Arklow Bank Seabird and Marine Mammal Monitoring Programme

Year 8 Final Report: July 2007 to June 2008

Arklow turbine

Report to Airtricity

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CORK ♦ ECOLOGY

Long Strand, Castlefreke, Clonakilty, Co. Cork
Website: www.corkecology.net E-mail: info@corkecology.net

Craigton Ecological Services
Ecological Survey and Data Solutions

48 Craigend Drive West, Milngavie, Glasgow, G62 7BG, UK
E-mail: craigton.ecological.services@phonecoop.coop

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Summary

Introduction

In August 2003, Airtricity and GE began the construction of an offshore wind farm of up to 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 Foreshore Lease for the development of the Arklow Bank wind farm was granted by the then 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.

This report presents the results of seabird and marine mammal survey work from Year 8, together with data from Years 5, 6 and 7 combined, for comparison.

Methodology

The methodology used for Year 8 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.

Results

Survey results from Year 8 and Years 5, 6 and 7 combined 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.

A total of 32 species of seabirds were identified on surveys in the Arklow Study Area in Year 8. In terms of overall numbers of birds in the Arklow Study Area, Kittiwake, Razorbill and Manx Shearwater were the most important species in Year 8, together accounting for 67.7 % of all birds recorded.

Discussion

Key species

Eight seabird species listed on Annex I of the EU Birds Directive (79/409/EEC) were recorded in the Arklow Study Area in Year 8. These included 2 diver species (Red-throated and Great Northern), Storm Petrel, Mediterranean Gull and 4 species of tern (Sandwich Tern, Roseate Tern, Arctic Tern and Common Tern).z

Most of these species occurred in very low numbers and would not be considered nationally important. However, the combined 4-year mean for Red-throated Diver over the Arklow Bank, for Years 5 to 8 was 36 birds, which is above the nationally important threshold of 20 birds.

There was evidence from Year 8 surveys that the Arklow Bank may be important for Common and Arctic Terns on passage migration in spring and autumn.

Kittiwake was the most numerous species recorded in the Arklow Study Area, with peak monthly counts over the Bank exceeding 15,000 birds in October. Although a 1 % threshold of national importance has not been set for Kittiwake, this peak would be approximately equivalent to 1.8 % of the all-Ireland breeding population.

In Year 8, peak numbers of Razorbills were recorded over the Bank in September. Although a similar pattern was recorded in August and September of Years 5 to 7, the Year 8 peak was considerably higher than previous years. While a 1 % threshold of national importance has not been set for Razorbill, the September peak would be approximately equivalent to 19.6 % of the all-Ireland breeding population.

Peak counts of Manx Shearwater in Year 8 also peaked over the Bank in September, with this count considerably exceeding previous years peaks. Again, no 1 % threshold of national importance has been set for Manx Shearwater, but the September peak would be approximately equivalent to 9.1 % of the all-Ireland breeding population.

Other important species recorded in the Arklow Study Area in Year 8 included Little Gull, Black-headed Gull, Common Gull and Guillemot.

Harbour Porpoise was the most commonly recorded marine mammal in the Arklow Study Area in Year 8, and was recorded in all months, with a peak of 31 animals recorded in September. This species is listed on Annex II and IV of the EU Habitats Directive (92/43/EEC).

Breeding seabirds at Wicklow Head

Numbers of seabirds have been monitored since 2001 as part of the ongoing Seabird and Marine Mammal Monitoring Programme for the Arklow Bank Wind Farm project.

In 2008, complete colony counts were conducted for six species breeding at Wicklow Head; Fulmar, Shag, Herring Gull, Kittiwake, Guillemot and Razorbill. Counts of Fulmar, Shag, Herring Gull, Guillemot and Razorbill increased in 2008 compared to 2007, while counts of Kittiwake decreased compared to 2007. Overall trends between 1999 and 2007 showed that numbers of Fulmar, Shag, Guillemot and Razorbill showed an increase, while Kittiwake showed a slight decline overall. Herring Gull numbers have declined since 1999 but have been increasing again in recent years.

The 2008 Kittiwake productivity estimate for Wicklow Head was lower than in the previous seven years. It may be that the drop in numbers recorded in 2008 is the start of a decline in numbers at Wicklow Head. It is therefore recommended that the monitoring of breeding seabirds at Wicklow Head should be continued in 2009.

Control site

A preliminary survey was conducted over Glassgorman Bank to establish its potential as a control area distinct from the Arklow Bank, but with similar habitats and bird communities. However, from the low numbers of birds recorded and the different species composition recorded on the survey, favouring scoter rather than gulls and auks, Glassgorman Bank did not appear to be a suitable control site. Further surveys of Glassgorman Bank are therefore not recommended.

Data sharing and publication

It is international best practice to disseminate offshore wind farm environmental data and also to publish results of offshore wind farm studies. The licensing conditions state that the Arklow Bank monitoring programme should follow international best practice. Data sharing also enables the project to receive reciprocal data from other areas for comparison, e.g. ESAS data from the Irish Sea, and information on breeding seabird numbers and success at other colonies in the Irish Sea. Data sharing recommendations were presented and summarised.

Statistical analyses of key species in Years 1 to 8

The main findings of the analyses were that a strong, statistically significant decline occurred in the numbers of the 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.

These results raise the possibility of Red-throated Divers on Arklow Bank 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 under the EU Birds Directive, it is recommended that continued monitoring Red-throated Divers should be a high priority.

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.

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.

Recommendations

- 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 occur in large numbers, such as Little Gull, Kittiwake, Guillemot, Razorbill, Manx Shearwater and Common Gull.
- The revised survey route for the Bank area, with transect legs orientated perpendicular to the Bank commenced in July of Year 9, and should be continued in Year 10. This will allow more powerful statistical analyses to be used and total numbers in the study area to be calculated with confidence limits;
- Surveys of breeding seabirds at Wicklow Head should also be continued as part of the overall Arklow Bank Seabird and Marine Mammal Monitoring Programme;
- Arklow Bank seabird and marine mammal survey data should be made available to JNCC and NBDC, for inclusion in their databases. In addition, seabird breeding data from Wicklow Head should be made available to the SMP database;
- The Year 8 Arklow Bank Seabird Monitoring Report should be published in the public domain, in accordance with best practice guidelines (Fox et al 2006, Langston et al 2006).

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1. Introduction

In August 2003, Airtricity and GE began the construction of an offshore wind farm of up to 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 then 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 Year 8, and also compares the Year 8 results with previous years.

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 Year 8 Arklow Bank Seabird and Marine Mammal Monitoring Programme are outlined below:

Boat Surveys

- Boat surveys of seabirds and marine mammals in the Arklow Study Area were conducted on a monthly basis;
- Plankton surveys were conducted at 10 sampling stations each month, (although these was discontinued after February 2008).

Seabird Colony Counts

- A survey of breeding seabirds at Wicklow Head was conducted in June and July 2008 (Cork Ecology 2008).

2. Methods

2.1 Survey methods

The methodology used for Year 8 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) and COWRIE standards (Camphuysen *et al* 2004), 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 Year 8, boat surveys were conducted by Dave Branagh, Eugene Archer, John Lovatt, Hugh Delaney 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.

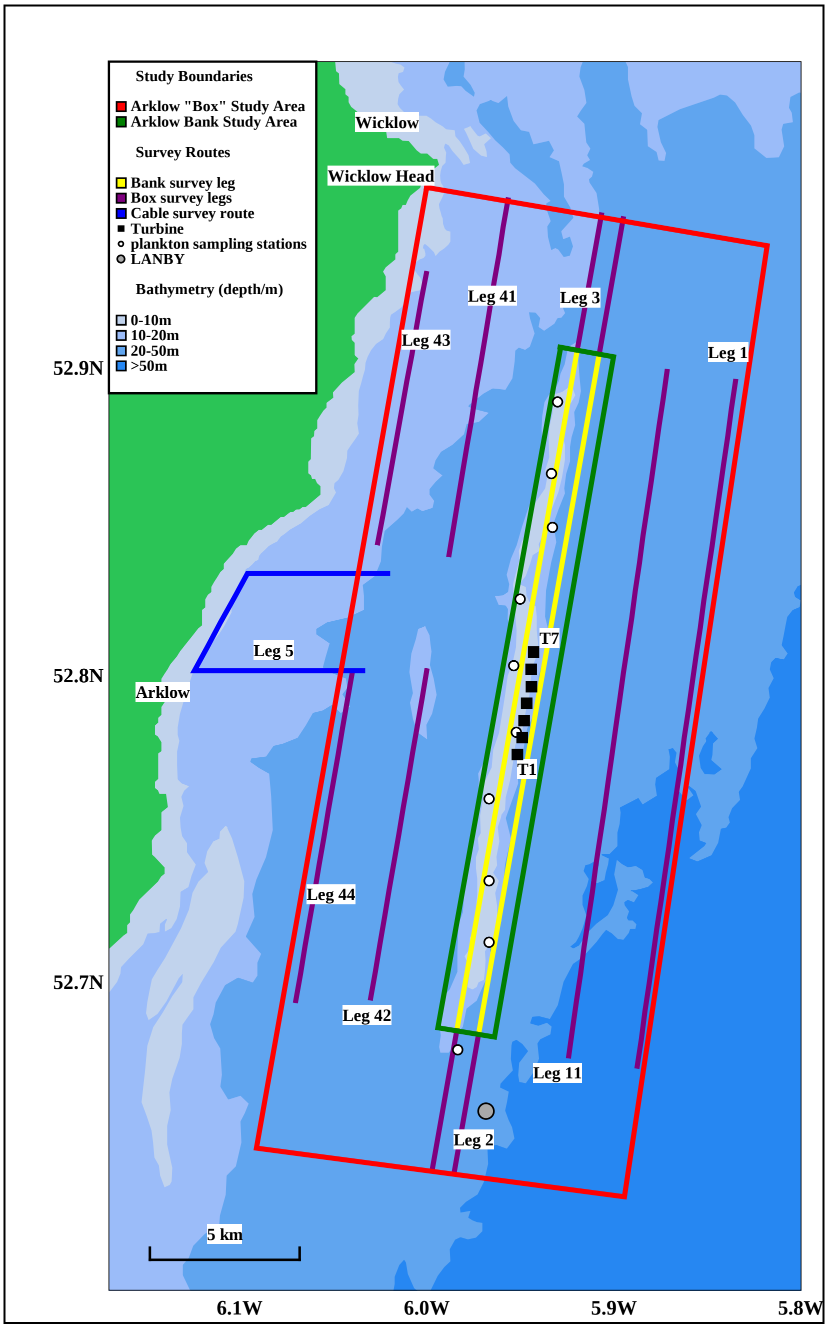
The survey legs have been modified slightly over the years and the changes are detailed in a previous report (CWC 2006).

2.3 Plankton Sampling

In Year 8, 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.

The plankton surveys were discontinued after February 2008, following a review of survey methods used in the Arklow Bank Monitoring Programme (Cork Ecology 2007a).

Figure 2.1 Map of Arklow Study Area



2.4 Weather conditions

A summary of survey weather conditions in Year 8 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 Arklow Study Area. Unidentified species groups such as Guillemot/Razorbill and Common/Arctic tern were divided out among the component species, based on the daily ratio on the date they were recorded.

JNCC provided ESAS survey data from 1981 to 2001 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. The western Irish Sea area was defined as those ¼ ICES rectangles between 52^o and 54 ^{o} N, and between 5 to 6.5 ^{o} W, which are fully/partly in Irish waters.

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.

Mean density 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. As recommended by Camphuysen *et al* (2004), only data collected in sea states of less than 5 were used to calculate species density. In this report, density maps were produced for Manx Shearwater, Little Gull, Black-headed Gull, Common Gull, Kittiwake, Common Tern, Arctic Tern, Guillemot and Razorbill.

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. In this report, abundance maps were produced for Red-throated Diver, Fulmar, Gannet, Shag, Herring Gull and Harbour Porpoise.

To calculate abundance for each ¼ ICES rectangle, the total number of birds was divided by the distance travelled. Monthly and seasonal abundance maps were compiled. Again, only data collected in sea states less than 5 were used to calculate species abundance. In the case of Harbour Porpoise, only data collected in sea states less than 4 were considered, as per COWRIE recommendations (Camphuysen *et al* 2004).

Sightings maps

For rare species (total less than 100 but more than 1 individual), incidental sightings were mapped. Data collected in all sea states were used.

2.7 Charts

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

Total numbers charts

Monthly totals are presented for the Bank survey legs and for the Box survey legs. The Bank survey legs were defined as km 1 to 35 of survey legs 2 and 3, i.e. the entire length of these two survey legs (Figure 2.1). Data collected in all sea states are shown.

As the Bank legs were surveyed twice per month in Year 8, 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 Arklow 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 each 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 Arklow Study Area can be calculated. Monthly totals for Years 5, 6 and 7 (all post-construction), are included for comparison with Year 8 numbers.

It should be noted that this is quite a crude estimate, as while surveys of the Bank legs were usually completed in one day, the Box survey legs were generally surveyed over two or more days, which may not have been consecutive.

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

Abundance/density charts

These charts show the mean monthly abundance (no. of birds/km travelled) or density (no. of birds/km^2) of species on the Bank and Box in Year 8. Data for Years 5 to 7 (post-construction) were reanalysed and average combined monthly values were calculated for comparison with the Year 8 data.

As with the abundance and density maps, only seabird data collected in sea states less than 5, and Harbour Porpoise data collected in sea states less than 4 were included in this analysis.

2.8 Methods of statistical analyses of data from Years 1 to 8

2.8.1 Analysis of key species

This report analyses the impact of the installation of the first seven turbines on the12 key species identified in previous reports (Cork Ecology 2007b, CWC 2004). The analyses presented here are more powerful and supersede those presented in the Year 7 report (Cork Ecology 2007b) as they also include the additional survey data collected during Year 8. The 12 key species for which analyses were conducted are Red-throated Diver, Fulmar, Manx Shearwater, Gannet, Shag, Guillemot, Razorbill, Kittiwake, Little Gull, Arctic Tern, Common Tern 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 cruise changed since the turbines were installed?
2) For the Bank legs (legs 2 and 3), has the relationship between the number of birds/porpoise and distance to the nearest turbine location changed since the turbines were installed?

In theses analyses we consider the changes in abundance and distribution with respect to three periods.

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 cannot be used as an effective control as they do not share comparable marine habitats, and bird communities with the Bank, where the turbines are being installed. Therefore the approach we have adopted is similar to that advocated by Fox *et al* (2006) (e.g. see their figure two) and involves comparing the relationship between bird numbers and distance from the turbines before and after the installation of the turbines. If turbines were responsible for an observed decline in bird numbers on a survey 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 are artefacts generated by the changes in methodology which have occurred during the course of this project (e.g. changes in the survey vessel, changes in the height of the viewing platform, changes in the 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 also have potentially masked genuine impacts.

As noted in section 2.2, although the Bank legs (legs 2 and 3) and Cable legs (leg 5) were usually surveyed on a monthly basis, the Box legs were surveyed bimonthly, with legs 1, 43 and 44 being surveyed in one month, and legs 11, 41 and 42 being surveyed in the following month. As bird numbers are likely to vary considerably from month to the next, 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 Year 1, allowing data from this year to also be included. Thus, as well as carrying out analyses for each leg based upon data from surveys where full coverage were achieved, analyses were also conducted based upon surveys that achieved:

- Complete coverage of km 11-30 of the inner Bank leg (leg 3);
- Complete coverage of km 1-9 of the Cable Route (leg 5);
- Complete coverage of km 10-15 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 *et al* 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 600m, and a 180° field of view were excluded from all analyses, as were data collected on 27th March 2007 with a 200m wide transect. Thus, all data included in analyses was collected with a 300m 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 300m transect, and scans beyond the 300m transect, being used on some surveys and not others. One approach to avoid any potential biases this may cause would be to only include records for birds on the water in transect in analyses. Although this might have been a suitable approach for species which are common within the Arklow Study Area and also spend a high proportion of their time on the water (e.g. auks), many of the species with which we are principally concerned are either too rare (e.g. Harbour Porpoise) or spend too high a proportion of their time in the air (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 300m 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 300m transect was employed than when it was not. This needs to be borne in mind when interpreting the results presented below.

In recent years, two observers have generally been employed 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 the installation of turbines, for the Bank legs, when data from a particular trip is available both facing towards and away from the Bank, the data collected by the observer facing the Bank has been used.

3. Results

3.1 Survey effort

Surveys were conducted over 22 days between July 2007 and June 2008, with a total of 3,689 km surveyed (Table 3.1). Figure 3.1 shows the survey coverage (number of surveys) in the Arklow Study Area in Year 8.

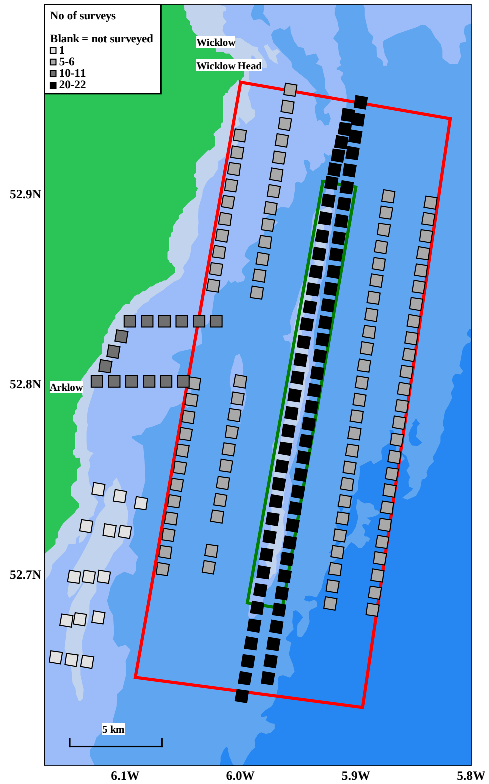
The aim was to survey the Bank legs twice monthly, the Cable Route once per month and half of the Box survey legs each month. This was achieved in most months, except January, where no survey was possible due to adverse weather conditions.

Table 3.1 Survey effort for the Arklow Study Area for Year 8

Area	No. of survey days	Km surveyed (all days)	Area surveyed in km^2 (all days) [1,2]
Bank	22	2,999.01	899.70
Box	11	529	158.70
Cable route	11	161	48.3
Total	**22**	**3,689.01**	**1,106.70**

1 Total includes survey effort gathered in all sea states
2 Total does not include Glassgorman surveys in March

Figure 3.1 Survey effort in the Arklow Study Area in Year 8



3.2 Raw numbers of seabirds in the Arklow Study Area in Year 8

A total of 32 species of seabirds were identified on surveys in Year 8. This compares to 28 species in Year 7, 26 species in Year 5 and 29 species in Year 6.

Totals for the most common seabird species for Year 8 are shown in Table 3.2. The three commonest species in the Arklow Study Area in Year 8 were Kittiwake, Razorbill and Manx Shearwater, which together accounted for 67.7 % of all birds recorded.

Table 3.3 summarises the occurrences of a further 18 species of seabirds which were less frequently recorded in the Arklow Study Area in Year 8.

To put these results into context, JNCC seabird distribution data from 1981 to 2001 for 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. The three commonest species in the western Irish Sea between 1981 to 2001 were Manx Shearwater, Guillemot and Fulmar, while in the four ¼ ICES rectangles, the three commonest species were Guillemot, Manx Shearwater and Razorbill.

3.2.1 Non-seabird species recorded in the Arklow Study Area in Year 8

A total of 49 birds of four non-seabird species were recorded in the Arklow Study Area in Year 8. Just over half of all non-seabirds recorded were Swallows (55.1 %), while just over a third were Starlings (34.7 %). The remaining species recorded were Curlew and Whimbrel (Appendix C).

Table 3.2 shows numbers of the commoner seabird species recorded in the Arklow Study Area in Year 8. Abundance or density data for these species is presented in the species accounts.

Table 3.2 Numbers of the most common seabirds recorded in the Arklow Study Area in Year 8

Species	Year 8	
	Number	No. of days
Red-throated Diver	60	14
Fulmar	38	10
Manx Shearwater	11,380	15
Gannet	512	22
Shag	327	19
Little Gull	6,825	14
Black-headed Gull	6,361	12
Common Gull	1,797	14
Herring Gull	74	9
Kittiwake	67,745	22
Common Tern	1,637	11
Arctic Tern	1,284	7
Guillemot	6,422	22
Razorbill	12,702	22
Small Gull Species [1]	5,030	4
Common/Arctic Tern[2]	1,384	11
Guillemot/Razorbill [3]	12,113	19
Total numbers	**135,691**	**22**

1 Unidentified small gulls. In later analysis these records were divided between Little Gulls, Black-headed Gulls, Common Gulls and Kittiwakes, based on daily ratios of these four 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 shows numbers of the less common seabird species recorded in the Arklow Study Area in Year 8. Sightings maps for these species are presented in the species accounts.

Table 3.3 Numbers of less common seabirds recorded in the Arklow Study Area in Year 8

Species	Year 8	
	Number	No. of days
Great Northern Diver	1	1
Great Shearwater	1	1
Sooty Shearwater	1	1
Storm Petrel	3	3
Cormorant	53	14
Common Scoter	25	3
Red-breasted Merganser	4	2
Pomarine Skua	4	3
Arctic Skua	13	5
Great Skua	2	2
Mediterranean Gull	1	1
Lesser Black-backed Gull	6	4
Great Black-backed Gull	54	14
Sandwich Tern	8	4
Roseate Tern	50	2
Black Guillemot	1	1
Little Auk	1	1
Puffin	4	3
Scoter species	109	2
Auk species	152	2
Total numbers	**493**	**22**

Table 3.4 Numbers [1] of common seabirds recorded on JNCC surveys between 1981 and 2001 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	256	92.58	17	13,722	38.55	228
Great Shearwater	9	100	1	165	28.48	3
Manx Shearwater	1,641	43.75	18	53,569	32.74	167
Storm Petrel	16	100	2	348	73.28	45
Gannet	125	88.8	18	5,899	57.25	221
Cormorant	6	100	4	251	74.1	41
Shag	2	0	1	329	69.0	46
Common Scoter	0	0	0	488	58.61	9
Scoter species	80	100	1	80	100	1
Little Gull	57	57.89	5	72	62.5	8
Great Skua	3	100	3	92	90.22	48
Black-headed Gull	2	100	2	636	84.83	41
Common Gull	8	87.5	3	211	64.93	26
Lesser Black-backed Gull	35	91.43	8	1,184	57.52	131
Herring Gull	13	23.08	3	2,168	52.26	128
Herring/Lesser black backed Gull	0	0	0	90	51.11	4
Greater Black-backed Gull	3	100	3	814	48.53	98
Kittiwake	525	58.67	21	11,270	48.39	232
Small gull species	11	27.27	3	92	83.70	6
Large gull species	6	83.33	2	1,034	54.84	63
Gull species	3	66.67	2	938	32.62	24
Sandwich Tern	0	0	0	81	79.01	20
Common Tern	17	100	4	1,081	74.19	46
Arctic Tern	2	50.0	2	163	68.1	31
Common/Arctic Tern	49	22.45	5	964	57.26	64
Tern species	1	0	1	290	30.34	24
Guillemot	1,925	6.44	21	32,255	3.77	230
Razorbill	894	8.05	20	6,752	10	180
Guillemot/Razorbill	105	48.57	14	7,804	7.03	135
Puffin	29	17.24	4	521	21.5	81
Auk species	8	0	1	202	26.24	39
Totals	**5,831**	**31.88**	**-**	**143,565**	**28.54**	**-**

1 n ≥ 60 birds recorded on JNCC surveys in western Irish Sea between 1981 to 2001; raw data supplied by JNCC

Table 3.5 Numbers [1] of less common seabird species recorded on JNCC surveys in the western Irish Sea between 1981 and 2001

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
Great Crested Grebe	2	1
Cory's Shearwater	3	1
Sooty Shearwater	22	11
Balearic Shearwater	19	11
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	23	17
Arctic Skua	56	25
Long-tailed Skua	2	2
Skua species	1	1
Small skua species	1	1
Mediterranean Gull	1	1
Sabine's Gull	5	5
Glaucous Gull	1	1
Common/Herring Gull	1	1
Black-backed gull species	23	8
Roseate Tern	19	6
Little Tern	11	2
Black Tern	7	5
Black Guillemot	6	3
Little Auk	2	2
Totals	**253**	**-**

1 n < 60 birds recorded on JNCC surveys in western Irish Sea between 1981 and 2001; raw data supplied by JNCC

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

A total of 30 seabird species were recorded over the Bank in Year 8, with 19 species recorded in the Box and 14 species over the cable route.

Numbers of the 14 commonest seabird species over the Bank, Box and Cable Route in Year 8 are shown in Table 3.6. Total numbers of birds over the Bank accounted for 96.5 % of all birds recorded in Year 8.

Table 3.6 Comparison of the most common seabird numbers over the Bank, Box and Cable route in Year 8

Species	Bank	Box	Cable
Red-throated Diver	54	3	3
Fulmar	31	7	0
Manx Shearwater	9,162	2,159	59
Gannet	470	42	0
Shag	318	7	2
Little Gull	6,819	6	0
Black-headed Gull	6,354	1	6
Common Gull	1,758	16	23
Herring Gull	70	0	4
Kittiwake	67,454	267	24
Common Tern	1,637	0	0
Arctic Tern	1,280	4	0
Guillemot	5,809	577	36
Razorbill	12,189	503	10
Small Gull Species [1]	5,030	0	0
Common/Arctic Tern [2]	1,358	26	0
Guillemot/Razorbill [3]	11,185	925	3
Total	**130,978**	**4,543**	**170**

1 Unidentified small gulls. In later analysis these records were divided between Little Gulls, Black-headed Gulls, Common Gulls and Kittiwakes, based on daily ratios of these four 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

Mean ranking of the most common species by raw numbers recorded in the Arklow Bank and Box Areas during Year 8, 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 Year 8, and also in Years 5, 6 and 7 (Cork Ecology 2007b). However, in the Box, Manx Shearwater was ranked 1st, with Kittiwake ranked 5th.

Razorbill, Guillemot/Razorbill and Manx shearwater were ranked 2nd to 4th commonest species respectively over the Bank in Year 8. In the Box, 2nd to 4th rankings were similar, with Guillemot/Razorbill, Guillemot and Razorbill ranked in descending order.

Little Gull was ranked 5th commonest species over the Bank in Year 8, while in the Box, Kittiwake was ranked in 5th.

Table 3.7 Common species rankings in the Arklow Bank & Box Areas in Year 8

Species	Bank	Box
Kittiwake	**1**	**5**
Razorbill	**2**	**4**
Guillemot/Razorbill	**3**	**2**
Manx Shearwater	**4**	**1**
Little Gull	**5**	11
Black-headed Gull	6	14
Guillemot	7	**3**
Small gull sp.	8	**-**
Common Gull	9	8
Common Tern	10	-
Common/Arctic Tern	11	7
Arctic Tern	12	12
Gannet	13	6
Shag	14	10
Herring Gull	15	-
Red throated Diver	16	13
Fulmar	17	9

3.2.3 Survey over Glassgorman Bank in March

A total of 15 km of survey coverage was conducted over Glassgorman Bank in March of Year 8, in an attempt to examine the feasibility of establishing a control area distinct from the Arklow Bank, but with similar habitats and bird communities. Five transects, each three km long and running east to west were surveyed.

Five seabird species were recorded, with a total of 35 individual birds (Table 3.8).

Table 3.8 Species recorded over Glassgorman Bank in March of Year 8

Species	Number recorded
Red-throated Diver	3
Common Scoter	17
Scoter species	12
Common Gull	1
Kittiwake	1
Razorbill	2

3.3 Flying birds

Numbers of the 15 most common seabird species recorded flying in the Arklow Study Area in Year 8 are shown in Table 3.9. The three species most frequently recorded in flight in Year 8 were Kittiwake, Little Gull and Manx Shearwater.

Table 3.9 Numbers of the most common seabirds recorded flying in Year 8

Species	No. of birds	No. of flying birds	% flying birds
Red-throated Diver	60	34	56.67
Fulmar	38	33	86.84
Manx Shearwater	11,380	742	6.52
Gannet	512	179	34.96
Shag	327	44	13.46
Little Gull	6,825	1,090	15.97
Black-headed Gull	6,361	146	2.3
Common Gull	1,797	250	13.91
Herring Gull	74	21	28.38
Kittiwake	67,745	7,344	10.84
Roseate Tern	50	28	56.0
Common Tern	1,637	478	29.20
Arctic Tern	1,284	514	40.03
Guillemot	6,422	696	10.84
Razorbill	12,702	347	2.73
Scoter species	109	109	100
Small Gull species [1]	5,030	2,215	44.04
Common/Arctic Tern [2]	1,384	514	37.14
Guillemot/Razorbill [3]	12,113	961	7.93
Total	**135,850**	**15,745**	**11.6 %**

1 Unidentified small gulls. In later analysis these records were divided between Little Gulls, Black-headed Gulls, Common Gulls and Kittiwakes, based on daily ratios of these four 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 8, 11.6 % of the most common species were recorded in flight. This compares to 24.67 % in Year 7, 5.95 % in Year 6 and 41.74 % recorded in Year 5 (Cork Ecology 2007b). The percentage of birds in flight was largely determined by the behaviour of gulls such as Little Gulls and Kittiwake, which can 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 Year 8. Distance from the turbines was not considered here, i.e. flying birds were included regardless of where they were recorded in flight. Sample sizes for many species were low, and this should be borne in mind when interpreting the results. Species with fewer than 20 individuals recorded in flight were not considered in this analysis.

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

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

In the Arklow Study Area, the majority of all flying birds of the most common seabird species were recorded below 20 m in height (97.2 %) (blue and green lines) (Figure 3.2). No auks, Fulmar, Shag, Manx Shearwater, Arctic Tern and Roseate Tern were recorded flying above 20m.

A similar pattern was recorded over the Bank, with the majority of all flying birds of the most common seabird species all recorded below 20 m in height (96.43 %) (Figure 3.3). Again, no auks, Fulmar, Shag, Manx Shearwater and Arctic Tern were recorded flying above 20m.

In Year 8, a total of eight species (Herring Gull, Gannet, Red-throated Diver, Black-headed Gull, Little Gull, Common Tern, Common Gull and Kittiwake) were recorded flying above 20 m in the Arklow Study Area (Figure 3.2). One unidentified Common/Arctic Tern was also recorded above 20 m.

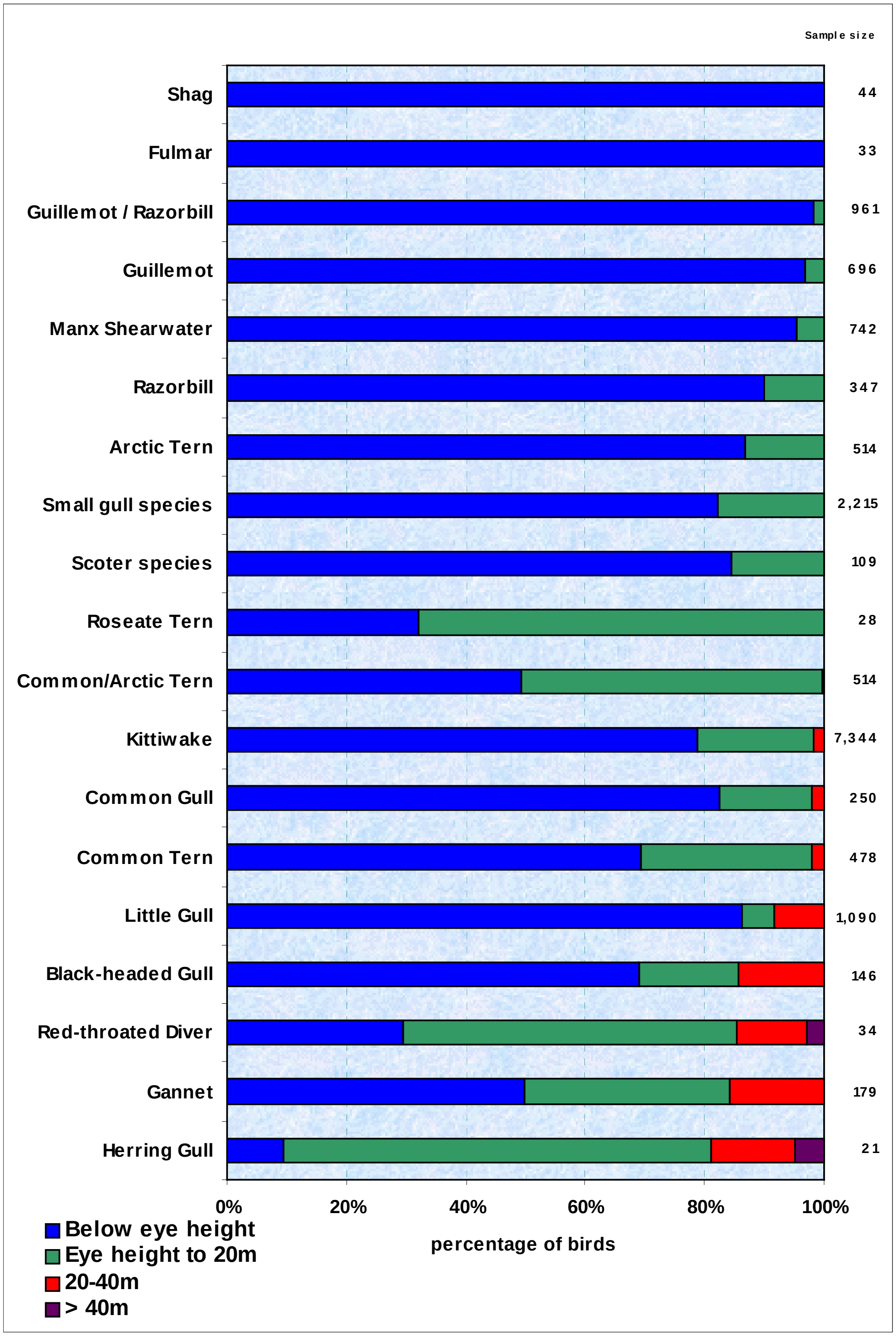
More than 10 % of all flying Herring Gulls, Gannets, Red-throated Divers and Black-headed Gulls were recorded flying above 20 m in the Arklow Study Area (Figure 3.2). Overall, numbers involved were low, with 4 Herring Gulls (19.05 %), 28 Gannets (15.64 %), 5 Red-throated Divers (14.7 %) and 21 Black-headed Gulls (14.38 %).

Less than 10% of all flying Little Gulls, Common Terns, Common Gulls and Kittiwakes were recorded flying above 20 m in the Arklow Study Area (Figure 3.2). Overall, the numbers involved were 89 Little Gulls (8.17 %), 10 Common Terns (2.09 %), 5 Common Gulls (2.0 %) and 124 Kittiwakes (1.69 %).

The same eight species were also recorded flying above 20 m over the Bank (Figure 3.3). More than 10 % of all flying Red-throated Divers, Gannets, and Black-headed Gulls were recorded flying above 20 m in the Arklow Study Area. Overall, the numbers involved were low, with 5 Red-throated Divers (17.24 %), 20 Gannets (14.08 %), 20 Black-headed Gulls (13.79 %).

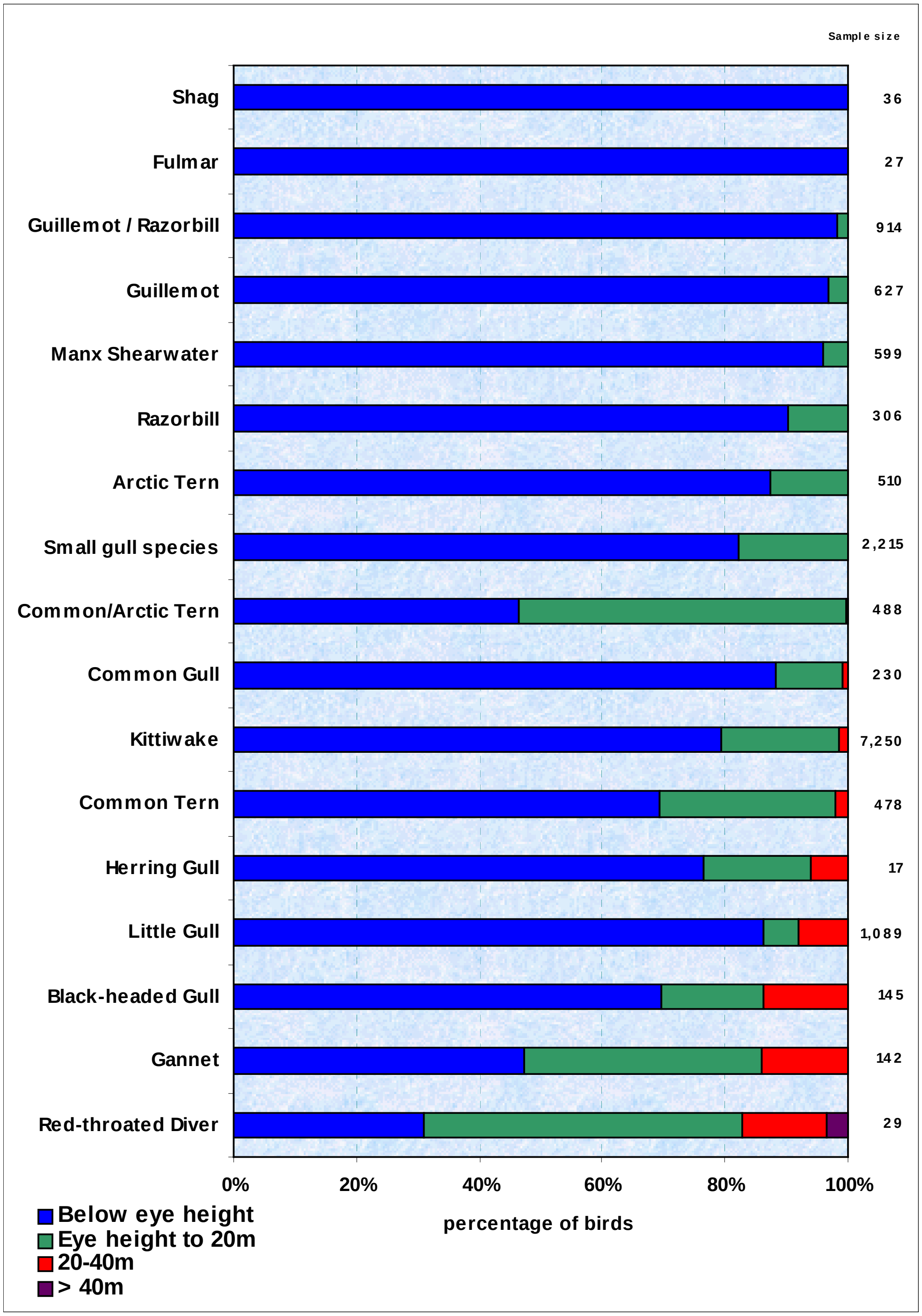
Less than 10% of all flying Little Gulls, Herring Gulls, Common Terns, Kittiwakes and Common Gulls were recorded flying above 20 m over the Bank (Figure 3.3). Overall, the numbers involved were 88 Little Gulls (8.08 %), 1 Herring Gull (5.88 %), 10 Common Terns (2.09 %), 113 Kittiwakes (1.56 %) and 2 Common Gulls (0.87 %).

Figure 3.2 Flight heights of seabird species in the Arklow Study Area in Year 8 [1]



1 Species with less than 20 individuals recorded flying are not shown

Figure 3.3 Flight heights of seabird species over the Bank in Year 8



3.4 Seabird Species Accounts

The following seabird species accounts present a summary of distribution and abundance within the Arklow Bank Study Area for Year 8, with a brief comparison with Years 5 to 7 combined, which covers the whole of the post-construction phase.

3.4.1 Red-throated Diver

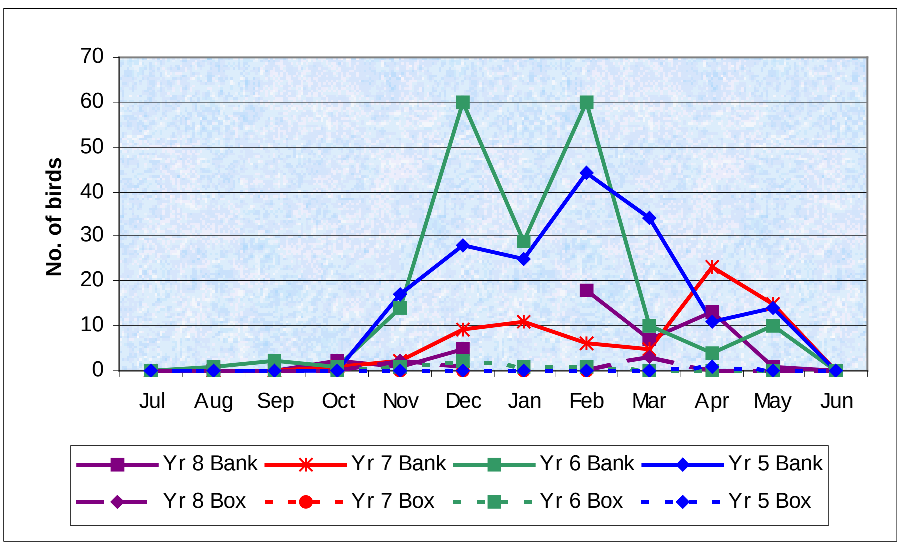
Red-throated Divers are winter visitors to the Arklow Study Area. The species is listed on Annex I of the EU Birds Directive (79/409/EEC).

Numbers in the Arklow Study Area

In Year 8, peak numbers of Red-throated Divers over the Bank were low between July and November, increasing slightly in December (Figure 3.4). Numbers peaked in February (18 birds), which was a similar pattern to Years 5 and 6, when peak numbers were 44 birds and 60 birds respectively. Numbers over the Bank in Year 7 peaked in April (23 birds).

Numbers of Red-throated Divers recorded in the Box were low in all four years, with a total of three birds recorded in March of Year 8 being the highest count (Figure 3.4).

Figure 3.4 Numbers of Red-throated Divers in the Bank and Box, Years 5 to 8



Mean monthly abundance

In Year 8, mean monthly abundance over the Bank was lower than Years 5 to 7 combined, with a peak of 0.07 birds/km in February (Figure 3.5). Mean monthly abundance in Years 5 to 7 peaked in December, when 0.22 birds/km were recorded.

Mean monthly abundance in the Box in Year 8 was lower, with a peak of 0.04 birds/km in November (Figure 3.5). This was higher than the combined mean monthly abundance for Years 5 to 7, which peaked at 0.02 birds/km, in December.

Figure 3.5 Red-throated Diver mean monthly abundance in the Bank and Box, Years 5 to 8

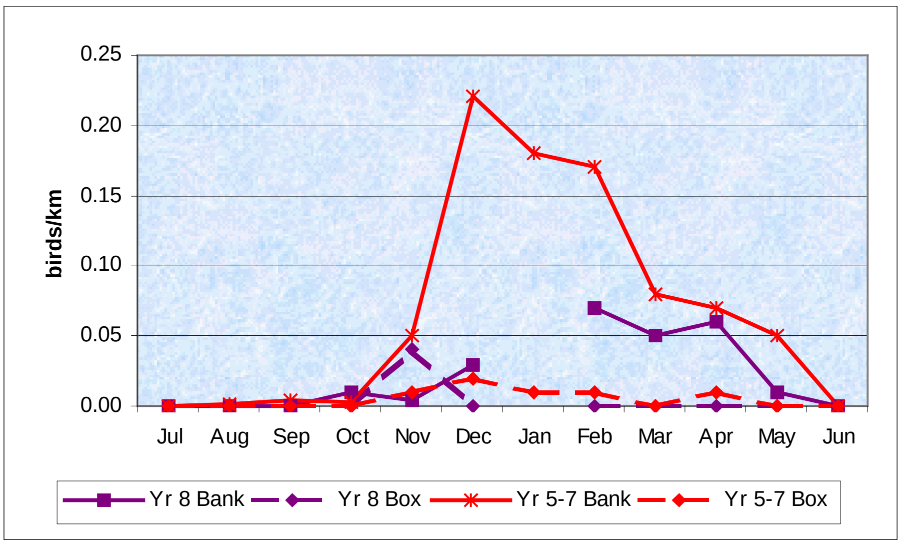


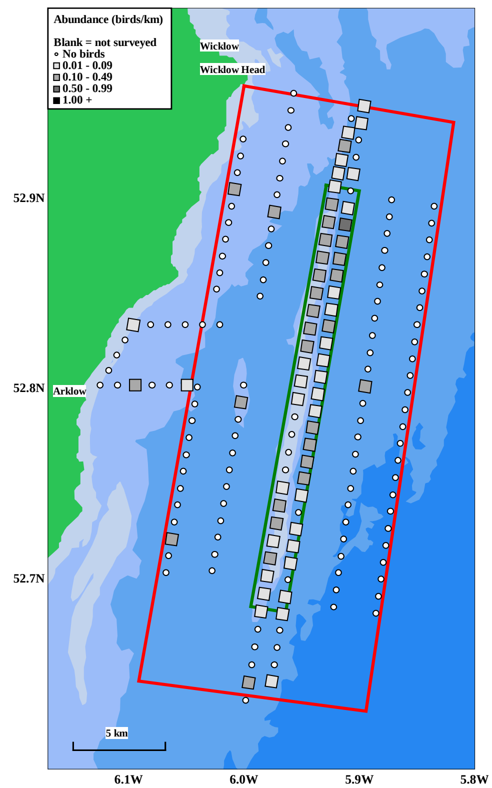
Figure 3.6 Red-throated Diver abundance in the Arklow Study Area, November to May

Years 5 to 7 - November to May

Between November and May of Years 5 to 7, Red-throated Divers were largely confined to the Bank, with low to moderate abundance recorded. Low to moderate abundance was recorded sporadically in the Box.

In addition, there were six Red-throated Divers recorded between August and October of Years 5 to 7 (not shown).

Years 5 to 7

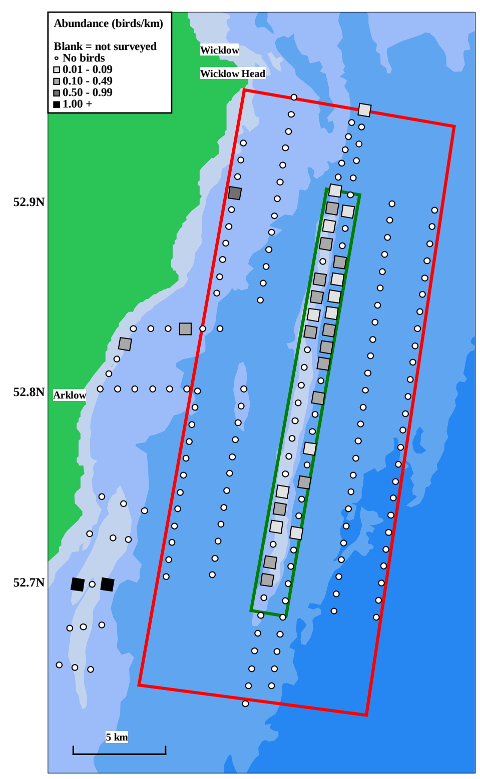


Year 8 - November to May

In Year 8, Red-throated Divers were again mostly found over the Bank between November and May. Highest abundances (1.75 birds/km) were recorded on the additional Glassgorman Bank surveys in March.

In addition, there were three Red-throated Divers recorded between August and October of Year 8 (not shown).

Year 8



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).

Years 5 to 7

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.

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

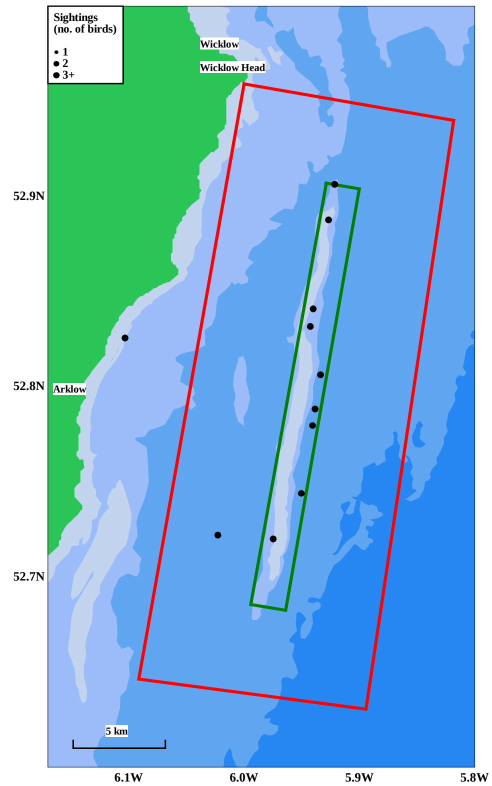
In Year 7, single birds were recorded in January and May. The majority of birds were recorded over the Bank in all three years.

Year 8

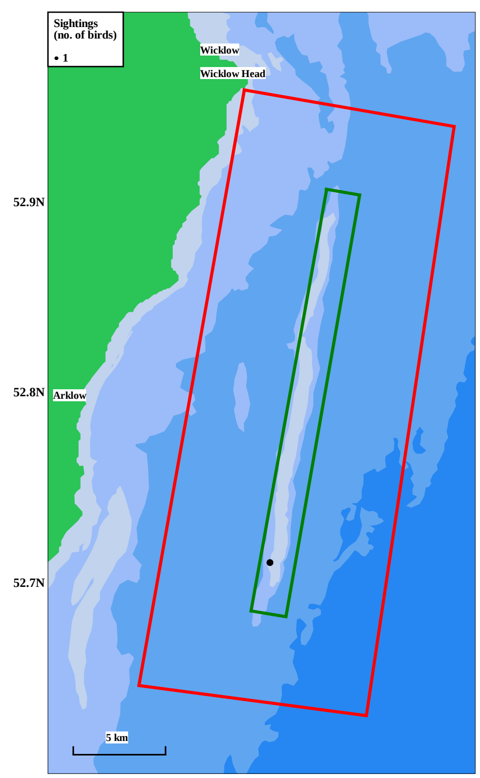
There was one sighting of Great Northern Diver over the Bank in March.

Figure 3.7 Great Northern Diver Sightings

Years 5 to 7



Year 8

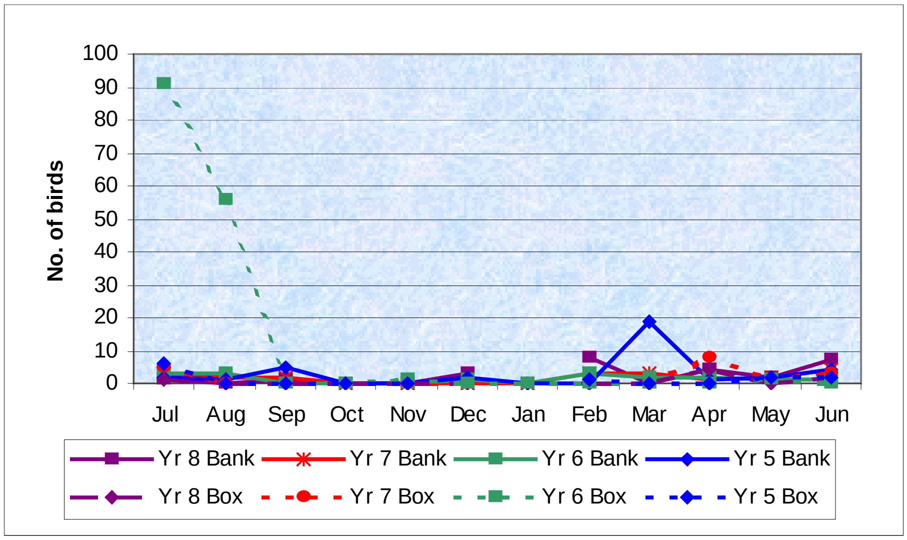


3.4.3 Fulmar

Numbers in the Arklow Study Area

Numbers of Fulmars recorded in the Arklow Study Area in Year 8 were very low, with a peak of 8 over the Bank in February, and 4 in the Box in June (Figure 3.8). Numbers in previous years were similarly low, apart from a high count of 91 birds in the Box in July of Year 6.

Figure 3.8 Numbers of Fulmars in the Bank and Box, Years 5 to 8



Mean monthly abundance

Fulmar mean monthly abundance over the Bank and Box in Year 8 was very low (Figure 3.9). This was similar to the combined mean monthly abundance for Years 5 to 7, 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 Fulmar mean monthly abundance in the Bank and Box, Years 5 to 8

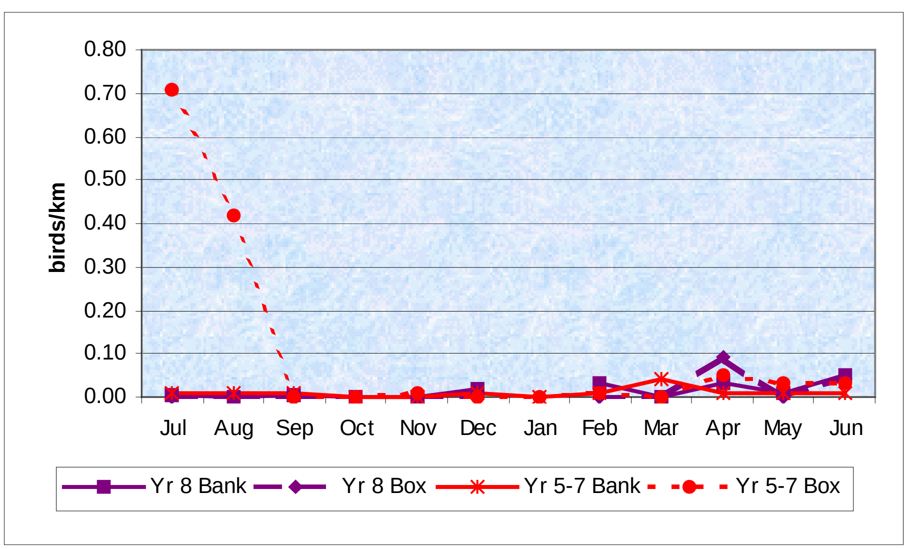


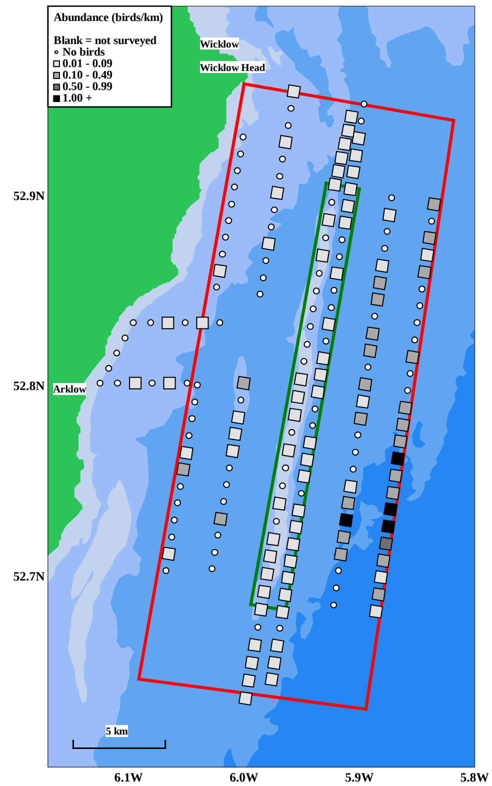
Figure 3.10 Fulmar abundance in the Arklow Study Area in all months

Years 5 to 7 – all months

Fulmars were scattered throughout the Arklow Study Area in Years 5 to 7. Abundances over the Bank were generally lower than in the Box.

Peak abundance was recorded along the southern end of the outer Box legs in July and August, with a maximum seasonal abundance of 2.13 birds/km recorded in this area.

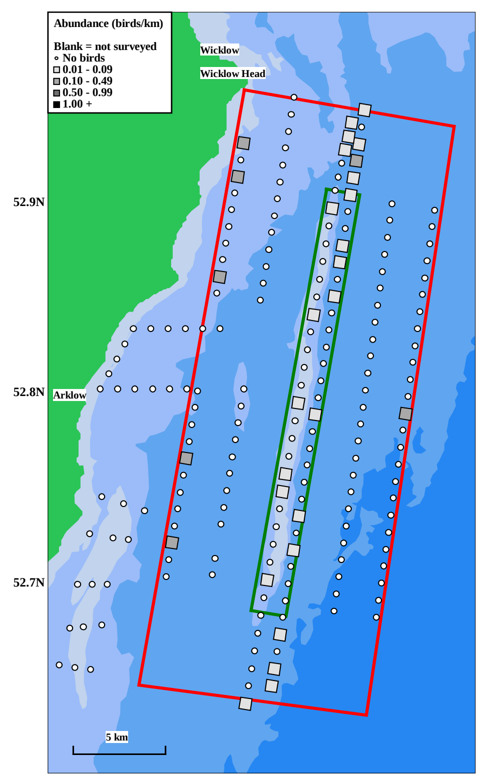
Years 5 to 7



Year 8 – all months

In Year 8, the majority of Fulmars were recorded over the Bank, with scattered birds recorded over the Box. There were no concentrations recorded in the outer Box legs as in Years 5 to 7.

Year 8



3.4.4 Manx Shearwater

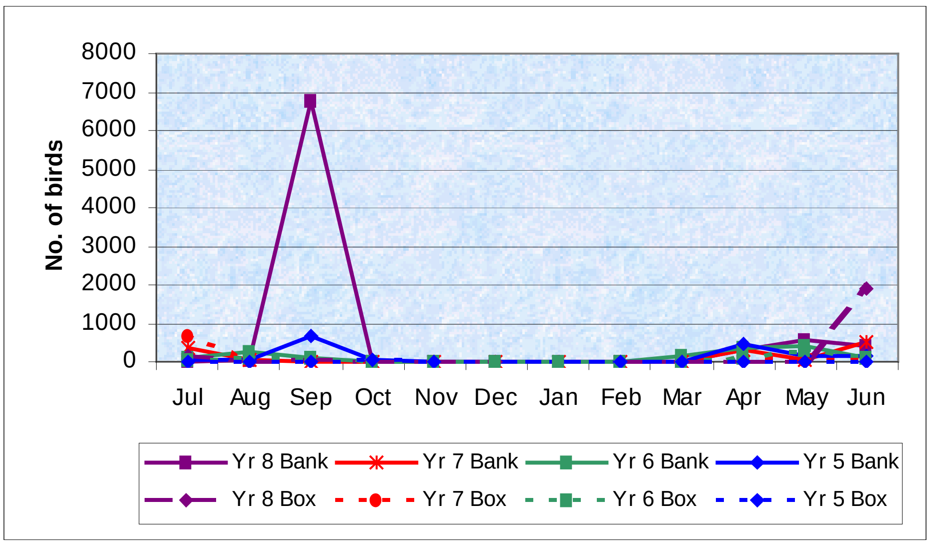
Numbers in the Arklow Study Area

Numbers of Manx Shearwaters in the Arklow Study Area in Year 8 peaked in September, when a peak count of 6,791 birds was recorded over the Bank (Figure 3.11). This was considerably higher than the previous peak Bank count of 661 birds in September of Year 5.

The peak total of Manx Shearwaters in the Box in Year 8 was also higher than in previous years, with 1,911 birds in June compared to the previous peak total of 661 birds in the Box in July of Year 7.

Manx Shearwaters are summer visitors to the Arklow Study Area, with no sightings between November and February in any year.

Figure 3.11 Numbers of Manx Shearwaters in the Bank and Box, Years 5 to 8



Mean monthly density

Year 8 mean monthly density over the Bank was low for most of the summer months, apart from September, when a peak of 87.19 birds/km² was recorded (Figure 3.12). This was considerably higher than the highest combined mean monthly density for Years 5 to 7 over the Bank, which was 5.36 birds/km² in April.

In the Box, peak mean monthly density in Year 8 was higher still, with a mean figure of 166.17 birds/km² recorded in June. In contrast, the highest combined mean monthly density for Years 5 to 7 in the Box was 20.00 birds/km² recorded in July.

Figure 3.12 Manx Shearwater mean monthly density in the Bank and Box, Years 5 to 8

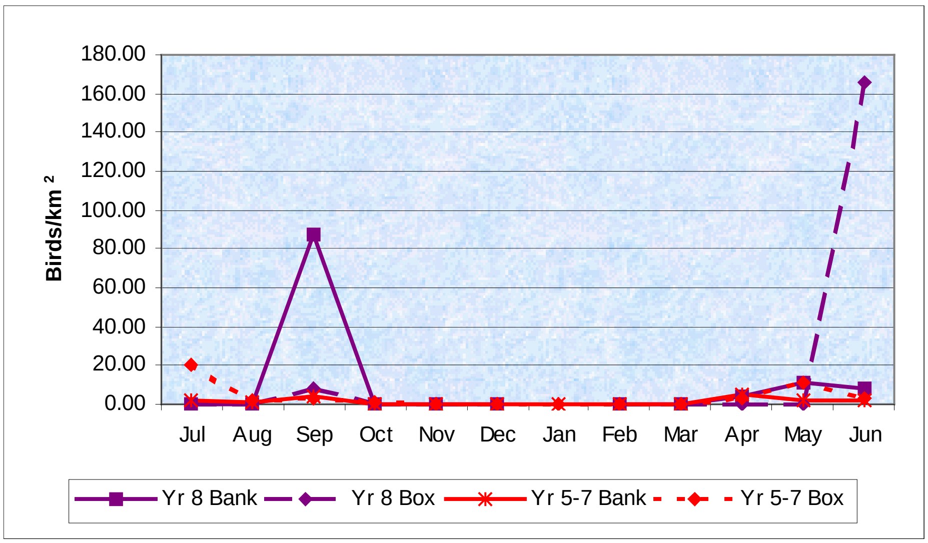


Table 3.10 Peak Manx Shearwater densities between March and October, Years 5 to 8 (> 50 birds/km²)

Year	Survey leg	Km waypoint	Seasonal Density
5 to 7	1	13	97.74
5 to 7	1	14	256.63
5 to 7	1	15	51.89
8	1	7	2,065.56
8	1	9	219.56
8	2	3	79.73
8	2	4	86.67
8	2	5	302.12
8	2	6	115.27
8	3	4	70.96
8	3	5	64.48
8	3	6	109.77
8	44	3	162.50

Figure 3.13 Manx Shearwater density in the Arklow Study Area from March to October

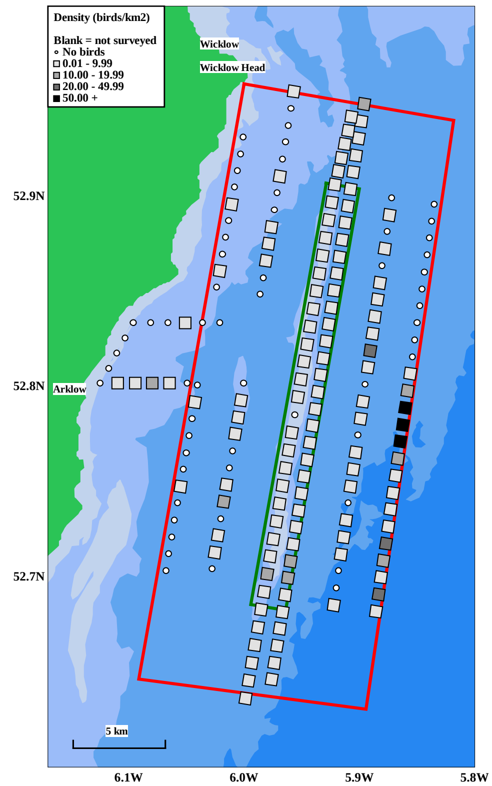
Years 5 to 7 – March to October

Manx Shearwaters are summer visitors to the Arklow Study Area, with no sightings between November and February.

Between March and October of Years 5 to 7, Manx Shearwaters were generally recorded in low densities along the Bank, and were also scattered throughout the Box and Cable Route at low densities.

Highest seasonal densities were recorded along the southern half of the outer Box leg, in May, July and September (Table 3.10).

Years 5 to 7



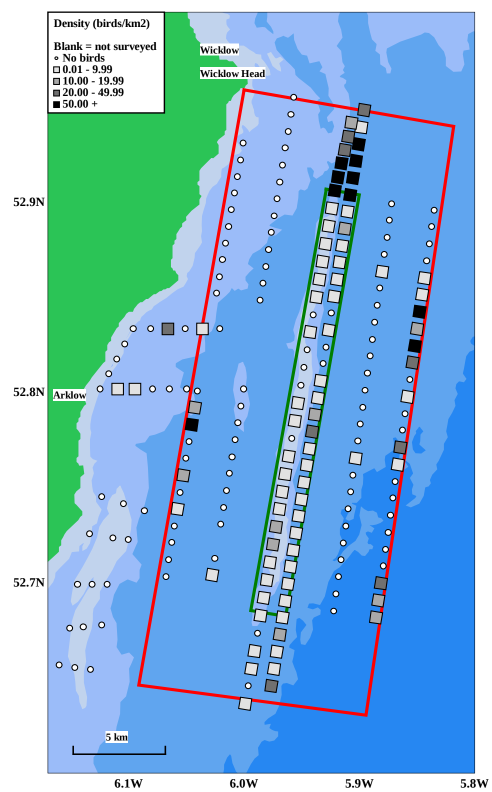
Year 8 – March to October

In Year 8, Manx Shearwaters were again widespread over the Bank between March and October. Density was generally low to moderate except at the northern end of the Bank, where highest densities were recorded (Table 3.10).

In the Box, Manx Shearwaters were found in highest density on the outer leg, with fewer birds elsewhere. Peak density was 2,065.56 birds/km² (Table 3.10).

Low to moderate density was recorded occasionally along the Cable Route.

Year 8



3.4.5 Other Shearwaters

Years 5 to 7

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.

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), and on the Birdwatch Ireland Red List, due to their global conservation status (Lynas *et al* 2007).

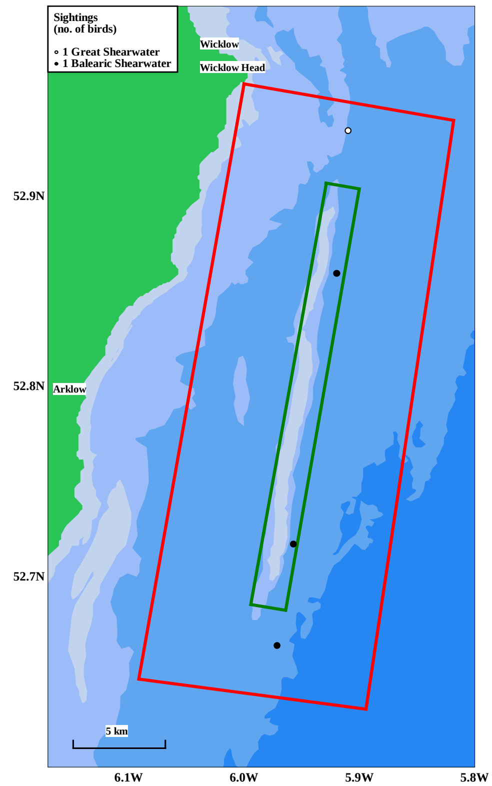
Year 8

One Great Shearwater was recorded on Bank leg 2, with one Sooty Shearwater recorded on Bank leg 3. Both sightings were in September.

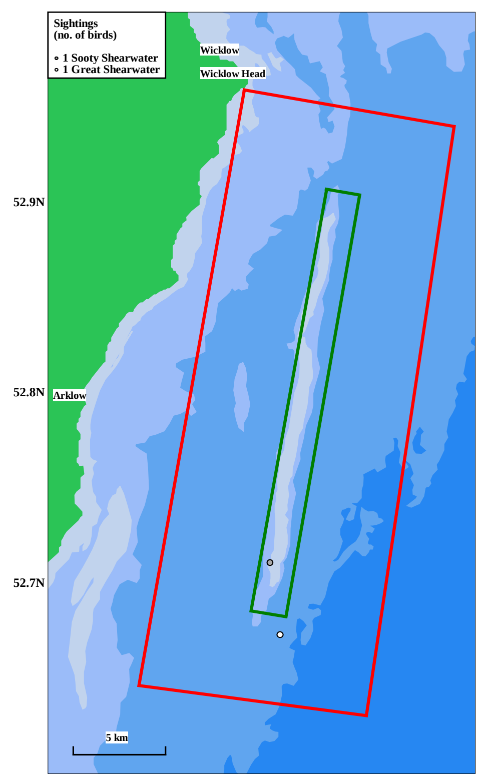
Sooty Shearwaters are listed on the Birdwatch Ireland Red List, due to their global conservation status (Lynas *et al* 2007).

Figure 3.14 Shearwater sightings

Years 5 to 7



Year 8



3.4.6 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).

Years 5 to 7

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

There were a total of 7 Storm Petrels recorded in Year 6; four in July and 3 in August. Birds were widely scattered throughout the Arklow 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.

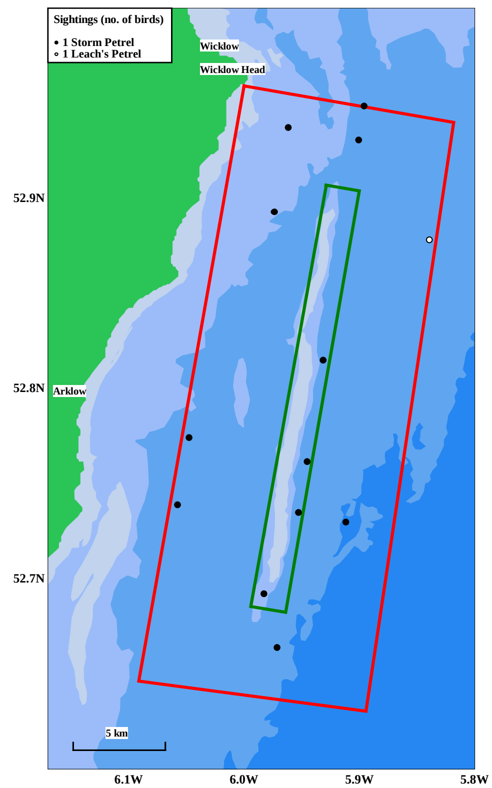
In Year 7, a total of five Storm Petrels were recorded, with 4 seen in July and one in August. As in Year 6, birds were scattered throughout the Arklow Study Area.

Year 8

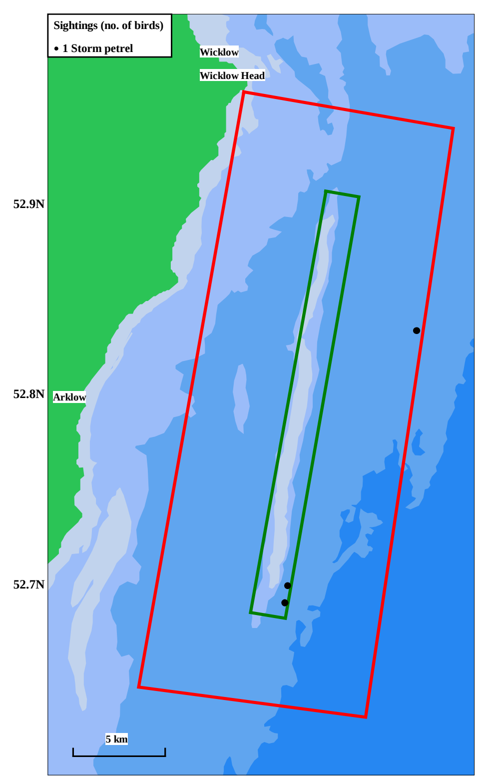
There were fewer Storm Petrels recorded in Year 8. One was seen at the southern end of Bank leg 2 in June, with another there in July, and a third in the east of the Box in July.

Figure 3.15 Petrel sightings

Years 5 to 7



Year 8



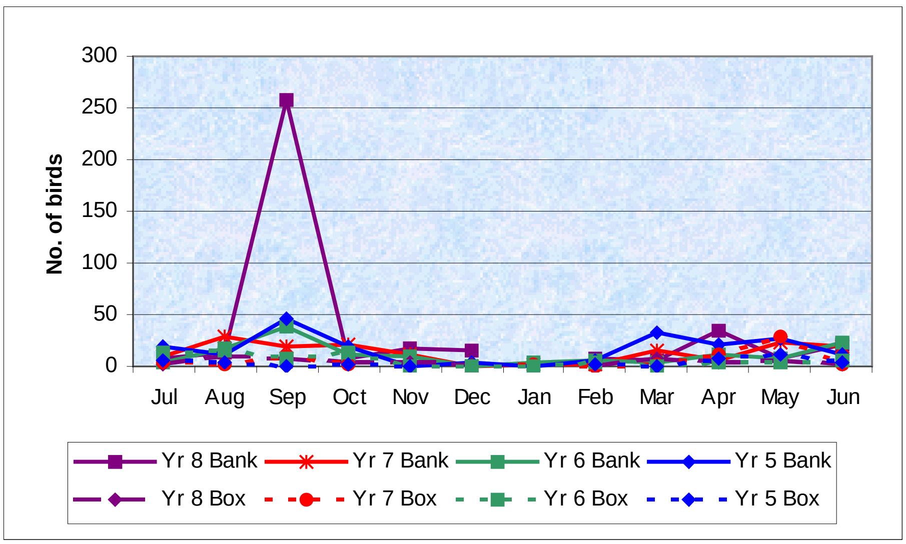
3.4.7 Gannet

Numbers in the Arklow Study Area

Numbers of Gannets in the Arklow Study Area in Year 8 peaked in September, when a peak count of 257 birds was recorded over the Bank (Figure 3.16). This was considerably higher than the previous peak Bank count of 47 birds in September of Year 5.

The peak total of Gannets in the Box in Year 8 was very low, with a total of 9 birds recorded in August.

Figure 3.16 Numbers of Gannets in the Bank and Box, Years 5 to 8



Mean monthly abundance

In Year 8, mean monthly abundance peaked at 0.96 birds/km over the Bank in September, which was considerably higher than the combined Years 5 to 7 mean monthly abundance for September (0.19 birds/km) (Figure 3.17).

In the Box, mean monthly abundance for Year 8 peaked at 0.22 birds/km, also in September. A slightly lower peak (0.18 birds/km) was recorded for the same month for Years 5 and 7 combined, with a peak of 0.31 birds/km recorded in May.

Figure 3.17 Gannet mean monthly abundance in the Bank and Box, Years 5 to 8

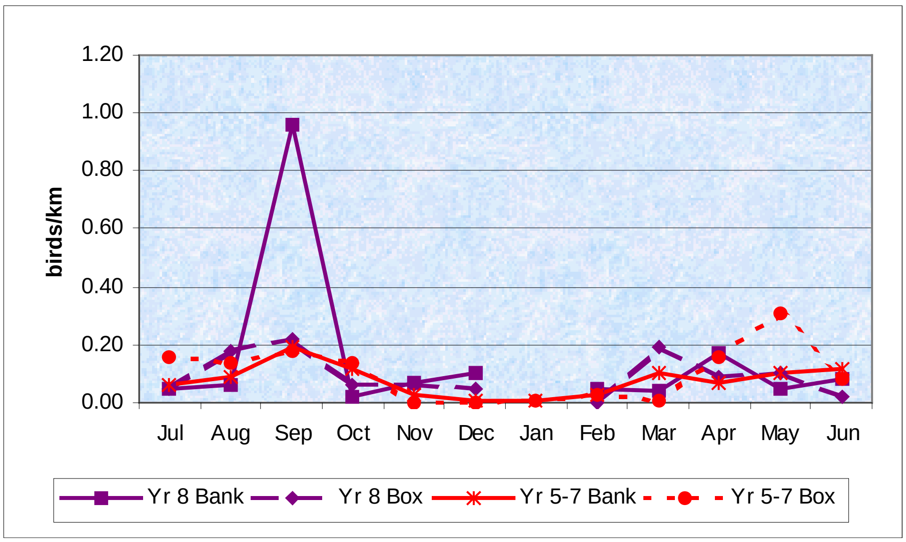


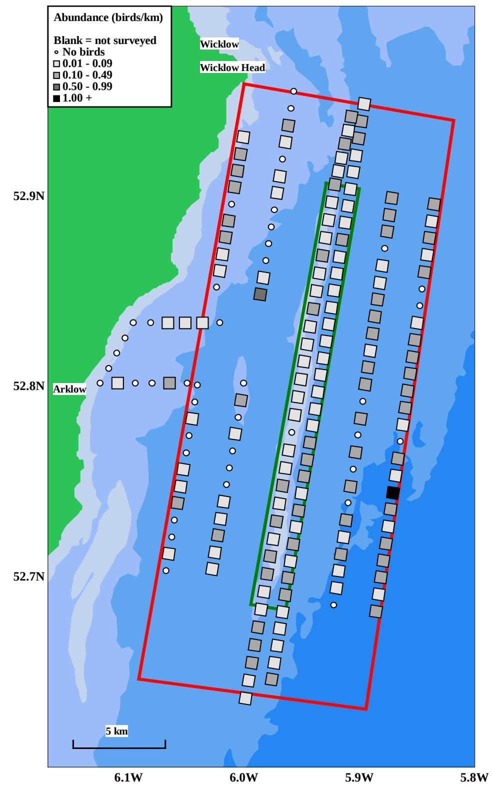
Figure 3.18 Gannet abundance in the Arklow Study Area in all months

Years 5 to 7

In Years 5 to 7, Gannets were widespread throughout the Arklow Study Area. Birds were recorded along the Bank in low to moderate abundance, with a patchier distribution over the Box and Cable Route.

Highest abundances were recorded along the southern end of the outer Box leg, with a peak of 1.0 birds/km.

Years 5 to 7

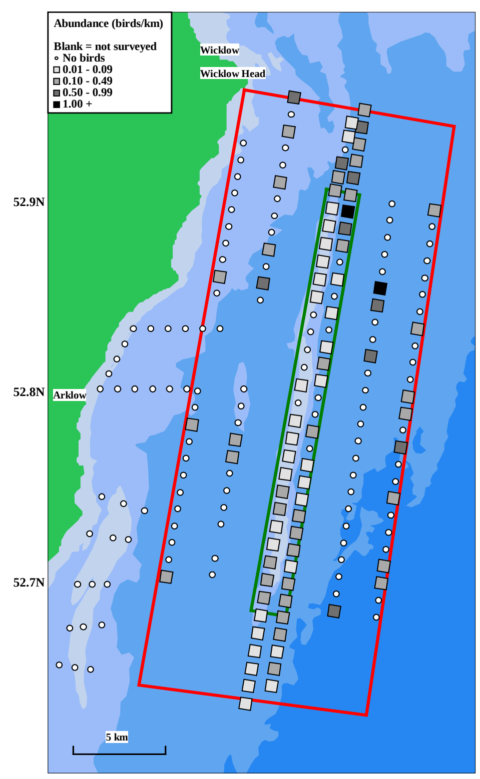


Year 8

In Year 8, Gannets were again recorded regularly over the Bank, with a more patchy distribution over the Box. No birds were recorded along the Cable Route.

Highest abundance (3.05 birds/km) was recorded at the north end of the Bank. Highest abundance in the Box (1.5 birds/km) was recorded on leg 11.

Year 8



3.4.8 Cormorant

Years 5 to 7

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.

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.

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.

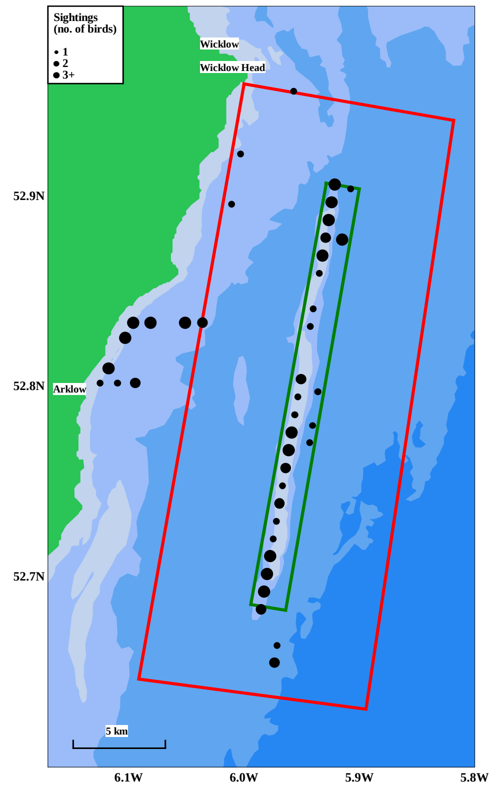
Year 8

In Year 7, a total of 52 Cormorants were recorded, with the peak month being December, when 19 were counted.

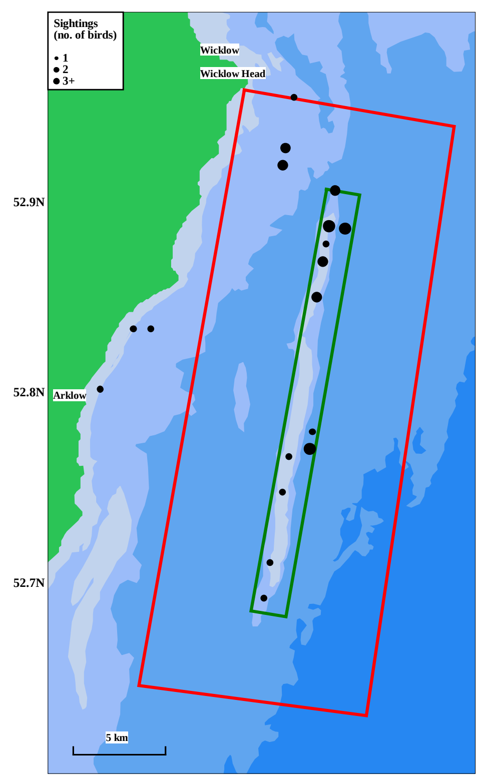
The majority of birds were over the northern end of the Bank, with lower numbers in the southern half of the Bank and in the Cable Route.

Figure 3.19 Cormorant sightings

Years 5 to 7



Year 8



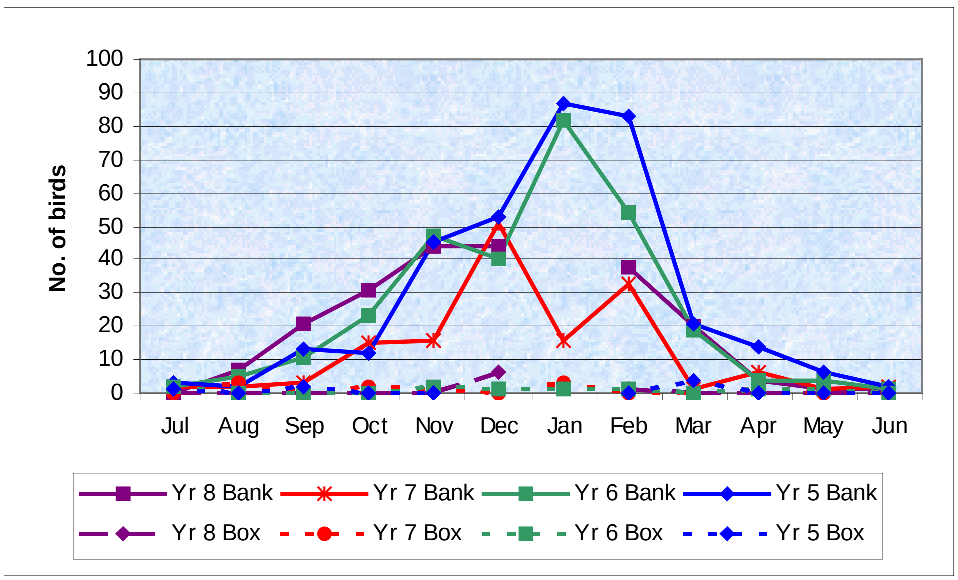
3.4.9 Shag

Numbers in the Arklow Study Area

Like previous years, the majority of Shags were found over the Bank in Year 8. Birds were seen in all months except July, with peak numbers recorded between October and March (Figure 3.20). Numbers over the Bank increased from August onwards, peaking in November and December (44 birds in both months), which was a similar pattern to that recorded in Years 5, 6 and 7. There was no survey in January due to bad weather, but numbers in February and March decreased, following the pattern of previous years. Low numbers were recorded between April and June.

Numbers recorded in the Box in Year 8 were much lower, with a peak total of 6 birds recorded in December.

Figure 3.20 Numbers of Shags in the Bank and Box, Years 5 to 8



Mean monthly abundance

The mean monthly abundance for Shags over the Bank in Year 8 was generally lower than the combined mean monthly abundance for Years 5 to 7, although both showed a similar pattern (Figure 3.21). Peak monthly mean abundance in Year 8 over the Bank was recorded in December (0.26 birds/km), which was similar to the mean December figure for Years 5 to 7 combined (0.31 birds/km).

Shag mean monthly abundance in the Box in Year 8 also peaked in December, with a similar value (0.29 birds/km). This was considerably higher than the peak monthly mean abundance for Years 5 to 7 (0.06 birds/km). Mean monthly abundance in the Box for the remaining months of Year 8 was low.

Figure 3.21 Shag mean monthly abundance in the Bank and Box, Years 5 to 8

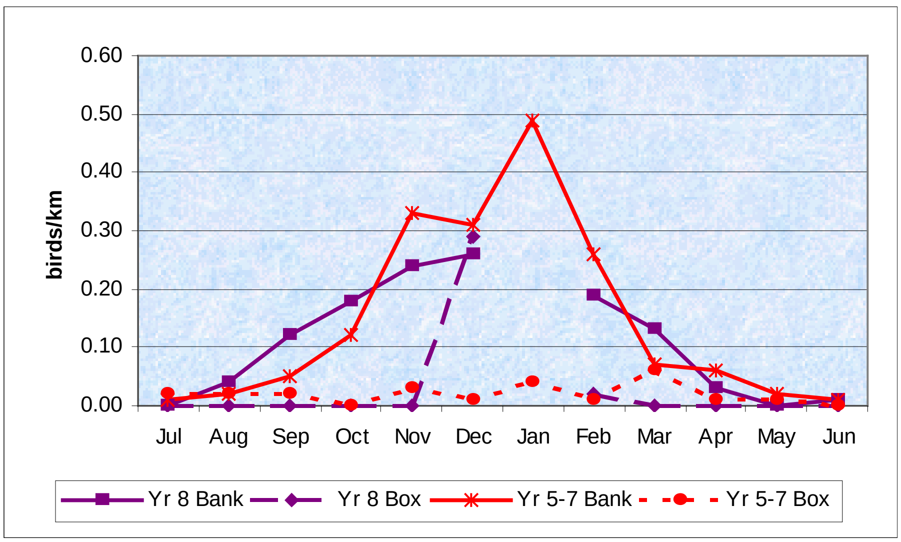


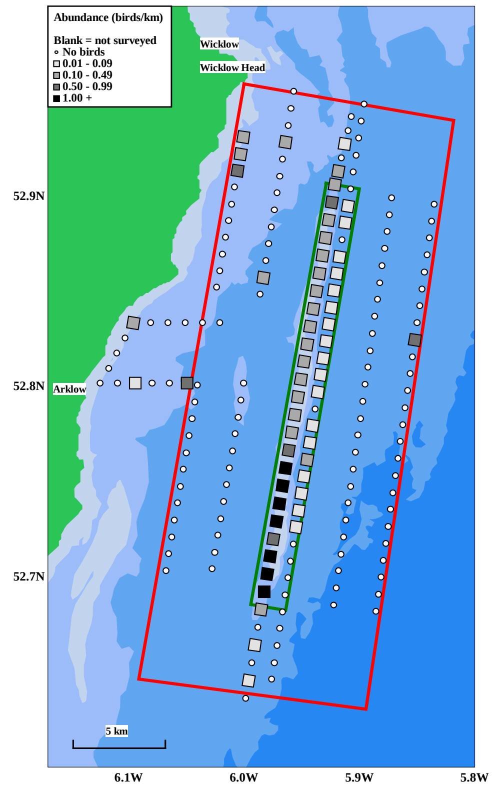
Figure 3.22 Shag abundance in the Arklow Study Area between October and March

Years 5 to 7 – October to March

Between Years 5 and 7, Shag distribution was almost exclusively over the Bank. The main concentrations were along the southern half of the inner Bank leg between October and March. Peak abundance ranged from 1.08 birds/km to 1.92 birds/km.

Few Shags were recorded elsewhere in the Arklow Study Area.

Years 5 to 7



Year 8

Shag distribution in the Arklow Study Area in Year 8 was similar to the previous three years, with the majority of birds recorded over the Bank.

Highest abundance was recorded on inner Box leg 41 (2.5 birds/km), with concentrations also recorded along the inner Bank leg. Here, abundance peaked at 2.08 birds/km.

Year 8

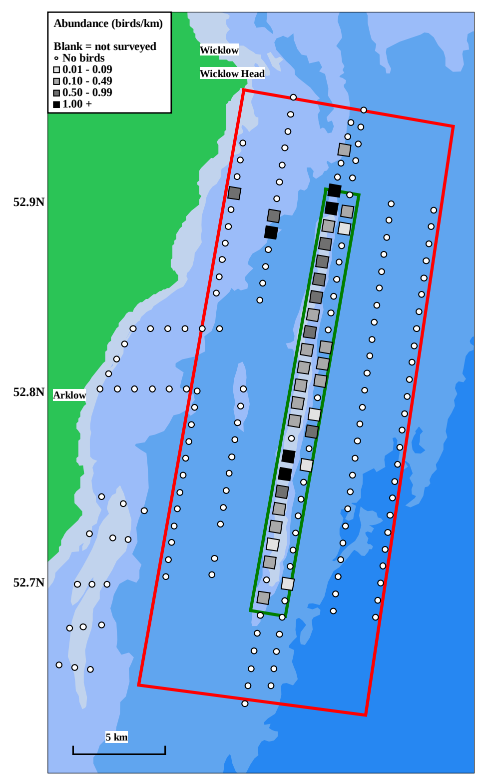


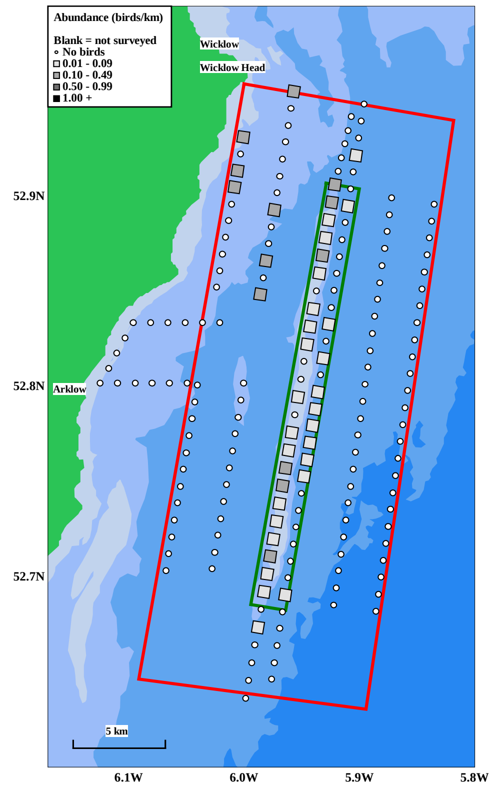
Figure 3.23 Shag abundance in the Arklow Study Area between April and September

Years 5 to 7 – April to September

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, and occasionally in moderate abundance on the inner Box legs.

Years 5 to 7

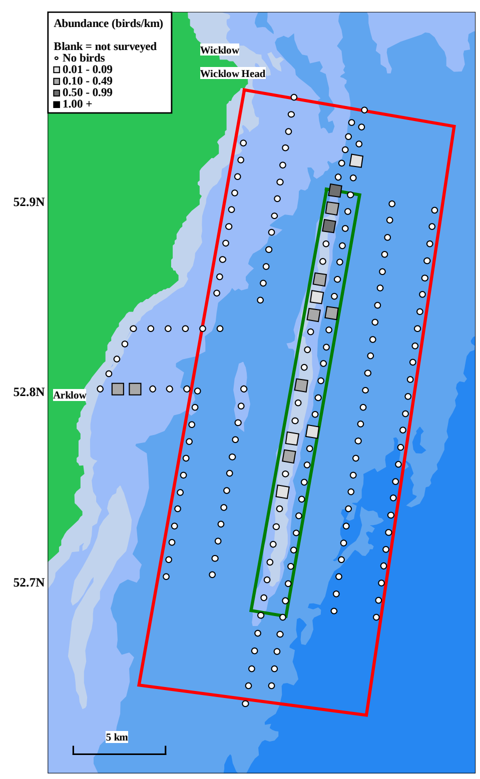


Year 8 - April to September

Shag abundance between April and September of Year 8 was similar to the three previous years, with low to moderate abundance recorded over the Bank.

There were no Shags recorded in the Box, and moderate abundance recorded along the Cable Route.

Year 8



3.4.10 Seaduck

Years 5 to 7

There were no sightings of seaduck in Year 5.

In Year 6, a total of 12 Common Scoter were seen, with a peak of 7 in June on the Cable Route. One Red-breasted Merganser was seen in March of Year 6, on the Cable Route.

A total of 30 Common Scoter were recorded in Year 7, with a peak of 27 in November in the Box. A further 20 unidentified scoter were seen in Year 7, in the Box, with a peak of 10 in December.

Year 8

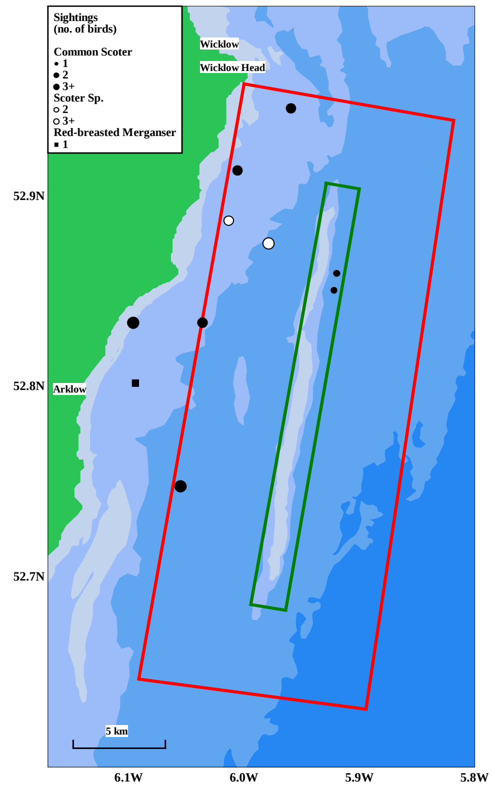
A total of 41 Common Scoter were positively identified in Year 8. A total of 17 were recorded on additional surveys on Glassgorman Bank to the south-west of Arklow Bank in March. In addition, 11 were over the Bank in September, with 12 there in November, and 1 in the Box in October.

A further 121 unidentified scoter were recorded, 17 in December and 92 in February in the Box, and 12 in March over Glassgorman Bank.

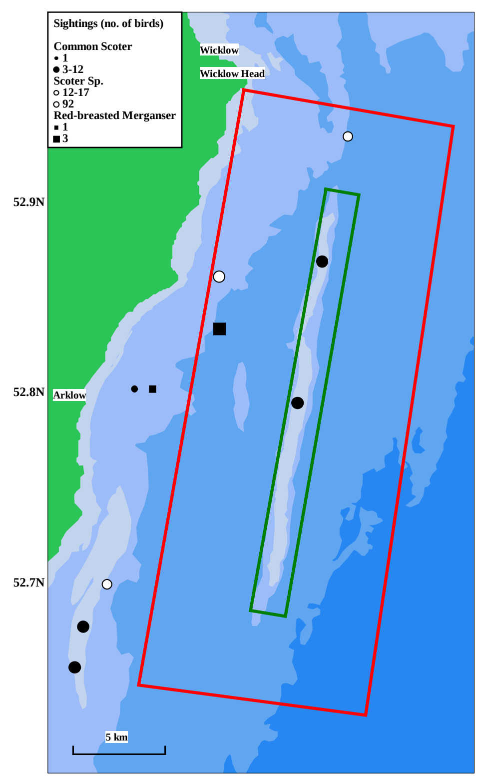
Four Red-breasted Mergansers were recorded in Year 8, one on the Cable Route in November, and three in the Box in February.

Figure 3.24 Seaduck sightings

Years 5 to 7



Year 8



3.4.11 Skuas

Years 5 to 7

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.

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.

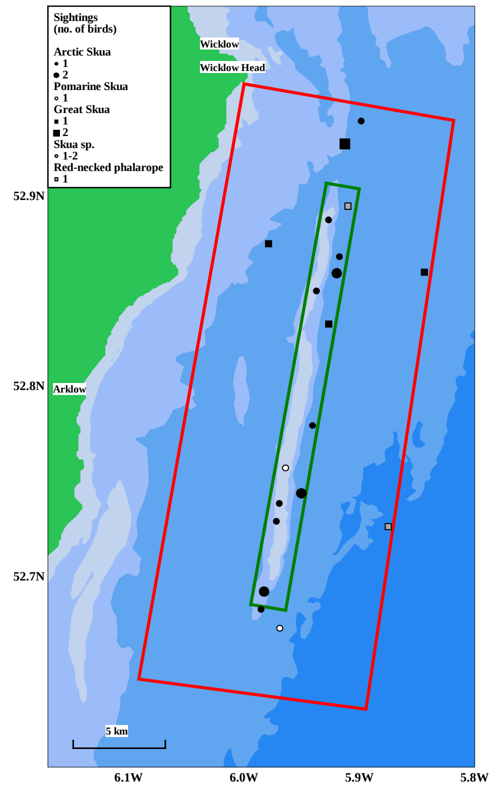
In Year 7, 4 Arctic Skuas were recorded over the Bank; 1 in August, 2 in September and 1 in October. Single Great Skuas were seen in the Box in April and September.

Year 8

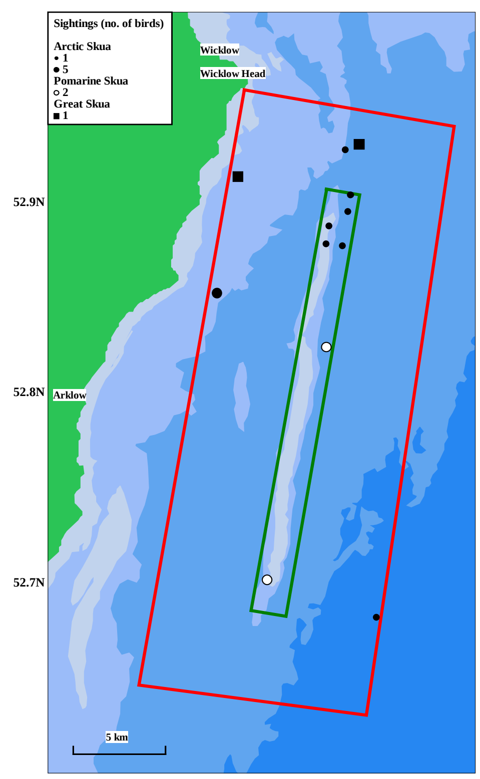
Three species of skua were again recorded in Year 8. Four Pomarine Skuas were seen over the Bank, two in September and two in November. A total of 13 Arctic Skuas were recorded, with singles in April, July and November, and 10 in September. The majority were over the Bank. Two Great Skuas were seen in the Box in September.

Figure 3.25 Skua sightings

Years 5 to 7



Year 8



3.4.12 Red-necked Phalarope

Two Red-necked Phalaropes were seen in Year 6, one over the Bank in August and one 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

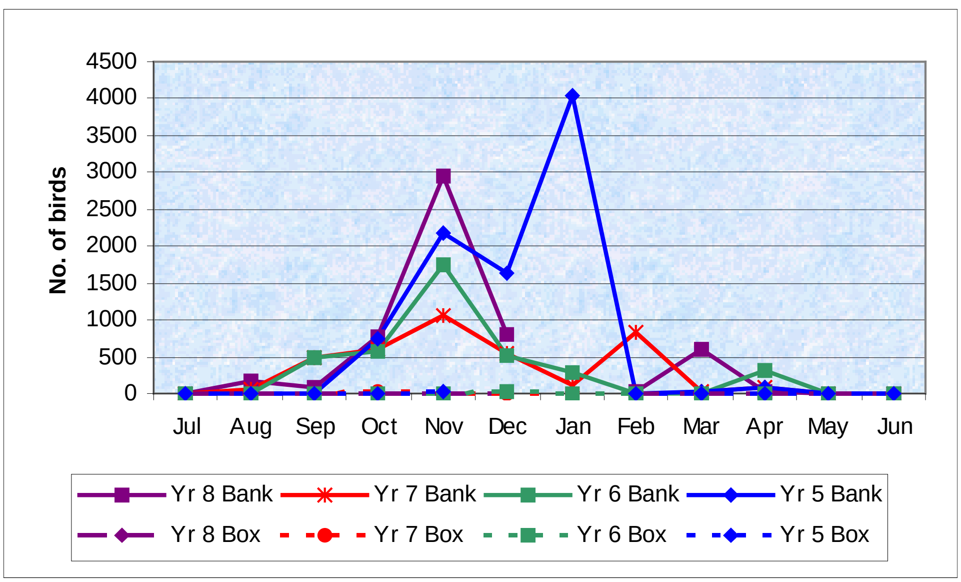
Numbers in the Arklow Study Area

In Year 8, numbers of Little Gulls recorded over the Bank began to increase in October, with a peak of 2,951 birds recorded in November (Figure 3.26). This was the highest peak in recent years. Numbers then decreased in December, which was similar to the pattern shown in Years 5 to 7, all of which showed a November peak, followed by a December drop. Although not directly comparable, a similar pattern was also shown in the pre-construction and construction phases (Years 1 to 4) (CWC 2004).

There was no January survey in Year 8 due to bad weather, however, lower numbers of Little Gulls were recorded between February and April, which was again similar to the pattern of recent years.

Numbers of Little Gulls in the Box were low throughout Year 8.

Figure 3.26 Numbers of Little Gulls in the Bank and Box, Years 5 to 8



Mean monthly density

The pattern of mean monthly density for Little Gulls in the Arklow Study Area was broadly similar between Year 8 and Years 5 to 7 combined (Figure 3.27). Mean monthly density over the Bank was low between July and September, and then increased from October to a peak of 38.02 birds/km^2 in November. This was slightly lower than the combined peak mean monthly density for Years 5 to 7 (48.63 birds/km^2), which also was recorded in November. Density dropped in December of Year 8, and remained low between February and June, with the exception of a peak of 18.14 birds/km^2 in March.

Mean monthly density for Little Gulls in the Box was low throughout Year 8, and in Years 5 to 7 combined.

Figure 3.27 Little Gull mean monthly density in the Bank and Box, Years 5 to 8

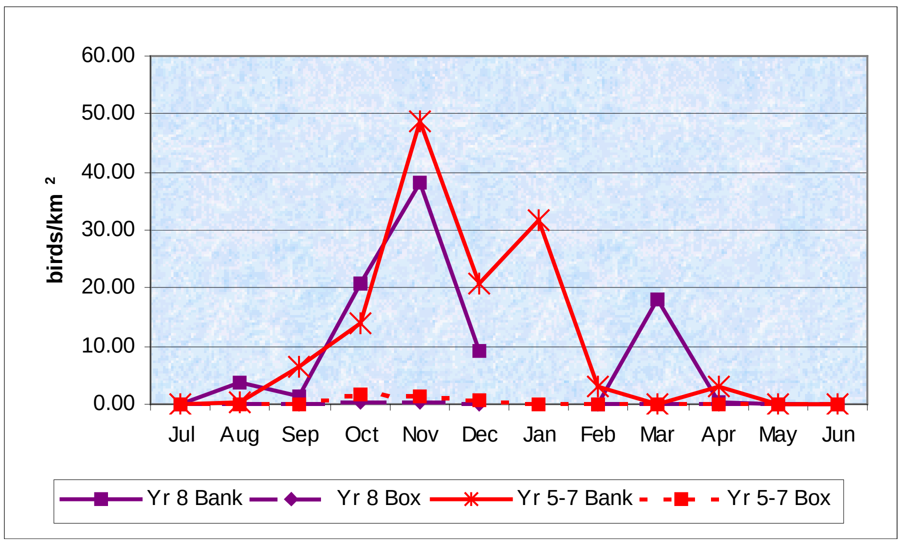
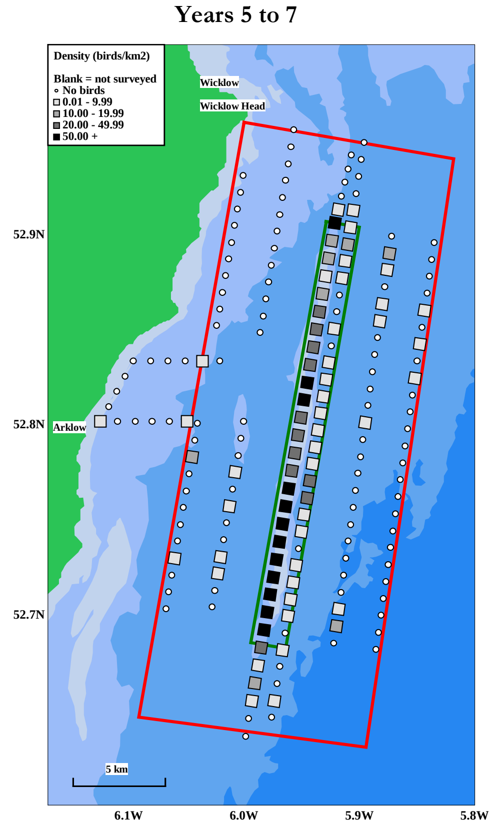


Figure 3.28 Little Gull density in the Arklow Study Area from September to January

Years 5 to 7 – September to January

In Years 5 to 7 combined, Little Gull density was highest over the Bank between September and January, with highest densities recorded along the inner Bank leg (Table 3.11).

Few birds were recorded in the Box and Cable Route over the same period.



Year 8 - September to December

Between September and December of Year 8, Little Gulls were predominantly found over the Bank, with highest density recorded along the northern half of the inner Bank leg (Table 3.11).

Very few Little Gulls were recorded in the Bank, on the outer legs.

There was no January survey in Year 8.

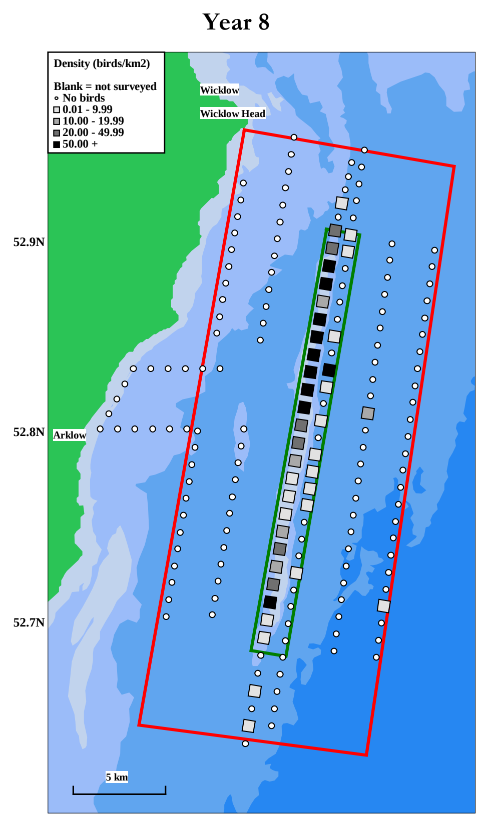


Table 3.11 Peak Little Gull densities between September and January, Years 5 to 7 combined and Year 8 [1] (> 50 birds/km^2)

Year	Survey leg	Km waypoint	Seasonal Density
5-7	3	6	77.27
5-7	3	15	53.1
5-7	3	16	51.14
5-7	3	21	84.56
5-7	3	22	96.36
5-7	3	23	127.1
5-7	3	24	145.95
5-7	3	25	80.03
5-7	3	26	87.71
5-7	3	27	74.1
5-7	3	28	93.91
5-7	3	29	54.08
8	2	14	72.92
8	3	8	75.59
8	3	9	99.78
8	3	11	90.02
8	3	12	53.81
8	3	13	181.04
8	3	14	100.91
8	3	15	75.14
8	3	16	121.01
8	3	27	62.62

1 No January survey in Year 8

Table 3.12 Peak Little Gull densities between February and April, Years 5 to 7 combined and Year 8 (> 50 birds/km^2)

Year	Survey leg	Km waypoint	Seasonal Density
5-7	3	23	53.6
8	3	22	56.92
8	3	25	154.74

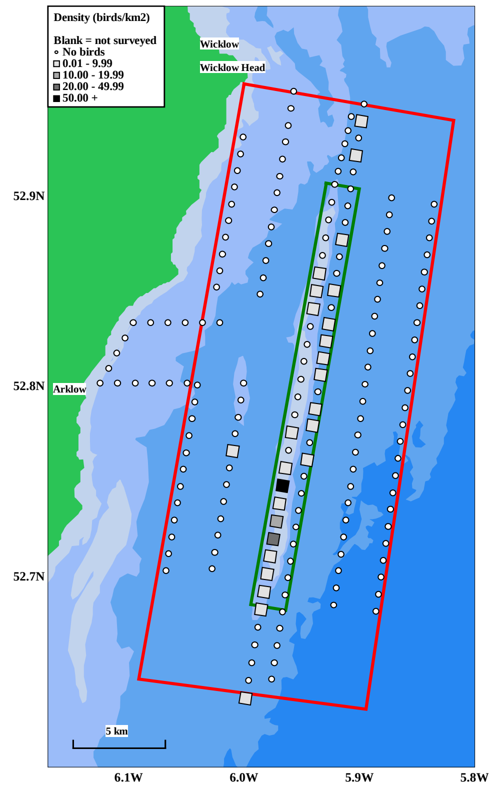
Figure 3.29 Little Gull density in the Arklow Study Area between February and April

Years 5 to 7 – February to April

Little Gull density was very low in the Arklow Study Area between February and April of Years 5 to 7 combined. Birds were scattered at mostly low densities over the Bank with a peak high density of 53.6 birds/km^2 on the inner Bank leg (Table 3.12).

Very few Little Gulls were recorded in the Box over the period.

Years 5 to 7



Year 8 - February to April

In Year 8, few Little Gulls were present in the Arklow Study Area. Birds were mostly restricted to the southern half of the inner Bank leg, where highest recorded density was 154.74 birds/km2 (Table 3.12).

No Little Gulls were recorded in the Box, Cable Route or Glassgorman Bank in these months.

Year 8

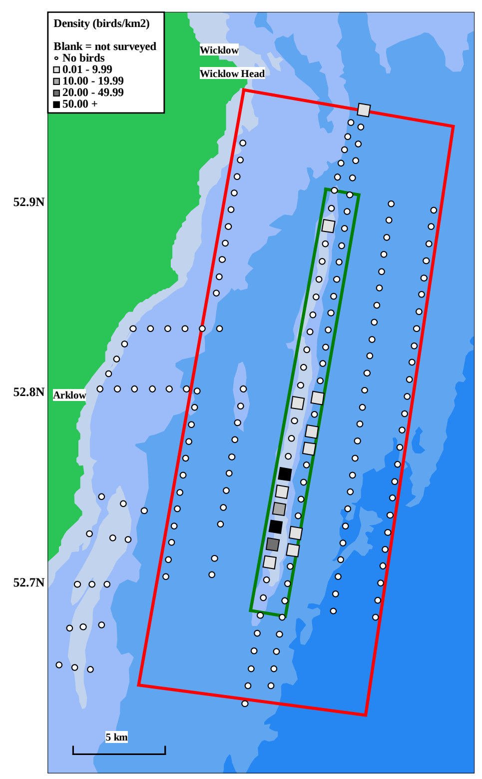


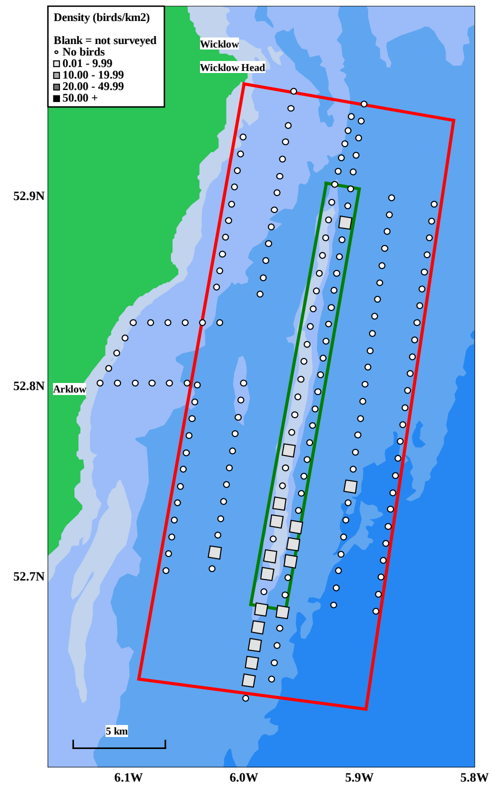
Figure 3.30 Little Gull density in the Arklow Study Area between May and August

Years 5 to 7 – May to August

Between May and August of Years 5 to 7 combined, Little Gulls were mostly scattered over the southern end of the Bank at low densities.

Occasional birds were recorded at low density in the Box over the period.

Years 5 to 7

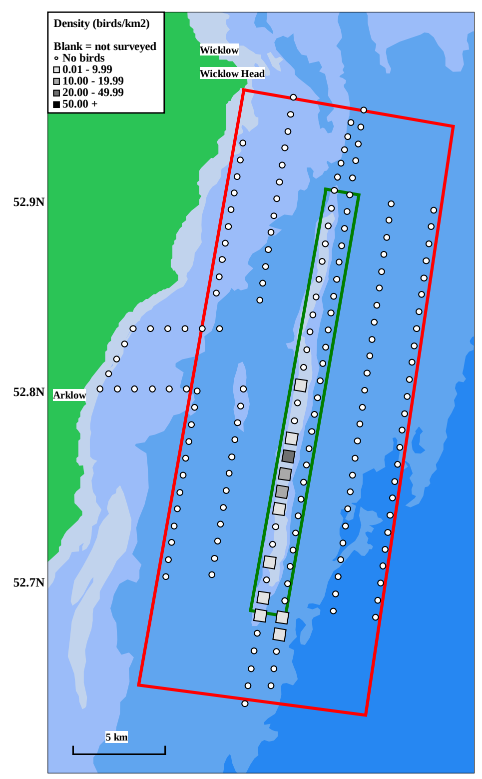


Year 8 - May to August

Little Gull distribution between May and August of Year 8 was similar to that recorded between February and April, with birds present in low to moderate density in the southern half of the inner Bank leg.

No Little Gulls were recorded in the Box or Cable Route between May and August.

Year 8



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).

Years 5 to 7

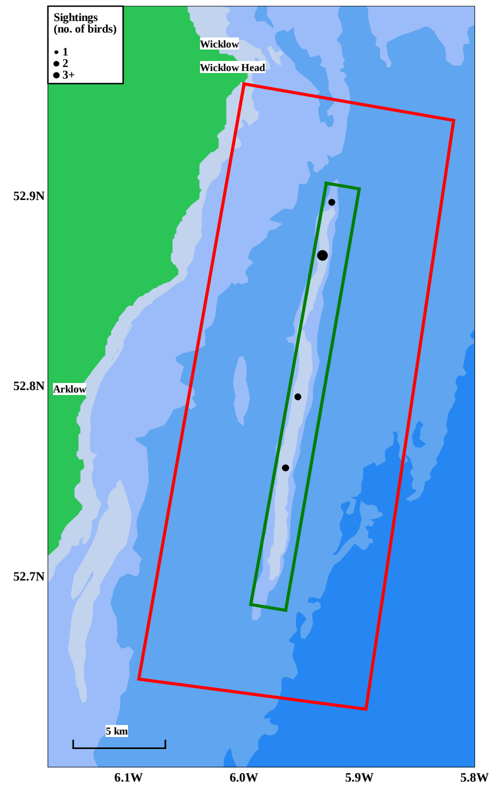
Three Mediterranean Gulls were seen in Year 5, with one in January and two in February. None were recorded in Year 6, while in Year 7, singles were seen in November and December. All sightings were over the Bank.

Year 8

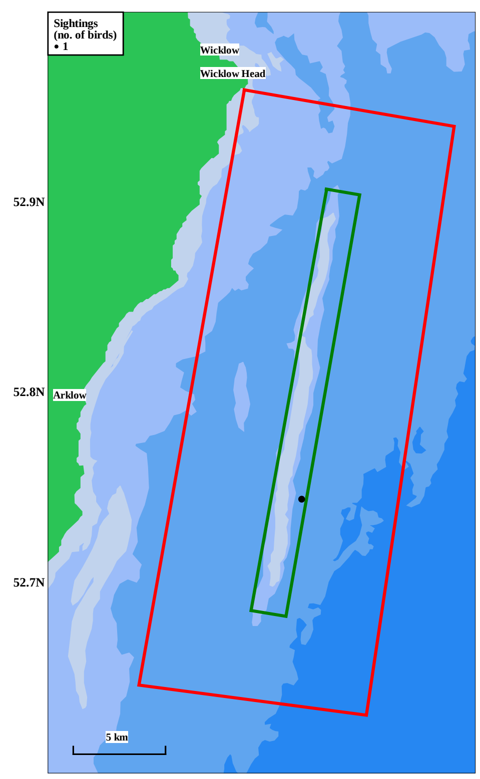
One Mediterranean Gull was seen over the Bank in November.

Figure 3.31 Mediterranean Gull sightings

Years 5 to 7



Year 8



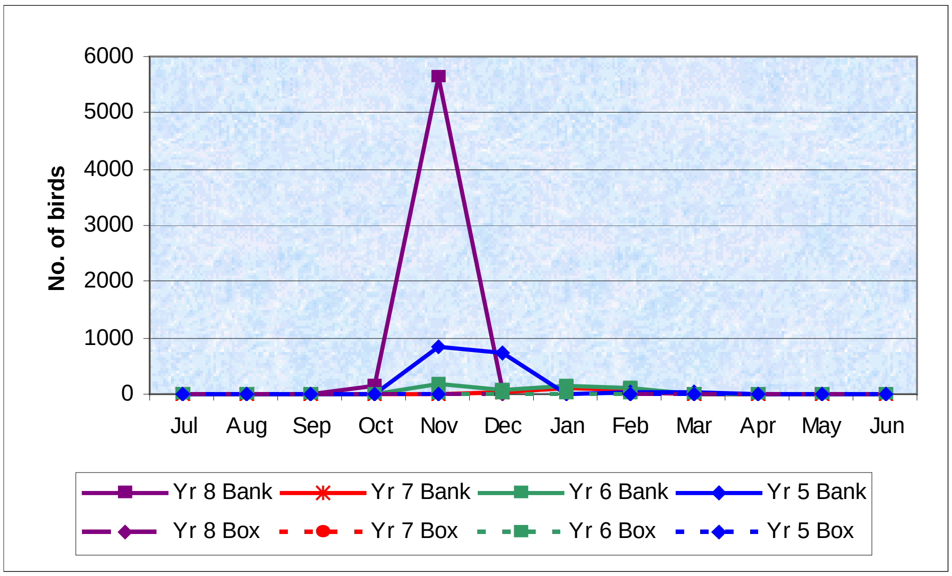
3.4.15 Black-headed Gull

Numbers in the Arklow Study Area

Numbers of Black-headed Gulls recorded over the Bank in Year 8 peaked in November, with a very high count of 5,641 birds recorded (Figure 3.32). This was considerably higher than the previous peak counts of 834 birds recorded in November, and 600 birds recorded in December of Year 5. Peak numbers of other gull species such as Little Gull, Common Gull and Herring Gull were also recorded in November of Year 8, over the Bank.

In contrast, low numbers of Black-headed Gulls were recorded in the remaining months of Year 8. Only one Black-headed Gull was recorded in the Box in Year 8, in February. Low numbers were also recorded in the Box in Years 5 to 7.

Figure 3.32 Numbers of Black-headed Gulls in the Bank and Box, Years 5 to 8



Mean monthly density

Black-headed Gull mean monthly density in the Arklow Study Area in Year 8 was very low in all months, apart from a peak of 93.90 birds/km² over the Bank in November (Figure 3.33). This peak was considerably higher than for the same period in Years 5 to 7 combined, when the peak density recorded was 6.77 birds birds/km² in December over the Bank.

Mean monthly density for Black-headed Gull in the Box was low for all months.

Figure 3.33 Black-headed Gull mean monthly density in the Bank and Box, Years 5 to 8

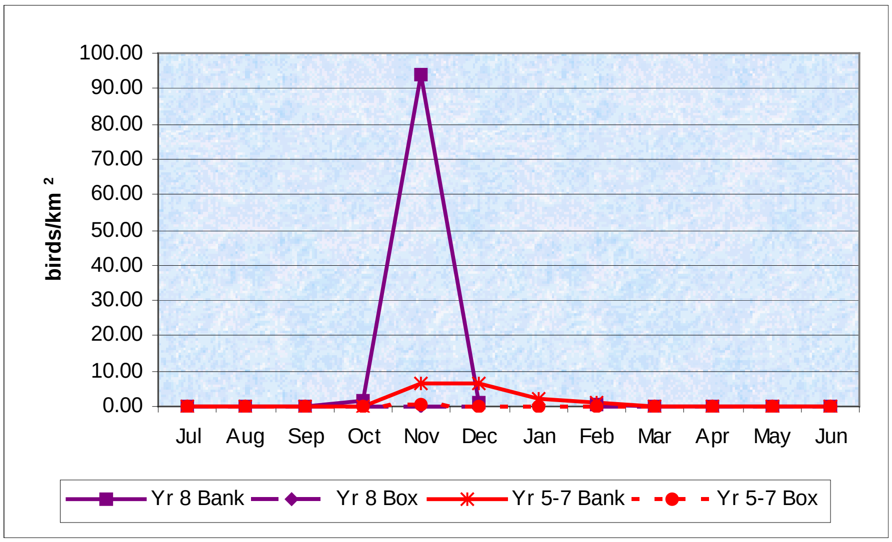


Table 3.13 Peak Black-headed Gull density between October and February, Years 5 to 8 (> 50 birds/km²)

Year	Survey leg	Km waypoint	Seasonal Density
5 to 7	5	9	51.59
8	2	14	163.92
8	2	15	228.96
8	2	16	278.83
8	2	17	137.08
8	2	25	260.0
8	2	26	183.33
8	2	27	123.33
8	3	7	74.0
8	3	17	63.52
8	3	21	64.43

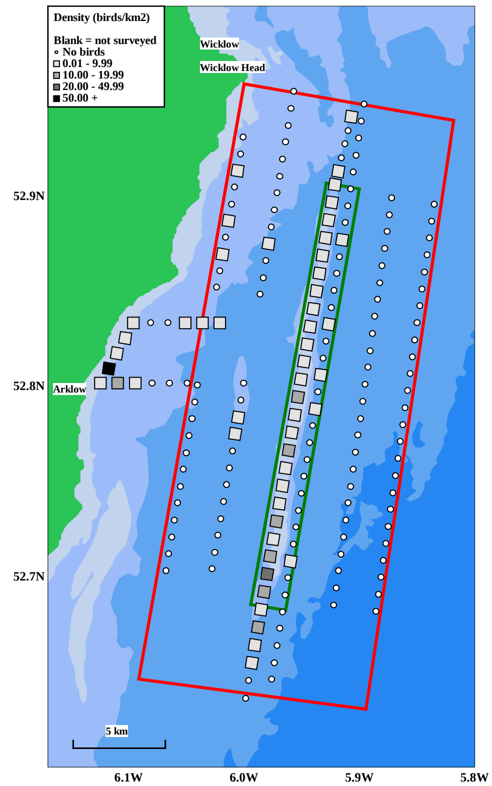
Figure 3.34 Black-headed Gull density between October and February

Years 5 to 7 – October to February

Black-headed Gulls were mostly recorded along the inner Bank leg between October and February at low to moderate density.

Lower density was recorded sporadically along the inner Box legs. Highest density of 51.59 birds/km² was recorded on the Cable Route.

Years 5 to 7



Year 8 – October to February

Between October and February of Year 8, Black-headed Gull distribution was mostly concentrated over the Bank. Highest density was recorded on the outer Bank legs (Table 3.13).

There were fewer birds recorded on the inner Box legs and Cable Route, compared to Years 5 to 7.

Year 8

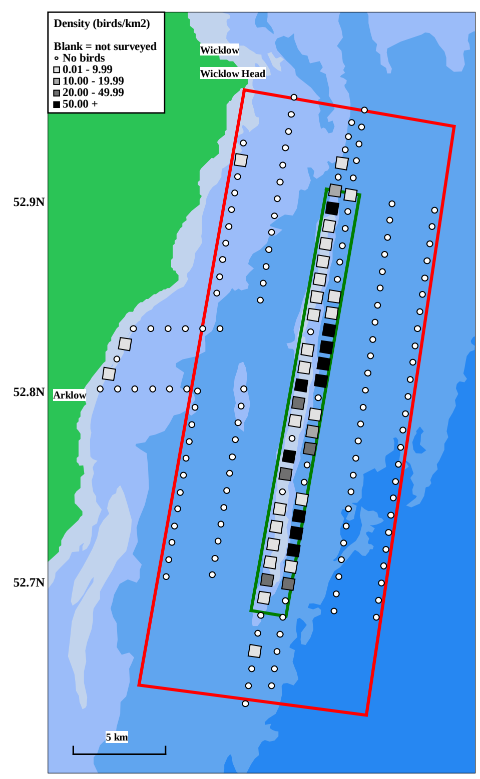
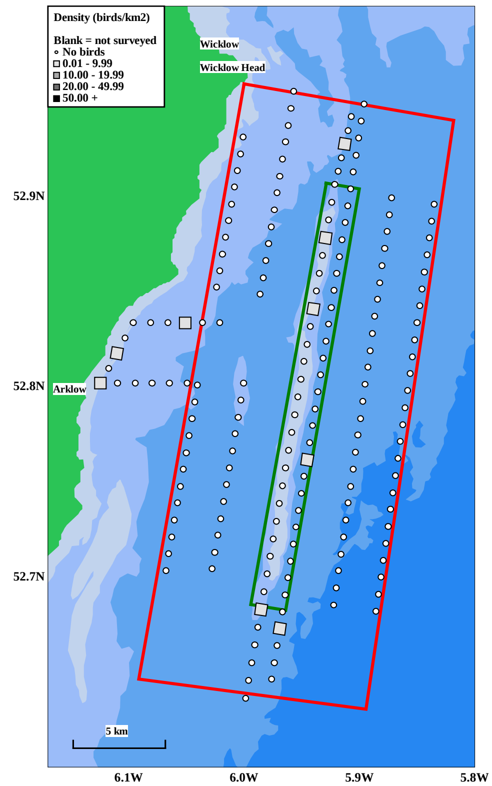


Figure 3.35 Black-headed Gull density between March and September

Years 5 to 7 – March to September

Black-headed Gull density was very low in the Arklow Study Area between March and September of Years 5 to 7, with birds recorded occasionally over the Bank and Cable Route at low density.

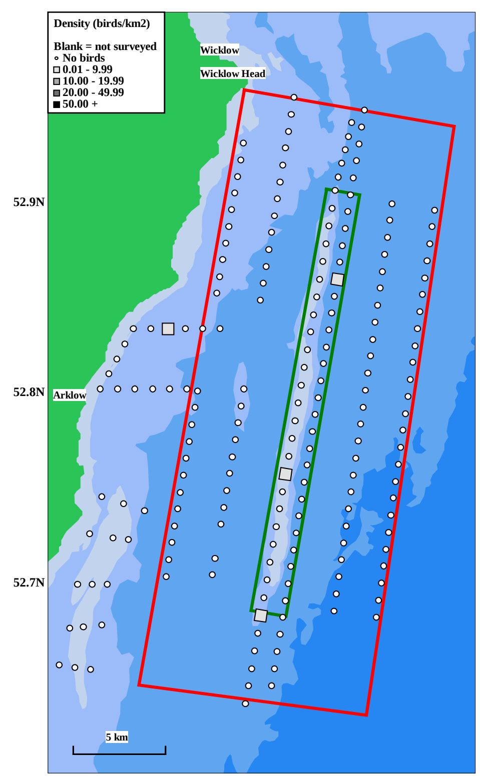
Years 5 to 7



Year 8 – March to September

In Year 8, very few Black-headed Gulls were recorded in the Arklow Study Area between March and September.

Year 8



3.4.16 Common Gull

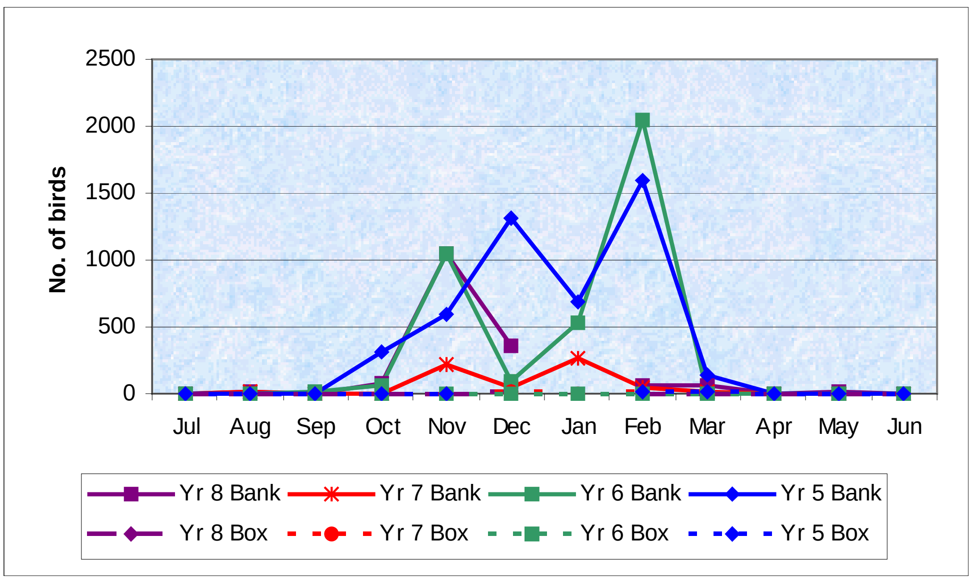
Numbers in the Arklow Study Area

Numbers of Common Gulls recorded over the Bank in Year 8 increased from October, with a peak of 1,042 birds in November (Figure 3.35). Numbers decreased again in December, and remained low between February and June (there was no survey in January due to bad weather).

Overall, peak numbers were higher than Year 7, but lower than Years 5 and 6, when numbers peaked in February (2,047 birds in Year 6, and 1,598 birds in Year 5).

Numbers of Common Gulls recorded in the Box in Year 8 and recent years, were low in all months.

Figure 3.35 Numbers of Common Gulls in the Bank and Box, Years 5 to 8



Mean monthly density

Common Gull mean monthly density in the Arklow Study Area was low throughout Year 8, apart from a peak of 19.17 birds/km² over the Bank in November (Figure 3.36). This was similar to the combined mean density figure for November in Years 5 to 7 (16.25 birds/km²). Peak mean monthly density over the Bank between Years 5 to 7 was recorded in February (26.26 birds/km²).

Mean monthly density for Common Gull in the Box was low for all months.

Figure 3.36 Common Gull mean monthly density in the Bank and Box, Years 5 to 8

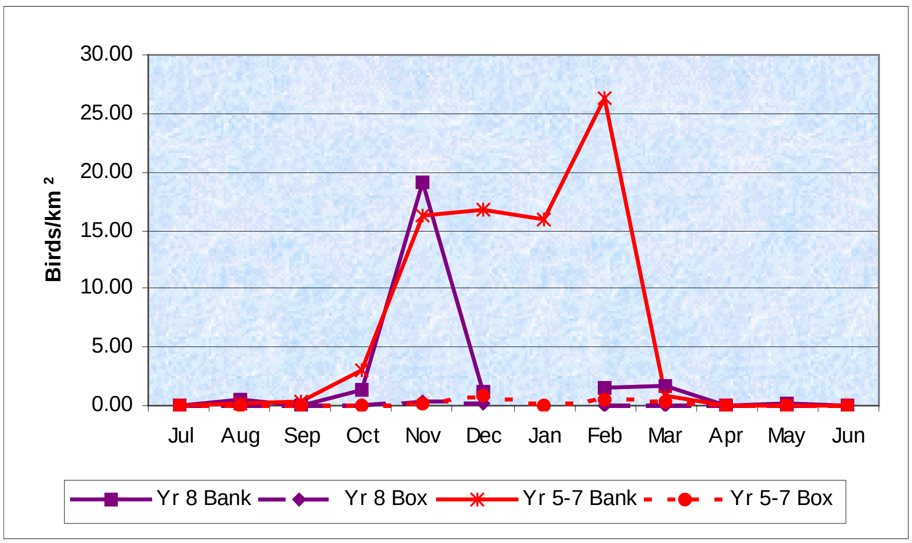


Table 3.14 Peak Common Gull density between October and February, Years 5 to 8 (> 50 birds/km²)

Year	Survey leg	Km waypoint	Seasonal Density
5 to 7	3	16	84.73
5 to 7	3	17	77.16
5 to 7	3	22	65.85
5 to 7	3	23	90.78
5 to 7	3	24	64.54
5 to 7	3	25	77.99
5 to 7	3	26	53.29
5 to 7	3	27	76.58
5 to 7	3	28	56.39
5 to 7	5	9	77.08
8	2	25	70.0
8	2	26	73.33
8	2	27	56.67

Figure 3.37 Common Gull density between October and February

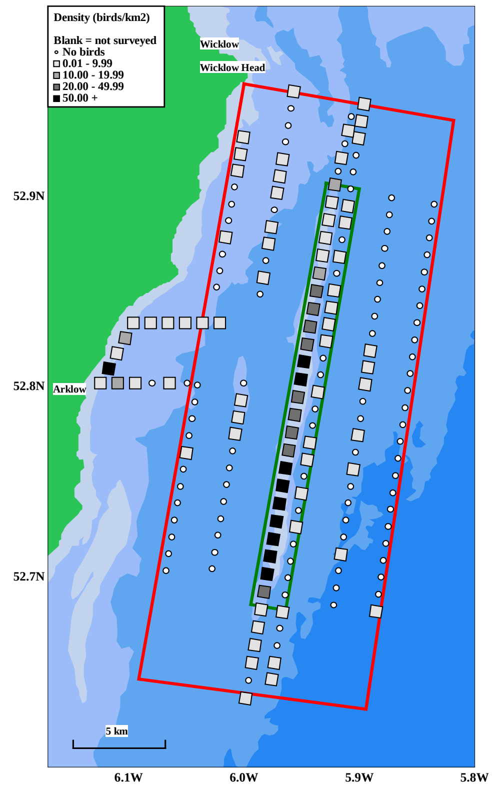
Years 5 to 7 – October to February

In Years 5 to 7, Common Gull density was highest along the inner Bank leg from November to February (Table 3.14).

In the Box, birds were scattered at low density in the northern half of the inner Box, and the southern half of the outer Box.

Density along the Cable Route was generally low to moderate, with highest density of 77.08 birds/km² (Table 3.14).

Years 5 to 7



Year 8 – October to February

In Year 8, Common Gulls were mostly restricted to the Bank, at low to moderate density. Highest density was recorded at the southern end of the outer Bank leg, with a peak of 73.33 birds/km² (Table 3.14).

Birds were also recorded occasionally at low density in the inner Box, and along the Cable Route at low to moderate density.

Year 8

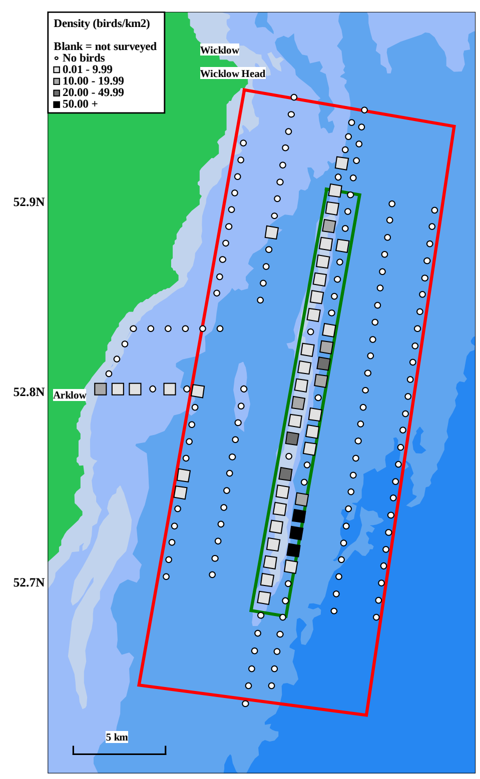
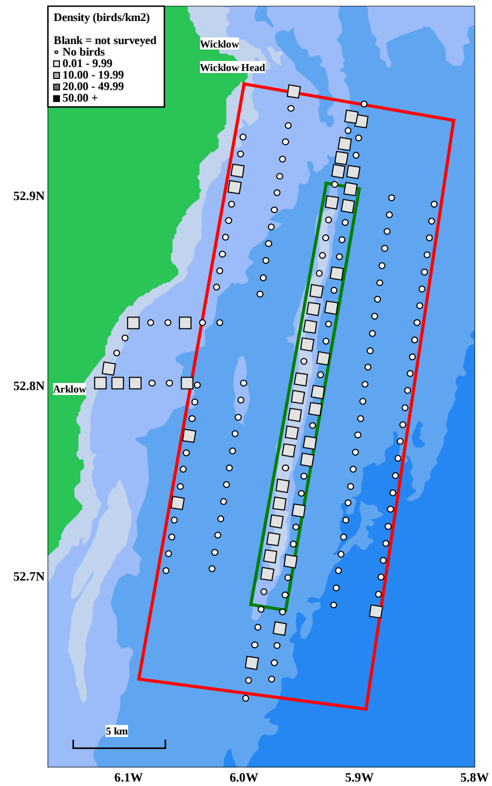


Figure 3.38 Common Gull density between March and September

Years 5 to 7 – March to September

Densities of Common Gulls were lower between March and September of Years 5 to 7, but the distribution pattern was generally similar to the winter months, with low densities regularly recorded along the Bank legs and scattered along the inner Box legs and Cable Route.

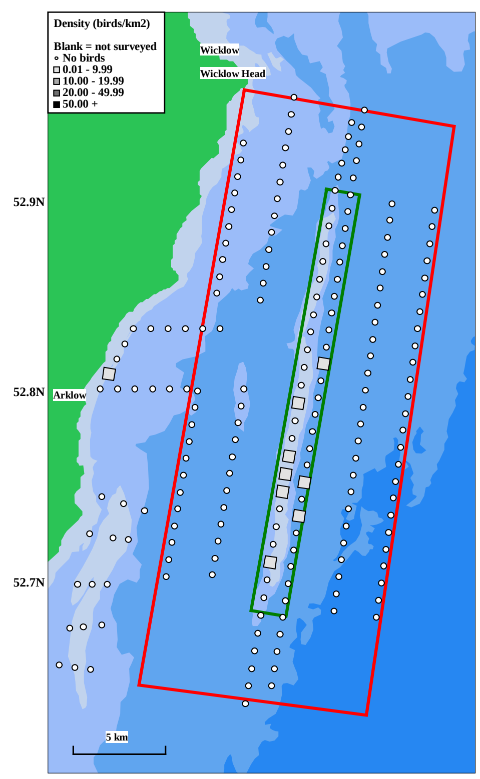
Years 5 to 7



Year 8 – March to September

There were few Common Gulls seen between March and September of Year 8, with occasional birds recorded at low density over the Bank.

Year 8



3.4.17 Lesser Black-backed Gull

Years 5 to 7

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.

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.

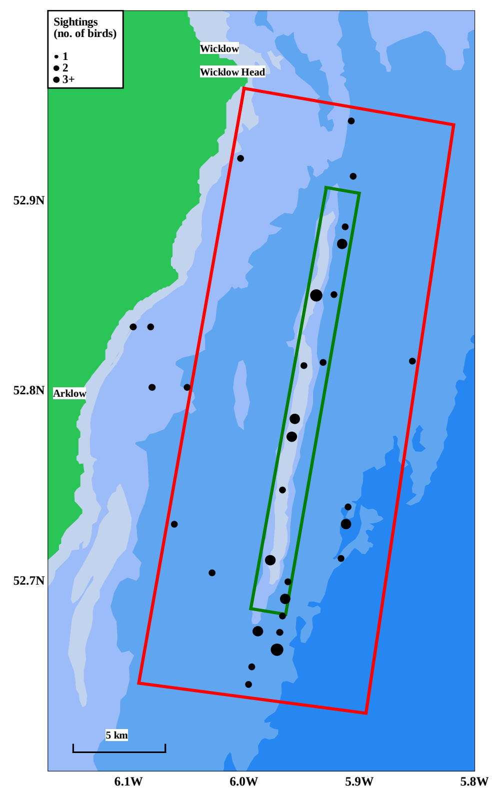
In Year 7, a total of 40 Lesser Black-backed Gulls were recorded between May and December, with a peak of 21 in July. The majority of sightings were over the Bank, with occasional sightings in the south of the Box and on the Cable Route.

Year 8

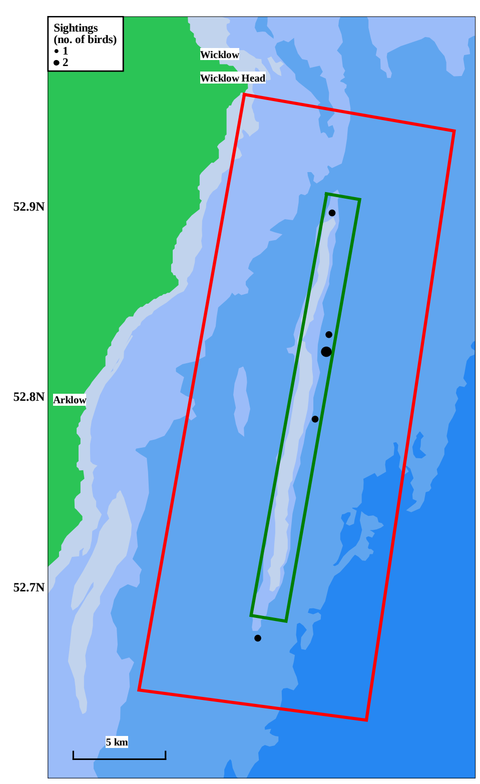
Fewer Lesser Black-backed Gulls were recorded in Year 8, with a total of 8 birds seen. This was similar to numbers seen in Year 5. Peak counts were two birds in May and 2 birds in November, with singles recorded in August and October. All sightings were over the Bank.

Figure 3.39 LBB Gull sightings

Years 5 to 7



Year 8



3.4.18 Great Black-backed Gull

Years 5 to 7

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.

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.

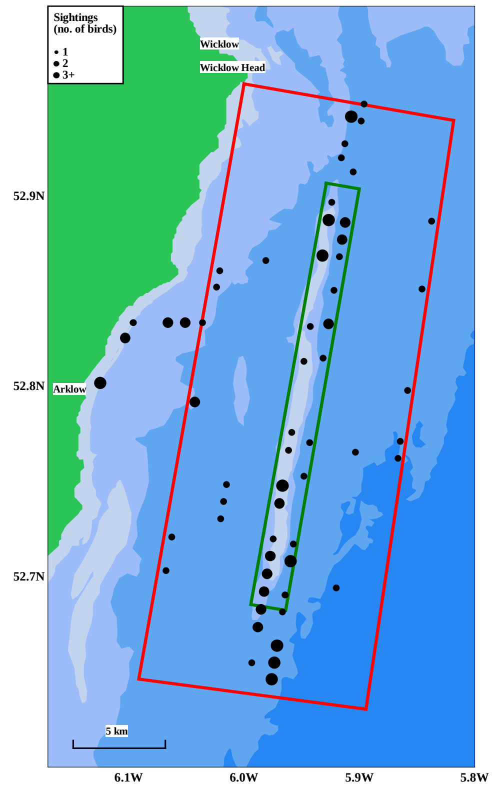
A total of 83 birds were recorded in Year 7. Birds were seen in all months except June, with the peak count of 42 recorded in August. Concentrations occurred at the northern and southern ends of the Box, with lower numbers over the Bank and Cable Route.

Year 8

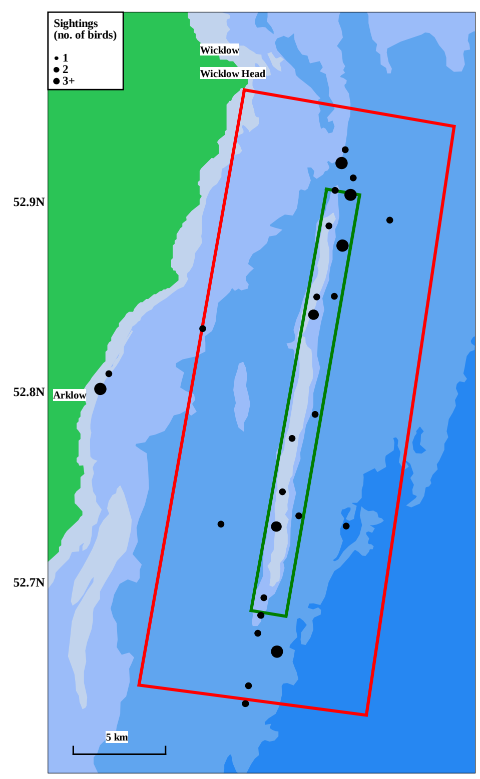
A total of 53 birds were recorded in Year 8. Birds were seen in all months except January when there was no survey, April and July. The peak count of 21 was recorded in September. Birds were scattered along the Bank, with fewer sightings in the Box and Cable Route.

Figure 3.40 GBB Gull sightings

Years 5 to 7



Year 8



3.4.19 Herring Gull

Numbers in the Arklow Study Area

Herring Gulls numbers over the Bank in Year 8 were low, with a peak of 31 birds in November (Figure 3.41). Numbers in Year 7 were similarly low, with a peak in August (29 birds), while numbers in Years 5 and 6 were lower. No Herring Gulls were recorded in the Box during Year 8.

Figure 3.41 Numbers of Herring Gulls in the Bank and Box, Years 5 to 8

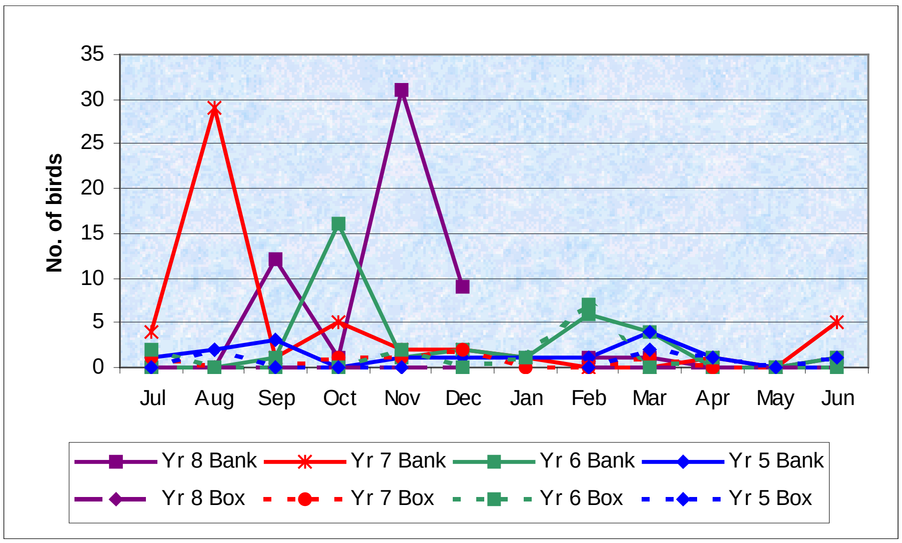


Figure 3.42 Herring Gull mean monthly abundance in the Bank and Box, Years 5 to 8

Mean monthly density

Mean monthly abundance over the Bank was very low throughout Year 8, with a peak of 0.16 birds/km in November (Figure 3.42). Similar abundance was recorded in Years 5 to 7.

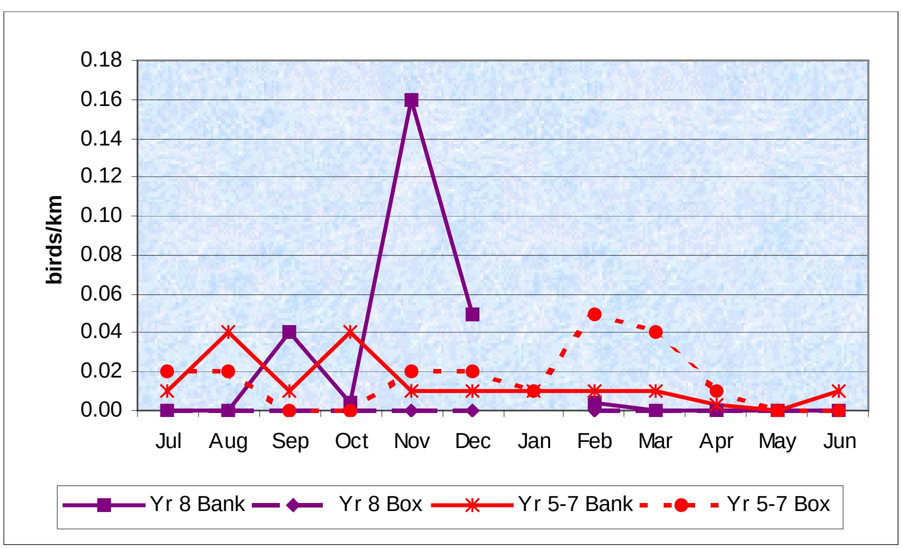


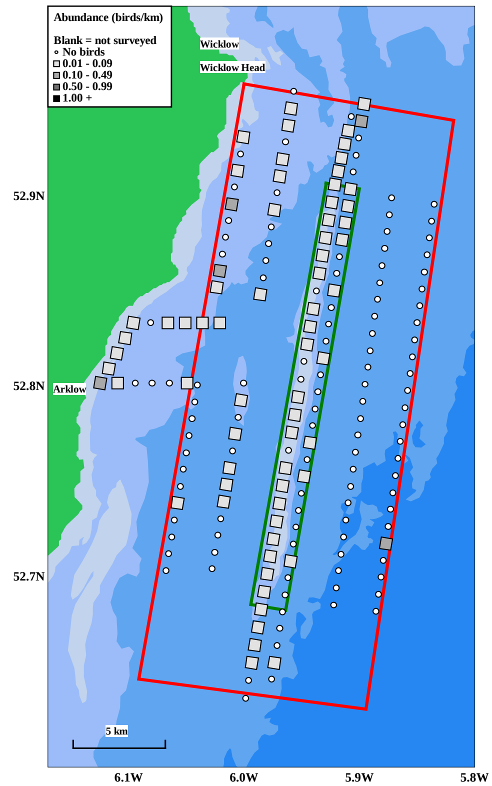
Figure 3.43 Herring Gull abundance in the Arklow Study Area in all months

Years 5 to 7

Herring Gull distribution between Years 5 and 7 was predominantly along the inner Bank and Box legs and along the Cable Route, at low to moderate abundance.

There were very few birds recorded on the outer Box legs over this period.

Years 5 to 7

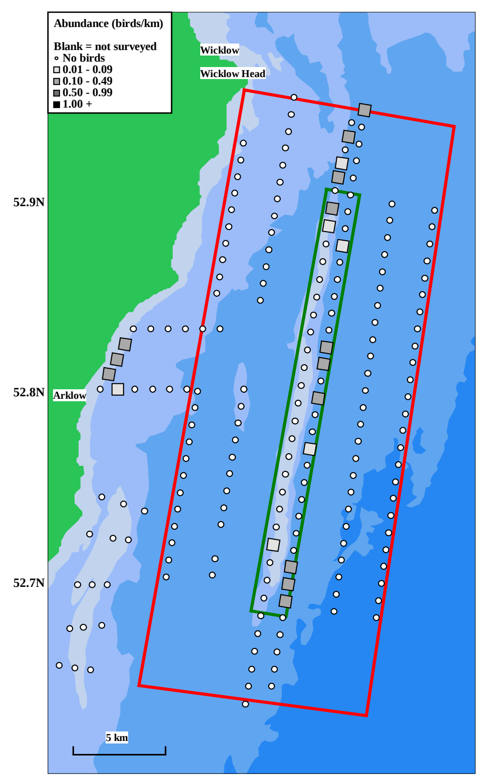


Year 8

Herring gull distribution in Year 8 was patchy, with birds recorded in low to moderate abundance along the Bank and Cable Route.

There were no Herring Gulls recorded in the Box in Year 8.

Year 8



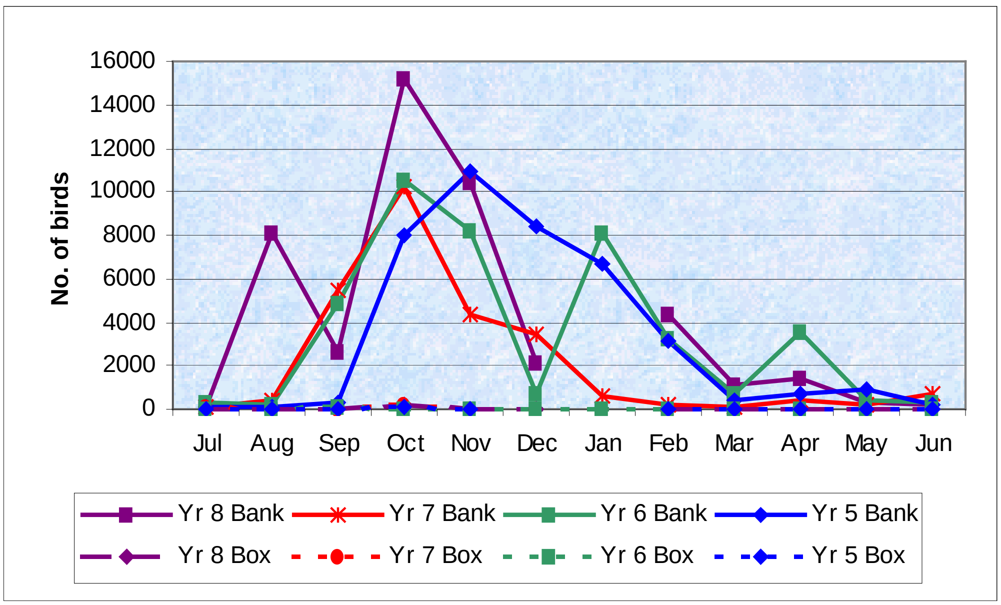
3.4.20 Kittiwake

Numbers in the Arklow Study Area

Numbers of Kittiwakes recorded over the Bank in Year 8 followed the pattern of Years 5 to 7, with an increase in numbers from August, reaching a peak in October of 15,215 birds (Figure 3.44). This was the highest peak recorded in the Arklow Study Area since the project began, and was above recent peaks of 10,243 birds in October of Year 7, and 10,528 birds in October of Year 6. Numbers in Year 5 peaked in November of Year 5, with 10,938 birds. Numbers decreased slightly in November, and then dropped considerably in December, remaining low until June. There was no January survey in Year 8 due to bad weather.

Numbers of Kittiwakes in the Box were low throughout Year 8. This was similar to Years 5 to 7.

Figure 3.44 Numbers of Kittiwakes in the Bank and Box, Years 5 to 8



Mean monthly density

Kittiwake mean monthly density over the Bank in Year 8 was low in July, but increased to 193.73 birds/km2 in August, which was considerably higher than the density recorded for the same period between Years 5 to 7 combined (Figure 3.45). Mean density was lower again in September of Year 8 but was almost identical compared to Years 5 to 7 combined. Mean density peaked in October of Year 8 at 256.03 birds/km^2, which was slightly higher than for October of Years 5 to 7 combined (223.92 birds/km^2). Mean density dropped in December of Year 8, and remained low for the remaining months.

Mean monthly density for Kittiwake in the Box was low for all months.

Figure 3.45 Kittiwake mean monthly density in the Bank and Box, Years 5 to 8

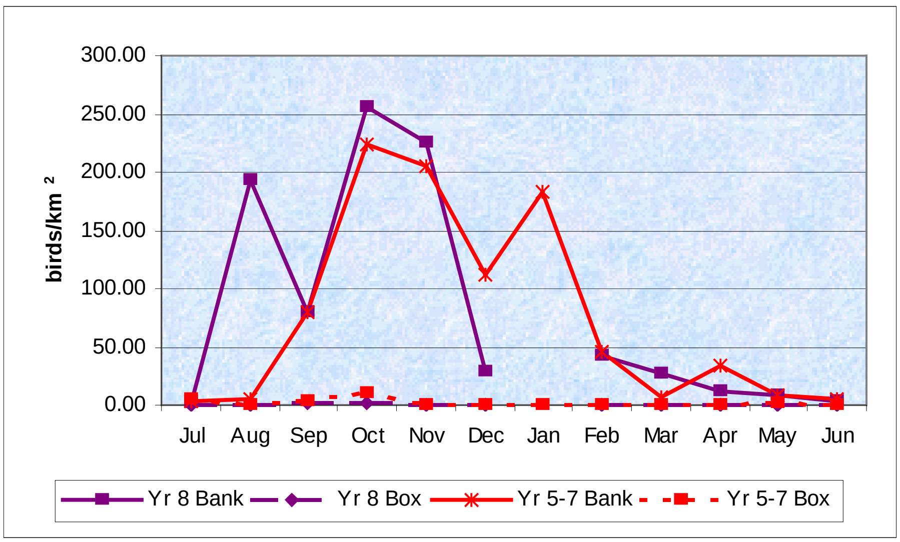


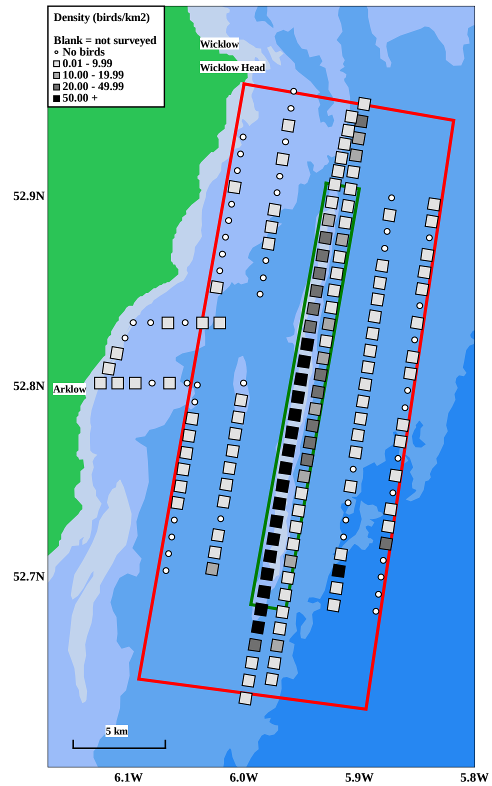
Figure 3.46 Kittiwake density in the Arklow Study Area from September to April

Years 5 to 7 – September to April

Between September and April of Years 5 to 7 combined, Kittiwakes were recorded at highest density along the inner Bank leg, where a peak density of 776.33 birds/km² was recorded (Table 3.15).

Low to moderate Kittiwake density was recorded on the outer Bank leg, with mostly low density recorded in the Box and Cable Route.

Years 5 to 7



Year 8 - September to April

In Year 8, Kittiwake density was high over the Bank between September and April, with a peak of 610.91 birds/km² (Table 3.16).

Kittiwakes were recorded at low density sporadically in the Box, Cable Route and over the Glassgorman Bank.

Year 8

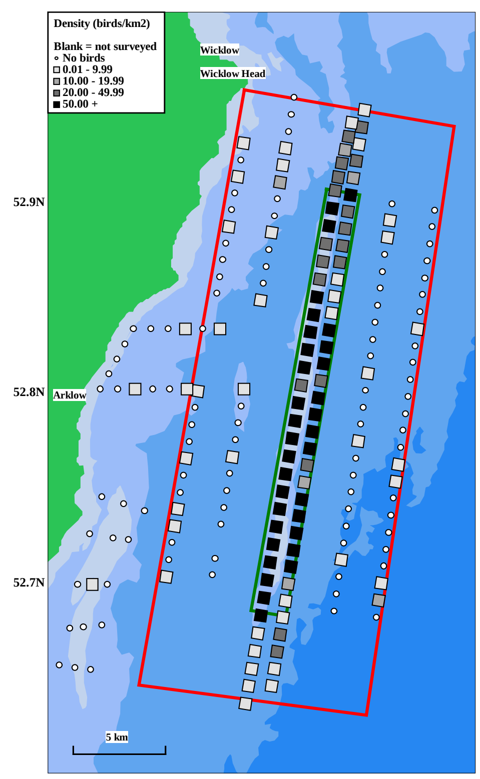


Table 3.15 Peak Kittiwake densities between September and April, Years 5 to 7 (> 50 birds/km^2)

Year	Survey leg	Km waypoint	Seasonal Density
5-7	3	15	73.1
5-7	3	16	108.96
5-7	3	17	117.19
5-7	3	18	146.56
5-7	3	19	123.39
5-7	3	20	150.27
5-7	3	21	236.85
5-7	3	22	323.71
5-7	3	23	406.13
5-7	3	24	502.14
5-7	3	25	549.97
5-7	3	26	668.8
5-7	3	27	776.33
5-7	3	28	724.35
5-7	3	29	636.21
5-7	3	30	267.03
5-7	3	31	98.38
5-7	11	23	71.67

Table 3.16 Peak Kittiwake densities between September and April, Year 8 (> 50 birds/km^2)

Year	Survey leg	Km waypoint	Seasonal Density
8	2	6	77.36
8	2	14	258.59
8	2	15	518.13
8	2	16	112.72
8	2	18	296.46
8	2	19	307.79
8	2	20	120.0
8	2	21	65.94
8	2	24	98.53
8	2	25	95.47
8	2	26	174.94
8	2	27	69.53
8	2	28	52.64
8	3	7	206.16
8	3	8	118.92
8	3	12	89.44
8	3	13	127.58
8	3	14	92.64
8	3	15	70.75
8	3	16	111.35
8	3	18	97.56
8	3	19	116.83
8	3	20	142.05
8	3	21	70.88
8	3	22	141.13
8	3	23	124.29
8	3	24	610.91
8	3	25	563.24
8	3	26	356.58
8	3	27	558.21
8	3	28	288.98
8	3	29	219.16
8	3	30	248.22

Figure 3.47 Kittiwake density in the Arklow Study Area between May and August

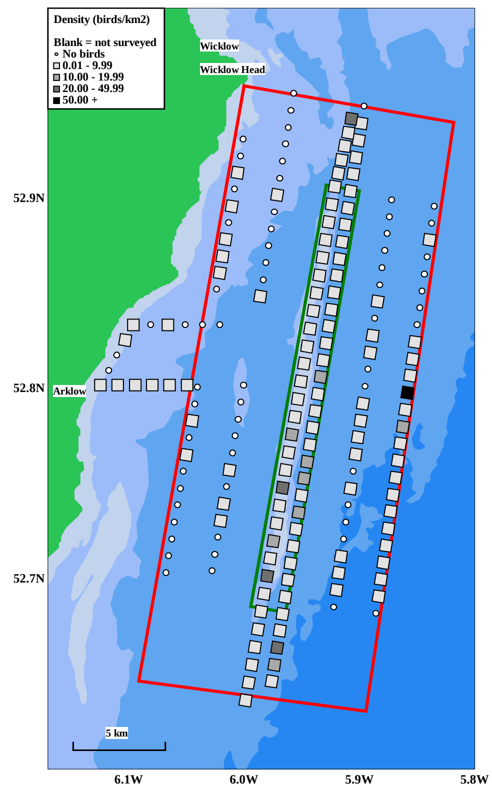
Years 5 to 7 – May to August

Kittiwake density between May and August of Years 5 to 7 combined was lower than for the autumn and winter months. Birds were recorded in low to moderate density over the Bank over the period.

Kittiwakes were less widespread in the Box, and generally occurred at low to moderate density, although highest density of 73.11 birds/km^2 was recorded on the outer Box leg (Table 3.17).

Low density was recorded on the Cable Route.

Years 5 to 7



Year 8 - May to August

Between May and August of Year 8, Kittiwakes were predominantly recorded over the Bank, with birds scattered at low density in the Box and Cable Route.

Over the Bank, highest density was recorded on the inner Bank leg (Table 3.17), with a peak of 837.18 birds/km^2. This was higher than the peak density recorded over the Bank during the winter months (Figure 3.46).

Low to moderate density was recorded on the outer Bank leg over the period.

Year 8

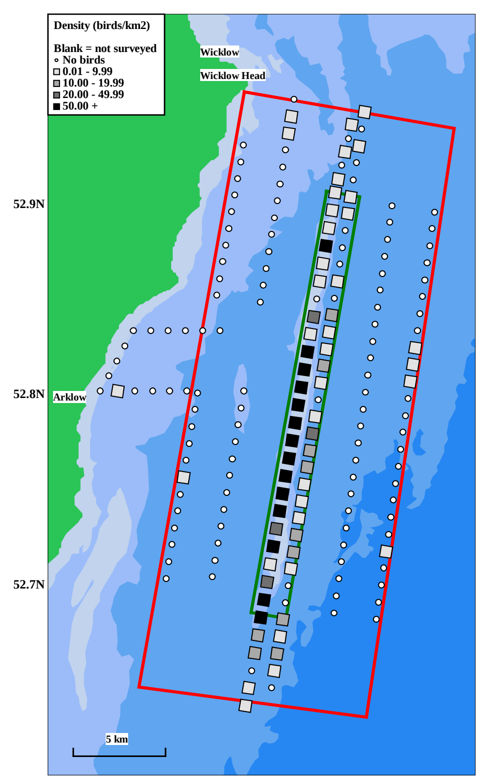


Table 3.17 Peak Kittiwake densities between May and August, Years 5 to 7 combined and Year 8 (> 50 birds/km²)

Year	Survey leg	Km waypoint	Seasonal Density
5-7	1	12	73.11
8	3	9	56.42
8	3	15	59.94
8	3	16	190.28
8	3	17	184.33
8	3	18	175.44
8	3	19	318.42
8	3	20	580.08
8	3	21	396.15
8	3	22	837.18
8	3	23	671.04
8	3	24	274.88
8	3	26	69.53
8	3	29	299.95
8	3	30	487.11

3.4.21 Common Tern

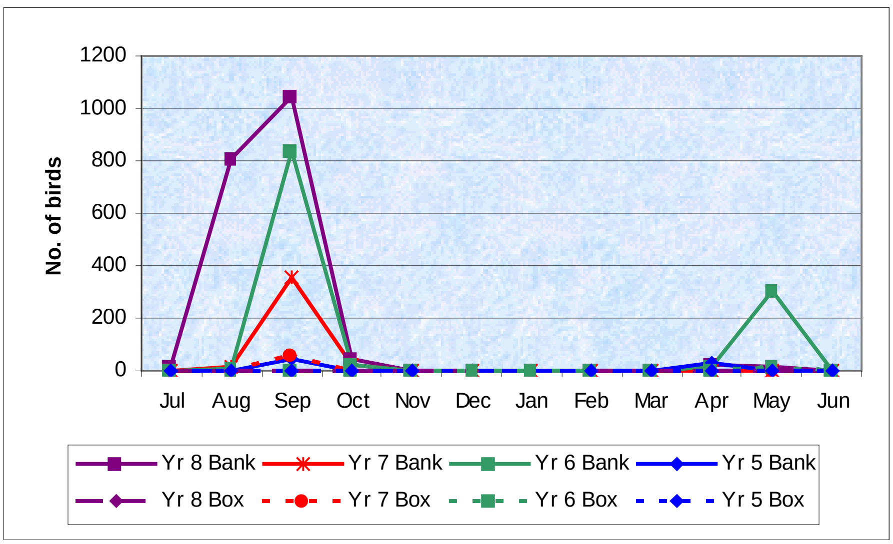
Common Terns are summer visitors to the Arklow Study Area and are recorded mainly on migration in spring and autumn. The species is listed on Annex I of the EU Birds Directive (79/409/EEC).

Numbers in the Arklow Study Area

In Year 8, Common Terns were recorded in the Arklow Study Area between April and October. Numbers were highest over the Bank in August and September, with a peak count of 1,043 birds recorded in September (Figure 3.48). September peaks over the Bank were also recorded in Year 7 (356 birds) and Year 6 (838 birds), with the Year 5 peak of 45 birds, also being recorded in September.

There were no Common Terns recorded in the Box in Year 8, while in Year 7, numbers in the Box peaked at 62 birds in September, with none seen in other months. Box totals for Years 5 and 6 were low.

Figure 3.48 Numbers of Common Terns in the Bank and Box, Years 5 to 8



Mean monthly density

Mean Common Tern density in the Arklow Study Area in Year 8 peaked in August at 15.95 birds/km^2 over the Bank (Figure 3.49). Mean density over the Bank dropped slightly in September (13.21 birds/km^2), but was still higher than the September peak recorded in Years 5 to 7 combined (9.94 birds/km^2). Few birds were recorded in the Arklow Study Area after September.

Mean Common Tern density in the Box in Year 8 was low throughout the summer months.

Figure 3.49 Common Tern mean monthly density in the Bank and Box, Years 5 to 8

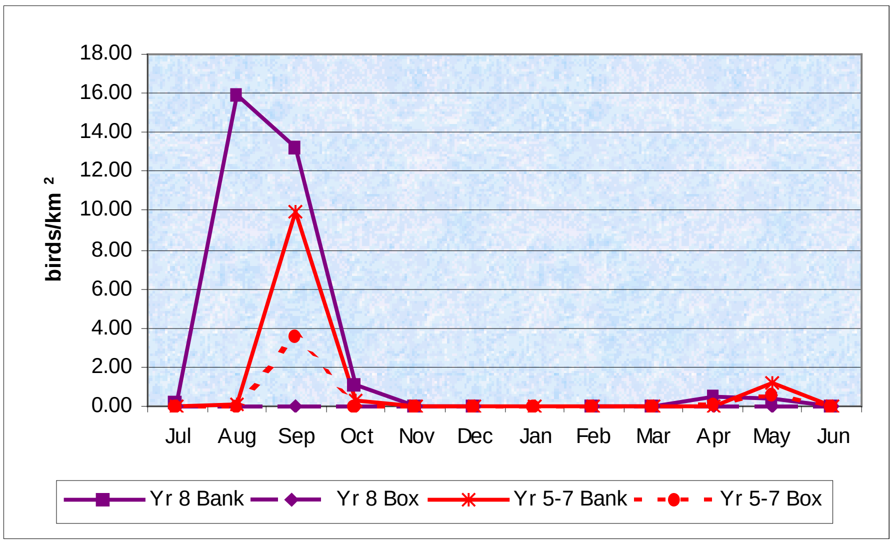


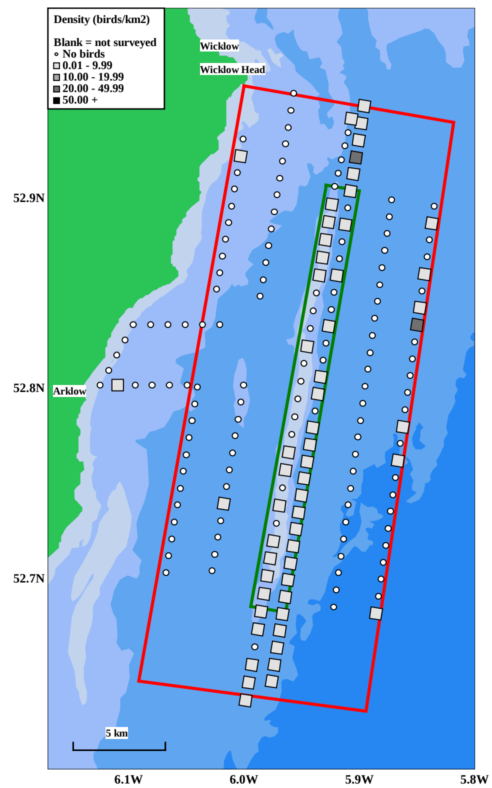
Figure 3.50 Common Tern density in the Arklow Study Area from April to October

Years 5 to 7 – April to October

Between April and October of Years 5 to 7 combined, Common Terns were mostly recorded in low to moderate density along the Bank.

Birds were also scattered at low to moderate density across the outer Box.

Years 5 to 7

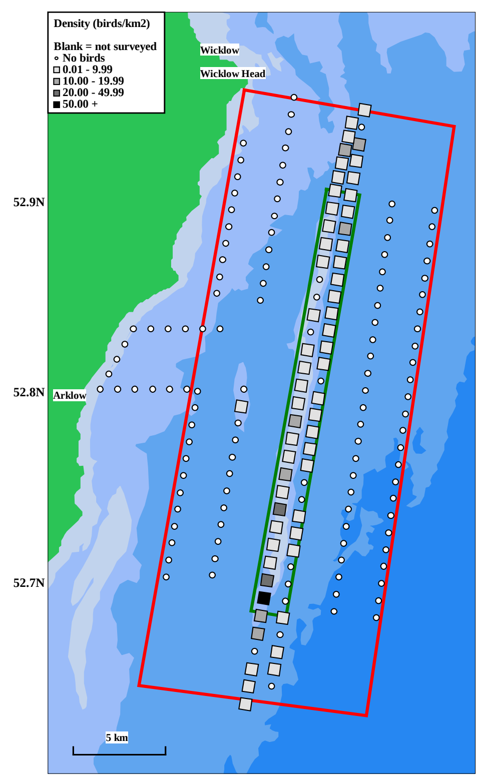


Year 8 – April to October

In Year 8, Common Terns were almost entirely restricted to the Bank legs, where they were mostly recorded in low to moderate density.

Highest density of 85.8 birds/km2 was recorded at the southern end of the inner Bank leg.

Year 8



3.4.22 Arctic Tern

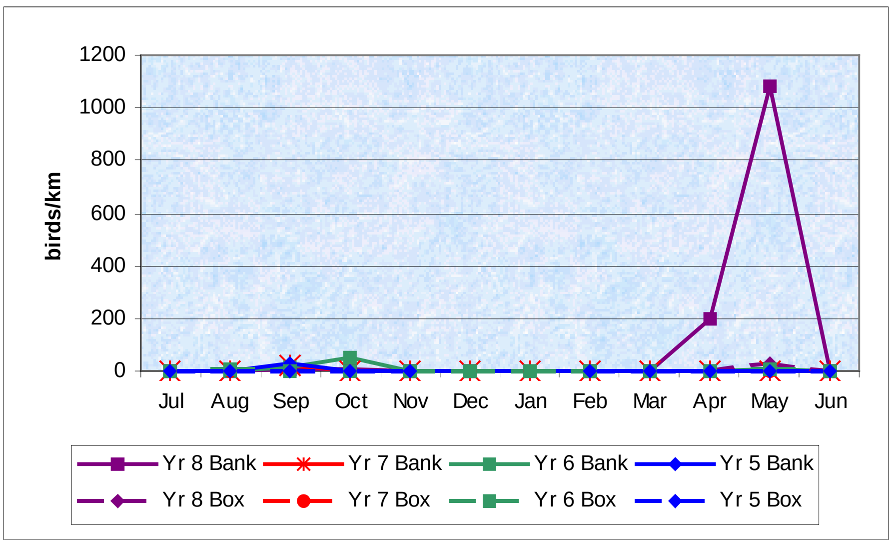
Arctic Terns are summer visitors to the Arklow Study Area and are recorded mainly on migration in spring and autumn. The species is listed on Annex I of the EU Birds Directive (79/409/EEC).

Numbers in the Arklow Study Area

In Year 8, Arctic Terns were only recorded over the Bank between April to June, September and October (Figure 3.51). Numbers peaked in May, when 1,081 birds were recorded over the Bank. This was considerably higher than the previous peak number of 50 over the Bank in October of Year 6, and presumably coincided with birds heading north on spring migration.

A total of 30 Arctic Terns were seen in the Box in May of Year 8, which was the highest total in recent years (Figure 3.51).

Figure 3.51 Numbers of Arctic Terns in the Bank and Box, Years 5 to 8



Mean monthly density

Mean Arctic Tern density in the Arklow Study Area was low throughout Year 8 apart from a peak of 36.22 birds/km² over the Bank in May (Figure 3.52).

Mean Arctic Tern density in the Box was low throughout the summer months of Years 5 to 8.

Figure 3.52 Arctic Tern mean monthly density in the Bank and Box, Years 5 to 8

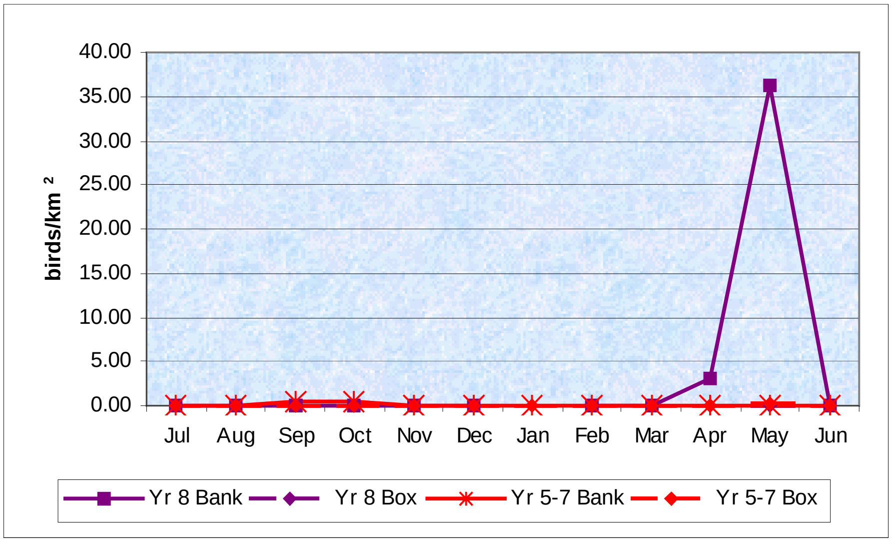
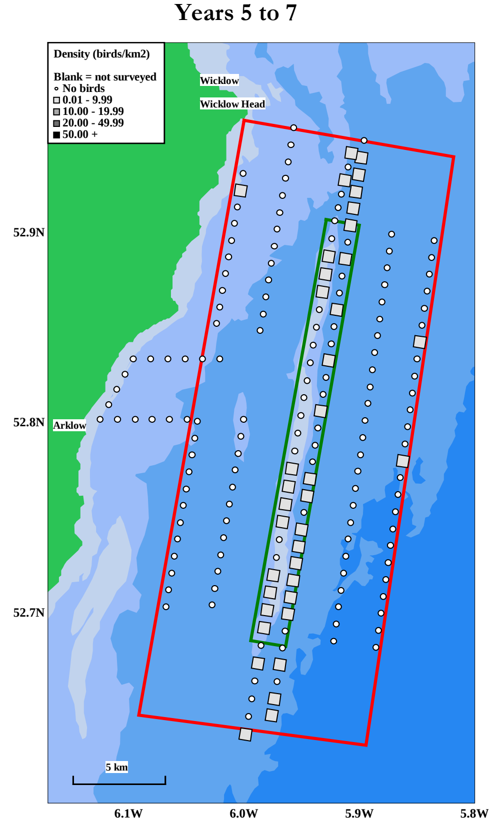


Figure 3.53 Arctic Tern density in the Arklow Study Area from April to October

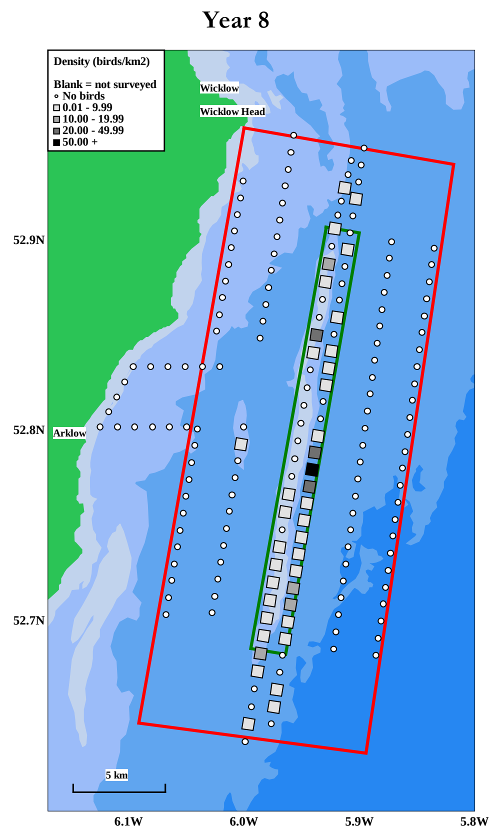
Years 5 to 7 – April to October

Overall, few Arctic Terns were seen in the Arklow Study Area during Years 5 to 7. Birds were recorded at low density over the Bank, and occasionally elsewhere between April and October.



Year 8 – April to October

Between April and October of Year 8, Arctic Terns were again predominantly recorded over the Bank. Density was higher than over the same period in Years 5 to 7, with the highest density of 62.23 birds/km2 recorded on the outer Bank leg. This reflects the higher numbers recorded over the Bank in May.



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).

Years 5 to 7

No Roseate Terns were recorded in Year 5. In Year 6, three were seen in May at the north end of the Bank. In Year 7, one Roseate Tern was recorded in October over the Bank.

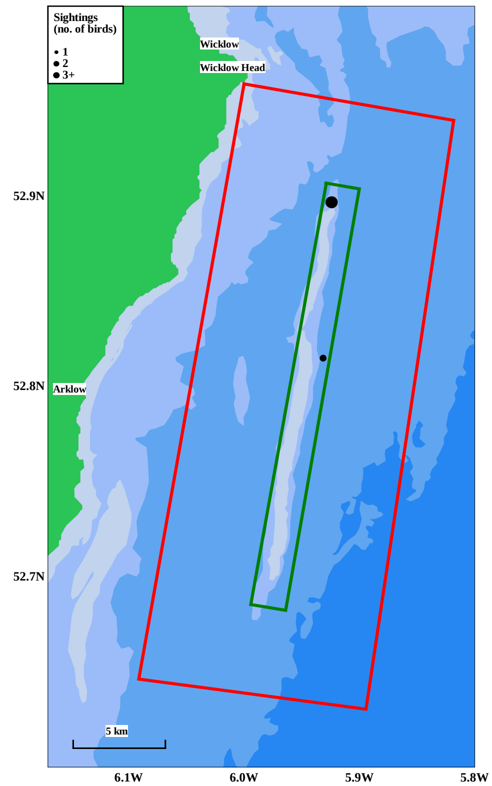
Year 8

In Year 8, a total of 41 Roseate Terns were recorded, all in early September. The majority of birds were recorded at the northern end of the Bank legs, with fewer sightings at the southern end of the Bank and one in the Box.

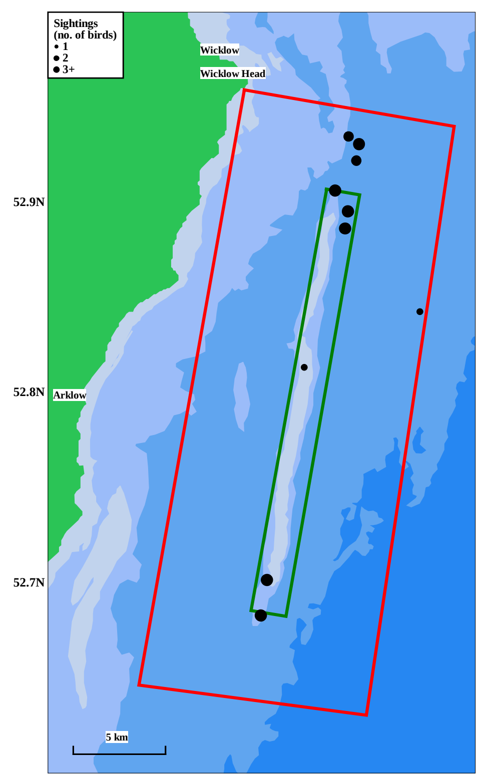
The largest flock recorded was 10 birds at the southern end of the Bank.

Figure 3.54 Roseate Tern sightings

Years 5 to 7



Year 8



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).

Years 5 to 7

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

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.

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.

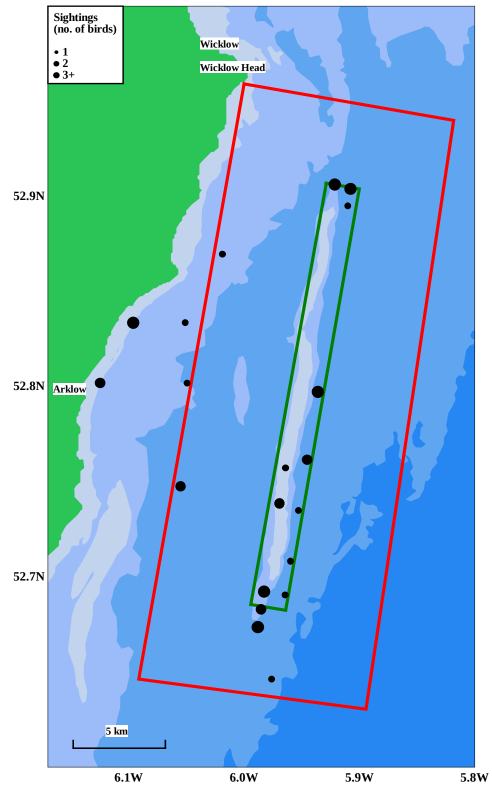
Year 8

A total of 8 Sandwich Terns were recorded in Year 8, with one in May, two in June, one in July and four in August.

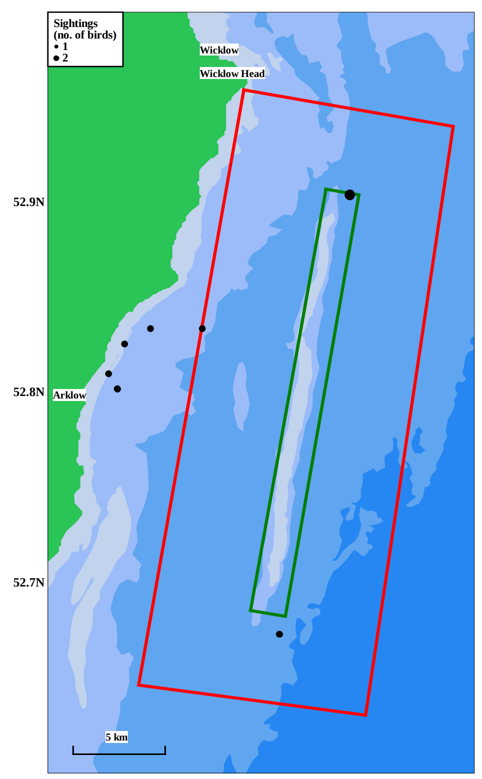
Birds were recorded at the north and south ends of the Bank and along the Cable Route.

Figure 3.55 Sandwich tern sightings

Years 5 to 7



Year 8



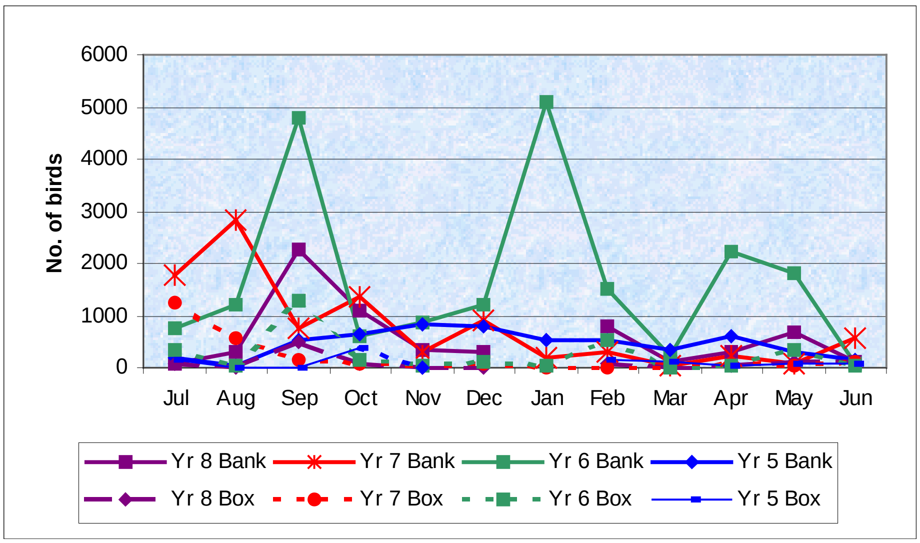
3.4.25 Guillemot

Numbers in the Arklow Study Area

Numbers of Guillemots recorded over the Bank in Year 8 increased from August and peaked in September (2,261 birds) before decreasing again in the remaining months (Figure 3.56). Month for month, numbers in Year 8 were similar to Year 7, when numbers peaked in August (2,826 birds). Highest peaks in recent years were recorded in September (4,790 birds) and January (5,077 birds) of Year 6. There was no January survey in Year 8 due to bad weather.

Numbers in the Box in Year 8 were lower than the Bank, with a peak of 484 birds in September.

Figure 3.56 Numbers of Guillemots in the Bank and Box, Years 5 to 8



Mean monthly density

Overall, mean monthly density in the over the Bank in Year 8 was lower than for Years 5 to 7 combined (Figure 3.57). Highest mean density occurred in September of Year 8, with a peak of 40.18 birds/km^2. This was slightly lower than the October density for Years 5 to 7 combined (46.75 birds/km^2). Peak mean density in Years 5 to 7 combined was recorded in January (71.02 birds/km^2), however there was no January survey in Year 8 for comparison. Mean monthly density over the Bank was lower from February to June in Year 8 and Years 5 to 7 combined.

In the Box, highest mean monthly density in Year 8 was also recorded in September, with a peak of 20.86 birds/km^2 (Figure 3.57). This was considerably lower than September of Years 5 to 7 combined, when mean density was 63.70 birds/km^2. Guillemot mean monthly density in the Box was lower for the remaining months.

Figure 3.57 Guillemot mean monthly density in the Bank and Box, Years 5 to 8

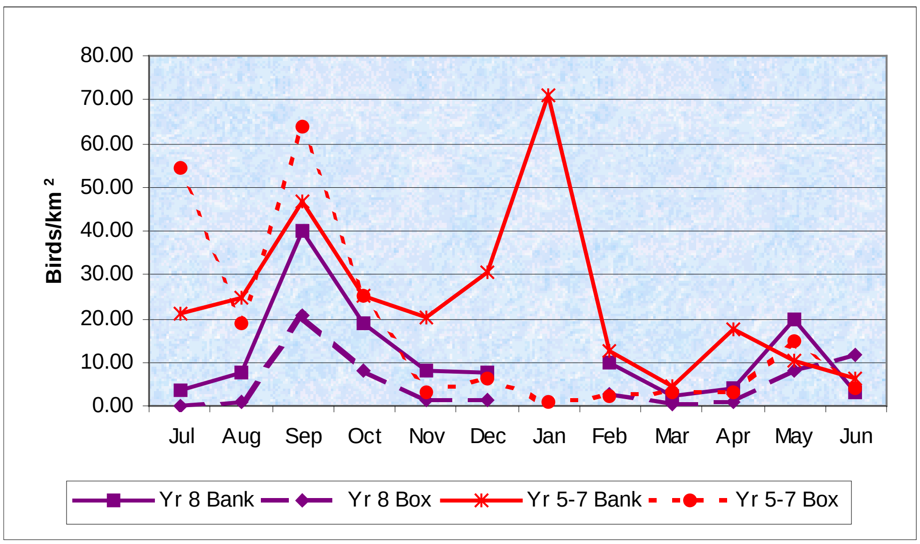


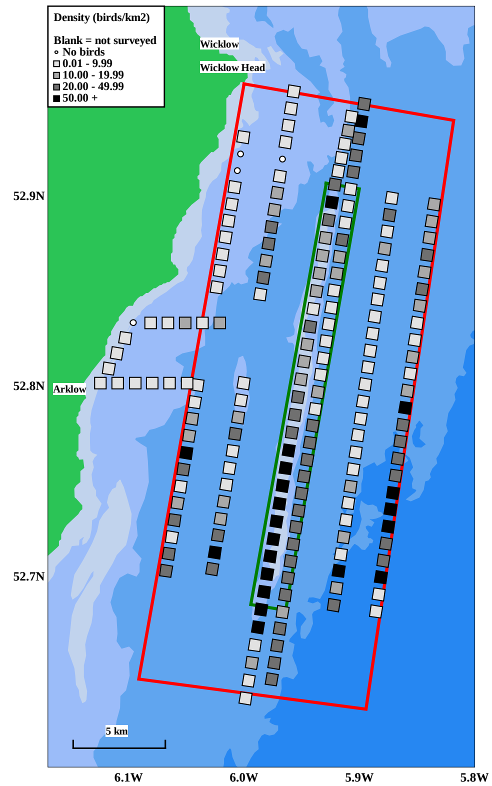
Figure 3.58 Guillemot density in the Arklow Study Area from September to January

Years 5 to 7 – September to January

Guillemots were recorded in mostly moderate density along the Bank between September and January of Years 5 to 7 combined, with highest density (281.77 birds/km²) recorded at the southern end of the inner Bank leg (Table 3.18).

Birds were found at lower density on the inner Box legs and Cable Route, and in moderate to high densities along the outer Box leg.

Years 5 to 7



Year 8 - September to December

Between September and December of Year 8, highest Guillemot density was recorded in the southern half of the inner Bank leg (148.25 birds/km²). High density was also recorded at the north end of the Bank (Table 3.18).

Occasional high density areas were also recorded on the outer Box legs, where peak density was 108.0 birds/km².

Guillemot density on the inner Box legs and Cable Route was predominantly low over these months. There was no January survey in Year 8.

Year 8

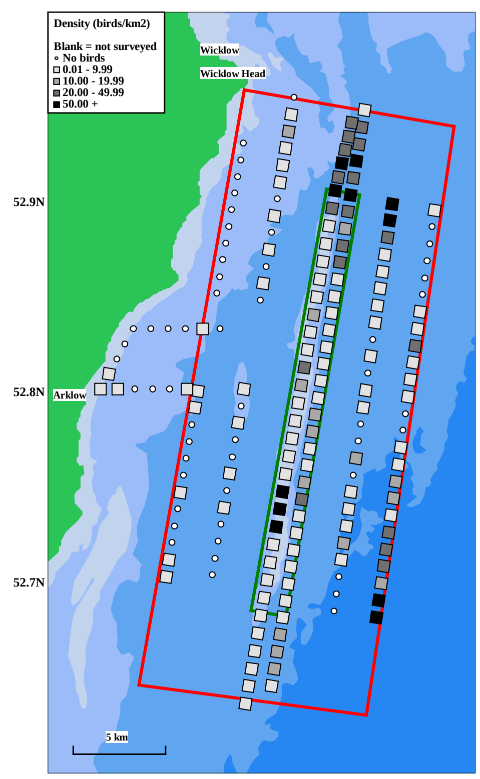


Table 3.18 Peak Guillemot densities from September to January, Years 5 to 7 combined and Year 8 [1] (> 50 birds/km²)

Year	Survey leg	Km waypoint	Seasonal Density
5-7	1	13	50.56
5-7	1	18	59.99
5-7	1	19	137.27
5-7	1	20	96.21
5-7	1	23	58.33
5-7	2	2	101.21
5-7	3	7	58.61
5-7	3	21	68.86
5-7	3	22	74.01
5-7	3	23	81.69
5-7	3	24	66.7
5-7	3	25	85.76
5-7	3	26	281.77
5-7	3	27	125.02
5-7	3	28	110.91
5-7	3	29	133.44
5-7	3	30	103.62
5-7	3	31	65.12
5-7	11	23	65.09
5-7	42	11	108.0
5-7	44	5	57.87
8	1	24	98.0
8	1	25	98.33
8	2	4	72.1
8	2	6	138.07
8	3	4	69.56
8	3	6	54.08
8	3	23	61.1
8	3	24	106.66
8	3	25	148.25
8	11	1	65.33
8	11	2	92.86

1 No January survey in Year 8

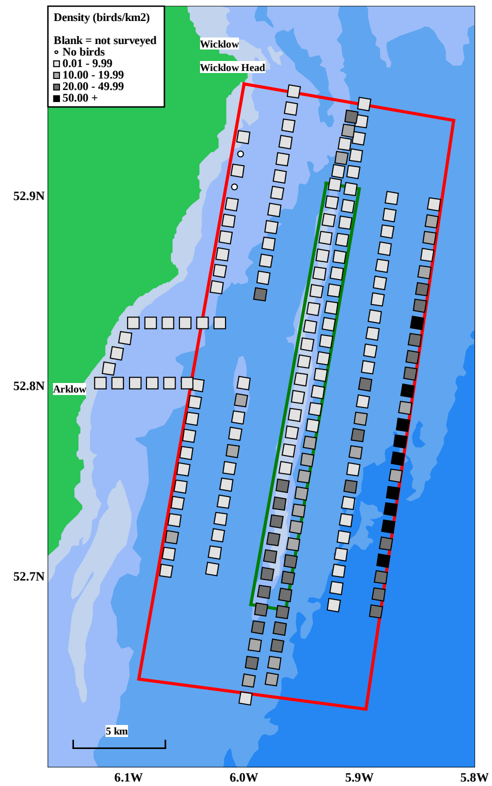
Figure 3.59 Guillemot density in the Arklow Study Area from February to August

Years 5 to 7 – February to August

Between February and August of Years 5 to 7 combined, Guillemot density was highest on the outer Box leg (275.33 birds/km^2) (Table 3.19). This was higher than recorded on the outer Box leg between September and January (Figure 3.58).

Elsewhere density was low to moderate.

Years 5 to 7



Year 8 - February to August

Guillemot density between February and August of Year 8 was predominantly low, with occasional moderate density recorded on the outer Bank leg and outer Box leg.

No Guillemots were recorded on surveys over the Glassgorman bank in March.

Year 8

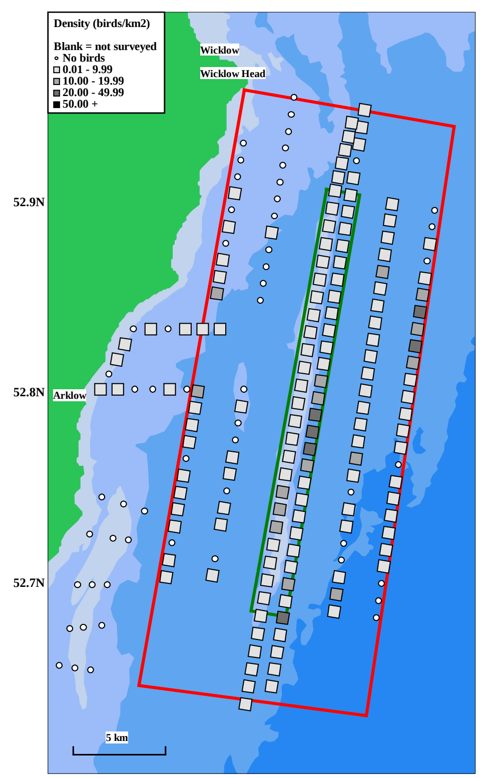


Table 3.19 Peak Guillemot densities between February and August, Years 5 to 7 combined (> 50 birds/km²)

Year	Survey leg	Km waypoint	Seasonal Density
5-7	1	8	97.14
5-7	1	12	85.81
5-7	1	14	275.33
5-7	1	15	135.17
5-7	1	16	122.0
5-7	1	18	52.0
5-7	1	19	85.33
5-7	1	20	60.0
5-7	1	22	66.67

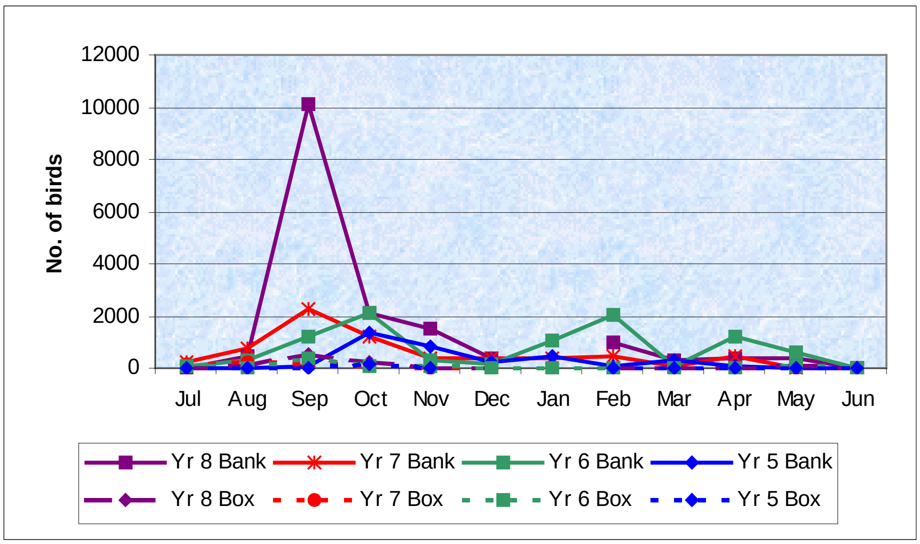
3.4.26 Razorbill

Numbers in the Arklow Study Area

Numbers of Razorbills in the Arklow Study Area in Year 8 peaked in September, when a peak count of 10,103 birds was recorded over the Bank (Figure 3.60). This was considerably higher than the previous peak Bank count of 2,247 birds in September of Year 7 and 2,099 birds in October of Year 6. Numbers decreased again in October, and showed a similar pattern to recent years for the remaining months of Year 8.

The peak total of Razorbills in the Box in Year 8 also occurred in September, with 539 birds recorded. This was the highest total for the Box in recent years (Figure 3.60).

Figure 3.60 Numbers of Razorbills in the Bank and Box, Years 5 to 8



Mean monthly density

Razorbill mean monthly density over the Bank in Year 8 peaked in September, with 169.73 birds/km^2, reflecting the unprecedented numbers of Razorbills recorded over the Bank during the month (Figure 3.61). Mean density dropped in October to 38.40 birds/km^2, which was similar to the peak mean October density recorded in Years 5 to 7 combined (40.73 birds/km^2). Mean density increased again in November, before decreasing for the remainder of Year 8.

In the Box, Razorbill mean monthly density in Year 8 increased from August onwards, with a peak of 23.60 birds/km^2 in October, before decreasing again for the remaining months (Figure 3.61). A similar pattern was recorded in Years 5 to 7 combined, with the highest mean density occurring in September (23.72 birds/km^2).

Figure 3.61 Razorbill mean monthly density in the Bank and Box, Years 5 to 7

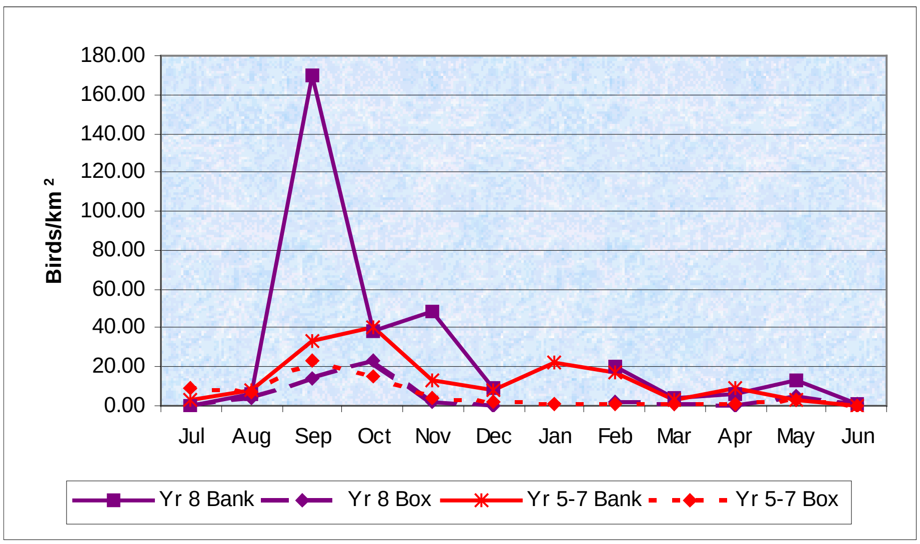


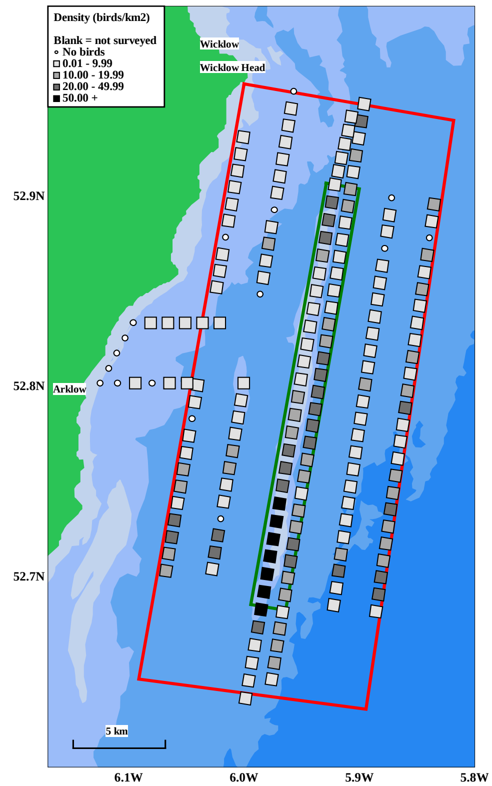
Figure 3.62 Razorbill density in the Arklow Study Area from September to February

Years 5 to 7 – September to February

Razorbills were widespread throughout the Arklow Study Area between September and February in Years 5 to 7 combined. Over the Bank, highest density was recorded in the southern half of the inner Bank leg, with a peak of 154.53 birds/km² (Table 3.20).

Razorbill density in the Box between September and February was low to moderate. Density was low over the Cable Route over the period.

Years 5 to 7



Year 8 - September to February

Between September and February of Year 8, Razorbills were recorded in highest density at the northern end of Leg 11, in the outer Box, where peak density was 335.5 birds/km² (Table 3.20).

Density was also high at the northern end of the Bank, and sporadically along the Bank, with a peak of 303.95 birds/km² (Table 3.20).

Fewer Razorbills were recorded on the inner Box legs and along the Cable Route over the period.

Year 8

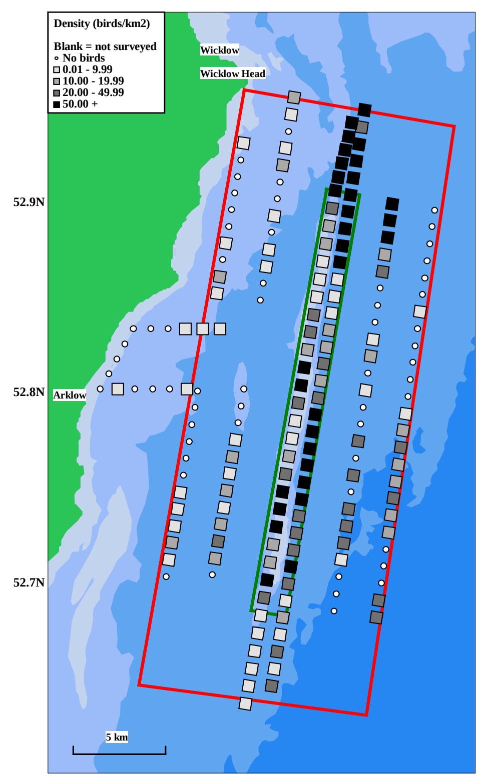


Table 3.20 Peak Razorbill densities from September to February, Years 5 to 7 combined and Year 8 (> 50 birds/km²)

Year	Survey leg	Km waypoint	Seasonal Density
5-7	3	24	55.82
5-7	3	25	72.4
5-7	3	26	154.53
5-7	3	27	90.79
5-7	3	28	75.72
5-7	3	29	120.3
5-7	3	30	74.77
8	2	1	79.22
8	2	3	58.36
8	2	4	122.2
8	2	5	169.76
8	2	6	435.9
8	2	7	303.95
8	2	8	240.75
8	2	9	150.07
8	2	10	106.56
8	2	19	63.58
8	2	20	122.5
8	2	21	100.59
8	2	22	50.33
8	2	23	72.79
8	2	24	84.44
8	2	28	89.81
8	3	1	51.43
8	3	2	90.42
8	3	3	114.23
8	3	4	149.2
8	3	5	117.26
8	3	6	90.11
8	3	16	69.33
8	3	17	76.38
8	3	23	75.67
8	3	24	175.46
8	3	25	232.54
8	3	28	58.94
8	11	1	300.0
8	11	2	335.5
8	11	3	113.19

Figure 3.63 Razorbill density in the Arklow Study Area from March to August

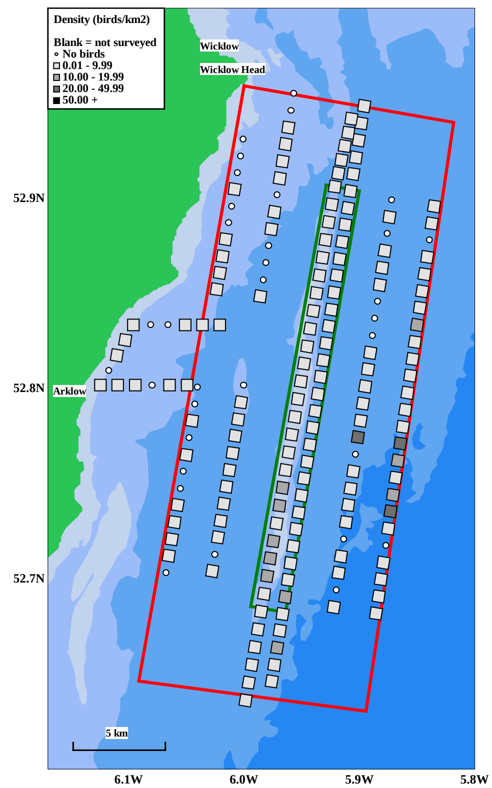
Years 5 to 7 – March to August

Razorbills were widespread at low to moderate densities throughout the Arklow Study Area between March and August in Years 5 to 7 combined.

Low to moderate density was recorded over the Bank, with mostly low density recorded in the Box and Cable Route.

Low densities were scattered in the Box.

Years 5 to 7

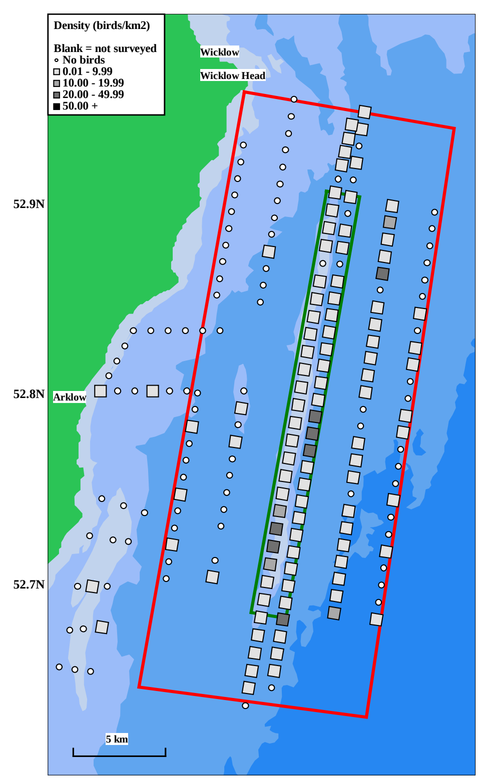


Year 8 - March to August

Razorbill distribution between March and August of Year 8 was similar to the same period in Years 5 to 7 combined, with low to moderate density recorded over the Bank, and more sporadically in the Box and Cable Route.

Low density was also recorded occasionally on March surveys of the Glassgorman Bank.

Year 8



3.4.27 Other auks

Years 5 to 7

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.

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

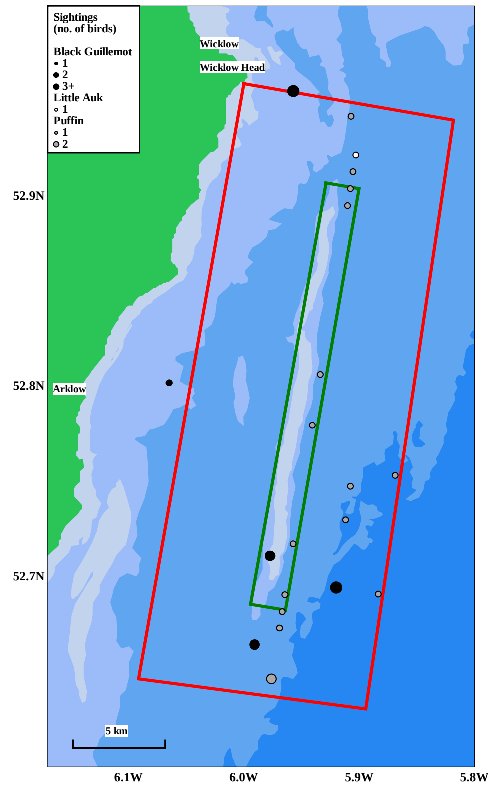
In Year 7, a total of ten Black Guillemots were seen, four in February, two in July and four in August, all in the Box. In addition, 15 Puffins were recorded, three in June, 10 in July, one in August and one in September. Birds were mostly scattered along the Bank and in the south east of the Box. No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

Year 8

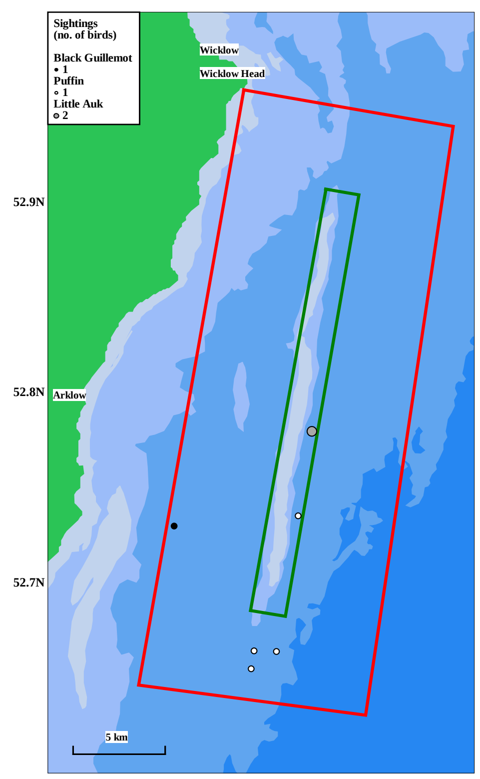
In Year 8, one Black Guillemot was recorded on the inner Box leg in November. Two Little Auks were recorded over the Bank in February. In addition, four Puffins were recorded over the Bank, one in April and three in September.

Figure 3.64 Auk sightings

Years 5 to 7



Year 8



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 in Year 8 (Table 3.21). Harbour Porpoise was the commonest species of cetacean (whale or dolphin), while Grey Seal was the only positively identified seal species encountered. In addition, 5 Risso's Dolphins were also recorded.

Table 3.21 Numbers of marine mammals recorded in the Arklow Study Area in Year 8

Species	Numbers recorded	No. of Days
Grey Seal	7	5
Risso's Dolphin	5	1
Harbour Porpoise	118	15
Total	**130**	**15**

Comparative data from JNCC surveys for the local ICES rectangles and the western Irish Sea is shown in Table 3.22.

Table 3.22 Numbers [1] of turtles, sharks, cetaceans and seal species recorded in the western Irish Sea between 1981 and 2001

Species	Nos. on JNCC surveys in western Irish Sea	No. of Days
Turtle species	1	1
Basking Shark	1	1
Grey Seal	9	9
Common Seal	2	2
Seal species	5	4
Minke Whale	11	9
Killer Whale	1	1
Small whale species	1	1
Risso's Dolphin	17	6
Harbour Porpoise	444	43
Bottlenose Dolphin	11	3
White-beaked Dolphin	7	2
Common Dolphin	382	14
Patterned dolphin species	2	1
Unidentified dolphin species	42	16
Cetacean species	5	5
Totals	**941**	**-**

1 raw data supplied by JNCC

Numbers of marine mammal species over the Bank, Box and Cable Route for Year 8 are shown in Table 3.23. Numbers of marine mammals over the Bank accounted for 86.9 % of all marine mammals recorded in the Arklow Study Area in Year 8, with 11.5 % recorded in the Box. In comparison, total numbers of marine mammals over the Bank in Year 7 accounted for 47.2 % of all marine mammals recorded, with 46.3 % 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, and in Year 5, the Bank accounted for 55.8 % of all marine mammals recorded, with 38.0 % recorded in the Box (Cork Ecology 2007b).

Table 3.23 Comparison of marine mammal numbers over the Bank, Box and Cable route in Year 8

Species	Bank	Box	Cable route
Grey Seal	5	1	1
Risso's Dolphin	0	5	0
Harbour Porpoise	108	9	1
Total	**113**	**15**	**2**

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 Year 8, with a brief comparison with Years 5 to 7 combined, which covers the whole of the post-construction phase.

3.6.1 Harbour Porpoise

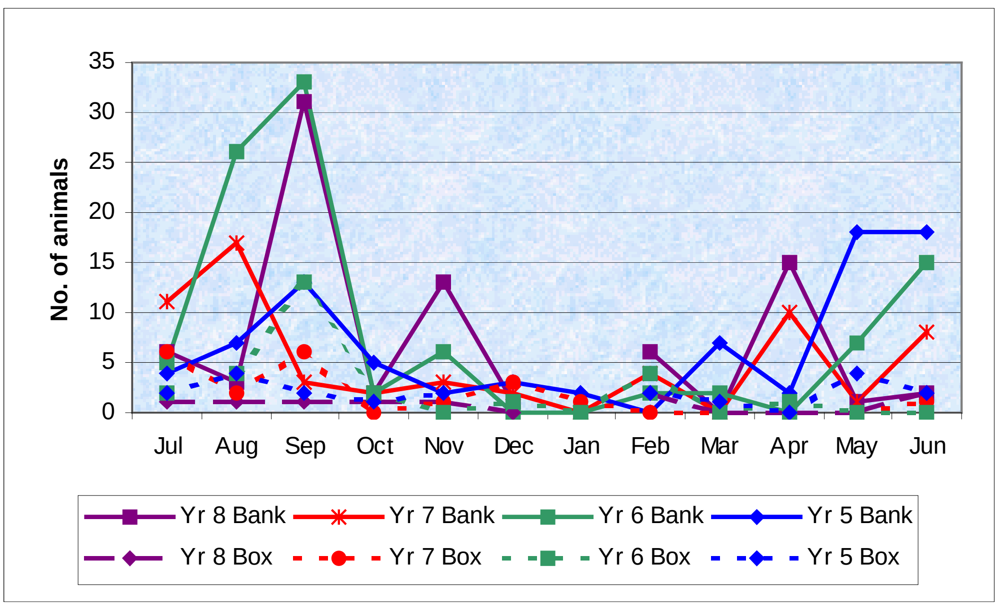
Harbour Porpoises are found in the Arklow Study Area throughout the year. They are listed on Annex II and IV of the EU Habitats Directive (92/43/EEC).

Numbers in the Arklow Study Area

Numbers of Harbour Porpoises over the Bank in Year 8 were low in July and August, but increased in September to a peak of 31 animals (Figure 3.65). This was slightly lower than the peak of 33 animals recorded in September of Year 6. Numbers over the Bank for the remaining months of Year 8 were lower, with 13 animals recorded in November and 15 animals in April the highest counts.

Low numbers of Harbour Porpoise were recorded in the Box throughout Year 8.

Figure 3.65 Numbers of Harbour Porpoises in the Bank and Box, Years 5 to 8



Mean monthly abundance

Mean monthly abundance for Harbour Porpoise over both the Bank in Year 8 was generally low, with a peak of 0.17 animals/km in September (Figure 3.66). This was slightly lower than the September peak 0.22 animals/km recorded in the Box in Years 5 to 7 combined.

Mean abundance for the remaining months in both the Bank and the Box was low for Year 8 and Years 5 to 7 combined.

Figure 3.66 Harbour Porpoise mean monthly abundance in the Bank and Box, Years 5 to 8

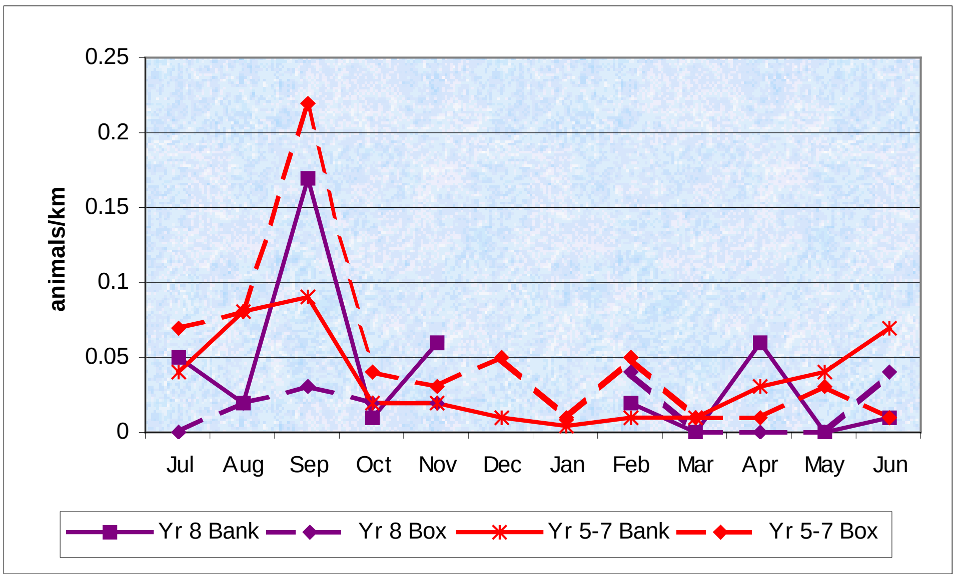
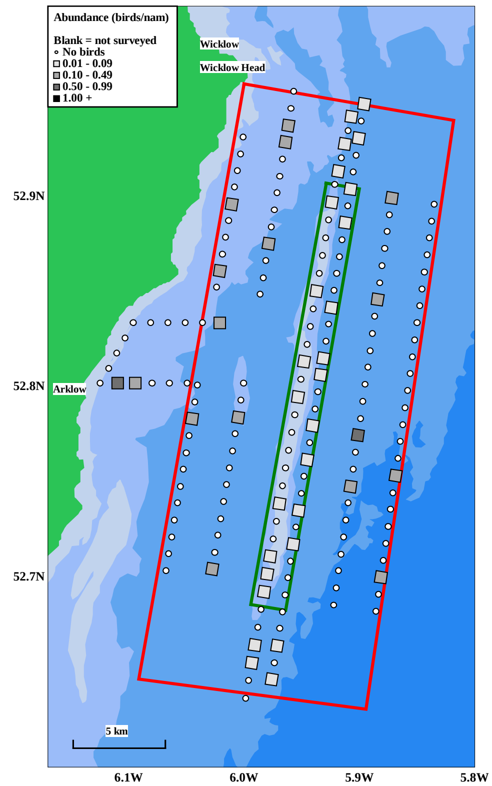


Figure 3.67 Harbour Porpoise abundance in the Arklow Study Area, October to March

Years 5 to 7 – October to March

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 along the Cable Route.

Years 5 to 7



Year 8 - October to March

In Year 8, Harbour Porpoise were more widespread at low to moderate abundance along the Bank between October and March than in the previous 3 years.

Elsewhere, animals were recorded at moderate abundance in the Box, with none recorded along the Cable Route at this time.

Year 8

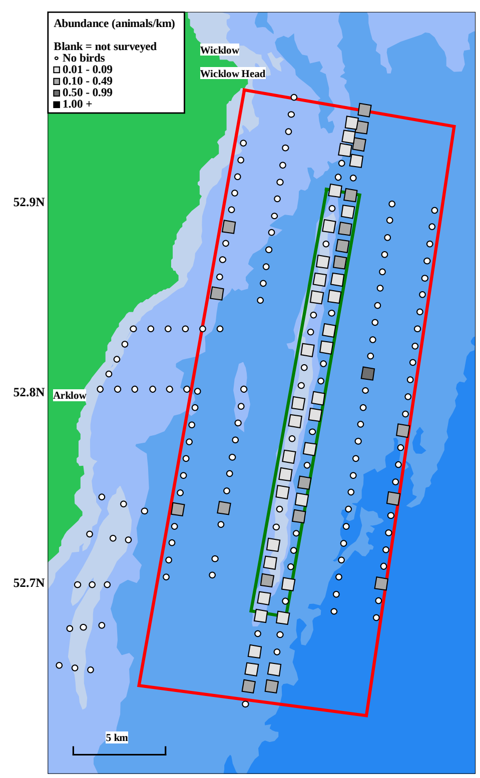


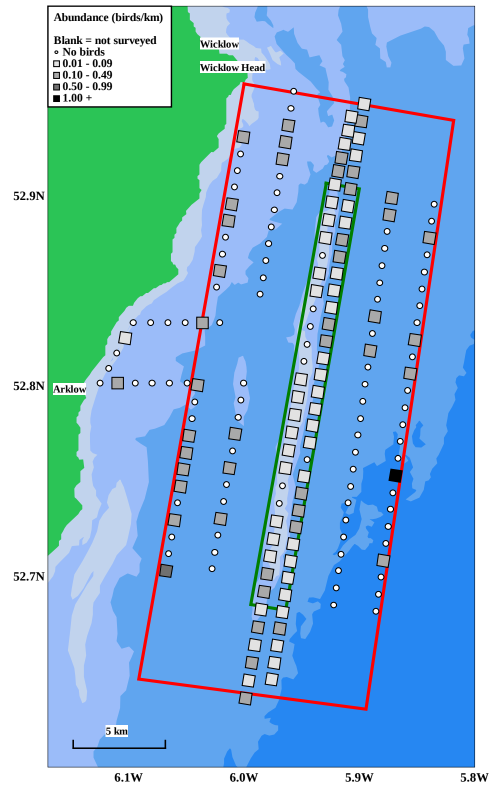
Figure 3.68 Harbour Porpoise abundance, April to September

Years 5 to 7 - April to September

Between April and September, Harbour Porpoises were more widespread along the Bank in low to moderate abundance.

Animals were also scattered throughout the Box and along the Cable Route, with peak abundance (1.29 animals/km) recorded on the southern half of the outer Box leg over this period.

Years 5 to 7

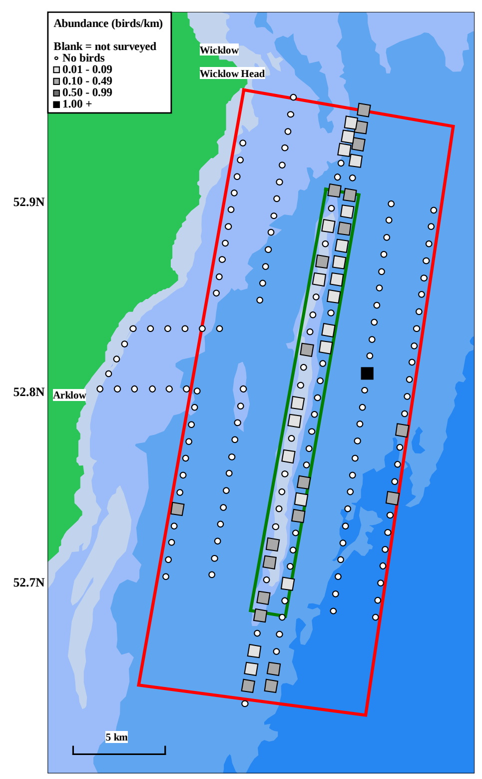


Year 8 - April to September

Harbour Porpoise distribution over the Bank between April and September of Year 8 was similar to the same period in Years 5 to 7, with Harbour Porpoises recorded in low to moderate abundance.

Fewer animals were recorded in the Box compared to Years 5 to 7, and there were none seen along the Cable Route. Highest abundance (1.0 animals/km) was recorded on outer Box leg 11, during this period.

Year 8



3.6.2 Other cetaceans

Years 5 to 7

In May of Year 5, four Risso's Dolphins were seen over the Bank with one at the north end of the Box, and another seen in June over the Bank.

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.

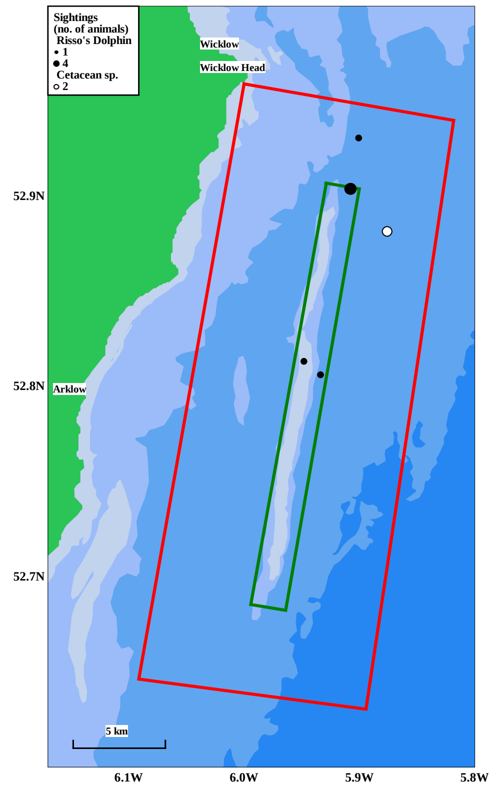
There were no sightings of other cetaceans in Year 7.

Year 8

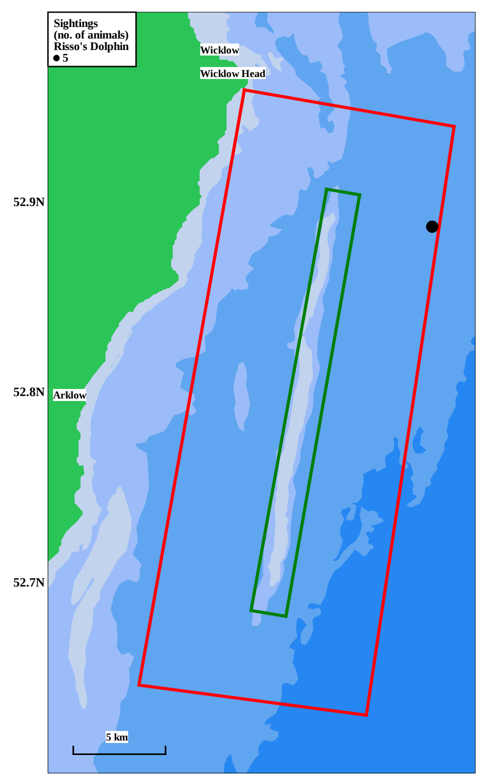
A group of five Risso's Dolphins were recorded on the eastern edge of the Box in June.

Figure 3.69 Other cetacean sightings

Years 5 to 7



Year 8



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).

Years 5 to 7

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

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.

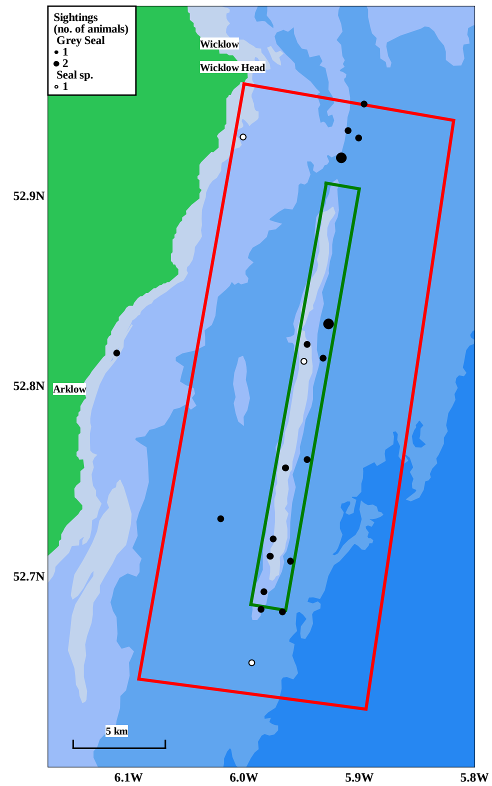
A total of 11 Grey Seals were recorded in Year 7, between July and November, April and June. Sightings were scattered along the Bank, the north end of the Box and the Cable Route.

Year 8

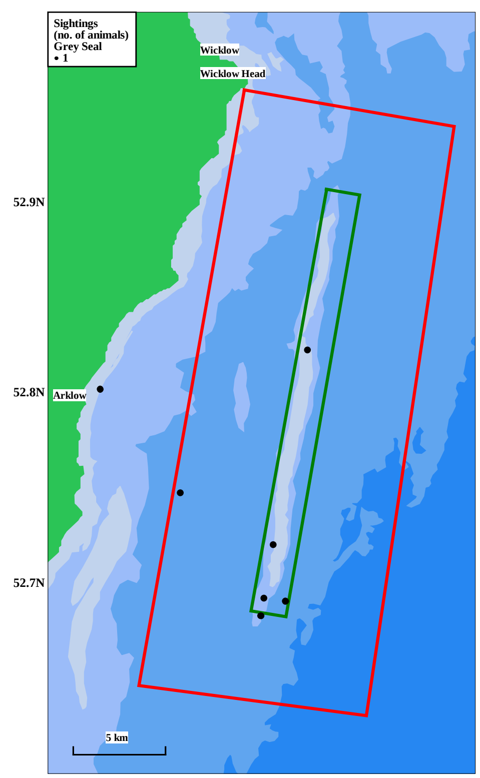
A total of seven Grey Seals were3 recorded in Year 8, with the majority recorded over the Bank. Six of the sightings were recorded between April and September, with the seventh in February.

Figure 3.70 Seal sightings

Years 5 to 7



Year 8



3.7 Plankton sampling

Year 8

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 3.24).

Table 3.24 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
	1	1	1		1	9	1
	2	1	1		2	38	2
	3	4	2		3	17	3
	4	0	0		4	4	3
	5	1	1		5	14	2
July	6	0	0	**Aug**	6	5	3
	7	0	0		7	26	6
	8	0	0		8	13	3
	9	2	1		9	3	2
	10	1	1		10	19	4
	Total	**10**	**6**		**Total**	**160**	**8**
	1	4	4		1	47	6
	2	13	3		2	58	5
	3	14	5		3	32	4
	4	5	2		4	7	3
	5	1	1		5	2	2
Sept	6	26	5	**Oct**	6	8	3
	7	4	1		7	11	3
	8	41	6		8	20	4
	9	25	5		9	75	3
	10	2	2		10	3	3
	Total	**135**	**9**		**Total**	**263**	**9**
	1	4	2		1	42	6
	2	1	1		2	50	5
	3	4	3		3	15	2
	4	0	0		4	6	3
	5	10	3		5	2	1
Nov	6	1	1	**Feb**	6	0	0
	7	5	2		7	1	1
	8	2	2		8	2	1
	9	7	4		9	32	3
	10	1	1		10	21	3
	Total	**35**	**6**		**Total**	**171**	**8**

In total, 10 plankton samples were taken each month between July and November, and in February. Due to inclement weather it was not possible to carry out the December or January sampling. Plankton sampling surveys were discontinued after February of Year 8.

Highest numbers of plankton were recorded in October, when a total of 263 individuals from 9 species/groups was recorded (Table 3.25). Plankton numbers were lower in other months with 171 in February and 160 in August the next highest monthly totals.

The most frequently recorded species/group were Copepods (296 individuals), with highest numbers recorded in October and February (Table 3.25). The next most frequently recorded species/groups were Shore Crabs (190 individuals), with highest numbers recorded in August. Sea Gooseberries (96 individuals) and Northern Krill (95) individuals) made up the next most frequently encountered group. The majority of both were recorded in October.

Table 3.25 Numbers of zooplankton per site per month

Species/ Group	Number of individuals						
	July	August	September	October	November	February	Total
Amphipods	0	2	6	5	9	0	**22**
Arrow Worms	0	0	17	6	0	5	**28**
Clupeid species	0	0	1	0	0	0	**1**
Comb jellies	3	1	14	2	1	0	**21**
Copepods	0	11	40	117	11	117	**296**
Unidentified eggs	1	4	0	0	0	9	**14**
Fish larvae	0	0	0	0	0	1	**1**
Goby species	0	1	0	1	0	0	**2**
Northern Krill	1	12	11	44	3	24	**95**
Polychaetes	1	0	1	2	0	2	**6**
Ribbon Worms	0	2	3	0	0	0	**5**
Sea Gooseberry	3	0	0	82	10	1	**96**
Shore crab	4	127	42	4	1	12	**190**
Total	**13**	**160**	**135**	**263**	**35**	**171**	**777**

4. Statistical analyses of data in Years 1 to 8

4.1 Statistical analyses 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.

4.1.2 Seasonality

For each species the first table provides a broad-brush summary of seasonal pattens of occurrence. For a particular month, the mean number of birds recorded at each position on each leg is 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 provides an estimate of the total number of birds which would be expected to be recorded during a single cruise which covered 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 are included in analyses of changes in abundance, then genuine changes during the time of year when the species was present can 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.

4.1.3 Distribution across legs

The second table in each species account also provides a summary of the distribution of records across the legs. This allows 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 as that 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 the installation of the turbines, based only upon those cruises 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 - number of birds/km^2.
- The relative density expressed these densities as a percentage of the maximum density recorded, to aid comparison of legs.

4.1.4 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 has changed significantly from the period before turbine installation to the period during installation, and also to 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 calculating 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 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 great 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 the installation of the turbines this was not surprising. Therefore when talking about changes in numbers, the species accounts below (Section 5.2) 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.

4.1.5 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 upon 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 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 Year 1 has been excluded.

4.2 Key species accounts

4.2.1 Red-throated Diver

Red-throated Diver records 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 (2 and 3), with 89% of birds recorded on these two legs combined both before and after turbines were installed (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 ($p<0.002$) in the mean numbers of Red-throated Divers recorded on the outer Bank Leg (leg 2) (Tables 4.2 & 4.3). The inclusion of the additional survey data collected during Year 8 has increased the statistical significance of this decline.

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	21	Yes
2	21.8	27	Yes
3	10.1	12	Yes
4	7.1	9	Yes
5	4.1	5	Yes
6	0.3	0	No
7	0.0	0	No
8	0.1	0	No
9	0.7	1	No
10	0.8	1	No
11	5.4	7	Yes
12	13.9	17	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	2.67	79	32	0.49	0.08	100	56
3	2.13	4.79	10	57	0.06	0.14	12	100
5	0.64	0.10	3	1	0.04	0.01	9	5
11	0.10	0.18	0	2	0.00	0.01	1	5
41	0.67	0.09	3	1	0.05	0.01	10	5
42	0.10	0.15	0	2	0.01	0.01	2	9
43	0.67	0.27	3	3	0.07	0.03	14	20
44	0.09	0.11	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 the installation of the first 7 turbines

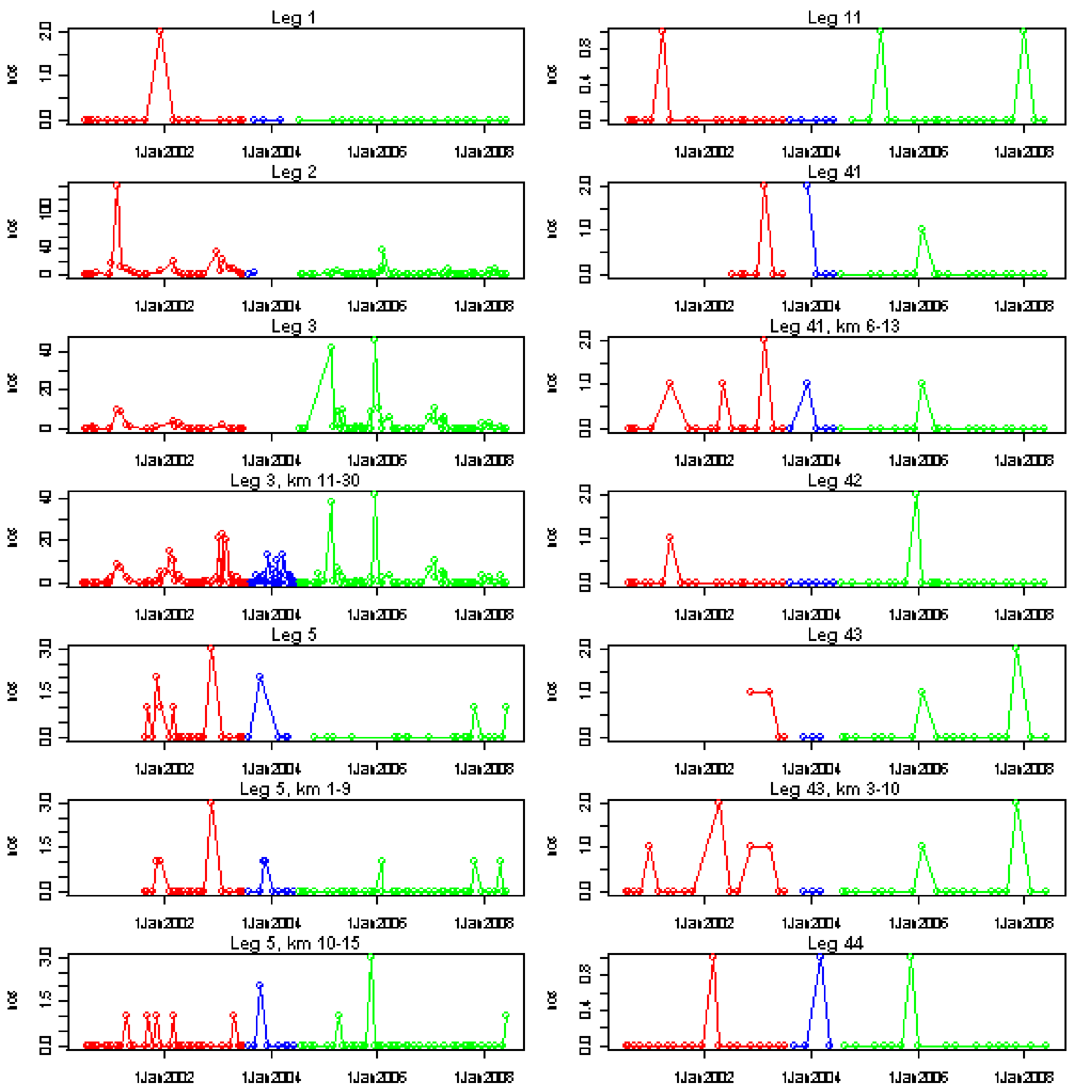
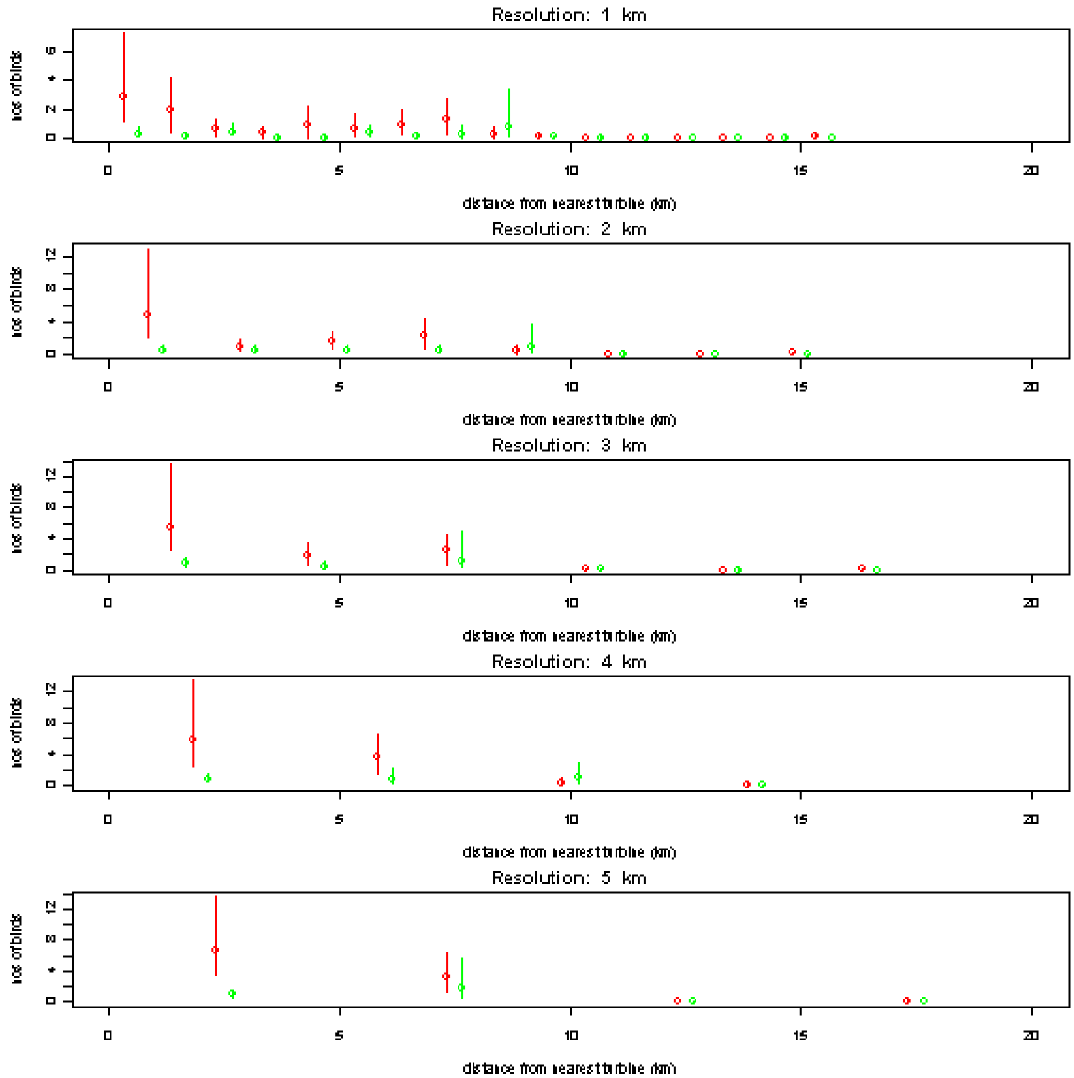


Figure 4.2 Numbers of Red-throated Divers on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



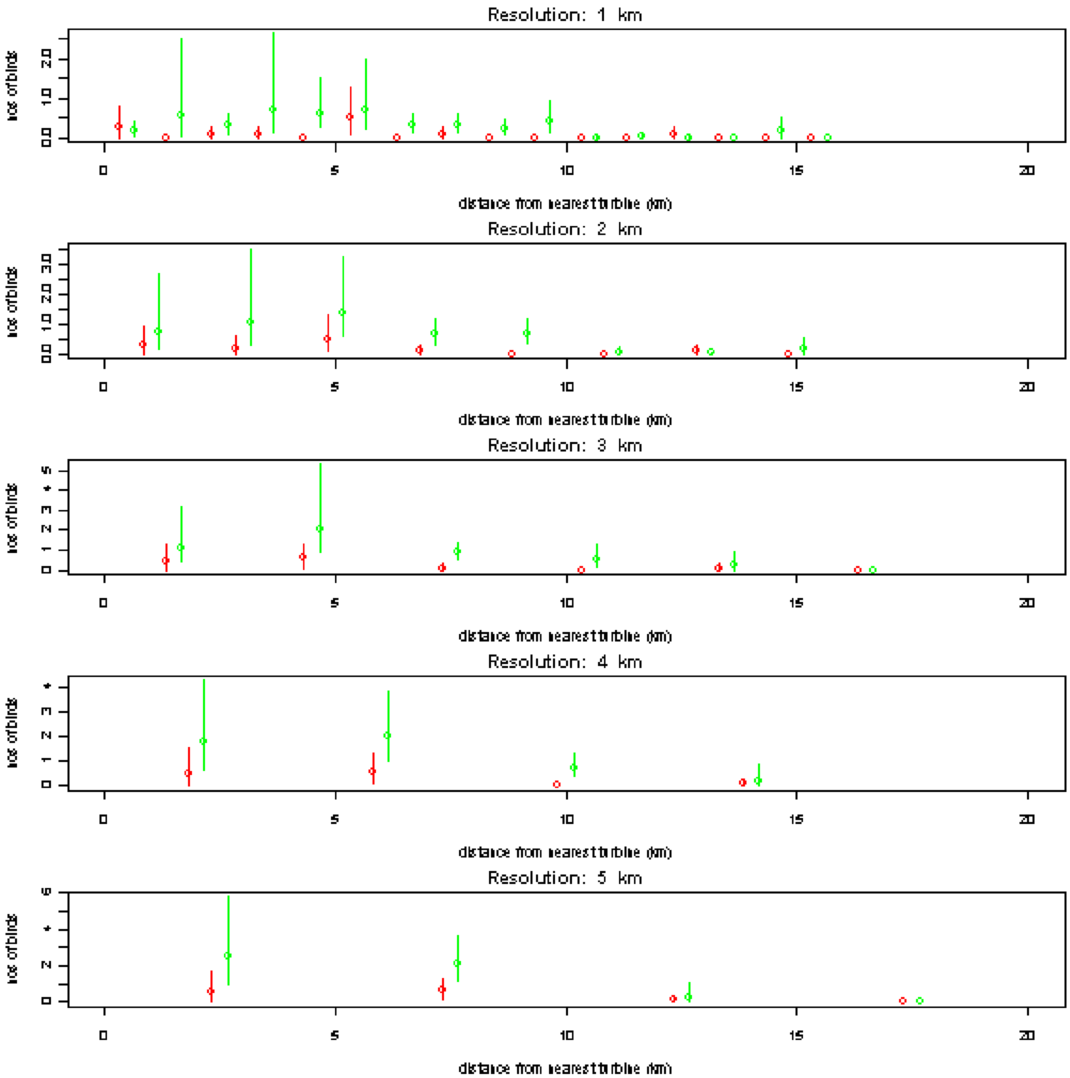
This pattern was consistent with the installation of the turbines being responsible for the decline. However, on the inner Bank leg (leg 3), there was no evidence of any such decline (Tables 4.2 and 4.3). The data for the relatively small number of surveys where the whole of the inner Bank leg (leg 3) was covered suggested a 2-fold increase in the number of birds present, although this increase was not statistically significant (Tables 4.2 and 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	1.00		0.00			11	0.4500	
2	17.18	7.63	51.88	17				0	1.00		2.67	1.44	6.05	39	0.0012	--
3	2.13	1.00	3.87	15				0	1.00		4.79	2.49	10.06	39	0.3060	
3, km 11-30	4.52	2.58	7.12	31	2.90	1.43	4.86	21	0.34		3.29	1.53	7.43	45	0.5125	
5	0.64	0.18	1.27	11	0.00			3	0.60		0.10	0.00	0.30	10	0.2005	
5, km 1-5	0.45	0.09	1.17	11	0.33	0.00	0.50	6	1.00		0.12	0.00	0.24	25	0.1375	
5, km 10-15	0.21	0.05	0.42	19	0.00			4	0.56		0.20	0.00	0.70	20	1.0000	
11	0.10	0.00	0.30	10	0.00			2	1.00		0.18	0.00	0.36	11	1.0000	
41	0.67	0.00	1.33	3	0.67	0.00	1.33	3	1.00		0.09	0.00	0.27	11	0.2143	
41, km 6-13	0.44	0.00	0.89	9	0.33	0.00	0.67	3	1.00		0.09	0.00	0.27	11	0.2372	
42	0.10	0.00	0.30	10	0.00			3	1.00		0.15	0.00	0.46	13	1.0000	
43	0.67	0.00	1.00	3	0.00			3	0.40		0.27	0.00	0.73	11	0.6291	
43, km 3-10	0.71	0.14	1.14	7	0.00			3	0.35		0.27	0.00	0.73	11	0.3128	
44	0.09	0.00	0.27	11	0.33	0.00	0.67	3	0.40		0.11	0.00	0.22	9	1.0000	

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 $p <0.05$.

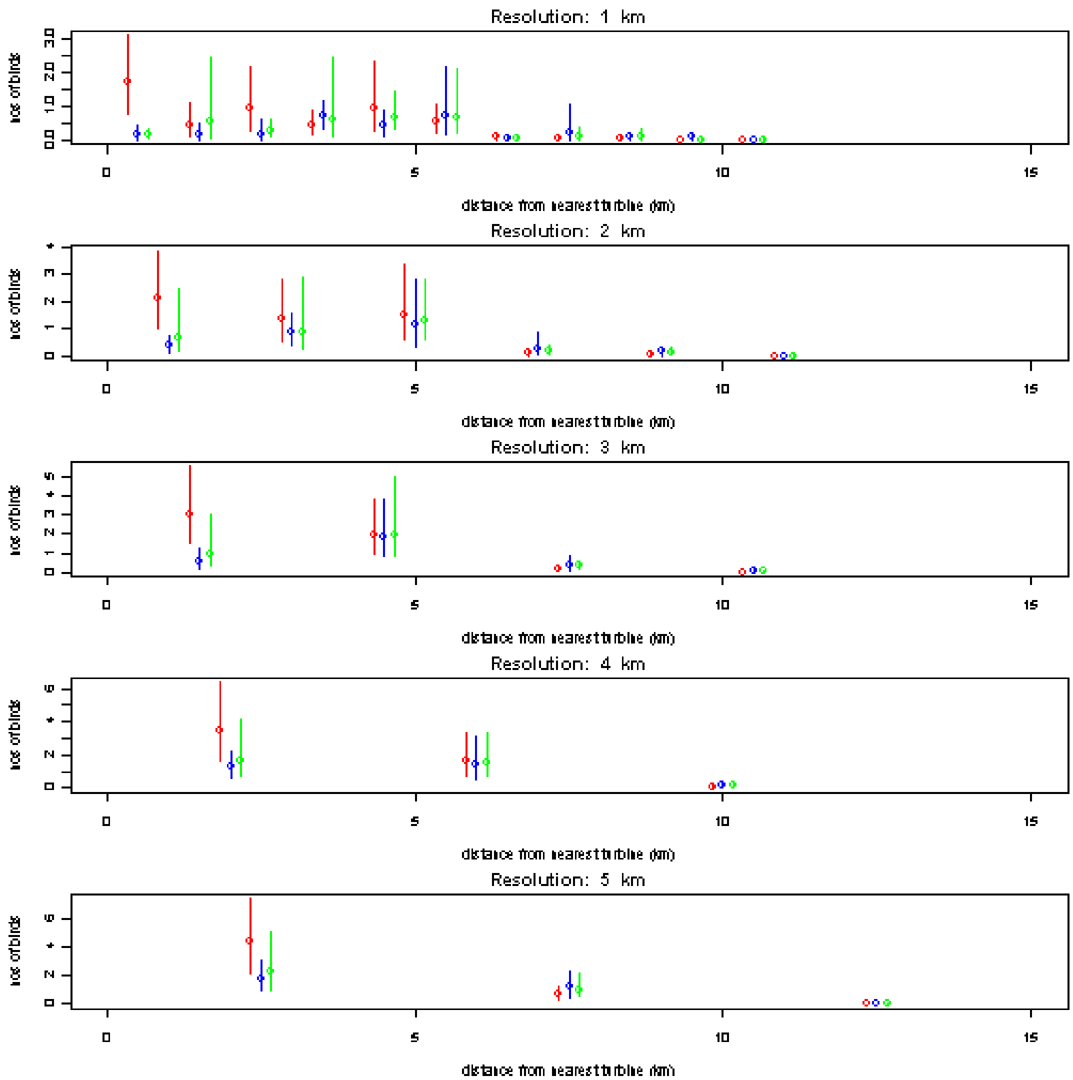
Figure 4.3 Numbers of Red-throated Divers on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



By contrast the larger data set based upon surveys covering km 11-30 of the inner Bank leg (leg 3) suggested a small, non significant decline in the number of birds recorded (Table 4.3). However, although the overall decline is insignificant, there is apparently a significant decline in the number of birds recorded within 1 km of the nearest turbine (Figure 4.4). Thus, the data for the inner Bank leg (leg 3) is contradictory, depending upon which particular data set is considered, but neither data set suggests a large decline in the number of Red-throated Divers present, strongly associated with the proximity of turbines, as is the case for the outer Bank leg (leg 2).

Much smaller numbers of Red-throated Divers were recorded on the other, non-Bank legs (Table 4.2, Figure 4.1). Fewer birds were recorded on the Cable Route, leg 5, and the two Box legs 41 and leg 43 after the installation of turbines than beforehand (Figure 4.1 and Table 4.3). Although these differences were not statistically significant, the small sample sizes for non-Bank legs, and small numbers of birds recorded, makes detecting genuine change on the non-Bank legs more difficult than on the Bank legs.

Figure 4.4 **Numbers of Red-throated Divers 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, 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 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 smaller, formal statistical analysis found no convincing evidence for declines, but visual inspection of time series suggested the possibility of a more widespread decline.

4.2.2 Fulmar

Fulmar records 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	4.7	5	Yes
3	11.2	11	Yes
4	9.2	9	Yes
5	5.1	5	Yes
6	7.2	7	Yes
7	27.1	27	Yes
8	23.0	23	Yes
9	7.7	8	Yes
10	0.3	0	No
11	0.6	1	No
12	2.2	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). 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, $P < 0.000001$ for leg 3 and $P < 0.0000001$ for leg 3, km 11-30). The inclusion of the additional survey data collected during Year 8 has increased the statistical significance of these declines.

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/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	3.78	6.44	29	53	0.15	0.26	100	100
2	2.59	0.70	20	6	0.07	0.02	49	8
3	1.69	0.32	13	3	0.05	0.01	32	4
5	0.24	0.06	2	0	0.02	0.00	10	2
11	2.07	3.41	16	28	0.08	0.14	55	53
41	0.33	0.24	3	2	0.03	0.02	17	7
42	1.06	0.40	8	3	0.09	0.03	59	13
43	1.00	0.07	8	1	0.10	0.01	66	3
44	0.39	0.43	3	4	0.03	0.04	21	14

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 appear 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 the numbers of Northern Fulmars recorded may also have declined on leg 42, leg 43 km 3-10 and leg 44.

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	5.56	18	1.50	0.00	1.50	2	0.44		6.44	0.63	28.63	16	0.98373430	
2	2.59	1.76	3.76	34	1.00	0.00	1.00	2	0.53		0.70	0.35	1.71	60	0.00024057	---
3	1.69	1.08	2.54	26				0	1.00		0.32	0.19	0.52	63	0.00000075	----
3, km 11-30	1.17	0.79	1.74	54	1.07	0.59	1.81	27	0.84		0.13	0.04	0.22	69	0.00000004	----
5	0.24	0.06	0.41	17	0.25	0.00	0.50	4	1.00		0.06	0.00	0.18	17	0.33528837	
5, km 1-5	0.18	0.00	0.35	17	0.14	0.00	0.29	7	1.00		0.06	0.00	0.14	36	0.31266846	
5, km 10-15	0.17	0.03	0.38	29	0.00			7	0.67		0.06	0.00	0.16	32	0.32240437	
11	2.07	1.27	3.00	15	1.00	0.25	1.50	4	0.33		3.41	0.12	15.41	17	0.99830455	
41	0.33	0.00	0.50	6	0.00			4	0.47		0.24	0.06	0.53	17	1.00000000	
41, km 6-13	0.27	0.00	0.93	15	0.00			5	0.80		0.12	0.00	0.29	17	0.67675890	
42	1.06	0.50	1.69	16	0.20	0.00	0.40	5	0.22		0.40	0.05	1.36	20	0.14824076	
43	1.00	0.00	1.67	3	0.00			2	0.40		0.07	0.00	0.20	15	0.03799020	-
43, km 3-10	0.50	0.14	0.93	14	0.00			2	0.73		0.07	0.00	0.20	15	0.05900383	
44	0.39	0.00	0.89	18	0.67	0.00	1.33	3	1.00		0.43	0.07	1.00	14	1.00000000	

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

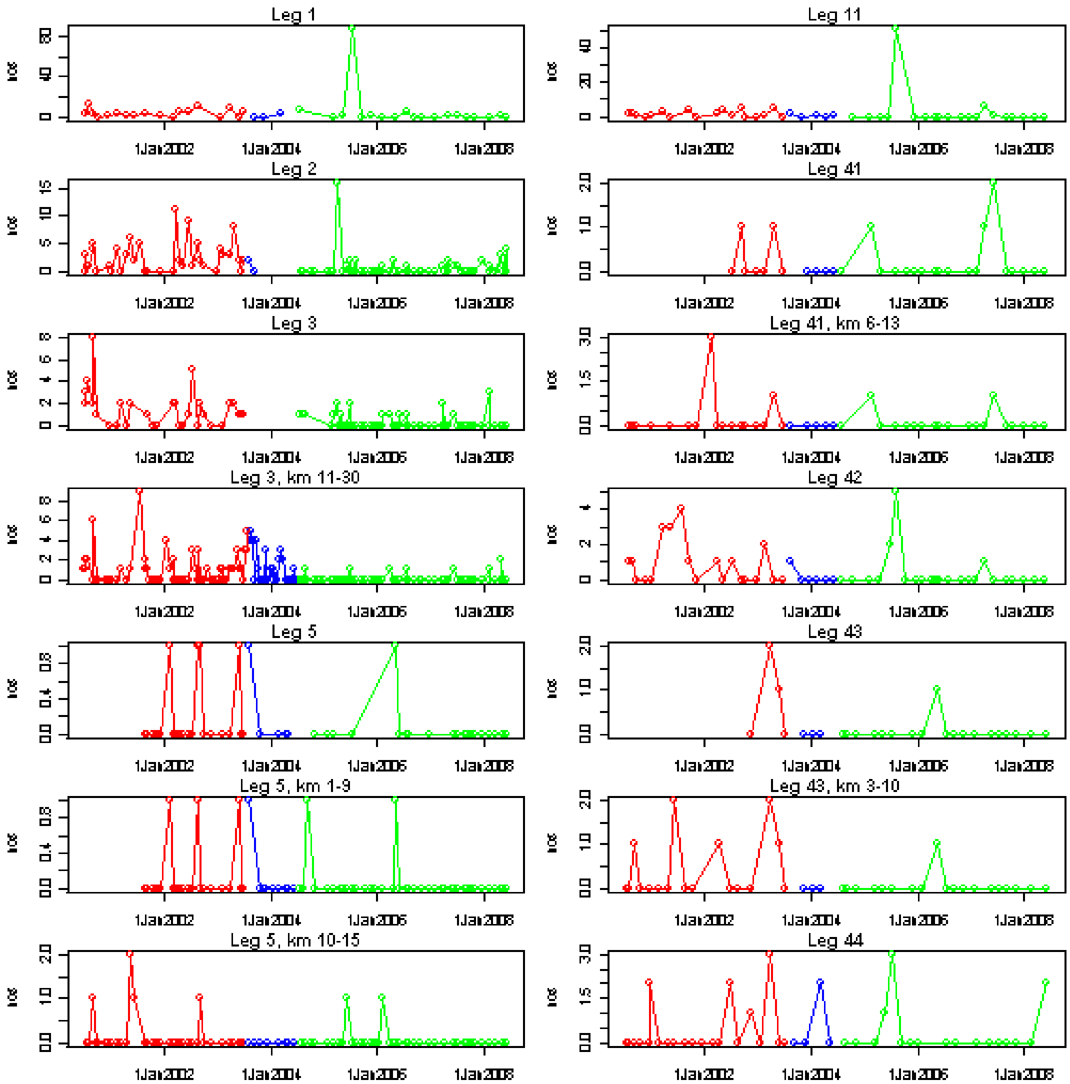


Figure 4.6 Numbers of Fulmars on the outer Bank leg (leg 2) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

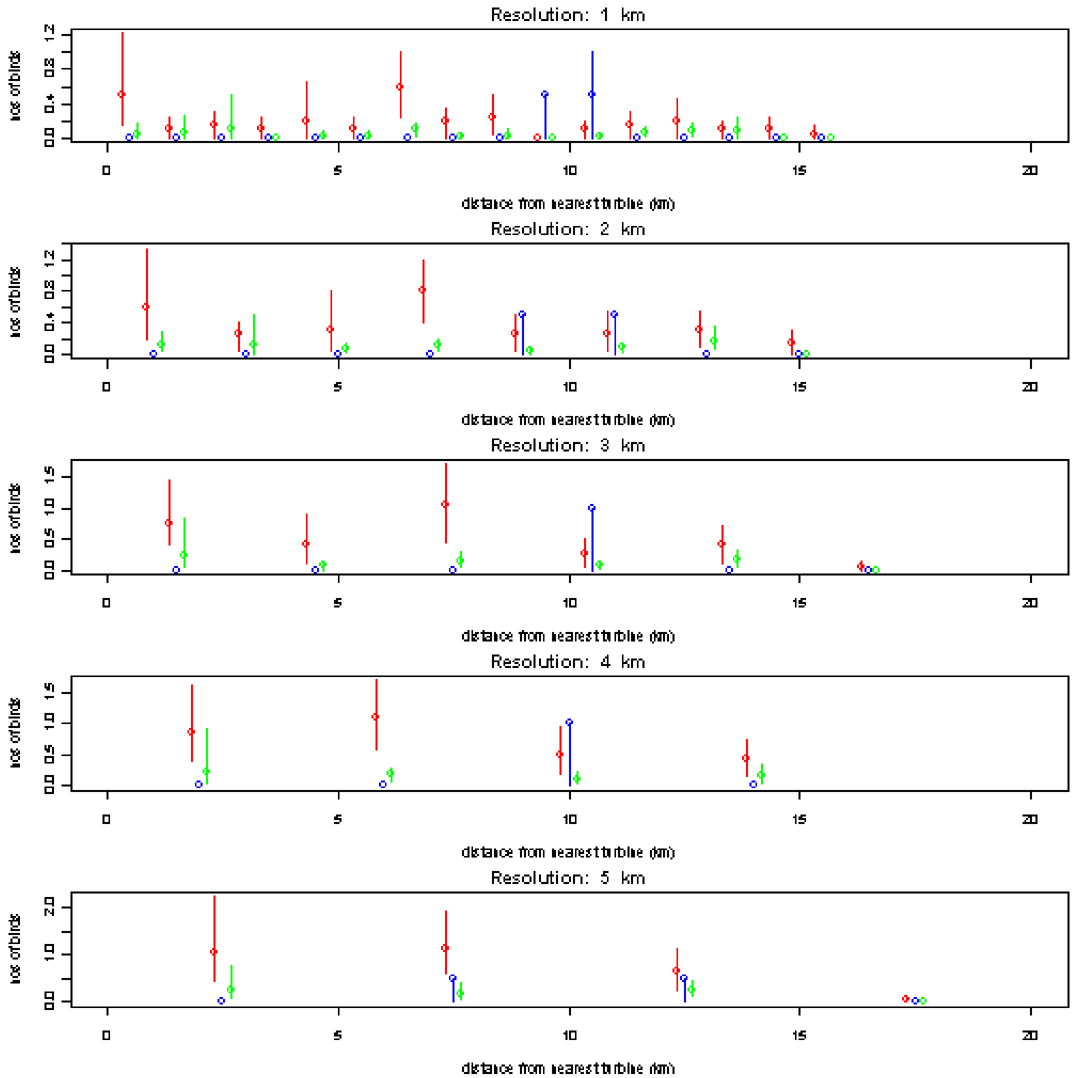


Figure 4.7 Numbers of Fulmars on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

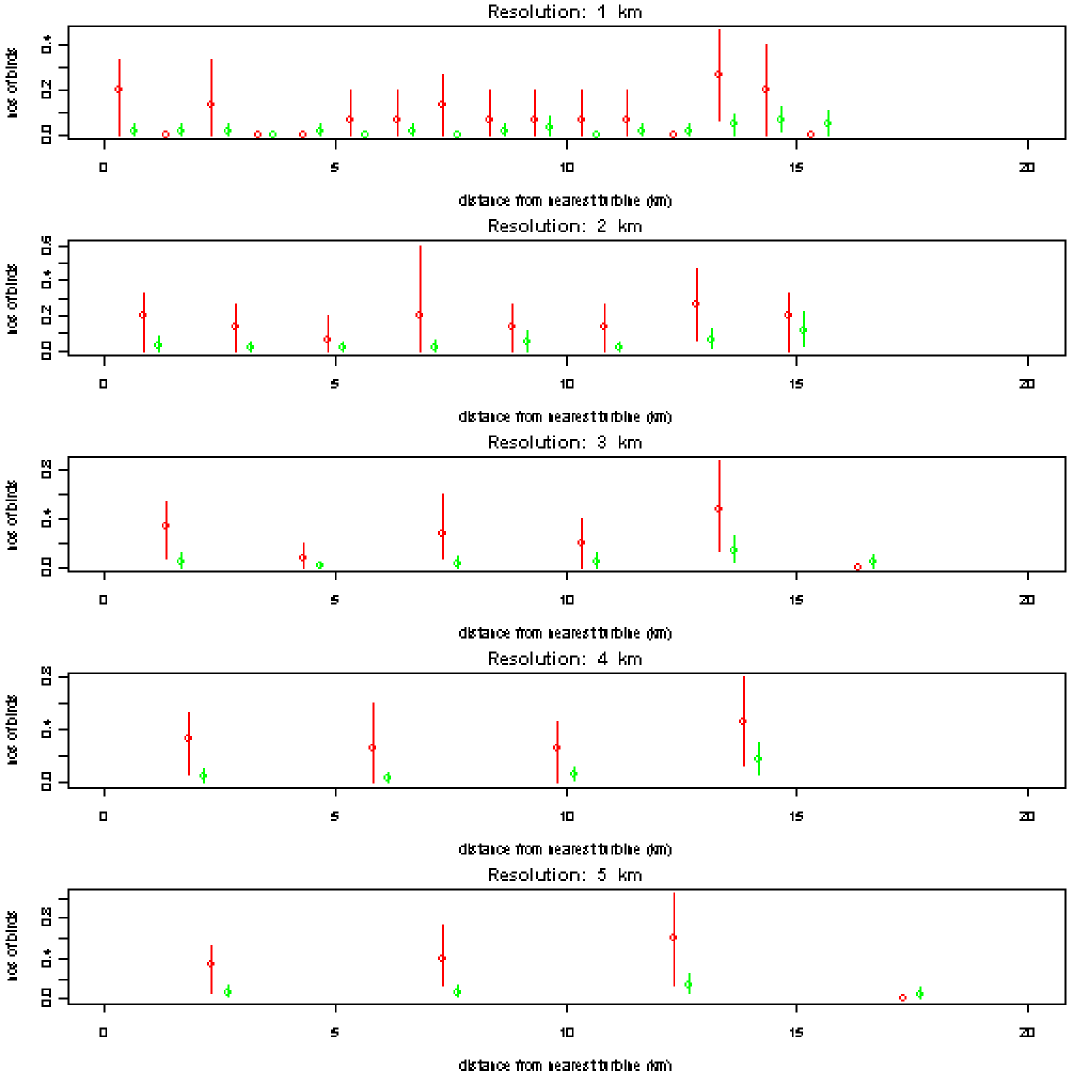
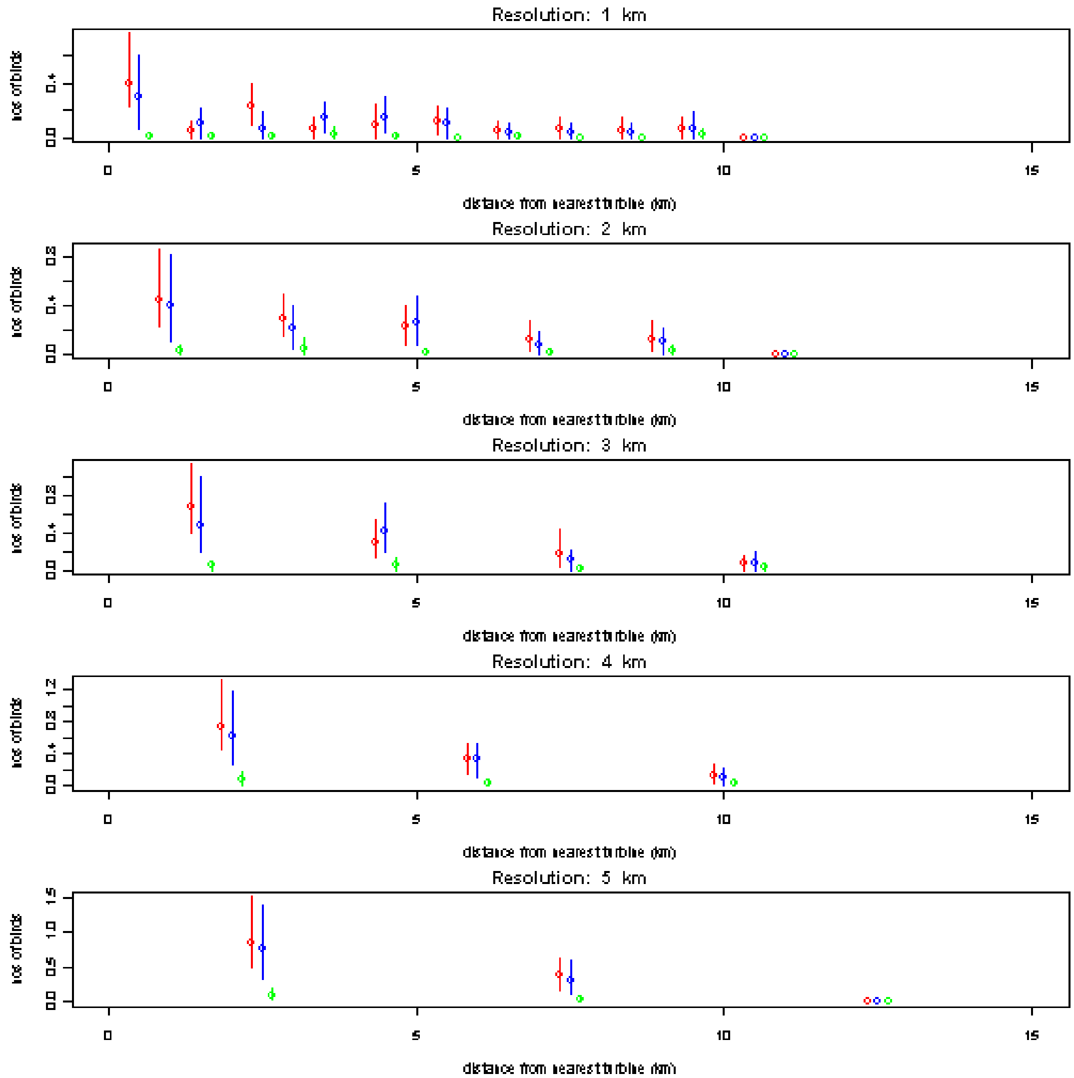


Figure 4.8 Numbers of Fulmars between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



Thus, recorded numbers of Fulmars 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 then the small numbers of birds involved is negligible compared to both national and international breeding populations (Mitchell *et al* 2004).

4.2.3 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 recorded 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	40.1	2	Yes
4	215.9	9	Yes
5	373.5	15	Yes
6	822.8	33	Yes
7	323.3	13	Yes
8	179.2	7	Yes
9	516.1	21	Yes
10	11.0	0	No
11	0.0	0	No
12	0.0	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/km²)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	38.14	239.92	19	50	1.53	9.60	89	100
2	47.70	85.20	23	18	1.36	2.43	79	25
3	35.61	75.24	17	16	1.02	2.15	59	22
5	2.07	13.85	1	3	0.14	0.92	8	10
11	43.08	33.09	21	7	1.72	1.32	100	14
41	15.50	6.91	8	1	1.19	0.53	69	6
42	12.85	10.79	6	2	1.07	0.90	62	9
43	3.33	1.75	2	0	0.33	0.18	19	2
44	6.46	17.73	3	4	0.54	1.48	31	15

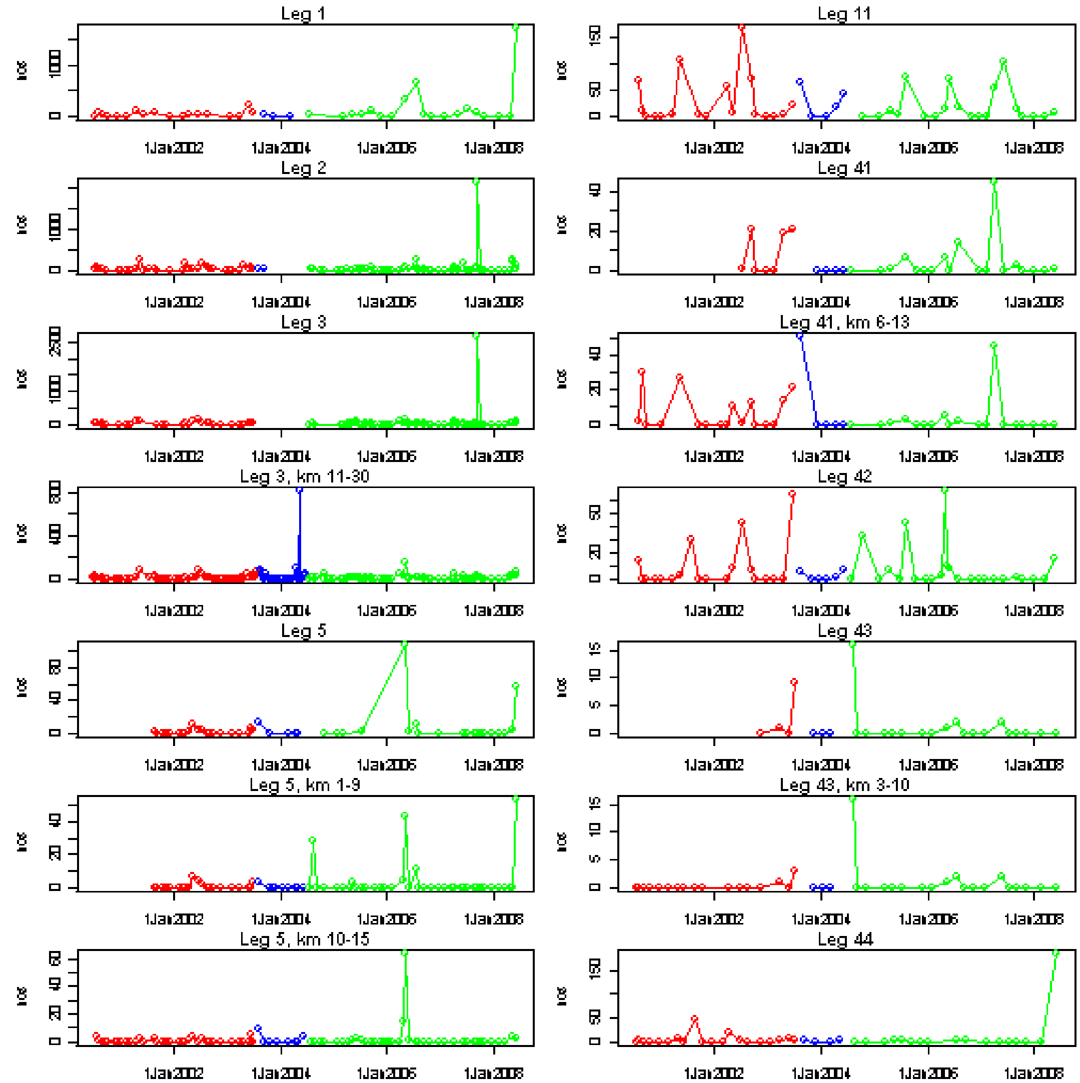
The only significant change in numbers was a weakly significant ($P< 0.05$) increase in numbers observed from km 11-30 of the inner Box leg (leg 3) between pre-installation and post turbine installation (Table 4.9), which was largely the result of a single unusual observation during turbine installation (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	17.19	87.17	14	5.50	0.00	11.00	2	0.38		239.92	73.00	827.76	13	0.07	
2	47.70	29.73	82.72	27	8.50	8.00	9.00	2	0.36		85.20	32.30	320.36	45	0.83	
3	35.61	21.73	56.54	23				0	1.00		75.24	19.10	293.38	50	0.95	
3, km 11-30	15.23	10.20	23.60	40	69.56	20.11	246.12	18	0.02	+	12.67	8.18	22.74	54	0.61	
5	2.07	1.00	4.14	14	3.00	0.00	6.00	4	0.79		13.85	1.77	39.78	13	0.26	
5, km 1-5	1.14	0.29	2.57	14	0.60	0.00	1.20	5	0.79		5.54	1.65	13.37	26	0.33	
5, km 10-15	0.83	0.35	1.51	23	2.00	0.00	5.77	6	0.21		3.71	0.54	16.54	24	0.45	
11	43.08	19.50	81.14	12	41.33	16.00	57.33	3	0.95		33.09	15.34	58.20	11	0.62	
41	15.50	1.00	20.50	4	0.00			2	0.13		6.91	2.18	22.49	11	0.30	
41, km 6-13	10.73	5.23	18.00	11	17.00	0.00	34.00	3	0.59		5.09	0.73	21.44	11	0.32	
42	12.85	4.85	29.20	13	4.33	1.00	6.33	3	0.59		10.79	3.72	25.88	14	0.80	
43	3.33	0.00	9.00	3	0.00			1	0.75		1.75	0.28	8.13	12	0.81	
43, km 3-10	0.33	0.00	1.08	12	0.00			1	1.00		1.75	0.25	7.01	12	0.46	
44	6.46	2.20	20.49	13	1.00	0.00	1.67	3	0.39		17.73	0.64	85.18	11	0.81	

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



There was no other evidence of any significant change in the numbers of Manx Shearwaters (Table 4.9, Figure 4.9) or their distribution on the Bank Legs (Figures 4.10, 4.11 and 4.12) associated with turbine installation.

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

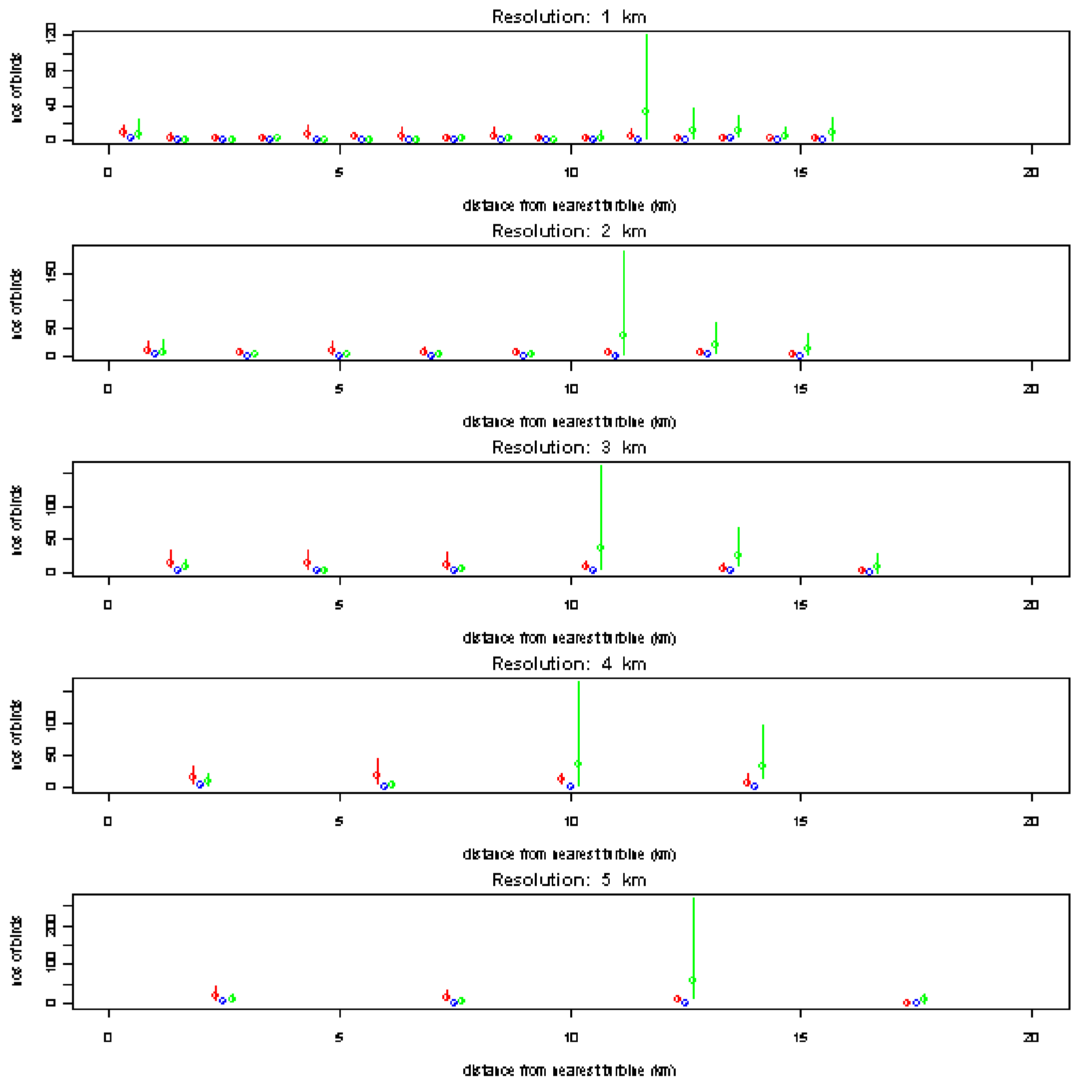


Figure 4.11 **Numbers of Manx Shearwaters on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions**

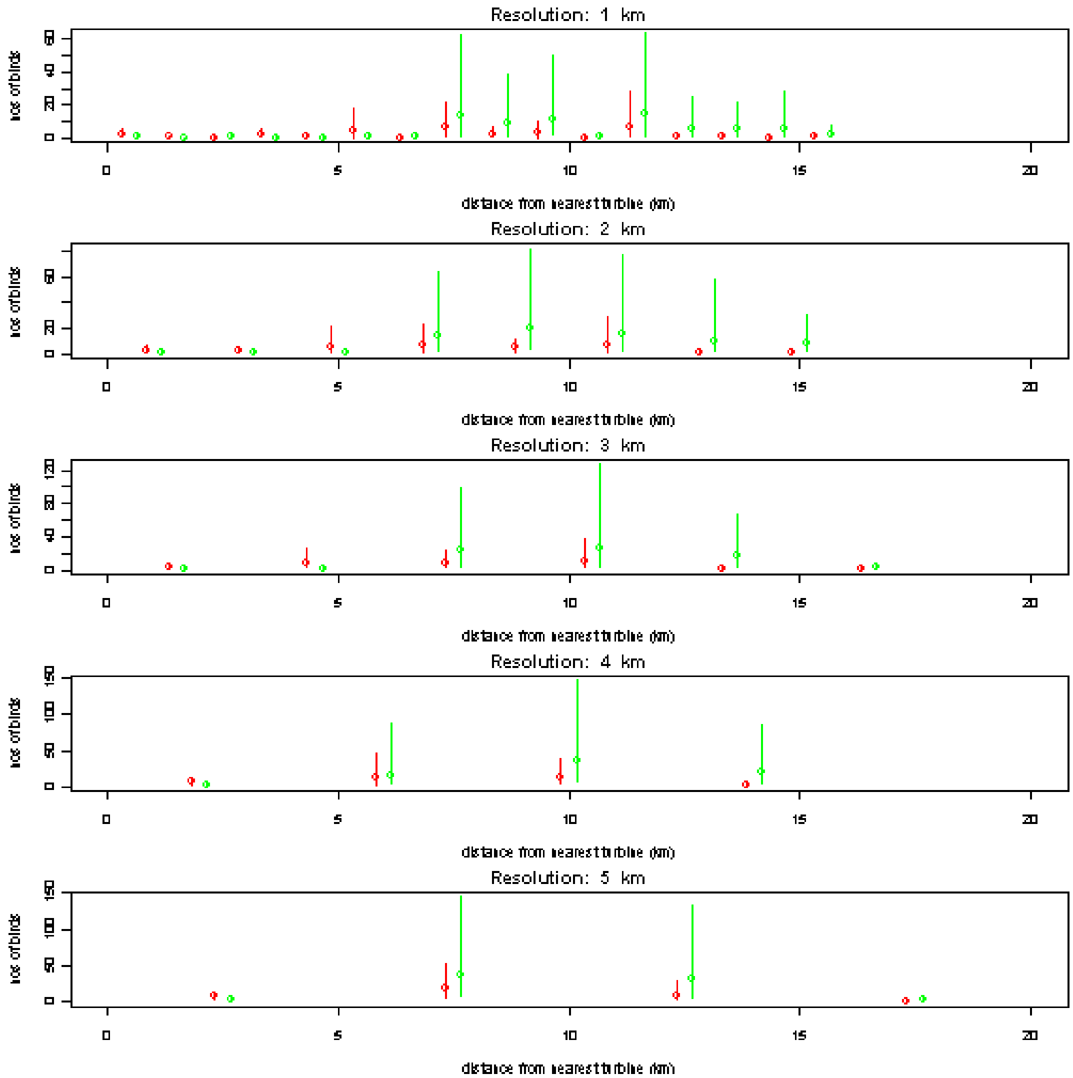
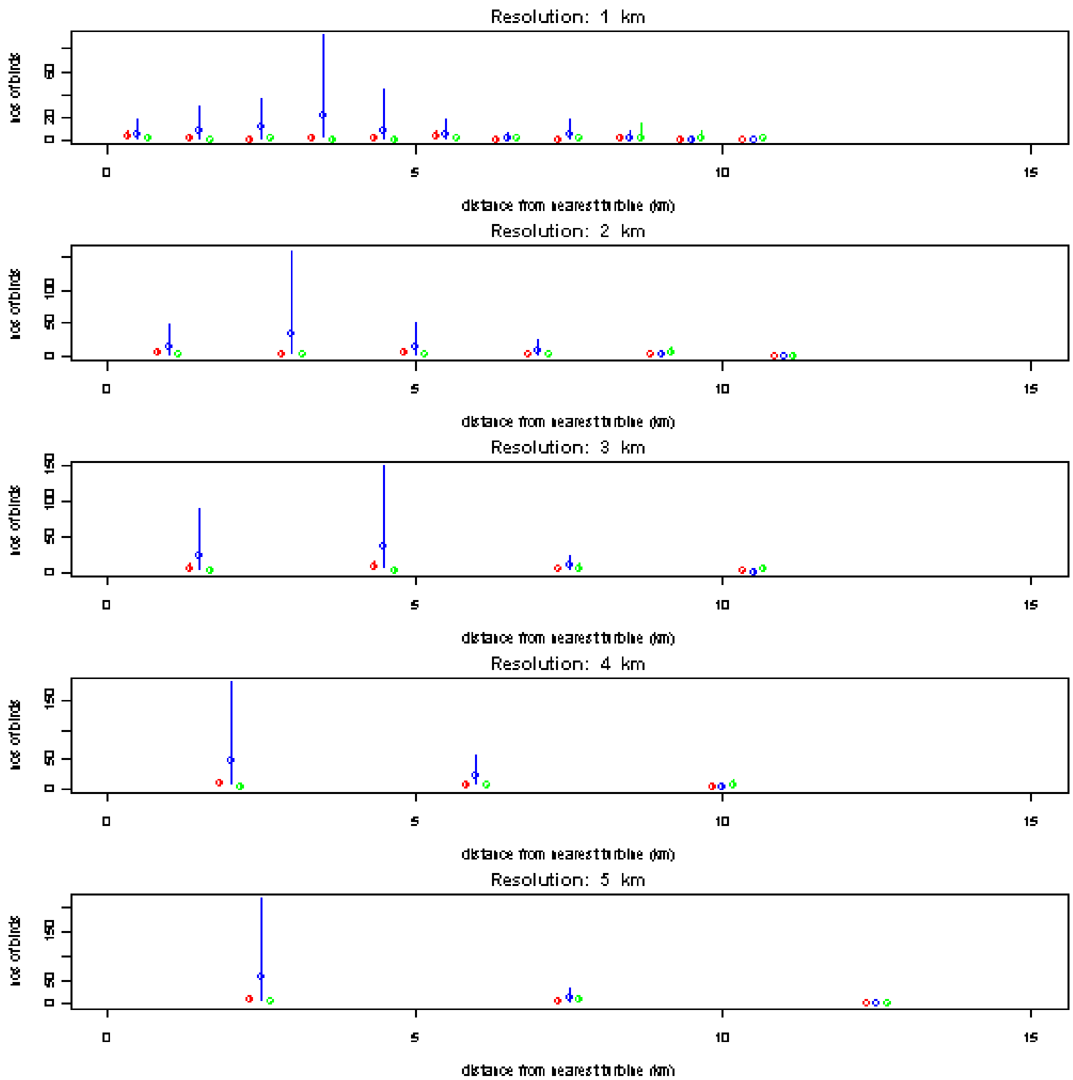


Figure 4.12 Numbers of Manx Shearwaters between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



Thus, there is no evidence of any impact of turbines on Manx Shearwater numbers or distribution. Even if impacts did occur they are unlikely to be important in conservation terms, given the small numbers of birds involved, which are negligible compared to both national and international breeding populations (Mitchell *et al* 2004).

4.2.4 Gannet

Although Gannets were most abundant during the summer months (Table 4.10), records were widely distributed throughout the year and all months were included in the analyses of changes in abundance (Table 4.10).

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	4.6	2	Yes
3	12.6	6	Yes
4	20.7	11	Yes
5	29.0	15	Yes
6	18.1	9	Yes
7	12.1	6	Yes
8	23.3	12	Yes
9	47.6	24	Yes
10	15.8	8	Yes
11	2.9	1	Yes
12	2.8	1	Yes

Gannet records were widely dispersed across the 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) (Table 4.11).

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	2.68	3.74	12	22	0.11	0.15	52	100
2	7.17	3.32	31	20	0.20	0.09	100	63
3	4.77	3.43	21	20	0.14	0.10	66	66
5	1.43	0.10	6	1	0.10	0.01	46	4
11	1.89	3.00	8	18	0.08	0.12	37	80
41	2.00	1.37	9	8	0.15	0.11	75	70
42	1.05	0.46	5	3	0.09	0.04	43	26
43	1.00	1.16	4	7	0.10	0.12	49	77
44	0.81	0.41	4	2	0.07	0.03	33	23

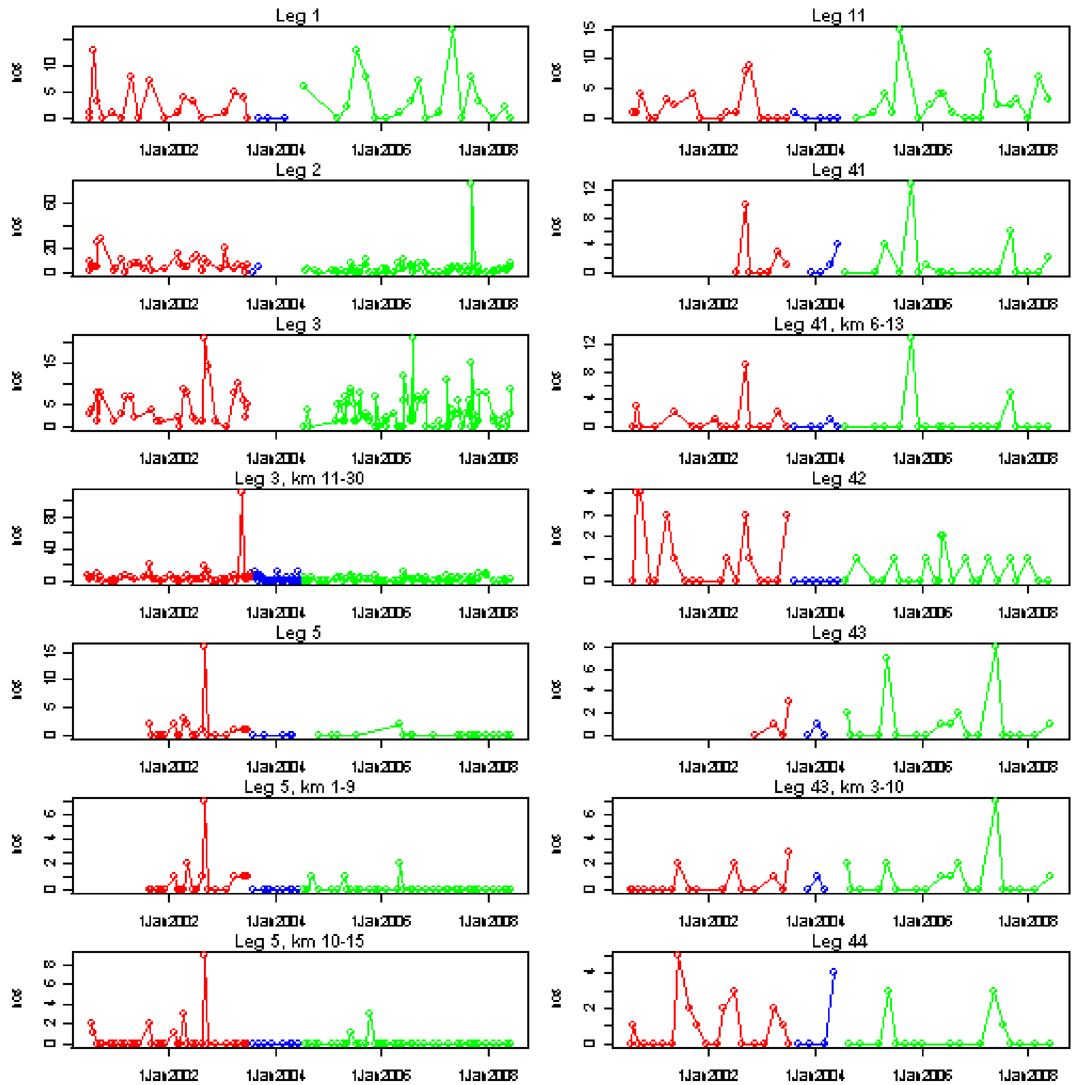
Highly significant declines in numbers occurred between pre- and post turbine installation on the Cable Route (leg 5) and from km 11-30 on the inner Bank leg (leg 3) (Table 4.12, $P < 0.01$ and $P < 0.002$ respectively). A weakly significant decline occurred on the outer Bank leg (leg 2) (Table 4.12, $P < 0.02$). Although not statistically significant, visual inspection of Figure 4.13 suggested numbers may have also declined from km 6-13 on leg 41 and on legs 42 and 44.

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	2.68	1.47	4.72	19	0.00			3	0.21		3.74	1.96	6.42	19	0.4822	
2	7.17	5.17	9.74	35	2.00	0.00	4.00	2	0.27		3.32	2.10	8.33	72	0.0154	-
3	4.77	3.53	6.86	30				0	1.00		3.43	2.65	4.56	74	0.1527	
3, km 11-30	4.89	2.80	12.16	61	2.00	1.12	3.19	33	0.29		1.60	1.18	2.24	84	0.0012	--
5	1.43	0.52	3.99	21	0.00			5	0.26		0.10	0.00	0.30	20	0.0082	--
5, km 1-5	0.71	0.29	1.90	21	0.00			9	0.24		0.09	0.00	0.23	43	0.0067	--
5, km 10-15	0.51	0.14	1.57	35	0.00			8	0.46		0.10	0.00	0.33	39	0.1272	
11	1.89	1.00	3.71	18	0.20	0.00	0.40	5	0.19		3.00	1.65	4.85	20	0.3399	
41	2.00	0.15	6.48	7	1.25	0.00	3.00	4	0.90		1.37	0.42	3.84	19	0.7638	
41, km 6-13	1.00	0.29	2.62	17	0.20	0.00	0.40	5	0.53		0.95	0.00	3.00	19	1.0000	
42	1.05	0.47	1.83	19	0.00			6	0.14		0.46	0.21	0.71	24	0.1069	
43	1.00	0.00	2.25	4	0.33	0.00	0.67	3	0.71		1.16	0.42	2.64	19	0.9627	
43, km 3-10	0.47	0.06	1.00	17	0.33	0.00	0.67	3	1.00		0.84	0.32	1.92	19	0.5432	
44	0.81	0.38	1.48	21	1.00	0.00	2.00	4	0.87		0.41	0.00	1.06	17	0.3588	

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 4.13 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

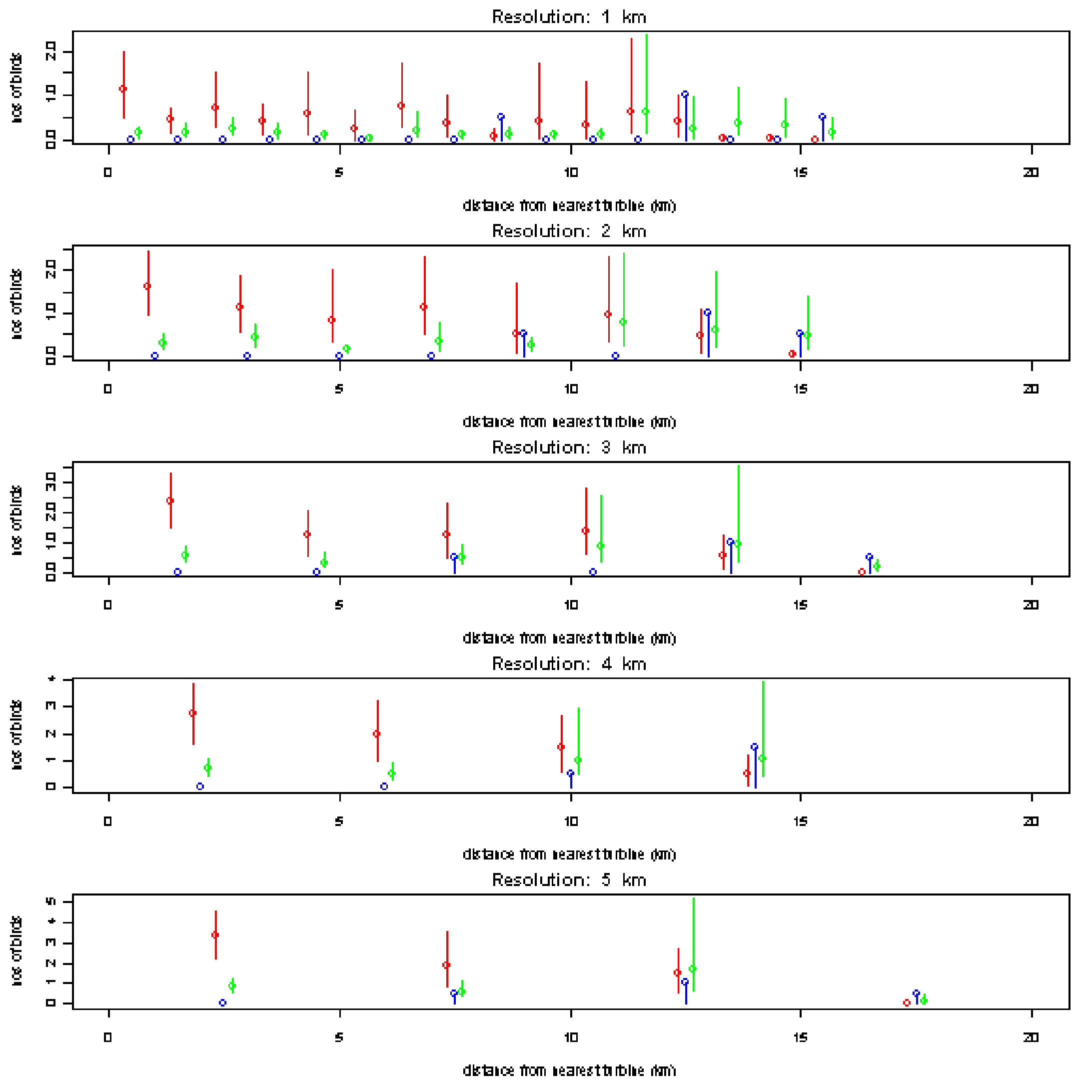


Figure 4.15 Numbers of Gannets on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

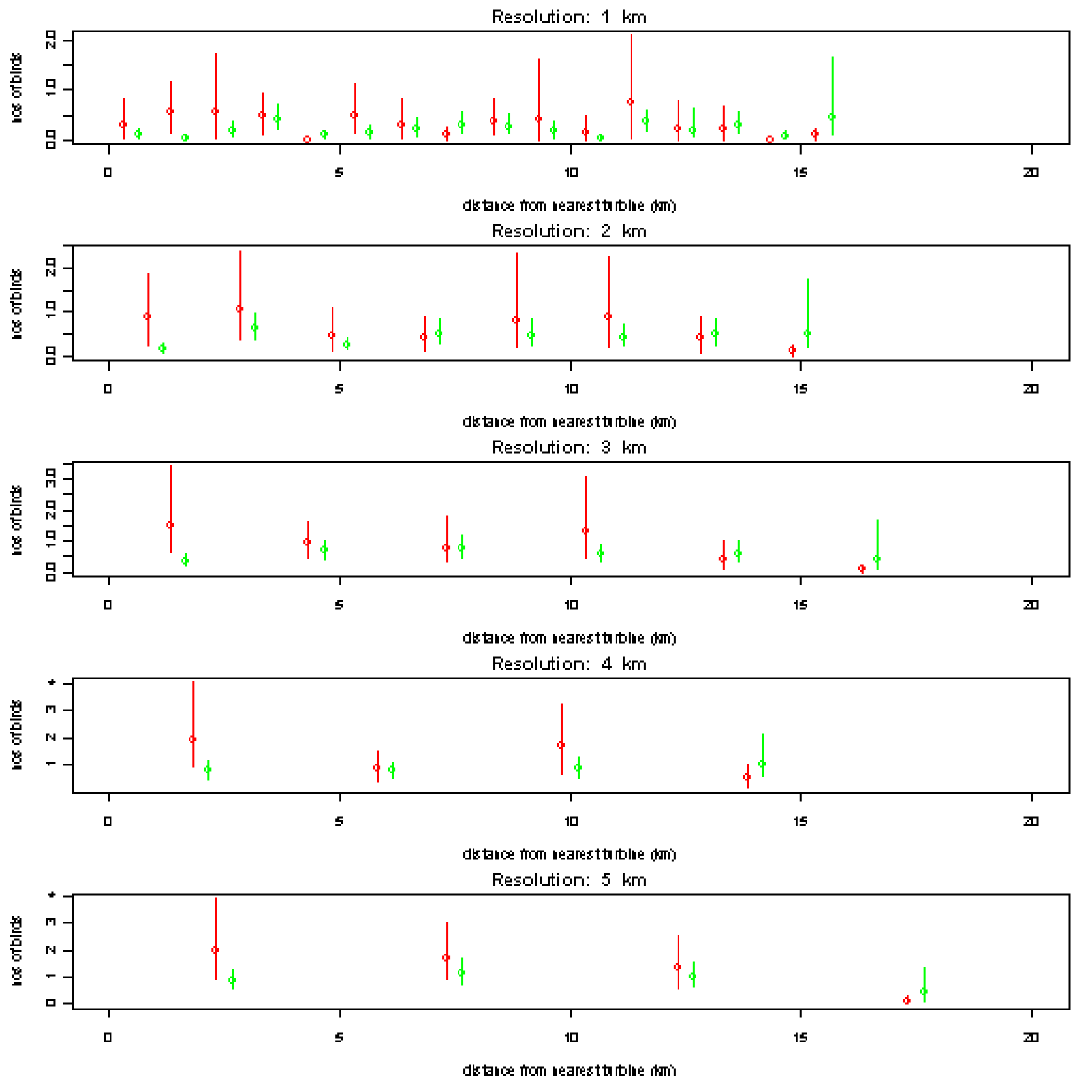
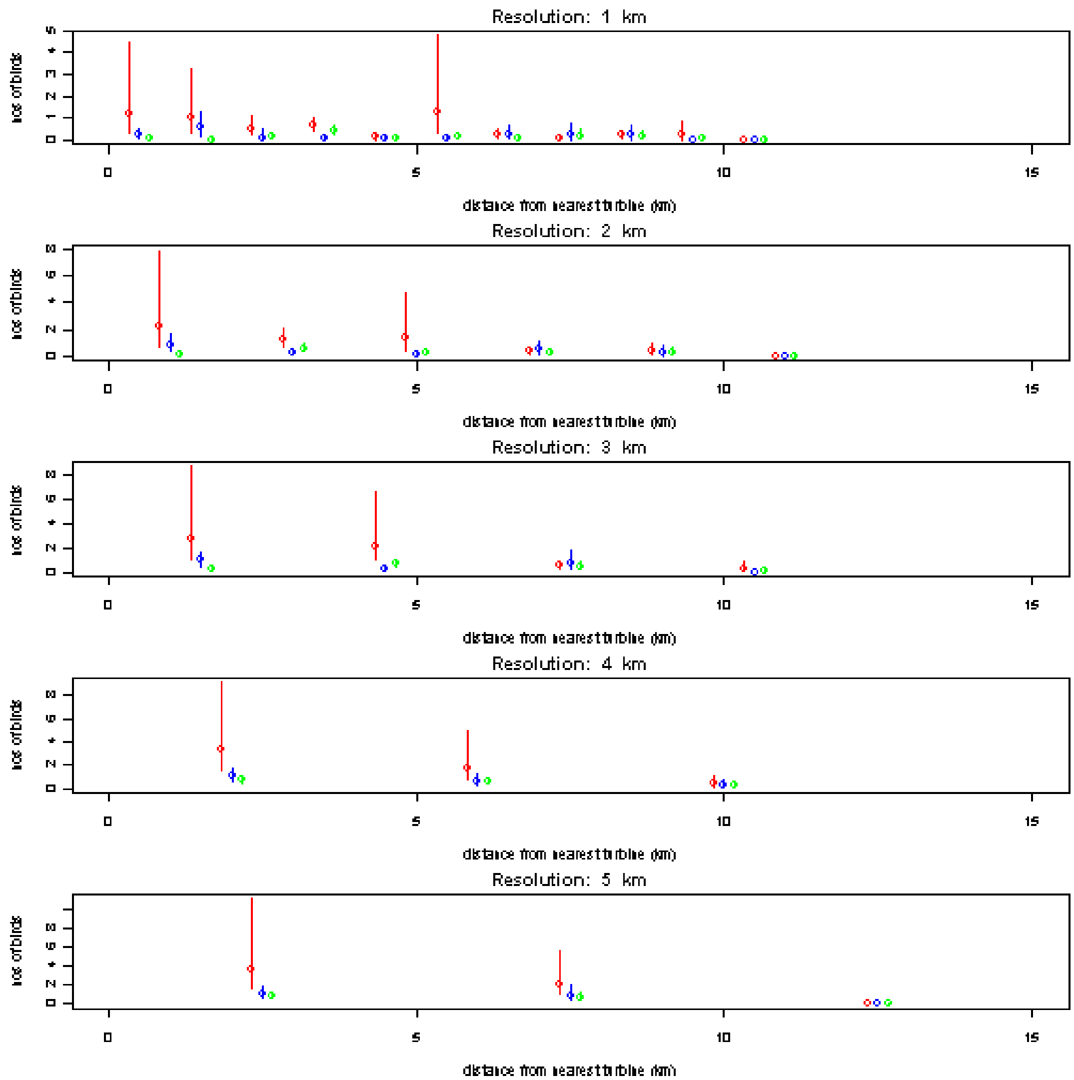


Figure 4.16 Numbers of Gannets between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



These results provided evidence of a decline in Gannet numbers on the Bank legs and Cable Route and perhaps more widely. Gannets were rated by Garthe and Hüppop (2004) to have a high potential vulnerability to collision risk from offshore windfarms, and a moderate vulnerability to helicopter and ship disturbance (Table 4.5). Gannets apparently showed an increased avoidance of the Horns Rev offshore wind farm area after erection of the turbines (Petersen *et al*. 2006). However, there was no evidence from the Arklow Bank study to suggest that turbine installation was responsible for the observed 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).

4.2.5 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	21	Yes
2	14.3	13	Yes
3	8.5	8	Yes
4	3.8	3	Yes
5	1.6	1	Yes
6	1.3	1	Yes
7	2.6	2	Yes
8	3.3	3	Yes
9	4.4	4	Yes
10	10.0	9	Yes
11	21.8	20	Yes
12	14.9	14	Yes

Shags were widely distributed across all survey legs, but were rarely recorded on the Box legs 1, 11, 42 and 44 and were 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/km²)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	0.05	0.16	1	1	0.00	0.01	3	3
2	1.09	0.89	28	8	0.03	0.03	47	10
3	1.03	8.77	26	77	0.03	0.25	45	100
5	0.52	0.10	13	1	0.03	0.01	53	3
11	0.00	0.00	0	0	0.00	0.00	0	0
41	0.86	0.74	22	6	0.07	0.06	100	23
42	0.05	0.00	1	0	0.00	0.00	7	0
43	0.25	0.74	6	6	0.03	0.07	38	29
44	0.05	0.00	1	0	0.00	0.00	6	0

Numbers increased significantly on the inner Bank leg (leg 3) between pre- and post construction ($P<0.003$, Table 4.15).

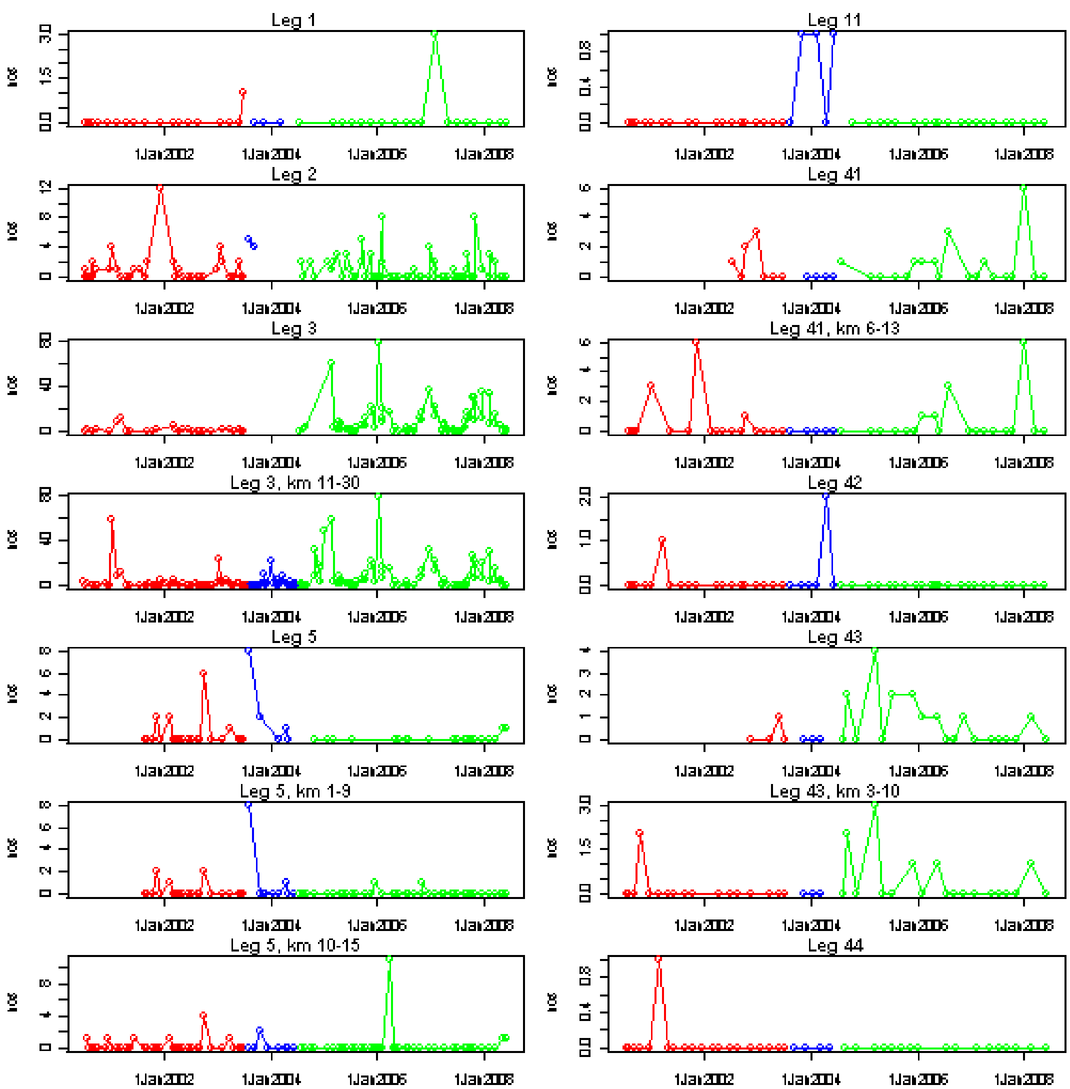
Table 4.15 Mean numbers of Shags on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	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	1.0000		0.16	0.00	0.47	19	1.0000	
2	1.09	0.63	2.54	35	4.50	4.00	4.50	2	0.0586		0.89	0.58	1.40	72	0.6299	
3	1.03	0.43	2.23	30				0	1.0000		8.77	6.22	12.40	74	0.0025	++
3, km 11-30	2.18	0.93	6.06	61	2.06	1.09	4.49	33	0.9638		7.71	5.19	11.48	84	0.0027	++
5	0.52	0.14	1.52	21	2.20	0.40	5.40	5	0.0592		0.10	0.00	0.25	20	0.2523	
5, km 1-5	0.24	0.00	0.57	21	1.00	0.00	4.10	9	0.2244		0.05	0.00	0.12	43	0.0837	
5, km 10-15	0.26	0.09	0.63	35	0.25	0.00	0.50	8	1.0000		0.33	0.03	1.48	39	0.9881	
11	0.00			18	0.60	0.00	0.80	5	0.0056	++	0.00			20	1.0000	
41	0.86	0.14	1.71	7	0.00			4	0.3212		0.74	0.26	1.85	19	0.8856	
41, km 6-13	0.59	0.06	1.84	17	0.00			5	0.6688		0.58	0.11	1.68	19	1.0000	
42	0.05	0.00	0.16	19	0.33	0.00	0.67	6	0.2400		0.00			24	0.4419	
43	0.25	0.00	0.50	4	0.00			3	1.0000		0.74	0.32	1.32	19	0.4840	
43, km 3-10	0.12	0.00	0.35	17	0.00			3	1.0000		0.42	0.16	0.95	19	0.2511	
44	0.05	0.00	0.14	21	0.00			4	1.0000		0.00			17	1.0000	

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.

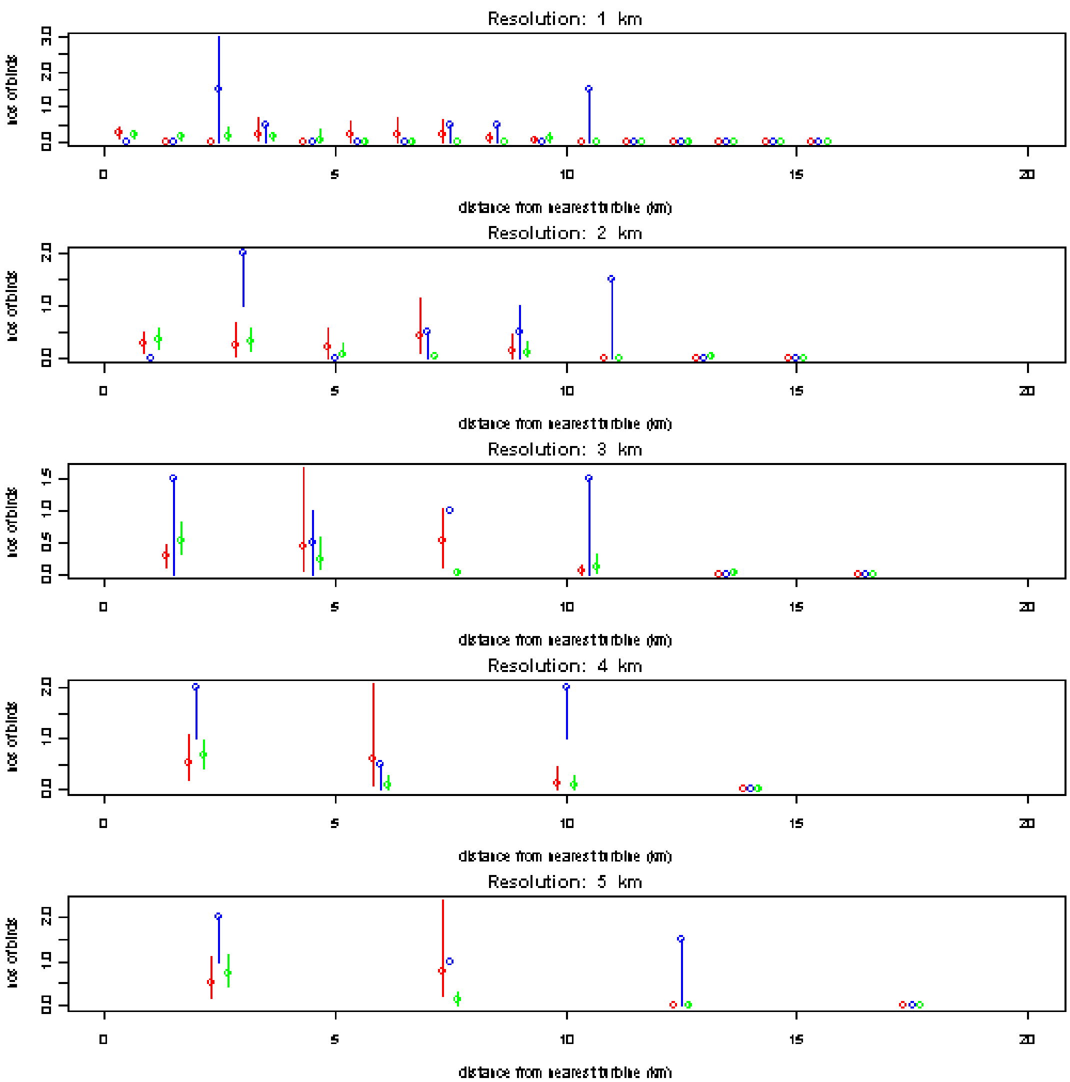
Numbers also increased significantly between pre-installation and during turbine installation on Box leg 11 (Table 4.15, P<0.01), although this is only due to the presence of one bird on three out of five surveys during turbine installation, compared to no birds present on all 18 trips pre-installation (Figure 4.17). Although not statistically significant, perusal of Figure 4.17 suggested the possibility that Shags may also have increased (from pre-installation to post 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



On the outer Bank leg (leg 2) there was no evidence of any change in the distribution of birds with respect to distance from 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



The increase of Shags on the inner Bank leg (leg 3) between pre- and post installation appeared to be related to the proximity of turbines, with the increase concentrated within 10 km of the nearest turbine (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

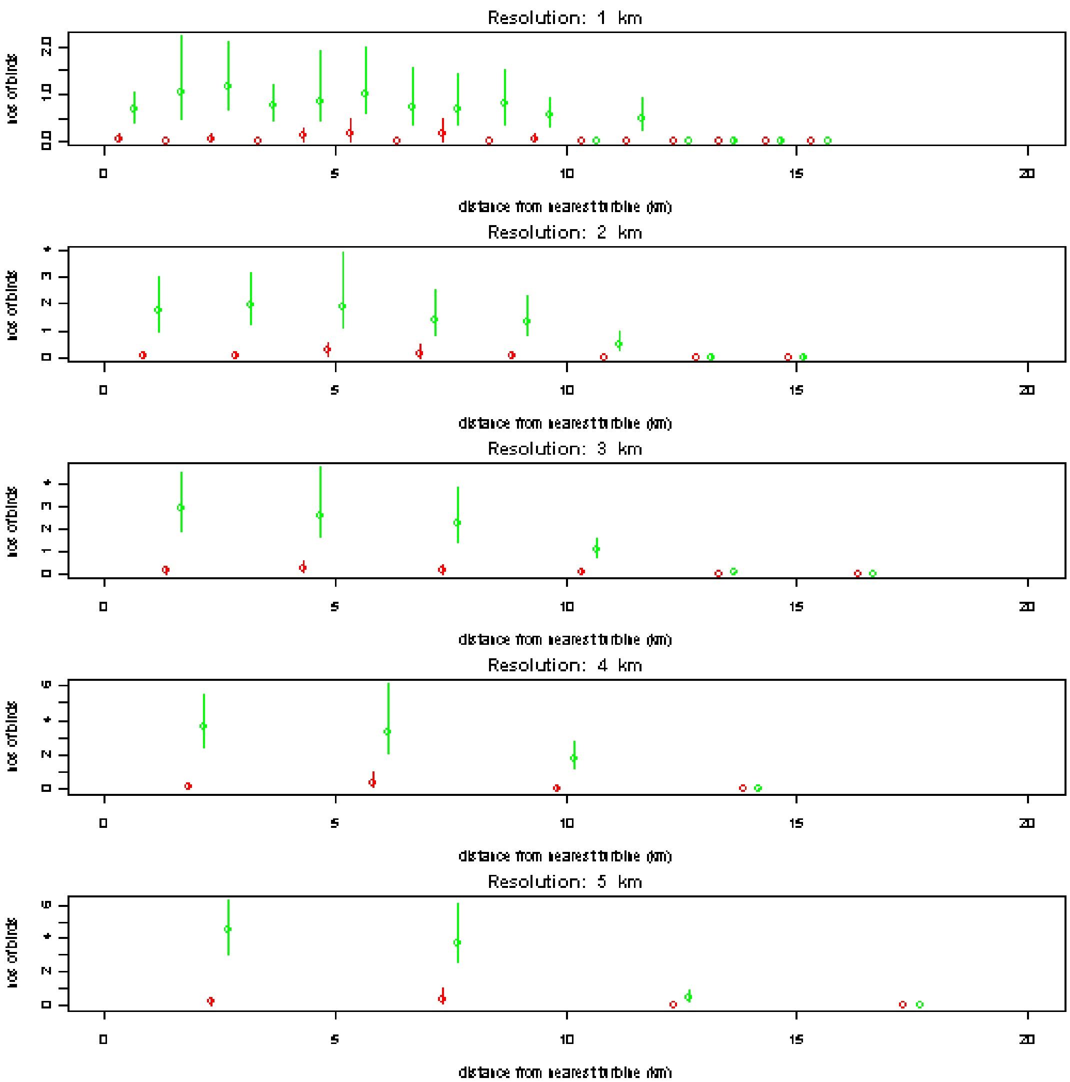
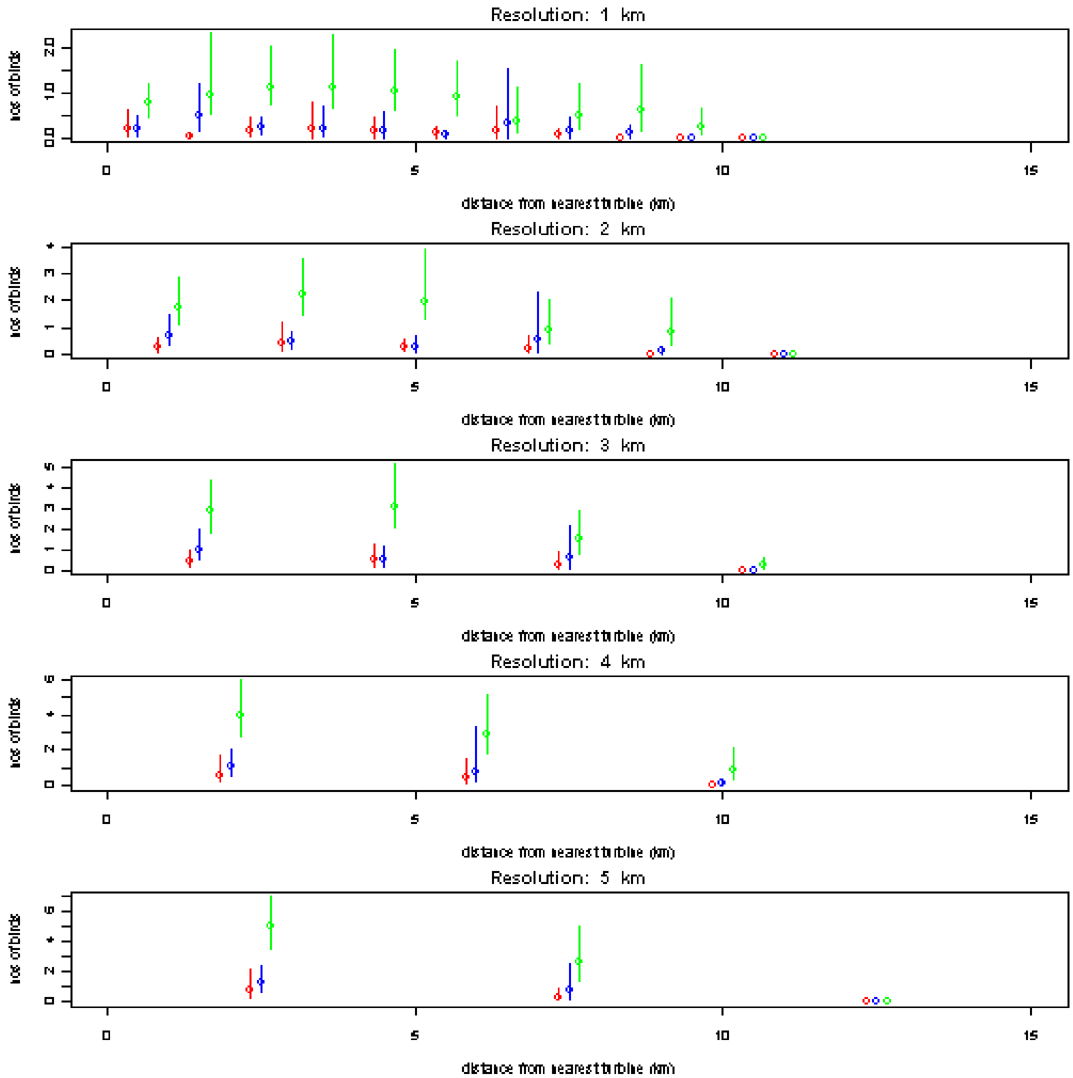


Figure 4.20 Numbers of Shags between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



In conclusion, there is strong evidence that Shags have increased on the inner Bank leg (leg 3), and this increase is related to proximity of the nearest turbine, suggesting that it may be related to their installation. One possible explanation for the increase would be if birds were attracted into the area by the additional roosting/resting opportunities provided by the turbines and other infrastructure. At Horns Rev, birds perched on parts of the wind farm infrastructure and fed within the wind farm (Christensen and Hounisen 2005). Garthe and Hüppop (2004) did not assess European Shag in their review of offshore wind farm sensitivity, but the closely-related Cormorant, was rated as having potentially high vulnerability to both collision and disturbance (Table 4.5).

4.2.6 Little Gull

Little Gulls are principally winter visitors to the Arklow Study Area, and only data from August to April was 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	48.3	3	Yes
3	79.3	5	Yes
4	69.3	4	Yes
5	0.5	0	No
6	0.4	0	No
7	3.4	0	No
8	19.8	1	Yes
9	83.5	5	Yes
10	183.8	11	Yes
11	733.4	43	Yes
12	403.6	24	Yes

Little Gulls records were concentrated on the Bank legs (legs 2 and 3), with 82% of birds recorded on the Bank legs before turbine installation, and 96% of birds recorded on the Bank legs after 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/km^2)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	1.08	2.18	1	1	0.04	0.09	3	2
2	50.57	33.56	61	15	1.44	0.96	100	19
3	17.80	178.38	21	81	0.51	5.10	35	100
5	0.20	1.50	0	1	0.01	0.10	1	2
11	6.92	3.25	8	1	0.28	0.13	19	3
41	0.00	0.00	0	0	0.00	0.00	0	0
42	0.77	1.06	1	0	0.06	0.09	4	2
43	0.00	0.00	0	0	0.00	0.00	0	0
44	5.81	1.55	7	1	0.48	0.13	34	3

The relative importance of the two Bank legs for Little Gulls reversed following the installation of the turbines. Before turbine installation, approximately 3 times as many birds were recorded on the outer Bank leg (leg 2) as on the inner Bank leg (leg 3). After turbine installation, the situation was reversed, with approximately 5 times as many birds recorded on the inner Bank leg (leg 3) as on the outer Bank leg (leg 2) (Table 4.17). Again, this is mainly because of a large increase, 10 fold, in the numbers of birds on the inner Bank leg (leg 3) (Table 4.17, Figure 21).

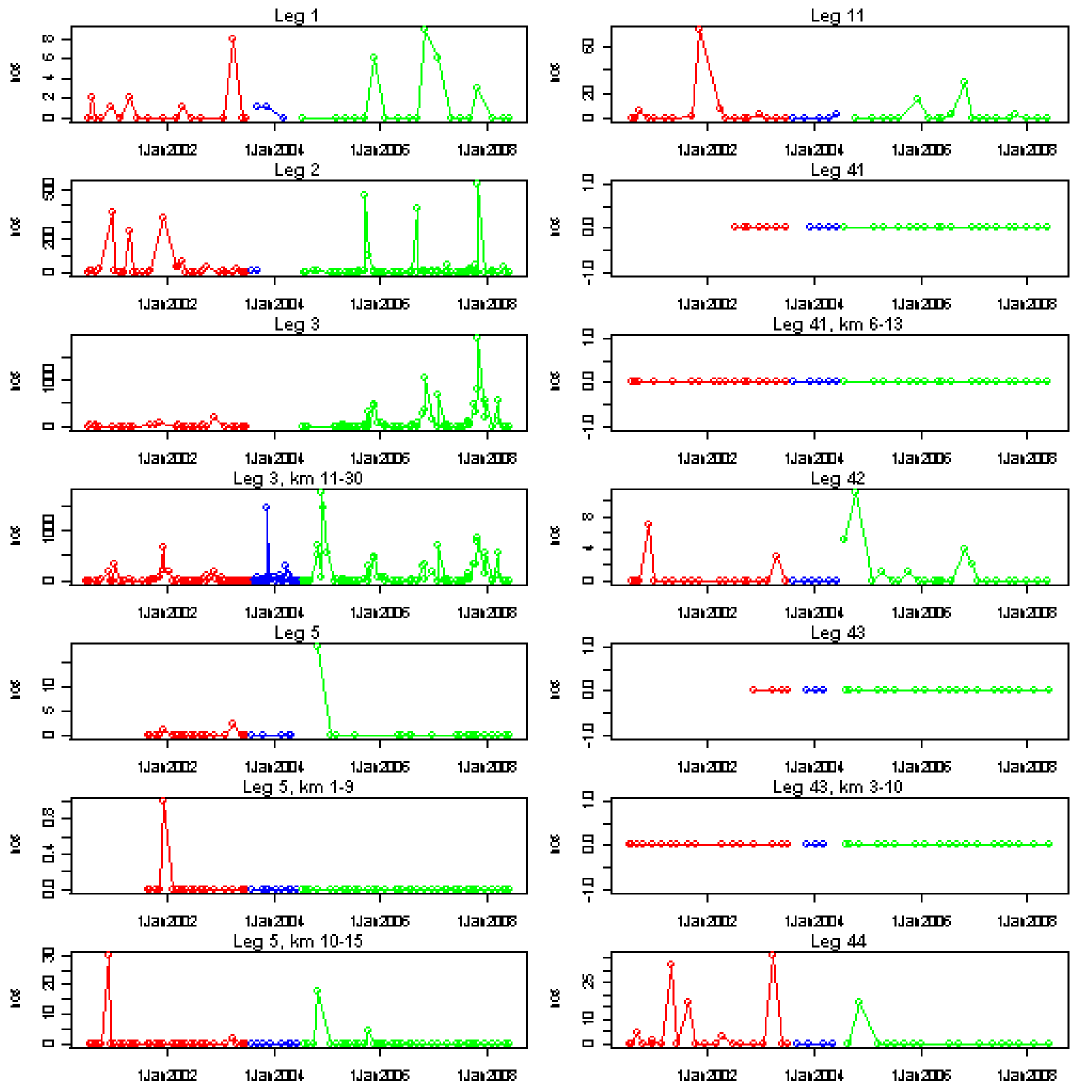
Table 4.18 Mean numbers of Little Gulls on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	1.08	0.31	2.92	13	0.67	0.00	0.67	3	0.86		2.18	0.55	4.09	11	0.354	
2	50.57	19.71	111.34	23	6.50	5.00	6.50	2	0.57		33.56	12.28	87.93	50	0.560	
3	17.80	6.26	50.10	20				0	1.00		178.38	109.71	300.26	52	0.033	+
3, km 11-30	49.93	25.36	109.12	43	88.32	24.45	279.56	25	0.56		197.58	126.64	320.86	60	0.006	++
5	0.20	0.00	0.60	15	0.00			4	0.82		1.50	0.00	3.00	12	0.600	
5, km 1-5	0.07	0.00	0.20	15	0.00			7	1.00		0.00			31	0.326	
5, km 10-15	1.23	0.00	5.78	26	0.00			6	0.84		0.79	0.00	2.80	28	0.810	
11	6.92	0.92	29.85	13	0.00			4	0.44		3.25	0.38	9.25	16	0.669	
41	0.00			5	0.00			3	1.00		0.00			15	1.000	
41, km 6-13	0.00			12	0.00			4	1.00		0.00			15	1.000	
42	0.77	0.00	2.15	13	0.00			5	0.79		1.06	0.28	3.22	18	0.780	
43	0.00			2	0.00			3	1.00		0.00			12	1.000	
43, km 3-10	0.00			12	0.00			3	1.00		0.00			12	1.000	
44	5.81	1.38	14.99	16	0.00			3	0.59		1.55	0.00	4.64	11	0.267	

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.

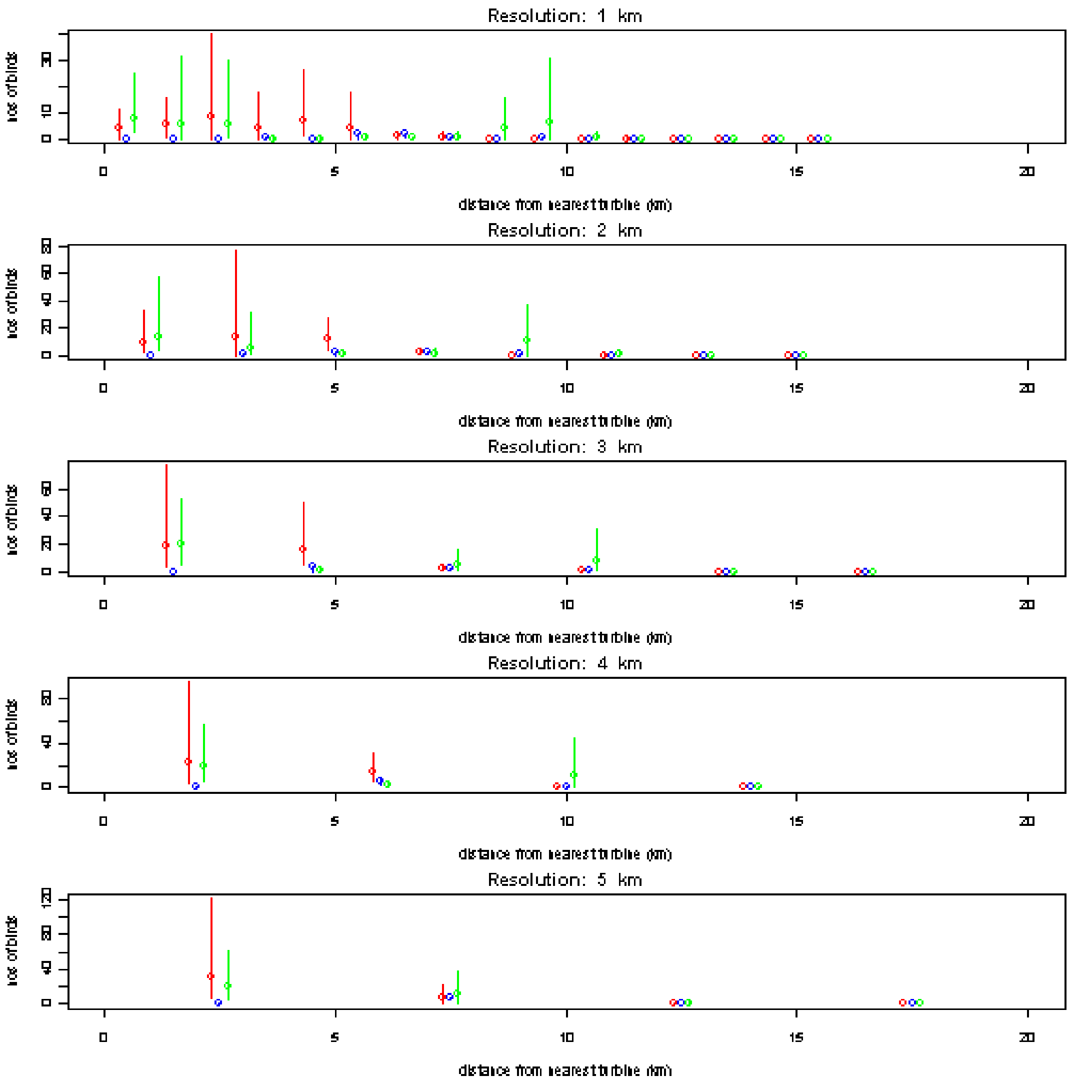
The small apparent decline on the outer Bank leg (leg 2) was not statistically significant (Table 4.18). For leg 3 the increase was only weakly significant (P<0.05) when surveys covering the whole leg were considered, but was more strongly significant (P<0.01) if surveys of just kms 11-30 were considered, reflecting the larger sample size this makes available (Table 4.18).

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



On the outer Bank leg (leg 2), where numbers did not change significantly, there was no significant change in the distribution of Little Gulls with respect to distance from the nearest turbine between the pre-and post installation phases (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), the increase in numbers took place within c. 12 km of the nearest turbine (Figures 23 and 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

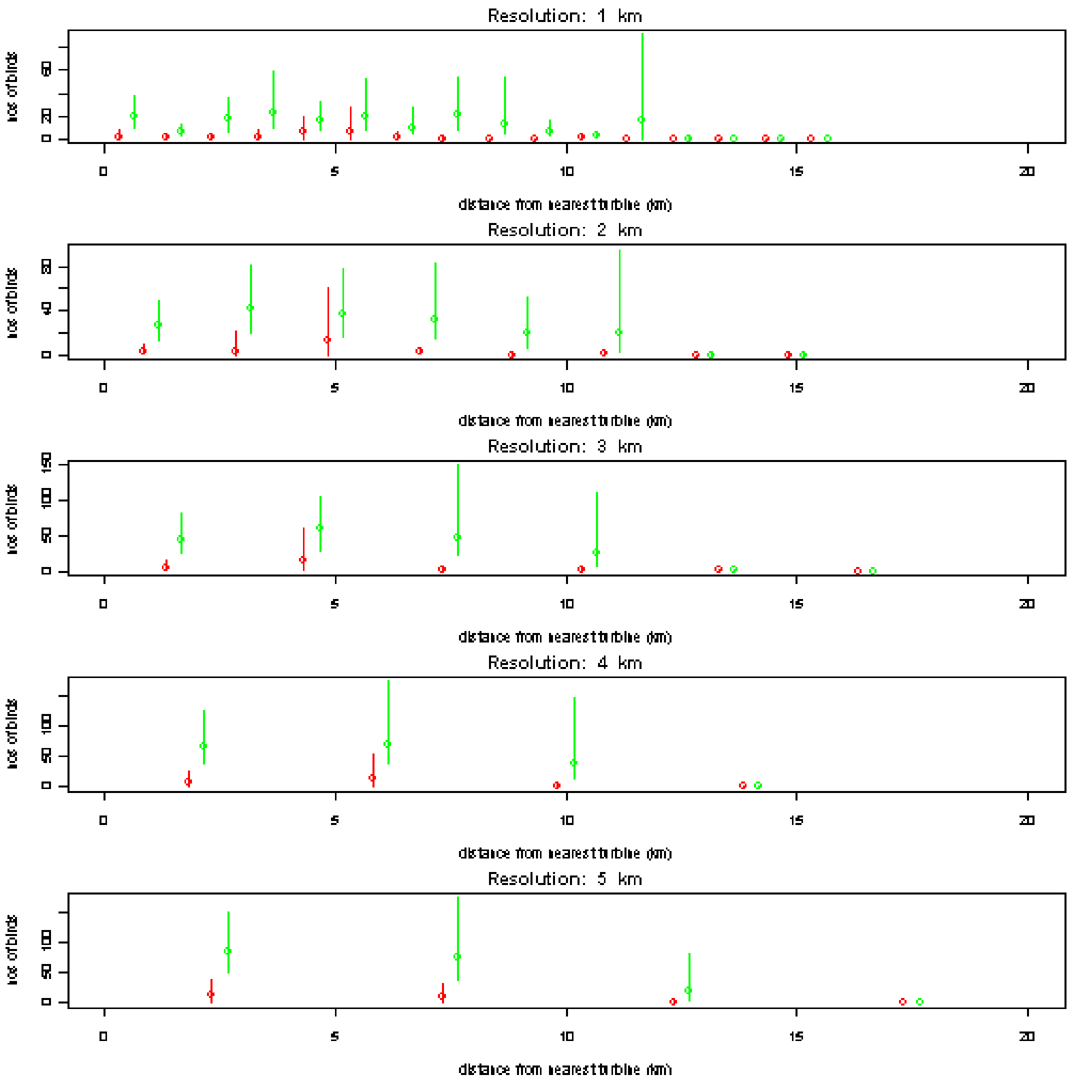
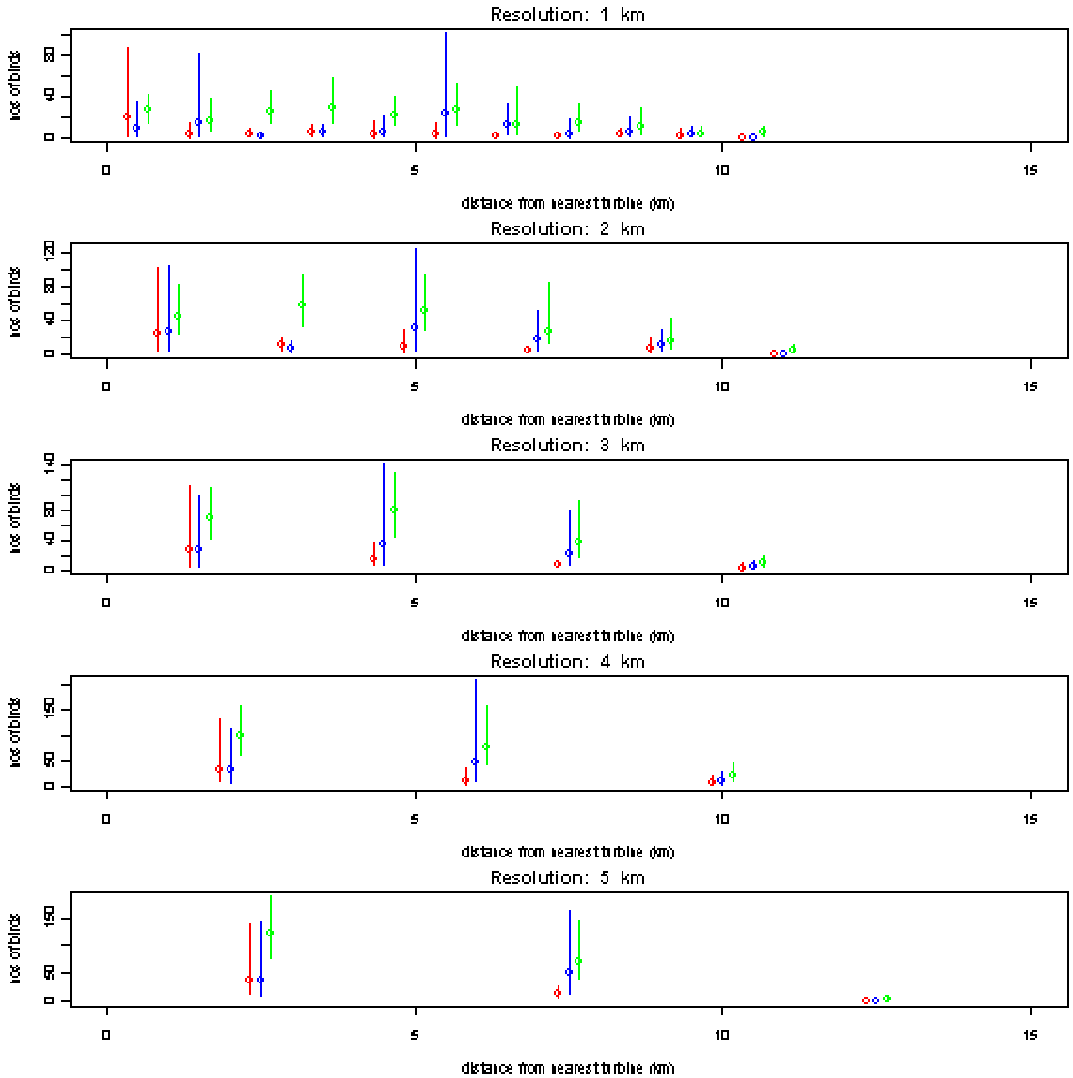


Figure 4.24 Numbers of Little Gulls between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



The similarity of the patterns observed for Little Gull with those observed for Kittiwake (see Section 4.2.7) suggest 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 numbers of Little Gulls present on the Bank has apparently increased since the installation of the turbines, with this increase being concentrated in the vicinity of the turbines.

4.2.7 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	1246.5	11	Yes
2	741.5	6	Yes
3	329.5	3	Yes
4	494.4	4	Yes
5	267.8	2	Yes
6	155.4	1	Yes
7	81.6	1	No
8	592.4	5	Yes
9	1044.0	9	Yes
10	2502.0	22	Yes
11	2849.4	25	Yes
12	1322.1	11	Yes

Kittiwakes were concentrated on the Bank legs, with 83% of birds and 97% of birds recorded on the two Bank legs pre- and post-installation respectively (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	8.13	10.80	2	1	0.33	0.43	5	1
2	216.34	352.22	59	21	6.18	10.06	100	27
3	86.96	1295.85	24	76	2.48	37.02	40	100
5	7.95	1.94	2	0	0.53	0.13	9	0
11	19.44	23.70	5	1	0.78	0.95	13	3
41	2.17	4.06	1	0	0.17	0.31	3	1
42	6.75	5.91	2	0	0.56	0.49	9	1
43	8.33	2.44	2	0	0.83	0.24	13	1
44	8.21	5.36	2	0	0.68	0.45	11	1

The relative importance of the Bank legs changed following turbine installation due principally to a c. 15 fold increase in numbers on the inner Bank leg (leg 3). Before installation, approximately 2.5 times as many birds were recorded on the outer Bank leg (leg 2) as on the inner Bank leg (leg 3), while after turbine installation, the relative importance of the two legs was reversed, with approximately 4 times as many birds recorded on the inner Bank leg (leg 3) as on the outer Bank leg (leg 2) (Table 4.20).

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

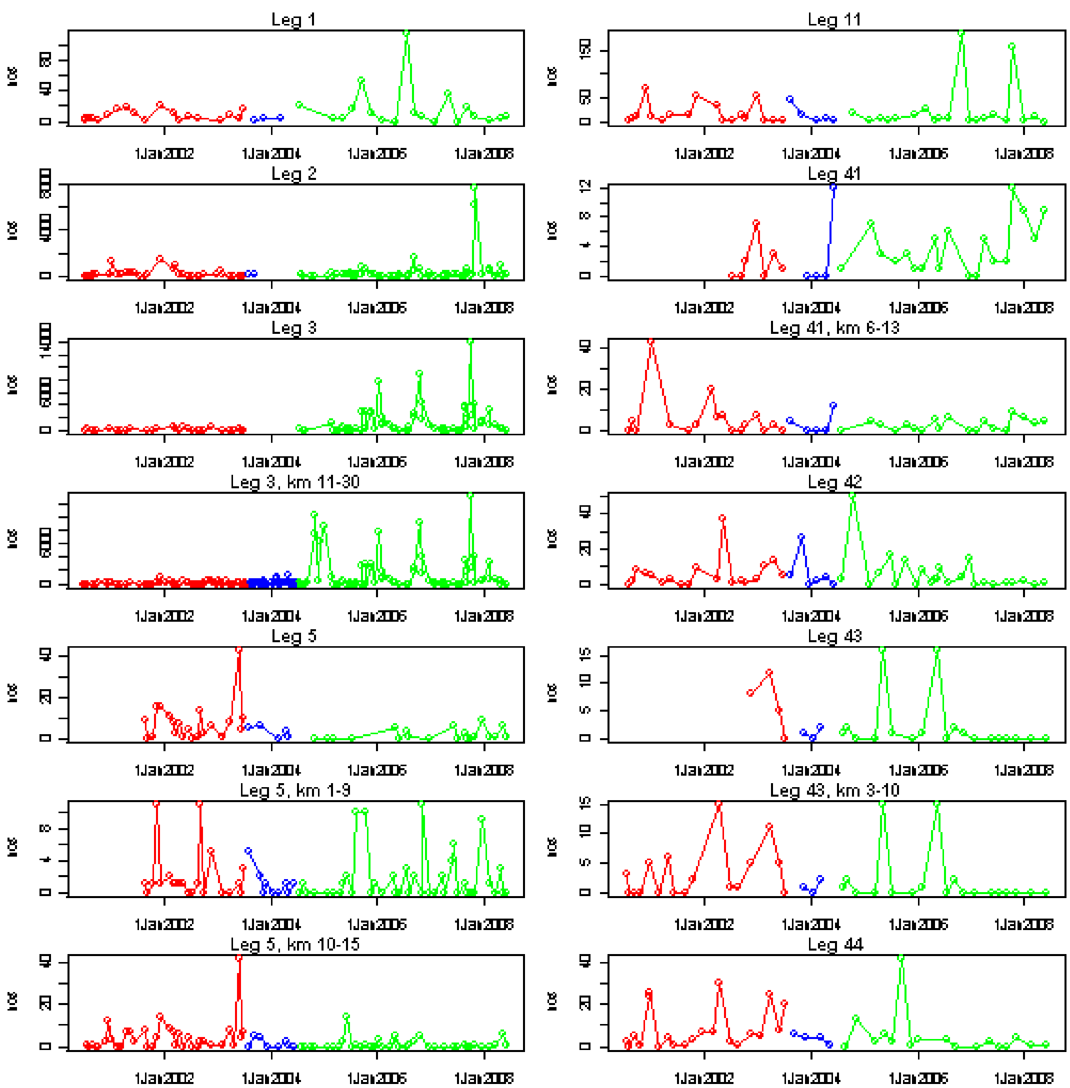
	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	8.13	5.31	11.40	16	3.33	2.00	3.33	3	0.25		10.80	5.64	20.94	15	0.54352	
2	216.34	103.02	384.89	29	125.50	73.00	125.50	2	0.82		352.22	145.49	819.43	65	0.69911	
3	86.96	41.91	170.57	25				0	1.00		1295.85	871.33	2130.46	67	0.01074	+
3, km 11-30	113.02	72.04	179.73	51	168.36	94.67	303.71	33	0.31		1529.61	1024.70	2273.90	75	0.00009	++++
5	7.95	5.05	15.13	19	3.00	0.61	4.80	5	0.28		1.94	0.82	3.71	17	0.00450	--
5, km 1-5	2.00	1.00	4.47	19	1.11	0.33	2.44	9	0.55		1.69	0.87	2.82	39	0.76417	
5, km 10-15	4.63	2.81	8.82	32	1.50	0.38	3.08	8	0.26		1.31	0.65	2.73	35	0.00488	--
11	19.44	11.13	33.38	16	14.80	5.01	38.40	5	0.65		23.70	8.15	56.14	20	0.73408	
41	2.17	0.67	4.81	6	3.00	0.00	6.00	4	0.86		4.06	2.61	5.78	18	0.26727	
41, km 6-13	6.33	2.47	18.20	15	3.20	0.00	8.00	5	0.65		2.67	1.61	4.06	18	0.22186	
42	6.75	3.94	14.09	16	6.17	1.50	18.17	6	0.94		5.91	3.00	13.21	23	0.81851	
43	8.33	5.00	10.67	3	1.00	0.00	1.67	3	0.10		2.44	0.50	6.44	16	0.06398	
43, km 3-10	3.40	1.60	6.33	15	1.00	0.00	1.67	3	0.49		2.25	0.44	6.13	16	0.53861	
44	8.21	4.53	13.35	19	3.75	1.00	5.00	4	0.43		5.36	2.00	17.43	14	0.46861	

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 increase in the number of birds 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 kms 11-30 were considered, reflecting the much larger samples this yields (Table 4.21, Figure 4.25).

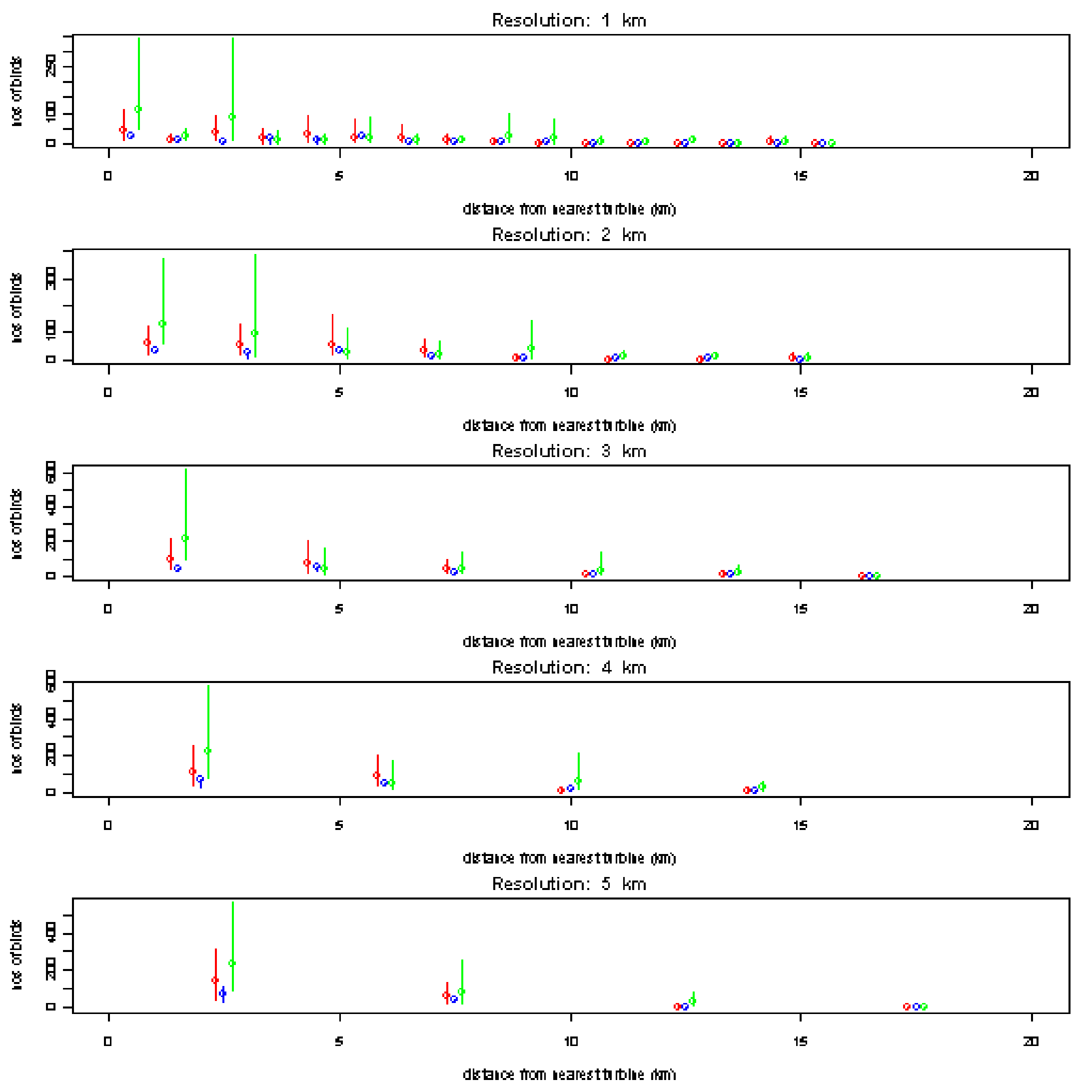
A significant decline (P<0.005) also occurred on the Cable Route, particularly on its southern section from km 10-15 (Table 4.21), but the number of birds involved was very small (Table 4.20), so that any impact on the population is likely to be negligible.

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



On the outer Bank leg (leg 2), where numbers did not change significantly, there was no significant change in the distribution of Kittiwakes with respect to distance from the nearest turbine between pre-and post installation (Figure 4.26), although the greatest apparent (i.e. non-significant) increases occurred within 3 km of the nearest turbines.

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



The increase in Kittiwake numbers on the inner Bank leg (leg 3) 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

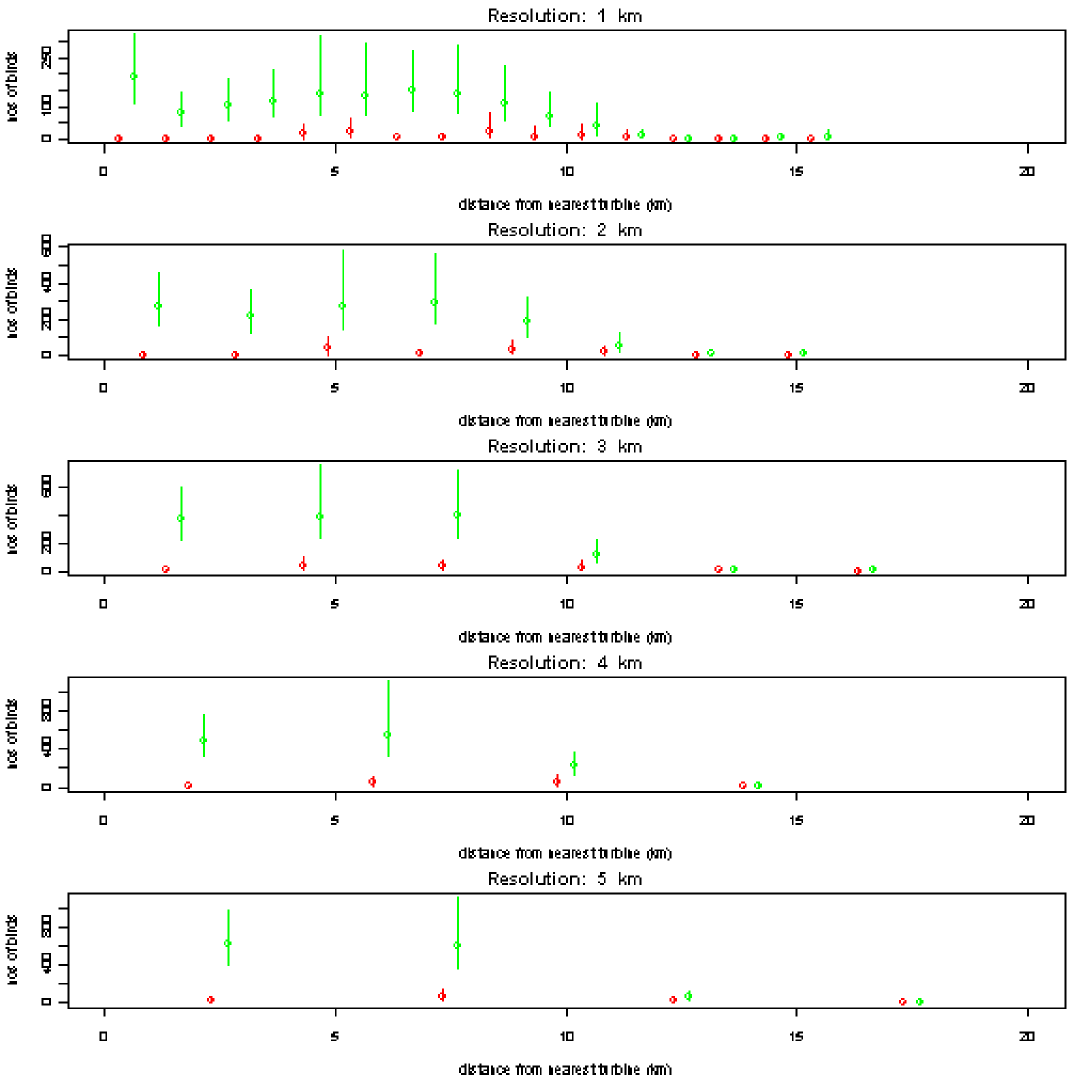
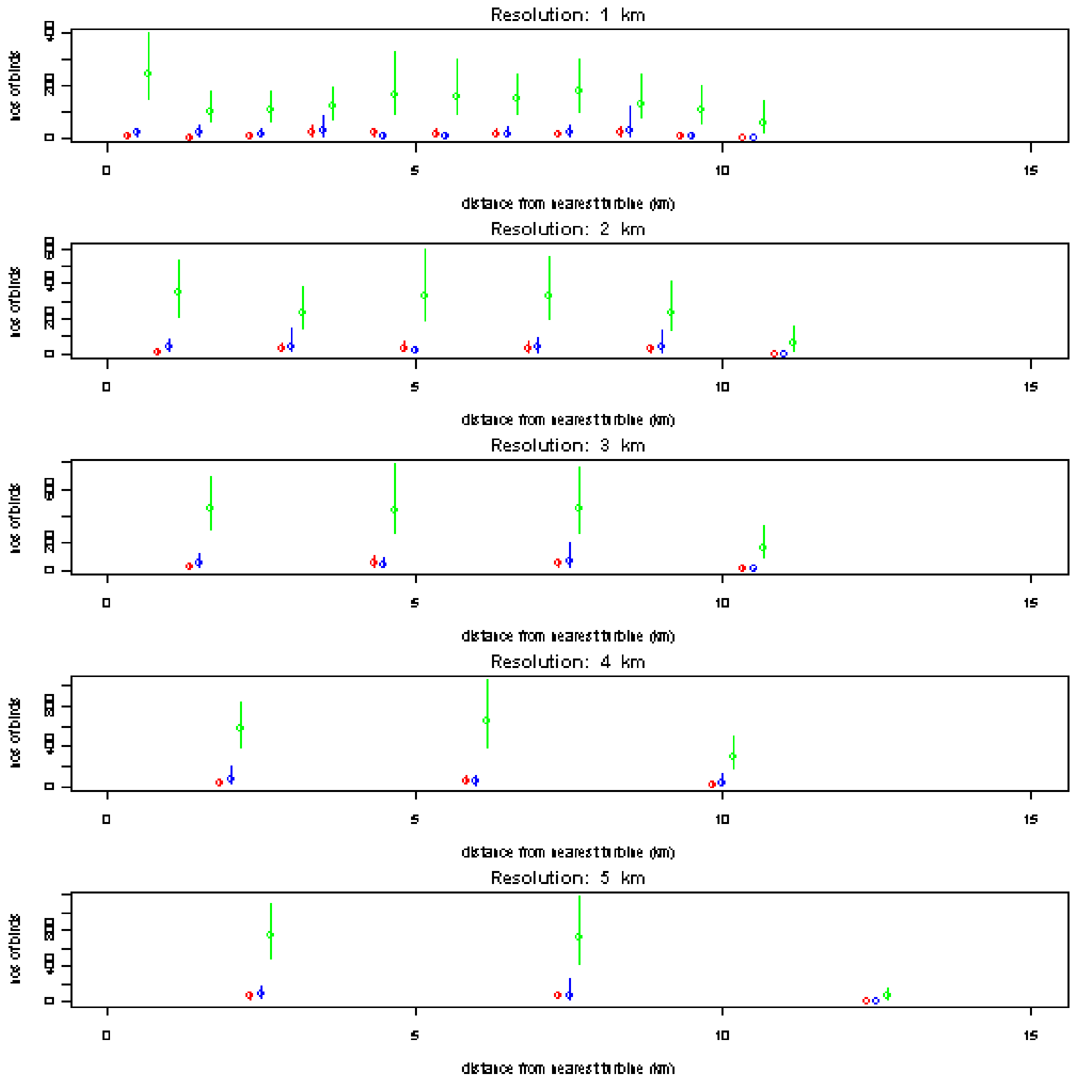


Figure 4.28 Numbers of Kittiwakes between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



It is unclear whether or not the installation of turbines was responsible for the observed changes in Kittiwake numbers, but the overall increase in numbers, and the positive association of these increases with the proximity of turbines, suggested that any potential impacts of the turbines have been benign.

4.2.8 Arctic Tern

Arctic Terns were uncommonly recorded in the Arklow Study Area, with birds only reported on 5 dates before turbine installation, 1 date during installation, and 17 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 April, May, 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	0.0	0	No
2	0.0	0	No
3	0.0	0	No
4	1.9	2	Yes
5	79.2	91	Yes
6	0.1	0	No
7	0.0	0	No
8	0.9	1	No
9	1.9	2	Yes
10	3.6	4	Yes
11	0.0	0	No
12	0.0	0	No

Both Bank legs (2 and 3) were consistently important, with more than 18% of birds recorded on the Bank both before and after turbine installation (Table 32). Birds were also recorded on the outer Box legs (1 and 11) and once on the inner Box leg 42, but no birds were recorded on the other inner Box Legs 41,43 and 44 and the Cable Route (leg 5).

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/km²)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	0.00	1.00	0	3	0.00	0.04	0	5
2	13.73	25.63	43	76	0.39	0.73	80	100
3	17.17	6.42	54	19	0.49	0.18	100	25
5	0.00	0.00	0	0	0.00	0.00	0	0
11	0.57	0.57	2	2	0.02	0.02	5	3
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

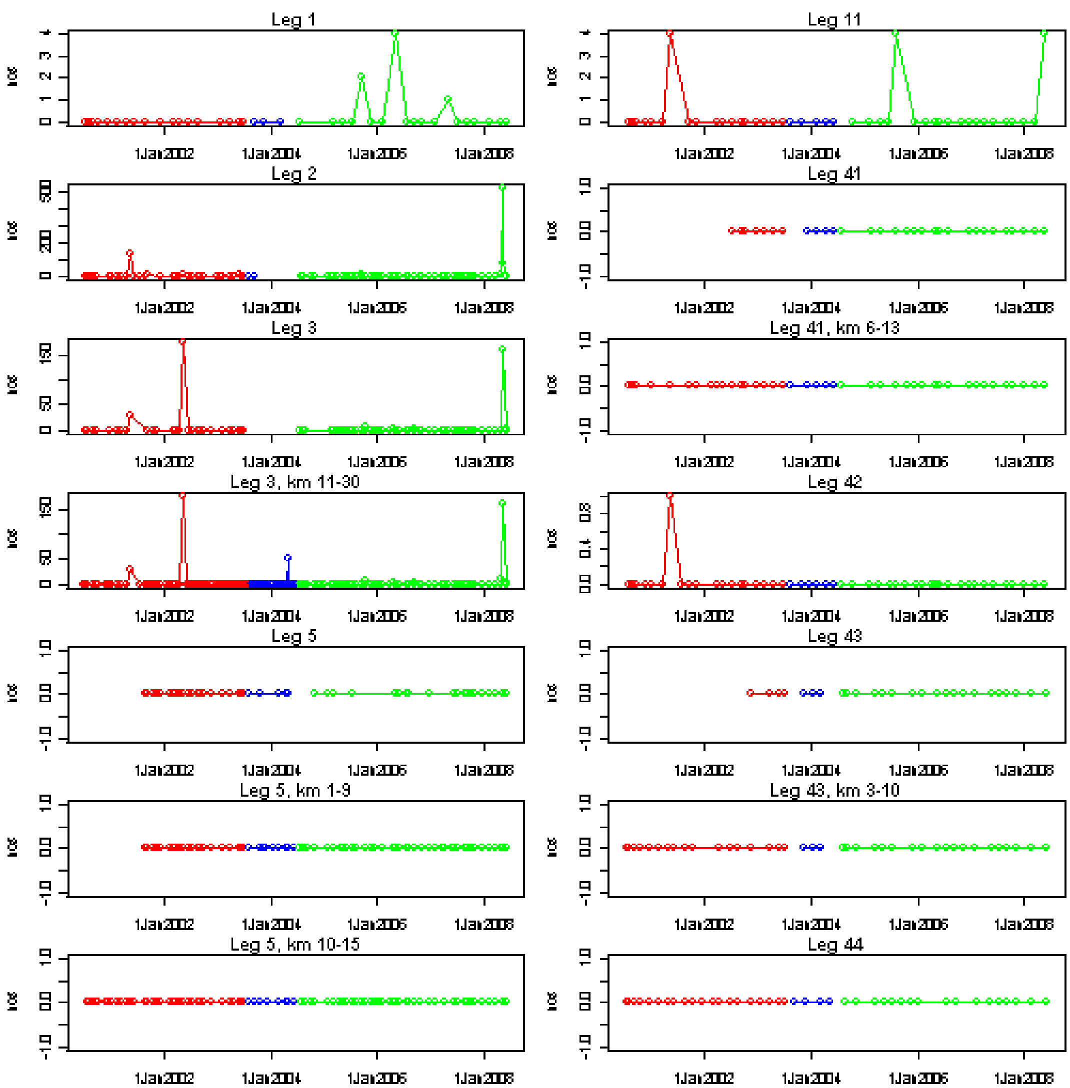
Table 4.24 Mean numbers of Arctic Terns on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	0.00			5	0.00			1	1.00		1.00	0.27	2.29	7	0.31	
2	13.73	1.02	50.43	11	0.00			1	0.75		25.63	1.31	115.71	24	0.90	
3	17.17	0.00	61.17	12				0	1.00		6.42	0.12	31.27	26	0.47	
3, km 11-30	11.28	0.00	50.00	18	3.85	0.00	11.54	13	0.90		6.07	0.31	22.86	29	0.61	
5	0.00			7	0.00			3	1.00		0.00			4	1.00	
5, km 1-5	0.00			7	0.00			3	1.00		0.00			14	1.00	
5, km 10-15	0.00			13	0.00			4	1.00		0.00			13	1.00	
11	0.57	0.00	1.14	7	0.00			2	1.00		0.57	0.00	1.71	7	1.00	
41	0.00			3	0.00			1	1.00		0.00			6	1.00	
41, km 6-13	0.00			7	0.00			1	1.00		0.00			6	1.00	
42	0.14	0.00	0.29	7	0.00			2	1.00		0.00			9	0.44	
43	0.00			1				0	1.00		0.00			6	1.00	
43, km 3-10	0.00			6				0	1.00		0.00			6	1.00	
44	0.00			6	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.

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

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



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 legs 2 and 3 as presented in Figure 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

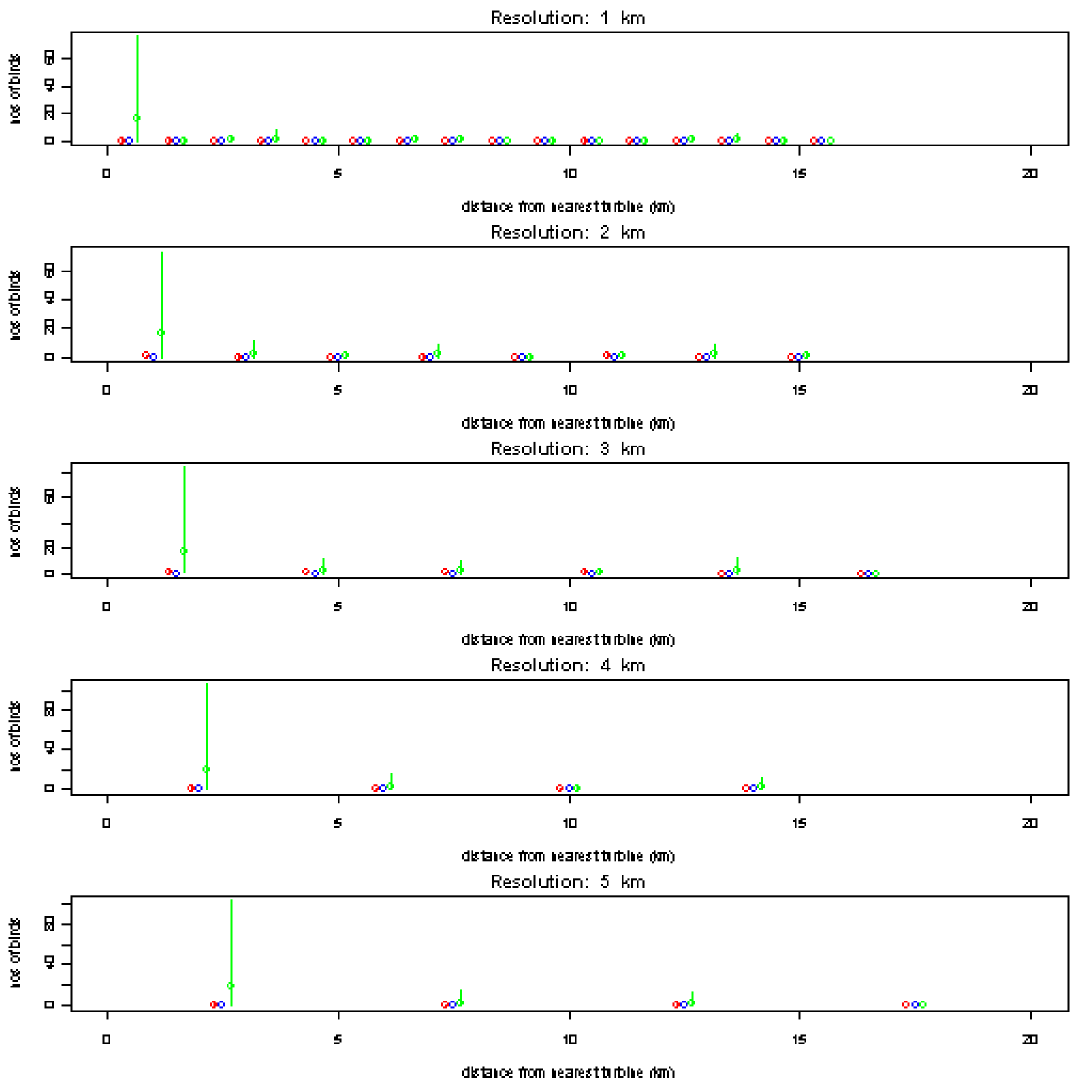


Figure 4.31 Numbers of Arctic Terns on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

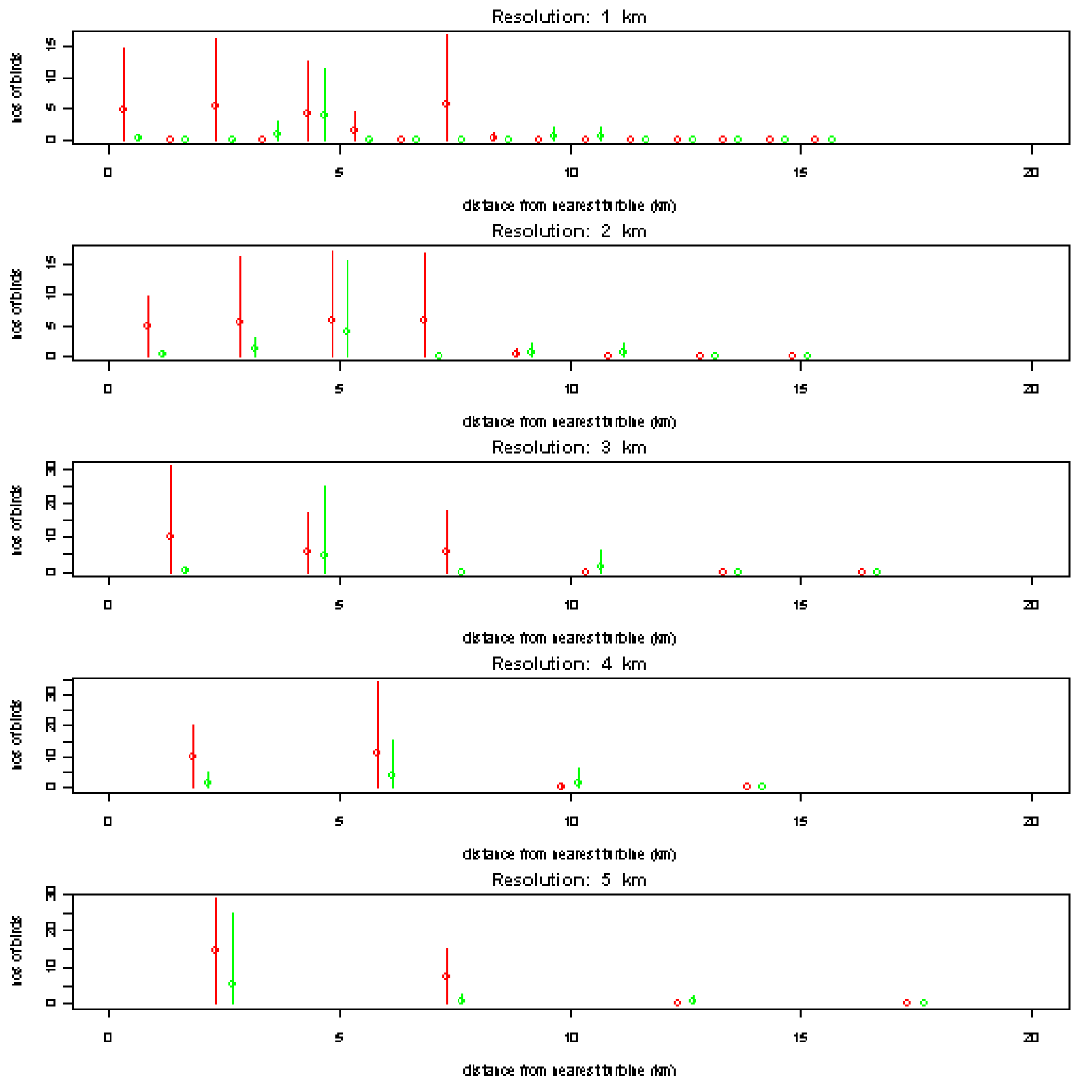
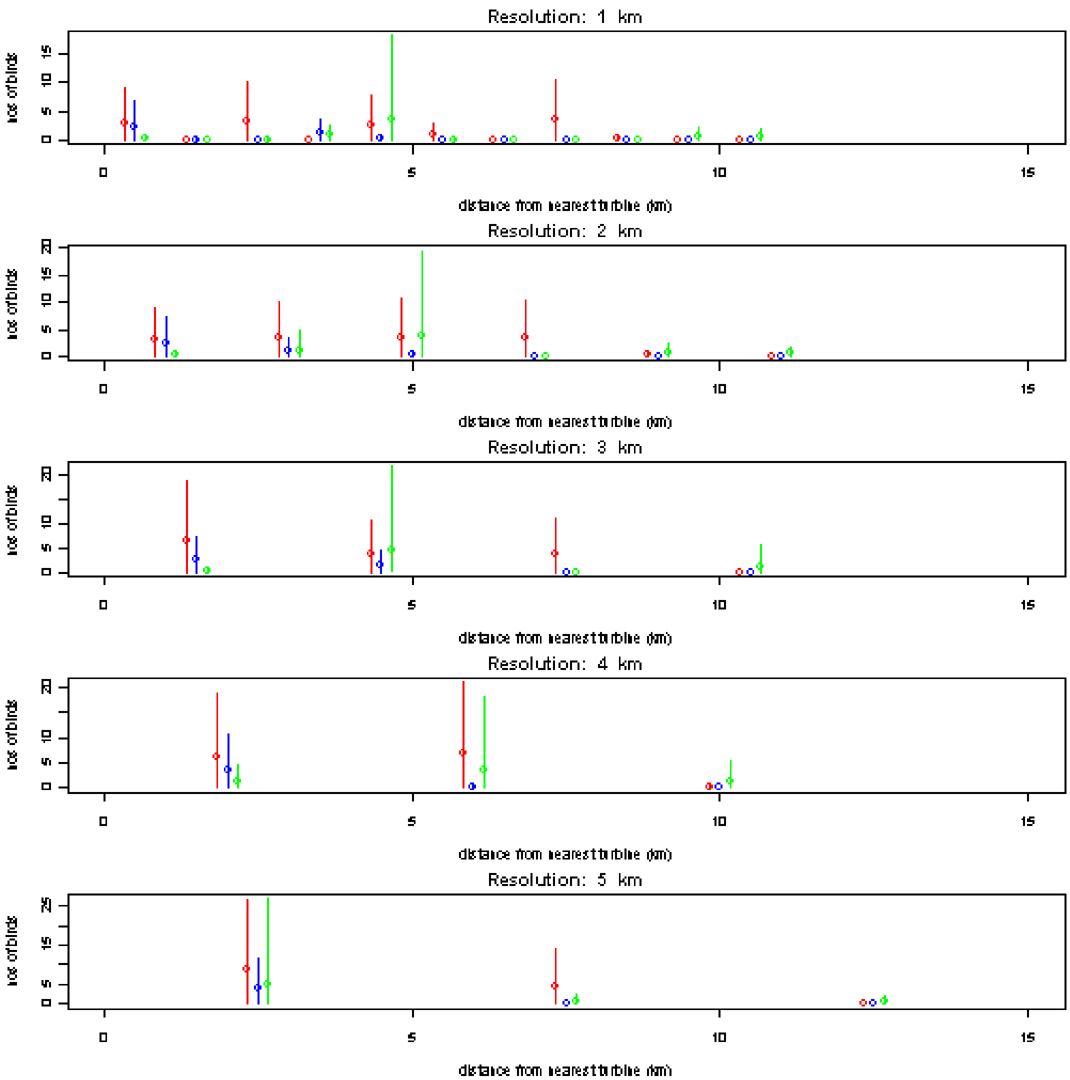


Figure 4.32 Numbers of Arctic Terns between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



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

4.2.9 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 31 dates after (Figure 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	0.0	0	No
2	0.0	0	No
3	0.5	0	No
4	2.8	2	Yes
5	9.3	7	Yes
6	0.2	0	No
7	3.8	3	Yes
8	41.0	29	Yes
9	79.7	56	Yes
10	4.7	3	Yes
11	0.0	0	No
12	0.0	0	No

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 4.26).

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	3.45	10	7	0.03	0.14	33	18
2	1.67	16.32	23	35	0.05	0.47	54	60
3	3.11	26.98	44	57	0.09	0.77	100	100
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	0.23	8	0	0.05	0.02	51	2
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

The two Bank legs (2 and 3) were the most important for this species both before and after turbine installation, and birds were also regularly recorded on the outermost Box leg (leg 1). (Table 35, Figure 45).

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

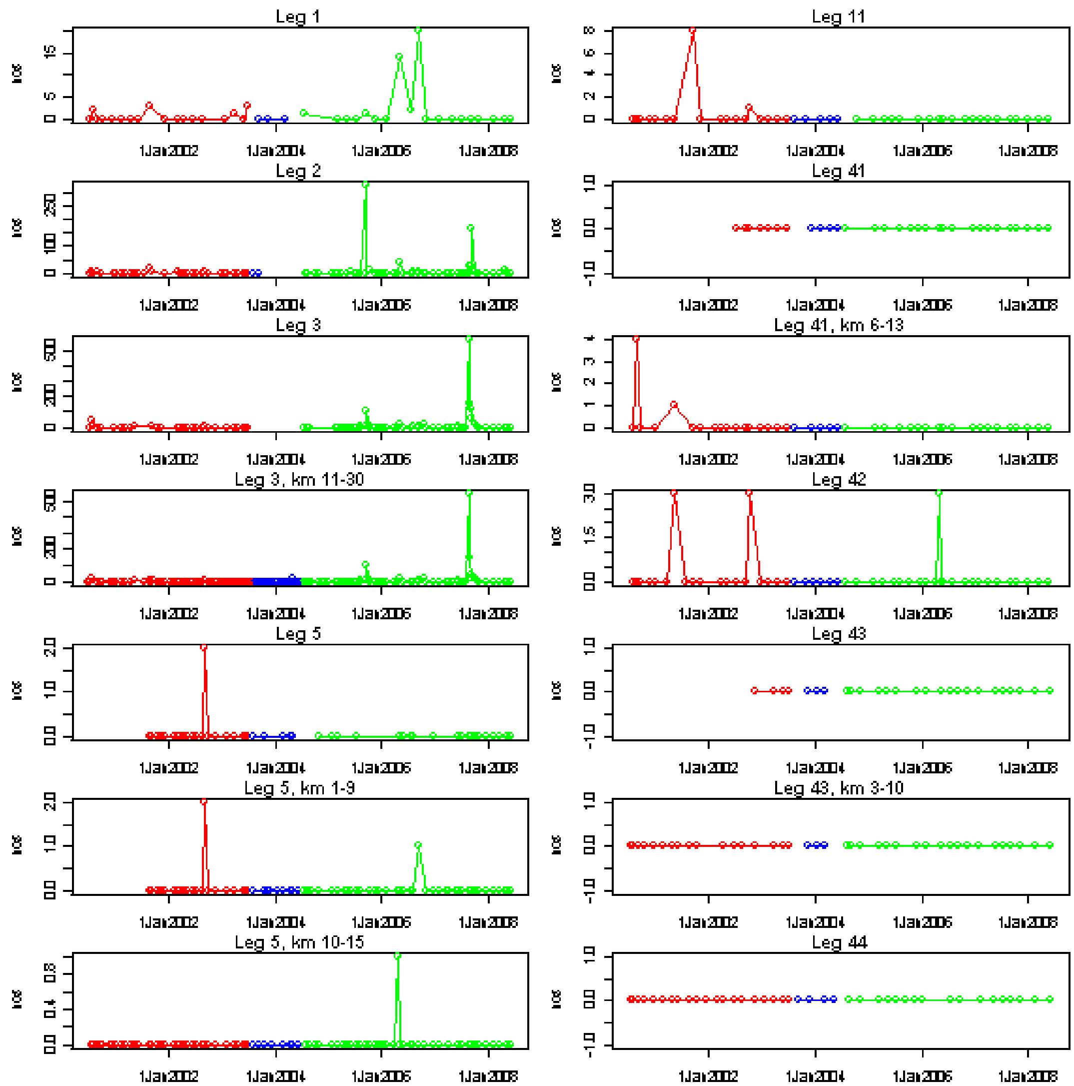
	Before				During						After					
Leg	Mean	LCL	UCL	n	Mean	LCL	UCL	n	p	sig	Mean	LCL	UCL	n	p	sig
1	0.73	0.00	1.45	11	0.00			1	1.00		3.45	0.36	9.36	11	0.37	
2	1.67	0.48	4.71	21	0.00			2	0.64		16.32	4.46	51.71	38	0.23	
3	3.11	0.63	13.47	19				0	1.00		26.98	8.85	83.09	41	0.31	
3, km 11-30	0.97	0.29	2.47	34	1.33	0.00	4.00	15	0.85		20.48	5.18	73.12	46	0.11	
5	0.18	0.00	0.55	11	0.00			4	1.00		0.00			9	1.00	
5, km 1-5	0.18	0.00	0.55	11	0.00			4	1.00		0.05	0.00	0.14	22	0.77	
5, km 10-15	0.00			19	0.00			5	1.00		0.05	0.00	0.14	21	1.00	
11	0.90	0.00	3.55	10	0.00			3	0.81		0.00			10	0.47	
41	0.00			4	0.00			1	1.00		0.00			10	1.00	
41, km 6-13	0.50	0.00	1.60	10	0.00			2	0.85		0.00			10	0.47	
42	0.55	0.00	1.09	11	0.00			3	1.00		0.23	0.00	0.69	13	0.58	
43	0.00			2				0	1.00		0.00			10	1.00	
43, km 3-10	0.00			11				0	1.00		0.00			10	1.00	
44	0.00			11	0.00			2	1.00		0.00			9	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.

Small groups of birds were also occasionally recorded on the Cable Route (leg 5), and the Box Legs 11, 41 and 42. No birds were recorded on the inner Box legs 43 and 44 (Table 4.27)

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

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



Although Figures 4.34 to 4.36 suggest that after turbines 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

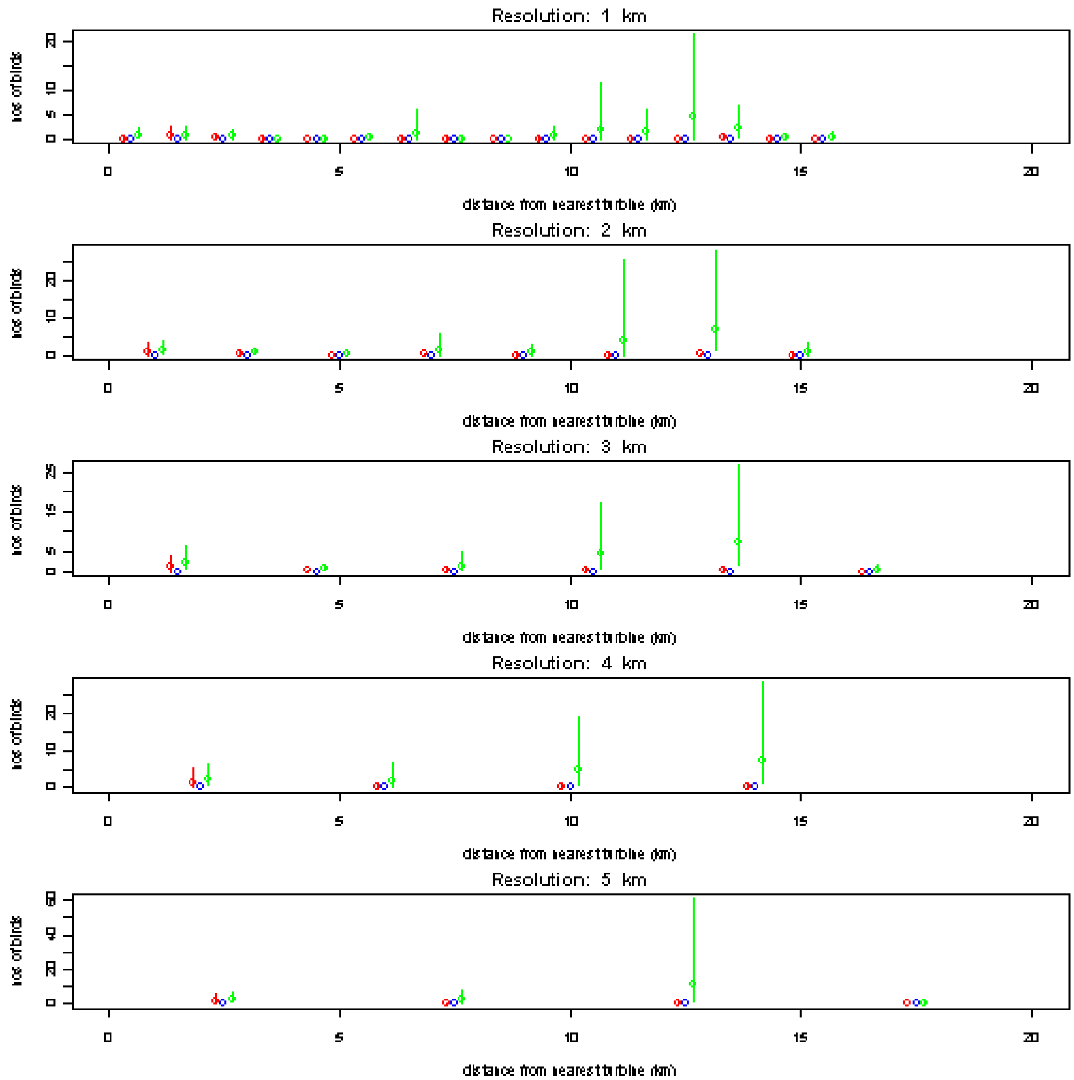


Figure 4.35 Numbers of Common Terns on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

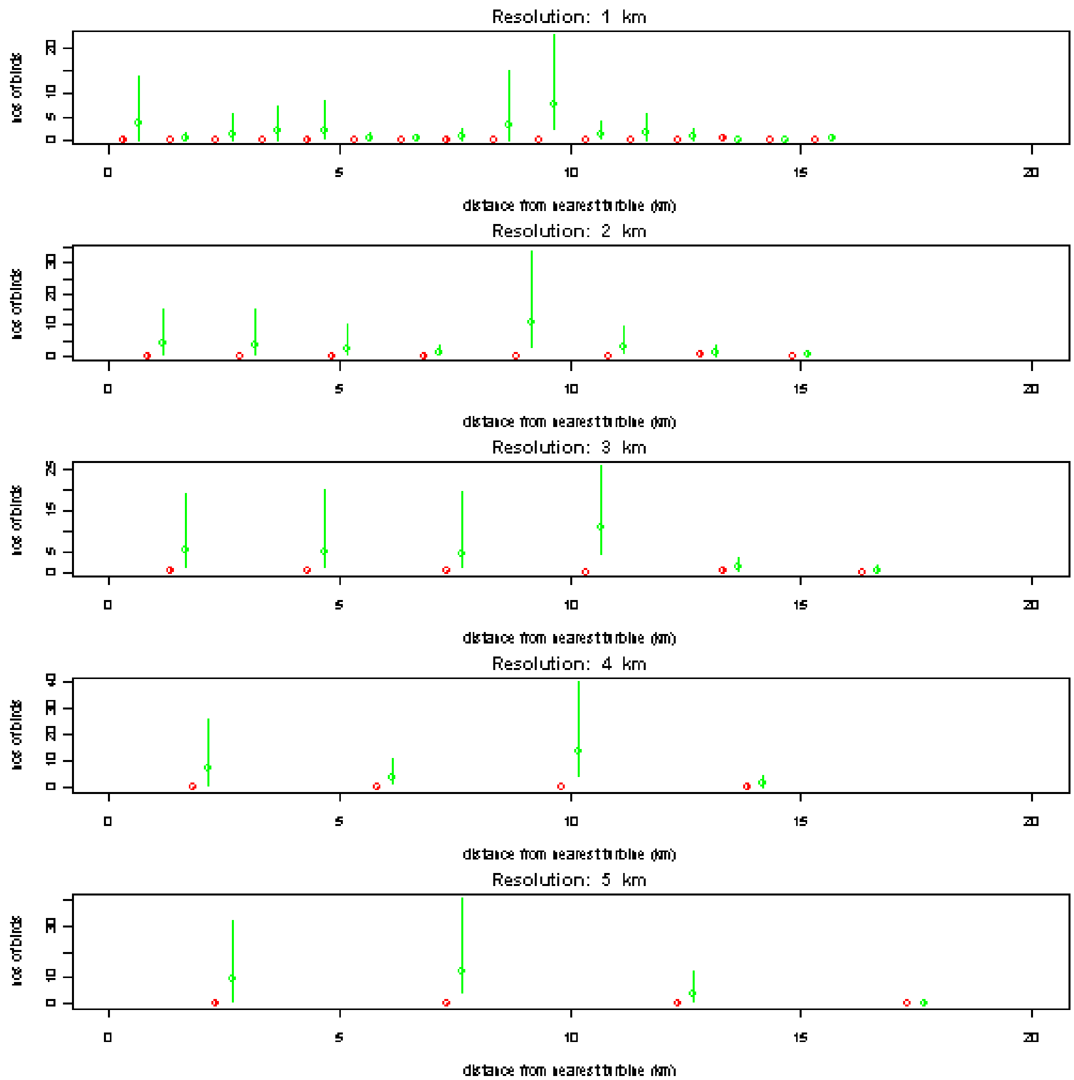
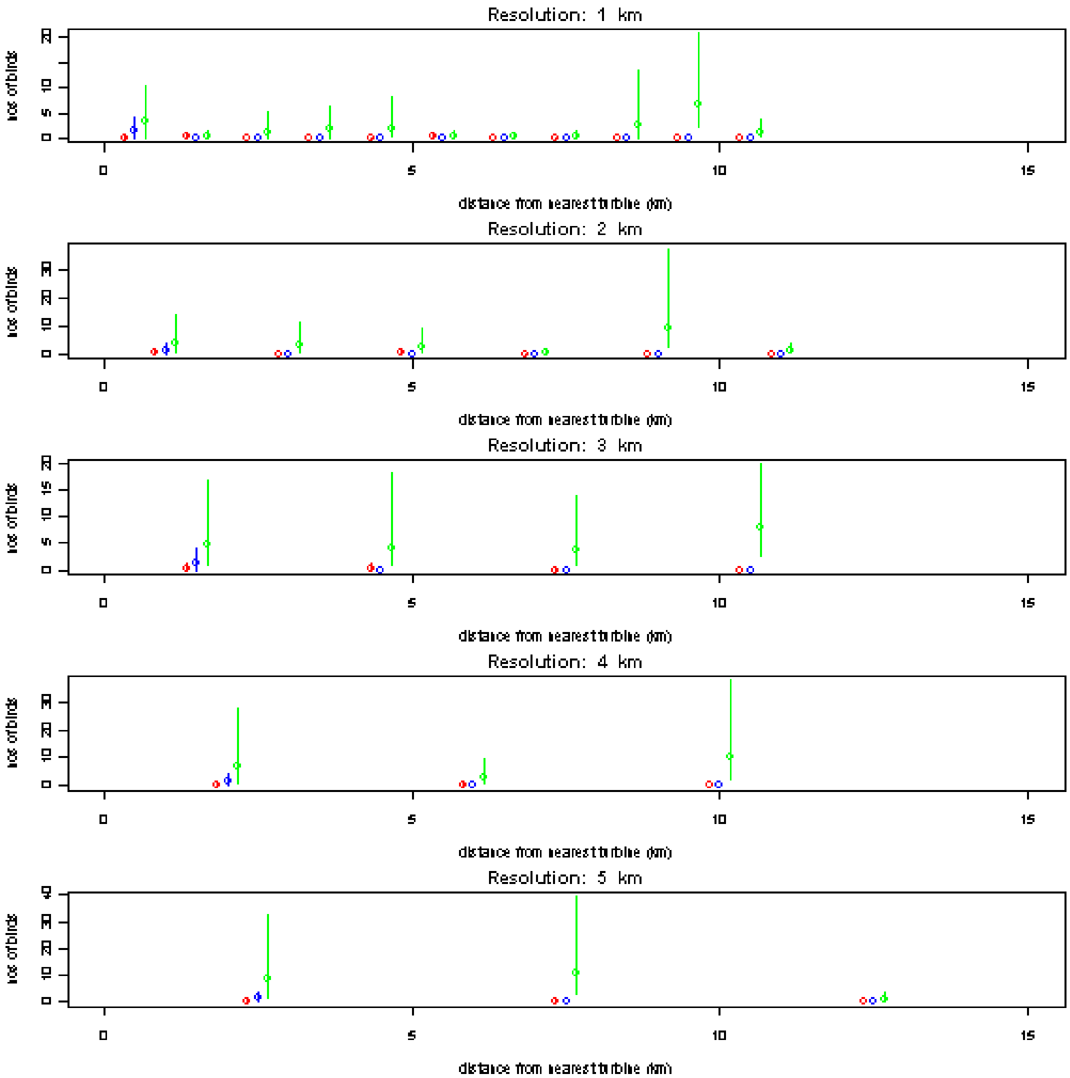


Figure 4.36 Numbers of Common Terns between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



In conclusion there was no detectable positive or negative impact of the turbines on Common Terns. However, although sample sizes were larger than for Arctic Terns, they were still small, and the failure to detect any impacts (positive or negative) could reflect a lack of power in the statistical tests rather than their absence.

4.2.10 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 was 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	0.5	0	No
4	14.4	4	Yes
5	129.9	33	Yes
6	1.5	0	No
7	4.2	1	Yes
8	57.1	14	Yes
9	177.3	45	Yes
10	9.5	2	Yes
11	0.0	0	No
12	0.0	0	No

The Bank legs (2 and 3) were the most important, with no birds recorded on inner 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	8.00	3	8	0.06	0.32	8	23
2	13.24	43.95	29	42	0.38	1.26	47	91
3	28.00	48.27	61	47	0.80	1.38	100	100
5	0.45	0.00	1	0	0.03	0.00	4	0
11	1.80	1.20	4	1	0.07	0.05	9	3
41	0.00	0.00	0	0	0.00	0.00	0	0
42	1.00	2.23	2	2	0.08	0.19	10	13
43	0.00	0.10	0	0	0.00	0.01	0	1
44	0.00	0.00	0	0	0.00	0.00	0	0

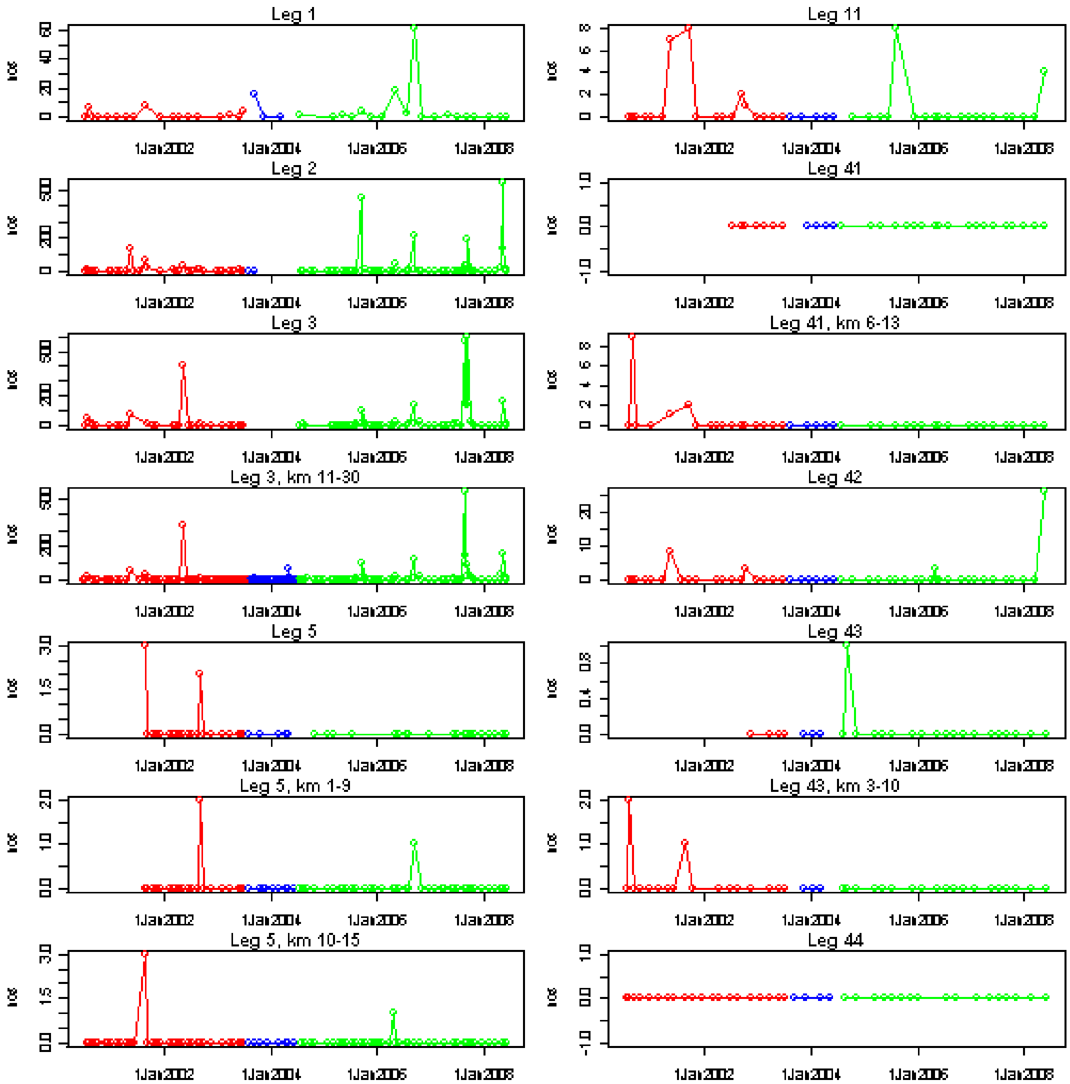
Table 4.30 Mean numbers of Common or Arctic Terns on each leg before, during and after turbine installation, with 95 % confidence limits, and an assessment of whether the mean was significantly different to pre-installation numbers

	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	3.45	11	15.00			1	0.08		8.00	1.09	32.85	11	0.37	
2	13.24	4.19	39.02	21	0.50	0.00	0.50	2	0.58		43.95	15.50	106.65	38	0.28	
3	28.00	4.66	95.05	19				0	1.00		48.27	17.51	114.67	41	0.57	
3, km 11-30	12.82	2.06	53.09	34	5.27	0.33	24.97	15	0.79		28.46	12.69	76.07	46	0.43	
5	0.45	0.00	1.18	11	0.00			4	0.79		0.00			9	0.48	
5, km 1-5	0.18	0.00	0.55	11	0.00			4	1.00		0.05	0.00	0.14	22	0.77	
5, km 10-15	0.16	0.00	0.47	19	0.00			5	1.00		0.05	0.00	0.14	21	0.74	
11	1.80	0.40	4.20	10	0.00			3	0.43		1.20	0.00	3.20	10	0.72	
41	0.00			4	0.00			1	1.00		0.00			10	1.00	
41, km 6-13	1.20	0.20	4.00	10	0.00			2	0.71		0.00			10	0.21	
42	1.00	0.00	3.00	11	0.00			3	0.82		2.23	0.00	8.31	13	0.95	
43	0.00			2				0	1.00		0.10	0.00	0.20	10	1.00	
43, km 3-10	0.27	0.00	0.73	11				0	1.00		0.00			10	0.48	
44	0.00			11	0.00			2	1.00		0.00			9	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.

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

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 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

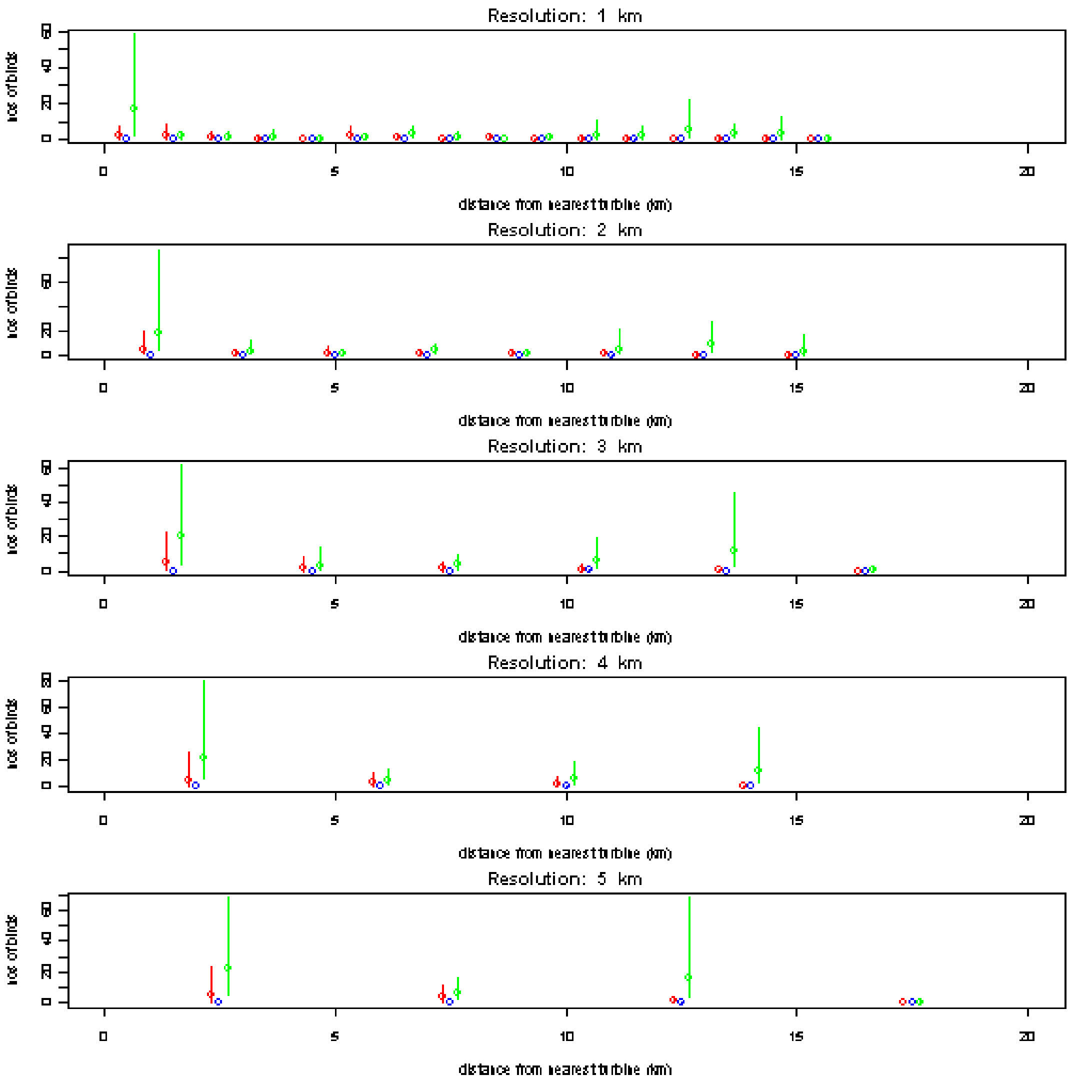


Figure 4.39 Numbers of Common or Arctic Terns on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

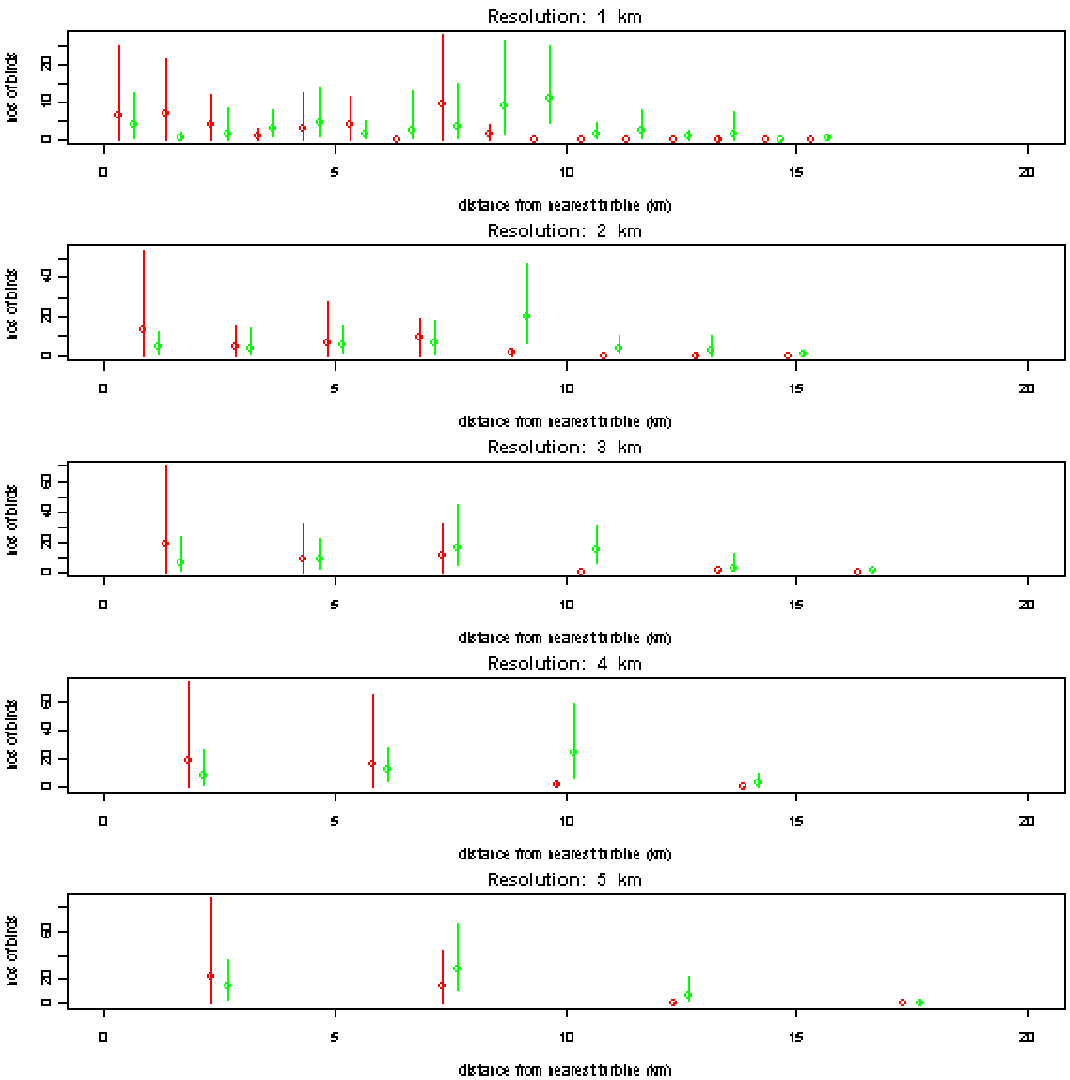
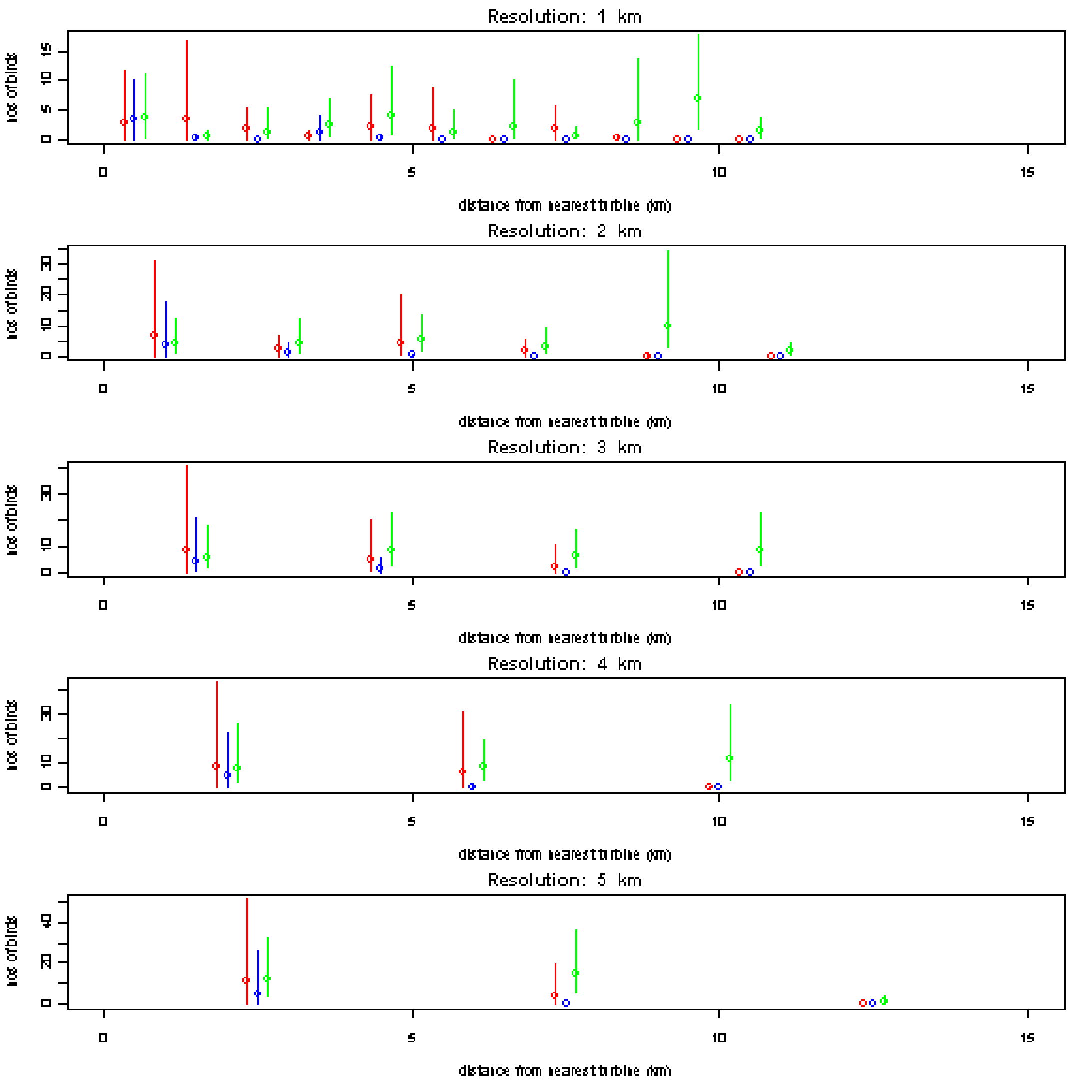


Figure 4.40 Numbers of Common or Arctic Terns between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



In conclusion there was no detectable positive or negative impact of turbines on the combined records of Common and Arctic Tern. The greater number of positive records (i.e. records when birds of one or other of the species was present) was likely to give greater statistical power than was available for the analyses 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.

4.2.11 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	9	Yes
2	403.3	9	Yes
3	154.7	3	Yes
4	194.3	4	Yes
5	458.2	10	Yes
6	153.5	3	Yes
7	730.9	16	Yes
8	336.3	8	Yes
9	634.4	14	Yes
10	353.9	8	Yes
11	263.5	6	Yes
12	370.1	8	Yes

Most birds were recorded on the Bank legs (legs 2 and 3), and on the offshore 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/km²)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	67.47	172.11	22	33	2.70	6.88	98	100
2	96.63	108.50	32	21	2.76	3.10	100	45
3	43.33	107.30	14	20	1.24	3.07	45	45
5	9.38	7.10	3	1	0.63	0.47	23	7
11	40.39	37.35	13	7	1.62	1.49	59	22
41	3.43	15.95	1	3	0.26	1.23	10	18
42	11.32	46.04	4	9	0.94	3.84	34	56
43	19.50	4.11	6	1	1.95	0.41	71	6
44	11.05	26.94	4	5	0.92	2.25	33	33

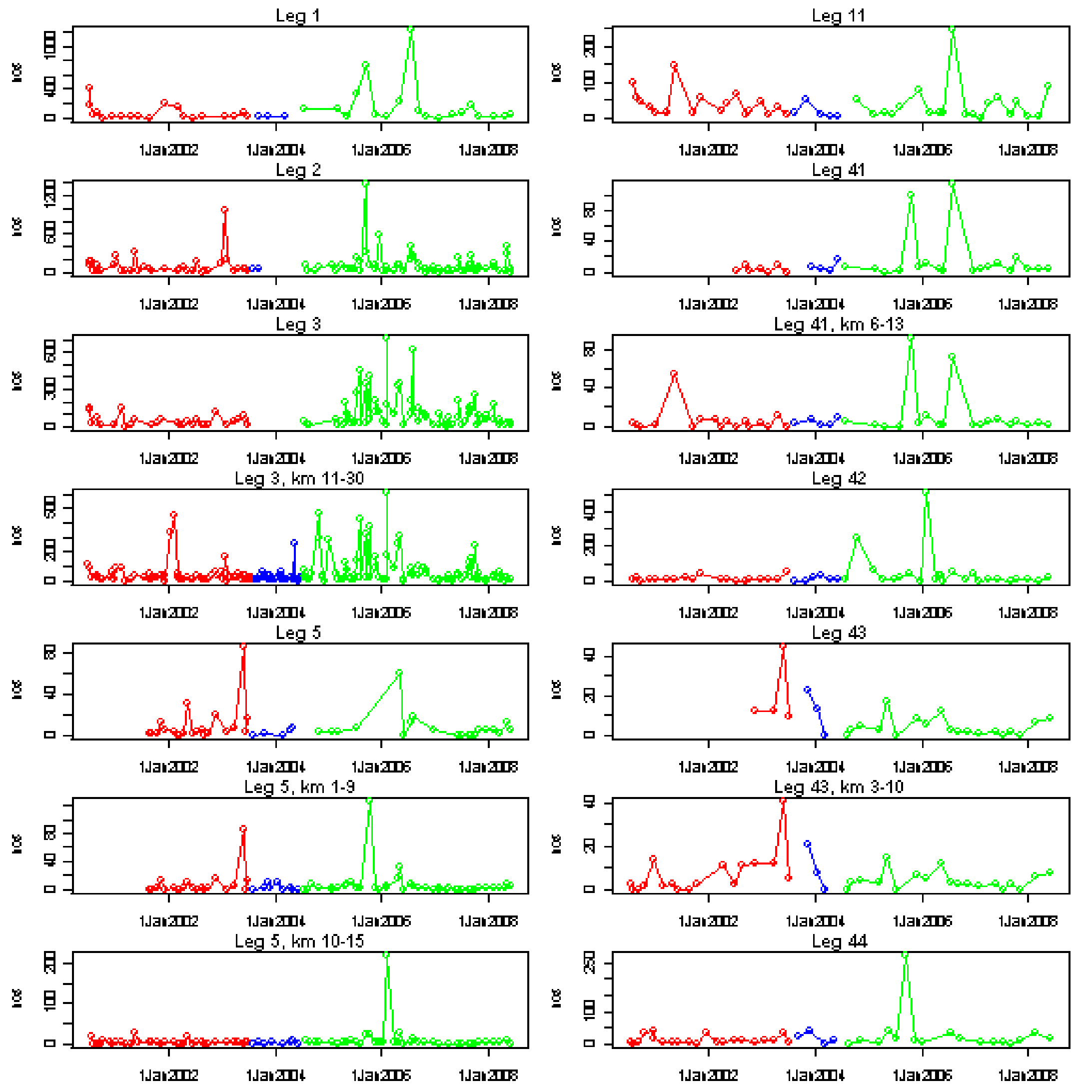
Mean numbers increased on 6 out of 9 legs and declined on the remaining 3 (Table 4.32). However, the only significant changes were a weakly significant ($P<0.05$) increase in Guillemot numbers on the inner Bank leg (leg 3), and a significant decrease in Guillemot numbers on Box leg 43 ($P <0.005$) (Table 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	67.47	33.50	136.11	19	14.00	8.00	25.00	3	0.39		172.11	87.19	417.43	19	0.1860	
2	96.63	61.55	187.31	35	43.50	43.00	43.50	2	0.54		108.50	79.18	184.83	72	0.7780	
3	43.33	30.68	61.71	30				0	1.00		107.30	82.48	148.42	74	0.0127	+
3, km 11-30	41.98	29.02	71.80	61	23.82	14.95	51.07	33	0.21		74.90	54.67	109.01	84	0.0564	
5	9.38	4.48	27.32	21	2.60	0.40	5.00	5	0.42		7.10	3.65	17.57	20	0.6656	
5, km 1-5	7.10	2.48	22.21	21	2.89	0.58	6.11	9	0.61		5.98	2.53	20.14	43	0.8855	
5, km 10-15	3.17	1.74	5.97	35	1.88	0.38	3.88	8	0.67		9.74	3.53	38.46	39	0.3234	
11	40.39	28.61	62.70	18	16.60	5.60	43.80	5	0.16		37.35	22.07	80.41	20	0.8639	
41	3.43	1.14	7.14	7	7.00	2.00	13.50	4	0.32		15.95	5.21	38.25	19	0.2072	
41, km 6-13	5.88	2.29	19.18	17	4.40	1.80	7.20	5	0.87		11.47	3.26	27.22	19	0.4020	
42	11.32	7.16	20.47	19	9.50	3.33	21.33	6	0.79		46.04	17.13	137.01	24	0.2123	
43	19.50	10.50	36.75	4	12.00	0.00	19.67	3	0.69		4.11	2.42	6.58	19	0.0032	--
43, km 3-10	6.82	3.76	14.61	17	9.67	0.00	16.67	3	0.66		3.95	2.53	6.21	19	0.3027	
44	11.05	6.86	17.22	21	17.50	2.75	29.50	4	0.44		26.94	9.47	76.20	17	0.3157	

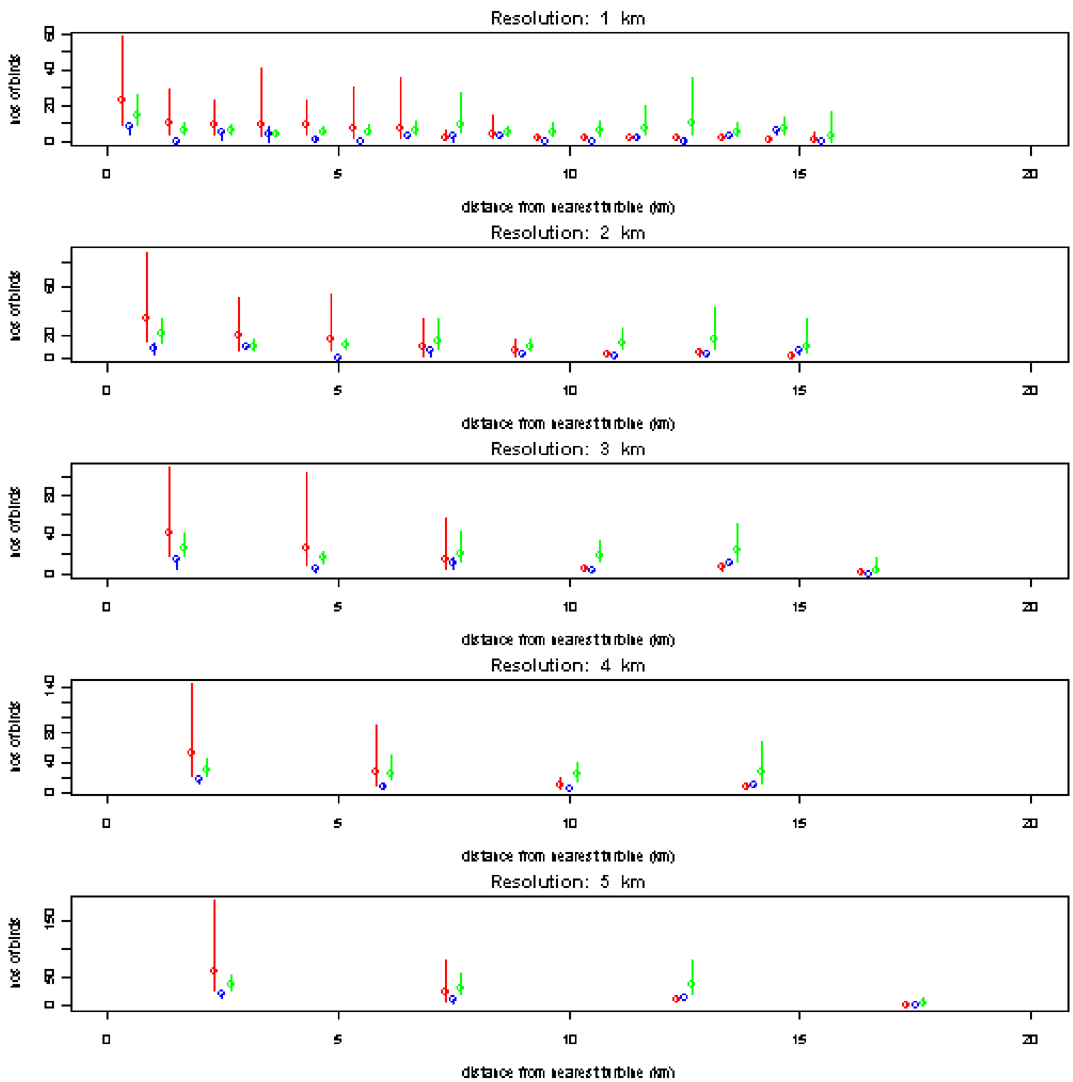
P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with p<0.0001
"+++" or "---" indicates a positive or negative 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 the outer Bank leg (leg 2), there was some redistribution of birds, with numbers declining within c.7 km of the turbines and increasing beyond this distance, although these changes may not be statistically significant (Figure 4.42).

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



By contrast, on the inner Bank leg (leg 3) Guillemot numbers appeared to increase over the full range of distances from the nearest turbine (Figures 4.43 and 4.44).

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

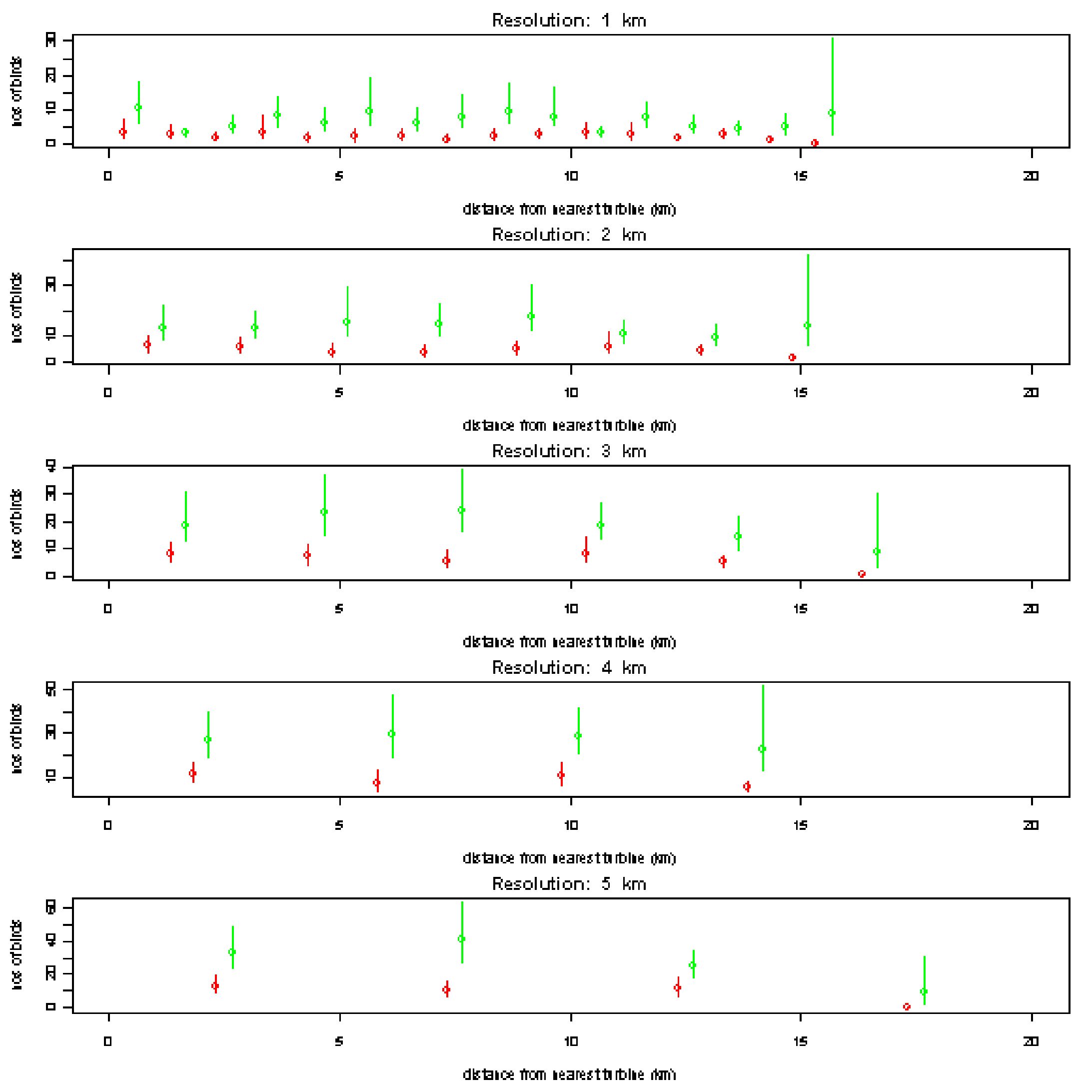
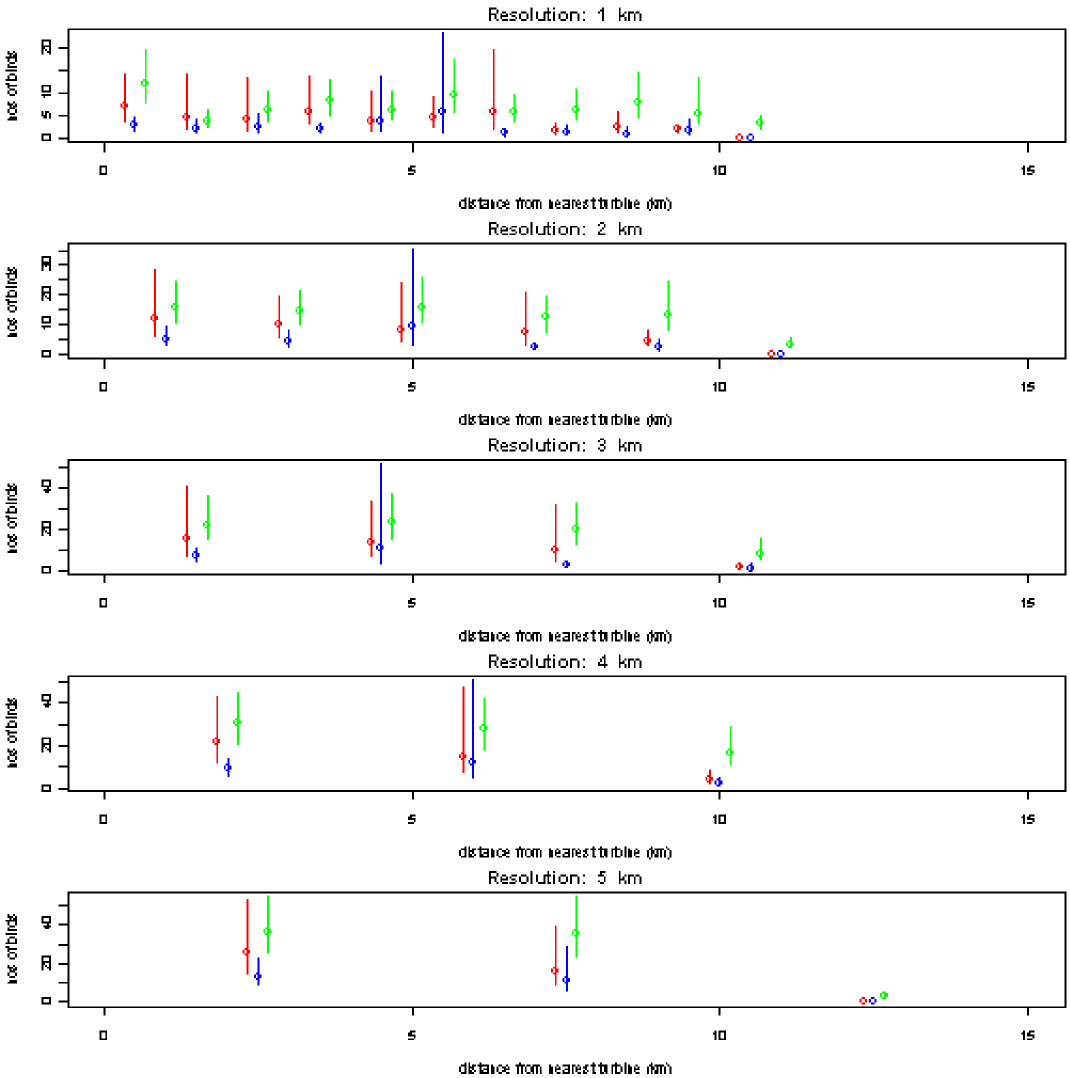


Figure 4.44 Numbers of Guillemots between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



Thus, trends for Guillemots varied between legs, with no overall trend, and while there was no evidence of any detrimental effect of turbines on the number of Guillemots, there may have been some redistribution of birds away from the turbines on the outer Bank leg (leg 2).

4.2.12 Razorbill

Razorbill records are widely distributed throughout the year, with no strong seasonal patterns, and all months apart from June 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	7	Yes
2	206.3	9	Yes
3	83.2	4	Yes
4	121.5	5	Yes
5	123.2	6	Yes
6	15.8	1	No
7	116.5	5	Yes
8	128.8	6	Yes
9	603.9	27	Yes
10	332.6	15	Yes
11	249.9	11	Yes
12	83.8	4	Yes

Most birds were recorded on the Bank legs (legs 2 and 3), and on the offshore Box (legs 1 and 11), with mean numbers of Razorbills apparently increasing on all legs (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	11.29	43.44	14	15	0.45	1.74	51	55
2	31.00	111.42	38	38	0.89	3.18	100	100
3	22.71	78.29	28	26	0.65	2.24	73	70
5	0.63	3.00	1	1	0.04	0.20	5	6
11	9.35	32.35	11	11	0.37	1.29	42	41
41	0.00	5.00	0	2	0.00	0.38	0	12
42	2.11	10.29	3	3	0.18	0.86	20	27
43	1.75	2.72	2	1	0.18	0.27	20	9
44	2.95	9.81	4	3	0.25	0.82	28	26

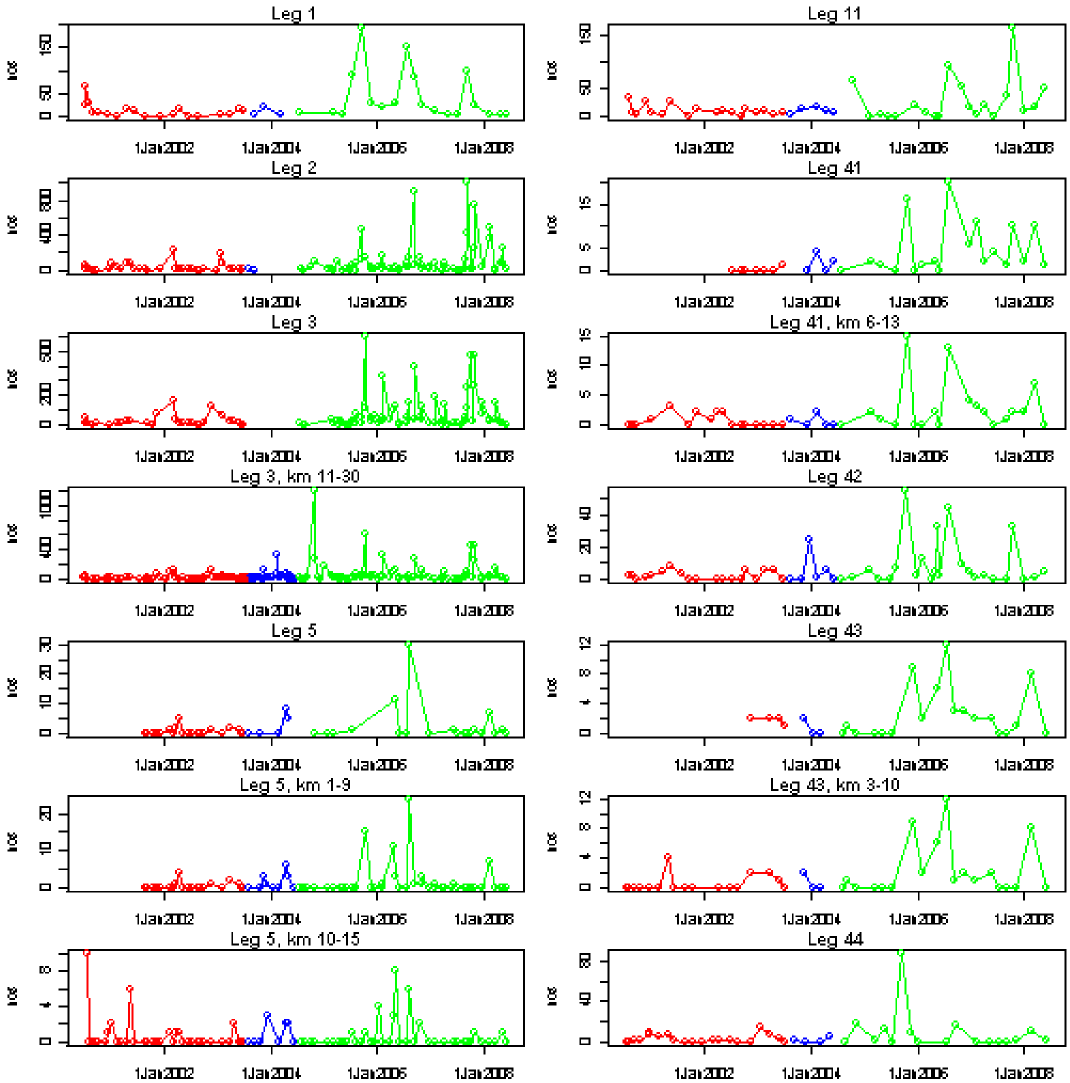
There was a highly significant increase ($P<0.005$) on km 11-30 of the inner Box leg (leg 3) and weakly significant increases ($P<0.05$) on both Bank legs (leg 2 and 3) and Box legs 1, 11,41 and 42 (Table 4.36, Figure 4.45).

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	6.33	26.11	17	9.67	4.00	15.33	3	0.85		43.44	22.09	79.03	18	0.024	+
2	31.00	17.66	56.35	32	5.50	2.00	9.00	2	0.39		111.42	73.61	170.57	65	0.024	+
3	22.71	12.00	47.18	28				0	1.00		78.29	54.74	118.66	66	0.021	+
3, km 11-30	15.12	9.95	23.93	57	32.13	17.19	73.20	30	0.07		73.30	47.21	139.04	76	0.004	++
5	0.63	0.21	1.42	19	2.60	0.00	5.20	5	0.07		3.00	0.65	9.50	17	0.192	
5, km 1-5	0.47	0.16	1.11	19	1.63	0.38	3.38	8	0.08		1.72	0.69	4.06	39	0.331	
5, km 10-15	0.75	0.28	1.75	32	1.00	0.29	1.86	7	0.87		0.77	0.31	1.56	35	1.000	
11	9.35	5.53	14.85	17	10.25	4.00	13.75	4	0.91		32.35	17.29	63.83	17	0.024	+
41	0.00			6	1.33	0.00	2.67	3	0.33		5.00	2.60	8.50	17	0.043	+
41, km 6-13	0.69	0.25	1.19	16	0.75	0.00	1.50	4	1.00		3.18	1.59	6.06	17	0.019	+
42	2.11	1.06	3.44	18	6.00	0.40	15.60	5	0.15		10.29	5.48	20.58	21	0.039	+
43	1.75	1.00	2.00	4	0.67	0.00	1.33	3	0.26		2.72	1.33	4.61	18	0.682	
43, km 3-10	0.60	0.13	1.33	15	0.67	0.00	1.33	3	1.00		2.44	1.06	4.43	18	0.077	
44	2.95	1.47	5.00	19	1.50	0.00	3.75	4	0.52		9.81	3.50	31.83	16	0.138	

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



Within the two Bank legs (legs 2 and 3), there was no evidence of any relationship between the increase in numbers and distance to the nearest turbine (Figures 4.46 to 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

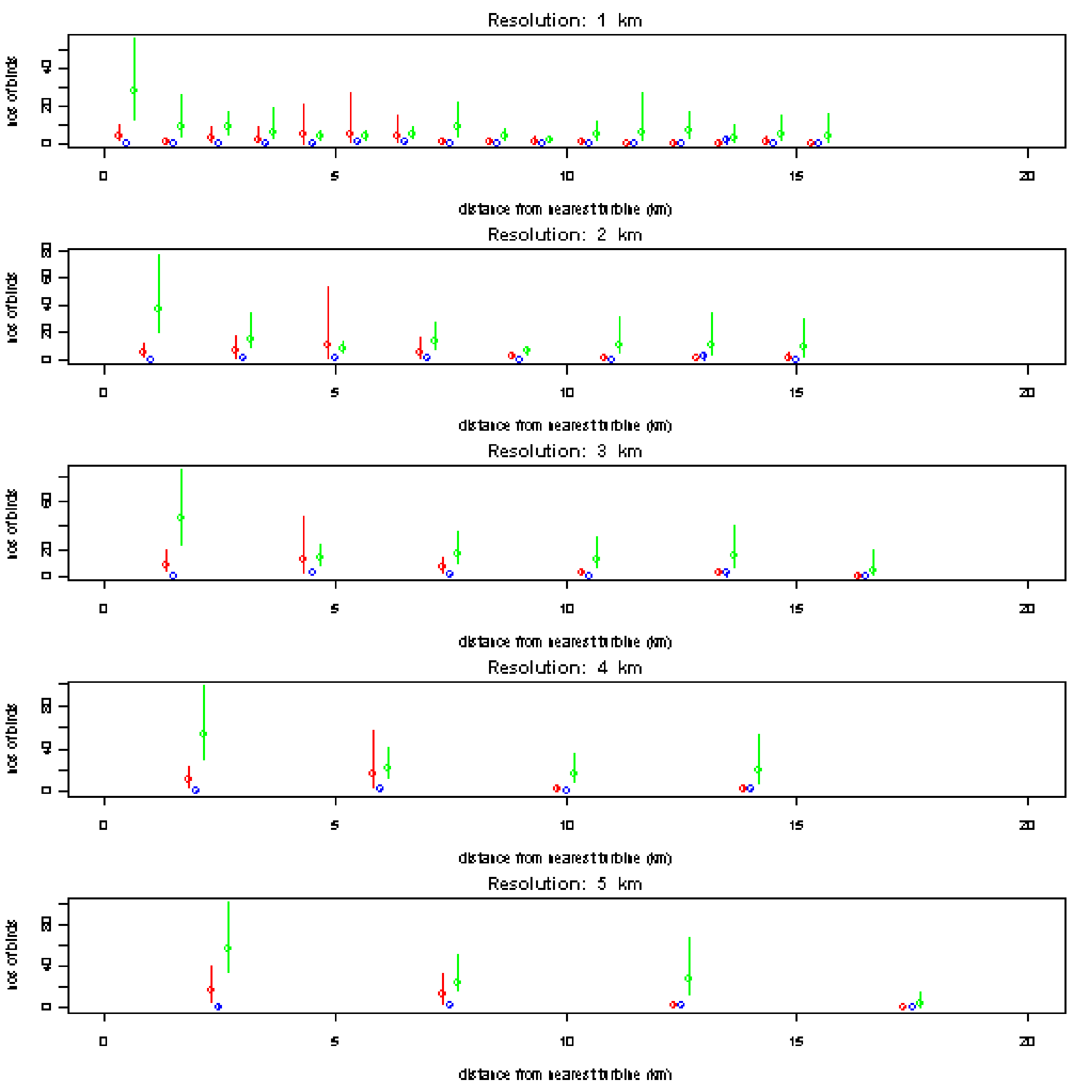


Figure 4.47 Numbers of Razorbills on the inner Bank leg (leg 3) recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions

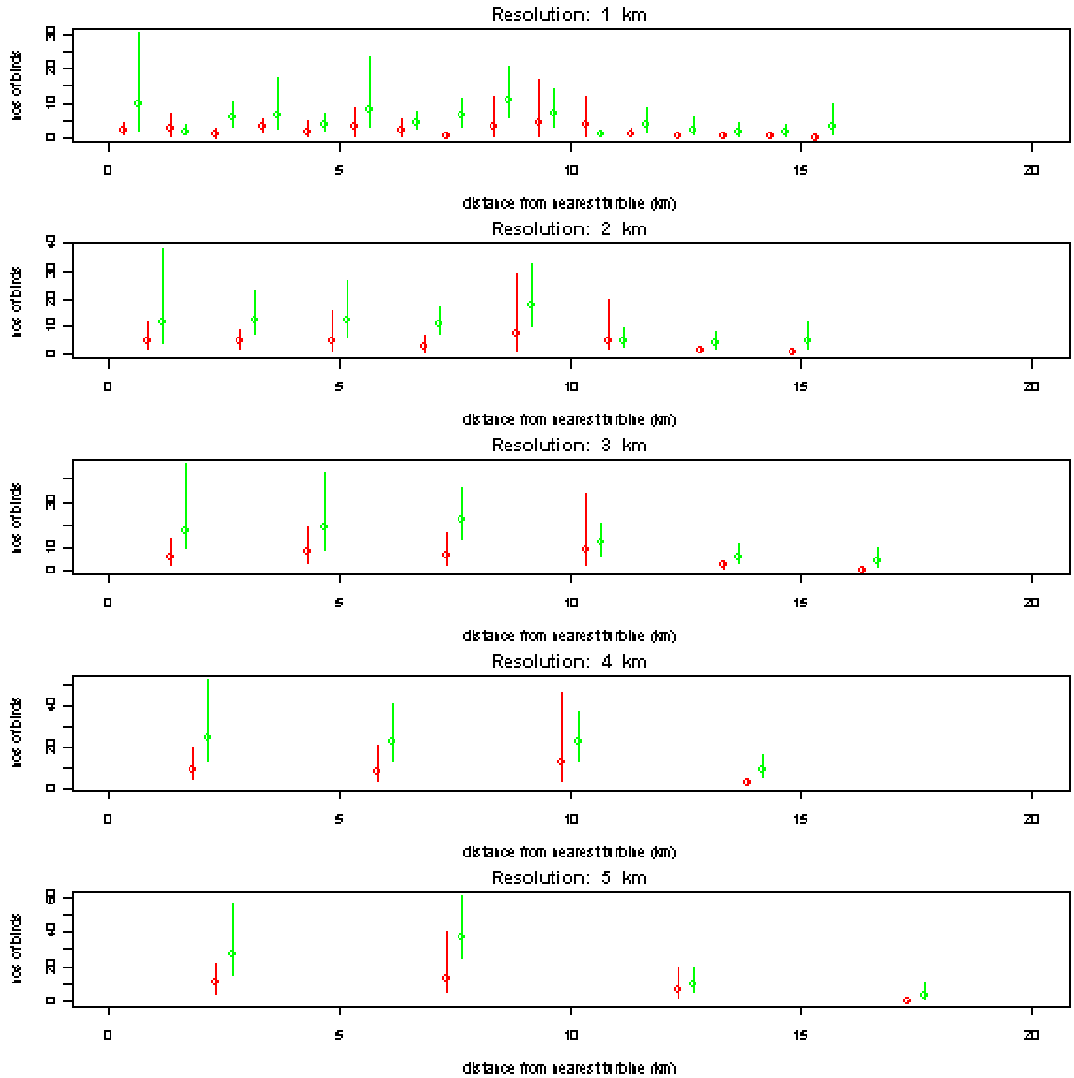
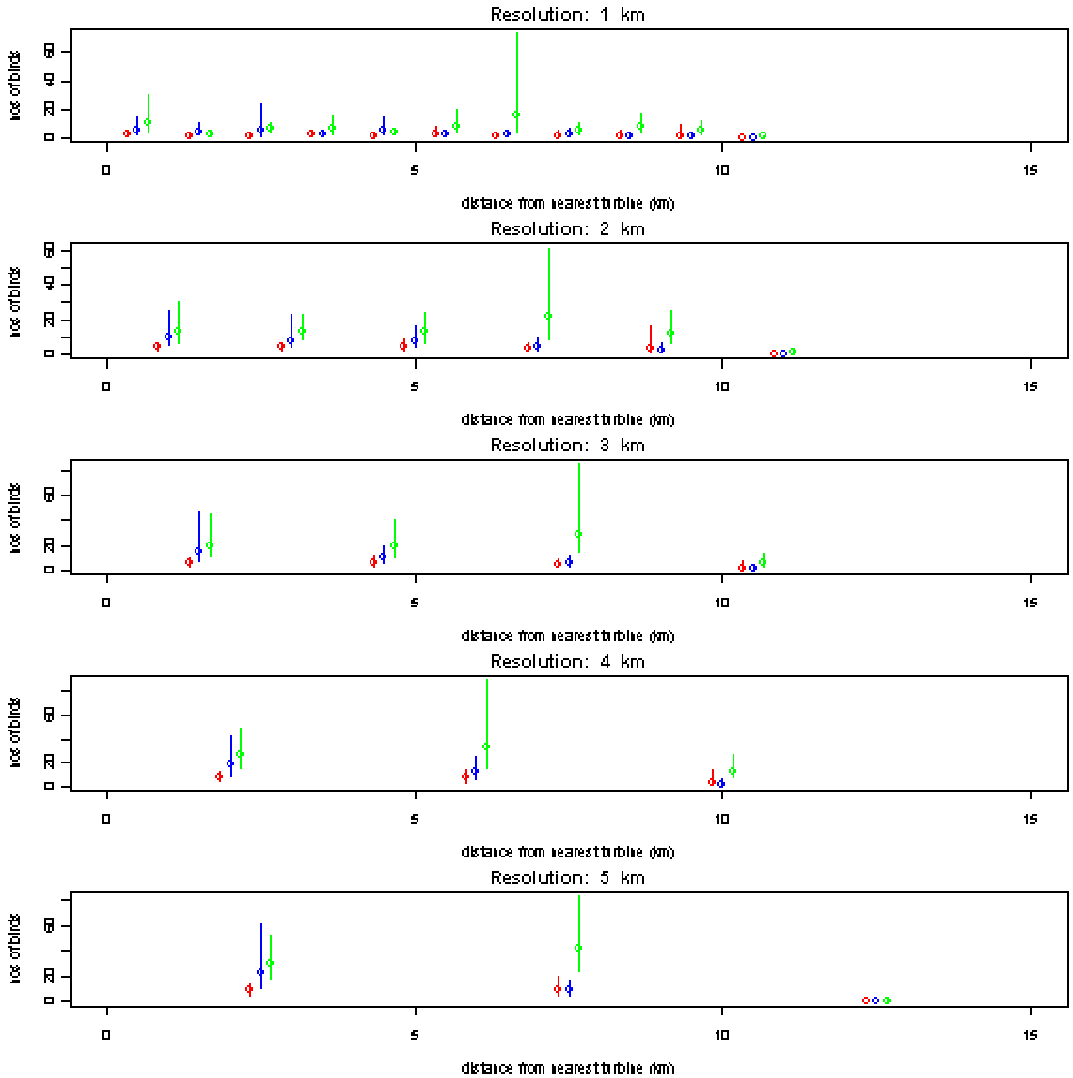


Figure 4.48 Numbers of Razorbills between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



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

4.2.13 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 dominate 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	1113.2	11	Yes
2	821.9	8	Yes
3	313.7	3	Yes
4	512.4	5	Yes
5	719.6	7	Yes
6	203.1	2	Yes
7	949.5	10	Yes
8	645.5	7	Yes
9	2050.7	21	Yes
10	1008.2	10	Yes
11	704.9	7	Yes
12	644.3	7	Yes

Most birds were recorded on the Bank legs (legs 2 and 3), and the offshore 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/km²)		Relative Density	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
1	108.42	286.68	23	24	4.34	11.47	99	97
2	153.06	272.13	32	23	4.37	7.78	100	66
3	81.47	414.34	17	35	2.33	11.84	53	100
5	10.86	10.15	2	1	0.72	0.68	17	6
11	57.28	85.40	12	7	2.29	3.42	52	29
41	4.57	23.05	1	2	0.35	1.77	8	15
42	15.26	59.25	3	5	1.27	4.94	29	42
43	26.75	7.26	6	1	2.68	0.73	61	6
44	16.14	38.76	3	3	1.35	3.23	31	27

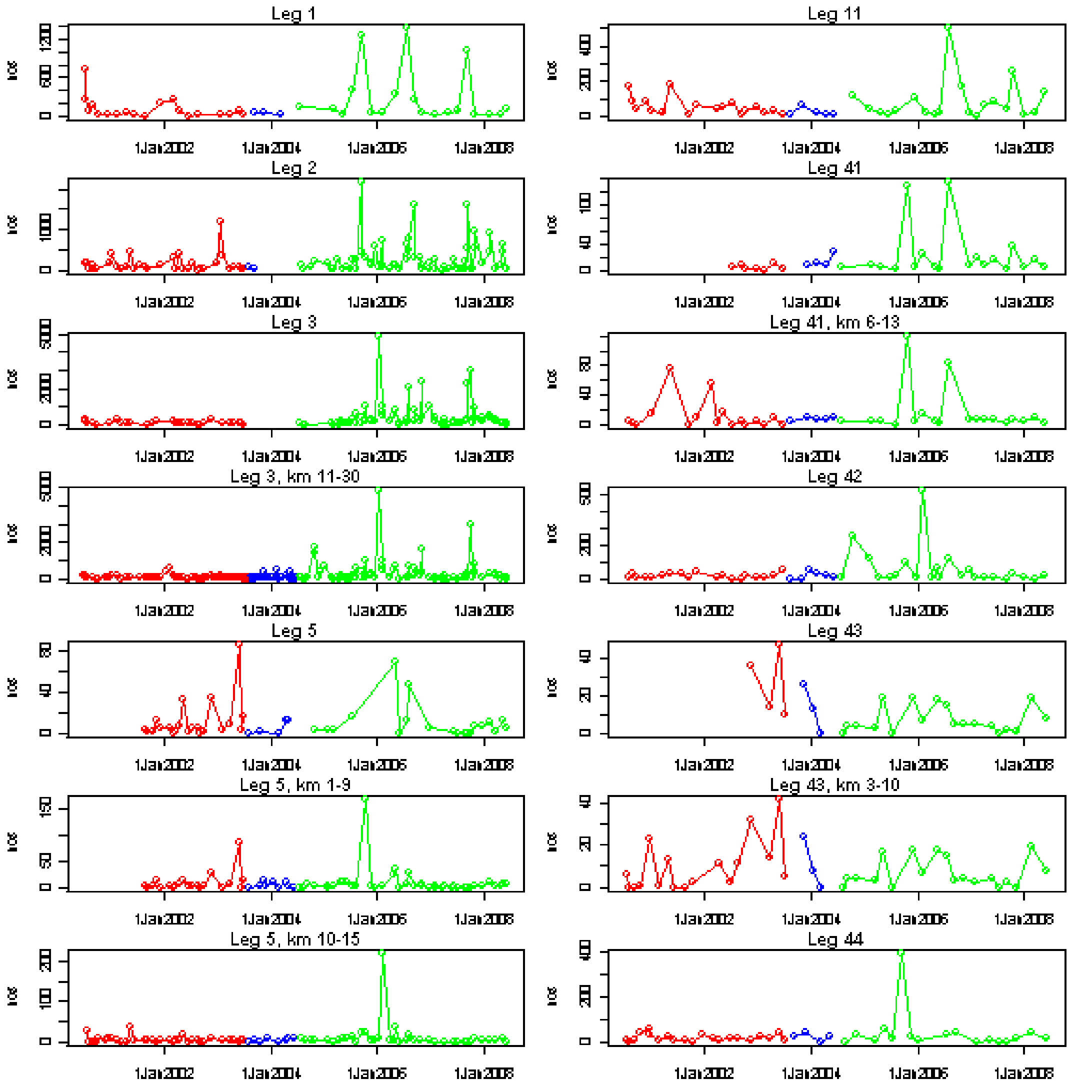
Mean numbers apparently increased on 7 out of 9 legs. For the inner Bank leg (leg 3), there was a highly significant increase on km 11-30 ($P<0.001$) and a weakly significant increase ($P<0.05$) for the leg as a whole. A significant decline ($P<0.01$) occurred on the inner Box leg 43 (Table 4.39, Figure 4.49).

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	108.42	56.94	238.00	19	30.00	13.00	39.67	3	0.38		286.68	138.01	524.48	19	0.1103	
2	153.06	99.29	265.17	35	50.50	48.00	50.50	2	0.41		272.13	201.76	402.23	72	0.1023	
3	81.47	59.55	115.86	30				0	1.00		414.34	289.54	668.78	74	0.0167	+
3, km 11-30	64.16	48.08	93.02	61	69.94	40.34	124.69	33	0.79		313.45	208.90	549.62	84	0.0007	+++
5	10.86	5.00	23.73	21	5.40	0.40	10.40	5	0.59		10.15	5.07	20.99	20	0.9128	
5, km 1-5	8.29	3.37	23.40	21	4.33	1.56	7.75	9	0.67		8.30	3.77	25.18	43	1.0000	
5, km 10-15	4.37	2.43	8.24	35	3.88	1.25	6.52	8	0.92		10.72	4.59	37.77	39	0.3964	
11	57.28	40.83	91.25	18	26.00	12.80	56.80	5	0.17		85.40	50.42	179.56	20	0.4079	
41	4.57	2.29	7.43	7	13.25	7.75	22.75	4	0.03	+	23.05	11.11	53.77	19	0.1029	
41, km 6-13	11.82	4.53	27.27	17	6.80	4.80	8.30	5	0.82		15.58	5.26	35.60	19	0.6980	
42	15.26	10.20	21.68	19	17.67	5.83	38.09	6	0.76		59.25	28.75	128.76	24	0.0692	
43	26.75	12.00	41.50	4	13.00	0.00	21.67	3	0.31		7.26	4.42	10.48	19	0.0043	--
43, km 3-10	9.59	5.24	17.14	17	10.67	0.00	18.67	3	0.94		6.74	4.16	10.40	19	0.4035	
44	16.14	10.16	22.95	21	20.00	4.75	29.00	4	0.67		38.76	13.54	130.00	17	0.2984	

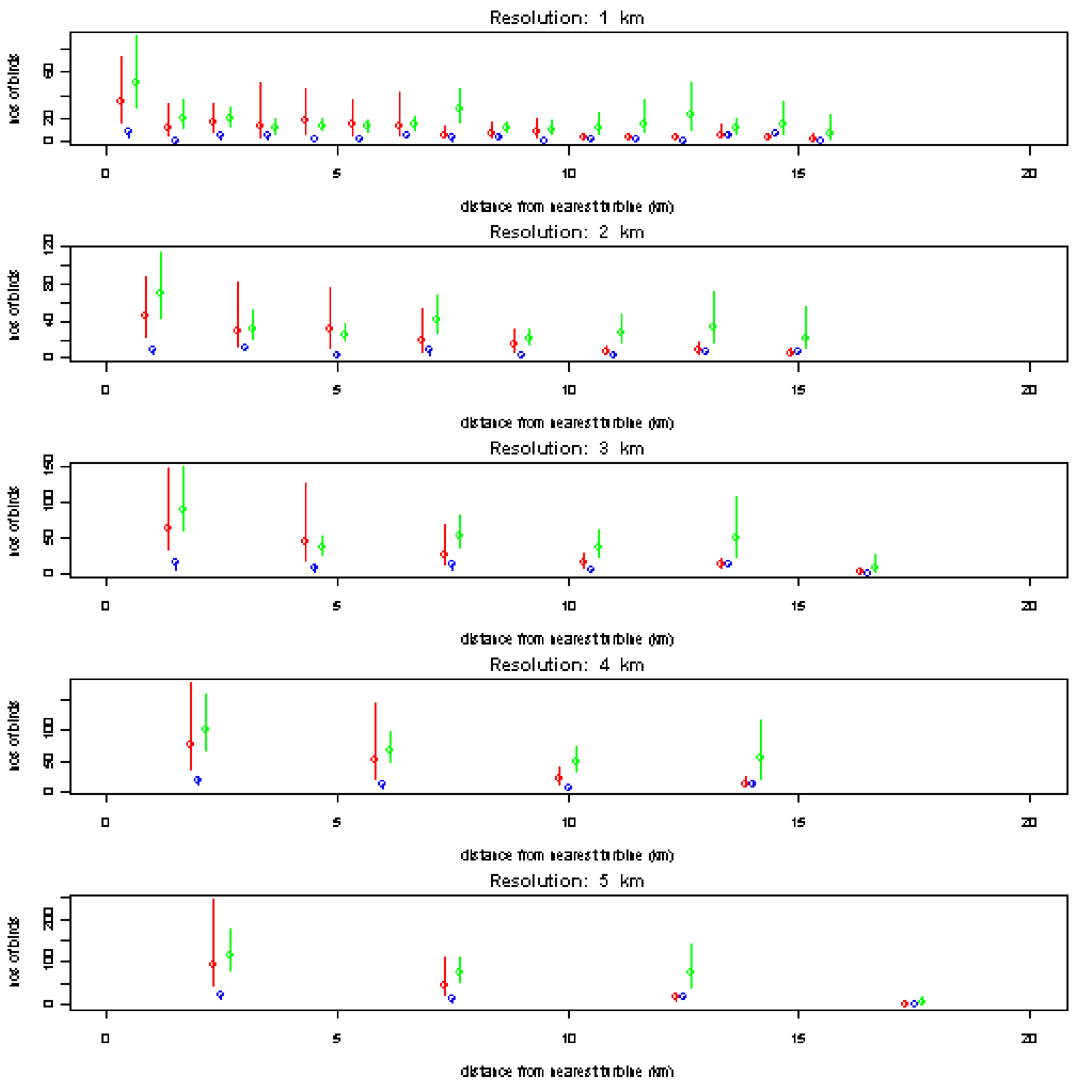
P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with $p<0.0001$
"+++" or "---" indicates a positive or 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 4.49 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/Razorbills on the outer Bank leg (leg 2) (Table 4.39), Figure 4.50 suggests that perhaps there was some redistribution of birds, with little change or a small decline in numbers within c.7 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/Razorbills appeared to have increased over the full range of distances from the nearest turbine (Figures 31 and 32).

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

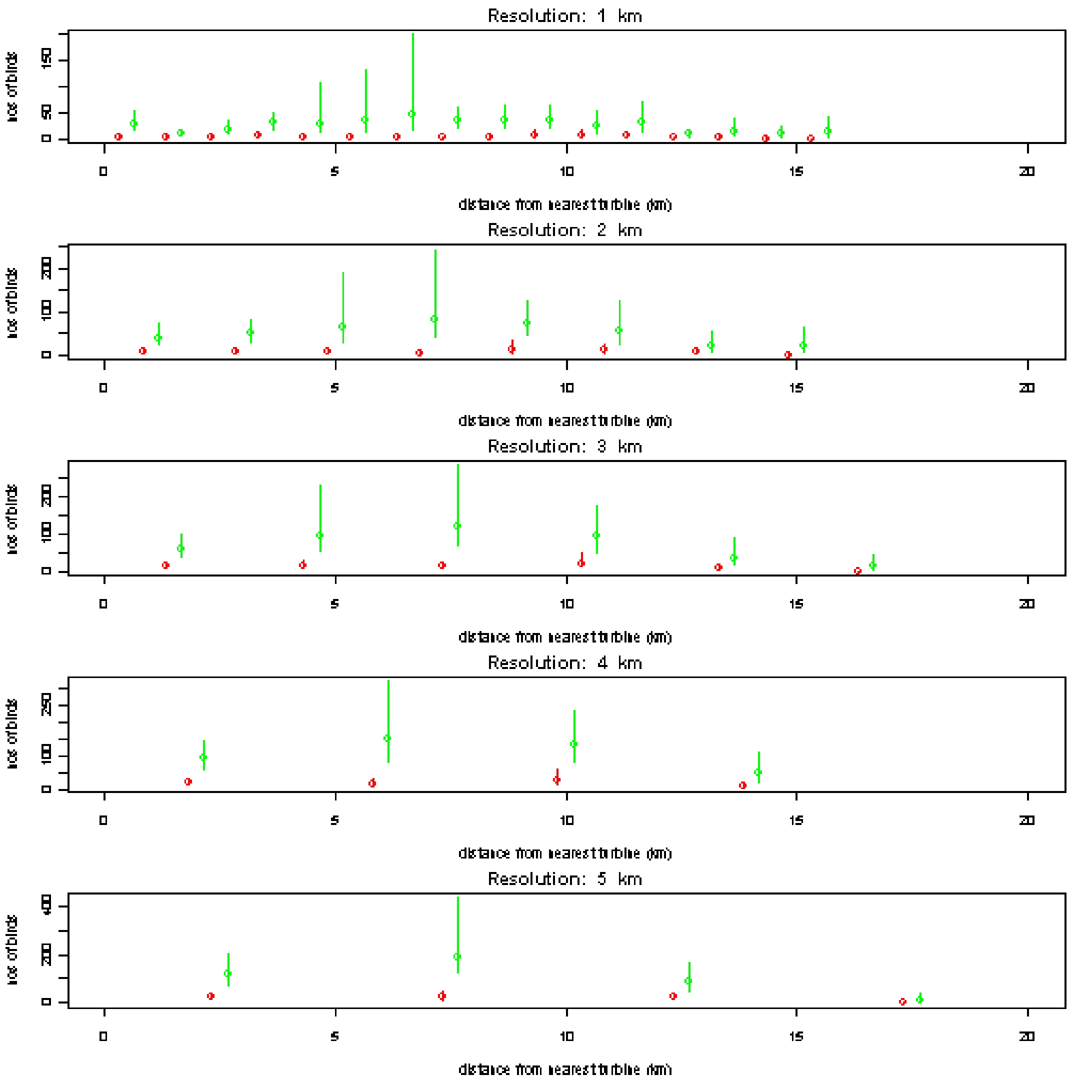
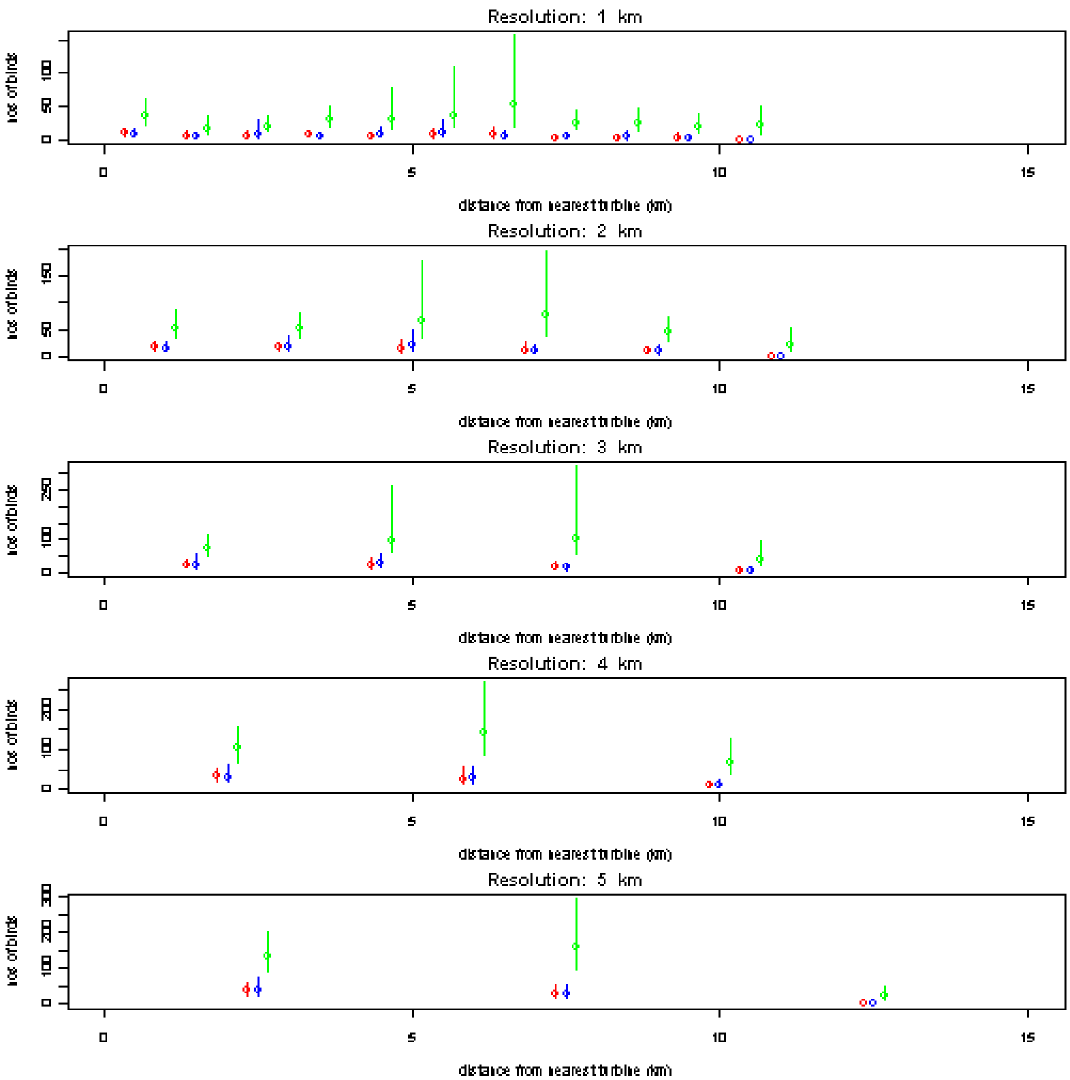


Figure 4.52 Numbers of Guillemots or Razorbills between km 11-30 of the inner Bank leg (leg 3), recorded at different distances from the nearest turbine before (red), during (blue) and after (green) turbine installation, at different resolutions



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 individual species were robust to the presence of some birds which could not be identified to species level.

4.2.14 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	9	Yes
3	2.1	3	Yes
4	5.7	8	Yes
5	10.6	14	Yes
6	5.9	8	Yes
7	9.0	12	Yes
8	9.5	13	Yes
9	13.1	18	Yes
10	4.2	6	Yes
11	3.9	5	Yes
12	1.8	2	Yes

Records were widely dispersed across the legs, although the Bank legs (2 and 3) and the outermost Box leg (leg 1) tended to be the most important (Table 4.41, Figure 4.53).

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	1.06	20	15	0.06	0.04	94	51
2	1.52	1.69	21	24	0.04	0.05	71	58
3	2.13	1.01	30	15	0.06	0.03	100	35
5	0.26	0.35	4	5	0.02	0.02	29	28
11	0.39	0.47	5	7	0.02	0.02	26	23
41	0.00	0.47	0	7	0.00	0.04	0	44
42	0.71	0.29	10	4	0.06	0.02	97	29
43	0.00	0.61	0	9	0.00	0.06	0	73
44	0.68	1.00	10	14	0.06	0.08	94	100

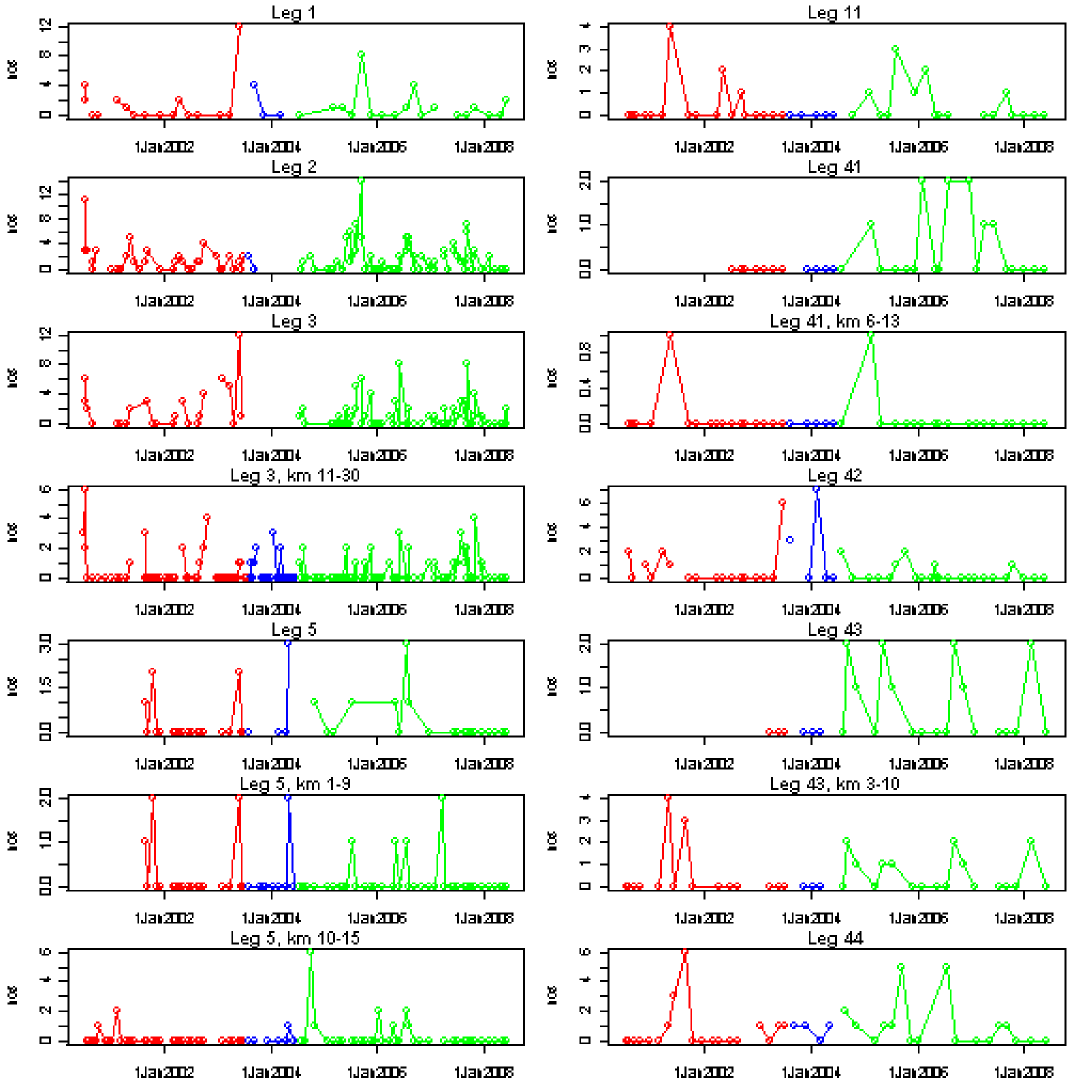
Statistical analysis detected a weakly statistically significant decline ($P<0.05$) in the numbers of Harbour Porpoise recorded on the inner Bank leg (leg 3), with a halving in the mean numbers recorded (Table 4.42), although there were no obvious trends in Figure 4.53.

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	0.50	4.19	16	1.33	0.00	2.67	3	1.00		1.06	0.44	2.39	18	0.70	
2	1.52	1.00	2.55	33	1.00	0.00	2.00	2	0.83		1.69	1.19	2.36	68	0.76	
3	2.13	1.22	3.78	23				0	1.00		1.01	0.64	1.51	69	0.03	-
3, km 11-30	0.57	0.31	1.02	51	0.32	0.11	0.68	28	0.40		0.42	0.24	0.62	79	0.43	
5	0.26	0.00	0.68	19	0.75	0.00	1.50	4	0.23		0.35	0.10	0.75	20	0.83	
5, km 1-5	0.26	0.05	0.58	19	0.22	0.00	0.67	9	1.00		0.12	0.02	0.26	42	0.41	
5, km 10-15	0.09	0.00	0.27	33	0.14	0.00	0.43	7	1.00		0.35	0.14	0.96	37	0.22	
11	0.39	0.06	1.11	18	0.00			5	0.68		0.47	0.12	0.94	17	0.87	
41	0.00			7	0.00			4	1.00		0.47	0.16	0.79	19	0.22	
41, km 6-13	0.06	0.00	0.18	17	0.00			5	1.00		0.05	0.00	0.16	19	1.00	
42	0.71	0.24	1.98	17	2.00	0.00	4.80	5	0.24		0.29	0.08	0.58	24	0.28	
43	0.00			3	0.00			3	1.00		0.61	0.22	0.94	18	0.36	
43, km 3-10	0.47	0.00	1.13	15	0.00			3	1.00		0.56	0.22	0.93	18	0.87	
44	0.68	0.21	1.68	19	0.75	0.00	1.00	4	1.00		1.00	0.41	2.00	17	0.61	

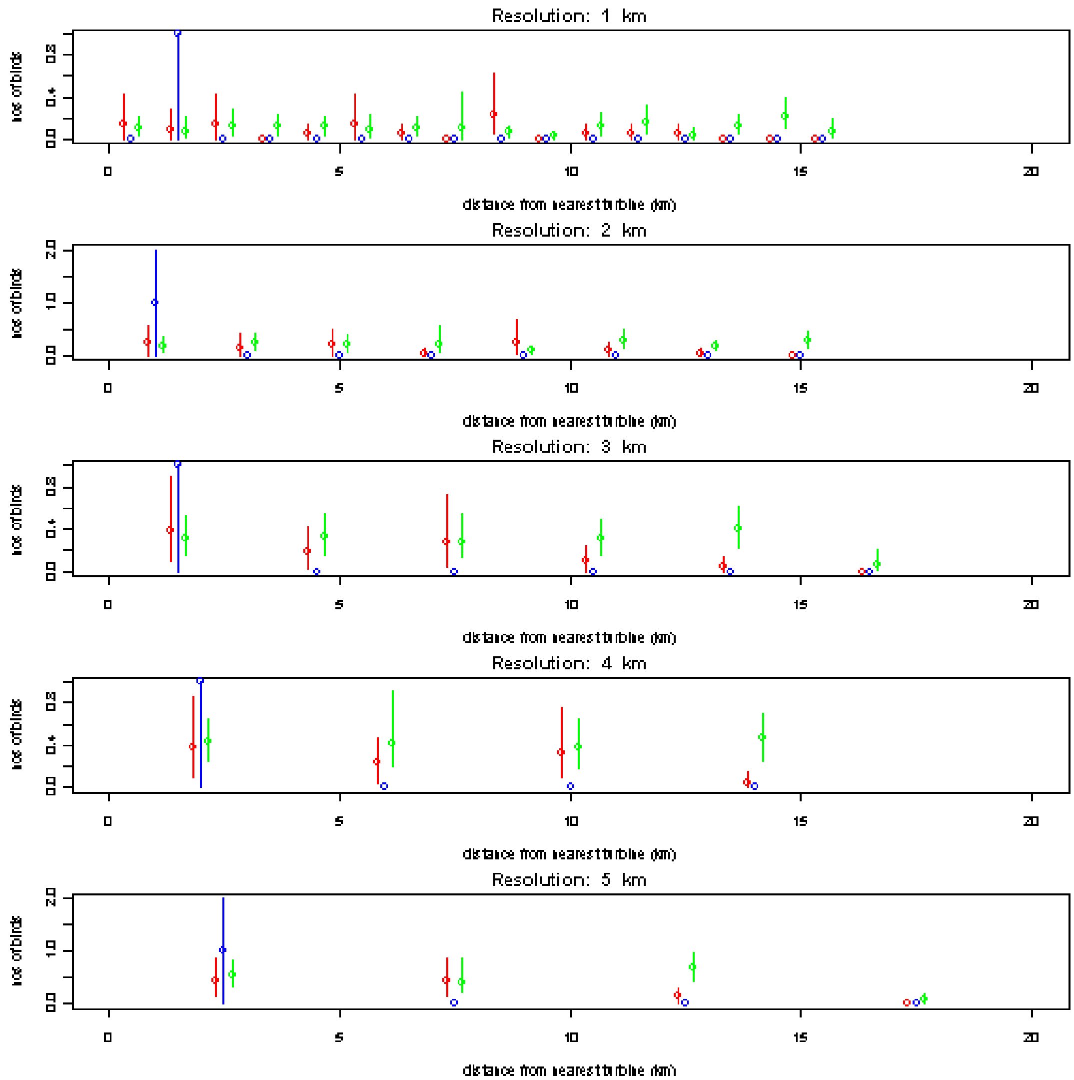
P gives the probability of a change as or more extreme to that observed occurring by chance
Sig. identifies statistically significant changes along with the direction of change
"++++" or "----" indicates a positive or negative change respectively with p<0.0001
"+++" or "---" indicates a positive or negative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



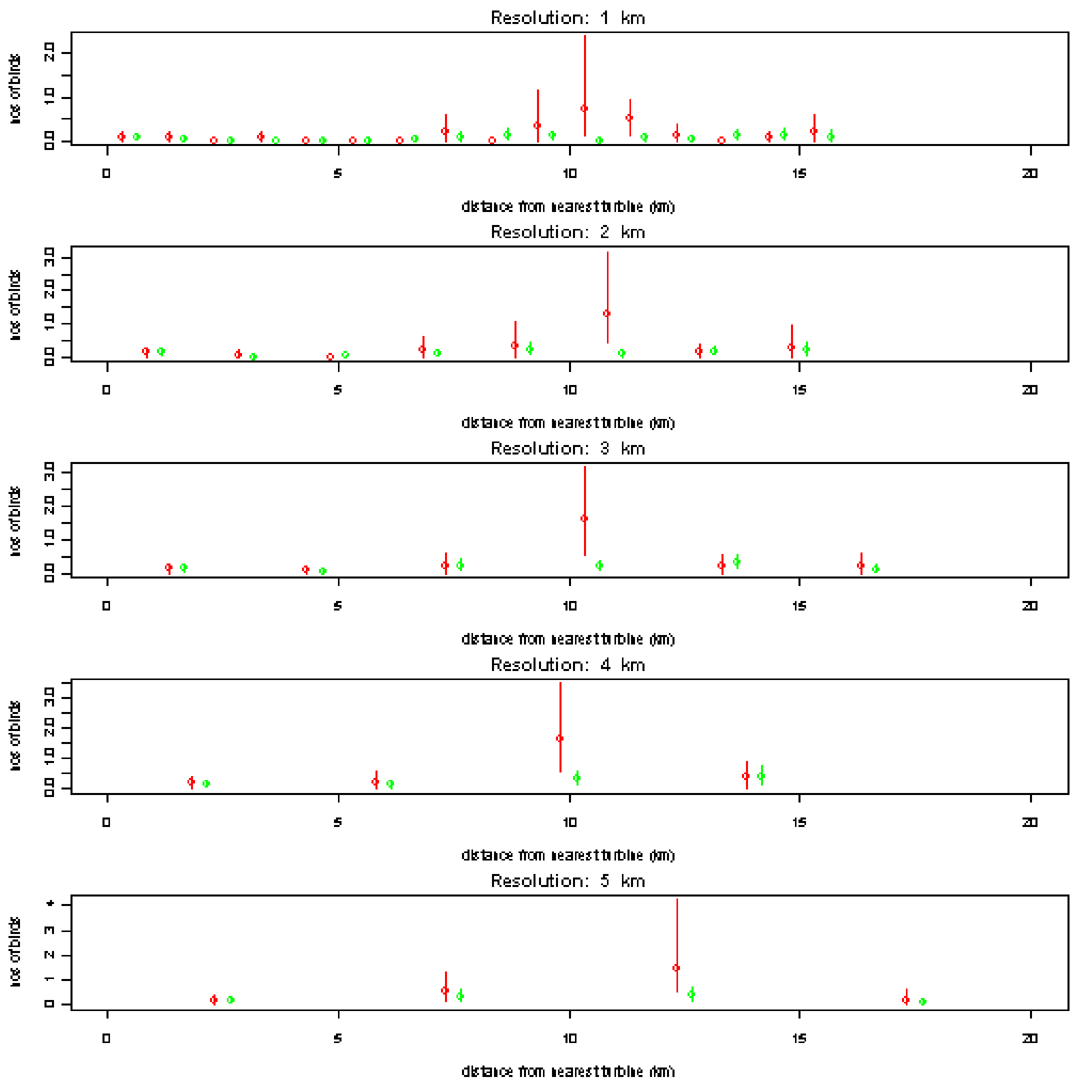
Although there was no overall change in the numbers of Harbour Porpoise recorded on the outer Bank leg (leg 2), there was some suggestion, with 5 km resolution, that numbers increased at 11-15 km from the turbines following installation, but did not change significantly closer in (Figure 4.54).

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



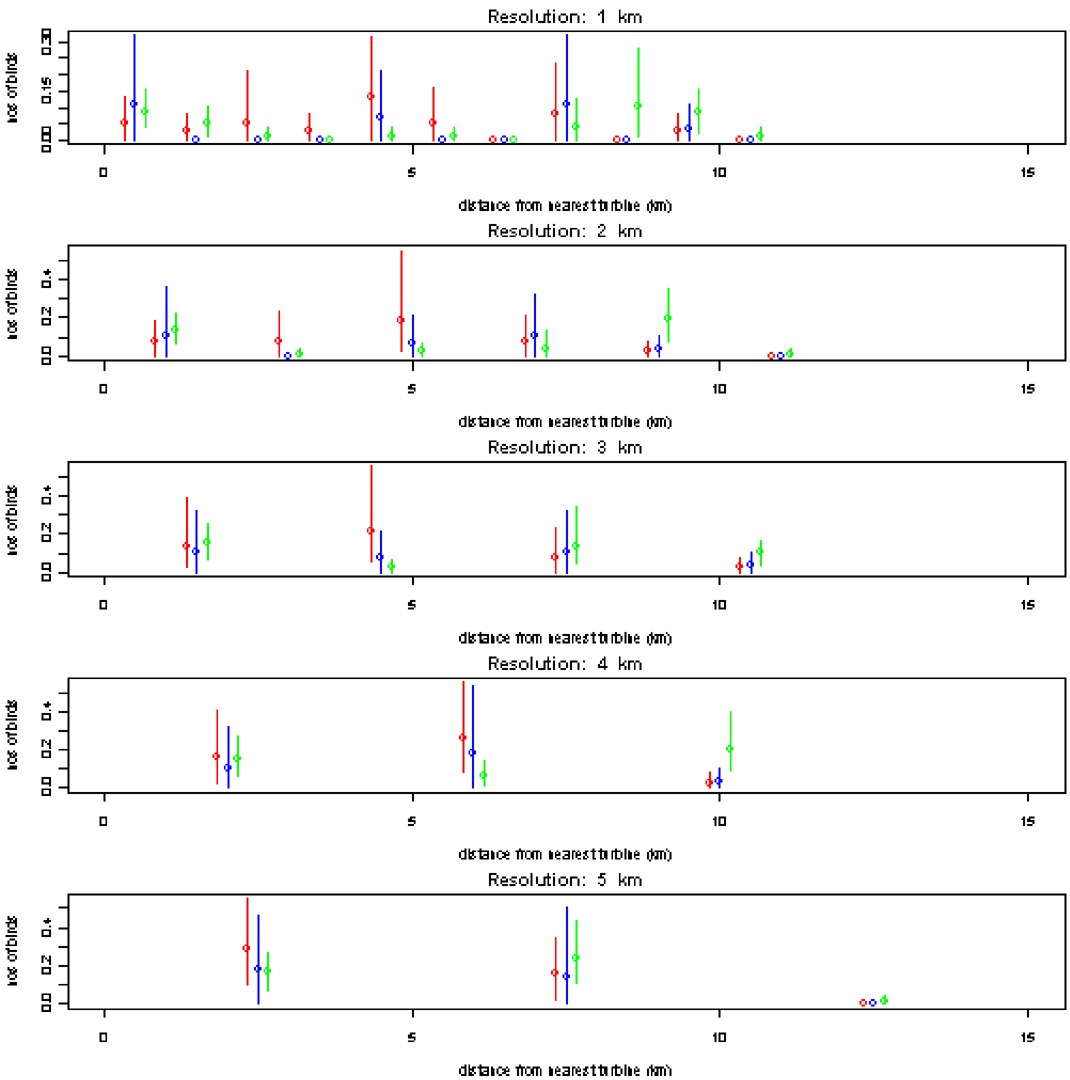
Before turbine installation, most of the Harbour Porpoise records on leg 3 occurred 8 to 12 km from where the turbines would be installed, and this is where the principal decline occurred (Figure 4.55). The scarcity of Harbour Porpoise records before turbine installation closer to the installation location prevents any meaningful interpretation of the effects of proximity to the turbines on the change in numbers.

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



When surveys covering km 11-30 of leg 3 were considered, giving a larger sample size, there is no evidence of any relationship between distance from the nearest turbine and the change in abundance of Harbour Porpoise following the installation of turbines (Figure 4.56).

Figure 4.56 Numbers 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 the numbers of Harbour Porpoises recorded on the inner Bank leg (leg 3), no strong trends in Harbour Porpoise numbers were obvious in Figure 4.53 for any of the legs. There is 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 (leg 3), and increase in Harbour Porpoise numbers at greater distances from the turbines on outer Bank leg (leg 2), raises this possibility.

5. Review of the impacts of offshore wind farms on birds at sea since 2007

5.1 Operating Wind Farms

There are several offshore wind farms currently in operation. Impacts arising from projects that have been developed since 2003 were discussed in the 2007 Final Report (Cork Ecology 2007b). Previous reports have discussed impacts from older projects (e.g. CWC 2006).

5.2 Projects with consent/under construction

Several projects that have been consented or already under construction were discussed in the 2007 Final Report (Cork Ecology 2007b). Additional information on new projects is included here.

Horns Rev II – Denmark

A second offshore wind farm at Horns Rev (Horns Rev II) is currently under construction. Horns Rev II is expected to consist of 95 wind turbines at 2.3 MW and 3 bigger test turbines with a total maximum effect of 15 MW. Horns Rev II will be situated 23 km northeast of the existing offshore wind farm Horns Rev 1. The offshore wind farm and the landing facilities will be commissioned in 2009. Impacts on birds arising from the project were summarised from the Non-Technical Summary (Dong Energy 2006).

Impacts from construction

Impacts in relation to birds were expected to be temporary. Construction activities will be concentrated in the summer months when very few birds are present in the Horns Rev area compared to the rest of the year.

Collision Risk

In relation to birds, there was a risk of collision between rotating turbine blades and migrating birds, and also the possibility that birds might avoid using the wind farm as a resting and foraging area due to the presence of wind turbines.

However, studies at the two demonstration offshore wind farms at Horns Rev and Nysted have shown that the risk of collision is minimal – the migratory birds detect the wind farm at large distances in the daytime as well as at night. The birds that enter the wind farm either fly through the wind farm along the wind turbine rows or leave the wind farm again immediately. The collision risk is thus estimated to be negligible.

The site is not thought to be an important resting and foraging area for most species with the exception of Common Scoter. Since 1999, when aerial bird counts were initiated in connection with the preliminary investigations for Horns Rev 1, and up until the spring of 2006, large numbers of Common Scoter have been recorded along the coast and on the reef. In the 2005/2006 winter, between 2,576 and 21,888 Common Scoter were recorded on the entire reef on six aerial bird counts. A significant number of these birds were recorded within the wind farm area. Although there is a potential tendency towards habituation at Horns Rev 1, it is still too soon to draw any conclusions. Hence the worst-case scenario was that the presence of the wind farm would entail the loss of an area of Common Scoter habitat corresponding to the size of the wind farm area.

Cumulative impacts

It is the first time that two large offshore wind farms have been located in the same local area, and therefore it is not possible in advance to determine if cumulative impacts will occur. The minimum distance between the two wind farms is approximately 14 km, therefore it was considered unlikely that the wind farms would constitute a barrier to migrating birds, just as they were not expected to have a blocking effect for the movement of fish and marine mammals.

The worst-case scenario given was that the presence of the two wind farms would result in the loss of common scoter habitat corresponding to the size of the two wind farm areas. The individuals would have to forage in other parts of the area, hence increasing the pressure on foraging locations in general in the area.

Monitoring

An environmental monitoring programme was recommended to investigate if migrating birds would use the 14 km wide "opening" between the two wind farms to migrate, as well as an investigation of the use of the area by Common Scoter, including determining any habituation effects.

Rødsand II offshore wind farm – Denmark

An EIA for a second offshore wind farm at Rødsand (Rødsand 2) has recently been published (Kahlert *et al* 2007). The total installed capacity will be 200 MW, and is expected to be producing electricity by September 2011. The site of the wind farm covers an area of 35 square kilometre and will be around 3 km west of the existing offshore farm at Rødsand.

The aim of the ornithological studies was to provide data in support of an impact assessment analysis for those staging, migrating and breeding birds that exploit and/or pass through the main proposal site for the Rødsand 2 development and two possible alternatives. The main findings of the EIA are summarised below (from Kahlert *et al* 2007).

Data from aerial surveys of resting and staging birds carried out during the Nysted offshore wind farm demonstration project were used in the EIA. In addition to other migration studies conducted for the Nysted offshore wind farm demonstration project, a combined radar and observational study involving six observation days was carried out in October 2006, the main migration period, in order to compile some basic information on the flight behaviour of terrestrial bird species in the area in order to assess whether terrestrial birds would be funnelled into Hyllekrog and on their onward migration cross the main proposal site of the Rødsand 2 wind farm in significant numbers.

A number of staging and resting bird species were found in high numbers in the study area. Most of these were almost exclusively found in the shallow and sheltered lagoon (Mute Swan, Brent Goose, Mallard and Goldeneye) and avoided the areas of the proposed wind farm sites. Common Eiders and Long-tailed Ducks were abundant in the study area, and positively selected the areas of the proposed wind farm sites.

Long-tailed Duck was shown to avoid the wind farm site and a zone of 2 km around the existing Nysted wind farm. Effects caused by the physical change of the habitat were considered insignificant. However, an estimated 344 to 1,244 Long-tailed Ducks would be displaced as a result of disturbance effect in the main wind farm proposal. The corresponding figures for the Alternative 1 wind farm site were between 286 and 1,128, and between 667 and 1,926 for the Alternative 2 site. With a Baltic/ western European population of 4.6 million Long-tailed Ducks this magnitude of displacement is insignificant in an international context. However this effect was considered small to moderate on a national scale (1.5 and 4.1% of the national wintering numbers of the species).

Common Eider positively selected for all three proposed wind farm sites, but showing least affinity for the Alternative 1 site. Displacement effects from wind turbines were not demonstrated during the investigations at the existing wind farm for this species, and the effect on the Rødsand 2 proposed sites was expected to be small for resting and staging Common Eiders.

Divers, Red-necked Grebe and Little Gull were present in the study area in low numbers, but are of conservation interest. Divers were shown to avoid wind farm sites and a 2 km zone around the farms. The Alternative 2 site involved most divers, while the main site involved least. The presence of divers in the study area did not reach numbers of international or national importance.

A review and field study of occurrences of migrating birds confirmed that the study area including the three proposed wind farm sites and the surrounding waters were of remarkable significance and part of the African-Eurasian migration route. Five species; Cormorant, Dark-bellied Brent Goose, Pintail, Common Eider and Little Gull were shown to occur in international important numbers, i.e. more than 1% of the flyway population was observed either during spring or autumn.

Two autumn migration hot-spots for terrestrial birds such as Cranes, birds of prey, pigeons and passerines were identified at Hyllekrog and Gedser Odde. Hyllekrog is less than 1 km north and northwest of the main proposal for a wind farm with an overlap of the main flight corridor at the western fringe of the proposed area. Furthermore, there is a potential risk that wind drift and attraction effects could increase the migration volume of terrestrial birds significantly in the main proposal site and be associated with enhanced collision risk. For this reason, it was suggested that individual turbines in the main proposal area are placed as far east and south as possible in order to minimise this potential enhance collision risk.

While there was some uncertainty about the avoidance response, potential attraction effects and collision risk among terrestrial birds, waterbirds were to a large extent expected to avoid a future Rødsand 2 wind farm given the experience from the Nysted wind farm. Despite the cumulative effects of increased migration distances likely to be undertaken at two offshore wind farms placed in the vicinity of each other, the added migration distance of Common Eiders, the dominant waterbird species, was insignificant compared to the total distance of their entire migration journey. More eiders were expected to collide with the turbines as their numbers could be doubled. However, only a small impact was expected as on mean not more than 100 Common Eiders were predicted to collide during the autumn season.

Offshore Wind Farms – Germany

Currently, only one offshore wind turbine had been installed in the German North Sea. However there are 19 approved North Sea offshore wind farms that are in the first phase of construction, with a further 46 projects currently in the approval process (BSH 2007). In the Baltic Sea, there is also currently only one offshore wind turbine in operation, with 5 approved offshore wind farms and a further 6 projects currently in the approval process.

However, 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.

Alpha Ventus

Alpha Ventus is the first German offshore wind farm. This pioneering project, situated approximately 45 kilometres to the north of Borkum in the German Bight, will provide essential experience in building and operating offshore wind farms. The project consists of 12 5MW turbines, and construction is expected to begin in the middle of July 2009.

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.

Djursland/Anholt Offshore Wind Farm - Denmark

Following experience with previous tenders for offshore wind farms in Denmark, the Danish Energy Agency has adjusted the previous tendering procedure, which was used for the tenders for Rødsand II and Horns Rev II. This means that the 400 MW offshore wind farm to be established between Djursland and Anholt will first undergo site development before being opened for public tenders. The Danish TSO, Energinet.dk, is responsible for site development, which has commenced.

The Danish Energy Agency expects to offer the 400 MW farm for tender in the first half of 2009, while the preliminary investigations are still being carried out. The tendering procedure will end when the EIA consultation procedure is over, which is expected to be in the first half of 2010.

The winner of the tender will then be awarded a concession, permission for preliminary investigations and permission to establish the farm, after which the main contractor can finalise contracts and start the detailed planning.

The adjusted model for the tendering procedure of the 400 MW farm at Djursland/Anholt is also characterised by the following:

- The EIA report will include siting of the farm and proposals for an alternative site. The sites will be mapped as early in the process as possible
- The results of the ongoing analyses of the area will be presented by Energinet.dk. These include e.g. analyses of geotechnical surveys, the environment and sailing/navigation.
- The Danish Energy Agency will submit the EIA report for a broad public consultation.

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. The proposed Docking Shoal site is located within the Greater Wash strategic area which is one of three areas designated by the UK Government in 2002 for further development of offshore wind farms. The proposed site is located approximately 14 km (8.7 miles) from Wells-next-the-Sea on the North Norfolk coast and 19.5 km (12.1 miles) from Skegness on the Lincolnshire coast at its closest points. The proposed development has approximately 500 MW installed generation capacity.

The site covers an overall area of 75 square kilometres, orientated roughly east to west. Turbines would be located in water depths ranging from 3 metres to 14 metres. In addition to the turbines and foundations, the development would have associated subsea cables and two or three offshore substations.

An Environmental Statement was submitted along with the consents application in December 2008. A total of 52 bird species were recorded within the proposed Docking Shoal Offshore Wind Farm site during 39 boat-based surveys and 15 aerial surveys carried out in the study area over three years. From boat-based surveys, Sandwich Tern, Little Gull and Razorbill were estimated to occur in nationally important numbers with Gannet, Arctic Skua, Lesser black-backed Gull, Kittiwake, Common Tern, Arctic Tern and Guillemot occurring in regionally important numbers.

Potential impacts on birds including disturbance and displacement effects by the wind farm and associated vessel traffic, and potential collision with wind turbines were studied. A range of impacts, many of which were either **negligible** or **minor**, were predicted. For the Sandwich Tern, which has been identified as the most sensitive species and which breeds in internationally important numbers in the National Nature Reserves at Scolt Head and Blakeney Point, a special research programme is ongoing (Centrica 2008).

Centrica was awarded an Agreement for Lease from the Crown Estate in 2004 for the development of a wind farm at Race Bank beyond territorial waters. The proposed development would have an installed capacity of up to 620 MW, covering a site of 75 square kilometres. It is oriented roughly north-west to south-east and located in water depths of 4 metres to 22 metres, approximately 27 kilometres off Blakeney Point on the north Norfolk coast at its closest point, and 28 km off the Lincolnshire coast at Chapel St Leonards. In addition to turbines and foundations, the development would have subsea cables and up to three offshore substations.

An Environmental Statement and an application for consent for the Race Bank development was submitted to the Department of Energy and Climate Change in January 2009 (Centrica 2009).

A total of 35 species were recorded within the proposed Race Bank Offshore Wind farm site during 25 boat-based surveys and 15 aerial surveys carried out in the study area over two years. From boat-based surveys, Little Gull and Sandwich Tern were estimated to occur in nationally important numbers with Fulmar, Gannet, Lesser Black-Backed Gull, Kittiwake, Common Tern, Guillemot and Razorbill occurring in regionally important numbers.

Potential impacts on birds including disturbance and displacement effects by the wind farm and associated vessel traffic, and potential collision with wind turbines were assessed. A range of impacts, many of which were **minor** or **negligible** were predicted.

For the Sandwich Tern, which has been identified as the most sensitive species, and which breeds in internationally important numbers in the National Nature Reserves at Scolt Head and Blakeney Point, a special research programme has been carried out. This has included tern tracking, prey surveys and observations of food items returned to chicks at the colony. A population modelling exercise is currently being undertaken to assess the potential impacts of the wind farm on the local Sandwich Tern populations. The cumulative effects on birds from Race Bank and other proposed wind farms in the Greater Wash are currently being discussed with Natural England (NE) and the Joint Nature Conservation Committee (JNCC).

Disturbance to wintering birds within the Wash SPA was not predicted as installation works are likely to take place during periods when wintering birds are not present. With respect to birds, no impacts arising from the installation of the cables were predicted (Centrica 2009).

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. The 500 MW project will consist of between 83 and 139 turbines, depending on available technology in 2010, with an onshore connection at Heysham. The wind farm would cover an area of 66 km² with the turbines sited in a grid pattern. The main findings of the EIA are summarised below (from RSK 2006).

The construction of the offshore wind farm is currently planned to commence in 2009.

To cover the possible designs, 3 scenarios were assessed in the EIA; 139 turbines of 3.6 MW, 111 turbines of 4.5MW and 83 turbines of 6 MW.

A number of bird surveys (aerial, boat, radar and onshore counts) were carried out in and around the WoDS area. The most abundant species recorded during the boat surveys were auks (notably Guillemot), Gulls and Gannet. Other species, including Red-throated Diver and Common Scoter were recorded in relatively low numbers, particularly within the wind farm area. Manx Shearwater was also abundant when peak counts were considered, but the population within the wind farm was highly variable between months and years. Peak counts tended to be recorded during July and August.

Construction impacts

It was assumed that disturbance caused during construction (and decommissioning) would result in the temporary displacement of all birds recorded during the boat surveys within 2km of the wind farm area. For most species numbers were sufficiently low that no impact was predicted as a result of disturbance caused by construction activities.

Whilst Guillemot, Razorbill, Lesser Black-backed Gull, Gannet and Manx Shearwater occurred in higher numbers, the potential magnitude of disturbance impacts was not considered to be substantial because; disturbance will be temporary; there is extensive alternative habitat available for all of these species; while peak counts for some species within the wind farm were relatively high, their stay in the area was short; monitoring at the Danish Horns Rev offshore wind farm indicated that gulls showed increased preference for the wind farm area during the construction period compared to preconstruction. On this basis the magnitude of potential disturbance / displacement impacts caused during the construction period were considered to be Negligible for all species.

Operational impacts - Disturbance / displacement

The most numerous species recorded within the proposed wind farm area were gulls, including Herring Gull and Lesser Black-backed Gull. Gulls are particularly tolerant of disturbance arising from vessel movements. The magnitude of potential impacts arising from displacement on gulls was, therefore, considered to be Negligible.

There is limited information on the likely response of auks to wind farm operation. Pre and post construction monitoring undertaken at Horns Rev indicated a possible avoidance effect, although high levels of ongoing construction works at the wind farm site could have affected the monitoring there. It is also acknowledged that possible shifts in the distribution of prey species cannot be discounted as a potential cause of changes in the distribution of auks and other seabird species. A key finding from the North Hoyle monitoring study was that Guillemot, and other auks, exhibited little difference in the level of foraging within the wind farm following construction. As it is unlikely that the construction of WoDS will result in the permanent loss of more than 5% of available habitat of the eastern Irish Sea it was, therefore, concluded that the likely magnitude of the displacement effect on these species was Low.

The sensitivity of Manx Shearwater to wind farms has not been fully assessed previously and it is not known how this species will respond to wind farm operation. It was assumed, that Manx Shearwater would avoid the wind farm, i.e. that displacement effects would be high. Although the effect may be strong, it was not expected that this would result in an impact of high magnitude to the Manx Shearwater population of the Irish Sea because; WoDS is located south-east of the locations where most Manx Shearwater were observed during boat surveys. In addition the time shearwaters are present in this area was very short; during June to September the large majority of Manx Shearwater were found to the west of the Irish Sea Front within the stratified waters of the western Irish Sea; Manx Shearwater forage over very large areas, responding to the availability of prey species.

As it is unlikely that the construction of the wind farm will result in the permanent loss of more than 5% of available habitat of the eastern Irish Sea it is, therefore, concluded that the likely magnitude of the displacement effect on this species was Low.

The origin of the gannets observed at WoDS was not clear (due to the large distance to the closest colonies) but it seemed most likely that they were foraging birds associated with Scottish colonies. While Gannets are colonial breeders they forage over large distances and are widespread throughout British coastal and marine waters. Aerial surveys undertaken during August 2004, for example, indicated observations of Gannets throughout the East Irish Sea and North welsh coast. It was considered unlikely that the operation of the wind farm would result in a substantial displacement of Gannets from favoured feeding areas, hence it was concluded that the likely magnitude of the displacement effect on this species was Low.

Collision mortality

There have been few systematic surveys of collision rates between birds and turbines in offshore wind farms. Consultation with English Nature and RSPB about WOW and WoDS indicated a key concern about migratory geese (Pink-footed Goose) and swans (Whooper Swan). In response to this concern offshore radar surveys were commissioned during the autumn migration period. The results of these surveys indicated a low likelihood of significant mortality of migratory species arising from collision with turbines at the wind farm, either alone or in-combination. There were few movements through the wind farm area recorded during the migratory period (by the radar survey) in October 2005, even though it was known that a passage of both species took place during the surveys. These observations suggested that these species may follow a coastal route that is concentrated inshore of WoDS. Consequently the magnitude of collision impacts on migratory species was predicted to be Negligible.

In addition to migratory species, the baseline surveys revealed the presence of a range of other species, including auks, ducks, gulls and other seabirds (such as Manx Shearwater). The flight heights of individuals of these species were recorded during boat surveys. Very few Auks flew at height categories above 15m and consequently the risk of these species colliding with turbine blades was considered to be Negligible. The majority of ducks including the highly sensitive Common Scoter were recorded below 15m during the boat surveys. During the radar survey a similar pattern was observed with all individuals placed in height categories below 30m. These findings were consistent with other surveys, particularly those undertaken at Shell Flat where the flight behaviour of large numbers of Common Scoter was observed during baseline surveys. As with that study it was concluded that the risk of ducks colliding with turbines was Negligible.

Some studies have indicated that gulls may be susceptible to collision, although they do have high flight manoeuvrability. For most gull species the number of birds observed flying at rotor height within the proposed wind farm area was sufficiently low to conclude that the magnitude of collision effects would be Negligible. Lesser Black-backed Gull was recorded more frequently at rotor height than other gull species and was, therefore, potentially at greater risk of collision. The Lesser Black-backed Gull potentially affected by the wind farm was considered to be of Very High sensitivity, due to the presence of the Morecambe Bay SPA. A more detailed collision risk modelling exercise was carried out for this species, which concluded that collision rates were unlikely to exceed 11 birds per annum and, therefore, the magnitude of this impact was considered to be negligible.

Gannet was also recorded in moderate numbers at rotor height. There was little evidence about the behaviour of Gannet around wind farms. It was expected that many individuals would avoid the wind farm area as alternative foraging habitat for this species is widespread in coastal and marine areas. While this species is not considered to be amongst the most sensitive to wind farm developments, it is only moderately manoeuvrable in flight. It was expected, therefore, that there would be some risk of collision of this species with turbine structures. Consequently it was predicted that there would be a Low magnitude impact due to collision for this species. All remaining species were observed in very low numbers at rotor height and hence the magnitude of the potential impact of collision for these species was considered to be Negligible.

Barrier effects

The baseline surveys for this assessment did not highlight any specific or regular movements of birds through the wind farm area between foraging and roosting areas. Small numbers of Common Scoter were observed, but considering the large number of birds known to be present to the south, these movements are considered to be of negligible magnitude. It was concluded, therefore, that the wind farm would have a Negligible magnitude barrier effect on foraging and migratory wildfowl.

Humber Gateway - England

The proposed Humber Gateway Offshore Wind Farm is a 300 MW wind farm which would consist of between 42 and 83 wind turbines, depending on the capacity of the turbines. The wind farm site covers an overall area of $35km^2$ and is located in waters of around 15m depth. A planning application was submitted in April 2008. The main findings of the EIA are summarised below (from E-ON 2008).

Bird surveys, by air and boat, were carried out to establish both the species and numbers present in the vicinity of the Humber Gateway site. The birds recorded were mostly seabirds, however occasionally some migratory waterfowl and passerines were noted. Also of note were rafts of flightless auks that occurred in late summer and early autumn during their post-breeding feather moult.

The site was used all year round although bird numbers varied with season. The nearest breeding colonies are located at Flamborough Head approximately 53km north of the site along the Holderness Coast. Construction, operation and decommissioning activities have the potential to cause impacts to birds using the Humber Gateway site. A number of types of impacts were considered including displacement due to habitat loss, impacts to flight lines and collision risk. Potential impacts on environmentally designated sites, the nearest of which is 8km away, were also assessed. However, any habitat loss will be temporary and bird populations were not expected to be affected. Careful routing of construction vessels will be used to minimise disturbance, particularly in relation to moulting seabirds which can form floating rafts.

In addition, the EIA studies indicated that there will be no significant displacement effects and that the number of collisions between birds and the turbines will be very low. On the basis of these findings, and taking into account these mitigation measures, the assessment concluded that there will be no significant impacts to birds.

Sceirde Offshore Wind Farm - Ireland

The proposed wind farm would consist of 20 wind turbines approximately 140 m in height, foundations, an offshore substation, undersea power cables, onshore power cable(s) to a newly constructed onshore switching station and associated works.

The main part of the development (i.e. turbines, foundations and substation) would be located off the County Galway coastline approximately 2.8km northeast of Sceirde Mór (Skerdmore), 5km southwest of Maoinis (Mweenish), Co. Galway, 14.3km southwest of Cill Chiaráin (Kilkieran), Co. Galway and 16.4km northwest of Inis Mór, Oileain Árainn (Inishmore, Aran Islands). The turbines would be placed in waters ranging from approximately 5 to 35m and would be 5km from the coast at the nearest point. The main findings of the EIA are summarised below (from Aqua-fact 2008).

Bird surveys were carried out from 2002 to 2003 in addition to a review of bird populations in the proposed wind farm area.

Twenty-four species of seabirds, wildfowl and waders were selected as key species, along with passerines. The key species were Black-throated Diver, Red-throated Diver, Great Northern Diver, Fulmar, Manx Shearwater, other shearwaters, Storm Petrel, Shag, Cormorant, Gannet, skua species, Herring Gull, Great Black-backed Gull, Kittiwake, Common Tern, Arctic Tern, Sandwich Tern, Black Guillemot, Barnacle Goose, Turnstone, Purple Sandpiper and Oystercatcher. The seabirds species were selected because they have the potential to occur in large numbers in the vicinity of the proposed wind farm or they have sensitive populations. The wildfowl and waders were chosen as key species because they occur in internationally important numbers at sites close to the development or they migrate though the vicinity of the proposed wind farm area. Passerines were chosen as they have the potential to occur in high numbers in the vicinity of the proposed wind farm.

The significance of the potential risk of birds colliding with the turbines in the Sceirde Rocks wind farm ranged from low to medium depending on the key species. Divers, terns, skua species and Gannet 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/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. Additionally, as divers and skua species are present in low numbers in the vicinity of the proposed wind farm area, the likelihood of a significant impact on their total Irish population was considered to be low.

The significance of the potential impact from habitat loss and disturbance to feeding sites was considered to be low and very low for all key species. This was due to the fact that there is a vast area around the proposed wind farm site available to these species. The very small area ($4.07km^2$) occupied by the wind farm is insignificant in relation to the wider area available to them.

The significance of the potential impact on the flight patterns of birds was mostly low although divers could be more susceptible to disturbance. However, given the low numbers of divers in the vicinity, the likelihood of a significant impact on their total Irish population was considered to be low. Potential significance of impacts from indirect changes to food sources ranged from low to very low.

Waders and wildfowl would not generally be affected by the wind farm as they are only likely to be present in the vicinity of the wind farm during migration, if at all. However, the oystercatcher was given a medium sensitivity to collisions with the turbines due to the fact that they can fly at heights similar to rotor blades. The oystercatcher is a common bird throughout Ireland and any mortalities will not impact the Irish population.

5.4 UK Round 3 projects

In June 2008, the Crown Estate announced proposals for the third round of offshore wind farm leasing in the UK. The key principle underlying the first two rounds of UK offshore wind farm development was a robust selection process of parties to develop, construct, finance and operate designated offshore wind projects. This is being carried forward into Round 3 (Crown Estate 2008).

There are also a number of new aspects to Round 3. The additional principles underpinning Round 3 are:

- **Zonal development**: The Crown Estate has identified indicative Zones for Round 3 offshore wind sites with a total targeted capacity of 25GW. The final determination of the location and size of these Zones are subject to the conclusions of the Offshore SEA, (DECC 2009), and may be further constrained by issues identified by key stakeholders and statutory bodies.
- **One company per Development Zone:** A Partner Company will be contracted through a competitive tender process to develop each Development Zone exclusively with The Crown Estate. This Partner may represent a consortium or single company.
- **Multiple Sites per Zone.** The Crown Estate expects that there is potential for more than one wind farm Site per Zone.

- **Direct investment by The Crown Estate.** The Crown Estate will co-invest with the contracted Partners in the development programme up to the point of achieving consents for wind farms.

Clear division of responsibilities. There will be a clear delineation between The Crown Estate and the Partner Company activities and responsibilities. When specific Sites have been identified, the Partner will secure planning and other requisite consents for each Site and arrange key contracts, including operational and financing contracts. The Crown Estate will provide the Agreement for Lease and Lease for each wind farm Site, in addition to the supporting the development activities.

6. Discussion

6.1 Overview of important species in the Arklow Study Area

Seabirds

Eight species listed on Annex I of the EU Birds Directive (79/409/EEC) were recorded in the study area in Year 8. These included 2 diver species (Red-throated and Great Northern), Storm Petrel, 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. In previous years, peak numbers of Red-throated Divers recorded over the Bank exceeded the 1 % nationally important threshold of 20 birds (Crowe 2005), with a maximum peak day count of 23 birds in Year 7, 60 birds in Year 6 and 44 birds in Year 5. Although the peak number of Red-throated Diver in Year 8 was 18 birds in February, the combined 4-year mean for the Arklow Bank, for Years 5 to 8 was 36 birds, which is nationally important.

There was evidence from Year 8 surveys that the Arklow Bank may be important for terns on passage migration in spring and autumn. For example, in May of Year 8, the peak day count of Arctic Tern was 1,081 birds, while in September, the peak day count over the Bank was 1,043 birds.

In terms of overall numbers of birds in the Arklow Study Area, Kittiwake, Razorbill and Manx Shearwater were the most important species in Year 8.

Kittiwake was the most numerous species recorded in the Arklow Study Area in Year 8, with peak monthly counts over the Bank exceeding 15,000 birds in October, and exceeded 10,000 birds in at least one month during Years 5 to 7. Although a 1 % threshold of national importance has not been set for Kittiwake, the October total would be approximately equivalent to 1.8 % of the all-Ireland breeding population (415,995 pairs- Mitchell *et al* 2004).

In Year 8, peak numbers of Razorbills were recorded over the Bank in September. A similar pattern was recorded in August and September of Years 5 to 7, but the Year 8 peak was considerably higher than previous years. 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, the September peak in Year 8 would be approximately equivalent to 19.6 % of the all-Ireland breeding population (51,530 individuals-Mitchell *et al* 2004). Peaks counts in the previous three years also exceeded 1 % of the all-Ireland breeding population (Cork Ecology 2007b).

Peak counts of Manx Shearwater in Year 8 also peaked over the Bank in September, with this count considerably exceeding previous years peaks. While a 1 % threshold of national importance has not been set for Manx Shearwater, the September peak in Year 8 would be approximately equivalent to 9.1 % of the all-Ireland breeding population (74,356 individuals-Mitchell *et al* 2004) in Year 8.

Other important species recorded in the Arklow Study Area in Year 8 included Little Gull, Black-headed Gull, Common Gull and Guillemot.

Numbers of all three species of gulls over the Bank peaked in November of Year 8. Little Gull numbers at this time were more than 3.5 times the 1 % internationally important threshold of 840 birds (Crowe 2005), while numbers of Black-headed Gulls were more than five times the nominal 1 % nationally important threshold of 1,000 birds (Crowe 2005). Similarly, Common Gull numbers were more than double the nominal 1 % nationally important threshold of 500 birds (Crowe 2005).

Highest numbers of Guillemots in the Arklow Study Area in Year 8 occurred in September, over the Bank. These 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). While a 1 % threshold of national importance has not been set for Guillemots, the Year 8 peak in September would be approximately equivalent to 0.95% of the all-Ireland breeding population (236,654 individuals-Mitchell *et al* 2004). Peaks counts in the previous two years exceeded 1 % of the all-Ireland breeding population (Cork Ecology 2007b).

In both September and November of Year 8, the total number of birds recorded over the Bank exceeded 20,000 birds. This is the threshold for international importance for a site to qualify as a Special Protection Area (SPA), although numbers of birds using the site must *regularly* exceed 20,000 birds (NPWS 2008). In September, numbers of Manx Shearwaters, Common Terns, Razorbills and Guillemots gave a combined total of 20,198 birds, while in November, the combined total of Little Gulls, Black-headed Gulls, Common Gulls, Kittiwakes and Razorbills was 21,509 birds. In the intervening month, October, numbers of Little Gulls, Kittiwakes, Guillemots and Razorbills totalled 19,185, with majority of these being Kittiwakes.

It is not clear why numbers of these species between September and November of Year 8 were so high, but these numbers do demonstrate both the importance of the Arklow Bank for these species, and the variability in seabird numbers in the Arklow Study Area between years. Given this variability, it is important that seabird surveys are continued in the Arklow Study Area, particularly in relation to the proposed future expansion of the Arklow Bank Wind Farm.

Marine Mammals

One species of seal recorded in the Arklow Study Area in Year 8 (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 Year 8 (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 in Year 8. A peak of 31 animals was recorded in the Arklow Study Area in September. Aerial surveys in 2005 yielded a total of 15,230 Harbour Porpoise in the Irish Sea (Macleod 2006).

6.2 Breeding seabirds at Wicklow Head

Numbers of seabirds breeding at Wicklow Head have been monitored since 2001 as part of the ongoing Seabird and Marine Mammal Monitoring Programme for the Arklow Bank Wind Farm project.

In 2008, complete colony counts were conducted for six species; Fulmar, Shag, Herring Gull, Kittiwake, Guillemot and Razorbill. Counts of Fulmar, Shag, Herring Gull, Guillemot and Razorbill increased in 2008 compared to 2007, while counts of Kittiwake decreased compared to

2007. Overall trends between 1999 and 2007 showed that numbers of Fulmar, Shag, Guillemot and Razorbill showed an increase, while Kittiwake showed a slight decline overall. Herring Gull numbers have declined since 1999 but have been increasing again in recent years (Cork Ecology 2008).

The 2008 Kittiwake productivity estimate for Wicklow Head was lower than in the previous seven years. However, early analysis of Kittiwake productivity in 2008 at other sites around UK and Ireland indicated that Kittiwake productivity at Wicklow Head in 2008 was in line with these other colonies (R Mavor *pers. comm.*).

Productivity was monitored at four other Kittiwake colonies in Ireland in 2005 and 2006, and all four colonies decreased in size (Mavor *et al* 2008). More recent data is not yet available. In contrast, numbers at Wicklow Head were stable in 2005 and 2006, and peaked in 2007, before decreasing in 2008. It may be that the drop in numbers recorded in 2008 is the start of a decline in numbers at Wicklow Head. It is therefore recommended that the monitoring of breeding seabirds at Wicklow Head should be continued in 2009.

6.3 Surveys of Glassgorman Bank to determine its suitability as a control site

A review of the Arklow Bank Monitoring Programme recommended that a preliminary survey should be conducted over Glassgorman Bank to establish its potential as a control area distinct from the Arklow Bank, but with similar habitats and bird communities (Cork Ecology 2007a). Five transects running east to west were surveyed in March of Year 8.

As the Glassgorman Bank is smaller and closer to shore that the Arklow Bank, it was anticipated that the species assemblage would be different and this was found to be the case. From the low numbers of birds recorded and the different species composition, favouring scoter rather than gulls and auks, Glassgorman Bank does not appear to be a suitable control site. Further surveys of Glassgorman Bank are therefore not recommended.

It is proposed to compare regional data from the Irish Sea for key species in the future, as there does not appear to be a suitably similar control site in the area.

6.4 Data sharing and publication

It is international best practice to disseminate offshore wind farm environmental data and also to publish results of offshore wind farm studies (e.g. COWRIE 2008, Fox *et al* 2006). The licensing conditions state that the Arklow Bank monitoring programme should follow international best practice. Data sharing also enables the project to receive reciprocal data from other areas for comparison, e.g. ESAS data from the Irish Sea, and information on breeding seabird numbers and success at other colonies in the Irish Sea.

At a meeting between Cork Ecology and Airtricity in February 2008, Airtricity requested a list of the potential databases for datasharing (Table 5.1) and agreed to come to a decision regarding making the data available in the near future.

Types of data sharing

There has been a long-standing agreement to make the Arklow Bank seabird and marine mammal survey data available to the ESAS database (in return for the use of ESAS data in the

Irish Sea) but this needs to be confirmed as only one year of data has been given to ESAS to date. It is hoped to submit data for years 2-8 to ESAS in 2009, following approval from Airtricity.

It is also recommended that Arklow Bank marine mammal data should be sent to the National Biodiversity Data Centre (NBDC), which is in the process of establishing a Joint Irish Cetacean database. Claire Pollock attended a meeting of the Joint Irish Cetacean database working group on 29 May 2008 in Waterford and reported that Airtricity were considering adding data to the database.

The seabird breeding data from the colony at Wicklow Head should also be sent to NBDC and Birdwatch Ireland, as well as to the Seabird Monitoring Programme (SMP) database held by JNCC.

Data sharing recommendations are summarised in Table 5.1.

It is proposed that data from the Arklow Bank Monitoring Programme should be added to the following databases:

Table 5.1 Data types and databases

Data type	Database
Wicklow head breeding seabird data	JNCC SMP (Seabird Monitoring Programme) database National Biodiversity Data Centre (NBDC) * NPWS/Birdwatch Ireland
ESAS seabird & marine mammal data from boat surveys	ESAS database (JNCC) NBDC* Joint Irish Cetacean Database

*Note: The NBDC is still in the early stages of development so may not be quite ready for all data types yet.

It is protocol for researchers wishing to use data from the ESAS database to get permission first from all data owners before getting permission to use the data. In addition, it could be made a condition of sharing the Arklow Bank data, that permission is also sought from Airtricity before use in the case of NBDC and Joint Irish Cetacean Database.

It is not considered necessary to impose any conditions on the use of the Wicklow Head breeding seabird data.

6.5 Statistical analysis of data from Years 1 to 8

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 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 *et al* 2006). 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 (Lynas *et al* 2007).

Therefore any decline in this species would be of considerable conservation importance. This species avoids ships and may be particularly vulnerable to disturbance. Divers were considered by Garthe and Hüppop (2004) to have high vulnerability to both potential collision and disturbance effects from offshore wind farms. These results raise the possibility of Red-throated Divers on Arklow Bank 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 Red-throated Divers should be a high priority.

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 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.

The Year 7 report included similar analyses to those presented here, but was based upon survey data from the Years 1 to 7 rather than Years 1 to 8. Because they include the Year 8 survey data, the analyses presented here are more powerful, and supersede those presented in the earlier report. The inclusion of this additional data within the analyses did not substantially change the conclusions from those reached last year, although the larger sampler sizes strengthened the statistical significance of a number of the observed trends, including the decline in Red-throated

Divers recorded on the outer Bank leg (leg 2). The conclusion of a weakly significant decline in the numbers of Harbour Porpoise on leg 3 remained unchanged.

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 occur in large numbers such as Little Gull, Kittiwake, Guillemot, Razorbill, Manx Shearwater and Common Gull.
- The revised survey route for the Bank area, with transect legs orientated perpendicular to the Bank commenced in July of Year 9, and should be continued in Year 10. This will allow more powerful statistical analyses to be used and total numbers in the study area to be calculated with confidence limits;
- Surveys of breeding seabirds at Wicklow Head should also be continued as part of the overall Arklow Bank Seabird and Marine Mammal Monitoring Programme;
- Arklow Bank seabird and marine mammal survey data should be made available to JNCC and NBDC, for inclusion in their databases. In addition, seabird breeding data from Wicklow Head should be made available to the SMP database;
- The Year 8 Arklow Bank Seabird Monitoring Report should be published in the public domain, in accordance with best practice guidelines (Fox et al 2006, Langston et al 2006).

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Appendix A

Survey weather conditions in Years 5, 6, 7 and 8

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

Table A4 Survey conditions for Year 8 (July 2007 to June 2008)

Trip No.	Date	Weather				
		Wind Dir	Wind force[1]	Sea-state[2]	Swell[3]	Visibility[4]
1	8/7	SW	2–6	2-5	Slight	Good-Ex
2	28/7	S-SE	2-3	1-2	Slight	Ex
3	27/8	NW-N	2-4	2-4	Slight	Good
4	28/8	N-NW	2-4	2-4	Slight	Good
5	4/9	SW-SE	2-5	2-5	Slight	Ex-Good
6	5/9	W	1-2	1-2	Slight	Good
7	10/10	NW-SE	2-4	2-4	Slight	Mod
8	11/10	SW	3-4	3-4	Slight	-
9	3/11	NW-N	2-4	2-4	Slight	Ex-Good
10	4/11	-	3	3	Slight	Good
11	21/12	SE	4-5	4-5	Mod	Good
12	22/12	W-SW	4-5	4-5	Mod	Good
13	10/2	SE	2-4	2-4	Slight	Good
14	12/2	SE	2-3	2-3	Slight	Good-Ex
15	18/3	NE-N	2-5	2-5	Slight	Good
16	19/3	N-NW	3-5	3-5	Slight	Good
17	23/4	S-SW	2-5	2-4	Slight	Good-Ex
18	27/4	NE-Var	1-2	1	Slight	Poor-Good
19	12/5	NE	3-4	3-4	Slight	Good
20	13/5	NW-N	5-6	5-6	Mod	Good
21	2/6	NE	2-3	2-3	Slight	Poor-Good
22	5/6	NW	5-6	5-6	Mod	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.

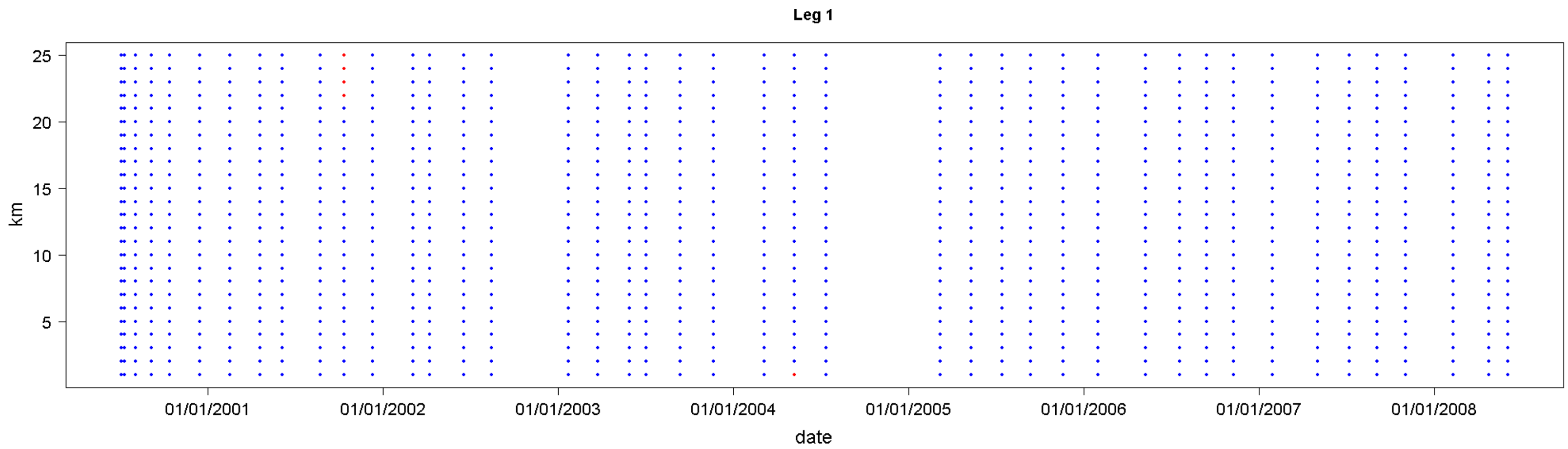


Figure B2 **Coverage of the Outer Bank leg (leg 2). Blue dots indicate km covered on a particular date. Red spots indicate km <u>not</u> covered for those dates when at least partial coverage achieved.**

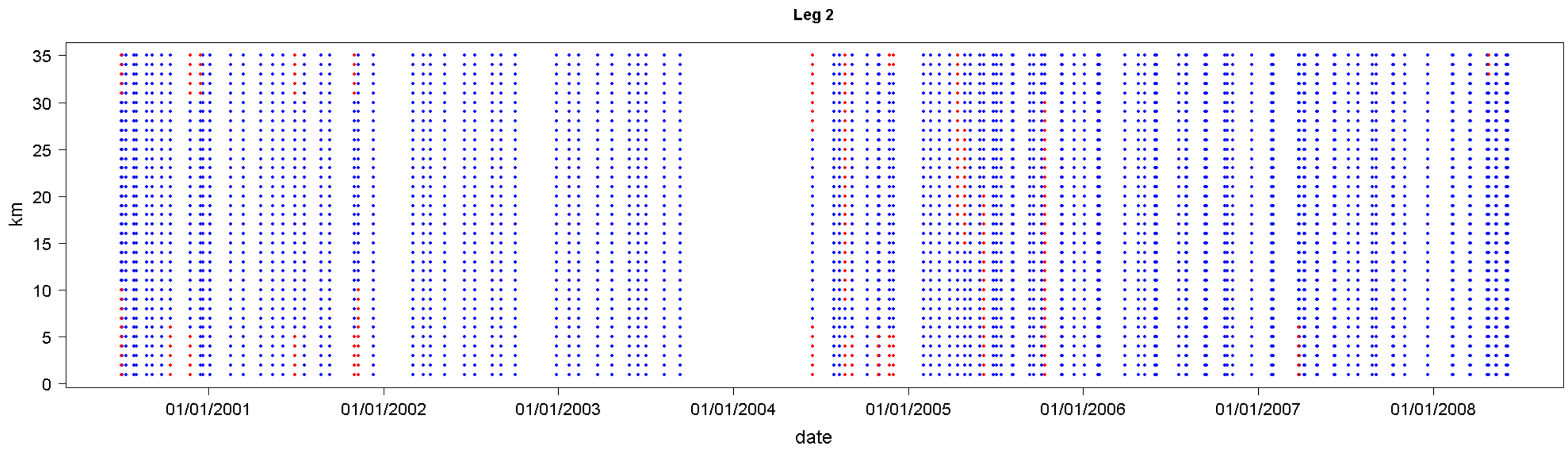


Figure B3 Coverage of the inner Bank leg (leg 3). Blue dots indicate km covered on a particular date. Red spots indicate km <u>not</u> covered for those dates when at least partial coverage achieved.

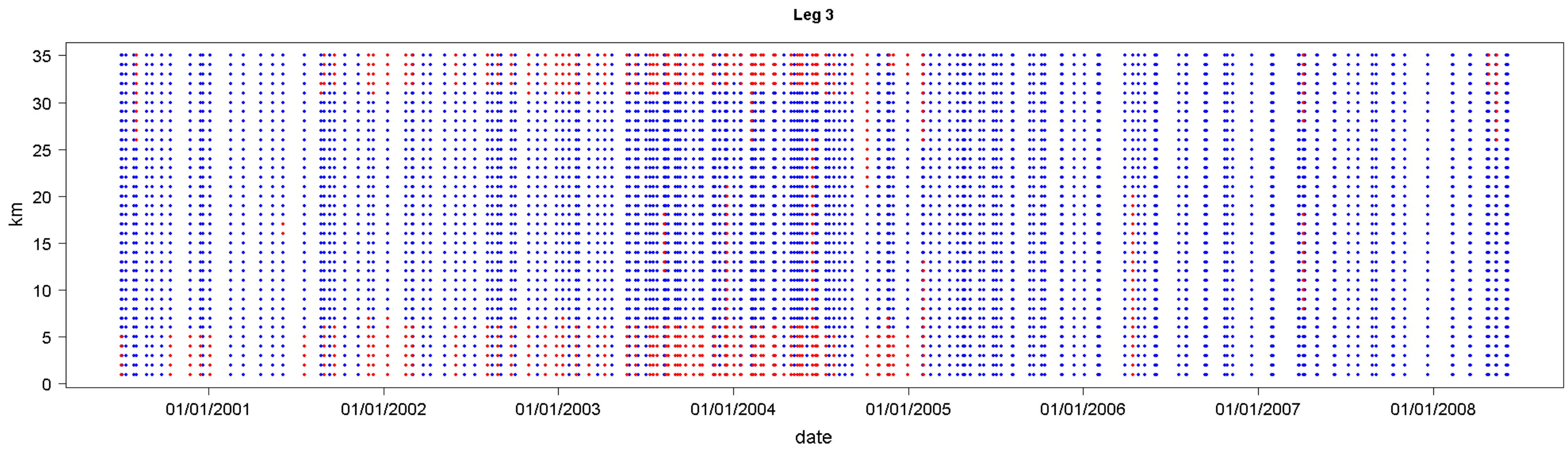


Figure B4 Coverage of the Cable Route (leg 5). Blue dots indicate km covered on a particular date. Red spots indicate km <u>not</u> covered for those dates when at least partial coverage achieved.

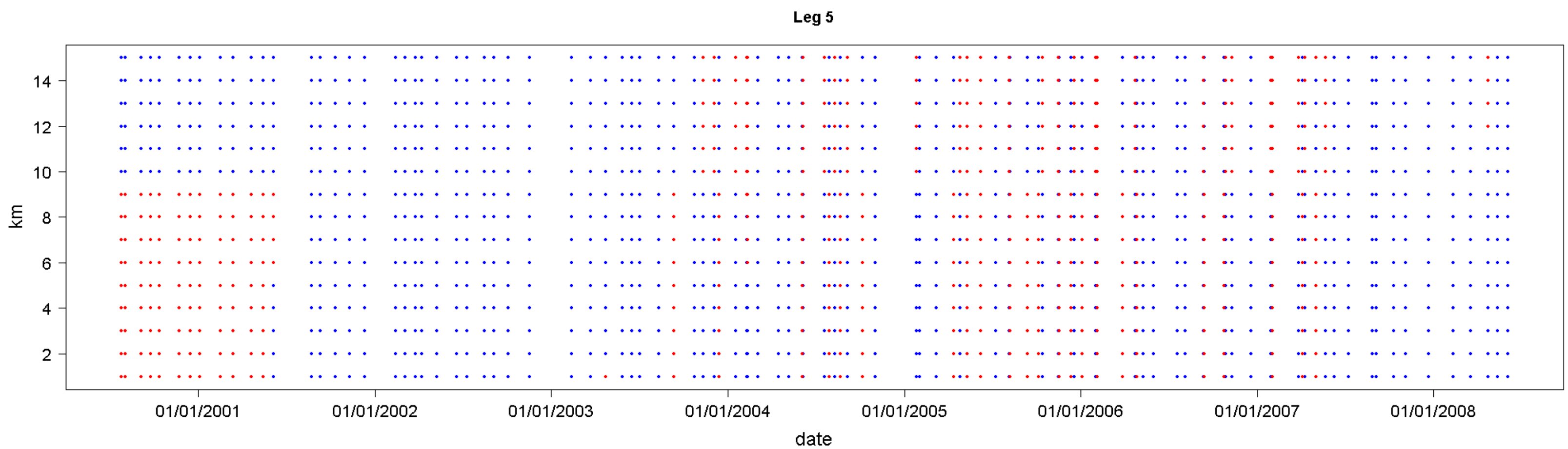


Figure B5 Coverage of Box leg 11. Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.

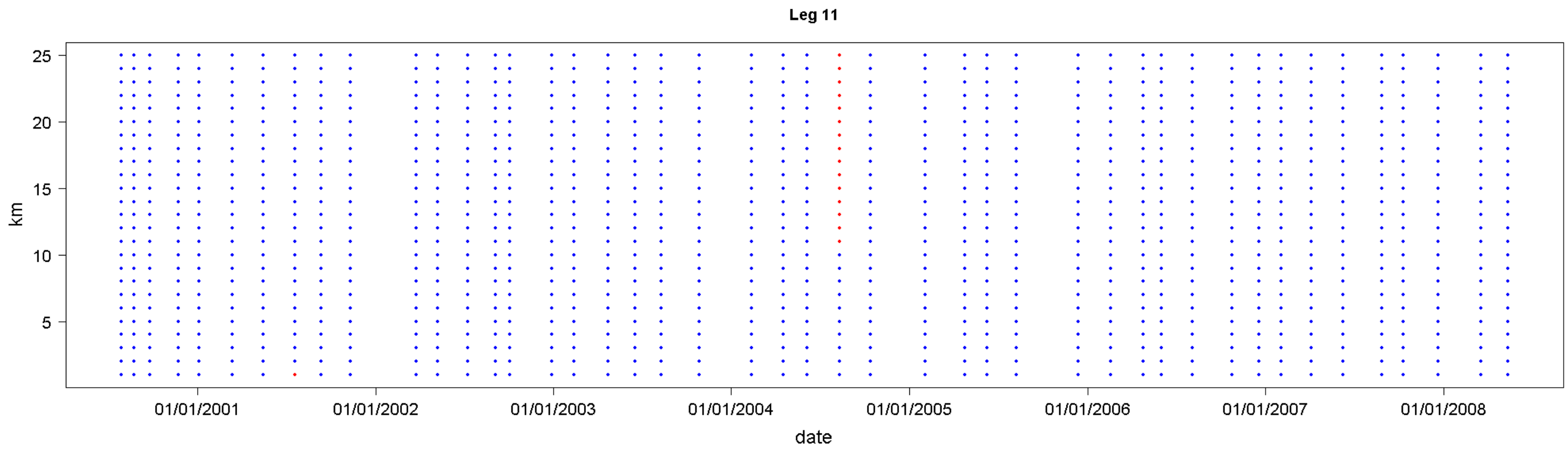


Figure B6 **Coverage of Box leg 41. Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.**

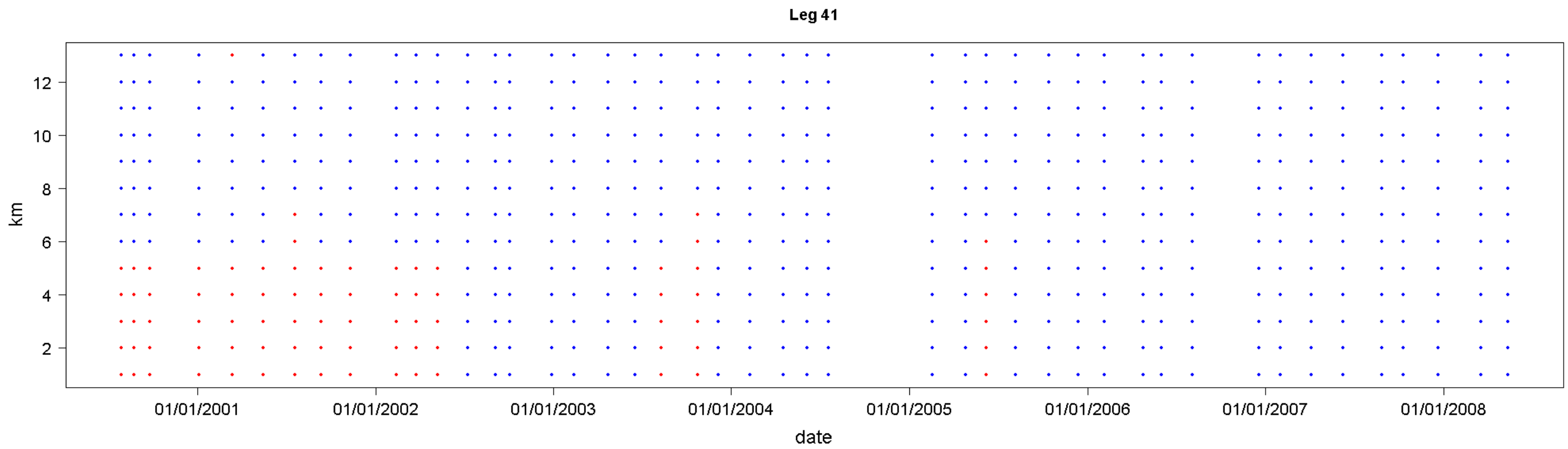


Figure B7 Coverage of Box leg 42. Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.

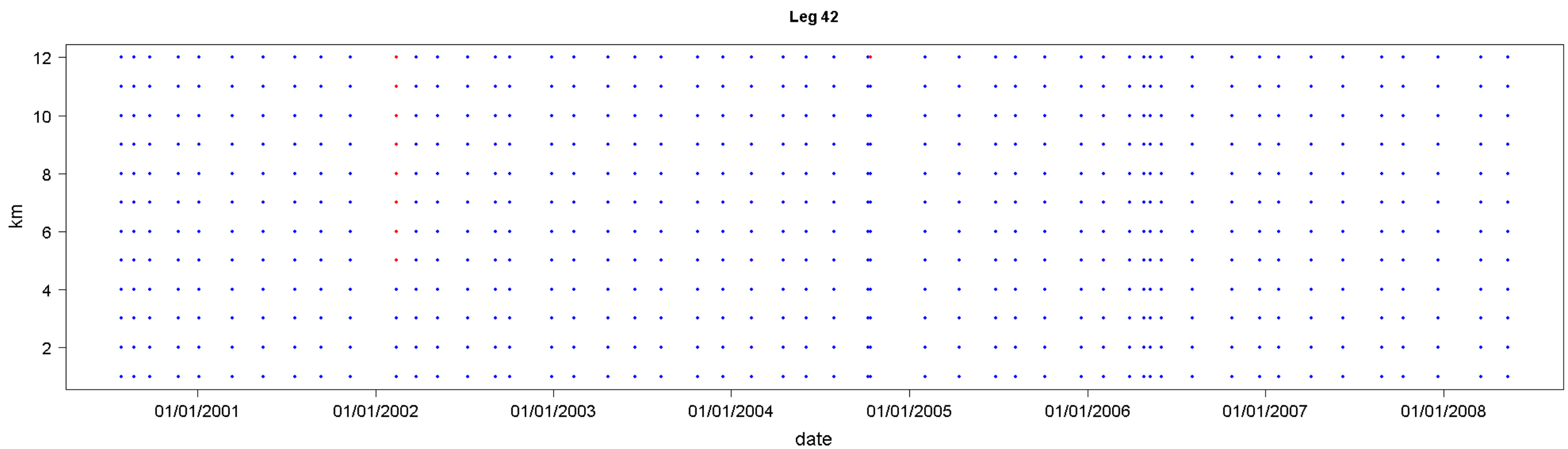


Figure B8 Coverage of Box leg 43. Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.

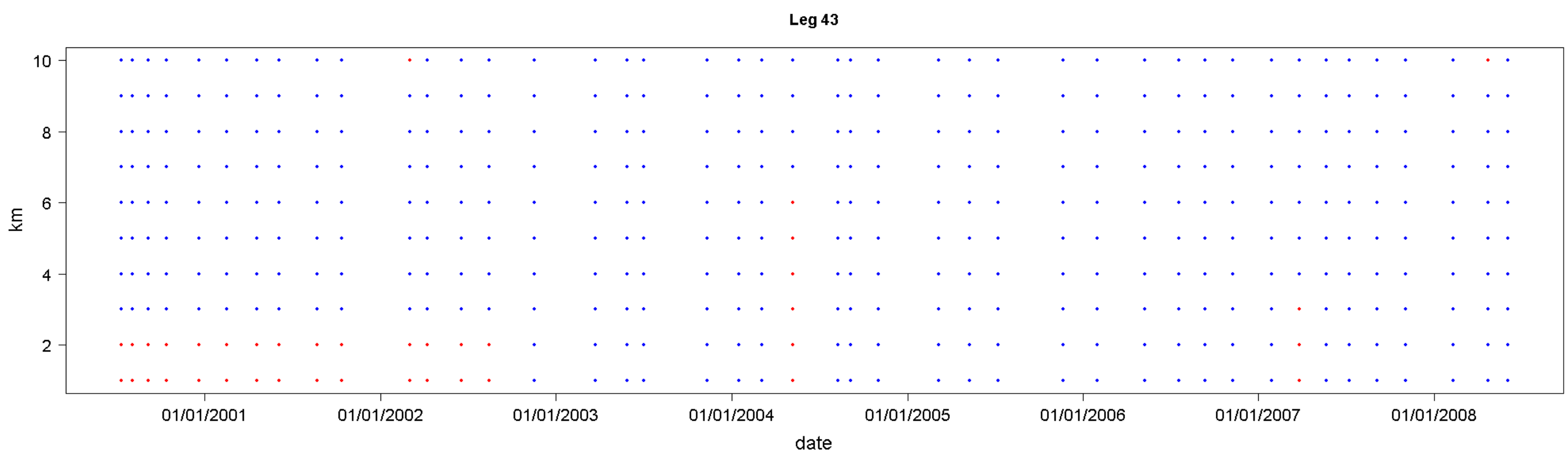
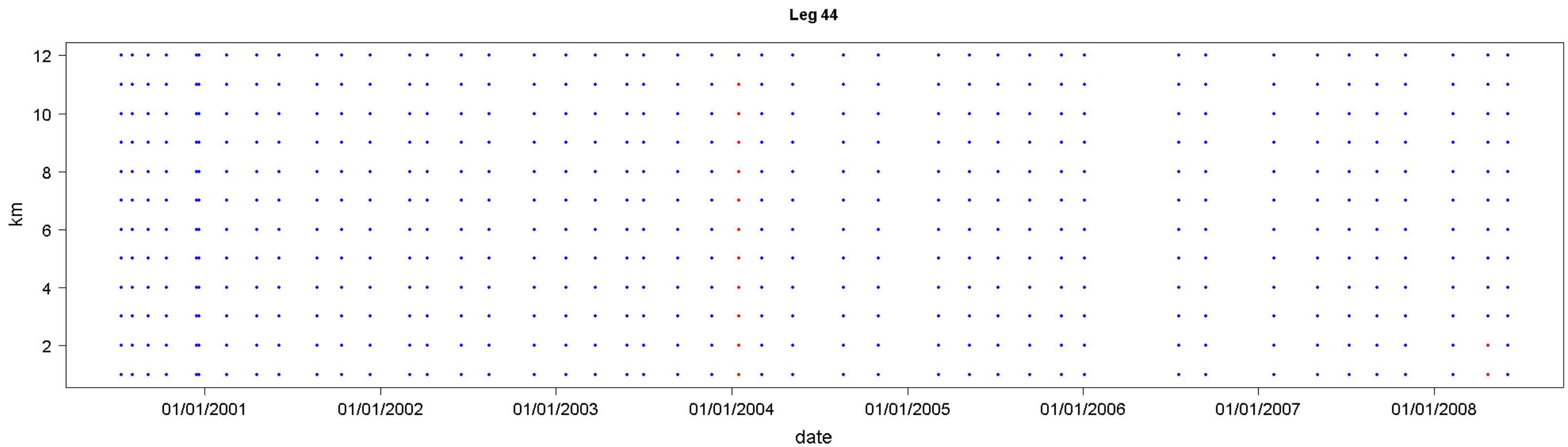


**Figure B9	Coverage of Box leg 44. Blue dots indicate km covered on a particular date. Red spots indicate km not covered for those dates when at least partial coverage achieved.**



Appendix C

Non-seabird species recorded in the Arklow Study Area in Years 5, 6, 7 and 8

Table C1 Numbers of non-seabirds recorded in the Arklow Study Area in Years 5 to 8

Species	Bank				Box				Cable Route			
	Year				Year				Year			
	5	6	7	8	5	6	7	8	5	6	7	8
Brent Goose	0	0	0	0	0	0	0	0	0	11	2	0
Shelduck	0	6	0	0	0	0	0	0	0	0	0	0
Merlin	0	0	0	0	0	0	0	0	0	0	1	0
Oystercatcher	0	0	0	0	0	0	0	0	0	0	1	0
Ringed Plover	0	0	1	0	0	0	0	0	0	0	1	0
Purple Sandpiper	0	0	0	0	0	0	1	0	0	0	0	0
Dunlin	0	0	5	0	0	0	0	0	0	0	0	0
Curlew	0	0	0	1	0	0	0	0	0	0	0	0
Whimbrel	0	0	0	4	0	0	0	0	2	0	0	0
Wader species	0	4	0	0	0	0	0	0	0	0	0	0
Swift	0	1	0	0	0	0	0	0	0	0	0	0
Skylark	1	0	0	0	0	0	0	0	0	0	0	0
Swallow	60	4	5	26	4	14	0	1	4	0	0	0
House Martin	0	3	0	0	0	0	0	0	0	0	0	0
Pipit species	1	0	0	0	0	0	0	0	0	0	0	0
Thrush species	8	0	0	0	0	0	0	0	0	0	0	0
Goldcrest	0	1	0	0	0	0	0	0	0	0	0	0
Starling	25	0	0	17	0	35	0	0	0	0	0	0
Chaffinch	0	0	0	0	0	0	0	0	0	1	0	0
Total	**95**	**19**	**11**	**48**	**4**	**49**	**1**	**1**	**6**	**12**	**5**	**0**