ahead and to the side of the vessel. Birds are recorded as either in flight or on the sea. Following the JNCC Seabirds at Sea recommendations, birds on the sea are recorded into five distance bands (0-50 m, 50-100 m, 100-200 m, 200-300 m and 300+ m). Birds are recorded continuously, at a steady speed of approximately 12 knots, with the precise time of each observation recorded where possible to give as accurate a position as possible (linking to the GPS position information being recorded simultaneously). A range-finder is used to estimate distances of the birds from the ship. All records of birds observed flying as well as those on the sea was recorded, with the height of flying birds estimated.

5.3.1. Data Collation

All data were collated and verified by NPC Ecology. Throughout this procedure, all data were visually inspected and any concerns referred back to the surveyors in order that any problems with the dataset could be resolved. All data were stored and managed using Microsoft Excel.

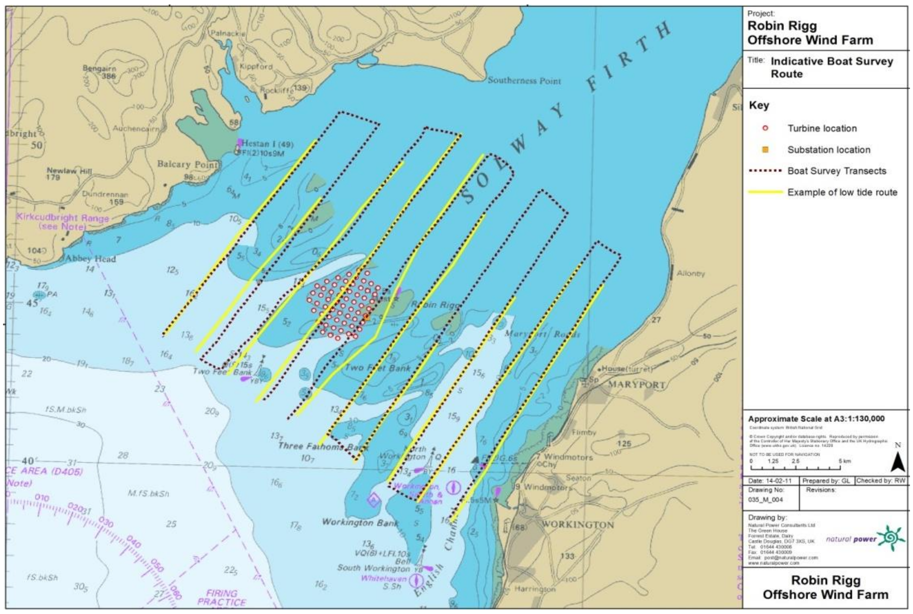


Figure 5.1: Sample survey route followed for bird and marine mammal surveys collected as part of the Robin Rigg MEMP.

5.3.2. Data processing

Data collected prior to October 2001 were removed from the dataset as data collected during this period were grouped in 10-minute blocks and so precise positions could not be extracted.

GPS tracks from each survey were obtained and imported into ArcGIS v10. Each individual survey transect was divided into survey blocks of 360000 m^2 (300 m either side of the transect line and 600 m long: see Figure 5.2).

Observations were then assigned to survey blocks and environmental data for each block were extracted including sea depth and sediment type at the midpoint of the block (data obtained from SeaZone Solutions Ltd) and distance of the block midpoint to the nearest coastline (see Figure 5.3). Tidal height for each block was also obtained using data supplied by the British Oceanographic Data Centre. Percentage gravel was calculated for each sediment class (in order to allow analysis of sediment type as a continuous covariate). Although sea state data were collected during the majority of surveys, it was not possible to use this as a factor in the analysis as information on sea state was not recorded during early surveys.

5.3.3. Target species

Key species of seabird to be targeted for analysis was defined in consultation with the RRMG and refined during the analysis process. These species are:

- Scaup;
- Common scoter;
- Red-throated diver;
- Manx shearwater;
- Gannet;
- Cormorant;
- Kittiwake;
- Herring gull;
- Great black-backed gull;
- Guillemot; and
- Razorbill.

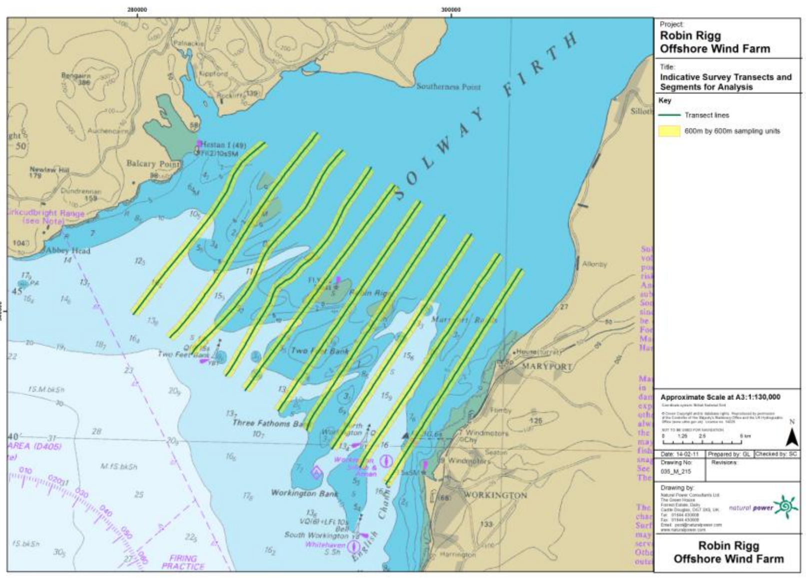


Figure 5.2: Example of 600 m buffers applied to survey transects for analysis.

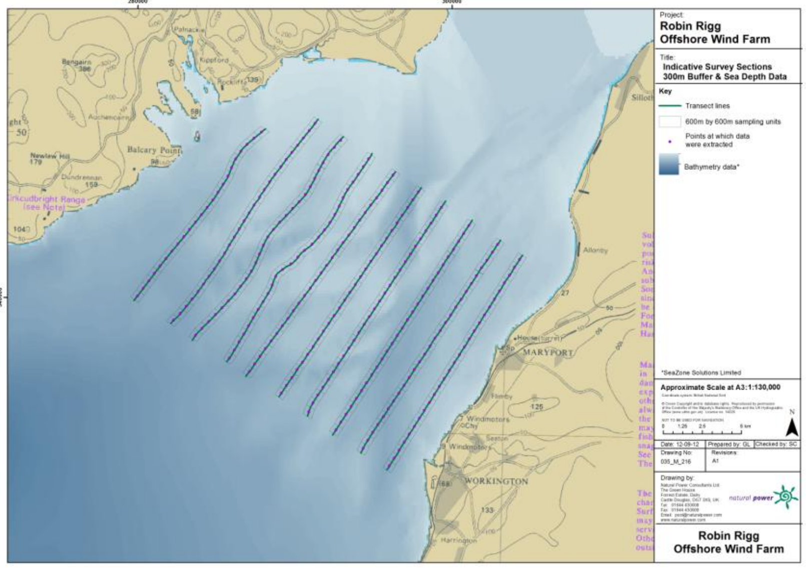


Figure 5.3: Example of sea depth data extrapolated for survey buffer zones.

5.3.4. Data exploration

All data exploration and subsequent analysis was performed in R[2] 2.13.1. Data exploration followed the protocol described by Zuur *et al*., (2009). This involved asking the following questions:

- Are there outliers in the explanatory variables;
- Is there even coverage of the explanatory variables;
- Is there collinearity among explanatory variables;
- Are there potential outliers in the response variable;
- Might the response variable be zero-inflated;
- Is there evidence of relationships between the response and explanatory variables; and
- Is there evidence of interactions.

Covariates examined included tidal height, depth adjusted for tidal height, distance to coast, percentage gravel, latitude, longitude, sea state, construction period and month.

5.3.5. Data analysis

The Robin Rigg dataset is a complex dataset with more advanced issues associated with it including autocorrelation and zero-inflation. In order to develop the optimal model for this type of data, these issues must be addressed. In addition, datasets associated with different species will require the implementation of differing analysis techniques to ensure that the most appropriate model is applied (see Section 5: Discussion for further details). Work on these models is underway but for the purpose of this update, we present data analysed in a standardised way across all species.

Abundance

For each species, mean numbers of birds observed per unit effort (sampling block) were compared among the three wind farm phases (pre-construction, construction and operation). In addition, data collected during the operational period were investigated separately, comparing operation years one and two. The average number of birds observed per sighting was also calculated for each period to look for evidence of changes in group size.

[2] R Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Spatial Distribution

Density surface plots were produced in order to illustrate the relative abundance and distribution for each species during the three phases of development.

For each species, behaviour (in flight or on the sea) and development phase, a two-dimensional x-y smooth was fitted using the GAM function in the *mgcv* package in *R* v2.13.1. Previously, analysis has incorporated distance sampling to allow estimation of densities. However, use of another modelling technique introduces additional uncertainty into the analysis meaning that patterns are less likely be detected and in addition, Distance sampling cannot account for undetected individuals that result in zero counts, which for some species is a possibility in our analysis. As the fundamental purpose of the MEMP was to record any "changes" (as opposed to absolute numbers) in the ecological environment as a result of the wind farm, it was decided not to incorporate Distance sampling into this round of modelling.

Predictions generated from models of birds in flight and on the sea were combined (including a correction factor for birds in flight which were truncated to 1km due to differences in survey methodology rather than the 300m truncation applied to birds on the sea) to produce a single density surface for each species for each development phase. Predictions were based on a 600 by 600m grid. Since survey methodology dictated that birds in flight could only be truncated to those observed within 1km as opposed to the 300m truncation applied to birds observed on the sea, a correction factor of 0.3 was applied to birds in flight.

Collision risk

Available flight height data were grouped into six bands (0-5 m; 6-25 m; 26-34 m; 35-125 m; 126-200 m and 200 m plus).These bands were chosen based on the known rotor height of the turbines used at Robin Rigg (35-125 m), bird behaviour and practicalities of collecting data. Where sufficient data were available, the proportion of birds flying in each band for each construction phase was calculated and compared using Chi-square tests. To aid this analysis and interpretation, all data above and below rotor height were combined into single bands (i.e. 0-34 m; 35-125 m and 126 m plus).

5.4. Results

A complete list of all birds recorded during the boat surveys can be found in Appendix 3 Table 3 along with maps illustrating the location sightings for all target species.

5.4.1. Scaup

Abundance

Scaup were highlighted in the ES as being present within the Solway Firth in regionally important numbers although not within 2 km of the wind farm area.

Few sightings of scaup were recorded during any phases of the development (see Table 5.6). As can be seen from Figure 5.4 below, all sightings occurred during the winter months (November-January). No Scaup were observed in operational year two. The average group size through the different construction periods can be seen in Figure 5.5.

Table 5.6: Number of sightings of Scaup recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	14 (705)	4 (351)	10 (705)
SPUE (IPUE)	0.002 (0.12)	0.000 (0.03)	0.001 (0.32)

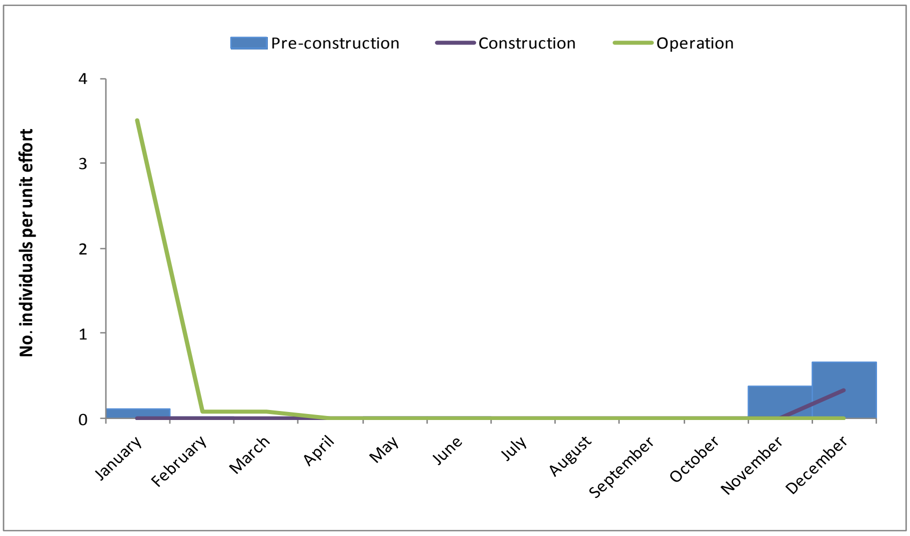


Figure 5.4: Mean number of Scaup observed per month during the pre-construction, construction and operational phases (on sea and in flight data combined).

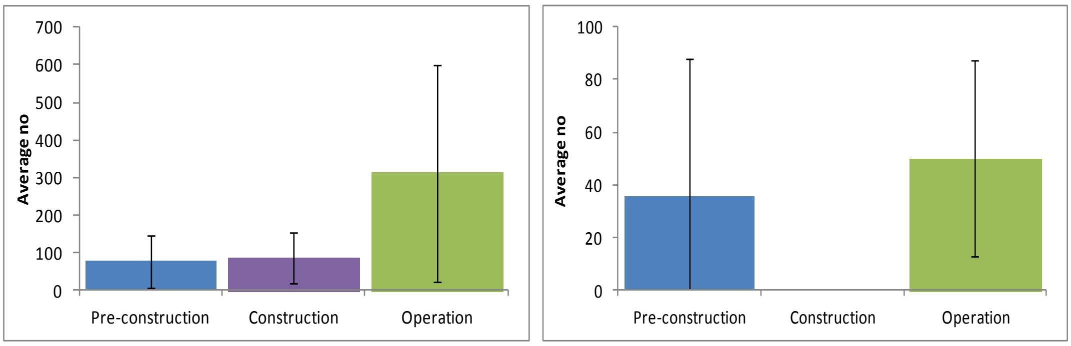


Figure 5.5: Mean group size of Scaup observed on the sea (left) and in flight (right) during the pre-construction, construction and operational phases (±standard deviation).

Distribution

The majority of the birds were observed in the north-west part of the survey area, close to the Scottish shore (see Figure 5.6). The low number of individual sightings for this species prevents density surface maps from being generated.

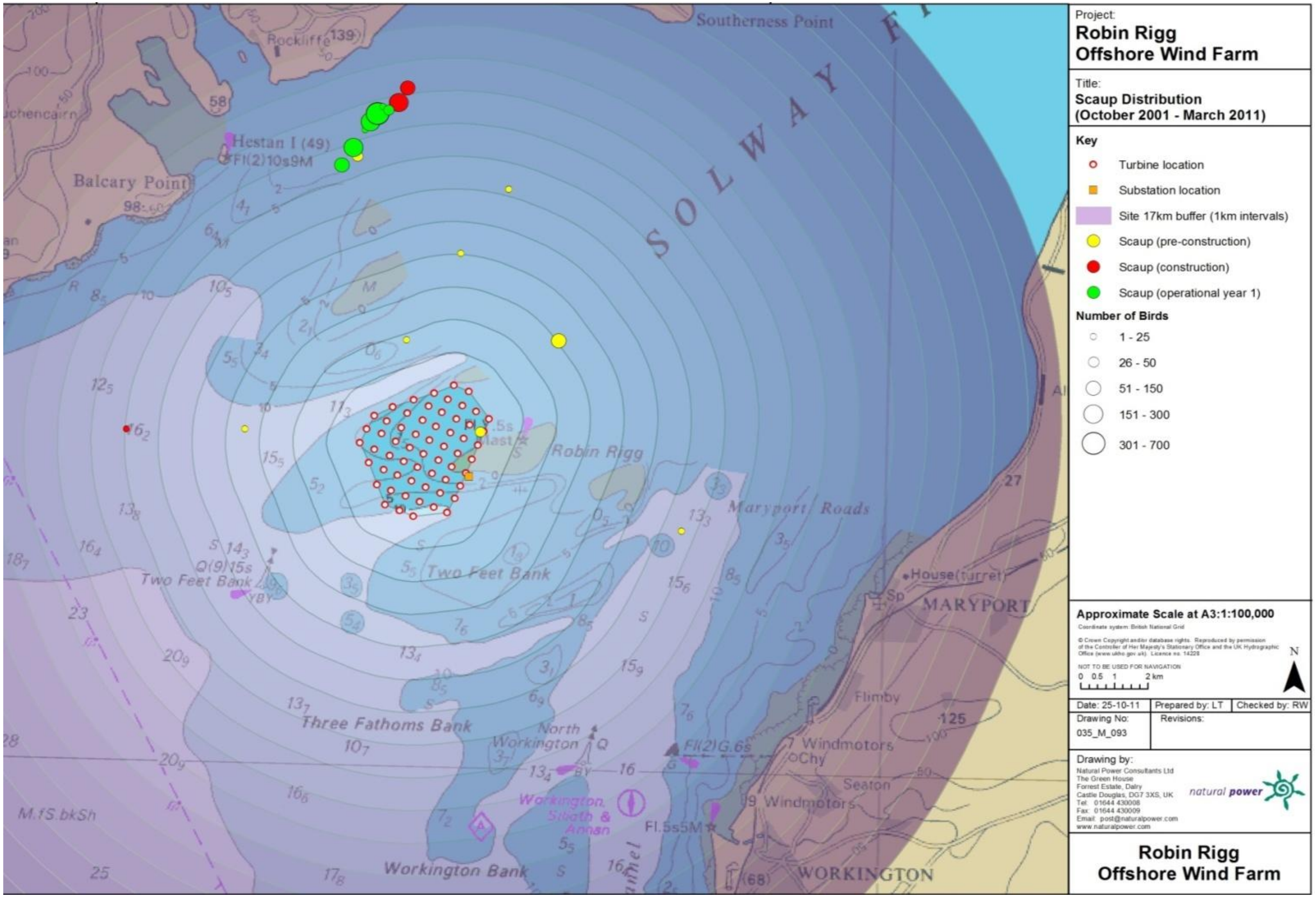


Figure 5.1: Locations of raw observations of Scaup during the pre-construction (yellow), construction (red) and operational (green) phases. The size of the symbols represents the size of the group of animals observed

Collision risk

The percentage of birds recorded in different height bands are illustrated in Table 5.7 and Figure 5.7 below. No birds were observed flying at rotor height and therefore no Chi-square test conducted as they are not considered to be at risk from collision.

Table 5.7: Percentage of Scaup recorded in different height bands. Rotor height = 35-125 m.

	Flight band (m)					
	1 (0–5)	2 (6–25)	3 (26–34)	4 (35– 125)	5 (126–200)	6 (200+)
Pre-construction	71.07	28.93	0	0	0	0
Construction	100	0	0	0	0	0
Operation	100	0	0	0	0	0

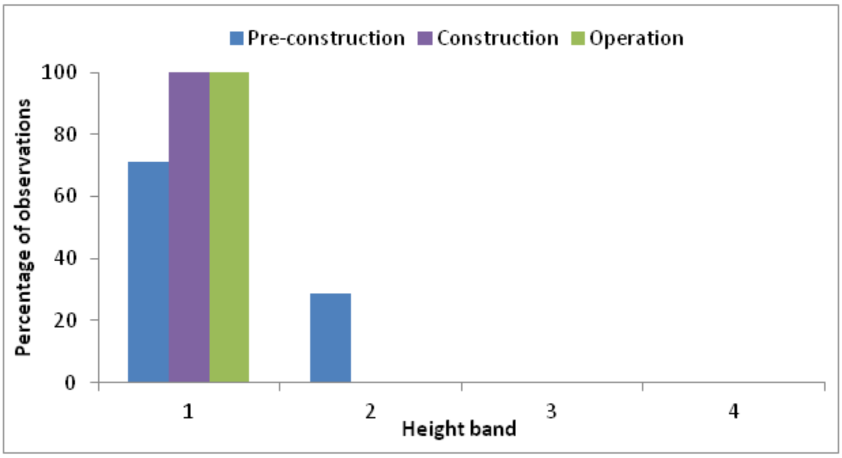


Figure 5.7: The percentage of Scaup recorded at different height bands relative to rotor height during the different phases of development.

5.4.2. Common scoter

Abundance

The number of common scoter recorded during each of the three development phases can be found in Table 5.8). The raw data suggest an increase in sightings but a decrease in numbers during the three phases of the development. Common scoter were observed throughout the year with more birds were observed during operational year one than two (see Figure 5.8). Large numbers were recorded during the summer and autumn in all periods (see Figure 5.9). The average group size through the different construction periods can be seen in Figure 5.10.

Table 5.8: Number of sightings of common scoter recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	739 (70660)	1948 (85961)	1063 (5821)
SPUE (IPUE)	0.13 (12.14)	0.16 (7.11)	0.16 (8.56)

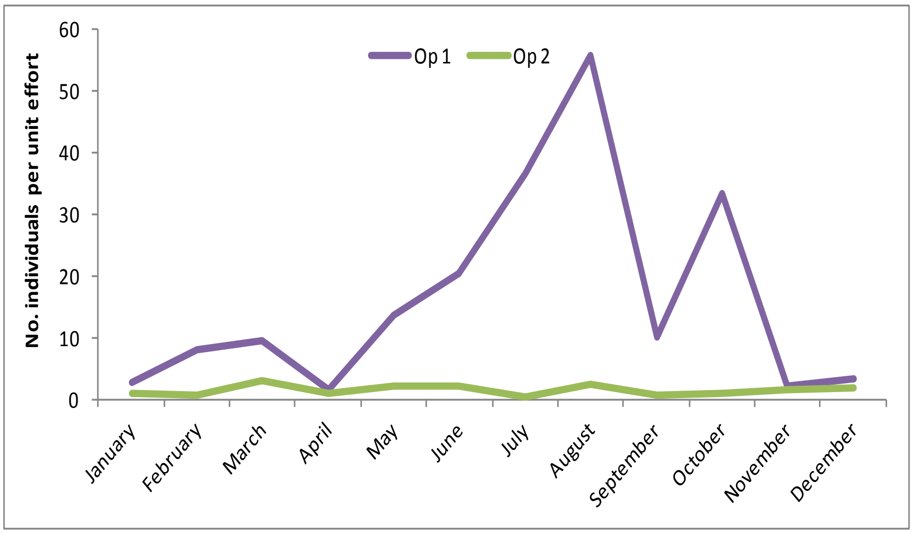


Figure 5.8: Mean number of common scoter observed during operational years one and two (on sea and in flight data combined).

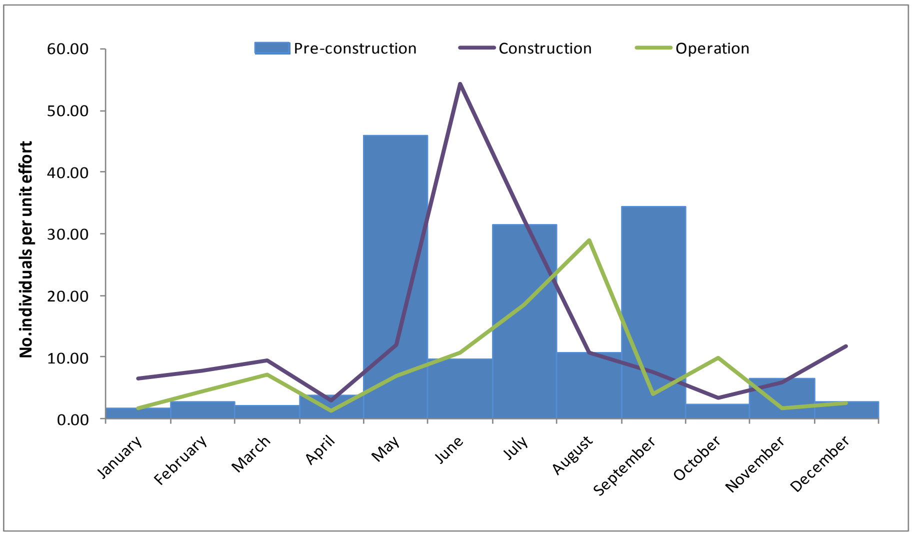


Figure 5.9: Mean number of common scoter observed per month during the pre-construction, construction and operational phases (on sea and in flight data combined).

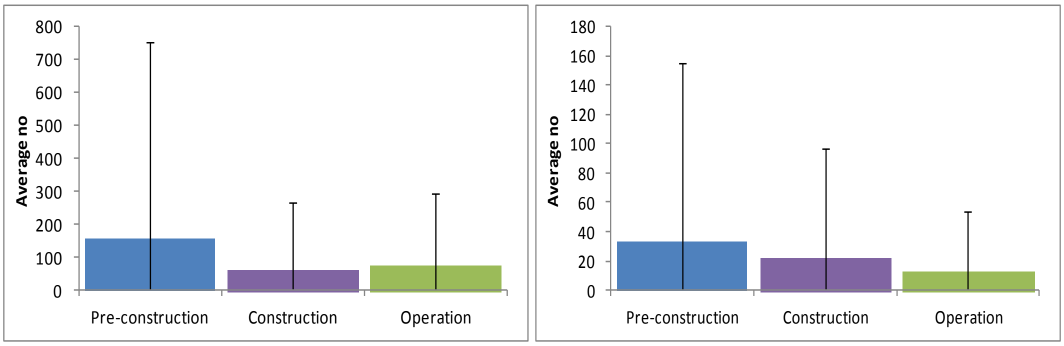


Figure 5.10: Mean number of common scoter observed per sighting on the sea (left) and in flight (right) during the pre-construction, construction and operational phases (±standard deviation).

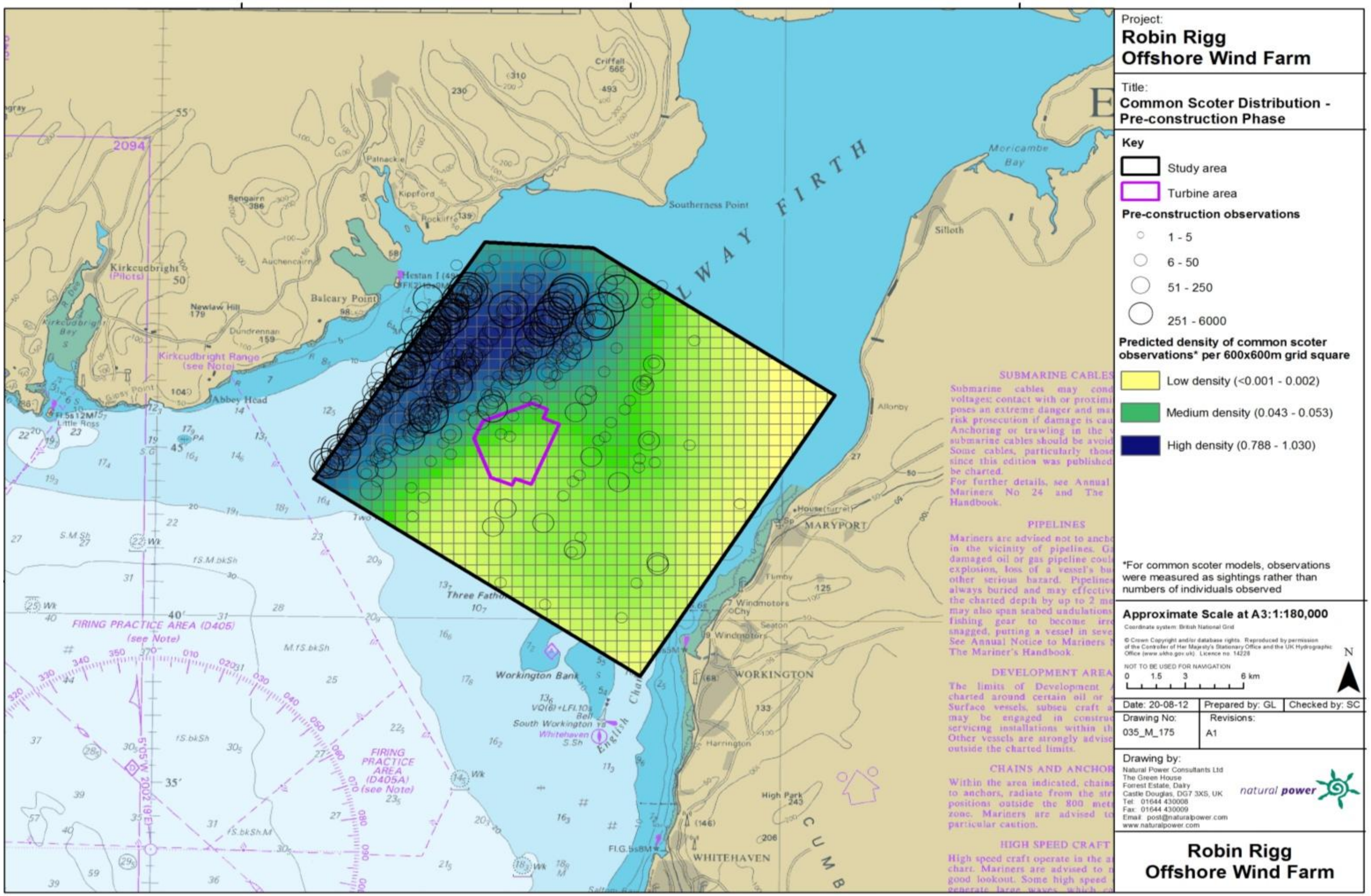


Figure 5.2: Density surface map of the predicted density of common scoter across the survey area during the pre-construction phase. Open circles show the locations of the raw observations.

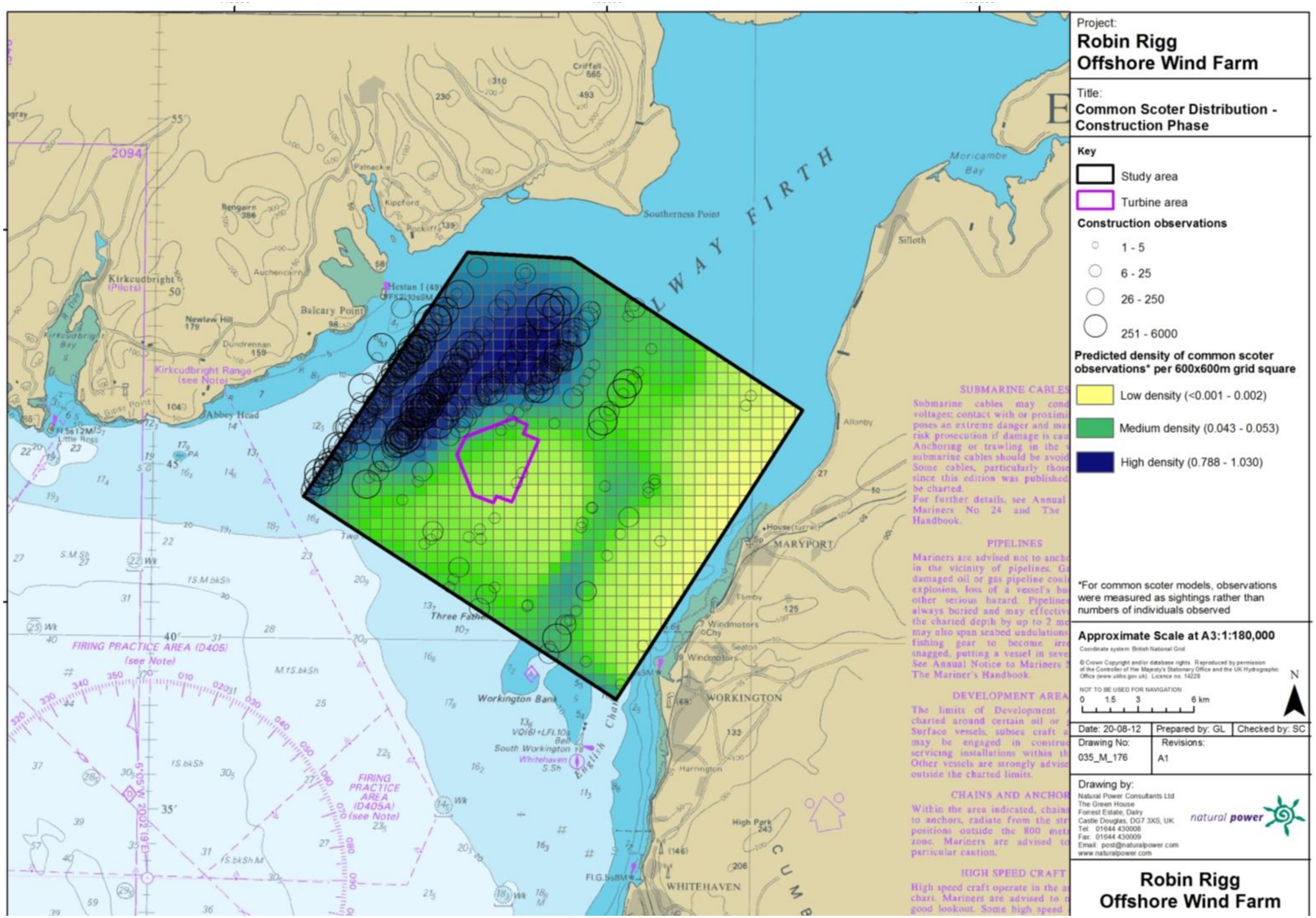


Figure 5.3: Density surface map of the predicted density of common scoter across the survey area during the construction phase. Open circles show the locations of the raw observations.

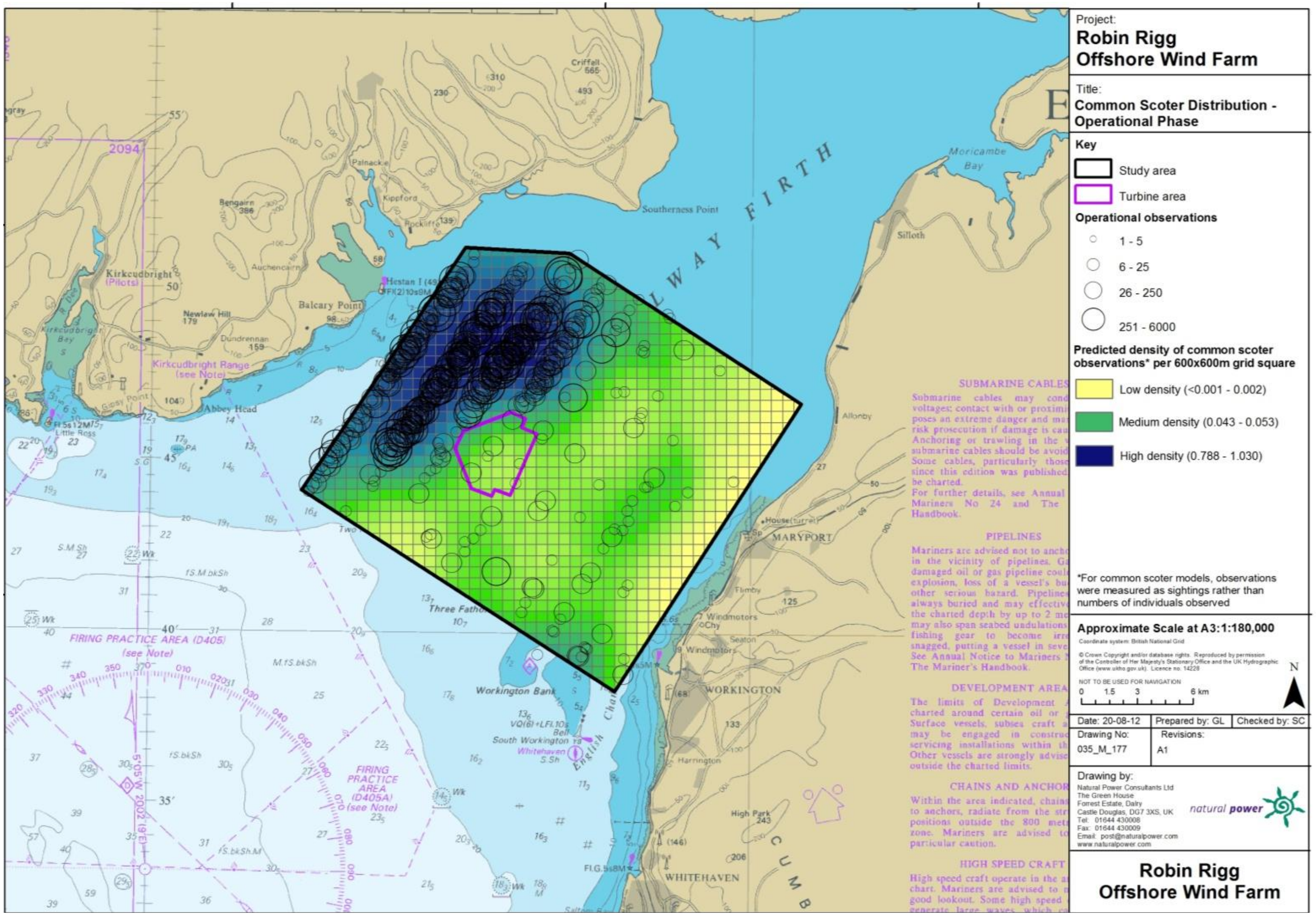


Figure 5.4: Density surface map of the predicted density of common scoter across the survey area during the operational phase. Open circles show the locations of the raw observations

Distribution

Common scoter were recorded predominantly to the northwest of the survey area (north-west of the wind farm site; see Appendix section 3.6 for map illustrating the raw sightings data). Density surfaces for common scoter shows no evidence of a change in distribution among the three phases of the development (see Figure 5.11 to Figure 5.13).

Collision risk

The percentage of common scoter recorded in different height bands relative to rotor height can be found in Table 5.9 and Figure 5.14. The band 35-125 represents rotor height. The majority of scoter were observed flying at less than 25 m height, resulting in less than 0.5% observed flying at rotor height. As the majority of observations occurred below rotor height a Chi Square was not attempted as they are not considered to be at risk from collision.

Table 5.9: Percentage of common scoter recorded in different height bands. Rotor height = 35-125 m.

	Flight band (m)					
	1 (0–5)	2 (6–25)	3 (26–34)	4 (35– 125)	5 (126–200)	6 (200+)
Pre-construction	61.02	38.84	0	0.06	0	0.08
Construction	60.7	38.75	0.06	0.5	0	0
Operation	79.46	20.38	0.10	0.07	0	0

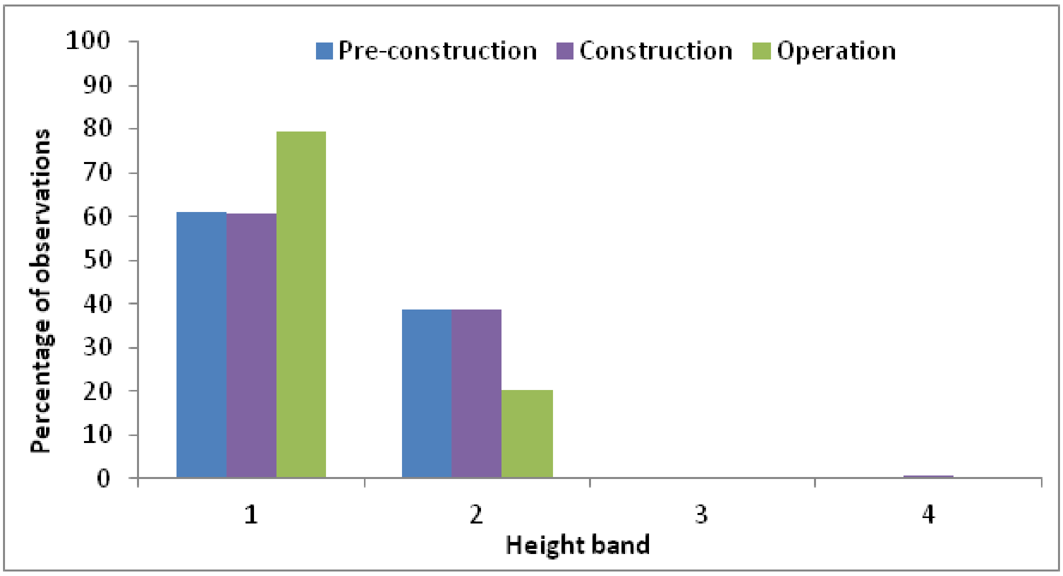


Figure 5.14: Percentage of common scoter recorded in different flight bands during the different stages of the development.

5.4.3. Red-throated diver

Abundance

The number of red-throated diver recorded during each of the three development phases can be found in Table 5.10 below. The raw data suggest a possible increase in abundance during the operational phase. Red-throated diver were recorded throughout the year, although numbers in operational year two were lower than those recorded in operational year one (Figure 5.15). Peak abundance pre-construction was in September (Figure 5.16). While a large number of birds were recorded for this month during the operational years, a greater abundance was recorded in April.

Average group size observed does not appear to have changed between the different stages of the wind farm (see Figure 5.17).

Table 5.10: Number of sightings of red-throated diver recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	254 (548)	375 (541)	462 (959)
SPUE (IPUE)	0.04 (0.09)	0.03 (0.04)	0.07 (0.15)

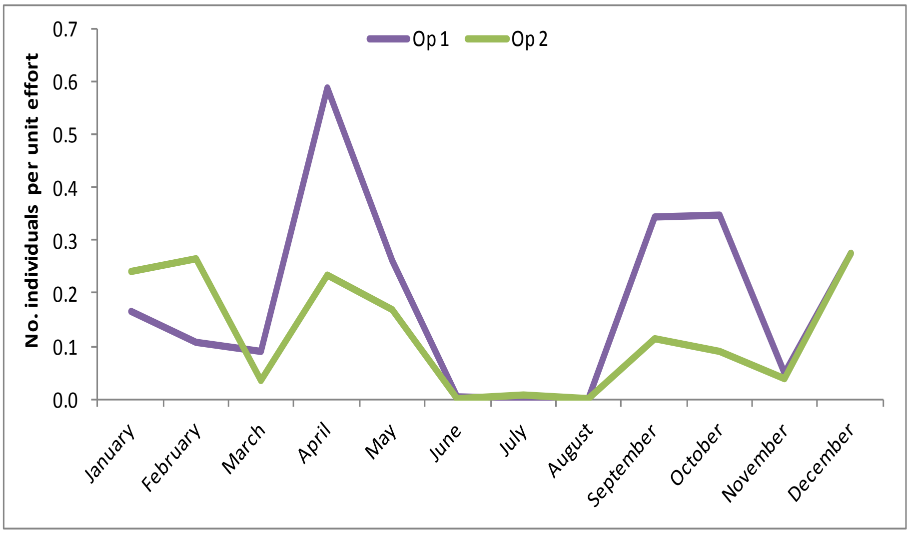


Figure 5.15: Mean number of red-throated diver observed during operational years one and two (birds in flight and on water combined).

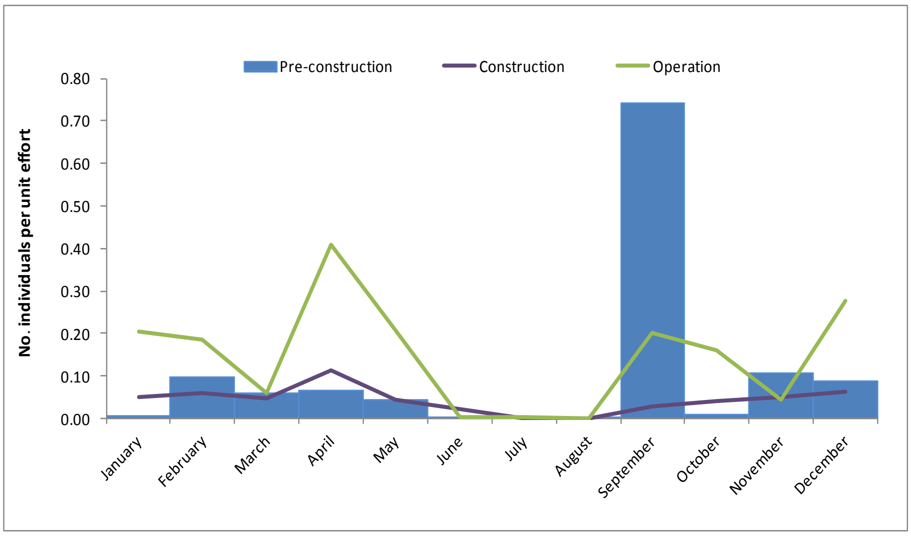


Figure 5.16: Mean number of red-throated diver observed per month during the pre-construction, construction and operational phase (birds in flight and on water combined).

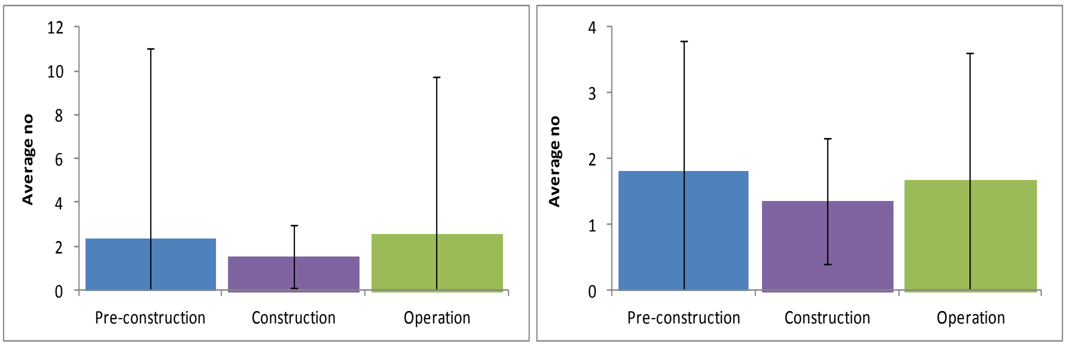


Figure 5.17: Mean number of red-throated diver observed per sighting (left) on the sea and (right) in flight during the pre-construction, construction and operational phases (±standard deviation).

Distribution

A map displaying the raw sightings data can be found in Appendix section 3.6. Density surfaces for red-throated diver for each of the three phases of the development can be found in Figure 5.18 to Figure 5.20.

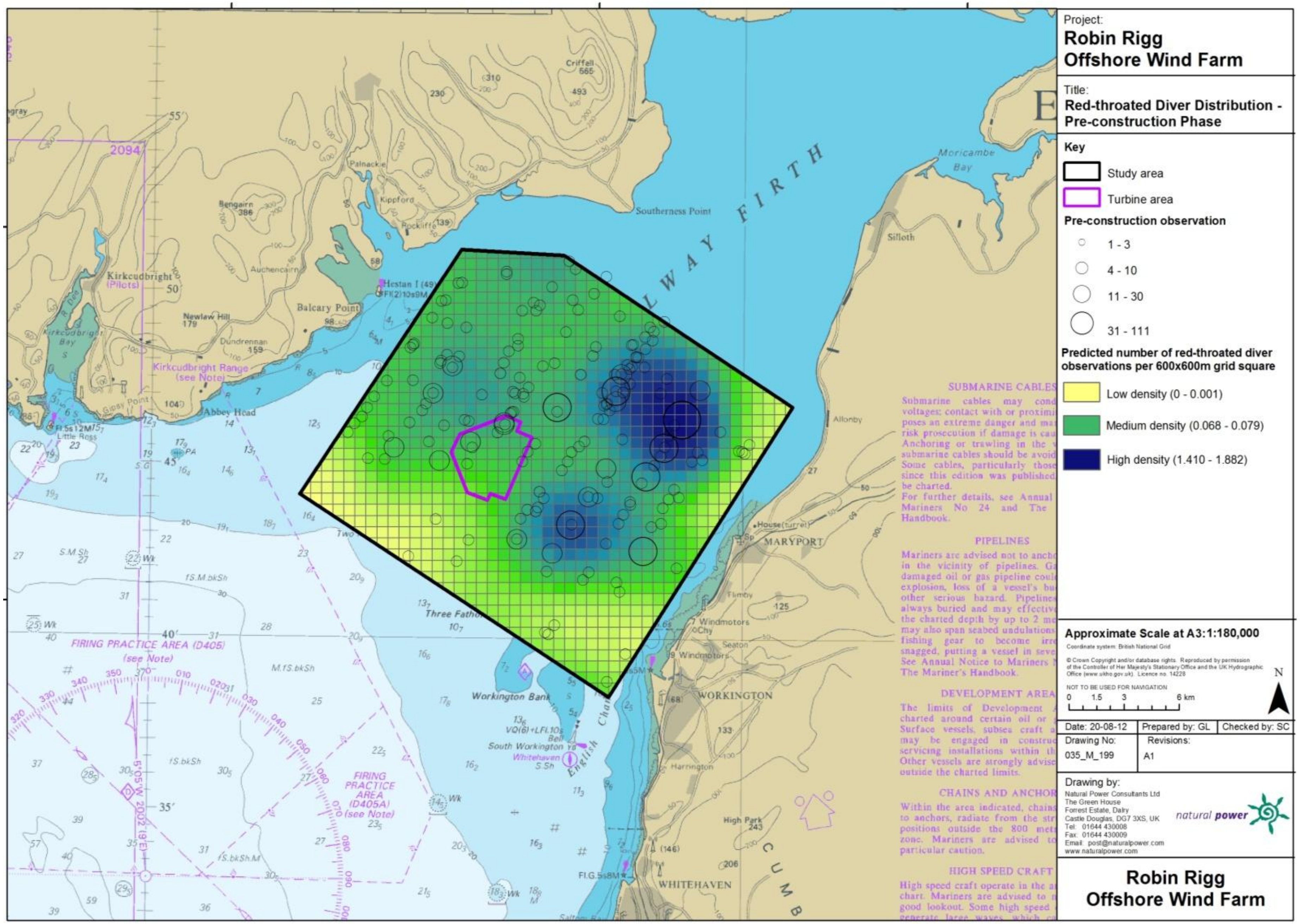


Figure 5.5: Density surface map of the predicted density of red-throated diver across the survey area during the pre-construction phase. Open circles show the locations of the raw observations.

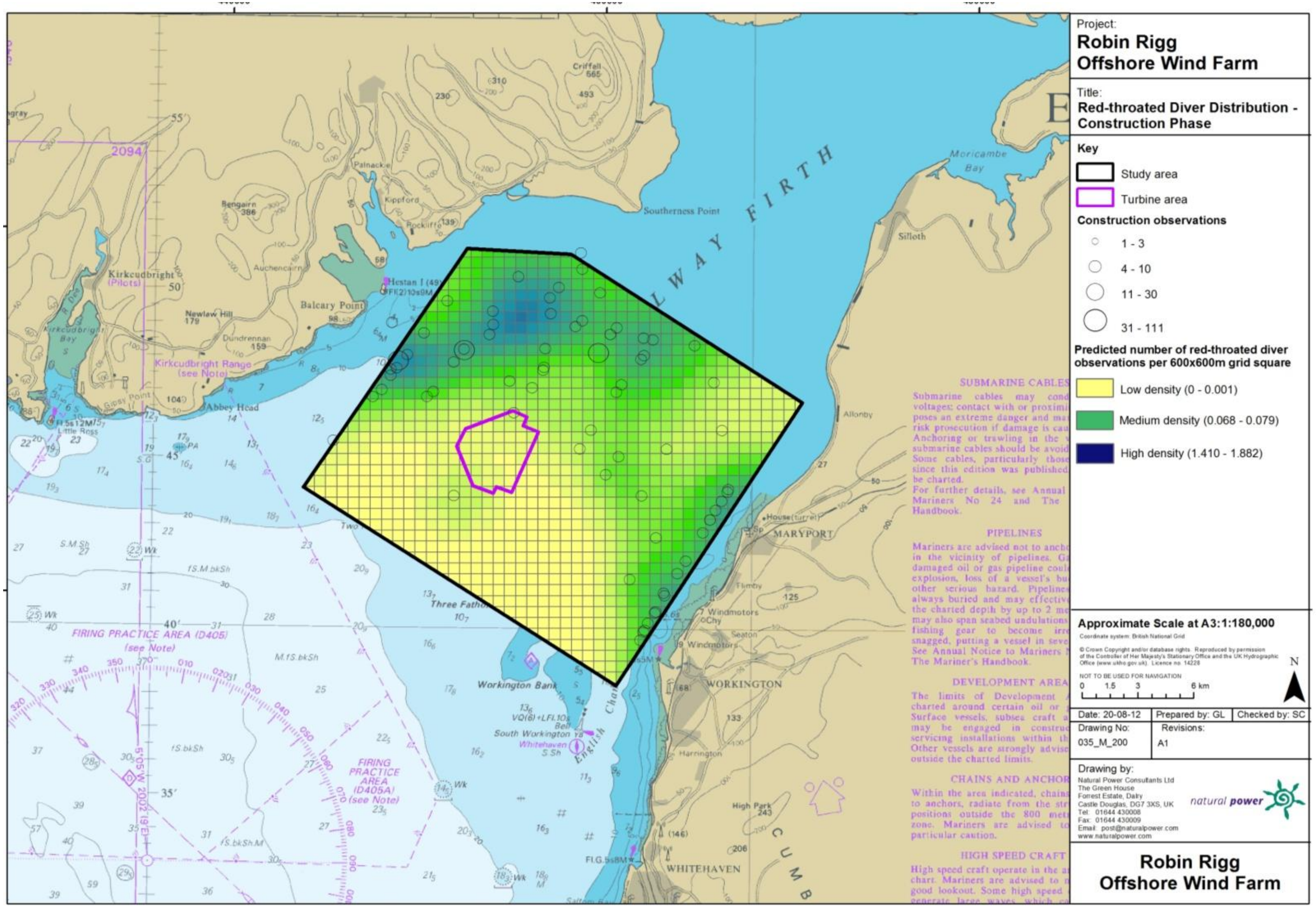


Figure 5.6: Density surface map of the predicted density of red-throated diver across the survey area during the construction phase. Open circles show the locations of the raw observations.

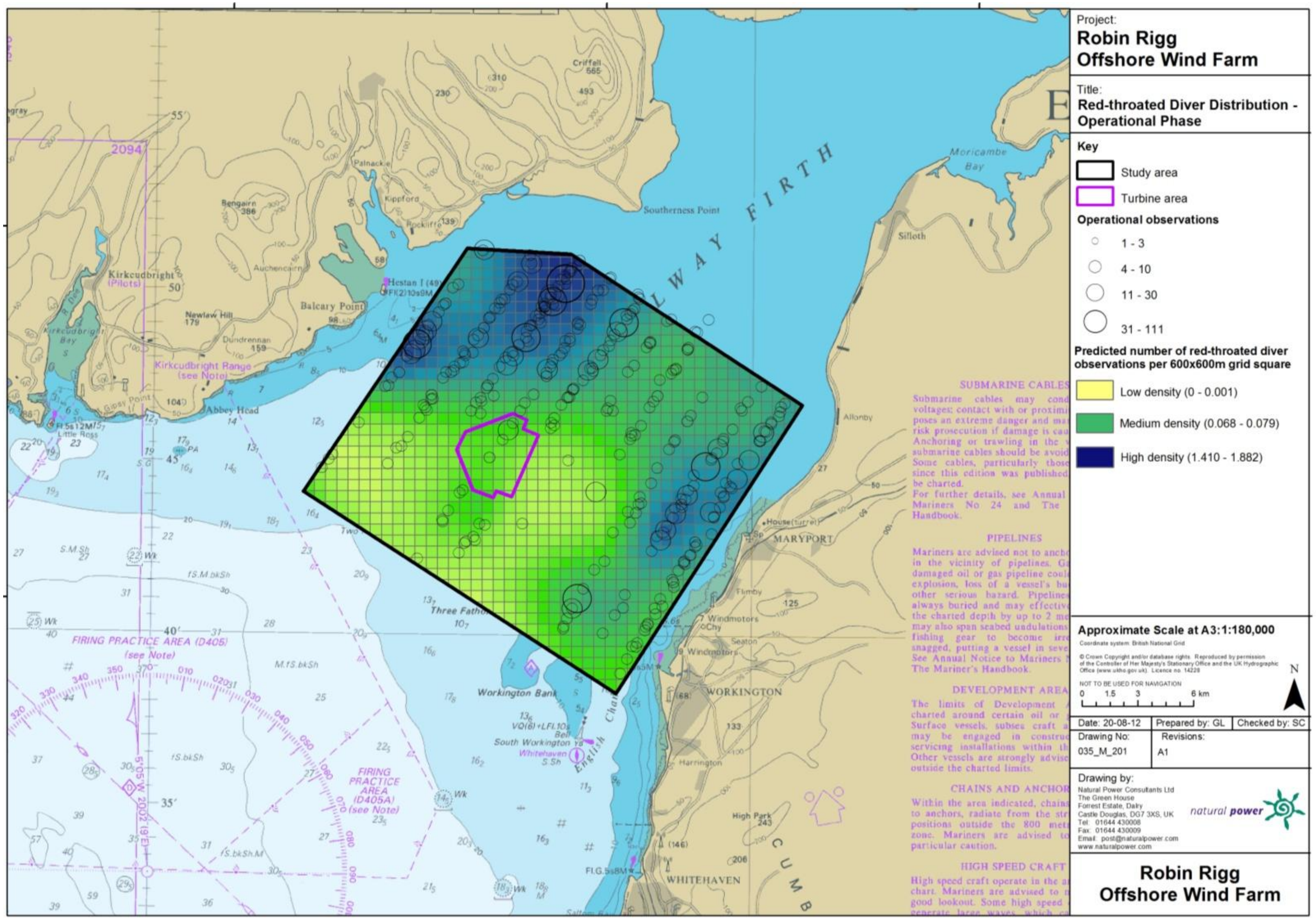


Figure 5.7: Density surface map of the predicted density of red-throated diver across the survey area during the operational phase. Open circles show the locations of the raw observations

Collision risk

The percentage of red-throated diver recorded in different height bands relative to rotor height can be found in Table 5.11 and Figure 5.21. The band 35-125 represents rotor height. As such a small number were observed flying at rotor height, it was considered that this species is not at risk from collision and so Chi Square was not attempted.

Table 5.11: Proportion of red-throated diver recorded in different height bands through the different stages of the development.

	Flight band (m)					
	1 (0–5)	2 (6–25)	3 (26–34)	4 (35– 125)	5 (126–200)	6 (200+)
Pre-construction	81.76	18.24	0	0	0	0
Construction	64.50	31.69	2.06	2.06	0	0
Operation	50.23	38.43	9.26	2.08	0	0

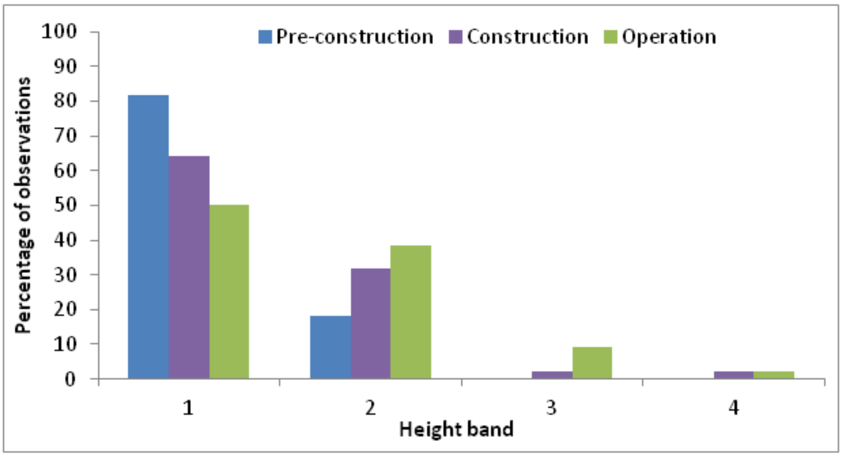


Figure 5.21: Percentage of red-throated diver recorded in different flight bands during the different stages of the development.

5.4.4. Manx shearwater

Abundance

The number of Manx shearwater recorded during each of the development phases can be found in Table 5.12 below. They were rarely seen on site, with slightly fewer birds observed during operational year two compared to one (Figure 5.22). The raw data indicate a decrease in observations during construction and operation combined with a change in when peak abundance occurs (Figure 5.23). The average group size during each period can be found in Figure 5.24.

Table 5.12: Number of sightings of Manx shearwater recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	140 (1566)	309 (1685)	178 (550)
SPUE (IPUE)	0.02 (0.27)	0.03 (0.14)	0.03 (0.08)

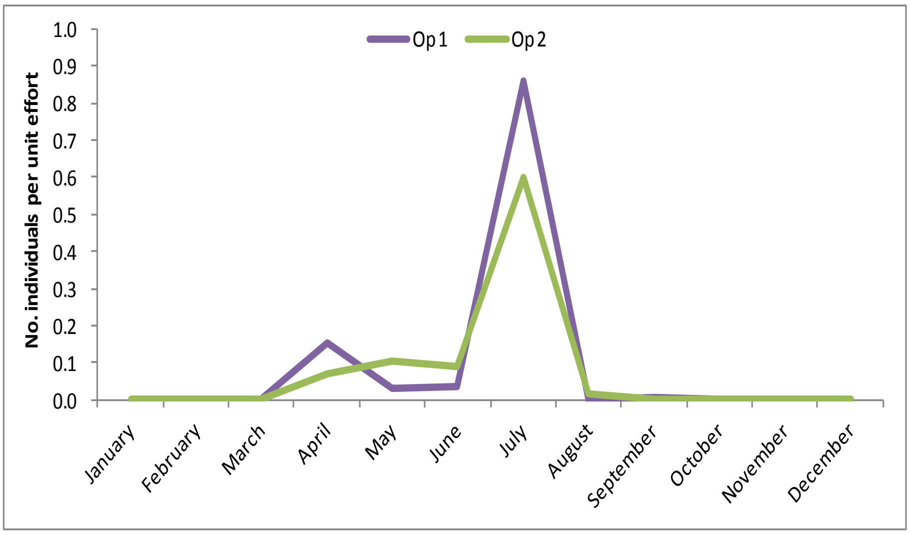


Figure 5.22: Mean number of Manx shearwater observed in flight per month during operational years one and two (birds in flight and on water combined).

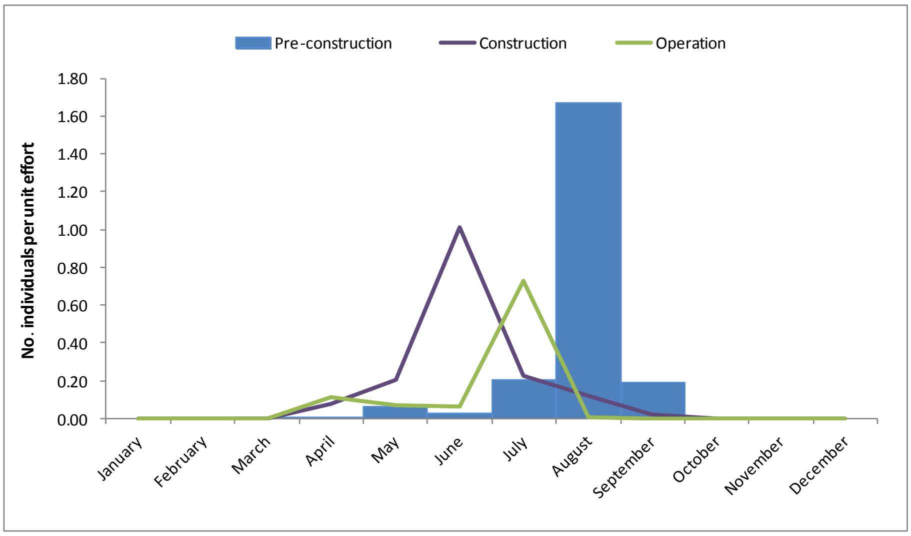


Figure 5.23: Mean number of Manx shearwater observed per month during the pre-construction, construction and operational phase (birds in flight and on water combined).

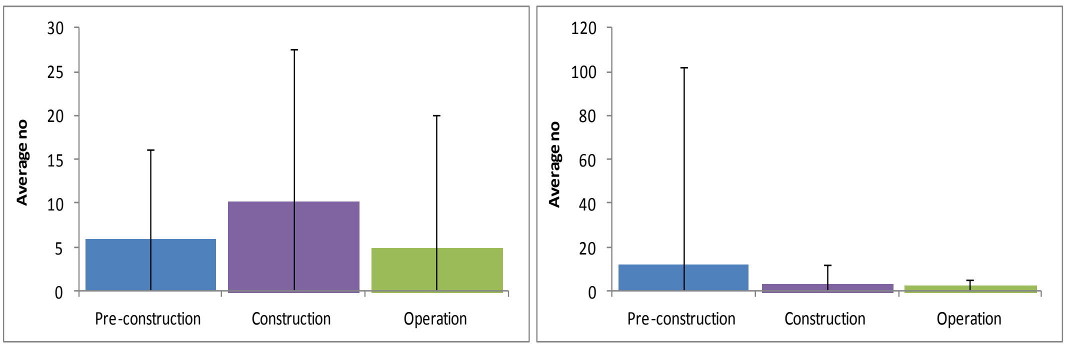


Figure 5.24: Mean number of Manx shearwater observed per sighting (left) on the sea and (right) in flight during the pre-construction, construction and operational phases (±standard deviation).

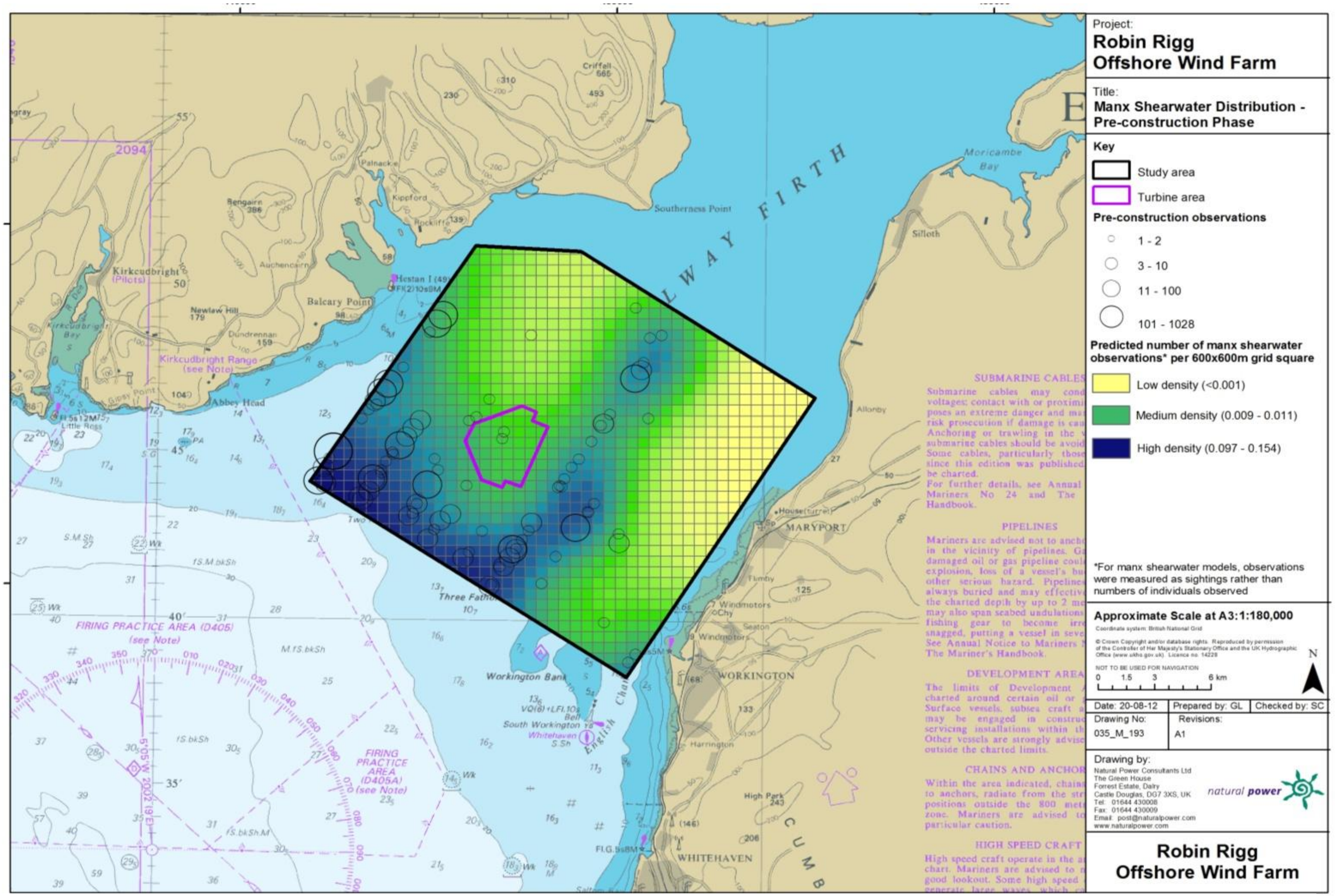


Figure 5.8: Density surface map of the predicted density of Manx shearwater across the survey area during the pre-construction phase. Open circles show the locations of the raw observations.

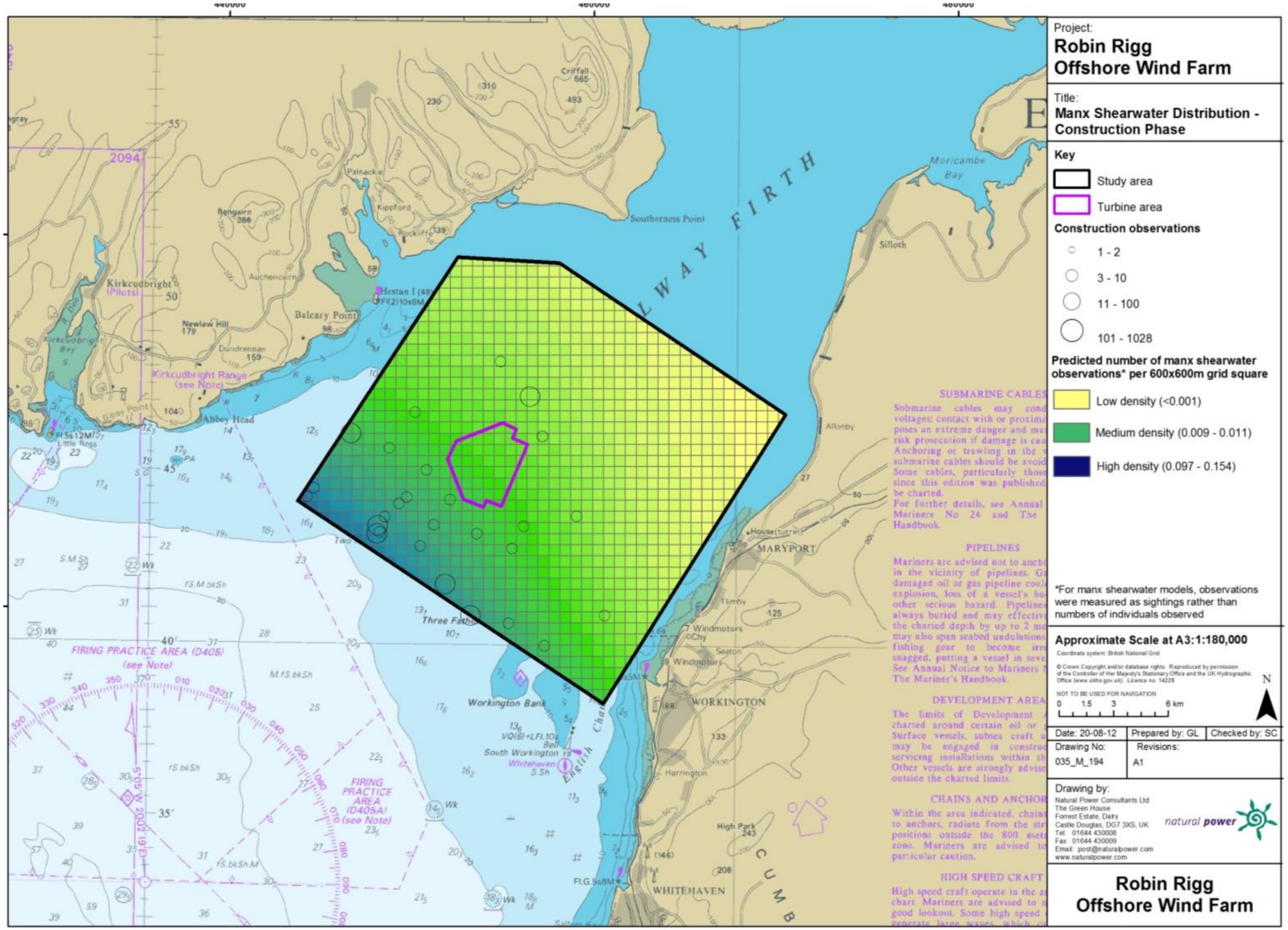


Figure 5.9: Density surface map of the predicted density of Manx shearwater across the survey area during the construction phase. Open circles show the locations of the raw observations.

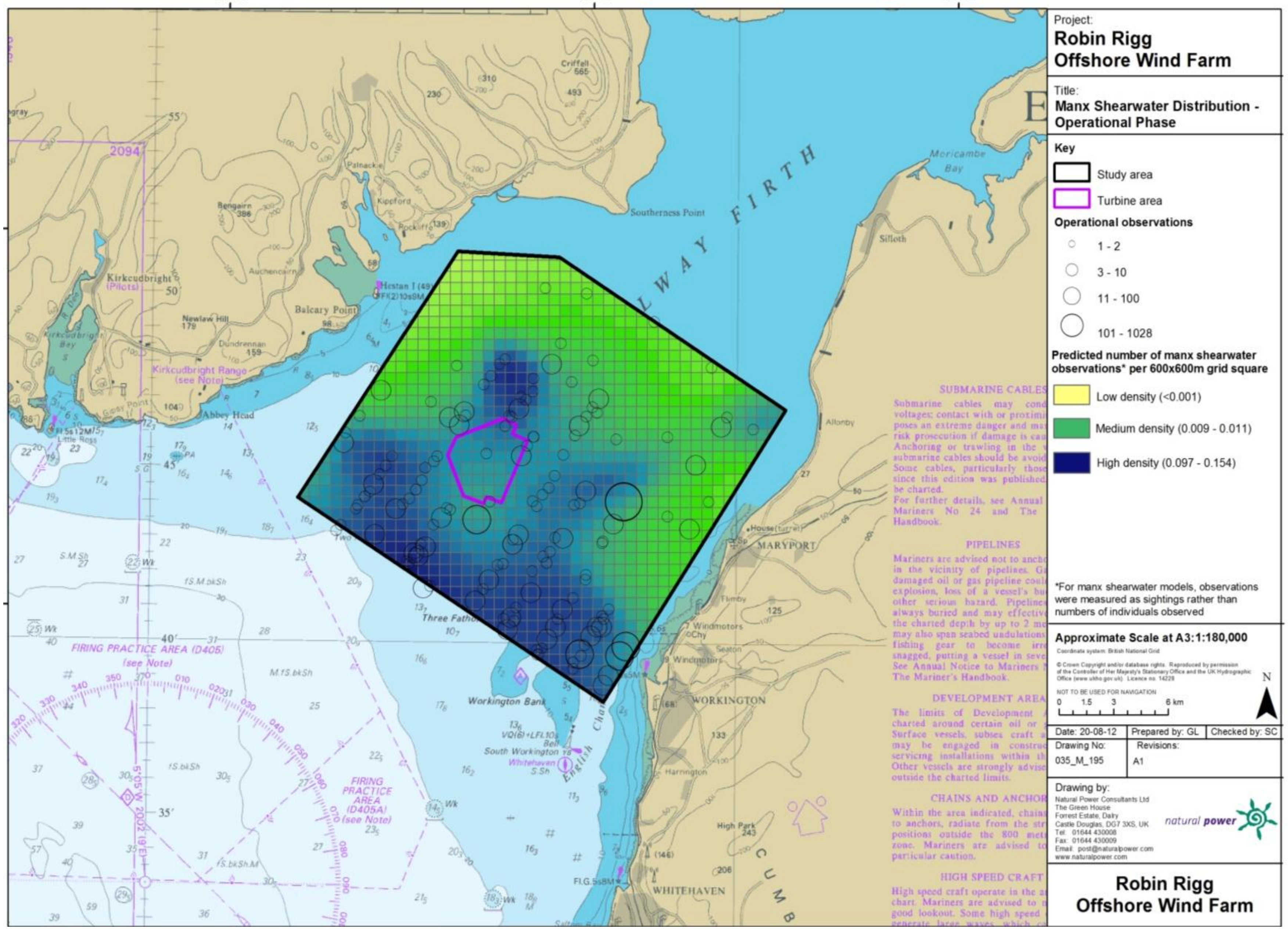


Figure 5.10: Density surface map of the predicted density of Manx shearwater across the survey area during the operational phase. Open circles show the locations of the raw observations.

Distribution

A map displaying the raw data can be found in Appendix section 3.6. Density surfaces for Manx shearwater for each of the three phases of the development can be found in Figure 5.25 to Figure 5.27.

Collision risk

The percentage of Manx shearwater recorded in different height bands relative to rotor height can be found in Table 5.13 and Figure 5.28. The band 35-125 represents rotor height. No Chi-square test was carried out for this species as no flights were observed at turbine rotor height and they are therefore not considered to be at risk from collision. A proportion of Manx shearwater were recorded in height Band 2 (6-25 m) during the construction period but the reasons for this are unclear.

Table 5.13: Proportion of Manx shearwater recorded at different flight bands through the spate stages of the development.

	Flight band (m)					
	1 (0–5)	2 (6–25)	3 (26–34)	4 (35– 125)	5 (126–200)	6 (200+)
Pre-construction	100	0	0	0	0	0
Construction	81.78	18.22	0	0	0	0
Operation	99.20	0.80	0	0	0	0

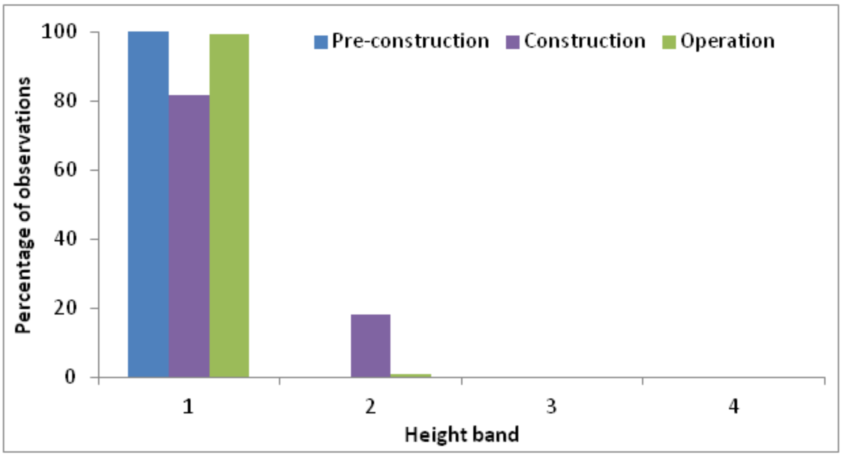


Figure 5.28: Percentage of Manx shearwater recorded in different flight bands during the different stages of the development.

5.4.5. Gannet

Abundance

The number of gannet recorded during each of the three development phases can be found in Table 5.14. While the number of sightings appears to have remained fairly constant, the raw data suggest a slight decline in the number of gannet recorded during and after construction. Gannet were seen primarily during the summer and autumn months with greater numbers recorded during operational year two compared to one (see Figure 5.29). Despite this, numbers post-construction still appear low than those recorded pre-construction (see Figure 5.30). Variation in the average group size observed during the different phases of the development is presented in Figure 5.31.

Table 5.14: Number of sightings of gannet recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	312 (476)	586 (848)	302(408)
SPUE (IPUE)	0.05 (0.08)	0.05 (0.07)	0.05 (0.06)

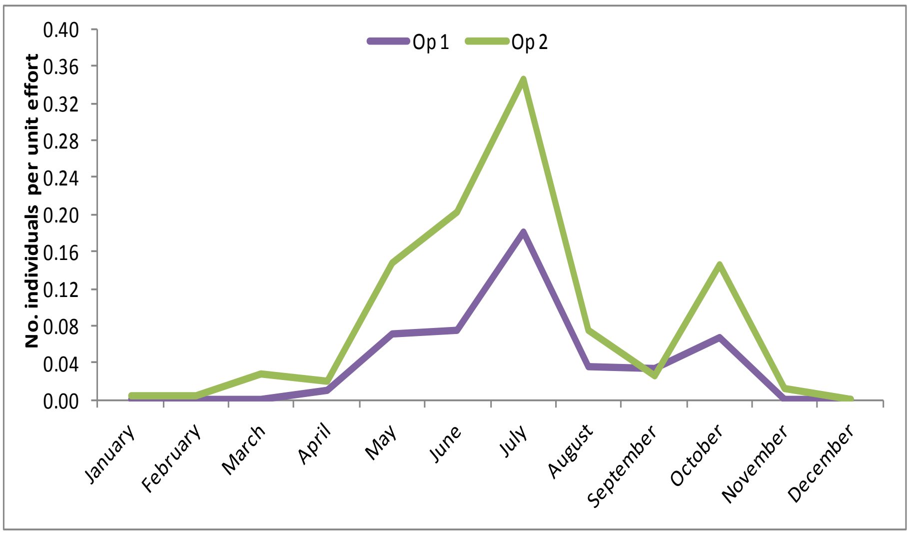


Figure 5.29: Mean number of gannet observed during operational years one and two (in flight and in sea combined).

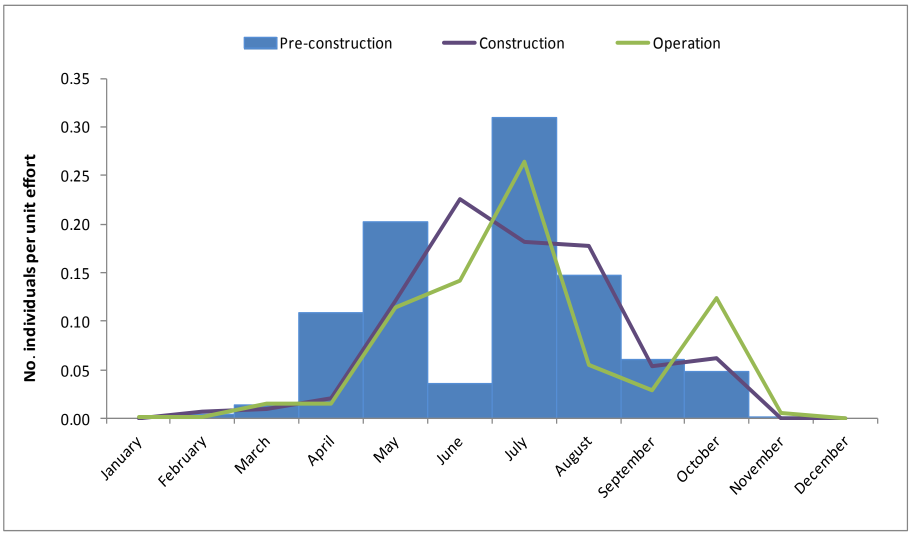


Figure 5.30: Mean number of gannet observed per month during the pre-construction, construction and operational phases (in flight and in sea combined).

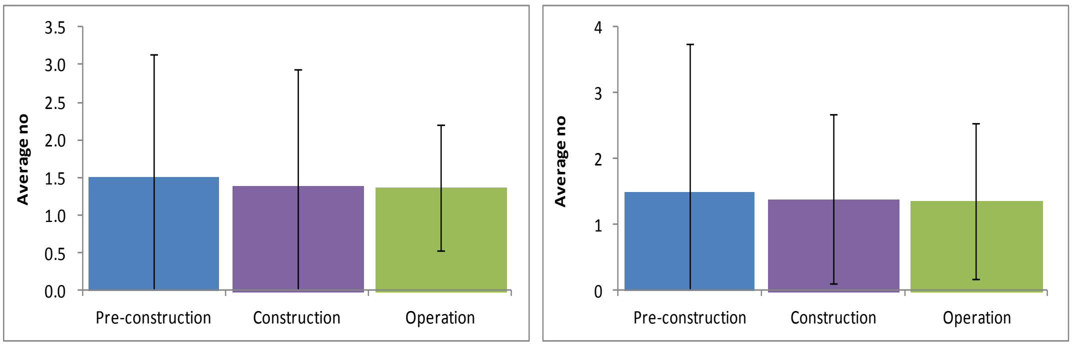


Figure 5.31: Mean number of gannet observed per sighting, on the sea (left) and in flight (right) during the pre-construction, construction and operational phases (±standard deviation).

Distribution

Gannet were recorded throughout the survey area (for map of raw data see Appendix 3, section 3.6). Density surfaces for gannet for each of the three phases of the development can be found in Figure 5.32 to Figure 5.34.

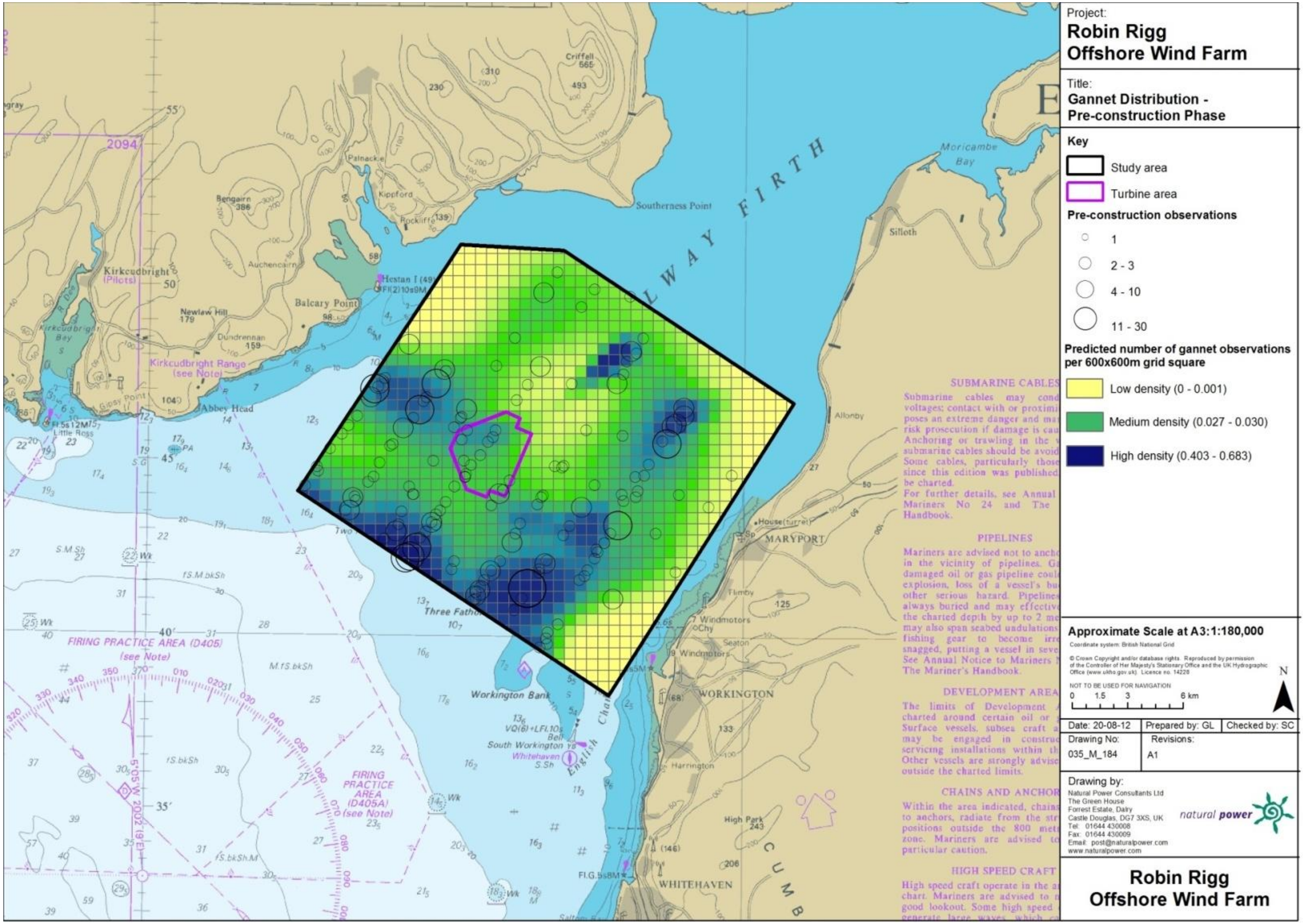


Figure 5.11: Density surface map of the predicted density of gannet across the survey area during the pre-construction phase. Open circles show the locations of the raw observations.

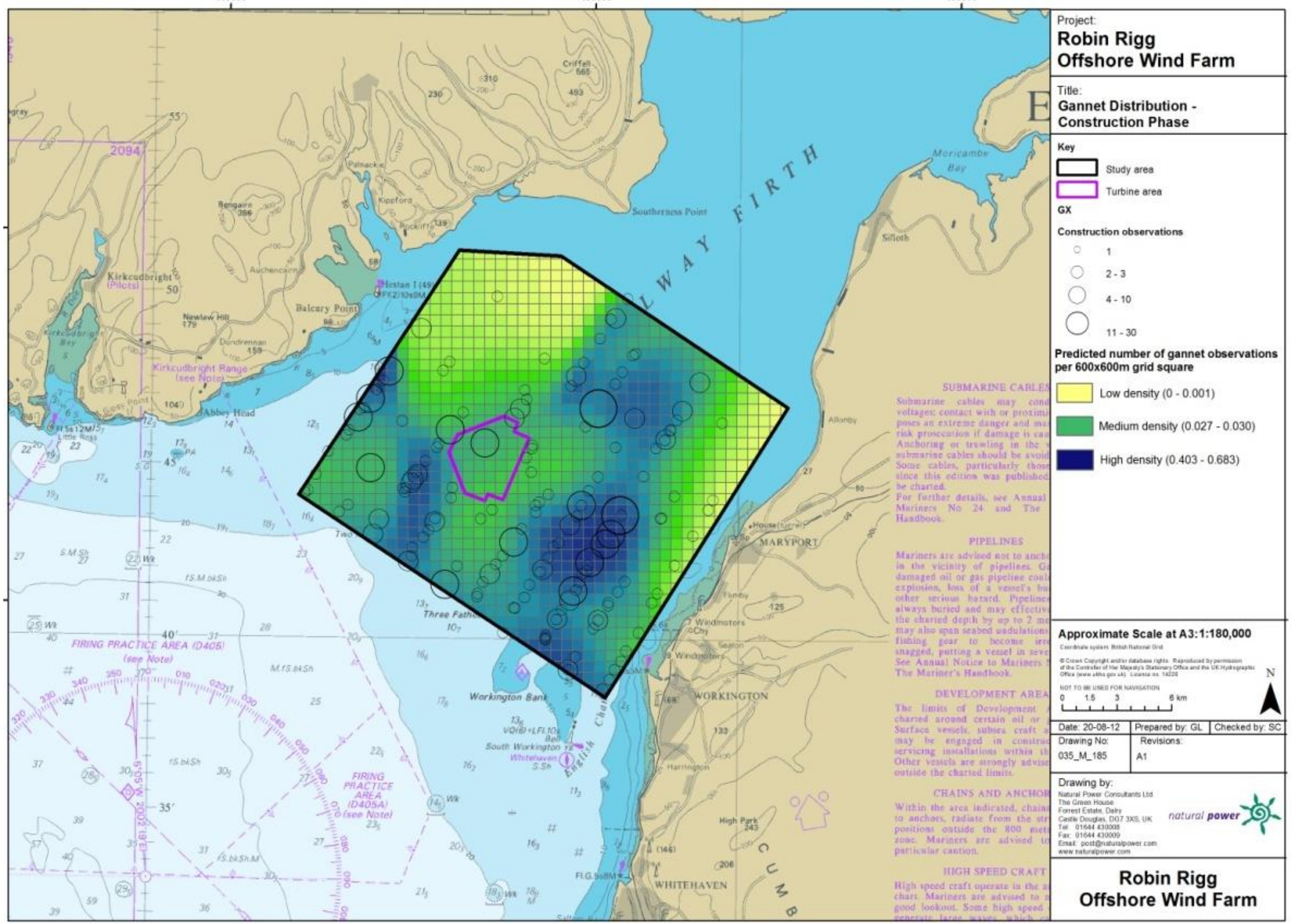


Figure 5.12: Density surface map of the predicted density of gannet across the survey area during the construction phase. Open circles show the locations of the raw observations.

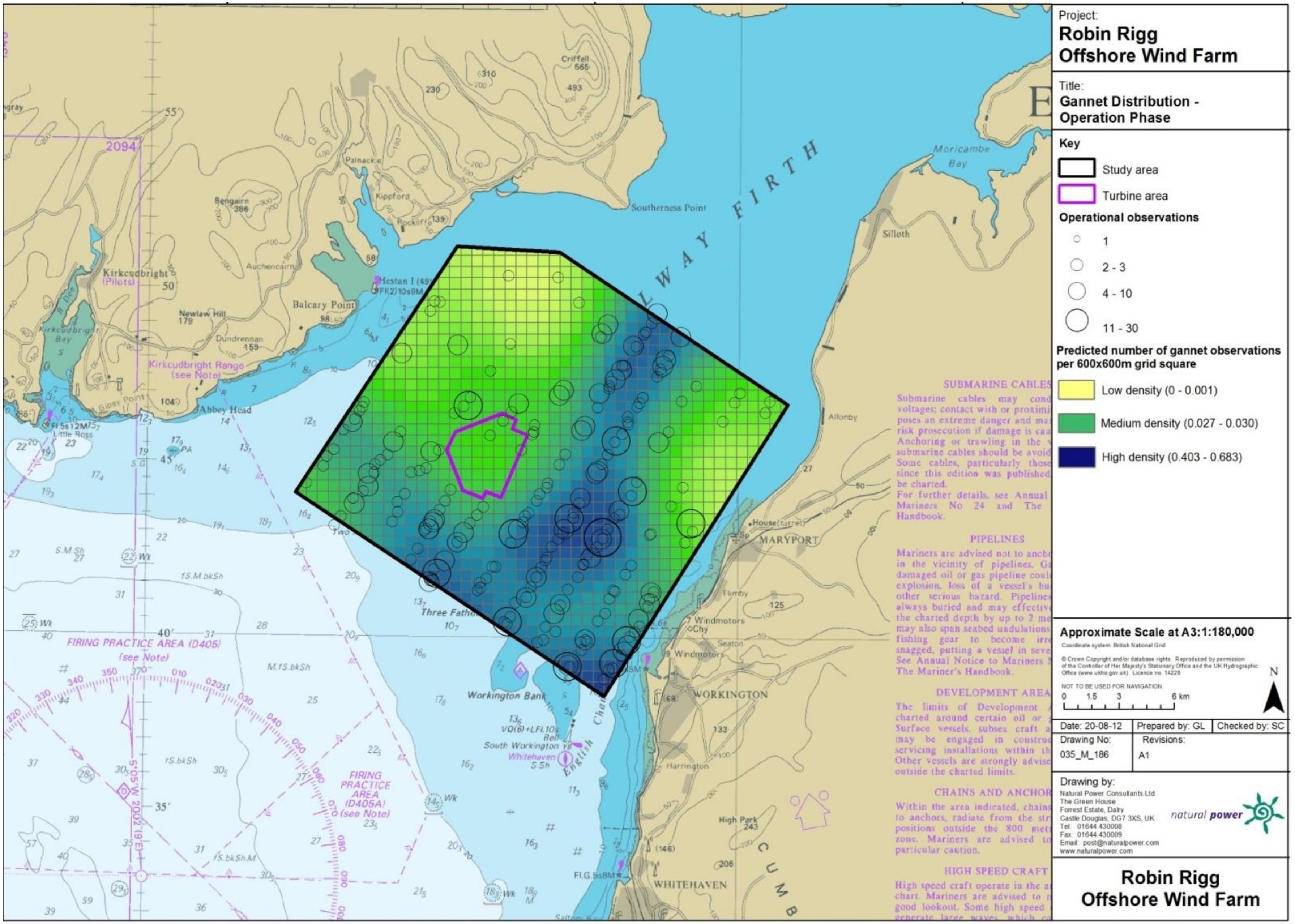


Figure 5.13: Density surface map of the predicted density of gannet across the survey area during the operational phase. Open circles show the locations of the raw observations.

Collision risk

The percentage of gannet recorded in different height bands relative to rotor height can be found in Table 5.15 and Figure 5.35. The band 35-125 represents rotor height. While the majority of flights were recorded below rotor height, sufficient were recorded in Band 4 to justify Chi Square analysis.

Data were combined for Chi-squared analysis and a significant difference was found between flight bands across the three periods (χ^2 = 9.0730, p = 0.011, 2 df). Significantly fewer birds were recorded in Band 4 during the pre-construction phase while significantly more than expected were recorded in Band 4 during the operational phase. This suggests that more gannets are recorded flying at rotor height now the wind farm is operational compared to previous phases of the development.

Table 5.15: Proportion of gannet recorded at different flight height bands through the different stages of the development. No birds were recorded above rotor height.

	Flight band (m)					
	1 (0–5)	2 (6–25)	3 (26–34)	4 (35– 125)	5 (126–200)	6 (200+)
Pre-construction	32.95	65.06	1.99	0	0	0
Construction	27.08	60.80	8.14	3.99	0	0
Operation	41.84	43.20	6.49	8.50	0	0

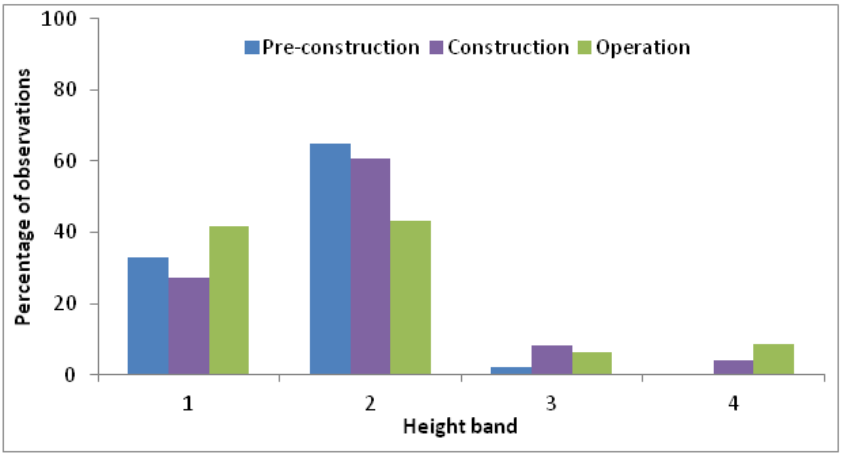


Figure 5.35: Percentage of gannet recorded in different flight bands during the different stages of the development. Figures in brackets represent total number.

5.4.6. Cormorant

Abundance

The number of cormorant recorded during each of the three development phases can be found in *Table 5.*16. The raw data suggest an increase in abundance during the construction and operational phases despite fewer cormorants being observed in operational year two compared to one (Figure 5.36). More cormorants have been observed during the winter months during and after construction of the wind farm (Figure 5.37). The average group size observed through the different phases of the development can be found in Figure 5.38.

Table 5.16: Number of sightings of cormorant recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	293 (452)	979 (3352)	749 (2189)
SPUE (IPUE)	0.05 (0.08)	0.08 (0.28)	0.11 (0.33)

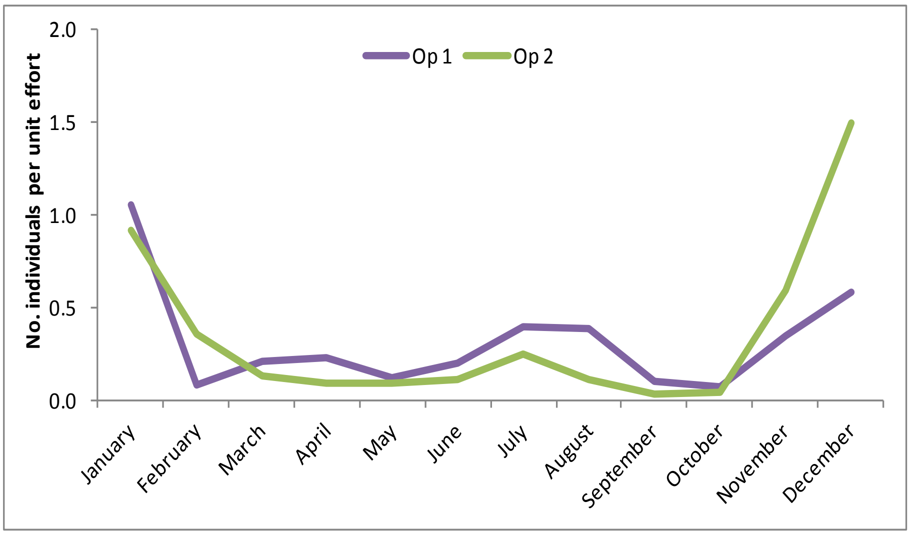


Figure 5.36: Mean number of cormorant recorded during operational years one and two (birds in flight and on sea combined).

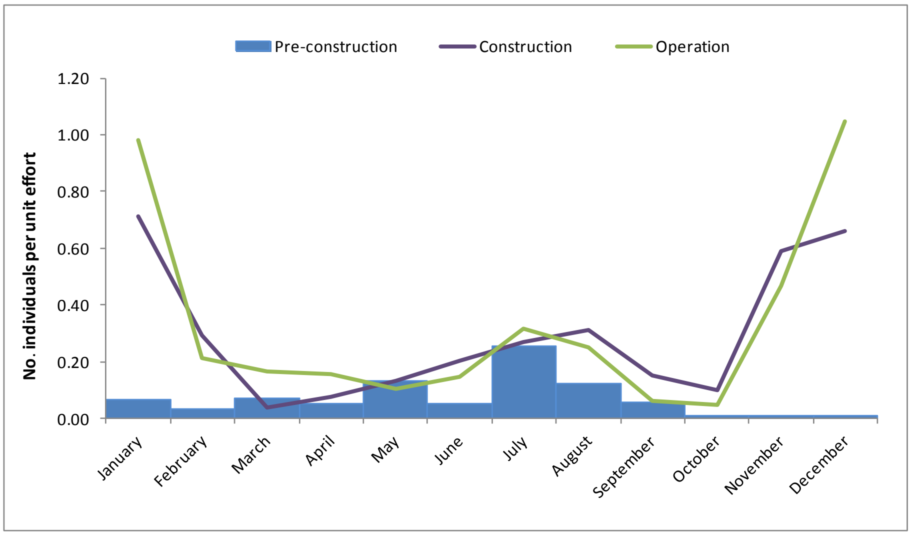


Figure 5.37: Mean number of cormorant observed per month during the pre-construction, construction and operational phases (birds in flight and on sea combined).

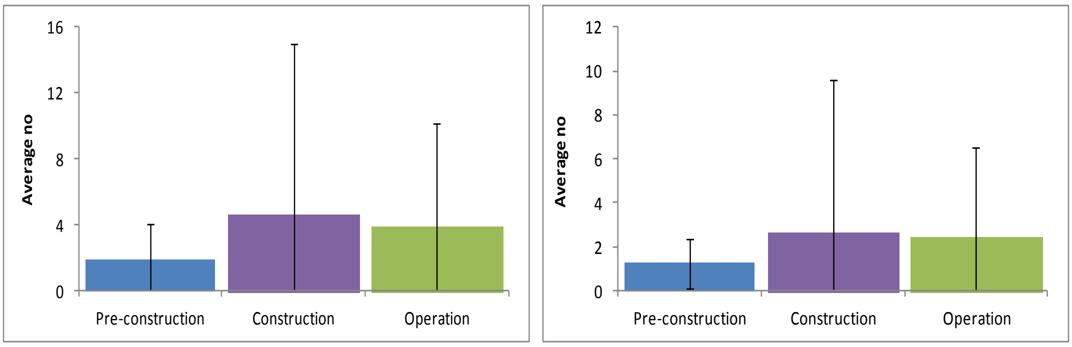


Figure 5.38: Mean number of cormorant observed per sighting on the sea (left) and in flight (right) during the pre-construction, construction and operational phases (±standard deviation).

Distribution

Cormorant were recorded throughout the survey area (for map of raw data see Appendix section 3.6). Density surfaces for cormorant for each of the three phases of the development can be found in Figure 5.39 to Figure 5.41. The location of peak abundance appears to have changed with concentrations appearing in the vicinity of the wind farm during and after the construction of the wind farm.

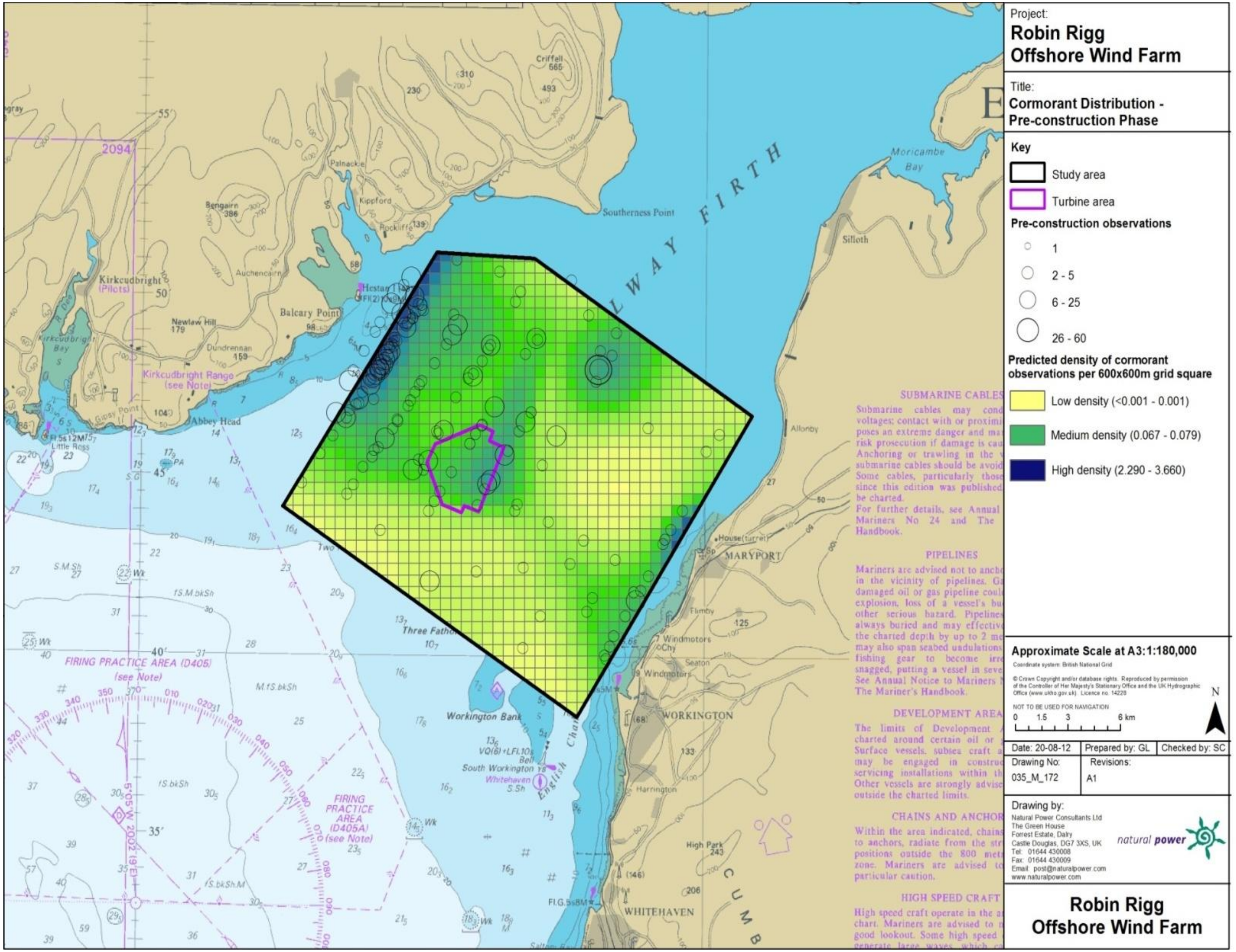


Figure 5.14: Density surface map of the predicted density of cormorant across the survey area during the pre-construction phase. Open circles show the locations of the raw observations.

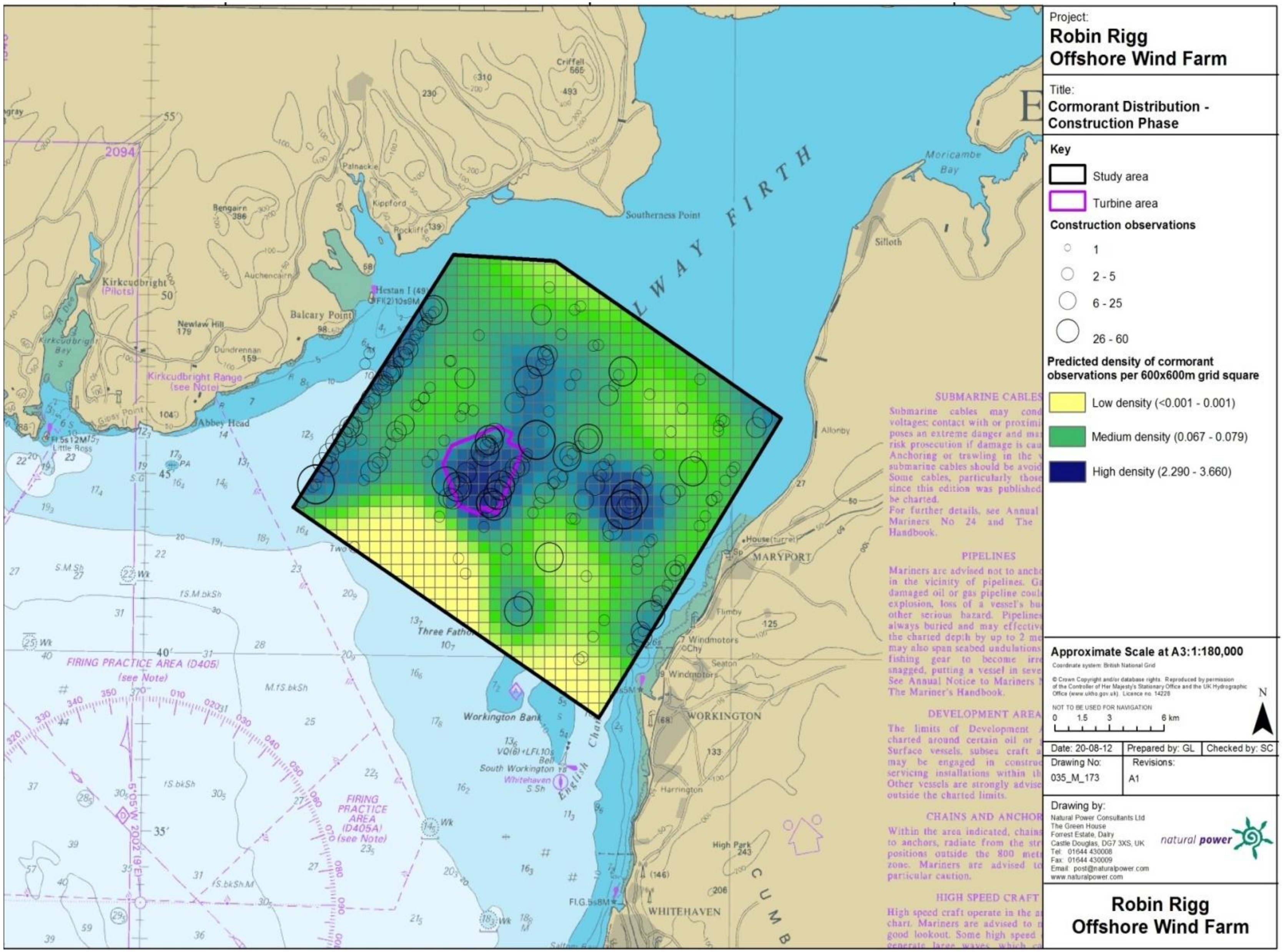


Figure 5.15: Density surface map of the predicted density of cormorant across the survey area during the construction phase. Open circles show the locations of the raw observations.

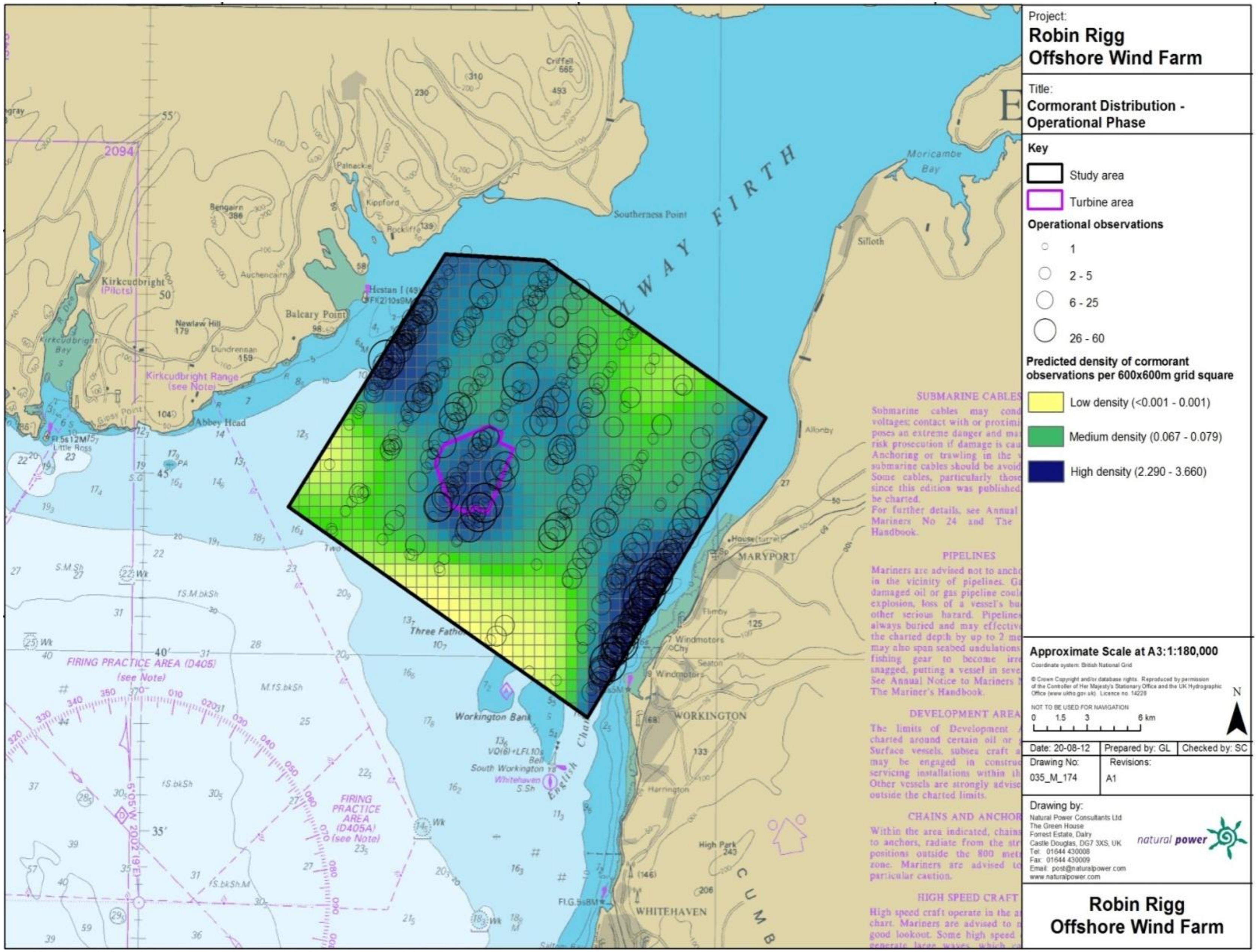


Figure 5.16: Density surface map of the predicted density of cormorant across the survey area during the operational phase. Open circles show the locations of the raw observations.

Collision risk

The percentage of cormorant recorded in different height bands relative to rotor height can be found in Table 5.17 and Figure 5.42. The band 4 (35-125 m) represents rotor height. Although a low number of cormorant were recorded at rotor height, it was still considered that this species is not generally at risk from collision and so Chi Squared was not attempted.

Table 5.17: Proportion of cormorant observed flying in different height bands through the three stages of the development.

	Flight band (m)					
	1 (0–5)	2 (6–25)	3 (26–34)	4 (35– 125)	5 (126–200)	6 (200+)
Pre-construction	75.00	24.48	0.52	0	0	0
Construction	64.85	32.36	1.65	1.14	0	0
Operation	67.70	23.97	5.76	2.58	0	0

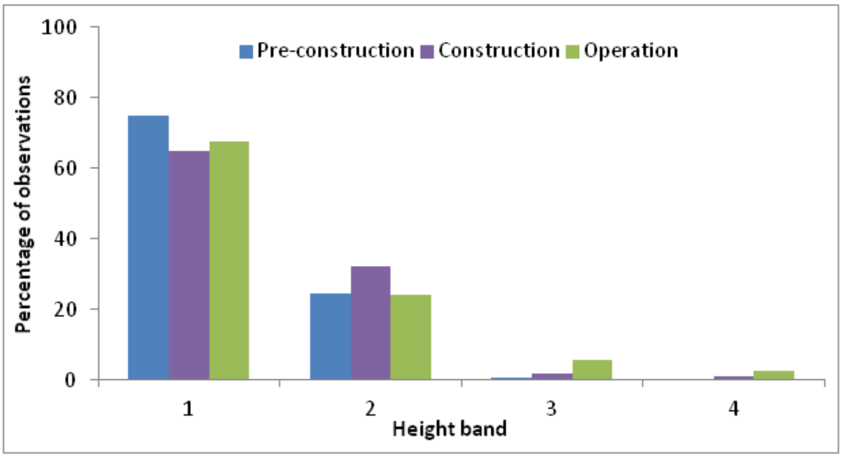


Figure 5.42: Percentage of cormorant recorded in different flight bands during the different stages of the development.

5.4.7. Kittiwake

Abundance

The number of kittiwake recorded through the three phases of the development can be found in Table 5.18. The raw data suggest that, overall, abundance within the survey are has remained fairly constant during the period under investigation. Monthly numbers of kittiwake observed during both operational years were similar (Figure 5.43). There is the suggestion of a drop in numbers during the months of March and April during the construction and operational phases but it is difficult to draw firm conclusions at this stage (Figure 5.44). The average group size observed through the different stages of the development can be found in Figure 5.45.

Table 5.18: Number of sightings of Kittiwake recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	466 (922)	903 (1779)	580 (1024)
SPUE (IPUE)	0.08 (0.16)	0.07 (0.15)	0.09 (0.16)

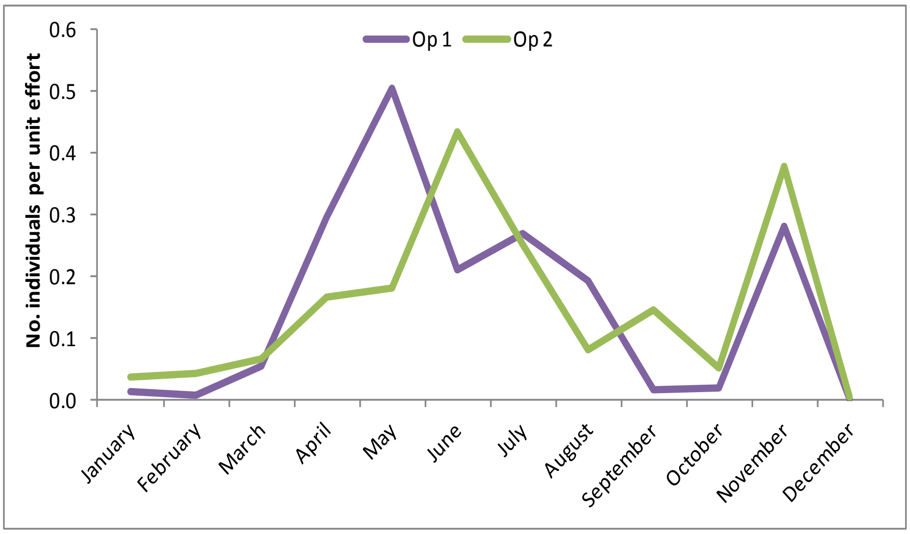


Figure 5.43: Mean number of kittiwake observed during operational years one and two (in flight and on the water combined).

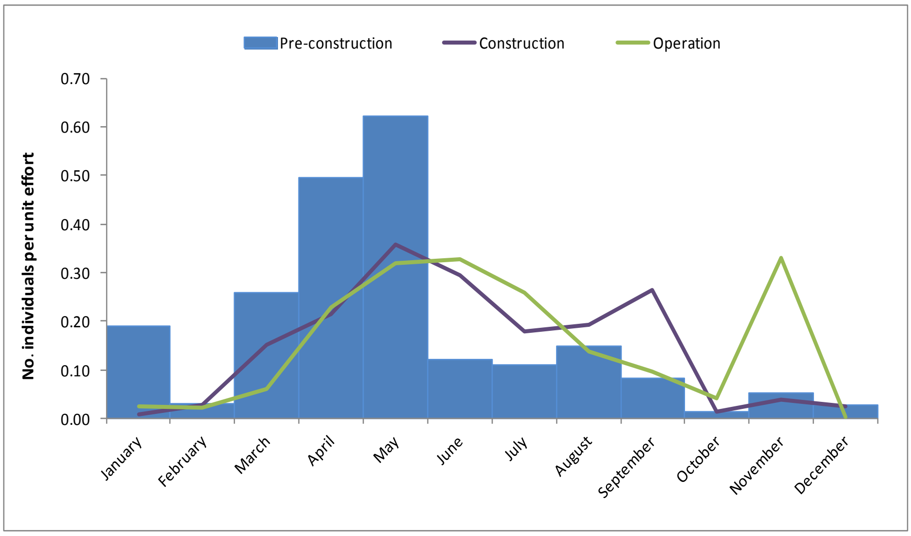


Figure 5.44: Mean number of kittiwake observed per month during the pre-construction, construction and operational phases (birds in flight and on sea combined).

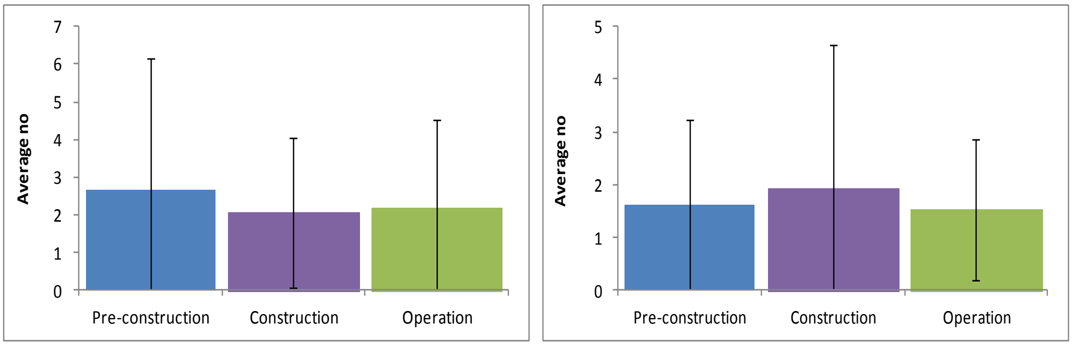


Figure 5.45: Mean number of kittiwake observed per sighting on the sea (left) and in flight (right) during the pre-construction, construction and operational phases (±standard deviation).

Distribution

Kittiwake were recorded throughout the survey area (for map of raw data see Appendix section 3.6). Density surfaces for kittiwake for each of the three phases of the development can be found in Figure 5.46 to Figure 5.48.

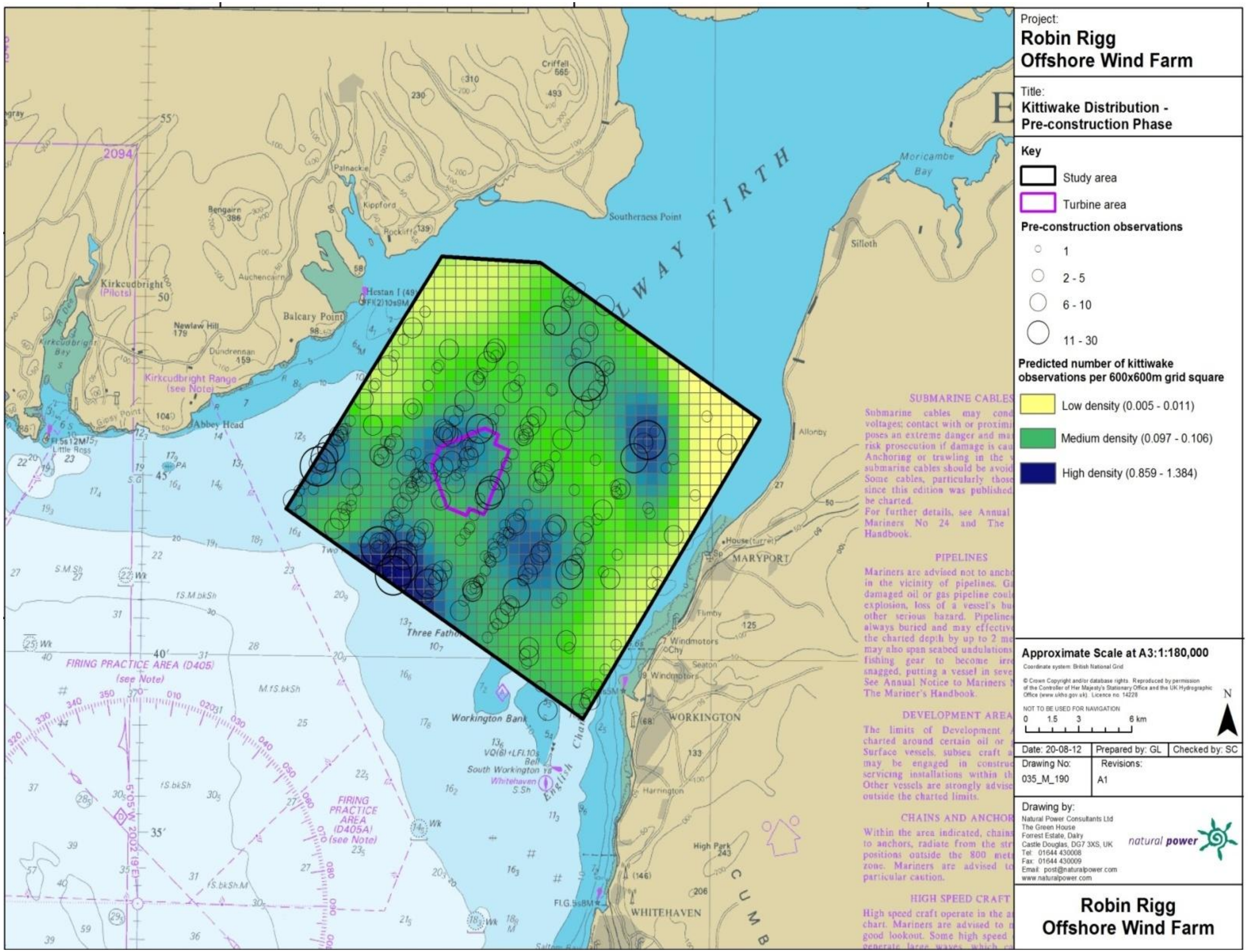


Figure 5.17: Density surface map of the predicted density of kittiwake across the survey area during the pre-construction phase. Open circles show the locations of the raw observations.

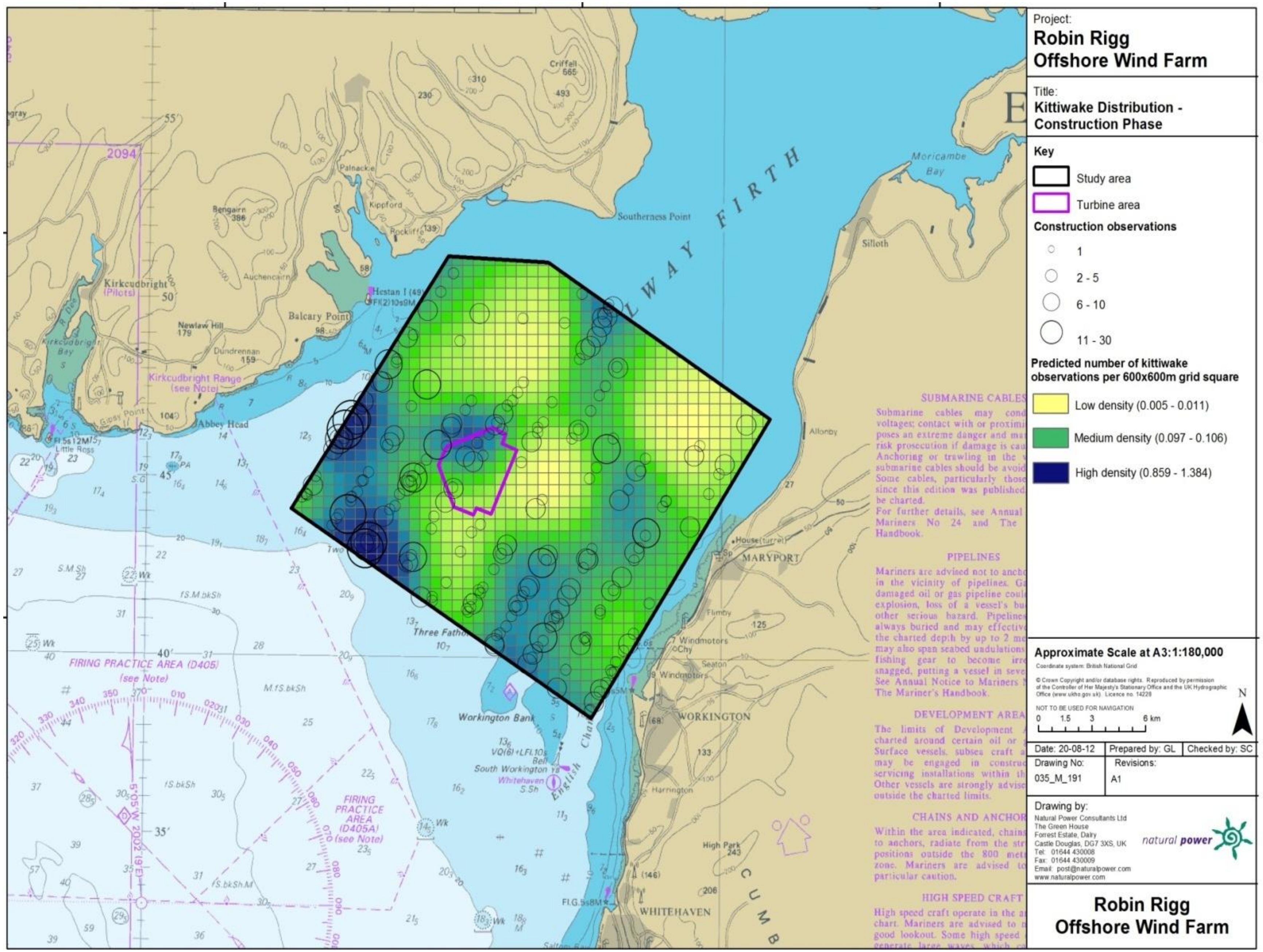


Figure 5.18: Density surface map of the predicted density of kittiwake across the survey area during the construction phase. Open circles show the locations of the raw observations.

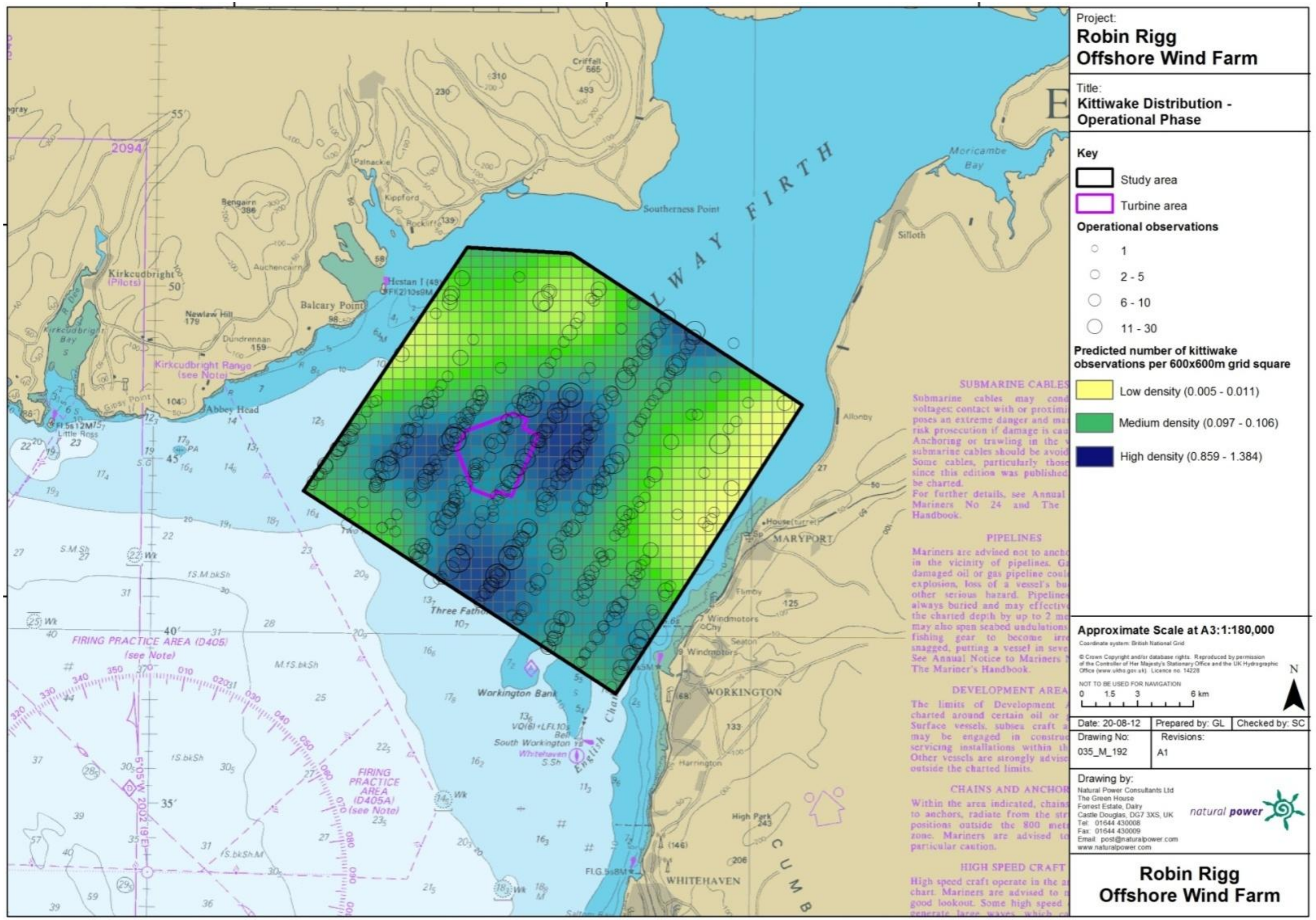


Figure 5.19: Density surface map of the predicted density of kittiwake across the survey area during the operational phase. Open circles show the locations of the raw observations.

Collision risk

The percentage of kittiwake recorded in different height bands relative to rotor height can be found in Table 5.19 and Figure 5.49. Band 4 (35-125 m) represents rotor height. As such a small number of birds were observed at rotor height, it is considered that generally, this species is at a low risk of collision and so Chi Squared was not attempted.

Table 5.19: Proportion of kittiwake observed flying at different height bands during the three stages of development.

	Flight band (m)					
	1 (0–5)	**2 (6–25)**	**3 (26–34)**	**4 (35– 125)**	**5 (126–200)**	**6 (200+)**
Pre-construction	49.69	48.43	0.84	1.04	0	0
Construction	25.86	70.16	23.0	1.68	0	0
Operation	38.67	55.25	3.24	2.86	0	0

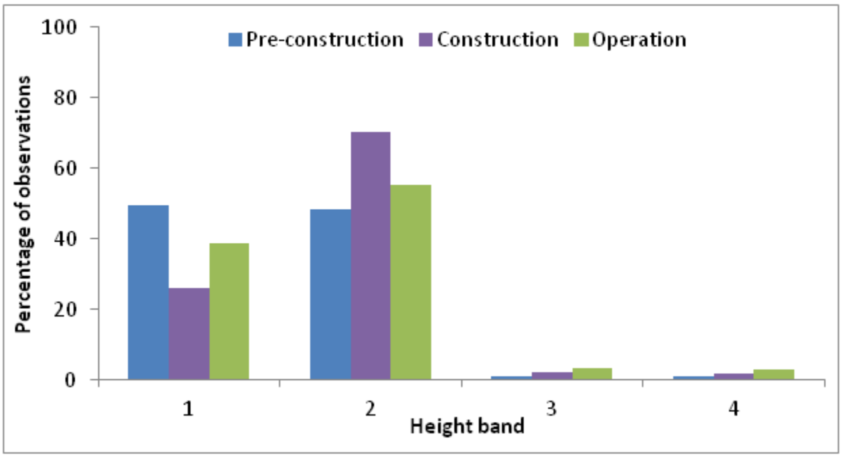


Figure 5.49: Percentage of kittiwake recorded in different flight bands during the different stages of the development.

5.4.8. Herring gull

Monthly presence

The number of herring gull recorded through the three phases of the development can be found in Table 5.20. The raw data suggest that while numbers during construction and operation are fairly consistent, numbers observed are lower than those recorded pre-construction. Numbers recorded during operational years one and two are similar apart from during May, when are larger number of birds were recorded during operational year one (Figure 5.50). Monthly fluctuations recorded through the three development phases are also similar (Figure 5.51). The average group size in each phase can be found in Figure 5.52.

Table 5.20: Number of sightings of herring gull recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	524 (1294)	785 (1727)	387 (875)
SPUE (IPUE)	0.09 (0.22)	0.06 (0.14)	0.06 (0.13)

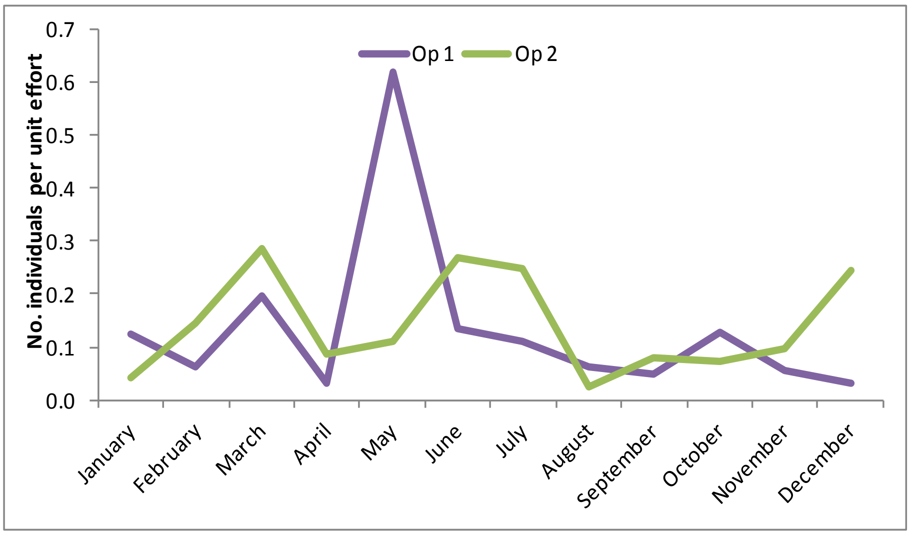


Figure 5.50: Mean number of herring gull recorded during operational years one and two (in flight and on sea combined).

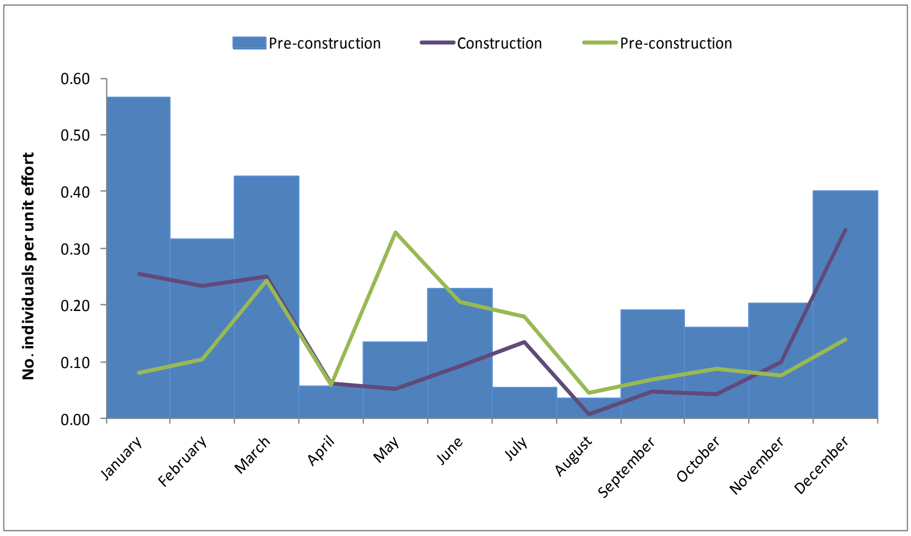
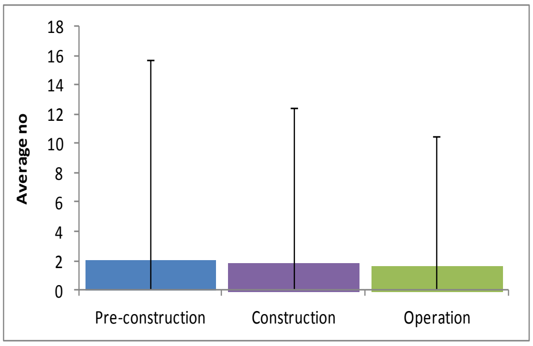


Figure 5.51: Mean number of herring gull observed per month during the pre-construction, construction and operational phases (in flight and on sea combined).



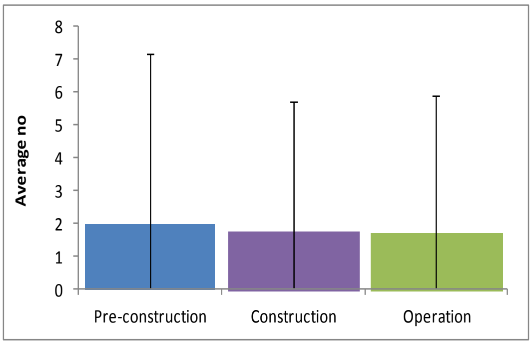


Figure 5.52: Mean number of herring gull observed per sighting (left) on the sea and (right) in flight during the pre-construction, construction and operational phases (±standard deviation).

Distribution

Herring gulls were recorded throughout the survey area (for map of raw data see Appendix section 3.6). Density surfaces for herring gull for each of the three phases of the development can be found in Figure 5.53 to Figure 5.55. A concentration of herring gull in the vicinity of the wind farm is apparent in the operations phase that was not present in previous phases.

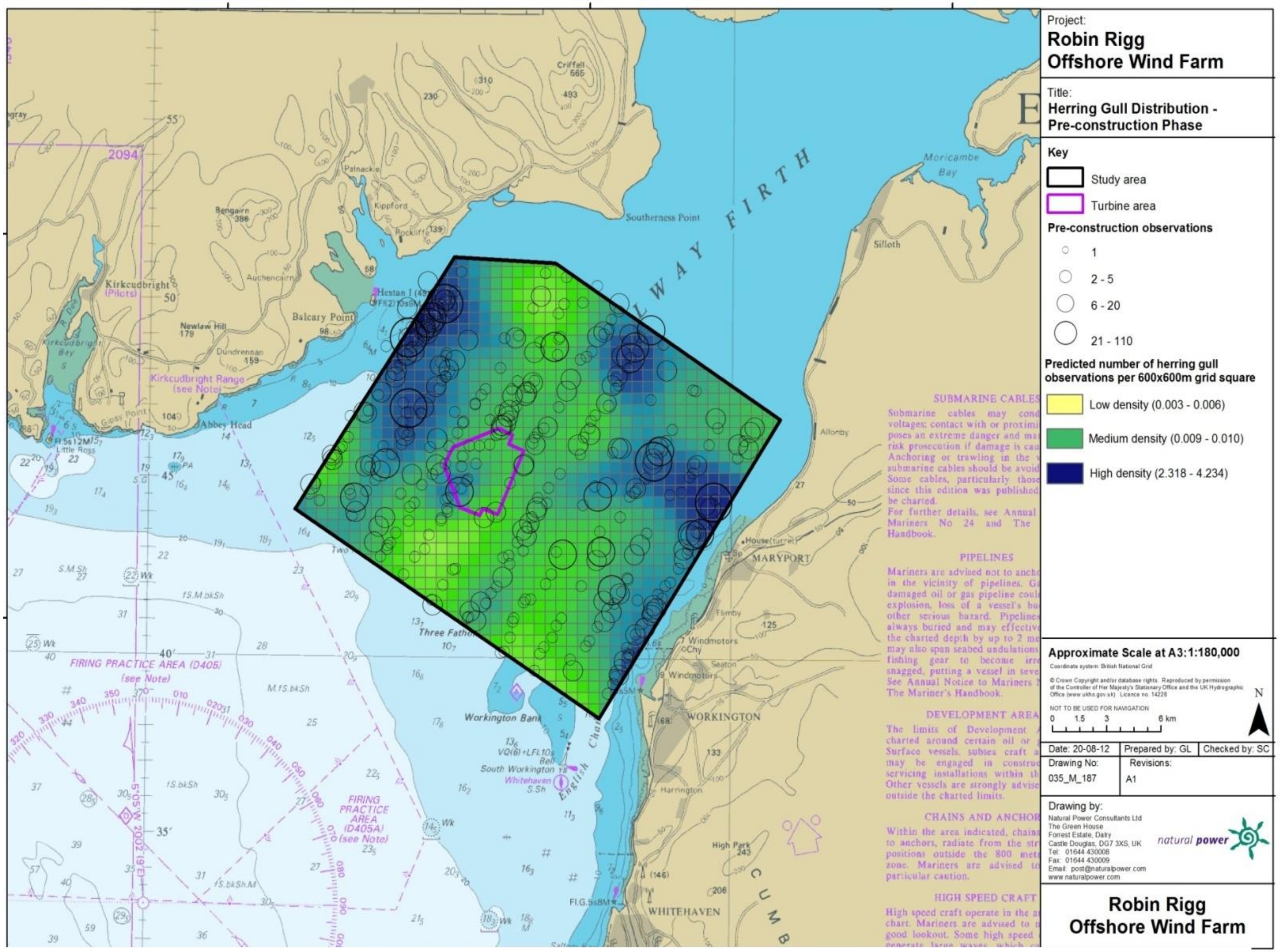


Figure 5.20: Density surface map of the predicted density of herring gull across the survey area during the pre-construction phase. Open circles show the locations of the raw observations.

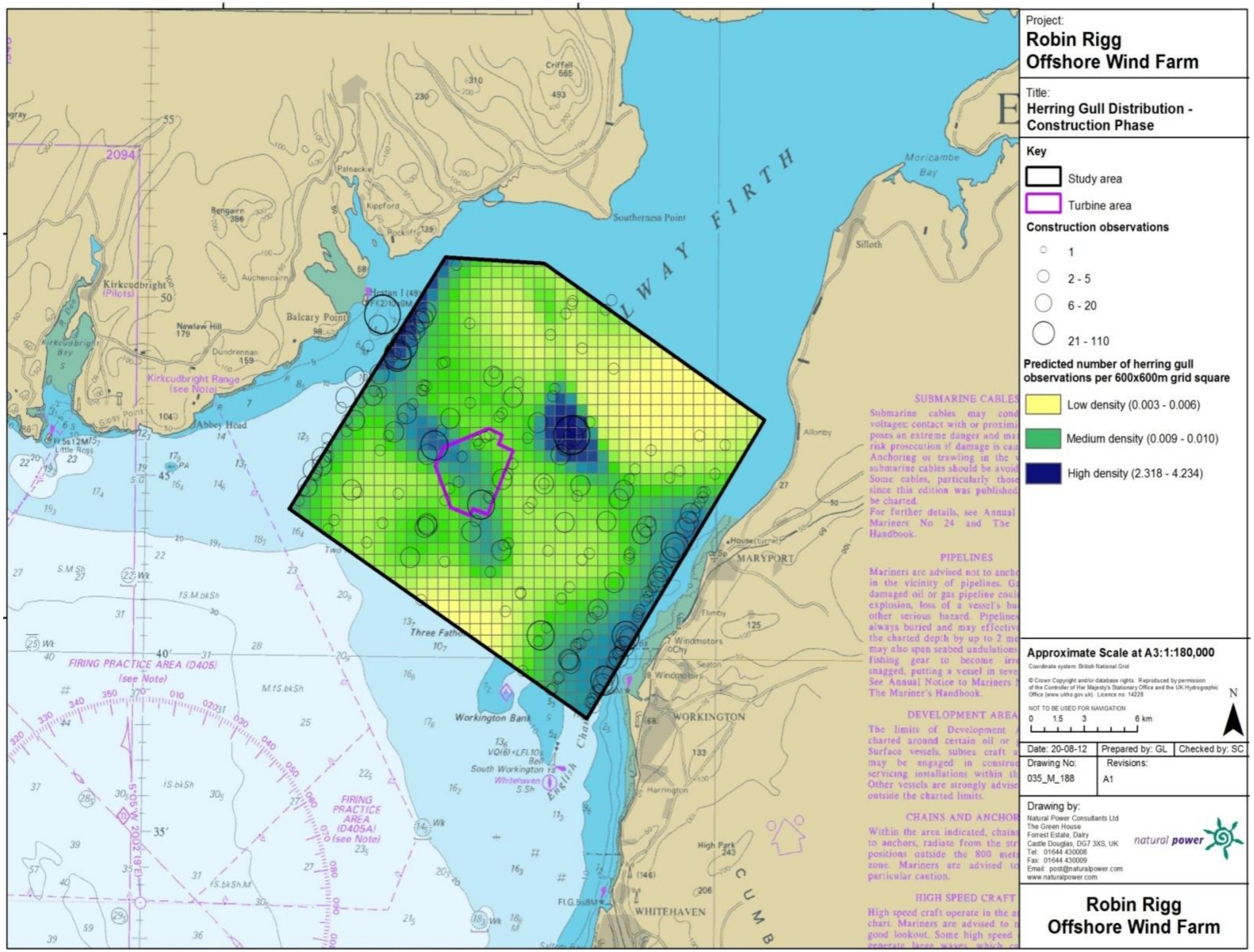


Figure 5.21: Density surface map of the predicted density of herring gull across the survey area during the construction phase. Open circles show the locations of the raw observations.

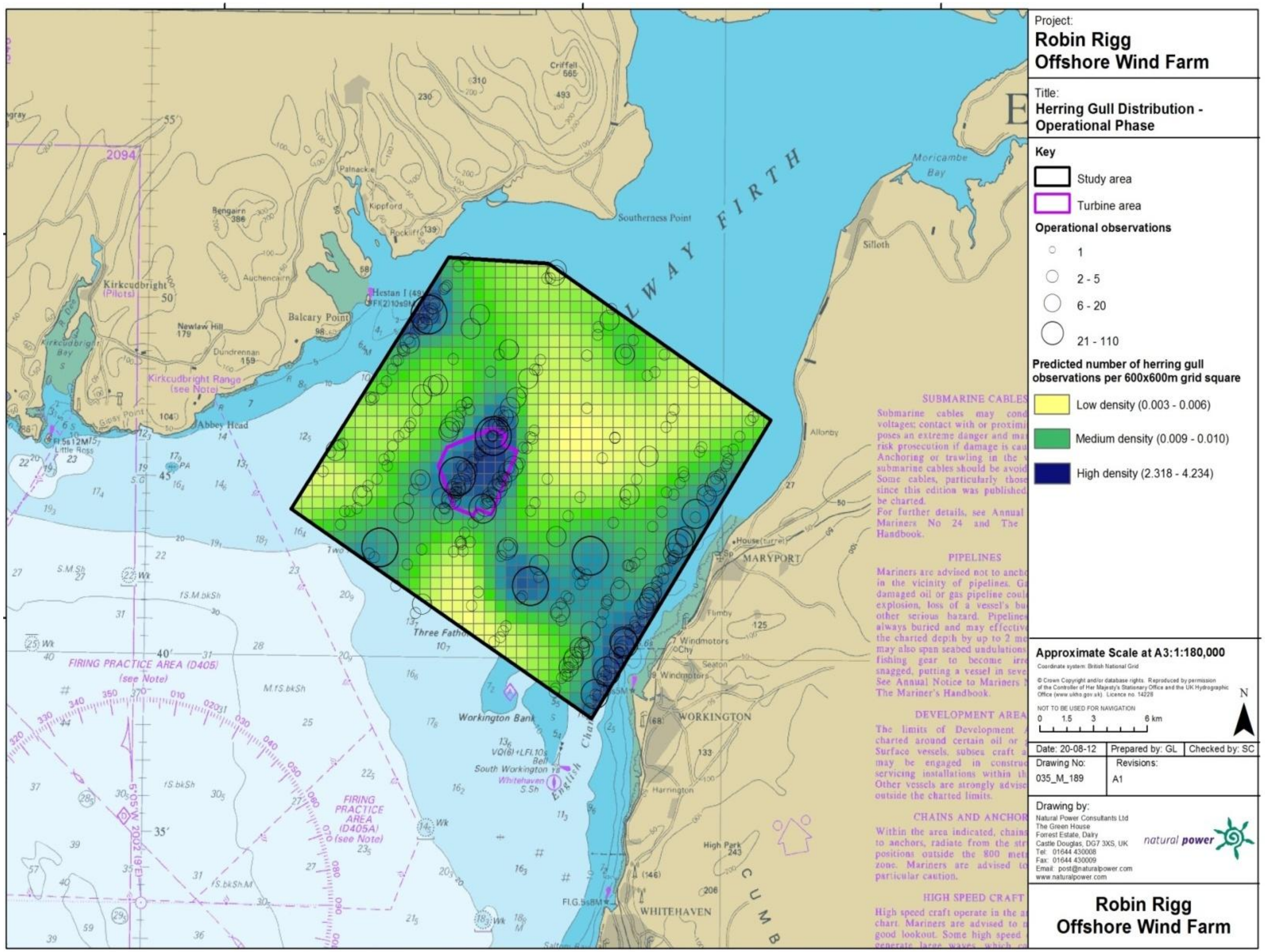


Figure 5.22: Density surface map of the predicted density of herring gull across the survey area during the operational phase. Open circles show the locations of the raw observations

Collision risk

The percentage of herring gulls recorded in different height bands relative to rotor height can be found in Table 5.21 and Figure 5.56. Height band 4 (35-125) represents rotor height. Data were combined for Chi-squared analysis and a significant difference was found between flight bands (χ^2 = 15.68, $p < 0.001$, 2 df). Fewer herring gulls than expected were observed flying at rotor height pre-construction, while more than expected were observed during the operation phases.

Table 5.21: Proportion of herring gull observed flying at different height bands during the three stages of development.

	Flight band (m)					
	1 (0–5)	2 (6–25)	3 (26–34)	4 (35– 125)	5 (126–200)	6 (200+)
Pre-construction	35.93	59.89	3.30	0.88	0	0
Construction	18.64	64.94	9.61	6.81	0	0
Operation	14.39	48.68	21.10	15.83	0	0

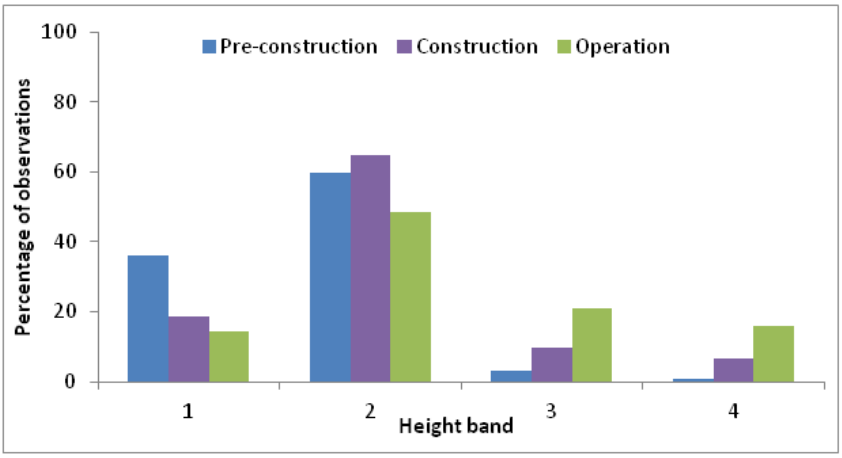


Figure 5.56: Percentage of herring gull recorded in different flight bands during the different stages of the development.

5.4.9. Great black-backed gull

Monthly presence

The number of great black-backed gulls recorded during the three phases of the development can be found in Table 5.22. The raw data suggest an increase in abundance during the operational years with similar numbers recorded in both years (Figure 5.57). The data also suggest an increase in winter abundance post-construction compared to pre-construction (Figure 5.58). The average group size recorded during the three phases of the development can be found in Figure 5.59.

Table 5.22: Number of sightings of great black-backed gull recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	162 (207)	367 (580)	266 (462)
SPUE (IPUE)	0.03 (0.04)	0.03 (0.05)	0.04 (0.07)

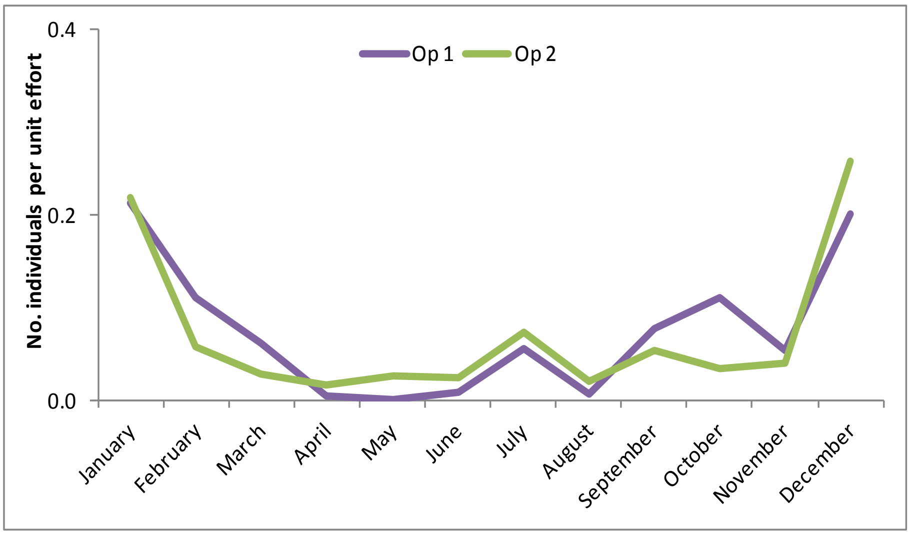


Figure 5.57: Mean number of great black-backed gulls observed in operational years one and two (on sea and in flight combined).

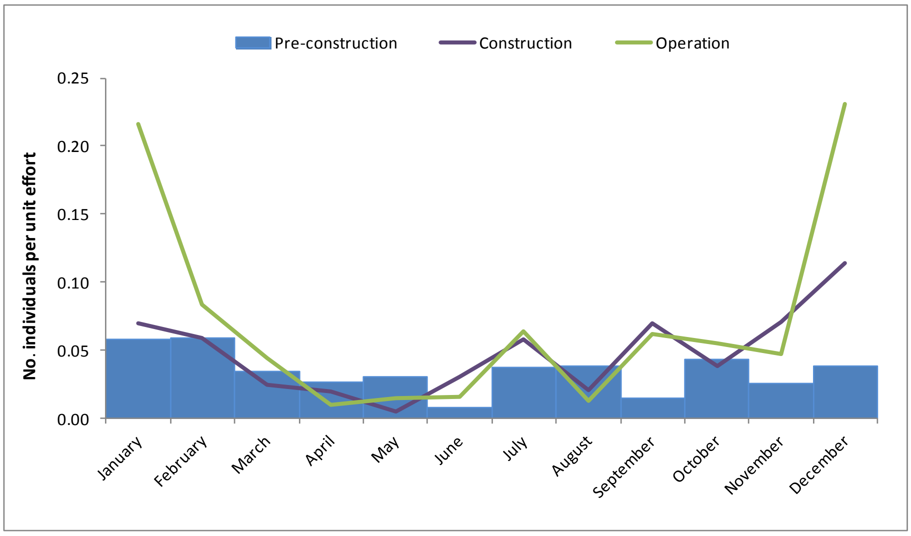


Figure 5.58: Mean number of great black-backed gull observed per month during the pre-construction, construction and operational phases (on sea and in flight combined).

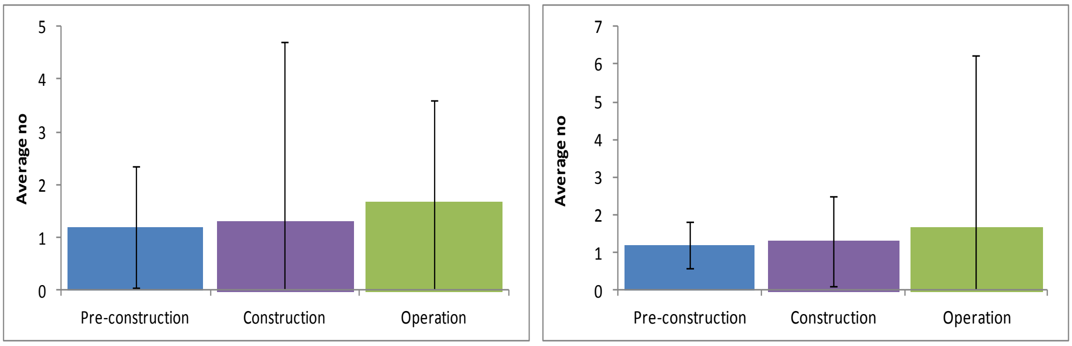


Figure 5.59: Mean number of great black-backed gull observed per sighting on the sea (left) and in flight (right) during the pre-construction, construction and operational phases (±standard deviation).

Distribution

Great black-backed gulls were recorded throughout the survey area (for map of raw data see Appendix section 3.6). Density surfaces for great black-backed gull for each of the three phases of the development can be found in Figure 5.60 to Figure 5.62.

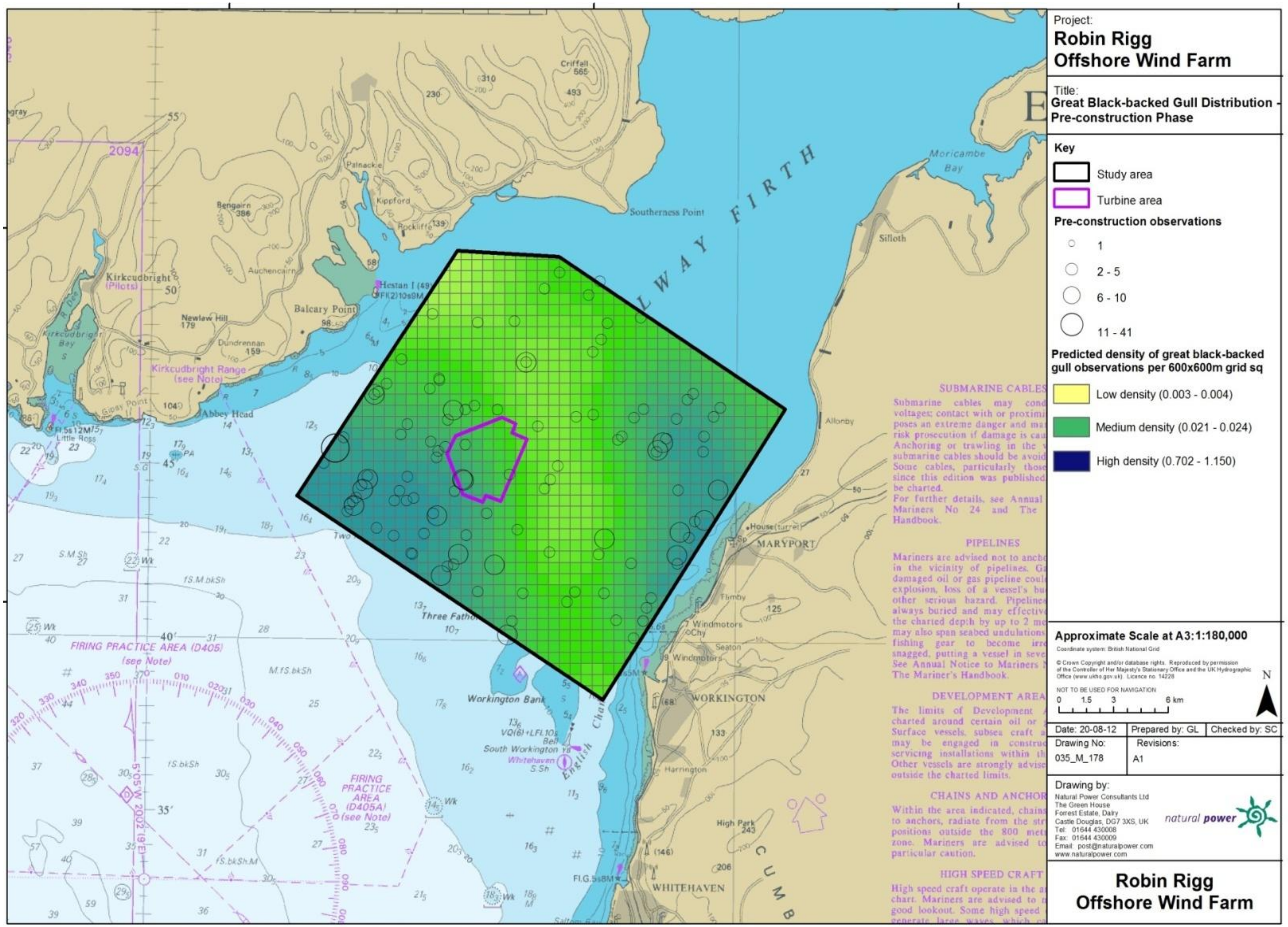


Figure 5.23: Density surface map of the predicted density of great black-backed gull across the survey area during the pre-construction phase. Open circles show the locations of the raw observations.

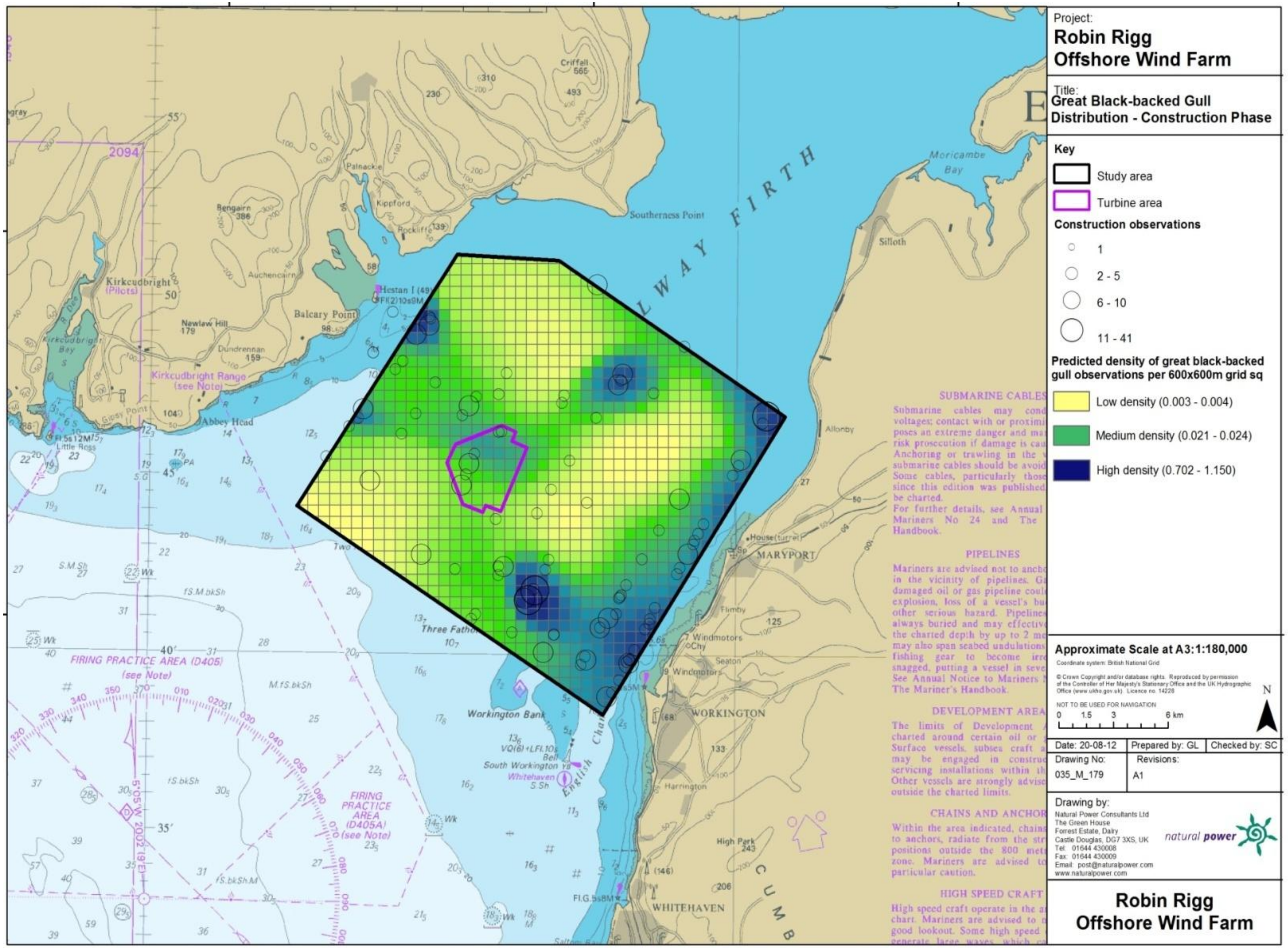


Figure 5.24: Density surface map of the predicted density of great black-backed gull across the survey area during the construction phase. Open circles show the locations of the raw observations.

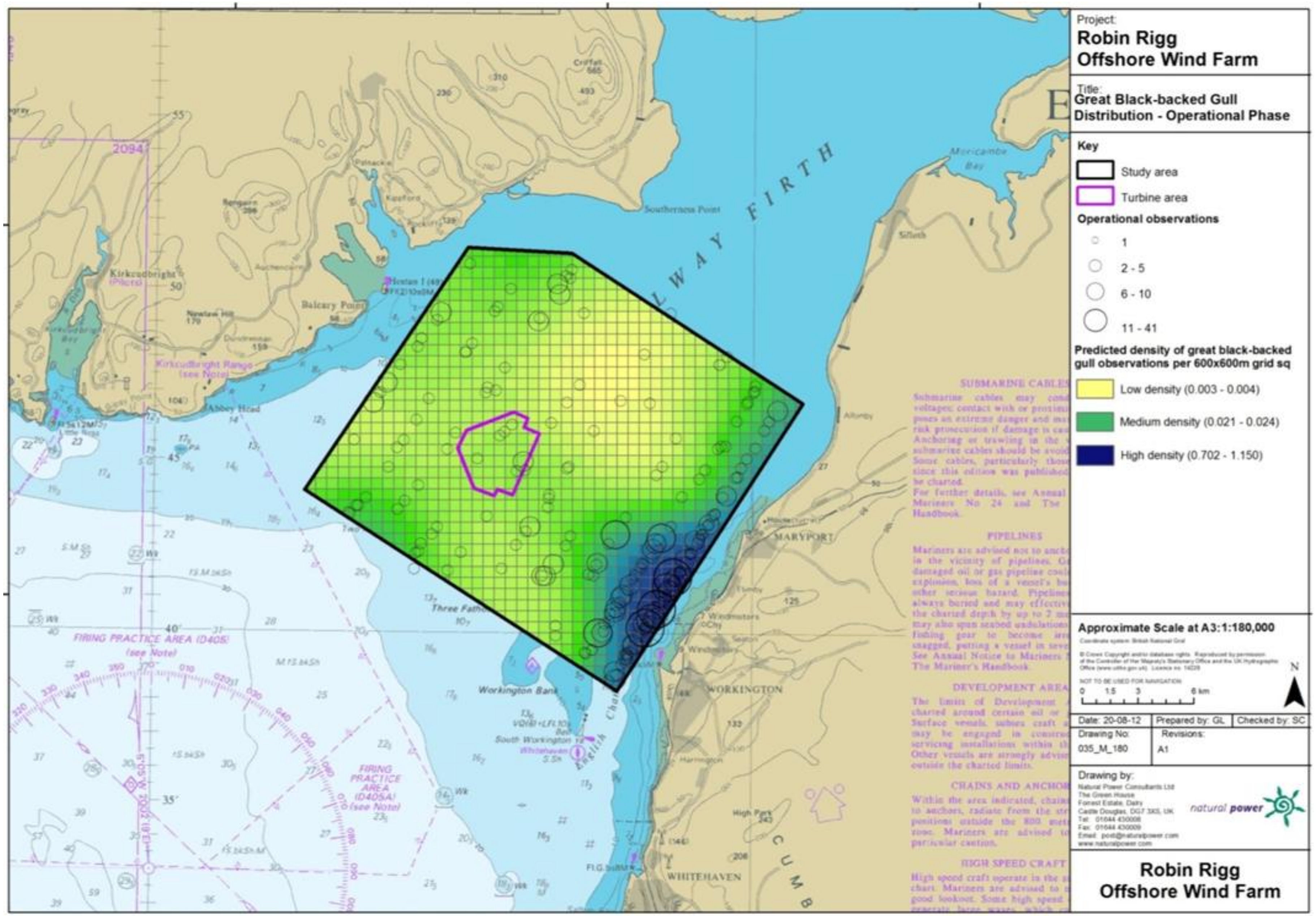


Figure 5.25: Density surface map of the predicted density of great black-backed gull across the survey area during the operational phase. Open circles show the locations of the raw observations.

Collision risk

The percentage of great black-backed gulls recorded in different height bands relative to rotor height can be found in Table 5.23 and Figure 5.63. The band 35-125 represents rotor height. Data were combined for Chi-squared analysis but no significant difference was found between flight bands (χ^2 = 4.92, p = 0.085, 2 df). While there appears to be no statistical difference in the proportion of birds flying at rotor height through the construction phases, there is still a risk of collision for this species although it should be noted that the majority of birds were recorded below height band 4.

Table 5.23: Proportion of great black-backed gull observed flying at different height bands during the three stages of development.

	Flight band (m)					
	1 (0–5)	2 (6–25)	3 (26–34)	4 (35– 125)	5 (126–200)	6 (200+)
Pre-construction	26.76	61.27	5.63	6.34	0	0
Construction	12.68	59.06	13.77	14.49	0	0
Operation	12.92	60.83	10.42	15.83	0	0

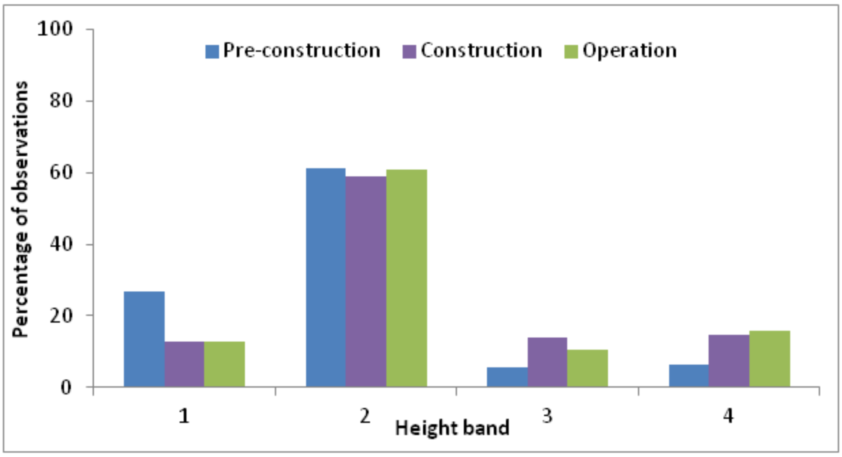


Figure 5.63: Percentage of great black-backed gull recorded in different flight bands during the different stages of the development.

5.4.10. Guillemot

Monthly presence

The number of guillemot recorded during the three stages of the development can be found in Table 5.24. The raw data suggest a decline during the construction phase with a degree of recovery post-construction. Similar numbers of birds were recorded in both operational years (Figure 5.64) with monthly patterns of abundance fairly consistent between of the phases of the development (Figure 5.65). The average group size for each phase can be found in Figure 5.66.

Table 5.24: Number of sightings of guillemot recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	2454 (4152)	4184 (5782)	2547 (3947)
SPUE (IPUE)	0.42 (0.71)	0.35 (0.48)	0.39 (0.60)

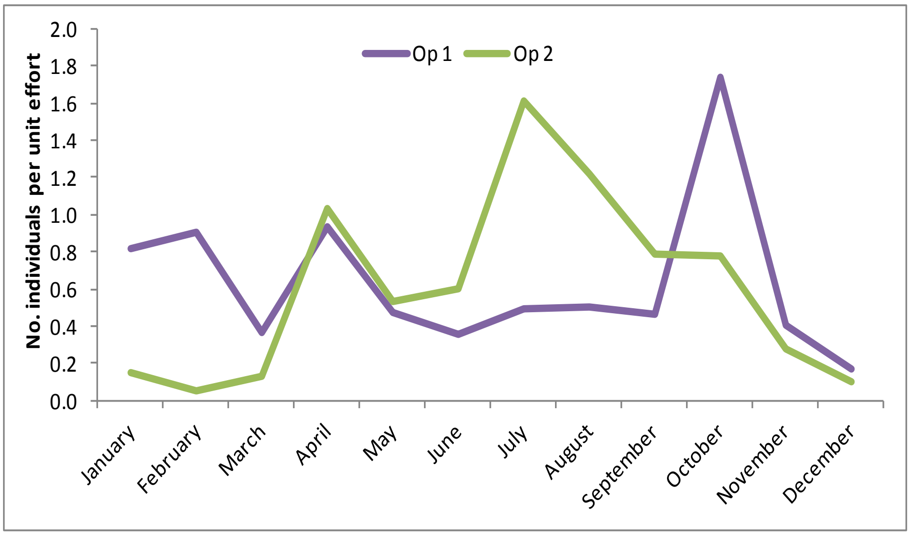


Figure 5.64: Mean number of guillemot observed during operational years one and two (in flight and on sea combined).

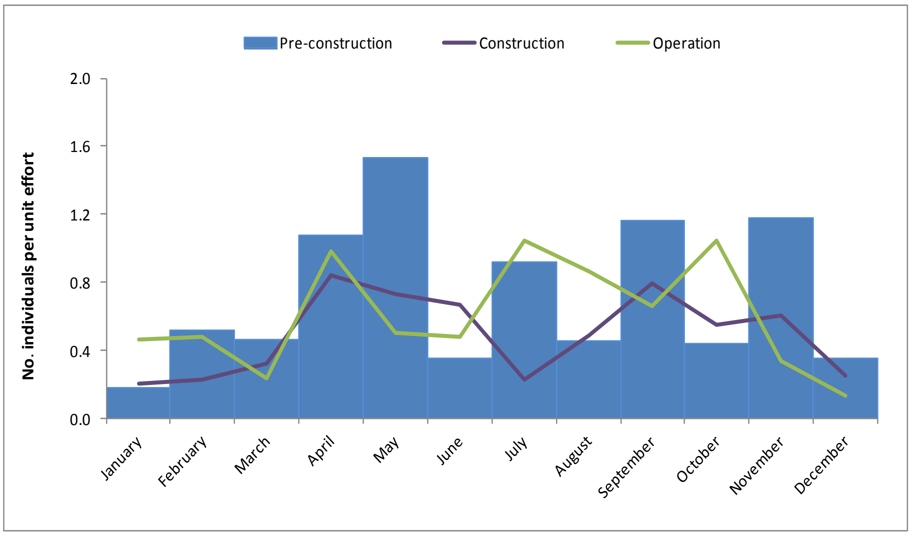


Figure 5.65: Mean number of guillemot observed per month during the pre-construction, construction and operational phases (in flight and on sea combined).

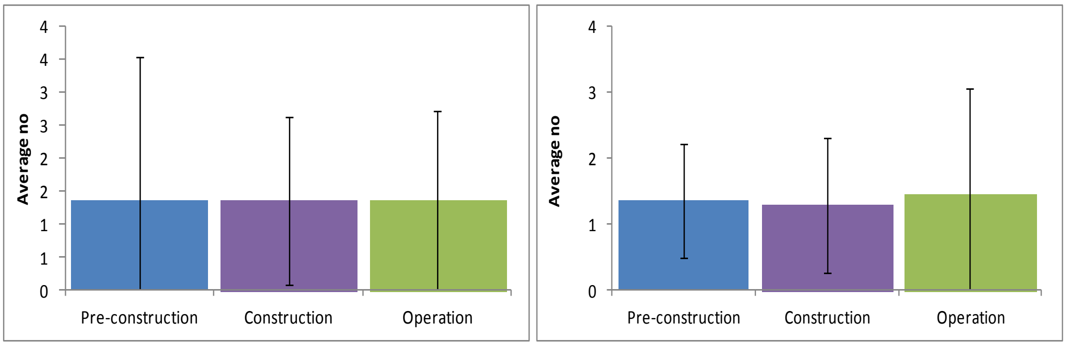


Figure 5.66: Mean number of guillemot observed per sighting on the sea (left) and in flight (right) during the pre-construction, construction and operational phases (±standard deviation).

Distribution

Guillemots were recorded throughout the survey area (for map of raw data see Appendix section 3.6). Density surfaces for guillemot for each of the three phases of the development can be found in Figure 5.67 to Figure 5.69. Higher concentrations of guillemots are associated with the deeper waters of the survey consistently through all phases of the development.

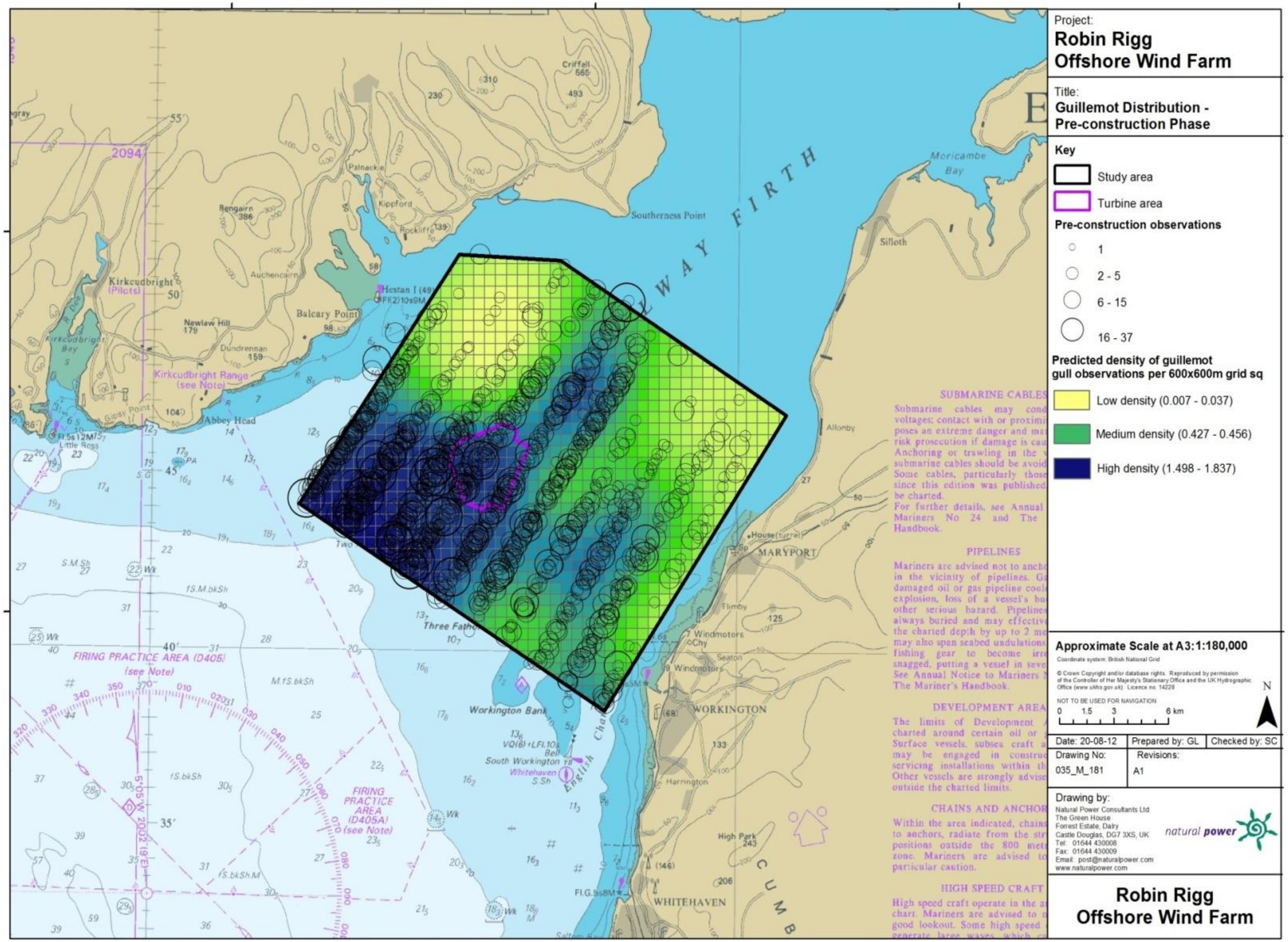


Figure 5.26: Density surface map of the predicted density of guillemot across the survey area during the pre-construction phase. Open circles show the locations of the raw observations.

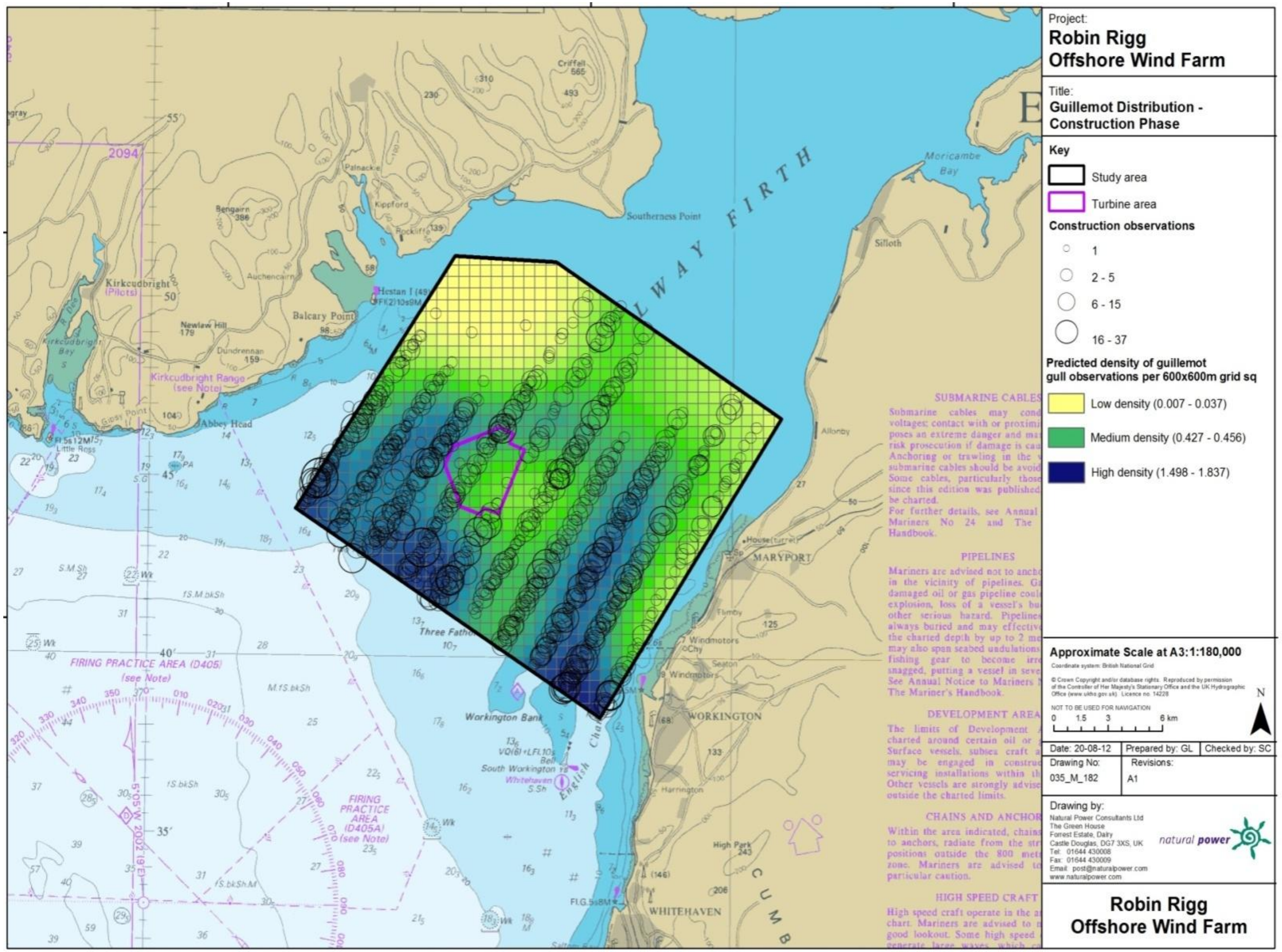


Figure 5.27: Density surface map of the predicted density of guillemot across the survey area during the construction phase. Open circles show the locations of the raw observations.

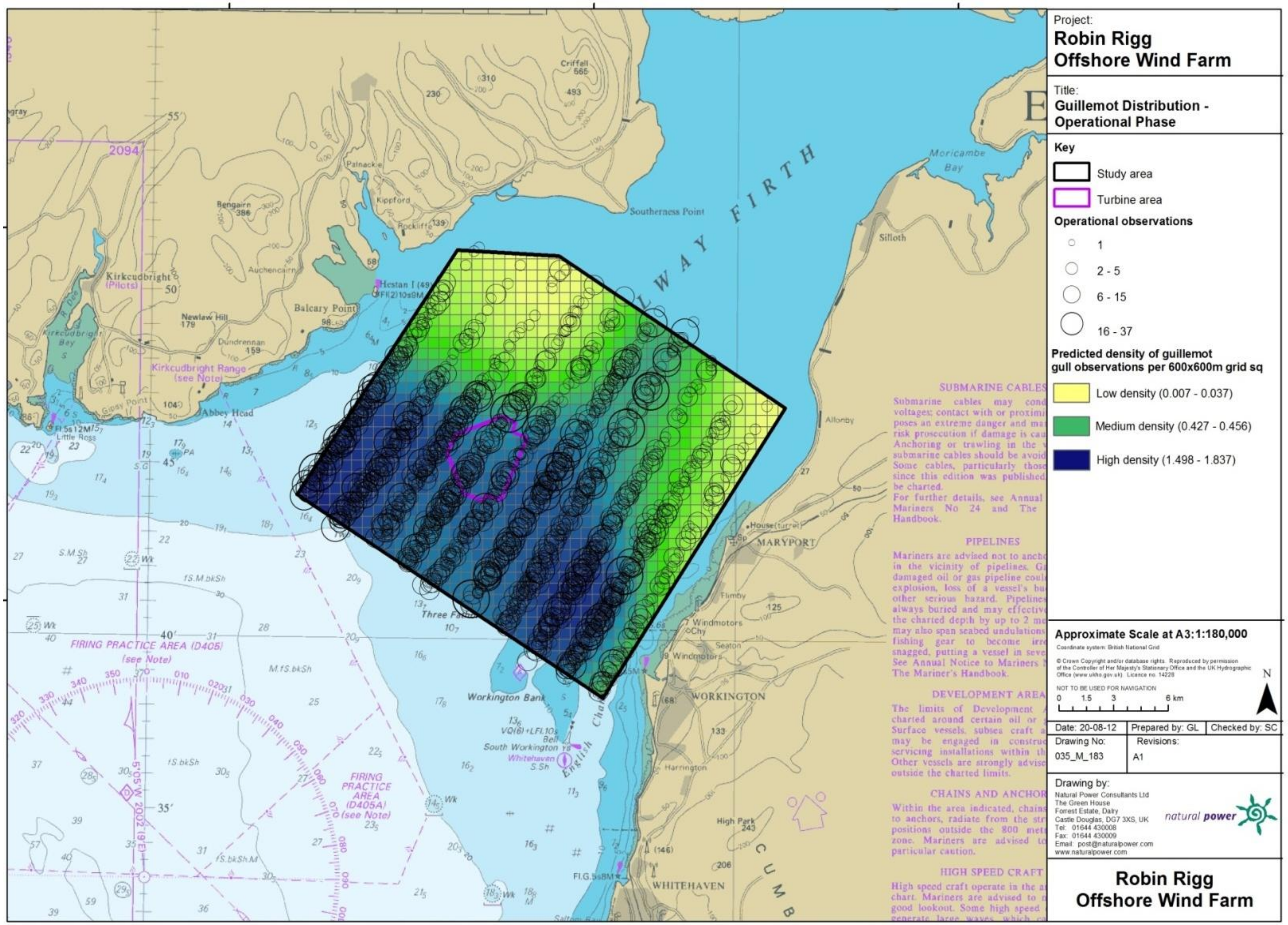


Figure 5.28: Density surface map of the predicted density of guillemot across the survey area during the operational phase. Open circles show the locations of the raw observations.

Collision risk

The percentage of guillemot recorded in different height bands relative to rotor height can be found in Table 5.25 and Figure 5.70. Band 4 (35-125 m) represents rotor height. No Chi-square test was carried out for this species as less than 1% of observed flights were at turbine rotor height and they are not considered to be at risk from collision.

Table 5.25: Proportion of guillemot recorded at different height bands through the three phases of development.

	Flight band (m)					
	1 (0–5)	2 (6–25)	3 (26–34)	4 (35– 125)	5 (126–200)	6 (200+)
Pre-construction	98.59	1.41	0	0	0	0
Construction	90.48	8.55	0.69	0.28	0	0
Operation	94.02	5.74	0.24	0	0	0

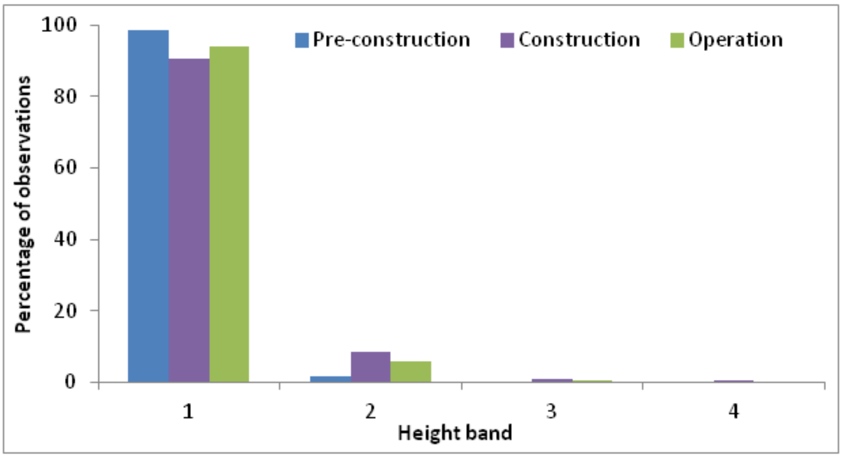


Figure 5.70: Percentage of guillemot recorded in different flight bands during the different stages of the development.

5.4.11. Razorbill

Monthly presence

The number of razorbills recorded during each phase of the development can be found in Table *5.26*. The raw data suggest a decline in abundance during the construction phase with a degree of recovery post-construction with slightly more birds recorded during operational year two compared to one (see Figure 5.71). Overall, the monthly pattern on abundance has remained consistent between phases (Figure 5.72) apart from during September when far more razorbill were recorded pre-construction compared to later years. The average group size recorded in each phase of the development can be found in Figure 5.73.

Table 5.26: Number of sightings of razorbill recorded during each phase of the construction of the wind farm. The numbers in brackets represent the number of individuals; SPUE = sightings per unit effort; IPUE = individuals per unit effort. Unit effort = 600 x 600m sampling block

	Pre-construction	Construction	Operational
No. Sightings (individuals)	691 (2196)	1235 (2957)	612 (1945)
SPUE (IPUE)	0.12 (0.38)	0.10 (0.24)	0.09 (0.30)

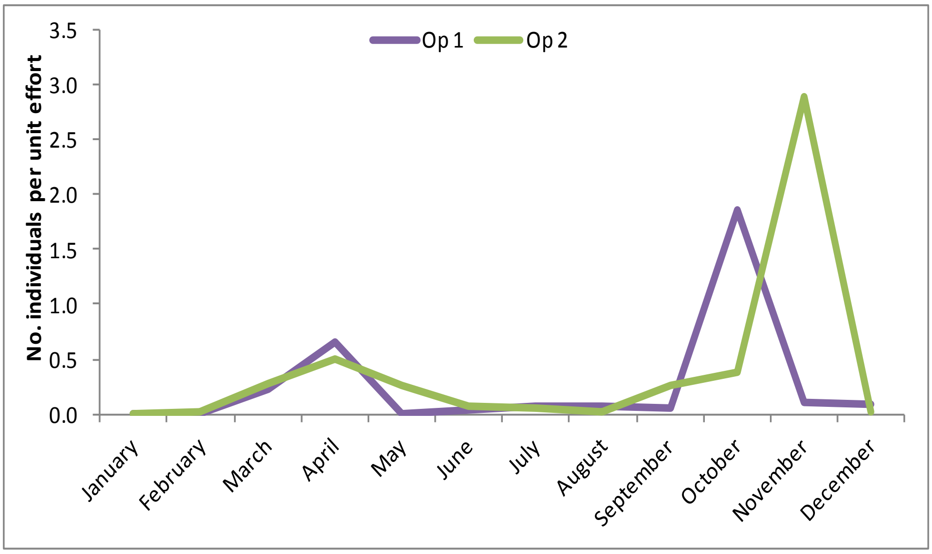


Figure 5.71: Mean number of razorbill observed during operational years one and two (in flight and in sea combined).

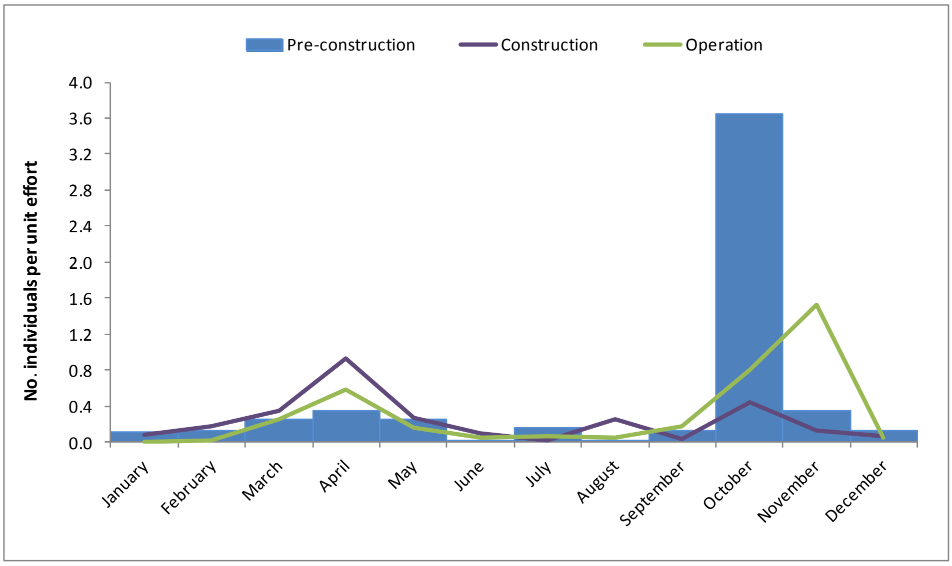


Figure 5.72: Mean number of razorbill observed per month during the pre-construction, construction and operational phases (in flight and in sea combined).

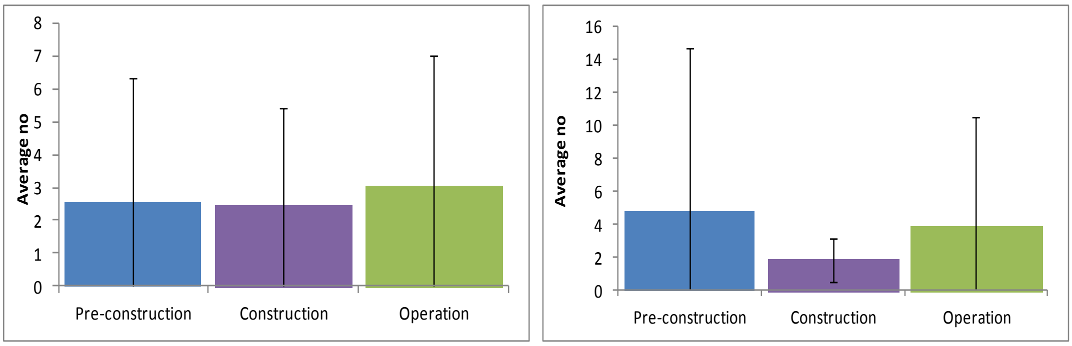


Figure 5.73: Mean number of razorbill observed per sighting on the sea (left) and in flight (right) during the pre-construction, construction and operational phases (±standard deviation).

Distribution

Razorbills were recorded throughout the survey area (for map of raw data (see Appendix section 3.6). Density surfaces for razorbill for each of the three phases of the development can be found in Figure 5.74 to Figure 5.76.

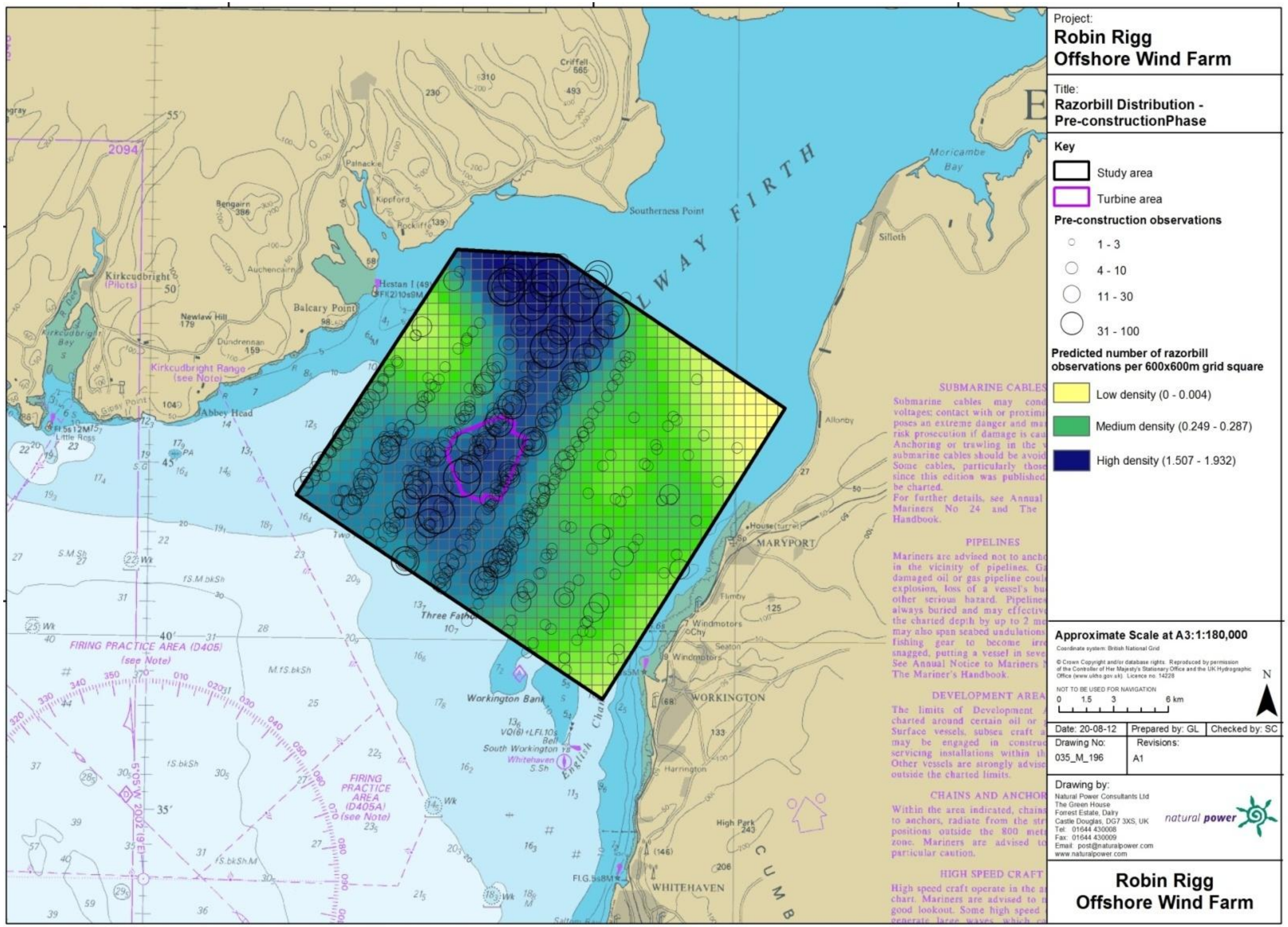


Figure 5.29: Density surface map of the predicted density of razorbill across the survey area during the pre-construction phase. Open circles show the locations of the raw observations.

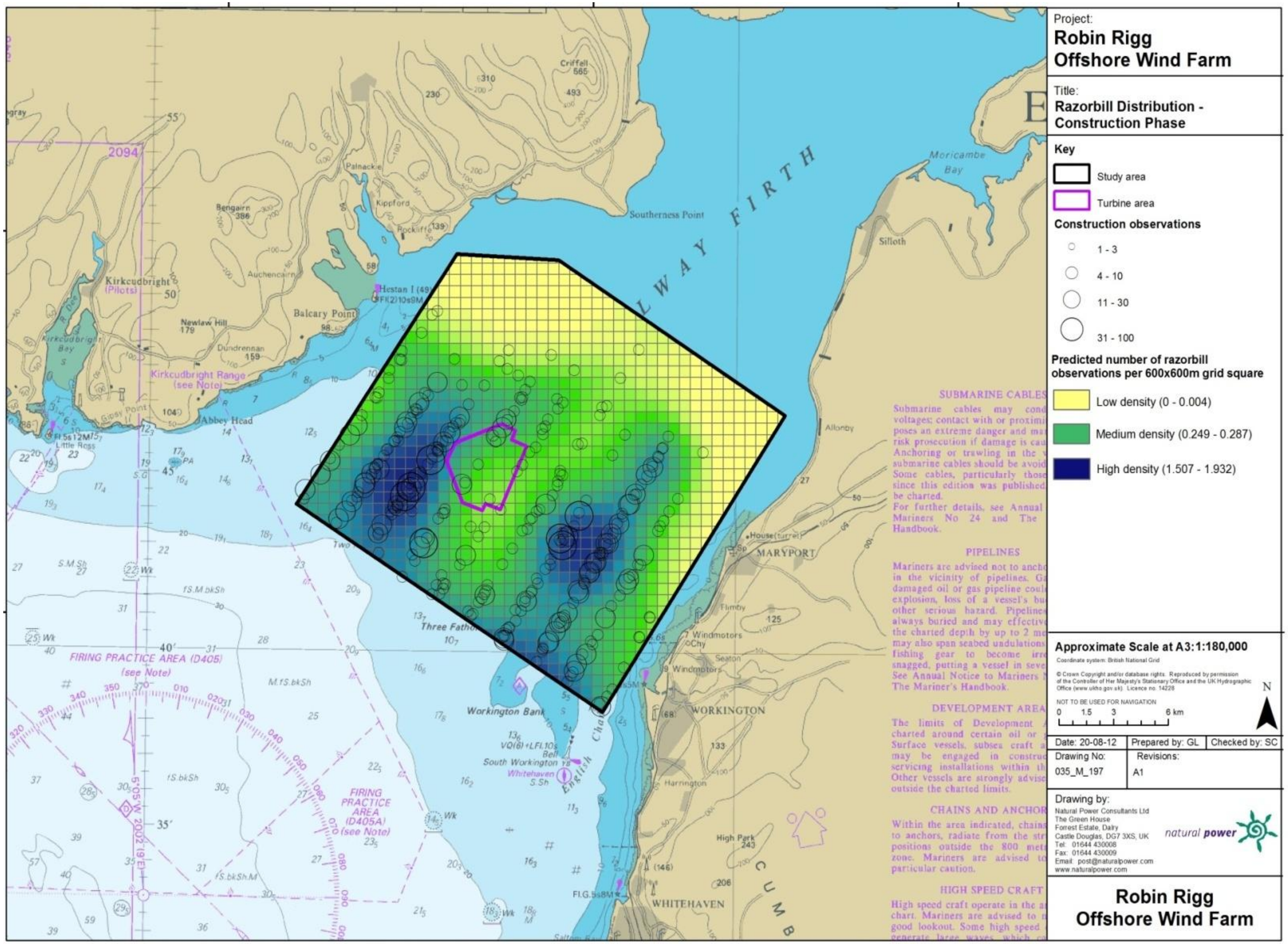


Figure 5.30: Density surface map of the predicted density of razorbill across the survey area during the construction phase. Open circles show the locations of the raw observations.

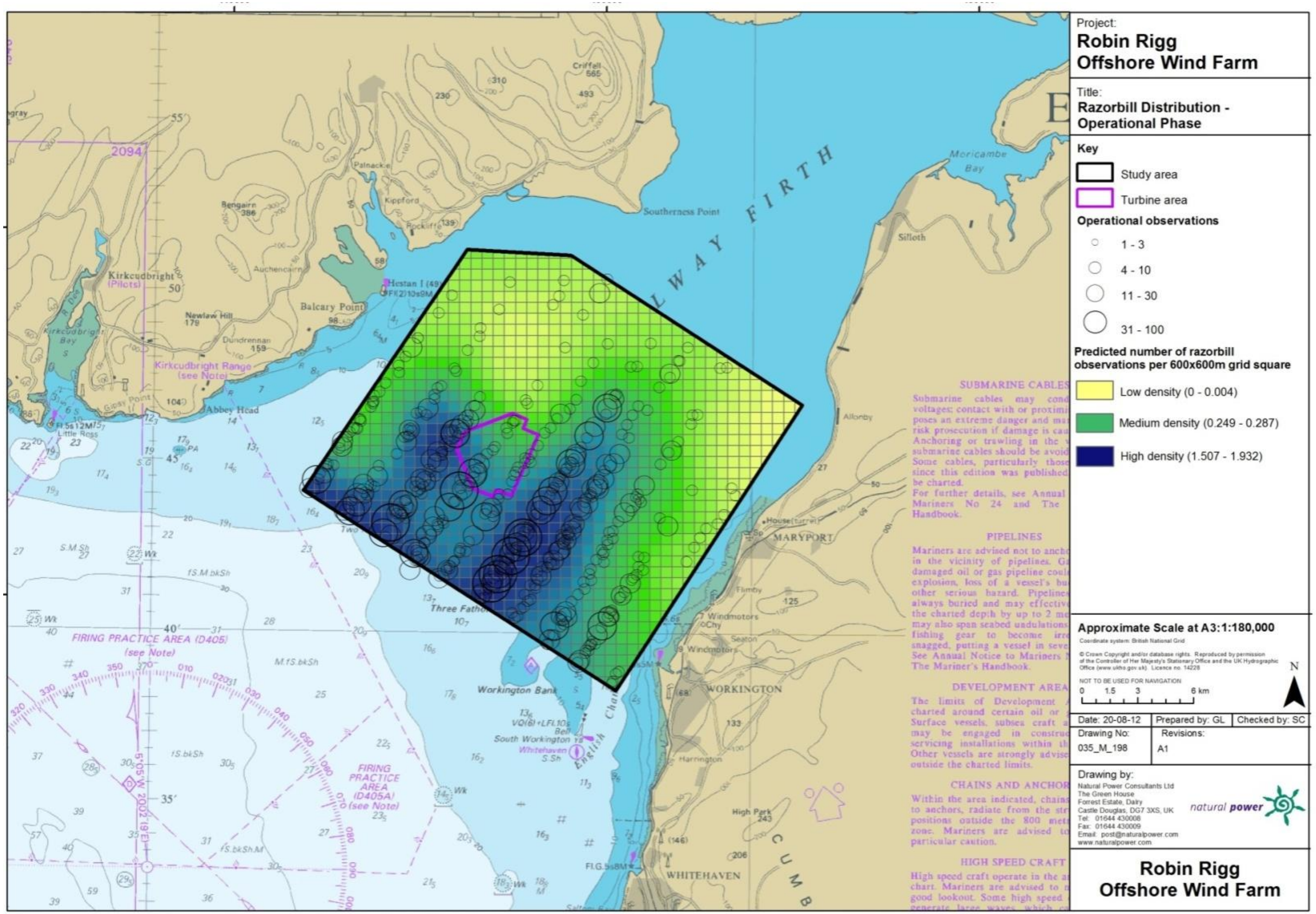


Figure 5.31: Density surface map of the predicted density of razorbill across the survey area during the operational phase. Open circles show the locations of the raw observations.

Collision risk

The percentage of razorbill recorded in different height bands relative to rotor height can be found in Table 5.27 and Figure 5.77. Band 4 (35-125 m) represents rotor height. No Chi-square test was carried out for this species as no flights were recorded at turbine rotor height and it was considered that this species is not at risk from collision.

Table 5.27: Proportion of razorbill recorded in different flight height bands through the three phases of the development.

	Flight band (m)					
	1 (0–5)	2 (6–25)	3 (26–34)	4 (35– 125)	5 (126–200)	6 (200+)
Pre-construction	99.57	0.43	0	0	0	0
Construction	91.20	8.80	0	0	0	0
Operation	94.44	5.56	0	0	0	0

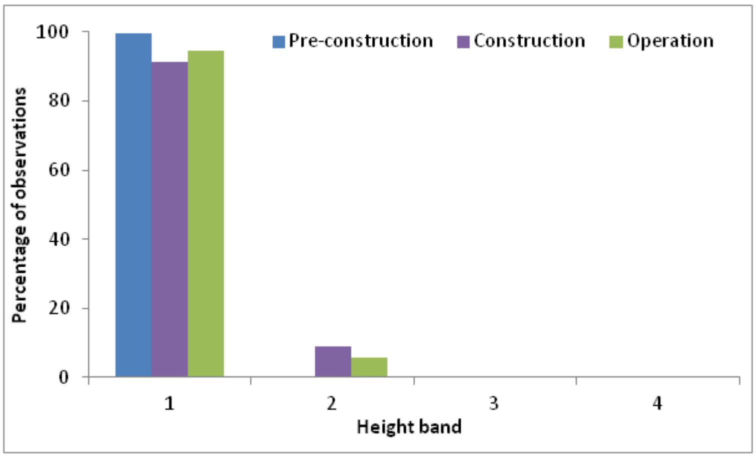


Figure 5.77: Percentage of razorbill recorded in different flight bands during the different stages of the development.

5.5. Discussion

The analysis presented in this report represents an update on previous reports to include the operational year two data. The MEMP requires five years of bird data with a review after three. A full discussion will be conducted as part of the review next year, including comparisons with results from other developments. The discussion presented here is more of a summary of the results to date, highlighting key points for future discussion.

5.5.1. Species accounts

Scaup

Boat surveys conducted for the ES only recorded Scaup occasionally; with two of those reports (November/December) containing flock sizes of nationally important numbers. Scaup were commonly observed around the mouth of the River Nith (Quinn *et al*., 1993) and in the shallow depths of the southern edge of the Blackshaw bank. During the ES boat surveys, occasional winter flocks entered the study area, although all sightings were observed to the north of proposed site. None were seen within 500 m of the proposed site and only a single flock observed within 2 km.

No Scaup were recorded during operational year two. Operational report one reported that all Scaup sightings occurred during the winter (November to February). Lower numbers were recorded during the construction stage but as sightings were so few it was impossible to draw any conclusions from this observation. During the entire study period (2001 – 2012), there have only been 28 sightings meaning that it is impossible to conduct any statistical analysis for this species.

The majority of sightings through all three phases have consistently been to the north-west of the wind farm, close to the Scottish coast. None were recorded within the wind farm area during either the construction or operational phases of the development. All flying birds during observed during construction and operational years have been below 5 m.

Common scoter

Common scoter feed primarily on bivalves, but will also take molluscs and crustaceans. Boat surveys conducted for the ES found that scoter distribution was restricted to the north-west of the study area with only a few recorded in the area of the proposed wind farm, coinciding with prey availability. Scoter were recorded in nationally important numbers with a dip in abundance during the winter. Peak observations were during August and September, during their pre-moult build up. Very few observations were made within 2 km of the proposed development. Collision risk analysis was performed as part of the ES, predicting an annual collision rate of 3.4, representing 0.3% of overall annual mortality.

Operational year one report illustrated that scoter distribution through the three phases of the development remained consistently close to the northern shore of the Solway. They were consistently recorded through the year, with peak numbers occurring during the summer and autumn. Analysis suggested a decline in scoter numbers during construction and greater drop in operational year one compared to pre-construction numbers. Fewer scoters were recorded in operational year two compared to one. The majority of observations of birds in flight were below 25 m during all phases of the development.

Red-throated diver

Red-throated divers are generalist feeders taking range of fish species including cod, herring and sprat. The size of prey taken is usually small although fish up to 25 cm are taken (Cramp, 1998). They are generally considered to be winter/spring visitors to the Solway Firth.

Data presented for the ES showed that divers were scattered throughout the study area with no particular concentrations, although there was a tendency for red-throated divers to occur in relatively shallow waters (5-10 m) compared to other diver species, moving out with the ebb tide to this maintain depth. Collision risk analysis was performed and predicted an annual collision rate of 3.3, representing 22.8% of overall annual mortality.

The operational year one report demonstrated that red-throated divers are seen throughout the year with greatest numbers recorded consistently during September, although numbers recorded during construction and operational year one were lower than those recorded for September pre-construction. Sightings were distributed throughout the survey area with high concentrations closer to southern shore and inner northern shore. A simple GLM suggested a decrease in numbers during the construction phase, increasing again during operational year one. The majority of flying birds were recorded below rotor height in all three phases although more were recorded in band 3 (26-34 m) during operational year one than in earlier phases.

Although numbers of red-throated diver observed during operational year two was lower than that recorded during year one, the overall abundance for the operational phase is still greater than that observed during construction. A small number of birds have been recorded at rotor height but the majority in all phases were below 25 m.

Manx shearwater

Boat surveys conducted for the ES only found Manx shearwater in the study area during the summer, with few recorded before late June and numbers declining by early August. They were mainly observed to the south and west of study area over relatively deep water. Almost no birds were seen in the northern and eastern parts of the study area. The largest gatherings were observed around high water on spring tides and birds were noted as leaving the study area as the tide ebbed. Although some birds were recorded in the vicinity of the proposed wind farm, the majority occurred 3-5 km away.

The summer occurrence of Manx shearwater was consistent through all phases of the development with the majority of sightings occurring between July and September. The data suggest a decrease in numbers during the construction phase, decreasing again during operational year one. A simple GLM found a decrease in numbers between construction and operational year one. Similar numbers were recorded in operational year two as in year one. Through all three periods of the development, sightings have been associated with areas of deeper water. All recorded flights were below 25 m.

Gannet

Boat surveys conducted as part of the ES found that gannet were most abundant during the summer months with a peak in late august. Only sporadic records were made between October and May. Sighting distribution was fairly evenly distributed though the study area apart from the shallow waters to the north-west. Numbers observed within the wind farm area were low, with more sightings occurring 2-5 km away from the development area.

Analysis in the operational year one report suggested a decline in gannet numbers during construction and continuing into operational year one. More gannet were observed during operational year two compared to one although these numbers are still slightly lower than those recorded pre-construction. More observations of birds flying at rotor height were reported during the operational phase compared to earlier phases of the development but 85% of sightings were below 25 m.

Cormorant

Two cormorant breeding colonies can be found within the Solway Firth, one at Portline (numbers pre-construction of international importance); and another at Balcary (numbers pre-construction of national importance). Surveys conducted for the ES generally found low numbers of cormorant within the survey area, with higher numbers recorded during the summer. It was considered that the study area represents part of the foraging area for birds at colonies between Port O' Warren and Balcary Point. The distribution of observations coincided with the location of the main breeding colony, with greatest numbers observed north-west of the study area. Small concentrations were observed adjacent to the wind farm area, thought mainly thought to be the result of birds roosting on a meteorological mast. Generally it was considered that the wind farm area didn't form an important part of cormorant range.

Analysis of operational year one data suggested an increase in numbers though the construction phase and in operational year one. Similar numbers were recorded in operational year two as year one suggesting this increase is being maintained. During the construction phase, the highest concentration of sightings coincided spatially with the construction area, suggesting a possible attraction to construction activities. During the operational years analysed to date, the spatial distribution of sightings shows the highest concentrations associated with coastal waters with a weaker concentration associated with the wind farm. Small numbers of flying birds have been recorded at rotor height although the majority of observations were below 25 m.

Kittiwake

Observations collected for the ES showed high occurrence during the spring and summer with numbers dropping during the winter months. Distribution was fairly even across the survey area with no particular concentrations reported.

The operational year one report found evidence of a decline in kittiwake numbers during construction and a possible recovery during operational year one. Monthly numbers of kittiwake observed during both operational years were similar although compared to pre-construction data they appear to be lower during the spring. No change in distribution between the construction phases is apparent and the majority of flying birds were observed flying below 25 m although a very small number have been recorded at rotor height.

Herring gull

Herring gulls have not been examined in previous reports nor were they discussed in detail within the ES although it was noted that they were present within the Solway Firth in nationally important numbers. It was decided to include them in this report as it has been suggested that gulls are potentially at a higher risk from collision with turbines than other species being investigated.

Herring gulls were recorded throughout the year with the greatest numbers recorded in the spring. Preliminary analysis suggested a decline in numbers during the construction and operational phases. The density surface map suggest a high concentration of herring gull developing around the operational wind farm, suggesting attraction to the turbines, possible as a roosting site. A number were observed flying at rotor height with greater numbers observed at this height during the operational phase compared to earlier years.

Great black-backed gull

As with herring gulls, great black-backed gulls have not been examined in previous reports nor were they discussed in detail within the ES.

Great black-backed gulls were recorded throughout the survey area and throughout the year with peak numbers observed during the winter. Preliminary analysis of the data suggests an increase in occurrence during the operational phase of the development with similar numbers recorded during both operational years. Unlike herring gull, the density surface maps suggest that great black-backed gulls are not being attracted to the wind farm. Around 15% of flying birds were observed at rotor height during both the construction and operational years.

Guillemot

Guillemot breeding colonies can be found within the Solway Firth at Balcary, with numbers of breeding pairs in regionally important numbers pre construction. Observations in the study area prior to the ES showed high abundance during the spring and summer with numbers declining from July onwards as birds leave the breeding colonies. They were observed throughout the study area with high concentrations in the south-west corner were relatively deep water (> 10 m) occurs close to the Scottish breeding colonies.

Analysis of the operational year one data suggested a possible decline in abundance during the construction phase with a degree of recovery in operational year one although not to the same levels recorded pre-construction. More birds were observed in operational year two than one although this increase primarily occurred in November. Distribution was more diffuse during the operational phase although guillemots still appear to prefer deeper waters. Virtually all flying birds were observed below 25 m.

Razorbill

Razorbills recorded as part of the ES were less abundant than guillemot but showed a similar pattern of occurrence with high numbers in the spring and summer. Their distribution was more evenly spread than that for guillemot with only the shallow waters at the northern edge of the survey area showing low occurrence. There appeared to be a tendency for both razorbill and guillemot to move out of the survey area with the ebb tide, possibly reflecting their preference for deeper waters.

Analysis of operational year one data suggested a decline in numbers during the construction phase with signs of recovery during operational year one although not to the same level as before construction. Similar numbers of razorbills were recorded in operational year two compared to one, maintaining the operational level. All sightings of flying birds were below 25 m.

5.5.2. General discussion

The Robin Rigg dataset is an extremely valuable resource providing an important contribution to our knowledge of the impacts of offshore wind developments. E.ON and NPC has recognised this and from the beginning, have aimed to analyse this dataset in a way that allows us to get the most out it. Whilst our previous analyses have been thorough, it was known that more complex issues regarding these datasets needed to be addressed.

Analysis presented in the operational year one report (Report 035_R_NPC_EON_4) highlighted a number of issues that were evident within the data set and how it was necessary to develop new approaches to analysing the data, a process that is now underway. Preliminary data exploration demonstrates that individual models are required for each species but a number of issues apply to all. All of the data sets are zero inflated, some to such a degree that analysis is not possible (for example Scaup). For some species, the level of zeros may mean that it is possible to analyse only one set of data (on sea or in flight). It may be possible to combine the “on water” and “in flight” data sets but this will require further investigation to confirm. Spatial autocorrelation is another problem common to all datasets and a number of the species have outliers which require further investigation. Analysis undertaken for marine mammals (see Chapter 6) are using a two-step modelling approach, a similar approach may be appropriate for birds.

Previously, analysis has incorporated Distance Sampling to allow estimation of densities. However, the use of another modelling technique introduces additional uncertainty into the analysis meaning that patterns are less likely to be detected. In addition, Distance Sampling cannot account for undetected individuals that result in zero counts, which for some species is a possibility in our analysis. As the fundamental purpose of the MEMP was to record any “changes” (as opposed to absolute numbers) in the ecological environment as a result of the wind farm, it was decided not to incorporate Distance Sampling into this round of analysis.

Data collection methods applied at Robin Rigg differ slightly from those commonly used today. Although a standardised method for collecting seabird data was first proposed in 1984 (Tasker *et al*., 1984), standardised methods for data collection at offshore wind farm developments were not produced until 2004 (Camphuysen *et al*., 2004), three years after data collection began at Robin Rigg. In order to allow comparisons to be made between the different phases of the development, the methodology originally implemented for the ES has been followed. This consistency between phases is essential if they are to be compared statistically. Additional data collection methods are now being implemented alongside the existing methods in order to collect data in a manner that corresponds with present best practices.

Collision risk to birds from offshore wind farms is a major concern when consenting projects, both at the individual level and the population level. Data presented in the ES found that only 5% of birds observed during the survey period were flying at a height greater than 20 m and would therefore be at risk if a turbine were present. Collision risk modelling was conducted for common scoter and red-throated diver as these species were highlighted as being present within the Solway in internationally important numbers and in both cases in was considered that the risk of collision would be very low

Examination of flight heights by target species has found that, as discussed in the ES, very few birds are flying at heights which could cause collision with the turbine blades. Of the 11 species examined, four had no birds flying at rotor height (Scaup, Manx shearwater, guillemot and razorbill) and three had less than 3% at rotor height (red-throated diver, cormorant and kittiwake) and are therefore not considered to be at risk.

Gannet were recorded at rotor height, with greater numbers recorded flying at rotor height during the operational phase than during the periods before, although this may be an artefact of data collection. It is notoriously difficult to judge how high a bird is flying without a point of reference (i.e. a turbine of known height). Given the low prevalence of gannets within the Solway Firth as a whole, it is considered that this species is at a low risk of collision at the population level.

Great black-backed gulls were the most prevalent at rotor height, with similar numbers for herring gull recorded. Significantly more herring gulls were recorded at rotor height during the operational years although the numbers for great black-backed gulls remained consistent. Similar results have been found at Horns Rev (Denmark) where it was suggested that these species were attracted to vessels associated with the wind farm or the possibility of roosting sites away from the coast (Zucco *et al*., 2006; Blew *et al*., 2008). Further analysis after the completion of operational year three will be conducted to investigate the risk of collision to birds.

5.6. Conclusions

- The Robin Rigg dataset is a valuable resource providing an important contribution to our knowledge of the impacts of offshore wind developments.
- Preliminary analysis suggests an increase in abundance for cormorant and great black-backed gull post-construction.
- A number of species (red-throated diver, gannet, kittiwake, guillemot, razorbill) exhibit possible decline during the construction phase with signs of recovery during the first two years of operation.
- Only Manx shearwater and common scoter show possible evidence of a decline in numbers but further analysis is required to confirm.
- Very few birds were observed flying at rotor height with herring gull, black-backed gull and gannet demonstrating the greatest risk although the numbers are still low.
- Preliminary data exploration demonstrates that individual models are required for each target species. This work is already under way and will be fully reported upon in the next report and in the publication of peer reviewed papers.
- A table summarising conclusions from each of the analysis reports produced to date can be found below.

Table 5.28: Summary of conclusions reported in this and previous analysis reports.

Ecological Group: Birds	Predictions from ES	Construction analysis	Operational year 1 analysis	Operational year 2 analysis
Common scoter	➢Some displacement expected (up to 800 m from wind farm area). ➢ Displacement from an area greater than 3 km required to influence national population. ➢ Collision impacts predicted to be low (3.4 birds per annum).	➢Some evidence for a decrease in birds across the whole survey area. ➢ Shift in focus of core areas for common scoter along the northern coastline in inshore areas. ➢ Changes unlikely to be linked to the Robin Rigg development.	➢ No indication of an impact on numbers observed on the sea within study area (pre vs. post). ➢ Some evidence for a decrease in number of flying birds (pre vs. post) but more data required to confirm.	➢Fewer birds recorded in Op 2 compared to Op 1. ➢No change in distribution. between phases. ➢Virtually all flying birds below 25 m - low collision risk.
Red-throated diver	➢ Some displacement expected (up to 800 m from wind farm area). ➢ Displacement from an area greater than 5 km required to influence national population. ➢ Collision impacts predicted to be low (3.3 birds per annum).	➢Across the survey area, more divers (all species) were observed in flight during the construction phase than pre-construction. ➢ Evidence for shift away from wind farm area during construction.	➢No overall decrease in numbers (pre vs. post), some evidence of a decrease in numbers within the wind farm site. ➢Wind farm area not used much prior to construction - impacts small.	➢Fewer birds recorded op 2 than Op 1 but overall, sightings higher compared to previous phases. ➢98% birds observed flying below rotor height.
Manx shearwater	➢ES survey work only recorded Manx shearwater in the Spring-Summer months (breeding season) with peak	➢Distribution similar between phases. ➢Some limited evidence for displacement during the construction	➢No evidence of difference in numbers on the water (pre vs. post) but a reduction in numbers in flight.	➢Increase in numbers from construction to operation phase. ➢ No birds observed flying

Ecological Group: Birds	Predictions from ES	Construction analysis	Operational year 1 analysis	Operational year 2 analysis
	counts between April and August.	period.		above 25 m.
Gannet	➢Predominantly recorded during the Spring-Summer (breeding season) with peak counts between April and October. ➢Observations evenly distributed across the survey area.	➢Evidence for a decrease in flight and on sea during the construction phase.	➢Decrease in numbers on the sea (pre vs. post) but not for birds in flight.	➢More observed in Op 2 compared to Op 1. ➢Small percentage observed flying at rotor height (4-9%).
Cormorant	➢Highest numbers recorded during the Spring-Summer with a focus in distribution in the north-west of the Solway. ➢The Solway population identified as medium sensitivity in the ES but with no significant impacts predicted.	➢Cormorant observations increased approximately three-fold both in flight and on the sea in proximity to Robin Rigg.	➢Increase in numbers in flight pre vs. construction. ➢Also in pre vs. post for both birds on the water and in flight. ➢Increased number within wind farm area during Op 1 although not as pronounced as for construction phase.	➢Numbers observed still higher than observed pre-construction. ➢Strong evidence for association with wind farm. ➢Less than 3% observed flying at rotor height.
Kittiwake	➢Highest numbers recorded in spring and summer (breeding season).	➢Possible indication of decrease in numbers during the construction phase.	➢Possible evidence of a decrease in numbers during construction and operation. ➢No clear evidence for changes in distribution relative to the wind farm area.	➢Numbers during operation now similar to those recorded pre-construction. ➢Less than 3% observed flying at rotor height.
Herring gull	➢Not discussed in detail within ES.	➢No analysis performed for this species.	➢Some evidence for a decline in numbers between pre and during construction.	➢Numbers still below pre-construction levels. ➢Possible evidence for association with wind farm. ➢ Potential collision risk – 16% observed flying at rotor height.
Great black-backed gull	➢Not discussed in detail within ES.	➢No analysis performed for this species.	➢Some evidence for an increase in numbers during all phases of	➢Numbers remain higher than pre-construction. ➢Few

Ecological Group: Birds	Predictions from ES	Construction analysis	Operational year 1 analysis	Operational year 2 analysis
			construction.	observations near wind farm. 16% observed flying at rotor height but generally, sightings not near wind farm.
Guillemot	➢Observed in the relatively deeper waters of the outer Solway. ➢Numbers were highest in spring-summer but with second peak in the autumn.	➢Evidence for a decrease in numbers in flight. ➢Evidence for a decrease on the sea during construction. ➢The data support partial displacement of away from the wind farm area during construction.	➢Decrease in numbers pre vs. construction. ➢Increase in numbers construction vs. operation.	➢Numbers remain consistent across operational years. ➢No birds observed flying at rotor height.
Razorbill	➢Less abundant than guillemot. ➢Distribution more even than that for guillemot.	➢No analysis performed for this species.	➢Decrease in numbers pre vs. construction. ➢Increase in numbers construction vs. operation.	➢Numbers continuing to increase in Op 2. ➢No birds observed flying at rotor height.

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