Arklow Bank Seabird and Marine Mammal Monitoring Programme

Year 7 Final Report: July 2006 to June 2007

Arklow turbine
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Report to Airtricity

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CORK ♦ ECOLOGY

Claire Pollock & Colin Barton

Long Strand, Castlefreke, Clonakilty, Co. Cork

Telephone 00 353 23 40665 or 00 353 87 2323 623
Website: www.corkecology.net E-mail: info@corkecology.net

Summary

Introduction

This report presents the results of survey work from Years 5, 6 and 7. Although Final Reports were produced for both Year 5 and Year 6, these did not contain distribution maps of seabird and marine mammals within the Study Area. This report also details results from a statistical analysis of all seven years of survey data from the Arklow Bank Seabird and Marine Mammal Monitoring Programme, covering three years of pre-construction baseline date, one year of data from the turbine construction phase, and three years of data from the operational phase, with 7 turbines in situ.

Methodology

The methodology used for Year 7 followed previous survey methodology. Seabirds and marine mammals were recorded using an adaptation of the standard Joint Nature Conservation Committee (JNCC) Seabirds at Sea survey method. Birds were counted ahead of the ship and out to the side usually in a 90º arc with a 300 m transect width. A snapshot method was used to assess densities for flying birds. In addition, the estimated height of flying birds was also recorded. This method complied with ESAS (European Seabirds at Sea) standards, and has also been used in surveys of the nearby Kish Bank and Codling Bank.

Statistical analysis was conducted on all seven years of survey data to assess the impact of the installation of the first seven turbines on the distribution and abundance of 12 key species. The key species selected were Red-throated Diver, Fulmar, Manx Shearwater, Gannet, Shag, Little Gull, Kittiwake, Arctic Tern, Common Tern, Guillemot, Razorbill and Harbour Porpoise. All statistical analyses were carried out using the R statistical package.

Results

Survey results from Years 5, 6 and 7 are presented as tables and maps, with a brief summary of the finding for each species. Three types of maps (density, abundance and sightings) were compiled to depict individual species abundance and distribution.

The three commonest species in the Arklow Study Area in Year 7 were Kittiwake, Guillemot and Razorbill, which together accounted for 66.3 % of all birds recorded. In Year 5, the three commonest species were Kittiwake, Little Gull and Common Gull, accounting for 78.4 % of all birds recorded, while in Year 6, Kittiwake, Guillemot and Razorbill were the three commonest species, accounting for 85.6 % of all birds recorded. Kittiwake was also the most frequently recorded species in Years 1-4.

The main findings of the statistical analysis carried out on all seven years of survey data were that a strong, statistically significant decline occurred in the numbers of Red-throated Divers on the outer Bank leg. This decline appeared to be strongly associated with the proximity of turbines. However, on the inner Bank leg, there was no evidence of a decline in Red-throated Divers numbers. The statistical analysis also found that although no strong trends in Harbour Porpoise numbers were obvious for any of the survey legs, a weakly statistically significant decline in Harbour Porpoise numbers was recorded on the inner Bank leg. However, there was no evidence that this decline was related to the proximity of the turbines.

Recommendations

Based on the results discussed in this report, it is recommended that:

- Seabird and marine mammal monitoring in the Arklow Bank Study Area should be continued, particularly in relation to the proposed future expansion of the Arklow Bank Wind Farm;
- Monitoring of the two key species highlighted here (Red-throated Diver and Harbour Porpoise) should be the priority, together with other potentially important species that can in large numbers such as Little Gull, Kittiwake, Guillemot, Razorbill and Common Gull.
- The revised survey route for the Bank area, with transect legs orientated perpendicular to the Bank, should be considered to allow for more powerful statistical analyses and total numbers in the study area to be calculated with confidence limits. If this new survey route is adopted, surveys of the Box and Cable routes should be discontinued;
- Plankton sampling should be discontinued, as to date no relationship between seabird abundance and prey abundance in the Arklow Study Area has been shown;
- The feasibility of establishing a control area distinct from the Arklow Bank, but with similar habitats and bird communities, should be examined, particularly in relation to the proposed future expansion of the Arklow Bank Wind Farm;
- The Year 7 Arklow Bank Seabird Monitoring Report should be published in the public domain, as it represents the first analysis of survey data gathered across the pre-construction, construction and early years of operation of the Arklow Bank Offshore Wind Farm.

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1. Introduction

In August 2003, Airtricity and GE began the construction of an offshore wind farm of 200 turbines on the Arklow Bank off Co Wicklow. The first seven turbines were installed between August and October 2003, and they became operational in June 2004. The turbines towers are 73 m high and the blades are 52 m long, with a minimum height of 21 m above the sea. An Environmental Impact Statement (EIS) was prepared in June 2001 in accordance with guidelines issued by the Department of the Marine (DMNR 2000). The EIS incorporated a full report on seabirds and marine mammals observed in the Arklow Bank Study Area between July 2000 and June 2001 (Coveney & Phalan 2001).

The Foreshore Lease for the development of the wind farm was granted by the Department of the Marine and Natural Resources in January 2002. Conditions in the lease specify that monitoring of species and habitats must continue during construction and for five years afterwards, with the aim of reporting on any significant impact on bird life or marine mammals, whether adverse or beneficial.

The EIS proposed an ongoing monitoring programme of seabirds and marine mammals. Following the first year of survey work for the EIS, Coveney Wildlife Consulting Ltd conducted monitoring for Years 2 to 5 of the programme (e.g. CWC 2006), with Fulmar Ecological Services managing the Year 6 monitoring programme (FES 2006). Cork Ecology have been managing the Arklow Bank seabird and marine mammal monitoring programme since October 2006 to date.

This report presents the results of survey work from Years 5, 6 and 7. Although Final Reports were produced for both Year 5 and Year 6, they did not contain distribution maps of seabird and marine mammals within the Study Area. This report also details results of statistical analyses conducted by Nigel Harding of Craigton Ecological Services on all seven years of survey data from the monitoring programme, covering three years of pre-construction baseline date, one year of data from the turbine construction phase, and three years of data from the operational phase, with 7 turbines in situ.

1.1 Arklow Bank Seabird and Marine Mammal Monitoring Programme

Overall Aim

To identify any significant adverse or beneficial impacts on birds and marine mammals caused by the Arklow Bank Wind Farm project and to distinguish these from natural variation. The main components of the Seabird and Marine Mammal Monitoring Programme are outlined below:

Boat Surveys

- Boat surveys of seabirds and marine mammals in the Arklow Study Area are conducted on a monthly basis;
- Plankton surveys are conducted at 10 sampling stations each month.

Seabird Colony Counts

- Annual surveys of breeding seabirds at Wicklow Head (e.g. Cork Ecology 2007a).

Review of Arklow Bank Seabird and Marine Mammal Monitoring Programme

- A review of the Arklow Bank Monitoring Programme was submitted to Airtricity in October 2007 (Cork Ecology 2007b).

2. Methods

2.1 Survey methods

The methodology used for Year 7 follows previous survey methodology (CWC 2006). In brief, seabirds and marine mammals were recorded using an adaptation of the standard Joint Nature Conservation Committee (JNCC) Seabirds at Sea survey method, which uses line transect methodology (see Webb & Durinck 1992 for further details). Birds were counted ahead of the ship and out to the side usually in a 90º arc with a 300 m transect width. Binoculars were used to confirm identifications as well as to scan ahead for species such as red-throated divers which are easily disturbed and take flight at some distance from the approaching vessel.

Birds on the water were assigned to distance bands (A = <50 m, B = 51-100 m, C = 101-200 m, D = 201–300 m, E =>300 m), according to their perpendicular distance from the ship's track. A snapshot method was used for flying birds, which takes the ship's speed into account and prevents overestimation of seabird densities. In addition, the estimated height of flying birds was also recorded. This method complies with ESAS (European Seabirds at Sea) standards, and was also used in surveys of the nearby Kish Bank and Codling Bank (Newton & Crowe, 1999, CWC 2002).

Marine mammals (seals and cetaceans) were recorded concurrently with the seabird surveys. Sightings were recorded using the same methodology as for birds on the water. Species, number of animals, direction and behaviour were recorded. All marine mammals and turtles on survey were noted regardless of the distance from the vessel.

Surveys were conducted on the M.V. Firehawk which has a platform fitted to attain an eye-height of 5m as recommended for ESAS surveys (Webb & Durinck 1992). In 2007, boat surveys were conducted by Dave Branagh, Eugene Archer and John Coveney.

2.2 Survey Route

There were a total of 7 survey legs in the Study Area which was divided into the "Bank" -legs 2 & 3; "Box" – legs 1, 11, 41, 42, 43, 44 and "Cable"- leg 5 (Figure 2.1). The legs were subdivided into 1 km sections.

The Bank survey legs were surveyed twice monthly while the Box survey legs were split into 2 groups (group 1-legs 1, 43, 44; group 2-legs 11, 41, 42) and surveyed in alternate months. The cable route was surveyed monthly.

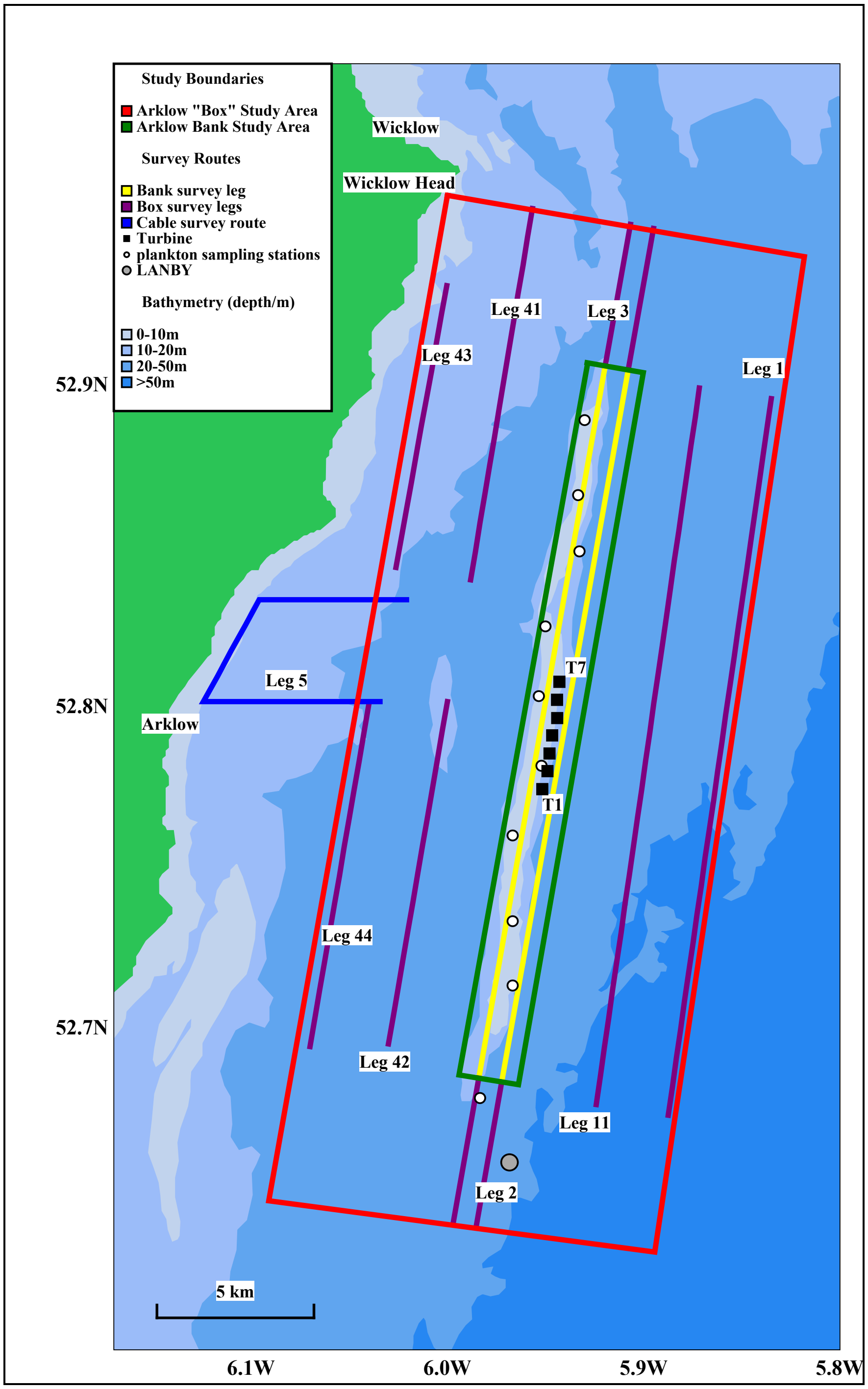
The Bank transects were surveyed using two observers, with one looking either side of the boat. For the Box and Cable Routes, counts were made by one observer, on one side of the boat with the second observer recording the data on the data sheets.

The survey legs have been modified slightly over the years and the changes are detailed in CWC (2006).

2.3 Plankton Sampling

In Years 5, 6 and 7, monthly plankton surveys were conducted at 10 sampling stations as in previous years. At each sampling station, a plankton net was towed behind the boat for ten minutes near the surface of the water. Any plankton collected was preserved in alcohol for later identification. The locations of the sampling stations are shown on Figure 2.1.

Figure 2.1 Map of Arklow Study Area



2.4 Weather conditions

A summary of survey weather conditions in Years 5, 6 and 7 is included in Appendix A. Wind direction and force, sea state, swell height and visibility were recorded at intervals throughout survey days. Surveys were carried out in good weather where possible, to maximise detection rates of birds and cetaceans on the water.

2.5 Data handling and analysis

The seabird and marine mammal data were entered onto a Paradox database, then printed and manually checked for any errors before an analysis of the data was conducted. Monthly abundance (no. of birds/km travelled) and density (no. of birds/km^2) estimates were calculated for the most commonly occurring species in the Study Area.

JNCC provided ESAS survey data from 1981 to 1998 for the Western Irish Sea for comparative purposes. These data are presented in section 3.2, summarised by the entire Western Irish Sea and also by the four ¼ International Council for the Exploration of the Seas (ICES) rectangles which the Arklow Study Area lies in.

2.6 Mapping strategy

Three types of maps (density, abundance and sightings) were compiled to depict individual species abundance and distribution, using the mapping package DMAP for Windows (Morton 2001).

Density Maps (birds/km^2)

This type of map was utilised for the most common species, defined as species with more than 1,000 birds recorded 'in transect' each year. This is defined as birds on the water within the transect area (i.e. within 300m), and flying birds included in snapshot. To account for decreased detection rates of birds on the water at increased distance from the ship, correction factors were applied to compensate for those birds missed. Correction factors were applied to birds on the water 'in transect'. As in previous years, correction factors from Stone *et al* (1995) were used.

Average densities for each ¼ ICES rectangle were calculated by dividing the total number of birds within a 300 m strip by the total area surveyed (See Webb & Durinck 1992 for further details). Monthly density maps were created, and depending on the distribution patterns, seasonal maps were compiled.

Abundance maps (birds/km travelled)

Abundance maps were used for less abundant species. All data including sightings of birds outside the 300 m band transect were utilised. Species with more than 100 birds but less than 1,000 'in transect' were mapped as abundance. An exception was Herring Gull, which had lower numbers, but was included as it had previously been mapped as abundance.

To calculate abundance for each ¼ ICES rectangle, the total number of birds was divided by the distance travelled. Again, monthly and seasonal abundance maps were compiled.

Sightings maps

For rare species (total less than 100 but more than 1 individual), incidental sightings were mapped.

2.7 Charts

In the species accounts, 2 types of chart are presented for the most common species.

Total numbers charts

As the Bank legs are surveyed twice per month, summing the total number of birds recorded per month would almost invariably result in double-counting. In order to get an estimate of the number of birds in the Study Area in each month, the peak number of birds on the Bank was calculated and this figure was presented in the numbers charts. Numbers of birds in the Box and Cable Route per month were also summed and added to the chart. By adding the figures on the chart for each month, a minimum estimate of the total numbers of birds in the Study Area can be calculated.

Because of the current layout of the transects, it was not possible to accurately extrapolate total numbers for the whole Arklow Study Area.

Abundance/density charts

These charts show the average monthly abundance (no. of birds/km travelled) or density (no. of birds/km^2) of species on the Bank and Box.

2.8 Methods of statistical analyses of data from Years 1 to 7

2.8.1 Analysis of key species

Previous reports have included assessments of the effect of the Arklow Bank wind farm on birds (e.g. CWC 2004). For this report, the impact of the installation of the first seven turbines on the distribution and abundance of 12 key species, selected from previous reports (CWC 2004), was analysed. The key species selected were Red-throated Diver, Fulmar, Manx Shearwater, Gannet, Shag, Little Gull, Kittiwake, Arctic Tern, Common Tern, Guillemot, Razorbill and Harbour Porpoise. The recording unit used was each individual survey where complete coverage of a leg during a single day was achieved. All statistical analyses were carried out using the R statistical package (Crawley 2007, Venables and Ripley 2002, R Development Core Team 2007). For each key species two questions were asked:

1) For each leg, has the total number of birds/porpoises recorded during an individual survey changed since the turbines were installed?

2) For the Bank legs (legs 2 and 3), has the relationship between the number of birds/porpoises and distance to the nearest turbine location changed since the turbines were installed?

In these analyses, changes in abundance and distribution with respect to three periods were considered:

1) Before installation: defined as before 1st August 2003.

2) During installation: defined as between 1st August 2003 and 30th June 2004.

3) After installation: defined as after 30th June 2004.

Bird numbers might change in the vicinity of a wind farm following the installation of turbines for many reasons, beside the installation of the turbines themselves. Therefore studies of the ecological impact of wind farms must be designed according to a Before-After-Control Impact protocol (Anderson et al. 1999), with trends (i.e. changes between Before and After) for the area potentially impacted by the turbines being compared with those observed on control areas, free of any such potential impact. In this study, the non-Bank legs could not be used as an effective control as they do not share comparable marine habitats and bird communities with the Bank, where the turbines have been installed. Therefore the approach adopted here was similar to that advocated by Fox et al. (2006) (e.g. see their figure two) and involved comparing the relationship between bird numbers and distance from the turbines before and after turbine installation. If turbines were responsible for an observed decline in numbers on a leg, then it might be expected that this decline would have been strongest in the immediate vicinity of the turbine locations. Conversely, if some other factor was responsible for the decline, then no such pattern would be expected. Effectively, the analysis considered areas more distant from the turbines, but still on the Bank, as control areas. This approach assumed that any impacts occurred at a spatial scale smaller than the length of the Bank legs.

The possibility cannot be eliminated that some of the changes in bird numbers identified in the species accounts below were artefacts generated by changes in methodology which have occurred during the course of this project (e.g. changes in survey vessel, changes in height of the viewing platform, changes in position of legs and changes in survey methodology such as whether or not a snapshot was used to count flying birds, and whether areas outside the transect were scanned). Thus, the analyses presented here should be regarded as tentatively identifying potential impacts worthy of further attention rather than categorically identifying actual impacts. It should be noted that as well as possibly generating artefacts, changes in methodology could potentially also have masked genuine impacts.

As noted in section 2.2, although the Bank and Cable Route legs (legs 2, 3 and 5) were usually surveyed on a monthly basis, the Box legs were surveyed bimonthly, with legs 1, 43 and 44 surveyed in one month, and legs 11, 41 and 42 surveyed the following month. As bird numbers are likely to vary considerably between months, this makes combining data from different legs in a single analysis problematic. For this reason, analyses have been carried out separately for each leg.

Coverage of legs has varied (Appendix B). Whereas Box legs 1, 11, 42 and 44 (Figure 2.1) were nearly always covered in their entirety, coverage of the Bank legs (legs 2 and 3), the Cable Route (leg 5) and Box legs 41 and 43 has varied considerably. Although the outer Bank leg (leg 2) was not covered at all from 13th September 2003 to 14 June 2004, on the dates it was surveyed, coverage was nearly always complete (Appendix B). However, the inner Bank leg (leg 3), Cable Route (leg 5) and Box legs 41 and 43 were often only partially covered, with the sections covered varying through time. This variation in coverage was another reason why separate analyses were carried out for each leg.

For legs where partial coverage was common, the requirement for complete coverage resulted in large amounts of data being rejected from the analyses. Therefore, for these legs, as well as carrying out analyses based upon surveys where full coverage of the whole leg was achieved, separate analyses for cases where full coverage of a predefined subsection of the original leg was achieved, were also conducted. These subsections were chosen so as to maximise the amount of data retained, and also to coincide with the larger recording units used in project Year 1, allowing data from this year to also be included. Thus, analyses were conducted based upon surveys that achieved:

- Complete coverage of km 11-30 of the inner Bank leg (leg 3);
- Complete coverage of km 10-15 of the Cable Route (leg 5);
- Complete coverage of km 1-5 of the Cable Route (leg 5);
- Complete coverage of km 6-13 of Box leg 41;
- Complete coverage of km 3-10 of Box leg 43.

To ensure compliance with the standards recommended by COWRIE (Camphuysen 2004) observations made in sea states above 4 for seabirds and 3 for marine mammals were excluded from all analyses. Data collected on 13th January 2005 with a transect width of 600 m, and a 180° field of view were also excluded from all analyses, as were data collected on 27th March 2007 with a 200 m wide transect. Thus, all data included in analyses was collected with a 300 m wide transect, and a 90° field of view. For part of the outer Bank leg (leg 2) on 12th September 2003, only Little Gulls and Kittiwakes were counted, so this data was excluded from all analyses for other species.

As noted earlier, survey methods have varied during the project, with snapshots to record flying birds within the transect, and scans beyond the transect being used on some surveys and not others. One approach to avoid any potential biases caused by changes in methodology would have been to only include records for birds on the water in transect in analyses. Although this might have been a suitable approach for common species within the study area that spend a high proportion of their time on the water (e.g. auks) many species with which we are principally concerned were either too uncommon (e.g. Harbour Porpoise) or else too aerial (e.g. Kittiwake and Little Gull) for this to be a viable approach. Therefore, in the following analyses all records of a species, whether or not in flight, and whether or not inside the 300 m wide transect were included. This should have minimised any biases that might have occurred in the number of flying birds recorded on account of whether or not a snapshot was used. However, more birds would be recorded when a scan beyond the transect is employed than when it is not. This needs to be borne in mind when interpreting the results presented below.

In later years, two observers have generally conducted counts on Bank legs, with one observer counting birds in the direction of the Bank, and the other observer generally counting birds in the other direction. In earlier years, when a single observer was employed on the Bank legs, the direction they were facing has not generally been recorded, although it seems probable that they would have been facing the Bank. Therefore, in analyses assessing the impact of turbine installation for Bank legs, when data using two observers facing towards and away from the Bank was available, the data collected by the observer facing the Bank has been used.

2.8.2 Analysis of plankton abundance and seabird abundance

Plankton samples have been collected in the Arklow Study Area since Year 1. In Year 1 samples were taken in and around flocks of Kittiwakes and Little Gulls with other samples taken away from any such flocks, for comparison. From Year 2 on, 10 sampling stations were assigned along the Bank. Each month, after the bird survey of the Bank legs, the plankton samples were taken. In addition, birds around the boat were recorded while the plankton net was being towed. At first, birds up to 300 m from the vessel were recorded but since December 2005 only birds within 50 m of the boat were recorded. Cork Ecology have recently collated all years of data into a central database for analysis. Where possible, bird data were linked to the plankton data.

It is only worthwhile continuing with the collection of plankton data if it helps explain and predict bird numbers. As surface feeders, Kittiwakes and Little Gulls will potentially exploit plankton as a food source. The analyses considered the relationship between their abundance and that of the two most common taxa within the plankton samples, Northern Krill and Sea Gooseberries.

Two data sets were used for bird numbers. The first of these were point counts made at the time the samples were collected. For these point counts, initially birds within 300 m were recorded but from December 2005 only birds within 50 m of boat were recorded. Secondly, on some dates, one or more of the Bank legs was surveyed on the same date that the plankton samples were collected. Each plankton sampling location has been associated with the 2 nearest km on the Bank legs. Usually both km for a particular sampling location were on the inner Bank leg (leg 3), but for samples 6 and 9 one km was taken from each of the Bank legs. The analyses only used plankton data collected at the 10 standard sampling positions. The analyses considered the relationship between bird and plankton abundance at three different spatial/temporal scales and asked the following questions:

On a particular date, were bird numbers highest at those sampling stations with the highest plankton abundance? Thus, this was looking for correlations at a spatial scale of c. 2-3 km (the distance between the sampling stations). If data from the point counts was used then bird data was collected at the same time as the plankton data. If data from the Bank legs was used, then the bird data was collected on the same day. Thus, if plankton abundance at different points on the Bank was fluctuating asynchronously on short time scales, and if birds were responding to these fluctuations, then it may be that the analyses using point counts would find a relationship between the plankton abundance and bird abundance, whereas the analyses based upon the survey legs would not, because by the time the bird survey took place the plankton, and birds would have changed location.

For analyses using data collected on Bank legs as the source of the bird data, we only considered sampling stations for which both associated bird km were covered on the same date as the plankton sample was collected, and dates for which such data was available for 7 or more of the 10 standard sampling locations. For analyses using point counts carried out at the same time as the plankton was collected as the source of the bird data, we only considered dates for which point count bird data was collected, and on which all 10 sampling stations were covered. Additionally, for both sources of bird data, dates for which no birds of the species under consideration were seen, or no plankton of the species under consideration where recorded were also excluded.

On different dates, was the total numbers of birds recorded summing across sampling stations related to the total abundance of plankton present? A significant relationship might be obtained at this spatial/temporal scale but not at the previous spatial scale if plankton abundance at particular points on the bank changed so rapidly that bird abundance did not track these local fluctuations, but on dates where more plankton was present on the bank as a whole, more birds were present.

Sampling stations 6 and 9 were excluded from this analysis because only on a small proportion of dates were both associated bird km covered on the same date as the plankton sample was collected. Dates were only included in this analysis if suitable data was available for all 8 other standard sampling stations. This analysis could only be performed using the bank survey data because the change in the distance from the boat at which birds were counted in the point count data means that data from different dates is not comparable.

Did sampling stations which, on average, had high plankton abundance have, on average, high bird abundance? A relationship might be found at this spatial/temporal scale if plankton abundance fluctuated greatly through time at different positions on the bank, and if these fluctuations were too rapid for birds to track them, but birds tended to feed at positions on the bank where, on average, plankton abundance was higher.

For the same reasons as for the previous analysis, sampling stations 6 and 9 were excluded, and this analysis could only be performed using the bank survey data. Again, dates were only included in this analysis if suitable data was available for all 8 other standard sampling stations.

3. Results

3.1 Survey effort

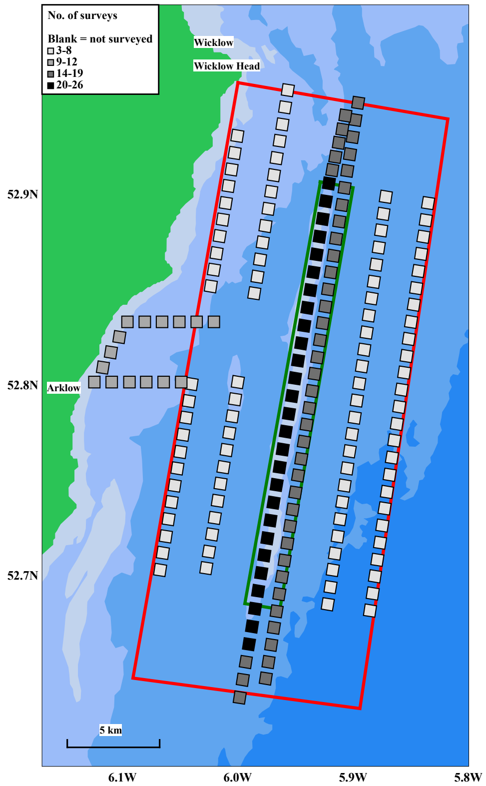
A summary of survey effort for Years 5, 6 and 7 is shown in Table 3.1. Figure 3.1 shows the survey coverage (number of surveys) in the Arklow Study Area in Years 5, 6 and 7.

Table 3.1 Survey effort for the Arklow Bank Study Area for Years 5, 6 and 7

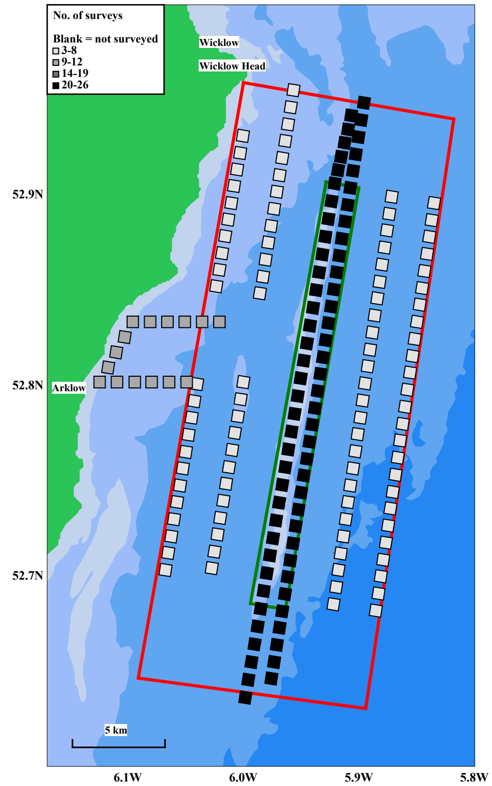
Area	No. of survey days	Km surveyed (all days)	Area surveyed in km² (all days)	Area size (km²)
Year 5 (July 2004 –June 2005)				
Bank	27	1,980.94	594.28	40
Box	29	986.68	296.00	360
Cable route	16	144.00	43.20	18.3
Total	**31**	**3,111.62**	**933.49**	**418.30**
Year 6 (July 2005 – June 2006)				
Bank	22	2,122.95	636.88	40
Box	28	1,324.36	397.31	360
Cable route	19	162.00	48.60	18.3
Total	**31**	**3,609.31**	**1,082.79**	**418.30**
Year 7 (July 2006 – June 2007)				
Bank	24	2,313.98	694.19	40
Box	27	1,409.61	422.88	360
Cable route	18	167.00	50.10	18.3
Total	**27**	**3,890.59**	**1,167.18**	**418.30**

Figure 3.1 Survey effort in the Arklow Study Area in Years 5, 6 and 7

Year 5



Year 6



Year 5

Survey effort in Year 5 was highest on the inner Bank leg, with between 20 and 26 surveys completed. The outer Bank leg received slightly less coverage, with between 16 and 19 surveys. The Cable Route was covered between 9 and 12 times, while each Box leg was covered every second month, subject to weather.

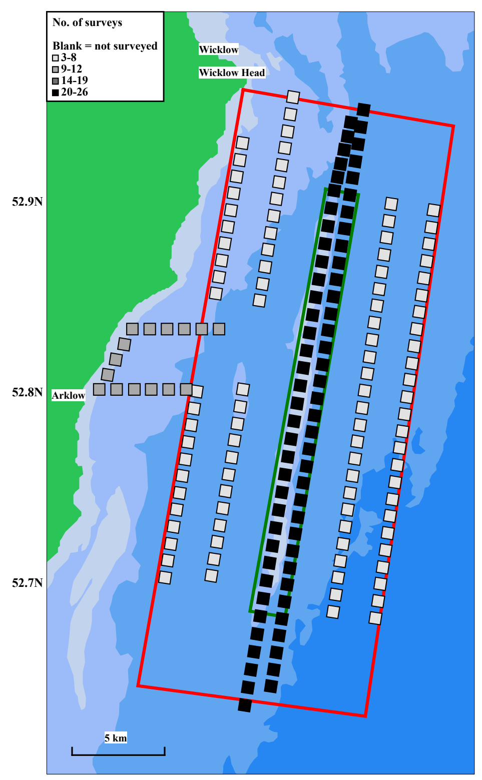
Year 6

Survey effort in Year 6 was similar to Year 5, although coverage of the outer bank leg was higher, with between 20 and 26 surveys completed. Survey effort elsewhere was similar to Year 5.

Year 7

Year 7 survey effort was similar to Year 6.

Year 7



3.2 Raw numbers of seabirds in the Arklow Study Area in Years 5, 6 and 7

A total of 28 species of seabirds were identified on surveys in Year 7. This compares to 26 species in Year 5 and 29 species in Year 6. A total of 34 seabird species were recorded during Years 5, 6 and 7 combined.

Totals for the most common seabird species for Years 5, 6 and 7 are shown in Table 3.2. The three commonest species in the Arklow Study Area in Year 7 were Kittiwake, Guillemot and Razorbill, which together accounted for 66.3 % of all birds recorded. In Year 5, the three commonest species were Kittiwake, Little Gull and Common Gull, accounting for 78.4 % of all birds recorded, while in Year 6, Kittiwake, Guillemot and Razorbill were the three commonest species, accounting for 85.6 % of all birds recorded. Kittiwake was also the most frequently recorded species in Years 1-4.

Table 3.3 summarises the occurrences of a further 19 species of seabirds which were less frequently recorded in the Arklow Study Area.

To put these results into context, JNCC data from the four ¼ ICES rectangles which encompass the Arklow Study Area, and from the western Irish Sea is shown in Tables 3.4 and 3.5.

3.2.1 Non-seabird species recorded in the Arklow Study Area in Years 5, 6 and 7

A total of 17 birds of seven non-seabird species were recorded in the Arklow Study Area in Year 7. In Year 6, 80 birds of seven non-seabird species and two unidentified species groups were recorded, while in Year 5, 86 birds of four non-seabird species and two unidentified species groups were recorded.

Just under half of all non-seabirds recorded were Swallows (49.7 %), with just under a quarter were Starlings (22.4 %). The remaining species recorded were Brent Goose, Shelduck, Merlin, Oystercatcher, Ringed Plover, Purple Sandpiper, Dunlin, Whimbrel, Swift, Skylark, Swallow, House Martin, Goldcrest, Starling, Chaffinch, unidentified pipit species and unidentified thrush species (Appendix C).

Table 3.2 Numbers of the most common seabirds recorded in Years 5 to 7 (> 100 birds)

Species	Year 5		Year 6		Year 7		Total number
	Number	No. of days	Number	No. of days	Number	No. of days	
Red-throated Diver	212	14	226	15	85	11	523
Fulmar	54	15	172	14	42	12	268
Manx Shearwater	2,146	20	2,750	17	2,676	17	7,572
Gannet	292	21	278	22	294	23	864
Cormorant	36	10	51	15	41	10	128
Shag	480	26	415	22	187	18	1,082
Little Gull	10,266	21	5,582	10	3,641	17	19,489
Black-headed Gull	1,973	16	673	11	386	15	3,032
Common Gull	6,955	17	4,607	18	880	21	12,422
Herring Gull	31	15	75	19	68	13	174
Great black-backed Gull	11	5	45	13	83	16	139
Kittiwake	51,396	30	56,563	28	29,939	27	137,898
Common Tern	21	4	789	8	111	8	921
Guillemot	6,389	31	15,084	31	10,499	27	31,972
Razorbill	2,975	29	7,010	29	6,146	27	16,131
Small Gull Species [1]	41	2	0	0	5,286	5	5,327
Common/Arctic Tern[2]	90	5	583	5	568	4	1,241
Guillemot/Razorbill [3]	4,122	28	17,877	25	9,284	25	31,293
Total numbers	**87,490**	**31 days**	**112,780**	**31 days**	**70,216**	**27 days**	**270,476**

1 Unidentified Little Gulls or Kittiwakes. In later analysis these records were divided between Little Gulls and Kittiwakes, based on daily ratios of these two species
2 Unidentified Common/Arctic Terns. In later analysis these records were divided between Common and Arctic Tern, based on daily ratios of these two species
3 Unidentified Guillemots/Razorbills. In later analysis these records were divided between Guillemots and Razorbills, based on daily ratios of these two species

Table 3.3 Numbers of less common seabirds recorded in Years 5 to 7 (< 100 birds)

Species	Year 5		Year 6		Year 7		Total number
	Number	No. of days	Number	No. of days	Number	No. of days	
Great Northern Diver	5	5	4	3	2	2	11
Great Shearwater	1	1	0	0	0	0	1
Balearic Shearwater	0	0	0	0	3	2	3
Storm Petrel	0	0	7	4	5	3	12
Leach's Petrel	0	0	1	1	0	0	1
Common Scoter	0	0	12	4	30	3	42
Red-breasted Merganser	0	0	1	1	0	0	1
Red-necked Phalarope	0	0	2	2	0	0	2
Pomarine Skua	1	1	1	1	0	0	2
Arctic Skua	3	2	8	3	4	4	15
Great Skua	1	1	2	2	2	2	5
Mediterranean Gull	3	3	0	0	2	2	5
Lesser Black-backed Gull	7	6	18	7	40	10	65
Sandwich Tern	6	4	29	6	10	5	45
Roseate Tern	0	0	3	1	1	1	4
Arctic Tern	9	2	78	6	3	2	90
Black Guillemot	0	0	2	1	10	4	12
Little Auk	1	1	0	0	0	0	1
Puffin	1	1	0	0	15	5	16
Puffin/Little Auk	2	1	0	0	0	0	2
Diver species	0	0	0	0	1	1	1
Scoter species	0	0	0	0	20	2	20
Skua species	0	0	3	2	0	0	3
Gull species	4	2	8	1	0	0	12
Tern species	0	0	0	0	2	1	2
Total numbers	**44**	**31 days**	**179**	**31 days**	**150**	**27 days**	**373**

Table 3.4 Numbers [1] of common seabirds recorded on JNCC surveys in the western Irish Sea and local ICES rectangles enclosing the Arklow Study Area

Species	Nos. on JNCC surveys in four ¼ ICES rectangles	% Flying	No. of Days	Nos. on JNCC surveys in W. Irish Sea[1]	% Flying	No. of Days
Fulmar	255	92.6	16	11,131	40.6	216
Manx Shearwater	1,594	44.4	15	47,906	33.3	155
Storm Petrel	16	100	2	322	68.8	37
Gannet	101	87.1	15	5,267	57.0	207
Cormorant	6	100	4	242	73.5	40
Shag	0	0	0	280	72.5	42
Common Scoter	0	0	0	485	58.4	8
Scoter species	80	100	1	80	100.0	1
Great Skua	2	100	2	76	92.1	42
Black-headed Gull	2	100	2	624	85.3	38
Common Gull	8	87.5	3	208	65.9	24
Lesser Black-backed Gull	29	89.7	7	970	59.5	121
Herring Gull	13	23.1	3	1,222	72.1	117
Herring/Lesser black backed Gull	0	0	0	90	51.1	4
Greater Black-backed Gull	2	100	2	543	64.5	88
Kittiwake	411	59.9	17	9,665	50.4	218
Small gull species	11	27.3	3	92	83.7	6
Large gull species	6	83.3	2	990	52.9	61
Gull species	3	66.7	2	911	31.2	19
Sandwich Tern	0	0	0	79	78.5	19
Common Tern	15	100	3	1,075	72.6	43
Arctic Tern	2	50	2	156	62.8	30
Common/Arctic Tern	49	22.5	5	57	21.1	5
Tern species	1	0	1	290	30.3	24
Guillemot	1781	4.9	17	28,238	3.9	216
Razorbill	773	4.1	16	5,982	9.0	169
Guillemot/Razorbill	88	45.5	13	7,153	7.0	132
Puffin	29	17.2	4	487	22.3	77
Auk species	8	0	1	193	27.5	39
Totals	**5,285**	**30.7**	**-**	**125,720**	**29.1**	**-**

1 n ≥ 60 birds recorded on JNCC surveys in western Irish Sea between 1981 to 1998; raw data supplied by JNCC

Table 3.5 Numbers [1] of less common seabird species recorded on JNCC surveys in the western Irish Sea

Species	Nos. on JNCC surveys in western Irish Sea	No. of Days
Red-throated Diver	9	5
Black-throated Diver	11	3
Great Northern Diver	2	2
Diver species	1	1
Sooty Shearwater	13	10
Mediterranean Shearwater	15	9
Shearwater species	1	1
Leach's Petrel	1	1
Petrel species	2	2
Shag or Cormorant	14	10
Long-tailed Duck	1	1
Duck species	4	1
Grey Phalarope	2	1
Pomarine Skua	20	15
Arctic Skua	45	20
Long-tailed Skua	2	2
Skua species	1	1
Little Gull	53	6
Sabine's Gull	4	4
Roseate Tern	19	6
Little Tern	11	2
Black Tern	7	5
Black Guillemot	6	3
Common/Herring Gull	1	1
Black-backed gull species	22	7
Totals	**269**	**-**

1 n < 60 birds recorded on JNCC surveys in western Irish Sea between 1981 and 1998; raw data supplied by JNCC

3.2.2 Comparison of seabird numbers over the Box, Bank & Cable Route

A total of 26 seabird species were recorded over the Bank in Year 7, with 23 species recorded in the Box and 14 species over the cable route. In Year 5, a total of 21 seabird species were recorded over the Bank in Year 7, with 23 species recorded in the Box and 12 species over the cable route, while in Year 6, there was a total of 27 seabird species were recorded over the Bank in Year 7, with 25 species recorded in the Box and 20 species over the cable route.

Numbers of the 15 commonest seabird species over the Bank, Box and Cable Route for Years 5, 6 and 7 are shown in Table 3.6. Total numbers of birds over the Bank in Year 7 accounted for 76.5 % of all birds recorded. In comparison, total numbers of birds over the Bank in Year 5 accounted for 92.2 % of all birds recorded, while total numbers of birds over the Bank in Year 6 accounted for 86.7 % of all birds recorded.

Table 3.6 Comparison of the most common seabird numbers over the Bank, Box and Cable route in Years 5, 6 & 7

Species	Bank			Box			Cable route		
	Year			Year			Year		
	5	6	7	5	6	7	5	6	7
Red-throated Diver	177	212	82	34	10	3	1	4	0
Fulmar	26	13	15	26	157	27	2	2	0
Manx Shearwater	1,551	1,475	583	561	1,146	2,081	34	129	12
Gannet	185	156	148	104	117	146	3	5	0
Cormorant	33	34	28	1	4	1	2	13	12
Shag	470	389	173	10	14	13	0	12	1
Little Gull	10,125	5,548	3,490	123	30	151	18	4	0
Black-headed Gull	1,788	644	94	171	13	23	14	16	269
Common Gull	6,820	4,474	334	88	99	81	47	34	465
Herring Gull	13	38	14	10	18	46	8	19	8
Great black-backed Gull	5	23	14	6	19	60	0	3	9
Kittiwake	49,145	54,326	28,031	2,231	2,202	1,871	20	35	37
Common Tern	20	390	65	1	398	45	0	1	1
Guillemot	4,204	9,193	5,227	2,119	5,405	5,211	66	486	61
Razorbill	2,564	5,633	4,378	411	1,330	1,729	0	47	39
Small Gull Species [1]	41	0	4,173	0	0	1,090	0	0	23
Common/Arctic Tern [2]	70	269	513	20	314	55	0	0	0
Guillemot/Razorbill [3]	3,461	14,947	6,366	657	2,905	2,915	4	35	3
Total	**80,698**	**97,764**	**53,728**	**6,573**	**14,181**	**15,548**	**219**	**845**	**940**

1 Unidentified Little Gulls or Kittiwakes. In later analysis these records were divided between Little Gulls and Kittiwakes, based on daily ratios of these two species
2 Unidentified Common/Arctic Terns. In later analysis these records were divided between Common and Arctic Tern, based on daily ratios of these two species
3 Unidentified Guillemots/Razorbills. In later analysis these records were divided between Guillemots and Razorbills, based on daily ratios of these two species

Average ranking of the most common species by raw numbers recorded in the Arklow Bank and Box Areas during Years 5, 6 and 7, together with the ¼ ICES rectangles and the western Irish Sea produced different profiles (Table 3.7). Kittiwake was ranked most common over the Bank in all three years. However, in the Box Kittiwake was ranked 4th in Year 7, 3rd in Year 6 and 1st in Year 5. The species was ranked 4th in JNCC data from both the ¼ ICES rectangles and western Irish Sea areas.

In Years 7 and 6, Guillemot/Razorbill, Guillemot and Razorbill were ranked 2nd to 4th commonest species respectively over the Bank, while in Year 5, Little Gull, Common Gull and Guillemot were ranked 2nd to 4th commonest species. In the Box, 2nd to 4th rankings were similar between all three years, with Guillemot/Razorbill, Kittiwake and Manx Shearwater all ranked, although the order varied slightly between years.

Small gull species were ranked in 5th place over the Bank in Year 7, with Little Gull in 6th. It is likely that many of the unidentified small gulls were Little Gulls. There were no unidentified small gulls in Year 6, and Little Gull was the 5th ranked species over the Bank, while in Year 5, Guillemot/Razorbill was ranked 5th. In the Box, Razorbill was ranked 5th in Year 7 and Year 5, with Manx Shearwater ranked 5th in Year 6.

Table 3.7 Common species rankings in the Arklow Bank & Box Areas in Years 5, 6 and 7, the surrounding ¼ ICES rectangles and the western Irish Sea (JNCC data)

Species	Year 7		Year 6		Year 5		1/4 ICES rectangles	Western Irish Sea
	Bank	Box	Bank	Box	Bank	Box		
Kittiwake	**1**	**4**	**1**	**3**	**1**	**1**	**4**	**4**
Guillemot/Razorbill	**2**	**2**	**2**	**2**	**5**	**3**	**7**	**5**
Guillemot	**3**	**1**	**3**	**1**	**4**	**2**	**1**	**2**
Razorbill	**4**	**5**	**4**	**4**	**6**	**5**	**3**	**6**
Small gull sp.	**5**	**6**	**-**	**-**	**13**	**-**	**-**	**-**
Little Gull	6	7	5	10	2	7	8	10
Manx Shearwater	7	3	7	5	8	4	2	1
Common/Arctic Tern	8	10	11	7	12	11	-	-
Common Gull	9	9	6	9	3	9	10	9
Shag	10	13	10	11	9	12	-	-
Gannet	11	8	13	8	10	8	6	7
Black-headed Gull	12	12	8	12	7	6	-	-
Red throated Diver	13	14	12	13	11	10	11	11
Common Tern	14	11	9	6	14	13	-	-

3.3 Flying birds

Numbers of the 15 most common seabird species recorded flying in the Arklow Study Area in Years 5, 6 and 7 are shown in Table 3.8. The three species most frequently recorded in flight in Year 7 were Kittiwake, Little Gull and Manx Shearwater. In Year 5, the three species most frequently recorded flying were Kittiwake, Little Gull and Common Gull, while in Year 6, Guillemot, Kittiwake and Manx Shearwater were the three species most frequently recorded in flight.

Table 3.8 Numbers of the most common seabirds recorded flying in Years 5, 6 & 7

Species	No. of birds			No. of flying birds			% flying birds		
	Year			Year			Year		
	5	6	7	5	6	7	5	6	7
Red-throated Diver	212	226	85	157	198	61	74.06	87.61	71.76
Fulmar	54	172	42	37	55	36	68.52	31.98	85.71
Manx Shearwater	2,146	2,750	2,676	760	977	521	35.41	35.53	19.47
Gannet	292	278	294	260	206	220	89.04	74.10	74.83
Cormorant	36	51	41	11	12	15	30.56	23.53	36.59
Shag	480	415	187	64	33	44	13.33	7.95	23.53
Little Gull	10,266	5,582	3,641	7,694	165	1,964	74.95	2.96	53.94
Black-headed Gull	1,973	673	386	1,653	99	117	83.78	14.71	30.31
Common Gull	6,955	4,607	880	3,832	90	142	55.10	1.95	16.14
Herring Gull	31	75	68	24	47	49	77.42	62.67	72.06
Great black-backed Gull	11	45	83	6	28	28	54.55	62.22	33.73
Kittiwake	51,396	56,563	29,939	20,193	1,496	7,650	39.29	2.64	25.55
Common Tern	21	789	111	9	65	44	42.86	8.24	39.64
Guillemot	6,389	15,084	10,499	755	2,206	241	11.82	14.62	2.30
Razorbill	2,975	7,010	6,146	201	344	314	6.76	4.91	5.11
Small Gull Species [1]	41	0	5,286	41	0	5,113	100.0	0	96.73
Common/Arctic Tern [2]	90	583	568	76	253	471	84.44	43.40	82.92
Guillemot/Razorbill [3]	4,122	17,877	9,284	744	437	289	18.05	2.44	3.11
Total	**87,490**	**112,780**	**70,216**	**36,517**	**6,711**	**17,319**	**41.74**	**5.95**	**24.67**

1 Unidentified Little Gulls or Kittiwakes. In later analysis these records were divided between Little Gulls and Kittiwakes, based on daily ratios of these two species
2 Unidentified Common/Arctic Terns. In later analysis these records were divided between Common and Arctic Tern, based on daily ratios of these two species
3 Unidentified Guillemots/Razorbills. In later analysis these records were divided between Guillemots and Razorbills, based on daily ratios of these two species

In Year 7, 96.73 % of 'Small Gull Species' were recorded in flight, while more than 80 % of all Red-throated Divers, Fulmars, Gannets, Herring Gulls and Common/Arctic Terns were recorded in flight. In Year 6, only two species, Red-throated Diver and Gannet, had more than 70 % of birds recorded in flight. In Year 5, 100 % of all "Small Gull Species" were recorded in flight, while over 70 % of all Red-throated Divers, Little Gulls and Herring Gulls were flying.

Overall, the percentage of birds in flight varied between years, with 24.67 % of the most common species in Year 7 recorded flying, compared to 5.95 % recorded in Year 6 and 41.74 % recorded in Year 5. The percentage of birds in flight is largely determined by the behaviour of gulls such as Little Gulls and Kittiwake, which occur in high numbers. High numbers (or percentages) in flight, particularly over the Bank, are indicative of feeding flocks.

Figures 3.2 and 3.3 show the flight heights for the most common seabird species recorded in the Arklow Study Area and over the Bank in Years 5, 6 and 7.

Flight heights were estimated to be in one of 4 bands:

- below eye height (< 5 m);
- between 5 m and 20 m (below turbine blade height)
- between 20 m and 40 m (turbine blade height)
- above 40 m (above turbine blade height)

In both the whole Arklow Study Area and over the Bank, the majority of all flying birds of the most common seabird species were recorded below 20 m in height (blue and green lines) (Figures 3.2 and 3.3). Red lines represent birds flying between 20 m and 40 m i.e. at the height of the turbine blades, although distance from the turbines is not considered here.

In total, 4.38 % of all flying birds of the most common seabird species in Year 7 were recorded between 20 and 40 m in height, compared to 1.36 % in Year 5 and 2.07 % in Year 6.

In the Arklow Study Area, Herring Gull, Greater black-backed Gull and Common Gull were most frequently recorded flying between 20 m and 40 m in Years 5, 6 and 7. When birds over the Bank were considered, the three most species most regularly recorded flying between 20 m and 40 m in Years 5, 6 and 7 were Herring Gull, Greater black-backed Gull and Gannet. It should be noted that the overall numbers of these species in the Arklow Study Area in Years 5, 6 and 7 were low.

Percentages of auks, Fulmars, Shags and Manx Shearwaters flying above 20 m in Years 5, 6 and 7 were very small or zero. In Year 7, 3.28 % of flying red-throated divers were recorded flying between 20 and 40 m in the whole Arklow Study Area, representing 2 birds. This compares to 7 % in Year 5 (2 birds) and 6.57 % in Year 6 (13 birds).

Gulls, Gannets and terns were generally more aerial than other seabirds. No Little Gulls were recorded flying between 20 and 40 m in the Arklow study Area in Years 6 and 7, compared to 5.2 % (400 birds) in Year 5. In Year 7, 2.05 % of Kittiwakes were recorded flying between 20 and 40 m (157 birds), compared to 0.31 % in Year 5 (63 birds) and 3.61 % in Year 6 (54 birds).

Three species (Black-headed Gull, Common Gull and Kittiwake) were recorded flying above 40m in Year 7. In Year 5, four species (Red-throated Diver, Gannet, Common Gull and Kittiwake) were recorded flying above 40 m, while in Year 6, 5 species (Red-throated Diver, Gannet, Common Gull, Herring Gull and Kittiwake) were recorded flying above 40 m. Again, care must be taken when interpreting the results as sample sizes for many species are low.

Figure 3.2 Flight heights of the most common seabird species in the Arklow Study Area in Years 5, 6 and 7

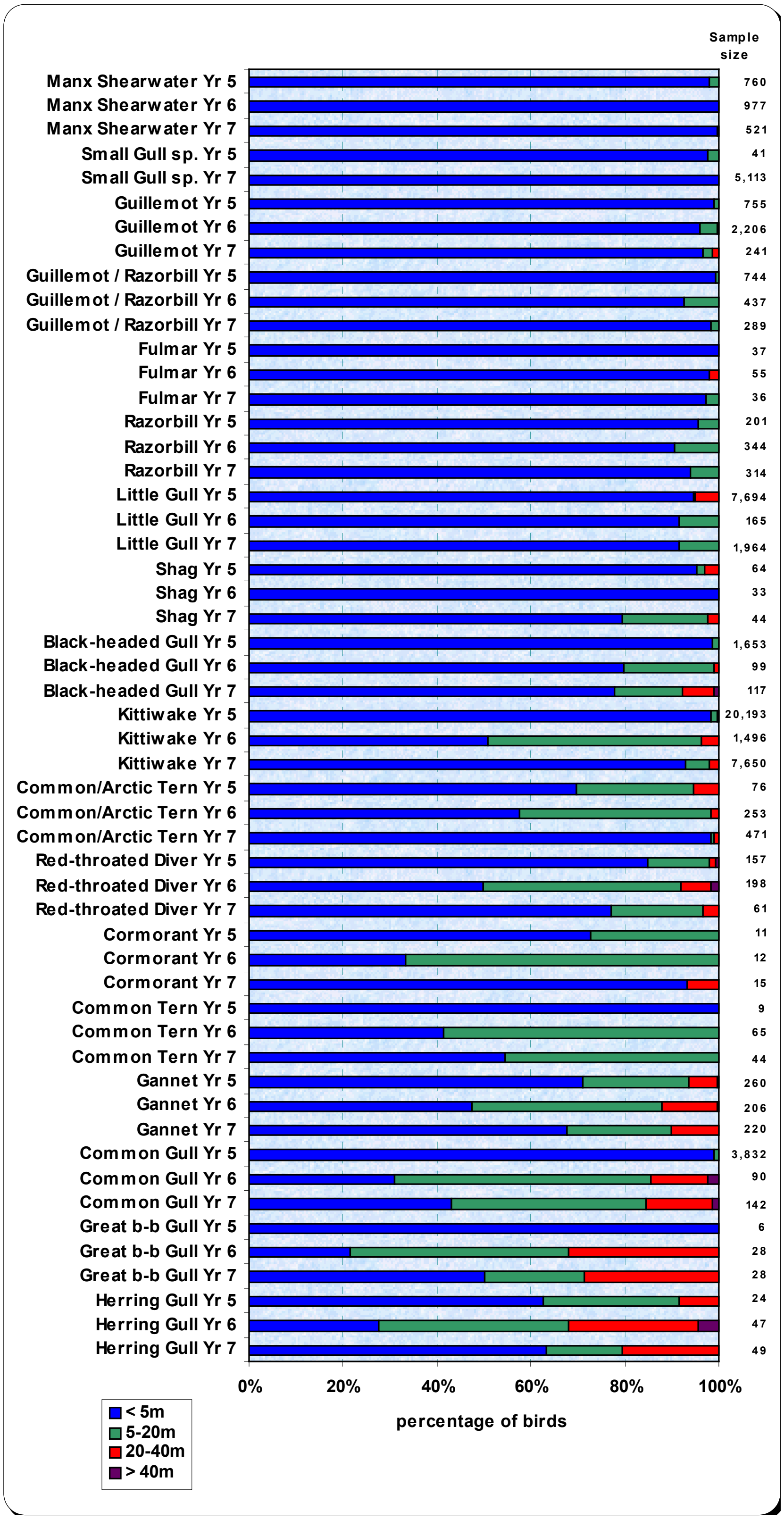
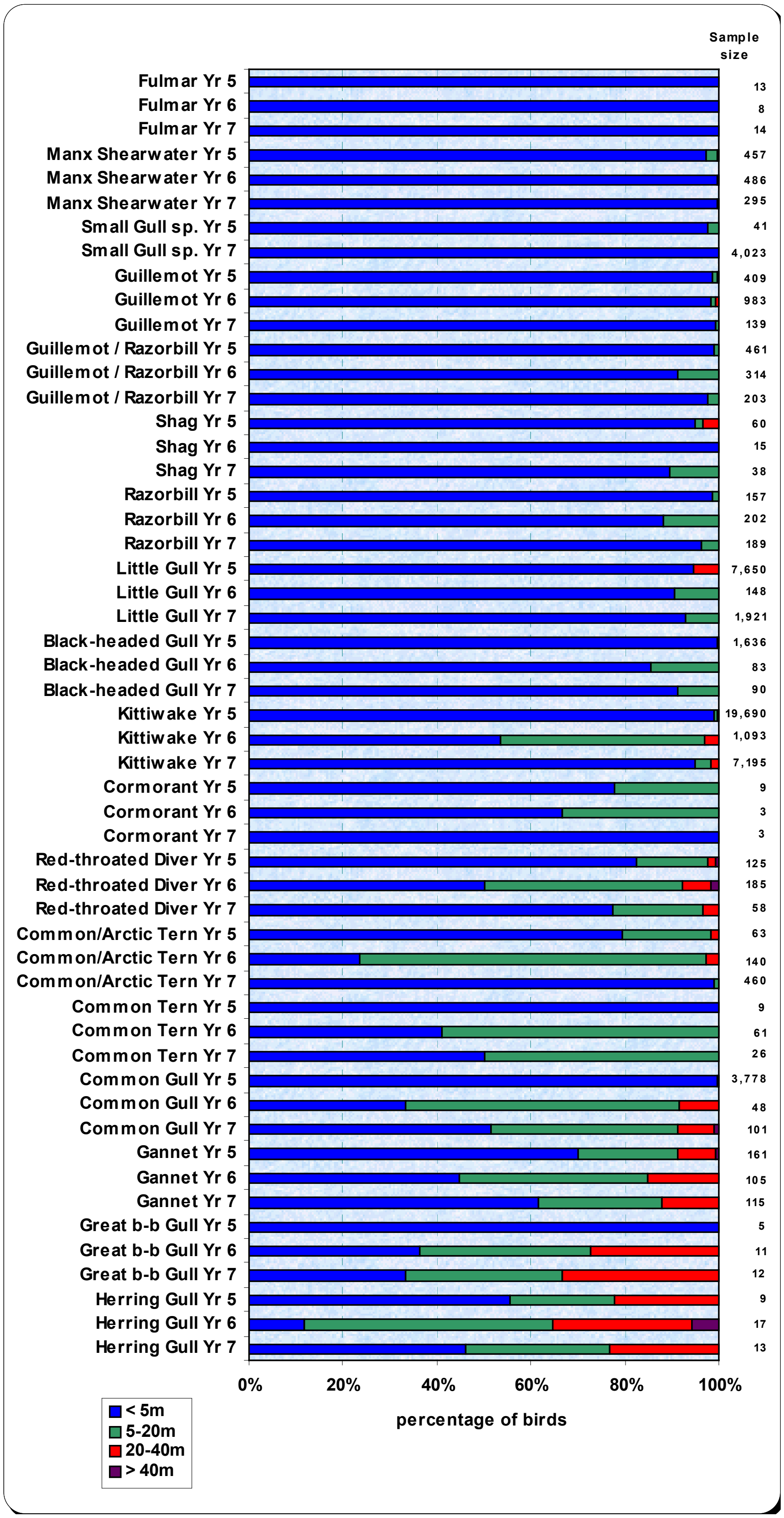


Figure 3.3 Flight heights of the most common seabird species over the Bank in Years 5, 6 and 7



3.4 Seabird Species Accounts

The following seabird species accounts present a summary of distribution and abundance within the Arklow Bank Study Area for Years 5, 6 and 7.

3.4.1 Red-throated Diver

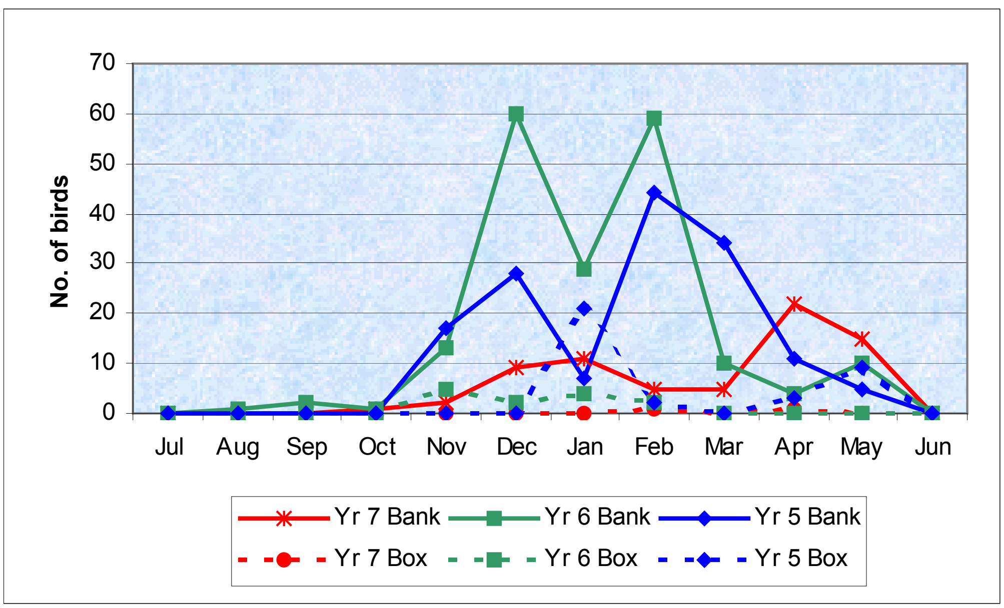
Red-throated Divers are winter visitors to the Arklow Study Area. The species is listed on Annex I of the EU Birds Directive (79/409/EEC).

Year 5

There were no Red-throated Divers recorded between July and October in Year 5 (Figure 3.4). Numbers over the Bank increased between November and December, dropped slightly in January and then peaked in February (44 birds), before decreasing again between March and June, when none were recorded. Numbers over the Box were generally low throughout the year, with peaks in January (21 birds) and May (9 birds).

Average monthly abundance in Year 5 over the Bank was low throughout the year. A similar pattern was recorded over the Box, with a peak of 5.14 birds/km in January the exception (Figure 3.5). However, survey effort was low in this month, resulting in this higher figure.

Figure 3.4 Numbers of Red-throated Divers in the Bank and Box [1], Years 5 to 7



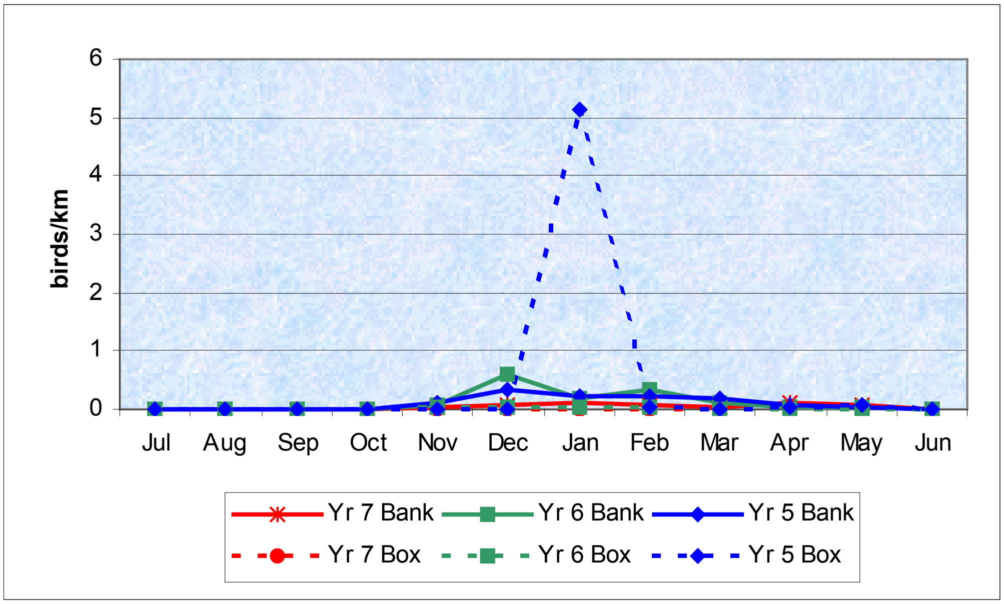
1 Includes cable route

Year 6

Numbers of Red-throated Divers between July and October of Year 6 were low, with just 4 birds recorded (Figure 3.4). As in Year 5, numbers over the Bank began to increase in November, reached a peak in December (60 birds), fell in January and peaked again in February (59 birds). Numbers were low from March to June. In the Box, numbers were low between November and February, with no birds recorded outside of these months. Five birds in November was the highest count.

Red-throated Diver average monthly abundance in Year 6 over the Bank and Box was low throughout the year, with a peak of 0.59 birds/km over the Bank in December (Figure 3.5).

Figure 3.5 Red-throated Diver average monthly abundance in the Bank and Box, Years 5 to 7



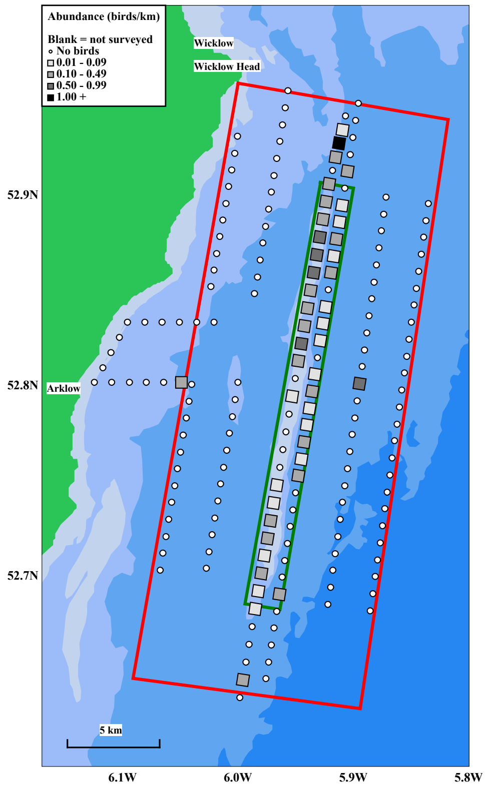
Year 7

Numbers of Red-throated Divers recorded in Year 7 were lower than the previous two years (Figure 3.4). Despite this, the general pattern of numbers over the Bank was similar to previous years. No birds were recorded between July and October, then numbers began to increase between November and January, dropped again in February and March, peaked in April (22 birds) and decreased again in May. Just one Red-throated Diver was recorded in the Box in Year 7, in February.

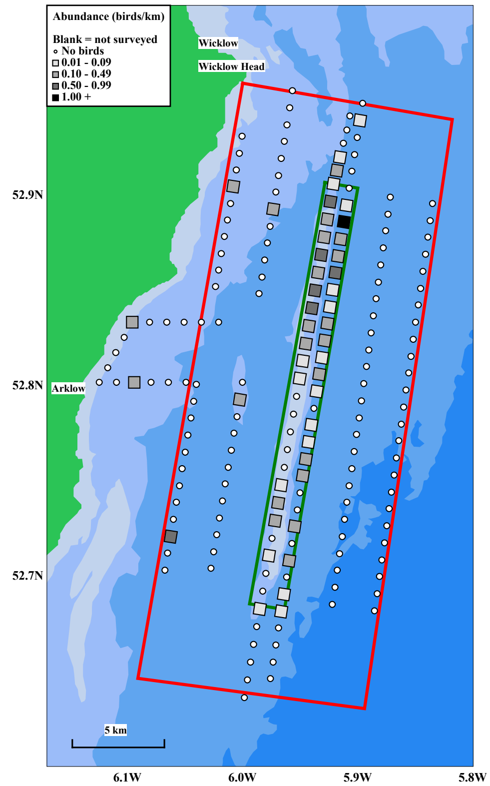
Red-throated Diver average monthly abundance over the Bank and Box in Year 7 was lower throughout the year than the two previous years (Figure 3.5).

Figure 3.6 Red-throated Diver abundance between November and May

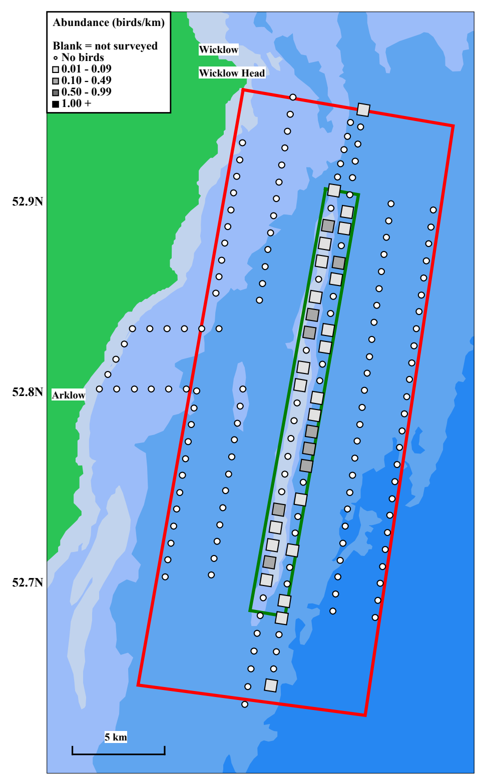
Year 5



Year 6



Year 7



Year 5

Between November and May, Red-throated Divers were largely confined to the Bank, with low abundances recorded occasionally in the Box. Abundance over the Bank was generally low. Highest abundance was recorded in the Box at the north end of Leg 3 in January, with a peak of 1.45 birds/km.

Year 6

Between November and May, the distribution of Red-throated Diver was similar to Year 5, with most birds recorded over the Bank. Like Year 5, seasonal abundance over the Bank was generally low, apart from on Leg 2, km 8, where 1.55 birds/km was recorded. Low abundances were recorded on the inner Box legs and Cable Route.

Year 7

Red-throated Diver abundance over the Bank between November and May was lower than the previous two years. Very low abundances were recorded occasionally in the Box.

3.4.2 Great Northern Diver

Great Northern Divers are uncommon winter visitors to the Arklow Study Area. The species is listed on Annex I of the EU Birds Directive (79/409/EEC).

Year 5

In Year 5 there were 5 sightings of Great Northern Diver, all over the Bank. Singles were seen in October, January and April, with two recorded in May.

Year 6

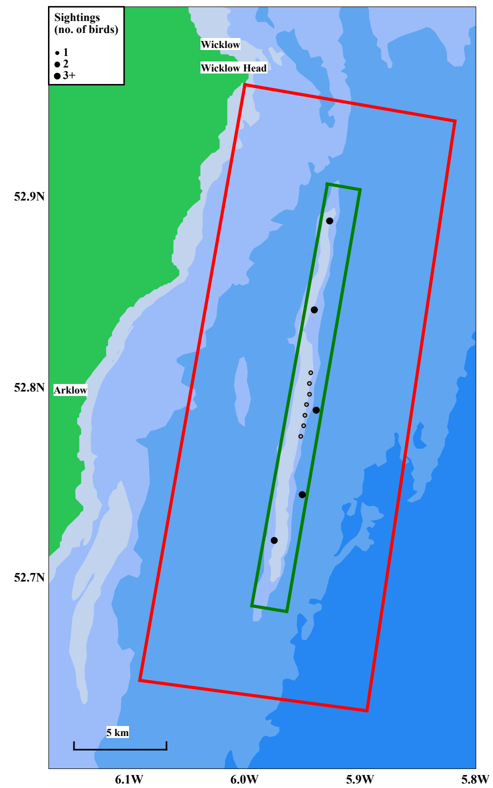
In Year 6, there were two Great Northern Divers seen in both October and November.

Year 7

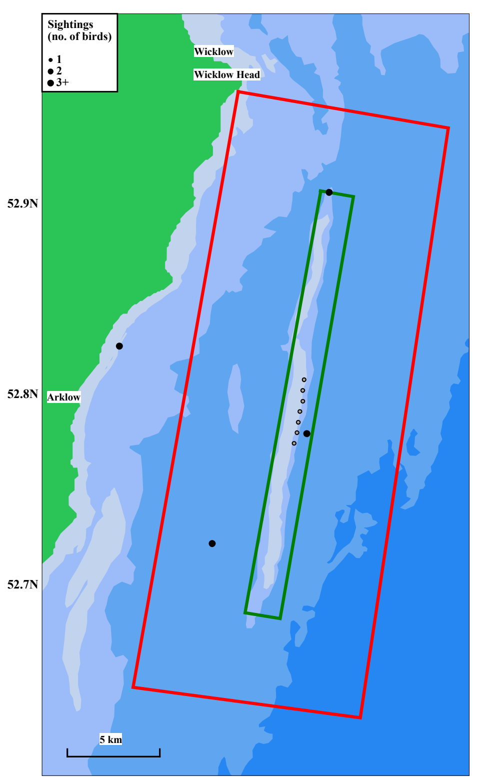
In Year 7, single birds were recorded in January and May. The majority of birds were recorded over the Bank in all three years.

Figure 3.7 Sightings in Years 5, 6 and 7

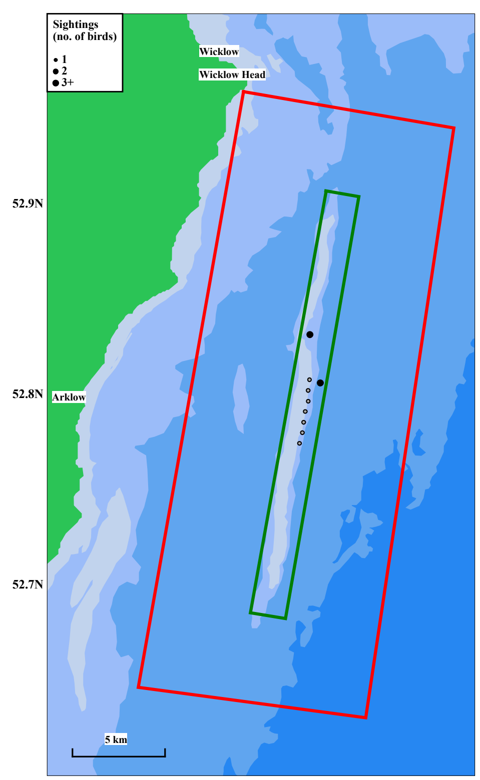
Year 5



Year 6



Year 7



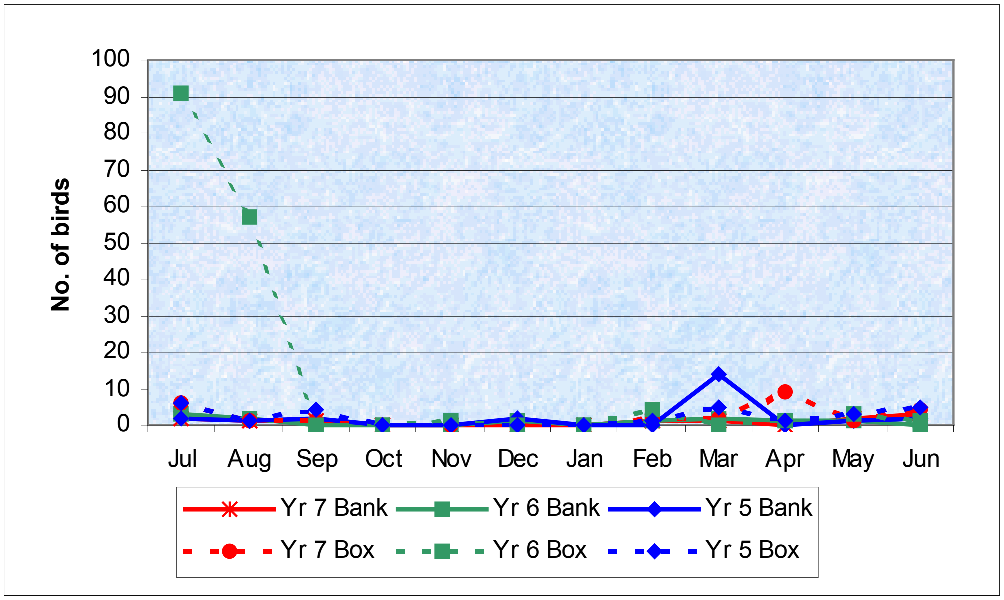
3.4.3 Fulmar

Year 5

Numbers of Fulmars recorded in the Arklow Study Area in Year 5 were low, with the peak counts being 14 birds over the Bank and 5 birds in the Box in March (Figure 3.8).

Fulmar average monthly abundance over the Bank and Box in Year 5 was very low (Figure 3.9).

Figure 3.8 Numbers of Fulmars in the Bank and Box [1], Years 5 to 7



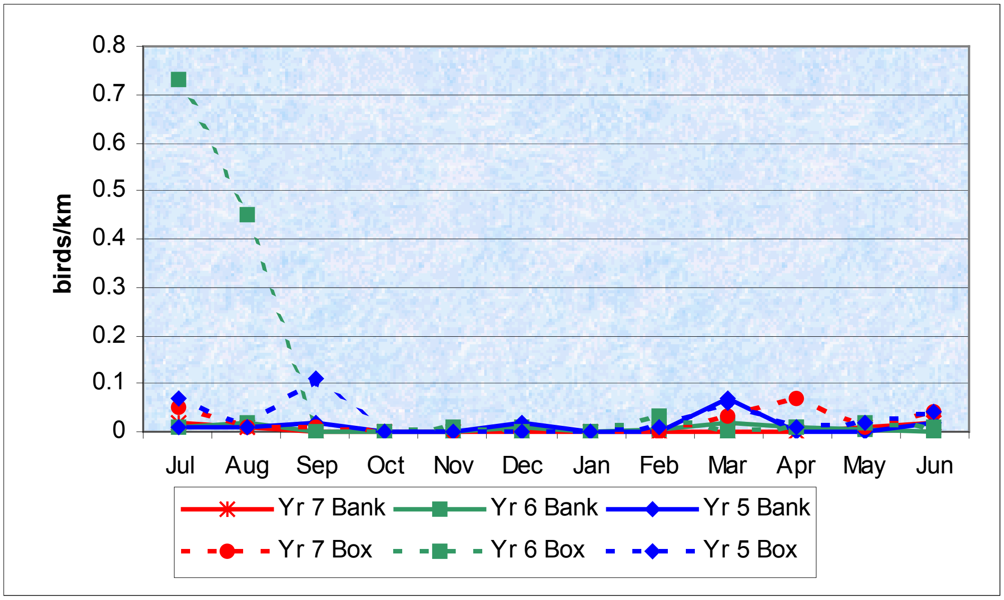
1 Includes cable route

Year 6

Peak numbers of Fulmars in Year 6 were recorded in the Box in July (91 birds), and August (57 birds, with low numbers recorded for the rest of the year (Figure 3.8). Numbers over the Bank were very low throughout the year, with 3 in July the highest count.

Fulmar average monthly abundance over the Bank and Box in Year 6 was generally very low, apart from in the Box in July and August when peaks of 0.73 birds/km and 0.45 birds/km were recorded (Figure 3.9).

Figure 3.9 Fulmar average monthly abundance in the Bank and Box, Years 5 to 7

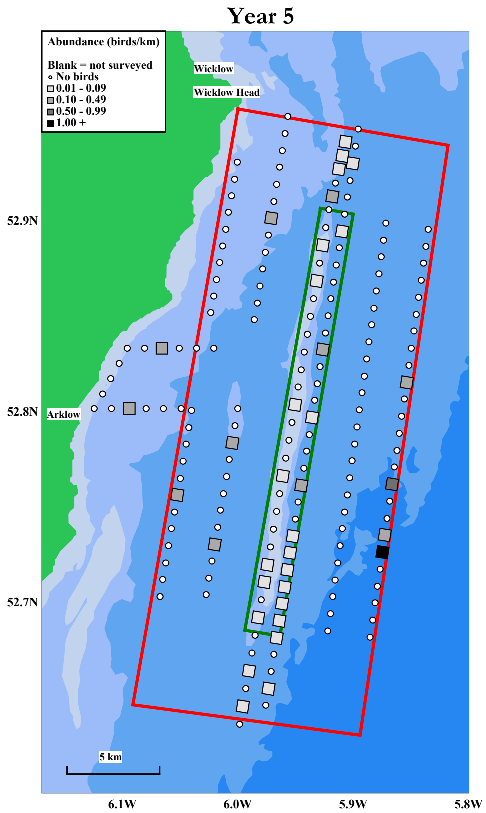


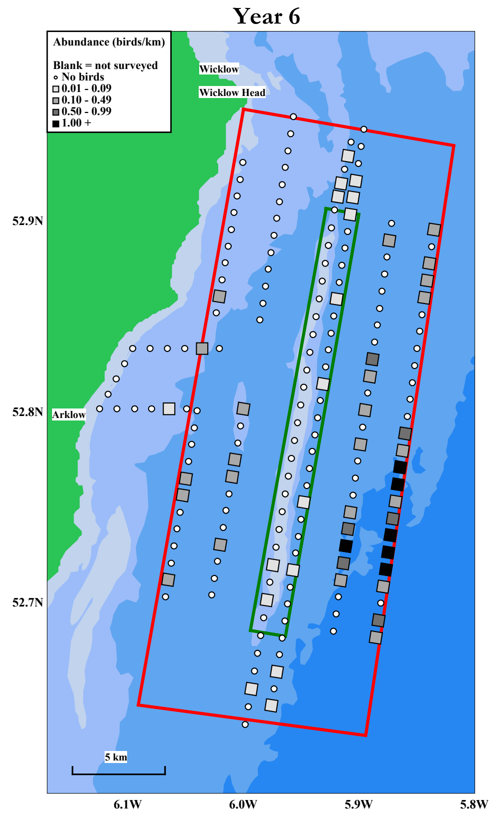
Year 7

Numbers of Fulmars recorded in Year 7 were similar to the two previous years, with just 11 birds seen over the Bank, and 26 birds in the Box. The peak count over the Bank was 3 birds in June, while the peak Box count was 9 birds in April (Figure 3.8).

Fulmar average monthly abundance over the Bank and Box in Year 7 was lower than the two previous years (Figure 3.9).

Figure 3.10 Fulmar abundance in Years 5, 6 and 7





Year 5

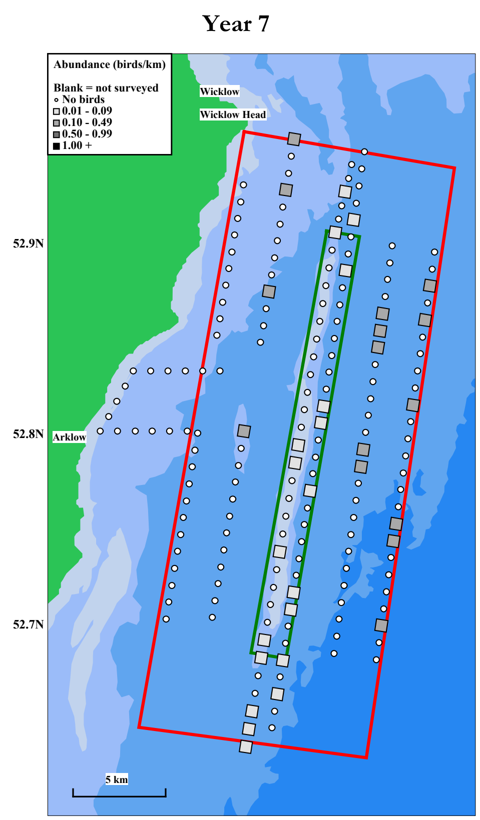
Fulmars were scattered throughout the Arklow Study Area with highest abundance recorded at the southern end of the outer Box leg in July. Abundances over the Bank were generally lower than in the Box.

Year 6

Like Year 5, peak abundances were again recorded along the southern end of the outer Box legs in July and August, with a maximum seasonal abundance of 4.40 birds/km recorded in this area. As in Year 5, abundance over the Bank was generally lower than over the Box.

Year 7

Low to moderate abundances were recorded over the Bank and the Box throughout the year.



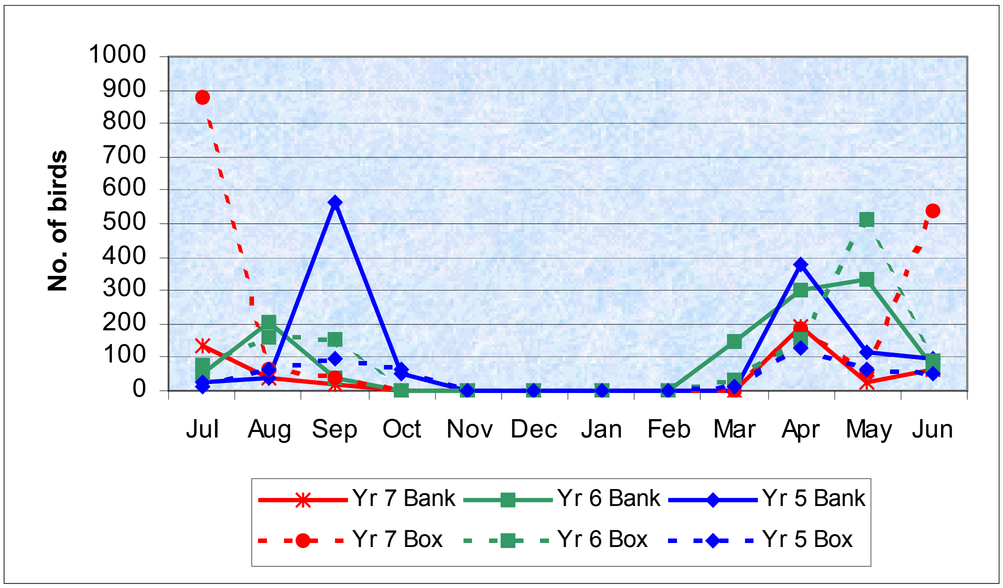
3.4.4 Manx Shearwater

Year 5

Manx Shearwaters were recorded in the Arklow Study Area between March and October in Year 5 (Figure 3.11). Over the Bank, numbers peaked in April (376 birds), and then decreased between May and August, before peaking again in September (565 birds). A similar pattern was recorded in the Box with 129 birds recorded in April, and 96 birds recorded in September.

When survey effort was applied to these numbers, the same pattern was shown (Figure 3.12). Highest average density was recorded in September with 21.28 birds/km^2 over the Bank and 11.28 birds/km^2 recorded over the Box.

Figure 3.11 Numbers of Manx Shearwaters in the Bank and Box [1], Years 5 to 7



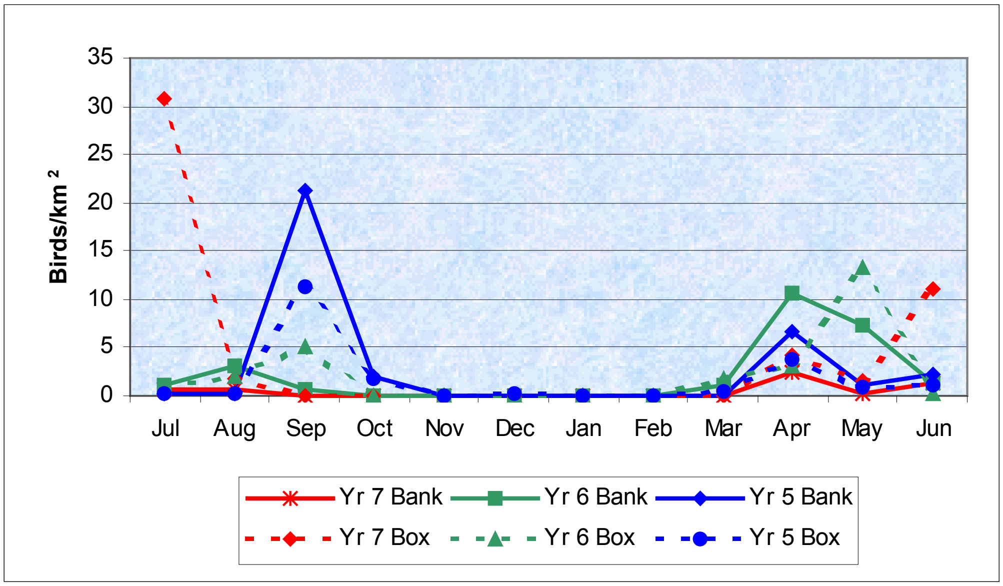
1 Includes cable route

Year 6

Numbers of Manx Shearwaters over the Bank in Year 6 were lower than in Year 5, with a peak of 335 birds recorded in May and a lower peak of 206 birds in August (Figure 3.11). Peak numbers in the Box were higher than over the Bank in May, with 514 birds recorded, and in September (154 birds). No birds were recorded between November and February.

When survey effort was applied to these numbers, a similar pattern was shown, although peak average density was recorded in April over the Bank (10.59 birds km^2) (Figure 3.12). Peak average density was recorded in the Box in May and was slightly higher than over the Bank (13.25 birds/km^2).

Figure 3.12 Manx Shearwater average monthly density in the Bank and Box, Years 5 to 7



Year 7

Numbers of Manx Shearwaters recorded over the Bank in Year 7 were lower than the two previous years, with a peak of 195 birds in April (Figure 3.11). In contrast, numbers recorded in the Box were higher than over the Bank for most months, with a peak of 876 birds recorded in July. No birds were recorded between November and February.

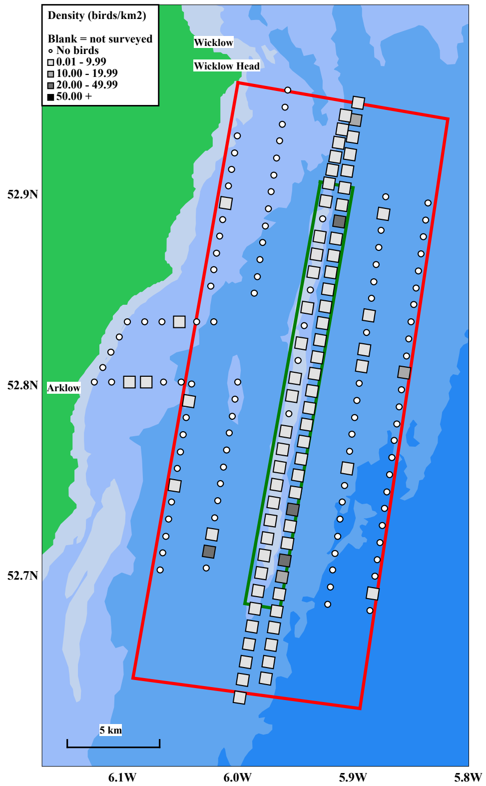
When survey effort was applied to these numbers, a similar pattern was shown (Figure 3.12). The peak average monthly density was recorded in the Box in July (30.74 birds/km^2). This was the highest average monthly density recorded in all three years.

Table 3.9 Peak Manx Shearwater densities between March and October in Years 6 and 7 (> 50 birds/km^2)

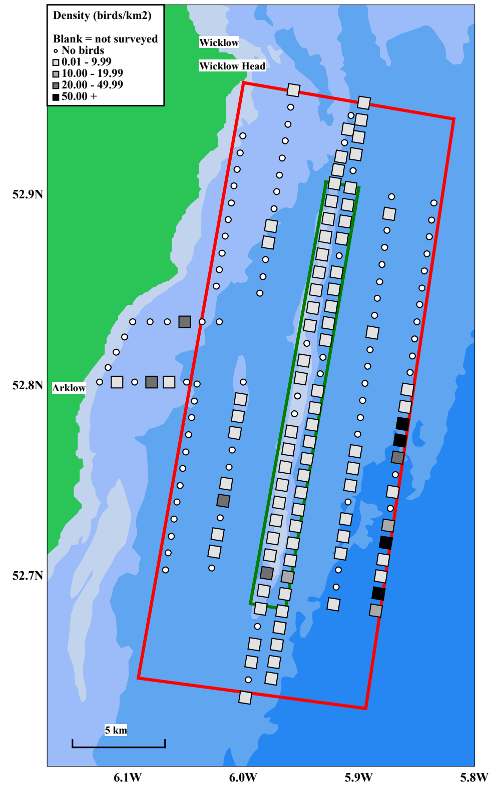
Year	Survey leg	Km waypoint	Seasonal Density
6	1	14	192.11
6	1	15	145.56
6	1	21	76.22
6	1	24	63.56
7	1	14	577.78
7	1	13	288.89
7	11	10	71.50
7	1	12	57.78

Figure 3.13 Manx Shearwater density between March and October

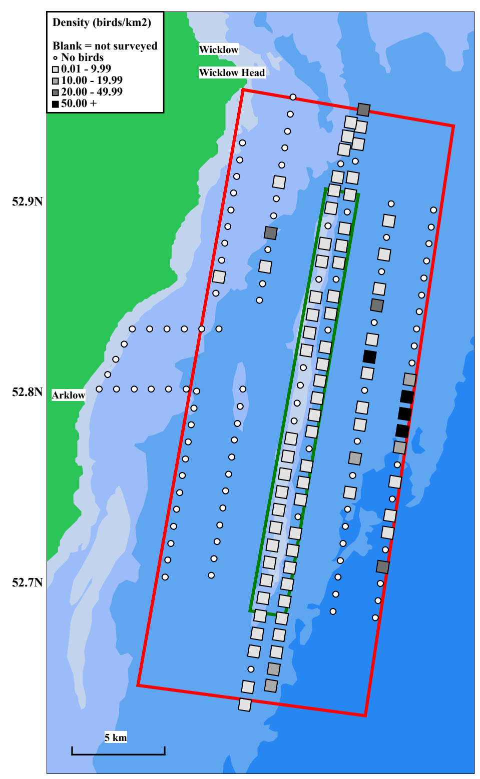
Year 5



Year 6



Year 7



Year 5

Manx Shearwaters were generally recorded in low densities along the Bank, and were also scattered throughout the Box and Cable Route at low densities. Peak seasonal density figures did not exceed 50 birds/km² in Year 5.

Year 6

Manx Shearwater distribution over the Bank between March and October was generally similar to Year 5, with birds recorded at low densities along the Bank. Highest seasonal densities were recorded along the southern half of the outer Box leg, in May and September (Table 3.9).

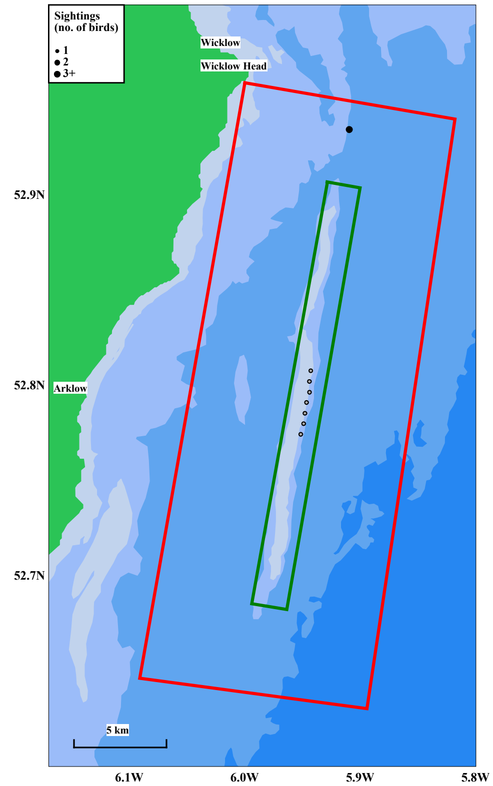
Year 7

Manx Shearwater distribution was similar to Years 5 and 6, with birds generally recorded at low densities along the Bank, and at higher densities along the southern half of the outer Box legs. Highest seasonal densities were recorded along the southern half of the outer Box leg in July (Table 3.9).

3.4.5 Great Shearwater

In Year 5, one Great Shearwater was recorded north of the Bank in September. This was the first record for the Arklow Study Area since the project began.

Figure 3.14 Sightings in Year 5



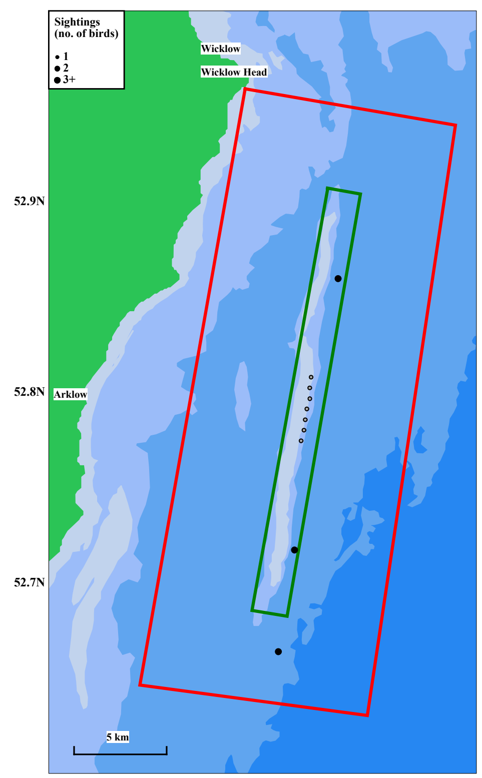
3.4.6 Balearic Shearwater

Balearic Shearwaters have a tiny breeding range and a small rapidly declining population due to predation at breeding colonies by introduced cats, and by-catch of foraging birds by long-line fisheries. The species is listed as Critically Endangered on the 2007 IUCN (World Conservation Union) Red List (Birdlife International 2007). The species is also listed on Annex I of the EU Birds Directive (79/409/EEC).

In Year 7, two Balearic Shearwaters were recorded in August, with a third seen in September.

Previously, one Balearic Shearwater was seen in Year 2 in the Box.

Figure 3.15 Sightings in Year 7



3.4.7 Petrels

Both Storm Petrel and Leach's Petrel are scarce in the Arklow Study Area. Both species are listed on Annex I of the EU Birds Directive (79/409/EEC).

Year 5

No Storm or Leach's Petrels were recorded in Year 5.

Year 6

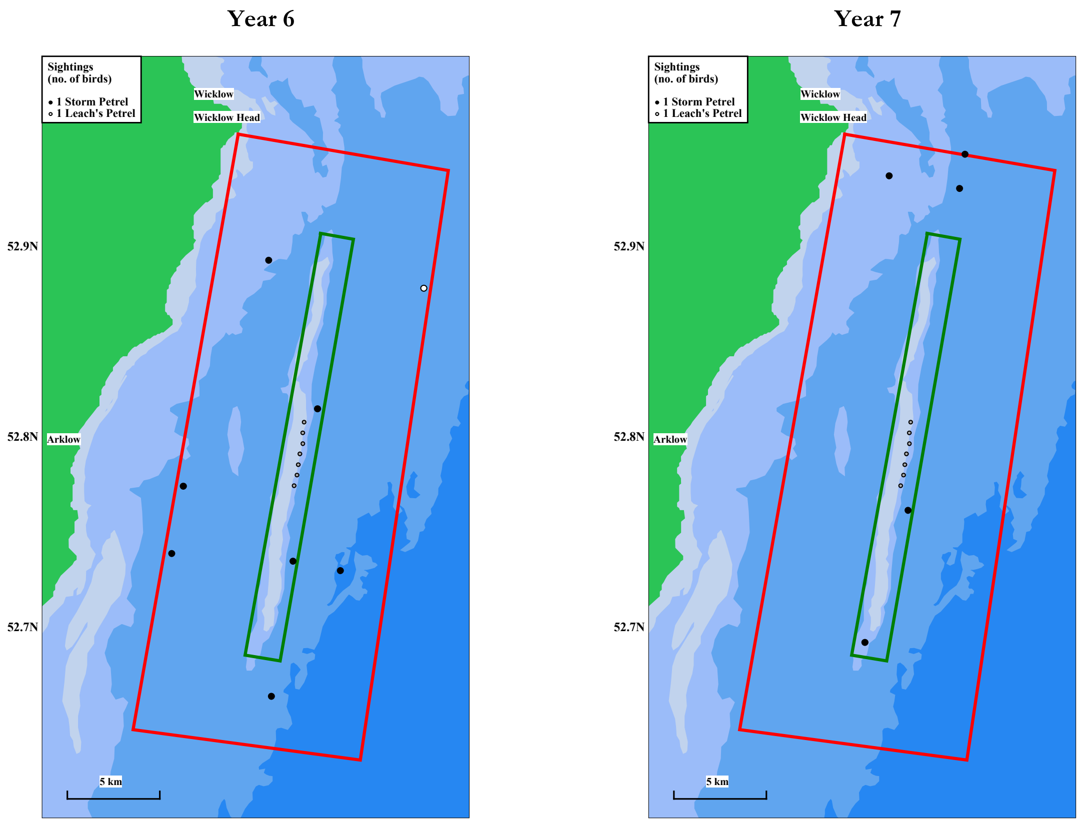
There were a total of 7 Storm Petrels recorded in Year 6; four in July and 3 in August (Figure 3.16). Birds were widely scattered throughout the Study Area.

In addition, one Leach's Petrel was recorded in July, in the north east of the Box. This was the first record in the Arklow Study Area since the project began.

Year 7

In Year 7, a total of five Storm Petrels were recorded, with 4 seen in July and one in August (Figure 3.16). As in Year 6, birds were scattered throughout the Study Area.

Figure 3.16 Petrel sightings in Years 6 and 7



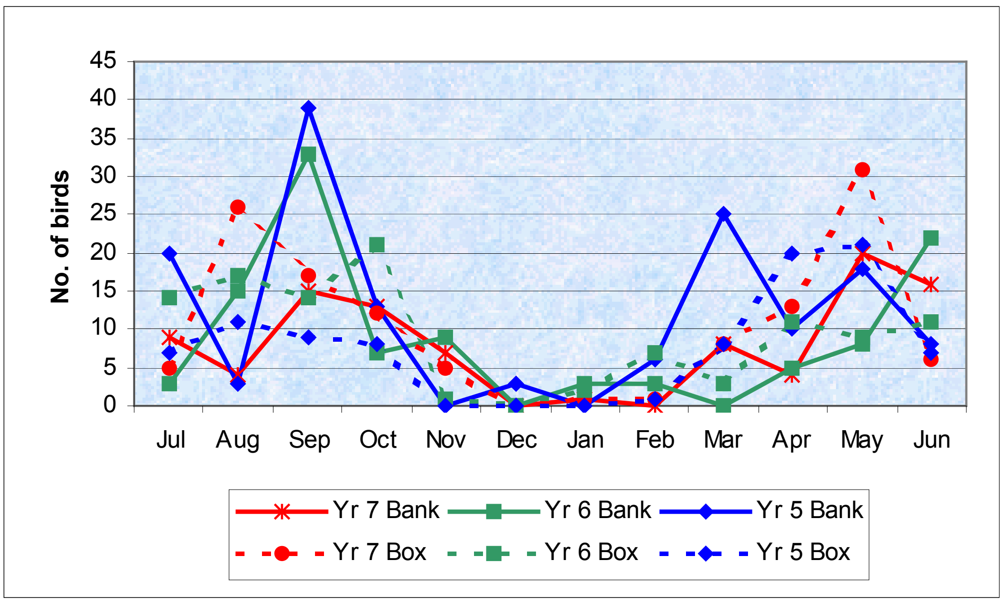
3.4.8 Gannet

Year 5

In Year 5, low numbers of Gannets were recorded in the Arklow Study Area in all months except November and January (Figure 3.17). Peak numbers over the Bank were recorded in September (39 birds) and March (25 birds). Numbers in the Box were lower, with a peak of 21 birds in May.

Average monthly abundance for Gannets in Year 5 was generally low, with a peak of 0.38 birds/km over the Bank and 0.28 birds/km in the Box in September (Figure 3.18). Both these peaks were the highest recorded in Years 5, 6 and 7.

Figure 3.17 Numbers of Gannets in the Bank and Box [1], Years 5 to 7



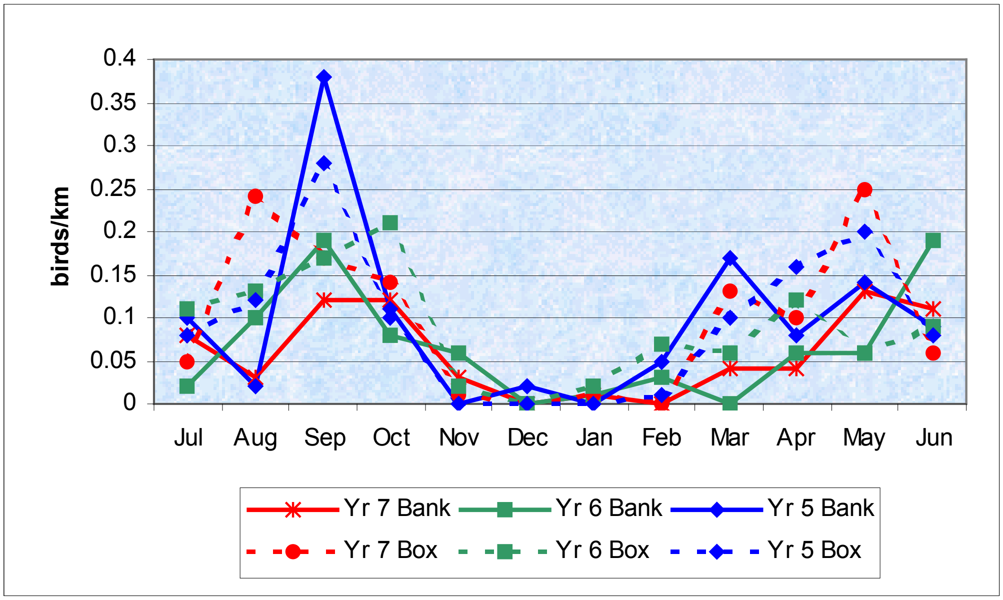
1 Includes cable route

Year 6

Numbers of Gannets over the Bank in Year 6 were lower than in Year 5 in all months except June, and showed a similar pattern (Figure 3.17). Peak numbers were recorded in September (33 birds). Numbers in the Box were higher than numbers over the Bank in July, August, October, and from February to May, with a peak of 21 birds in October.

In Year 6, average monthly abundance for Gannets was generally lower than Year 5, with a peak of 0.19 birds/km over the Bank in September and June, and 0.21 birds/km in the Box in October (Figure 3.18).

Figure 3.18 Gannet average monthly abundance in the Bank and Box, Years 5 to 7



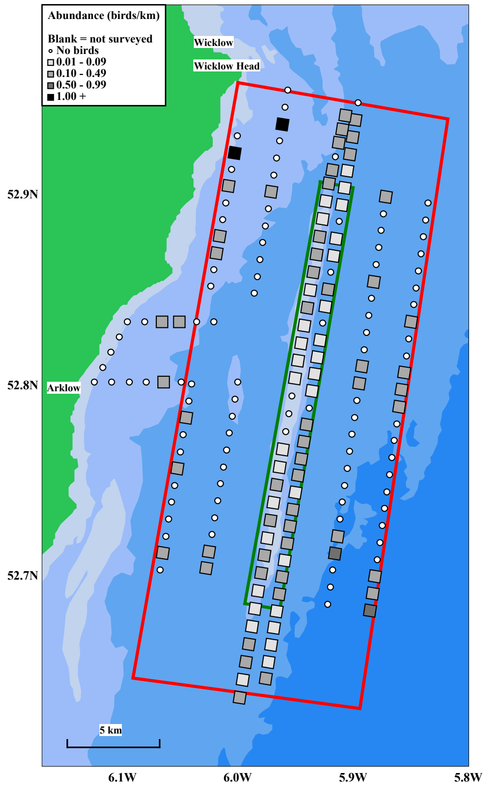
Year 7

In Year 7, Gannet numbers over the Box were generally lower than in the previous two years, with a peak of 20 birds in May (Figure 3.17). Numbers in the Box were similar, although there were two higher peaks, one in August (26 birds) and one in May (31 birds). No birds were recorded in the Study Area in December or over the Bank in February.

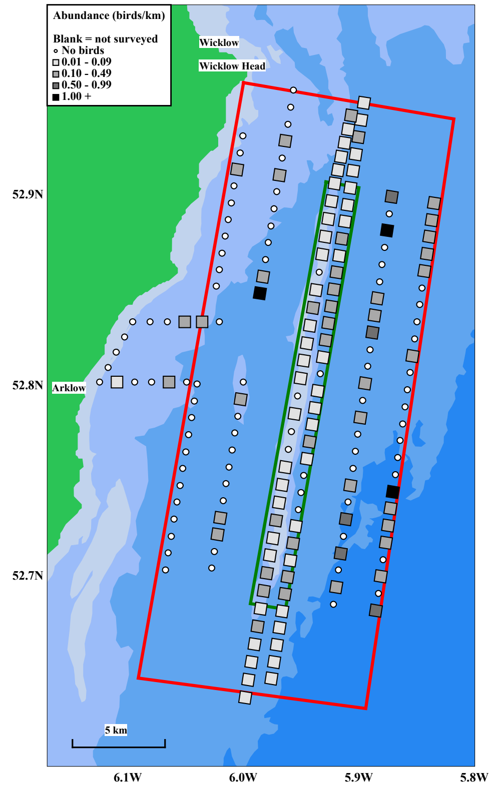
Average monthly abundance for Gannets over the Bank in Year 7 was generally lower than the two previous years, but showed a similar pattern, with a peak of 0.13 birds/km over the Bank in May. Average monthly abundance in the Box was generally higher than the Bank throughout the year, and was similar to Year 5 figures for the Box, with a peak of 0.25 birds/km in May (Figure 3.18).

Figure 3.19 Gannet abundance in all months for Years 5, 6 and 7

Year 5



Year 6



Year 5

Gannets were recorded along the Bank in low to moderate numbers, with a patchier distribution over the Box and Cable Route. Highest abundance was recorded in the north-west corner of the Box, with a peak of 1.33 birds/km.

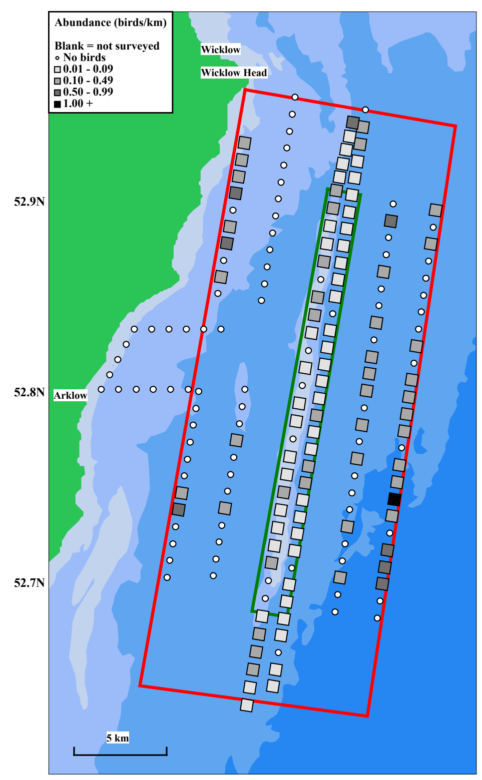
Year 6

Gannet distribution in Year 6 was similar to Year 5, with low to moderate numbers recorded along the Bank, and a more patchy distribution in the Box and Cable Route. Highest abundance was recorded occurred in the Box, with a peak of 1.83 birds/km.

Year 7

Gannet distribution in Year 7 was similar to Years 5 and 6, with low to moderate numbers recorded over the Bank. Highest abundances were recorded along the southern end of the outer Box leg, with a peak of 1.40 birds/km.

Year 7



3.4.9 Cormorant

Year 5

A total of 36 Cormorants were recorded in Year 5, between September and April. The majority of birds were seen along the Bank, with peak numbers recorded in November when 11 birds were seen.

Year 6

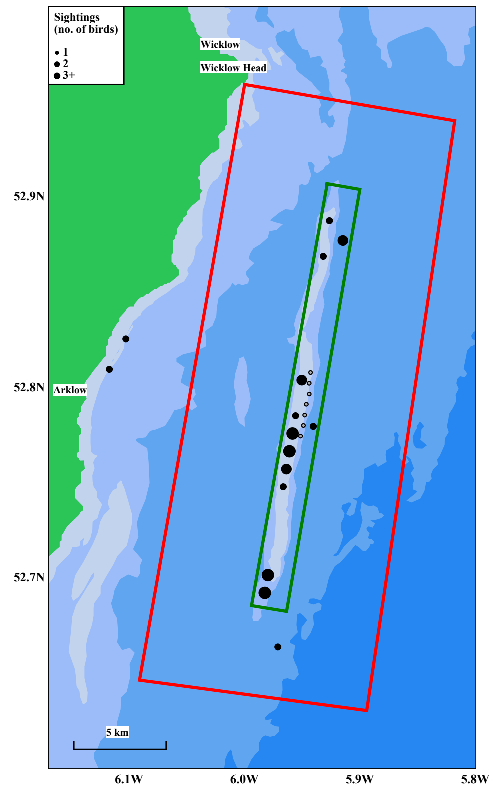
Numbers increased in Year 6, with a total of 51 birds between August and May. Again, most birds were along the Bank, however higher numbers were recorded on the Cable Route than in Year 5. Peak numbers were again recorded in November, with 20 seen.

Year 7

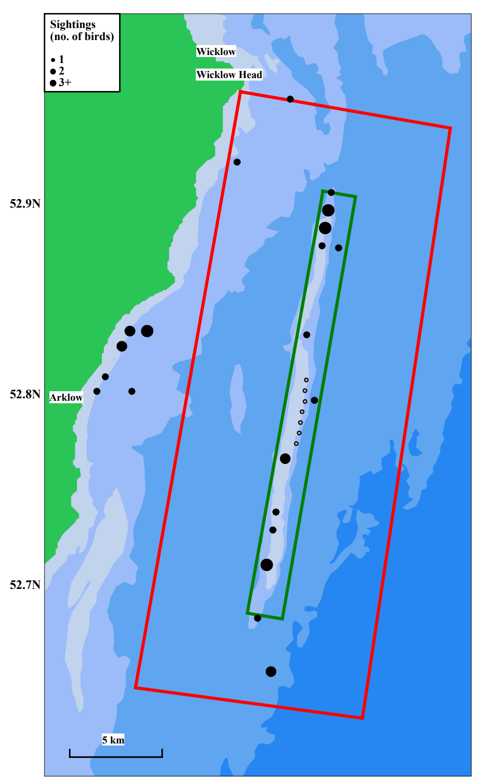
In Year 7, a total of 41 Cormorants were recorded, with the peak month being October, when 19 were counted. The majority of birds were over the northern end of the Bank, with low numbers also seen along the Cable Route.

Figure 3.20 Sightings in Years 5, 6 and 7

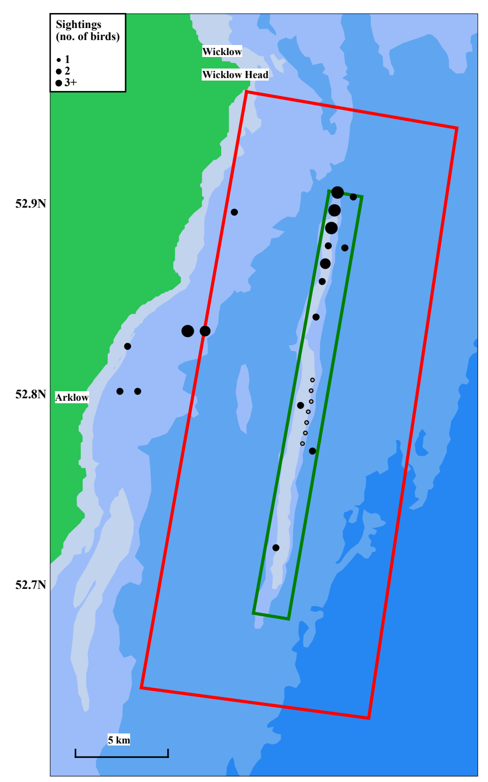
Year 5



Year 6



Year 7



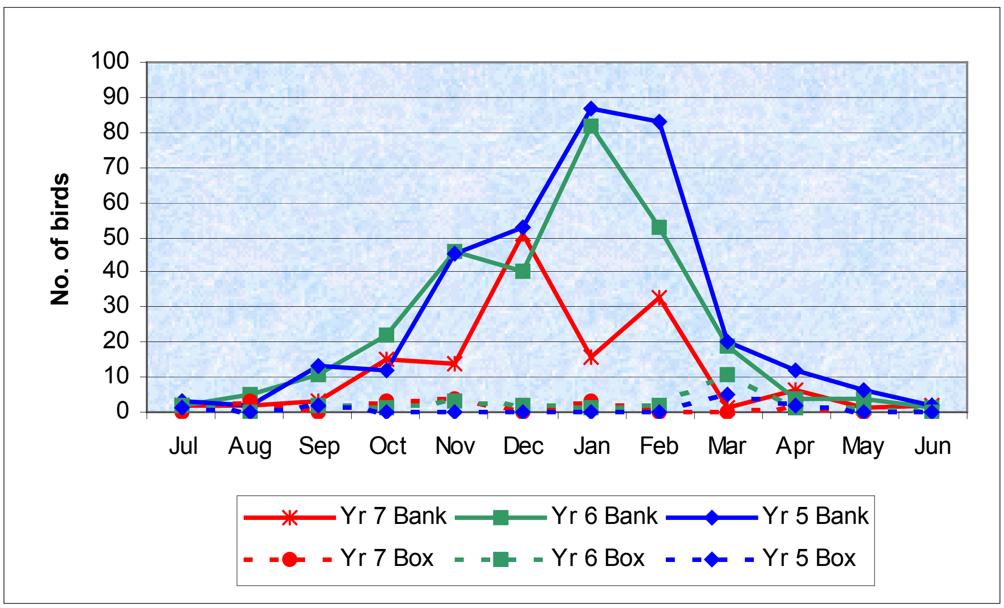
3.4.10 Shag

Year 5

In Year 5, the majority of Shags were found over the Bank. Birds were seen in all months, with peak numbers recorded between October and March. Numbers over the Bank increased from September onwards, peaking in January (87 birds), decreasing slightly in February (83 birds), before dropping considerably in March. A total of just 10 birds were seen in the Box (Figure 3.21).

The average monthly abundance for Shags over the Bank in Year 5 was generally low, apart from in January, when a peak of 2.31 birds/km was recorded (Figure 3.22). Shag abundance in the Box was low throughout the year.

Figure 3.21 Numbers of Shags in the Bank and Box [1], Years 5 to 7



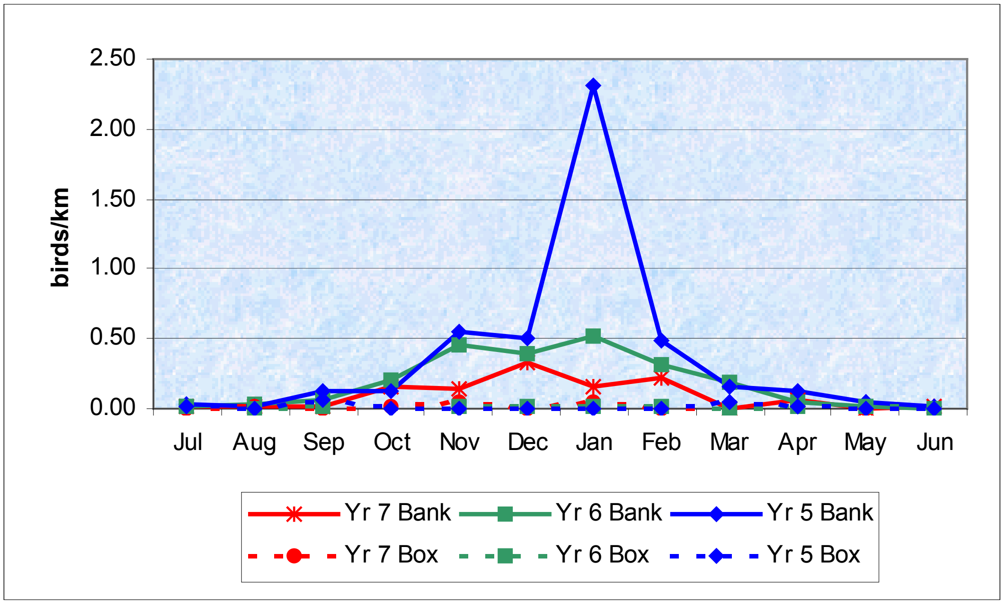
1 Includes cable route

Year 6

Shag numbers in Year 6 showed a similar pattern to Year 5, with a peak of 82 birds over the Bank in January, which was slightly lower than Year 5 (Figure 3.21). Numbers over the Box were low throughout the year, with a peak of 11 birds in March.

Shag monthly average abundance in Year 6 was generally low, with highest average monthly abundance recorded between November and February (Figure 3.22). A peak of 0.52 birds/km was recorded in January. Shag abundance in the Box was low throughout the year.

Figure 3.22 Shag average monthly abundance in the Bank and Box, Years 5 to 7



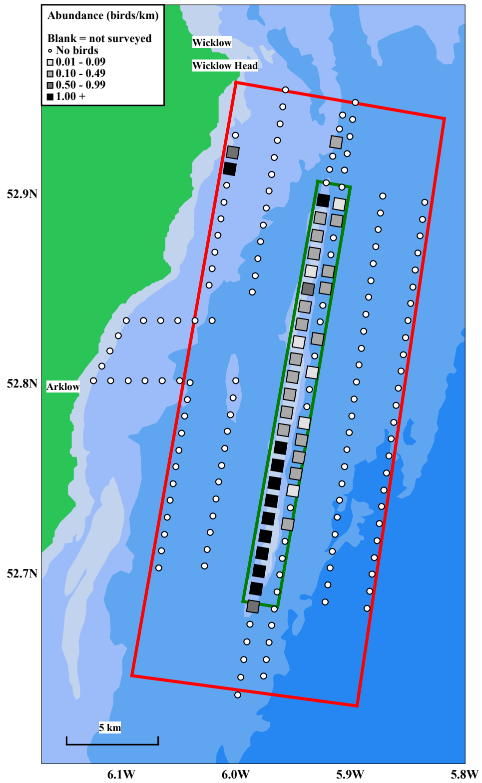
Year 7

Numbers of Shags over the Bank in Year 7 were lower than the previous two years, although the same pattern was observed (Figure 3.21). Numbers increased from September onwards, peaking in December (51 birds) and then decreasing until a smaller peak in February (33 birds), with low numbers after that. Numbers over the Box were very low throughout the year, with a peak count of 4 birds in November.

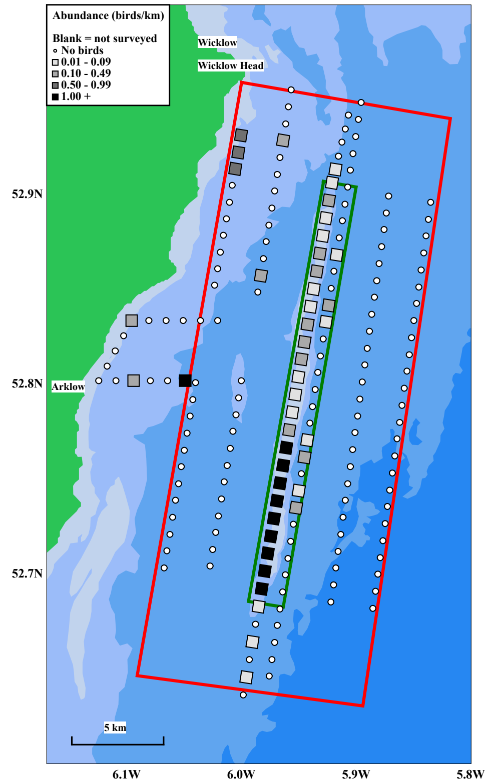
In Year 7, monthly average abundance of Shags was generally low, with a peak of 0.33 birds/km recorded in December (Figure 3.22). Shag abundance in the Box was low throughout the year.

Figure 3.23 Shag abundance between October and March

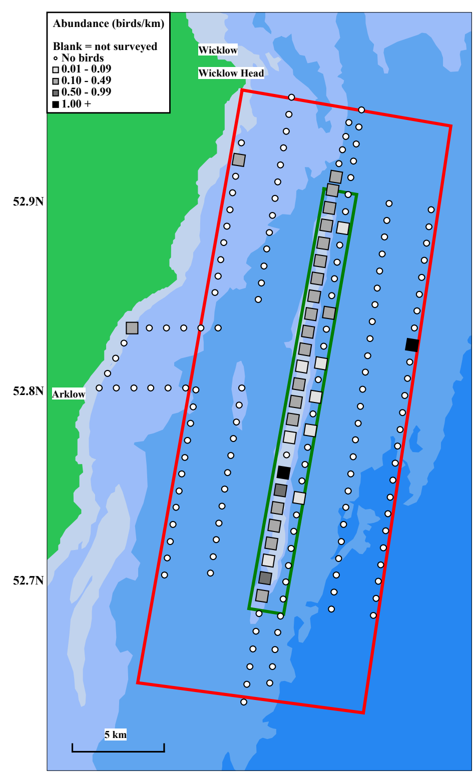
Year 5



Year 6



Year 7



Year 5

Shag distribution was almost exclusively over the Bank. The main concentrations were along the southern half of the inner Bank leg between December and February, where peak abundance ranged from 1.01 birds/km to 3.18 birds/km.

Year 6

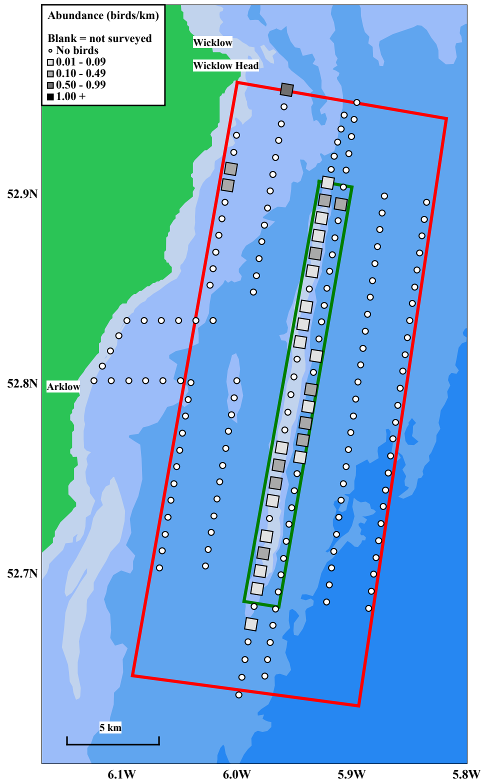
Shag distribution between October and March was similar to Year 5, with the majority of Shags recorded over the Bank, particularly along the southern half of the inner Bank leg between November and February. Peak abundance ranged from 1.10 birds/km to 2.00 birds/km.

Year 7

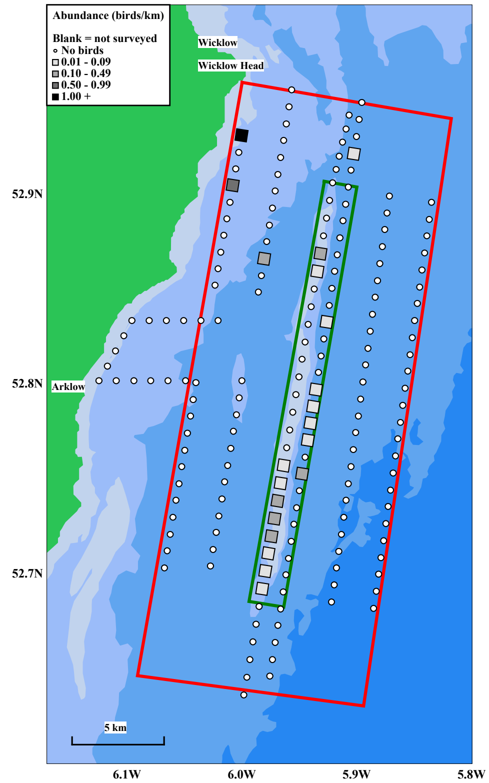
Although the number of Shags recorded between October and March were lower than the two previous years, distribution was largely similar, with birds mainly found along the inner Bank leg. Peak abundance ranged from 1.31 birds/km to 1.5 birds/km.

Figure 3.24 Shag abundance between April and September

Year 5



Year 6



Year 5

Numbers of Shags between April and September were much lower than in October to March, but the overall distribution was similar. Birds were found mainly along the Bank in low to moderate abundance.

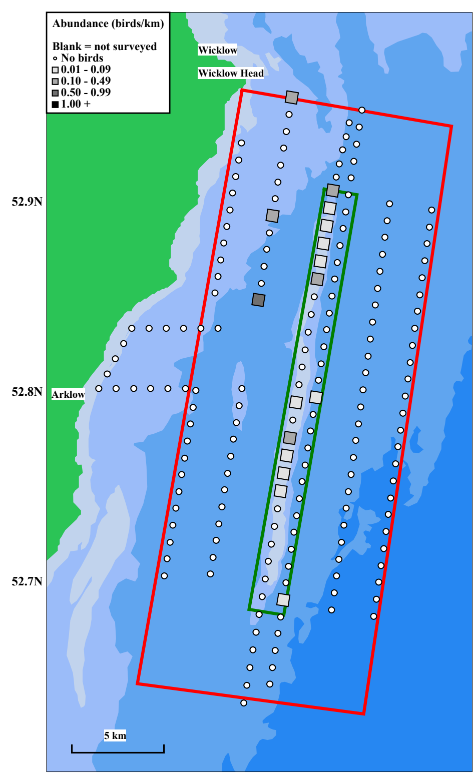
Year 6

Shag distribution between April and September was similar to the same period in Year 5, with birds found along the Bank and on the northern end of the inner Box leg in low to moderate abundance. Peak abundance was 1.00 birds/km.

Year 7

Shag distribution between April and September was similar to the two previous years, with birds recorded in low abundance numbers in areas of the inner Bank leg and occasionally in moderate abundance on the inner Box legs.

Year 7



3.4.11 Skuas

Figure 3.25 Sightings in Years 5, 6 and 7

Year 5

Three species of skua were recorded in low numbers in the Arklow Bank Study Area between Years 5 and 7. In Year 5, 3 Arctic Skuas were seen over the Bank, 1 in June and 2 in September, with 1 Pomarine Skua seen in August and 1 Great Skua in September. The latter 2 sightings were in the Box

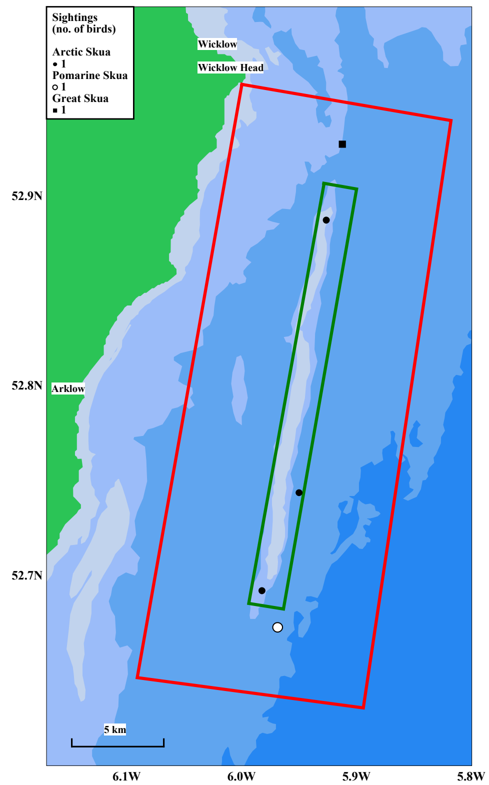
Year 6

In Year 6, 8 Arctic Skuas were recorded, 2 in August, 4 in September and 2 in October, while 1 Pomarine Skua and 2 Great Skuas were seen in September. All were over the Bank, apart from 2 Arctic Skuas over the Box. Three unidentified skuas were also recorded, 1 in September and 2 in October.

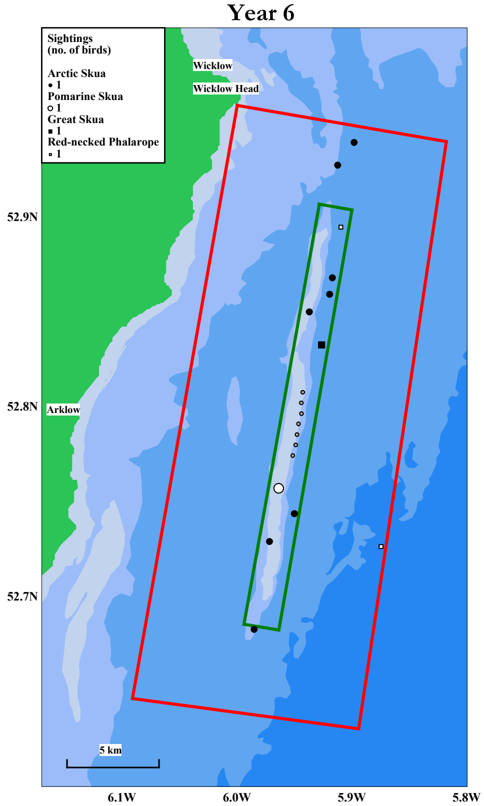
Year 7

In Year 7, 4 Arctic Skuas were recorded over the Bank; 1 in August, 2 in September and 1 in October. Single Great Skuas were seen in the Box in April and September

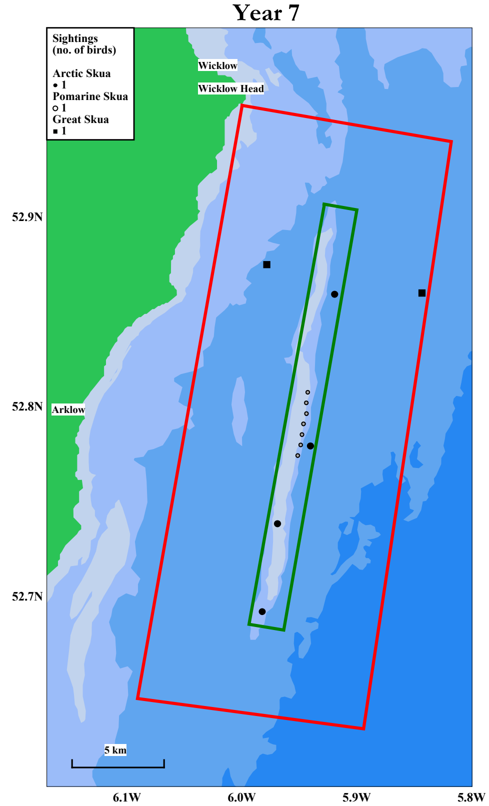
Year 5



Year 6



Year 7



3.4.12 Red-necked Phalarope

Two Red-necked Phalaropes were seen in Year 6, 1 over the Bank in August and 1 at the eastern edge of the Box in September (Figure 3.25). These were the first records for the project.

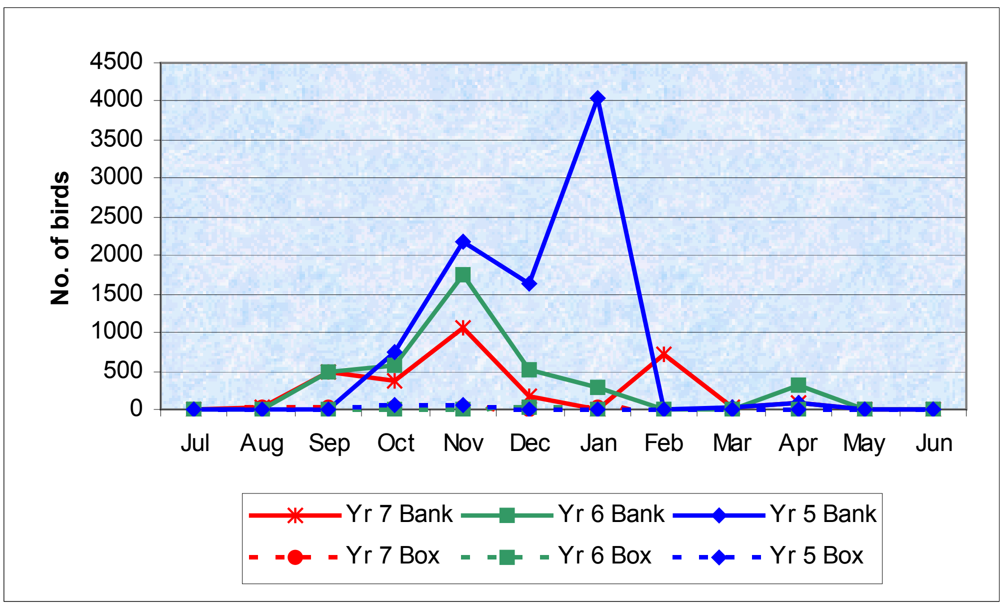
3.4.13 Little Gull

Year 5

Peak numbers of Little Gulls were recorded over the Bank between October and January, with peak monthly totals of 2,165 birds in November and 4,032 birds in January (Figure 3.26). Numbers were very low between February and September. In the Box, numbers were low throughout the year, with a peak of 63 birds in November.

Average monthly density over the Bank in November was similar to Years 6 and 7, while the January Bank average of 195.08 birds/km^2 was considerably higher than the subsequent two years (Figure 3.27). Average monthly density in the Box was low throughout the year.

Figure 3.26 Numbers of Little Gulls in the Bank and Box [1], Years 5 to 7



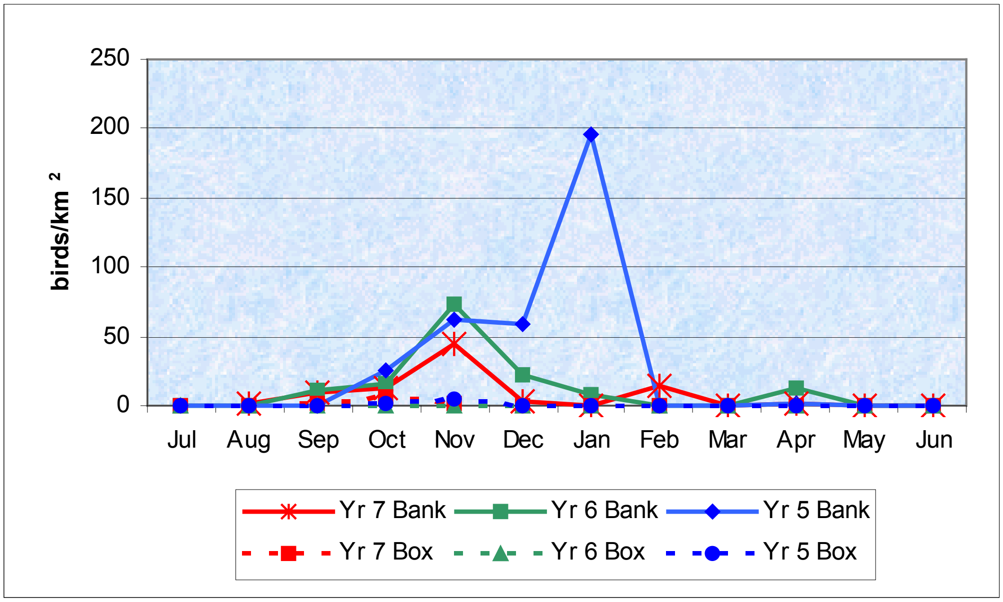
1 Includes cable route

Year 6

In Year 6, numbers of Little Gulls over the Bank were lower, with a November peak monthly total of 1,752 birds (Figure 3.26). Unlike Year 5, there was no peak in January, and numbers gradually decreased from December, with a slight increase in numbers in April (322 birds). Numbers were low in the Box throughout the year.

Average monthly density over the Bank in November was slightly higher than Years 5 and 7, at 73.44 birds/km^2 (Figure 3.27). Average density over the Bank for the remaining months was low. Average monthly density in the Box was low throughout the year.

Figure 3.27 Little Gull average monthly density in the Bank and Box, Years 5 to 7



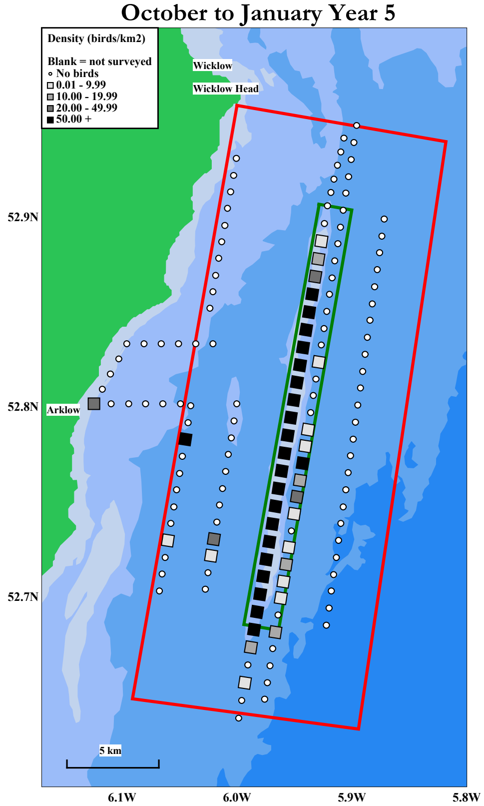
Year 7

Numbers of Little Gulls over the Bank in Year 7 were lower than the two previous years, although there was still an obvious peak in numbers in November, when the peak monthly total was 1,048 birds (Figure 3.26). Numbers decreased after November until February, when a peak monthly total of 720 birds was recorded. Numbers were low after February. In the Box, numbers were low throughout the year with a peak of 39 birds in October.

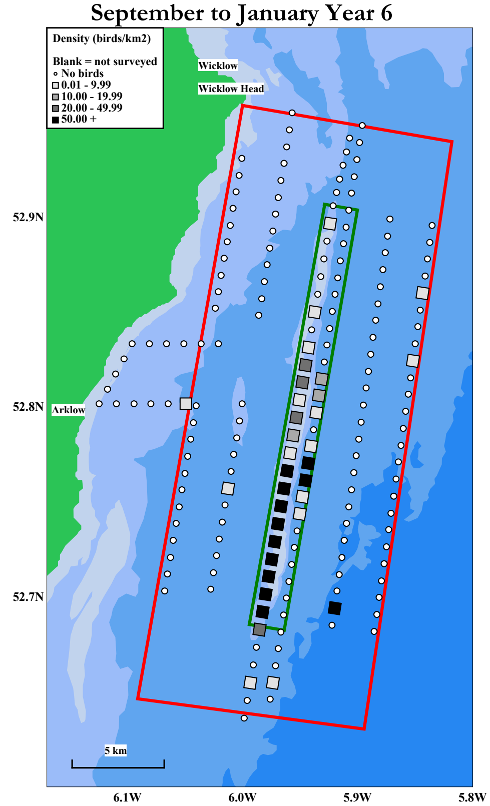
Average monthly density over the Bank in November was slightly lower than the two previous years, at 45.36 birds/km^2 (Figure 3.27). Average density over the Bank for the remaining months was low. Average monthly density in the Box was low throughout the year.

Figure 3.28 Little Gull density between September and January

October to January Year 5



September to January Year 6



Year 5

Little Gull density was highest over the Bank between October and January, with highest densities found along the inner Bank leg (Table 3.10). Few birds were recorded in the Box at this time.

Year 6

Little Gull density was highest over the Bank between September and January, again with highest densities found along the inner Bank leg (Table 3.11). Like Year 5, few birds were recorded in the Box at this time.

Year 7

Little Gull density in Year 7 was lower than in the two previous years, and was highest over the Bank between September and December. Highest densities were recorded at the northern end of the inner Bank leg (Table 3.12). In the Box, Little Gulls were more widespread than in the previous two years, although densities were still low to moderate.

September to December Year 7

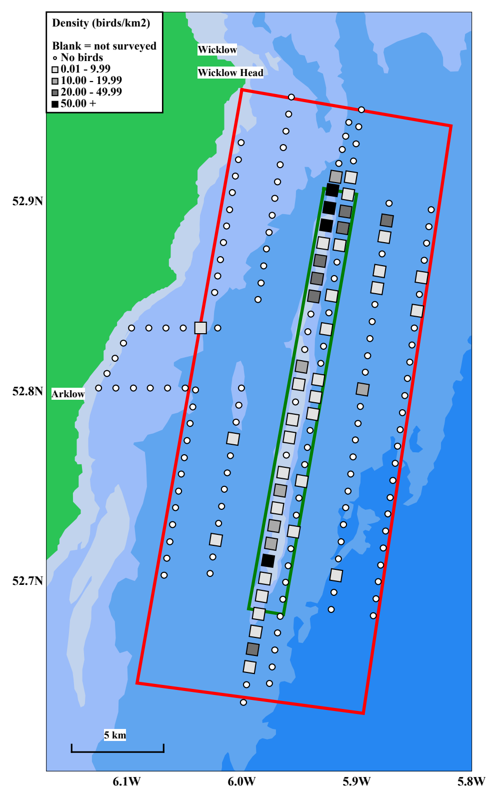


Table 3.10 Peak Little Gull densities between October and January, Year 5 (> 50 birds/km^2)

Year	Survey leg	Km waypoint	Seasonal Density
5	2	21	58.33
5	3	11	60.59
5	3	12	125.53
5	3	13	79.55
5	3	14	117.86
5	3	15	157.10
5	3	16	118.69
5	3	17	108.33
5	3	18	60.54
5	3	19	95.87
5	3	20	118.94
5	3	21	204.43
5	3	22	202.47
5	3	23	237.29
5	3	24	276.04
5	3	25	223.60
5	3	26	181.30
5	3	27	93.70
5	3	28	247.49
5	3	29	85.50
5	3	30	59.52
5	44	3	74.67

Table 3.11 Peak Little Gull densities between September and January, Year 6 (> 50 birds/km^2)

Season & Year	Survey leg	Km waypoint	Seasonal Density
6	2	21	60.67
6	2	22	73.21
6	3	21	86.46
6	3	22	116.11
6	3	23	163.04
6	3	24	191.70
6	3	25	53.36
6	3	26	106.47
6	3	27	78.31
6	3	28	85.72
6	3	29	83.99
6	11	24	53.33

Table 3.12 Peak Little Gull densities between September and December, Year 7 (> 50 birds/km^2)

Season & Year	Survey leg	Km waypoint	Seasonal Density
Sep to Dec Year 7	3	6	289.77
Sep to Dec Year 7	3	7	68.45
Sep to Dec Year 7	3	8	52.57
Sep to Dec Year 7	3	27	76.14

Table 3.13 Peak Little Gull densities between January and March, Year 7 (> 50 birds/km^2)

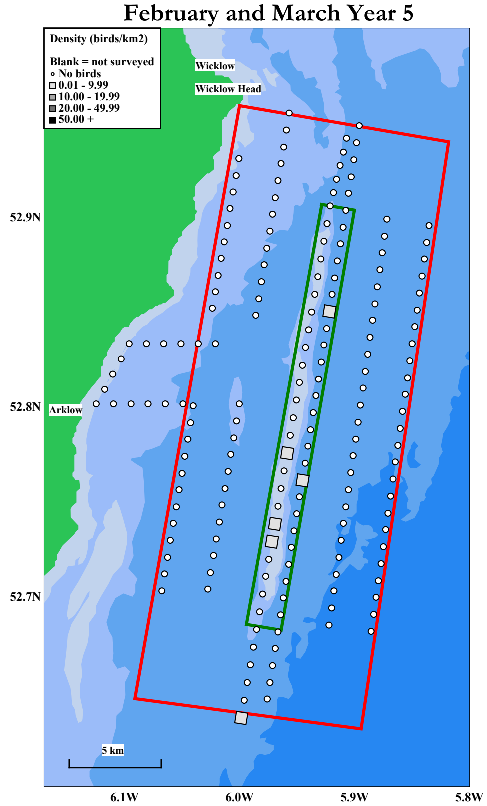
Year	Survey leg	Km waypoint	Seasonal Density
7	3	23	122.06

Table 3.14 Peak Little Gull densities in April, Year 6 (> 50 birds/km^2)

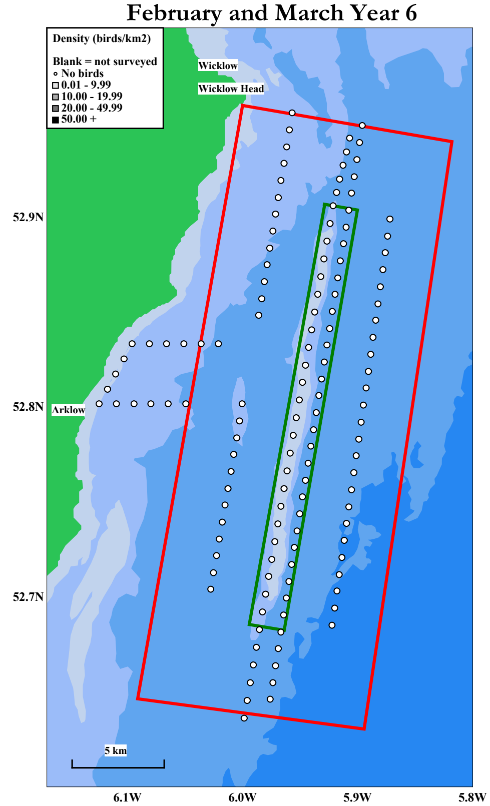
Year	Survey leg	Km waypoint	Seasonal Density
6	3	23	72.26
6	3	25	55.58
6	3	26	173.42

Figure 3.29 Little Gull density between January and March

February and March Year 5



February and March Year 6



Year 5

Little Gull density was very low in the Arklow Study Area in February and March. Birds were scattered in low densities over the Bank and in 1 km at the southern end of the Box.

Year 6

No Little Gulls were recorded in the Arklow Study Area in February and March of Year 6.

Year 7

Few Little Gulls were recorded over the Bank between January and March. Birds were largely confined to the southern end of the inner Bank leg in February, where highest density was 122.06 birds/km² (Table 3.13).

January to March Year 7

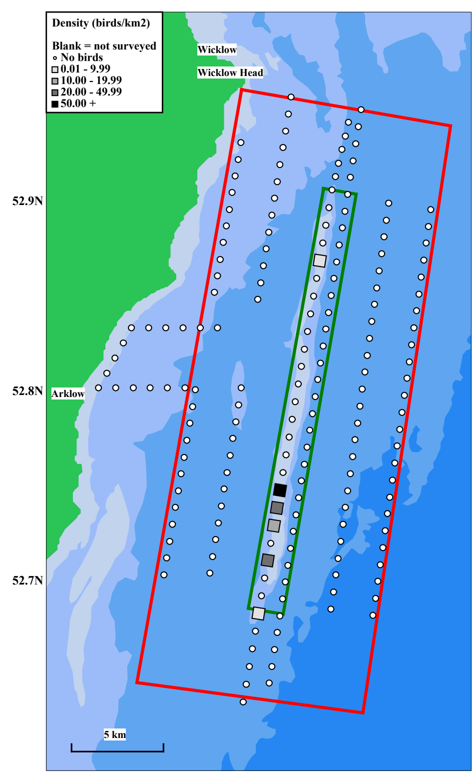
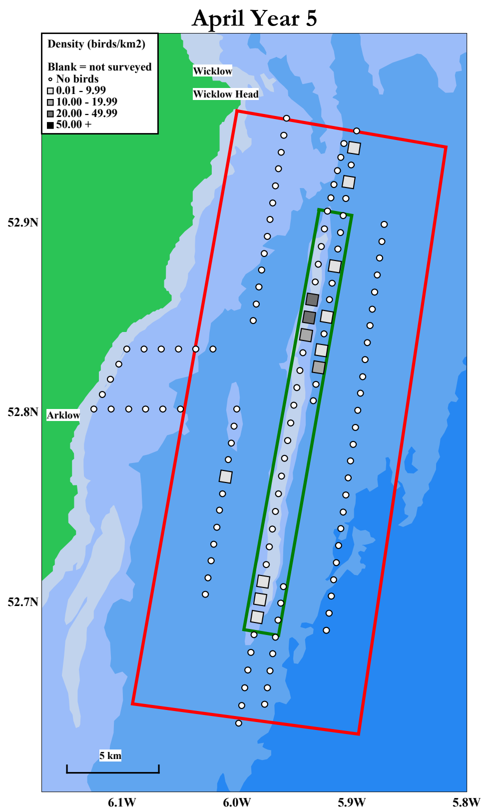
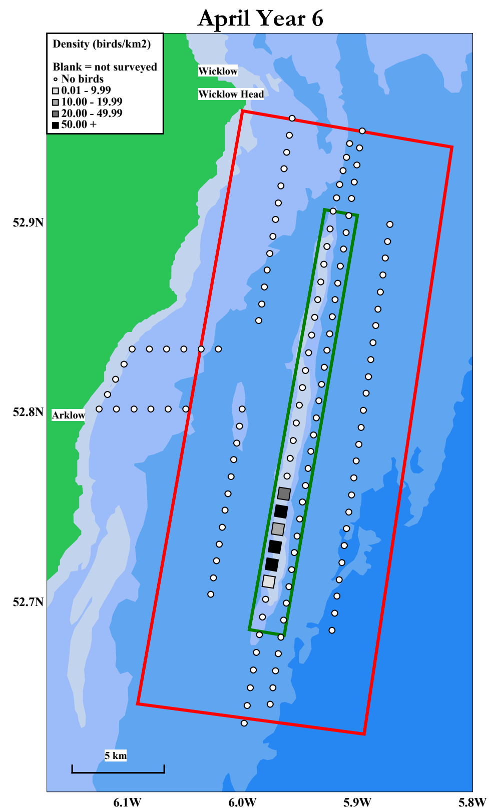


Figure 3.30 Little Gull density in April





Year 5

In April, Little Gulls were predominantly found over the Bank, with highest concentrations over the northern half of the inner Bank leg. Few birds were recorded at low densities in the Box.

Year 6

In contrast to Year 5, all Little Gulls were recorded in the southern half of the inner Bank leg in April of Year 6, with no birds recorded in the Box. High density figures are shown in Table 3.14.

Year 7

In April, Little Gulls were recorded in low to moderate densities along the southern end of the inner Bank leg, and in the middle of the outer Bank leg. No birds were recorded in the Box during the month.

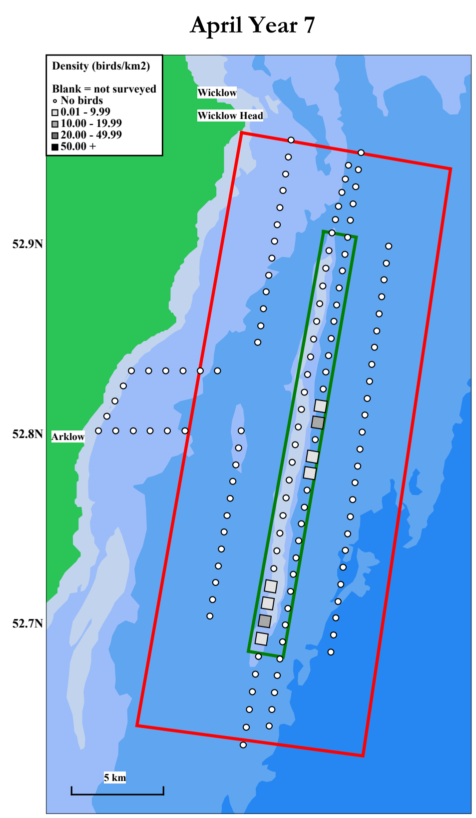
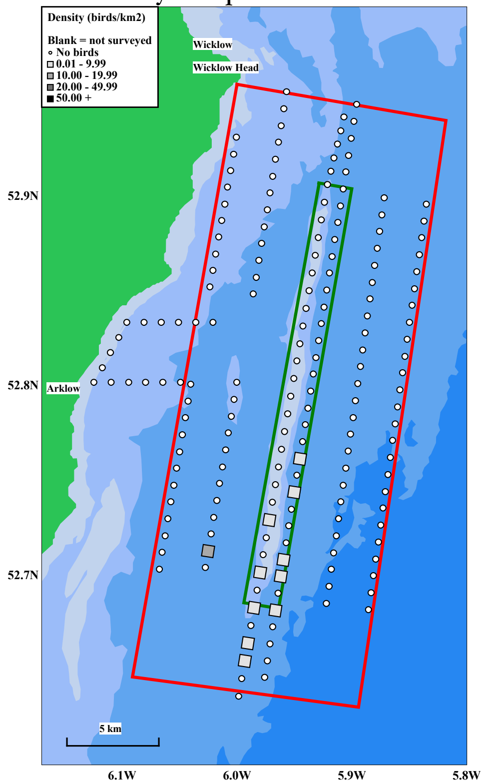
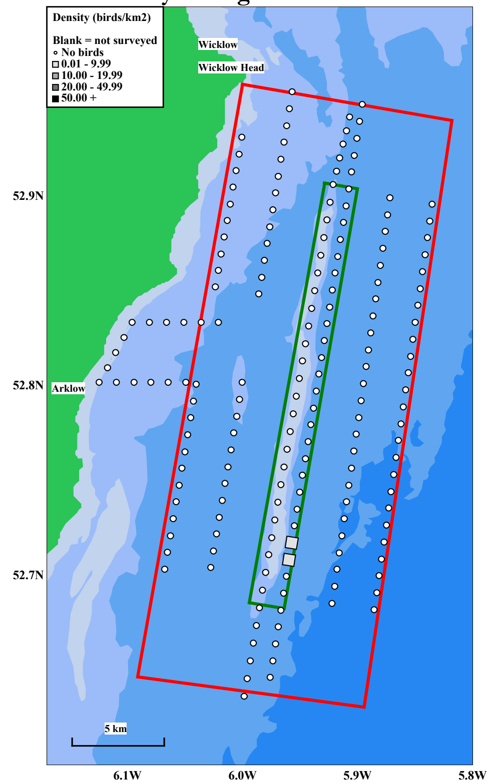


Figure 3.31 Little Gull density between May to September

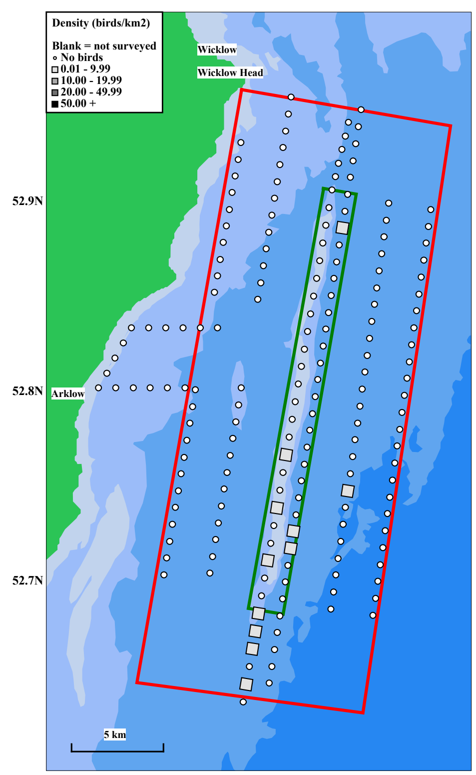
May to September Year 5



May to August Year 6



May to August Year 7



Year 5

Between May and September, Little Gulls were mostly scattered over the southern end of the Bank at low densities.

Year 6

Few Little Gulls were present in the Arklow Study Area between May to August. Birds were recorded at low densities over the Bank in August.

Year 7

Little Gulls were scattered at low densities over the southern end of the Bank and Box between May and August.

3.4.14 Mediterranean Gull

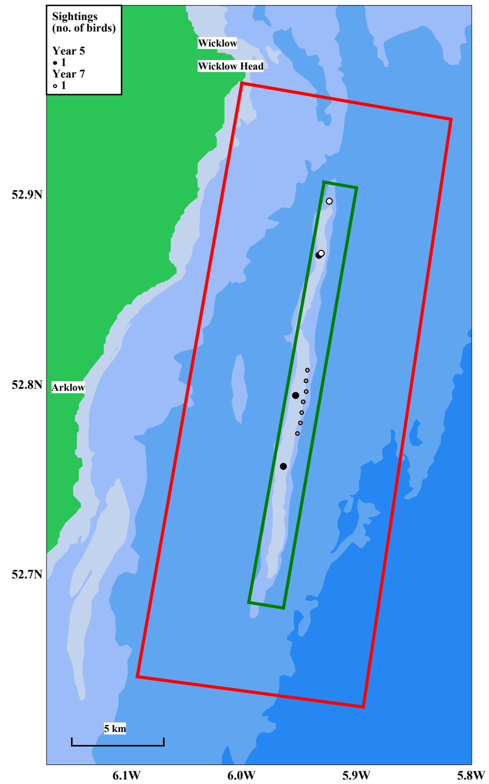
Mediterranean Gulls are scarce in the Arklow Study Area and are listed on Annex I of the EU Birds Directive (79/409/EEC).

A total of five Mediterranean Gulls were recorded in the Arklow Bank Study Area between Years 5 and 7. Three were seen in Year 5, with one in January and two in February.

None were recorded in Year 6.

In Year 7, singles were seen in November and December. All sightings were over the Bank.

Figure 3.32 Sightings in Years 5 & 7



3.4.15 Black-headed Gull

Year 5

Large numbers of Black-headed Gulls were recorded in November (834 birds) and December (600 birds) (Figure 3.33). Numbers were very low over the Bank for the remaining months. In the Box, numbers were low in all months except December, when 150 birds were recorded.

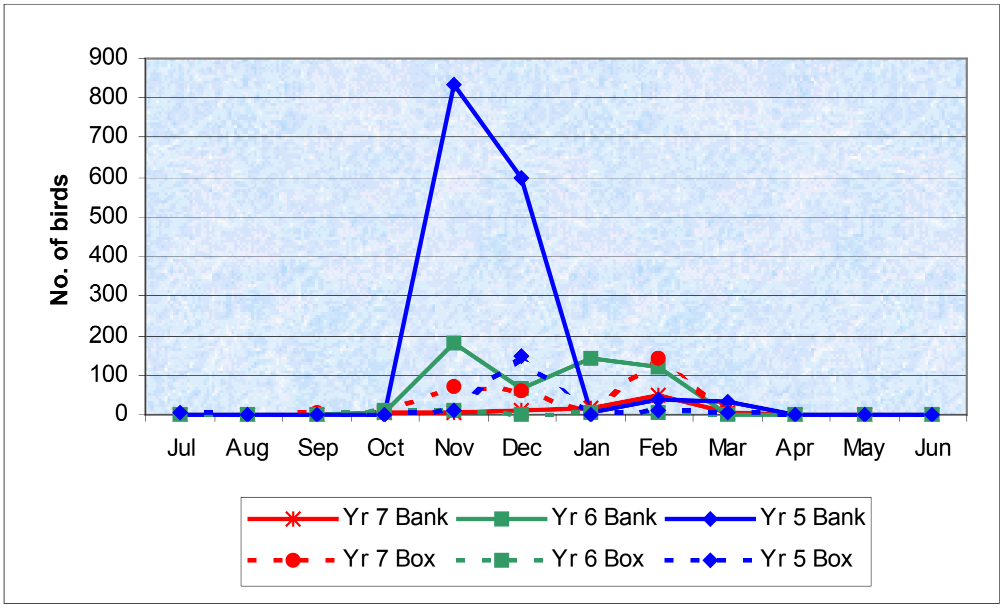
Black-headed Gull average monthly abundance was very low in the Arklow Study Area in Year 5, apart from November and December over the Bank, and in December in the Box (Figure 3.34). Over the Bank, peak average monthly abundance was 5.67 birds/km in December, while the December peak in the Box was 10.42 birds/km.

Year 6

No Black-headed Gulls were recorded over the Bank between July and September (Figure 3.33). Numbers were low in October, increasing to a peak of 183 birds in November, falling slightly in December and then increasing again in January (143 birds) and remaining around this level in February (123 birds). Few birds were recorded in the Box in Year 6, with a peak of 10 birds in October.

Black-headed Gull average monthly abundance was very low in the Arklow Study Area in Year 6, with a peak of 1.16 birds/km over the Bank in November (Figure 3.34).

Figure 3.33 Numbers of Black-headed Gulls in the Bank and Box [1], Years 5 to 7



1 Includes cable route

Year 7

Numbers of Black-headed Gulls over the Bank were lower than in the previous two years, with 47 birds in February the peak count (Figure 3.33). In the Box, numbers between November and February were higher than previous years, with peaks in November (71 birds) and February (140 birds).

Average monthly abundance was very low throughout the year (Figure 3.34).

Figure 3.34 Black-headed Gull average monthly abundance in the Bank and Box, Years 5 to 7

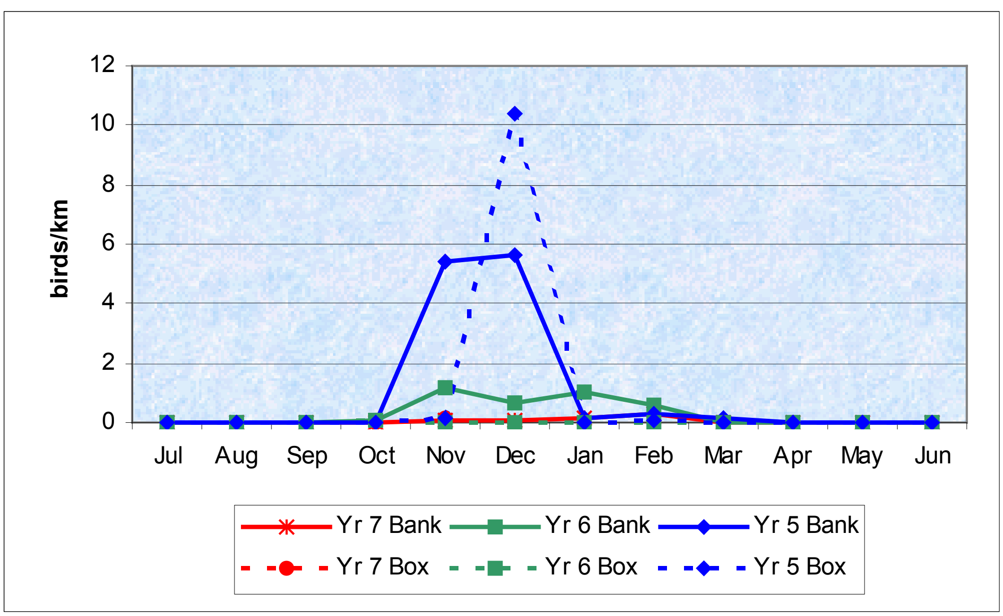
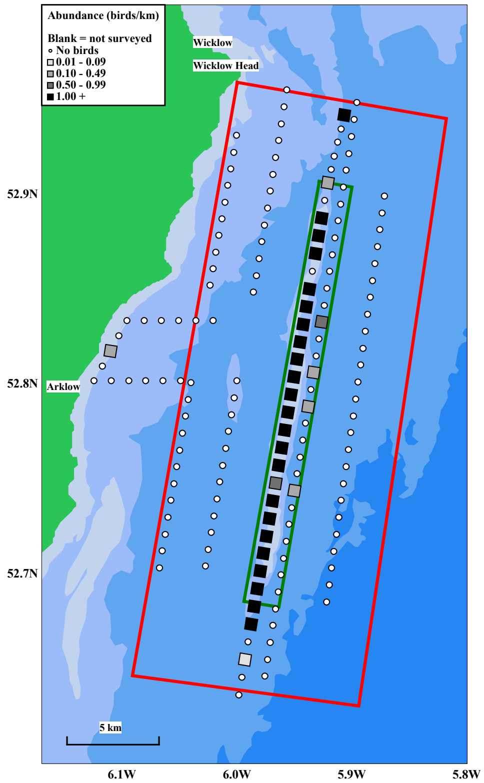
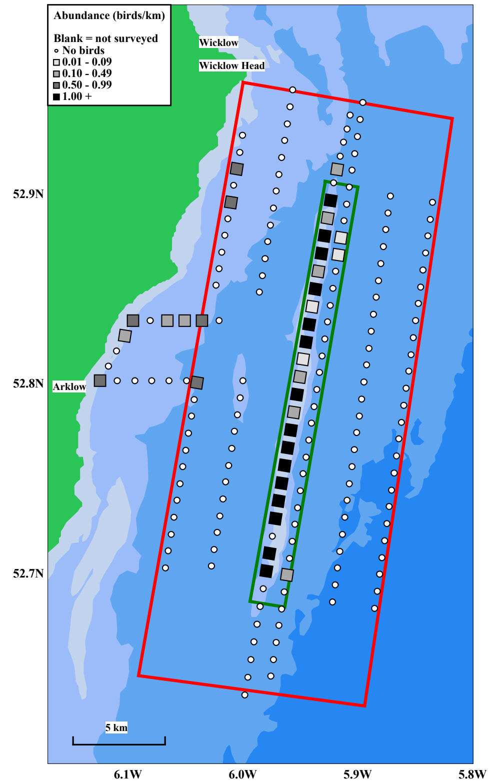


Figure 3.35 Black-headed Gull abundance between April and September

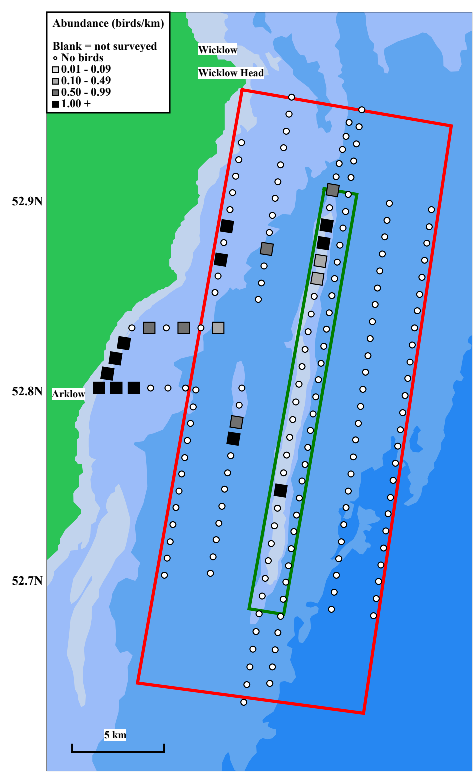
Year 5



Year 6



Year 7



Year 5

Black-headed Gulls were mostly recorded along the inner Bank leg between April and September, with highest abundance recorded in November and December. Peak abundance ranged from 1.06 birds/km to 10.30 birds/km.

Year 6

Distribution between April and September was similar to Year 5, with highest abundance over the inner Bank leg in November and January and lower abundance on the inner Box leg and Cable Route. Peak abundance ranged from 1.10 birds/km to 1.91 birds/km.

Year 7

Black-headed Gull distribution was more restricted between April and September, with the majority of birds found at the north end of the inner Bank leg, and along the Cable Route. Highest abundance was recorded over the Cable Route in November and ranged from 1.08 birds/km to 15.0 birds/km.

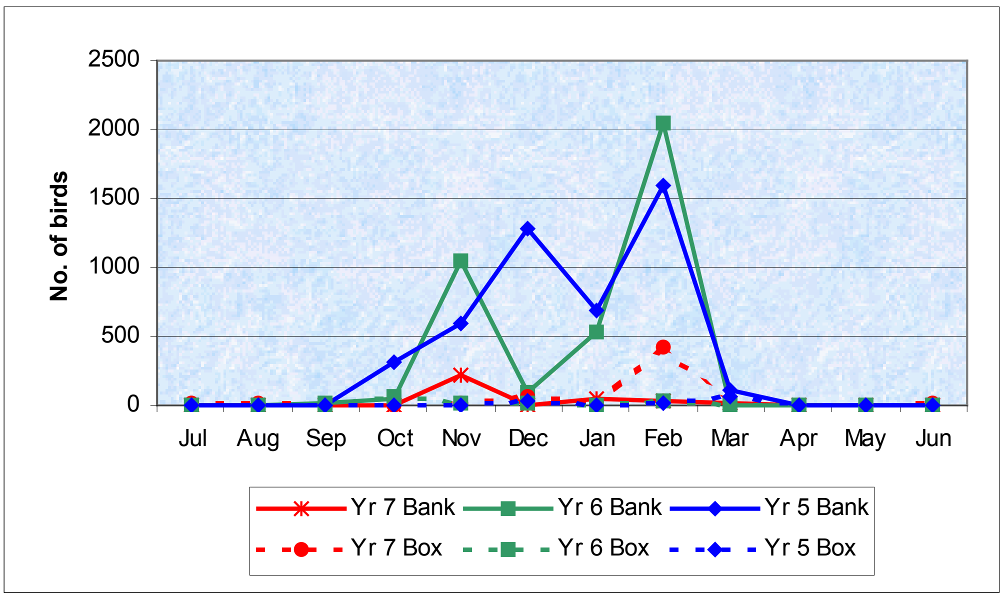
3.4.16 Common Gull

Year 5

Few Common Gulls were recorded in the Arklow Study Area between April and September (Figure 3.36). Numbers over the Bank began to increase from October onwards, peaking at 1,278 birds in December and 1,598 birds in February, before dropping considerably in March. Numbers in the Box were low throughout the year.

Average monthly density over the Bank was highest between November and February, with the peak of 60.37 birds/km² recorded in December (Figure 3.37). Outside this period, average monthly density over the Bank was low, as was the average monthly density in the Box throughout the year.

Figure 3.36 Numbers of Common Gulls in the Bank and Box [1], Years 5 to 7



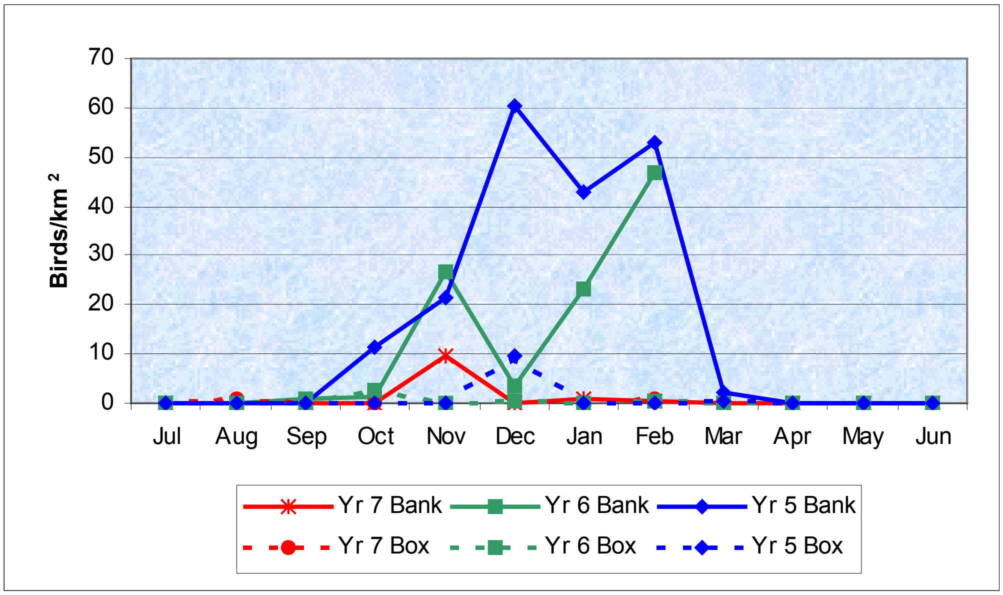
1 Includes cable route

Year 6

In Year 6, numbers over the Bank peaked between November (1,041 birds) and February (2,047 birds), with low numbers recorded outside this period (Figure 3.36). Numbers in the Box were low throughout the year.

Common Gull average monthly density over the Bank was generally lower than in Year 5, although the November peak of 26.89 birds/km² was higher (Figure 3.37). Numbers decreased in December, before rising to a peak of 47.0 birds/km², which was slightly below the Year 5 February peak. Average monthly density in the Box was very low throughout the year.

Figure 3.37 Common Gull average monthly density in the Bank and Box, Years 5 to 7



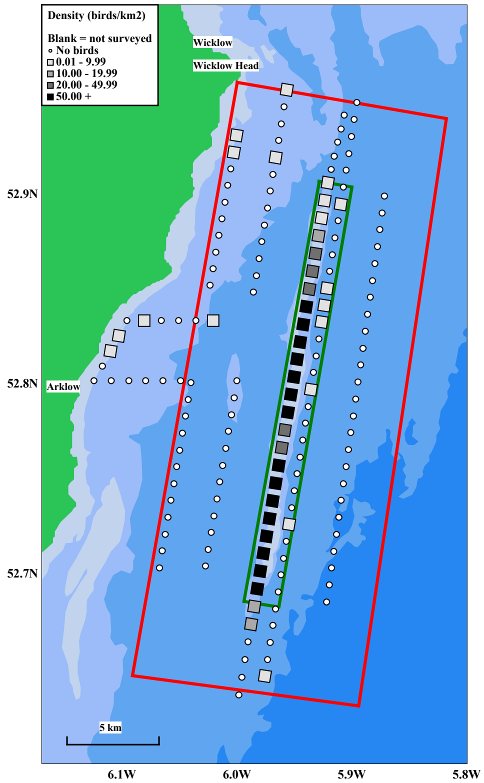
Year 7

Numbers of Common Gulls over the Bank were lower in Year 7 than in the two previous years, with a peak of 214 birds recorded in November (Figure 3.36). This was considerably lower than both Years 5 and 6. There was no February peak recorded over the Bank, however numbers in the Box peaked at 417 birds during the month, which was considerably higher than any other monthly total during all three years.

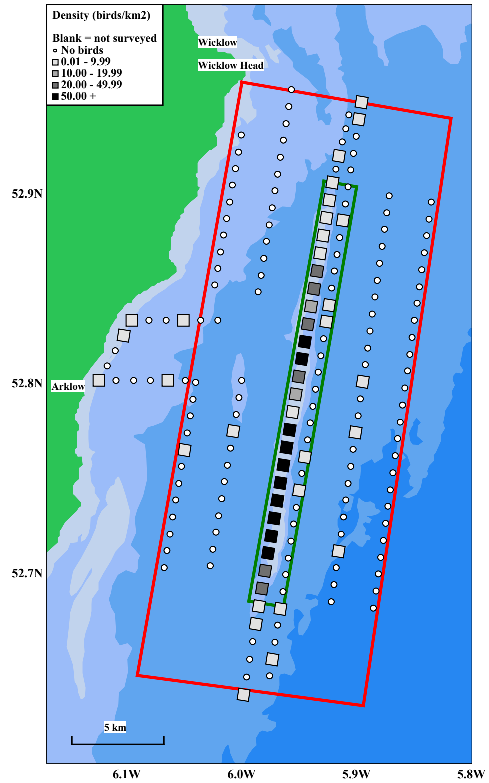
Average monthly density over the Bank in Year 7 was much lower than in the previous two years, with a peak in November of 9.41 birds/km^2 (Figure 3.37). Average monthly density over the Bank was low for all other months, as was the average monthly density in the Box throughout the year.

Figure 3.38 Common Gull density between November and February

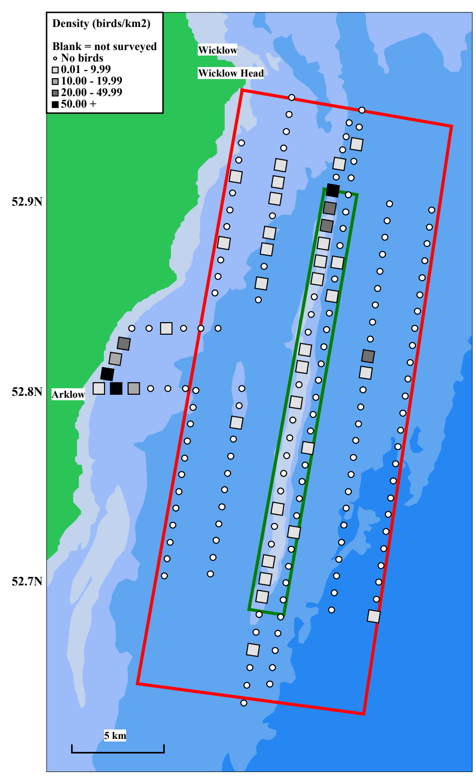
Year 5



Year 6



Year 7



Year 5

In Year 5, Common Gull density was highest along the inner Bank leg from December to February (Table 3.15). Elsewhere, birds were scattered at low densities in the northern half of the inner Box, and Cable Route.

Year 6

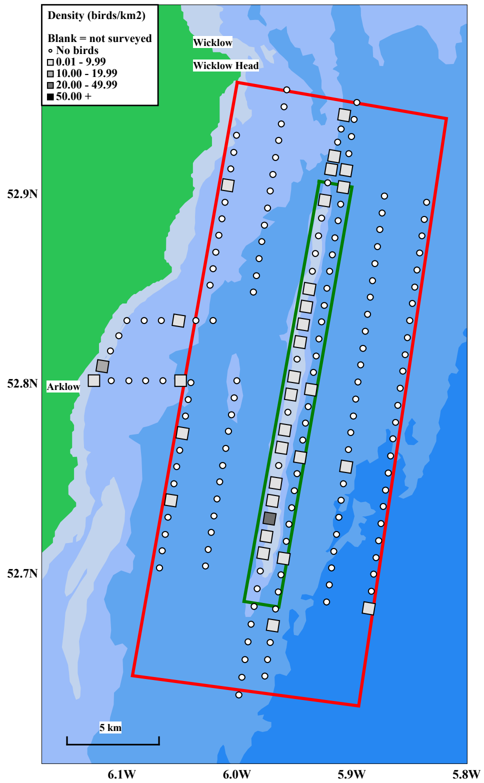
Common gull distribution between November and February of Year 6 was similar to Year 5, with highest densities recorded along the inner Bank leg in November, January and February (Table 3.15). Elsewhere, birds were scattered at low densities in the Box, and Cable Route.

Year 7

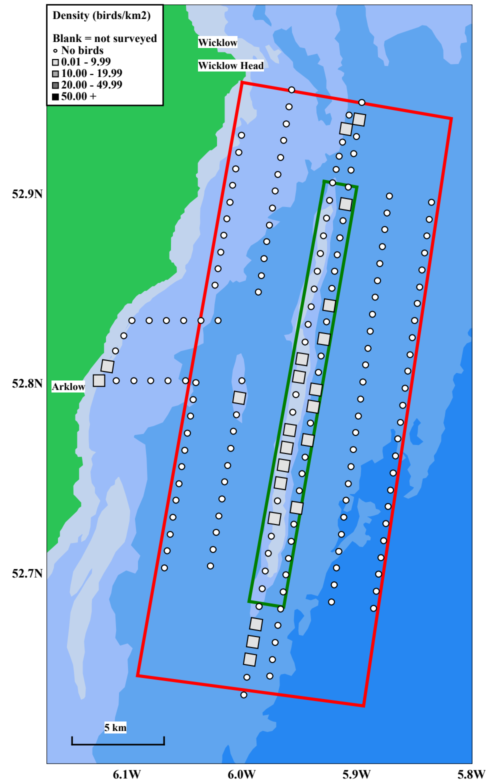
Common Gull densities in Year 7 were lower than in the two previous years, with highest densities recorded at the north end of the inner Bank leg and along the Cable Route (Table 3.15). Densities elsewhere along the Bank and scattered in the Box were generally low.

Figure 3.39 Common Gull density between March and October

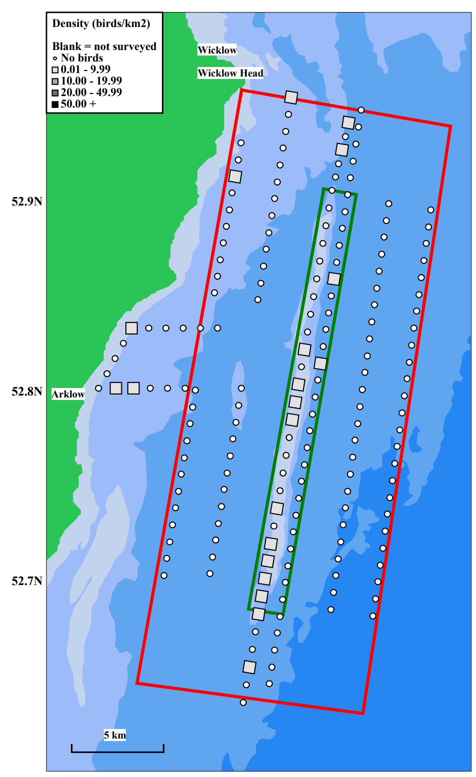
Year 5



Year 6



Year 7



Year 5

Densities of Common Gulls were lower between March and October, but the distribution pattern was generally similar to the winter months, with low densities regularly recorded along the inner Bank leg and scattered elsewhere.

Year 6

The distribution of Common Gulls between March and October was generally similar to the same period in Year 5, with low densities recorded over the Bank and scattered elsewhere.

Year 7

Common Gull distribution between March and October was generally similar to Years 5 and 6, with low densities recorded over the Bank and scattered elsewhere.

Table 3.15 Peak Common Gull densities between November and February, in Years 5, 6 and 7 (> 50 birds/km^2)

Year	Survey leg	Km waypoint	Seasonal Density
5	3	14	87.48
5	3	15	54.54
5	3	16	147.56
5	3	17	223.15
5	3	18	104.72
5	3	19	73.01
5	3	22	89.07
5	3	23	80.58
5	3	24	91.38
5	3	25	95.06
5	3	26	77.69
5	3	27	84.73
5	3	28	158.71
5	3	29	78.96
6	3	15	63.52
6	3	16	130.86
6	3	20	70.74
6	3	21	63.84
6	3	22	122.28
6	3	23	211.21
6	3	24	115.61
6	3	25	73.05
6	3	26	95.28
6	3	27	160.71
7	3	6	53.76
7	5	9	248.50
7	5	11	98.00

3.4.17 Lesser Black-backed Gull

Year 5

Seven Lesser Black-backed Gulls were recorded in Year 5, with 3 in March, two in July, one in November and one in December. Two of these were over the Bank with the remaining five sightings in the Box.

Year 6

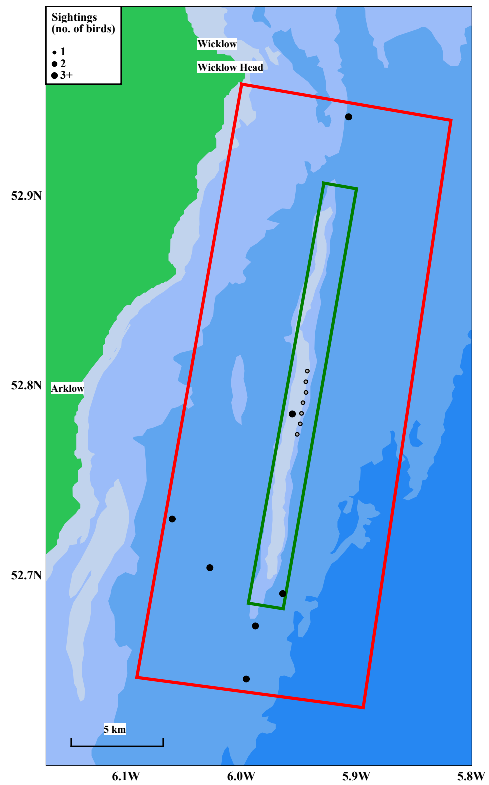
In Year 6, numbers recorded increased to 18, spread between February and September, with a peak of 8 in September. Sightings were scattered along the Bank, in the south east of the Box and on the Cable Route.

Year 7

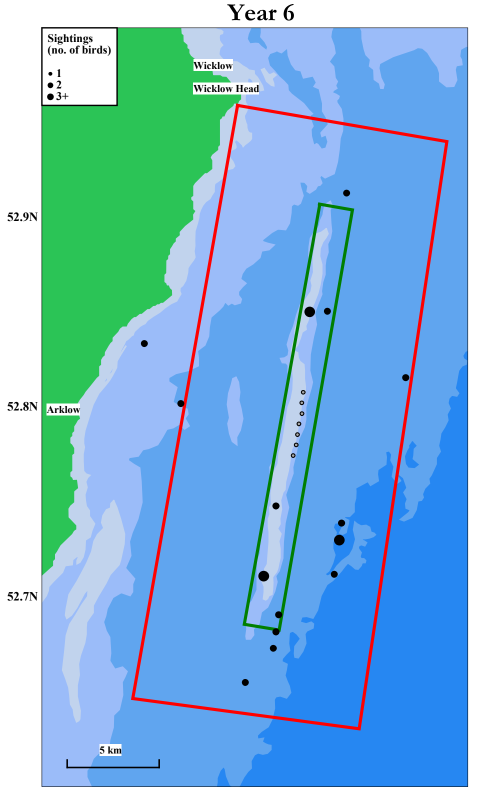
In Year 7, a total of 40 Lesser Black-backed Gulls were recorded between May and December, with a peak of 21 in July. The majority of sightings were over the Bank, with occasional sightings in the south of the Box and on the Cable Route.

Figure 3.40 Sightings in Years 5, 6 and 7

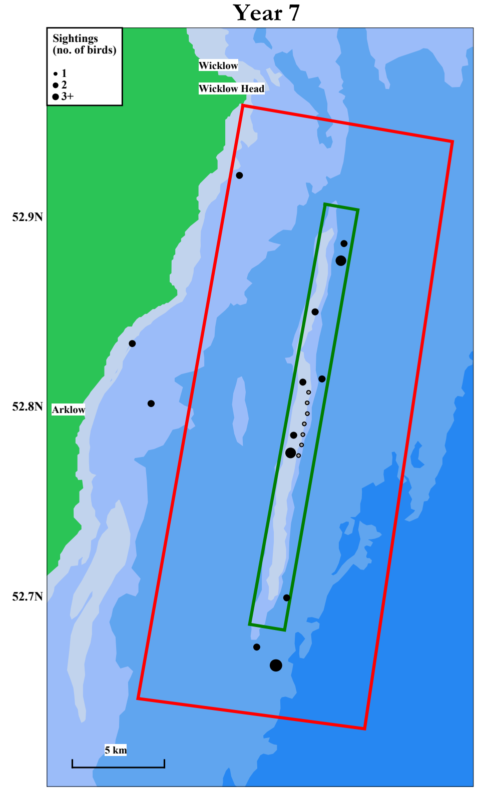
Year 5



Year 6



Year 7



3.4.18 Great Black-backed Gull

Year 5

Eleven Great Black-backed Gulls were recorded in Year 5, with 1 in January, 2 in May, 4 in October, 3 in November and 1 in December.

Year 6

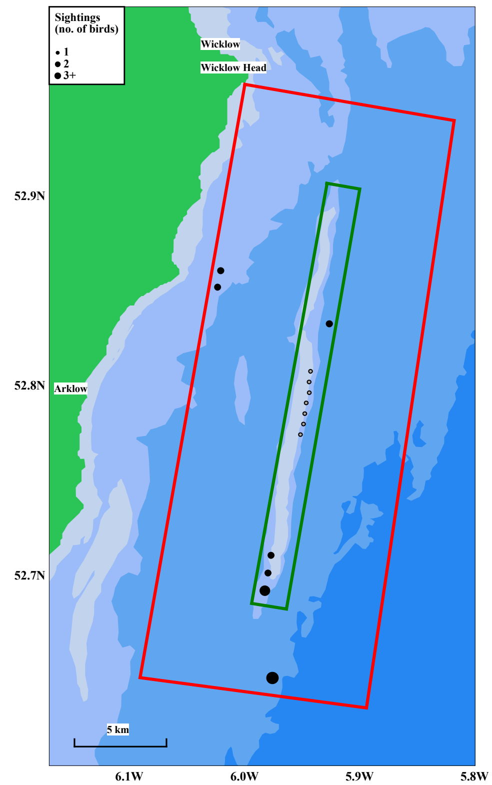
In Year 6, numbers increased to 45 recorded in all months except March, May and June. A peak of 11 was recorded in February, with 10 in September, and low numbers in other months. Largest numbers were recorded over the Bank, with scattered sightings in the Box and Cable Route.

Year 7

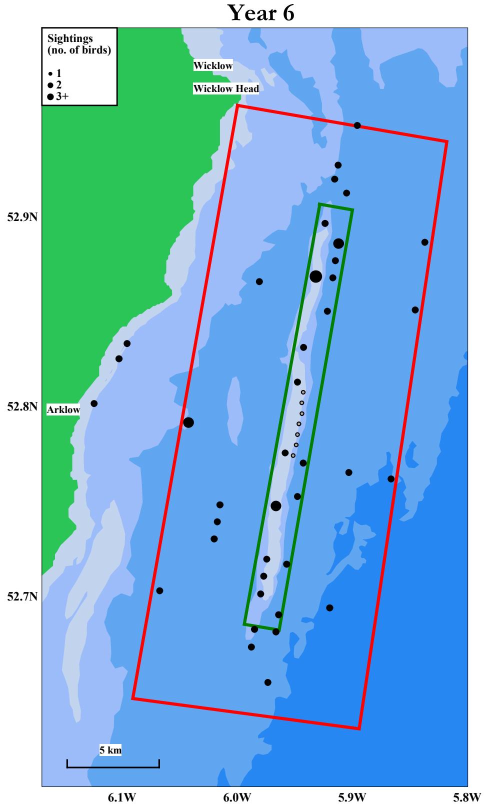
A total of 83 birds were recorded in Year 7. Birds were seen in all months except June, with the peak count of 42 recorded in August. Concentrations occurred at the northern and southern ends of the Box, with lower numbers over the Bank and Cable Route.

Figure 3.41 Sightings in Years 5, 6 and 7

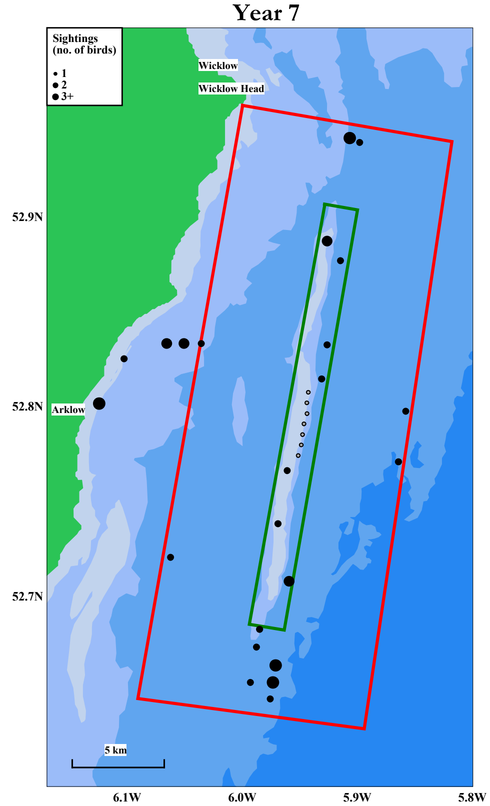
Year 5



Year 6



Year 7



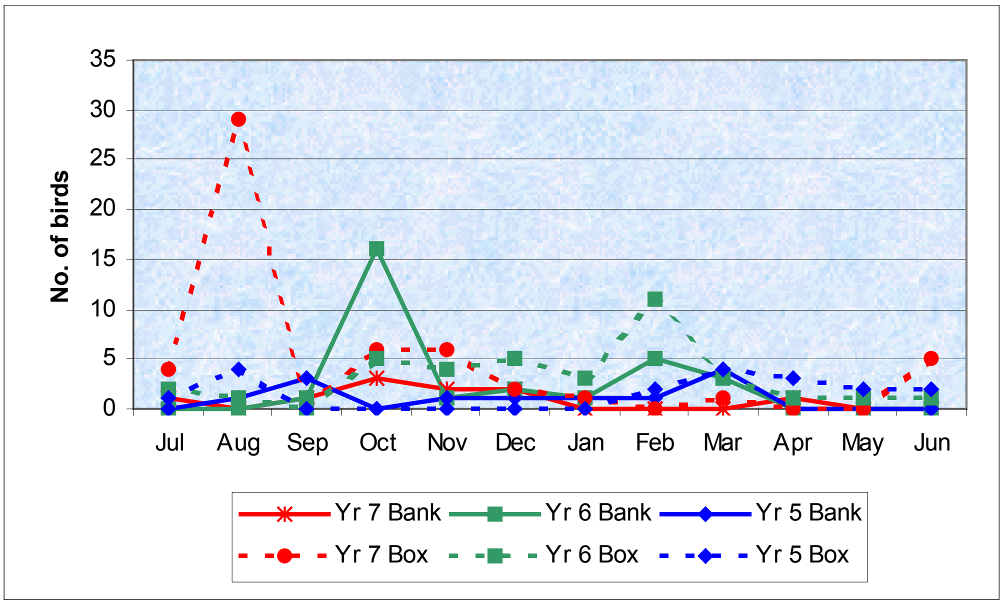
3.4.19 Herring Gull

Year 5

Low numbers of Herring Gulls were recorded over the Bank between November to March, and in August, with a peak of 4 birds in March (Figure 3.42). Low numbers were recorded in the Box between February and August, with a peak of 4 birds in March and August.

Average monthly abundance was very low over the Bank and Box throughout Year 5 (Figure 3.43).

Figure 3.42 Numbers of Herring Gulls in the Bank and Box [1], Years 5 to 7



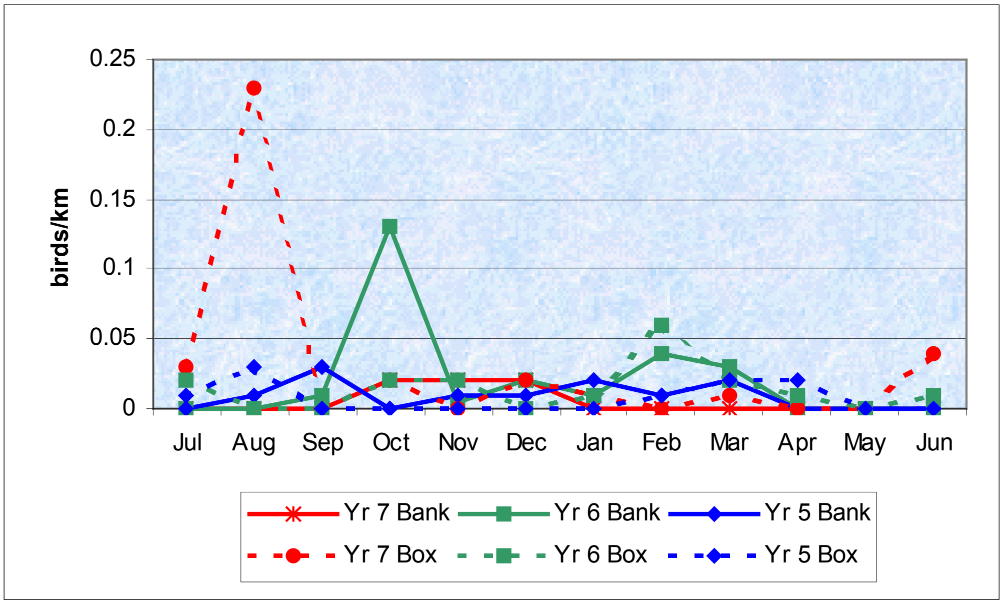
1 Includes cable route

Year 6

Herring Gulls were recorded in low numbers over the Bank between September and March. Peak numbers were higher than Year 5, with 16 birds in October the highest count (Figure 3.42). Herring Gulls were recorded in the Box in low numbers in all months except September, with a peak of 11 birds in February.

Average monthly abundance was low over the Bank in all months, with a peak of 0.13 birds/km in October (Figure 3.43). Average monthly abundance in the Box was also low throughout the year.

Figure 3.43 Herring Gull average monthly abundance in the Bank and Box, Years 5 to 7



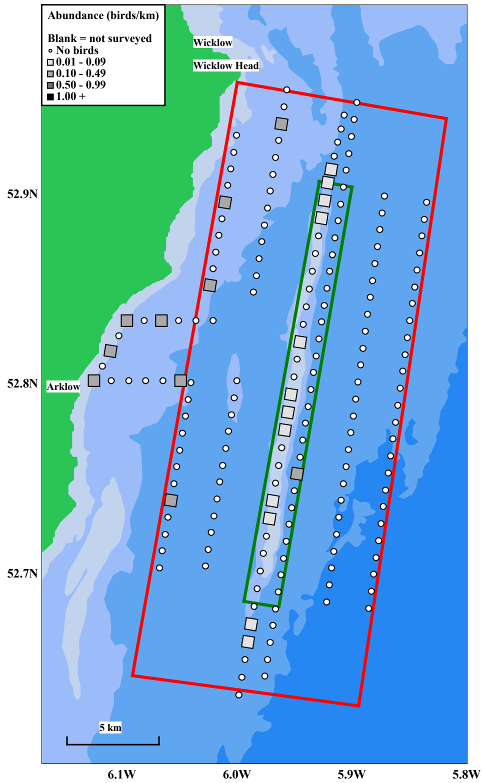
Year 7

Herring Gulls were recorded over the Bank in low numbers in July, September to December and in April (Figure 3.42). The peak monthly total was 3 in October, which was lower than the two previous years. Numbers in the Box were generally higher, with birds seen in July, August, October to January, March and June, and a peak of 29 birds in August, which was the highest monthly total of the three years.

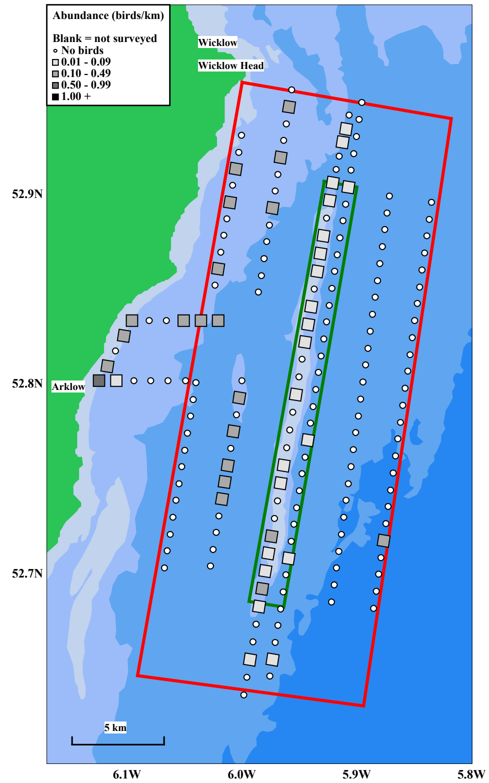
Average monthly abundance over the Bank was very low in all months (Figure 3.43). In the Box, average monthly abundance was also low throughout the year, with a peak of 0.23 birds/km in August.

Figure 3.44 Herring Gull abundance between Years 5, 6 and 7

Year 5



Year 6



Year 5

Herring Gull distribution in Year 5 was predominantly along the inner Bank and Box legs and along the Cable Route, at low to moderate abundance.

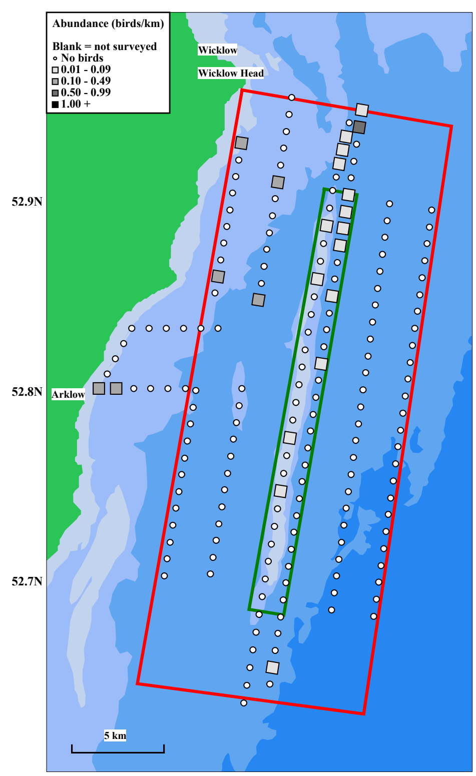
Year 6

Distribution in Year 6 was similar to Year 5, with most Herring Gulls found in low to moderate abundance along the inshore Bank and Box legs, and Cable Route.

Year 7

In Year 7, Herring Gulls were found in low abundance scattered along the Bank, with birds also recorded occasionally in moderate abundance on the northern sections of the inner Box legs and Cable Route.

Year 7



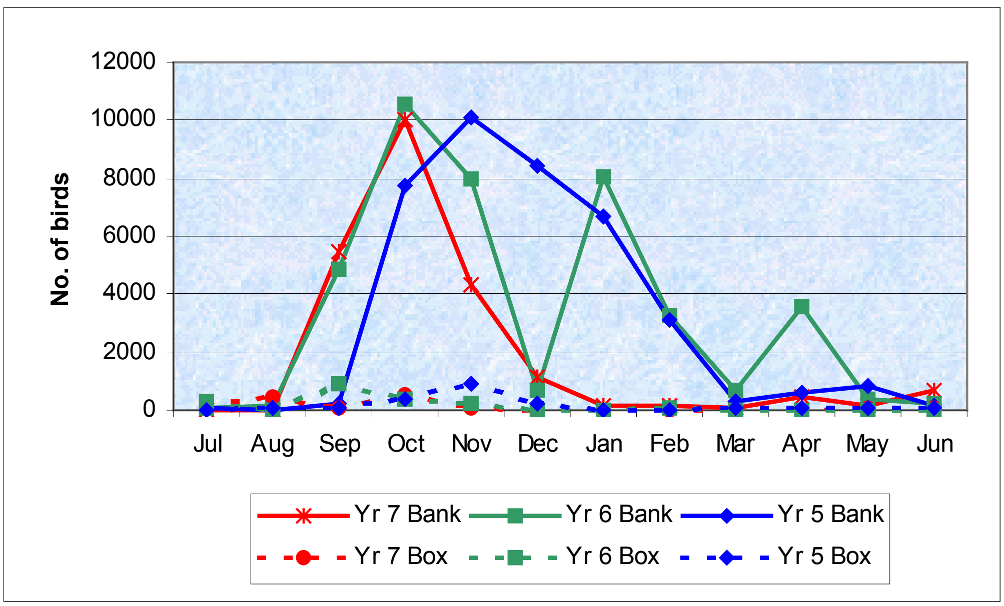
3.4.20 Kittiwake

Year 5

Highest numbers of Kittiwakes were recorded over the Bank between October and February, with lower numbers between March and September (Figure 3.45). In October, 7,768 birds were recorded in October, rising to a peak of 10,075 birds in November, with numbers gradually decreasing from December to March. Numbers were low in the Box throughout the year.

Average monthly density over the Bank was highest between October and February, with a peak in October of 304.89 birds/km², rising to 461.41 birds/km² in January, which was the highest average monthly density recorded in all three years (Figure 3.46). In the Box, highest average monthly density was recorded in November, with a peak of 75.15 birds/km².

Figure 3.45 Numbers of Kittiwakes in the Bank and Box [1], Years 5 to 7



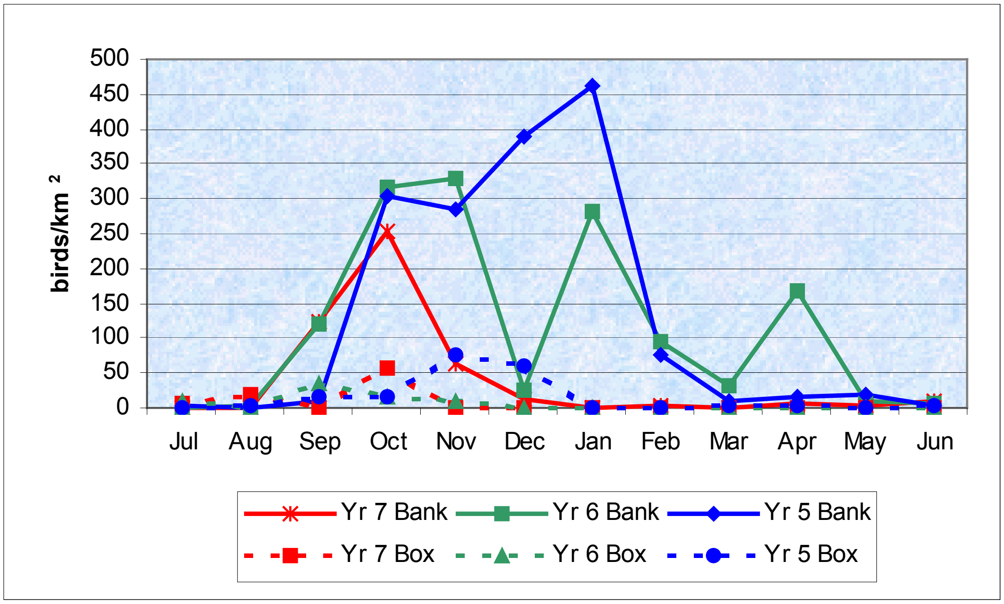
1 Includes cable route

Year 6

Numbers of Kittiwakes over the Bank in Year 6 were similar to Year 5, with a similar pattern, although numbers began to increase from September onwards, with a peak of 10,520 birds in October (Figure 3.45). Numbers then decreased to 8,009 birds in November, before dropping to just 706 birds in December, with an increase to 8,059 birds in January. Numbers decreased again until a peak of 3,561 birds in April. Numbers in the Box were low throughout the year.

Kittiwake average monthly density over the Bank showed a similar pattern to Year 5 between September and February, with a peak of 328.18 birds/km² in November (Figure 3.46). There was a steep drop in density in December, and the January peak of 280.36 birds/km² was lower than Year 5. Unlike Years 5 or 7, there was an increase in April to a peak of 166.69 birds/km². Average monthly density over the Box was low throughout the year.

Figure 3.46 Kittiwake average monthly density in the Bank and Box, Years 5 to 7



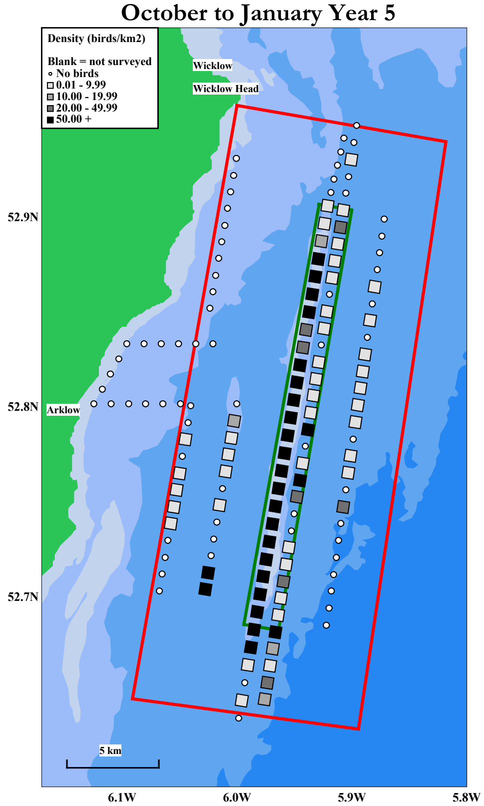
Year 7

Like Year 6, numbers of Kittiwakes over the Bank in Year 7 showed a peak in October, with a peak of 10,014 birds, which was very similar to peak numbers in the two previous years (Figure 3.45). Unlike Years 5 and 6, numbers fell sharply after this peak, with few birds recorded after November. Numbers in the Box were low throughout the year.

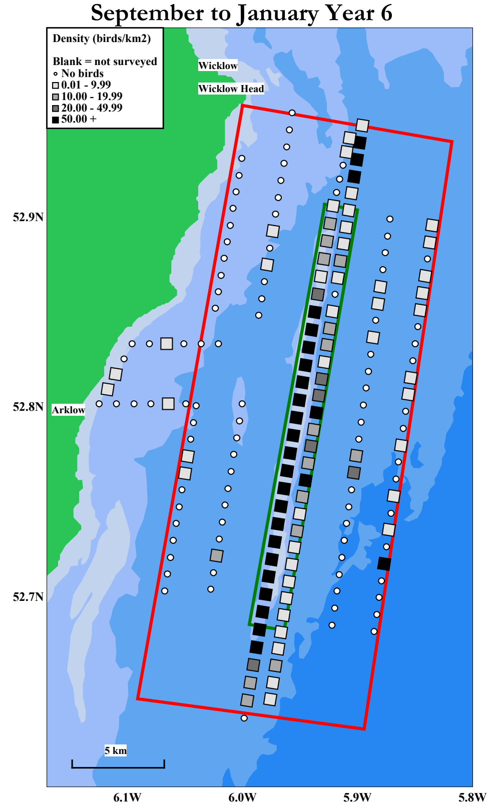
Average monthly density over the Bank in Year 7 was highest in October, although the peak of 254.24 birds/km^2 was lower than the two previous years (Figure 3.46). Average monthly density was low over the Bank for the other months of the year, and in the Box in all months.

Figure 3.47 Kittiwake density abundance between September and January

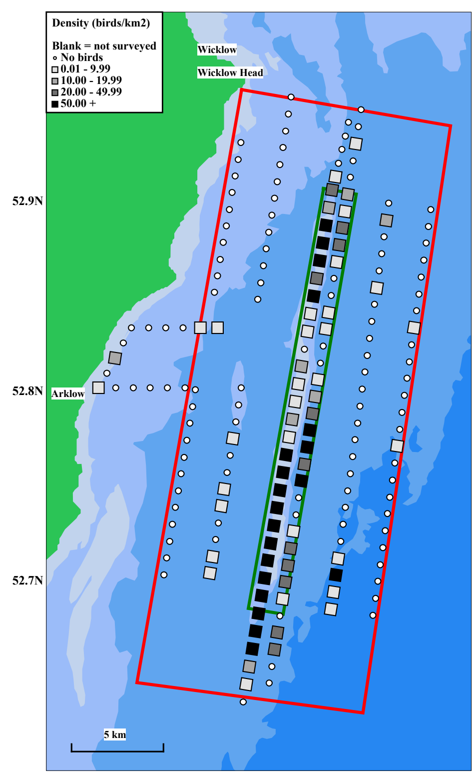
October to January Year 5



September to January Year 6



September to January Year 7



Year 5

Highest densities of Kittiwakes between October and January were predominantly along the inner Bank leg (Table 3.16). Lower densities were recorded on the outer Bank leg and in the Box.

Year 6

Kittiwake distribution between September and January in Year 6 was similar to Year 5, with highest densities along the inner Bank leg (Table 3.17). Lower densities were recorded on the outer Bank leg and in the Box and Cable Route.

Year 7

In Year 7, highest densities of Kittiwakes between September and January were again along the inner Bank leg, with some high density areas on the outer Bank leg (Table 3.18). Low to moderate densities were scattered in the Box and Cable Route.

Table 3.16 Peak Kittiwake densities between October and January, Year 5 (> 50 birds/km²)

Year	Survey leg	Km waypoint	Seasonal Density
5	2	19	61.50
5	2	22	93.33
5	2	31	65.00
5	3	9	118.58
5	3	10	96.26
5	3	11	93.33
5	3	12	150.26
5	3	15	222.67
5	3	16	356.76
5	3	17	546.35
5	3	18	516.25
5	3	19	404.30
5	3	20	385.78
5	3	21	868.25
5	3	22	518.41
5	3	23	497.04
5	3	24	1,137.64
5	3	25	1,147.75
5	3	26	1,043.50
5	3	27	2.318.28
5	3	28	1,634.83
5	3	29	1,989.55
5	3	30	906.86
5	3	31	582.35
5	42	11	51.33
5	42	12	154.00

Table 3.17 Peak Kittiwake densities between September and January, Year 6 (> 50 birds/km^2)

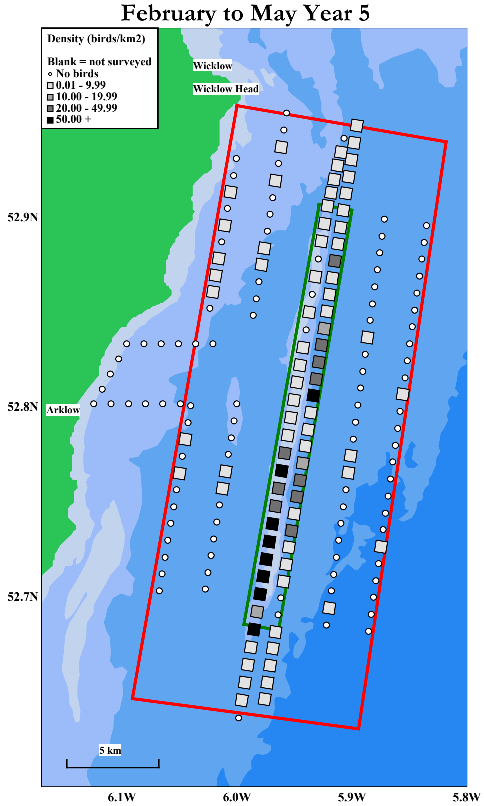
Year	Survey leg	Km waypoint	Seasonal Density
6	1	21	65.56
6	2	2	104.13
6	2	3	52.50
6	2	4	59.21
6	2	18	72.92
6	2	22	71.46
6	3	12	60.77
6	3	13	83.50
6	3	14	160.75
6	3	15	154.54
6	3	16	193.92
6	3	17	104.50
6	3	18	248.76
6	3	19	174.65
6	3	20	183.05
6	3	21	210.19
6	3	22	643.03
6	3	23	847.33
6	3	24	1,006.67
6	3	25	1,083.74
6	3	26	1,658.10
6	3	27	928.96
6	3	28	929.59
6	3	29	1,077.32
6	3	30	490.05
6	3	31	74.78

Table 3.18 Peak Kittiwake densities between September and January, Year 7 (> 50 birds/km^2)

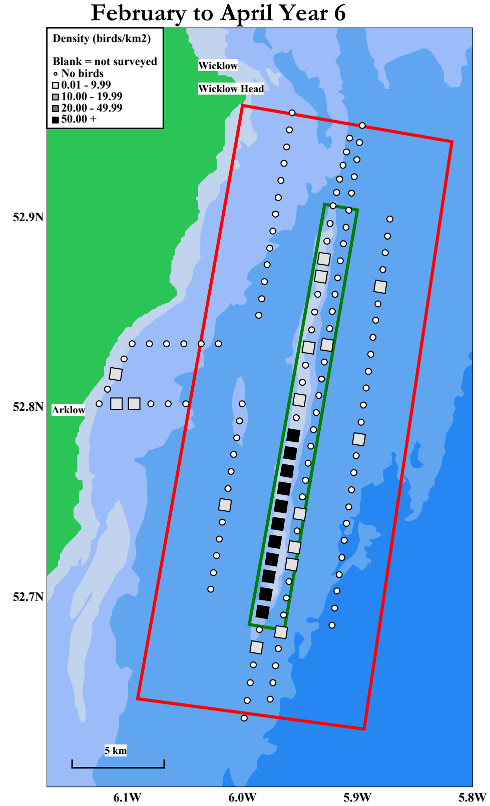
Year	Survey leg	Km waypoint	Seasonal Density
7	2	20	126.46
7	2	21	125.03
7	2	23	54.56
7	3	8	83.37
7	3	9	60.93
7	3	10	59.29
7	3	12	61.14
7	3	21	259.39
7	3	22	336.89
7	3	23	519.83
7	3	24	425.87
7	3	25	548.47
7	3	26	628.23
7	3	27	679.27
7	3	28	1,322.55
7	3	29	642.48
7	3	30	69.29
7	3	31	104.07
7	3	32	234.49
7	11	23	

Figure 3.48 Kittiwake density abundance between February and May

February to May Year 5



February to April Year 6



Year 5

Highest densities of Kittiwakes between February and May were predominantly along the southern half of the inner Bank leg (Table 3.19). Lower densities were recorded on the outer Bank leg and scattered through the Box.

Year 6

Kittiwake distribution between February and April in Year 6 was similar to Year 5, with highest densities along the inner Bank leg (Table 3.19). Lower densities were scattered on the outer Bank leg and in the Box and Cable Route.

Year 7

In Year 7, densities of Kittiwakes between February and April were lower than the two previous years, with density exceeding 50 birds/km² in just one km square on the inner Bank leg (Table 3.19). Low densities were scattered elsewhere on the Bank and Box.

February to April Year 7

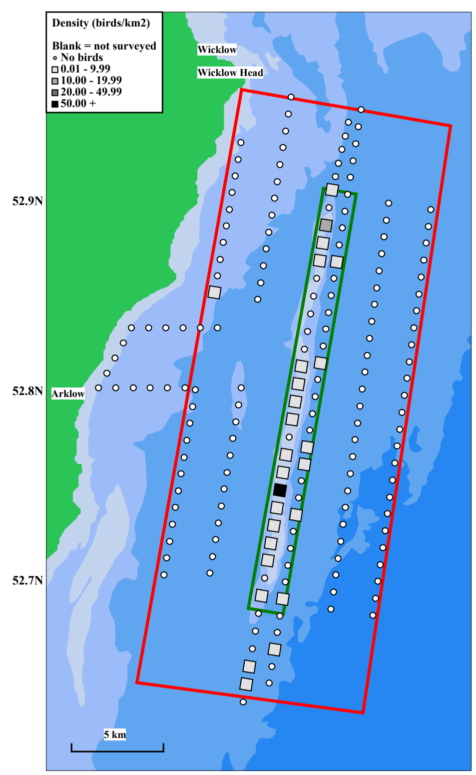


Table 3.19 Peak Kittiwake densities between February and May, Years 5, 6 and 7 (> 50 birds/km^2)

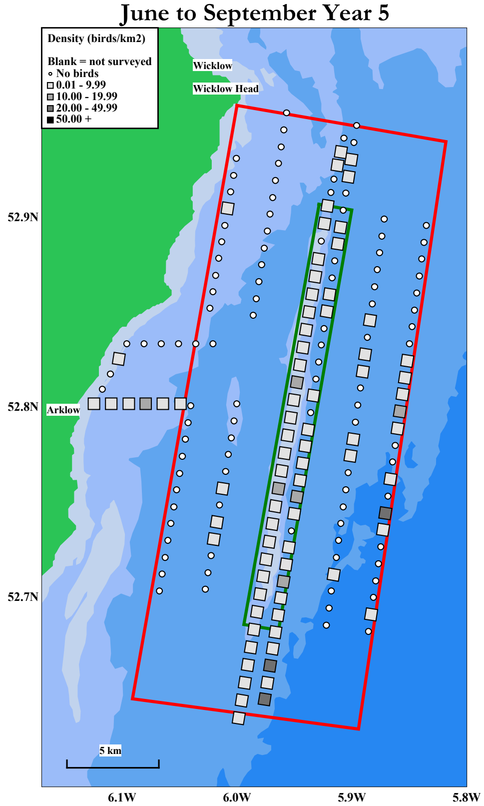
Season & Year	Survey leg	Km waypoint	Seasonal Density
Feb to May, Year 5	2	17	72.00
Feb to May, Year 5	3	21	86.46
Feb to May, Year 5	3	24	74.71
Feb to May, Year 5	3	25	129.38
Feb to May, Year 5	3	26	86.50
Feb to May, Year 5	3	27	138.94
Feb to May, Year 5	3	28	193.64
Feb to May, Year 5	3	30	118.08
Feb to Apr, Year 6	3	19	149.36
Feb to Apr, Year 6	3	20	421.32
Feb to Apr, Year 6	3	21	109.13
Feb to Apr, Year 6	3	22	373.52
Feb to Apr, Year 6	3	23	427.32
Feb to Apr, Year 6	3	24	305.93
Feb to Apr, Year 6	3	25	293.48
Feb to Apr, Year 6	3	26	351.73
Feb to Apr, Year 6	3	27	1,085.42
Feb to Apr, Year 6	3	28	482.01
Feb to Apr, Year 6	3	29	239.67
Feb to Apr, Year 7	3	23	60.11

Table 3.20 Peak Kittiwake densities between May and August, Years 6 and 7 (> 50 birds/km^2)

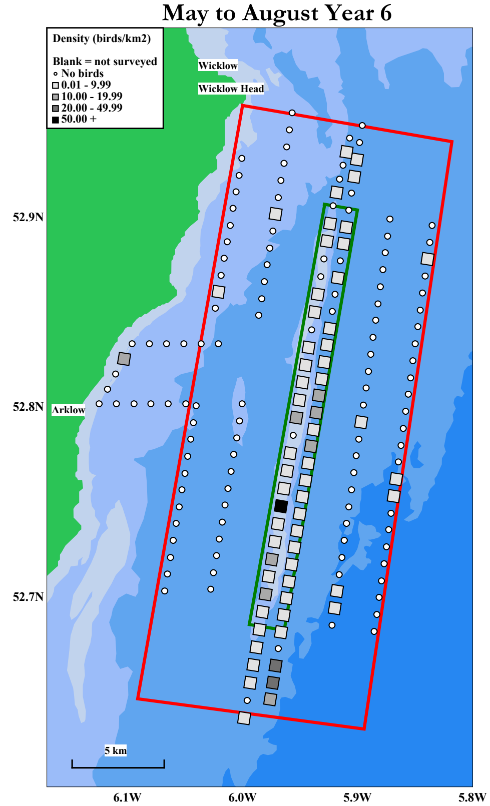
Year	Survey leg	Km waypoint	Seasonal Density
6	3	23	61.42
7	1	12	210.00
7	3	1	109.13

Figure 3.49 Kittiwake density abundance between May and September

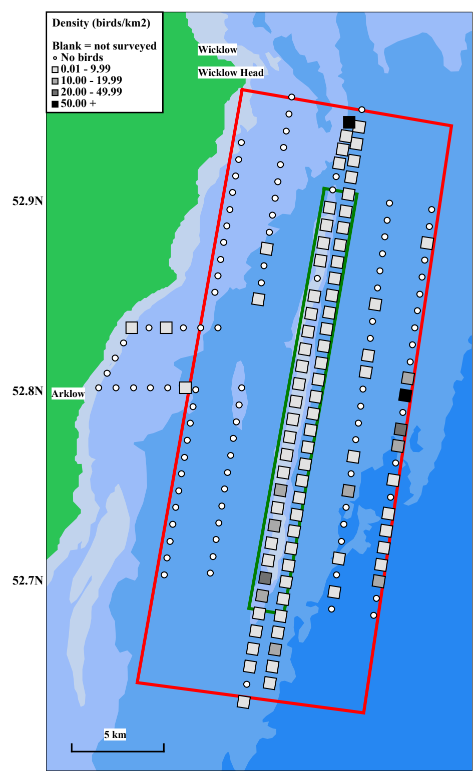
June to September Year 5



May to August Year 6



May to August Year 7



Year 5

Between June and September, low to moderate densities of Kittiwakes were recorded along the Bank and scattered through the Box and Cable Route.

Year 6

Distribution between May and August in Year 6 was similar to Year 5, with low to moderate densities of Kittiwakes recorded along the Bank and scattered through the Box and Cable Route. Kittiwake density exceeded 50 birds/km^2 in one km square on the inner Bank leg (Table 3.20).

Year 7

In Year 7, Kittiwakes were found in low density along the Bank, with birds also scattered in low to moderate density in the Box legs and Cable Route. Kittiwake density exceeded 50 birds/km^2 in two km squares in the Box (Table 3.20).

3.4.21 Common Tern

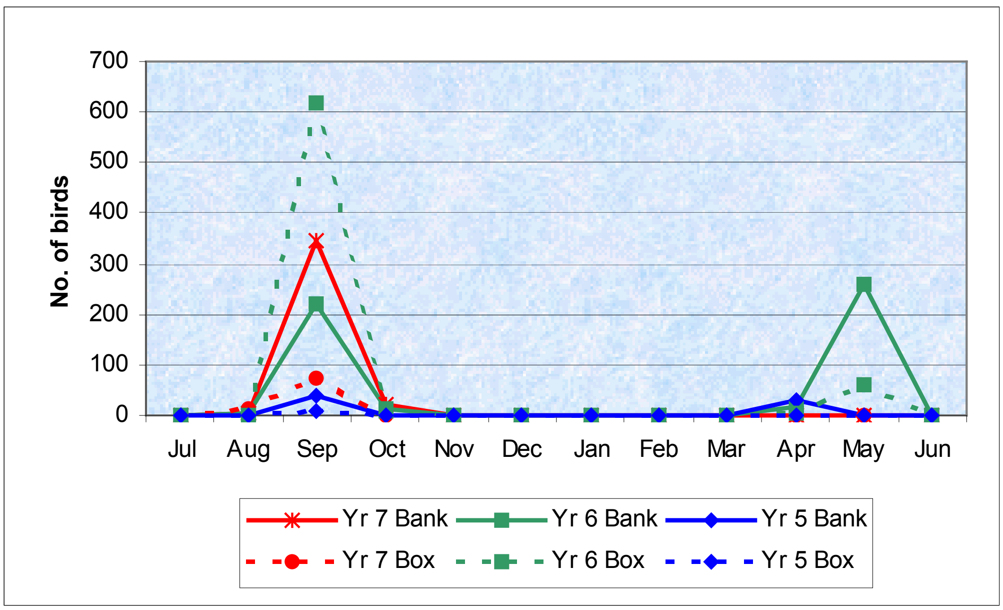
Common Terns are summer visitors to the Arklow Study Area and are recorded mainly on migration in spring and autumn. The species is listed on Annex I of the EU Birds Directive (79/409/EEC).

Year 5

In Year 5, Common Terns were only recorded over the Bank in July, September, April and May. Numbers were low, with a peak of 38 birds in September (Figure 3.50). A total of 11 Common Terns were seen in the Box in September.

Average monthly abundance was very low in the Arklow Study Area in Year 5, with a peak of 0.37 birds/km in both the Bank and Box in September (Figure 3.51).

Figure 3.50 Numbers of Common Terns in the Bank and Box [1], Years 5 to 7



1 Includes cable route

Year 6

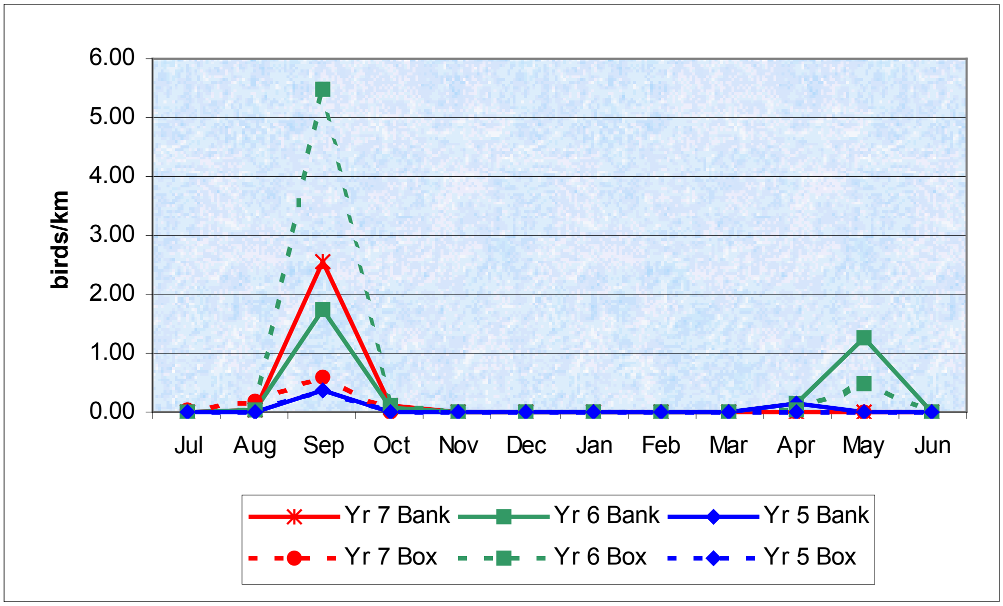
Common Terns were recorded in the Arklow Study Area between April and October in Year 6, with no birds seen in June or July (Figure 3.50). Over the Bank, a peak of 259 birds was recorded in May, with 221 birds recorded in September. Numbers in the Box peaked in September, when 618 birds were recorded, the highest number in all three years.

Average monthly abundance over the Bank was low, with a peak of 1.26 birds/km in May and a higher peak of 1.74 birds/km in September (Figure 3.51). Common Tern distribution in the Box was similar with a peak of 0.47 birds/km in May and a September peak of 5.50 birds/km, which was the highest for all three years.

Year 7

Common Terns were recorded over the Bank between August and October, and in June (Figure 3.50). Peak numbers were recorded in September (336 birds), which was the highest Bank total in all three years. Numbers in the Box also peaked in September, with 74 birds recorded.

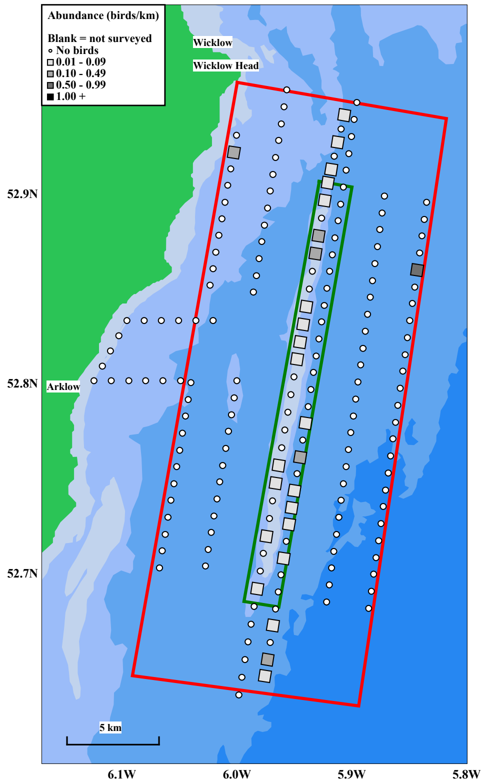
Figure 3.51 Common Tern average monthly abundance in the Bank and Box, Years 5 to 7



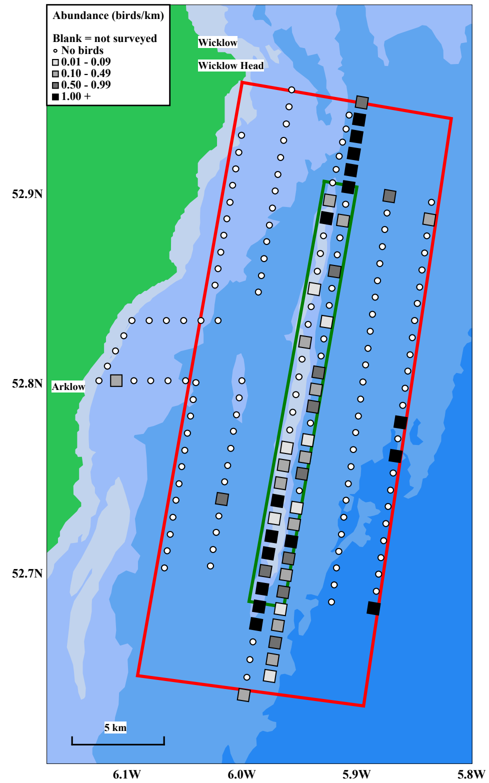
There was no peak in average monthly abundance in May of Year 7, and average abundance was low in all months except September, when 2.54 birds/km were recorded over the Bank, with 0.60 birds/km recorded in the Box at this time (Figure 3.51).

Figure 3.52 Common Tern abundance between April and October

Year 5



Year 6



Year 5

Between April and October, Common Terns were recorded in low to moderate abundance along the Bank and scattered in the northern half of the Box. Birds were most widespread in September.

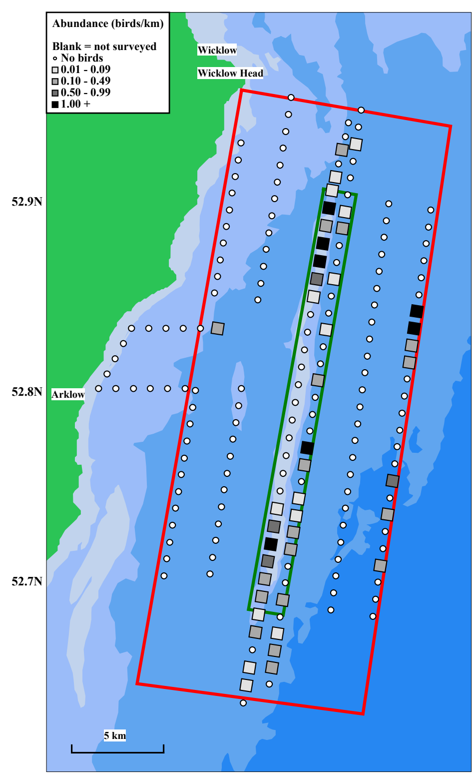
Year 6

Between April and October, Common Terns were recorded mainly in the southern half of the Bank and scattered across the Box. Highest abundances were recorded on the southern end of the inner Bank leg in May and at the north end of Leg 2, in the Box in September. Peak abundance ranged from 1.02 birds/km to 11.95 birds/km.

Year 7

Common Terns were recorded in highest abundances at the north and south end of the Bank and along the outer Box leg in August and September. Peak abundance ranged from 1.12 birds/km to 16.00 birds/km.

Year 7



3.4.22 Arctic Tern

Arctic Terns are summer visitors to the Arklow Study Area and are recorded in low numbers mainly on migration in autumn. The species is listed on Annex I of the EU Birds Directive (79/409/EEC).

Year 5

Nine Arctic Terns were recorded in Year 5, eight in September and one in October. The majority of sightings were at the northern end of the Bank.

Year 6

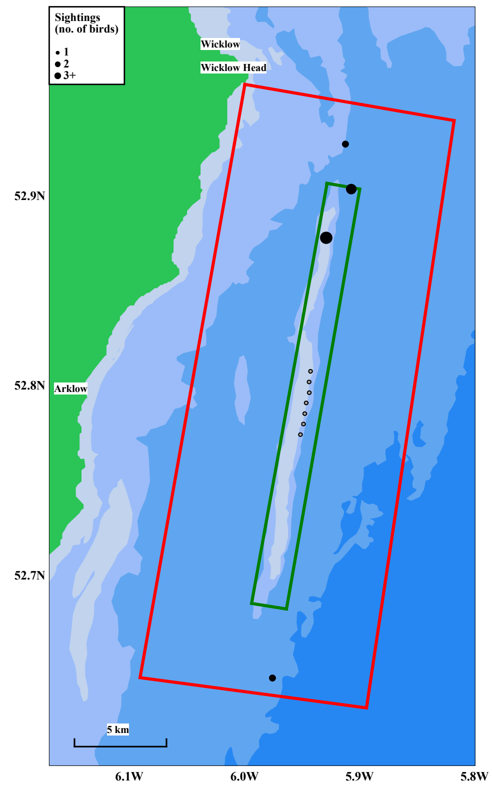
In Year 6, the total number of Arctic Terns recorded in the Arklow Bank Study Area increased to 78, with a peak of 57 in October. Sightings were along the Bank and along the eastern edge of the Box.

Year 7

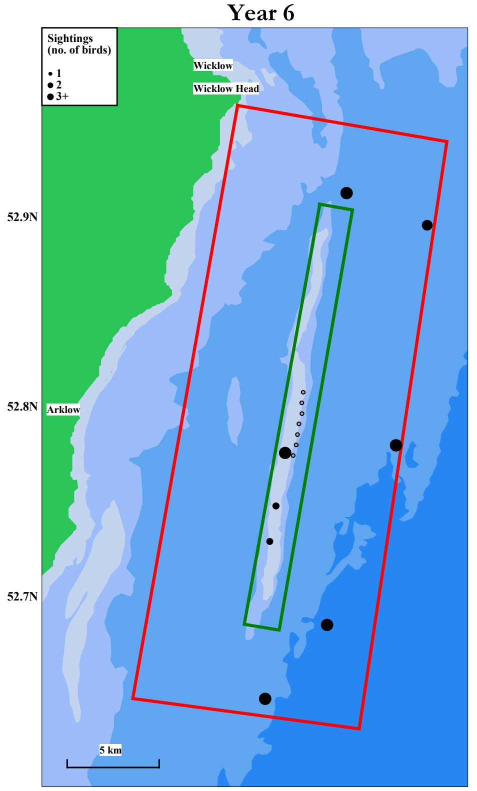
Very few Arctic Terns were recorded in Year 7, with only one in May and two in September.

Figure 3.53 Sightings in Years 5, 6 and 7

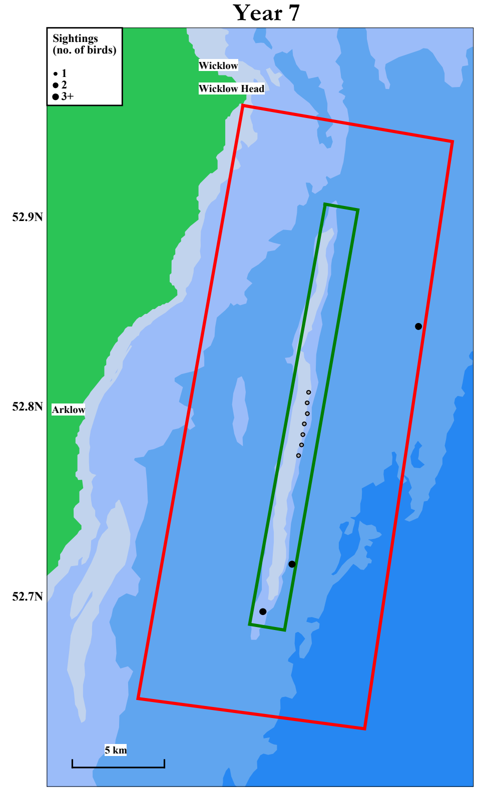
Year 5



Year 6



Year 7



3.4.23 Roseate Tern

Roseate Terns are one of Europe's most threatened seabirds and is listed on Annex I of the EU Birds Directive (79/409/EEC).

Year 5

No Roseate Terns were recorded in Year 5.

Year 6

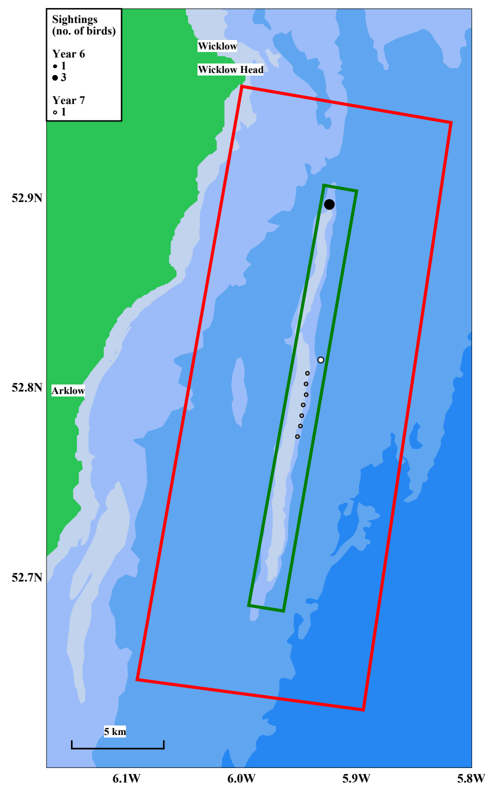
In Year 6, three were seen in May at the north end of the Bank.

Year 7

In Year 7, one Roseate Tern was recorded in October over the Bank.

Figure 3.54 Sightings in Years 6 and 7

Year 5



3.4.24 Sandwich Tern

Sandwich Terns are summer visitors to the Arklow Study Area and are listed on Annex I of the EU Birds Directive (79/409/EEC).

Year 5

Six were recorded in Year 5, with singles seen in July, September and October and 3 in August (Figure 3.55).

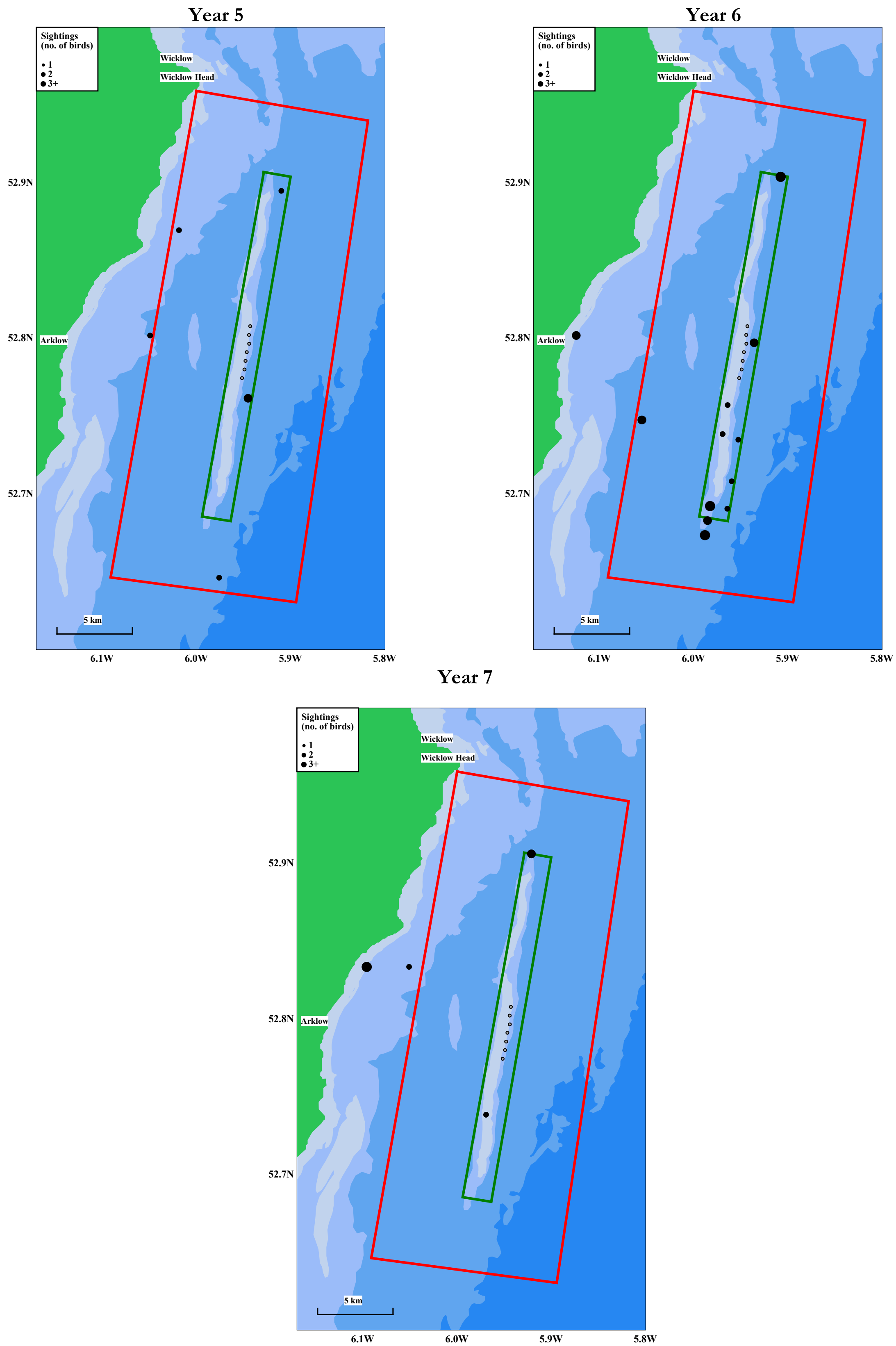
Year 6

In Year 6, a total of 29 Sandwich Terns were recorded in the Arklow Study Area, with 15 in April, one in July, 10 in September and three in October. The majority of birds were recorded over the Bank (Figure 3.55).

Year 7

In Year 7, a total of 10 Sandwich Terns were recorded, with two in April, five in June, one in July and two in September. Birds were recorded over the Bank and Cable Route (Figure 3.55).

Figure 3.55 Sandwich Tern sightings between Years 5, 6 and 7



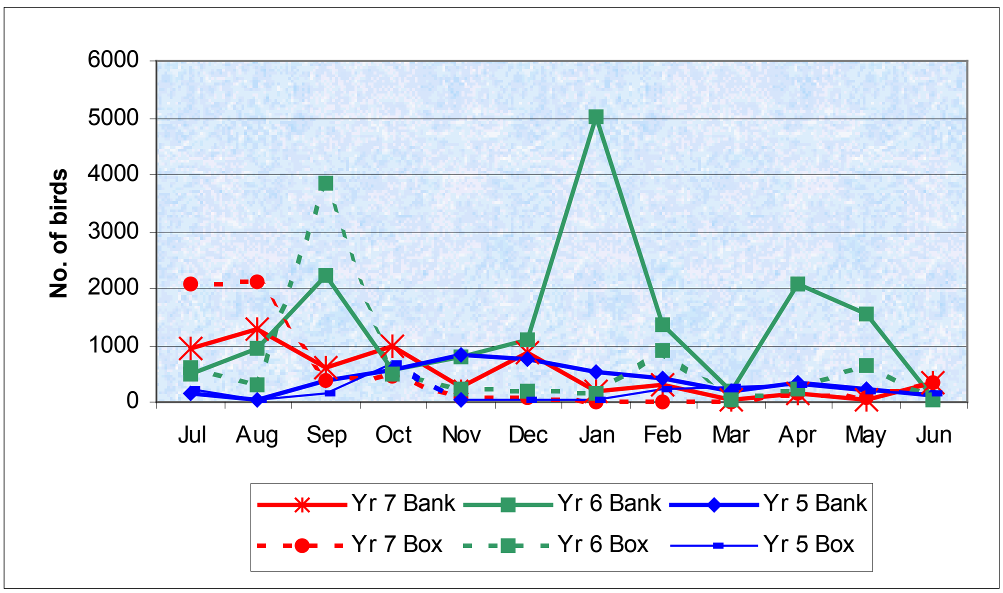
3.4.25 Guillemot

Year 5

Numbers of Guillemots recorded over the Bank in Year 5 gradually increased from August onwards, peaked in November (820 birds) and then dropped again in the remaining months (Figure 3.56). Numbers in the Box were generally lower than over the Bank, with a peak of 675 birds in October.

Average monthly density over the Bank was highest between December and January, with a peak in December of 43.4 birds/km², falling slightly to 42.56 birds/km² in January (Figure 3.57). In the Box, highest average monthly density was recorded in October, with a peak of 35.97 birds/km².

Figure 3.56 Numbers of Guillemots in the Bank and Box [1], Years 5 to 7



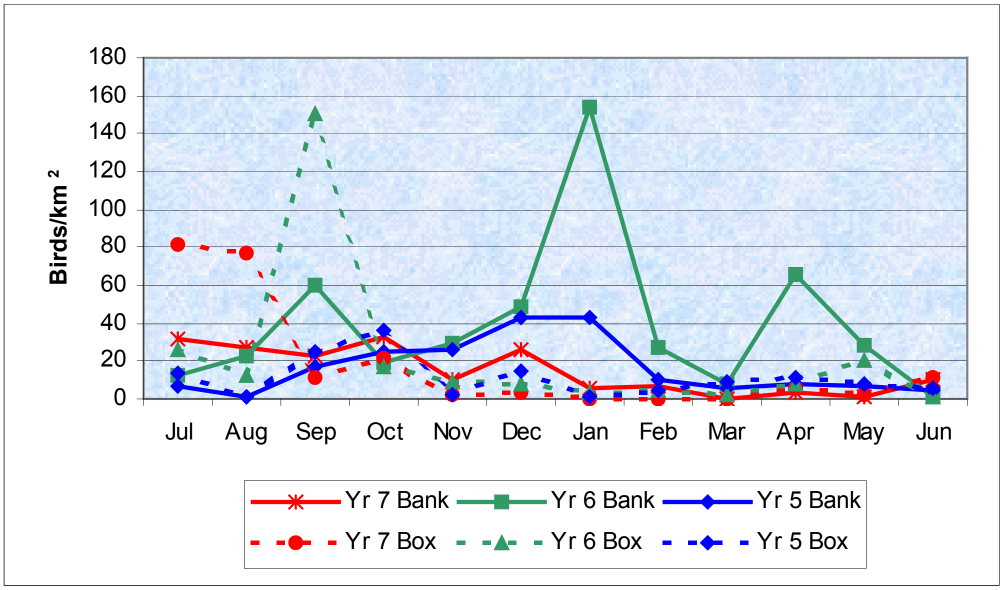
1 Includes cable route

Year 6

Numbers of Guillemots over the Bank in Year 6 fluctuated more widely than in Year 5 or Year 7, increasing from July to a peak of 2,234 birds in September (Figure 3.56). Numbers then decreased before rising to a three year high of 5,013 birds in January. Numbers dropped again in February, with very few birds seen in March, followed by an April peak of 2,078 birds, and a decrease in May and June. In the Box, numbers rose to a peak of 3,851 birds in September, with lower peaks of 910 birds in February, and 652 birds in May.

Average monthly density over the Bank showed three main peaks during Year 6 (Figure 3.57). The first peak of 59.84 birds/km² in September increased to 153.91 birds/km² in January, with a lower peak in April of 65.65 birds/km². In the Box, highest average monthly density was recorded in September, with a peak of 150.52 birds/km². Average monthly density was low in all other months.

Figure 3.57 Guillemot average monthly density in the Bank and Box, Years 5 to 7



Year 7

Numbers of Guillemots over the Bank in Year 7 were similar to Year 5 in that they were more stable, with no large peaks. Numbers were highest between July and December, with a peak of 1,298 birds recorded in August (Figure 3.56). Numbers in the Box were higher than the Bank in July and August, with a peak of 2,098 birds in August. Lower numbers were recorded in the remaining months.

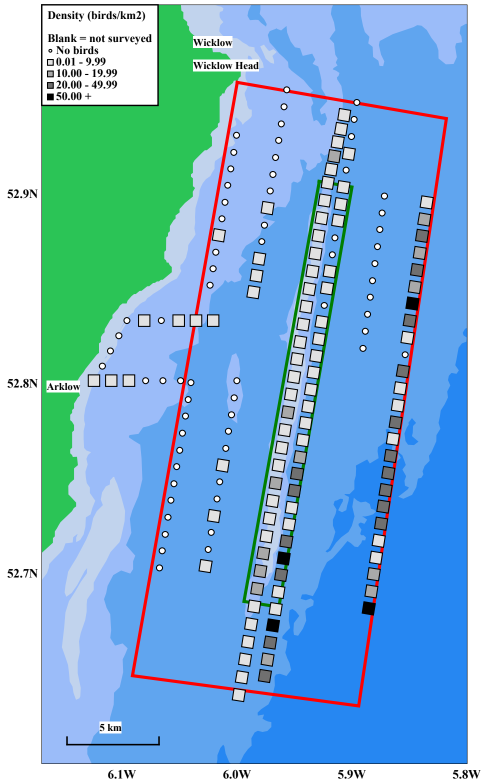
Overall, average monthly density over the Bank in Year 7 was lower than Year 6, and similar to Year 5, with a peak in October of 32.87 birds/km² (Figure 3.57). In the Box, highest average monthly density was recorded in July, with a peak of 81.22 birds/km², falling slightly to 77.16 birds/km² in August.

Table 3.21 Peak Guillemot densities between July and September, Year 5 (> 50 birds/km²)

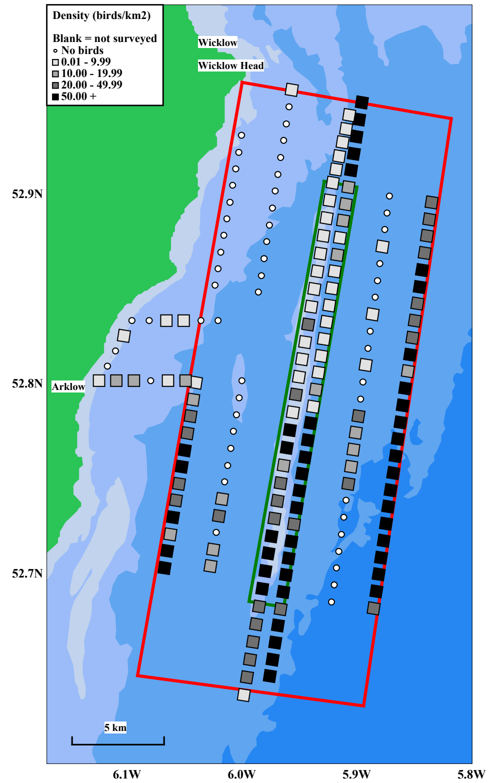
Year	Survey leg	Km waypoint	Seasonal Density
5	1	7	56.00
5	1	25	56.00
5	2	28	53.39
5	2	32	60.75

Figure 3.58 Guillemot density between July and September

Year 5



Year 6



Year 5

Guillemots were recorded in low to moderate densities along the Bank, with high density patches at the southern end of the outer Bank leg (Table 3.21). Birds were found in low densities on the inner Box legs and Cable Route, and in moderate to high densities along the outer Box leg.

Year 6

High densities of Guillemots were recorded over the southern half of both Bank legs (Table 3.22). Densities were also high along the outer Box leg, at each end of the Bank legs and along the southern half of the inner Box leg.

Year 7

Distribution was similar to Year 6, with high densities along the southern half of the outer Bank leg, and low to moderate densities elsewhere on the Bank (Table 3.23). High densities were also recorded on the outer Box legs, and at each end of the Bank legs.

Year 7

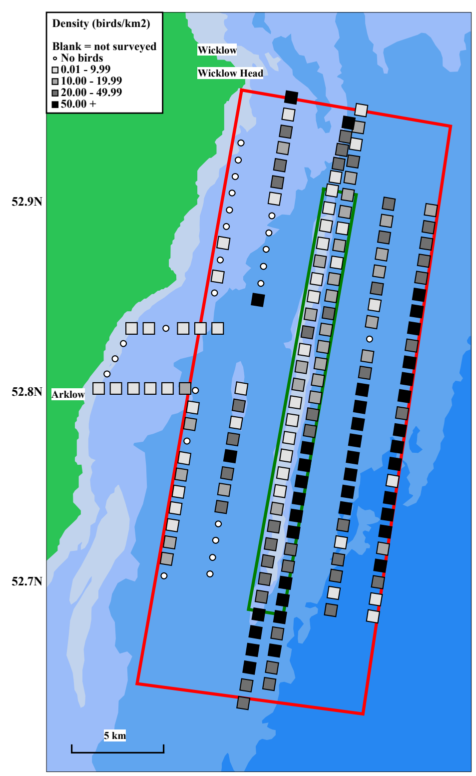


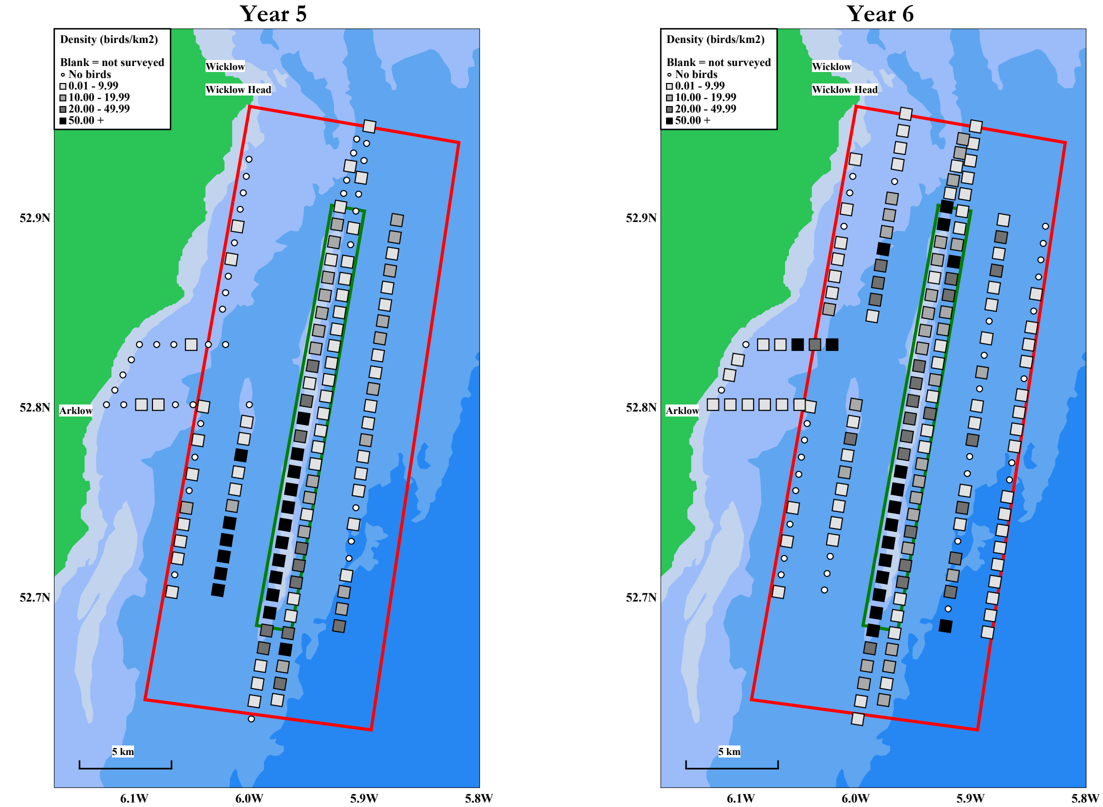
Table 3.22 Peak Guillemot densities between July and September, Year 6 (> 50 birds/km^2)

Year	Survey leg	Km waypoint	Seasonal Density
6	1	5	58.33
6	1	6	88.67
6	1	10	62.00
6	1	12	70.00
6	1	13	140.00
6	1	14	126.00
6	1	15	164.62
6	1	16	115.62
6	1	17	142.92
6	1	18	184.63
6	1	19	409.23
6	1	20	299.01
6	1	21	117.96
6	1	22	121.33
6	1	23	263.67
6	1	24	58.33
6	2	1	78.94
6	2	2	292.00
6	2	3	86.17
6	2	4	132.83
6	2	5	100.54
6	2	20	60.97
6	2	21	53.17
6	2	22	68.32
6	2	23	67.25
6	2	24	58.86
6	2	25	64.04
6	2	27	111.63
6	2	28	104.99
6	2	29	80.42
6	2	30	130.29
6	2	32	95.26
6	2	33	130.00
6	2	34	53.46
6	2	35	81.91
6	3	20	50.15
6	3	21	62.33
6	3	26	55.77
6	3	27	72.09
6	3	28	67.73
6	3	29	82.88
6	44	5	146.93
6	44	6	117.01
6	44	9	84.00
6	44	11	107.33
6	44	12	65.33

Table 3.23 Peak Guillemot densities between July and September, Year 7 (> 50 birds/km^2)

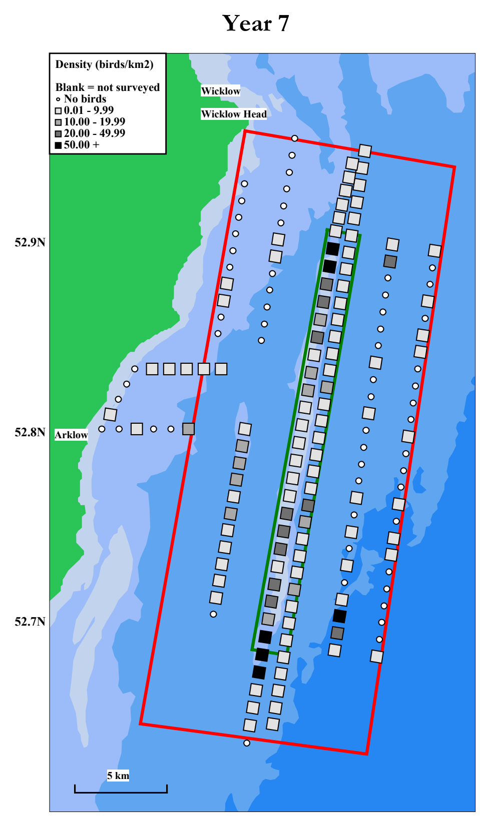
Year	Survey leg	Km waypoint	Seasonal Density
7	1	6	81.67
7	1	7	67.67
7	1	8	273.00
7	1	10	55.18
7	1	11	106.75
7	1	12	238.23
7	1	14	898.33
7	1	15	191.33
7	1	16	350.00
7	1	18	74.67
7	1	19	221.90
7	1	20	124.95
7	1	22	77.00
7	2	21	108.38
7	2	22	53.28
7	2	23	62.88
7	2	24	54.44
7	2	25	77.09
7	2	26	52.14
7	2	29	89.37
7	2	30	93.63
7	2	31	134.17
7	2	33	131.30
7	3	1	210.83
7	3	30	150.70
7	3	31	87.30
7	3	32	70.80
7	3	33	86.65
7	11	12	112.00
7	11	13	90.87
7	11	14	65.33
7	11	15	353.67
7	11	16	126.00
7	11	17	51.33
7	11	18	280.00
7	11	19	79.89
7	41	1	88.67
7	41	13	280.00
7	42	5	98.00

Figure 3.59 Guillemot density between October and January



Year 5

Between October and January, Guillemot density was highest over the southern half of the inner Bank leg and on leg 42 in the Box (Table 3.24). Elsewhere densities were low to moderate, although coverage was not complete.



Year 6

Guillemot density was highest over the southern half of the inner Bank leg between October and January, with occasional high density patches elsewhere (Table 3.24). Elsewhere densities were low to moderate.

Year 7

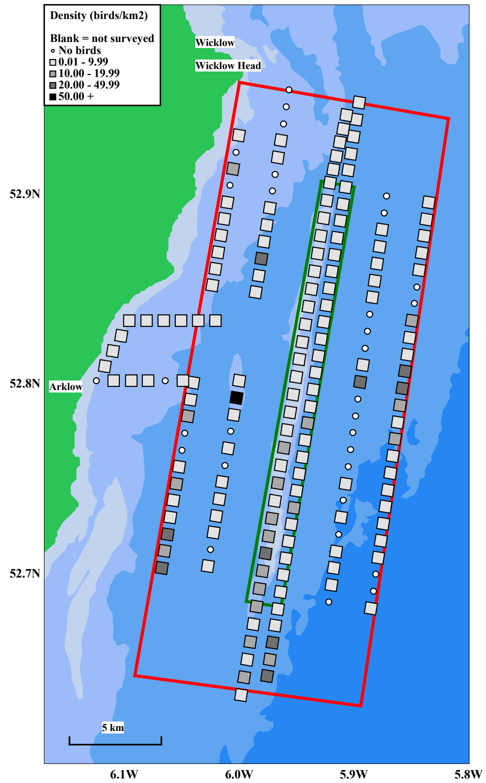
Guillemot density between October and January was lower than in the two previous years, with low to moderate densities generally recorded along the Bank and Box. High densities were found at the north and south end of the inner Bank leg and at the south end of Leg 11 in the Box (Table 3.24).

Table 3.24 Peak Guillemot densities between October and January, Years 5, 6 & 7 (> 50 birds/km^2)

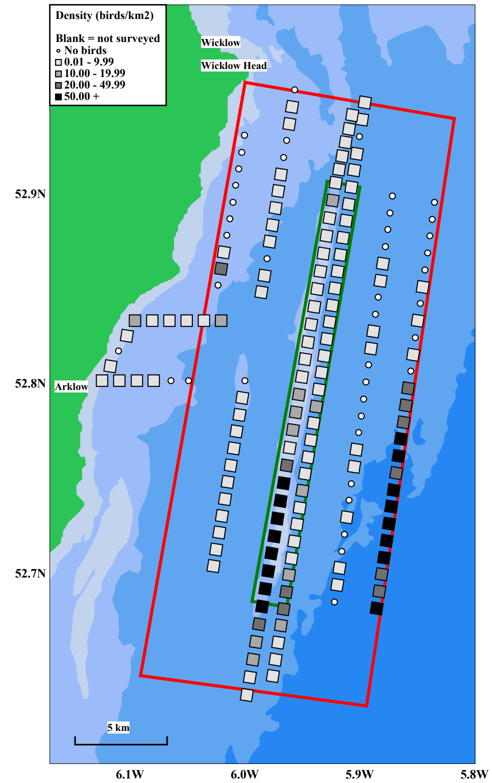
Year	Survey leg	Km waypoint	Seasonal Density
5	2	32	56.19
5	3	18	54.47
5	3	20	57.19
5	3	21	104.70
5	3	22	74.19
5	3	23	79.38
5	3	24	126.11
5	3	25	114.11
5	3	26	98.05
5	3	27	140.77
5	3	28	79.49
5	3	29	112.23
5	42	4	67.67
5	42	8	56.00
5	42	9	56.00
5	42	10	126.00
5	42	11	375.67
5	42	12	121.33
6	2	9	122.56
6	3	6	68.58
6	3	7	61.27
6	3	21	85.41
6	3	22	160.51
6	3	23	170.09
6	3	24	93.15
6	3	25	161.97
6	3	26	762.48
6	3	27	226.38
6	3	28	251.45
6	3	29	171.69
6	3	30	188.29
6	5	1	52.50
6	5	3	52.74
6	11	25	58.13
6	41	9	58.33
7	3	7	150.47
7	3	8	154.00
7	3	29	152.36
7	3	30	140.44
7	3	31	181.11
7	11	23	105.02

Figure 3.60 Guillemot density between February and June

Year 5



Year 6



Year 5

Guillemots were widespread at low to moderate densities throughout the Arklow Study Area between February and June, with density exceeding 50.00 birds/km^2 in just one km square (Table 3.25).

Year 6

High densities of Guillemots were recorded along the southern half of the inner Bank leg and the outer Box leg between February and June (Table 3.25). Birds were widespread at low to moderate densities elsewhere.

Year 7

Guillemots were again widespread at low to moderate densities throughout the Arklow Study Area between February and June, with density exceeding 50.00 birds/km^2 in just one km square on the outer Box leg (Table 3.26).

Year 7

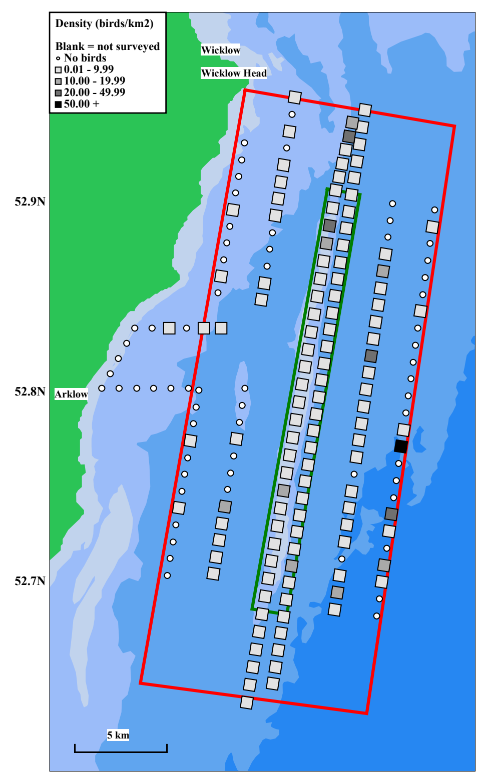


Table 3.25 Peak Guillemot densities between February and June, Years 5, 6 & 7 (> 50 birds/km^2)

Year	Survey leg	Km waypoint	Seasonal Density
5	42	2	52.67
6	1	15	386.22
6	1	16	56.00
6	1	18	163.33
6	1	19	79.33
6	1	20	93.33
6	1	21	93.33
6	1	22	200.67
6	1	25	74.67
6	3	23	98.79
6	3	24	93.74
6	3	25	61.26
6	3	26	137.72
6	3	27	133.23
6	3	28	107.12
6	3	29	108.67
6	3	30	76.67
7	1	15	98.00

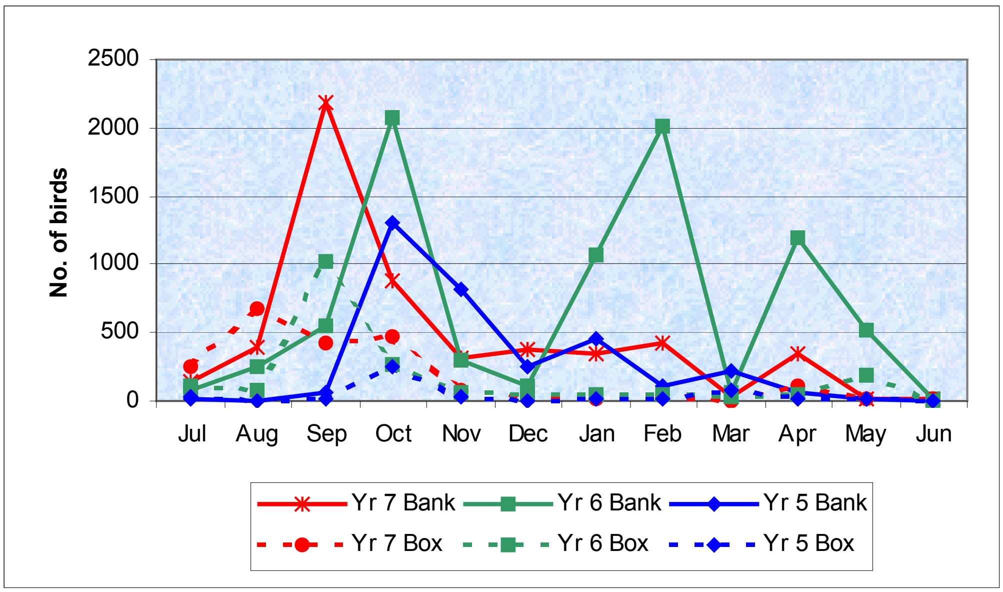
3.4.26 Razorbill

Year 5

Razorbill numbers over the Bank were low between July and September, rising to a peak of 1,311 birds in October, before decreasing again from November to June (Figure 3.61). Numbers in the Box were lower, with a peak in October of 253 birds.

Razorbill average monthly density over the Bank was highest between October and January, with a peak in October of 53.39 birds/km², falling to 33.72 birds/km² in January (Figure 3.62). In the Box, highest average monthly density was also recorded in October, with a peak of 16.67 birds/km².

Figure 3.61 Numbers of Razorbills in the Bank and Box [1], Years 5 to 7



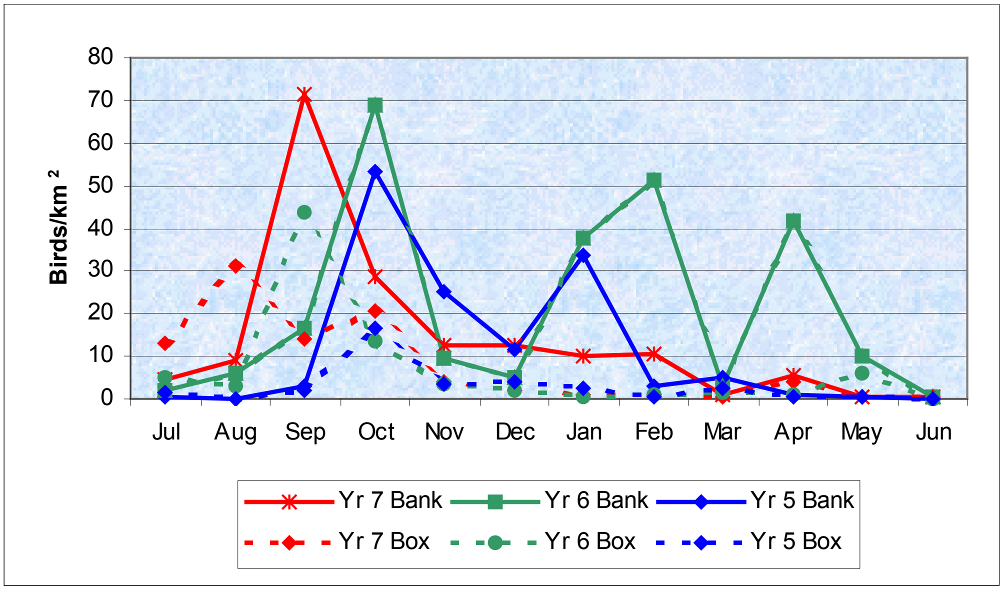
1 Includes cable route

Year 6

Numbers of Razorbills over the Bank showed a similar pattern to Year 5 between July and December, with a peak of 2,083 birds in October (Figure 3.61). Numbers increased again in January, reached a peak of 2,012 birds in February, fell sharply in March, before peaking again in April, with 1,187 birds. Numbers in the Box were lower, with a peak in September of 1,027 birds.

Razorbill average monthly density over the Bank peaked in October, with 69.15 birds/km² (Figure 3.62). Average monthly density fell in November and December, and then increased again in January, reaching 51.17 birds/km² in February, with a lower peak of 41.63 birds/km² in April. In the Box, highest average monthly density was recorded in September, with a peak of 43.57 birds/km².

Figure 3.62 Razorbill average monthly density in the Bank and Box, Years 5 to 7



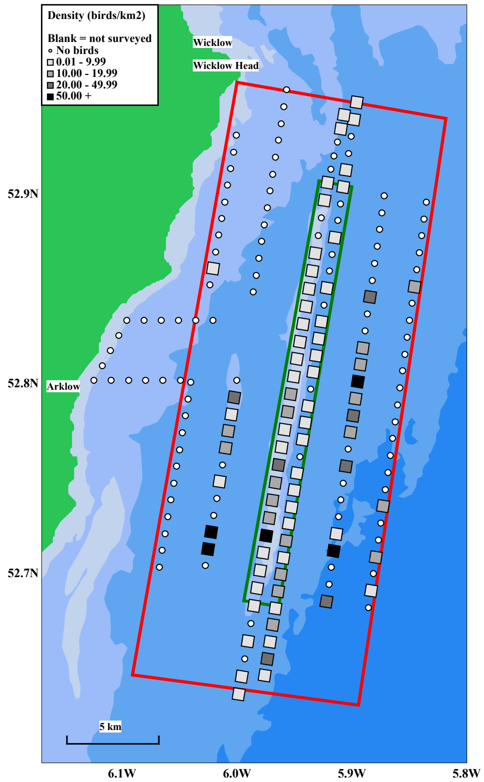
Year 7

Numbers of Razorbills over the Bank in Year 7 followed a similar pattern to Year 5, although numbers peaked in September (2,184 birds), rather than October (Figure 3.61). This was the highest number recorded during all three years. Numbers in the Box were lower, and most birds were recorded between July and October, with a peak of 673 birds in August.

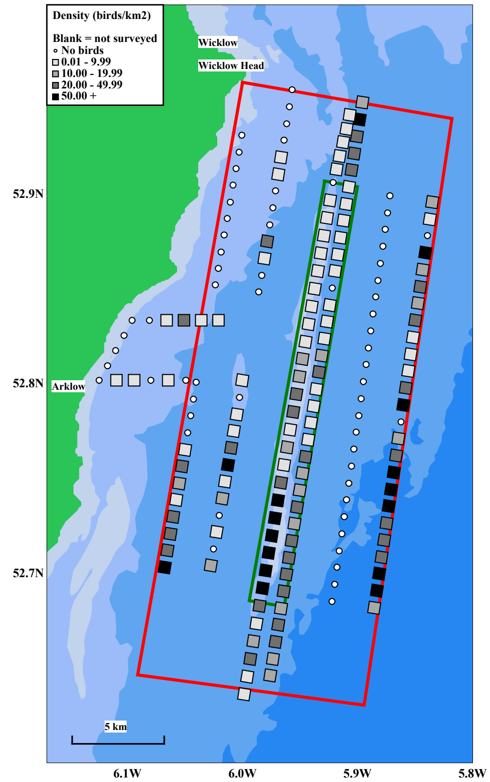
Average monthly density over the Bank in Year 7 peaked a month earlier than Year 5 and 6, with 71.60 birds/km^2 recorded in September (Figure 3.62). In the Box, highest average monthly density was recorded in August, with a peak of 31.44 birds/km^2.

Figure 3.63 Razorbill density between July and October

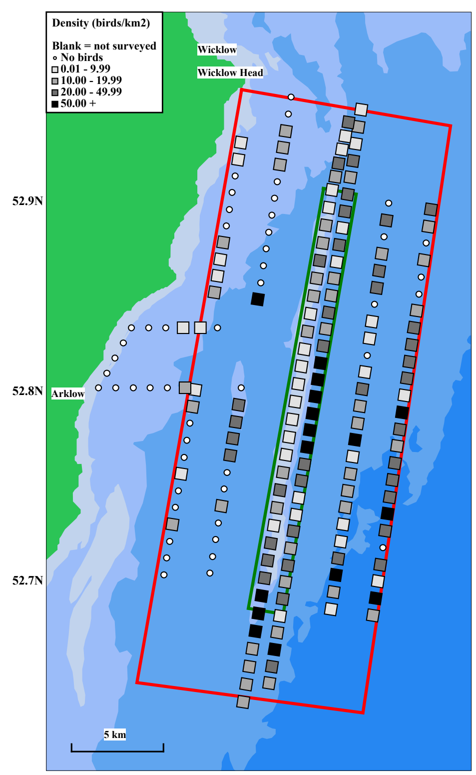
Year 5



Year 6



Year 7



Year 5

Razorbills were widespread at low to moderate densities over the Bank between July and October, with density exceeding 50.00 birds/km^2 in just one km square (Table 3.26). Higher densities were recorded in the southern half of the Box.

Year 6

High densities of Razorbills were recorded along the southern half of the inner Bank leg, with moderate densities on the outer Bank leg (Table 3.26). High densities were also recorded along the outer Box leg and southern half of the inner Box legs, with low to moderate densities elsewhere.

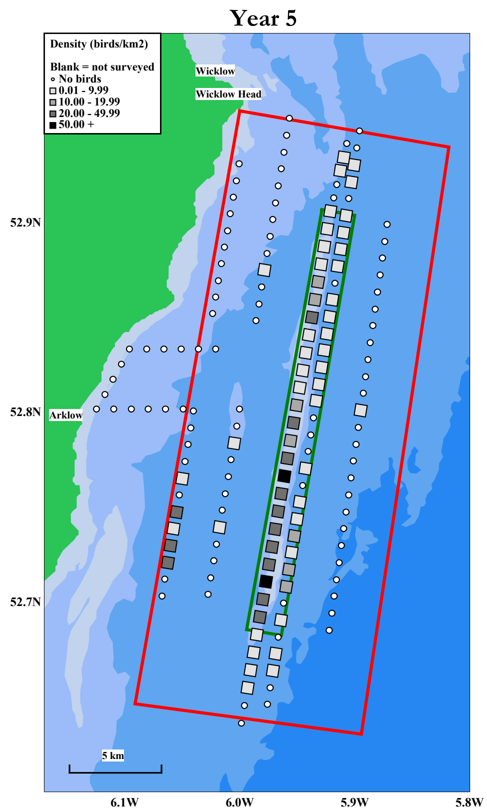
Year 7

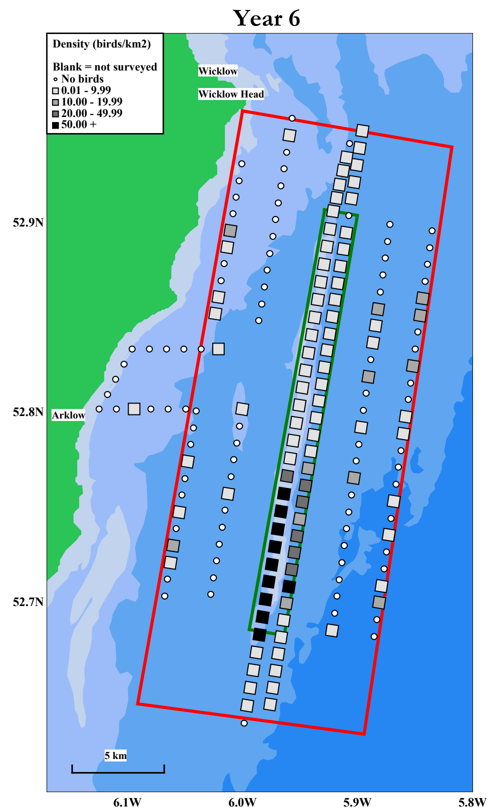
Razorbills were generally widespread at moderate densities between July and October, with high densities along the outer Bank leg, the southern end of the inner Bank leg, and on the outer Box legs (Table 3.26).

Table 3.26 Peak Razorbill densities between July and October, Years 5, 6 & 7 (> 50 birds/km^2)

Year	Survey leg	Km waypoint	Seasonal Density
5	3	26	318.78
5	11	22	70.00
5	42	10	63.33
5	42	11	76.67
6	1	4	55.00
6	1	13	60.00
6	1	17	59.37
6	1	18	52.19
6	1	19	109.03
6	1	23	62.50
6	1	24	60.00
6	2	2	76.13
6	3	24	58.55
6	3	25	53.41
6	3	26	80.23
6	3	27	127.84
6	3	28	115.60
6	3	29	54.69
6	42	6	52.50
7	1	13	52.50
7	1	19	114.75
7	1	24	52.50
7	2	16	97.22
7	2	17	54.67
7	2	18	86.00
7	2	19	95.44
7	2	20	70.00
7	2	21	86.77
7	2	33	59.79
7	3	29	108.53
7	3	30	123.47
7	3	31	126.12
7	11	15	128.03
7	11	23	88.21
7	41	13	65.00

Figure 3.64 Razorbill density between November and February





Year 5

Razorbills were widespread at low to moderate densities over the Bank between November and February, with density exceeding 50.00 birds/km^2 in two km squares (Table 3.27). Low densities were scattered in the Box.

Year 6

High densities of Razorbills were recorded along the southern half of the inner Bank leg and the outer Box leg between November and February (Table 3.27). Birds were widespread at low to moderate densities elsewhere on the Bank, with low to moderate densities scattered in the Box.

Year 7

Razorbills were again widespread at low to moderate densities along the Bank between November and February, with highest densities at the north end of the inner Bank leg (Table 3.27). Low densities were scattered in the Box.

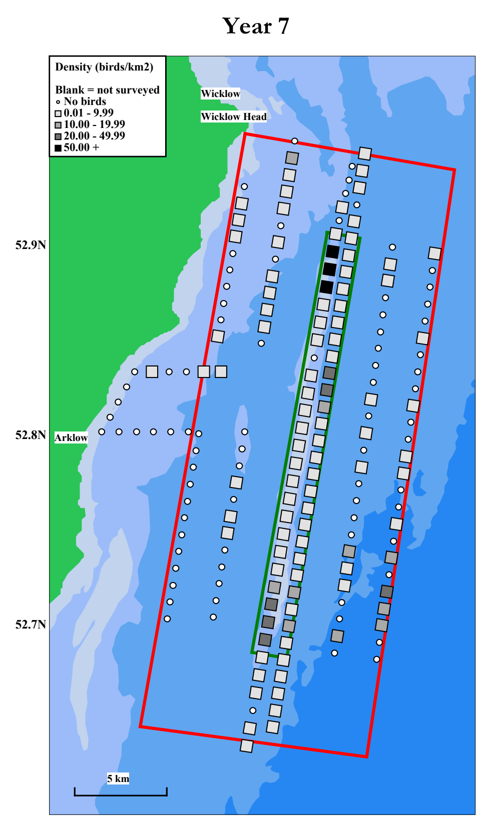


Table 3.27 Peak Razorbill densities between November and February, Years 5, 6 & 7 (> 50 birds/km^2)

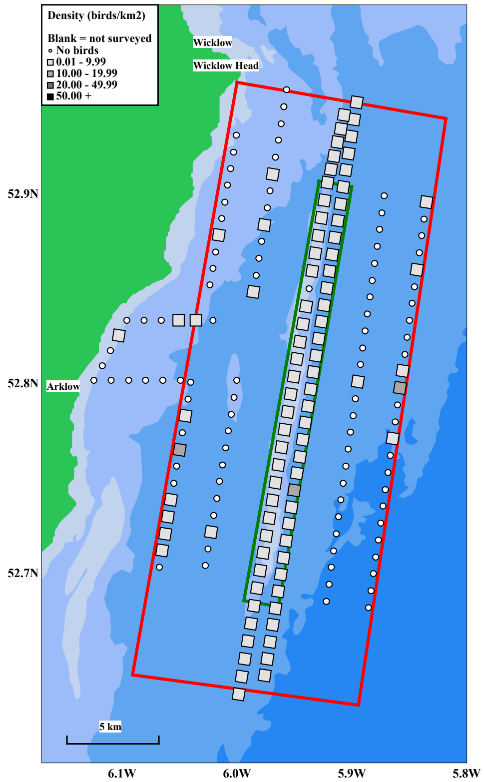
Year	Survey leg	Km waypoint	Seasonal Density
5	3	21	79.18
5	3	27	69.94
6	2	28	51.11
6	3	22	69.30
6	3	23	76.20
6	3	24	79.29
6	3	25	157.58
6	3	26	140.35
6	3	27	90.66
6	3	28	76.35
6	3	29	240.24
6	3	30	139.97
7	3	7	80.17
7	3	8	151.87
7	3	9	91.45

Table 3.28 Peak Razorbill densities between March to June in Year 6 (> 50 birds/km^2)

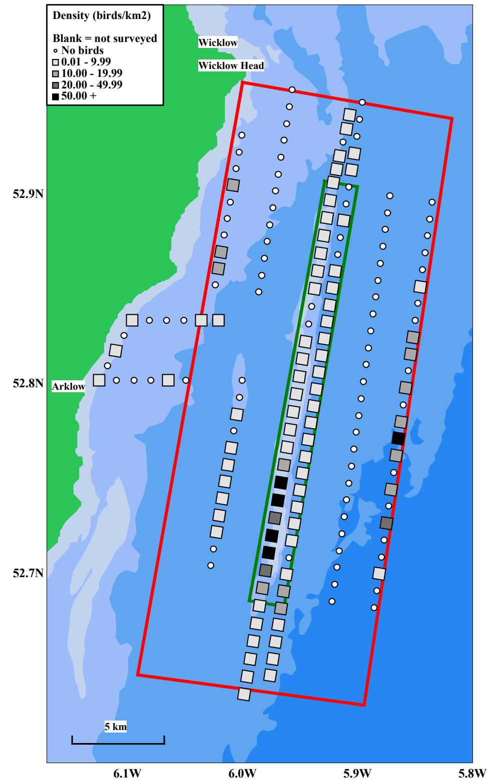
Year	Survey leg	Km waypoint	Seasonal Density
6	1	15	121.19
6	3	23	63.86
6	3	24	91.64
6	3	26	88.64
6	3	27	78.17

Figure 3.65 Razorbill density between March and June

Year 5



Year 6



Year 5

Razorbills were widespread at low to moderate densities over the Bank between March and June. Densities in the Box were generally low.

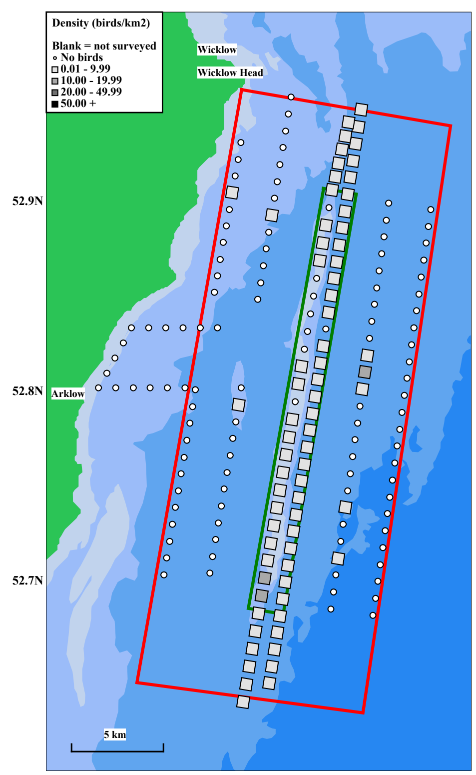
Year 6

High densities of Razorbills were recorded along the southern half of the inner Bank leg and the outer Box leg between March and June (Table 3.28), with low densities elsewhere.

Year 7

Razorbills were widespread along the Bank at low to moderate densities between March and June. Low densities were scattered in the Box.

Year 7



3.4.27 Other auks

Year 5

In Year 5, one Little Auk was seen in the northern end of the Box in April, and one Puffin was recorded at the southern end of the Box in August.

Year 6

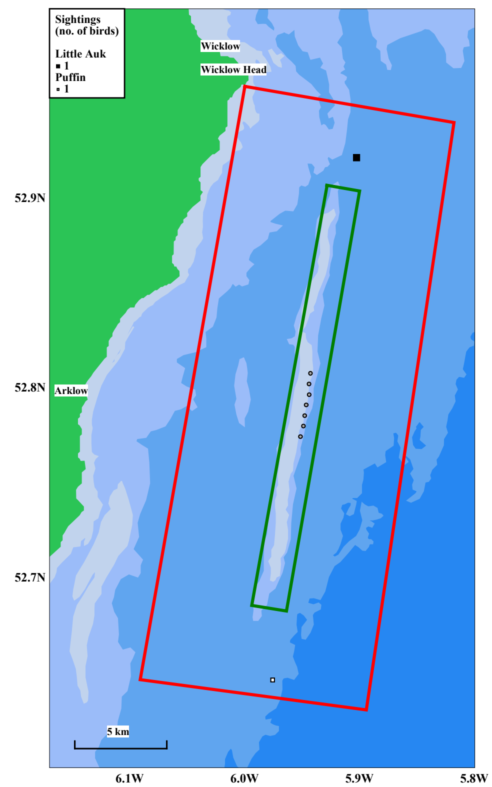
In Year 6, two Black Guillemots were recorded in January over the Bank. No Puffins or Little Auks were recorded in Year 6.

Year 7

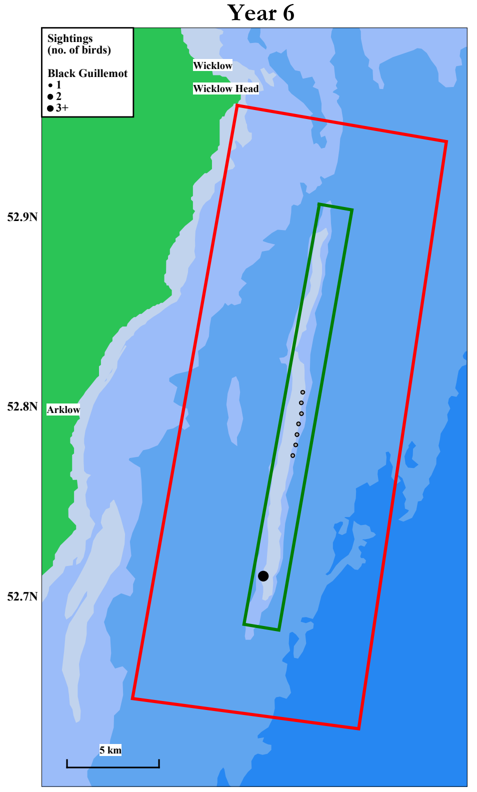
In Year 7, a total of ten Black Guillemots were seen, four in February, two in July and four in August, all in the Box. In addition, 15 Puffins were recorded, three in June, 10 in July, one in August and one in September. Birds were mostly scattered along the Bank and in the south east of the Box. No Little Auks were recorded in Year 7.

Figure 3.66 Sightings in Years 5, 6 and 7

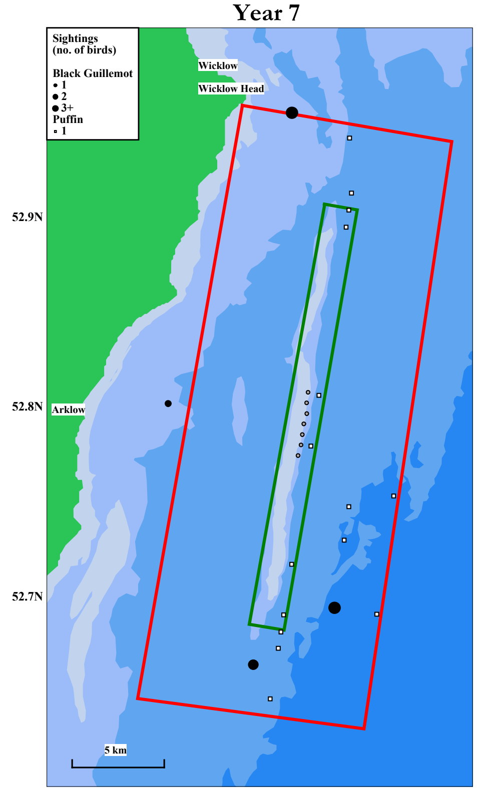
Year 5



Year 6



Year 7



3.5 Raw numbers of marine mammals recorded in the Arklow Study Area

Three species of marine mammals were recorded in the Arklow Study Area over Years 5 to 7 (Table 3.29). Harbour Porpoise was the commonest species of cetacean (whale or dolphin), while Grey Seal was the only positively identified seal species encountered. In addition, six unidentified seals and two unidentified cetaceans were also recorded.

Table 3.29 Numbers of marine mammals recorded in the Arklow Study Area in Years 5, 6 and 7

Species	Numbers recorded			No. of Days		
	Year 5	Year 6	Year 7	Year 5	Year 6	Year 7
Grey Seal	3	5	11	2	4	10
Risso's Dolphin	6	1	0	3	1	0
Harbour Porpoise	120	163	110	25	23	20
Seal species	0	4	2	0	2	2
Cetacean species	0	2	0	0	1	0
Total	**129**	**175**	**123**	**31 days**	**31 days**	**27 days**

Comparative data from JNCC surveys for the local ICES rectangles and the western Irish Sea is shown in Table 3.30.

Table 3.30 Numbers of turtles, sharks, cetaceans and seal species recorded in the ¼ ICES rectangles around the Arklow Study Area and in the western Irish Sea

Species	Nos. on JNCC surveys in four ¼ ICES rectangles	No. of Days	Nos. on JNCC surveys in western Irish Sea	No. of Days
Turtle species	0	0	1	1
Basking Shark	0	0	1	1
Grey Seal	0	0	7	7
Common Seal	0	0	2	2
Seal species	0	0	5	4
Minke Whale	0	0	10	8
Killer Whale	0	0	1	1
Small whale species	0	0	1	1
Risso's Dolphin	0	0	17	6
Harbour Porpoise	3	2	397	37
Bottlenose Dolphin	0	0	11	3
White-beaked Dolphin	0	0	7	2
Common Dolphin	0	0	256	13
Cetacean species	1	1	4	4
Totals	**4**	**-**	**764**	**-**

Numbers of marine mammal species over the Bank, Box and Cable Route for Years 5, 6 and 7 are shown in Table 3.31. Numbers of marine mammals over the Bank accounted for 47.2 % of all marine mammals recorded in the Arklow Study Area in Year 7, with 46.3 % recorded in the Box. In comparison, total numbers of marine mammals over the Bank in Year 5 accounted for 55.8 % of all marine mammals recorded, with 38.0 % recorded in the Box. In Year 6 total numbers of marine mammals over the Bank accounted for 46.3 % of all marine mammals recorded, with 50.3 % recorded in the Box.

Table 3.31 Comparison of marine mammal numbers over the Bank, Box and Cable route in Years 5, 6 & 7

Species	Bank			Box			Cable route		
	Year			Year			Year		
	5	**6**	**7**	**5**	**6**	**7**	**5**	**6**	**7**
Grey Seal	2	2	7	1	3	3	0	0	1
Risso's Dolphin	5	1	0	1	0	0	0	0	0
Harbour Porpoise	65	78	49	47	80	54	8	5	7
Seal species	0	0	2	0	3	0	0	1	0
Cetacean species	0	0	0	0	2	0	0	0	0
Total	**72**	**81**	**58**	**49**	**88**	**57**	**8**	**6**	**8**

3.6 Marine Mammal Species Accounts

The following marine mammal species accounts present a summary of distribution and abundance within the Arklow Bank Study Area for Years 5, 6 and 7.

3.6.1 Harbour Porpoise

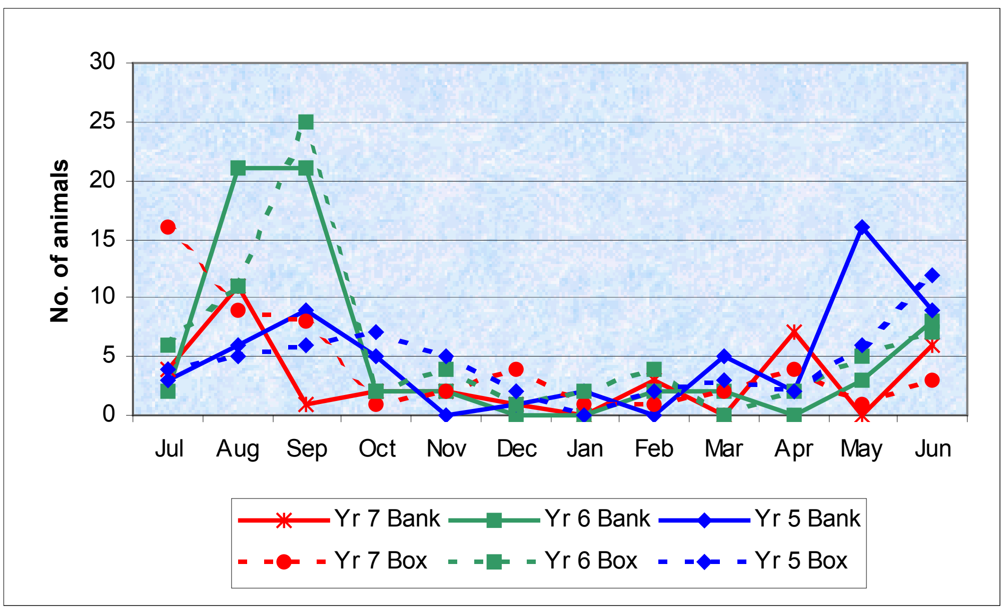
Harbour Porpoises are found in the Arklow Study Area throughout the year. They are listed on Annex II and IV of the EU Habitats Directive (92/43/EEC).

Year 5

Numbers of Harbour Porpoises over the Bank were generally low throughout Year 5, with a peak of 9 animals in September, and the highest count of 15 animals recorded in May (Figure 3.67). Numbers recorded in the Box showed a similar pattern but were slightly lower, with peaks in October (7 animals) and June (12 animals).

Average monthly abundance for Harbour Porpoise over both the Bank and Box was very low throughout the year, with a peak of 0.21 animals/km in the Box in September (Figure 3.68).

Figure 3.67 Numbers of Harbour Porpoises in the Bank and Box [1], Years 5 to 7



1 Includes cable route

Year 6

In Year 6, numbers of Harbour Porpoises over the Bank increased from July to a peak of 21 animals in both August and September (Figure 3.67). Numbers decreased after this and were low between October and April, increasing slightly again in May and June. Numbers in the Box showed a similar pattern, with a peak of 25 animals in September.

Average monthly abundance for Harbour Porpoise over both the Bank and Box was very low throughout the year, with a peak of 0.27 animals/km in the Box in September (Figure 3.68).

Year 7

Numbers of Harbour Porpoises over the Bank in Year 7 were generally lower than the two previous years, with a peak of 11 animals recorded in August, and lower numbers during the rest of the year (Figure 3.67). Numbers in the Box were highest in July, with a peak of 16 animals recorded. Numbers dropped from August onwards.

Average monthly abundance for Harbour Porpoise over both the Bank and Box was very low throughout Year 7, with a peak of 0.15 animals/km in the Box in January (Figure 3.68).

Figure 3.68 Harbour Porpoise average monthly abundance in the Bank and Box, Years 5 to 7

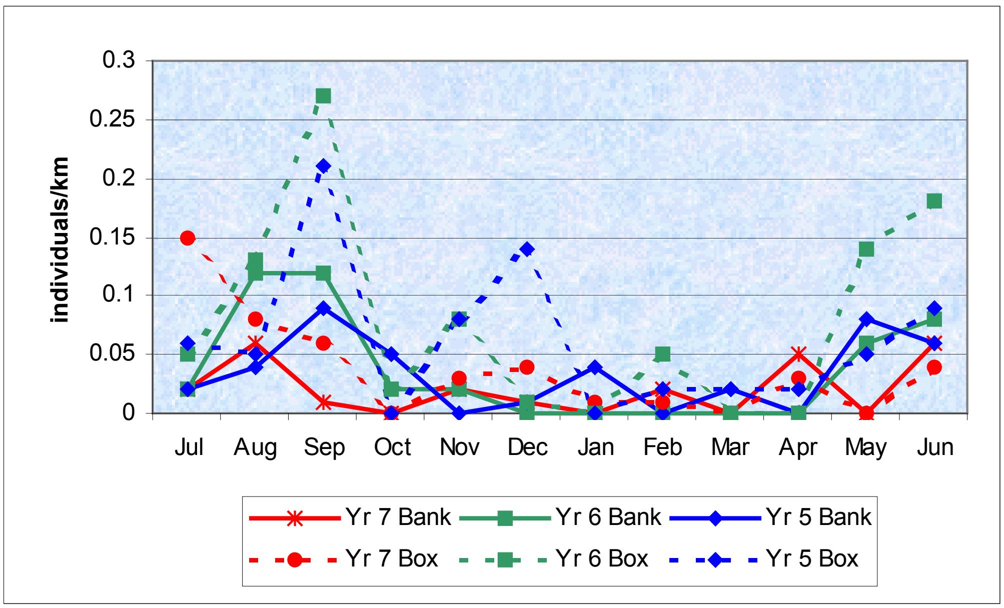
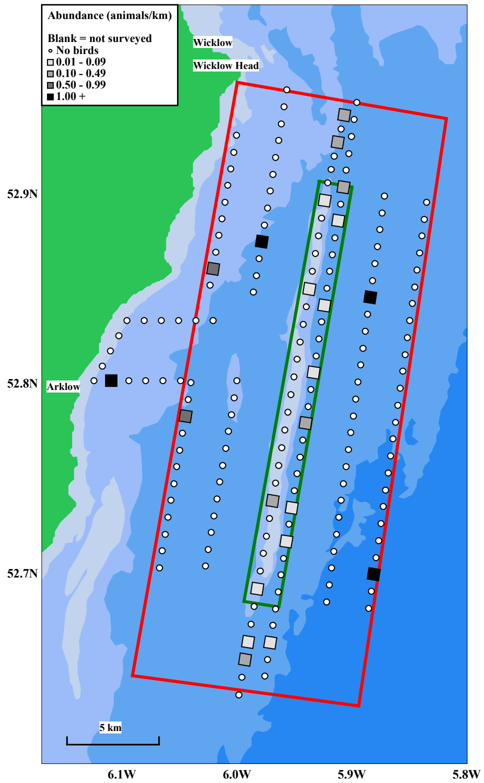
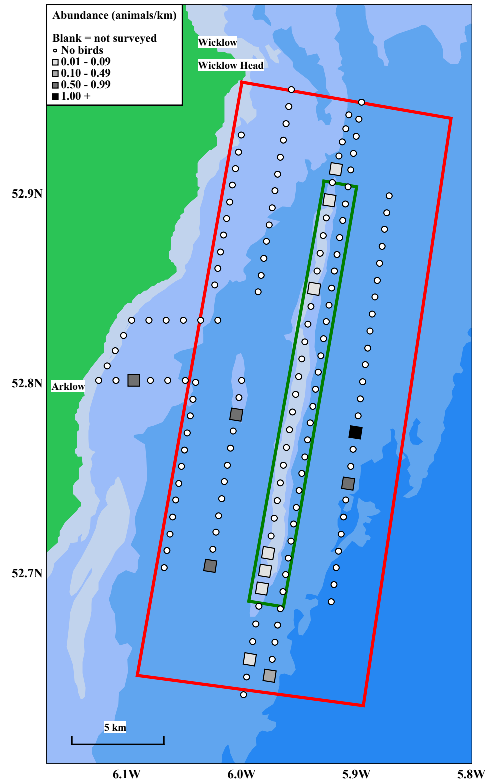


Figure 3.69 Harbour Porpoise abundance between October and March

Year 5



Year 6



Year 5

Between October and March, Harbour Porpoises were scattered along the Bank in low to moderate abundance, with occasional higher abundances scattered in the Box and Cable Route. Peak abundance was 1.75 animals/km.

Year 6

Between October and March, Harbour Porpoises were scattered along the inner Bank leg in low abundance, with occasional higher abundances in the Box and Cable Route. Peak abundance was 1.00 animals/km.

Year 7

Between October and March, Harbour Porpoises were scattered over the Bank in low abundance, with occasional higher abundances in the Box and Cable Route. Peak abundance was 1.00 animals/km.

Year 7

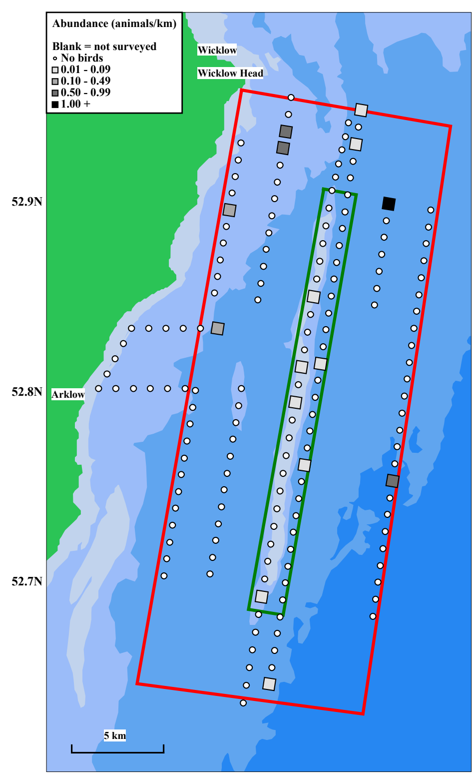
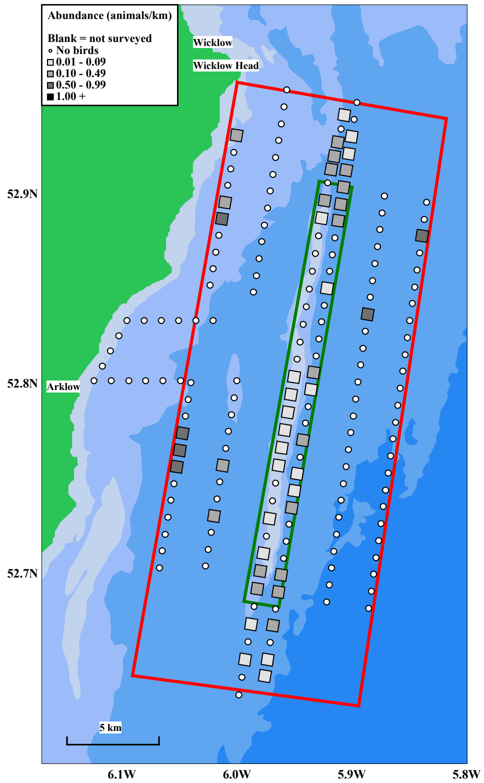
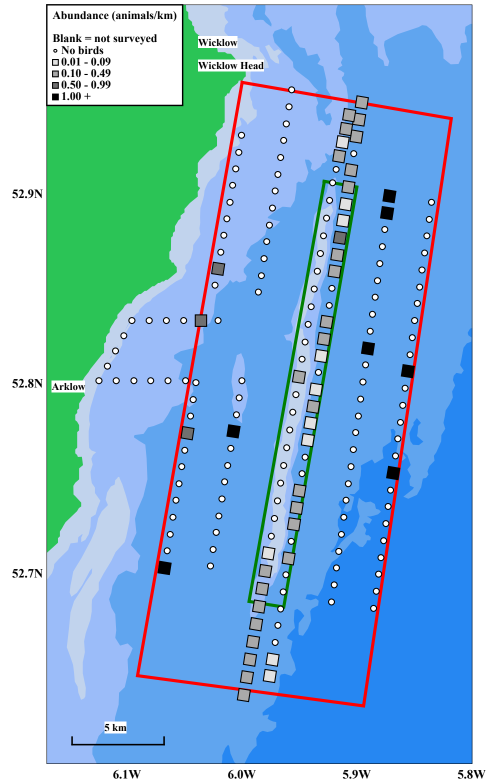


Figure 3.70 Harbour Porpoise abundance between April and September

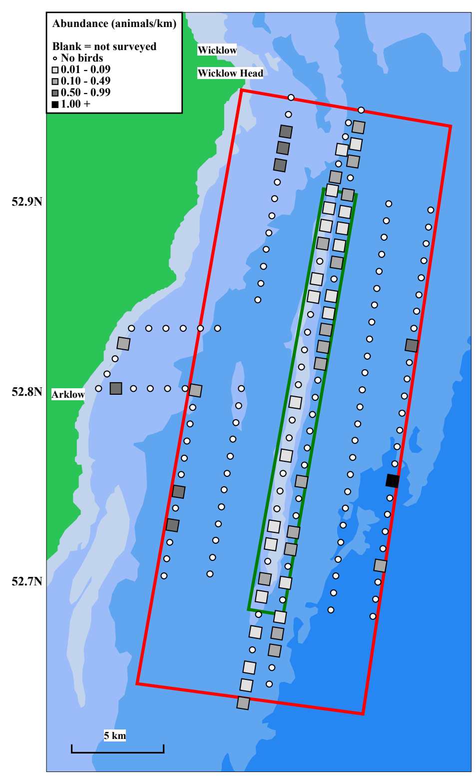
Year 5



Year 6



Year 7



Year 5

Between April and September, Harbour Porpoises were more widespread along the Bank in low to moderate abundance, with occasional higher abundances scattered in the Box.

Year 6

Between April and September, Harbour Porpoises were recorded along the outer Bank leg in low to moderate abundance, with occasional higher abundances scattered in the Box. Peak abundance was 3.00 animals/km.

Year 7

Between April and September, Harbour Porpoises were recorded in low to moderate abundance mainly at the north and south ends of the Bank. Higher abundances were scattered in the Box and Cable Route. Peak abundance was 1.00 animals/km.

3.6.2 Other cetaceans

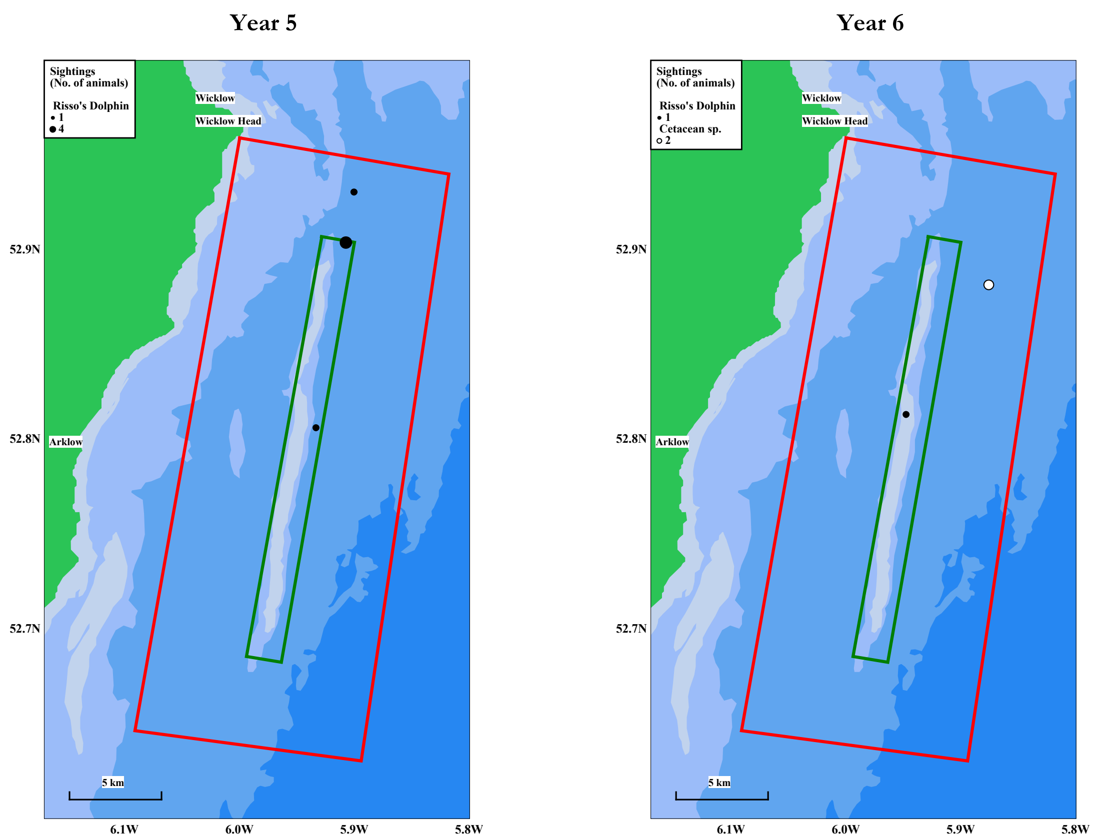
Year 5

In May of Year 5, four Risso's Dolphins were seen over the Bank with another at the north end of the Box. One Risso's Dolphin was seen in June over the Bank (Figure 3.71).

Year 6

In Year 6, one Risso's Dolphin was seen in August, over the Bank. In addition, two unidentified cetaceans were also recorded in the Box in December (Figure 3.71).

Figure 3.71 Other cetacean sightings in Years 5 and 6



3.6.3 Seals

Grey Seals are recorded irregularly in the Arklow Study Area. They are listed on Annex II and V of the EU Habitats Directive (92/43/EEC).

Year 5

Three Grey Seals were recorded in Year 5, with singles over the Bank and Box in May, and one over the Bank in December).

Year 6

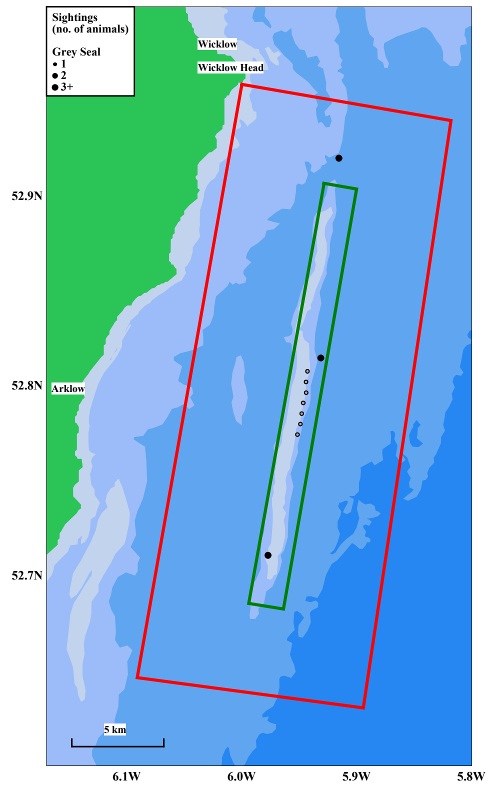
In Year 6, five Grey Seals were recorded, two in February, and singles in May, October and November. In addition, four unidentified seals were also seen, three in May and one in August.

Year 7

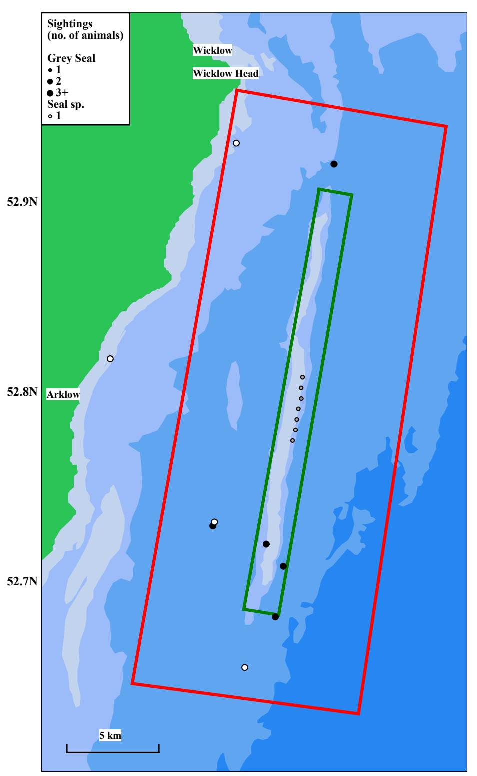
A total of 11 Grey Seals were recorded in Year 7, between July and November, April and June. Sightings were scattered along the Bank, the north end of the Box and the Cable Route. In addition, two unidentified seals were recorded in Year 7, one in January and one in July, over the Bank.

Figure 3.72Sightings in Years 5, 6 and 7

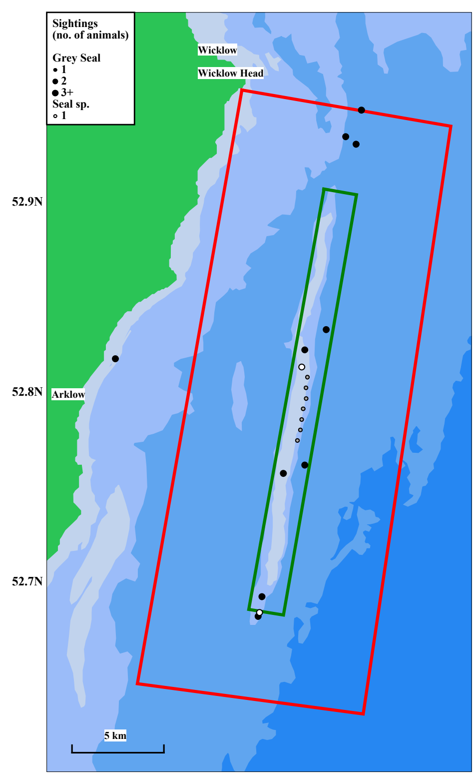
Year 5



Year 6



Year 7



3.7 Plankton sampling

Results of plankton sampling for Years 5 and 6 have been presented in previous reports (e.g. CWC 2004b and FES 2006).

Year 7

Numbers of zooplankton found per site per month were recorded, as well as the number of species or group of species found at each site per month (Table 3.32).

Table 3.32 Numbers of zooplankton per site per month

Month	Sampling Station	No. of Individuals	No. of Species/groups	Month	Sampling Station	No. of Individuals	No. of Species/groups
Feb	1	56	3	April	1	4	2
	2	0	0		2	51	3
	3	0	0		3	161	5
	4	3	2		4	56	3
	5	1	1		5	25	4
	6	2	2		6	20	3
	7	4	3		7	9	4
	8	44	7		8	57	5
	9	51	4		9	14	2
	10	0	0		10	16	4
	Total	**161**	**9**		**Total**	**413**	**8**
May	1	6	4	July	1	11	2
	2	6	3		2	81	2
	3	83	9		3	323	5
	4	13	4		4	59	5
	5	5	2		5	-	-
	6	58	6		6	13	5
	7	61	5		7	90	4
	8	28	5		8	120	4
	9	45	6		9	28	4
	10	11	5		10	78	6
	Total	**318**	**11**		**Total**	**803**	**7**
Aug	1	50	4	Sept	1	4	2
	2	48	5		2	28	6
	3	64	4		3	52	7
	4	142	4		4	6	3
	5	60	4		5	6	5
	6	15	4		6	17	3
	7	33	4		7	7	5
	8	115	8		8	17	8
	9	150	8		9	94	7
	10	105	5		10	18	5
	Total	**782**	**11**		**Total**	**249**	**10**
Oct	1	8	5	Dec	1	38	2
	2	4	2		2	2,376	1
	3	5	4		3	1,324	2
	4	9	4		4	3,690	1
	5	11	3		5	1,383	2
	6	28	3		6	1,520	1
	7	12	3		7	310	1
	8	14	5		8	794	2
	9	34	2		9	870	1
	10	11	3		10	644	1
	Total	**136**	**6**		**Total**	**12,949**	**3**

In total, 10 plankton samples were taken each month throughout the year. Due to inclement weather it was not possible to carry out the November, January or March sampling, while the June sampling was not carried out as the net was damaged collecting the last May sample and a new net could not be sourced in time for the June survey.

Highest numbers of organisms were recorded in December, when a total of 12,949 individuals from 3 species/groups was recorded (Table 3.32). Nearly all of these were Northern Krill, with a total of 12,938 Northern Krill recorded during the month (Table 3.33). Numbers of Northern Krill recorded in other months was considerably lower.

Numbers of organisms were much lower in all other months with 803 in July and 782 in August the next highest monthly totals (Table 3.32).

After Northern Krill, the next most frequently recorded species/groups were *Porcellanidae* crabs (819 individuals) and Shore Crabs (668 individuals), with the majority of both recorded in July and August (Table 3.33). Unidentified Copepods made up the next most frequently encountered group, with a total of 501 individuals recorded. The majority of these were recorded in April.

Table 3.33 Numbers of zooplankton by species/group per month

Species / Group	Number of individuals								
	July	**August**	**September**	**October**	**December**	**February**	**April**	**May**	**TOTAL**
Amphipods	16	15	47	4	0	2	0	8	**92**
Anthozoans	0	0	0	0	0	0	0	13	**13**
Arrow Worms	0	5	52	15	0	10	0	11	**93**
Brittle Star	0	0	1	0	0	0	0	0	**1**
Comb jellies	78	9	24	4	0	0	1	29	**145**
Sea Gooseberry	0	0	0	0	10	1	3	12	**26**
Copepods	0	2	45	80	0	71	260	43	**501**
Unidentified eggs	79	45	0	0	0	1	41	139	**305**
Goby species	1	3	3	0	0	0	0	1	**8**
Northern Krill	6	5	51	32	12,938	66	151	2	**13,251**
Polychaetes	0	0	5	0	0	0	2	0	**7**
Ribbon Worms	0	0	0	0	0	1	0	0	**1**
Porcellanidae crabs	413	402	3	0	1	0	0	0	**819**
Prawn species	0	1	0	0	0	0	0	0	**1**
Shrimp species	0	0	0	0	0	7	3	2	**12**
Shore crab	210	291	18	1	0	2	88	58	**668**
Unidentified small fish	0	4	0	0	0	0	0	0	**4**
Total numbers	**803**	**782**	**249**	**136**	**12,949**	**161**	**413**	**318**	

4. Statistical analyses of data from Years 1 to 7

4.1 Statistical analysis of key species

4.1.1 Introduction

The analyses for each key species all followed the same approach, and are presented in a common format. This format is explained below.

Seasonality

For each species the first table provides a broad brush summary of seasonal patterns of occurrence. For a particular month, the mean number of birds recorded at each position on each leg was calculated, across all records for that position. This catered for the variable coverage of legs. For each month, summing the mean numbers from different legs provided an estimate of the total number of birds which would be expected to be recorded during a single survey covering each leg in its entirety once. This estimate was used to calculate an overall estimate of the percentage of birds expected to be recorded in each month.

For seasonal species (e.g. Manx Shearwater), if data from months when the species was wholly or largely absent were included in analyses of changes in abundance, then genuine changes during the time of year when the species was present could be masked. Therefore we adopted the convention that for such analyses, only months where more than 1 % of records were expected to occur were included. The months included in the analyses are indicated in the second table presented, the seasonal summary table for each species.

Distribution across legs

The second table in each species account also provides a summary of the distribution of records across the legs. This allowed the relative importance of different legs for each species to be assessed. Obviously impacts in areas important for a species are potentially more important than impacts in less important areas. The underlying data was the same used in the analyses of changes in abundance, described in more detail below. The table presents:

- The mean number of birds recorded on each leg on surveys before and after turbine installation, based only upon those surveys achieving full coverage;
- On the basis of these means, the estimated % of birds which would be recorded on this leg during a single survey covering all legs once was calculated, again for before and after turbine installation;
- The mean numbers of birds were also expressed as a density, nos/km^2.
- The relative density expressed these densities as a percentage of the maximum density recorded, to aid comparison of legs.

Changes in abundance

The third table summarises the mean numbers of birds recorded on each leg before, during and after turbine installation, and asked, for each leg, whether the mean number of birds recorded had changed significantly from the period before turbine installation to the period during installation, and also the period after installation. For each mean, non-parametric 95 % confidence limits were calculated based upon 1,000 bootstrap replicates using the adjusted percentile (BC_a) method (Davison and Hinkley 1997). The statistical significance of the change in means was assessed using the non-parametric permutation test (Hothorn and Hornik 2006, Arnholt 2007), which calculated an exact p-value for the observed difference in means by performing all possible permutations of the data, and calculated the proportion of these yielding a difference in means greater than that observed.

Given the large number of statistical tests carried out, a small number of false positives is to be expected, so it is suggested that in the species accounts which follow, relatively little credence should be given to what are referred to as "weakly significant" results, which have P values of less 0.05 but greater than or equal to 0.01.

Although significant changes in abundance between the period before turbine installation, and the period after installation were recorded relatively frequently, very few significant changes were observed between the period before turbine installation and the period during installation. Given the relatively small sample sizes available for the period during installation this was not surprising. Therefore when talking about changes in bird numbers, the species accounts (Section 4) implicitly compare the pre-construction period (i.e. before the turbines were installed) with the post-construction period (i.e. after turbine installation) unless explicitly stated otherwise.

Changes in distribution

For each species, a series of figures are included showing the mean numbers of birds recorded at different distances from the turbines before, during and after installation. This analysis was restricted to data from the Bank legs (legs 2 and 3 and km 11-30 of leg 3). The figures also show 95 % confidence limits, calculated based on 1,000 bootstrap replicates using the adjusted percentile (BC_a) method (Davison and Hinkley 1997). The GRASS GIS package (GRASS Development Team, 2007) was used to calculate the distance to the nearest turbine location for each observation.

In project Year 1, bird numbers were recorded in sections of 5 km length or longer. In subsequent years, data was recorded for each individual km of each leg. The analyses of the changes in the distribution presented here have been carried out at 1 km resolution and so the data from project Year 1 has been excluded.

4.2 Key species accounts

Red-throated Diver

Red-throated Divers occurred mainly during the winter and spring months, from November through to May (Table 4.1). The vast majority of records, and the highest densities occurred on the two Bank legs (legs 2 and 3), with 89 % of birds recorded here before the turbines were installed, and 93 % of birds recorded here after turbine installation (Table 4.2). However, the relative importance of the two Bank legs changed between pre- and post-turbine installation, principally due to a highly significant 6-fold decline ($p<0.01$) in the mean numbers of Red-throated Divers recorded on the outer Bank leg (leg 2) (Table 4.2 & Table 4.3).

Table 4.1 Summary statistics showing the seasonal distribution of Red-throated Diver records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	16.9	18	Yes
2	25.9	28	Yes
3	11.7	13	Yes
4	8.1	9	Yes
5	5.1	6	Yes
6	0.2	0	No
7	0.0	0	No
8	0.1	0	No
9	0.8	1	No
10	0.7	1	No
11	6.1	7	Yes
12	16.5	18	Yes

Table 4.2 Summary statistics showing the distribution of Red-throated Diver records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	0.22	0.00	1	0	0.01	0.00	2	0
2	17.18	3.10	79	31	0.49	0.09	100	50
3	2.13	6.17	10	62	0.06	0.18	12	100
5	0.64	0.00	3	0	0.04	0.00	9	0
11	0.10	0.13	0	1	0.00	0.01	1	3
41	0.67	0.13	3	1	0.05	0.01	10	5
42	0.10	0.20	0	2	0.01	0.02	2	9
43	0.67	0.11	3	1	0.07	0.01	14	6
44	0.09	0.14	0	1	0.01	0.01	2	7

Figure 4.1 suggested that the turbines were installed close to where the highest numbers of Red-throated Divers were recorded on the outer Bank leg (leg 2) during baseline surveys. The decline in mean numbers was concentrated within 5 km of the nearest turbine, and was particularly strong within 1-2 km of the nearest turbine (Figure 4.2).

Figure 4.1 Numbers of Red-throated Divers on each leg before (red), during (blue) and after (green) turbine installation

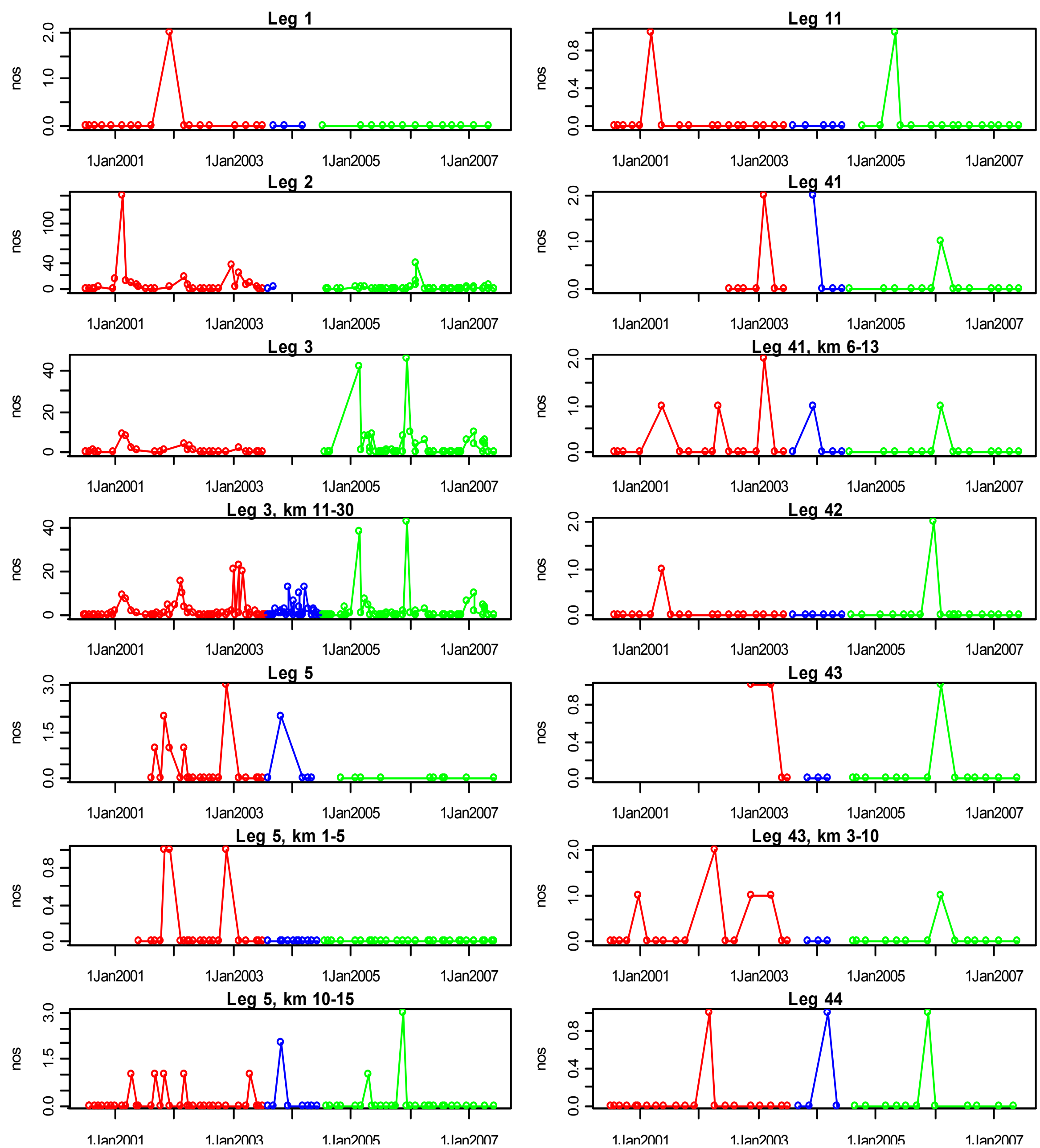
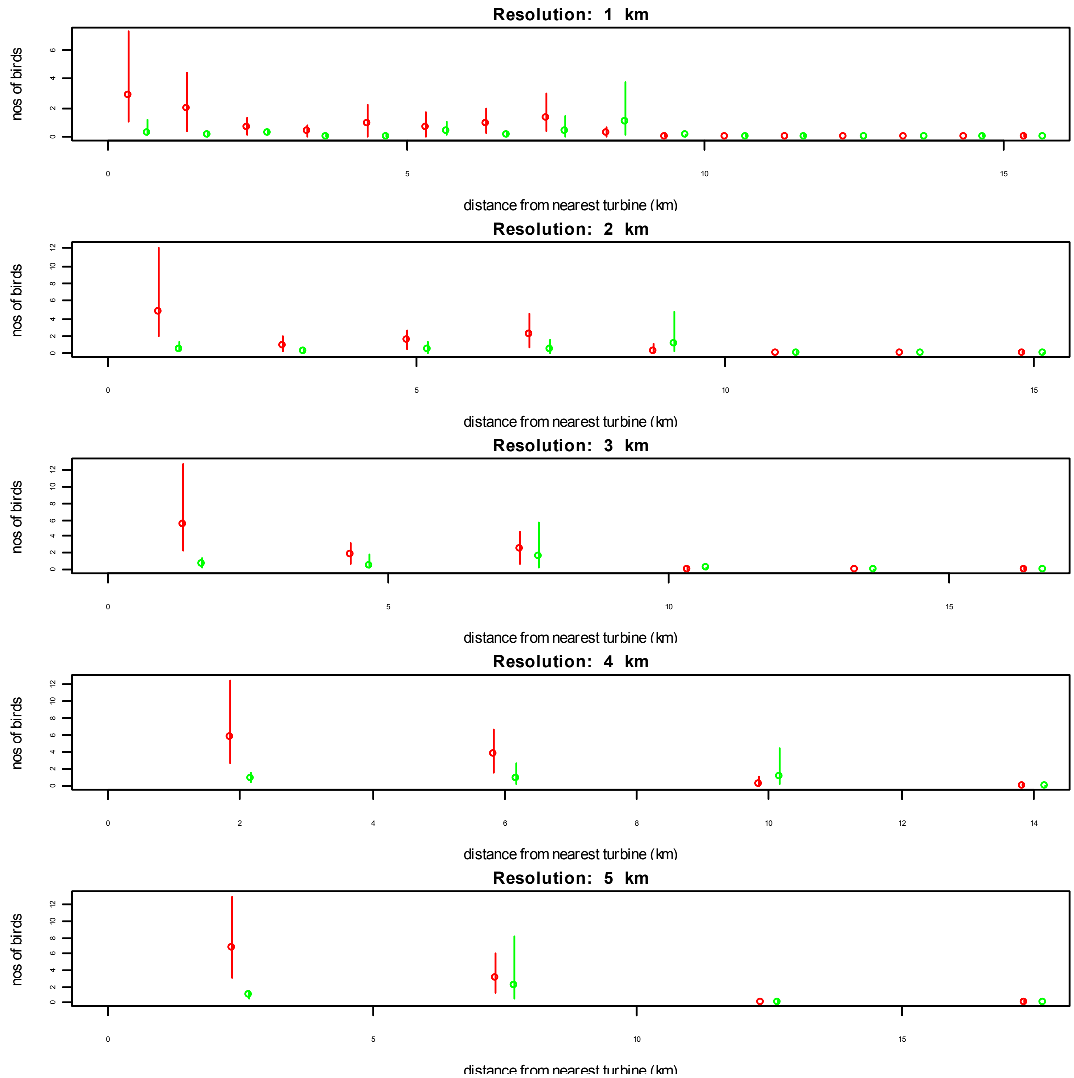


Figure 4.2 Numbers of Red-throated Divers on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



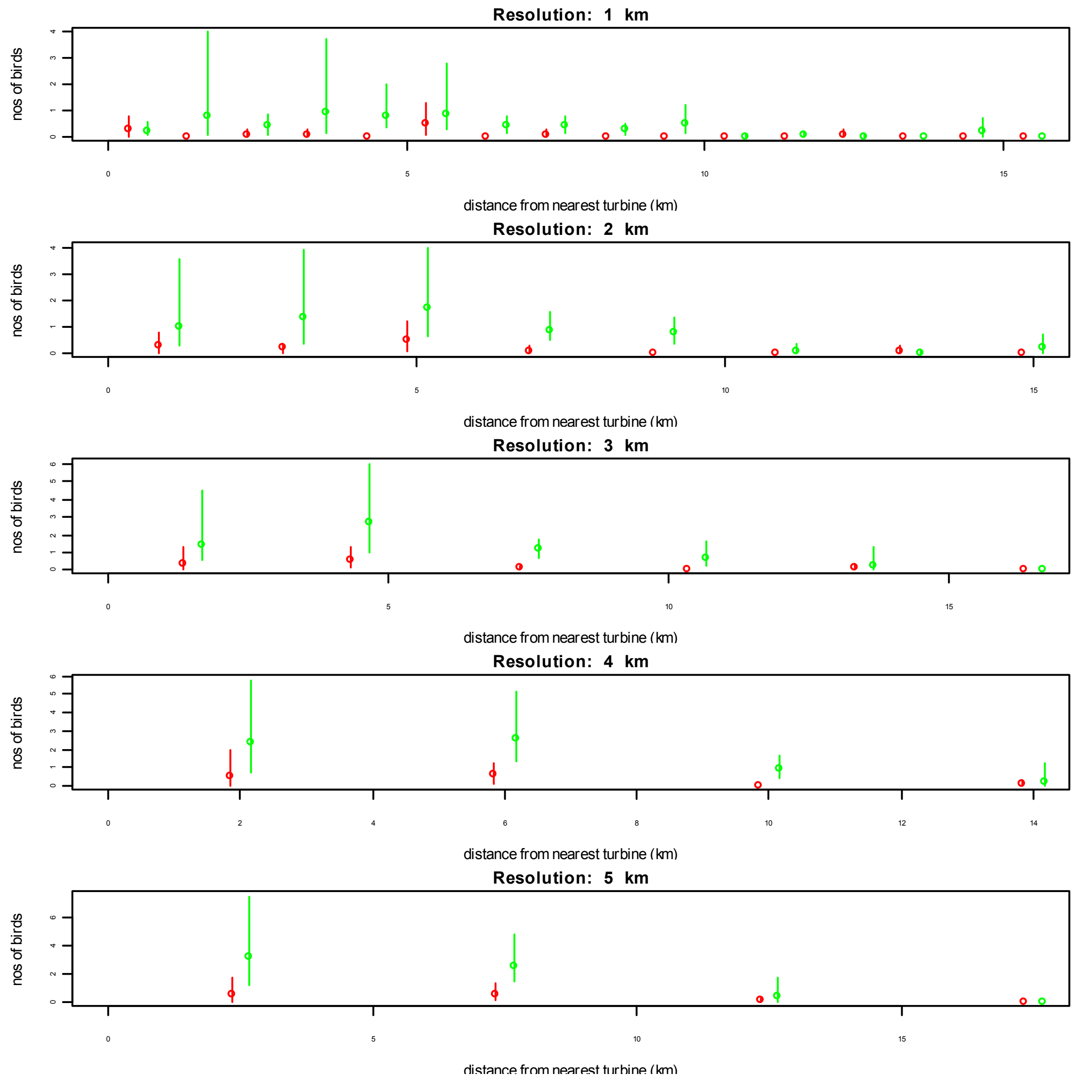
This pattern was consistent with the installation of the turbines being responsible for the decline. However, on the inner Bank leg (leg 3), there was no evidence of any such decline (Table 4.2 & Table 4.3). The data for the relatively small number of surveys where the whole of leg 3 was covered suggested a 3-fold increase in the number of birds present, although this increase was not statistically significant (Table 4.2 & Table 4.3). This increase was widespread between 2 and 9 km from the nearest turbine (Figure 4.3), providing no evidence for any effect of turbine proximity.

Table 4.3 Mean numbers of Red-throated Divers on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	0.22	0.00	0.67	9	0.00			2	1.00000		0.00			8	1.00000	
2	17.18	7.47	44.31	17				0	1.00000		3.10	1.48	9.92	29	0.00459	--
3	2.13	1.00	3.85	15				0	1.00000		6.17	3.45	12.06	29	0.16721	
3, km 11-30	4.52	2.77	7.33	31	2.90	1.43	4.91	21	0.33565		4.06	1.82	8.76	34	0.83861	
5	0.64	0.18	1.36	11	0.00			3	0.60165		0.00			5	0.27976	
5, km 1-5	0.27	0.00	0.45	11	0.00			8	0.22807		0.00			19	0.04064	-
5, km 10-15	0.21	0.05	0.38	19	0.00			4	0.56228		0.27	0.00	0.95	15	1.00000	
11	0.10	0.00	0.30	10	0.00			2	1.00000		0.13	0.00	0.38	8	1.00000	
41	0.67	0.00	1.33	3	0.67	0.00	1.33	3	1.00000		0.13	0.00	0.38	8	0.27273	
41, km 6-13	0.44	0.00	0.89	9	0.33	0.00	0.67	3	1.00000		0.13	0.00	0.38	8	0.45294	
42	0.10	0.00	0.30	10	0.00			3	1.00000		0.20	0.00	0.60	10	1.00000	
43	0.67	0.00	0.67	3	0.00			3	0.40000		0.11	0.00	0.22	9	0.12727	
43, km 3-10	0.71	0.14	1.14	7	0.00			3	0.35000		0.11	0.00	0.33	9	0.09135	
44	0.09	0.00	0.27	11	0.33	0.00	0.67	3	0.39560		0.14	0.00	0.29	7	1.00000	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with p<0.0001
"+++" or "---" indicates a positive or negative change with p <0.001
"++" or "--" indicates a positive or negative change with p <0.01
"+" or "-" indicates a positive or negative change with p <0.05.

Figure 4.3 Numbers of Red-throated Divers on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



Much smaller numbers of Red throated Divers were recorded on the non-Bank legs (Table 4.2, Figure 4.1). A weakly significant decline ($p<0.05$) occurred in the number of birds recorded on km 1-5 of leg 5 (Cable Route) (Table 4.3). Results also suggested that fewer birds were recorded on leg 5, leg 41 km 6-13 and leg 43 km 3-10 after the installation of turbines than beforehand (Figure 4.1 & Table 4.3). Although these differences were not statistically significant, the small sample sizes for non-Bank legs, and low numbers of birds recorded, made detecting genuine change on the non-Bank legs more difficult than on the Bank legs.

In conclusion, a strong, statistically significant decline occurred in the numbers of Red-throated Divers found on the outer Bank leg (leg 2). This leg was by far the most important for this species (with 79 % of birds recorded) before the turbines were installed. This decline appeared to be strongly associated with the proximity of turbines. However, on the inner Bank leg (leg 3), there was no evidence of any decline in Red-throated Divers numbers.

On non-Bank legs, where numbers of birds were much lower, formal statistical analysis found no convincing evidence for declines, but visual inspection of time series suggested the possibility of a more widespread decline. The threshold for All-Ireland importance is just 20 birds (Crowe 2005), which suggests that numbers of Red-throated Divers wintering on the Arklow Bank are of national importance. Therefore any decline in this species would be of considerable conservation importance. This species avoids ships and may be particularly vulnerable to disturbance. These results raise the possibility of Red-throated Divers being negatively affected by the installation of the first seven turbines. Therefore, given the potential conservation importance of this population, and its Annex I status, it is recommended that continued monitoring of Red-throated Divers should be a high priority.

Fulmar

Fulmars were widely distributed throughout the year in low numbers, with most birds recorded during July and August, and fewest during the winter months (October-February). Records from October and November were excluded from the analyses of changes in abundance (Table 4.4).

Table 4.4 Summary statistics showing the seasonal distribution of Fulmar records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	2.0	2	Yes
2	6.0	5	Yes
3	13.6	12	Yes
4	8.5	7	Yes
5	6.2	6	Yes
6	8.2	7	Yes
7	30.1	27	Yes
8	26.5	23	Yes
9	8.4	7	Yes
10	0.3	0	No
11	0.8	1	No
12	2.1	2	Yes

Before turbine installation, Fulmars were most abundant on the four legs furthest from the shore, including both Bank legs, and the two outer Box legs (legs 1,11, 2 and 3, Table 4.5), although overall numbers involved were low. However, following turbine installation the relative importance of the Bank legs has declined greatly (Table 4.5) because of highly significantly declines in Fulmars on both Bank legs (Table 4.6, $P< 0.001$ for leg 2, $P < 0.00001$ for leg 3 and $P < 0.000001$ for leg 3, km 11-30).

Evidence for both Bank legs suggested that before turbine installation, relatively high numbers of Fulmars occurred within 1 km of where the turbines were subsequently installed (Figures 4.6, 4.7 and 4.8). However, on both Bank legs, declines appeared to have occurred across a wide range of distances from the nearest turbines (Figures 4.6, 4.7 and 4.8). Thus, if the declines observed reflect the impact of the turbines then these impacts must be operating at a scale comparable to the size of the Bank. Potential mechanisms for impacts at such a scale are unclear. Although not statistically significant, Figure 4.5 suggested that numbers of Fulmars recorded may also have declined on leg 42, leg 43 km 3-10 and leg 44.

Table 4.5 Summary statistics showing the distribution of Fulmar records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km²)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	0.22	0.00	1	0	0.01	0.00	2	0
2	17.18	3.10	79	31	0.49	0.09	100	50
3	2.13	6.17	10	62	0.06	0.18	12	100
5	0.64	0.00	3	0	0.04	0.00	9	0
11	0.10	0.13	0	1	0.00	0.01	1	3
41	0.67	0.13	3	1	0.05	0.01	10	5
42	0.10	0.20	0	2	0.01	0.02	2	9
43	0.67	0.11	3	1	0.07	0.01	14	6
44	0.09	0.14	0	1	0.01	0.01	2	7

Thus, the numbers of Fulmars recorded have declined on the Bank legs and maybe elsewhere. However, there was no evidence that declines were associated with proximity to the turbines. Even if the observed declines were due to turbine installation, the small numbers of birds involved is negligible compared to both national and international breeding populations (Mitchell et al. 2004).

Table 4.6 Mean numbers of Fulmars on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	3.78	2.39	5.61	18	1.50	0.00	3.00	2	0.4368421		9.18	0.82	48.64	11	0.5696888	
2	2.59	1.82	3.79	34	1.00	0.00	1.00	2	0.5253968		0.68	0.27	2.11	44	0.0007241	---
3	1.69	1.12	2.46	26				0	1.0000000		0.36	0.19	0.53	47	0.0000042	----
3, km 11-30	1.17	0.76	1.83	54	1.07	0.56	1.74	27	0.8398489		0.12	0.04	0.19	52	0.0000004	----
5	0.24	0.06	0.41	17	0.25	0.00	0.50	4	1.0000000		0.11	0.00	0.33	9	0.6278504	
5, km 1-5	0.11	0.00	0.28	18	0.11	0.00	0.33	9	1.0000000		0.07	0.00	0.19	27	1.0000000	
5, km 10-15	0.17	0.03	0.38	29	0.00			7	0.6743316		0.08	0.00	0.21	24	0.5200327	
11	2.07	1.27	3.00	15	1.00	0.13	1.50	4	0.3297214		4.46	0.15	21.49	13	0.9389452	
41	0.33	0.00	0.52	6	0.00			4	0.4666667		0.31	0.00	0.69	13	1.0000000	
41, km 6-13	0.27	0.00	0.96	15	0.00			5	0.8026316		0.15	0.00	0.31	13	0.8753968	
42	1.06	0.50	1.75	16	0.20	0.00	0.40	5	0.2190771		0.50	0.06	1.47	16	0.2960251	
43	1.00	0.00	1.67	3	0.00			2	0.4000000		0.09	0.00	0.27	11	0.0631868	
43, km 3-10	0.50	0.14	0.86	14	0.00			2	0.7250000		0.09	0.00	0.27	11	0.1268116	
44	0.39	0.00	0.89	18	0.67	0.00	1.33	3	1.0000000		0.40	0.00	1.29	10	1.0000000	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with p<0.0001
"+++" or "---" indicates a positive or negative change with p <0.001
"++" or "--" indicates a positive or negative change with p <0.01
"+" or "-" indicates a positive or negative change with p <0.05.

Figure 4.5 Numbers of Fulmars on each leg before (red), during (blue) and after (green) turbine installation

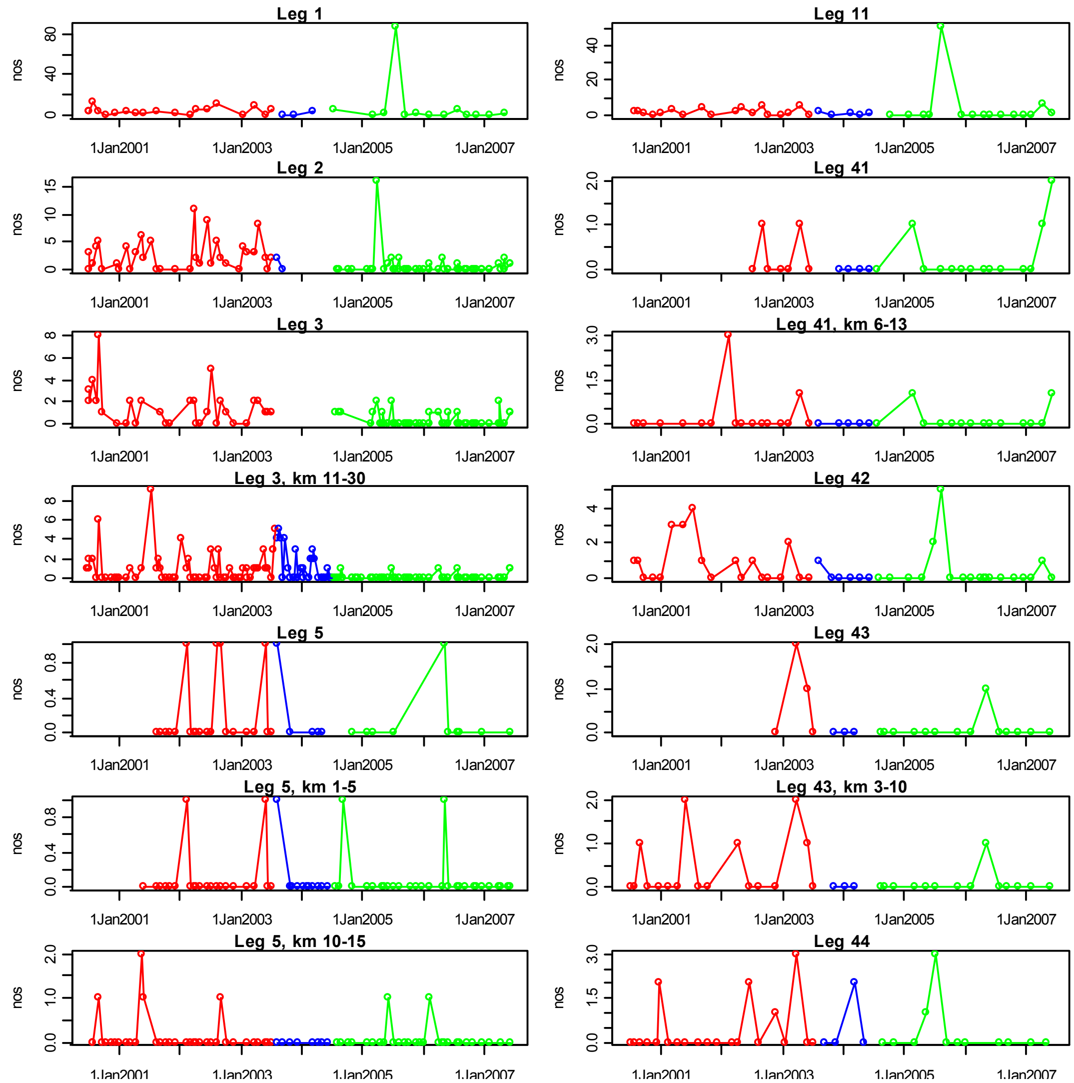


Figure 4.6 Numbers of Fulmars on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

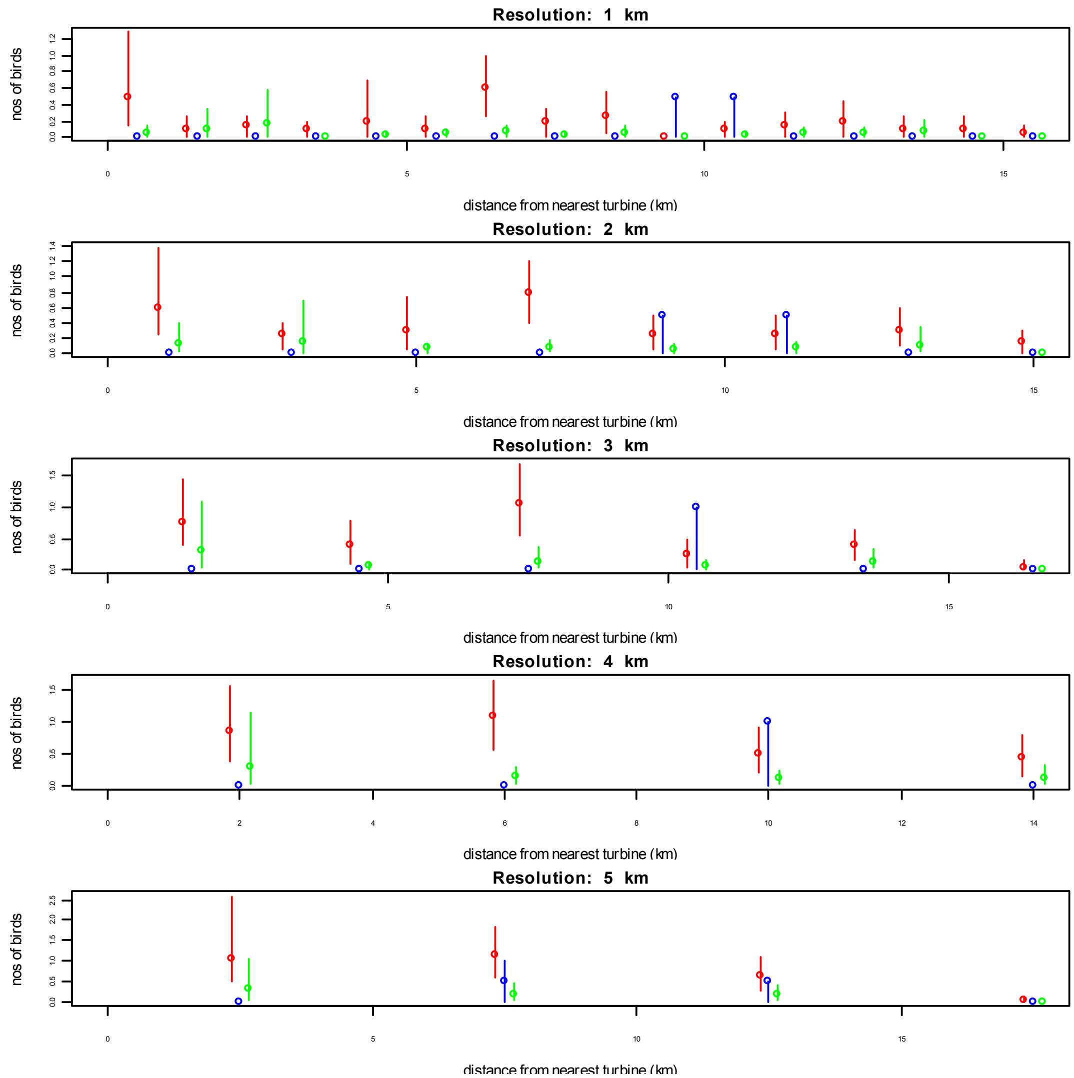


Figure 4.7 **Numbers of Fulmars on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions**

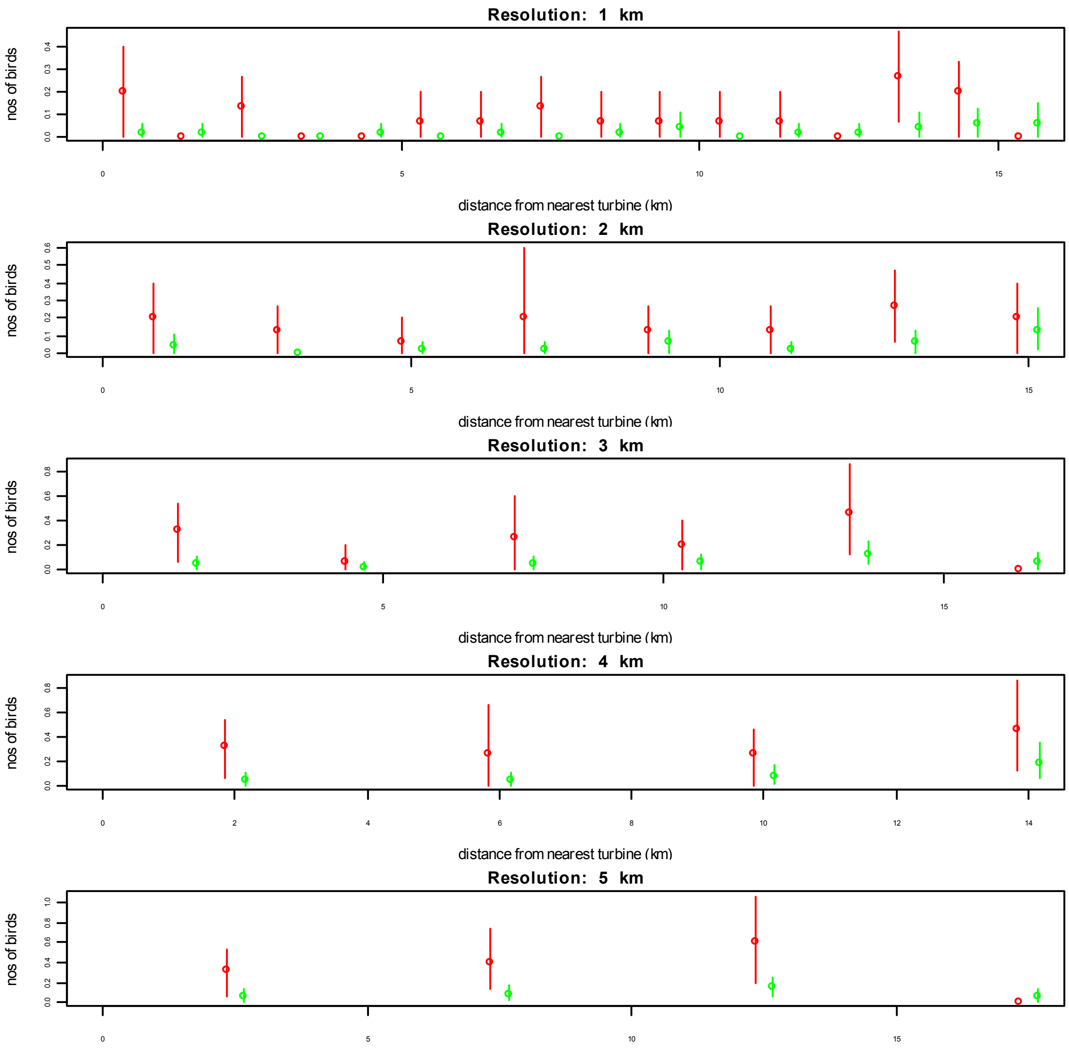
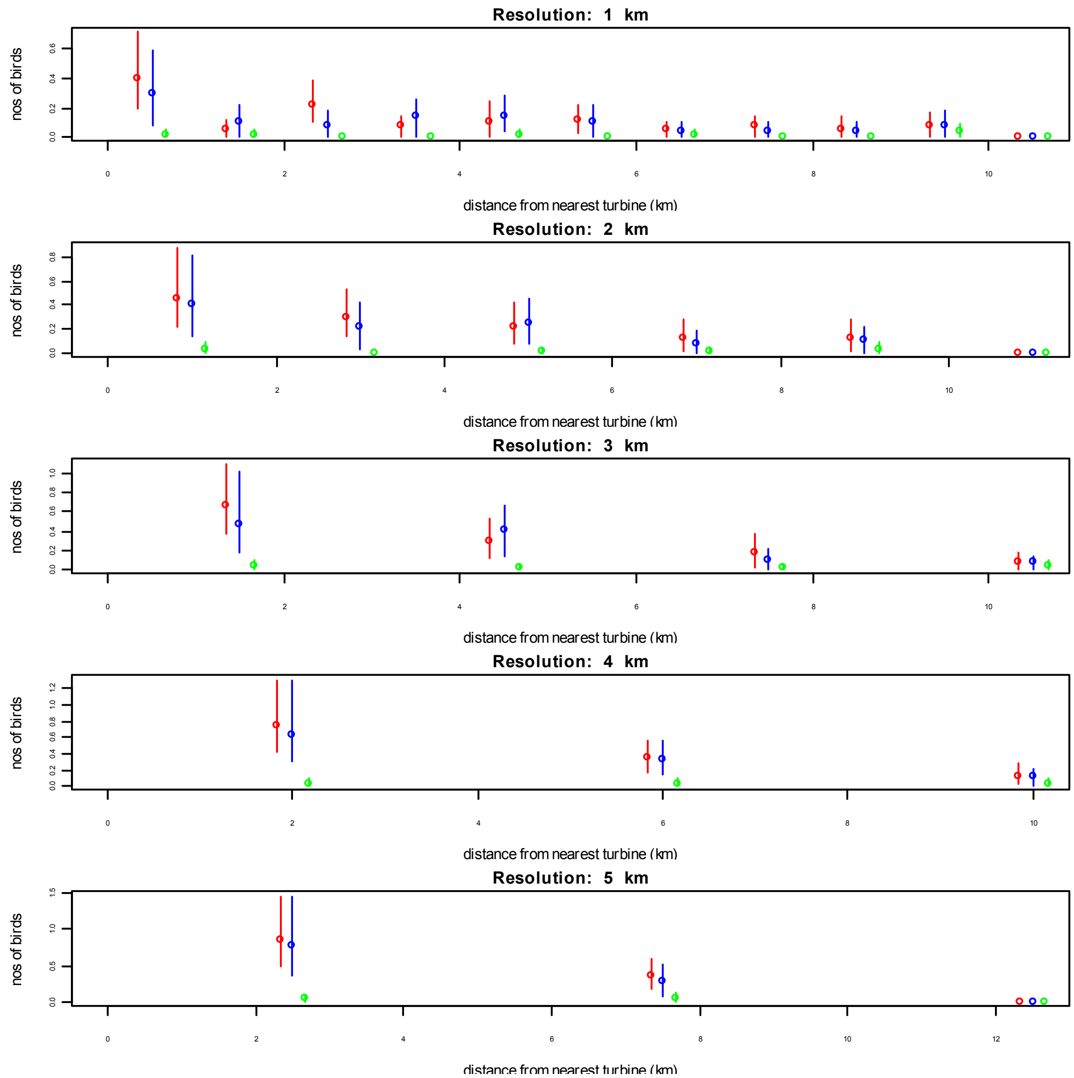


Figure 4.8 **Numbers of Fulmars between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions**



Manx shearwater

Manx shearwater is a summer visitor to the Arklow Study Area, with no records from November to February. Only records from March to September were included in the analyses of change in abundance (Table 4.7). Records were widely distributed across the legs (Table 4.8), although the greatest numbers tended to be records on the two outer Box legs (legs 1 and 11) and also the two Bank legs (legs 2 and 3).

Table 4.7 Summary statistics showing the seasonal distribution of Manx Shearwater records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	0.0	0	No
2	0.0	0	No
3	53.8	4	Yes
4	246.4	16	Yes
5	369.4	24	Yes
6	175.8	11	Yes
7	333.9	22	Yes
8	199.3	13	Yes
9	139.4	9	Yes
10	13.3	1	No
11	0.0	0	No
12	0.1	0	No

Table 4.8 Summary statistics showing the distribution of Manx Shearwater records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	38.1	131.9	19	49	1.5	5.3	89	100
2	47.7	30.7	23	11	1.4	0.9	79	17
3	35.6	23.1	17	9	1.0	0.7	59	13
5	2.1	17.3	1	6	0.1	1.2	8	22
11	43.1	43.4	21	16	1.7	1.7	100	33
41	15.5	9.0	8	3	1.2	0.7	69	13
42	12.8	12.3	6	5	1.1	1.0	62	19
43	3.3	2.3	2	1	0.3	0.2	19	4
44	6.5	1.3	3	0	0.5	0.1	31	2

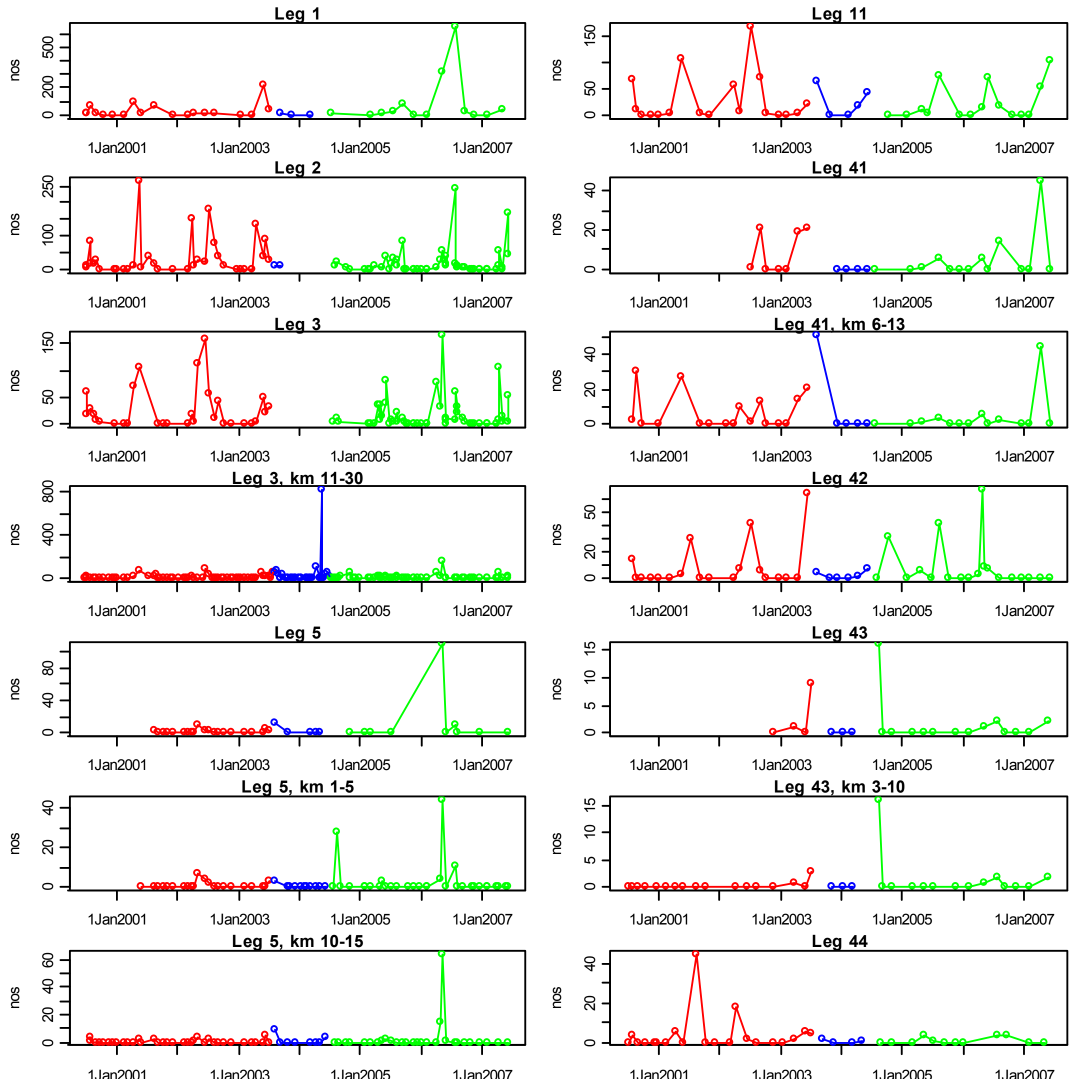
The only significant change in numbers was a weakly significant ($P < 0.05$) increase in numbers observed from km 11-30 of the inner Box leg (leg 3) between pre-installation and the turbine installation phase (Table 4.9), which was largely the result of a single unusual observation during the turbine installation period (Figure 4.9).

Table 4.9 Mean numbers of Manx Shearwaters on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	38.14	19.29	83.09	14	5.50	0.00	5.50	2	0.375		131.89	31.56	346.28	9	0.109	
2	47.70	28.39	82.15	27	8.50	8.00	8.50	2	0.357		30.72	18.52	54.84	32	0.275	
3	35.61	21.88	58.54	23				0	1.000		23.13	14.31	38.53	38	0.221	
3, km 11-30	15.23	10.19	23.23	40	69.56	20.51	208.17	18	0.023	+	11.46	6.61	27.39	41	0.492	
5	2.07	0.93	4.00	14	3.00	0.00	6.00	4	0.790		17.29	0.43	63.43	7	0.163	
5, km 1-5	1.07	0.27	2.58	15	0.60	0.00	1.20	5	0.795		4.74	1.11	11.63	19	0.328	
5, km 10-15	0.83	0.35	1.53	23	2.00	0.00	5.50	6	0.209		4.67	0.44	22.44	18	0.208	
11	43.08	19.17	82.89	12	41.33	16.00	57.33	3	0.945		43.38	21.69	72.51	8	0.992	
41	15.50	1.00	20.50	4	0.00			2	0.133		9.00	2.38	24.64	8	0.523	
41, km 6-13	10.73	4.55	17.18	11	17.00	0.00	34.00	3	0.591		7.00	1.13	23.92	8	0.573	
42	12.85	4.54	29.40	13	4.33	1.00	6.33	3	0.586		12.27	3.63	32.36	11	0.955	
43	3.33	0.00	6.33	3	0.00			1	0.750		2.33	0.33	7.89	9	0.932	
43, km 3-10	0.33	0.00	1.08	12	0.00			1	1.000		2.33	0.33	7.56	9	0.158	
44	6.46	2.08	16.60	13	1.00	0.00	1.67	3	0.389		1.25	0.38	2.25	8	0.256	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with $p<0.0001$
"+++" or "---" indicates a positive or negative change with $p <0.001$
"++" or "--" indicates a positive or negative change with $p <0.01$
"+" or "-" indicates a positive or negative change with $p <0.05$.

Figure 4.9 **Numbers of Manx Shearwaters on each leg before (red), during (blue) and after (green) turbine installation**



Although on both Bank legs (legs 2 &3), mean numbers were greater before turbine installation than after, this difference was not statistically significant (Table 4.9). However, for both Bank legs, results suggested that birds may have redistributed following turbine installation so that less birds were recorded within c 12 km of the nearest turbine, and more birds beyond this distance, than in the pre-installation period (Figure 4.10 and Figure 4.11 respectively).

Figure 4.10 **Numbers of Manx Shearwaters on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions**

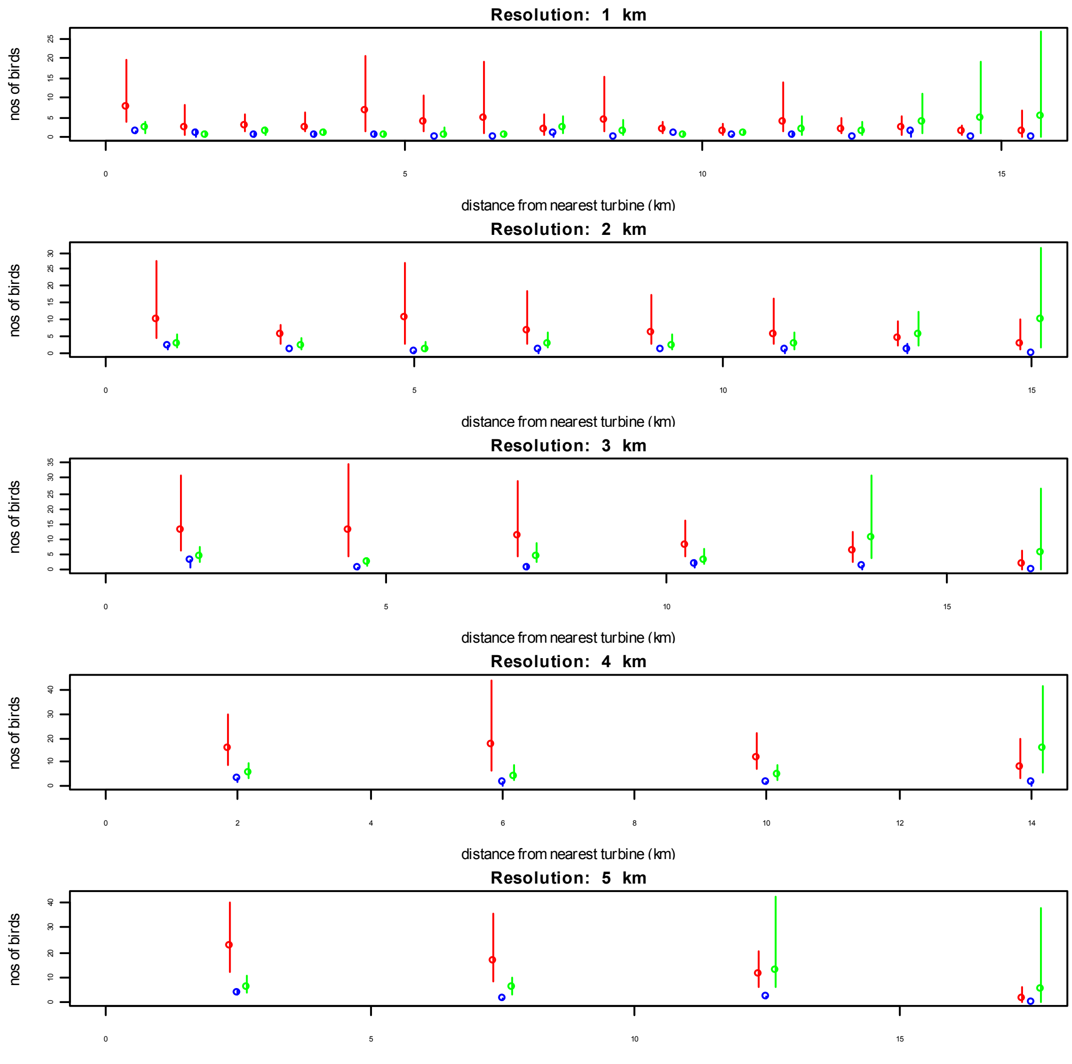
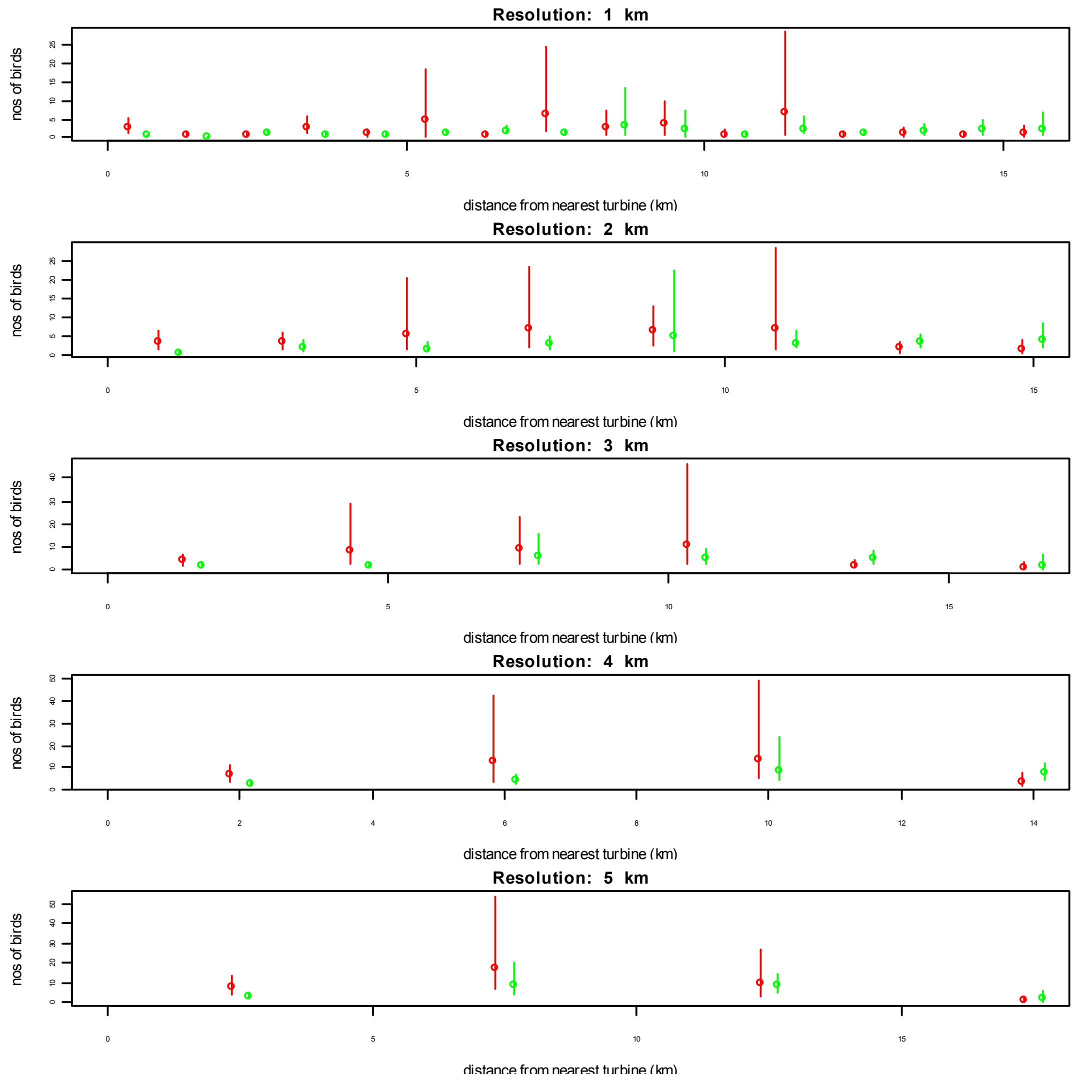


Figure 4.11 Numbers of Manx Shearwaters on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



On the non-Bank legs, no significant changes in numbers were recorded (Table 4.9). Although the relatively small sample sizes meant that detecting genuine changes on these legs may be more difficult than for the bank legs, visual inspection of Figure 4.9 provided no support for the existence of any such undetected patterns.

Thus, there was no clear evidence of any impact of turbines on numbers of Manx Shearwaters, although birds may have redistributed on both Bank legs (legs 2 and 3) to avoid the turbines. However, any impacts are likely to be of little conservation importance, given the small numbers of birds involved, which were negligible compared to both national and international breeding populations (Mitchell et al. 2004).

Gannet

Although Gannets were most abundant during the summer months (Table 4.10), records were widely distributed throughout the year, with only records from November and December excluded from the analyses of changes in abundance (Table 4.11).

Table 4.10 Summary statistics showing the seasonal distribution of Gannet records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	7.2	4	Yes
2	4.5	2	Yes
3	11.8	6	Yes
4	20.1	11	Yes
5	28.5	15	Yes
6	20.4	11	Yes
7	13.2	7	Yes
8	23.4	12	Yes
9	36.0	19	Yes
10	19.1	10	Yes
11	1.5	1	No
12	1.5	1	No

Table 4.11 Summary statistics showing the distribution of Gannet records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	2.9	5.3	11	27	0.12	0.21	54	100
2	7.7	2.8	30	14	0.22	0.08	100	38
3	5.2	3.6	20	18	0.15	0.10	67	48
5	1.7	0.3	6	1	0.11	0.02	51	8
11	2.3	3.5	9	17	0.09	0.14	41	66
41	2.3	1.5	9	8	0.18	0.12	82	55
42	1.3	0.5	5	3	0.10	0.04	47	21
43	1.3	1.9	5	10	0.13	0.19	61	91
44	1.0	0.6	4	3	0.08	0.05	38	24

Table 4.12 Mean numbers of Gannets on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

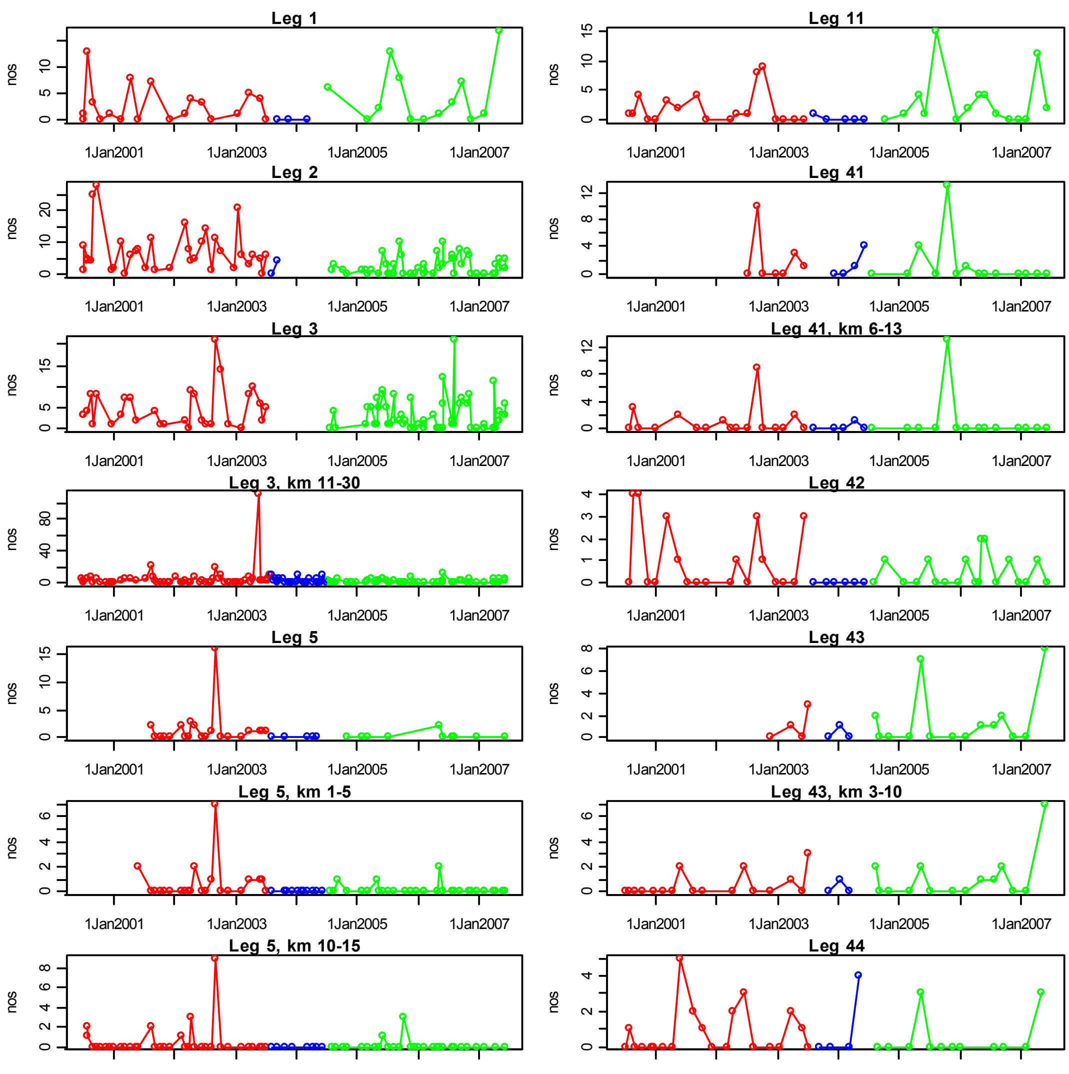
	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	2.94	1.59	5.00	17	0.00			2	0.32164		5.27	2.91	9.54	11	0.19803	
2	7.69	5.66	10.45	32	2.00	0.00	2.00	2	0.23351		2.78	1.98	3.63	45	0.00001	----
3	5.19	3.74	7.09	27				0	1.00000		3.57	2.57	4.96	49	0.12421	
3, km 11-30	5.65	3.27	15.73	52	2.36	1.32	3.61	28	0.31014		1.68	1.19	2.42	53	0.00144	--
5	1.67	0.67	5.78	18	0.00			5	0.25564		0.25	0.00	0.75	8	0.36078	
5, km 1-5	0.79	0.32	2.11	19	0.00			9	0.18637		0.15	0.00	0.37	27	0.03578	-
5, km 10-15	0.60	0.20	1.80	30	0.00			7	0.44945		0.16	0.00	0.60	25	0.33439	
11	2.27	1.20	4.13	15	0.20	0.00	0.40	5	0.12784		3.46	1.64	6.85	13	0.44150	
41	2.33	0.33	7.17	6	1.67	0.00	3.00	3	0.94048		1.50	0.08	4.96	12	0.79557	
41, km 6-13	1.13	0.33	3.40	15	0.25	0.00	0.50	4	0.54696		1.08	0.00	3.25	12	1.00000	
42	1.25	0.56	2.05	16	0.00			5	0.12463		0.53	0.24	0.88	17	0.12489	
43	1.33	0.00	2.33	3	0.50	0.00	0.50	2	0.90000		1.91	0.73	4.36	11	0.93407	
43, km 3-10	0.53	0.13	1.07	15	0.50	0.00	0.50	2	1.00000		1.36	0.55	3.09	11	0.21744	
44	1.00	0.47	1.82	17	1.33	0.00	2.67	3	0.86404		0.60	0.00	1.20	10	0.48986	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with $p<0.0001$
"+++" or "---" indicates a positive or negative change with $p <0.001$
"++" or "--" indicates a positive or negative change with $p <0.01$
"+" or "-" indicates a positive or negative change with $p <0.05$.

Gannets records were widely dispersed across all legs, although they tended to be most abundant on the two Bank legs (legs 2 and 3) and also on the two offshore Box legs (legs 1 and 11). Highly significant declines in numbers occurred before and after turbine installation on the outer Bank leg (leg 2) and from km 11-30 on the inner Bank leg (leg 3) (Table 4.12, $P < 0.00002$ and $P < 0.002$ respectively).

A weakly significant decline occurred from km 1-5 on the Cable Route (leg 5) (Table 4.12, $P < 0.05$). Although not statistically significant, visual inspection of Figure 4.13 supported the hypothesis of a more general decline on leg 5, and also suggested numbers may have declined between km 6-13 of leg 41, leg 42 and leg 44 (the inner Box legs).

Figure 4.13 Numbers of Gannets on each leg before (red), during (blue) and after (green) turbine installation



On the Bank legs, there was no evidence that declines were related to proximity to the nearest turbine (Figures 4.14, 4.15 and 4.16).

Figure 4.14 Numbers of Gannets on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

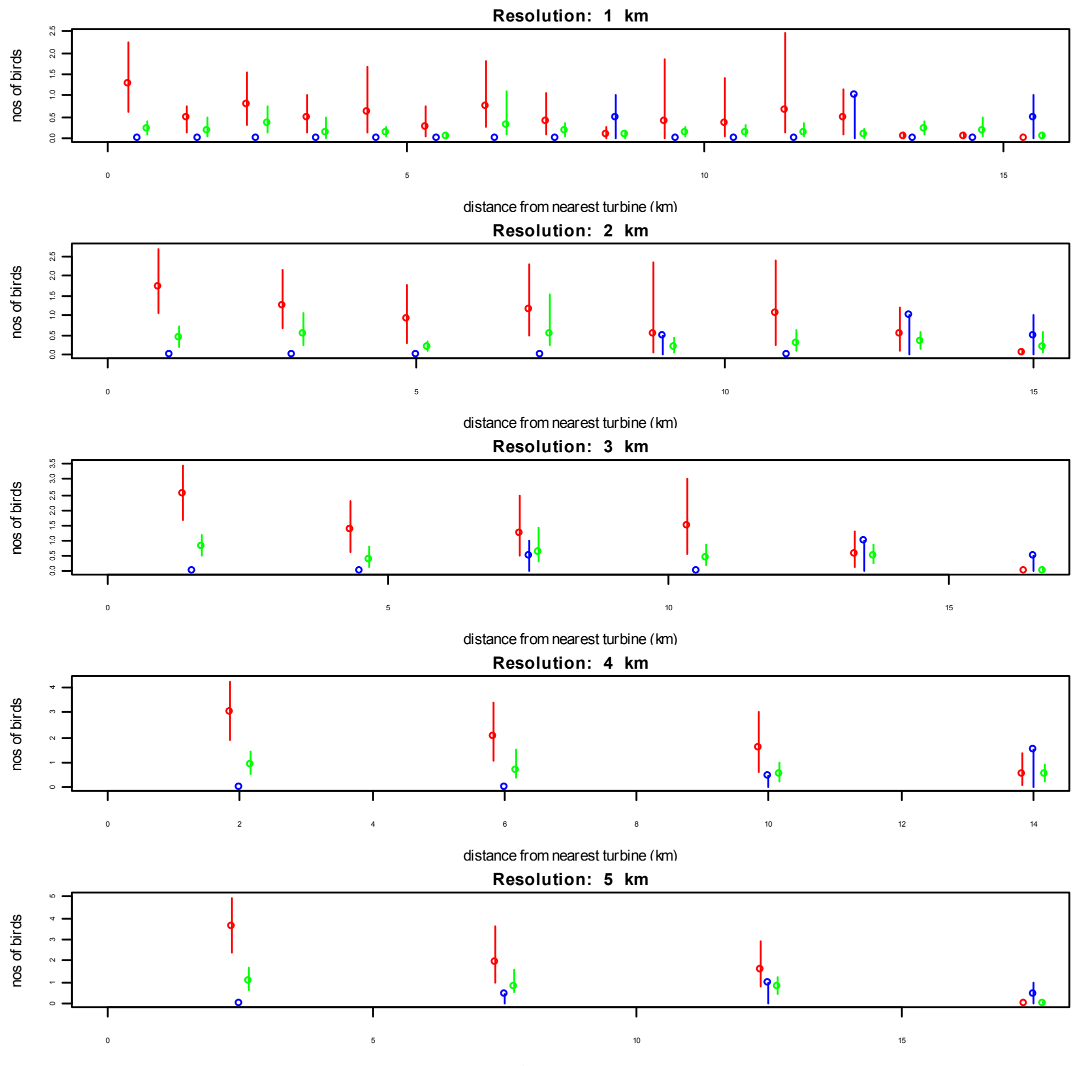


Figure 4.15 **Numbers of Gannets on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions**

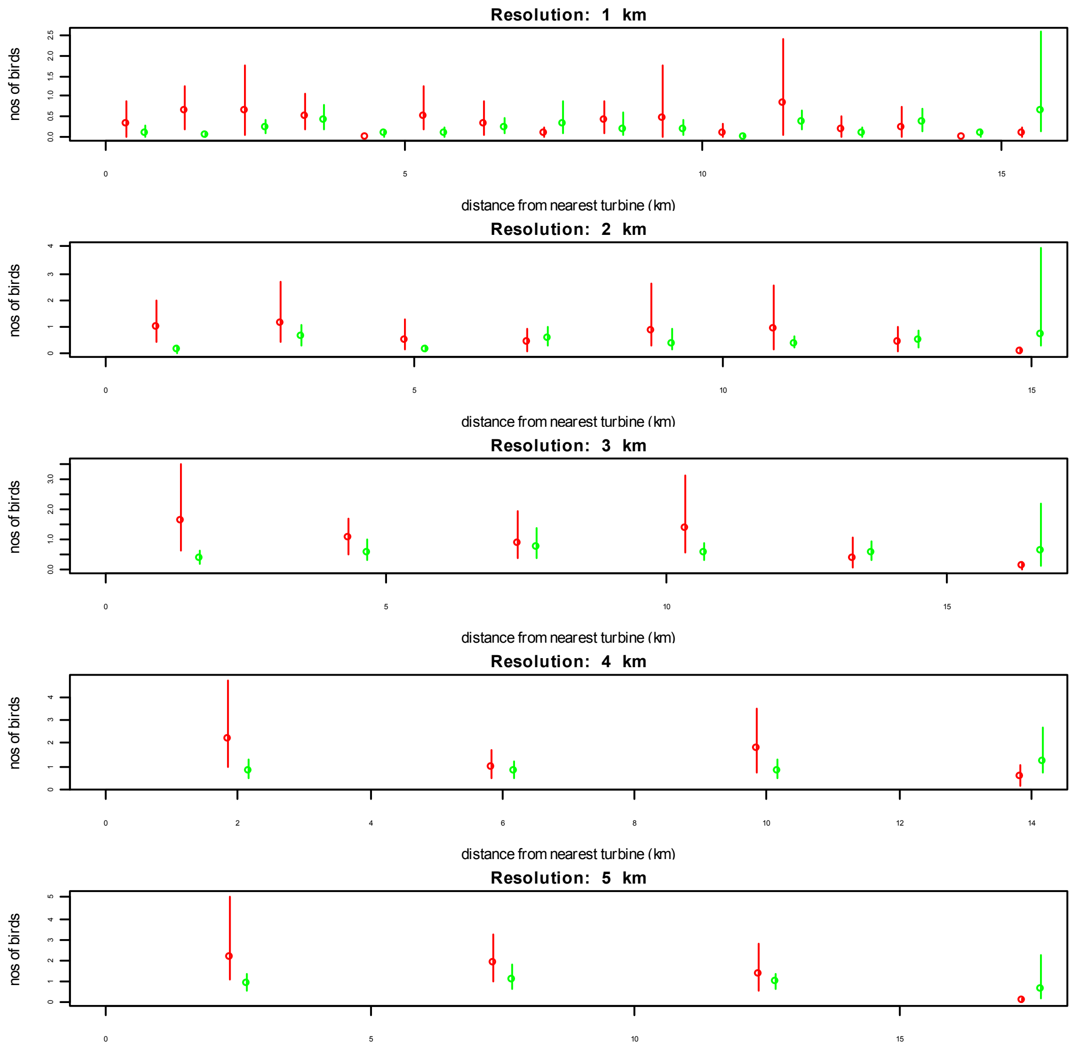
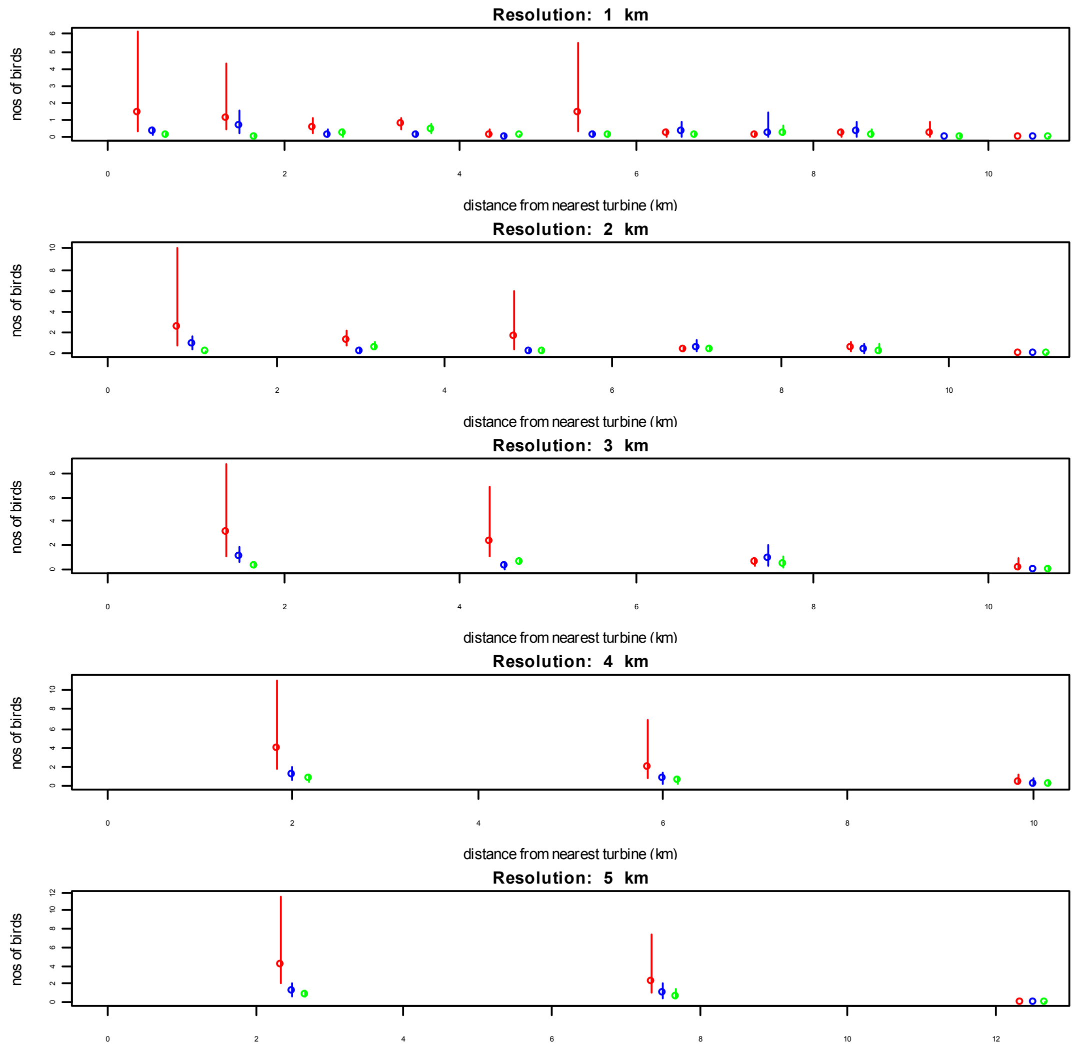


Figure 4.16 Numbers of Gannets between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



These results provided evidence of a decline in Gannet numbers on the Bank and perhaps more widely. However, there was no evidence to suggest that the installation of the turbines was responsible for these declines. Furthermore any possible impacts are likely to be of little potential conservation importance, given the small numbers of birds involved, which were negligible compared to both national and international breeding populations (Mitchell et al. 2004).

Shag

Although shags were most abundant during the winter months, records occurred throughout the year, with all months included in the change in abundance analyses (Table 4.13).

Table 4.13 Summary statistics showing the seasonal distribution of Shag records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	22.8	22	Yes
2	13.7	13	Yes
3	8.5	8	Yes
4	4.0	4	Yes
5	1.6	2	Yes
6	1.3	1	Yes
7	3.0	3	Yes
8	3.4	3	Yes
9	3.7	3	Yes
10	9.2	9	Yes
11	21.3	20	Yes
12	13.2	12	Yes

Shags were widely distributed across all survey legs, but were rarely recorded on the Box legs (legs 1, 11, 42 and 44) and most abundant on the Bank legs (legs 2 and 3) (Table 4.14).

Table 4.14 Summary statistics showing the distribution of Shag records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	0.05	0.23	1	2	0.002	0.009	3	4
2	1.09	0.88	28	9	0.031	0.025	47	11
3	1.03	7.78	26	75	0.030	0.222	45	100
5	0.52	0.00	13	0	0.035	0.000	53	0
11	0.00	0.00	0	0	0.000	0.000	0	0
41	0.86	0.57	22	5	0.066	0.044	100	20
42	0.05	0.00	1	0	0.004	0.000	7	0
43	0.25	0.93	6	9	0.025	0.093	38	42
44	0.05	0.00	1	0	0.004	0.000	6	0

Numbers increased significantly on the inner Bank leg (leg 3) following turbine installation ($P<0.01$, Table 4.15), and from pre-installation to during the turbine installation phase on Box leg 11 (Table 4.15, $P<0.01$), due to the presence of one bird on 3 out of five surveys during turbine installation, compared to no birds present on all 18 trips pre-installation (figure 4.17).

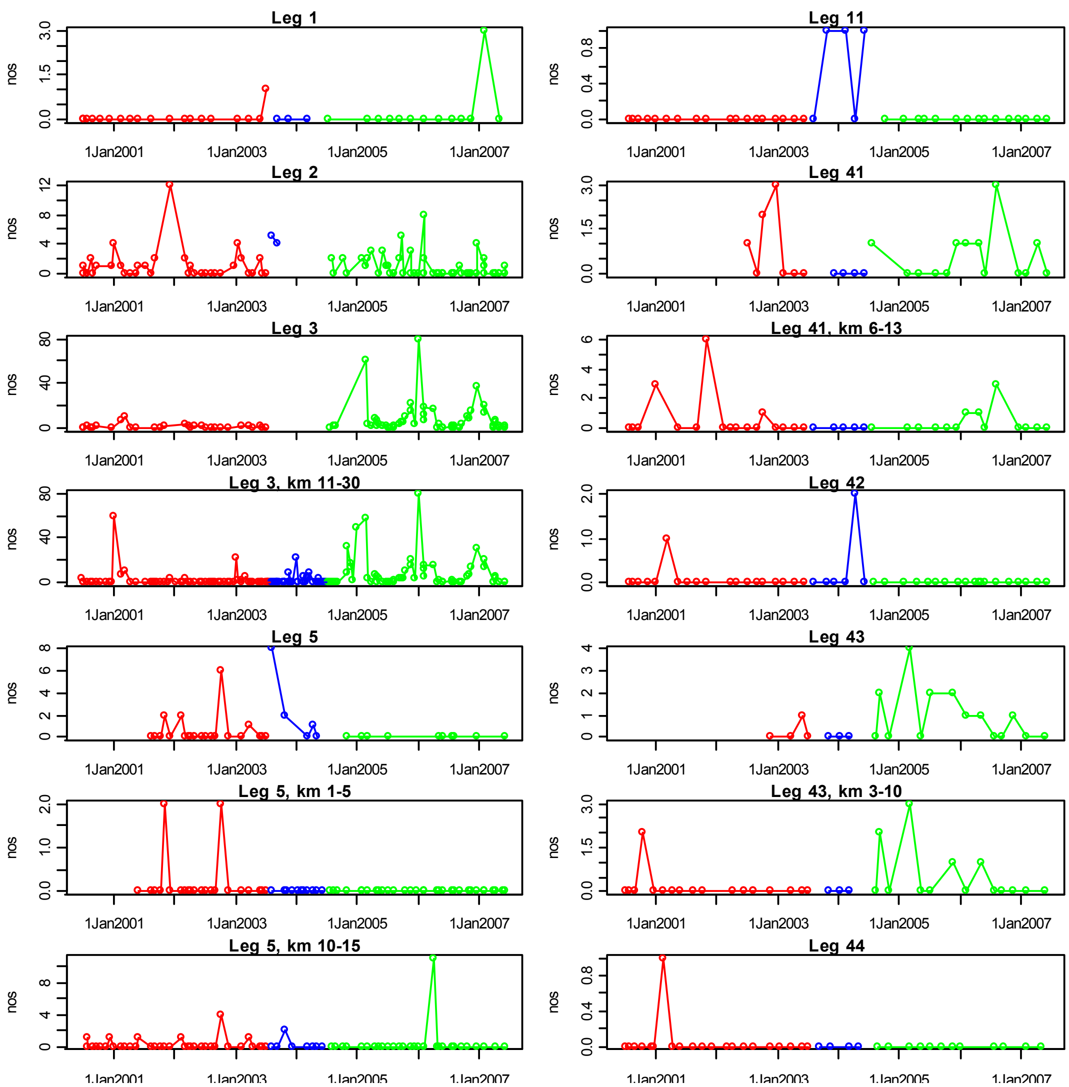
Table 4.15 Mean numbers of Shags on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	0.05	0.00	0.16	19	0.00			3	1.000		0.23	0.00	0.69	13	0.751	
2	1.09	0.63	2.33	35	4.50	4.00	5.00	2	0.059		0.88	0.54	1.42	52	0.656	
3	1.03	0.47	2.14	30				0	1.000		7.78	5.12	13.34	54	0.007	++
3, km 11-30	2.18	0.89	6.64	61	2.06	1.07	4.24	33	0.964		7.95	5.19	12.80	63	0.004	++
5	0.52	0.14	1.49	21	2.20	0.40	6.40	5	0.059		0.00			10	0.357	
5, km 1-5	0.18	0.00	0.36	22	0.00			11	0.542		0.00			32	0.161	
5, km 10-15	0.26	0.09	0.67	35	0.25	0.00	0.75	8	1.000		0.38	0.00	1.14	29	0.969	
11	0.00			18	0.60	0.00	0.80	5	0.006	++	0.00			15	1.000	
41	0.86	0.10	1.71	7	0.00			4	0.321		0.57	0.21	1.14	14	0.643	
41, km 6-13	0.59	0.06	1.78	17	0.00			5	0.669		0.36	0.07	0.93	14	0.739	
42	0.05	0.00	0.16	19	0.33	0.00	0.67	6	0.240		0.00			19	1.000	
43	0.25	0.00	0.50	4	0.00			3	1.000		0.93	0.43	1.64	14	0.360	
43, km 3-10	0.12	0.00	0.35	17	0.00			3	1.000		0.50	0.14	1.07	14	0.236	
44	0.05	0.00	0.14	21	0.00			4	1.000		0.00			12	1.000	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with $p<0.0001$
"+++" or "---" indicates a positive or negative change with $p <0.001$
"++" or "--" indicates a positive or negative change with $p <0.01$
"+" or "-" indicates a positive or negative change with $p <0.05$.

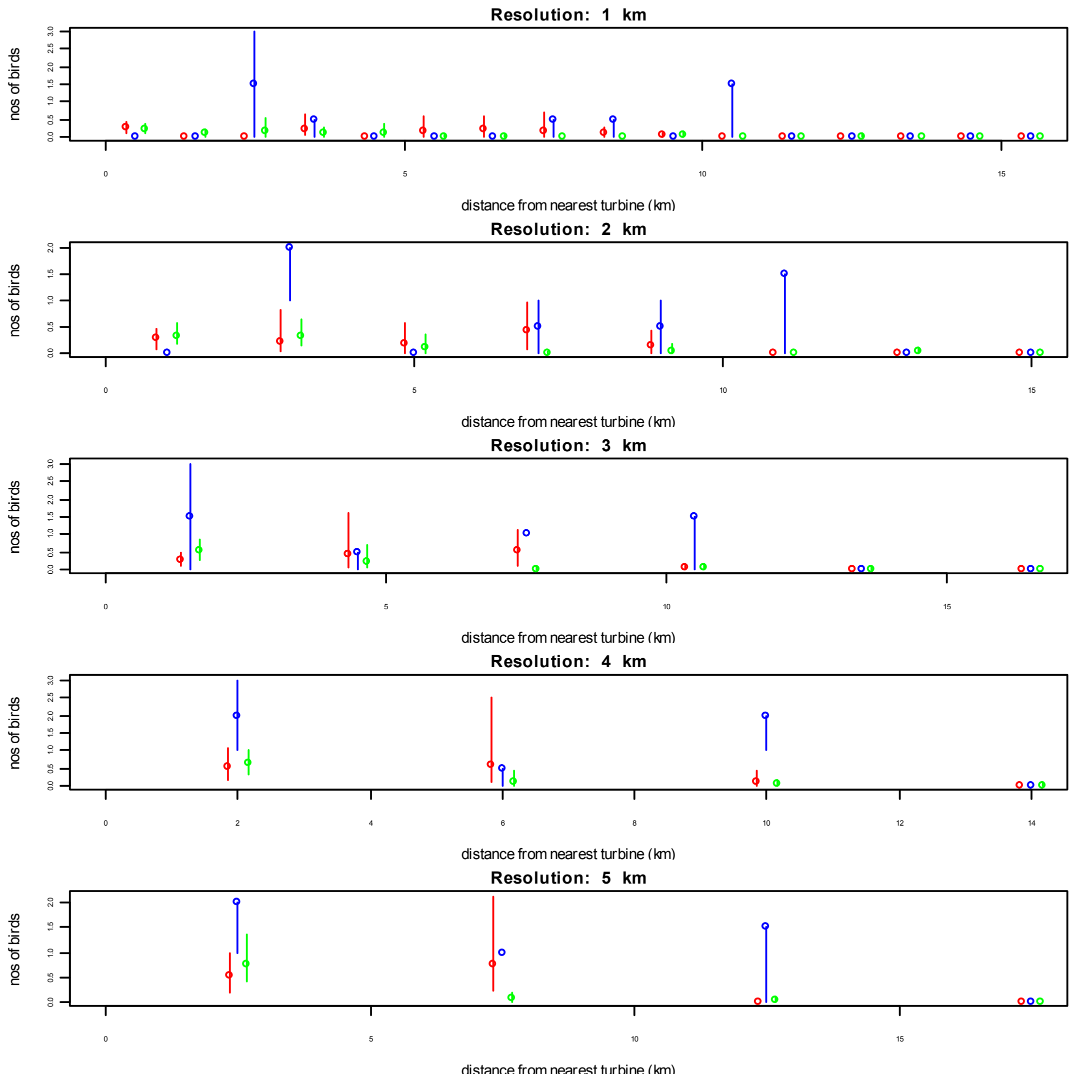
Although not statistically significant, perusal of Figure 4.17 suggested the possibility that Shags may also have increased (from pre-installation to post turbine installation) in parts of the Inner Box (leg 43), but declined on the Cable Route (leg 5).

Figure 4.17 Numbers of Shags on each leg before (red), during (blue) and after (green) turbine installation



There was no evidence of Shags redistributing on the outer Bank leg (leg 2) with respect to distance from the turbines (Figure 4.18).

Figure 4.18 Numbers of Shags on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



There was also no evidence that the increase of Shags on the inner Bank leg (leg 3) was related to the proximity of the turbines (Figures 4.19 and 4.20).

Figure 4.19 **Numbers of Shags on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions**

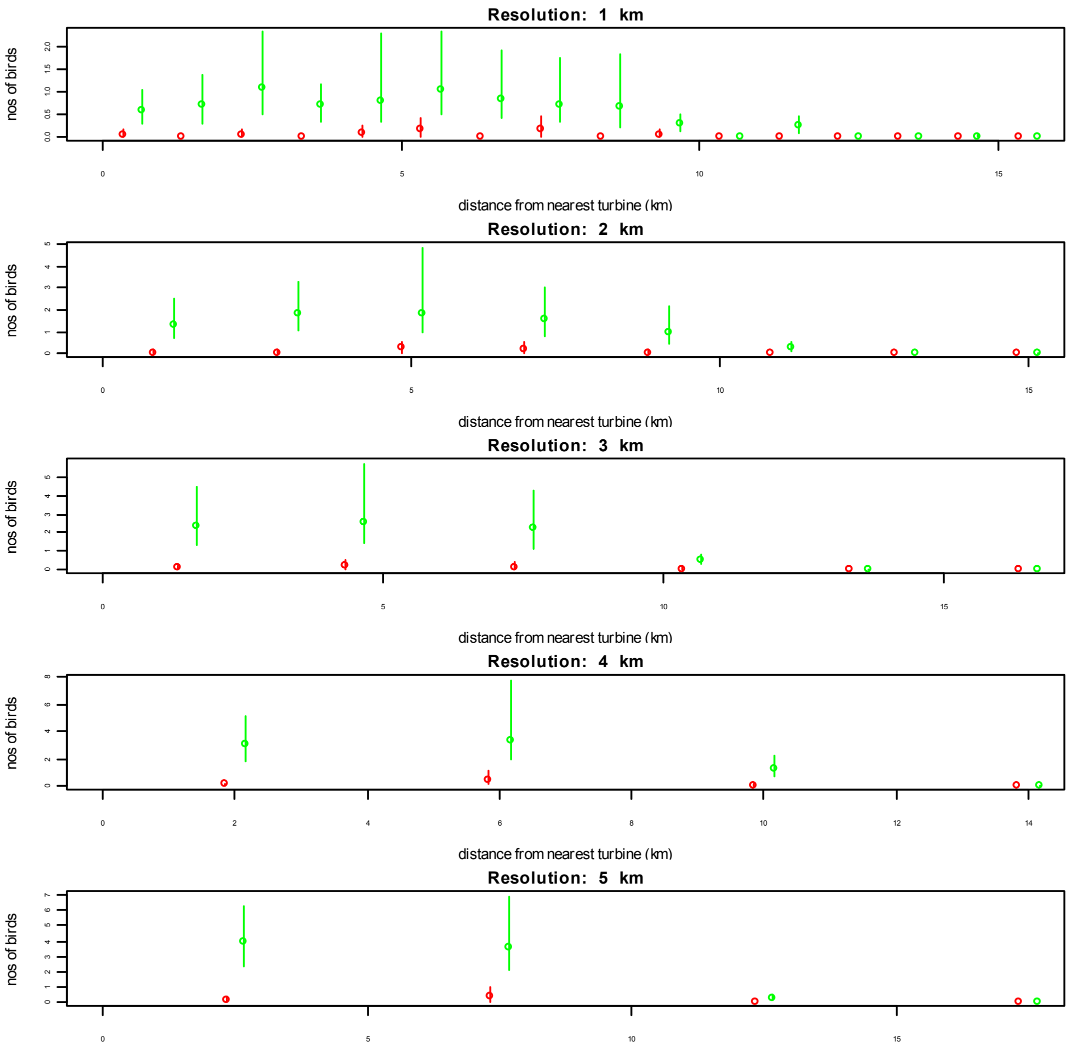
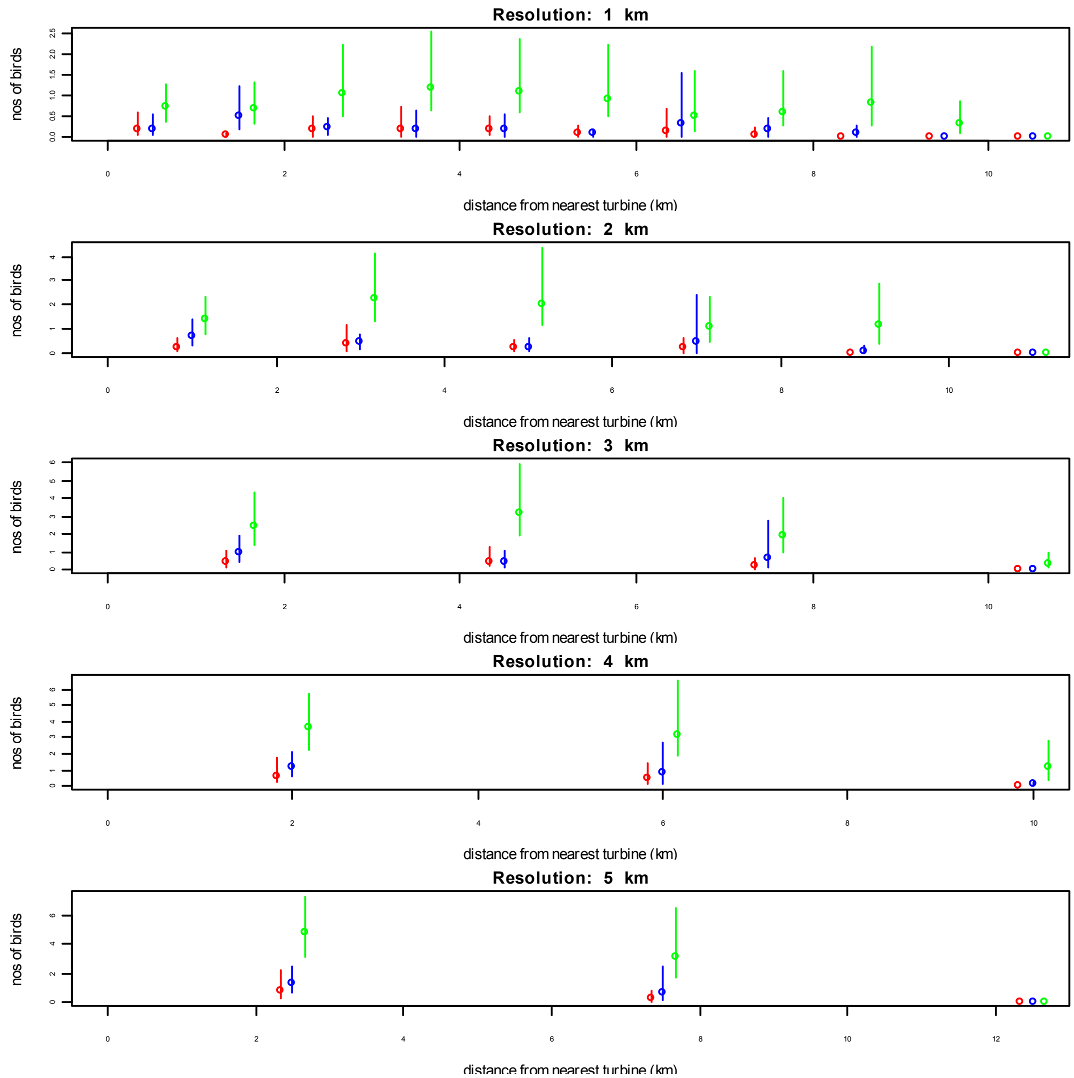


Figure 4.20 Numbers of Shags between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



In conclusion, there was strong evidence that Shags have increased on the inner Bank leg (leg 3). Numbers may have also changed on other legs. However, there was no evidence that any of these changes was related to the installation of the turbines.

Little Gull

Little gulls were mainly recorded in the Arklow Study Area between autumn and spring, with only data from September to April included in the analysis of changes in abundance (Table 4.16).

Table 4.16 Summary statistics showing the seasonal distribution of Little Gull records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	89.6	5	yes
2	56.6	3	yes
3	60.6	4	yes
4	89.3	5	yes
5	0.6	0	no
6	0.4	0	no
7	3.6	0	no
8	12.0	1	no
9	96.4	6	yes
10	146.9	9	yes
11	689.9	40	yes
12	461.8	27	yes

Little gulls records were concentrated on the Bank legs (legs 2 and 3), with 83 % of birds recorded on the Bank legs before turbine installation, and 91 % of birds recorded on the bank legs after their installation (Table 4.17).

Table 4.17 Summary statistics showing the distribution of Little Gull records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km²)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	1.2	3.0	1	2	0.0	0.1	3	3
2	60.9	33.1	63	18	1.7	0.9	100	25
3	19.6	131.1	20	73	0.6	3.7	32	100
5	0.2	4.5	0	2	0.0	0.3	1	8
11	7.5	4.6	8	3	0.3	0.2	17	5
41	0.0	0.0	0	0	0.0	0.0	0	0
42	0.8	1.6	1	1	0.1	0.1	4	4
43	0.0	0.0	0	0	0.0	0.0	0	0
44	5.8	2.4	6	1	0.5	0.2	28	5

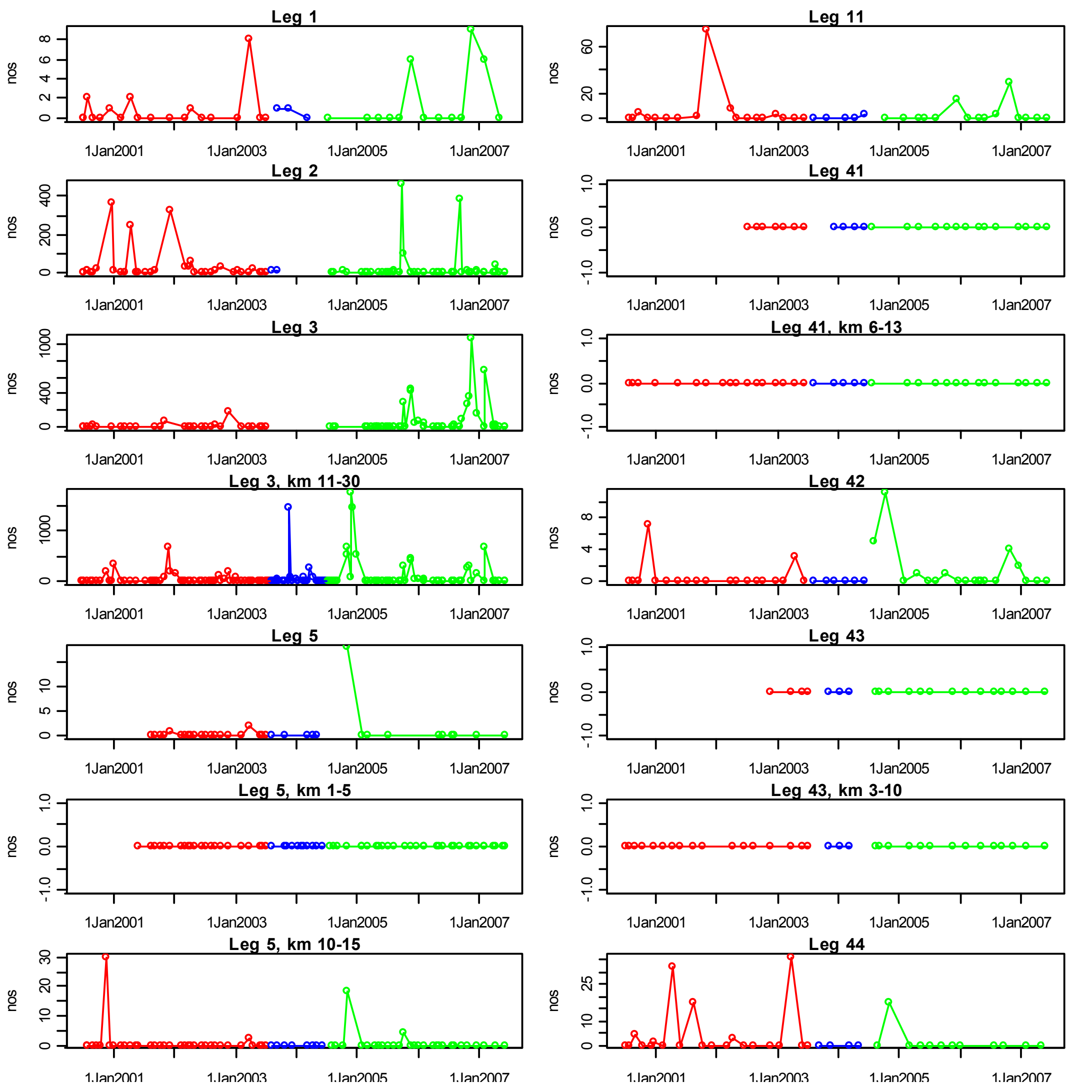
Table 4.18 Mean numbers of Little Gulls on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	1.2	0.3	4.6	10	0.6667	0	1	3	0.87		3.0	0.0	5.6	7	0.26	
2	60.9	23.3	126.3	19	8			1	0.55		33.1	6.0	98.3	31	0.41	
3	19.6	6.7	66.0	18				0	1.00		131.1	65.0	245.3	31	0.05	
3, km 11-30	57.9	29.7	124.4	37	95.826	23.435	421.7	23	0.62		208.3	120.3	395.4	38	0.02	+
5	0.2	0.0	0.6	13	0			3	0.84		4.5	0.0	9.0	4	0.24	
5, km 1-5	0.0			13	0			8	1.00		0.0			20	1.00	
5, km 10-15	1.4	0.0	5.4	23	0			5	0.85		1.2	0.0	4.2	18	0.95	
11	7.5	0.8	26.5	12	0			3	0.46		4.6	0.0	12.2	10	0.86	
41	0.0			5	0			3	1.00		0.0			9	1.00	
41, km 6-13	0.0			11	0			3	1.00		0.0			9	1.00	
42	0.8	0.0	2.6	12	0			4	0.80		1.6	0.3	4.4	12	0.58	
43	0.0			2	0			3	1.00		0.0			8	1.00	
43, km 3-10	0.0			9	0			3	1.00		0.0			8	1.00	
44	5.8	0.6	15.9	13	0			3	0.64		2.4	0.0	4.9	7	0.56	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with p<0.0001
"+++" or "---" indicates a positive or negative change with p <0.001
"++" or "--" indicates a positive or negative change with p <0.01
"+" or "-" indicates a positive or negative change with p <0.05.

The changes in Little Gull numbers followed a similar pattern to those observed for Kittiwakes. As for Kittiwake, the relative importance of the two bank legs (legs 2 and 3) reversed following the installation of the turbines, with approximately 3 times as many Little Gulls recorded on the outer Bank leg (leg 2) compared to the inner Bank leg (leg 3) before turbine installation. After turbine installation, approximately 4 times as many Little Gulls were recorded on the inner Bank leg (leg 3) as on the outer Bank leg (leg 2) (Table 4.17). Again, this was because of an apparent decline in numbers on the outer Bank leg (leg 2) and an increase in numbers on the inner Bank leg (leg 3) (Figure 4.21).

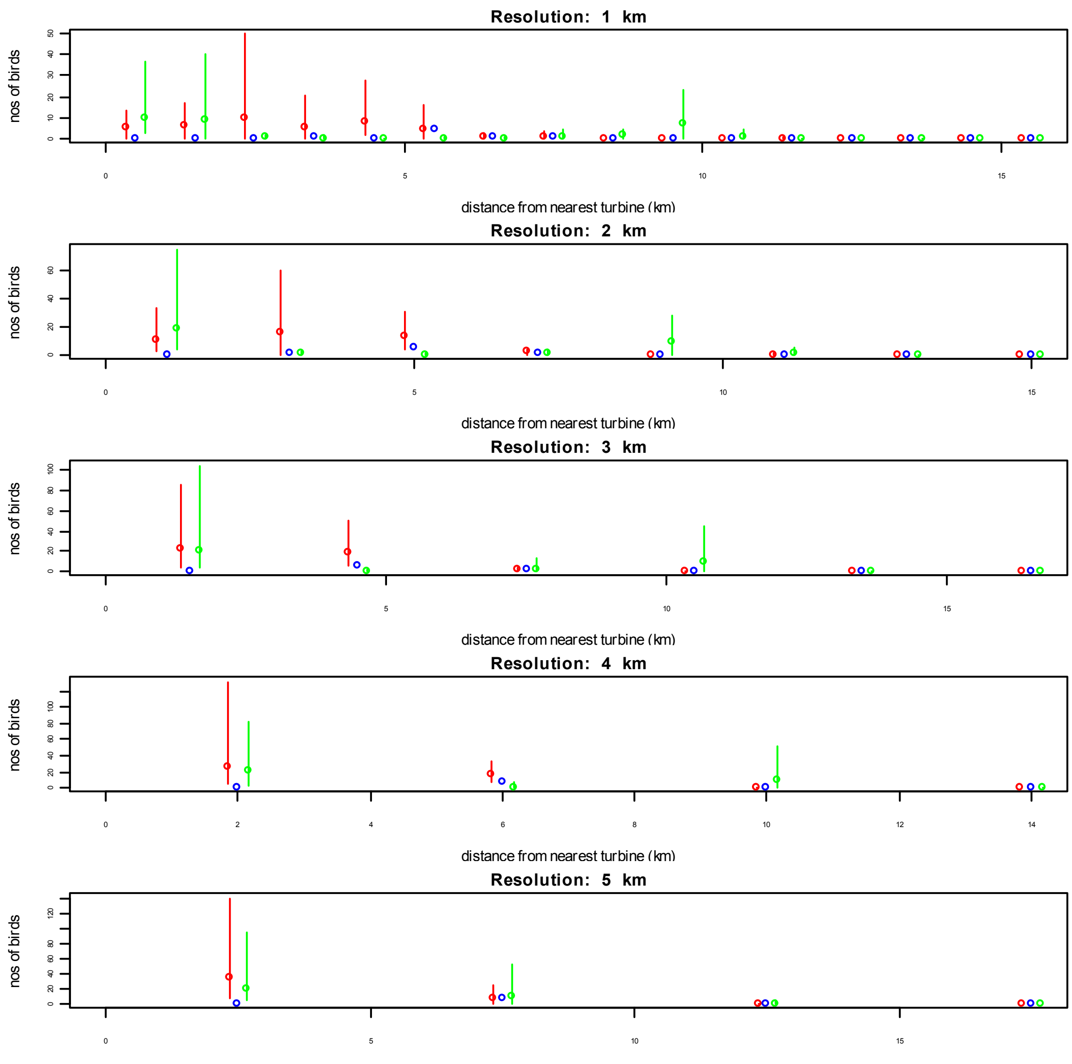
Figure 4.21 Numbers of Little Gulls on each leg before (red), during (blue) and after (green) turbine installation



The decline on the outer Bank leg (leg 2) was not statistically significant (Table 4.18). For the inner Bank leg (leg 3) the increase narrowly missed statistical significance (P=0.05) when surveys covering the whole leg were considered and was weakly statistically significant if surveys of just kms 11-30 were considered, on the basis of the larger sample size available (Table 4.18).

On the outer Bank leg (leg 2) the decline occurred between 3 and 6 km from the turbine (Figure 4.22).

Figure 4.22 Numbers of Little Gulls on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



On the inner Bank leg (leg 3), numbers increased within c. 12 km of the turbines (Figures 4.23 and 4.24).

Figure 4.23 Numbers of Little Gulls on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

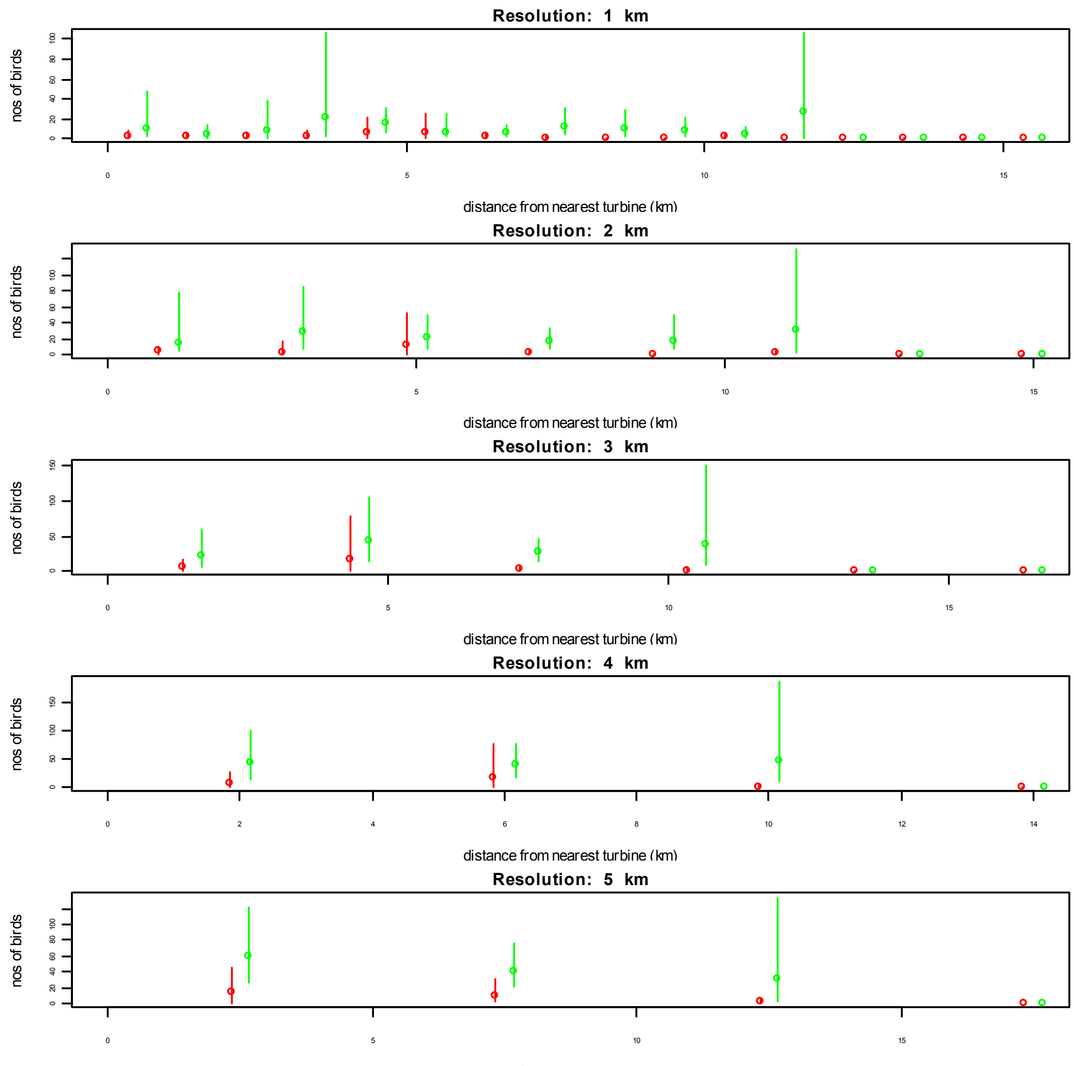
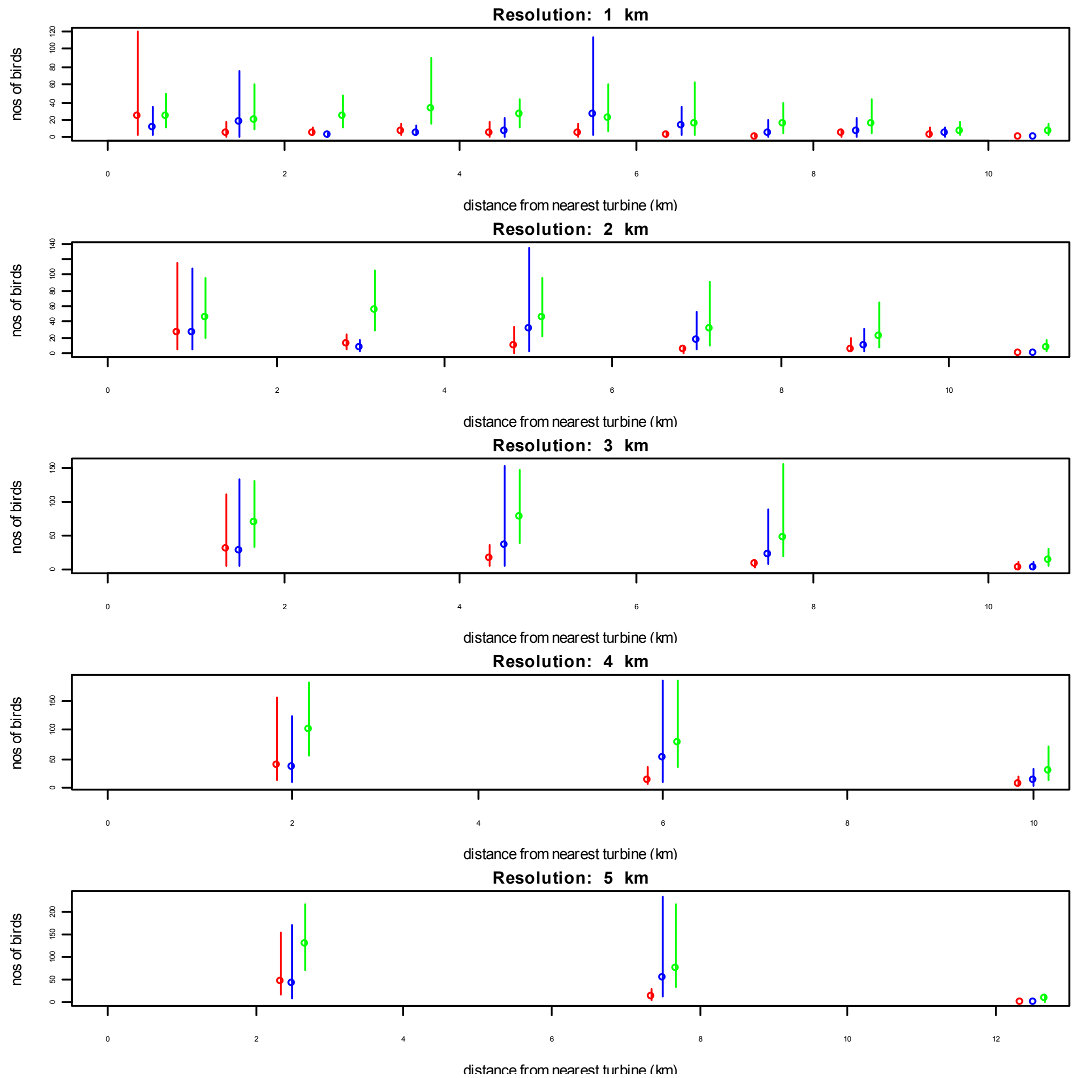


Figure 4.24 Numbers of Little Gulls between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



The similarity of the patterns observed for Little Gull with those observed for Kittiwake suggested a single underlying cause. As the wintering population of Little Gulls on the Arklow Bank regularly exceeds the 1 % threshold of international importance (> 840 birds – Crowe 2005), any negative impact arising from the turbines would be significant. However, there was no evidence for any such negative impact, indeed, the greater magnitude of the (significant) increase on the inner Bank leg (leg 3) compared to the (insignificant) decline on the outer Bank leg (leg 2) was consistent with an overall increase in numbers since the installation of the turbines.

Kittiwake

Kittiwakes were most abundant during the winter months (September-February), but were widely distributed throughout the year, with only records from July excluded from the analyses of changes in abundance (Table 4.19).

Table 4.19 Summary statistics showing the seasonal distribution of Kittiwake records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	1,246.5	13	Yes
2	598.1	6	Yes
3	299.9	3	Yes
4	470.2	5	Yes
5	281.5	3	Yes
6	165.8	2	Yes
7	91.4	1	No
8	101.7	1	Yes
9	965.9	10	Yes
10	2,043.2	21	Yes
11	2,171.4	22	Yes
12	1,466.8	15	Yes

Kittiwakes were concentrated on both Bank legs, with 83 % of birds recorded on the two bank legs before turbine installation, and 95 % recorded after turbine installation (Table 4.20).

Table 4.20 Summary statistics showing the distribution of Kittiwake records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	8.1	12.6	2	1	0.3	0.5	5	2
2	216.3	121.6	59	10	6.2	3.5	100	12
3	87.0	984.2	24	85	2.5	28.1	40	100
5	7.9	1.5	2	0	0.5	0.1	9	0
11	19.4	20.2	5	2	0.8	0.8	13	3
41	2.2	2.8	1	0	0.2	0.2	3	1
42	6.8	7.3	2	1	0.6	0.6	9	2
43	8.3	3.3	2	0	0.8	0.3	13	1
44	8.2	6.9	2	1	0.7	0.6	11	2

Table 4.21 Mean numbers of Kittiwakes on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

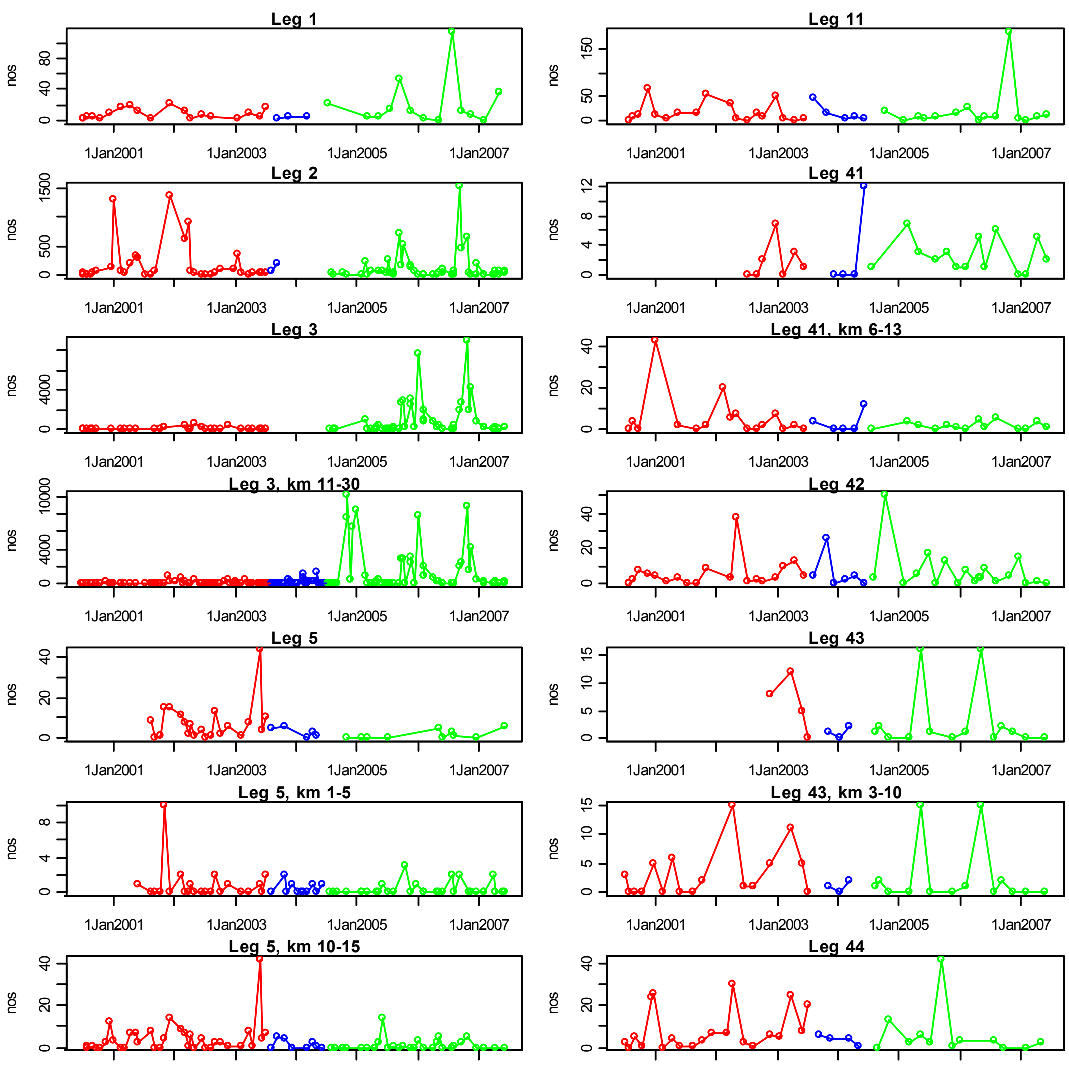
	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	8.13	5.75	11.82	16	3.33	2.00	3.33	3	0.24768		12.60	5.10	27.10	10	0.38470	
2	216.34	116.11	418.70	29	125.50	73.00	125.50	2	0.81505		121.62	66.21	240.69	47	0.20997	
3	86.96	42.87	174.80	25				0	1.00000		984.18	596.33	1682.10	49	0.01291	+
3, km 11-30	113.02	73.52	176.76	51	168.36	93.41	296.40	33	0.30923		1414.79	853.11	2273.09	56	0.00003	++++
5	7.95	4.95	15.16	19	3.00	0.80	4.60	5	0.27555		1.50	0.13	3.49	8	0.06724	
5, km 1-5	0.90	0.30	2.96	20	0.45	0.09	0.82	11	0.76668		0.31	0.10	0.66	29	0.24347	
5, km 10-15	4.63	2.84	9.38	32	1.50	0.38	3.00	8	0.26224		1.38	0.62	3.38	26	0.02576	-
11	19.44	11.71	33.30	16	14.80	5.00	38.29	5	0.64598		20.20	7.27	77.31	15	0.97900	
41	2.17	0.67	4.83	6	3.00	0.00	6.00	4	0.85714		2.77	1.62	4.08	13	0.68904	
41, km 6-13	6.33	2.70	15.46	15	3.20	0.00	8.00	5	0.65415		2.00	0.92	3.08	13	0.21217	
42	6.75	4.00	14.36	16	6.17	1.33	16.50	6	0.93662		7.28	3.70	17.31	18	0.89392	
43	8.33	5.00	10.67	3	1.00	0.00	1.67	3	0.10000		3.25	0.69	8.17	12	0.13187	
43, km 3-10	3.40	1.60	6.33	15	1.00	0.00	1.67	3	0.48897		3.00	0.58	6.67	12	0.84848	
44	8.21	4.26	13.19	19	3.75	1.00	5.00	4	0.42575		6.90	2.30	19.85	10	0.77227	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with p<0.0001
"+++" or "---" indicates a positive or negative change with p <0.001
"++" or "--" indicates a positive or negative change with p <0.01
"+" or "-" indicates a positive or negative change with p <0.05.

The relative importance of the Bank legs changed following turbine installation due to a c. 11 fold increase in numbers on the inner Bank leg (leg 3), and a c .50 % decline on the outer Bank leg (leg 2). Before turbine installation there were approximately 2.5 times as many birds recorded on the outer Bank leg (leg 2) as on the inner Bank leg (leg 3). After turbine installation the relative importance of the two Bank legs was reversed, with approximately 8 times as many Kittiwakes on the inner Bank leg (leg 3) as on the outer Bank leg (leg 2) (Table 4.20).

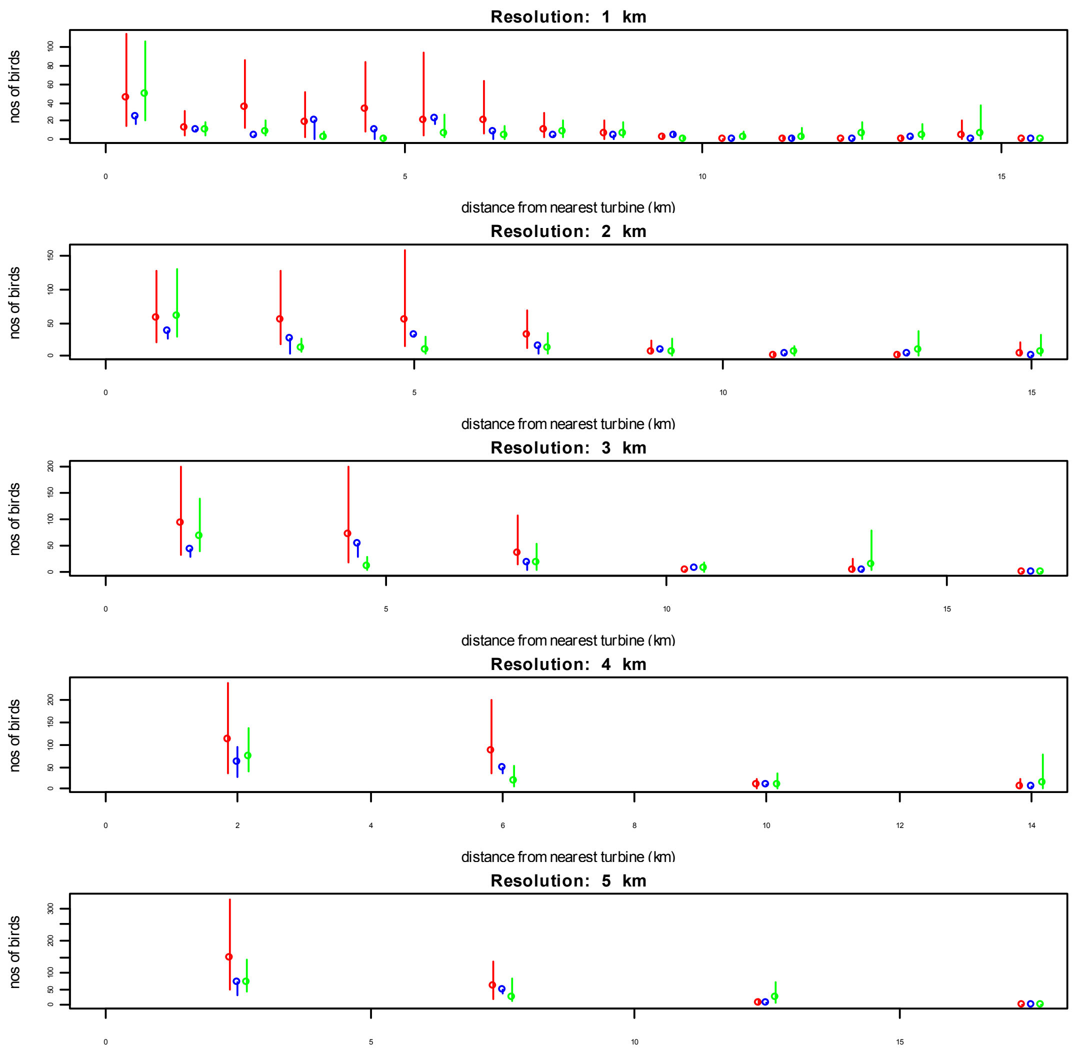
The decline in the number of Kittiwakes recorded on the outer Bank leg (leg 2) was not statistically significant (Table 4.21 & Figure 4.25). The increase in numbers on the inner Bank leg (leg 3) was weakly significant (P<0.05) if only complete surveys of the entire leg were considered, but was strongly significant (P<0.0001) if surveys of just kms 11-30 were considered, on the basis of the larger sample size available (Table 4.21). A weakly significant decline (P<0.05) also occurred on leg 5 km 10-15 (Cable Route).

Figure 4.25 Numbers of Kittiwakes on each leg before (red), during (blue) and after (green) turbine installation



Before the installation of the turbines, the principal concentrations of Kittiwakes on the outer Bank leg (leg 2) were all within c. 8 km of the turbines, and this was where the declines took place (Figure 4.26).

Figure 4.26 Numbers of Kittiwakes on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



In contrast to this, on the inner Bank leg (leg 3), the increase in numbers was concentrated within c. 10 km of the turbines (Figure 4.27 and 4.28).

Figure 4.27 Numbers of Kittiwakes on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

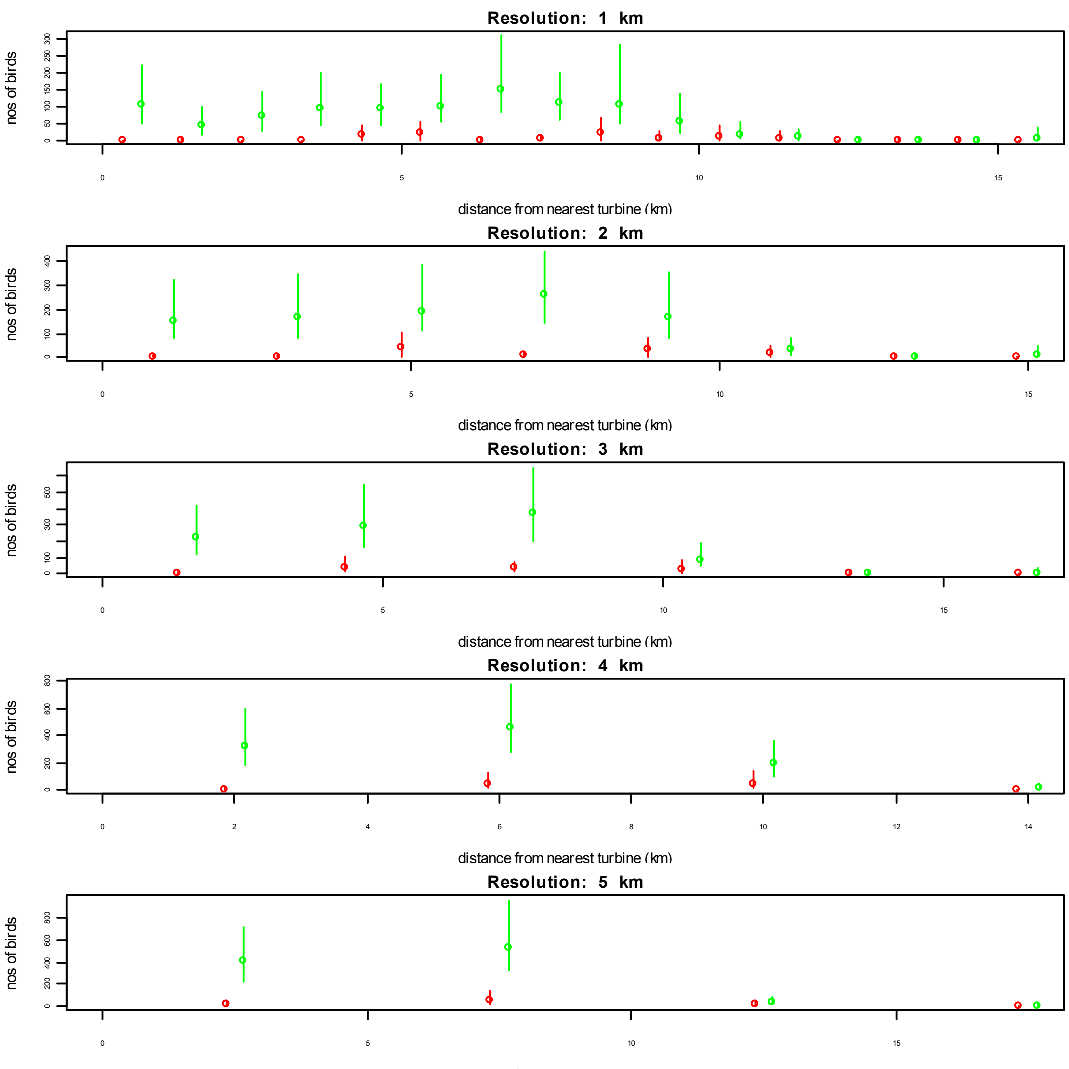
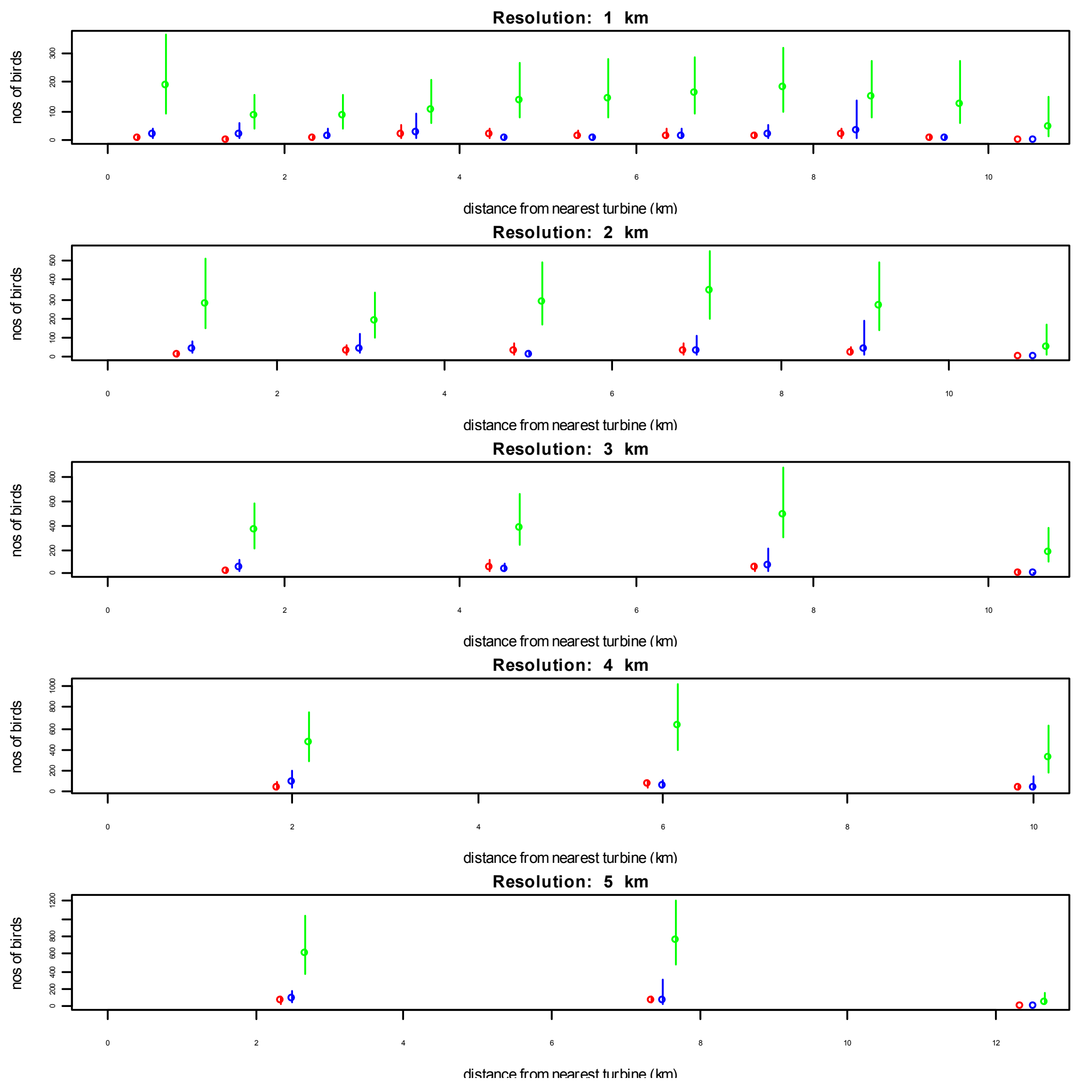


Figure 4.28 Numbers of Kittiwakes between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



Thus, Kittiwakes have decreased near the turbines on the outer Bank leg (leg 2) and increased near the turbines on the inner Bank leg (leg 3). However, it was unclear whether or not the installation of turbines was responsible for these changes but given the different responses of the birds on the two different Bank legs, and the overall increase in numbers of Kittiwakes these results suggested that any potential impacts have been benign.

Arctic Tern

Arctic Terns were uncommonly recorded in the Arklow Study Area, with birds only reported on five dates before turbine installation, one date during installation, and ten dates after installation (Figure 4.29). Most records were of birds on migration passing through the Study Area in spring and autumn, and the months of May, August, September and October were included in the change in abundance analysis (Table 4.22).

Table 4.22 Summary statistics showing the seasonal distribution of Arctic Tern records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	0.00	0	No
2	0.00	0	No
3	0.00	0	No
4	0.05	0	No
5	23.28	75	Yes
6	0.00	0	No
7	0.00	0	No
8	1.07	3	Yes
9	2.24	7	Yes
10	4.61	15	Yes
11	0.00	0	No
12	0.00	0	No

Both Bank legs (legs 2 and 3) were consistently important, with more than 10 % of birds recorded on the Bank both before and after turbine installation (Table 4.23). Birds were also recorded on the outer Box legs (legs 1 and 11) but no birds were recorded on the Cable Route (leg 5), and on the inner Box legs (legs 41, 43 and 44).

Table 4.23 Summary statistics showing the distribution of Arctic Tern records across all survey legs

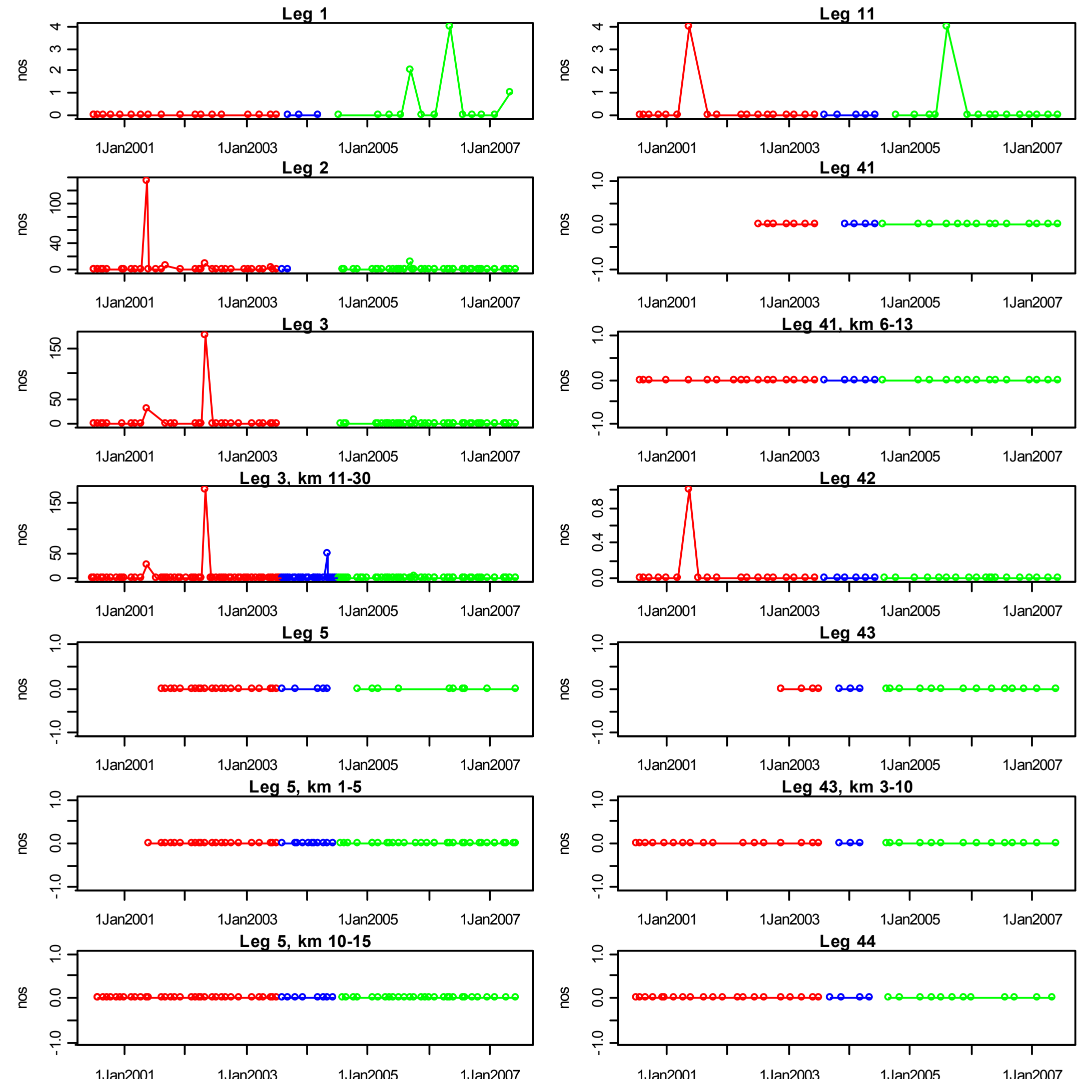
Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	0.00	1.40	0	42	0.00	0.06	0	100
2	12.67	0.58	39	17	0.36	0.02	68	30
3	18.73	0.35	58	11	0.54	0.01	100	18
5	0.00	0.00	0	0	0.00	0.00	0	0
11	0.57	1.00	2	30	0.02	0.04	4	71
41	0.00	0.00	0	0	0.00	0.00	0	0
42	0.14	0.00	0	0	0.01	0.00	2	0
43	0.00	0.00	0	0	0.00	0.00	0	0
44	0.00	0.00	0	0	0.00	0.00	0	0

Table 4.24 Mean numbers of Arctic Terns on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	**Mean**	**LCL**	**UCL**	**n**	**Mean**	**LCL**	**UCL**	**n**	**p**	**sig**	**Mean**	**LCL**	**UCL**	**n**	**p**	**sig**
1	0.00			6	0.00			1	1.00		1.40	0.20	3.00	5	0.06	
2	12.67	1.25	47.33	12	0.00			2	0.54		0.58	0.00	2.65	19	0.08	
3	18.73	0.00	66.73	11				0	1.00		0.35	0.00	1.53	20	0.12	
3, km 11-30	10.15	0.00	35.20	20	3.57	0.00	10.71	14	0.90		0.32	0.00	1.23	22	0.22	
5	0.00			8	0.00			3	1.00		0.00			2	1.00	
5, km 1-5	0.00			8	0.00			3	1.00		0.00			10	1.00	
5, km 10-15	0.00			13	0.00			4	1.00		0.00			10	1.00	
11	0.57	0.00	1.71	7	0.00			2	1.00		1.00	0.00	2.00	4	1.00	
41	0.00			2				0	1.00		0.00			3	1.00	
41, km 6-13	0.00			7	0.00			1	1.00		0.00			3	1.00	
42	0.14	0.00	0.43	7	0.00			2	1.00		0.00			6	1.00	
43	0.00			1				0	1.00		0.00			6	1.00	
43, km 3-10	0.00			7				0	1.00		0.00			6	1.00	
44	0.00			7	0.00			2	1.00		0.00			5	1.00	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with p<0.0001
"+++" or "---" indicates a positive or negative change with p <0.001
"++" or "--" indicates a positive or negative change with p <0.01
"+" or "-" indicates a positive or negative change with p <0.05.

Figure 4.29 Numbers of Arctic Terns on each leg before (red), during (blue) and after (green) turbine installation



There were no obvious consistent patterns in Figure 4.29, and no statistically significant changes in the numbers of Arctic Terns associated with the installation of the turbines were detected (Table 4.24). However, given the small sample sizes, this was perhaps not surprising.

The small sample sizes and great variability in bird numbers between dates mean the relationships between numbers of birds and distance from the turbines on the Bank legs (legs 2 and 3) as presented in Figures 4.30 to 4.32 were unlikely to be significant.

Figure 4.30 Numbers of Arctic Terns on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

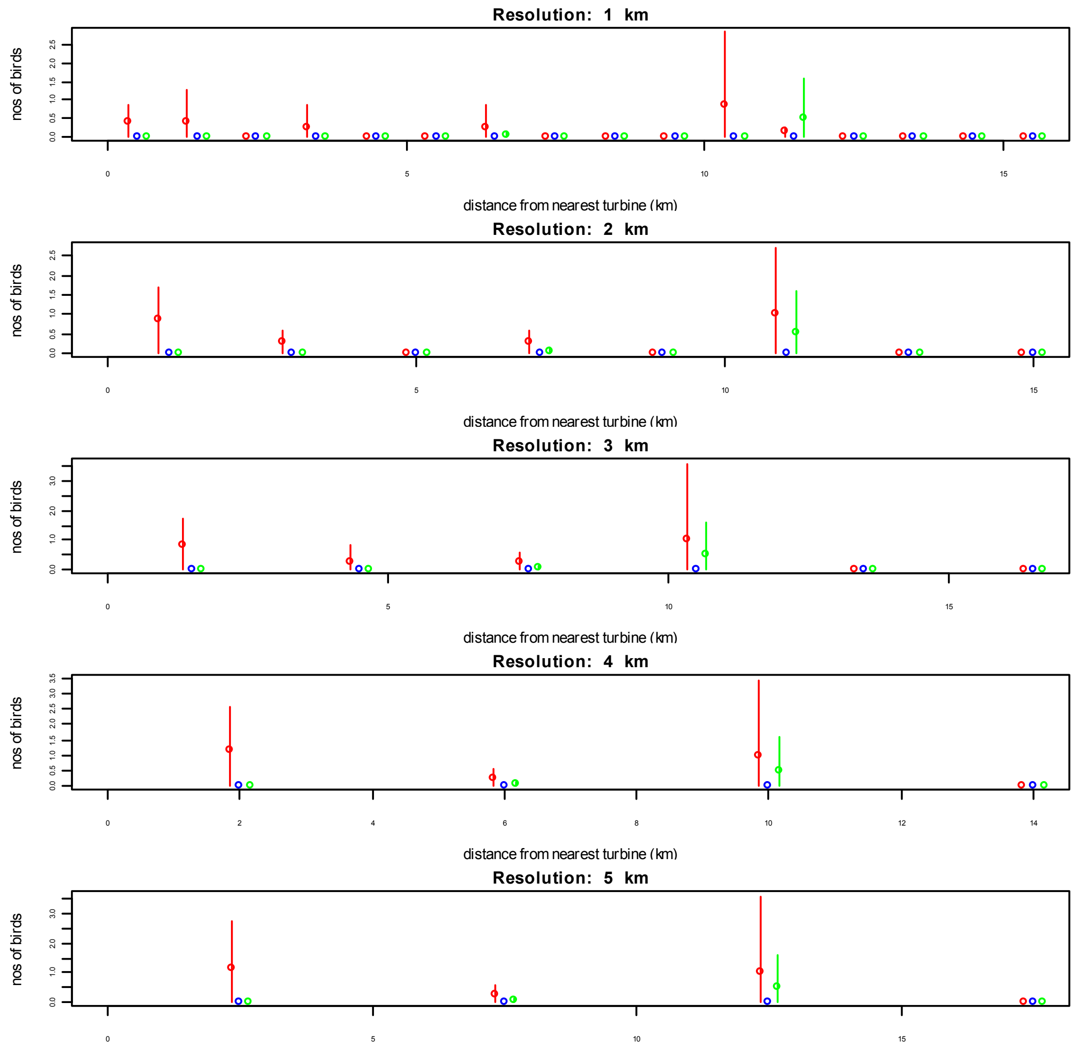


Figure 4.31 Numbers of Arctic Terns on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

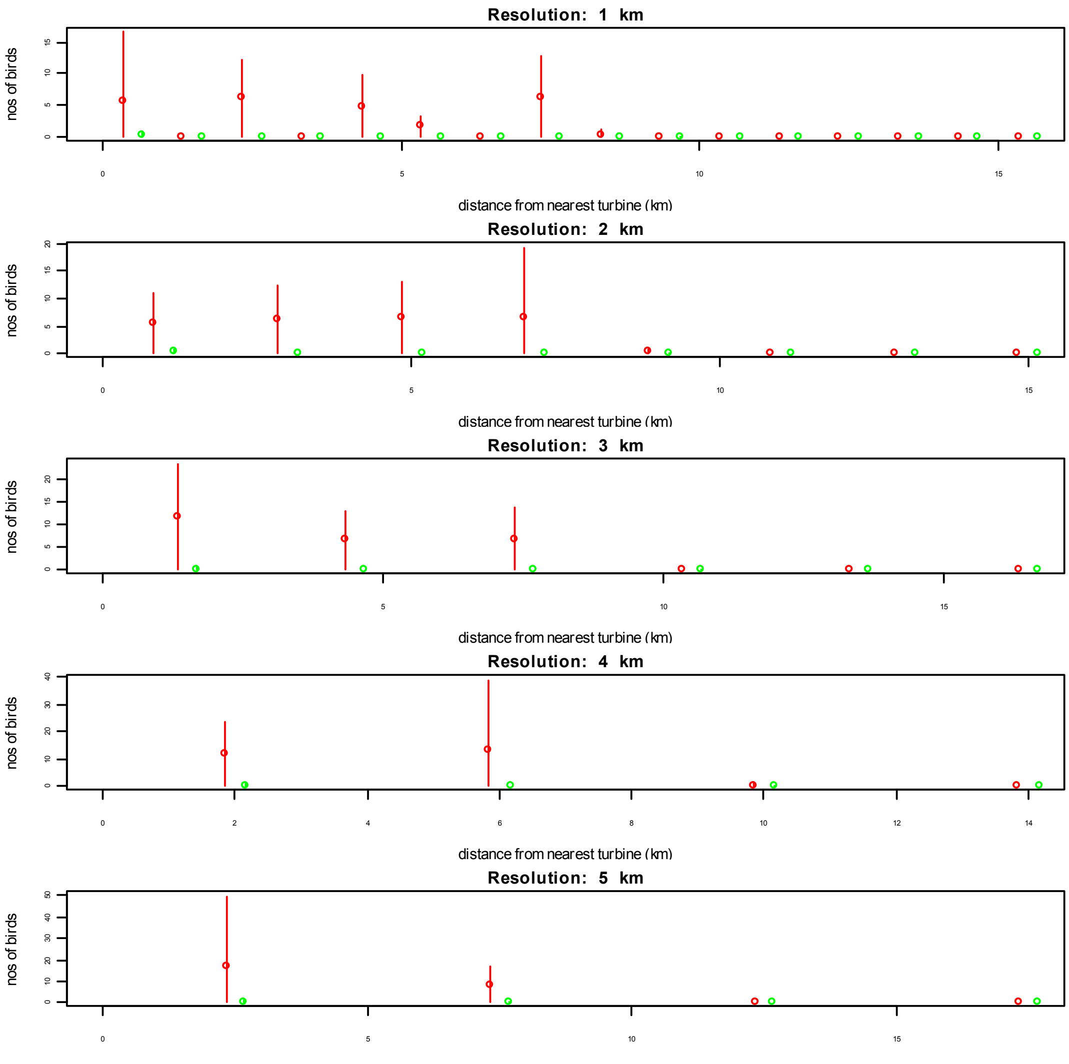
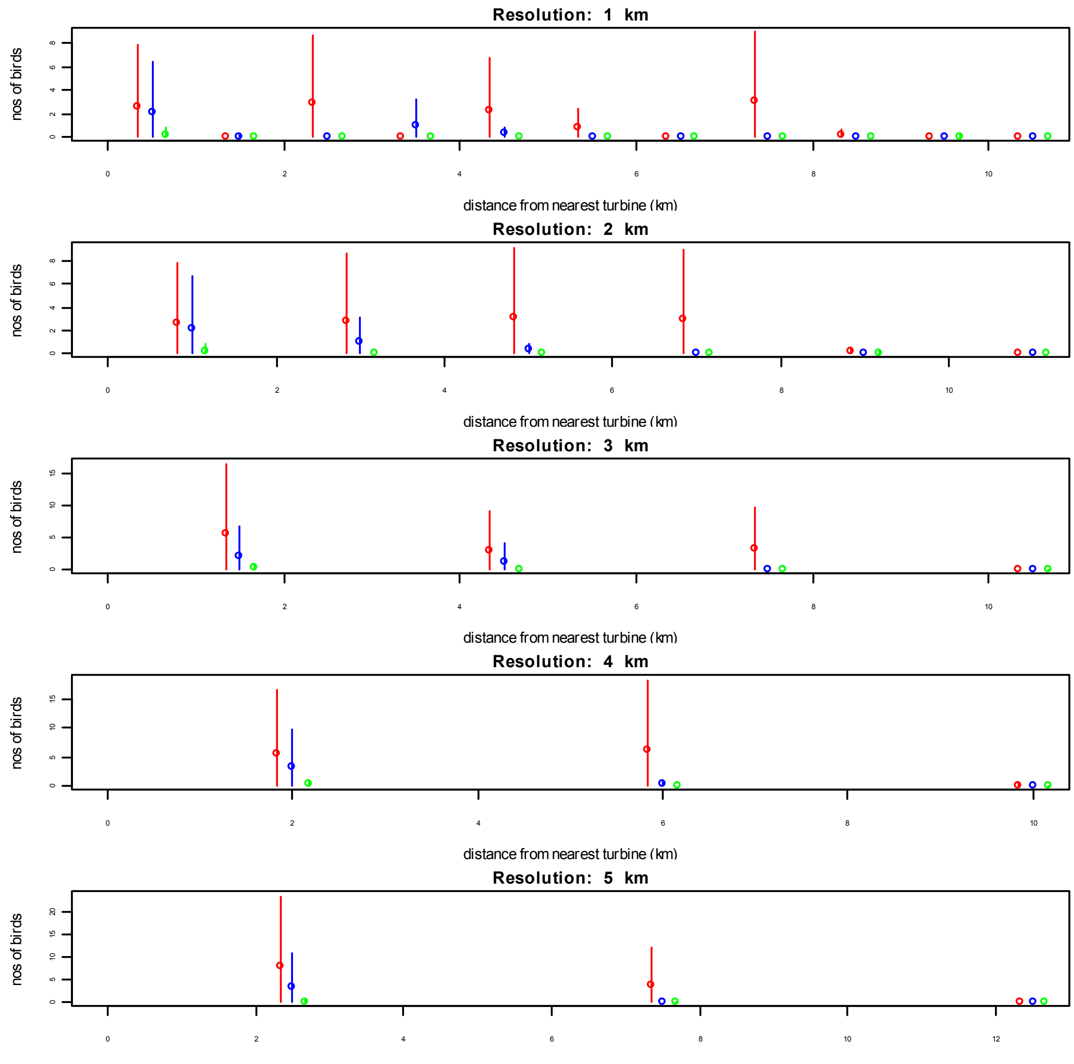


Figure 4.32 Numbers of Arctic Terns between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



In summary, the number of Arctic Tern records were too small for any meaningful analysis of the impact of turbines to be made.

Common Tern

Common Terns were recorded more regularly than Arctic Terns, with birds present on 17 dates before turbine installation, 4 dates during installation, and 19 dates after (Figure 4.33). Most records were of birds on migration passing through the Study Area in spring and autumn, and the months of April to May, and July to October were included in the change in abundance analysis (Table 4.25).

Table 4.25 Summary statistics showing the seasonal distribution of Common Tern records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	0.00	0	No
2	0.00	0	No
3	0.61	1	No
4	2.60	3	Yes
5	9.96	12	Yes
6	0.09	0	No
7	3.94	5	Yes
8	6.12	7	Yes
9	56.29	68	Yes
10	3.52	4	Yes
11	0.00	0	No
12	0.00	0	No

The two Bank legs (legs 2 and 3) were the most important for Common Tern both before and after turbine installation, and birds were also regularly recorded on the outer Box leg (leg 1) (Table 4.26). Small groups of Common Terns were also occasionally recorded on the Cable Route (leg 5), and on Box legs 11, 41, and 42. No birds were recorded on Box legs 43 and 44.

Table 4.26 Summary statistics showing the distribution of Common Tern records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	0.73	4.75	10	19	0.03	0.19	33	47
2	1.67	14.30	23	58	0.05	0.41	54	100
3	3.11	5.42	44	22	0.09	0.15	100	38
5	0.18	0.00	3	0	0.01	0.00	14	0
11	0.90	0.00	13	0	0.04	0.00	41	0
41	0.00	0.00	0	0	0.00	0.00	0	0
42	0.55	0.30	8	1	0.05	0.03	51	6
43	0.00	0.00	0	0	0.00	0.00	0	0
44	0.00	0.00	0	0	0.00	0.00	0	0

Table 4.27 Mean numbers of Common Terns on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	0.73	0.18	1.55	11	0.00			1	1.00		4.75	0.75	11.27	8	0.10	
2	1.67	0.52	4.76	21	0.00			2	0.64		14.30	1.00	64.56	27	0.70	
3	3.11	0.63	12.26	19				0	1.00		5.42	1.51	21.48	31	0.77	
3, km 11-30	0.97	0.35	2.49	34	1.33	0.00	4.00	15	0.85		4.29	0.97	14.91	35	0.33	
5	0.18	0.00	0.55	11	0.00			4	1.00		0.00			4	1.00	
5, km 1-5	0.18	0.00	0.55	11	0.00			4	1.00		0.06	0.00	0.19	16	0.75	
5, km 10-15	0.00			19	0.00			5	1.00		0.06	0.00	0.19	16	0.46	
11	0.90	0.00	3.44	10	0.00			3	0.81		0.00			7	0.74	
41	0.00			4	0.00			1	1.00		0.00			7	1.00	
41, km 6-13	0.50	0.00	1.80	10	0.00			2	0.85		0.00			7	0.49	
42	0.55	0.00	1.09	11	0.00			3	1.00		0.30	0.00	0.90	10	1.00	
43	0.00			2				0	1.00		0.00			8	1.00	
43, km 3-10	0.00			11				0	1.00		0.00			8	1.00	
44	0.00			11	0.00			2	1.00		0.00			7	1.00	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
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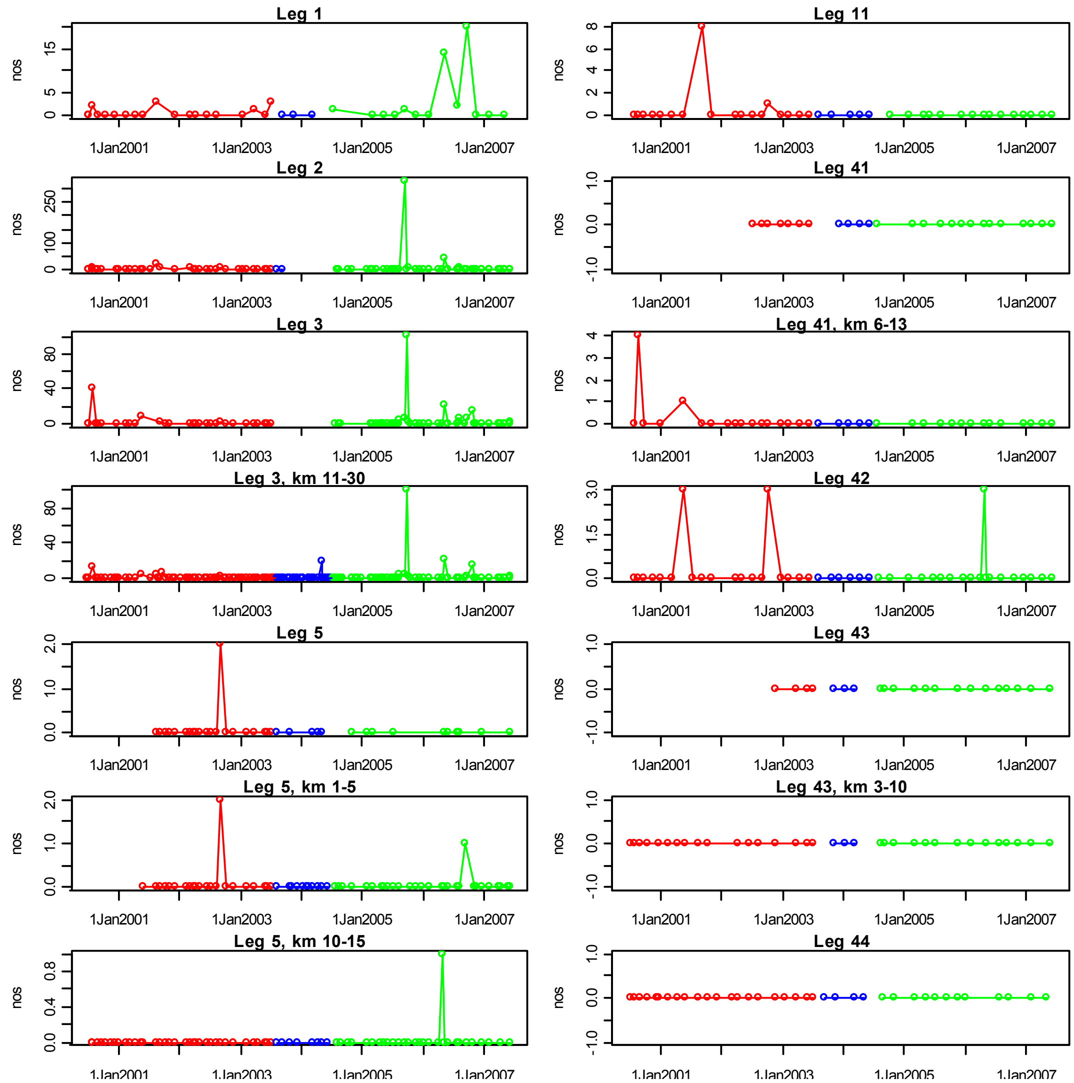
"++" or "--" indicates a positive or negative change with p <0.01
"+" or "-" indicates a positive or negative change with p <0.05.

Figure 4.33 Numbers of Common Terns on each leg before (red), during (blue) and after (green) turbine installation



There were no obvious consistent patterns in Figure 4.33, and no statistically significant changes in the numbers of Common Terns associated with the installation of the turbines were detected (Table 4.27).

Although Figures 4.34 to 4.36 suggested that after turbine installation, more Common Terns were recorded at greater distances from the turbines than previously, the small sample sizes and great variability in the numbers of birds between dates, indicated that no great significance should be attached to this result.

Figure 4.34 Numbers of Common Terns on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

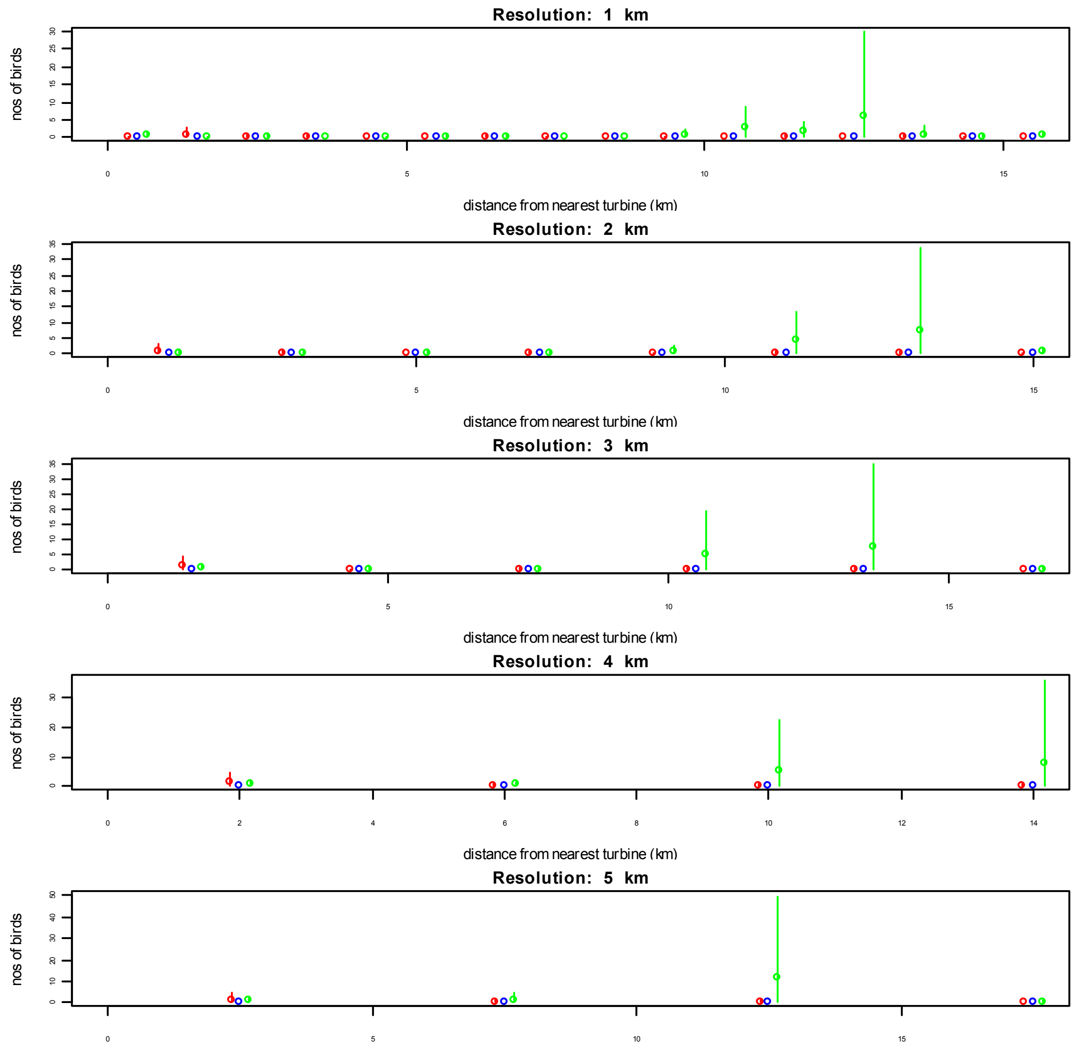


Figure 4.35 Numbers of Common Terns on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

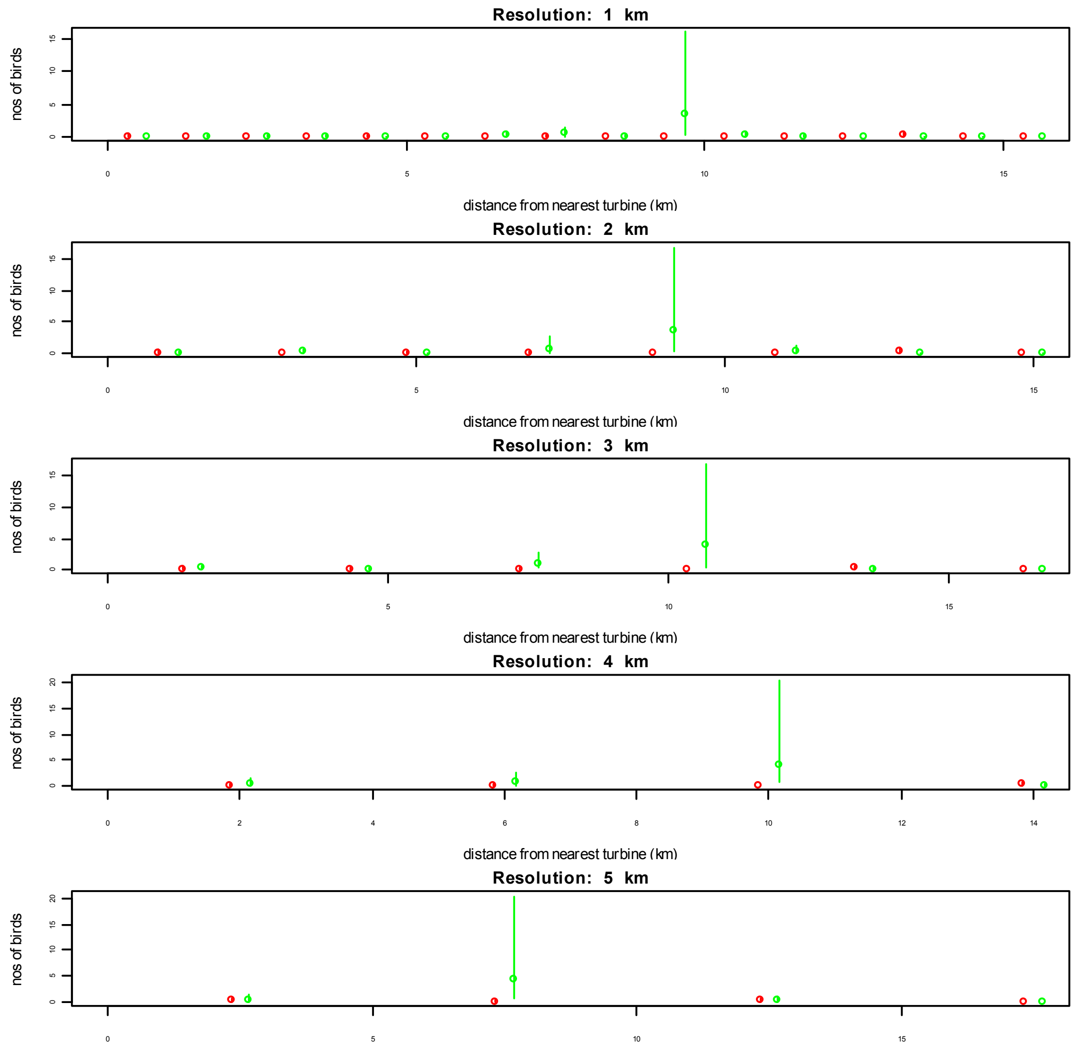
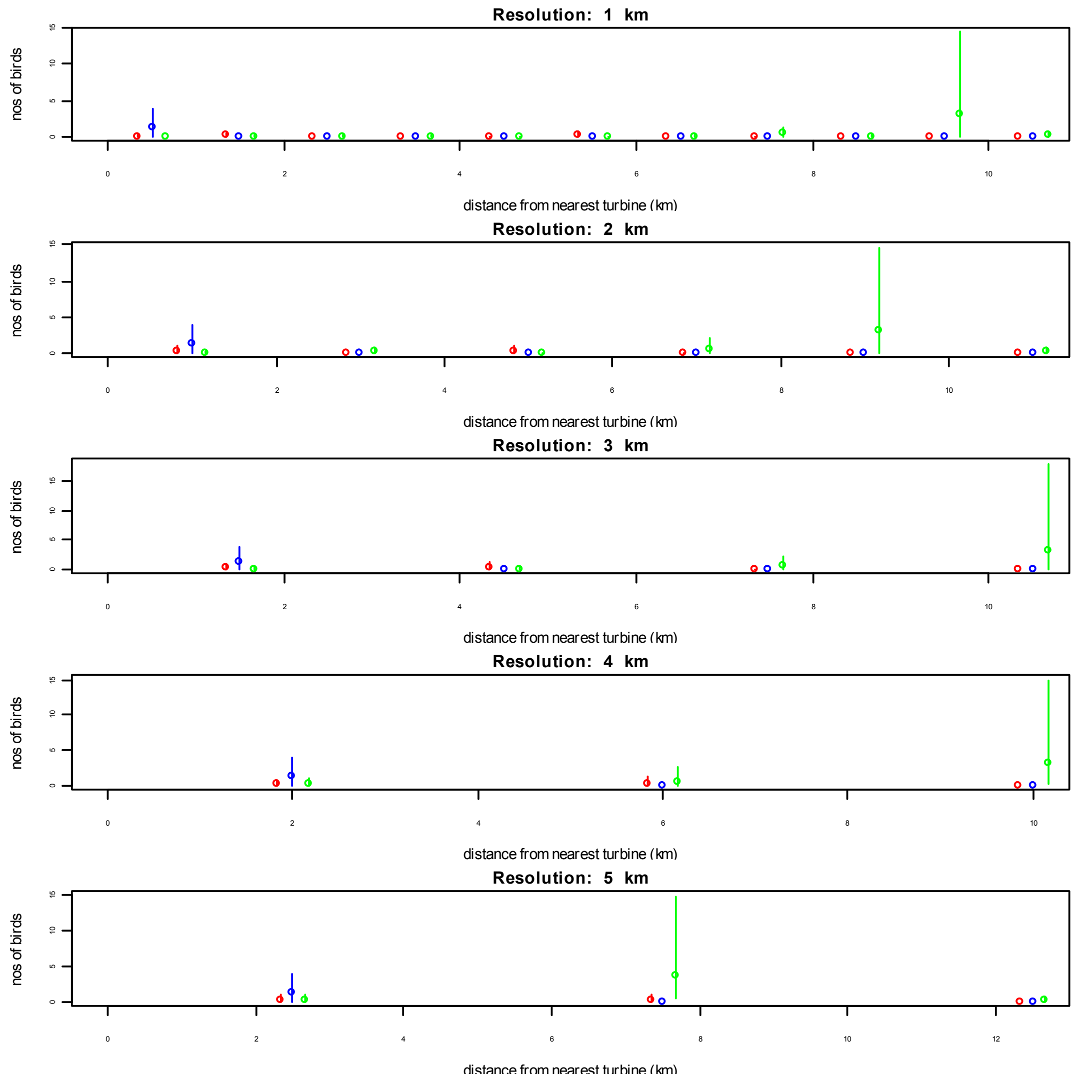


Figure 4.36 Numbers of Common Terns between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



In conclusion there was no detectable positive or negative impact of the turbines on Common Terns. However, although there were more records and larger sample sizes than for Arctic Terns, overall sample sizes were still small, which could still reflect a lack of power in the statistical tests.

Common/Arctic Terns

This category included birds identified on surveys as Arctic Terns, or identified as Common Terns, or identified as one of these two species, as sometimes it is not possible to distinguish between them at sea.

Most records of Common or Arctic Terns were of birds on migration passing through the Study Area in spring and autumn, and the months of April to May, and July to October were included in the change in abundance analysis (Table 4.28).

Table 4.28 Summary statistics showing the seasonal distribution of Common or Arctic Tern records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	0.0	0	no
2	0.0	0	no
3	0.6	0	no
4	2.6	1	yes
5	62.3	27	yes
6	1.3	1	no
7	4.2	2	yes
8	19.3	8	yes
9	133.6	58	yes
10	8.2	4	yes
11	0.0	0	no
12	0.0	0	no

The Bank legs (legs 2 and 3) were the most important, with no birds recorded on Box legs 43 and 44 (Table 4.29).

Table 4.29 Summary statistics showing the distribution of Common or Arctic Tern records across all survey legs

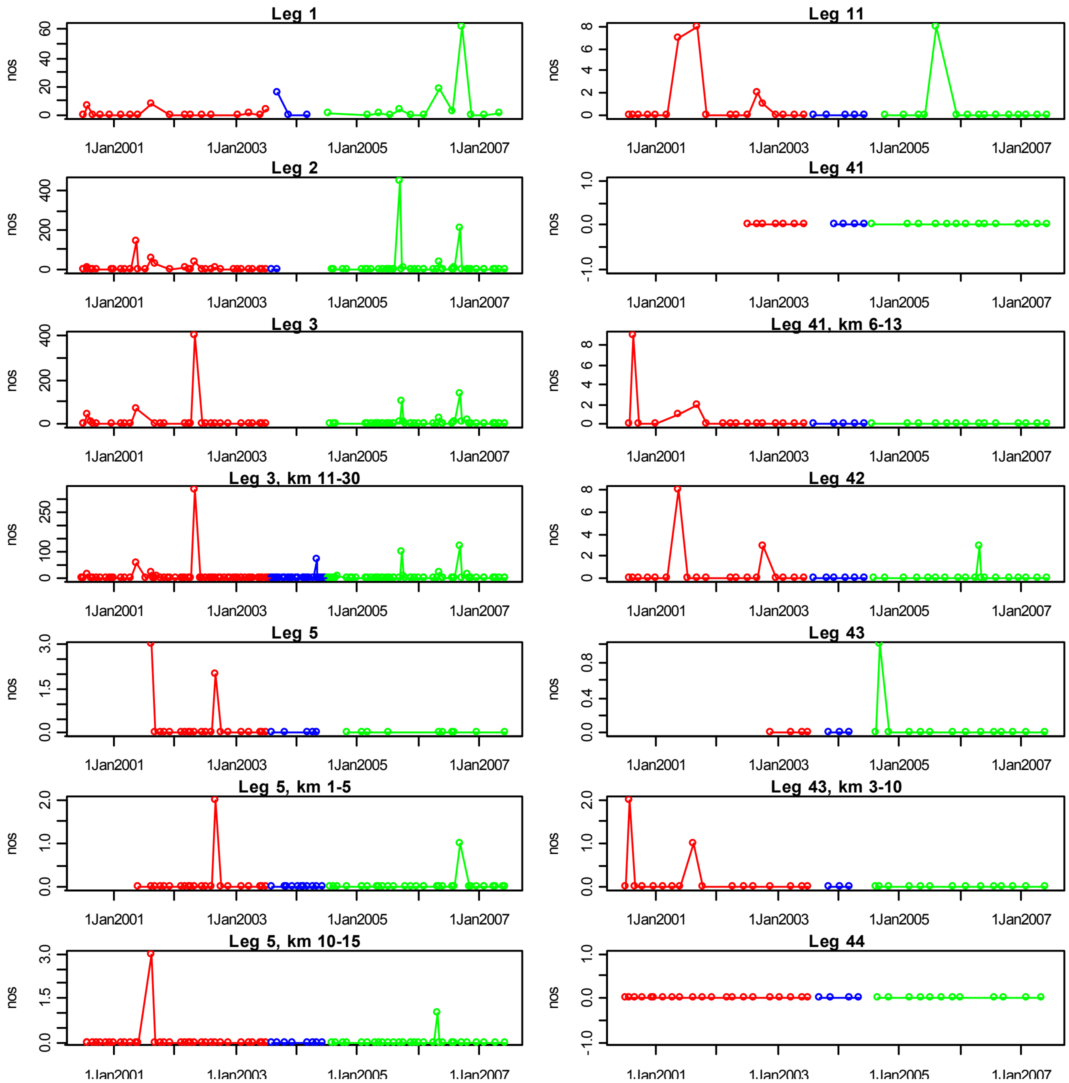
Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km²)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	1.55	11.00	3	22	0.06	0.44	8	57
2	13.24	26.89	29	54	0.38	0.77	47	100
3	28.00	10.16	61	20	0.80	0.29	100	38
5	0.45	0.00	1	0	0.03	0.00	4	0
11	1.80	1.14	4	2	0.07	0.05	9	6
41	0.00	0.00	0	0	0.00	0.00	0	0
42	1.00	0.30	2	1	0.08	0.03	10	3
43	0.00	0.13	0	0	0.00	0.01	0	2
44	0.00	0.00	0	0	0.00	0.00	0	0

Table 4.30 Mean numbers of Common or Arctic Terns on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	1.55	0.36	3.34	11	15.00			1	0.08		11.00	1.75	37.46	8	0.10	
2	13.24	3.79	39.67	21	0.50	0.00	0.50	2	0.58		26.89	4.17	102.30	27	0.64	
3	28.00	4.63	135.63	19				0	1.00		10.16	3.39	29.78	31	0.41	
3, km 11-30	12.82	2.03	50.12	34	5.27	0.27	22.24	15	0.79		8.14	2.23	22.97	35	0.81	
5	0.45	0.00	1.18	11	0.00			4	0.79		0.00			4	0.79	
5, km 1-5	0.18	0.00	0.55	11	0.00			4	1.00		0.06	0.00	0.19	16	0.75	
5, km 10-15	0.16	0.00	0.47	19	0.00			5	1.00		0.06	0.00	0.19	16	1.00	
11	1.80	0.30	4.48	10	0.00			3	0.43		1.14	0.00	2.29	7	0.72	
41	0.00			4	0.00			1	1.00		0.00			7	1.00	
41, km 6-13	1.20	0.20	4.11	10	0.00			2	0.71		0.00			7	0.43	
42	1.00	0.00	3.45	11	0.00			3	0.82		0.30	0.00	0.90	10	0.74	
43	0.00			2				0	1.00		0.13	0.00	0.38	8	1.00	
43, km 3-10	0.27	0.00	0.73	11				0	1.00		0.00			8	0.49	
44	0.00			11	0.00			2	1.00		0.00			7	1.00	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
“++++” or “----“ indicates a positive or negative change respectively with p<0.0001
“+++” or “---“ indicates a positive or negative change with p <0.001
“++” or “--“ indicates a positive or negative change with p <0.01
“+” or “-“ indicates a positive or negative change with p <0.05.

Figure 4.37 **Numbers of Common or Arctic Terns on each leg before (red), during (blue) and after (green) turbine installation**



There were no obvious consistent patterns in Figure 4.37, and no statistically significant changes in the numbers of birds associated with the installation of the turbines were detected (Table 4.30).

There were no obvious relationships between distance from the turbines and changes in the numbers of birds (Figures 4.38 to 4.40).

Figure 4.38 Numbers of Common or Arctic Terns on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

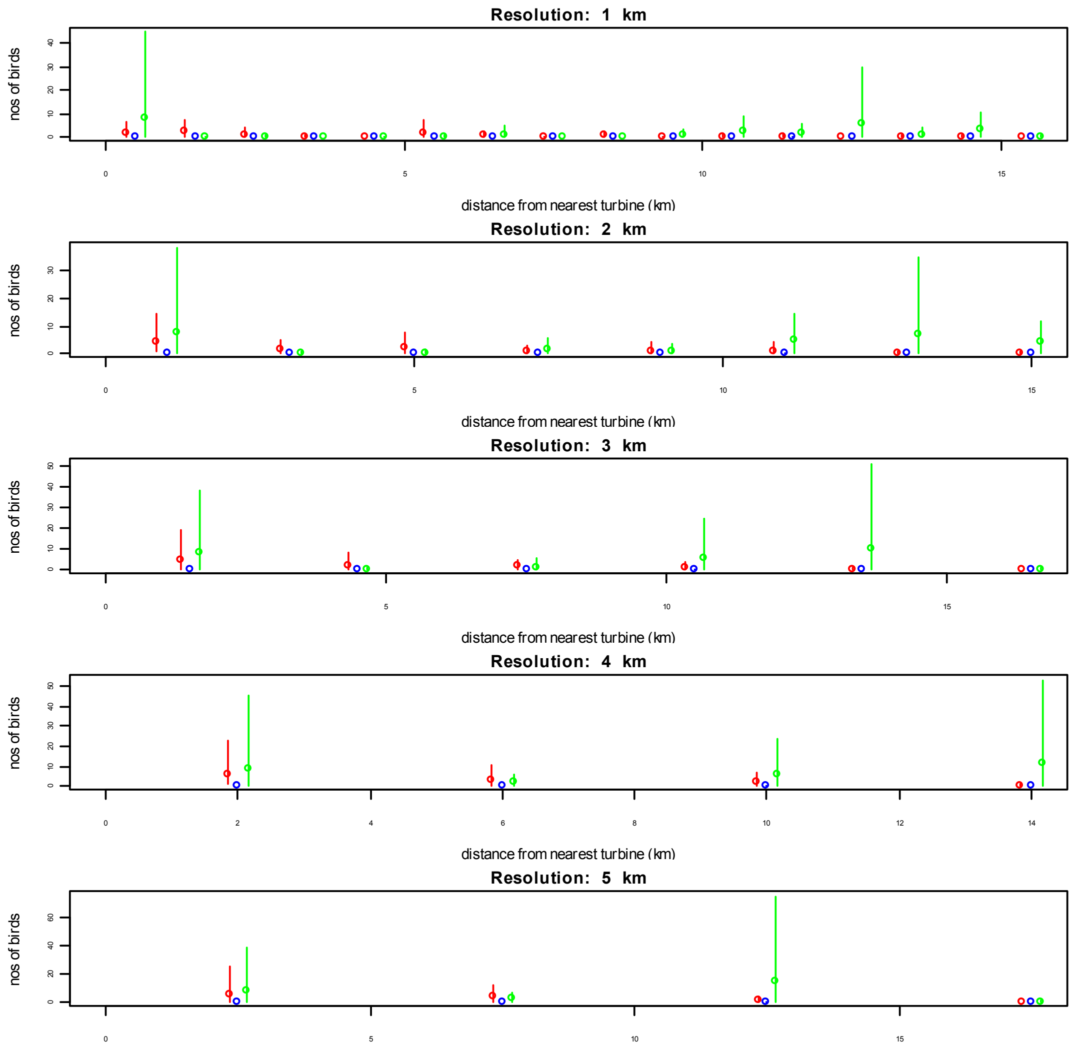


Figure 4.39 Numbers of Common or Arctic Terns on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

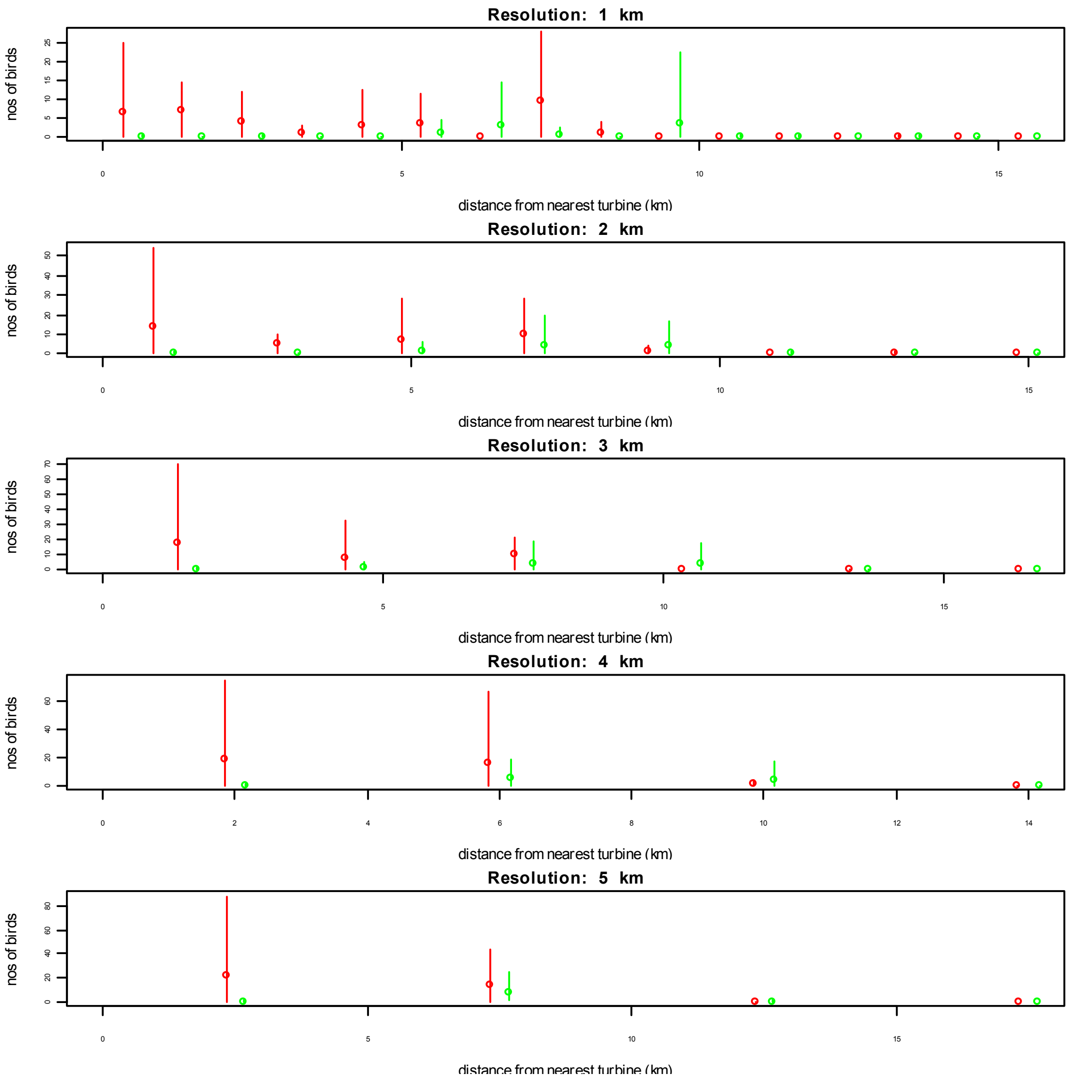
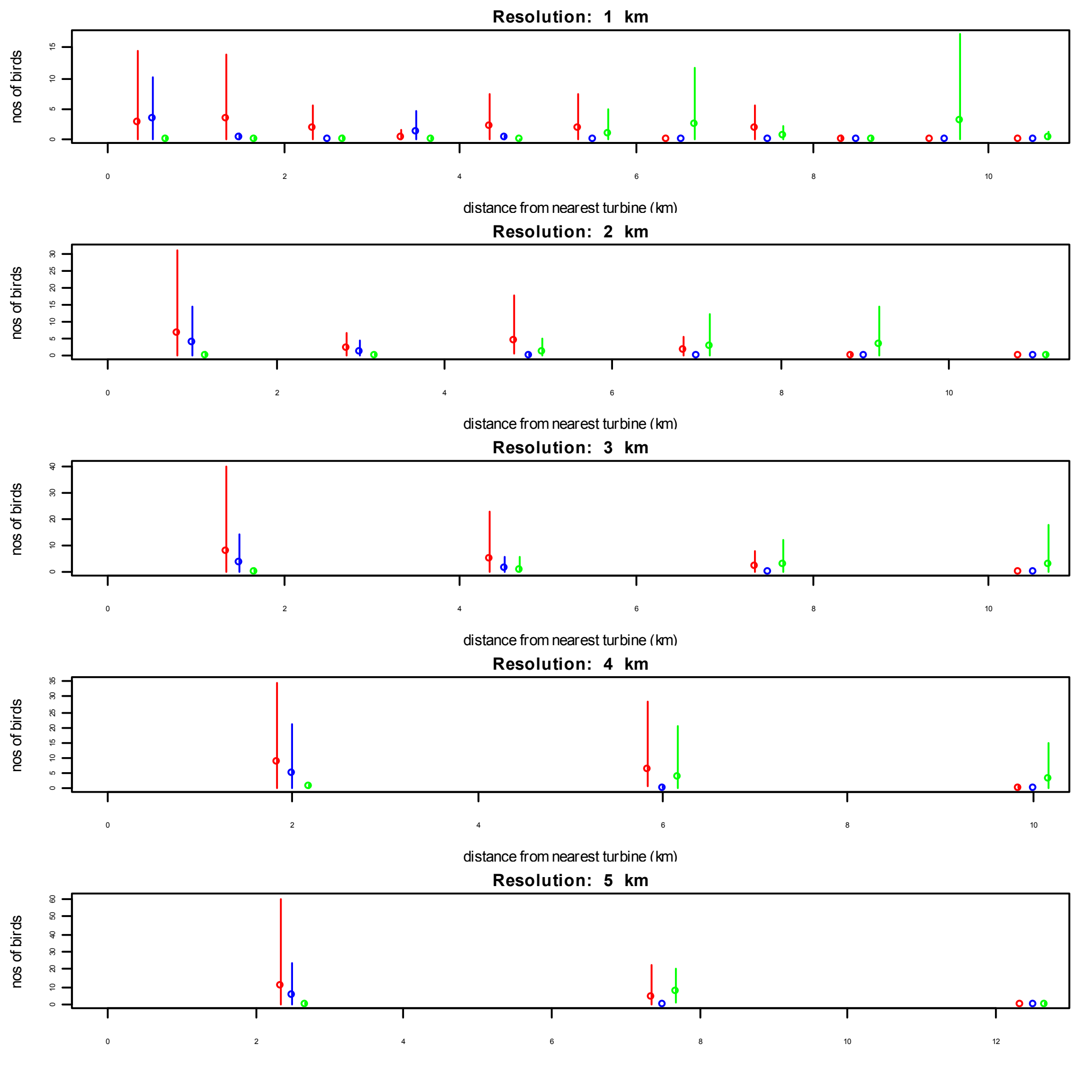


Figure 4.40 Numbers of Common or Arctic Terns between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



In conclusion there was no detectable positive or negative impact of the turbines on the combined records of Common and Arctic Terns combined. The greater number of positive records (i.e. records when birds of one or other species was present) was likely to give greater statistical power than was available for the analysis of the individual species. However, it should be noted that if the two species differed in their response to turbine installation, this would be masked by combining their numbers.

Guillemot

Guillemot records were widely distributed throughout the year, with no strong seasonal patterns, and all months were included within the analyses of change in abundance (Table 4.31).

Table 4.31 Summary statistics showing the seasonal distribution of Guillemot records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	389.9	8	Yes
2	388.5	8	Yes
3	161.6	3	Yes
4	215.3	5	Yes
5	431.2	9	Yes
6	142.8	3	Yes
7	817.6	18	Yes
8	387.2	8	Yes
9	637.5	14	Yes
10	387.2	8	Yes
11	280.8	6	Yes
12	407.3	9	Yes

Most birds were recorded on the Bank legs (legs 2 and 3), and on the outer Box legs (legs 1 and 11) (Table 4.32).

Table 4.32 Summary statistics showing the distribution of Guillemot records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	67.5	228.4	22	36	2.7	9.1	98	100
2	96.6	116.9	32	19	2.8	3.3	100	37
3	43.3	119.3	14	19	1.2	3.4	45	37
5	9.4	10.9	3	2	0.6	0.7	23	8
11	40.4	39.8	13	6	1.6	1.6	59	17
41	3.4	19.4	1	3	0.3	1.5	10	16
42	11.3	57.1	4	9	0.9	4.8	34	52
43	19.5	4.4	6	1	2.0	0.4	71	5
44	11.0	33.8	4	5	0.9	2.8	33	31

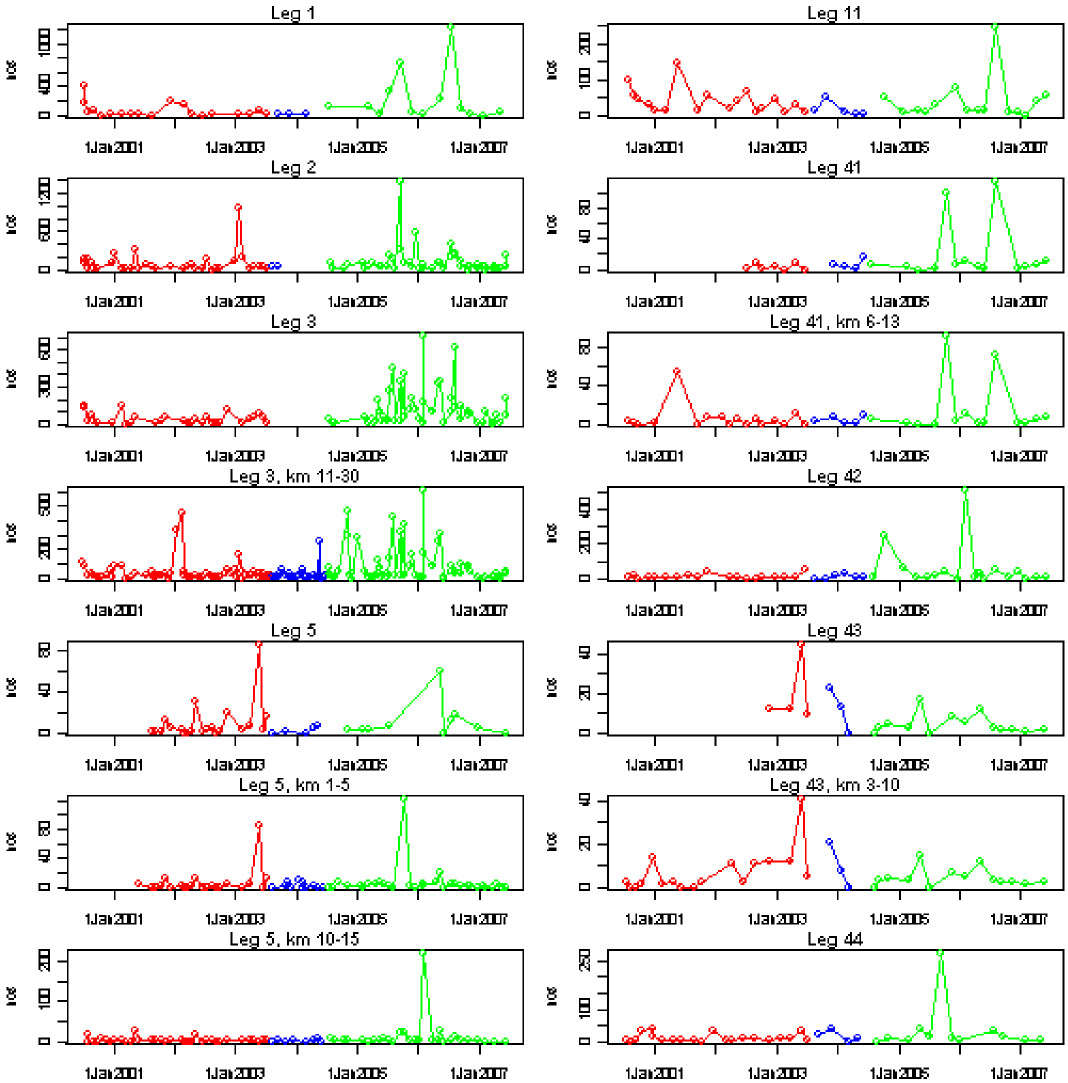
Guillemot numbers increased significantly on the inner Bank leg (leg 3) ($P<0.01$) and on leg 42, although this increase was only weakly significant ($P<0.05$). There was a significant decline in the numbers of guillemots recorded on leg 43 ($P <0.01$) (Table 4.33 & Figure 4.41).

Table 4.33 Mean numbers of Guillemots on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	67.5	34.0	132.2	19	14.0	8.0	19.7	3	0.388		228.4	89.3	515.5	13	0.051	
2	96.6	60.0	199.8	35	43.5	43.0	43.5	2	0.544		116.9	82.1	215.1	52	0.665	
3	43.3	31.1	61.7	30				0	1.000		119.3	87.6	169.3	54	0.008	++
3, km 11-30	42.0	28.1	72.0	61	23.8	14.8	50.0	33	0.209		85.3	58.4	127.3	63	0.024	+
5	9.4	4.3	25.0	21	2.6	0.4	5.0	5	0.415		10.9	4.3	29.0	10	0.880	
5, km 1-5	6.3	2.0	19.2	22	2.5	0.7	5.3	11	0.658		6.3	2.2	21.8	32	1.000	
5, km 10-15	3.2	1.7	6.0	35	1.9	0.4	3.9	8	0.675		12.5	4.2	57.1	29	0.075	
11	40.4	27.0	58.4	18	16.6	5.4	44.2	5	0.163		39.8	21.0	96.8	15	0.978	
41	3.4	1.0	7.0	7	7.0	2.0	13.5	4	0.321		19.4	4.9	50.1	14	0.202	
41, km 6-13	5.9	2.2	16.6	17	4.4	1.9	7.2	5	0.870		14.6	3.4	33.7	14	0.271	
42	11.3	7.0	19.0	19	9.5	3.3	22.3	6	0.791		57.1	22.4	154.8	19	0.043	+
43	19.5	9.8	36.8	4	12.0	0.0	19.7	3	0.686		4.4	2.6	7.9	14	0.007	--
43, km 3-10	6.8	3.6	13.9	17	9.7	0.0	16.7	3	0.662		4.2	2.6	7.6	14	0.445	
44	11.0	6.2	16.9	21	17.5	2.8	29.5	4	0.438		33.8	9.4	123.7	12	0.157	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with p<0.0001
"+++" or "---" indicates a positive or negative change with p <0.001
"++" or "--" indicates a positive or negative change with p <0.01
"+" or "-" indicates a positive or negative change with p <0.05.

Figure 4.41 Numbers of Guillemots on each leg before (red), during (blue) and after (green) turbine installation



Although there was no significant change in the overall numbers of Guillemot on in outer Bank leg (leg 2), Figure 4.42 suggested that perhaps there has been some redistribution of birds, with numbers declining within c.6 km of the turbines and increasing beyond this distance, although these changes may not be statistically significant. By contrast, on the inner Bank leg (leg 3) Guillemots appeared to increase over the full range of distances from the nearest turbine (Figures 4.43 and 4.44).

Figure 4.42 **Numbers of Guillemots on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions**

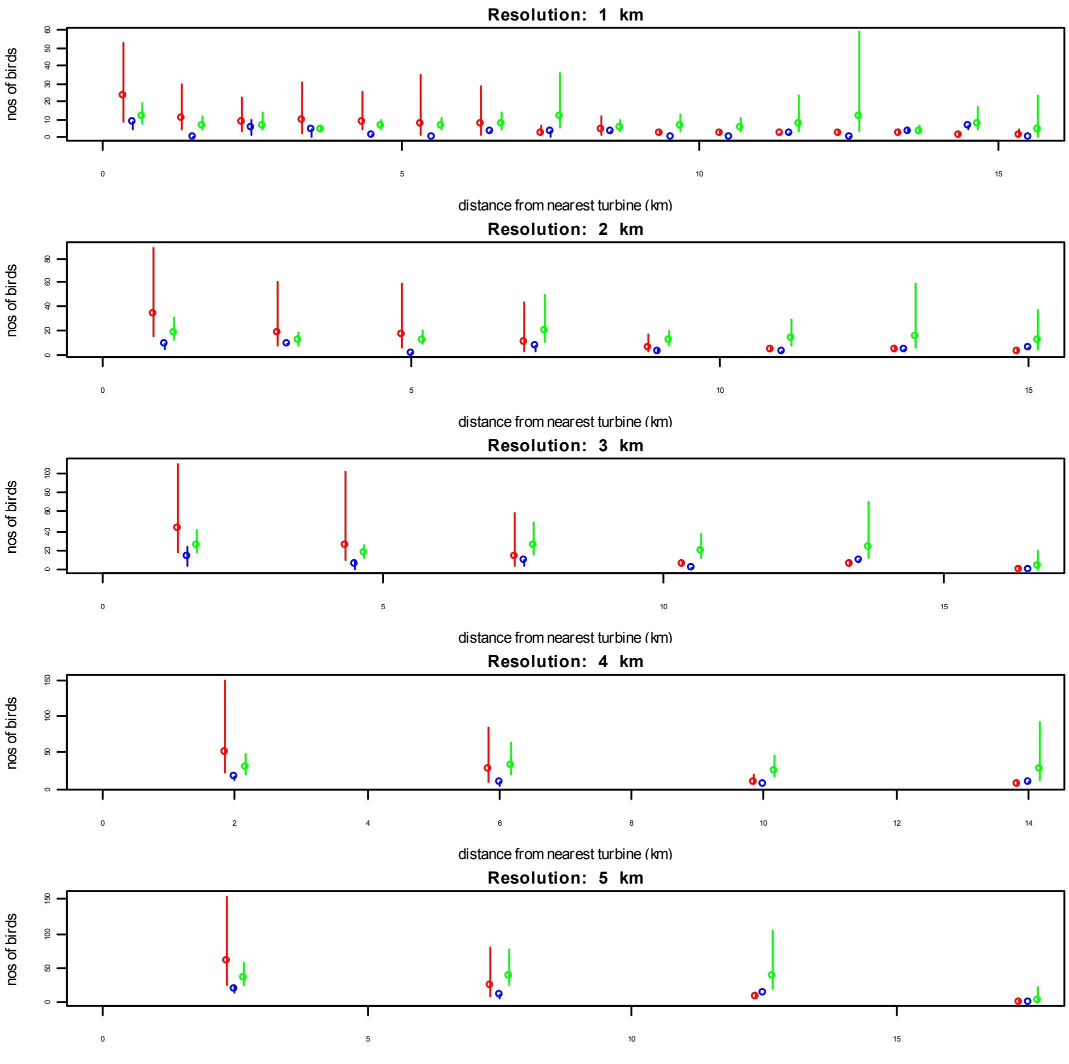


Figure 4.43 **Numbers of Guillemots on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions**

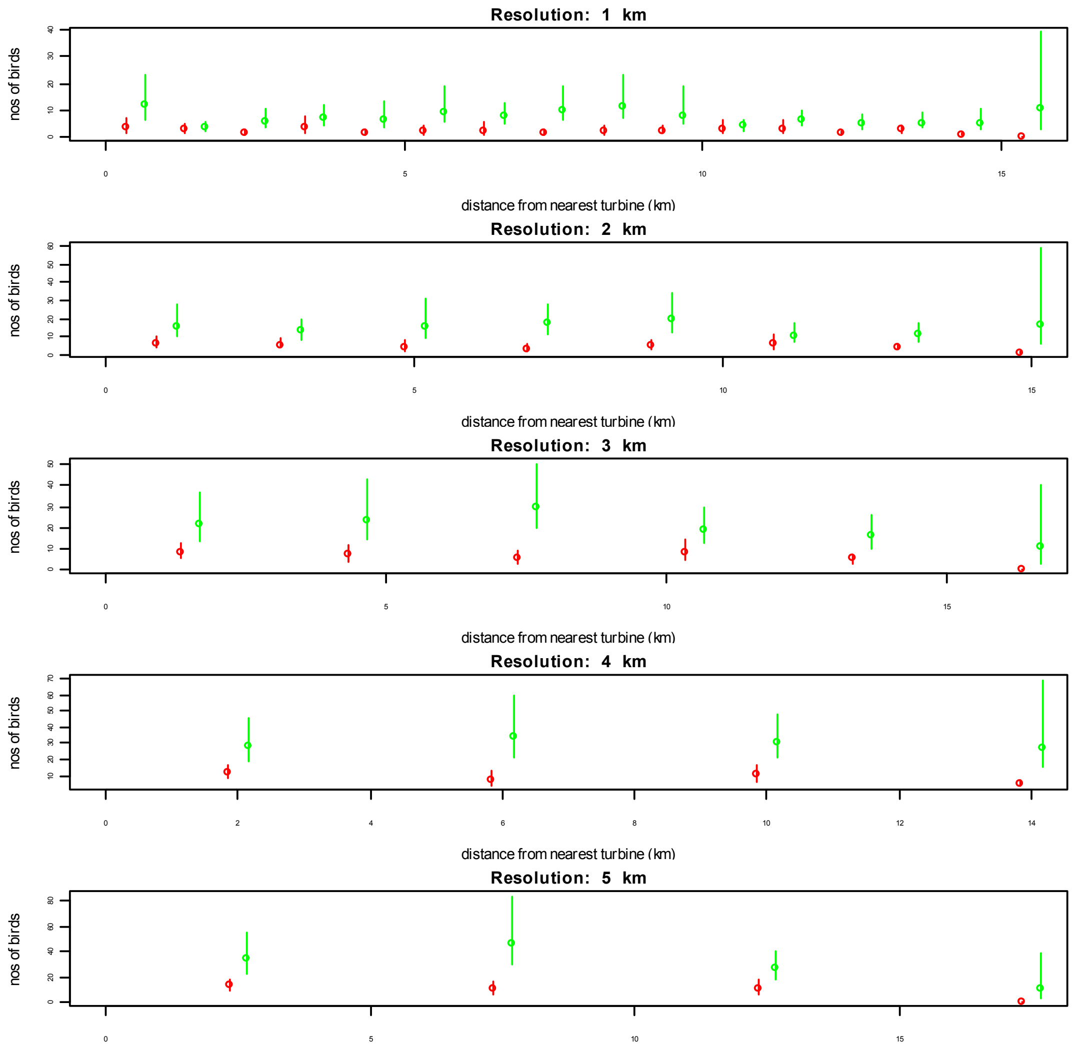
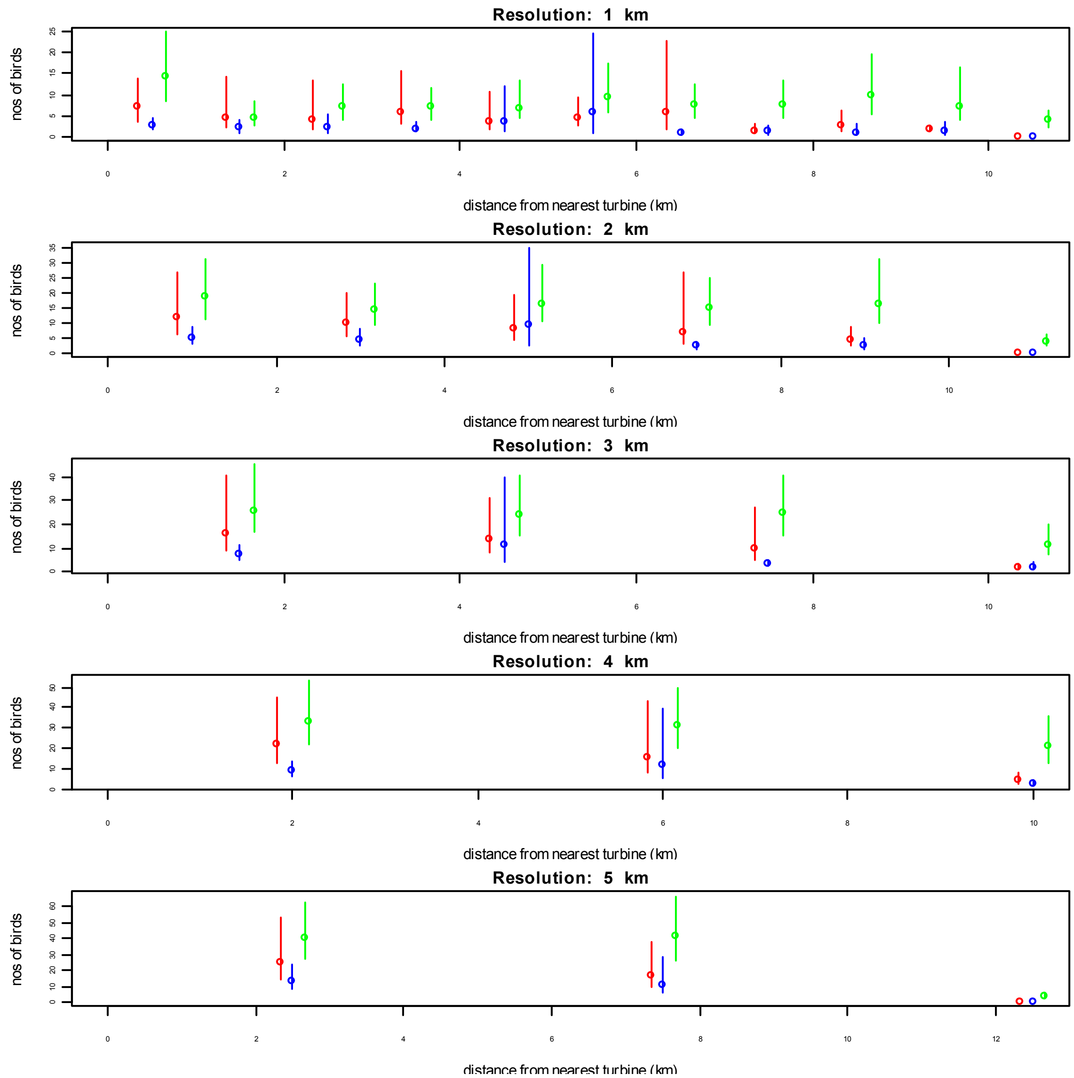


Figure 4.44 Numbers of Guillemots between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



Thus, trends for Guillemots varied between legs, and while there was no evidence of any detrimental effect of turbines on the number of Guillemots, it was considered possible that some redistribution of birds away from the turbines has occurred on the outer Bank leg (leg 2).

Razorbill

Razorbill records were widely distributed throughout the year, with no strong seasonal patterns, and all months apart from May were included within the analyses of change in abundance (Table 4.34).

Table 4.34 Summary statistics showing the seasonal distribution of Razorbill records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	146.5	8	Yes
2	167.2	10	Yes
3	72.9	4	Yes
4	122.5	7	Yes
5	88.9	5	Yes
6	16.1	1	No
7	130.8	8	Yes
8	120.0	7	Yes
9	317.2	18	Yes
10	323.5	19	Yes
11	150.6	9	Yes
12	74.3	4	Yes

Most birds were recorded on the Bank legs (legs 2 and 3), and on the outer Box legs (legs 1 and 11) (Table 4.35).

Table 4.35 Summary statistics showing the distribution of Razorbill records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	11.3	49.8	14	20	0.45	1.99	51	97
2	31.0	71.8	38	29	0.89	2.05	100	100
3	22.7	62.7	28	26	0.65	1.79	73	87
5	0.6	5.3	1	2	0.04	0.35	5	17
11	9.4	22.8	11	9	0.37	0.91	42	44
41	0.0	5.1	0	2	0.00	0.39	0	19
42	2.1	11.2	3	5	0.18	0.93	20	45
43	1.8	2.9	2	1	0.18	0.29	20	14
44	2.9	12.0	4	5	0.25	1.00	28	49

Numbers of Razorbills increased significantly on Box leg 1 ($P<0.01$) and from km 11-30 on the inner Bank leg (leg 3) ($P<0.01$), as well as on Box leg 41 from km 6-13 and on Box leg 42, although increases on these last two legs were only weakly significant ($P<0.05$) (Table 4.36).

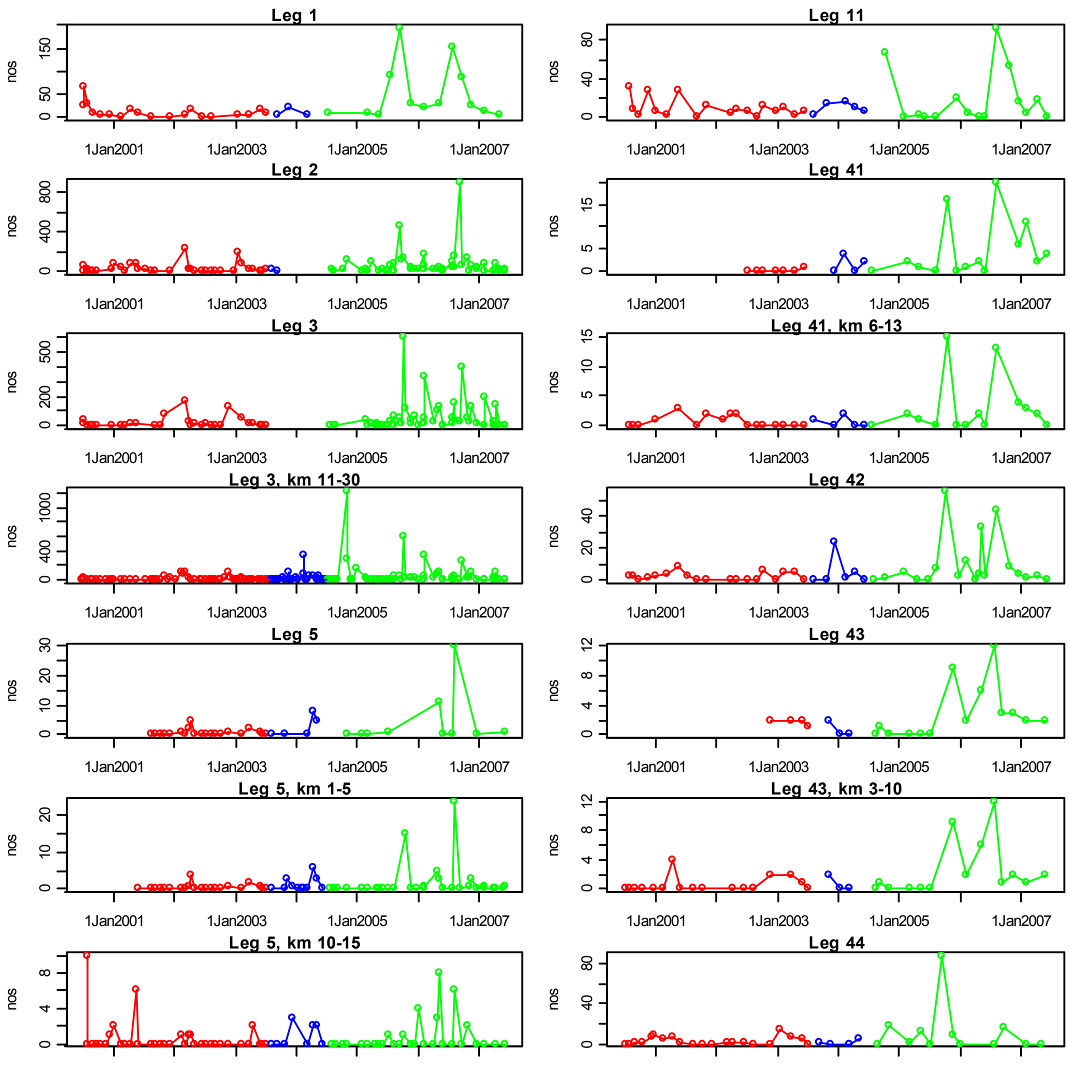
Table 4.36 Mean numbers of Razorbills on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	11.29	5.94	22.13	17	9.67	4.00	15.33	3	0.852		49.85	24.94	98.10	13	0.009	++
2	31.00	18.14	57.66	32	5.50	2.00	5.50	2	0.389		71.77	42.72	137.56	47	0.123	
3	22.71	11.43	42.91	28				0	1.000		62.69	37.95	105.33	48	0.068	
3, km 11-30	15.12	9.01	23.65	57	32.13	17.67	78.04	30	0.071		68.96	36.33	151.58	57	0.004	++
5	0.63	0.21	1.47	19	2.60	0.00	5.20	5	0.072		5.25	0.25	17.37	8	0.071	
5, km 1-5	0.47	0.16	1.06	19	1.30	0.30	2.77	10	0.200		1.83	0.59	4.75	29	0.338	
5, km 10-15	0.75	0.25	1.72	32	1.00	0.29	1.86	7	0.871		0.96	0.38	2.16	26	0.713	
11	9.35	5.54	15.04	17	10.25	4.00	13.75	4	0.907		22.75	10.49	46.58	12	0.106	
41	0.00			6	1.33	0.00	2.67	3	0.333		5.08	2.25	9.58	12	0.054	
41, km 6-13	0.69	0.25	1.19	16	0.75	0.00	1.50	4	1.000		3.50	1.42	7.17	12	0.019	+
42	2.11	1.06	3.36	18	6.00	0.40	16.40	5	0.150		11.19	4.91	21.85	16	0.012	+
43	1.75	1.00	2.00	4	0.67	0.00	1.33	3	0.257		2.86	1.36	5.14	14	0.707	
43, km 3-10	0.60	0.13	1.33	15	0.67	0.00	1.33	3	1.000		2.57	1.07	5.36	14	0.065	
44	2.95	1.53	5.05	19	1.50	0.00	3.75	4	0.524		12.00	3.54	34.79	12	0.066	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with p<0.0001
"+++" or "---" indicates a positive or negative change with p <0.001
"++" or "--" indicates a positive or negative change with p <0.01
"+" or "-" indicates a positive or negative change with p <0.05.

Consideration of mean numbers in Table 4.36 and the time series (particularly peak numbers), in Figure 4.45 suggested that Razorbill numbers may have increased across all survey legs, with increases approaching statistical significance (P<0.1) on the inner Bank leg (leg 3), on the Cable Route (leg 5), and on Box legs 41, 43 (from km 3-10) and 44.

Figure 4.45 Numbers of Razorbills on each leg before (red), during (blue) and after (green) turbine installation



For the bank legs, there was no evidence that the changes in numbers were related to proximity of the nearest turbine (Figures 4.46, 4.47, and 4.48).

Figure 4.46 Numbers of Razorbills on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

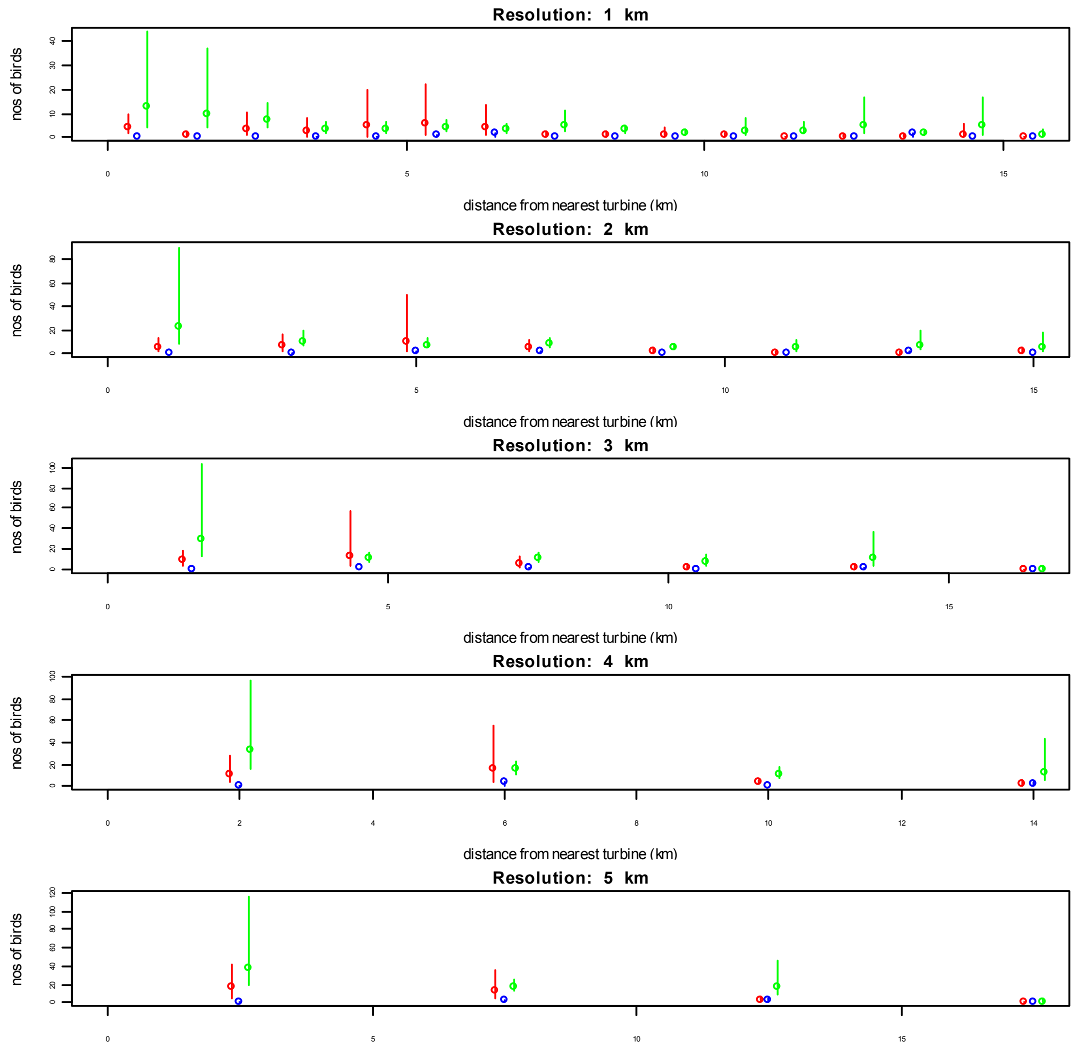


Figure 4.47 Numbers of Razorbills on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

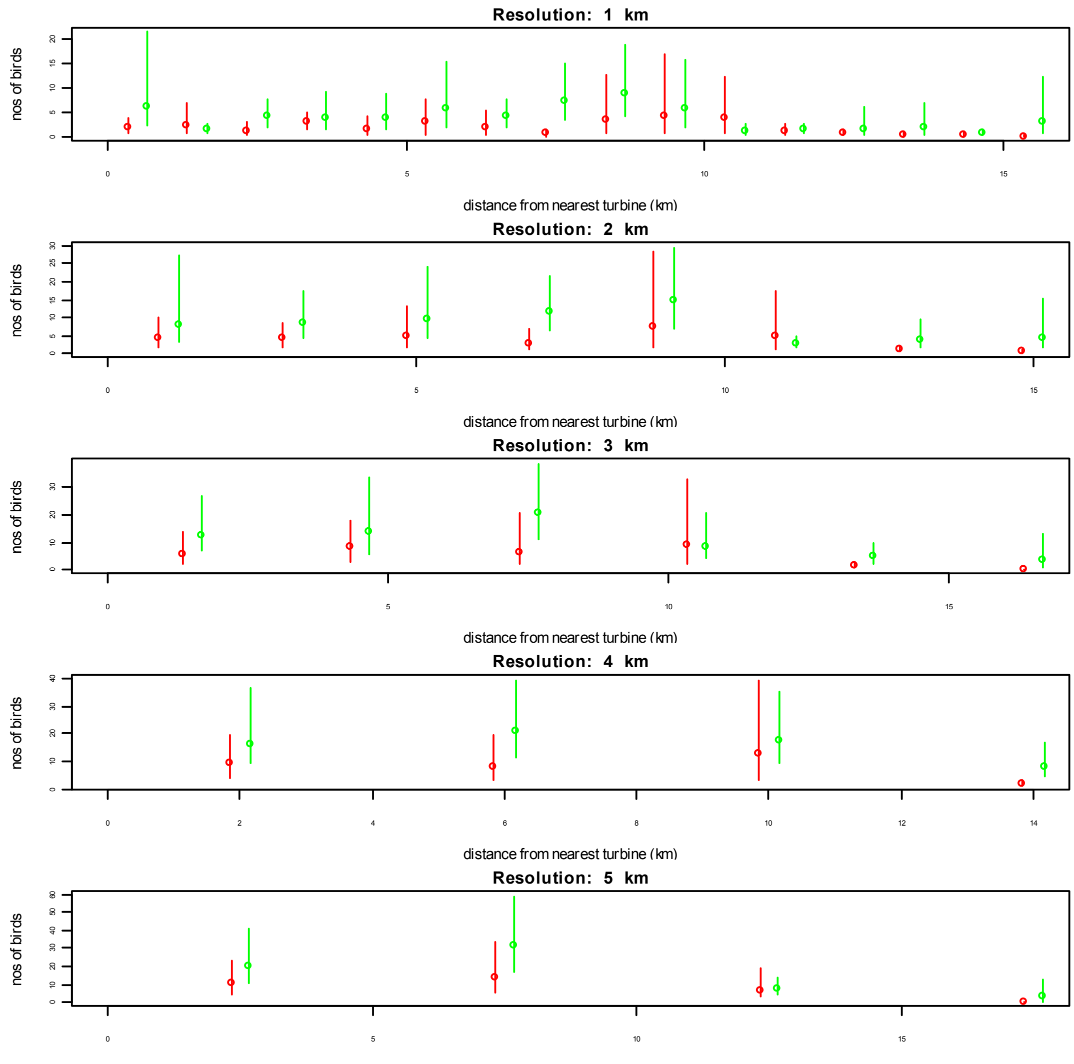
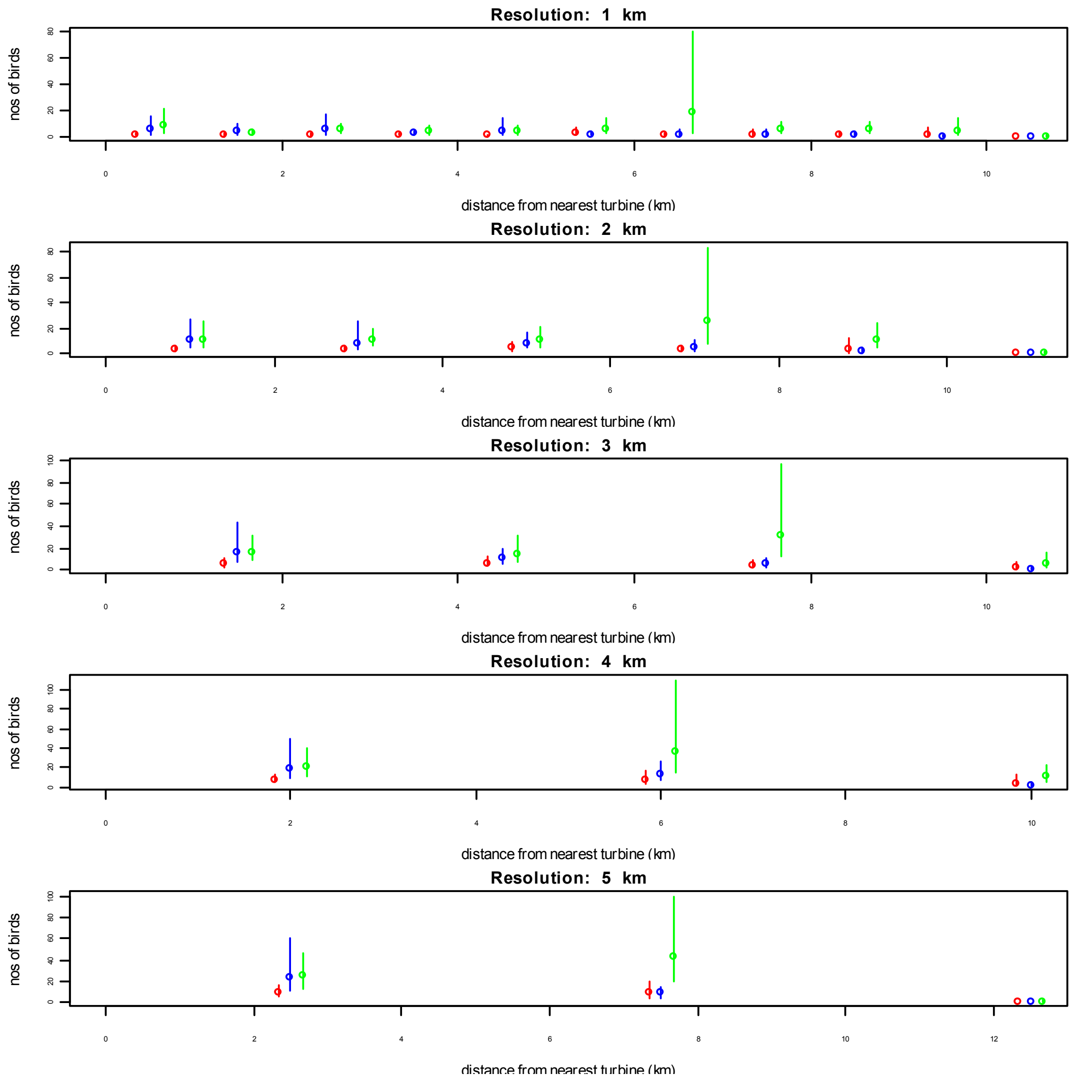


Figure 4.48 Numbers of Razorbills between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



Thus, Razorbills have increased generally, with no evidence of any impact of turbines.

Guillemot/Razorbill

This category included birds identified in the field as Guillemots, or identified as Razorbills, or identified as one of these two species, as sometimes it was not possible at sea to distinguish between them. Birds identified as Guillemots dominated this category, and the results were similar to those for Guillemots. Guillemot or Razorbill records were widely distributed throughout the year, with no strong seasonal patterns, and all months were included within the analyses of change in abundance (Table 4.37).

Table 4.37 Summary statistics showing the seasonal distribution of Guillemot or Razorbill records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	536.5	8	Yes
2	555.6	9	Yes
3	234.5	4	Yes
4	337.8	5	Yes
5	520.1	8	Yes
6	158.9	2	Yes
7	948.4	15	Yes
8	507.2	8	Yes
9	954.7	15	Yes
10	710.8	11	Yes
11	431.3	7	Yes
12	481.7	8	Yes

Most birds were recorded on the Bank legs (legs 2 and 3), and on the outer Box legs (legs 1 and 11) (Table 4.38).

Table 4.38 Summary statistics showing the distribution of Guillemot or Razorbill records across all survey legs

Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	78.1	278.2	21	33	3.1	11.1	87	100
2	125.3	182.2	33	21	3.6	5.2	100	47
3	64.7	175.3	17	21	1.8	5.0	52	45
5	10.0	15.2	3	2	0.7	1.0	19	9
11	49.6	58.0	13	7	2.0	2.3	55	21
41	3.6	24.1	1	3	0.3	1.9	8	17
42	13.3	66.6	4	8	1.1	5.5	31	50
43	21.3	7.3	6	1	2.1	0.7	59	7
44	13.8	45.8	4	5	1.2	3.8	32	34

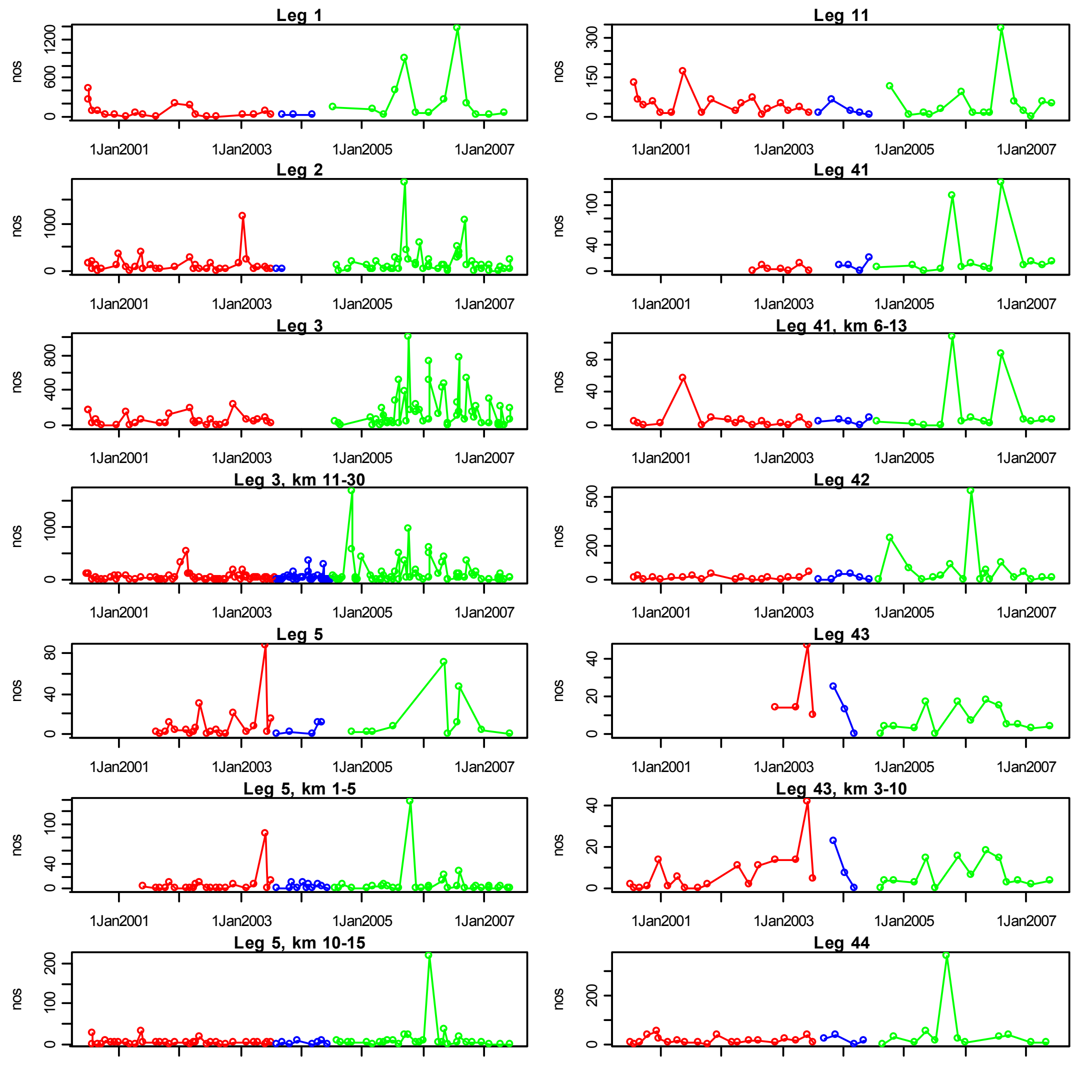
Table 4.39 Mean numbers of Guillemots or Razorbills on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	78.05	40.97	149.34	19	23.67	13.00	29.00	3	0.419		278.231	128.018	600.413	13.000	0.031	+
2	125.34	81.18	224.02	35	49.00	45.00	49.00	2	0.462		182.154	126.278	315.059	52.000	0.356	
3	64.67	43.90	89.66	30				0	1.000		175.259	120.429	237.193	54.000	0.007	++
3, km 11-30	56.23	39.73	87.14	61	53.06	32.57	90.42	33	0.871		147.841	98.828	266.360	63.000	0.006	++
5	9.95	4.67	22.23	21	5.20	0.40	10.00	5	0.587		15.200	4.800	39.135	10.000	0.546	
5, km 1-5	6.73	2.32	22.39	22	3.64	1.55	6.32	11	0.785		8.031	2.969	25.531	32.000	0.851	
5, km 10-15	3.86	2.03	7.45	35	2.75	0.63	5.75	8	0.810		13.379	4.759	50.523	29.000	0.095	
11	49.56	34.89	75.52	18	25.80	12.60	56.60	5	0.245		58.000	31.963	130.595	15.000	0.771	
41	3.57	1.29	6.67	7	8.50	2.50	14.50	4	0.167		24.071	7.357	57.286	14.000	0.121	
41, km 6-13	6.53	2.82	19.92	17	5.00	2.20	7.20	5	0.871		17.643	4.286	43.120	14.000	0.252	
42	13.32	8.68	20.99	19	14.50	3.83	29.67	6	0.868		66.579	29.845	160.526	19.000	0.016	+
43	21.25	11.00	38.75	4	12.67	0.00	21.00	3	0.629		7.286	4.382	10.786	14.000	0.022	-
43, km 3-10	7.35	3.94	15.75	17	10.33	0.00	18.00	3	0.636		6.786	3.929	10.357	14.000	0.892	
44	13.81	8.62	20.46	21	19.00	4.00	31.00	4	0.524		45.750	13.333	180.402	12.000	0.104	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with p<0.0001
"+++" or "---" indicates a positive or negative change with p <0.001
"++" or "--" indicates a positive or negative change with p <0.01
"+" or "-" indicates a positive or negative change with p <0.05.

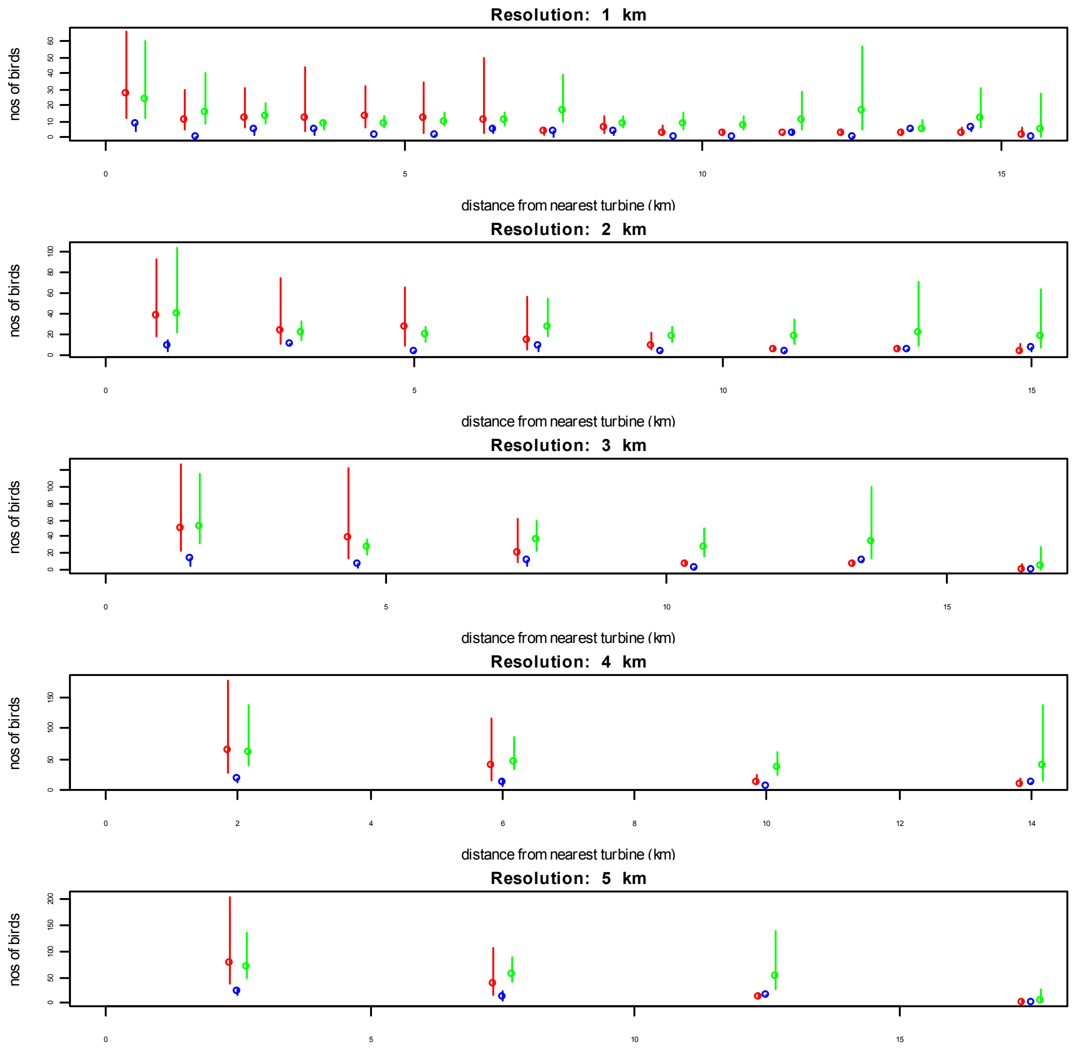
Numbers increased significantly on the inner Bank leg (leg 3) (P<0.01) and on Box legs 1 and 42, although this increase was only weakly significant (P<0.05). There was also a weakly significant decline in the numbers of Guillemots or Razorbills recorded on Box leg 43 (P <0.05) (Table 4.39 and Figure 4.49).

Figure 4.49 Numbers of Guillemots or Razorbills on each leg before (red), during (blue) and after (green) turbine installation



Although there was no significant change in the overall numbers of Guillemots or Razorbills on the outer Bank leg (leg 2), Figure 4.50 suggested that perhaps there was some redistribution of birds, with little change or a small decline in numbers within c.6 km of the turbines and increasing numbers beyond this distance, although these changes may not be statistically significant.

Figure 4.50 Numbers of Guillemots or Razorbills on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



By contrast, on the inner Bank leg (leg 3) Guillemots or Razorbills appeared to have increased over the full range of distances from the nearest turbine (Figures 4.51 and 4.52).

Figure 4.51 Numbers of Guillemots or Razorbills on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

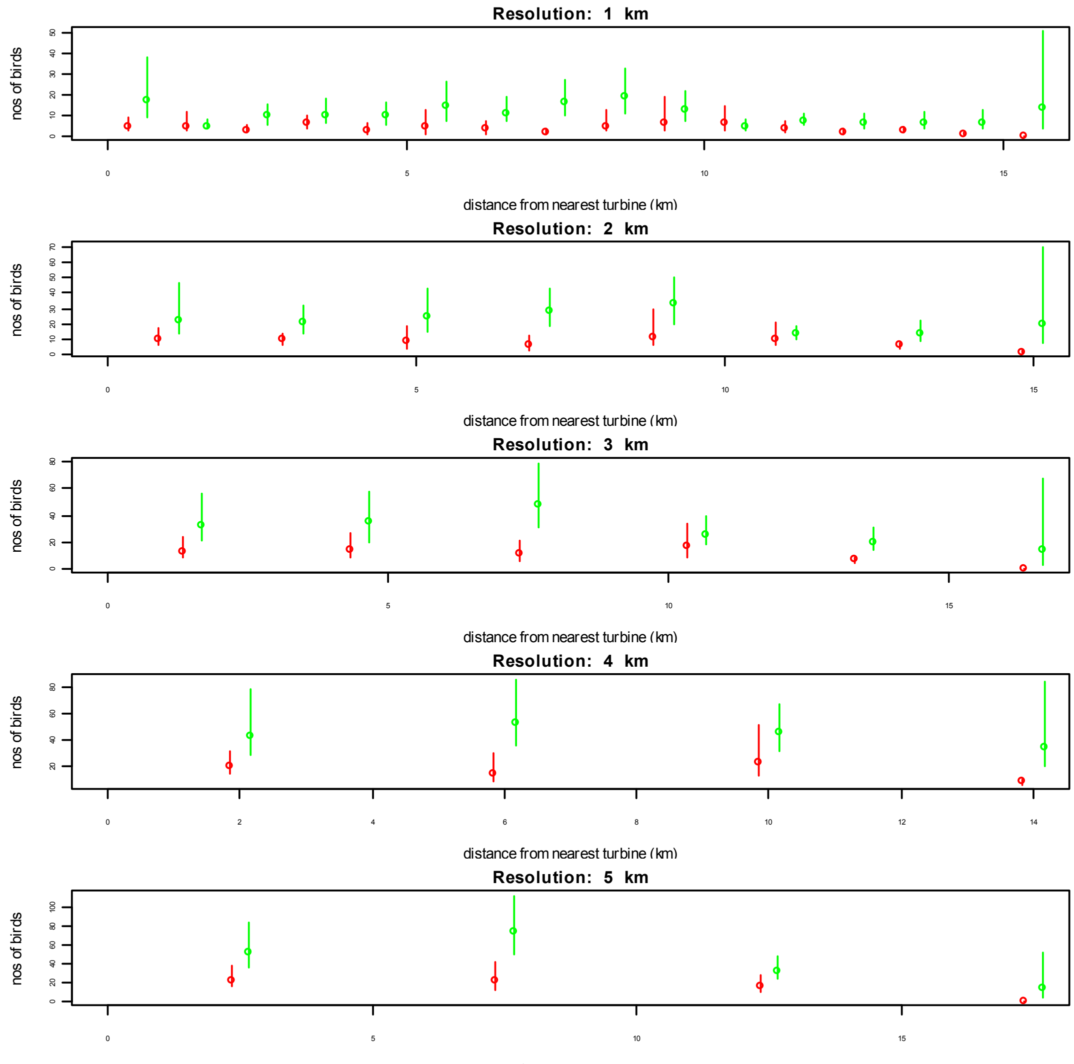
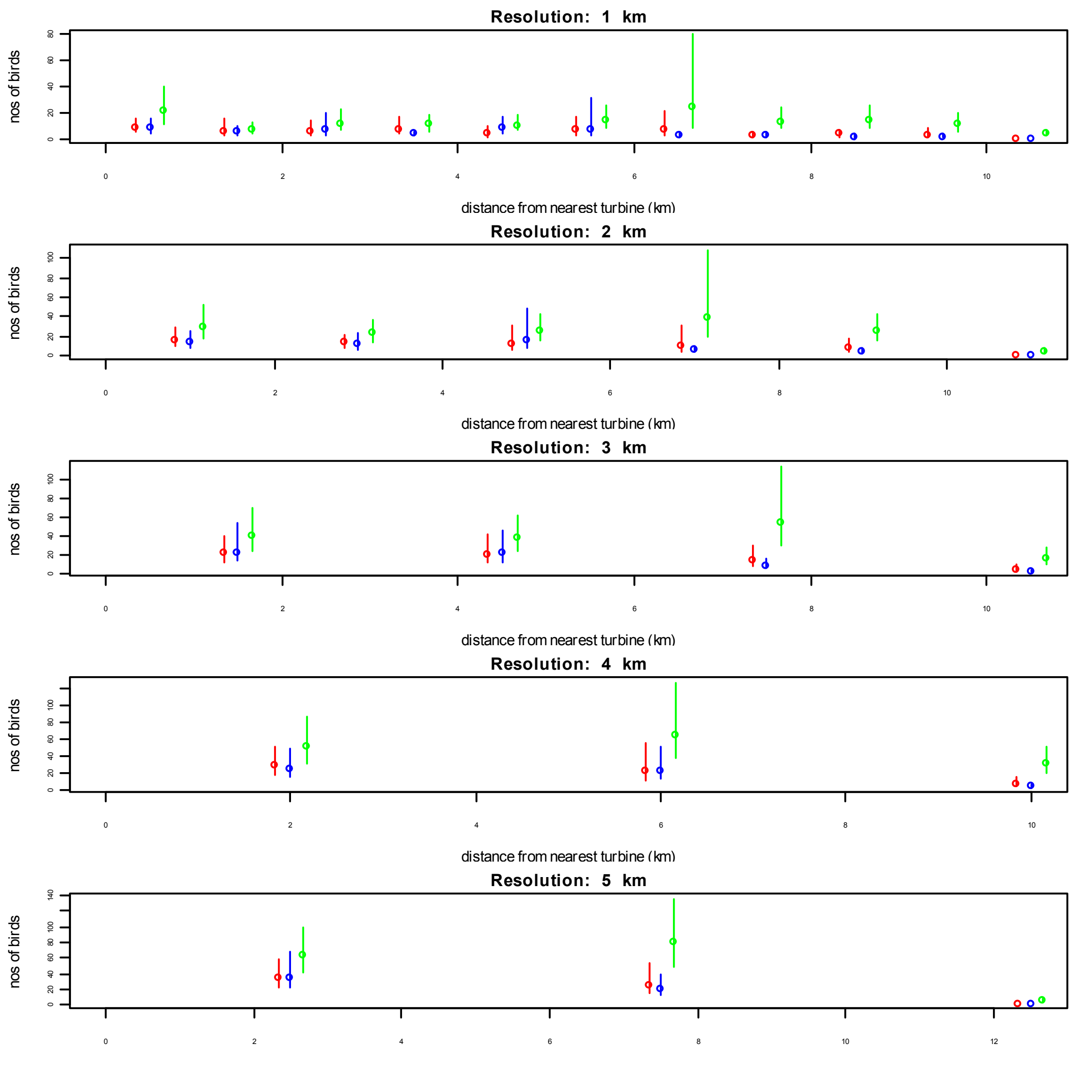


Figure 4.52 Numbers of Guillemots or Razorbills between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



These results were consistent with those obtained when guillemots and razorbills were considered separately, and suggested that the conclusions reached with respect to the changes in numbers and potential impacts of turbines for these species were robust to the presence of some birds which could not be identified to species level.

Harbour Porpoise

Although Harbour Porpoises tended to be more abundant during the summer months, records occurred throughout the year, and all months were included in the change in abundance analysis (Table 4.40).

Table 4.40 Summary statistics showing the seasonal distribution of Harbour Porpoise records

Month	Expected total numbers	Expected % of all birds	Included in change of abundance analysis
1	2.1	3	yes
2	6.5	8	yes
3	2.7	3	yes
4	6.3	8	yes
5	12.4	16	yes
6	6.2	8	yes
7	9.7	12	yes
8	10.8	13	yes
9	12.7	16	yes
10	5.1	6	yes
11	3.4	4	yes
12	2.4	3	yes

Records were widely dispersed across all survey legs, although the Bank legs (legs 2 and 3) and outer Box leg (leg 1) tended to be the most important (Table 4.41 and Figure XX 53).

Table 4.41 Summary statistics showing the distribution of Harbour Porpoise records across all survey legs

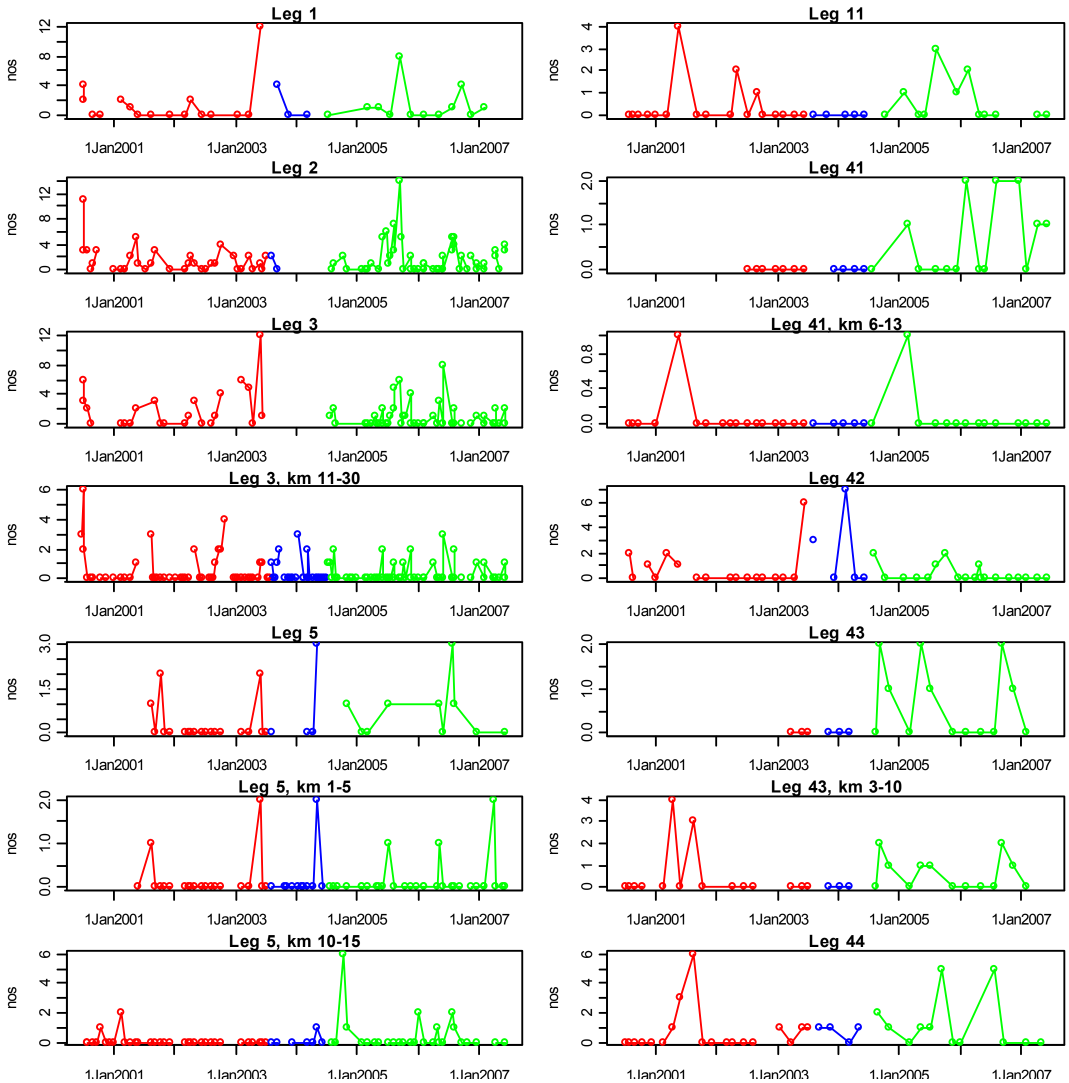
Leg	Mean number		Estimated % of all birds on this leg		Density (nos/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	1.44	1.33	20	16	0.06	0.05	94	51
2	1.52	1.83	21	22	0.04	0.05	71	50
3	2.13	0.94	30	11	0.06	0.03	100	26
5	0.26	0.70	4	8	0.02	0.05	29	45
11	0.39	0.58	5	7	0.02	0.02	26	22
41	0.00	0.64	0	8	0.00	0.05	0	47
42	0.71	0.32	10	4	0.06	0.03	97	25
43	0.00	0.69	0	8	0.00	0.07	0	66
44	0.68	1.25	10	15	0.06	0.10	94	100

Table 4.42 Mean numbers of Harbour Porpoise on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	1.44	0.44	3.98	16	1.33	0.00	2.67	3	1.00		1.33	0.42	3.27	12	0.95	
2	1.52	0.94	2.58	33	1.00	0.00	2.00	2	0.83		1.83	1.23	2.81	48	0.59	
3	2.13	1.17	3.70	23				0	1.00		0.94	0.53	1.53	49	0.03	-
3, km 11-30	0.57	0.29	1.02	51	0.32	0.07	0.68	28	0.40		0.33	0.18	0.53	58	0.21	
5	0.26	0.05	0.63	19	0.75	0.00	1.50	4	0.23		0.70	0.20	1.40	10	0.22	
5, km 1-5	0.15	0.00	0.40	20	0.18	0.00	0.55	11	1.00		0.13	0.00	0.34	31	1.00	
5, km 10-15	0.09	0.00	0.30	33	0.14	0.00	0.43	7	1.00		0.48	0.15	1.22	27	0.09	
11	0.39	0.06	1.18	18	0.00			5	0.68		0.58	0.17	1.17	12	0.73	
41	0.00			7	0.00			4	1.00		0.64	0.21	1.00	14	0.12	
41, km 6-13	0.06	0.00	0.18	17	0.00			5	1.00		0.07	0.00	0.21	14	1.00	
42	0.71	0.18	1.82	17	2.00	0.00	4.80	5	0.24		0.32	0.05	0.63	19	0.46	
43	0.00			3	0.00			3	1.00		0.69	0.23	1.15	13	0.30	
43, km 3-10	0.47	0.00	1.27	15	0.00			3	1.00		0.62	0.21	1.00	13	0.73	
44	0.68	0.26	1.74	19	0.75	0.00	1.00	4	1.00		1.25	0.42	2.50	12	0.38	

P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with $p<0.0001$
"+++" or "---" indicates a positive or negative change with $p<0.001$
"++" or "--" indicates a positive or negative change with $p<0.01$
"+" or "-" indicates a positive or negative change with $p<0.05$.

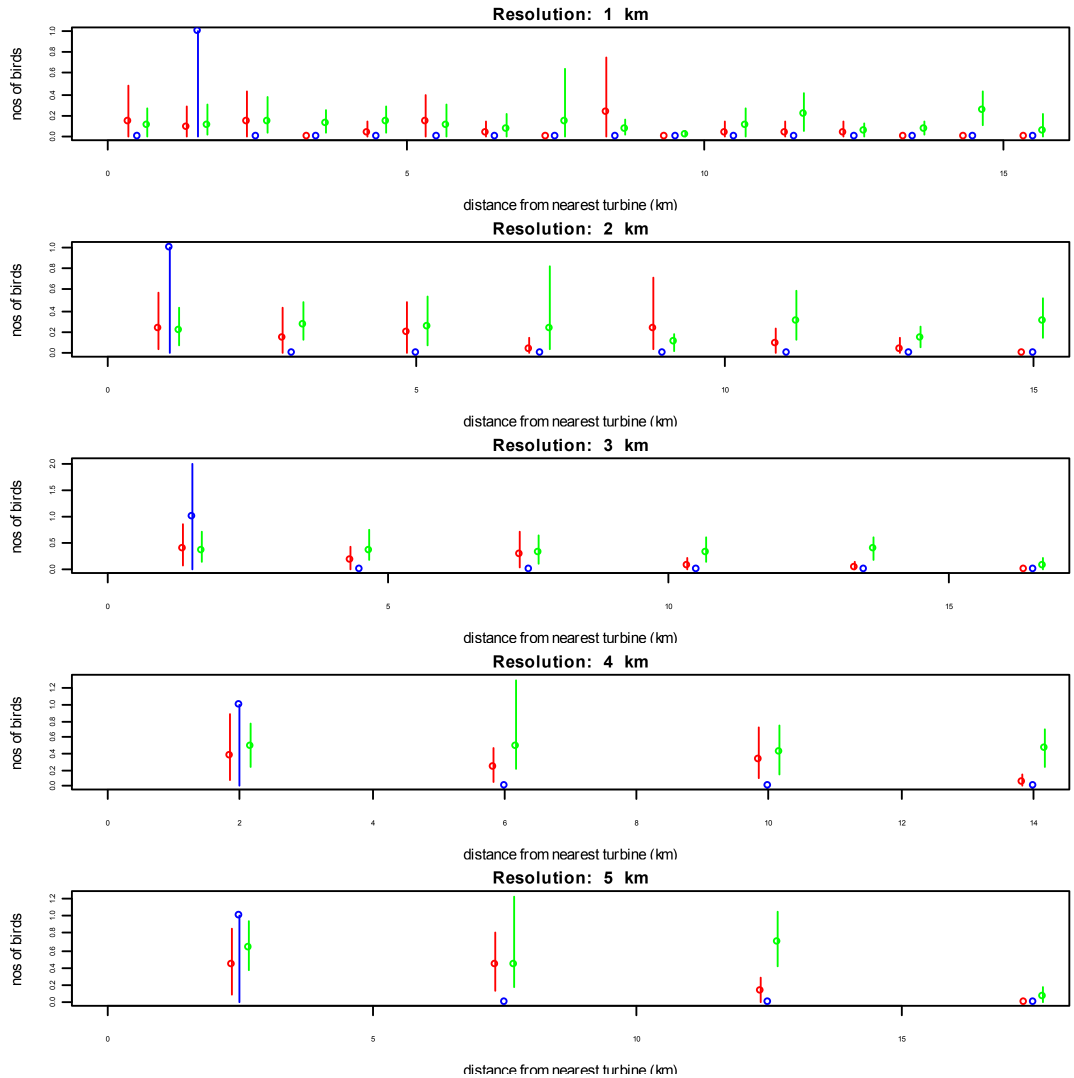
Figure 4.53 **Numbers of Harbour Porpoise on each leg before (red), during (blue) and after (green) turbine installation**



There were no obvious trends in Figure 4.53, although formal statistical analysis detected a weakly statistically significant decline (P<0.05) in the numbers of Harbour Porpoise recorded on the inner Bank leg (leg 3), with a halving in the mean numbers recorded (Table 4.42).

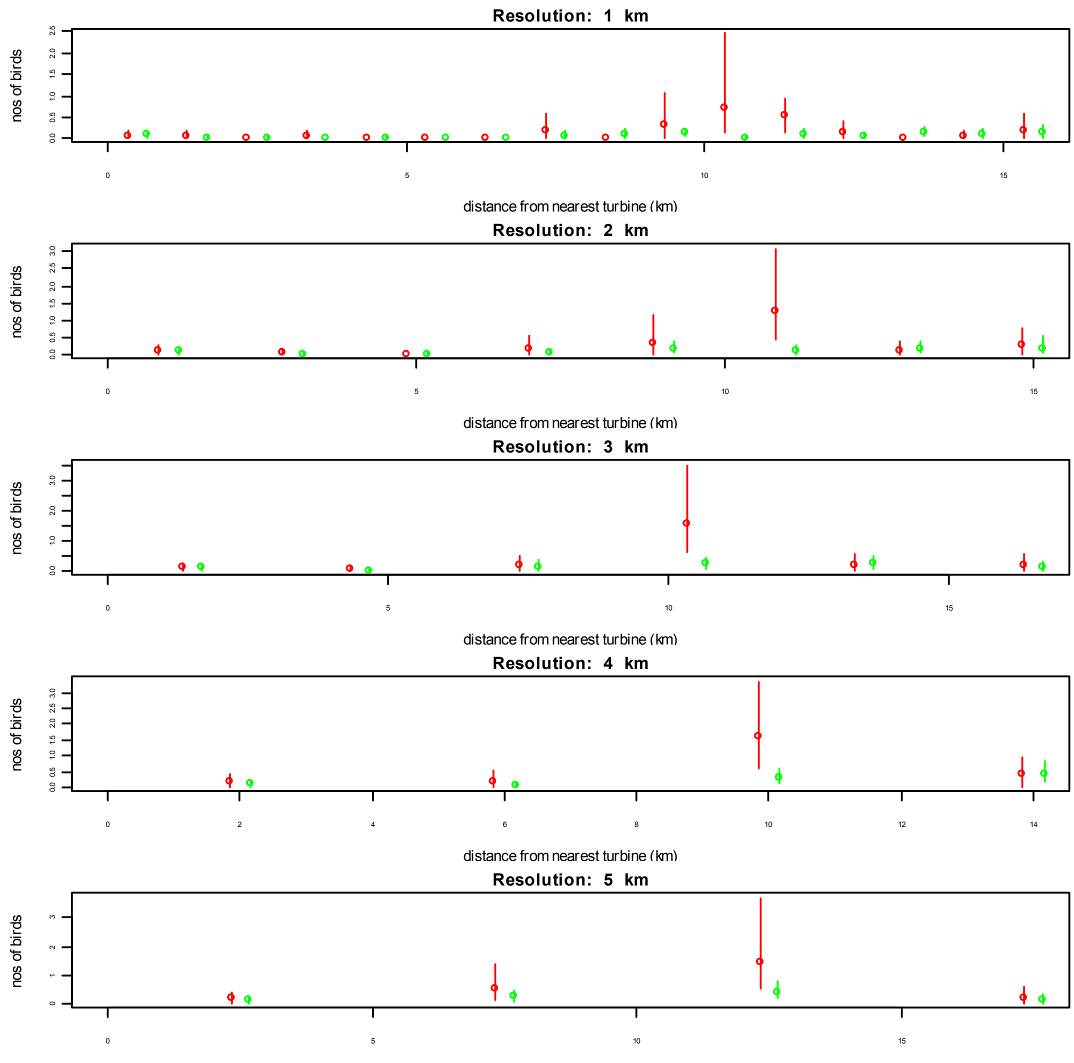
Although there was no overall change in the numbers of Harbour Porpoise recorded on the outer Bank leg (leg 2), there was some suggestion, with 5 km resolution, that numbers increased at 11-15 km from the turbines following installation, but did not change significantly closer in (Figure 4.54).

Figure 4.54 Numbers of Harbour Porpoise on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



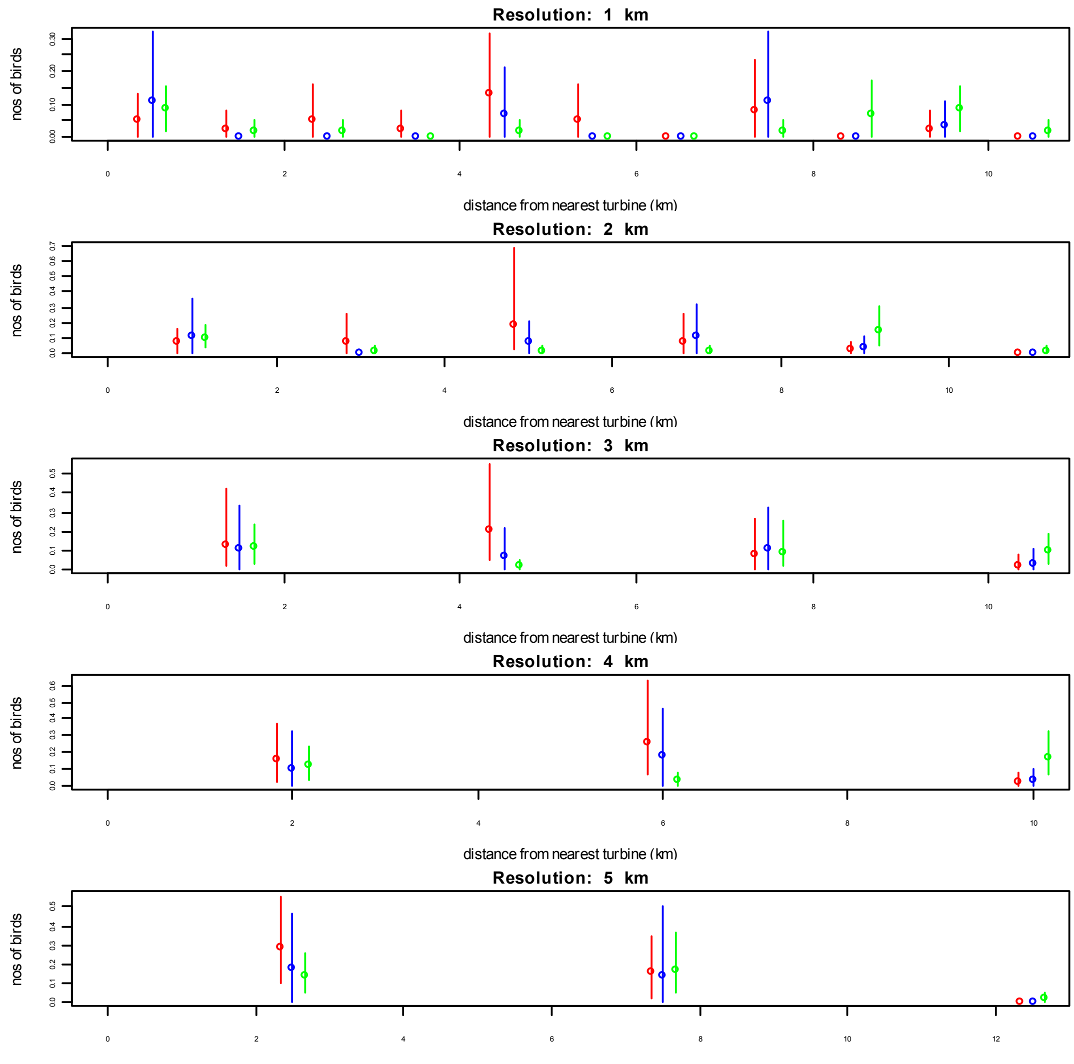
Before turbine installation, most Harbour Porpoise records on the inner Bank leg (leg 3) occurred 8 to 12 km from the final turbine locations, and this was where the principal decline occurred (Figure 4.55).

Figure 4.55 Numbers of Harbour Porpoise on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



The scarcity of Harbour Porpoise records before turbine installation closer to the installation location prevented any meaningful interpretation of the effects of proximity to the turbines on the change in numbers. When km 11-30 of leg 3 was considered, which gave a larger sample size, there was no evidence of any relationship between distance from the nearest turbine and the change in abundance of Harbour Porpoise following turbine installation (Figure 4.56).

Figure 4.56Numbers of Harbour Porpoise between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



In summary, although formal statistical analysis found a weakly statistically significant decline in Harbour Porpoise numbers recorded on the inner Bank leg (leg 3), no strong trends in numbers were obvious for any of the survey legs. There was no evidence that the decline on the inner Bank leg (leg 3) was related to proximity of the turbines, although it was possible that on the outer Bank leg (leg 2), Harbour Porpoise numbers increased at distances of 10-15 km from the turbines, but not closer to them.

Thus, on balance it is concluded that although there was no strong evidence for any negative impact of the turbines on Harbour Porpoises, the weakly statistically significant decline on the inner Bank (leg 3), and the increase in Harbour Porpoise numbers at greater distances from the turbines on the outer Bank (leg 2), raises this possibility. Given that Harbour Porpoise requires strict protection on the basis of its listing on Annex II and IV of the EU Habitats Directive, it is recommended that monitoring of Harbour Porpoises in the Arklow Bank Study Area is continued.

4.3 Statistical analysis of plankton abundance and bird abundance

The analyses considered the relationship between bird and plankton abundance at three different spatial/temporal scales and asked the following questions:

On a particular date was bird abundance higher at sampling stations where plankton abundance was higher?

Spearman rank correlations were used to look for positive associations between plankton and bird numbers across plankton sampling sites on a particular date. Separate tests were carried out for each date with adequate data (see below). The proportion of dates for which a significant positive correlation at the 5% level was found were then calculated. If there was a positive association between bird numbers and plankton numbers, then the proportion of dates upon which a positive association was found should be significantly greater than 5 % (according to the binomial distribution).

Irrespective of the source of the bird data, or the bird species, or the plankton species, only on a small percentage of dates was there a significant positive correlation between plankton and bird abundance across sampling sites, and this proportion of dates was not significantly greater than would be expected by chance (Table 4.43). Thus, on any particular survey date, there was no evidence that bird abundance was related to plankton abundance across different sites.

Table 4.43 Correlations between bird and plankton abundance across different sampling sites on the same date

Source of bird data	Bird species	Plankton Species	Number of dates	Number of dates with significant positive correlation	Proportion of dates with significant positive correlation	Probability of obtaining this many significant correlations by chance
Bank survey	Little Gull	Northern Krill	10	1	0.10	0.40
Bank survey	Kittiwake	Northern Krill	17	1	0.06	0.58
Bank survey	Little Gull	Sea gooseberry	10	0	0.00	1.00
Bank survey	Kittiwake	Sea gooseberry	16	0	0.00	1.00
Point Count	Little Gull	Northern Krill	6	1	0.17	0.26
Point Count	Kittiwake	Northern Krill	18	2	0.11	0.23
Point Count	Little Gull	Sea gooseberry	4	0	0.00	1.00
Point Count	Kittiwake	Sea gooseberry	15	2	0.13	0.17

On dates where plankton abundance was higher, was the number of birds recorded also higher?

This analysis considered the relationship between the total numbers of birds recorded on a particular date and total plankton abundance. Plankton abundance was calculated by summing the numbers of plankton across sampling sites. Bird abundance was calculated by summing the number of birds for the two associated bird km for each sampling station across sampling stations.

Irrespective of the bird species, or the plankton species, there was no significant positive correlations between total bird abundance and total plankton abundance across dates (Table 4.44).

Table 4.44 Spearman rank correlation between total bird abundance and total plankton abundance across different dates. P values one-sided testing for positive association between plankton and bird abundance.

Bird species	Plankton species	rs	n	p
Little Gull	Northern Krill	1184.7	20	0.32
Kittiwake	Northern Krill	892.6	20	0.08
Little Gull	Sea gooseberry	1322.1	20	0.49
Kittiwake	Sea gooseberry	1359.1	20	0.54

For sites where mean plankton abundance was higher, was mean bird abundance higher?

This analysis considered the relationship between the mean number of birds recorded at each sampling station and the mean plankton abundance at the same sampling station. Mean plankton abundance for each sampling station was calculated by summing plankton numbers across dates. Mean bird abundance for each sampling station was calculated by summing the number of birds for the two associated bird km across dates.

Irrespective of the bird species, or the plankton species, there was no significant positive correlations between mean bird abundance and mean plankton abundance across different sampling stations (Table 4.45).

Table 4.45 Spearman rank correlations between mean bird abundance and mean plankton abundance across different sites. P values one-sided testing for positive association between plankton and bird abundance

Bird species	Plankton species	rs	n	p
Little Gull	Northern Krill	74	8	0.396503
Kittiwake	Northern Krill	80	8	0.467436
Little Gull	Sea gooseberry	102	8	0.708929
Kittiwake	Sea gooseberry	110	8	0.786062

5. Review of the impacts of offshore wind farms on birds at sea since 2003

5.1 Operating Wind Farms

There are several offshore wind farms currently in operation. Impacts arising from projects that have come into operation since 2003 are discussed below, where information was available. Previous reports have discussed impacts from older projects (e.g. CWC 2006).

Horns Rev - Denmark

Horns Rev is 14 km west-south-west of Blavands Huk on the west coast of Denmark. This area is important for waterbird migration, as well as holding internationally important numbers of several wintering species. A total of 80 x 1.8 MW turbines are now in operation in water depths of 6.5 to 13 m. The last turbine at Horns Rev was put into operation in December 2002.

Details of baseline and construction monitoring are discussed in CWC 2006. Since the wind farm came into operation, monitoring of the impact of the wind farm on waterbirds in the area has been on-going. The final report on bird studies at Horns Rev was recently published (Petersen *et al* 2006). Studies on the hazards that offshore turbines pose to birds and the physical and ecological effects that these may cause were conducted between 1995 and 2005. A series of hypotheses were tested to see if birds showed reactions to the turbines once erected, relative to their "unaffected" behaviour recorded during pre-construction baseline studies. The effects of the construction of the wind farms at sea could then be predicted from the hypotheses and validated by post construction monitoring and data collection. Studies primarily involved waterbirds, because these species exploit the offshore environment in general, and the study area in particular. Denmark also has a special responsibility for the maintenance of these species populations and the habitats that they use. In addition, many species of waterbird are long lived, with relatively low annual breeding success, which makes them more susceptible to additional mortality.

The studies considered that there are three main potential effects on birds following the construction of a wind farm:

1. Birds avoiding the vicinity of the turbines as a behavioural response to a visual (or other) stimulus. This can have two effects:

- A barrier effect affecting bird movement patterns;
- The displacement of birds from a favoured location, equivalent to habitat loss.

2. Physical changes due to construction (physical habitat loss, modification to bottom flora and fauna and creation of novel habitats, e.g. for resting on the static superstructure).

3. Significant changes to a population as a result of birds colliding with turbines (mortality).

Results of radar studies on migration routes of waterbirds showed that birds generally avoided Horns Rev wind farm, although responses were highly species specific. Some species (e.g. divers and Gannets) were almost never seen flying between turbines, others rarely (e.g. Common Scoter) whilst others showed little avoidance behaviour (e.g. Cormorants and gulls). Overall, at Horns Rev, 71-86 % of all bird flocks heading for the wind farm at 1.5-2 km distance avoided entering the wind farm. There was considerable movement of birds along the periphery of the wind farm, as birds preferred to fly around rather than between the turbines. Changes in flight direction tended to occur closer to the wind farm by night than day at both sites, but avoidance rates remained high in darkness, when it was also shown birds tend to fly higher. Few data on avoidance behaviour were available during conditions of poor visibility, because intense migration generally slows and ceases during such conditions.

Comparison of pre- and post construction aerial surveys of waterbird abundance and distribution in and around Horns Rev offshore wind farm showed that waterbirds generally avoided the turbines (at least during the three years following construction), although responses were highly species specific. Divers at Horns Rev showed complete avoidance of the wind farm area during the three years post construction period, despite being present in average densities prior to construction. Common Scoter were absent from Horns Rev pre-construction, but occurred in large numbers in the vicinity of the wind farm, but were almost never seen within the turbines despite up to 381,000 in the general area. Terns and auks also occurred in the area but were almost never seen within the Horns Rev wind farm post erection. No species demonstrated enhanced use of the waters within the Horns Rev wind farm after the erection of turbines.

It was considered that the proportion of birds displaced from potential feeding habitat (as a result of the construction of the wind farm) was relatively small and therefore unlikely to be significant. However, additional impacts arising from the construction of other such wind farms may constitute a more significant effect. Consideration of cumulative effects of offshore wind farms along an avian flyway is an important priority in the future. A recent workshop on Cumulative Impact Assessment concluded that while there is not an agreed definition of cumulative impact, it was recognised that a Cumulative Impact Assessment (CIA) report needs to be structured in a way that presents impacts across a specified timescale and from specified sources. In addition, analysis such as Population Viability Analysis (PVA) have the potential to be key in predicting impacts at the wider regional (i.e. biogeographical population) and temporal scales needed for CIA (Norman *et al* 2007).

The avoidance responses shown by waterbirds at Horns Rev mean that many fewer birds come within the risk zone of the rotor blade sweep zone. Radar study results demonstrated that birds may show avoidance responses up to 5 km from the turbines, and that >50 % of birds heading for the wind farm avoid passing within it. Radar studies at Horns Rev also confirm that many birds entering the wind farm reorientate to fly between turbine rows, frequently equidistant between turbines, further minimising collision risk.

Nysted offshore wind farm – Denmark

Nysted offshore wind farm at Rødsand in the Baltic Sea comprises 8 rows of 9 turbines, located approximately 10 km from the Danish coast, south-west of the eastern Rødsand bar and south-east of the western Rødsand bar. The 72 2.3MW turbines were constructed in water depths of 6.5 to 9 m, at the edge of the Femer Belt strait, which is just outside a large bay protected under the EU Birds and Habitats Directives, the Ramsar Convention and by national nature reserve regulations. The wind farm generates sufficient electricity to supply 145,000 single-family houses with renewable energy. The turbines were erected between May and July 2003 and they gradually came into operation from July to mid-September 2003.

The final report on bird studies at Nysted was recently published (Petersen *et al* 2006). Studies showed that the area between Hyllekrog and Gedser Odde is situated on one of the most important migration routes in Northern Europe, with a minimum of 300,000 waterfowl, 15,000 raptors and 200,000 passerines migrating during daytime in September-October. Spring migration peaks in April and May, when up to 43,000 Eider and 4,000 Brent Geese may move through the area. The extent of migration at night through the area is not known in detail. Large numbers of waterfowl are also known to migrate through the waters south of Lolland Falster, with moulting and wintering flocks also recorded in the area.

During the construction phase, it was found that the relative number of flocks of birds crossing the eastern edge of the wind farm area at night was lower than during the base-line period, although this was not consistently significant. This was not found during daytime migration. Hence, construction activities during daytime, which included the presence of several ships, work associated with the foundations as well as occasional noisy activity, did not appear to affect the flight trajectories of birds.

Even if the migration route through the wind farm was less used at night (possibly as a result of the construction work), it was concluded that the effects on flight behaviour were minor, temporal and of relative short duration. The main construction period was completed by summer 2003 and lasted only one spring migration season. Overall, flight trajectories during construction did not change dramatically i.e. the main migration route was located north of the wind farm area just as was observed during the base-line study.

The collision risk potential with structures associated with the construction work would be reduced by the apparent observed avoidance response, at least under conditions of good visibility. However, given that flying birds may be attracted to lights during foggy conditions, the possibilities of increased collision risk during such periods could not be excluded.

Once operational, evidence for effects on birds from the wind farm was based on radar observations of migration routes of waterbirds, passing through the eastern gate of the wind farm. Migration data from the three base-line years were compared with those from autumn 2003, after the wind turbines had been commissioned. Although the results were based on a single year, they suggested that while the mean migration route of waterbirds at night showed no significant change, in daylight, there was a lateral change in migration route towards the south in 2003, which was significant from 3,000 m distance from the eastern gate.

Although these results need cautious interpretation, given that they were based on a single year, they offer some support for the hypothesis that waterbirds adjusted their migratory routes to the south and north as a result of the visual presence of the turbines over an approach distance of 3,000 m, under conditions of good visibility by day.

Although there was a lack of clear directional response by night, the results did show an increase in the variability of track orientation within 1,000 m of the eastern gate, which suggested a reduced response and shorter response distance at night. This supports one of the main predictions under the main hypothesis, namely that at night, reaction distances, in terms of lateral deflection, will occur closer to the wind farm. However, it should be remembered that these were tentative preliminary conclusions that require further study to allow for differences in migration volume and wind conditions.

The overall percentage of waterbirds that passed through the eastern gate of the wind farm area in autumn 2003 (8.9 %) was lower than recorded in the three base-line years (48.1 %, 35.2 % and 23.9 % between 2000-2002 respectively). This result was consistent even when controlling for the effects of wind, time of day (i.e. day versus night) and for the latitudinal position as birds approached the wind farm. By day, 4-7 % of tracks passed the eastern gate, compared to 11-24 % by night. Logistic regression analyses on these results suggested an active avoidance of entering the eastern gate, compared to the base-line results, that was not explained by prevailing wind conditions. These preliminary results also suggested that because of this avoidance, the potential collision risk was reduced by waterbirds adjusting their migration routes at some distance from the wind farm.

Long-tailed Ducks showed statistically significant reductions in density post construction in the Nysted wind farm (and in sectors 2 km outside) where they had shown higher than average densities prior to construction. This strongly suggests major displacement of this species from formerly favoured feeding areas, although the absolute numbers were relatively small and therefore of no significance to the population overall.

No species demonstrated enhanced use of the waters within the wind farm after the erection of turbines, but it was clear, for example amongst Cormorants at Nysted, that the wind farm area was used occasionally for social feeding by very large numbers of birds post construction.

The Nysted Thermal Animal Detection System (TADS - a remote infra red video monitoring system) and radar studies confirmed that waterbirds (mostly Eider) reduced their flight altitude within the wind farm, flying more often below rotor height than they did outside the wind farm. A stochastic predictive collision model was developed to estimate the numbers of Eiders, the most common species in the area, likely to collide with the sweeping turbine blades each autumn at the Nysted wind farm. Using parameters (including those described above) derived from radar investigations and TADS, and 1,000 iterations of the model, it was predicted with 95 % certainty that out of 235,000 passing birds, 0.018 - 0.020 % would collide with all turbines in a single autumn (41-48 individuals), equivalent to less than 0.05 % of the annual hunt in Denmark (currently c. 70,000 birds). With such a low level of probability of collision expected at any one turbine, it was predicted that the TADS monitoring system would fail to detect a single collision of a waterbird during more than 2,400 hours of monitoring that was undertaken at the site, and this proved to be the case. This level of monitoring resulted in a mere 11 bird detections well away from the sweep area of the turbine blades, 2 passing bats, two passing objects that were either small birds or bats, a moth and one collision of a small bird.

Kentish Flats Offshore Wind Farm - England

Kentish Flats Offshore Wind Farm was given consent in March 2003. The Danish power company Elsam purchased the project from Global Renewable Energy Partners in November 2003. Since July 2006 Elsam has become part of other, larger power companies and today Kentish Flats is owned and operated by Vattenfall.

The foundation installation began in summer 2004 and the installation of the turbines began in late May 2005. Commissioning of the entire wind farm took place in September 2005. The 30 turbine project was the largest wind farm in the UK in 2005. The site is a large, flat and shallow plateau in Herne Bay, north of Whitstable approx. 60 km east of central London. The wind farm is arranged in a regular grid of five east-west rows each of six turbines, sited in an area of 10 km^2 just outside the main Thames shipping lanes. The spacing between each turbine and rows of turbines is 700 meters. The wind farm is connected to the overall grid via three buried cables from the wind farm to the shore, which continues onwards by buried cables to the onshore sub-station. The generated electricity is fed into the electricity network via a sub-station at Herne Bay for use in the local grid serving the needs of the communities of North Kent around Canterbury, Herne Bay and Whitstable. The water depth is on average five meters.

The use of the Kentish Flats wind farm site by bird species was investigated by site-specific bird surveys which continued throughout the planning and construction phase. The assessment of impacts on bird species concluded that disturbance or collision effects on feeding, roosting, breeding or migratory behaviour of all bird species would not be significant due principally to the small numbers of birds recorded at the site. A possible exception was the potential disturbance of feeding diver species in winter, as a result of piling operations during the construction phase, if they occurred between November and March. However, this impact was reduced by mitigation so that it was not considered significant. It was also considered that noise from by cabling operations could disturb wading bird species, but mitigation suggested avoiding the sensitive roosting and over-wintering periods. Numerous sites around the Thames Estuary coastline are designated for their conservation interest. No direct impacts on any of these sites were predicted as a result of construction, operation or decommissioning (Global Renewable Energy Partners 2002). No monitoring reports regarding impacts on birds during the construction and operational phases to date were available.

Scroby Sands Wind Farm - England

Scroby Sands wind farm is located approximately 2.5 km off Great Yarmouth, Norfolk. It consists of thirty 2 MW wind turbines, giving a total generating capacity of 60 MW. Construction began in October 2003 on the shallow, submerged northern section of Scroby Sands, and the wind farm was commissioned in December 2004.

Initial consultations identified the colony of 200 - 300 pairs of Little Terns on the coast opposite the Sands as the most important ornithological issue. There were also concerns about potential turbine collisions for migratory waterfowl as they arrive and depart from nearby coastal wetlands. These breeding and wintering sites are SPAS under the EU Birds Directive.

Surveys of the feeding usage of the Sands by Little Terns in 1995 and 1999, showed that up to one third of the colony fed in an area of sheltered water 1 - 2 km south of the wind farm site, at low tide. Less significant numbers of common terns also fed there. It was concluded that there would be no significant impact on breeding terns, given the separation between the feeding area and the wind farm. It was also noted that little terns nest in close proximity to a coastal wind farm in Cumbria. It was recommended however that monitoring of the little terns should be continued after construction of the wind farm.

Worst case analyses of the collision risk for the most sensitive migratory waterfowl species in the area, estimated that up to 310 Bean Geese and 750 Bewick's Swans might pass through the site twice a year. The analyses demonstrated insignificant collision risks. Risks to migrating landbirds were also considered to be negligible.

No seabird surveys were conducted around the site. However, a desk analysis of previous JNCC seabird surveys to assess the significance of the site for seabirds showed numbers of seabirds in the area were very low and therefore any losses due to disturbance or collisions would be insignificant. It also concluded that red-throated divers in the area would be unlikely to be significantly disturbed, given that the species nests close to onshore turbines in Orkney (Powergen Renewables 2001). The lack of a dedicated seabird survey of the wind farm may be a weakness in the seabird assessment, given that the standard JNCC surveys may not have surveyed the shallow Sands area adequately. No monitoring reports regarding impacts on birds during the construction and operational phases to date were available.

Barrow Offshore Wind Farm – England

British and Danish energy groups Centrica and DONG Energy have developed a 90 MW wind farm in the East Irish Sea approximately 7 km south west of Walney Island, near Barrow-in-Furness. Initial plans for Barrow Offshore Wind Farm (BOW) were promoted by Warwick Energy Limited and full consent was granted for the development in 2003, prior to BOW's acquisition by Centrica and DONG. The wind farm has 30 3MW turbines and was completed in June 2006 with generation of first power in March 2006.

The wind farm is a rectangular site covering an area of approximately ten km^2. The 30 turbines are in four rows, two with seven turbines and two with eight. The turbines are spaced 500 m apart and the rows are spaced 750 metres apart. No monitoring reports regarding impacts on birds during the construction and operational phases to date were available.

North Hoyle Offshore Wind Farm - Wales

North Hoyle Offshore Wind Farm is located approximately 7.5 km from the North Wales coast off Prestatynl and Rhyl. Construction began in April 2003, with first power generation in November 2003. The project consists of 30 wind turbines, each rated at 2 megawatts.

The North Hoyle site possesses a number of attributes as a location for an offshore wind farm, including an excellent wind resource and no known environmental sensitivities. No significant environmental impacts were identified by the EIA. The site is beyond the foraging range and water depths preferentially selected by most of the important seabird populations in the bay. Surveys on the North Hoyle site have not identified any bird population sizes that could require European designation. Surveys during 2000/2001 have identified wintering populations of common scoter and red-throated diver in Liverpool Bay, however North Hoyle was considered to be of negligible importance as a feeding area for these birds during the breeding season. No significant movements of important populations through North Hoyle were observed or would be expected. (NWP Offshore Ltd. 2002).

The overall conclusion from the EIA was that the North Hoyle offshore wind farm would not significantly affect bird populations (NWP Offshore Ltd. 2002). No monitoring reports regarding impacts on birds during the construction and operational phases to date were available.

Burbo Bank Offshore Wind Farm – England

The Burbo Bank Offshore Wind Farm in Liverpool Bay was granted consent to build in July 2003. The offshore construction phase was split into two seasons. In spring and summer 2006 foundations and cables were installed and in spring and summer of 2007 the turbines were installed and commissioned. The wind farm was officially opened on 18th October 2007. The Burbo offshore wind farm is situated on Burbo Flats in Liverpool Bay. At its closest point, the site is approximately 6.4 km (4.0 miles) from the Sefton coast line and 7.2 km from North Wirral. The wind farm consists of 25 wind turbines, each with a rated capacity of 3.6 MW, with an overall maximum output of 90 MW.

Key species considered in surveys of the site included common scoter, red-throated diver, common tern, cormorant, red-breasted merganser, auks and little gulls.

With the exception of red-throated diver, the significance of impacts on all species and groups of species was assessed as being low to very low. Although the risks of impacts on red-throated divers were considered to be low, the high sensitivity of the species led the ornithological consultants to conclude that the significance of impacts should be regarded as being of medium level, rather than low. Overall it was deemed that Burbo Offshore would not have a significant effect on bird populations within, or passing through Liverpool Bay. (Seascape Energy Ltd. 2002). No monitoring reports regarding impacts on birds during the construction and operational phases to date were available.

Egmond aan Zee Offshore Wind Farm – The Netherlands

The Egmond aan Zee wind farm is the first offshore wind farm built in the North Sea off the Dutch coast. Consented in 2002 and becoming operational in 2007, the wind farm comprises 36 wind turbines, each with a capacity of 3 MW. The wind farm is located 10 to 18 kilometres from the coast at Egmond aan Zee, and the total area covers around 27 km2. The Dutch Ministry of Economic Affairs has clearly designated the wind farm as a demonstration project.

The wind farm is linked to a comprehensive Monitoring and Evaluation Programme that is being carried out in cooperation with leading research institutes. The programme aims to fill the gaps in knowledge and experience in the field of technology, economy, nature and environment. Consequently there are two parts to the NSW-MEP: Ecology and Technology. The total research programme started during the construction period in 2006 and will run until 2012.

Prior to the construction of the wind farm the Dutch government conducted an extensive on-site study. Seabirds were monitored in 2002-2004 in eight ship-based surveys. Bird counts were performed with binoculars from a sailing ship in a study area of ca 900 km_2, including the future wind farm. The area was sampled by sailing ten equidistant parallel transect lines, perpendicular (east-west) to the coast. The surveys were scheduled throughout the year, in order to include important bird features such as breeding, moulting, migrating and wintering. Both flying and swimming birds were counted. Counts were performed on both sides of the ship in counting strips (transects) of 300 m long and 'five minutes' wide (ca. 1.5 km), according to standard ESAS protocol. Foraging behaviour, flight altitudes, flight patterns of observed birds, salinity and water temperature were also recorded. Fishing vessels were recorded using radar. Because the monitoring ship itself easily disturbs Eider and Scoter, additional radar studies were carried out in the study on migrating birds (MEP NSW 2006).

Results from the baseline study were not suitable to predict future bird densities and distribution, gave valuable insight in bird behaviour and recent trends in bird numbers and will be used to demonstrate deviations in distribution patterns following construction. Deviations from the expected distribution pattern after construction could be an indication of displacement of birds from their feeding grounds or disturbance effects on bird flight paths due to the wind turbines. Birds can be at risk from both collision and disturbance from wind farms. The risk is relatively high for species with limited population size, particularly if their distribution range is limited to near shore waters (divers, scoters, Little Gull). The risk of collisions is greatest for species that reach altitudes in flight that coincide with the future rotor heights. Such birds are probably most at risk during adverse weather conditions or at night (MEP NSW 2006).

A similar monitoring programme will be run for two to five years and will be able to draw conclusions about the impact of the wind farm on the local environment. The research is to be carried out by independent scientific institutes (MEP NSW 2006).

5.2 Projects with consent/under construction

Inner Dowsing & Lynn Offshore Wind Farms - England

Construction of the Lynn and Inner Dowsing offshore wind farms is underway. Subject to weather conditions, Centrica hopes to have both wind farms operational by the end of 2008. Foundations for the 54 turbines are planned to be installed during 2007, as will the power cables connecting the turbines and the wind farms to shore. Installation of the 3.6 MW wind turbine generators will take place during 2008. Each turbine tower will be approximately 80 m above mean sea level and have a rotor diameter of 107 m, giving a total height to the blade tip of 134 m. The turbines will cover an area of 20 km^2 with the closest row of turbines being 5 km from the coast and the furthest being 9 km offshore. The wind farms will have an operational life of 20 years.

At the Inner Dowsing Offshore wind farm, located 5-7km off the Lincolnshire coast, the principle finding from bird surveys was that the site and surrounding areas surveyed have low populations of birds. The most likely impacts upon species of conservation concern were potential disturbance during construction work to divers feeding within the wind farm area from November to March, and potential disturbance during construction work to gannets feeding within the wind farm area in November and early July. (Offshore Wind Power Ltd. 2002).

At the Lynn Offshore wind farm, there were no recommendations on areas of ornithological interest to be avoided, as there were no significant impacts predicted upon birds from the construction, operation and decommissioning.

Monopiling work, will be avoided during the peak diver season (from November to March), and the peak Gannet periods in November. For work during early July, Gannet numbers will be observed and where a critical threshold is reached, ornithological advice will be taken. No divers, Gannets, Guillemots or any other species seen within the wind farm study area were expected to be displaced in their distribution once the wind farm is built. No mitigation measures were considered necessary for flight line disruption potentially caused by the operation of the wind farm. Collision risks were considered to be insignificant as birds take avoidance action whenever possible. (AMEC 2002).

Greater Gabbard Offshore Wind Farm - England

The Greater Gabbard Offshore Wind Farm will feature up to 140 turbines, located around two sand banks known as the Inner Gabbard and The Galloper, approximately 23 km off the coast of Suffolk. The energy produced by this 500 MW wind farm will be enough to power over 415,000 homes, more than the domestic demand of Suffolk. Subsea cables landing at Sizewell near Leiston in Suffolk will export the power that is generated. Underground onshore cables will connect these subsea cables to a new sub-station, to be built near the existing Sizewell Nuclear Power Stations. An application for consent for these offshore works was submitted in October 2005 and consent was granted in early 2007.

Between February and March 2004, the study area surveyed encompassed 487 km^2 over 10 transects. The entire study area from April 2004 spanned 730 km^2, comprising the wind farm footprint, and the reference area comprising the surrounding buffer zone and two control areas, over nine transects. The area of study was changed in accordance with revisions to the location and alignment of the proposed wind farm (Banks *et al* 2005).

Marine mammal surveys were undertaken concurrently with the boat-based bird surveys. For both areas, surveys were spread over on consecutive days, where weather allowed. The field methods used were adapted from Webb and Durink (1992) and have been developed to maximise accuracy, repeatability, and suitability for two observers, remaining consistent with COWRIE recommendations (Camphuysen *et al.* 2004). Transects were spaced at 1.8 nm intervals, running parallel to the coast for the first three surveys, and perpendicular to the coast thereafter, and also conform to COWRIE recommendations (Banks *et al* 2005).

Two trained observers were present on the observation deck, itself 8 m above sea level, both counting birds simultaneously. One observer scanned through an arc of 90° to the port side, the other 90° to the starboard side. Marine mammal sightings were noted by the two trained mammal surveyors on board. The position of each sighting was recorded by estimating the animal's position in relation to the boat. Visual scanning was carried out continuously, using the naked eye to detect all birds on the sea or marine mammals (within the transect) on the surveyor's side of the boat and, with lower priority, birds seen in the air (Banks *et al* 2005).

The period of each recording sequence was two minutes. The majority of each two minute period was devoted to counting water-borne birds or marine mammals that fell within predetermined 'distance bands', defined as being up to 300 m perpendicular to the boat. This method was effectively a line transect method, that subsequently allowed analysis using distance sampling techniques (Buckland *et al.* 2001).

Surveys commenced in April 2004 and were undertaken on a monthly basis, as weather conditions permitted, until July 2005. During the earliest surveys (February 2004 – March 2004), transects were designed to run parallel to the coastline, and coverage of the ten transects typically took two days. From April 2004, the design of the survey changed so that transects ran perpendicular to the coast. Nine transects were travelled, usually over two days. The 'short legs' travelled between main transects to preserve the spacing of 2 km were often used to make additional bird counts on these surveys (Banks *et al* 2005).

These surveys continue to be undertaken. As far as possible, no survey was conducted in a Beaufort sea state of more than 3; in line with current guidance on survey techniques (Camphuysen *et al.* 2004). However, on occasions the sea stare did exceed this for short periods. A total of 16 surveys were included in the analysis undertaken for the EIA (Banks *et al* 2005).

Very few species were estimated to occur in numbers approaching national importance in the Greater Gabbard area, even when considering the entire survey areas of 730 km^2 and 1,060 km^2 employed by the later boat surveys and the aerial surveys. Red-throated Divers were estimated to be present in nationally important numbers on one survey only (March 2004), whilst Black-throated Divers were recorded in similarly important numbers (depending on choice of threshold) on the same survey. These results were not repeated in the second winter of survey, however. Lesser Black-backed Gulls were estimated to occur in nationally important numbers on one occasion (March 2005), whilst Great Black-backed Gull estimates approached national importance (0.94 %) in December 2004. Great Skua peak estimates on one occasion exceeded the national importance threshold; as this count was in September, it may have included birds on passage (Banks *et al* 2005).

An assessment of regional importance was made, based on numbers estimated to be present in the Greater Gabbard study area and the neighbouring study areas in the wider Thames offshore region, using winter aerial surveys. This technique suggested that many of the marine species for which wintering estimates are not known did occur in at least regionally important numbers. For example, within the Greater Gabbard study area, peak winter numbers of Fulmar and Kittiwake represented 93 % and 45 % of the regional total peak numbers respectively. Other species deemed to be at least regionally important included Gannet, Common Gull, Herring Gull, Great Black-backed Gull and the auks (Banks *et al* 2005).

Some sensitive and threatened marine species, such as Common Scoter and Sandwich Tern, were rarely seen in the Greater Gabbard area by either survey method. It does not appear that this area holds any value for wintering seaducks or breeding terns. Cormorants and Shags were also scarcely seen, as these species are more coastal (Banks *et al* 2005).

The EIA assessment showed that the main effects of the wind farm would only be of very low or low Significance to the bird species of conservation importance presently found offshore at Greater Gabbard and onshore at Sizewell. The risk of collisions for migrating skuas perhaps posed the greatest threat to bird life offshore. It should be noted, though, that the actual effects on bird mortality and thus populations of displacement following disturbance / habitat loss are difficult to predict or monitor. Given present knowledge, however, none of the effects appeared significant in terms of EIA Regulations (Banks *et al* 2005).

London Array Offshore Wind Farm – England

The proposed wind farm will be situated midway between the Kent and Essex coastlines, more than 20 km (12 miles) from each shore. It will consist of up to 271 turbines, installed on the Long Sand and Kentish Knock banks and in the Knock Deep channel that lies between. It will occupy an area of up to 245 km^2 in water depths ranging from 0 to 23 m.

In 2006, Swale Borough Council refused planning permission for an electricity substation at Cleve Hill. London Array appealed against the decision and, following a Public Inquiry in March 2007, consent for the substation was granted in August 2007. `Work on the first phase of the wind farm is now planned for 2009 (London Array 2007).

For the original EIA, a comprehensive programme of field bird surveys was undertaken for two full years plus an additional third winter, which has provided a detailed picture of how bird populations are using the proposed wind farm area and its surrounds. This has included a total of 30 boat-based surveys (carried out at approximately monthly intervals), 14 aerial surveys of the main aerial survey area (focussed primarily on the mid-winter period when the ornithological importance of the area was highest, though with some during summer too) and a further 4 aerial surveys of the wider region (RPS 2005).

Boat surveys were undertaken within a study area that included all of the proposed wind farm site, plus a buffer around that site. The extent of this buffer area was designed to include at least 2 km from the proposed wind turbine locations, though in some parts extended as far as 6 km. Aerial surveys were undertaken over a much wider area, to provide additional information on the wind farm site itself and also its local and regional context. Initially during August 2002 through to January 2004 this included an area of 2,750 km^2, comprising most of the outer Thames estuary. In February 2004 this area was extended to include the other two Round 2 offshore wind farm licence areas in the Thames region at Greater Gabbard and Thanet, and in winter 2004-05 over a greater area to the north (along the Suffolk coast) and south (along the whole Kent coast) to extend the regional context. The extended areas formed part of the overall extended programme of aerial survey undertaken by WWT under contract to the DTI. Additional data were also available from the adjacent Greater Wash count sectors too (including the area around the Scroby Sands wind farm).

Survey work found that high numbers of divers (predominantly Red-throated Divers) were recorded from December through to March, with few birds present outside this period and none recorded during May-September. The February surveys in 2004 and 2005 both recorded very high numbers of divers. In February 2004 a single flock of 4,000 birds was seen flying through the area. These birds were heading low (<10 m above the sea) northeast, parallel to the survey transects, with no indication that they were specifically using the boat survey area (other than over-flying it). Similar high numbers were recorded during the aerial survey in this period. The February 2005 survey found two large flocks of divers on the sea over sandbanks. Although these diver numbers were exceptional, numbers during the other winter surveys were also high, with a relatively high proportion of birds being seen in the wind farm site (plus a 1 km buffer) (RPS 2005).

As part of the EIA, surveys were commissioned during February and March 2005 to directly observe the behaviour of divers within the Thames Estuary in response to vessel movements). The response of divers was observed closely in response to the approach of the survey vessel. It was found that whilst there were few clear patterns for flocks, it appeared that most individuals flew at approximately 90° to the survey vessel route and then tended to continue to fly in the direction of their initial take-off. The very large majority of birds observed flew below rotor height. The implication of these findings is that disturbed divers will tend to displace away from the source of disturbance through low, direct flight. It was concluded, therefore, that disturbed birds are at low risk of collision with turbines (RPS 2007).

Overall the EIA identified only a single bird group that would be likely to be significant affected by the proposed development, divers (primarily red-throated and to a lesser degree black-throated), using a precautionary worst-case assessment. The main impact on these birds would be likely to be displacement from a zone around the wind turbines (though the extent of such a zone is uncertain), and to a lesser extent collision risk (though these two impacts would be likely to be mutually exclusive). The main concern was not so much that there would definitely be a significant impact but that the current state of knowledge of such species at offshore wind farms and at the proposed scale of the London Array site is not sufficient to be able to conclusively demonstrate that a significant effect would not occur (RPS 2005).

Lower significance effects would also be likely to occur on a range of other species, including gulls, other seabirds, and migratory waterfowl, but none of these would be likely to be significant in the context of the EIA Regulations (RPS 2005).

Gunfleet Sands 1 & 2 Offshore Wind Farms - England

The Gunfleet Sands 1 project received consents in 2003 and 2004 to construct up to 30 turbines, each of a maximum capacity of 3.6 MW, thus yielding a total capacity of 108 MW. The proposed extension, Gunfleet Sands 2, was awarded a lease option agreement by Crown Estate in December 2003 and includes up to 22 turbines with a maximum total capacity of 64 MW. If Gunfleet Sands 2 is consented the aim is to develop both projects at the same time. The construction phase for the total project comprising Gunfleet Sands 1 and 2 will commence in the first half of 2008 and turbines will be installed during 2009.

Bird surveys for the Gunfleet Sands 1 project involved 23 boat surveys undertaken at the Gunfleet Sands site in South-eastern England between October 2001 and June 2002. The survey information indicated that the Gunfleet Sands are used by a variety of marine or semi-marine species of birds and that they occur in low to moderate numbers. The area occupied by the development did not represent a key or unique habitat for the marine birds of the wider Thames estuary. The choice of this site for the development avoided the more sensitive mudflat and saltings habitats used by waders and wildfowl of the Essex coast. Flight line records indicated that the project was unlikely to alter the movements of these groups of birds along the Essex coast.

Boat surveys of the Gunfleet Sands 1 survey area have continued since the submission of the Environmental Statement, as it was agreed that surveys would continue following consent in order to establish a baseline against which the effects of wind farm construction and operation can be evaluated. An interim report of the results collected during the period July 2002 – December 2004 was produced in February 2005. The Gunfleet Sands 2 Environmental Statement presented survey results collected during the period January 2005 – February 2007. Since November 2004 monitoring surveys have been undertaken over a revised survey area of approximately 126.7km². The revised survey area fully covers Gunfleet Sands 2 as well as adjacent buffer and reference areas, between 2-4 km of the wind farm boundary (RPS 2007).

Aerial surveys were flown within the region of the wind farm between March 2005 and August 2006. In addition, data from aerial surveys conducted for the Gunfleet Sands 1 EIA, collected over the period 2002-2003, was also considered within the Gunfleet Sands 2 EIA (RPS 2007).

The Gunfleet Sands 2 EIA reported that the most abundant species recorded in the wind farm area were Common Scoter, Diver species/Red-throated Diver, Gulls, and Guillemot. Within the 1 km buffer zone beyond the actual wind farm area the numbers of divers recorded increased above the UK 1 % threshold (49 birds), with a peak count of 139 birds, just over 30 % of the total survey area peak count (447 birds). Gull species also increased although numbers were still considerably lower than the peak counts (RPS 2007).

Within the 2 km buffer zone there was a further increase in the numbers of divers recorded, with the peak count of 239 birds equating to over 50 % of the peak count across the entire survey area. Numbers of gulls also increased with the greatest increase observed for Herring Gull. The peak count of Guillemot recorded (162 birds) in the 2 km buffer equated to over 50 % of the peak count (363 birds) across the entire survey area, however the numbers recorded did not indicate a population of conservation importance (RPS 2007).

Apart from gulls, relatively few birds were observed at rotor height (taken to be heights above 15 m), although a total of 52 divers (approximately 5.8 % of all diver records) and 21 swans (presumably Mute Swan) were recorded above 15 m. Of the gulls, Lesser black-backed Gull (45 % of all flights recorded) and Herring Gull (28 % of all flights recorded) were the most numerous species recorded above 15 m, followed by Common Gull (23 % of all flights recorded). The majority of Kittiwake flights (75 %) occurred between 5-15 m (RPS 2007).

The Gunfleet Sands 2 site was found to be unlikely to support significant numbers of waterfowl. The surveys identified that the Gunfleet Sands 2 site did not support significant populations of species that were of importance with respect to coastal designated sites. There was also no indication that any of the species from these sites regularly passed through the site (RPS 2007).

A systematic assessment of the potential impacts arising from the proposed construction, operation and decommissioning of the wind farm, alone and in-combination with other developments in the Thames Estuary was undertaken and it was concluded that in all cases the overall effects were likely to be negligible or low. When these predictions were combined with sensitivity on a species by species basis it was concluded that there would be no impacts of Medium, High or Very High significance (RPS 2007).

In addition the EIA considered potential impacts on bird populations associated with sites of importance for nature conservation including coastal SPAs and the Thames Estuary potential SPA. Where it was thought likely that some or all individuals of a species observed within the wind farm survey areas formed part of a qualifying population for a SPA then the sensitivity of that species was considered Highly Sensitive. For some species this was considered to be a highly precautionary approach. In all cases, however, a significant effect on SPA populations, including the Thames Estuary potential SPA, was not predicted for Gunfleet Sands 2, either alone or in combination with other developments or activities (RPS 2007).

Ormonde Offshore Wind Farm – England

The proposed Ormonde Offshore Wind Farm will be located in an area approximately 4.0 x 2.5 km, located about 10 km offshore off Walney Island in Cumbria and adjacent to the 30-turbine 90MW Barrow Offshore Windfarm which has been in operation since 2006. The proposal is to install 30 x 3.6 MW wind turbines within the area, with a total generating capacity of 108 MW. Two small gas fields will also be developed alongside the installation. The project was given consent in February 2007. Offshore construction is planned to commence in 2008, with first energy generated in 2009.

Detailed birds surveys were undertaken to gain a fuller understanding of the fauna in the Ormonde and surrounding area. Studies included monthly ship based and seasonal aerial surveys between May 2004 and April 2005, a survey of autumn migrating wildfowl and collation of shoreline bird count data from the proposed cable landfall at Heysham. The results indicated that compared to the adjacent areas of Morecambe Bay and Shell Flat, the project area was of no particular significance to breeding, feeding or roosting birds, although a number of migrant species, such as Pink Footed Geese, did use the airspace as part of the much larger East Irish Sea flyway. It was concluded that no bird group would be likely to be significantly affected by the presence of the Ormonde Project, even when using a precautionary worst-case assessment. A range of low/negligible impacts would be likely to occur on a variety of species, including resident gulls and other seabirds, and migratory waterfowl, however, none of these would be likely to be significant in the context of the EIA Regulations (Eclipse Energy 2005).

Thanet Offshore Wind Farm – England

The Thanet project is located approximately 11 km to the east of Margate, Kent. The development is planned to be in place in 2008. The Thanet project is expected to have a total capacity of up to 300 MW, with between 60 and 100 turbines, depending on the size chosen. The project was given consent in December 2006. Work on the turbine foundations is planned to commence in September 2008 and the turbines will be installed in the summer and autumn of 2009.

Aerial and boat based bird surveys were conducted as part of the EIA. The surveys showed very low numbers of seabirds using or flying over the Thanet site. Those recorded included Razorbill and Guillemot, small numbers of terns, Red-throated Divers and gulls. Other seabirds included Fulmar, Kittiwake and Gannet with Common Scoter seen rarely.

The EIA showed that due to the low number of birds recorded at the Thanet site and the fact that they generally flew near to the surface of the sea, impacts were negligible to minor adverse. Disturbance to the important overwintering populations of birds within Pegwell Bay would be avoided by installing the cables outside the winter period (November to March) (Warwick Energy 2005).

Walney Offshore Wind Farm – England

The Walney project will be located 14 km west of Isle of Walney in the East Irish Sea. Concession allows for generating capacity of up to 450 MW and up to 216 turbines. The project is fully owned by DONG Energy.

A two-year bird assessment was undertaken between 2004 and 2006 for the EIA. Boat surveys started in May 2004 and aerial surveys have been conducted, first in 2002 and regularly since February 2004. The surveys covered the wind farm site and surrounding waters, to obtain a good picture of the bird species living and foraging at Walney Offshore Windfarm site (DONG 2006).

Migrating birds, such as Whooper Swan and Pink-footed Goose, were also assessed. In October 2005 a research vessel was placed for a month at the Walney Offshore Windfarm site and recorded migrating birds using horizontal and vertical radar. Simultaneously, a team of ornithologists recorded the occurrence and movements of species at the onshore bird sanctuaries (DONG 2006).

The Walney Offshore Windfarm is located in an area of relatively low bird density. The populations of most species are small, although species of conservation importance are present, including Common Scoter, Herring Gull, Lesser Black-backed Gull, Manx Shearwater, Pink-footed Goose, Red-throated Diver, Sandwich Tern and Whooper Swan. The observations of Manx Shearwater indicated that they may feed in the western part of the boat survey area. Although some of these records were within the western part of the proposed Walney Offshore Windfarm, the majority were located several kilometres to the west of the wind farm boundary and may be associated with deeper water. During July and August, Manx Shearwaters were present in considerable numbers at the western part of the site. The construction of the wind farm may result in displacement of this species, but the impacts were assessed as only minor in nature. The impacts of the wind farm on habitat loss and displacement on all other were also assessed, and it was concluded that the impacts may be regarded as negligible (DONG 2006).

With regard to migratory species, the investigations revealed that only a few Whooper Swan and Pink-footed Geese passed the site when migrating, and the impacts from collision and barrier effects were assessed to be negligible. Common Scoter flew through the site, but always at heights below the rotor blades, so it was concluded that the risk of these ducks colliding with turbines was negligible. There was a low collision risk for other species. In total the impacts of the windfarm on bird species were assessed to be negligible (DONG 2006).

An additional ornithological report as an addendum to the Walney Offshore Windfarm Environmental Statement reporting on results of aerial surveys undertaken between October 2005 and February 2006 was submitted in March 2007 (DONG 2007). The project has been given consent (BWEA 2007).

Teeside Offshore Wind Farm – England

Teeside Offshore Wind Farm is currently being developed by EDF Energy. The project's proposed location is 1.5 km offshore between the mouth of the River Tees and the town of Redcar, Teesside. The wind farm, which has been given consent (BWEA 2007), will have 30 turbines and a generating capacity of 90 MW.

The requirement for wind farms to be a minimum of 8 km from shore and 13 km from Sites of Special Scientific Interest (SSSI) only applies to Round 2 developments as these are designed to house a significantly greater number of larger turbines, than those proposed for Teesside.

In relation to birds, the developers agreed the scope of the ornithological studies as part of the EIA in conjunction with both English Nature and the RSPB. The ornithological study consisted of a comprehensive programme of boat, shore-based and aerial surveys undertaken by specialist ornithologists during 2002 and 2003.

In addition, all potential impacts on the Special Protection Area (SPA), SSSI (Site of special scientific interest) and Ramsar sites were extensively studied as part of the comprehensive Environmental Impact Assessment (EIA) carried out for the proposed wind farm.

These results were then examined in a longer term context using additional data from the Tees Estuary and Hartlepool Bay Wetland Bird Survey (WeBS) counts and from long term bird records kindly supplied by Teesside Bird Club. The results indicated that there would not be a significant impact for any species (EDF Energy 2004). No further information was available for this project.

Rhyl Flats Offshore Wind Farm – Wales

National Wind Power Limited has completed the purchase of the offshore wind farm site at Rhyl Flats, approximately 10 km off the North Wales coast. The project was initially developed by Celtic inshore Wind Power Ltd. The wind farm was given consent in December 2002 and is expected to consist of 25 3.6 MW turbines, with a maximum output of 90 MW.

In July 2007, offshore foundation construction at the Rhyl Flats Offshore Wind Farm site started with installation of the scour protection. Installation of the foundation piles themselves will commence in April 2008, marking the start of the main offshore works period. The first turbines are expected to start generating in November 2008, with project completion anticipated in July 2009.

The EIA concluded that there may be some general disturbance effects during construction when birds normally using the area will maintain a stand-off distance from the works, but that in general the effects during operation will be limited and were not considered to be significant, particularly as the wind farm development will not give rise to any impacts on sites designated for nature conservation interest. It is also possible that there will be creation of new marine habitat around the turbine bases which may create new foraging habitat for birds. With the exception of Cormorant, few species were considered likely to forage in the area of the wind farm because of its distance from the shore and the depth of water.

Common scoter, which occur in nationally important numbers in the study area, was considered to be the main benthic feeding bird species which could be affected by habitat loss. However, significant impacts were not predicted because benthic habitat loss will be small, their preferred food source is scarce in the location of the wind farm and scoter numbers are low in the months when most construction activity is likely to take place (April to August). Moulting common scoter could be affected by laying of the subsea cable. However, the work period will be short.

Modelling indicated that collision risk was greatest for red-throated divers, but that no significant impacts were likely. Proposed lighting for the site was designed to reduce the risk of attracting birds to the turbines. Bird flight lines were not expected to be significantly affected as there will be a gap of 335 m between rotor blades to reduce the risk of a barrier effect from the turbines.

As part of the EIA, the impacts of the proposed wind farm at Rhyl Flats were assessed in conjunction with the nearby North Hoyle wind farm project. The development of both the North Hoyle and the Rhyl Flats offshore wind farms will result in a slight increase in the extent and intensity of the effects on seascape and landscape character, compared to the development of either project on its own. It has been found however that these heightened impacts relate to altered views in Colwyn Bay: and to terrestrial archaeology. No other potential negative cumulative impacts were predicted. (Celtic Offshore Wind Ltd. 2002).

As part of the licence obligations, monitoring of birds and marine wildlife that inhabit the area is ongoing. Of particular interest are over-wintering sea birds including Common Scoter and Red Throated Diver. The monitoring will establish current populations, and will continue during construction and operation of the wind farm, thus allowing valuable data on the effects of offshore wind farms on marine species to be collected. No monitoring reports regarding impacts on birds were available.

Scarweather Sands Offshore Wind Farm – Wales

The Scarweather Sands Offshore Wind Farm scheme is located in Swansea Bay to the west of Porthcawl. The development will consist of 30 turbines with a total generating capacity of up to 108MW. Although approved in 2004, the project has now apparently been postponed until 2008/9 because the scheme is not currently financially viable (E.ON 2005). No further information on the project was available.

Beatrice Offshore Wind Farm – Scotland

The Beatrice demonstrator project consists of two deep water wind turbines of 5MW capacity located on the seabed in approximately 45 m of water and about 1.6 km and 2.3 km from the Beatrice Alpha oil platform, linked by a subsea cable. Lasting for approximately five years, the demonstrator project will be used to examine the feasibility and benefits of creating a commercial deepwater wind farm at this site. The first turbine was installed in summer 2006, and the second turbine was installed in August 2007.

A year-long survey of birds at the Demonstrator site was completed by experienced ornithologists. The survey programme, which was discussed with JNCC and RSPB both before and during the survey, did not follow the methodology adopted for other, commercial scale wind farms. Rather, the Beatrice programme was designed to obtain very site-specific data about the use that birds made of the offshore area in which the Demonstrator Project would be located, using the nearby Beatrice Alpha installation as an observation platform. It was recognised that the Beatrice platforms themselves and the day-to-day offshore activities associated with oil and gas operations in the area might already be influencing the local presence, distribution and activities of bird. It was, therefore, concluded that a survey programme focussed on the Beatrice site, and the area of the Demonstrator turbines in particular, was most appropriate for the purposes of the proposed, small-scale Demonstrator Project.

Observations were made from the nearby Beatrice platform, situated 1,581 m and 2,331 m to the north-west of the proposed locations for the turbines respectively. Two vantage points were used to give a view from the platform to the south-east, overlooking the Demonstrator site. One was located at a height of 30 m and the other 41 m above sea level. Vantage point watches lasting five to nine hours were conducted for two consecutive days, giving a total of 171 hours of observation in 2005. Two periods of observation were undertaken each month during August and October, when bird numbers were expected to be higher as a result of seasonal migration.

Bird studies showed that auk species, Great black-backed Gulls, Herring Gulls, Gannets, Fulmars and Kittiwakes were the species most likely to interact with the turbine blades.

The EIA concluded that the effects of the Demonstrator Project on birds, and in particular species which are the qualifying interests of adjacent SPAs in the Moray Firth, were likely to be small. The turbines will occupy a small area of the Smith Bank in which birds were seen flying, “loafing” and occasionally feeding. The turbines would not present a major barrier to migrating birds, nor would they exclude or displace individuals from important feeding areas.

With the exception of Great black-backed Gulls, the additional potential increase in natural mortality of the Moray Firth bird populations as a result of the presence of turbines was estimated to be <1 %. For Great black-backed Gulls, the potential mortality was estimated to be about 2.5 % of the natural mortality of the population. This was based on an estimated average number of 8,000 birds in the Moray Firth area, and must be treated with caution, since numbers of Great black-backed Gulls in the Moray Firth vary significantly with the season (Talisman Energy 2005).

Robin Rigg Offshore Wind Farm - Scotland

The 180 MW Robin Rigg Wind Farm will consist of 60 three MW turbines and will be located on a shallow sandbank approximately 6.4 miles from the Scottish coast and 7.1 miles from the English coast, in the middle of the Solway Firth. The project was consented in March 2003, and construction began in summer 2007, with commissioning anticipated in 2009.

The EIA concluded that direct loss of habitat through the construction of the turbine bases and cabling would be of such a small scale that they would not be significant in terms of their impact on bird habitats. For most species, the magnitude of the collision risk was deemed to be negligible, and none of the overall collision risks that would be likely to result from the proposed offshore wind farm were deemed to be significant (Natural Power 2002).

In terms of indirect effects, the wind farm could potentially affect local bird populations by disturbing them and displacing them from an area around the turbines. For the two species that occurred in the study area in nationally important numbers, Red-throated Diver and Common Scoter, displacement zones of more than 5 km and 3 km respectively would be needed to create a significant impact. Given that the maximum displacement distance that has been demonstrated at existing wind farms is 800 m, it was concluded that disturbance to these species would be very unlikely (Natural Power 2002).

The proposed mitigation measures included maximising the distance from internationally and nationally important nature conservation sites; avoiding known bird concentrations and maximizing distance from nationally and regionally important seabird breeding colonies. Ongoing monitoring is proposed (Natural Power 2002).

Codling Bank Offshore Wind Farm - Ireland

The Codling Wind Park would be a 220 turbine offshore wind farm on the Codling Bank, 13 km off the east coast of Ireland between Greystones and Wicklow. The site would be constructed over 3-7 phases, each phase lasting spring and autumn of a single year. Pre-construction monthly surveys were carried out between April 2001 and March 2003 (CWC 2002).

The Codling Bank area was not considered to be of particular sensitivity for birds. The nearest protected area for breeding or over wintering birds lies on the coast at the Murrough, more than 13 km from the wind farm. Nevertheless comprehensive boat and aircraft bird surveys were carried out over an area of more than 580 km^2 to allow a full picture to be formed of the importance of the Codling Bank and the wider area for bird populations of the Irish Sea.

The key species identified in the study area included Manx Shearwater, Guillemot, Razorbill, Shag and Gannet. The most important potential impacts were considered to be disturbance of the birds through construction activity and through movement and noise from wind turbines during the operating period, subsequent displacement of birds from the wind farm area, and collision risks with turbine blades. Collision risks for migrating birds were considered along with resident species.

The response of seabirds to wind turbines is not well understood. However, since the wind farm area did not contain higher concentrations of seabirds than surrounding areas of the Irish Sea, in the absolute worst case assumption that all birds using the site during the baseline surveys would not use it during construction and operation, and moreover would not find other suitable areas, there would be no significant effect on the global or Irish Sea population of any species (CWC 2002).

Collision risks on birds have been broadly estimated through observation of flight heights. At highest tides the minimum distance of rotor blades over the sea surface would be 30 m. Collision risks would be negligible or zero for the four most important species in the Study Area: during monthly surveys 100 % of flying Manx Shearwaters, Guillemots, and Shags, and 99 % of Razorbills, flew at heights below 7 m. More detailed analysis of collision risks for species that were observed flying over 7 m during surveys (but not necessarily above 30 m) - namely Kittiwakes and Gannets - showed that these species were unlikely to be at significant risk of collision with turbine blades (CWC 2002).

A 99 year Foreshore Lease to construct and operate a wind farm on the Codling Bank was issued by the Minister for Communications, Marine and Natural Resources in November 2005.

Lillgrund Offshore Wind Farm – Sweden

This 48 turbine 110 MW project is located in the southern Oresund between Denmark and Sweden, and is Sweden's largest offshore wind farm, lying 7 km from the Swedish coast and 9 km from Denmark. The developers, Vattenfall, acquired the permits to build in 2004. The turbines have been constructed and commercial operation was due to commence in autumn 2007.

The southern Oresund is an important staging and wintering area for waterfowl with a maximum of 40,000 present off the Swedish coast in autumn. Large numbers of migratory landbirds also pass through the site. A bird monitoring programme began in the autumn of 2001 and aimed to monitor the bird presence before, during and after construction of the wind farm and to assess the behaviour of migratory birds as they pass (Green & Nilsson 2001). No monitoring reports regarding impacts on birds during the construction phase were available.

Offshore Wind Farms - Germany

In 2006, a total of 33 applications for offshore wind farms were in various stages of development within the German Exclusive Economic Zone (EEZ) in the North and Baltic Seas (Köller *et al* 2006). A total of 15 offshore wind farms have been approved for the German North Sea EEZ, with another three offshore wind farms approved for the German Baltic Sea EEZ, and several more applications submitted (BSH 2007). There have also been additional permits granted for wind farms in coastal waters less than 12 nautical miles offshore (Köller *et al* 2006).

However, only one offshore wind turbine had been installed up to 2006, as there have been delays with several projects concerning the approval of the cable lines from the respective Federal Land. It is expected that establishment of offshore wind farms will be a gradual process from 2007 onwards (Köller *et al* 2006).

Research on impacts of offshore wind farms in the German EEZ on seabirds has been recently published (Köller *et al* 2006). The main conclusions were that large numbers of both day-flying and night-flying migrating birds cross the German Bight, with considerable variation in migration intensity, time, altitude and species depending on the season and weather conditions. It has been estimated that significant proportions (>1 %) of the bio-geographical populations of 18 species pass Helgoland during migration. Almost half of these birds fly at "dangerous" altitudes. Although migrating birds normally seem able to avoid obstacles, terrestrial birds in particular are attracted to illuminated offshore structures in poor visibility caused by drizzle and mist. It was concluded that in a few nights each year, a large number of avian interactions at offshore plants can be expected, especially when considering the extent of planned offshore wind farms. Several mitigation measures were offered:

- Abandonment of plans for wind farms in zones with dense migration e.g. in nearshore areas or along "migration corridors";

- Alignment of turbines in rows parallel to the main migratory direction;
- Several kilometre-wide free migration corridors between wind farms;
- Shut-down of turbines at night with bad weather/visibility and high migration intensity;
- Refraining from large-scale continuous illumination;
- Measures to make wind turbines generally more recognisable to birds.

It was also concluded that in any wind farm assessment, the habitat loss must be considered together with the habitat already lost due to other wind farms in the vicinity i.e. a cumulative approach for impact assessment is required.

Offshore Wind Farms - Belgium

Since 2001, various project initiatives have been launched in view of exploiting offshore wind energy in the Belgian part of the North Sea, but not one project has been realised yet. It is, however, expected that the first offshore wind farm will be operational at Thornton Bank, in 2008 (C-power 2007).

The first Belgian experiences concerned a plan for a 100 MW project at Vlakte van de Raan by Electrabel - Jan De Nul and a 100 MW project at Wenduinebank by C-power. In June 2002, the environmental permit and the authorisation for the exploitation and the construction of an offshore wind farm on the Vlakte van de Raan were granted to Electrabel – Jan De Nul. The project consisted of 50 wind turbines (2 MW) 12-15 km from the coastline at Knokke- Heist. In February 2003, the permit and the authorisation were granted for the exploitation and installation of electricity cables on the seabed. Finally, the project received the domain concession and had thus the necessary permits and authorisations to go ahead. Due to various reasons, both the Vlakte van de Raan and the Wenduinebank projects have been annulled. In the meantime, the Belgian Government has determined a preferred zone for the development for offshore wind energy. Currently, there remains only one project which is fully authorised: Thornton Bank (POWER 2005).

The Thornton Bank offshore wind farm will be built at Thornton Bank by C-Power, a consortium of five companies. With a distance of 37 km to Oostend, the wind farm will not be visible from the coast. In the past, visual disturbance has been an important issue, as it contributed to the rejection of the offshore wind farm at Vlakte van Raan. The project will consist of sixty turbines rating between 3.6 and 5 MW, resulting in a total capacity of approximately 216-300 MW.

A concession for the project was granted in 2003 and an environmental permit was granted in 2004. Thornton Bank will be built in three phases with the first phase expected to be commissioned in 2008. Final realisation and operation is due in 2010 (POWER 2005). No further information regarding impacts on birds was available.

Q7-WP – The Netherlands

The Q7WP offshore wind farm Q7-WP is situated on the Dutch Continental Shelf at a distance of more than 23 km from the shore and in water with a depth of 20 – 25 m, to reduce the visibility from shore and to reduce the effects on migrating and foraging birds. The spacing between the individual wind turbines will be approximately 550 m. The project is currently under construction, and is due to be completed by late 2007.

The project consists of 60 2 MW turbines, with a rotor diameter of 80m and a tower height of 59m above sea level. The wind farm is connected by sub-sea cables to the grid at the substation at Velsen.

The permit application was submitted in December 1999. The Environmental Impact Assessment study started in May 2000. The Environmental Impact Assessment report was accepted in August 2001. The permit was granted on February 18th, 2002. The permits for the offshore and onshore cables and for the dune crossing of the cables were also granted in early 2002.

However, in December 2004 the Dutch government started an assessment of possible over subsidising or violation of EU Guidelines of the project. Although the European Commission had already confirmed in June 2004 that Offshore Windpark Q7-WP was not overly subsidised and was not in violation of EU Guidelines on national support of environmental projects, confirmation from the Dutch government was received in February 2006 (E-connection 2006).

As part of the permitting procedure an extensive Environmental Impact Assessment report was produced. This report concluded that an offshore wind farm in deep water and at a great distance off the coast, would have no negative effects on the ecosystem of the North Sea, other users of the North Sea and/or the environment (E-connection 2006). No further information regarding impacts on birds was available.

5.3 Offshore wind farms awaiting planning decisions

Limited information on possible impacts on seabirds for several offshore wind farms that have submitted applications was available. If these projects are granted permission they are scheduled to begin construction from 2009 onwards.

Lincs Offshore Wind Farm – England

The proposed 250 MW Lincs Offshore Wind Farm 8 km/5 miles off the Lincolnshire coast in the Greater Wash is being developed by Centrica. Subject to consent, construction of the Lincs Offshore Wind Farm would not begin until 2009. It is proposed that Lincs would be built immediately to the east of the consented Lynn and Inner Dowsing Wind Farms. There would be between 41 and 83 turbines (depending on size and capacity of turbine used) in 10–15 m of water. The total capacity would be 250 MW with each turbine in the region of between 3 and 6 MW. The turbines are likely to have a maximum tower height of 100 m and a maximum blade length of 70 m. There will be undersea cables between the turbines and the shore. Centrica submitted an application for consent for the Lincs Wind Farm in January 2007.

A series of aerial and boat-based bird surveys were conducted for the EIA (Centrica 2007a). A total of 10,356 individuals of 78 identified bird species (including subspecies) were recorded from boat-based surveys within the Lincs study area. Aerial surveys of the Greater Wash strategic area recorded a total of 12,446 birds.

Of the species recorded, Little Gull and Red-throated Diver occurred in nationally important numbers, with Common Scoter, Great Northern Diver, Fulmar, Gannet, Common Gull, Lesser black-backed Gull, Common Tern, Guillemot and Razorbill in regionally important numbers.

The potential impacts on birds included disturbance and displacement effects by the wind farm and its associated vessel traffic and collision risk with turbines. A range of impacts, many of which were either negligible or minor, were predicted. For some species, these were predicted to be of a greater significance but were considered to be acceptable. Although the export cable is planned to pass through the Wash SPA, disturbance to wintering birds within the SPA was not predicted, as installation works would take place outside the winter months.

Docking Shoal & Race Bank Offshore Wind Farms – England

In 2003 Centrica was awarded an Agreement for Lease from the Crown Estate for the development of a wind farm at Docking Shoal. Subject to consent and Centrica's board approval, construction would not begin until 2011 at the earliest. The Docking Shoal Offshore Wind Farm would be located on a shallow sand bank, approximately 17 km from the north Norfolk coast and 19 km from the Lincolnshire coast at its closest point. Environmental studies are being carried out at the Docking Shoal wind farm including surveys of birds and marine mammals (Centrica 2007b). Many of these studies are being carried out in conjunction with the Race Bank & Lincs Offshore Wind Farms.

Subject to consent and Centrica's board approval, construction of the Race Bank Wind Farm would not begin until 2013 at the earliest. The Race Bank Offshore Wind Farm would be located on a shallow sandbank, approximately 21 km from the north Norfolk coast and 27 km from the Lincolnshire coast at its closest point.

Both wind farms will have a total capacity of 500 MW and will have between 72 and 166 turbines (depending on size and capacity). The turbines have not yet been chosen but would be in the region of 3 MW to 7 MW, with a maximum tower height of 100 m and a maximum blade length of 75 m. The wind farms would be connected to the shore by underground cables.

Separate consents applications for Docking Shoal and Race Bank will be made based on detailed Environmental Impact Assessments. Studies will address such issues as marine ecology and ornithology, shipping and navigation, socio-economic impacts, commercial fishing and coastal processes.

Sheringham Shoal Offshore Wind Farm – England

If approved, the wind farm will consist of between 63 and 105, 3 MW to 5 MW wind turbines, with a total power capacity of 315 MW. The minimum distance to shore from the nearest turbine will be approximately 17 km with the farthest turbine sited around 23 km from shore. Scira Offshore Energy submitted its Environmental Statement for the offshore part of the Sheringham Shoal Offshore Wind Farm with the relevant planning authorities in May 2006. The project is now awaiting consent (BWEA 2007).

An intensive 2 year bird survey programme was followed for the EIA, with advice from Natural England and the RSPB. Boat-based surveys were started in 2004 with the frequency of one to three times a month, depending on the season. Observations were carried out by a 2 person team and followed COWRIE guidelines (Camphuyesen *et al* 2004). A total of 29 boat-based surveys were carried out between March 2005 and February 2006. Aerial surveys of the Greater Wash Strategic Area, including the Sheringham Shoal Wind Farm site, were undertaken from November 2004 to August 2005 and carried out by the Wildfowl & Wetland Trust (WWT) for the DTI (Scira Offshore Energy 2006).

In addition, radar surveys were carried out during October 2004 and September 2005. The equipment used was located close to sea level onshore at Weybourne, providing an unobstructed view of the offshore area. This provided an indication of bird movement and behaviour through the site during autumn migration (Scira Offshore Energy 2006).

During the surveys, species of note included Sandwich and Common Terns, Little Gulls and Razorbills, Gannets, Lesser Black-backed Gulls and Guillemots (Scira Offshore Energy 2006).

Although the surveys showed relatively few numbers of birds using or flying through the area, bird species were assessed in relation to their risk of collision and the level of potential disturbance and displacement from the area during construction and operation. This concluded that no single species would be likely to incur impacts that were considered to be significant (Scira Offshore Energy 2006).

In order to minimise disturbance during operation and to reduce any possible barrier effect, the wind farm will be designed so that the corridors between the rows of turbines are orientated in the main flying direction of the north Norfolk Tern population which travel between breeding sites on the coast and foraging areas of sea to the north east of the wind farm site (Scira Offshore Energy 2006).

Overall the presence of the wind farm was considered to have a minor adverse impact on Terns and Razorbills, and a negligible impact on other species. The nature and magnitude of actual impacts on all species of concern will be assessed through a monitoring programme which will be developed in consultation with Natural England (Scira Offshore Energy 2006).

Cirrus Shell Flats Offshore Wind Farm - England

In January 2003 an application was submitted by Cirrus Energy to the DTI under the Transport and Works Act 1992 (TWA) for consent to develop a 324MW (90 turbine) offshore windfarm in Liverpool Bay, off the north west coast of England. The development was commonly known as the Shell Flat Offshore Windfarm. The site was located on a sandbank protruding 20 km out from the coast between Blackpool and Cleveleys in the Eastern Irish Sea.

The application was generally well received by consultees and members of the public. However, two main objections were received from statutory consultees, relating to a species of bird present on the site (Common Scoter), and the potential impacts on aviation radar.

Cirrus Energy worked closely with these objectors, in particular the Royal Society for the Protection of Birds (RSPB), Natural England (formerly English Nature) and the Ministry of Defence (MoD) following the application submission, in an effort to agree suitable mitigation measures that could be implemented. As these discussions failed to reach a suitable resolution, Cirrus Energy has proposed to relocate the windfarm.

The proposed wind farm will comprise up to 90 turbines each with a maximum tip height up to 130 m above Lowest Astronomical Tide (LAT) and will be located partially on the Shell Flat sandbank. The site would also be suitable for a fewer number of larger turbines e.g. 63 x 4.5MW turbines. The revised application was submitted in January 2007.

A total of nine boat surveys took place over an area of approximately 337 km^2 in the vicinity of the proposed CSFA (Cirrus Shell Flat Array) wind farm area between March 2002 and March 2003. Information on the species, number, age, behaviour, direction and flight height and direction was recorded during these surveys. Each boat survey typically took 9 hours once on site. The surveyors on 2 occasions encountered bad weather as a survey progressed.

It was decided to use transects separated by 2 km to limit double recording of birds displaced by the presence of the survey vessel. There were no days on which boat and aerial surveys were undertaken concurrently. The east to west boat transects started at the north of the site and progressed south (RSK 2007).

Aerial surveys were undertaken in the region of the wind farm between August 2002 and July 2006. Common Scoter was the most abundant species recorded within the CSFA site (and indeed within the aerial survey area as a whole). A peak of 286 birds occurred within the wind farm including a 1 km buffer area (827 birds including a 2 km buffer), although over 24,000 birds were seen in the whole region. The peak count within the wind farm area was therefore 1.2 % of the peak count the whole region. Few scoters occurred on the northern periphery of CSFA and beyond. Low numbers were present in the whole region during the 'moulting period' of June to August, with large numbers building up from November. Very few scoters were present in the wind farm area during the moulting period (RSK 2007).

Aside from Common Scoter, auks were the most abundant species recorded in the boat surveys. The vast majority of auks were identified to species and Guillemot was the most abundant with the exception of March 2003 when large numbers of Razorbills were recorded. The peak number of Guillemots occurred in February 2003, when 669 individuals were recorded (RSK 2007).

Boat surveys also recorded Red-throated Divers in all winter surveys with peak numbers occurring in March 2002, and good numbers also present in March 2003. The distribution of Red-throated Diver records from the boat surveys was scattered with no obvious aggregations either within or outside of the wind farm area (RSK 2007).

Red-throated Divers were scarcely recorded on aerial surveys with a peak count of 4 birds occurring within the site and its 2 km buffer area. The preferred areas for this species are the shallow coastal waters to the south of CSFA, with very few records from the wind farm area itself (RSK 2007).

In terms of the effects of construction, noise and vibration has the potential to disturb bird populations. Most species numbers were sufficiently low, (notably Manx Shearwater and Lesser Black backed Gull) that no impact was predicted as a result of disturbance caused by construction activities. Other species, including gulls, may actually remain within the construction area, attracted by enhanced foraging opportunities. It was expected that the most sensitive species, including seaducks and divers, would be displaced from active construction areas during the construction phase. The most sensitive populations in the region of construction are the Common Scoter and Red-throated Diver populations. However, relatively few Red-throated Diver were found to be present within the CSFA site. The weather typically experienced in the late winter period (February and March when Scoter are increasing body mass prior to their return migration) will probably limit the work that can be achieved on the site. During the moulting period (July – September) and winter period (October – March) construction traffic will avoid entering the wind farm and export cable corridor from a southerly direction, eliminating any potential disturbance effects arising from this activity (RSK 2007).

Assuming implementation of these measures, the potential magnitude of disturbance arising from construction activities was considered to be of negligible magnitude and low significance. During the operational phase of the development, it was expected that Common Scoter (the species of greatest concern) will avoid turbines. This is because Common Scoter may be deterred from approaching turbine structures due to their physical presence, ongoing maintenance activities and, to a much lesser extent, operational noise. Survey results indicated that it was unlikely displacement arising from CSFA will result in significant effects on Common Scoter population.

It was assumed that the relatively small number of birds likely to be displaced from the wind farm and adjacent areas would relocate to other foraging areas, with little or no overall effect on the wider population (RSK 2007).

There was potential for further disturbance effects arising from unco-ordinated maintenance access to the windfarm. The worst case scenario would involve repeated disturbance of moulting Common Scoter flocks (typically concentrated at the southern part of Shell Flat) during the period late July through to September or wintering flocks between October and early April. Repeated disturbance of this kind combined with displacement arising from the operational wind farm would be an impact of greater magnitude than that arising from the presence of the wind farm alone and potentially, therefore, of medium significance. The mitigation measures described above (primarily the routing of construction traffic) will assist in eliminating potential disturbance effects (RSK 2007).

West of Duddon Sands Offshore Wind Farm - England

The West of Duddon Sands project will be located 13 km west of the Isle of Walney in the East Irish Sea. Project partners are DONG Energy, Scottish Power and Eurus. The 500 MW project is to develop an offshore wind farm with between 83 and 139 turbines, depending on available technology in 2010, which would have an onshore connection at Heysham. The wind farm would cover an area of 66 km² with the turbines sited in a grid pattern. Their hub height could range from 95 metres to 110 metres depending upon which size of turbines are used. The EIS has been submitted (BWEA 2007) but no further information on the project was available.

Gwent y Mor Offshore Wind Farm - Wales

The Gwynt y Môr site is located 13 kilometres (8 miles) off the North Wales coast at the nearest point to shore, 16 kilometres (10 miles) from Llandudno, and 18 kilometres (11 miles) from the Wirral. The project will feature between 150 and 250 wind turbines with a maximum project capacity of 750 MW. Turbines in the range of 3MW Class to 5MW Class are likely, with a maximum tip height of 165 m, a maximum hub height and rotor diameter of 98 m and 134 m respectively, and c. 450 m to 1000 m distance between turbines. The construction phase of Gwynt y Môr is anticipated to last for up to 3 years, assuming the continuous build of 750MW.

In November 2005, npower renewables submitted consent applications for permission to build and operate the offshore sections of the Gwynt y Môr Offshore Wind Farm. Since then, additional studies and surveys have been commissioned by npower renewables to clarify the potential environmental effects, in response to questions raised by consultees during the consultation period. This supplementary information was submitted in August 2007. If the project is granted consent, npower renewables hopes to start building the wind farm in 2010.

Additional information has been collected on the movement of birds, particularly Common Scoter, in and around the wind farm, the feeding behaviour and availability of food for scoter and the behaviour of birds during storms within Liverpool Bay (N Power 2007).

This additional information has demonstrated that small scale movements of scoter occur throughout the day and night with movements offshore at night to roost, but that there was no significant movement between populations off North Wales and off the coast of North West England. It was also shown that the deeper water within the wind farm area combined with a lower density of prey (when compared to shallower inshore areas) means that scoter are unlikely to favour the wind farm area for feeding (N Power 2007).

Information on bird movements during storms showed that seabirds (such as Leach's Petrel) tend to arrive in the northern parts of Liverpool Bay and then follow a coastal route south and along the North Wales coast. It is also noted that these birds tend to fly very close to the sea. It was concluded that there was no increased risk of collision with the Gwynt y Môr turbines (N Power 2007).

Oriel Offshore Wind Farm - Ireland

Oriel Wind Farm Ltd. plans to build an offshore wind farm in the north-western Irish Sea, off the east coast of Ireland. The wind farm will have a capacity of 250-330 MW and will comprise fifty-five 4.5-6MW turbines. The Foreshore License area is an irregular shaped hexagon, approximately 14.5 km at its longest point and approximately 9 km at its widest point. Its distance from the coast ranges from 5 km at its nearest point to approximately 16 km at its furthest point. The Lease area, located in the north-eastern region of the Foreshore Licence area is approximately 28 km^2, 6.6 km long and 5.3 km at its widest points. An application was lodged with the Department of Communications Marine and Natural Resources (DCMNR) in February 2007 for a Foreshore Lease for the purpose of constructing an offshore wind farm (Oriel Windfarm Ltd 2007).

The JNCC survey method for seabirds was used in this assessment. The basic methodology was to record all birds in a 90º scan from dead ahead out to a 300m on one side of the boat. Within the transect most or all of the birds were picked up with the naked eye. Binoculars of 7x or 8x magnification were used to scan for missed birds and to confirm identifications. Rare or more conspicuous birds beyond the 300m transect were also recorded but were excluded from analyses (Aquafact 2007).

JNCC analysis of these methods has shown that inclusion of all flying birds may lead to significant overestimates. Therefore, scans for flying birds were made every minute (using a timer) and only those seen during the scan and within the 300m transect were recorded as 'in transect' and used for analyses. Wind force and direction, visibility, cloud cover sea state and boat speed were recorded during each survey (Aquafact 2007).

The site and where possible a 5 km perimeter was surveyed seasonally for seabirds on 2 days per month in April 2006, June 2006, July 2006 and January 2007. Due to adverse weather conditions, 2 day surveys in Jan-Feb 2006 and Sept-Oct 2006 were not conducted (Aquafact 2007).

Eleven 300 m transects, varying in length from 6 to 18 km were surveyed during the 4 months. Two surveyors were required to carry out the surveys, one to survey the 11 transects and the second to continually scan for the presence of common scoters and divers that were disturbed easily and flew out of transect. It took two days to cover all 11 transects. The waypoints were programmed into two GPSs (one for the surveyors and one for the skipper of the boat). The time of arrival at each waypoint was recorded by the observer and communication was maintained between the observer and the wheelhouse in relation to position (Aquafact 2007).

Impacts from construction, maintenance and decommissioning activities required for the Oriel wind farm development on bird species in the area were thought likely to be minimal and short-term and were not of concern. The proposed development was not believed to adversely impact on the integrity of near-by Special Protection Areas (Aquafact 2007).

Effects from offshore cable laying operations in the wind farm area will be short-term and localised on the seabed. Such operations were not thought likely to cause significant impacts on seabirds. Impacts in the SPA area (if a route is selected that crosses the SPA) will be mitigated against (Aquafact 2007).

The construction period will involve increased vessel activity in the area, transporting materials to the site and carrying out installation of the foundations and turbines. In addition, cable installation between turbines and the shore will also be carried out. The construction of the wind farm is likely to cause temporary disturbance to birds feeding in the vicinity of the construction site and possibly disturbance to migrating birds. Construction operations are most likely to be carried out during spring, and summer months, when weather conditions are most stable and construction could continue for several seasons. Highest numbers of seabirds are likely to occur in and around the wind farm area during the summer months and several species are likely to use the area as feeding grounds (Aquafact 2007).

The significance of the potential risk of birds colliding with the turbines in the Oriel wind farm ranged from low to medium depending on the key species. Gannets, divers and terns were considered the species most susceptible to collision. However, studies from the Horns Rev wind farm showed that Gannets and divers actively avoided the wind farm area. Arctic and Common terns however did enter the wind farm area but after a few hundred metres changed their flight pattern and left the wind farm area (Aquafact 2007).

The significance of the potential impact from habitat loss was considered medium for Manx Shearwaters, terns, Guillemots and Razorbills. From the baseline studies, terns and Razorbills were more common outside the Lease area than within it. Manx shearwater and Guillemots were very numerous within the Lease area but also in most parts of the study area. It was predicted that terns and Razorbills would not be significantly impacted by habitat loss due to their low occurrence in the Lease area. While Manx Shearwater and Guillemots were common within the Lease area, their high presence outside the Lease area, suggested that they were common in a much wider area than the study area. For this reason, the presence of the wind farm was not believed to significantly impact on their habitat (Aquafact 2007).

Disturbance to feeding sites was also thought potentially significant for Red-throated Divers, terns, Guillemots and Razorbills. The significance of the potential impact on the flight patterns of birds was mostly low, although divers and Manx Shearwaters could be more susceptible to disturbance. For the reasons stated in the previous two paragraphs, the disturbance to feeding sites and flight patterns was believed to be insignificant (Aquafact 2007).

Potential significance of impacts from indirect changes to food sources ranged from very low to low. Waders and wildfowl will not generally be affected by the wind farm, as they are only likely to be present in the wind farm area during migration, if at all (Aquafact 2007).

In conclusion, the proposed wind farm was not believed to pose a significant risk of collision to the three most susceptible species. Nor was it believed to pose a significant risk of habitat loss for the four most sensitive species. Disturbance to feeding sites and flight patterns was believed to be insignificant. Waders and wildfowl will not generally be affected by the wind farm as they are only likely to be present in the wind farm area during migration, if at all (Aquafact 2007).

Operations will be timed to avoid sensitive periods. The timescale of construction/maintenance activities and the movement of construction/maintenance vessels will be kept to a minimum. Appropriate turbine lighting and turbine colour will be selected to reduce the risk of bird collision. There should be the option to shut down the turbines in the short-term to avoid excessive bird mortality, if necessary (Aquafact 2007).

Long term monitoring of bird populations and behaviour in and around the wind farm area will be carried out. Exact survey schedules and methodologies will be devised, in consultation with Birdwatch Ireland, the Royal Society for the Protection of Birds and NPWS prior to the commencement of works (Aquafact 2007).

The monitoring programme is proposed from the present up to and through construction and for a period afterwards. This programme includes provision for regular review as knowledge of the wind farm area and the effects of the wind park increases. The aim of the programme is to detect any significant changes in the patterns of bird usage of the wind farm area that are caused by the wind farm and to distinguish these from other factors such as natural variability. The monitoring programme will also contribute to measuring any cumulative impacts that may arise should other wind farms be developed in the area (Aquafact 2007).

Kish Bank Offshore Wind Farm - Ireland

The Kish Bank is located approximately 10 km east of Dalkey and Dun Laoghaire in county Dublin. It runs in a south/south-easterly direction from the entrance of the Dublin Bay for about 10-12 km, although the bank continues for a further 10 km as the Bray Bank.

A one hundred wind turbine project is proposed. In August 2000 the Department of Marine and Natural Resources awarded foreshore licenses to the Kish Consortium to allow detailed studies to be carried out on the Kish and Bray Banks.

A preliminary assessment of the ornithological importance of the Kish Bank was carried out in August and September of 1999 (Newton & Crowe 1999). Twenty-five seabird species and a single wader species (Dunlin) were recorded. Guillemots, Kittiwakes and Common Terns were the most commonly recorded species. Roseate Terns, kittiwakes and Common Terns were the predominant species seen roosting on the Kish lighthouse. A range of distributional patterns was evident. Limited data prevented the assessment of tidal and/or weather effects on bird densities or distribution. Observed flight heights ranged between 0.5 m to 35 m.

The authors stated that the data clearly demonstrate 'the importance of the Kish Bank for seabirds during the late summer/early autumn.' Densities of birds were much greater than previously reported at sea around the Irish coast. In excess of 600 Roseate Terns were present on the Kish Bank, representing about a third of the breeding adults of the European (Irish/British/French) populations. The authors also stated that much more information needs to be gathered on the marine ecology of the Kish Bank before significant development activities such as wind farms or aggregate extraction commence. They proposed a number of recommendations, such as for example that bird surveys be conducted throughout the whole year, especially in mid-winter (December-February), spring (April-May) and in summer (June/July) to evaluate the usage of the area by migratory winter waterfowl (Newton & Crowe 1999).

In 2006 two companies owned by Saorgus Energy Ltd applied for two foreshore leases to construct an offshore wind farm on the Kish and Bray Banks. This application is currently being assessed by the Department of Communications, Marine and Natural Resources.

Cape Wind Offshore Wind Farm - USA

The Cape Wind offshore wind farm proposal is currently undergoing a rigorous review under the National Environmental Policy Act (NEPA), which requires an Environmental Impact Statement (EIS) to be submitted. The project is also being reviewed under the Massachusetts Environmental Policy Act (MEPA), which requires an Environmental Impact Review (EIR) and the Cape Cod Commission's Development of Regional Impact (DRI) process.

In November 2004 the Army Corps of Engineers (former developers) released the combined Draft Environmental Impact Statement (DEIS), Draft Environmental Impact Report (DEIR), and Development of Regional Impact (DRI). Detailed bird activity mapping in Nantucket Sound from radar, boat and aerial observations were provided in the DEIS. There was less bird activity over Horseshoe Shoal (proposed site) than in many other areas of Nantucket Sound. The estimated small number of birds killed by wind turbines was unlikely to cause bird population declines (USACE 2004).

As part of the environmental review, extensive bird research has been conducted on Nantucket Sound using high resolution avian radar, over-flights, and boat transects. Studies conducted during the last four years showed that sensitive species, including endangered Roseate Terns and Piping Plovers, generally avoided the 24-square-mile footprint of the proposed project (Cape Wind 2007). No further information on predicted impacts on birds for this project was available.

5.4 Proposed future projects

In addition to the projects already discussed above, there are several other proposed offshore projects currently in the early stages of development, for which information on possible impacts on birds was not available (BWEA 2007). These include:

- Horns Rev II Offshore Wind Farm – Denmark 200 MW
- Rodsand II Offshore Wind Farm – Denmark
- Ijmuiden, Holland, 100 MW
- Uttgrunden II, Sweden, 72 MW
- Barsebank, Sweden, 750 MW
- Long Island, USA, 140 MW
- Cape Trafalgar, Spain, 500 MW
- Dudgeon East, England, 300 MW
- Humber Gateway, England, 300 MW
- Triton Knoll, England, 1,200 MW
- Westernmost Rough, England, 180-240 MW

6. Discussion

6.1 Methods

A recent review of the Arklow Bank Seabird and Marine Mammal Monitoring Programme made several recommendations for change (Cork Ecology 2007b). In particular, it was recommended that the transect legs should be orientated so that they are perpendicular to the Bank. A revised survey route for the Bank area was suggested, following a zig-zag pattern running north-south on each side of the Bank (Appendix D). If this revised survey design is adopted, the new grid would be surveyed every 2 months and the current Box and Cable routes would be discontinued. However, to provide better quality data in the vicinity of the Bank, and also to allow comparisons with earlier years data, it was recommended that surveys of the current Bank legs should also be maintained (Cork Ecology 2007b).

The rationale for the suggested changes is to allow more powerful statistical analyses such as krigging and spatial regression/generalised linear models to be conducted on the data and to allow total numbers of birds in the study area to be extrapolated with confidence limits.

The review also suggested that plankton sampling should be discontinued (see 6.2.2 below).

The other major recommendation from the Review was to examine the feasibility of establishing a control area distinct from the Arklow Bank but with similar habitats and bird communities. This would allow any changes recorded on the Bank legs to be placed in context and would also allow any potential site-specific impacts of the turbines to be distinguished from changes affecting the wider local population. The inclusion of such a local survey/reference area is recommended best practice (Camphuysen *et al* 2004). One possible control site that might be suitable is the nearby Glassgorman Bank, although it is unclear at this stage whether this area supports similar bird communities to the Arklow Bank.

These recommendations are particularly relevant in relation to the proposed future expansion of the Arklow Bank Wind Farm.

6.2 Overview of important species in the Study Area

Seabirds

Eleven species listed on Annex I of the EU Birds Directive (79/409/EEC) were recorded in the study area between years 5 and 7. These included 2 diver species (Red-throated and Great Northern), 3 petrels (Balearic Shearwater, Storm Petrel and Leach's Petrel), Red-necked Phalarope, Mediterranean Gull and 4 species of tern (Sandwich Tern, Roseate Tern, Arctic Tern and Common Tern).

Most of these species occurred in very low numbers and would not be considered nationally important. However, peak numbers of Red-throated Divers recorded over the Bank exceeded the 1 % nationally important threshold of 20 birds (Crowe 2005) in all three years, with a maximum peak count of 22 birds in Year 7, 60 birds in Year 6 and 44 birds in Year 5.

Although overall numbers of terns were low, the Arklow Study Area may be important for birds on passage. For example in September of Year 6, c.800 Common Terns were recorded.

In term of overall numbers of birds in the Arklow Study Area, Kittiwake, Little Gull, Common Gull, Guillemot and Razorbill were the most important species.

Kittiwake was the most numerous species recorded n the Arklow Study Area, with peak monthly counts over the Bank between October and November exceeding 10,000 birds in all three years. Although a 1 % threshold of national importance has not been set for Kittiwake, these totals would be approximately equivalent to 1 % of the all-Ireland breeding population (415,995 pairs-Mitchell *et al* 2004).

Peak numbers of Little Gulls recorded over the Bank in November exceeded the 1 % internationally important threshold of 840 birds (Crowe 2005) in all three years. The maximum peak count of 4,032 birds (4.8% biogeographic population) was recorded on the Bank in January of Year 5.

Large numbers of Guillemots were recorded in the Arklow Study Area in Year 6, with lower numbers recorded in Years 5 and 7. The peak of 4,000 birds in the Box in September of Year 6 were most likely moulting birds, as Guillemots form large flocks in late summer while they undergo a full body moult and are flightless for a few weeks at this time (Rees & Hope Jones 1985). JNCC surveys in the Irish Sea also recorded high densities of Guillemots at this time (Pollock *et al* 1997). However high numbers of Guillemots can also occur at other times of years e.g. the peak count of 5,013 birds over the Bank in January of Year 6. While a 1 % threshold of national importance has not been set for Guillemots, numbers of birds recorded in the Arklow Study Area did exceed 1% of the all-Ireland breeding population (236,654 individuals-Mitchell *et al* 2004) in Year 6.

Peak numbers of Razorbills were recorded over the Bank in August and September in all three years with high numbers also recorded in February of Year 6. Like Guillemots, Razorbills form large moulting flocks in late summer and they are also flightless at this time (Rees & Hope Jones 1985). While a 1 % threshold of national importance has not been set for Razorbill, peak counts exceeded 1 % of the all-Ireland breeding population (51,530 individuals-Mitchell *et al* 2004) in all three years.

Peak monthly counts of Common Gulls recorded over the Bank between November and February were more than double the nominal 1 % nationally important threshold of 500 birds (Crowe 2005) in Years 5 and 6. The maximum peak count recorded in Year 7 was 417 birds in the Box in February.

Marine Mammals

One species of seal recorded in the Arklow Study Area in Years 5, 6 and 7 (Grey Seal) is listed on Annex II and V of the EU Habitats Directive (92/43/EEC) and two cetacean species recorded in the Arklow Study Area in Years 5, 6 and 7 (Harbour Porpoise and Risso's Dolphin) are listed on Annex II and IV of the EU Habitats Directive (92/43/EEC).

Harbour Porpoise was the most commonly recorded marine mammal in the Arklow Study Area and was recorded in all months. A peak of 47 animals was recorded in the Arkow Study Area in September of Year 6. Aerial surveys in 2005 yielded a total of 15,230 Harbour Porpoise in the Irish Sea (Macleod 2006).

6.3 Statistical analyses of data from Years 1 to 7

6.3.1 Seabirds and Harbour Porpoise

The purpose of the statistical analyses carried out has been to highlight cases where the available evidence suggested that the installation of the first seven turbines may possibly have had an impact, either positive or negative, on bird or cetacean species, and which therefore should be paid particular attention to in the future. The quality of the available data (with the many changes in methodology) and also the inherent difficulties of relatively small data sets and potentially complex patterns of spatial and temporal autocorrelation (e.g. if Little Gulls have a good breeding season in one year, then the numbers at the Arklow Bank the following winter, and indeed possibly several winters hence may be elevated) mean that greater certainty is not possible. On this basis the one species that stands out in the analyses as being of particular concern, given both the potential impacts recorded, and the importance of the Arklow Bank population was Red-throated Diver.

The main findings of the analyses were that a strong, statistically significant decline occurred in the numbers of Red-throated Divers on the outer Bank leg (leg 2). This decline appeared to be strongly associated with the proximity of turbines. However, on the inner Bank leg (leg 3), there was no evidence of a decline in Red-throated Divers numbers.

In the Box and Cable Route, where numbers of birds were much lower, results suggested the possibility of a more widespread decline.

A study of bird numbers in and around the Horns Rev offshore Wind Farm in Denmark, also reported an increased avoidance of the wind farm area by Red-throated Divers (and Common Scoter and Guillemot/Razorbill), including zones of 2 and 4 km around the wind farm after the erection of turbines (Peterson 2005).

The reason for this observed change in avoidance of the wind farm area was unknown, but disturbance effects from the wind turbines were considered one possible reason. Disturbance from increased human activity associated with maintenance of the wind turbines and changes in the distribution of food resources in the study area were also thought to be possible factors.

Red-throated Diver is listed on Annex I of the EU Birds Directive (79/409/EEC), and numbers recorded on the Arklow Bank during the winter months regularly exceeded the all-Ireland 1 % nationally important threshold of 20 birds (Crowe 2005). The species is also considered of medium conservation concern by Birdwatch Ireland, and has been Amber-listed as it is a rare breeding species in Ireland, with an unfavourable conservation status in Europe (Newton *et al* 1999).

The statistical analyses also found that although no strong trends in Harbour Porpoise numbers were obvious for any of the survey legs, a weakly statistically significant decline in Harbour Porpoise numbers was recorded on the inner Bank leg (leg 3). However, there was no evidence that this decline was related to the proximity of the turbines.

Harbour porpoise numbers are declining for a number of potential reasons such as fisheries interactions (gear entanglement), pollution and habitat disturbance (IWDG 2007). As Harbour Porpoise is listed on Annex II of the EU Habitats Directive (92/43/EEC), Ireland is required to designate Special Areas of Conservation (SACs) that correspond to the ecological requirements of the species. In addition, inclusion on Annex IV of the Habitats Directive requires Ireland to take necessary measures to protect Harbour Porpoise from deliberate disturbance, amongst other stipulations (Article 12 Working Group 2005).

Given that conservation status of both species, it is recommended that seabird and marine mammal monitoring in the Arklow Bank Study Area is continued, particularly in relation to the proposed future expansion of the Arklow Bank Wind Farm. Monitoring of the two key species highlighted here (Red-throated Diver and Harbour Porpoise) should be the priority, together with other potentially important species that can occur in large numbers such as Little Gull, Kittiwake and Guillemot.

6.3.2 Plankton abundance and seabird abundance

There was no evidence of any significant relationship between plankton abundance and bird abundance at the three spatial and temporal scales used to examine this question. Establishing relationships between seabird abundance and prey abundance in the marine environment is notoriously difficult however, because of both the practical issues of collecting accurate data, and conceptual issues of the appropriate spatial and temporal scale to look for relationships. In conclusion, it is suggested that plankton surveys are likely to add little or no explanatory power to analyses relating bird abundance to more easily, and cheaply, measured environmental variables such as distance from the coast and water depth. Therefore it is recommended that the plankton sampling should be discontinued.

6.4 Review of impacts of offshore wind farms on birds

The review of impacts of offshore wind farms on birds shows that while the majority of original EIAs for offshore projects predict that no significant impacts are likely to arise, most EIAs state that monitoring surveys for seabirds and other wildlife will be ongoing during the construction phase and over the early years of operation. However, several of the projects described in this review are now in operation but very few have publicly published results of these ongoing seabird monitoring studies. Thus, it is difficult to draw many conclusions about the impacts of offshore wind farms on birds from the few cases that have been published.

Best Practice Guidelines from the Irish Wind Energy Association (IWEA) state that "ecological impacts should be monitored for a time after commissioning", and that "any relevant information learned, either good or bad should be make known to all relevant parties, and also the wind energy industry in general, so that future wind developments may learn from the successes and mistakes of earlier ones" (IWEA 1996). Similarly, the Best Practice Guidelines from the British Wind Energy Association state that "once a wind farm is operational, environmental monitoring should be continued to provide information for further projects" (BWEA 1994).

A recent conference organised by the British Ornithologist's Union (BOU) on renewable energy and birds recommended that communication between interested parties should be improved, with the need to "share experiences and disseminate information widely" highlighted. Currently much work is unpublished "grey" literature, that is not readily accessible and has not been independently assessed in terms of scientific rigour (Fox *et al* 2006, Langston *et al* 2006).

COWRIE (Collaborative Offshore Wind Research Into The Environment) is to develop a system and plan that will bring together all the environmental data and information collected by each developer in UK waters during site investigations. UK Developers are currently required to give this data to The Crown Estate. They have asked COWRIE to provide a system that will look after and manage the data and make it available to all interest groups (COWRIE 2007). Public publication of the Year 7 Arklow Bank Seabird Monitoring Report would be in line with this new COWRIE initiative and recent recommendations from the BOU (Fox *et al* 2006, Langston *et al* 2006).

It is therefore recommended that this monitoring report should be published in the public domain, as it represents the first analysis of survey data gathered across the pre-construction, construction and early years of operation of the Arklow Bank Offshore Wind Farm.

7. Recommendations

Based on the results discussed in this report, it is recommended that:

- Seabird and marine mammal monitoring in the Arklow Bank Study Area should be continued, particularly in relation to the proposed future expansion of the Arklow Bank Wind Farm;
- Monitoring of the two key species highlighted here (Red-throated Diver and Harbour Porpoise) should be the priority, together with other potentially important species that can in large numbers such as Little Gull, Kittiwake, Guillemot, Razorbill and Common Gull.
- The revised survey route for the Bank area, with transect legs orientated perpendicular to the Bank, should be considered to allow for more powerful statistical analyses and total numbers in the study area to be calculated with confidence limits. If this new survey route is adopted, surveys of the Box and Cable routes should be discontinued;
- Plankton sampling should be discontinued, as to date no relationship between seabird abundance and prey abundance in the Arklow Study Area has been shown;
- The feasibility of establishing a control area distinct from the Arklow Bank, but with similar habitats and bird communities, should be examined, particularly in relation to the proposed future expansion of the Arklow Bank Wind Farm;
- The Year 7 Arklow Bank Seabird Monitoring Report should be published in the public domain, as it represents the first analysis of survey data gathered across the pre-construction, construction and early years of operation of the Arklow Bank Offshore Wind Farm.

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Appendix A

Survey weather conditions in Years 5, 6 and 7

Table A1 Survey conditions for Year 5 (July 2004 to June 2005)

Trip No.	Date	Weather				
		Wind Dir	Wind force[1]	Sea-state[2]	Swell[3]	Visibility[4]
1	13/7	S-SE	2-3	2-3	Slight	Ex
2	19/7	S	1-4	1-3	Slight	Ex
3	30/7	NE	1-3	1-2	Slight	Good - Ex
4	10/8	NE	2	2	Slight	Poor – Ex
5	21/8	Var-SE	2-4	1-3	Slight	Ex
6	5/9	Var	1-2	1	Slight	Mod-Ex
7	7/10	Var-N	2	1-2	Slight	Good-Ex
8	31/10	NW	2-3	1	Slight	Good
9	1/11	N	3-4	1-2	Slight	Good-Ex
10	23/11	SW	2-3	2	Slight	Good-Ex
11	1/12	E	3	2	Slight	Mod-Good
12	31/12	NW	3	2	Slight	Ex
13	13/1	S	3	2-3	Slight	Ex
14	25/1	NE	3	3	Slight	Ex
15	31/1	W	2	3	Slight	Ex
16	2/2	W-NW	2-4	1-2	Slight	Ex
17	16/2	W	2-3	1-3	Slight	Ex
18	7/3	N-NW	2-3	1-2	Slight	Ex
19	29/3	E	2	2	Slight	Mod
20	13/4	S-SW	3	2-3	Slight	Ex
21	25/4	W	2	2	Slight	Good
22	26/4	SE	2-3	2-5	Slight	Ex
23	29/4	S	3-5	3-5	Slight	Ex
24	10/5	NE	2-3	2-3	Moderate	Mod-Ex
25	11/5	SE	2	2	Slight	Good
26	30/5	SE	1	1-2	Slight	Ex
27	7/6	SE	4	4-5	Slight	Ex
28	8/6	S	2	2	Slight	Ex
29	27/6	SE	2	1-2	Slight	Ex

[1] **Wind** – Beaufort scale - 0= calm, 1= light air, 2= light breeze, 3= gentle breeze, 4= moderate breeze, 5= fresh breeze, 6= strong breeze, 7= near gale, 8= gale

[2] **Sea-state** – international sea state codes - 0= calm, 1= slight ripples – no foam crests, 2= small wavelets – no whitecaps, 3= large wavelets – few whitecaps, 4= longer waves – many whitecaps, 5= moderate waves- some spray, 6 = large waves- many whitecaps, frequent spray

[3] **Swell** - calm = 0m, slight = <2m, moderate=2-4m, large = >4m

[4] **Visibility**: - poor = < 1km, moderate = 1-9.99km, good = c.10km, excellent = >10km

Table A2 Survey conditions for Year 6 (July 2005 to June 2006)

Trip No.	Date	Weather				
		Wind Dir	Wind force[1]	Sea-state[2]	Swell[3]	Visibility[4]
1	4/7	SE	2-3	2-3	Slight	Ex
2	8/7	Var-SW	1-2	1	Calm	Mod-Good
3	14/7	SW	2-3	1-3	Slight	Good-Ex
4	6/8	Var-SW	1-2	1-2	Slight	Ex
5	7/8	N	1-2	1-2	Slight	Ex
6	8/8	S	2	1-2	Slight	Ex
7	12/9	Var-SE	1	1-2	Slight	Ex
8	20/9	SW-W	1	1-2	Slight	Ex
9	6/10	S	2-3	1-2	Slight	Good
10	13/10	W-NW	2-4	2	Slight	Ex
11	16/11	N	4	2	Mod	Good
12	17/11	Var	2	2	Calm	Ex
13	12/12	-	4	0	Large	-
14	13/12	W	2	0	-	-
15	19/12	SW-W	2	2	Slight	Ex
16	4/1	-	3-4	1-2	Slight	Good
17	31/1	SW	2-4	3	Slight	-
18	3/2	NE	4	-	Slight	-
19	4/2	NE	2	0	Slight	-
20	18/2	NW	3	0	Slight	Ex
21	29/3	-	-	-	Slight	Mod
22	15/4	-	-	-	Slight	-
23	23/4	-	4	-	Slight	-
24	26/4	-	4	-	Slight	-
25	10/5	-	-	0	Calm	Mod
26	31/5	NW	2	-	Mod	-
27	1/6	E-S	3-5	-	Slight	-
28	3/6	N	2	0	Slight	-

[1] **Wind** – Beaufort scale - 0= calm, 1= light air, 2= light breeze, 3= gentle breeze, 4= moderate breeze, 5= fresh breeze, 6= strong breeze, 7= near gale, 8= gale

[2] **Sea-state** – international sea state codes - 0= calm, 1= slight ripples – no foam crests, 2= small wavelets – no whitecaps, 3= large wavelets – few whitecaps, 4= longer waves – many whitecaps, 5= moderate waves- some spray, 6 = large waves- many whitecaps, frequent spray

[3] **Swell** - calm = 0m, slight = <2m, moderate=2-4m, large = >4m

[4] **Visibility**: - poor = < 1km, moderate = 1-9.99km, good = c.10km, excellent = >10km

Table A3 Survey conditions for Year 7 (July 2006 to June 2007)

Trip No.	Date	Weather				
		Wind Dir	Wind force[1]	Sea-state[2]	Swell[3]	Visibility[4]
1	19/7	SW	2-3	1-3	Slight	Ex
2	20/7	S	3-4	3	Slight	Poor
3	4/8	S	2-4	2-3	Slight	Good
4	5/8	N-SE	2-4	2-3	Slight	Good
5	12/9	SE-S	2-4	2-4	Slight	Good
6	14/9	SE-S	2-3	2	Slight	Good
7	15/9	SW	3	3	Slight	Good
8	24/10	S-NW	3-6	2-5	Calm-Mod	Poor
9	28/10	S-SW	4-5	4	Mod	-
10	1/11	N	3-6	5-6	Mod	Good
11	9/11	N-SW	3-4	3	Slight	Mod
12	18/12	NE	3	2-4	Slight	Ex
13	19/12	N-NE	1-3	1-2	Slight	Good
14	20/12	N-NE	2	2	Slight	Good
15	29/1	NW	2-3	2-3	Slight	Poor-Good
16	1/2	SW	2-3	1	Slight	Mod
17	2/2	N-NW	3-5	3-5	Slight	Mod
18	27/3	NE	3	1	Calm	Mod
19	28/3	NW	4	2	Slight	Good
20	5/4	N-NE	1-3	1-2	Slight	Mod
21	7/4	N	2	2	Slight	Ex
22	9/4	SW	1-2	1-2	Slight	Ex
23	3/5	N-NE	3	3-4	Slight	Good
24	5/5	SW	3-4	3-4	Slight	Good
25	22/5	S	3-4	3-4	Calm-Mod	Good
26	9/6	N-NE	2	1-2	Slight	Mod-Good
27	10/6	N-NW	2-3	2-3	Slight	Poor-Good

[1] **Wind** – Beaufort scale - 0= calm, 1= light air, 2= light breeze, 3= gentle breeze, 4= moderate breeze, 5= fresh breeze, 6= strong breeze, 7= near gale, 8= gale

[2] **Sea-state** – international sea state codes - 0= calm, 1= slight ripples – no foam crests, 2= small wavelets – no whitecaps, 3= large wavelets – few whitecaps, 4= longer waves – many whitecaps, 5= moderate waves- some spray, 6 = large waves- many whitecaps, frequent spray

[3]**Swell** - calm = 0m, slight = <2m, moderate=2-4m, large = >4m

[4]**Visibility**: - poor = < 1km, moderate = 1-9.99km, good = c.10km, excellent = >10km

Appendix B

Statistical analysis of survey effort on individual survey legs

Figure B1 Coverage of Bank leg 1. Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.

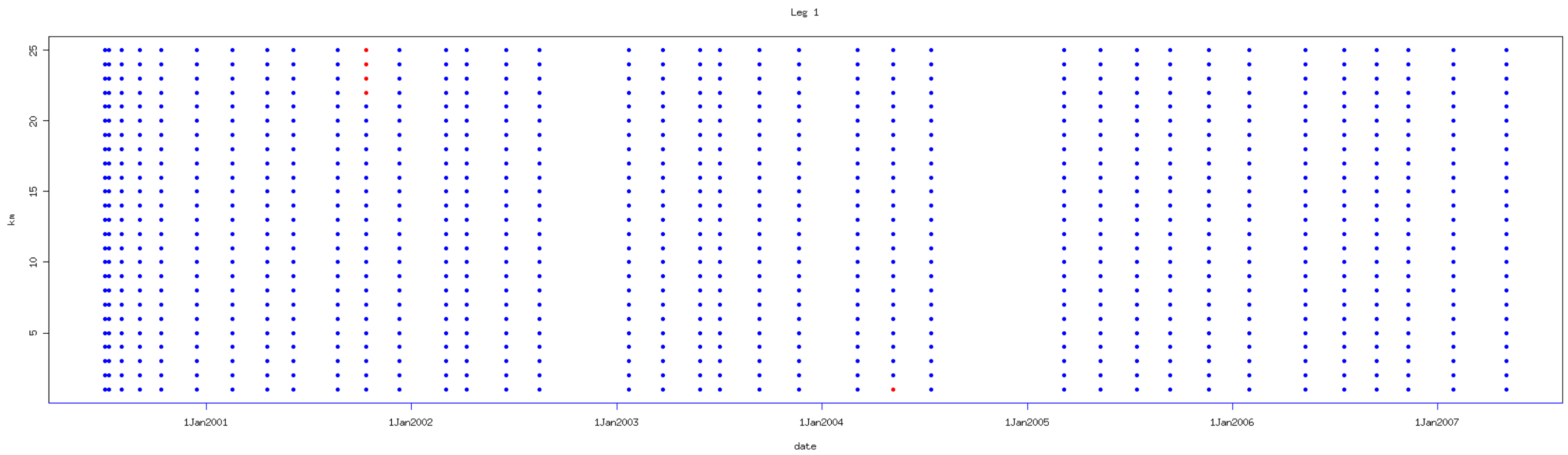


Figure B2 Coverage of the Outer Bank leg (leg 2). Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.

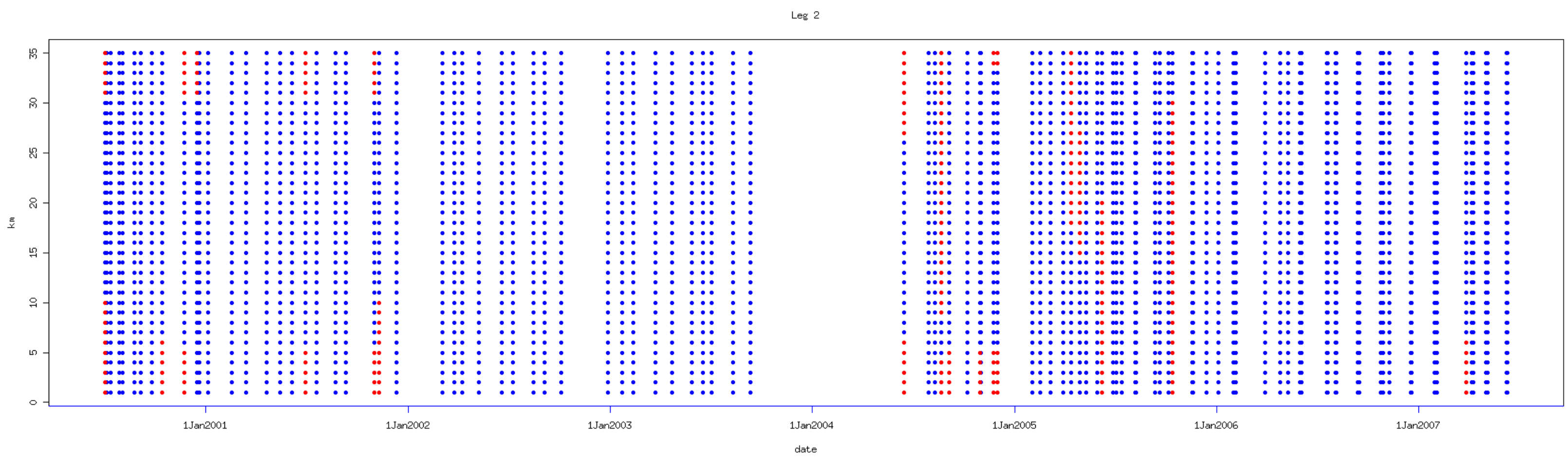


Figure B3 Coverage of the inner Bank leg (leg 3). Blue dots indicate km covered on a particular date. Red spots indicate km <u>not</u> covered for those dates when at least partial coverage achieved.

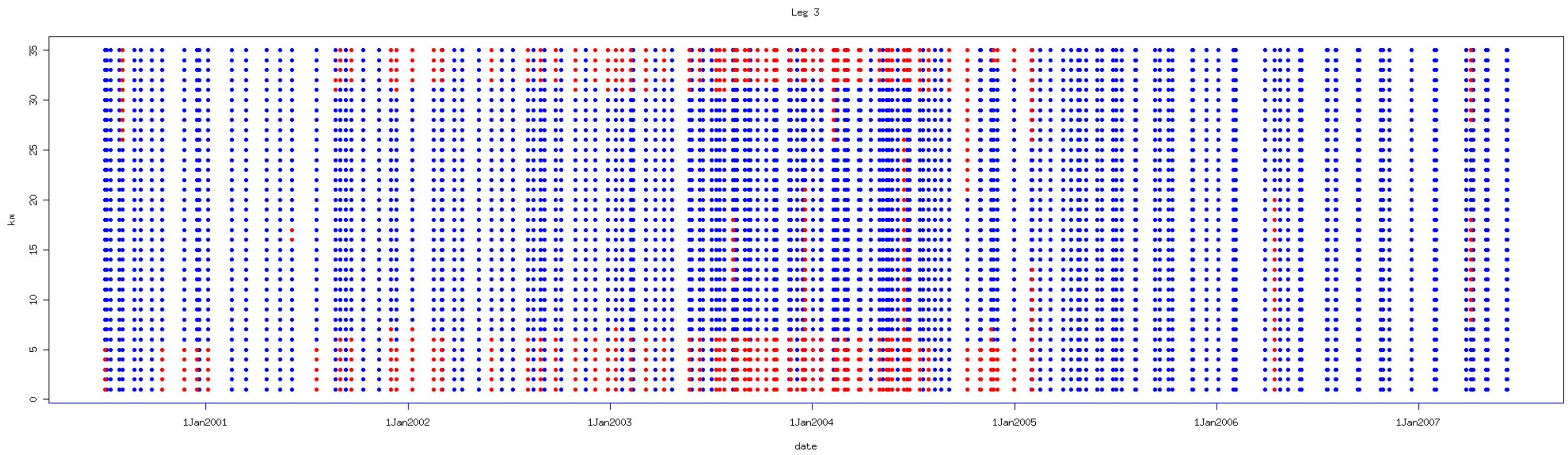


Figure B4 Coverage of the Cable Route (leg 5). Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.

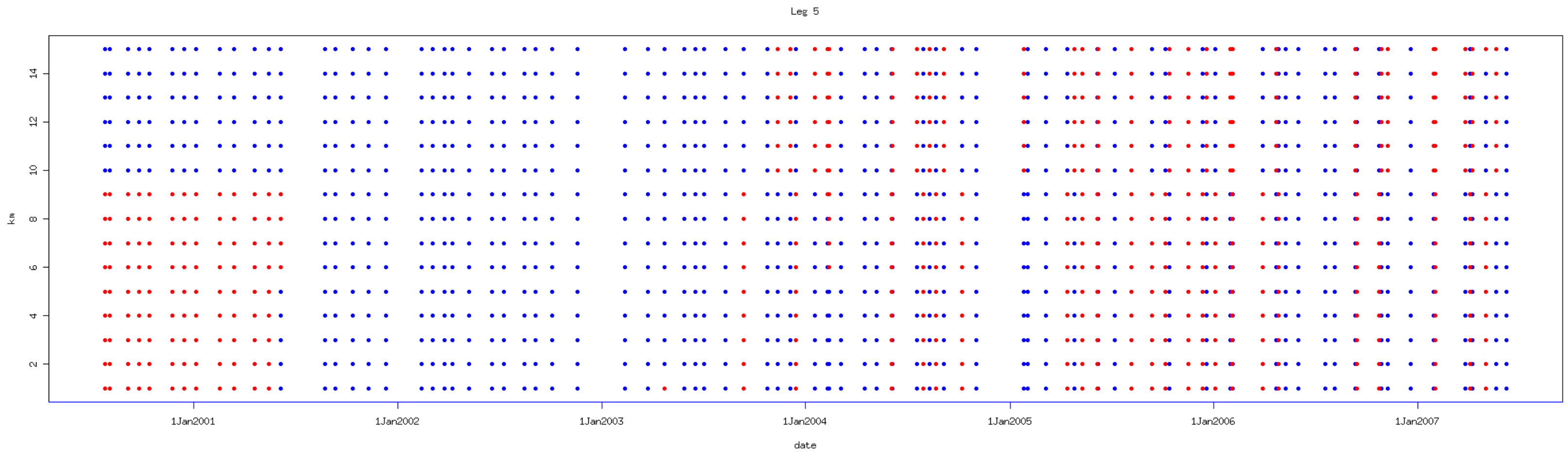


Figure B5 Coverage of Box leg 11. Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.

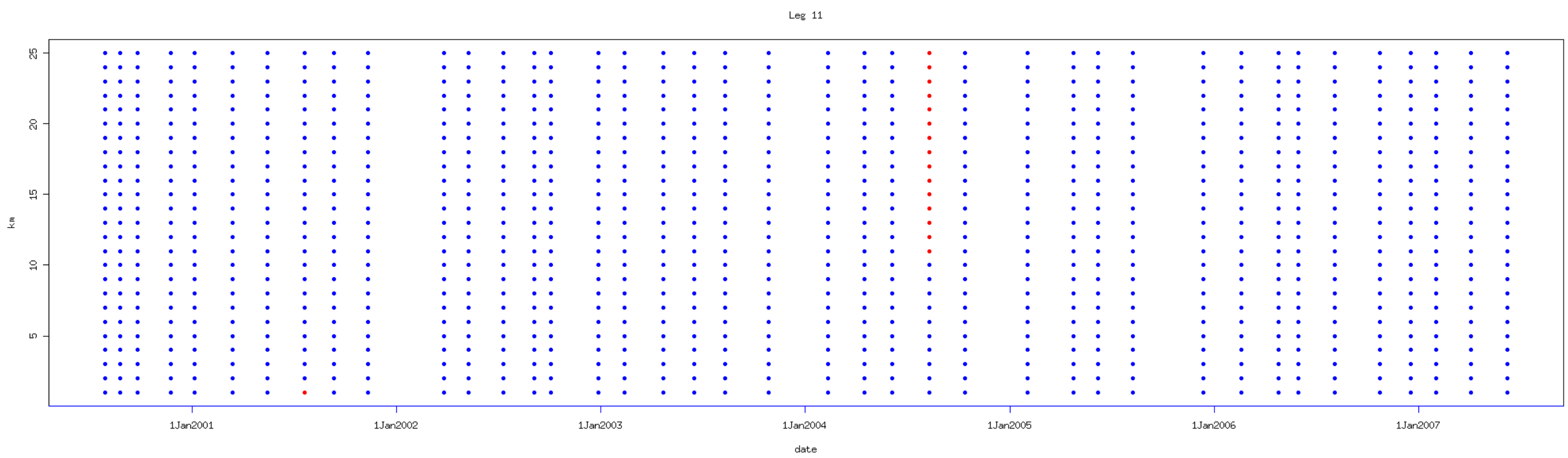


Figure B6 Coverage of Box leg 41. Blue dots indicate km covered on a particular date. Red spots indicate km <u>not</u> covered for those dates when at least partial coverage achieved.

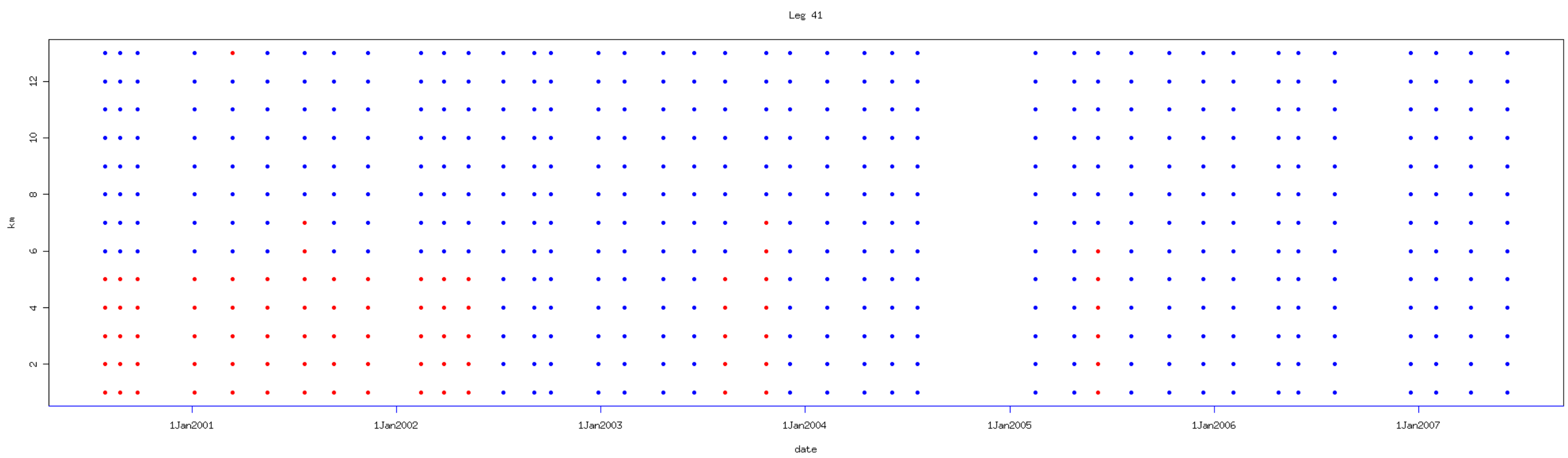


Figure B7 Coverage of Box leg 42. Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.

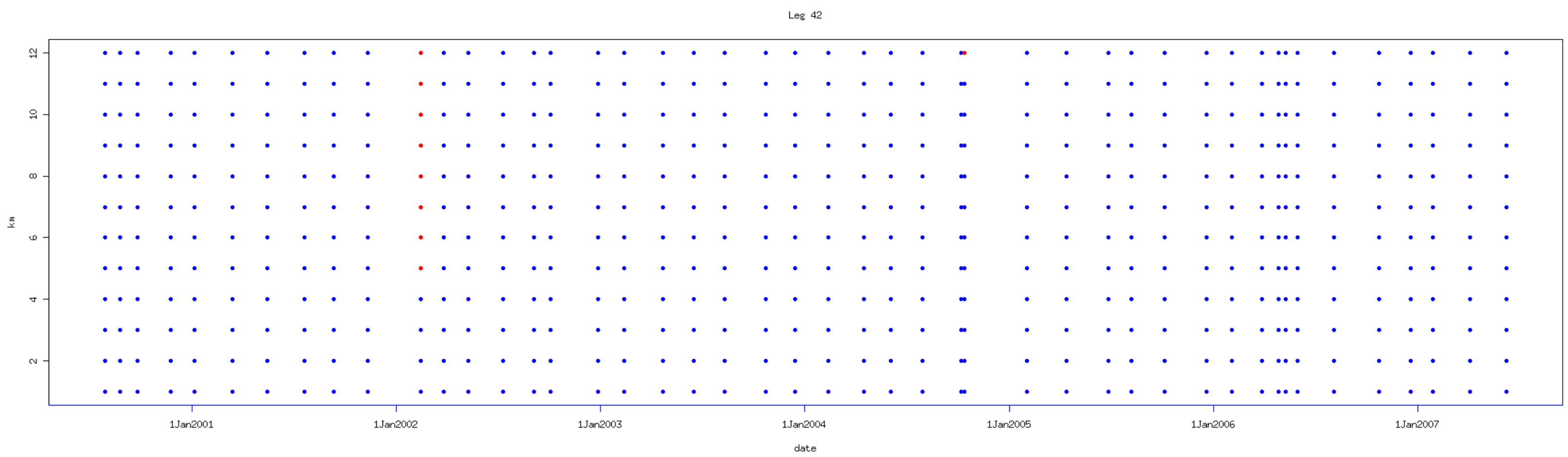


Figure B8 Coverage of Box leg 43. Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.

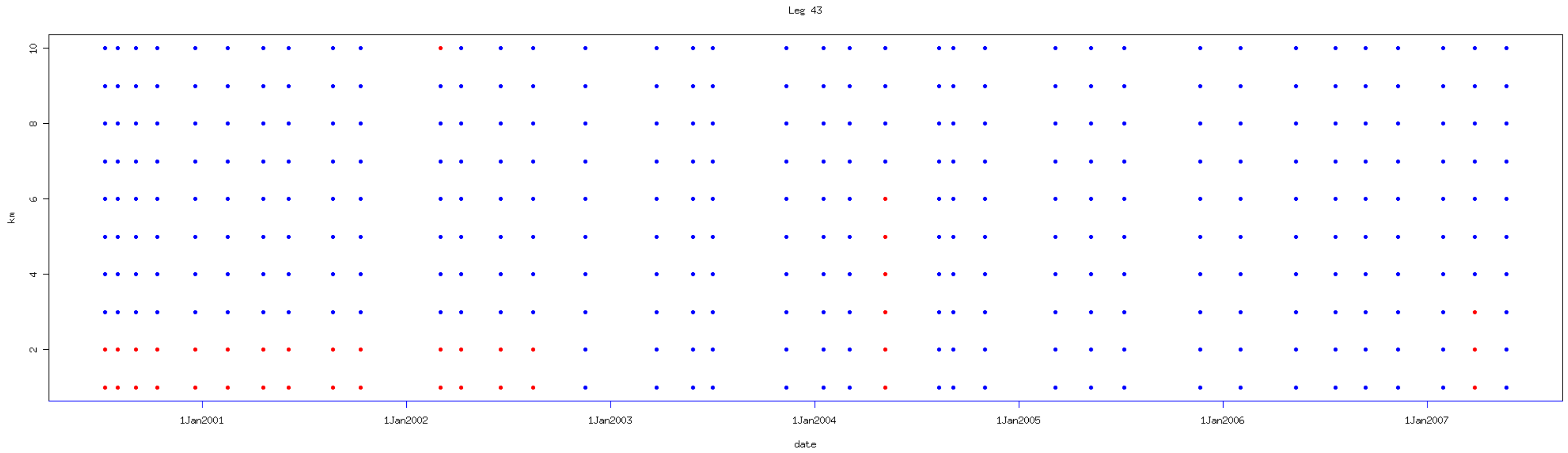
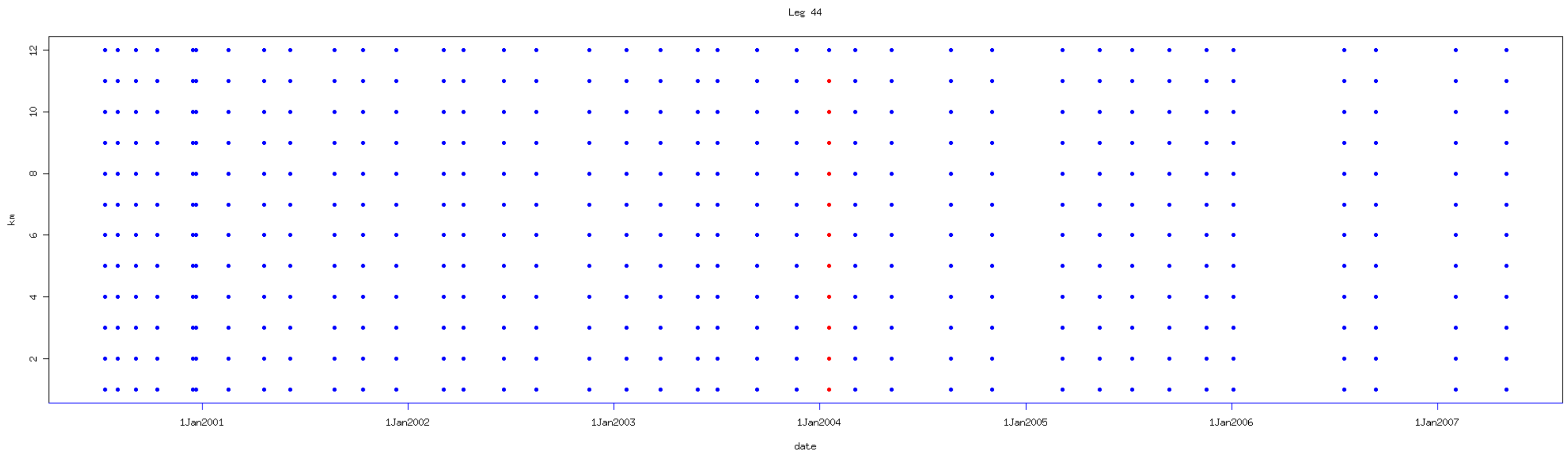


Figure B9 Coverage of Box leg 44. Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.



Appendix C

Non-seabird species recorded in the Arklow Study Area in Years 5, 6 and 7

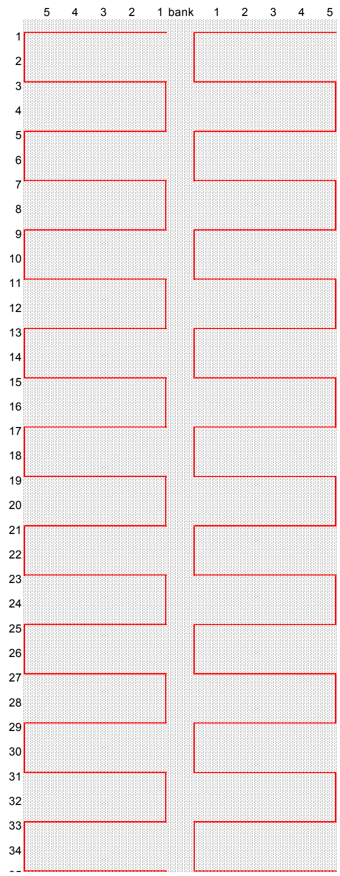
Table B1 Numbers of non-seabirds recorded in the Arklow Study Area in Years 5, 6 & 7

Species	Bank			Box			Cable route		
	Year			Year			Year		
	5	6	7	5	6	7	5	6	7
Brent Goose	0	0	0	0	0	0	0	11	2
Shelduck	0	6	0	0	0	0	0	0	0
Merlin	0	0	0	0	0	0	0	0	1
Oystercatcher	0	0	0	0	0	0	0	0	1
Ringed Plover	0	0	1	0	0	0	0	0	1
Purple Sandpiper	0	0	0	0	0	1	0	0	0
Dunlin	0	0	5	0	0	0	0	0	0
Whimbrel	0	0	0	0	0	0	2	0	0
Wader species	0	4	0	0	0	0	0	0	0
Swift	0	1	0	0	0	0	0	0	0
Skylark	1	0	0	0	0	0	0	0	0
Swallow	60	4	5	4	14	0	4	0	0
House Martin	0	3	0	0	0	0	0	0	0
Pipit species	1	0	0	0	0	0	0	0	0
Thrush species	8	0	0	0	0	0	0	0	0
Goldcrest	0	1	0	0	0	0	0	0	0
Starling	25	0	0	0	35	0	0	0	0
Chaffinch	0	0	0	0	0	0	0	1	0
Total	**95**	**19**	**11**	**4**	**49**	**1**	**6**	**12**	**5**

Appendix D

Suggested revised survey route for Arklow Bank surveys

Figure C1 Suggested revised survey route for Arklow Bank surveys



Red lines show survey route. Bank assumed to be circa 1 km wide giving a box of 11 km east-west by 35 km north south. There are 18 transects, extending 5 km from bank on either side, the first 0.5 km from the northern boundary of the box and the last 0.5 km north of the boxes southern edge. With 2 km between each of these transects, no point is further than 1 km from nearest transect. Note by surveying the sections running north-south, this will achieve more detailed coverage in the vicinity of the bank. (indeed almost complete north-south coverage, although sometimes from one side of the bank, sometimes from the other).