

Arklow Bank Seabird and Marine Mammal Monitoring Programme

Year 9 Final Report:
July 2008 to June 2009



Arklow turbine

© Claire Pollock, Cork Ecology

Report to Airtricity

May 2010

CORK ♦ ECOLOGY

Long Strand, Castlerefke, Clonakilty, Co. Cork

Website: www.corkecology.net E-mail: info@corkecology.net



St Claire Farm, Holm, Orkney, KW17 2RZ, UK
E-mail: craigton.ecological.services@phonecoop.coop

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

This report should be cited as:

Barton, C., Pollock, C. & Harding, N. 2010. Arklow Bank Seabird and Marine Mammal Monitoring Programme Year 9 Final Report. A report to Airtricity.

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 survey work from Year 9, and also compares the Year 9 results with previous years.

Methodology

Seabirds and marine mammals were recorded using the standard Joint Nature Conservation Committee (JNCC) Seabirds at Sea survey method which complies with ESAS (European Seabirds at Sea) standards. Birds were counted ahead of the ship and out to one side usually in a 90° arc with a 300 m transect width. A snapshot method was used to assess densities for flying birds. A one minute recording interval was used. In addition, the estimated height of flying birds was also recorded.

A revised survey route for the Bank area, with transect legs orientated perpendicular to the Bank commenced in July of Year 9. In addition, north-south surveys of the bank legs were continued to allow comparison of numbers of birds from previous years. The change in route was designed to increase the statistical power of the dataset in calculating species population estimates.

For the first time in this study, distance sampling was used to calculate monthly population estimates for key seabirds and marine mammals in the Arklow Bank Study Area from July 2008 to June 2009.

Results

Survey results from Year 9 and Years 5 to 8 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 29 species of seabirds were identified on surveys in the Arklow Study Area in Year 9. In terms of overall numbers of birds in the Arklow Study Area, Kittiwake, Razorbill and Guillemot were the most important species in Year 9, together accounting for 63.2 % of all birds recorded.

Discussion

Key species

Seven species listed on Annex I of the EU Birds Directive (79/409/EEC) were recorded in the study area in Year 9. These included one diver species (Red-throated Diver), Storm Petrel, Mediterranean Gull and four species of tern (Sandwich Tern, Roseate Tern, Arctic Tern and Common Tern).

Most of these species occurred in very low numbers and would not be considered nationally important. However, in four of the last five years, peak numbers of Red-throated Divers recorded over the Bank have exceeded the 1 % nationally important threshold of 20 birds. In Year 9, the maximum day count was 25 birds, recorded in January. This compares to a maximum peak day count of 18 birds in Year 8, 23 birds in Year 7, 60 birds in Year 6 and 44 birds in Year 5. The combined 5-year mean for the Arklow Bank, for Years 5 to 9 was 34 birds, which is above the nationally important threshold of 20 birds.

Kittiwake was the most numerous species recorded in the Arklow Study Area in Year 9, although numbers recorded were lower than in Year 8. Although a 1 % threshold of national importance has not been set for Kittiwake, the October Year 9 Bank total (7,799 birds), would be approximately equivalent to 0.9 % of the all-Ireland breeding population. Peak Bank counts in Year 8 and Year 7 both exceeded 1 % of the all-Ireland breeding population. In comparison, statistical analyses of Kittiwake data for Year 9 gave a maximum population estimate for the whole Arklow Study Area of 3,100 in April, approximately equivalent to 0.4 % of the all-Ireland breeding population.

In Year 9, peak numbers of Razorbills were recorded over the Bank in January, which differed from previous years, when numbers peaked in August and September. While a 1 % threshold of national importance has not been set for Razorbill, the January Bank peak in Year 9 (1,932 birds), would be approximately equivalent to 3.7 % of the all-Ireland breeding population. Peak Bank counts in Year 8 and Year 7 also exceeded 1 % of the all-Ireland breeding population. In comparison, statistical analyses of Razorbill data for Year 9 gave a maximum population estimate for the whole Arklow Study Area of 5,093 birds in September, approximately equivalent to 9.9 % of the all-Ireland breeding population.

Peak counts of Guillemots in Year 9 peaked over the Bank in February, although this count was not as high as peaks recorded in previous years. While a 1 % threshold of national importance has not been set for Guillemot, the February Bank peak in Year 9 (1,055 birds), would be approximately equivalent to 1.4 % of the all-Ireland breeding population. Peak Bank counts in Year 8 and Year 7 also exceeded 1 % of the all-Ireland breeding population. In comparison, statistical analyses of Guillemot data for Year 9 gave a maximum population estimate for the whole Arklow Study Area of 6,982 birds in September, approximately equivalent to 9.4 % of the all-Ireland breeding population.

Little Gull numbers in Year 9 were much lower, with no large midwinter peak as has been recorded in previous years. As before, the majority of Little Gulls were recorded over the Bank.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Other important species recorded in the Arklow Study Area in Year 9 included Black-headed Gull, Manx Shearwater and Common Gull.

Harbour Porpoise was the most commonly recorded marine mammal in the Arklow Study Area in Year 9 and was recorded in all months. A peak of 27 animals was recorded in the Arklow Study Area in June of Year 9. Statistical analyses of Harbour Porpoise data for Year 9 gave a maximum population estimate for the Arklow Study Area of 126 animals available for detection at the surface in June. 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 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 2009, complete colony counts were conducted for six species; Fulmar, Shag, Herring Gull, Kittiwake, Guillemot and Razorbill. In 2009, counts of Fulmar, Shag and Herring Gull decreased slightly compared to 2008, while numbers of Kittiwake, Guillemot and Razorbill all increased. Overall trends between 1999 and 2009 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 2009 Kittiwake productivity estimate of 1.03 (\pm 0.10 SE) was the highest at Wicklow Head since 2004. Preliminary results of Kittiwake productivity at other sites around the UK and Ireland for 2009 indicate that productivity at Wicklow Head in 2009 was similar to other censused colonies (R Mavor and M Parsons *pers comm*). It is recommended that the monitoring of breeding seabirds at Wicklow Head should be continued in 2010.

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 are presented and summarised.

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 9 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).

Table of Contents

1.	Introduction	11
1.1	Arklow Bank Seabird and Marine Mammal Monitoring Programme	11
2.	Methods	13
2.1	Survey methods.....	13
2.2	Survey Route	13
2.3	Weather conditions.....	16
2.4	Data handling and analysis	16
2.5	Mapping strategy.....	16
2.6	Charts	17
2.7	Methods of statistical analyses of data for Year 9.....	18
3.	Results	22
3.1	Survey effort.....	22
3.2	Raw numbers of seabirds in the Arklow Study Area in Year 9	24
3.3	Flying birds	32
3.4	Seabird Species Accounts	38
3.5	Raw numbers of marine mammals recorded in the Arklow Study Area.....	131
3.6	Marine Mammal Species Accounts	133
4.	Statistical analyses of Year 9 data	140
4.1	Red-throated Diver.....	140
4.2	Little Gull	142
4.3	Kittiwake	144
4.4	Guillemot	144
4.5	Razorbill	146
4.6	Harbour Porpoise	147
4.7	Discussion.....	149
5.	Review of the impacts of offshore wind farms on birds at sea	151
5.1	Operating Wind Farms	151
5.2	Offshore wind farms in Scottish Territorial Waters.....	151
5.3	UK Round 3 projects.....	151
6.	Discussion.....	158
6.1	Overview of important species in the Arklow Study Area.....	158
6.2	Breeding seabirds at Wicklow Head	160
6.3	Statistical analyses of Year 9 data	161
6.4	Data sharing and publication.....	162
7.	Recommendations	164
8.	Acknowledgements	164
9.	References	165

Appendix A	103
Appendix B	109
Appendix C	132
Appendix D	145

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 June 2009.

This report presents the results of survey work from Year 9, and also compares the Year 9 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 9 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;

Seabird Colony Counts

- A survey of breeding seabirds at Wicklow Head was conducted in June and July 2009 (Cork Ecology 2009).

2. Methods

2.1 Survey methods

As in previous years (CWC 2006), 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 one side usually in a 90° 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. All survey legs were surveyed using a main observer, and a scribe, as per Camphuysen (2004). Surveys were conducted on one side of the boat, with any marine mammals, flocks of Little Gulls and rare birds on the other side of the boat, also recorded.

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). The count interval for surveys was 1 minute intervals, and synchronised GPS recorders were used to record the vessel position every minute.

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 of travel and behaviour were recorded. In addition, the angle of the sighting using an angle board and the radial distance was estimated either using a range finder or if no horizon, a visual estimate in metres was made. 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 9, boat surveys were conducted by Dave Branagh, John Lovatt, Hugh Delaney and John Coveney.

2.2 Survey Route

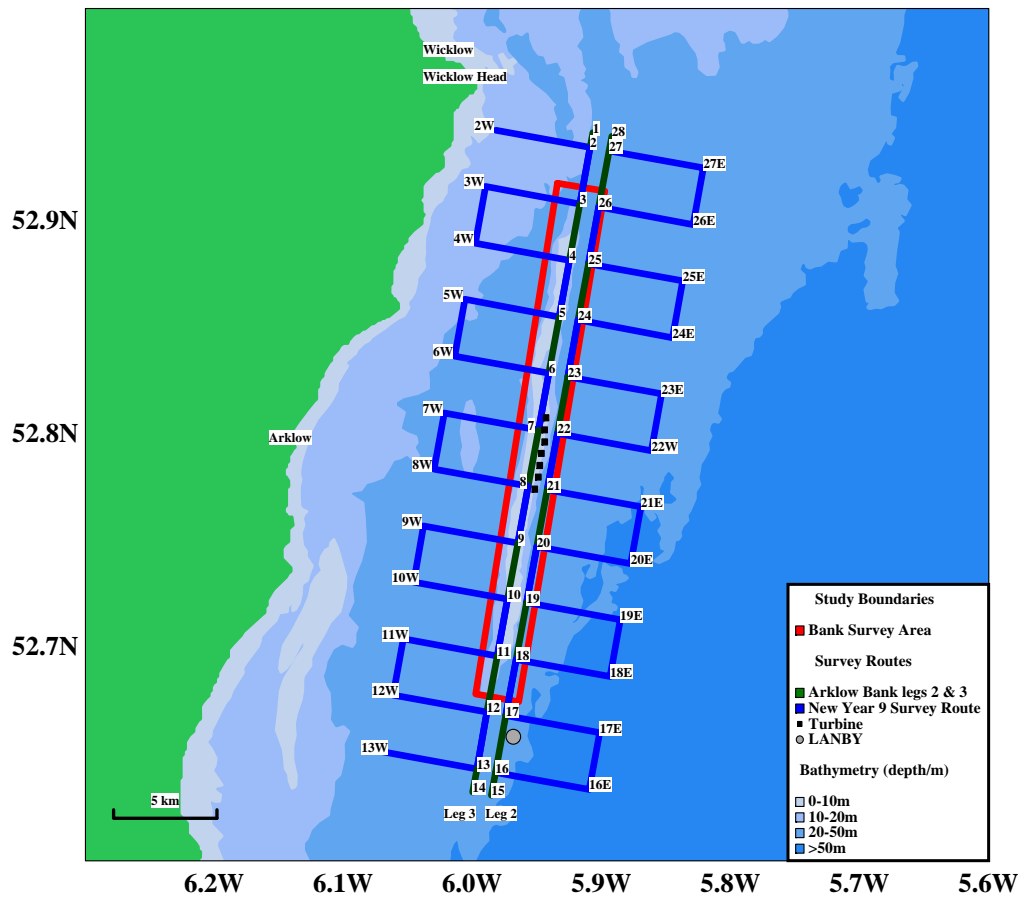
A revised survey route was adopted in July 2008, following recommendations in a review of the Arklow Bank Monitoring Programme (Cork Ecology 2007a). The revised survey route consisted of two components - legs 2 and 3 running north-south on either side of the Arklow Bank (Figure 2.1) were surveyed twice each month, as in previous survey years. The new Year 9 route, which runs perpendicular to the Arklow Bank was covered once per month (Figure 2.1).

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

The new survey route allows greater statistical power in analysing the data and calculating species population estimates. The bank legs (2 & 3) were continued to allow comparison with previous years.

Changes to survey legs in previous years are detailed in a previous report (CWC 2006).

Figure 2.1 Map of Year 9 Arklow Study Area



2.3 Weather conditions

A summary of survey weather conditions in Year 9 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.

2.4 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/km²) 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° and 54° N, and between 5 to 6.5° W, which are fully/partly in Irish waters.

2.5 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/km²)

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,

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Common Gull, Kittiwake, Common Tern, Arctic Tern, Guillemot and Razorbill. Although in year 9 Little Gull, Common and Arctic Tern did not have 1,000 birds 'in transect', density were maps were used to allow comparison with previous years.

In year 9, while 1 minute recording intervals were used in data collection, a grid of 1 km was used for mapping purposes. Data more than 1 km off the survey route were excluded from maps.

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. Two exceptions were Herring Gull and Fulmar, which had lower numbers, but were included as they 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 $\frac{1}{4}$ 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).

In year 9, while 1 minute recording intervals were used in data collection, a grid of 1 km was used for mapping purposes. Data more than 1 km off the survey route were excluded from maps.

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.

2.6 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 (legs 2 and 3) for Years 5 to 9 and for the revised Box survey route for Year 9 only. Totals for the Box from previous years were not shown on these charts, as the survey route was changed at the start of Year 9 and these totals are not directly comparable. 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 9, 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 recorded on the revised Box route each month in Year 9 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 Bank totals for Years 5 to 8 (all post-construction), are included for comparison with Year 9 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, surveys on the revised Box route were generally surveyed over two or more days, which may not have been consecutive and this can result in double counting of birds.

Abundance/density charts

These charts show the mean monthly abundance (no. of birds/km travelled) or density (no. of birds/km²) of species on the Bank and revised Box route in Year 9. Data for the Bank for Years 5 to 8 (post-construction) were reanalysed and average combined monthly values were calculated for comparison with the Year 9 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.

2.7 Methods of statistical analyses of data for Year 9

2.7.1 Introduction

We used distance sampling to calculate monthly population estimates for key seabirds and marine mammals in the Arklow Bank Study Area from July 2008 to June 2009. Distance Sampling is a widely-used group of closely related methods for estimating the density and/or abundance of biological populations from data collected usually using line transects or point counts (Buckland *et al.* 2001, 2004). It caters for the fact that animals more distant from the observer are less likely to be detected, and corrects the resulting population estimates accordingly. For distance sampling to be applied, perpendicular distances of clusters of animals from the survey line must be recorded. A detection function is then fitted to these observed distances, and used to estimate the proportion of objects missed within transect. This then allows an absolute estimate of the number and density of animals present to be made.

2.7.2 Methods

The Arklow Study Area is 11 km wide by 35 km long (Figure 2.1). To provide continuity with previous data, and provide more detailed coverage for the key Bank area, the 35 km long Bank legs surveyed in previous studies were also surveyed in Year 9 (Figure 1 - Appendix B). Each Bank leg was surveyed twice in each month. In addition, a survey grid was surveyed each month which ensured coverage extended 5 km from the development area. This was achieved by surveying 12 transects at 3 km intervals on each side of the bank, with each transect 5 km in length (Figure 1 - Appendix B). This ensures coverage extends to at least 5 km from the proposed development area, fulfilling the Department of Marine requirement.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

For the purposes of population estimation the Arklow Study Area was subdivided into three sections: Western Box, Eastern Box and Bank. The original design envisaged a Bank section of 1 km width, and Box sections each of 5 km width. However, in practise the routes followed by the survey vessel following the Bank legs, and sections of the survey grid running along the Bank often had to be further than 1 km apart to ensure safe operation (Figure 2 - Appendix B). Therefore, we used a Box section of 2 km width, with both Box sections being correspondingly reduced to 4.5 km wide. To ensure even coverage, we calculated population estimates for the Bank section using only the data from the two Bank legs (Figure 3 - Appendix B). The population estimates for the two Box sections were calculated using only data collected within them from the transects running perpendicular to the Bank (Figure 4 - Appendix B).

In these analyses we calculated design based population estimates, with each transect treated as a sample. To ensure even coverage within each of the sections, and statistically independent samples, data collected from the connectors between transects, and from transects other than the Bank legs within the Bank section, were excluded (Figures 3 & 4 - Appendix B). However, for alternative model based analyses, such as Density Surface Modelling (Thomas et al. 2010) which derive distribution maps and population estimates from predictive models, such data could potentially be included, and so is valuable.

The standard ESAS methodology used for this study is a line transect methodology. A transect width of 300m was used. For these analyses, birds recorded outside the transect were ignored. For recording birds on the water, this 300m band was subdivided into 4 distance bands from the trackline: Band A (0–50m), Band B (50–100m), Band C (100–200m) and Band D (200–300m). The detection function model used to estimate the proportion of birds within the transect escaping detection is calculated using this distance data.

Birds in flight were recorded using a regular snapshot count of birds flying over the transect and within 300m distance ahead of the ship. For birds in flight no distance data was recorded, and so no detection function could be fitted. Therefore we have assumed that all flying birds within transect were detected.

For all analyses we used the Conventional Distance Sampling engine within Distance 6.0 (Thomas *et al.* 2010). To ensure adequate sample sizes for detection function modelling we used data pooled across all 12 months survey and 3 sections. However, we estimated population size and density, (and thus encounter rate and group size) separately for each section/month combination. We estimated the variance in encounter rate empirically using the default design-derived estimator (R^2/P^2 , Fewster *et al.* 2009).

For birds on the water we fitted a detection function model to the distance data, based upon a half normal key function with cosine adjustment terms. For birds in flight, 100% detection was modelled by assuming a uniform key function with no adjustment terms. Estimates of group size can be biased if either size-biased detection or underestimation of the size of detected clusters is taking place. We corrected for these potential biases using the default method within Distance, in which log cluster size is regressed on estimated probability of detection.

Within Distance, we calculated separate population estimates for birds on the water and birds in flight for each section/month combination, assuming 100% detectability for birds in flight, and estimating the probability of detection for birds on the water using detection function modelling. The total numbers/densities of birds either for the whole study area or for each section/month combination were estimated by summing these estimates.

When summing population/density estimates the variance of the combined estimates was calculated by summing the variance estimates for the individual estimates, making the working assumption that the original estimates are uncorrelated random variables.

Given such variance estimates for combined density estimates, 95% confidence limits can potentially be calculated using equations 3.72 to 3.74 in Buckland *et al.* (2001:77). We have adopted this approach successfully in other studies. However, for this study, and for the Bank in particular, this approach appears to greatly underestimate the 95% confidence limits for the combined estimate, compared to what we would be expected, given the 95% confidence limits for the individual estimates. We think this was because the density estimates for the Bank are based upon just two transects/samples, violating the assumptions of large sample sizes underpinning Buckland *et al.*'s equation 3.73. Therefore we have adopted the more conservative estimate of estimating the upper and lower 95% confidence limits for the combined population estimates as the sum of the corresponding confidence limits for the original estimates. This will tend to overestimate slightly the uncertainty in estimates, rather than (grossly) underestimate it.

Following the recommendations of Camphuysen *et al.* (2004), only observations made in sea states of 4 or less were included in analyses for seabirds, and only observations made in sea states of 3 or less were included in analyses for marine mammals. Given each bank

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

leg is 35 km long and covered twice in each month, the total survey effort in the Bank section in each month is expected to be c. 140 km. For each box section, with 12 transects each of 4.5 km each covered once a month, the expected survey effort in each month is c. 54 km. The observed survey efforts for each section in each month when all survey effort is included irrespective of sea state are generally close to the expectations (Table 1 – Appendix B). For the analyses of seabird data, the exclusion of data collected in sea states 5 or more, generally had relatively little impact on the effort achieved.

For the analyses of marine mammal data, the exclusion of data collected in sea states of 4 or more has a more marked impact on the survey effort achieved in particular sections in particular months, for example the Bank in July 2008, and the Bank and Eastern Boxes in June 2009.

3. Results

3.1 Survey effort

Surveys were conducted over 38 days between July 2008 and June 2009, with a total of 3,877.26 km surveyed (Table 3.1). Figure 3.1 shows the survey coverage (number of surveys) in the Arklow Study Area in Year 9. Survey routes for individual months are included in Appendix C.

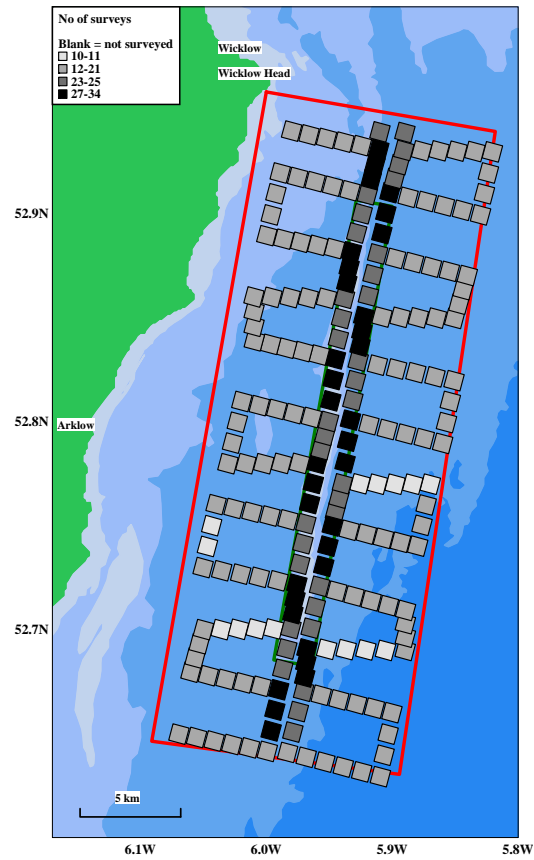
The aim was to survey the Bank legs twice monthly, and the new Year 9 route, running perpendicular to the Arklow Bank, once per month. This was achieved in all months.

Table 3.1 Survey effort for the Arklow Study Area for Year 9

Area	No. of survey days	Km surveyed (all days)	Area surveyed in km ² (all days) ¹
Bank	38	2,085.06	625.52
New Route	32	1,792.20	537.67
Total	38	3,877.26	1,163.19

¹ Total includes survey effort gathered in all sea states

Figure 3.1 Survey effort in the Arklow Study Area in Year 9



3.2 Raw numbers of seabirds in the Arklow Study Area in Year 9

A total of 29 species of seabirds were identified on surveys in Year 9. This compares to 32 species in Year 8, 28 species in Year 7, 26 species in Year 6 and 29 species in Year 5.

Totals for the most common seabird species for Year 9 are shown in Table 3.2. The three commonest species in the Arklow Study Area in Year 9 were Kittiwake, Razorbill and Guillemot, which together accounted for 63.2 % of all birds recorded.

Table 3.3 summarises the occurrences of a further 15 species of seabirds which were less frequently recorded in the Arklow Study Area in Year 9.

To put these results into context, JNCC seabird distribution data from 1981 to 2001 for the four $\frac{1}{4}$ 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 $\frac{1}{4}$ 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 9

A total of 75 birds of 10 non-seabird species were recorded in the Arklow Study Area in Year 9. Two thirds of all non-seabirds recorded were Swallows (66.6 %) (Appendix D).

Table 3.2 shows numbers of the commoner seabird species recorded in the Arklow Study Area in Year 9. 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 9

Species	Year 9	
	Number	No. of days
Red-throated Diver	154	21
Fulmar	43	17
Manx Shearwater	3,252	23
Gannet	400	37
Shag	488	32
Little Gull	1,491	25
Black-headed Gull	6,027	19
Common Gull	1,861	21
Herring Gull	81	20
Kittiwake	27,843	38
Common Tern	523	10
Arctic Tern	5	3
Guillemot	6,972	38
Razorbill	8,159	38
Small Gull Species ¹	3,257	9
Common/Arctic Tern ²	357	7
Guillemot/Razorbill ³	7,088	38
Total numbers	68,001	38

1 Unidentified small gulls. In later analyses, 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 analyses, these records were divided between Common and Arctic Tern, based on daily ratios of these two species

3 Unidentified Guillemots/Razorbills. In later analyses, 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 9. 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 9

Species	Year 9	
	Number	No. of days
Storm Petrel	6	3
Cormorant	51	20
Common Scoter	89	9
Pomarine Skua	2	2
Arctic Skua	8	6
Great Skua	2	2
Grey Phalarope	1	1
Mediterranean Gull	3	3
Lesser Black-backed Gull	11	9
Great Black-backed Gull	50	19
Sandwich Tern	4	3
Roseate Tern	89	5
Black Tern	1	1
Black Guillemot	4	3
Puffin	4	4
Scoter species	2	1
Auk species	20	2
Total numbers	347	38

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

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

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
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

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

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 and revised Box route

A total of 28 seabird species were recorded over the Bank in Year 9, with 23 species recorded on the revised Box route, with transects running perpendicular to the Bank.

Numbers of the 14 commonest seabird species over the Bank, and revised Box route in Year 9 are shown in Table 3.6. Total numbers of birds over the Bank accounted for 84.8 % of all birds recorded in Year 9.

Table 3.6 Comparison of the most common seabird numbers over the Bank, and on the revised Box route in Year 9

Species	Bank	Revised Box Route
Red-throated Diver	146	8
Fulmar	24	19
Manx Shearwater	1,887	1,365
Gannet	205	195
Shag	451	37
Little Gull	1,355	136
Black-headed Gull	5,624	403
Common Gull	1,634	227
Herring Gull	32	49
Kittiwake	26,651	1,192
Common Tern	460	63
Arctic Tern	5	0
Guillemot	4,335	2,637
Razorbill	6,229	1,930
Small Gull Species ¹	3,257	0
Common/Arctic Tern ²	104	253
Guillemot/Razorbill ³	5,258	1,830
Total	57,657	10,344

1 Unidentified small gulls. In later analyses, 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 analyses, these records were divided between Common and Arctic Tern, based on daily ratios of these two species

3 Unidentified Guillemots/Razorbills. In later analyses, these records were divided between Guillemots and Razorbills, based on daily ratios of these two species

3.3 Flying birds

Numbers of the 15 most common seabird species recorded flying in the Arklow Study Area in Year 9 are shown in Table 3.7. The three species most frequently recorded in flight in Year 9 were Kittiwake, Black-headed Gull and Common Gull.

Table 3.7 Numbers of the most common seabirds recorded flying in Year 9

Species	No. of birds	No. of flying birds	% flying birds
Red-throated Diver	154	115	74.7
Fulmar	43	36	83.7
Manx Shearwater	3,252	1,130	34.7
Gannet	400	306	76.5
Shag	488	82	16.8
Little Gull	1,491	876	58.8
Black-headed Gull	6,027	3,397	56.4
Common Gull	1,861	1,560	83.8
Herring Gull	81	56	69.1
Kittiwake	27,843	8,611	30.9
Common Tern	523	291	55.6
Guillemot	6,972	935	13.4
Razorbill	8,159	1,028	12.6
Small Gull species ¹	3,257	1,995	61.3
Common/Arctic Tern ²	357	252	70.6
Guillemot/Razorbill ³	7,088	2,333	32.9
Total	67,996	23,003	33.8

1 Unidentified small gulls. In later analyses, 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 analyses, these records were divided between Common and Arctic Tern, based on daily ratios of these two species

3 Unidentified Guillemots/Razorbills. In later analyses, these records were divided between Guillemots and Razorbills, based on daily ratios of these two species

In Year 9, 33.8 % of the most common species were recorded in flight. This compares to 11.6 % in Year 8, 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 9. 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 Year 9, the majority of all flying birds of the most common seabird species were recorded below 20 m in height (98.9 %) (blue and green lines) (Figure 3.2). No auks, Fulmar, Shag, Manx Shearwater or small gull species 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 (99.2 %) (Figure 3.3). Again, no auks, Fulmar, Shag, Manx Shearwater or small gull species were recorded flying above 20m.

In Year 9, a total of eight species (Herring Gull, Gannet, Red-throated Diver, Common Tern, Little Gull, Kittiwake, Common Gull and Black-headed Gull) and 55 unidentified Common/Arctic Terns were recorded flying above 20 m in the Arklow Study Area (Figure 3.2).

More than 10 % of all flying Herring Gulls and Gannets were recorded flying above 20 m in the Arklow Study Area in Year 9 (Figure 3.2). Overall, the numbers of birds involved were low, with 12 out of 56 Herring Gulls (21.4 %) and 34 out of 306 Gannets (11.1 %) recorded above 20 m.

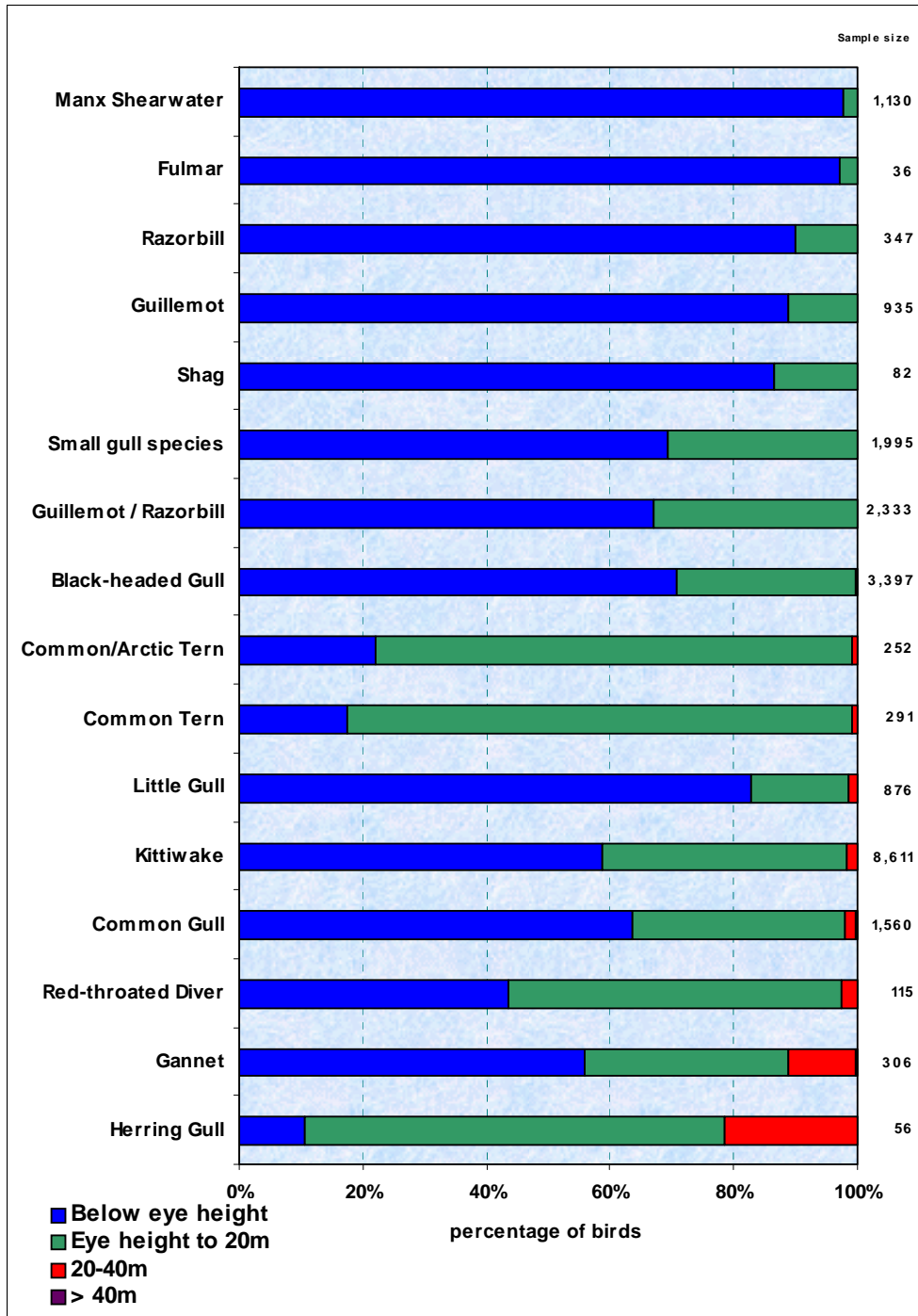
Less than 10% of all flying Red-throated Divers, Common Gulls, Kittiwakes, Little Gulls, Common Terns, unidentified Common/Arctic Terns and Black-headed Gulls were recorded flying above 20 m in the Arklow Study Area (Figure 3.2). Overall, the numbers involved were 3 out of 115 Red-throated Divers (2.6 %), 32 out of 1,560 Common Gulls (2.0 %), 138 out of 8,611 Kittiwakes (1.6 %), 12 out of 876 Little Gulls (1.4 %), 3 out of 291 Common Terns (1.0 %), 2 out of 252 unidentified Common/Arctic Terns (0.8 %) and 10 out of 3,397 Black-headed Gulls (0.3 %).

The same eight species were also recorded flying above 20 m over the Bank in Year 9 (Figure 3.3). More than 10 % of all Herring Gulls and Gannets were recorded flying above 20 m over the Bank. Overall, the numbers involved were low, with 4 out of 23 Herring Gulls (17.4 %) and 18 out of 161 Gannets (11.2 %) recorded above 20 m over the Bank in Year 9.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

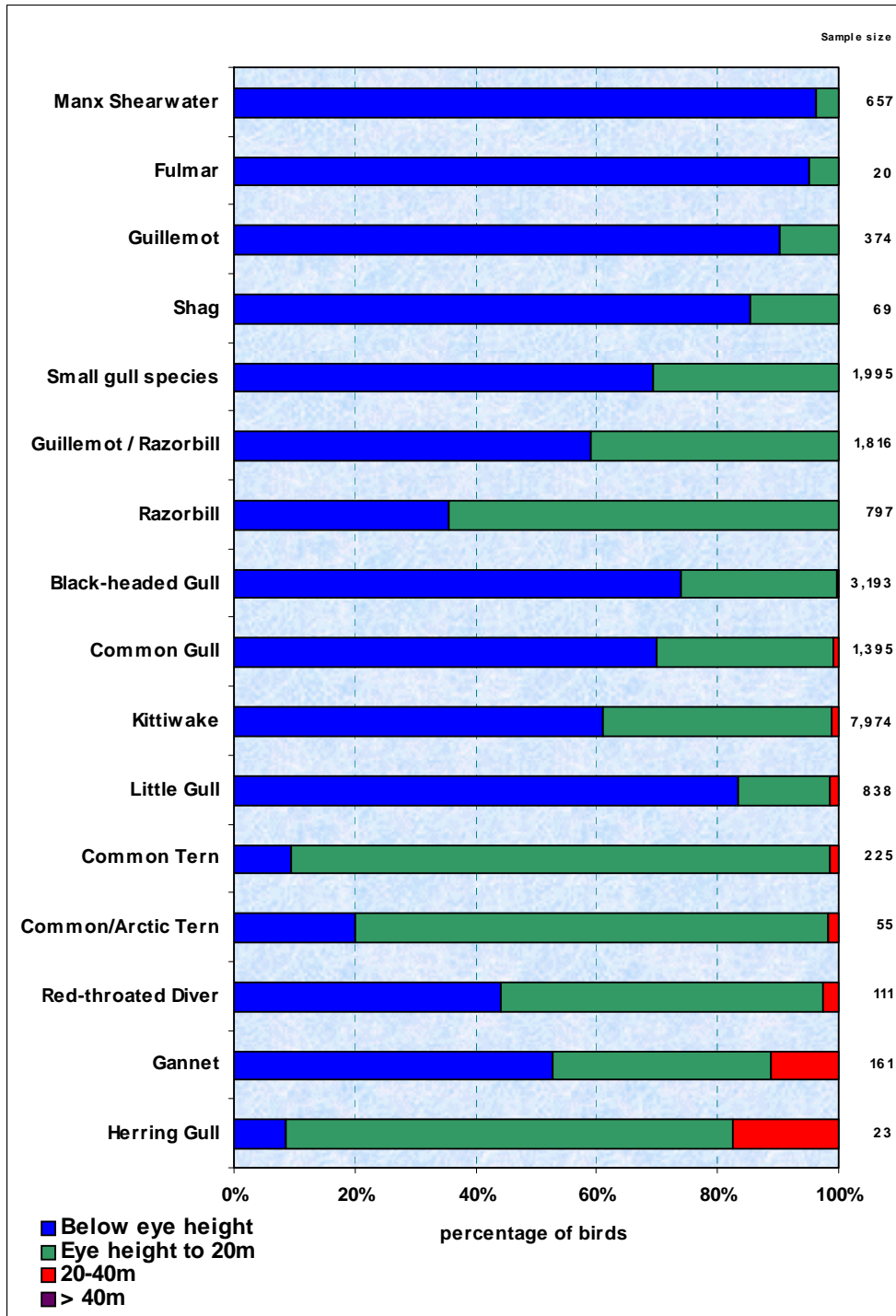
Less than 10% of all flying Red-throated Divers, unidentified Common/Arctic Terns, Common Terns, Little Gulls, Kittiwakes, Common Gulls, and Black-headed Gulls were recorded flying above 20 m over the Bank in Year 9 (Figure 3.3). Overall, the numbers involved were 3 out of 111 Red-throated Divers (2.7 %), 1 out of 55 unidentified Common/Arctic Terns (1.8 %), 3 out of 225 Common Terns (1.3 %), 11 out of 838 Little Gulls (1.3 %), 90 out of 7,974 Kittiwakes (1.1 %), 12 out of 1,395 Common Gulls (0.9 %) and 7 out of 3,193 Black-headed Gulls (0.2 %).

Figure 3.2 Flight heights of seabird species in the Arklow Study Area in Year 9 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 9 ¹



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

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 9, with a brief comparison with Years 5 to 8 combined, which covers the whole of the post-construction phase. Numbers of each species recorded over the Bank for Year 5 to Year 9, and the revised Box route for Year 9 only are shown as charts, along with mean monthly abundance or density charts for the Bank and the revised Year 9 Box survey route. Distribution maps showing density, abundance or sightings for Year 9 and Years 5 to 8 combined are also included.

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).

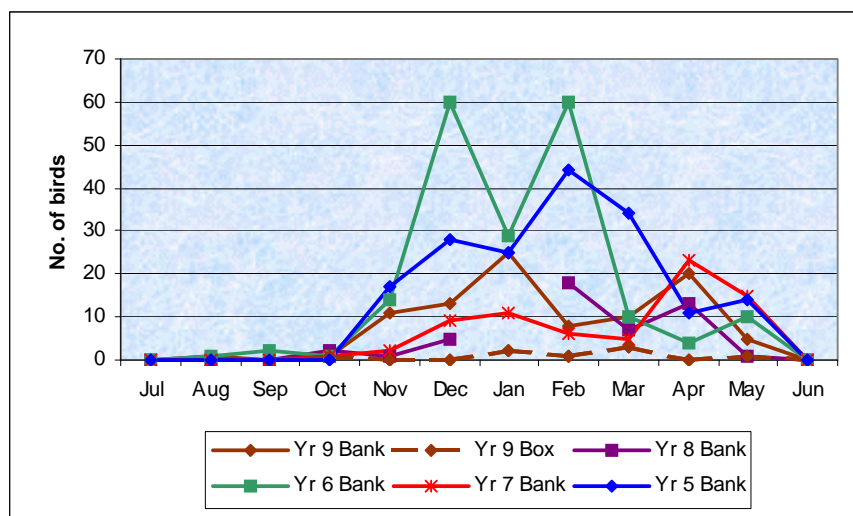
Numbers in the Arklow Study Area

In Year 9, Red-throated Divers were recorded in all months except June, July and September.

Peak numbers of Red-throated Divers recorded over the Bank exceeded the 1 % nationally important threshold of 20 birds (Crowe 2005), with a maximum day count of 25 birds recorded in January (Figure 3.4). This compares to a maximum peak day count of 18 birds in Year 8 (although there was no January count in Year 8), 23 birds in Year 7, 60 birds in Year 6 and 44 birds in Year 5. The combined 5-year mean for the Arklow Bank, for Years 5 to 9 was 34 birds, which is nationally important.

Numbers of Red-throated Divers on the revised Year 9 Box route were lower than over the Bank, with a peak of 3 birds in March (Figure 3.4).

Figure 3.4 Numbers of Red-throated Divers in the Arklow Study Area, Years 5 to 9



Mean monthly abundance

In Year 9, mean monthly abundance over the Bank showed a similar pattern to Years 5 to 8 combined, although the January peak was slightly higher in Year 9 (with a peak of 0.3 birds/km (Figure 3.5). Mean monthly abundance in Years 5 to 8 peaked in December and January, when 0.2 birds/km were recorded. Mean monthly abundance in the Box in Year 9 was low throughout the year (Figure 3.5).

Figure 3.5 Red-throated Diver mean monthly abundance in the Arklow Study Area, Years 5 to 9

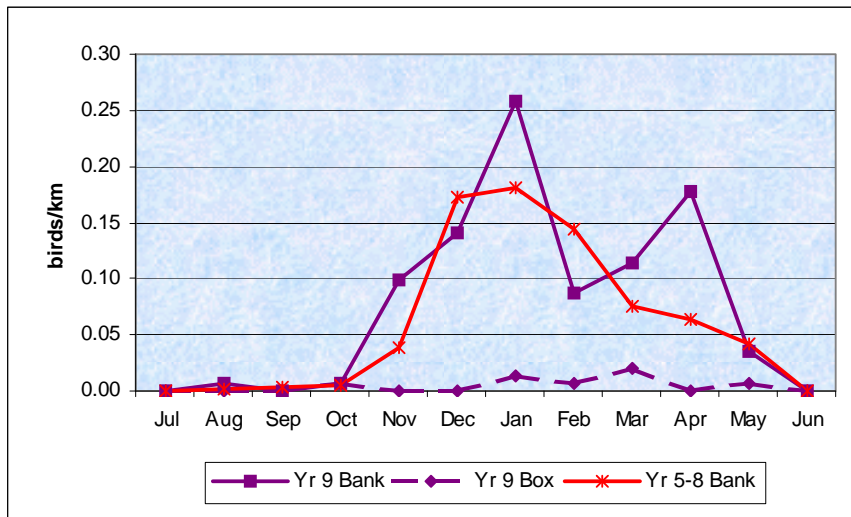
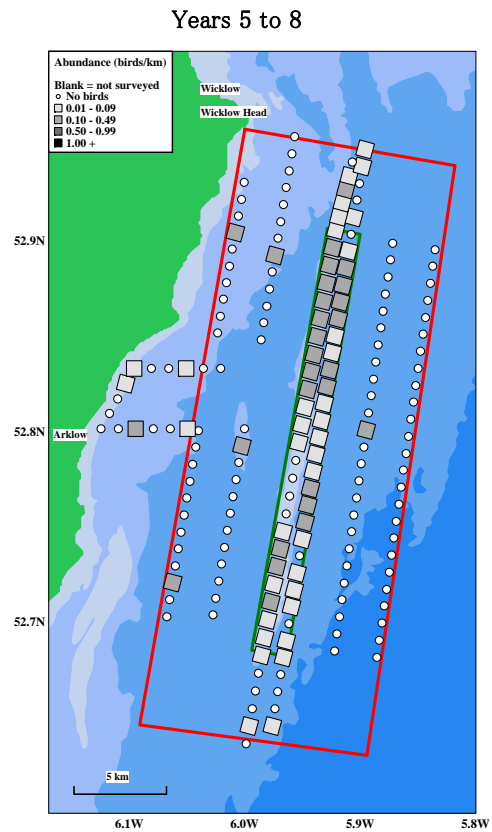


Figure 3.6 Red-throated Diver abundance in the Arklow Study Area, November to May

Years 5 to 8 – November to May

Between November and May of Years 5 to 8, 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 and Cable Route.

In addition, there were nine Red-throated Divers recorded between August and October of Years 5 to 8 (not shown).



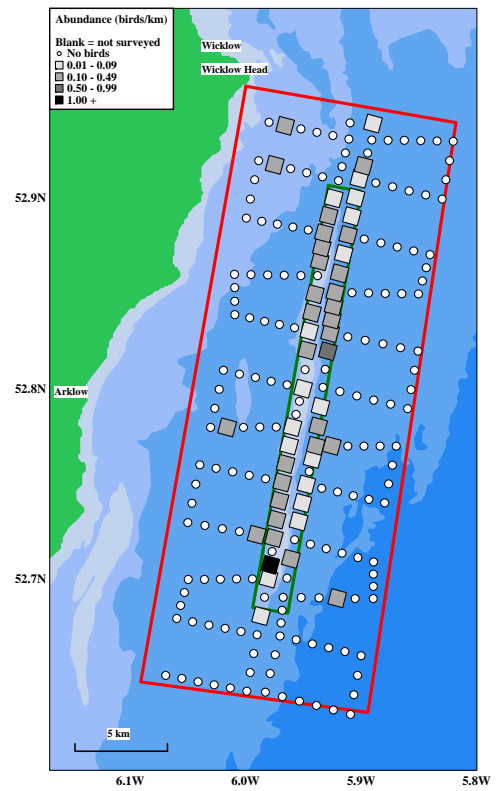
Years 5 to 8

Year 9

Year 9 – November to May

In Year 9, Red-throated Divers were again mostly found over the Bank between November and May. Highest abundance (1.1 birds/km) was recorded at the southern end of the inner Bank leg.

In addition, there were two Red-throated Divers recorded between August and October of Year 9 (not shown).



3.4.2 Great Northern Diver

Figure 3.7 Great Northern Diver Sightings

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 8

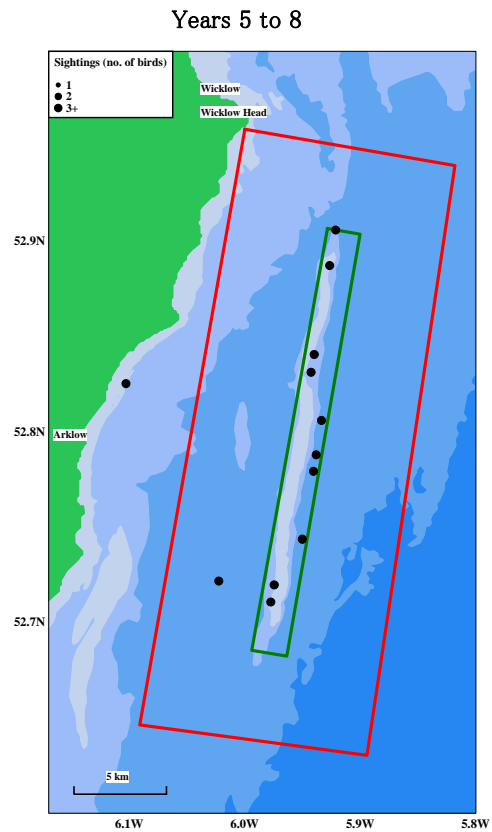
The majority of birds were recorded over the Bank in all four years.

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.

There was one sighting of Great Northern Diver over the Bank in March of Year 8.



Year 9

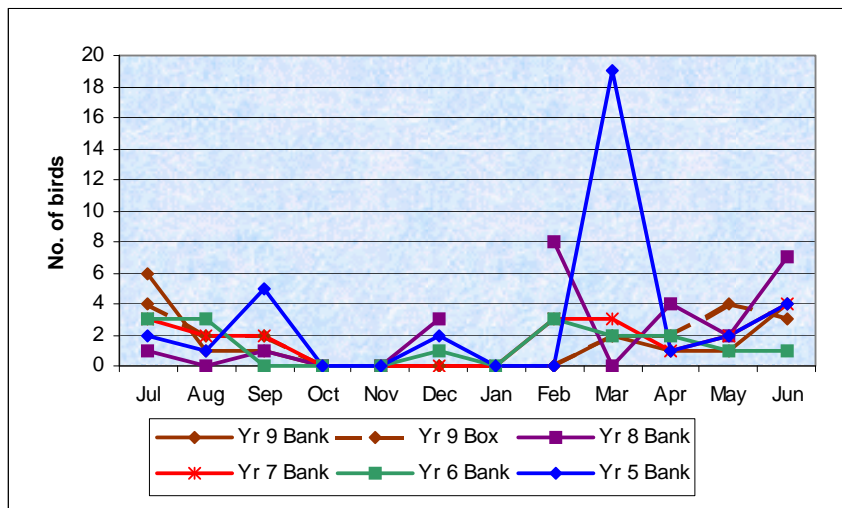
There were no sightings of Great Northern Diver in the Arklow Study Area in Year 9.

3.4.3 Fulmar

Numbers in the Arklow Study Area

Numbers of Fulmars recorded in the Arklow Study Area in Year 9 were very low, with a total of 48 birds recorded. Numbers recorded over the Bank peaked in July (6 birds) (Figure 3.8). Numbers over the Bank in previous years were similarly low, with a peak of 19 birds in March of Year 5. Numbers of Fulmars on the revised Year 9 Box route were similar to the Bank, with a peak of 4 birds in July and May (Figure 3.8).

Figure 3.8 Numbers of Fulmars in the Arklow Study Area, Years 5 to 9



Mean monthly abundance

Fulmar mean monthly abundance over the Bank and Box in Year 9 was very low (Figure 3.9). This was similar to the combined mean monthly abundance over the Bank for Years 5 to 8.

Figure 3.9 Fulmar mean monthly abundance in the Arklow Study Area, Years 5 to 9

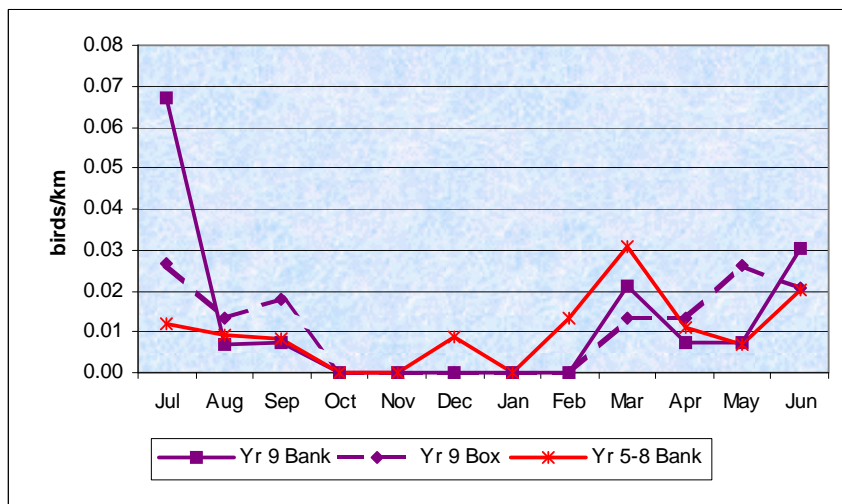
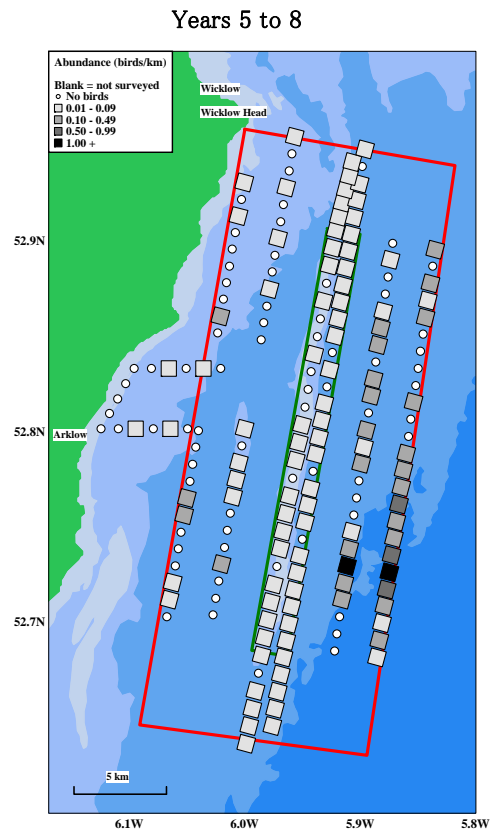


Figure 3.10 Fulmar abundance in the Arklow Study Area in all months

Years 5 to 8 - all months

Fulmars were scattered throughout the Arklow Study Area in Years 5 to 8. Abundances over the Bank were generally lower than in the Box.

Peak abundance was recorded along the southern end of the outer Box legs, with a peak abundance of 1.7 birds/km recorded in this area.

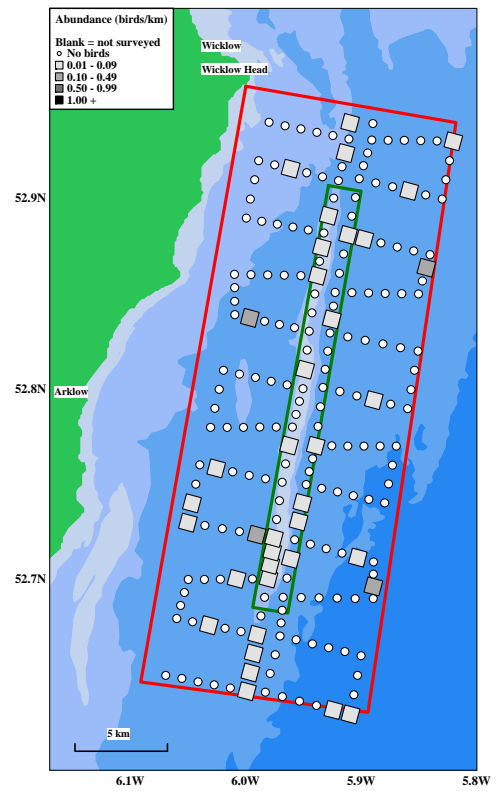


Years 5 to 8

Year 9

Year 9 - all months

In Year 9, Fulmars were scattered throughout the Arklow Study Area, with no obvious concentrations recorded. Numbers were most regular over the inner Bank leg.

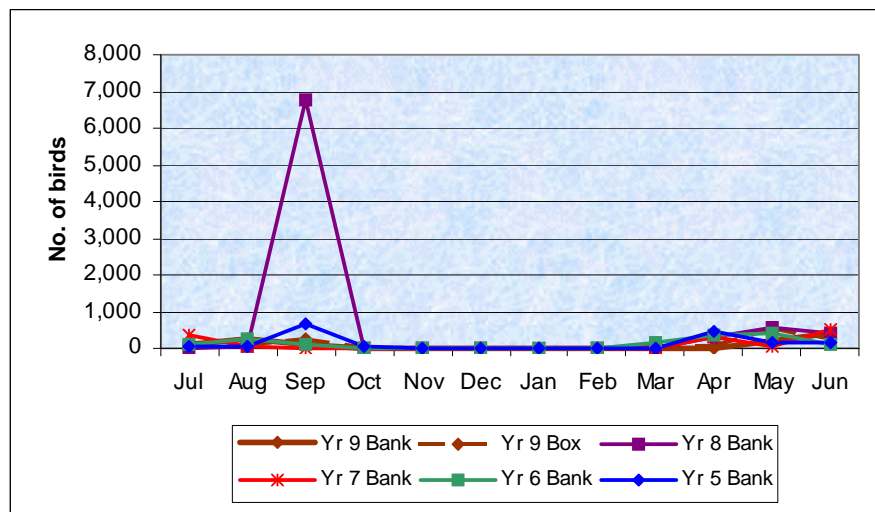


3.4.4 Manx Shearwater

Numbers in the Arklow Study Area

Manx Shearwaters are summer visitors to the Arklow Study Area, with no sightings between November and February in any year. Numbers over the Bank peaked in June, (424 birds) (Figure 3.11). This was similar to counts from previous years, except Year 8, when a peak of 6,791 birds was recorded in September. Numbers of Manx Shearwaters on the revised Year 9 Box route were similar to the Bank, with a peak of 546 birds in May (Figure 3.11).

Figure 3.11 Numbers of Manx Shearwaters in the Arklow Study Area, Years 5 to 9



Mean monthly density

Year 9 mean monthly density over the Bank peaked in June (18.4 birds/km²), while density on the revised Box route peaked in May (8.4 birds/km²) (Figure 3.12). There was a slight peak in both areas in September, but this was much lower than the peak recorded in September over the Bank in combined Years 5 to 8 (28.5 birds/km²).

Figure 3.12 Manx Shearwater mean monthly density in the Arklow Study Area, Years 5 to 9

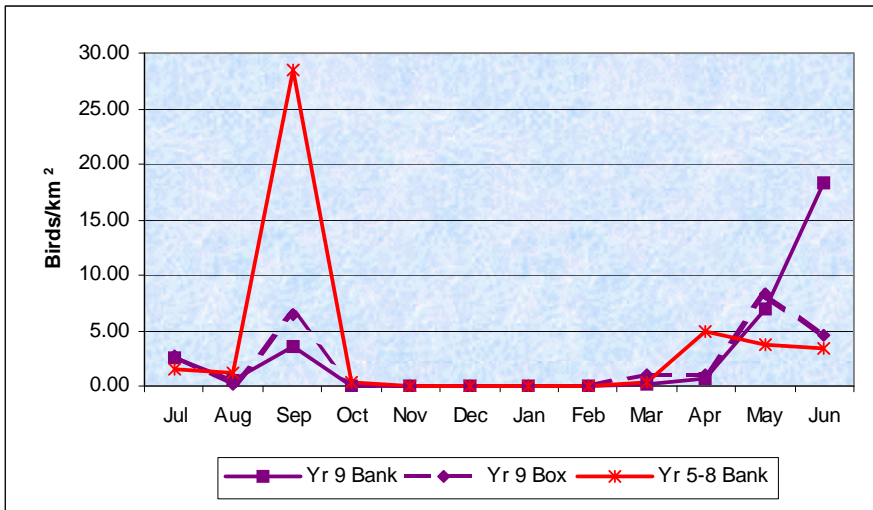


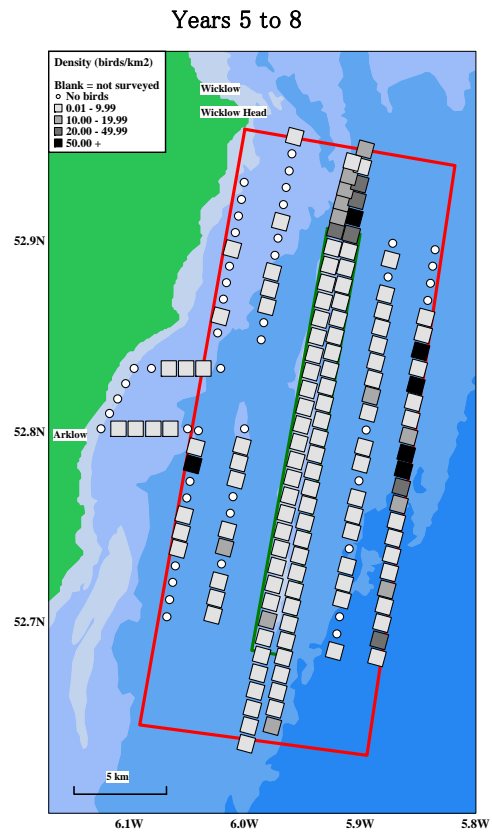
Figure 3.13 Manx Shearwater density in the Arklow Study Area from March to October

Years 5 to 8 - March to October

Between March and October of Years 5 to 8, Manx Shearwaters were generally recorded in low densities along the Bank, although moderate to high density was recorded at the northern end of the Bank, with a peak of 75.5 birds/km² on the offshore Bank leg.

Birds were also regularly recorded on the offshore Box legs, where peak density ranged between 54.9 and 516.4 birds/km².

Fewer Manx Shearwaters were recorded on the inner Box legs, where highest density was 54.2 birds/km², and on the Cable Route.



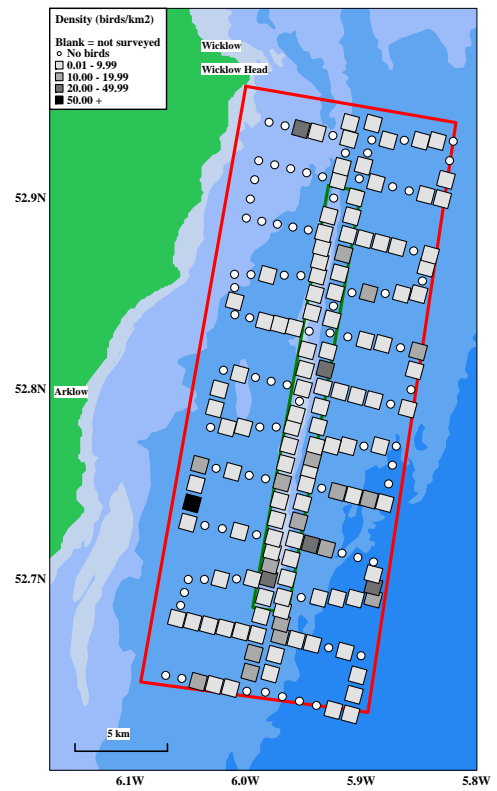
Year 9

Year 9 - March to October

In Year 9, Manx Shearwaters were again widespread over the Bank between March and October. Density was generally low to moderate, and were lower than the peak density recorded on the Bank over the same months in Years 5 to 8 combined.

Along the revised Box route, Manx Shearwater distribution was patchier than over the Bank, with a peak density of 69.8 birds/km², in the south-west of the Arklow Study Area.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report



3.4.5 Other Shearwaters

Figure 3.14 Shearwater sightings

Years 5 to 8

In Year 5, one Great Shearwater was recorded north of the Bank in September. This was the first record for the Arklow Study Area since the project began. A second Great Shearwater was recorded on Bank leg 2 in September of Year 8.

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

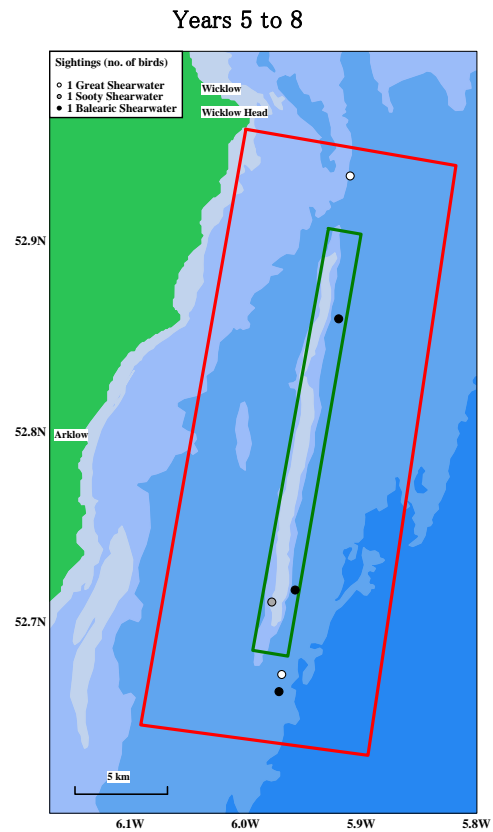
Balearic Shearwaters have a tiny breeding range and a small rapidly declining population. The species is listed as Critically Endangered on the 2007 IUCN (World Conservation Union) Red List (Birdlife International 2007), and is also listed on Annex I of the EU Birds Directive (79/409/EEC), and on the Birdwatch Ireland Red List, due to their global conservation status (Lynas *et al* 2007).

One Sooty Shearwater was recorded on Bank leg 3 in September of Year 8.

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

Year 9

No other species of shearwater were recorded during Year 9.



3.4.6 Petrels

Storm Petrels are scarce in the Arklow Study Area, while Leach’s Petrel is very rare in the area. Both species are listed on Annex I of the EU Birds Directive (79/409/EEC).

Years 5 to 8

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

In Year 6, there were 7 Storm Petrels recorded; four in July and 3 in August. Birds were scattered throughout the Arklow Study Area.

In Year 7, 5 Storm Petrels were recorded; 4 in July and 1 in August. As in Year 6, birds were scattered throughout the Arklow Study Area.

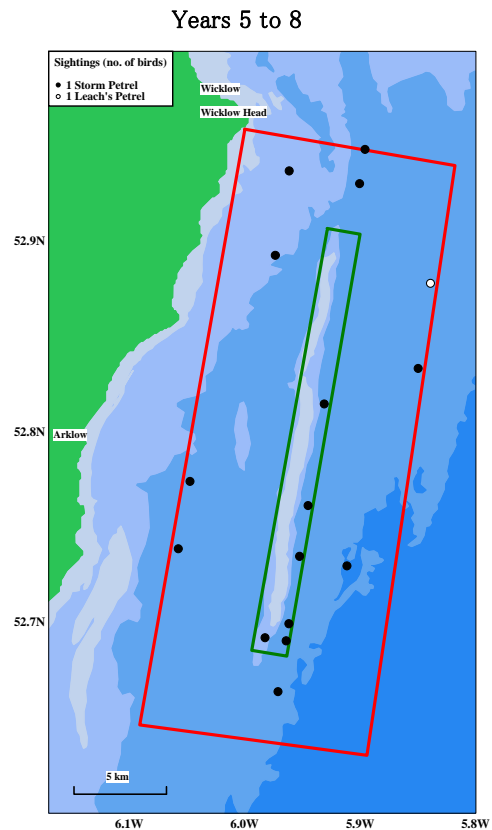
In Year 8, 3 Storm Petrels were recorded; 1 in June, and 2 in July.

One Leach’s Petrel was recorded in July of Year 6, in the north east of the Box. This was the first record in the Arklow Study Area since the project began.

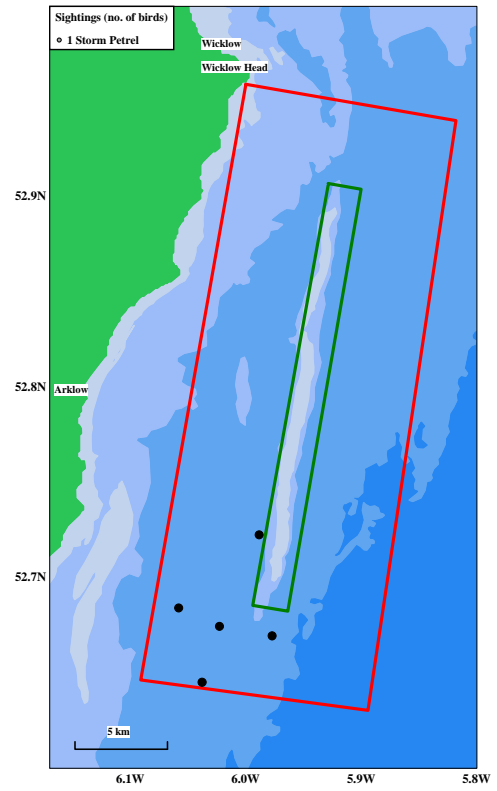
Year 9

In Year 9, a total of 5 Storm Petrels were recorded; 1 in June and 4 in July. All sightings occurred at the southern end of the Arklow Study Area, on the revised Box route.

Figure 3.15 Petrel sightings



Year 9

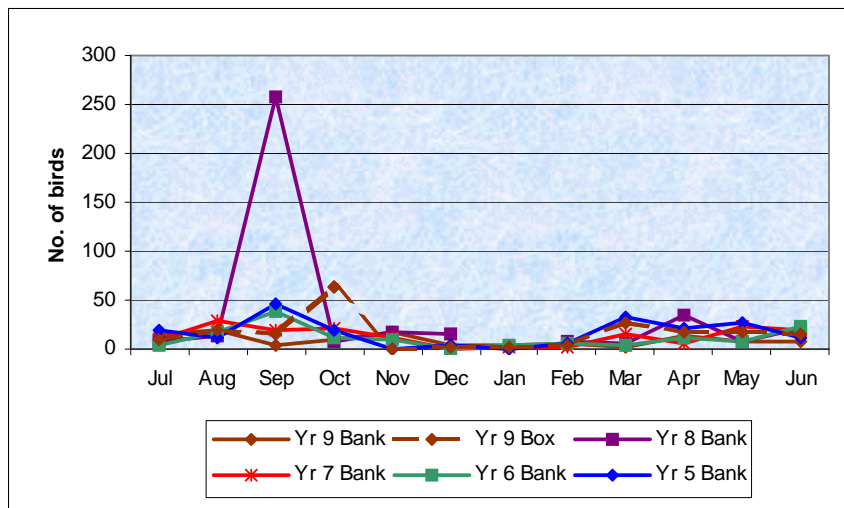


3.4.7 Gannet

Numbers in the Arklow Study Area

Numbers of Gannets in the Arklow Study Area in Year 9 were lower than recorded in Year 8, with a total of 400 birds recorded. Numbers over the Bank peaked in August (19 birds)(Figure 3.16). This was similar to previous years except Year 8, when a peak of 257 birds was recorded in September. Numbers of Gannets on the revised Year 9 Box route were similar to the Bank, with a peak of 64 birds in October (Figure 3.16).

Figure 3.16 Numbers of Gannets in the Arklow Study Area, Years 5 to 9



Mean monthly abundance

In Year 9, mean monthly abundance over the Bank was low throughout the year. On the revised Box route, mean monthly abundance was also low, but showed a peak of 0.4 birds/km in October (Figure 3.17). This equalled the peak recorded in September of Years 5 to 8 combined.

Figure 3.17 Gannet mean monthly abundance in the Arklow Study Area, Years 5 to 8

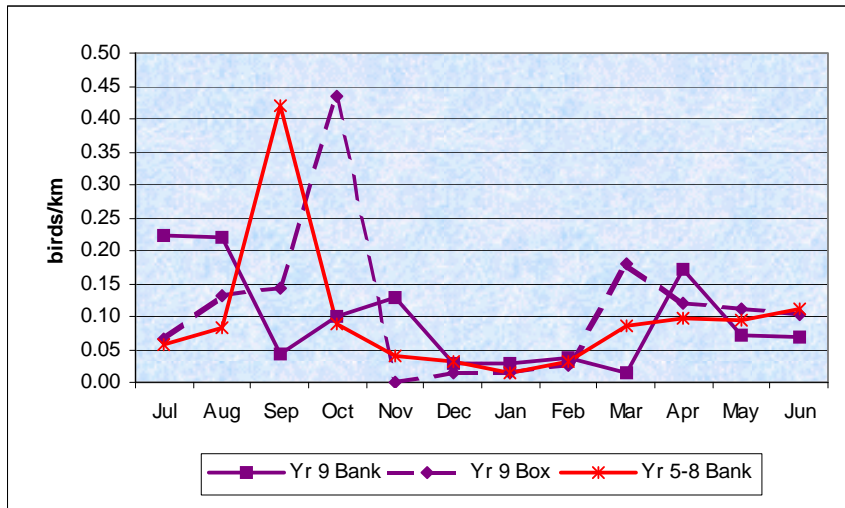
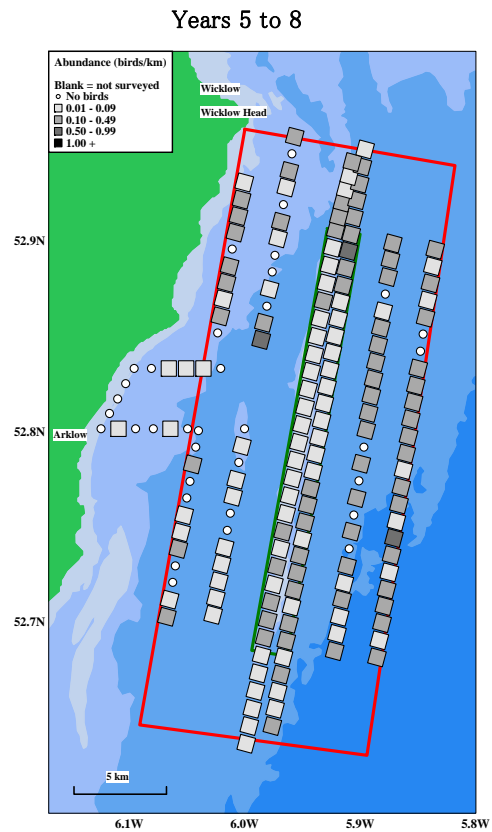


Figure 3.18 Gannet abundance in the Arklow Study Area in all months

Years 5 to 8

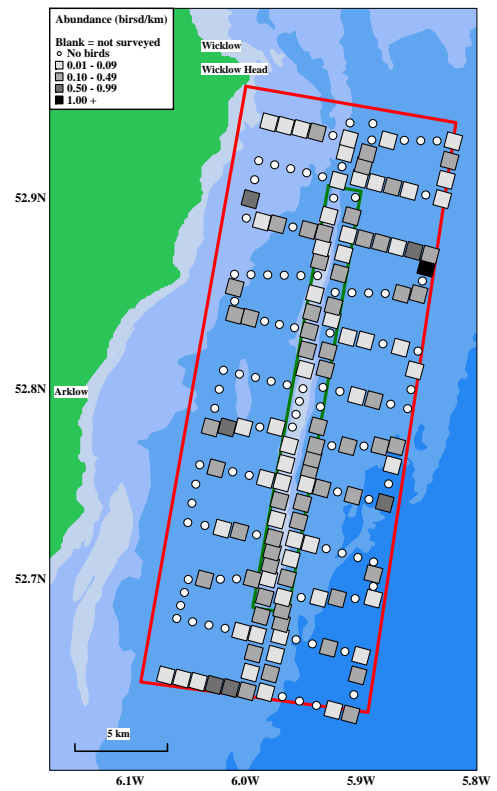
In Years 5 to 8, Gannets were widespread throughout the Arklow Study Area. Birds were recorded along the Bank in low to moderate abundance, with a patchier distribution over the Box and Cable Route.



Year 9

Year 9

In Year 9, Gannets were recorded throughout the Arklow Study Area in low to moderate numbers throughout the year, with a peak of 2.8 birds/km recorded in the north east of the Study Area, on the revised Box route.



3.4.8 Cormorant

Figure 3.19 Cormorant sightings

Years 5 to 8

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.

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

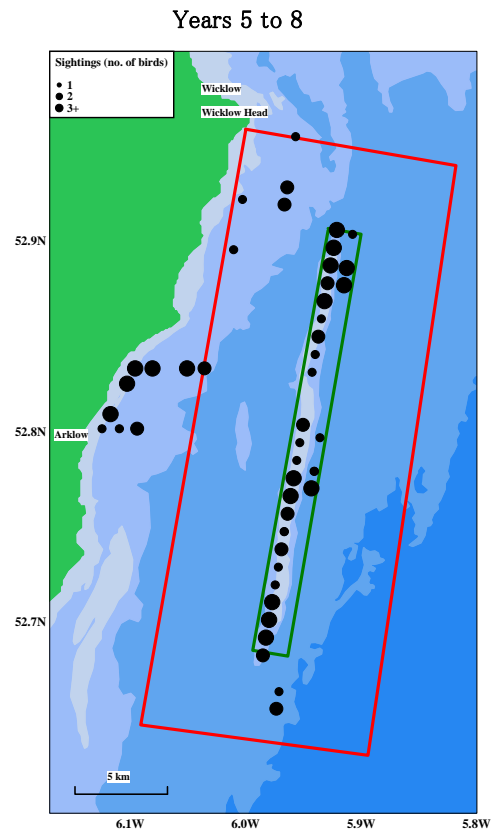
In Year 7, a total of 41 Cormorants were recorded, with a peak of 19 birds in October. The majority of birds were over the northern end of the Bank, with low numbers also seen along the Cable Route.

In Year 8, a total of 52 Cormorants were recorded, a peak of 19 birds in December. 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.

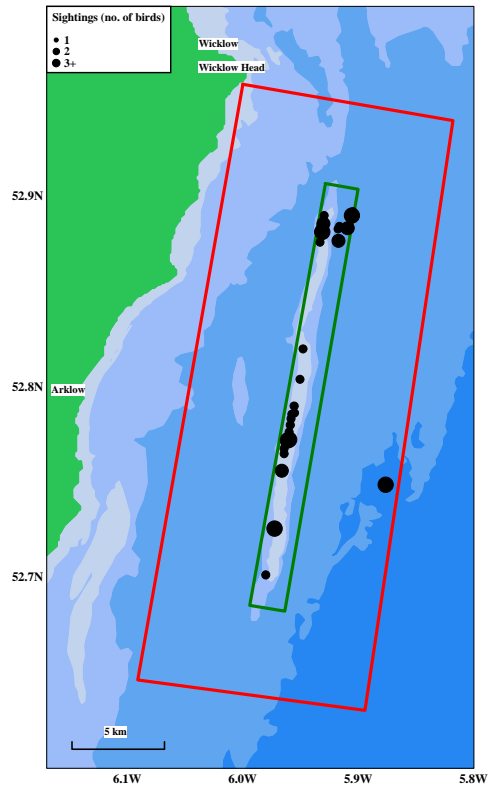
Year 9

In Year 9, a total of 51 Cormorants were recorded, although there was no obvious seasonal peak in numbers with a maximum of 9 birds in December, 8 birds in October and 7 in April, August and September.

The majority of birds were recorded over the Bank.



Year 9

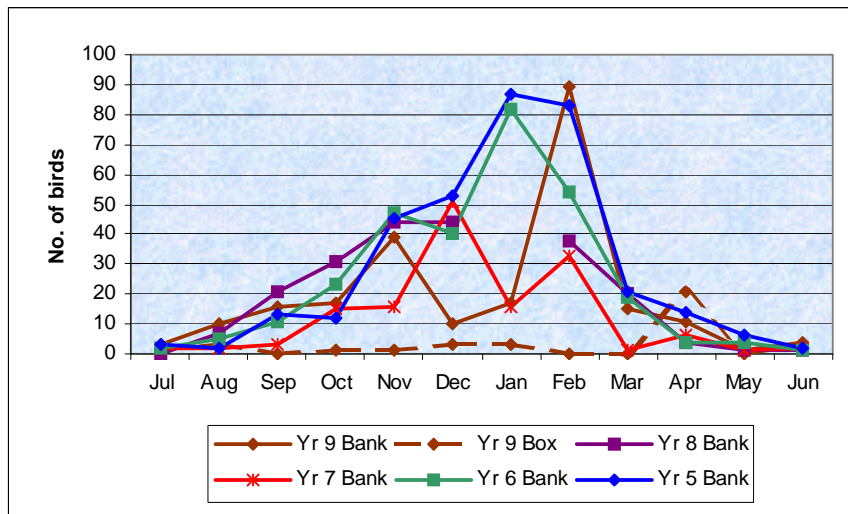


3.4.9 Shag

Numbers in the Arklow Study Area

A total of 488 Shags were recorded in the Arklow Study Area in Year 9, with the majority of birds recorded over the Bank. Birds were recorded over the Bank in all months, and numbers peaked in February (89 birds), which was similar to Years 5 and 6 (Figure 3.20). Like previous years, numbers decreased again between March and June. Low numbers of Shags were recorded on the revised Year 9 Box route, apart from in April (21 birds) (Figure 3.20).

Figure 3.20 Numbers of Shags in the Arklow Study Area, Years 5 to 9



Mean monthly abundance

The mean monthly abundance for Shags over the Bank in Year 9 showed a similar pattern to the combined mean monthly abundance for Years 5 to 8, although mean abundance in Year 9 peaked in February (1.1 birds/km), while mean abundance peaked in January (0.5 birds/km) in Years 5 to 8 combined (Figure 3.21). Monthly mean abundance on the revised Box route in Year 9 was very low throughout the year, apart from a slight increase in April (0.1 birds/km).

Figure 3.21 Shag mean monthly abundance in the Arklow Study Area, Years 5 to 8

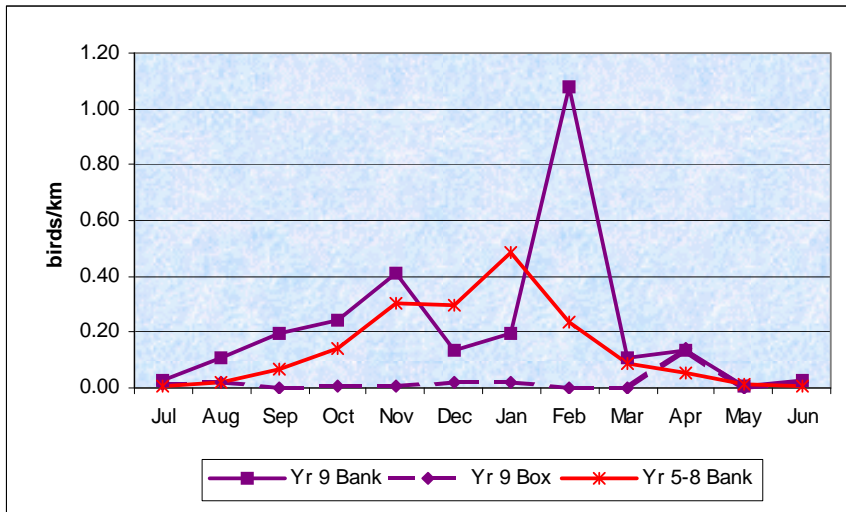
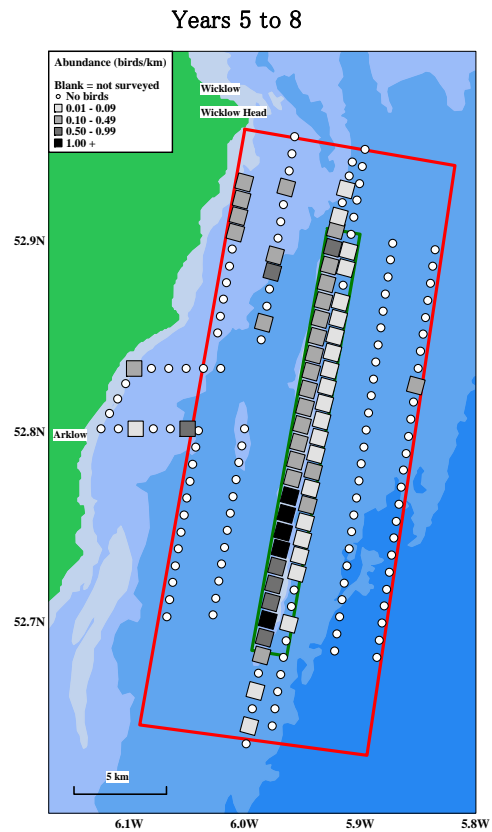


Figure 3.22 Shag abundance in the Arklow Study Area between October and March

Years 5 to 8 - October to March

Between Years 5 and 8, 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 was 1.6 birds/km.



Years 5 to 8

Year 9

Year 9

Shag distribution in the Arklow Study Area between October and March in Year 9 was similar to the previous four years, with the majority of birds recorded over the Bank.

Peak abundance was recorded on the inner Bank leg and ranged from 1.1 to 3.8 birds/km, which was higher than the peak abundance recorded over the same period in Years 5 to 8 combined.

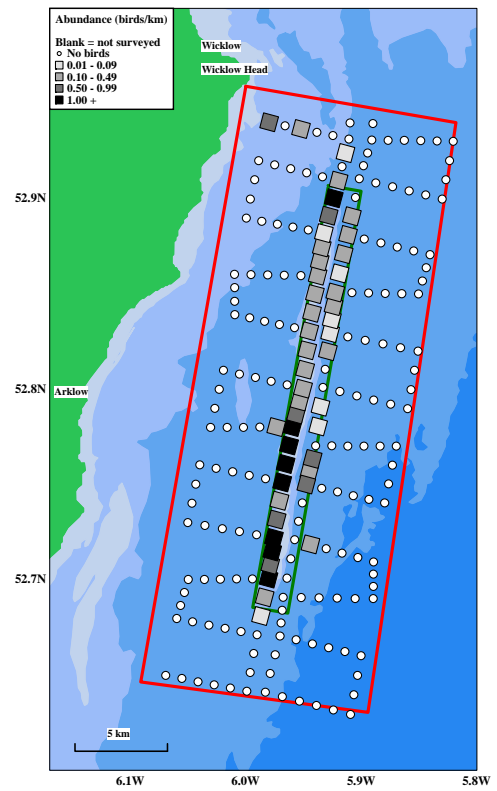
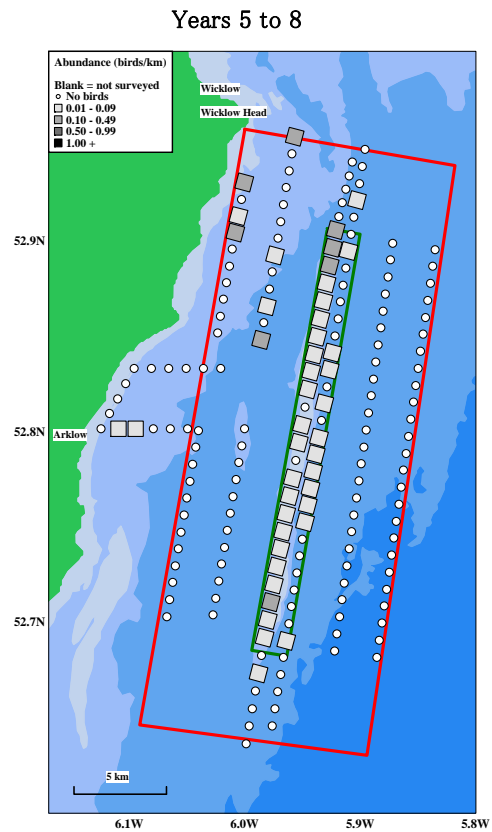


Figure 3.23 Shag abundance in the Arklow Study Area between April and September

Years 5 to 8 - April to September

Numbers of Shags between April and September in Years 5 to 8 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 and Cable Route.

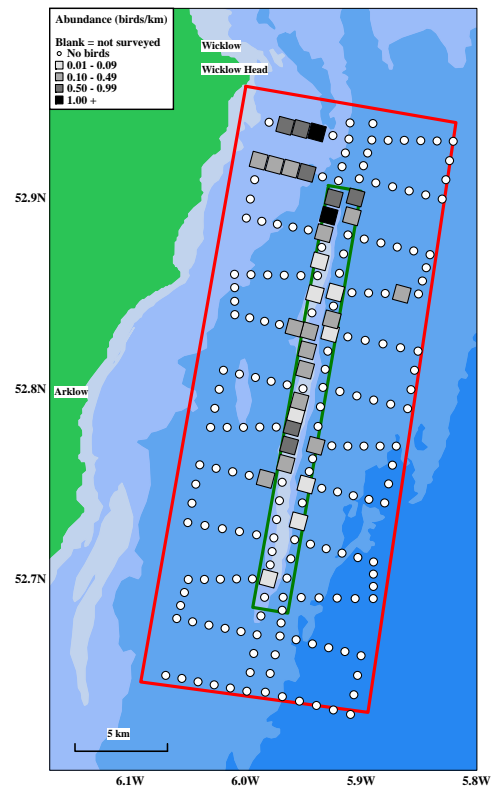


Year 9

Year 9 – April to September

Shag abundance between April and September of Year 9 was similar to the previous four years, with low to moderate abundance recorded over the Bank, and fewer birds recorded on the revised Box route.

Highest abundance at this time (1.8 birds/km) was recorded at the northern end of the Arklow Study Area, on the revised Box route.



3.4.10 Seaduck

Figure 3.24 Seaduck sightings

Years 5 to 8

There were no sightings of seaduck in Year 5.

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

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

A total of 41 Common Scoter were recorded in Year 8. Peak Bank counts involved 11 birds in September, with 12 seen in November.

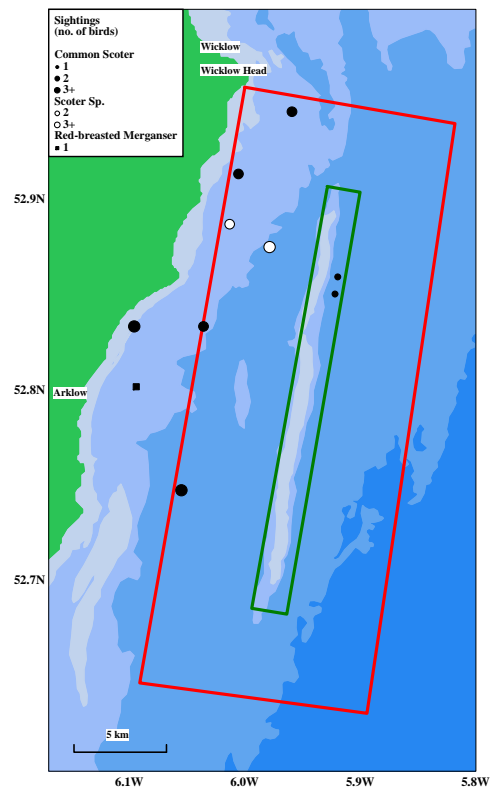
A further 121 unidentified scoter were recorded, 17 in December and 92 in February in the Box.

Four Red-breasted Mergansers were recorded in Year 8, one in November, and three in February.

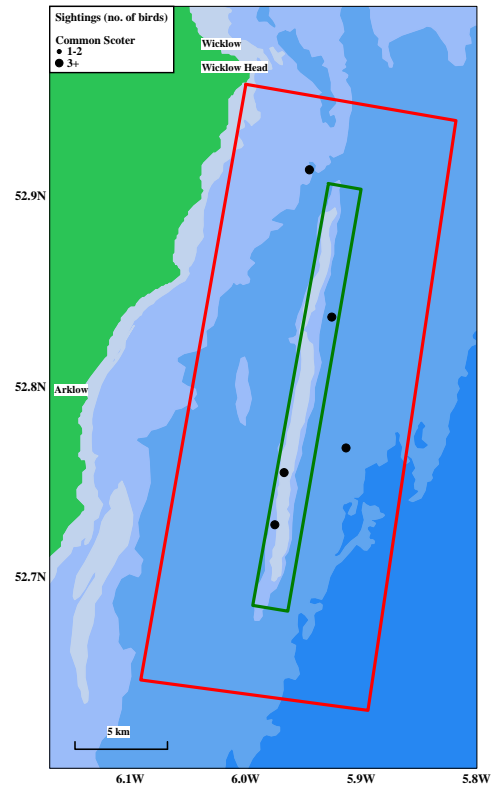
Year 9

A total of 89 Common Scoter were recorded in Year 9, with a peak of 51 in February. Most sightings were recorded over the Bank.

Years 5 to 8



Year 9



3.4.11 Skuas

Figure 3.25

Skua & Grey Phalarope sightings

Years 5 to 8

Three skua species were recorded in the Arklow Bank Study Area between Years 5 and 8, with the majority seen in autumn. In Year 5, 3 Arctic Skuas were seen over the Bank, with 1 Pomarine Skua and 1 Great Skua in the Box.

In Year 6, 8 Arctic Skuas, 1 Pomarine Skua and 2 Great Skuas were seen over the Bank, with 2 Arctic Skuas over the Box. Three unidentified skuas were also recorded.

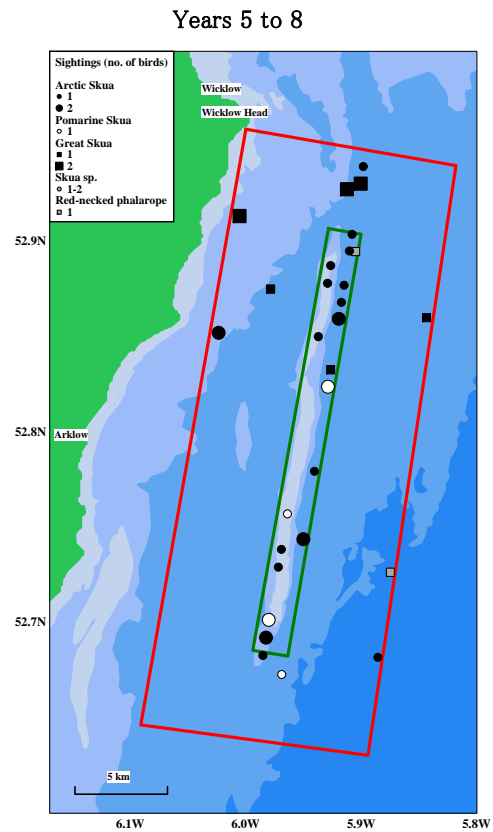
In Year 7, 4 Arctic Skuas were recorded over the Bank, with two Great Skuas seen in the Box.

In Year 8, 4 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.

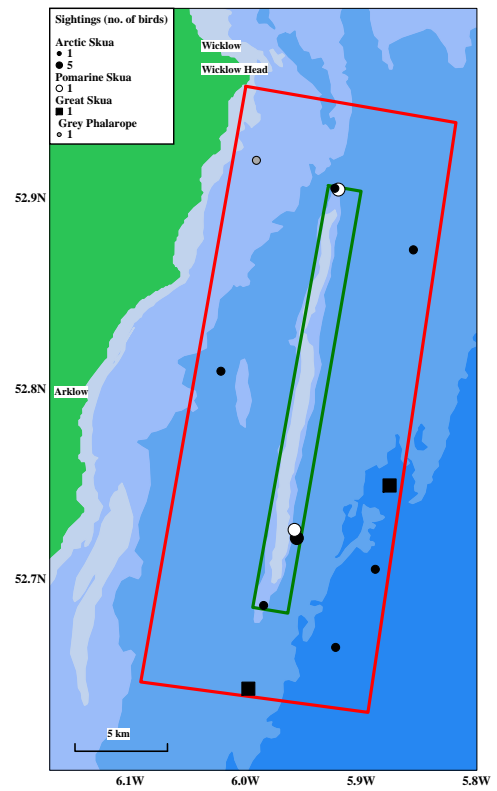
Year 9

Numbers of Skuas recorded within the Arklow Study Area in Year 9 were similar to the previous 4 years, with 3 species recorded.

Two Pomarine Skuas were recorded over the Bank in October. A total of 8 Arctic Skuas were seen, with 2 in July, 5 in September and 1 in October. Birds were scattered throughout the Arklow Study Area. Single Great Skuas were recorded on the revised Box route in October and November.



Year 9



3.4.12 Grey Phalarope

One Grey Phalarope was seen in Year 9, in the north-west of the Arklow Study Area in November (Figure 3.25).

3.4.13 Little Gull

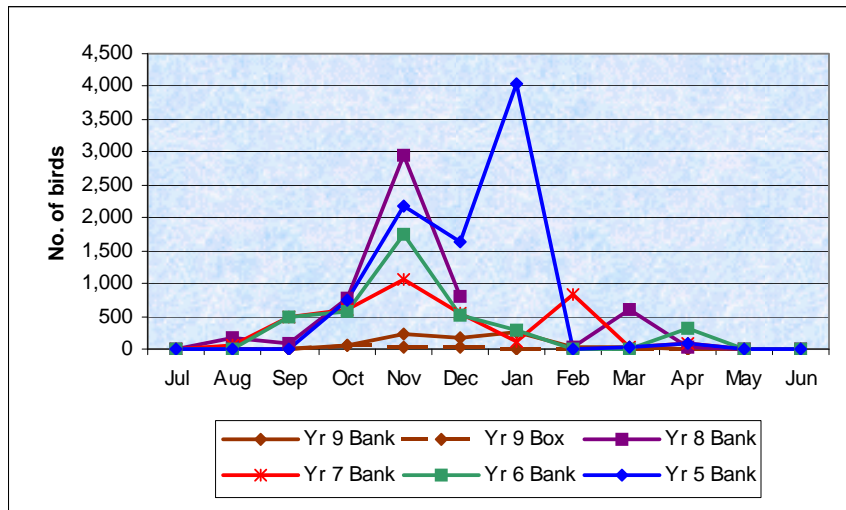
Numbers in the Arklow Study Area

Little Gull numbers in Year 9 were much lower than Years 5 to 8, with a total of 1,491 Little Gulls recorded in the Arklow Study Area. Like previous years, the majority of Little Gulls were recorded over the Bank in Year 9.

Numbers over the Bank were similar to previous years between April and August, but there was no large midwinter peak as has been recorded in previous years (e.g. 4,032 birds in January of Year 5) (Figure 3.26). Numbers over the Bank in Year 9 peaked at 255 birds in January, with numbers decreasing again from February onwards.

Numbers of Little Gulls on the revised Year 9 Box route were low, with a peak of 44 birds in October (Figure 3.26).

Figure 3.26 Numbers of Little Gulls in the Arklow Study Area, Years 5 to 9



Mean monthly density

The pattern of mean monthly density for Little Gulls in the Arklow Study Area was broadly similar to previous years however, mean density was much lower in Year 9 than for Years 5 to 8. While density over the Bank did peak in November and January, the mean density recorded (5.9 birds/km² in November and 4.3 birds/km² in January), was considerably lower than for the same months in Years 5 to 8 (45.4 birds/km² in November and 31.7 birds/km² in January) (Figure 3.27).

Mean monthly density for Little Gulls on the revised Box route was low throughout Year 9.

Figure 3.27 Little Gull mean monthly density in the Arklow Study Area, Years 5 to 9

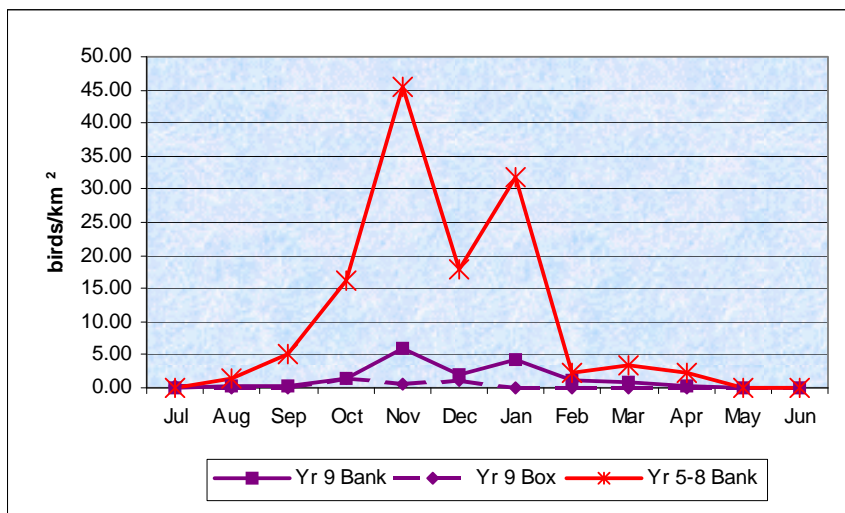


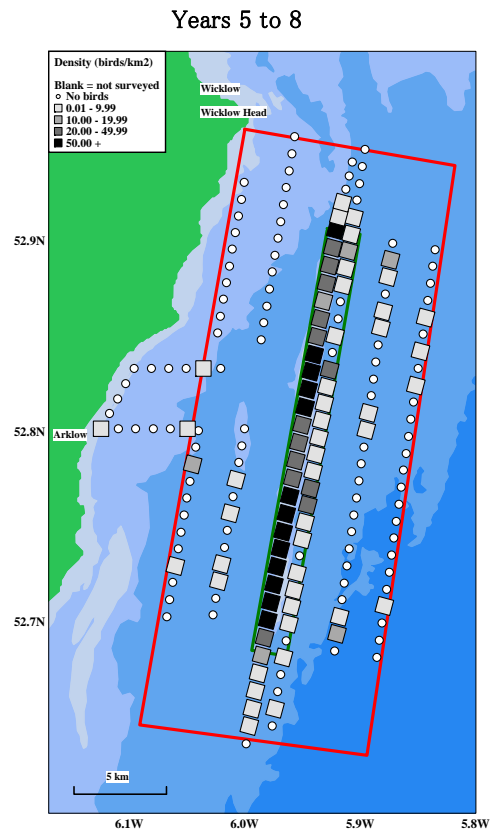
Figure 3.28 Little Gull density in the Arklow Study Area from September to January

Years 5 to 8 - September to January

In Years 5 to 8 combined, Little Gull density was highest over the Bank between September and January, with highest densities recorded along the inner Bank leg. Peak density ranged from 50.8 to 117.6 birds/km².

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

There was no January survey in Year 8.



Year 9

Year 9 – September to January

Between September and January of Year 9, Little Gulls were predominantly found over the Bank, in low to moderate density, particularly along the southern half of the inner Bank leg.

Little Gulls were patchily distributed at mostly low density on the revised Box route, with highest density (75.6 birds/km²) recorded near the southern end of the inner Bank leg.

Overall, Little Gull density between September and January in Year 9 was lower than in Years 5 to 8 combined, with no high density concentrations recorded over the Bank at this time.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

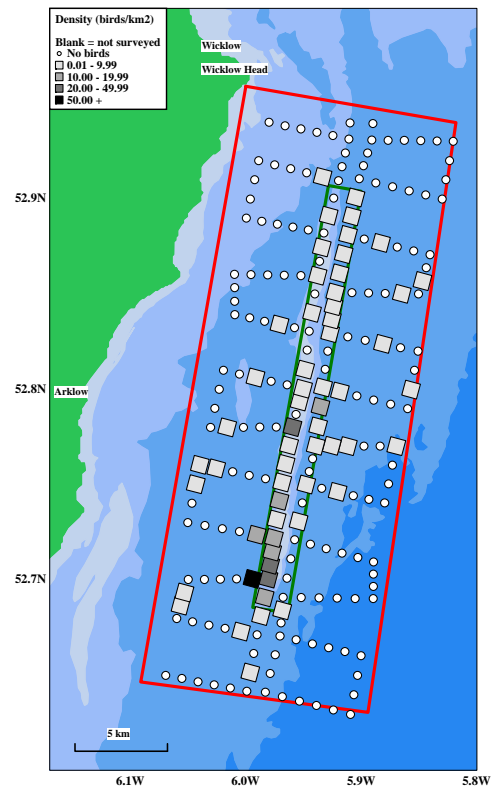
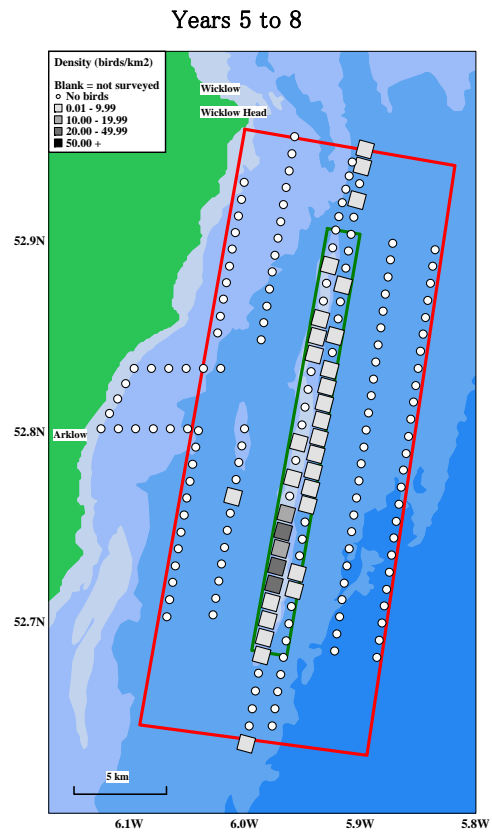


Figure 3.29 Little Gull density in the Arklow Study Area between February and April

Years 5 to 8 - February to April

Little Gull density was very low in the Arklow Study Area between February and April of Years 5 to 8 combined. Birds were scattered at mostly low densities over the Bank with a slight increase in density on the southern half of the inner Bank leg.

Very few Little Gulls were recorded in the Box and no Little Gulls were recorded on the Cable Route over the period.



Year 9

Year 9 - February to April

Little Gull density in the Arklow Study Area between February and April of Year 9 was similar to previous years. Birds were restricted to the centre and southern half of the Bank, at low density.

Very few Little Gulls were recorded on the revised Box route in these months.

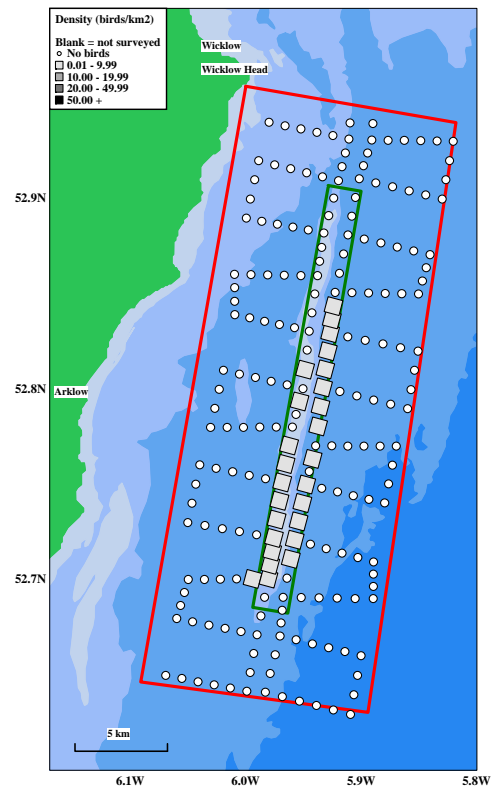
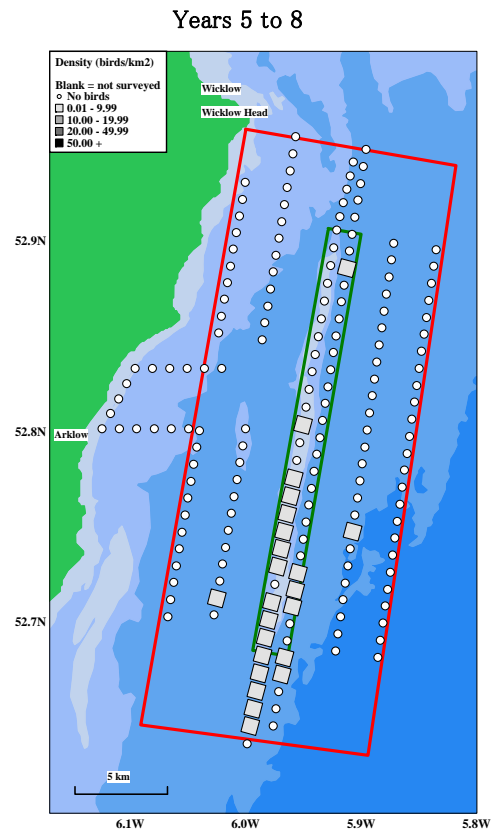


Figure 3.30 Little Gull density in the Arklow Study Area between May and August

Years 5 to 8 - May to August

Between May and August of Years 5 to 8 combined, Little Gulls were mostly scattered over the southern end of the Bank at low densities.

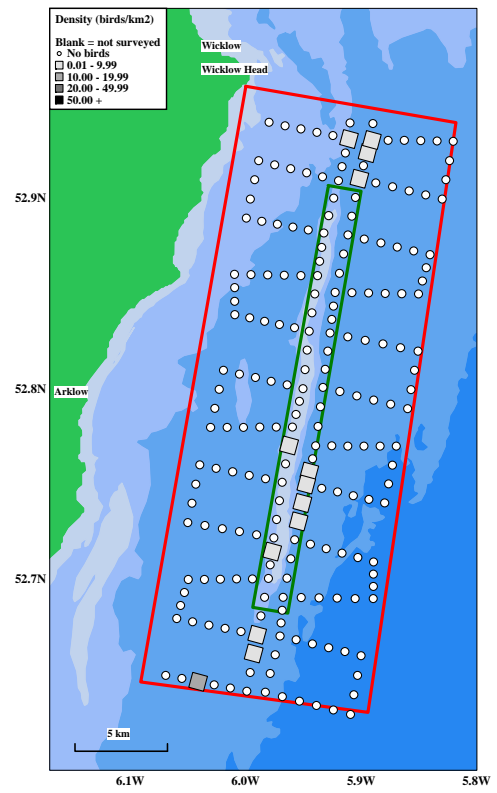
Occasional birds were recorded at low density in the Box over the period. No Little Gulls were recorded on the Cable Route between May and August.



Year 9

Year 9 – May to August

Like previous years, there were very few Little Gulls recorded between May and August of Year 9. Birds were present at low density at the north and south ends of the Bank legs, with very few birds recorded on the revised Box route.



3.4.14 Mediterranean Gull

Figure 3.31 Mediterranean Gull sightings

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

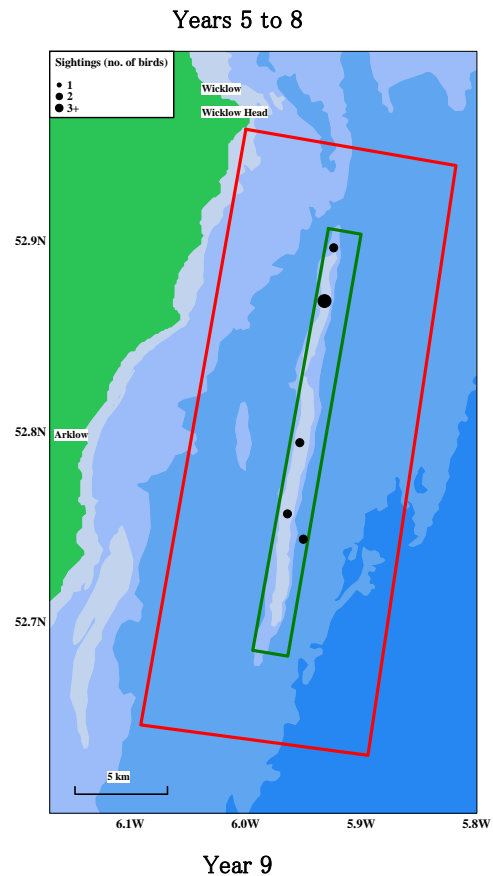
Years 5 to 8

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.

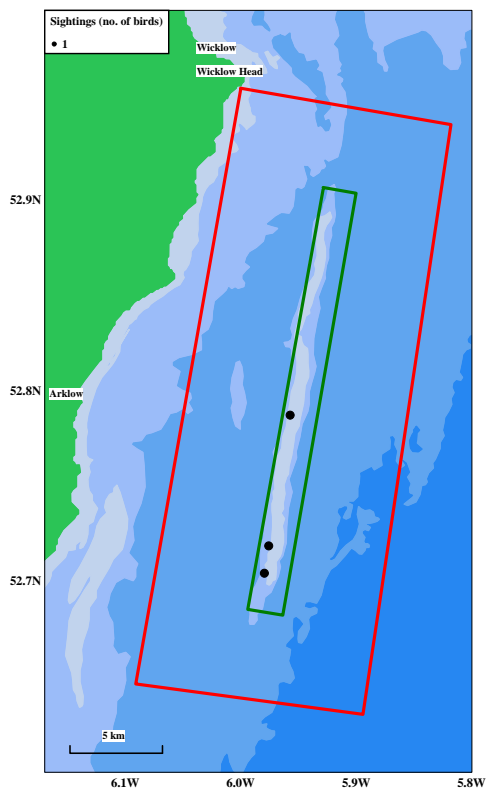
One Mediterranean Gull was seen over the Bank in November of Year 8.

All sightings were over the Bank.



Year 9

Three Mediterranean Gulls were recorded in Year 9, in January, April and October. All 3 individuals were seen over the Bank.



3.4.15 Black-headed Gull

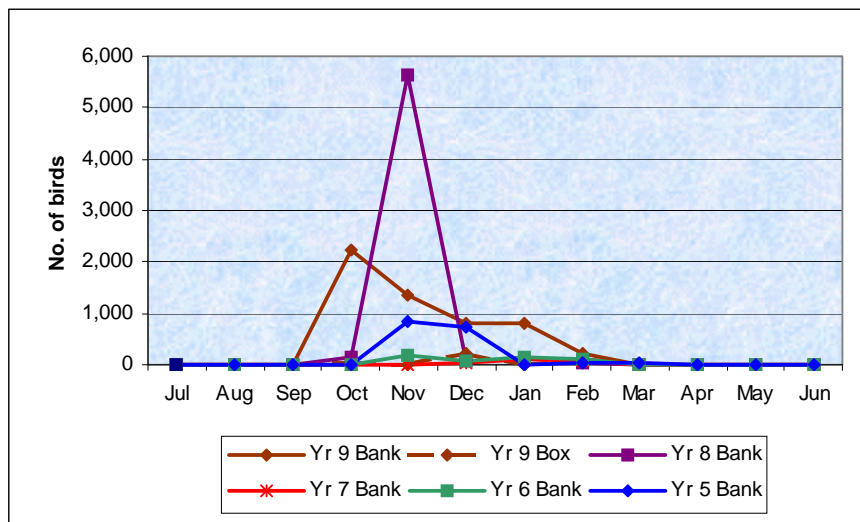
Numbers in the Arklow Study Area

A total of 6,027 Black-headed Gulls were recorded in the Arklow Study Area in Year 9, with most birds found over the Bank between October and February. Numbers of Black-headed Gulls over the Bank in Year 9 peaked in October (2,244 birds), which was the second highest count over the period (Figure 3.32). The peak count of 5,641 birds was recorded in November of Year 8.

Following the October peak, numbers of Black-headed Gulls over the Bank decreased again.

Numbers of Black-headed Gulls recorded on the revised Year 9 Box route were lower than over the Bank, with a peak of 231 birds in October (Figure 3.32).

Figure 3.32 Numbers of Black-headed Gulls in the Arklow Study Area, Years 5 to 9



Mean monthly density

Black-headed Gull mean monthly density over the Bank in Year 9 increased from October, and reached a peak of 28.5 birds/km² in November. This was similar to the mean peak density recorded in November between Years 5 to 8 combined (33.6 birds/km²). This was largely due to a large increase in numbers in November of Year 8. Black-headed Gull density in Year 9 decreased again in December, and was low for the remaining months of Year 9 (Figure 3.33).

Mean monthly density for Black-headed Gull on the revised Box route was low for all months with a peak of 5.3 birds/km² in December (Figure 3.33).

Figure 3.33 Black-headed Gull mean monthly density in the Arklow Study Area, Years 5 to 9

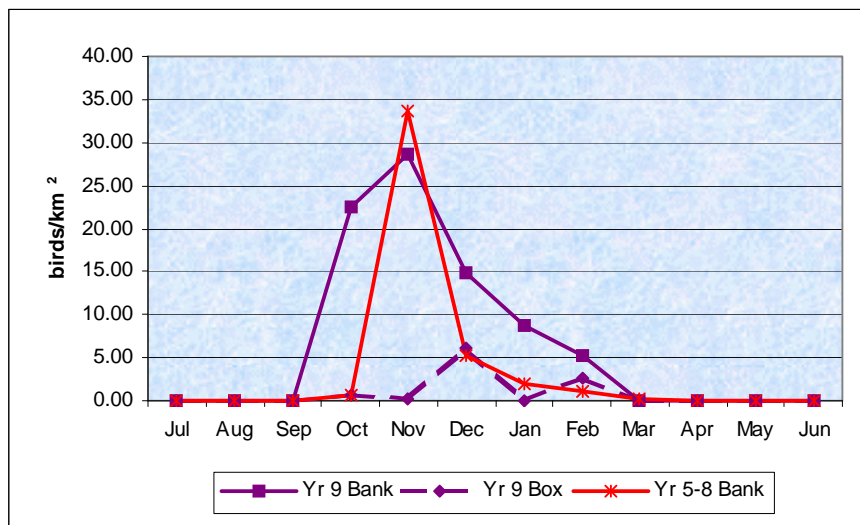
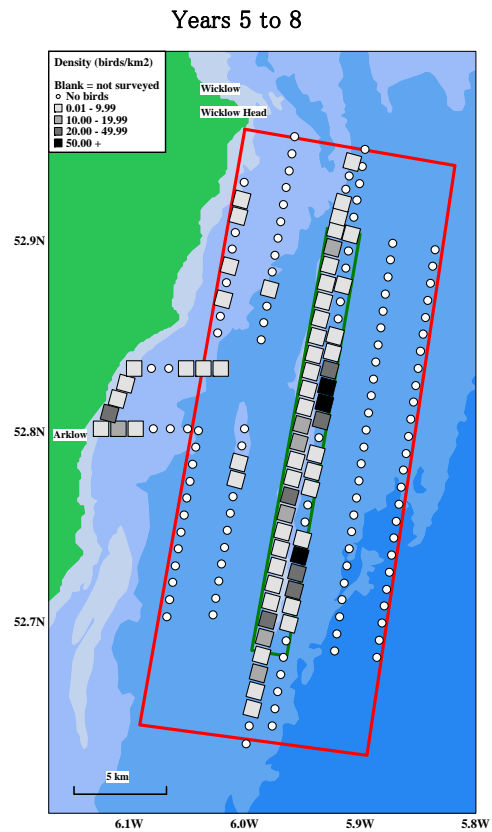


Figure 3.34 Black-headed Gull density between October and February

Years 5 to 8 - October to February

In Years 5 to 8 combined, Black-headed Gulls were recorded on the Bank legs at mostly low to moderate density between October and February, with highest density recorded on the outer Bank leg (62.1 to 75.6 birds/km²).

Black-headed Gulls were recorded sporadically along the inner Box legs at low density, while birds were recorded at low to moderate density on the Cable Route in these months.



Year 9 - October to February

Between October and February of Year 9, Black-headed Gull distribution was mostly concentrated over the Bank. Highest density was recorded in the middle of the Bank, and on the southern half of the inner Bank leg. Peak density in Year 9 was higher than was recorded over the same period in Years 5 to 8 combined, and ranged between 52.8 to 199.6 birds/km².

Away from the Bank, Black-headed Gulls were scattered throughout the Arklow Study Area at low density, with birds recorded more regularly on the inshore legs of the revised Box route, compared to the legs offshore from the Bank.

Year 9

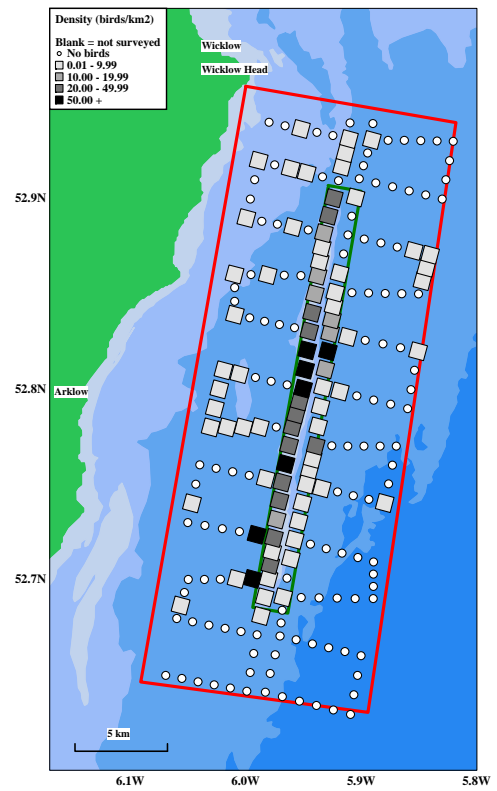
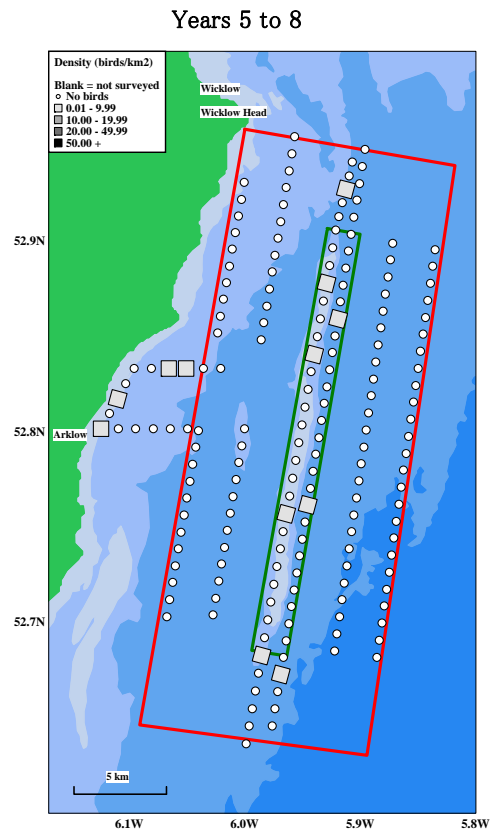


Figure 3.35 Black-headed Gull density between March and September

Years 5 to 8 - March to September

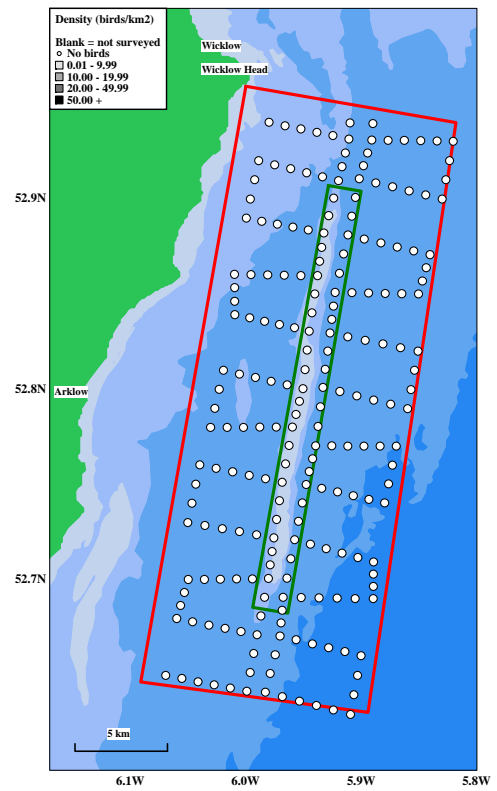
Black-headed Gull density was very low in the Arklow Study Area between March and September of Years 5 to 8, with birds recorded occasionally over the Bank and Cable Route at low density.



Year 9

Year 9 - March to September

No Black-headed Gulls were recorded in transect in the Arklow Study Area between March and September of Year 9.

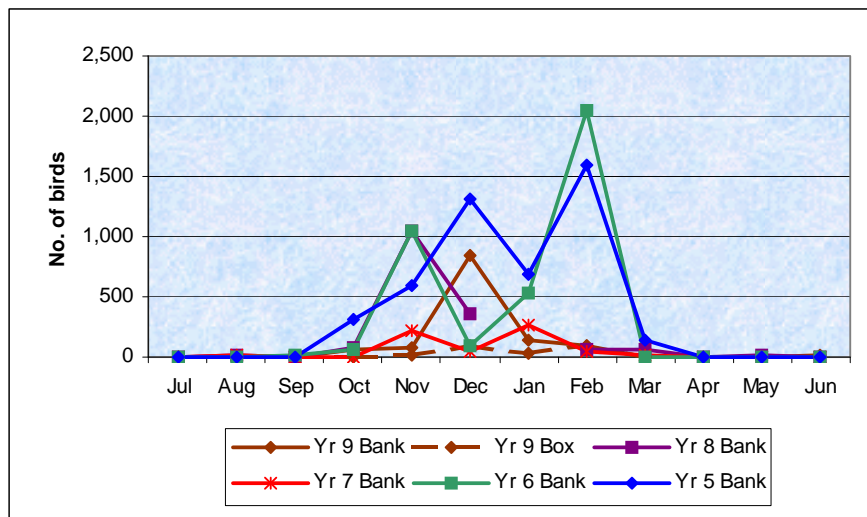


3.4.16 Common Gull

Numbers in the Arklow Study Area

A total of 1,861 Common Gulls were recorded in the Arklow Study Area in Year 9, with most birds found over the Bank between October and February. Numbers of Common Gulls recorded over the Bank in Year 9 increased from October, with a peak of 843 birds in December. Numbers decreased again from January onwards (Figure 3.36). The December peak was lower than the peaks recorded in Year 5 but higher than other years, although there was no large peak recorded in February as was recorded in Years 5 and 6 (2,047 birds in Year 6, and 1,598 birds in Year 5). Numbers of Common Gulls recorded on the revised Year 9 Box route showed a similar pattern to the Bank, but were lower, with a peak of 92 birds in December (Figure 3.35).

Figure 3.36 Numbers of Common Gulls in the Arklow Study Area, Years 5 to 9



Mean monthly density

Common Gull mean monthly density over the Bank in Year 9 was low from July to October, and increased from November, reaching a peak of 13.8 birds/km² in December. This was slightly higher than the density recorded in December in Years 5 to 8 combined (12.6 birds/km²) (Figure 3.37). In Years 5 to 8 combined, Common Gull mean density over the Bank was highest between October and February, with a peak of 19.5 birds/km² recorded in February. Common Gull density over the Bank was low from March to June of Year 9.

Mean monthly density for Common Gull on the revised Box route was low for all months with a peak of 2.1 birds/km² in December (Figure 3.36).

Figure 3.37 Common Gull mean monthly density in the Arklow Study Area, Years 5 to 9

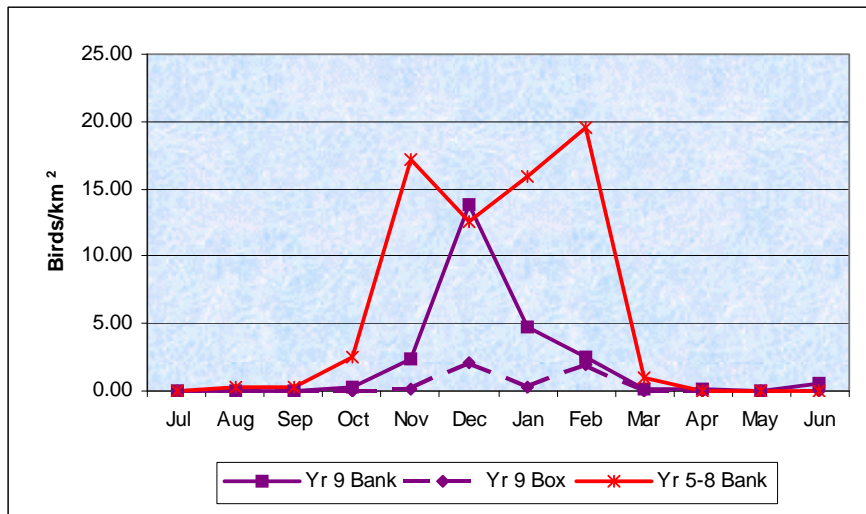


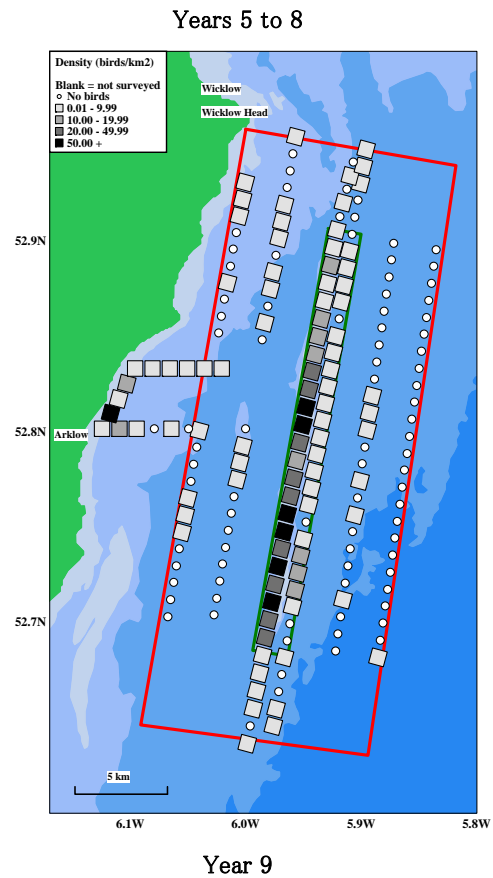
Figure 3.38 Common Gull density between October and February

Years 5 to 8 - October to February

In Years 5 to 8, Common Gull density was highest along the inner Bank leg from October to February, with highest density ranging from 58.1 birds/km² to 70.9 birds/km².

In the Box, Common Gulls were scattered at low density.

Density along the Cable Route was generally low to moderate, with highest density of 58.9 birds/km².



Year 9 - October to February

In Year 9, Common Gulls were recorded at low to moderate density over the Bank, with highest density recorded at the southern end of the inner Bank leg (61.3 birds/km²). This was slightly lower than the peak density recorded on the Bank over the same period in Years 5 to 8 combined.

On the revised Box route, Common Gulls were scattered at low to moderate density inshore of the Bank, but were scarce further offshore, east of the Bank.

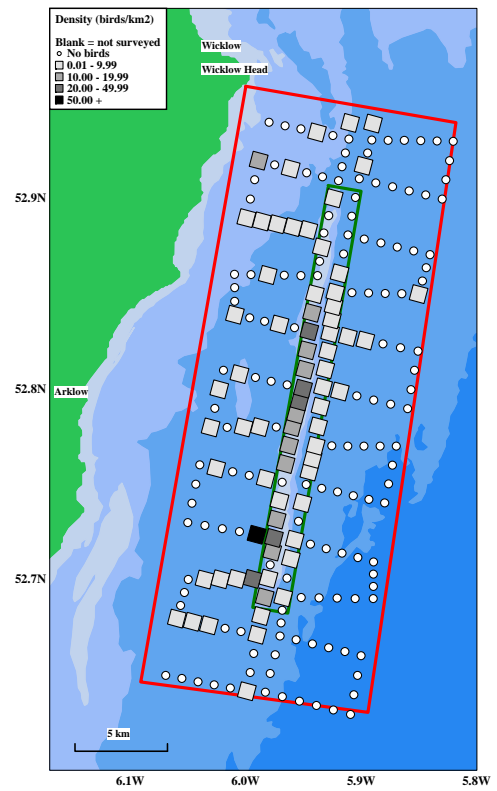
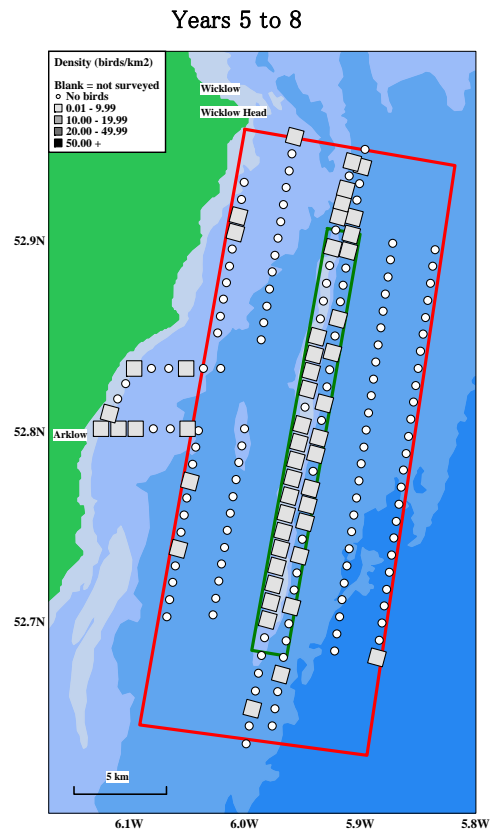


Figure 3.39 Common Gull density between March and September

Years 5 to 8 - March to September

Common Gull density between March and September of Years 5 to 8 was low, 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.

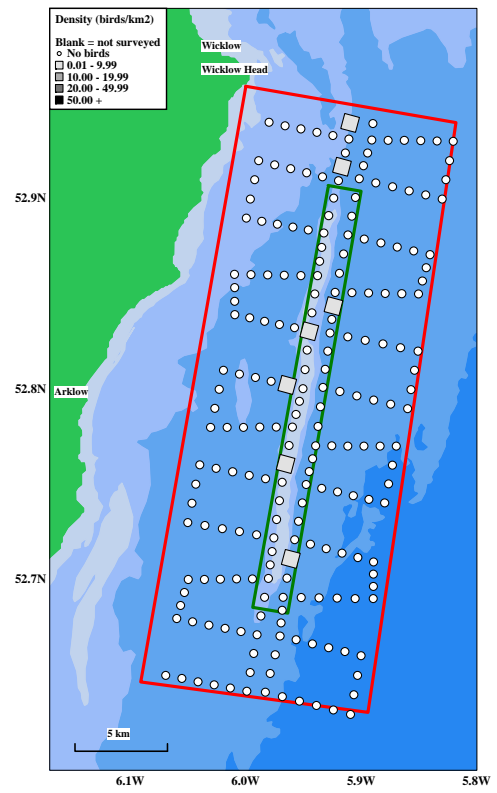


Year 9

Year 9 - March to September

There were fewer Common Gulls seen in transect between March and September of Year 9, compared to previous years. Occasional low densities were recorded over the Bank and northern end of the revised Box route.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report



3.4.17 Lesser Black-backed Gull

Figure 3.40 LBB Gull sightings

Years 5 to 8

Seven Lesser Black-backed Gulls were recorded in Year 5; 3 in March, 2 in July, 1 in November and 1 in December. Two of these were over the Bank with the remaining five sightings in the Box.

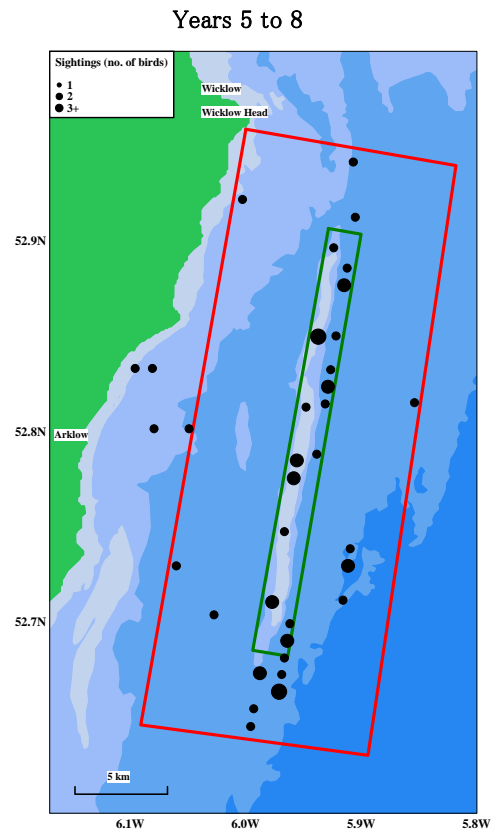
In Year 6, numbers recorded increased to 18, spread between February and September, with a peak of 8 in September. Sightings were scattered across the Arklow Study Area.

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.

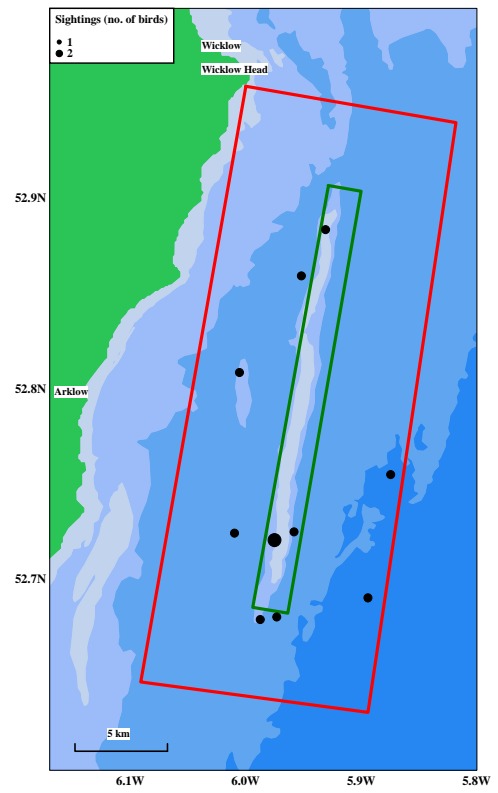
Fewer Lesser Black-backed Gulls were recorded in Year 8, with 8 birds seen. This was similar to numbers seen in Year 5. Peak counts were two birds in May and 2 birds in November, with singles recorded in August and October. All sightings were over the Bank.

Year 9

A total of 11 Lesser Black-backed Gulls were recorded in the Arklow Study Area in Year 9, with a peak of 3 birds in April. The majority of sightings were over the Bank.



Year 9



3.4.18 Great Black-backed Gull

Figure 3.41 GBB Gull sightings

Years 5 to 8

In Year 5, 11 Great Black-backed Gulls were recorded; 1 in January, 2 in May, 4 in October, 3 in November and 1 in December.

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

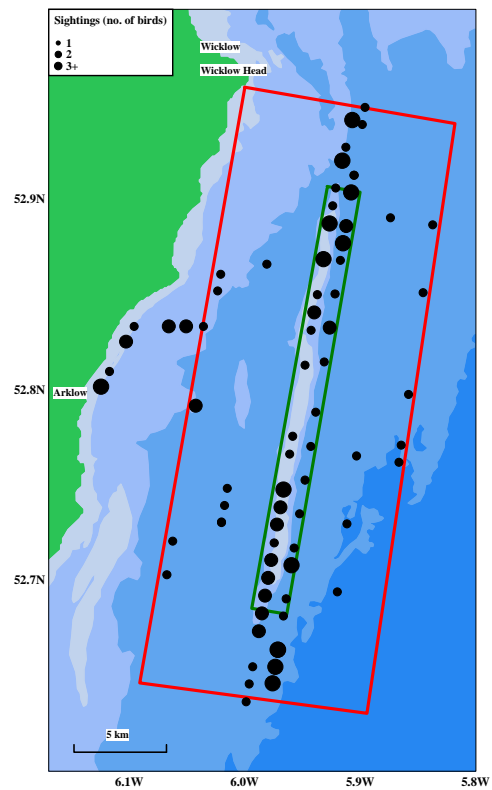
A total of 83 birds were recorded in Year 7. Birds were seen in all months except June, with a peak count of 42 in August. Concentrations occurred at the north and south ends of the Box, with lower numbers over the Bank and Cable Route.

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

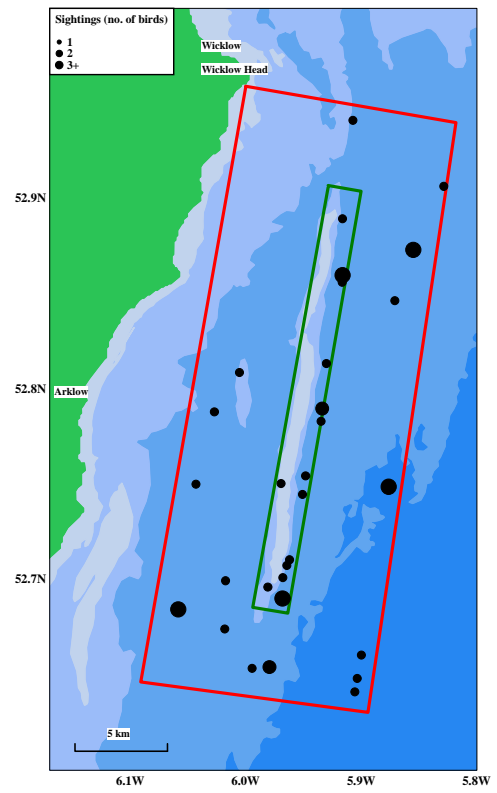
Year 9

Great Black-backed Gull numbers in Year 9 were similar to Year 8, with 50 birds recorded. Birds occurred in all months, with a peak of 14 in August, and lower numbers in other months. Birds were scattered throughout the Arklow Study Area.

Years 5 to 8



Year 9

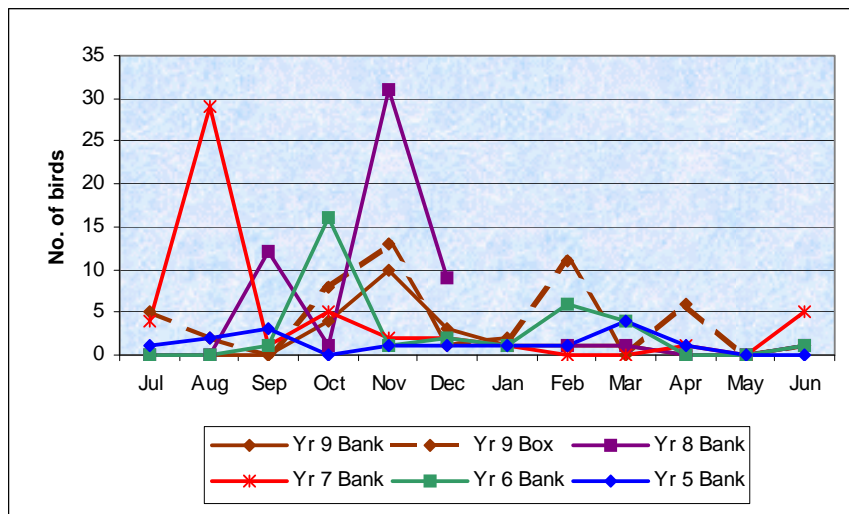


3.4.19 Herring Gull

Numbers in the Arklow Study Area

A total of 81 Herring Gulls were recorded in the Arklow Study Area in Year 9, with the majority of birds recorded between October and March. Numbers recorded over the Bank in Year 9 were similar to previous years, with a peak of 10 birds in November (Figure 3.41). In Year 8, numbers over the Bank also peaked in November (31 birds), while the peak in Year 7 was recorded in August (29 birds). Numbers of Herring Gulls on the revised Year 9 Box route were generally slightly higher than over the Bank, with a peak of 13 birds in November, and 11 birds in February (Figure 3.42).

Figure 3.42 Numbers of Herring Gulls in the Arklow Study Area, Years 5 to 9



Mean monthly abundance

Mean monthly abundance over the Bank was very low throughout Year 9, with a peak of 0.09 birds/km in November (Figure 3.43). Similar abundance was recorded on the revised Year 9 route. Mean monthly abundance over the Bank in Years 5 to 8 was similarly low.

Figure 3.43 Herring Gull mean monthly abundance in the Arklow Study Area, Years 5 to 9

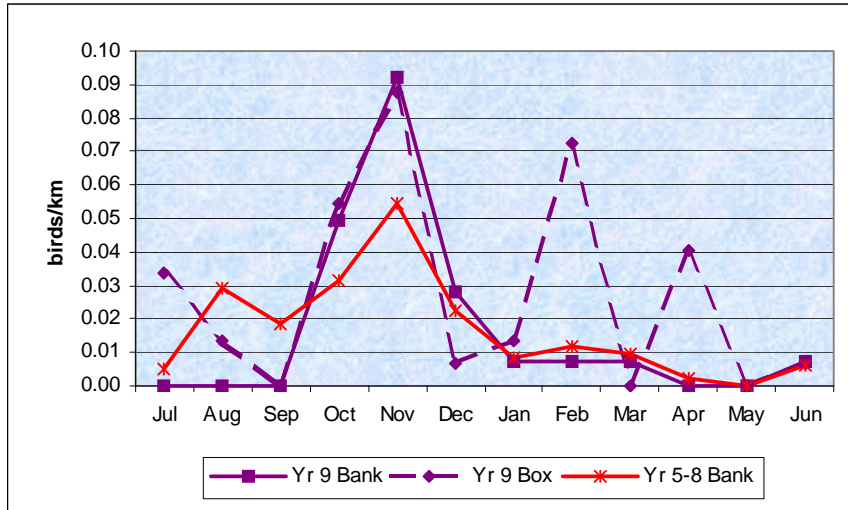
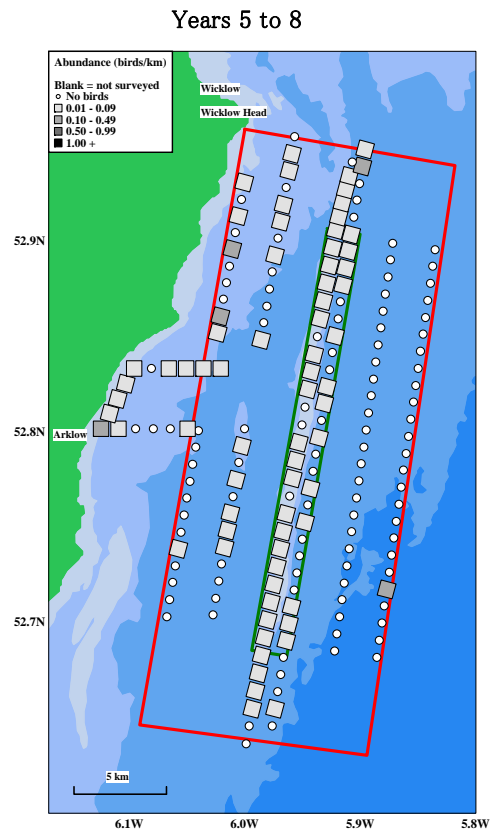


Figure 3.44 Herring Gull abundance in the Arklow Study Area in all months

Years 5 to 8

Herring Gull distribution between Years 5 and 8 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. No Herring Gulls were recorded in the Box in Year 8.

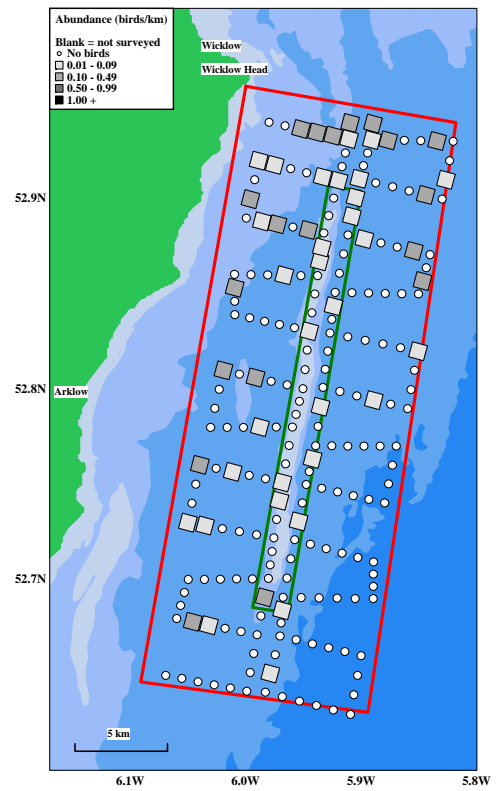


Year 9

Year 9

Herring gull distribution throughout Year 9 was patchy, but similar to Years 5 to 8, with birds recorded in low to moderate abundance throughout the Arklow Study Area.

There was a slight northerly bias to Herring Gull distribution, and birds in the southern half of the Study Area were more scattered, with very few birds recorded in the south-east of the Study Area.



3.4.20 Kittiwake

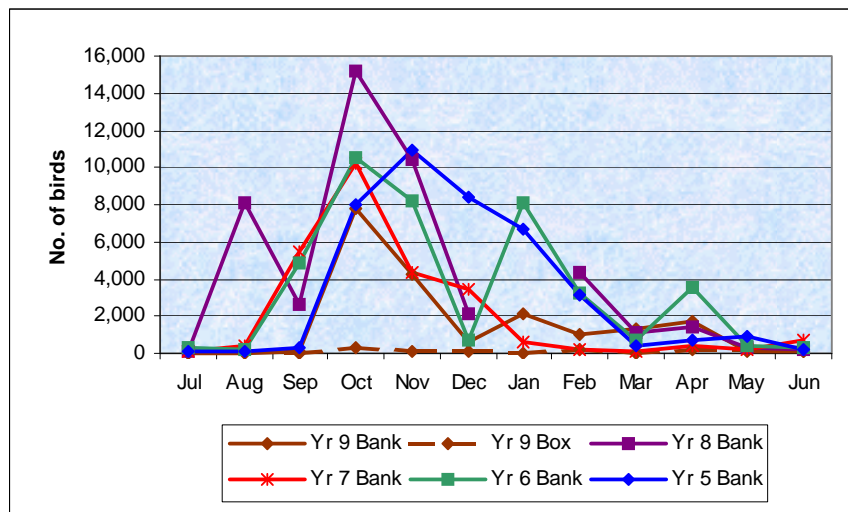
Numbers in the Arklow Study Area

A total of 27,843 Kittiwakes were recorded in the Arklow Study Area in Year 9, with most birds recorded over the Bank between October and April.

Numbers of Kittiwakes recorded over the Bank in Year 9 followed the pattern of Years 5 to 8, with an increase in numbers from September, reaching a peak in October of 7,799 birds (Figure 3.44). This was lower than the highest peak recorded over the Bank (15,215 birds in Year 8), and was also lower than the October peaks of 10,243 birds in Year 7, and 10,528 birds in Year 6. Numbers in Year 5 peaked in November, with 10,938 birds. For the remainder of Year 9, numbers decreased from November onwards.

Numbers of Kittiwakes on the revised Year 9 Box route were low, with a peak of 319 birds recorded in October (Figure 3.45).

Figure 3.45 Numbers of Kittiwakes in the Arklow Study Area, Years 5 to 9



Mean monthly density

Kittiwake mean monthly density over the Bank in Year 9 was lower than Years 5 to 8 combined, apart from in March and April. Mean density was highest in November of Year 9, which was a similar pattern to Years 5 to 8 combined, but a lower mean peak (77.7 birds/km² compared to 233.7 birds/km² in October of Years 5 to 8 combined) (Figure 3.46). Mean density dropped in December of Year 9 and then increased slightly again until April (56.6 birds/km²), before decreasing again for May and June.

Mean monthly density for Kittiwake on the revised Box route was low in all months of Year 9.

Figure 3.46 Kittiwake mean monthly density in the Arklow Study Area, Years 5 to 9

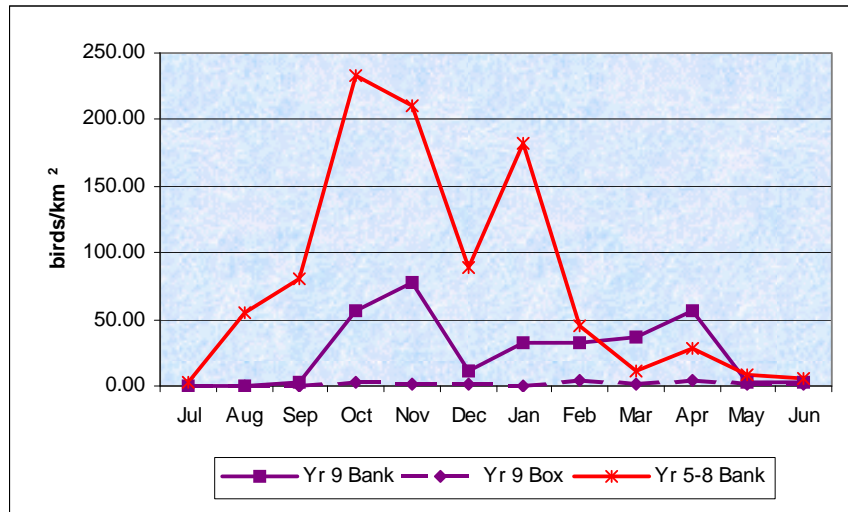
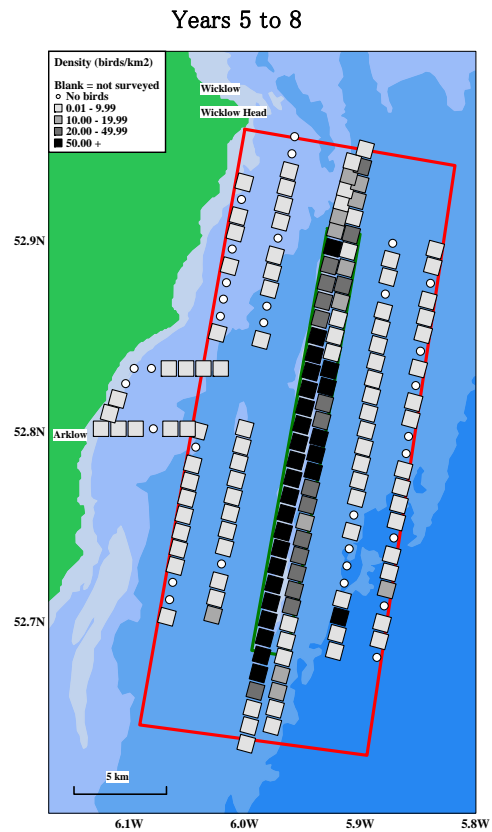


Figure 3.47 Kittiwake density in the Arklow Study Area from September to April

Years 5 to 8 - September to April

Between September and April of Years 5 to 8 combined, Kittiwakes were concentrated at highest density along the inner Bank leg and to a lesser degree the outer Bank leg. Highest density on the inner bank leg ranged from 51.5 to 725.9 birds/km², while peak density on the outer Bank leg ranged from 55.5 to 145.4 birds/km².

Kittiwake density on the Box legs and Cable Route was mostly low, with a peak of 59.7 birds/km² at the southern end of the outer Box leg.



Year 9

Year 9 – September to April

In Year 9, Kittiwake density was generally moderate to high over the Bank between September and April, particularly in the middle sections of both inner and outer Bank legs. Peak density ranged from 50.6 to 207.4 birds/km². This was lower than peak density recorded on the Bank over the same period in Years 5 to 8 combined.

Kittiwakes were recorded at mostly low density on the revised Box route between September and April.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

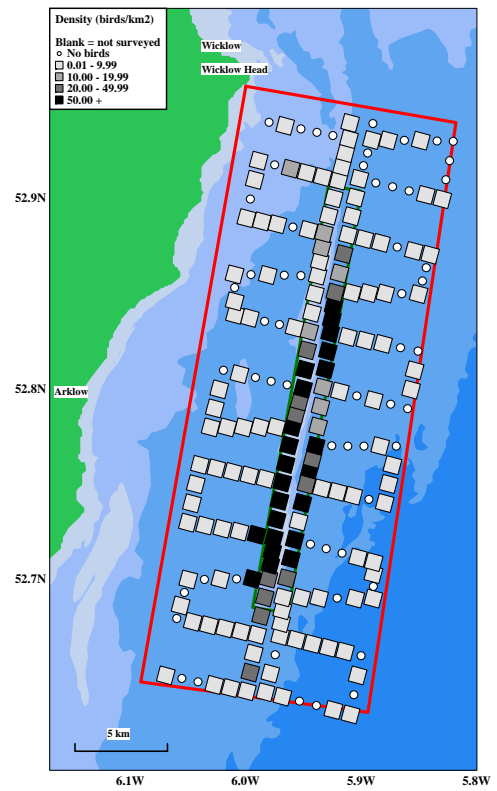
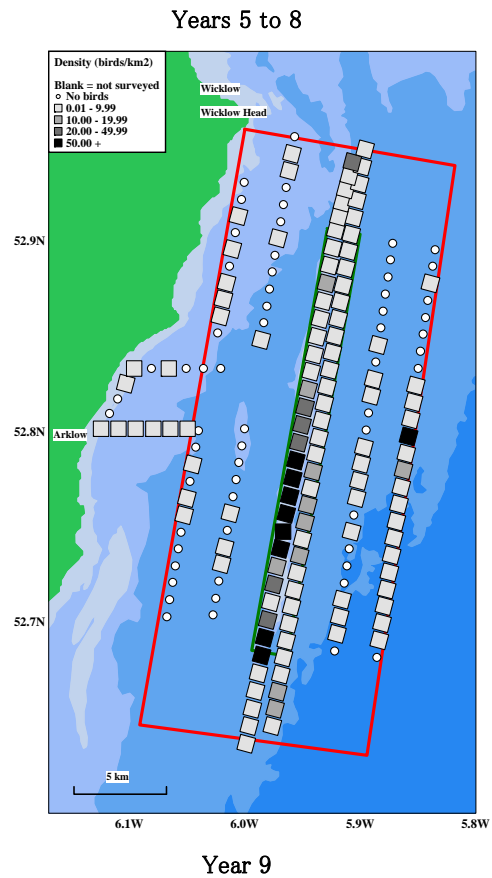


Figure 3.48 Kittiwake density in the Arklow Study Area between May and August

Years 5 to 8 - May to August

Between May and August of Years 5 to 8 combined, Kittiwakes were predominantly recorded over the Bank, where highest density occurred on the inner Bank leg (53.9 to 156.3 birds/km²).

Kittiwakes were less widespread in the Box, particularly on the inner Box legs, and generally occurred at low to moderate density, although highest density of 62.7 birds/km² was recorded on the outer Box leg. Low density was recorded on the Cable Route.

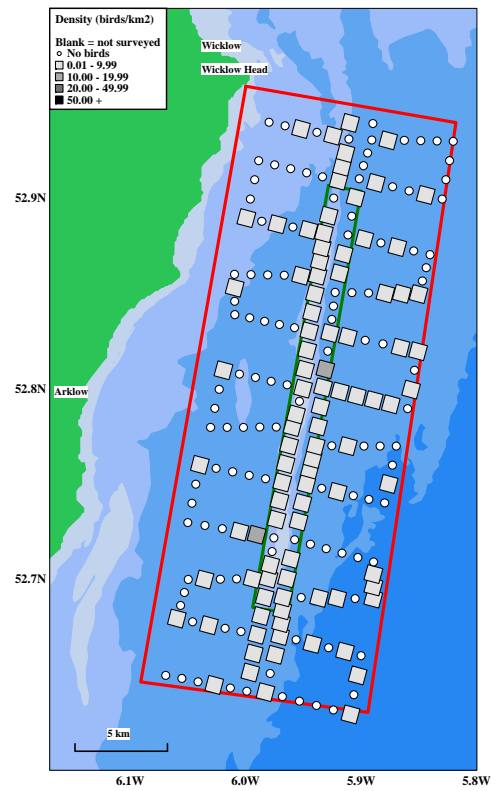


Year 9 - May to August

Between May and August of Year 9, Kittiwakes were scattered at predominantly low density throughout the Arklow Study Area.

Birds were most regular over the Bank, however there were no high concentrations of birds recorded in these months, unlike in Years 5 to 8 combined..

Arklow Bank Seabird Monitoring Programme Year 9 Final Report



3.4.21 Common Tern

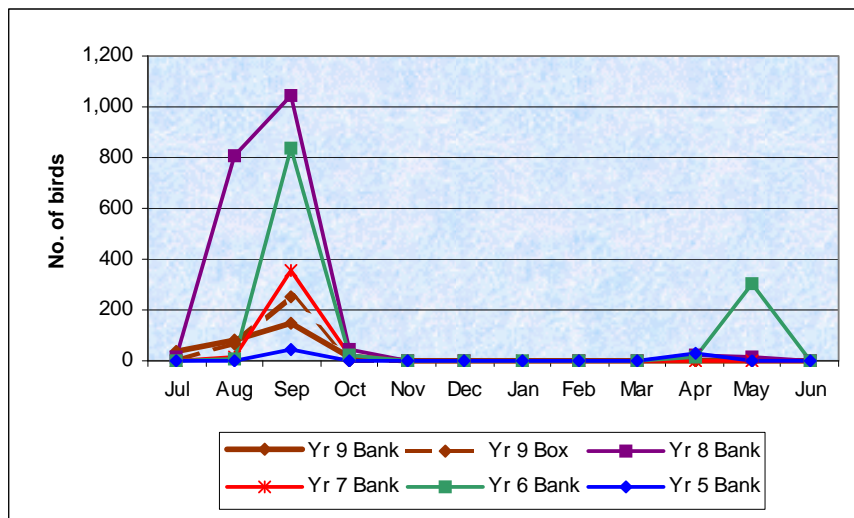
Common Terns are summer visitors to the Arklow Study Area and are recorded mainly on migration in spring and autumn. The species is listed on Annex I of the EU Birds Directive (79/409/EEC).

Numbers in the Arklow Study Area

In Year 9, a total of 523 Common Terns were recorded in the Arklow Study Area between April and October. Numbers over the Bank peaked in September which was similar to previous years, although the Year 9 peak total (149 birds) was lower than Year 8 (1,043 birds), Year 7 (356 birds) and Year 6 (838 birds). The Year 5 peak (45 birds) was also recorded in September (Figure 3.48).

Common Terns were only recorded on the revised Year 9 Box route in August and September, when numbers were higher than over the Bank (251 birds) (Figure 3.49).

Figure 3.49 Numbers of Common Terns in the Arklow Study Area, Years 5 to 9



Mean monthly density

Mean Common Tern density over the Bank and revised Box route in Year 9 was low throughout the summer months, but peaked in September (3.1 birds/km²) (Figure 3.50). This was lower than the peak mean density recorded in Years 5 to 8 combined, which also occurred in September (10.9 birds/km²).

Figure 3.50 Common Tern mean monthly density in the Arklow Study Area, Years 5 to 9

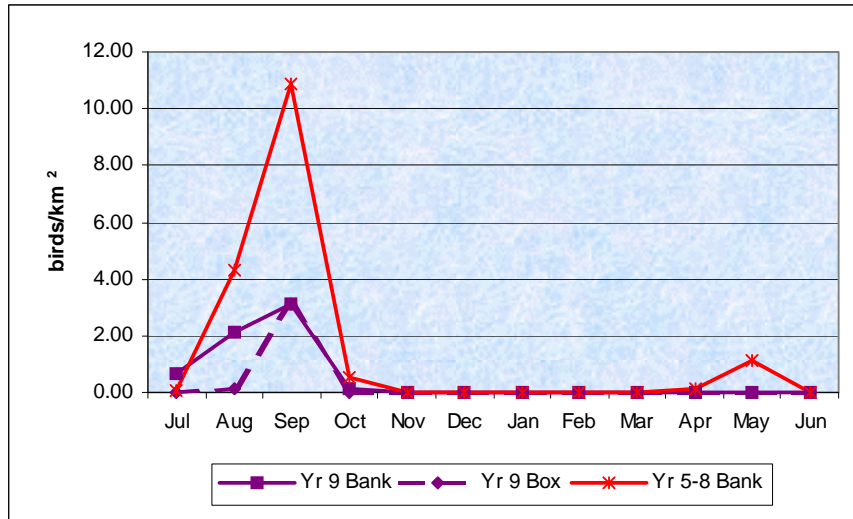
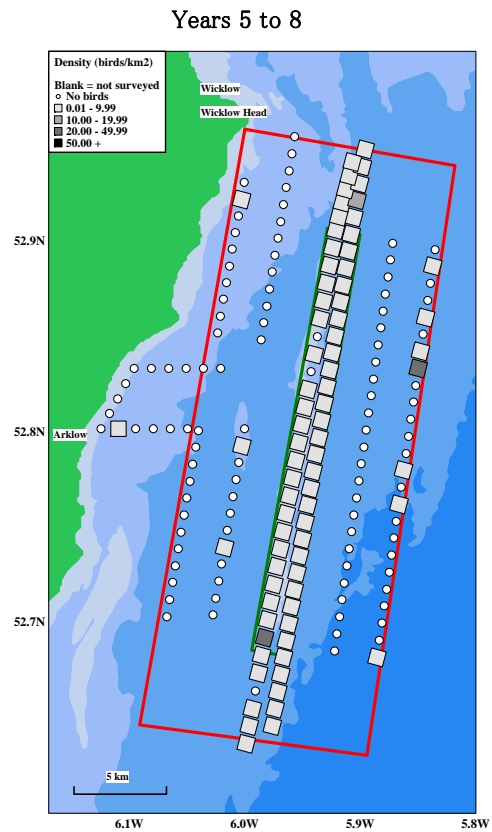


Figure 3.51 Common Tern density in the Arklow Study Area from April to October

Years 5 to 8 - April to October

Between April and October of Years 5 to 8 combined, Common Terns were mostly recorded in low to moderate density along the Bank.

Birds were also scattered at low to moderate density on the outer Box leg, and occasionally in the inner Box and Cable Route.

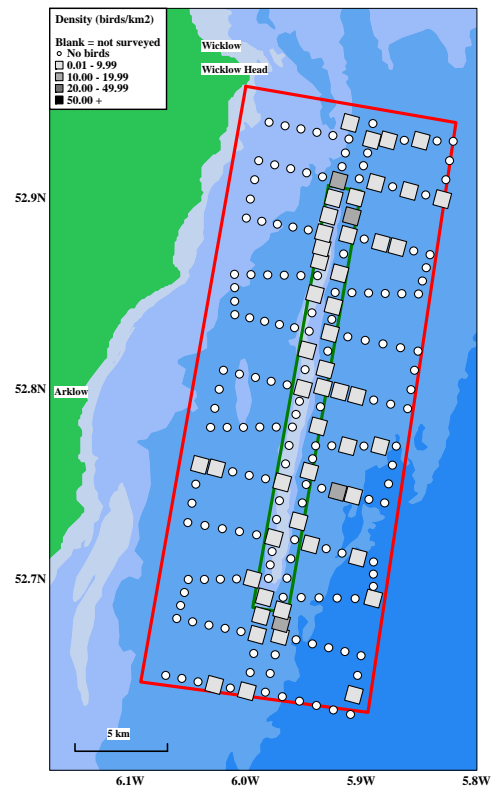


Year 9

Year 9 - April to October

Between April and October of Year 9, Common Terns were mostly recorded over the Bank legs, and on the offshore transects of the revised Box route. Birds were recorded in low to moderate density.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report



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).

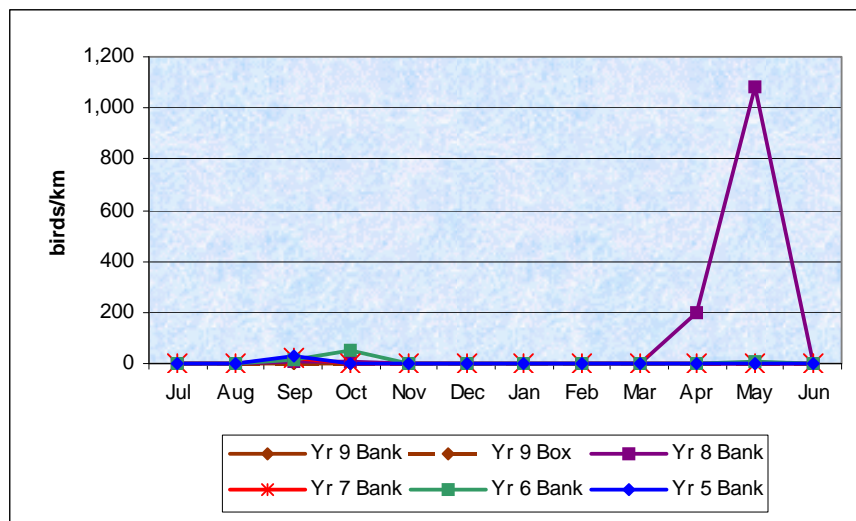
Numbers in the Arklow Study Area

Numbers of Arctic Terns recorded in the Arklow Study Area in Year 9 were very low, with a raw total of only five birds seen over the Bank between August and October. In Year 8, Arctic Terns were 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.

No Arctic Terns were recorded on the revised Box route in Year 9 (Figure 3.52).

Figure 3.52 Numbers of Arctic Terns in the Arklow Study Area, Years 5 to 9



Mean monthly density

Mean Arctic Tern density over the Bank and revised Box route was low throughout the summer months of Year 9. There was no peak in bird density recorded in May, unlike Years 5 to 8 combined (Figure 3.53).

Figure 3.53 Arctic Tern mean monthly density in the Arklow Study Area, Years 5 to 9

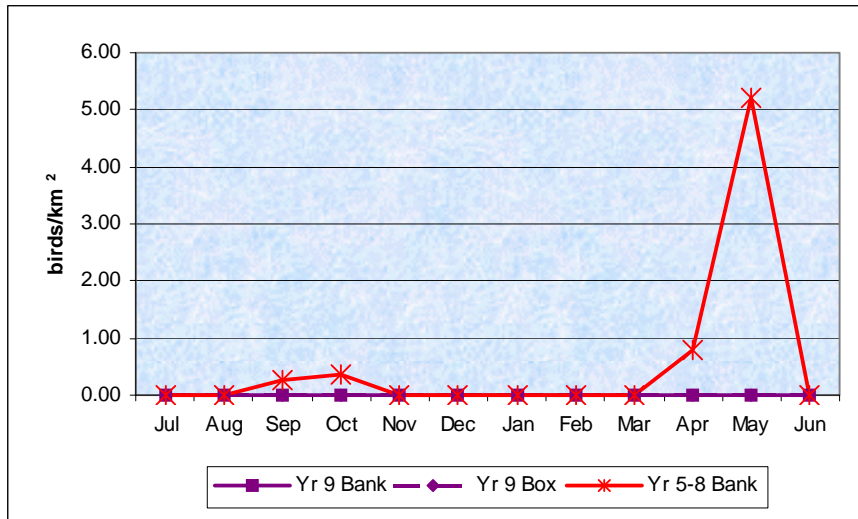
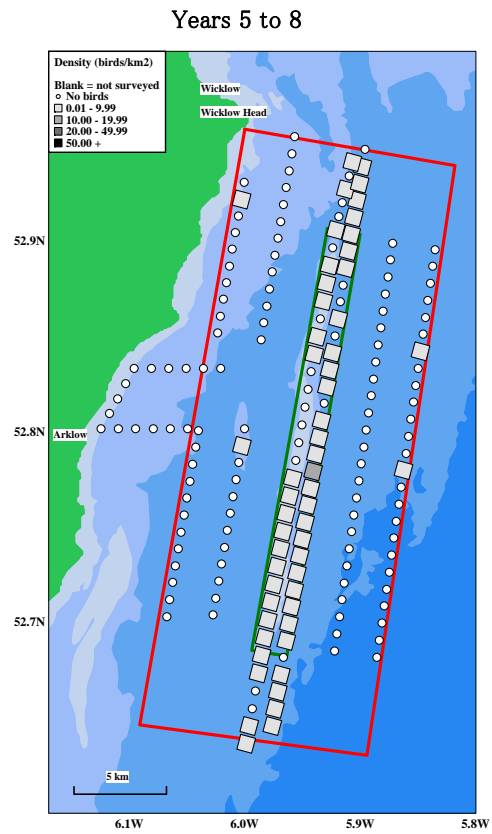


Figure 3.54 Arctic Tern density in the Arklow Study Area from April to October

Years 5 to 8 - April to October

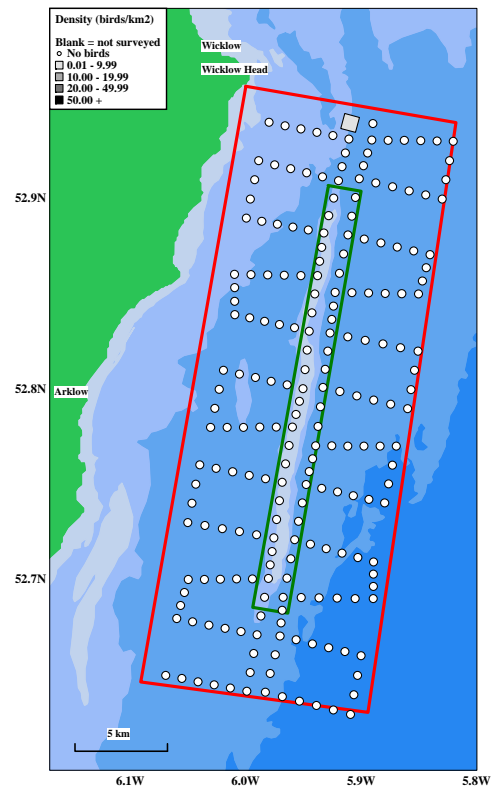
Overall, few Arctic Terns were seen in the Arklow Study Area during Years 5 to 8 combined. Birds were recorded at low to moderate density over the Bank, and occasionally elsewhere between April and October.



Year 9

Year 9 - April to October

Very few Arctic Terns were recorded in the Arklow Study Area in Year 9, with low density recorded in only 1 km at the north end of the inner bank leg in October.



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 8

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.

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.

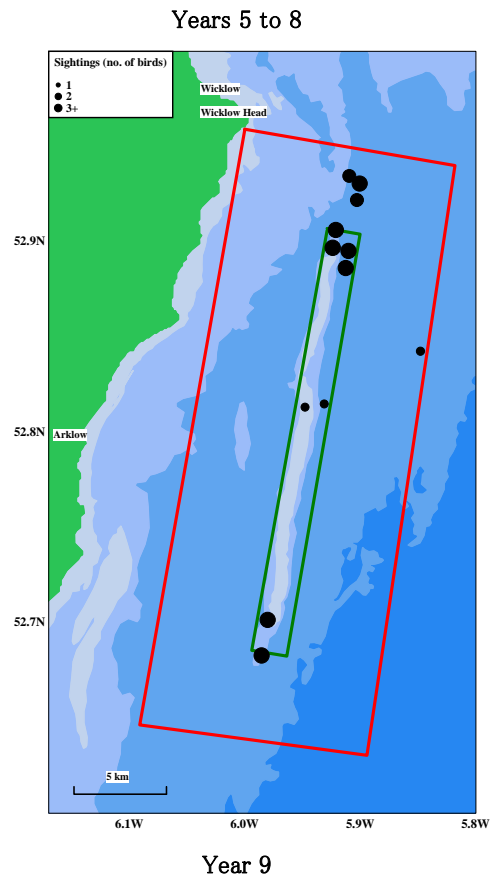
The largest flock recorded was 10 birds at the southern end of the Bank.

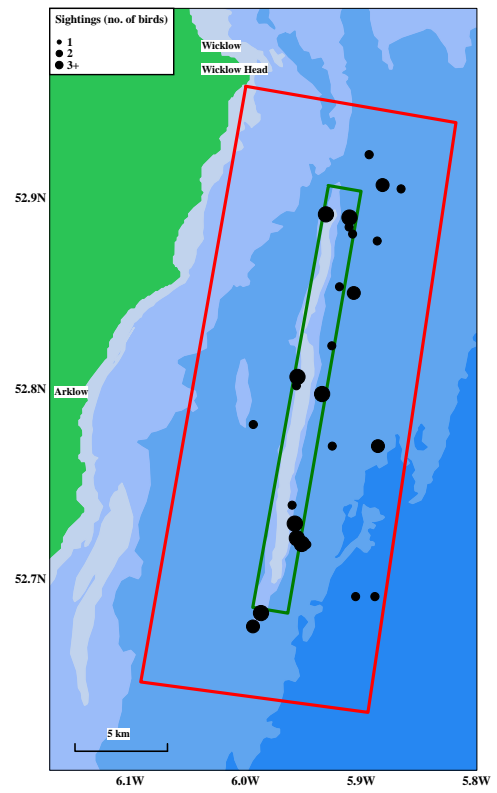
Year 9

In Year 9, a total of 89 Roseate Terns were recorded in the Arklow Study Area, with the majority (78 birds) seen in September.

Most birds were recorded over the Bank, with lower numbers seen on the offshore transects of the revised Box route.

Figure 3.55 Roseate Tern sightings





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 8

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

In Year 6, 29 Sandwich Terns were recorded, with 15 in April, one in July, 10 in September and three in October. The majority of birds were recorded over the Bank.

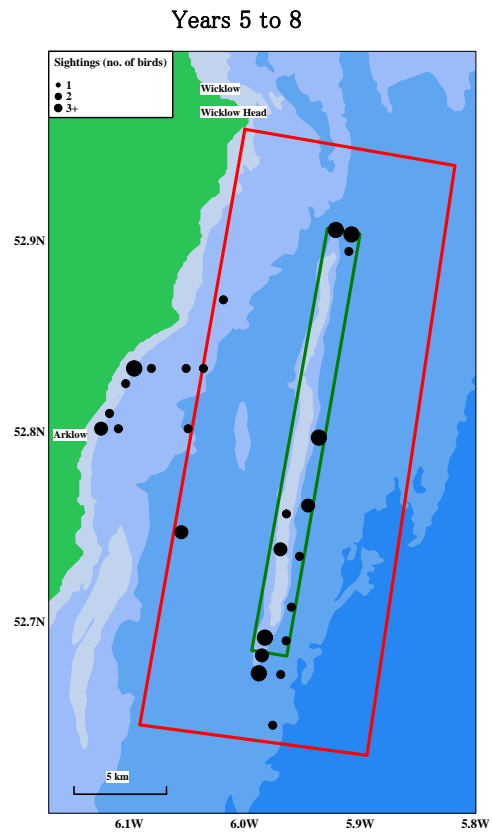
In Year 7, 10 Sandwich Terns were recorded, with two in April, five in June, one in July and two in September. Birds were recorded over the Bank and Cable Route.

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.

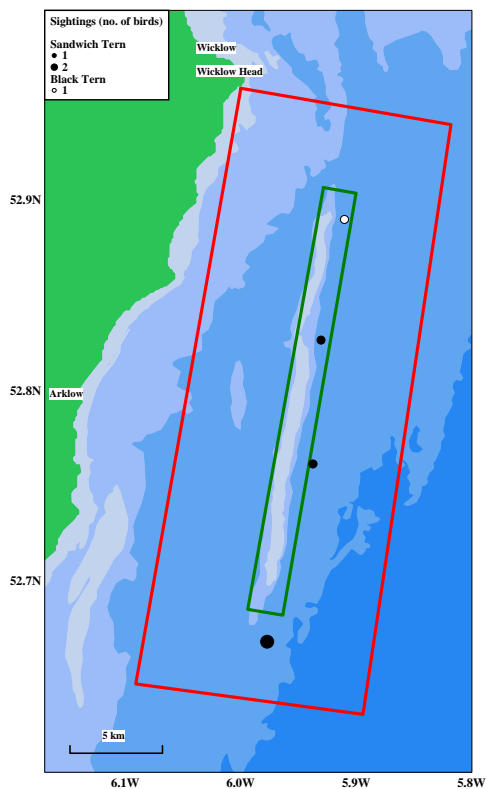
Year 9

There were just 4 Sandwich Terns recorded in the Arklow Study Area in Year 9; 1 in March, 2 in June and 1 in October. All sightings were in the vicinity of the Bank.

Figure 3.56 Other tern sightings



Year 9



3.4.25 Black Tern

One Black Tern was seen in Year 9, at the north end of the Bank in September (Figure 3.57).

3.4.26 Guillemot

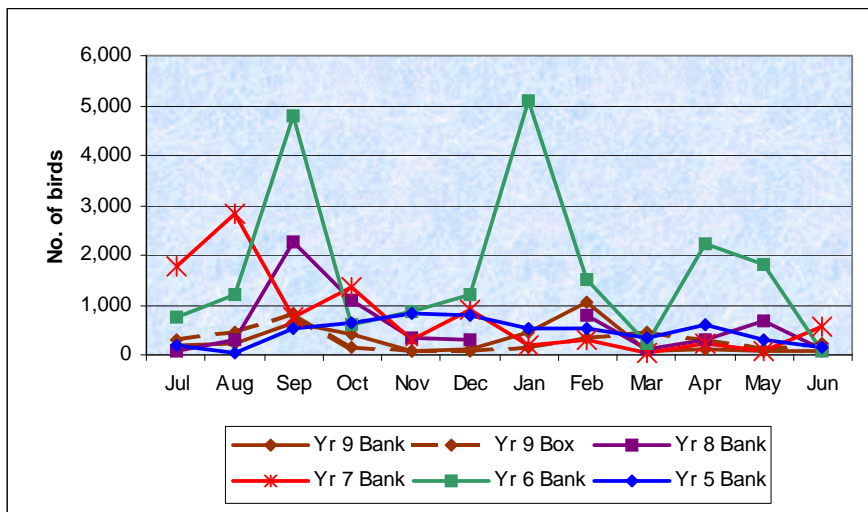
Numbers in the Arklow Study Area

A total of 6,972 Guillemots were recorded in the Arklow Study Area in Year 9. Numbers over the Bank were generally similar to previous years, although there were no large counts of birds recorded. Peak count on the Bank was 1,055 birds in February, which was similar to previous years for this time of year (Figure 3.56).

Highest peaks in recent years were recorded in September (4,790 birds) and January (5,077 birds) of Year 6.

Numbers of Guillemots on the revised Year 9 Box route were similar to numbers over the Bank in Year 9, with a peak of 837 birds in September (Figure 3.57).

Figure 3.57 Numbers of Guillemots in the Arklow Study Area, Years 5 to 9



Mean monthly density

Overall, mean monthly density in the over the Bank in Year 9 was generally lower than for Years 5 to 8 combined (Figure 3.57). Mean density showed a peak in September, which was lower than the same month in Years 5 to 8 combined. Peak mean density in Years 5 to 8 combined was recorded in January (71.0 birds/km²), while mean density over the bank in Year 9 peaked in February (42.2 birds/km²). Mean density was lower for the remaining months of Year 9.

On the revised Box route in Year 9, highest mean density was recorded in September, with a peak of 26.6 birds/km² (Figure 3.58). Guillemot mean monthly density on the revised Box route was lower for the remaining months of Year 9.

Figure 3.58 Guillemot mean monthly density in the Arklow Study Area, Years 5 to 9

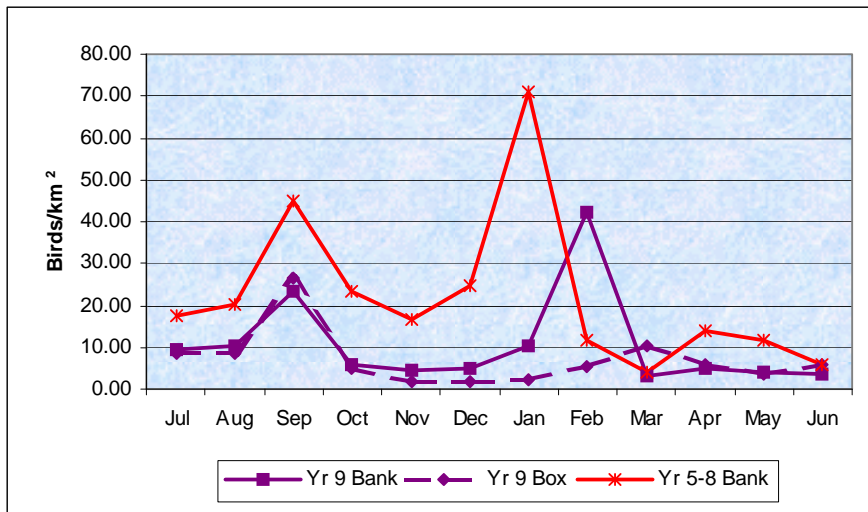


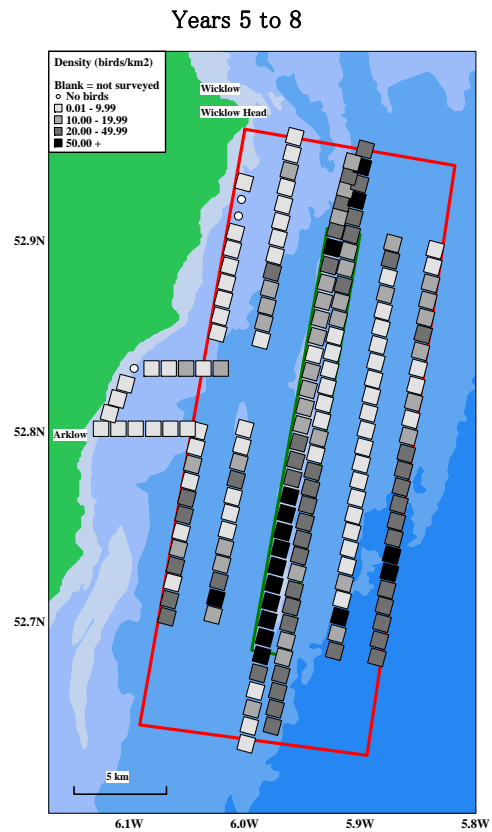
Figure 3.59 Guillemot density in the Arklow Study Area from September to January

Years 5 to 8 - September to January

Guillemots were recorded in mostly moderate to high density along the Bank between September and January of Years 5 to 8 combined. Highest density on the inner Bank leg ranged from 50.8 to 213.9 birds/km²) at the southern end of the inner Bank leg. On the outer Bank leg, peak density was 76.8 birds/km² at the northern end of the leg.

Guillemots were found at lower density on the inner Box legs, with a peak of 94.5 birds/km². On the outer Box legs, highest density was 105.3 birds/km².

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



Year 9

Year 9 – September to December

Between September and December of Year 9, Guillemots were widely distributed throughout the Arklow Study Area at mostly low to moderate density. Highest density (97.9 birds/km²) was recorded in the southern half of the outer Bank leg.

Overall, Guillemot density between September and December was lower in Year 9 compared to Years 5 to 8 combined.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

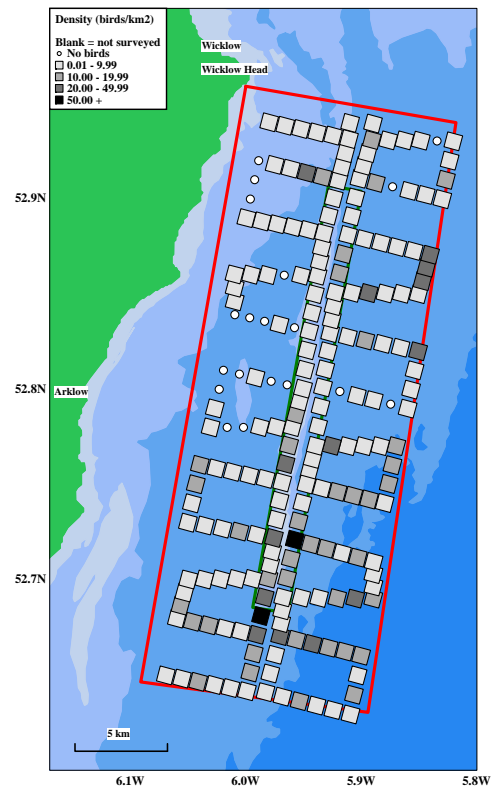
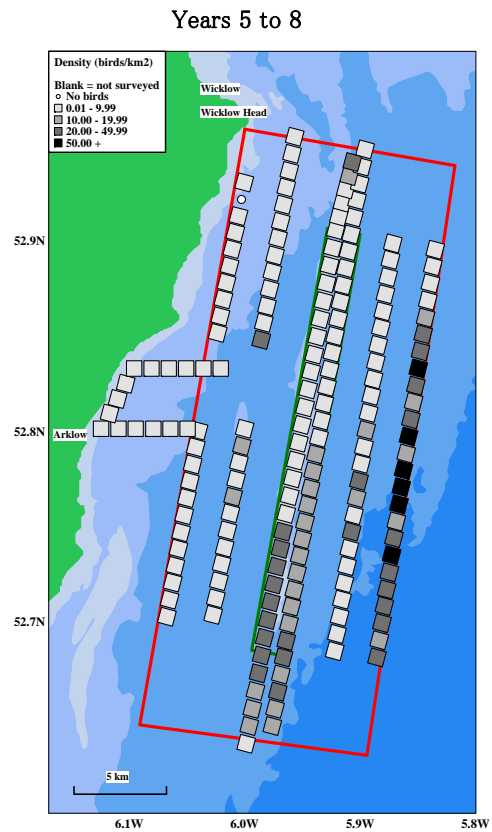


Figure 3.60 Guillemot density in the Arklow Study Area from February to August

Years 5 to 8 - February to August

Between February and August of Years 5 to 8 combined, Guillemot density was highest on the outer Box leg, and ranged from 61.5 to 194.1 birds/km².

Guillemot density on the Bank at this time was low to moderate, with mostly low density recorded on the inner Box legs and on the Cable Route.

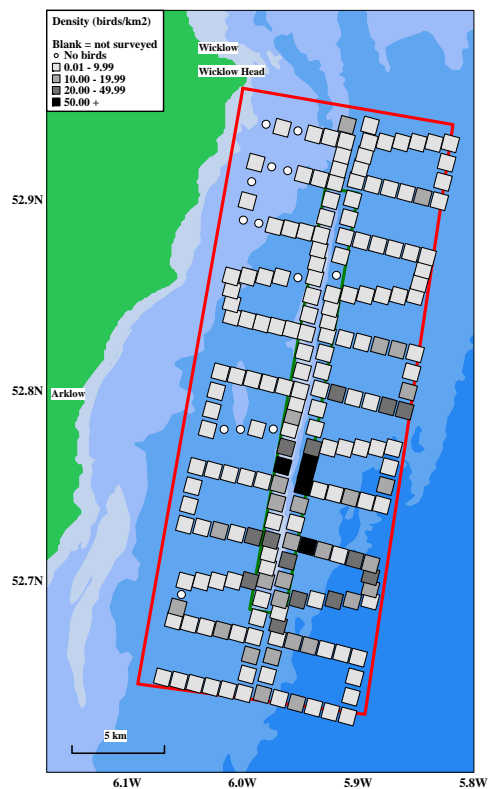


Years 5 to 8

Year 9

Year 9 - February to August

Guillemot density between February and August of Year 9 was again predominantly low, with moderate to high density recorded in the central section of the Bank. Peak density (95.2 birds/km²) was recorded on the outer Bank leg at this time, which was similar to the peak density recorded between September and January.



3.4.27 Razorbill

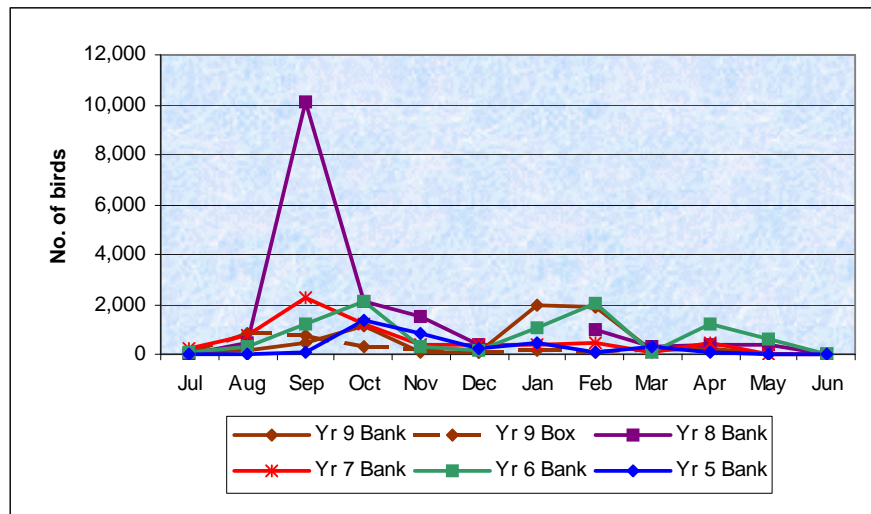
Numbers in the Arklow Study Area

A total of 8,159 Razorbills were recorded in the Arklow Study Area in Year 9, although unlike Year 8, there were no large counts. Numbers over the Bank peaked in January and February (1,932 birds and 1,852 birds respectively), which was similar to previous years (Figure 3.60).

Highest numbers of Razorbills over the Bank were recorded in September of Year 8, (10,103 birds). 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 of Razorbills on the revised Year 9 Box route were lower than numbers over the Bank, with a peak of 816 birds in August (Figure 3.61).

Figure 3.61 Numbers of Razorbills in the Arklow Study Area, Years 5 to 8



Mean monthly density

Razorbill mean monthly density over the Bank in Year 9 showed a peak in September, although this was well below the peak of 73.3 birds/km² recorded in September of Years 5 to 8 combined (Figure 3.61). Mean density of Razorbills over the bank in Year 9 decreased again until February, when they peaked at 82.8 birds/km², which was higher than previously recorded on the Bank. Mean density was low again for the remaining months of Year 9.

On the revised Box route in Year 9, Razorbill mean monthly density increased from August, with a peak of 24.7 birds/km² in September, which was slightly higher than the corresponding figure recorded over the bank for this month (19.9 birds/km²) (Figure 3.62). Mean Razorbill density on the revised Box route for the remaining months of Year 9 was low.

Figure 3.62 Razorbill mean monthly density in the Arklow Study Area, Years 5 to 9

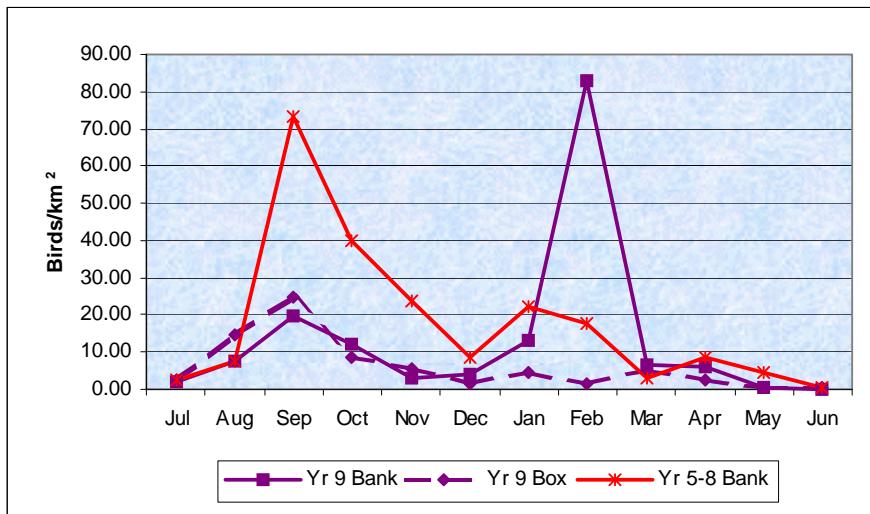
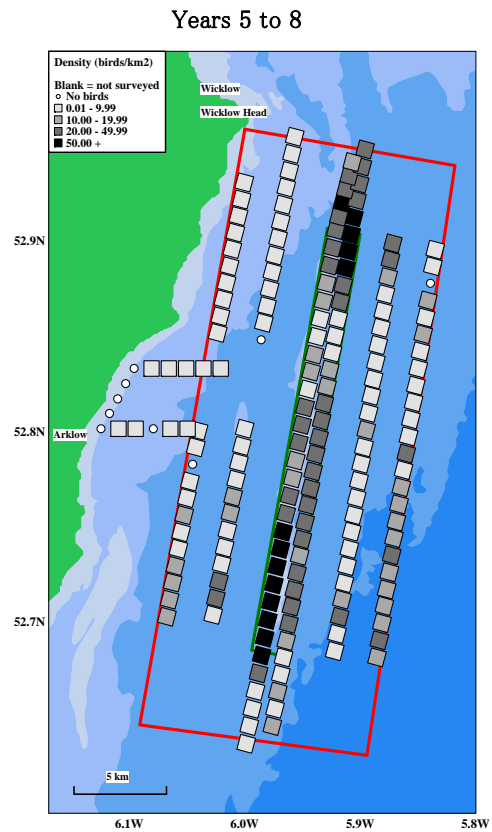


Figure 3.63 Razorbill density in the Arklow Study Area from September to February

Years 5 to 8 - September to February

Razorbills were widespread throughout the Arklow Study Area between September and February in Years 5 to 8 combined. Over the Bank, highest density on the southern half of the inner leg ranged from 55.5 to 119.1 birds/km². At the northern end of the outer Bank leg, peak density ranged from 55.8 to 127.6 birds/km².

Razorbill density in the Box between September and February was low to moderate. Density was low over the Cable Route over the period, with no Razorbills recorded on the inshore leg of the Cable Route.



Years 5 to 8

Year 9

Year 9 – September to February

Between September and February of Year 9, Razorbills were recorded in highest density in the southern half of the Bank legs, with a peak of 217.7 birds/km² on the inner Bank leg. This was higher than the peak density recorded on the Bank legs over the same months in Years 5 to 8 combined.

Razorbills were widespread at low to moderate density on the revised Box route between September and February.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

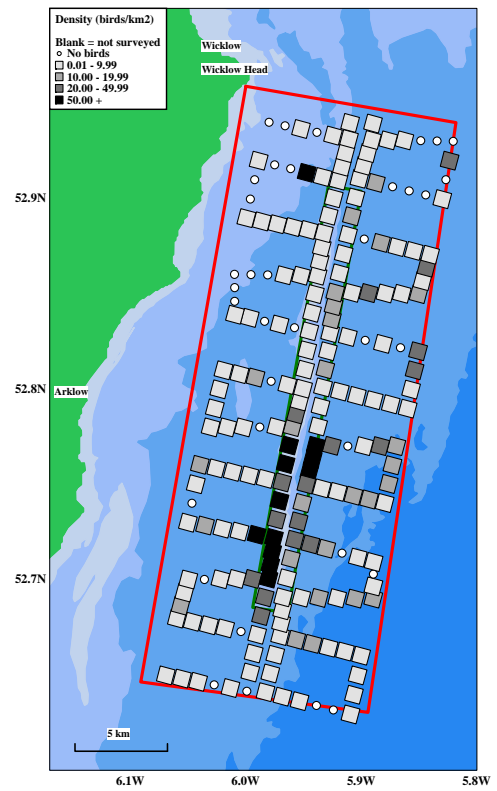
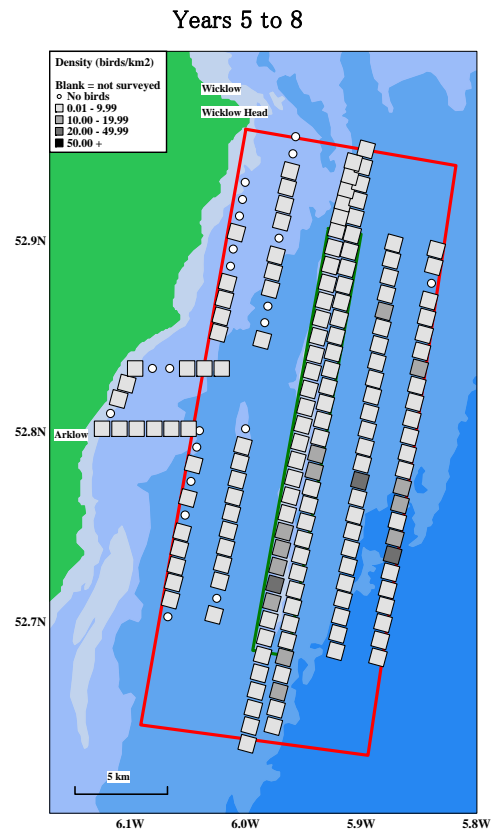


Figure 3.64 Razorbill density in the Arklow Study Area from March to August

Years 5 to 8 - March to August

Razorbills were widespread at low to moderate densities throughout the Arklow Study Area between March and August in Years 5 to 8 combined.

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



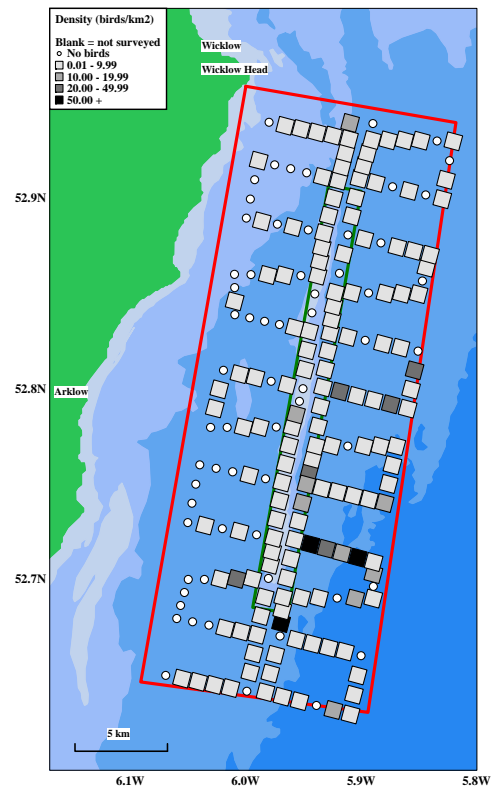
Year 9

Year 9 – March to August

Razorbills were widespread throughout the Arklow Study Area between March and August of Year 9 at mostly low to moderate density, although birds were less widespread inshore of the Bank.

Peak density was recorded on the offshore transect on the revised Box route in the south-east of the Study Area (93.4 birds/km²). This was higher than over the same months in Years 5 to 8 combined, when no density above 49.9 birds/km² was recorded.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report



3.4.28 Other auks

Years 5 to 8

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.

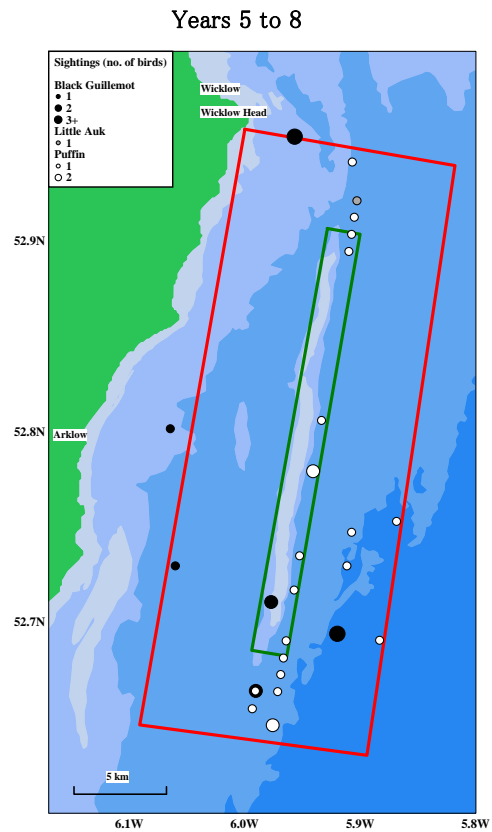
In Year 7, ten Black Guillemots were seen, four in February, two in July and four in August, all in the Box. In addition, 15 Puffins were recorded, three in June, 10 in July, one in August and one in September. Birds were mostly scattered along the Bank and in the south east of the Box. No Little Auks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

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.

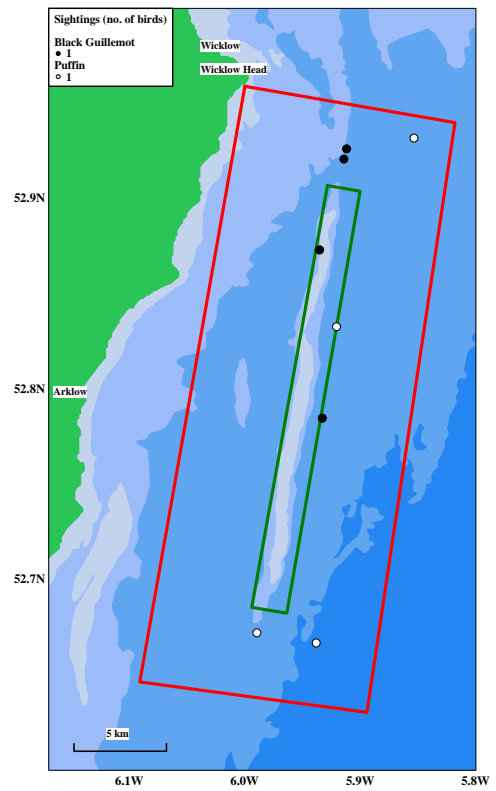
Year 9

In Year 9, four Black Guillemots were recorded; 1 in April, 2 in June and 1 in October, over the Bank. Four Puffins were also recorded, with individuals seen in May, June, July and October. All sightings were in the vicinity of the Bank or further offshore.

Figure 3.65 Auk sightings



Year 9



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

Two species of marine mammals were recorded in the Arklow Study Area in Year 9 (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.

Table 3.21 Numbers of marine mammals recorded in the Arklow Study Area in Year 9

Species	Numbers recorded	No. of Days
Grey Seal	29	14
Harbour Porpoise	137	33
Total	166	38

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 of turtles, sharks, cetaceans and seal species recorded in the western Irish Sea between 1981 and 2001 ¹

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 9 are shown in Table 3.23. Numbers of marine mammals over the Bank accounted for 51.8 % of all marine mammals recorded in the Arklow Study Area in Year 9, with 48.2 % of all marine mammals recorded on the revised Box route.

Table 3.23 Comparison of marine mammal numbers over the Bank and revised Box route in Year 9

Species	Bank	Box
Grey Seal	15	14
Harbour Porpoise	71	66
Total	86	80

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

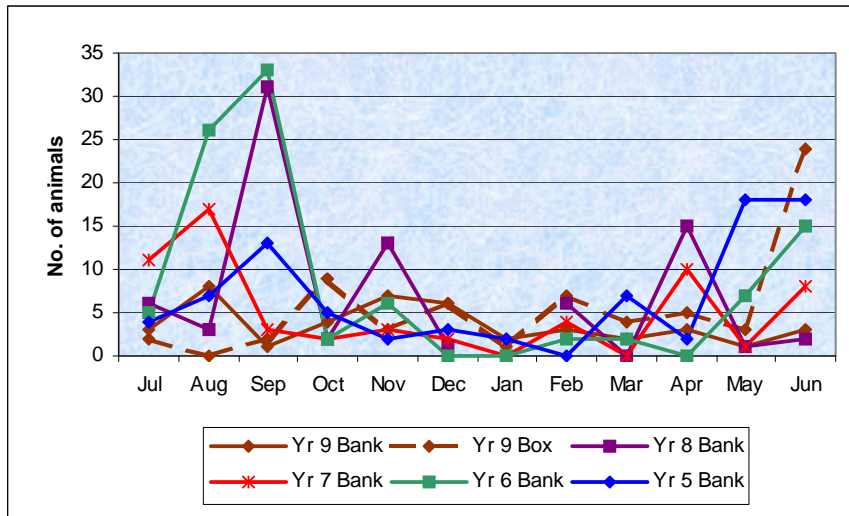
3.6.1 Harbour Porpoise

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

A total of 137 Harbour Porpoises were recorded in the Arklow Study Area in Year 9. Numbers of Harbour Porpoises over the Bank in Year 9 were similar to previous years, although there was no peak in numbers recorded in late summer has was recorded in Years 6 to 8 (Figure 3.65). The highest count over the Bank in Year 9 was just eight animals in August. Numbers of Harbour Porpoise on the revised Year 9 Box route were low for most of the year, with a peak of 24 animals recorded in June, which exceeded numbers recorded in June on the Bank from Years 5 to 9 (Figure 3.66).

Figure 3.66 Numbers of Harbour Porpoises in the Arklow Study Area, Years 5 to 8



Mean monthly abundance

Mean monthly abundance for Harbour Porpoise over both the Bank and on the revised Box route in Year 9 was generally low, with a peak of 0.09 animals/km over the Bank in November (Figure 3.67). Mean monthly abundance for Years 5 to 8 was similarly low, with a slightly higher peak of 0.12 animals/km recorded in September.

Figure 3.67 Harbour Porpoise mean monthly abundance in the Arklow Study Area, Years 5 to 9

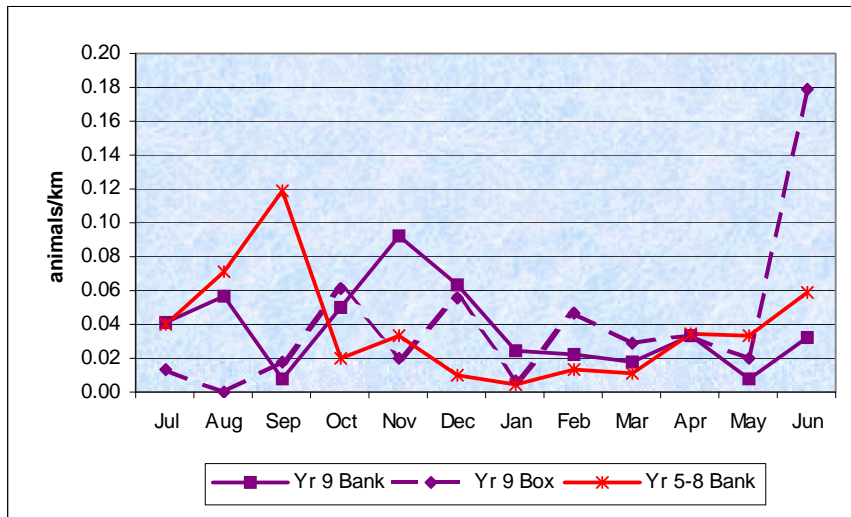
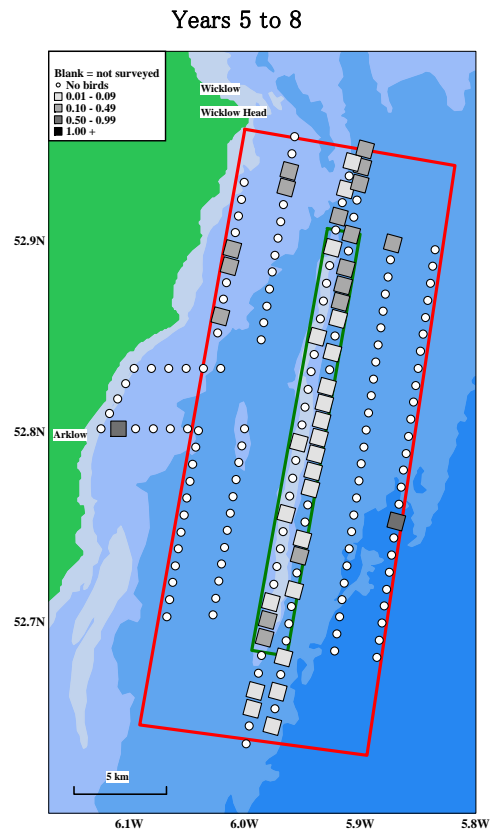


Figure 3.68 Harbour Porpoise abundance in the Arklow Study Area in all months

Years 5 to 8

In Years 5 to 8, Harbour Porpoises were recorded along the Bank in low to moderate abundance, with occasional higher abundances scattered in the Box and along the Cable Route.

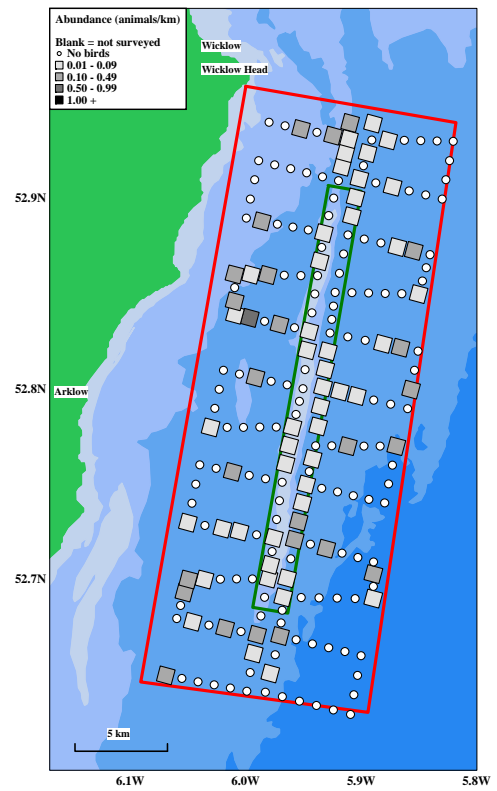


Years 5 to 8

Year 9

Year 9

In Year 9, Harbour Porpoises were scattered throughout the Arklow Study Area at low to moderate density. Animals were recorded in all months, except on the revised Box route in August.



3.6.2 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 8

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.

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

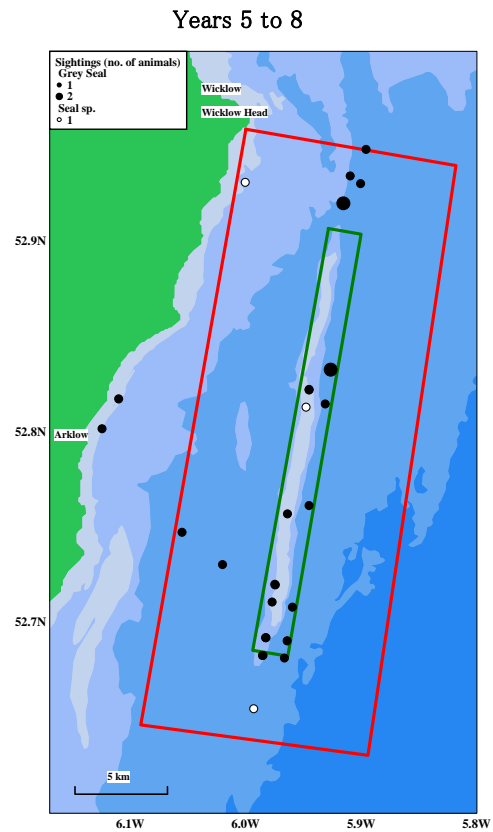
Year 9

Numbers of Grey Seals in the Arklow Study Area in Year 9 were much higher than previous years, with a total of 29 animals recorded.

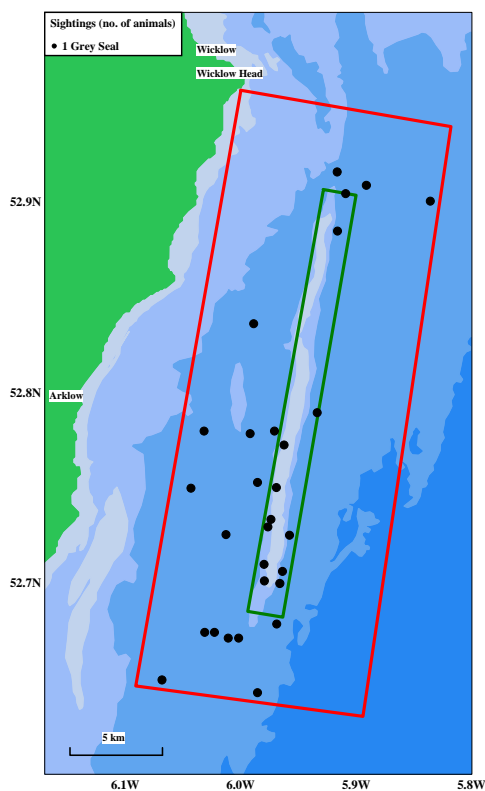
Animals were recorded between April and November, with peaks of 9 in June, and 5 in April and August, with lower numbers in other months.

Sightings were most frequent in the southern half of the Arklow Study Area, over the Bank and on the inshore transects of the revised Box route.

Figure 3.69 Seal sightings



Year 9



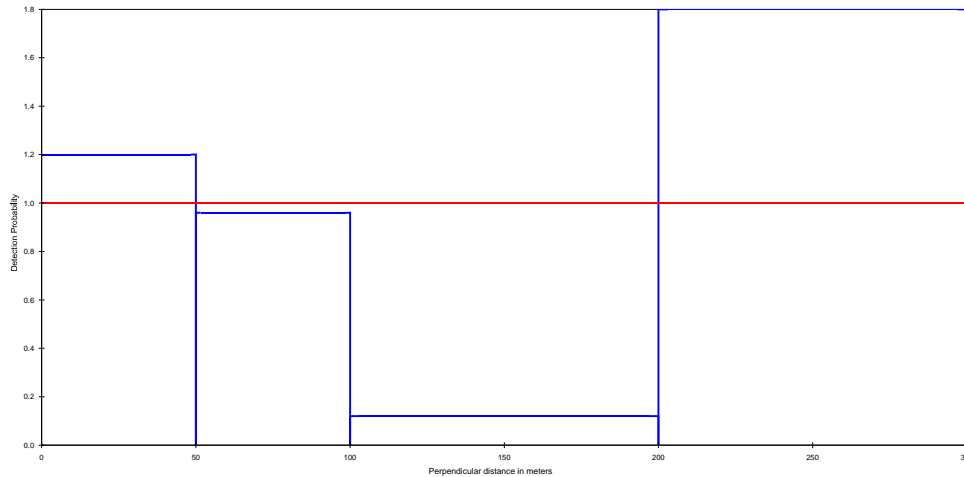
4. Statistical analyses of Year 9 data

Six key species were considered for the Year 9 statistical analyses; Red-throated Diver, Little Gull, Kittiwake, Guillemot, Razorbill and Harbour Porpoise. Methods used in the statistical analyses are described in Section 2.7.

4.1 Red-throated Diver

There were a total of 25 observations of Red-throated Divers on the water, involving a total of 30 birds. However, there was no consistent decline in the numbers of Red-throated Divers with increasing distance from the observer, and so no meaningful detection function could be fitted to the data (Figure 4.1).

Figure 4.1 Scaled histogram of detection distances for Red-throated Divers on the water within the 300m transect (based upon data pooled across all 12 months and 3 sections).



Therefore, for Red-throated Diver we calculated minimum population estimates by assuming 100% detectability for both birds on the water and birds in flight. When calculating population estimates for birds in flight and birds on the water combined we have combined the data before analysis so as to maximise sample sizes.

The maximum estimated population size for Red-throated Divers in the Arklow Study Area during Year 9 was 41 birds in March. This exceeded the 1 % nationally important threshold of 20 birds (Crowe 2005). Estimates between October and May varied between 7 and 41 birds, while no birds were present for the remainder of the year (Table 2 - Appendix B). The vast majority of birds occurred on the Bank, with no birds recorded in the Eastern Box, and only two sightings of birds in the Western box (Table 3 - Appendix B).

The confidence limits associated with these population estimates are very wide, and they must be treated with great caution (Tables 2 and 3 - Appendix B). This is because of the

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

small number of observations, and also because the vast majority of observations occurred within the Bank zone, which is surveyed, necessarily, from just two transects. As a result, variance estimates for the encounter rate, for which the sample size is the number of transects, are very high.

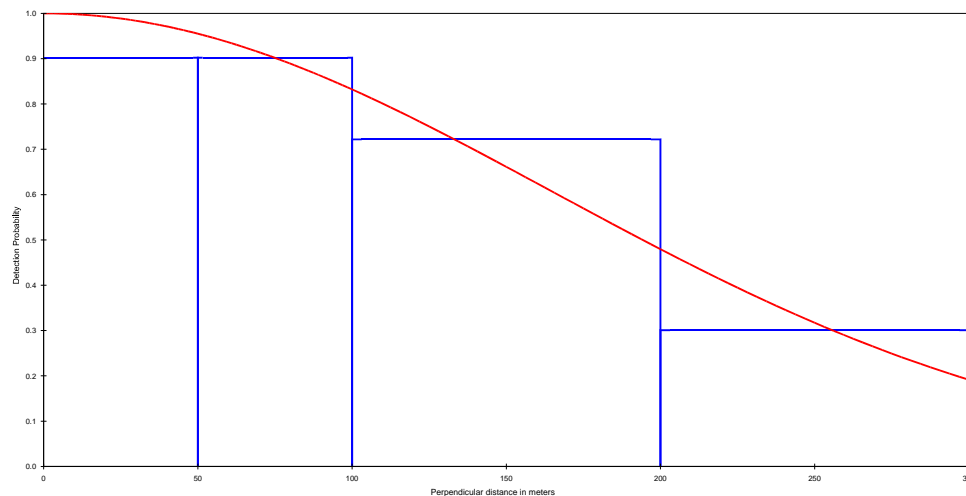
The small number of observations also leads to uncertainty in the population estimates. For example, the population estimate of 19 birds in the Western Box in March, out of a total population estimate of 41 birds for that month, is based upon a single observation of two birds.

Another reason to be cautious of the Red-throated Diver population estimate was the high proportion of birds recorded in flight, for a species which generally spends most of its time on the water (Table 4 - Appendix B). This species is particularly vulnerable to disturbance from vessels, and it may be that these birds were flushed ahead of the survey vessel before they were detected on the water. However, if they originated from outside the transect, then this could potentially inflate the population estimates.

4.2 Little Gull

For Little Gulls on the water, the detection function model provided a close fit to the data (Figure 4.2), and gave an estimate for the probability of detection of 64% (95% confidence limits: 51% to 81%).

Figure 4.2 Scaled histogram of detection distances for little gulls on the water within the 300m transect (based upon data pooled across all 12 months and 3 sections).



Little Gulls were absent during May and June, with population estimates varying between 13 and 570 during the remaining months of the year, with a maximum population estimate for the Arklow Study Area of 570 birds in November (Table 5 - Appendix B). This is below the 1% internationally important threshold of 840 birds (Crowe 2005), however numbers of Little Gulls recorded in Year 9 were lower than previous years (see Section 3.4.13).

The vast majority of birds were recorded on the Bank (Table 6 - Appendix B), with the small sample size (i.e. number of transects) again leading to very wide confidence limits for

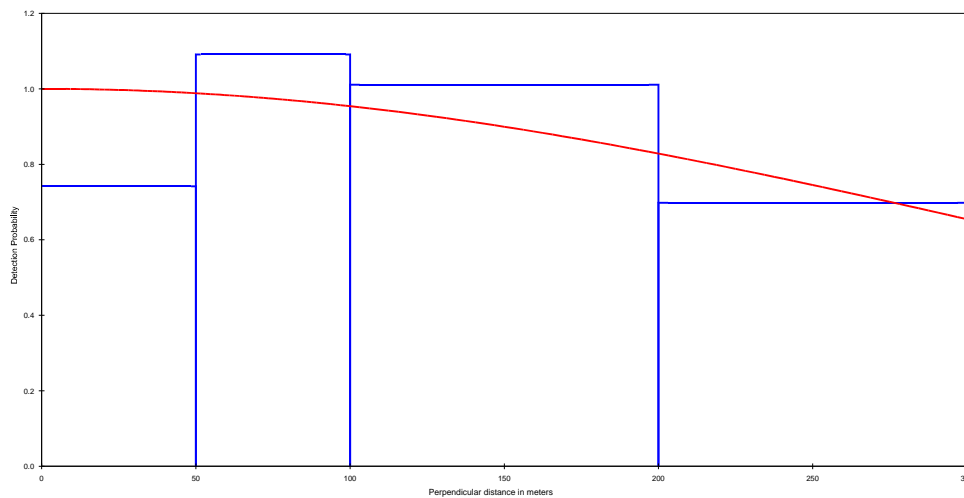
Arklow Bank Seabird Monitoring Programme Year 9 Final Report

the Bank population estimates (Table 6 - Appendix B) and thus the overall population estimates. Both birds on the water and birds in flight made important contributions to the overall population estimate, with the relative importance varying between months (Table 7 - Appendix B).

4.3 Kittiwake

For Kittiwakes on the water, the detection function model provided a reasonable fit to the data (Figure 4.3). However, the apparent lower probability of detecting birds in the immediate vicinity of the vessel (0–50m) suggested that the key assumption of standard distance sampling analyses (that the observer detects all animals on the transect line) may be violated. This suggests that the estimate for the probability of detection of 88% (95% confidence limits: 78–98%) may be biased.

Figure 4.3 Scaled histogram of detection distances for kittiwakes on the water within the 300m transect (based upon data pooled across all 12 months and 3 sections).



Kittiwakes were present throughout Year 9, although numbers were highest between October and May (Table 8 - Appendix B), with a maximum population estimate for the Arklow Study Area of 3,100 in April. This total would be approximately equivalent to 0.4 % of the all-Ireland breeding population (415,995 pairs – Mitchell *et al* 2004).

Kittiwakes were distributed throughout the Arklow Study Area, although generally most birds, and the highest population estimates, were associated with the Bank (Table 9 - Appendix B). Both flying birds and birds on the water contributed significantly to the overall population estimates (Table 10 - Appendix B). Again, the very wide associated confidence limits (Tables 8, 9 and 10 - Appendix B) suggested these population estimates should be treated with caution.

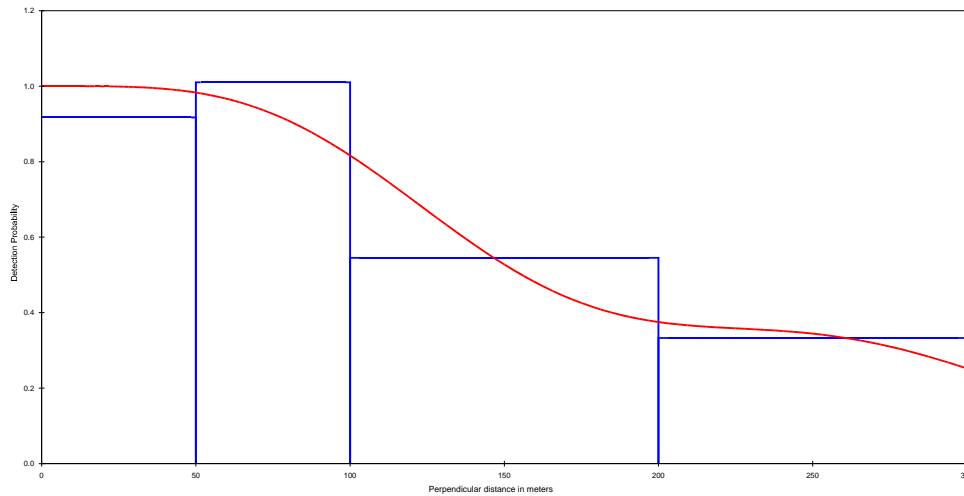
4.4 Guillemot

For Guillemot and Razorbill we only considered birds positively identified to species. In the field, it can be difficult to distinguish between the two species, and so for these two species, the population estimates should be regarded as minimum estimates.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

The detection function model for Guillemot appeared to provide a reasonable fit to the data (Figure 4.4). However, the observed probability of detection within 50m of the vessel (Band A) was apparently slightly lower than between 50 and 100m (Band B).

Figure 4.4 Scaled histogram of detection distances for Guillemots on the water within the 300m transect (based upon data pooled across all 12 months and 3 sections)



The detection function followed a characteristic S shape, with detectability consistently high across both the inner two distance bands (0–100m) and low across the outer two distance bands (100–300m), changing rapidly between the two.

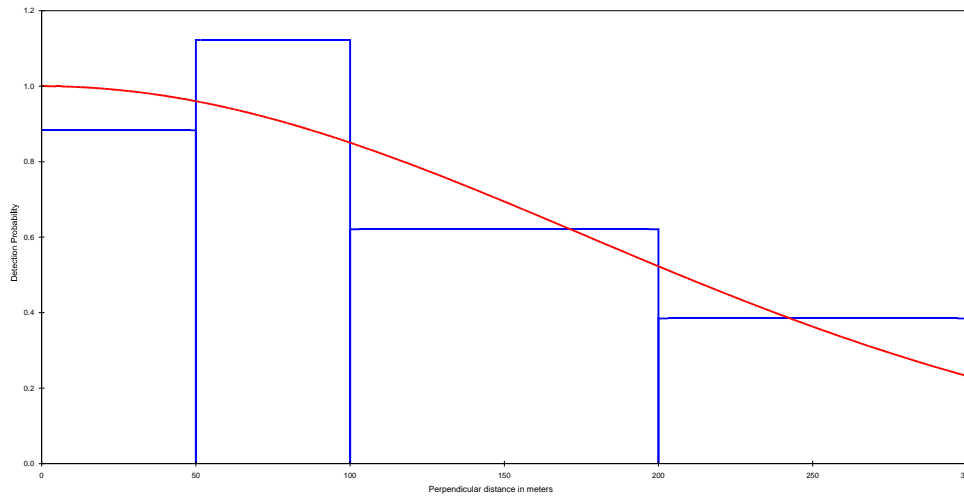
Bearing in mind the limitations discussed above, the fitted detection function model suggested a probability of detection for Guillemots on the water of 61% (95% confidence limits: 55%–69%). Guillemots were recorded throughout the year, across all sections (Table 12 - Appendix B) with a maximum population estimate for the Arklow Study Area of 6,982 birds in September (Table 11 - Appendix B). This would be approximately equivalent to 9.4 % of the all-Ireland breeding population (74,356 individuals – Mitchell *et al* 2004).

Birds on the water dominated the population estimates (Table 13 - Appendix B). The larger number of sightings resulted in narrower confidence limits than for the other species (Tables 11, 12 and 13 - Appendix B), although the uncertainty in estimates was still considerable.

4.5 Razorbill

The detection function model for Razorbill appeared to provide a reasonable fit to the data (Figure 4.5). However, like Guillemot, the observed probability of detection within 50m of the vessel (Band A) was apparently slightly lower than between 50 and 100m (Band B). The fitted detection function model for Razorbill suggested a probability of detection of 67% (95% confidence limits: 62%–72%).

Figure 4.5 Scaled histogram of detection distances for Razorbills on the water within the 300m transect (based upon data pooled across all 12 months and 3 sections).



Razorbills were present in numbers throughout the year, and distributed across all sections (Table 15 - Appendix B) with a maximum population estimate for the Arklow Study Area of 5,093 birds in September (Table 14 - Appendix B). This would be approximately equivalent to 9.9 % of the all-Ireland breeding population (51,530 individuals – Mitchell *et al* 2004).

Birds on the water dominated the population estimates (Table 16 - Appendix B). Again, the confidence intervals for the population estimates were wide, and so the estimates should be treated with caution.

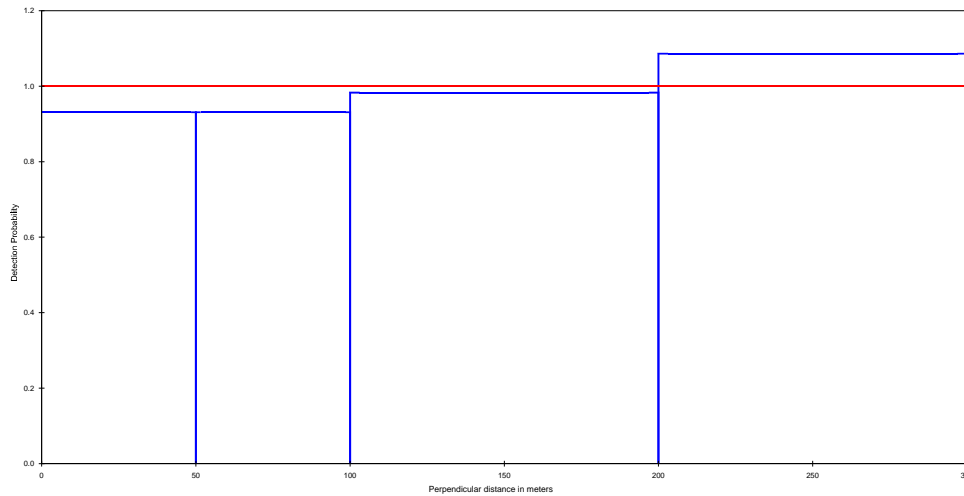
4.6 Harbour Porpoise

Although the 58 observations of Harbour Porpoise recorded in transect represented a reasonable sample size for detection function modelling, the data suggested an unlikely pattern, with apparently no diminution in the probability of detection with increasing distance from the observer (Figure 4.6). We calculated minimum population estimates by assuming 100% detectability. However, as animals under the water are unavailable for detection, this is a relative rather than an absolute population estimate, providing an estimate of the number of animals available for detection at the surface rather than the total number of animals present.

Harbour porpoise were recorded throughout the year (Table 17 - Appendix B), and across all the sections (Table 18 - Appendix B), with a maximum population estimate for the Arklow Study Area of 126 animals available for detection at the surface in June, and population estimates of 20 or more individuals in 8 out of 12 months. The small number of observations, with many occurring on the two Bank legs (Table 18 - Appendix B), yielded

wide confidence limits for this species, suggesting that the estimates should be treated with considerable caution.

Figure 4.6 Scaled histogram of detection distances for Harbour Porpoise on the water within the 300m transect (based upon data pooled across all 12 months and 3 sections).



4.7 Discussion

For all six key species, the statistical analyses conducted on the Year 9 data were preliminary, and based on one year’s data and the results produced here should be treated with caution.

For Red-throated Diver, the apparent probability of detection by the surveyors was greater at 200–300m from the vessel than at 0–50m. Such a pattern was most probably due to divers on the trackline ahead of the vessel flying off in response to the approaching vessel, before they were detected by the surveyors. Birds further away from the trackline i.e. in Bands C or D, would be less likely to fly off as the vessel approached. Red-throated Divers are known to respond in this way to approaching vessels, which is why they are often surveyed using aerial surveys. Greater effort to scan well ahead of the vessel for divers on the water would help to increase the number of birds detected on the water before they flush.

For Kittiwakes on the water, standard Distance theory would suggest that the apparent lower probability of detecting birds in the immediate vicinity of the vessel (Band A) was a result of not all birds on the survey trackline being detected (Buckland *et al.* 2001). However, it is considered more likely that this pattern resulted from most of the birds occurring close to the Bank, in waters too shallow for the vessel to pass directly over, as the same pattern was not recorded for the similar sized (and thus as likely to be detected) Little Gull. If this were the case, then Kittiwakes would be recorded on the outer bands of the transect (Bands B to D).

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

For both Guillemot and Razorbill, the observed probability of detection in Band A was apparently slightly lower than Band B. This may have been due to birds closest to the survey vessel diving in response to its approach, and surfacing again in Band B, further away from the vessel.

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

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), while more recent projects (2007 and 2008) were summarised in the 2008 Final Report (Cork Ecology 2009). Previous reports have discussed impacts from older projects (e.g. CWC 2006).

5.2 Offshore wind farms in Scottish Territorial Waters

On 22 May 2008, The Crown Estate requested initial expressions of interest from companies wishing to be considered for developing commercial scale wind farms within Scottish territorial waters. Following the initial registration process, The Crown Estate invited registered companies to submit project proposals for assessment. By the close of this application process 23 site applications had been received from a total of 14 development companies and consortia.

Ten companies and consortia were awarded exclusive development rights over their chosen sites, allowing the project developers to commence with further site surveys and investigations prior to submitting consent applications. If all of these sites were to be constructed in full, they could provide a potential installed capacity of over 6 GW of offshore wind energy.

A lease which enables the developer to actually go ahead with construction works will only be granted by The Crown Estate once the developer has conducted a site specific Environmental Impact Assessment (EIA) and obtained statutory consents and permissions from the Scottish Government.

Following this high level of interest in the development of offshore wind farms in Scottish territorial waters, the Scottish Government is currently conducting a Strategic Environmental Assessment (SEA) for offshore wind in territorial waters. The SEA will ensure the significant offshore wind resource is developed strategically and is planned to be completed within one year.

5.3 UK Round 3 projects

In June 2008, the Crown Estate announced proposals for the third round of offshore wind farm leasing in the UK. There are 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.

The Crown Estate is currently undertaking a number of enabling actions. These commenced in 2009 and include aerial bird surveys, marine mammal research and funding for the industry aviation plan. The overall purpose is to de-risk and accelerate development within Round 3.

The bid and award process was concluded at the end of 2009 for the nine offshore wind development zones. The development partners will now lead the early stages of development of the zones and will identify potential wind farm sites to take forward.

The nine Round 3 zones are detailed as follows:

Moray Firth

- The total zone area is 520 km², equivalent to 28 km distance to mainland
- Minimum depth is 30 m and Maximum depth is 57 m

Firth of Forth

- The proposed capacity is almost double Scotland's existing renewable generation capacity
- The total zone area is 2,852 km² - only a fraction of which will be developed
- The zone lies directly outside the 12 nm (22 km) territorial waters limit
- The average distance to shore is 53.8 km and extends to approximately 80 km offshore at its furthest point
- The mean water depth of the zone is 50 m and ranges between 30 and 80 metres
- The zone is approximately 40 km wide (east to west) and 70 km long (north to south)
- There are four Scottish Territorial Waters development sites immediately inshore of the zone; Bell Rock, Inch Cape, Neart na Gaoithe and Forth Array

Dogger Bank

- The Dogger Bank zone is located off the east coast of Yorkshire between 125 and 195 kilometres offshore.
- It extends over approximately 8,660 km² with its outer limit aligned to UK continental shelf limit
- This is the largest zone in Round 3, equivalent in size to North Yorkshire
- The water depth ranges from 18-63 metres.

- As the development partner, Forewind will now begin to carry out the extensive surveys, assessments and planning required for the consent process. The consortium's commitment is to secure all the necessary consents for the construction and development of Dogger Bank, up to the point of an investment decision, which is anticipated around late 2014.
- Forewind has agreed with The Crown Estate a target installed capacity of 9GW, though the zone has a potential for approximately 13GW, which equates to around 10 per cent of the total projected UK electricity requirements.
- If developed it is likely to be the world's largest offshore wind project.

Hornsea

- The Hornsea zone will provide enough electricity to meet 4 per cent of all electricity demand in the UK and power approximately 3 million homes
- The total zone area is 4,735 km²
- The zone lies between 34 km and 190 km off the Yorkshire coast
- Water depths across the zone are predominantly between 30 and 40 m, with maximum depths to 70 m
- The zone is adjacent to the River Humber, 200 km south of Newcastle and 75 km north of the Wash

Norfolk

- The total zone area is 6036.8 km²
- 55.5 km distance to mainland
- Minimum depth is 5 m, maximum depth is 70.1 m
- This is the shallowest of all the Round 3 zones.

Hastings

- The Hastings zone is located off the West Sussex coastline, out to sea off Brighton
- The area is 270.2 km²
- It is over 13 km from the coast at its closest point and nearly 26 km at its furthest
- Minimum depth around 19 m, maximum depth up to 62 m

West of Isle of Wight

- The total zone area is 723.7 km²
- 20.7 km distance to mainland
- Minimum depth is 27.8 m, maximum depth is 56.3 m.

- Target capacity: Around 30 per cent of the zone could be developed, providing approximately 900 MW of capacity, producing approximately 2.8 TWh/year

Bristol Channel

- The total Bristol Channel zone area is 949.7 km²
- 24.4 km distance to mainland
- The Atlantic Array site extends over 492 km² with water depths ranging from 23 to 56 metres
- The Atlantic Array site is 14 km from the north Devon coast and 18 km from the south Wales coast at its closest point
- The Atlantic Array site already benefits from having a connection agreement with National Grid, which will enable first power to be exported from the project in late 2015.

Irish Sea

- The zone is approximately 15 km (9 miles) from the southern boundary of the zone to Anglesey, over 20 km to the Isle of Man and over 40 km to the Cumbrian coast
- Total area of approximately 2,200 km²
- Potential capacity of the zone is over 4 GW.
- Water depth (min approximately 28 m and max is approx 78 m)

6. Discussion

6.1 Overview of important species in the Arklow Study Area

Seabirds

Seven species listed on Annex I of the EU Birds Directive (79/409/EEC) were recorded in the study area in Year 9. These included 1 diver species (Red-throated Diver), 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 four of the last 5 years, peak numbers of Red-throated Divers recorded over the Bank have exceeded the 1 % nationally important threshold of 20 birds (Crowe 2005). In Year 9, the maximum day count was 25 birds recorded in January. This compares to a maximum peak day count of 18 birds in Year 8 (although there was no January count in Year 8), 23 birds in Year 7, 60 birds in Year 6 and 44 birds in Year 5. The combined 5-year mean for the Arklow Bank, for Years 5 to 9 was 34 birds, which is nationally important.

In terms of overall numbers of birds in the Arklow Study Area, Kittiwake, Razorbill and Guillemot were the most important species in Year 9.

Kittiwake was the most numerous species recorded in the Arklow Study Area in Year 9, although numbers recorded were lower than in Year 8. Although a 1 % threshold of national importance has not been set for Kittiwake, the October Year 9 total for the Bank (7,799 birds) would be approximately equivalent to 0.9 % of the all-Ireland breeding population (415,995 pairs – Mitchell *et al* 2004). Peak Bank counts in Year 8 and Year 7 also exceeded 1 % of the all-Ireland breeding population (Cork Ecology 2007 and 2009). In comparison, statistical analyses of Kittiwake data for Year 9 gave a maximum population estimate for the whole Arklow Study Area of 3,100 in April. This total would be approximately equivalent to 0.4 % of the all-Ireland breeding population (Mitchell *et al* 2004).

In Year 9, peak numbers of Razorbills were recorded over the Bank in January, which differed from previous years, when numbers peaked in August and September. While a 1 % threshold of national importance has not been set for Razorbill, the January Bank peak in Year 9 (1,932 birds) would be approximately equivalent to 3.7 % of the all-Ireland breeding population (51,530 individuals – Mitchell *et al* 2004). Peak Bank counts in Year 8 and Year 7 also exceeded 1 % of the all-Ireland breeding population (Cork Ecology 2007 and 2009). In comparison, statistical analyses of Razorbill data for Year 9 gave a maximum population estimate for the whole Arklow Study Area of 5,093 birds in September. This would be approximately equivalent to 9.9 % of the all-Ireland breeding population (Mitchell *et al* 2004).

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Peak counts of Guillemots in Year 9 peaked over the Bank in February, although this count was not as high as peaks recorded in previous years. While a 1 % threshold of national importance has not been set for Guillemot, the February Bank peak in Year 9 (1,055 birds) would be approximately equivalent to 1.4 % of the all-Ireland breeding population (74,356 individuals—Mitchell *et al* 2004). Peak Bank counts in Year 8 and Year 7 also exceeded 1 % of the all-Ireland breeding population (Cork Ecology 2007 and 2009). In comparison, statistical analyses of Guillemot data for Year 9 gave a maximum population estimate for the whole Arklow Study Area of 6,982 birds in September. This would be approximately equivalent to 9.4 % of the all-Ireland breeding population (Mitchell *et al* 2004).

Other important species recorded in the Arklow Study Area in Year 9 included Black-headed Gull, Manx Shearwater, Common Gull and Little Gull.

Marine Mammals

Two species of marine mammal (Grey Seal and Harbour Porpoise) were recorded in the Arklow Study Area in Year 9. (Grey Seal) is listed on Annex II and V of the EU Habitats Directive (92/43/EEC), while Harbour Porpoise is 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 in Year 9 and was recorded in all months. A peak of 27 animals was recorded in the Arklow Study Area in June. Statistical analyses of Harbour Porpoise data for Year 9 gave a maximum population estimate for the Arklow Study Area of 126 animals available for detection at the surface in June. 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 2009, complete colony counts were conducted for six species; Fulmar, Shag, Herring Gull, Kittiwake, Guillemot and Razorbill. In 2009, counts of Fulmar, Shag and Herring Gull decreased slightly compared to 2008, while numbers of Kittiwake, Guillemot and Razorbill all increased.

Overall trends between 1999 and 2009 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 2009a).

The 2009 Kittiwake productivity estimate of 1.03 (\pm 0.10 SE) was the highest at Wicklow Head since 2004. Preliminary results of Kittiwake productivity at other sites around the UK and Ireland for 2009 indicate that productivity at Wicklow Head in 2009 was similar to other censused colonies (R Mavor and M Parsons *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 and increasing again in 2009. It is recommended that the monitoring of breeding seabirds at Wicklow Head should be continued in 2010.

6.3 Statistical analyses of Year 9 data

For this report, we have used Conventional Distance Sampling to calculate population estimates for key species within the Arklow Study Area. Although such estimates are potentially useful in allowing the regional, national and international importance of the seabird and marine mammal populations using the study area to be placed into context, all of the estimates shared a common problem of very wide confidence limits.

A major contributor, across species, to these wide confidence intervals was the great uncertainty in encounter rate estimates for the Bank section which resulted from these estimates being based upon just two transects.

Model-based approaches to estimating population density such as Density Surface Modelling offer the potential for much narrower confidence limits in such scenarios, whilst also generating distribution maps. Investigating the use of such approaches would be a natural development from the analyses presented here.

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. 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. A similar discussion was held at a meeting between Cork Ecology and Airtricity in May 2009, however to date there has been no data sharing.

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 was hoped to submit data for years 2–8 to ESAS in 2009, following approval from Airtricity, however approval has still not been granted.

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. A request from the Joint Irish Cetacean database for any marine mammal data from Irish waters has recently been issued by the National Biodiversity Data Centre.

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) *

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

	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.

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 9 Arklow Bank Seabird Monitoring Report, and reports for previous years, should be published in the public domain, in accordance with best practice guidelines (Fox et al 2006, Langston et al 2006).

8. Acknowledgements

Thanks to the dedicated team of observers; John Coveney, Dave Branagh, Eugene Archer, Hugh Delaney and John Lovatt, and to the captain, Finbar Harding, and crew of the Firehawk for braving the elements each month in order to survey the Arklow Study Area.

Thanks to Andy Webb and Tim Dunn of the JNCC Seabirds at Sea Team for providing relevant ESAS survey data for comparison with data from the Arklow Study Area.

9. References

- BirdLife International. 2007. Species factsheet: *Puffinus mauretanicus*. Available online at: <http://www.birdlife.org>
- Buckland, S. T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers and L. Thomas 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press.
- Buckland, S. T., Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2004. Advanced distance sampling. Oxford University Press.
- Camphuysen, C.J., Fox, T., Leopold, M.F. & Petersen, I.K. 2004. Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the UK. A report for COWRIE.
- Cork Ecology. 2009a. Arklow Bank Seabird and Marine Mammal Monitoring Programme: Wicklow Head Seabird Colony Monitoring 2009. A Report for Airtricity.
- Cork Ecology. 2009b. Arklow Bank Seabird and Marine Mammal Monitoring Programme: Year 8 Report - July 2007 to June 2008. A Report for Airtricity.
- Cork Ecology. 2007a. Review of Arklow Bank Seabird and Marine Mammal Monitoring Programme 2001 - 2007. A Report for Airtricity.
- Cork Ecology. 2007b. Arklow Bank Seabird and Marine Mammal Monitoring Programme: Year 7 Report - July 2006 to June 2007. A Report for Airtricity.
- Coveney J. & Phalan, B. 2001. Arklow Bank Seabird and Marine Mammal Survey July 2000–June 2001. Prepared for Fehily Timoney & Company, Cork for the EIS for the Arklow Bank wind farm.
- Coveney Wildlife Consulting Ltd. 2004. Seabird and Marine Mammal Survey of the Arklow Bank to assess the effects of the wind farm being built there: Years 1 to 4: July 2000 - June 2004. A report for Airtricity.
- Crowe, O. 2005. Ireland's Wetlands and their Waterbirds: Status and Distribution. Birdwatch Ireland, Newtownmountkennedy, Co. Wicklow.
- Crown Estate. 2008. Supporting information relating to the announcement of Round 3.
- CWC (Coveney Wildlife Consulting). 2002. 'Birds' in: Offshore Wind Farm at Codling Bank, Environmental Statement. Natural Power.
- CWC (Coveney Wildlife Consulting). 2006. Seabird & Marine Mammal Surveys to Assess the Effects of the Arklow Bank Wind Farm. Unpublished report for Airtricity Ltd.
- DECC (Department of Energy and Climate Change). 2009. UK Offshore Energy Strategic Environmental Assessment. Future Leasing for Offshore Wind Farms and Licensing for Offshore Oil & Gas and Gas Storage. Environmental Report. January 2009.

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

DMNR (Department of the Marine & Natural Resources). 2000. Offshore electricity generating stations - note for intending developers. Department of the Marine & Natural Resources.

Fewster, R.M., Buckland, S.T., Burnham, K.P., Borchers, D.L., Jupp, P.E., Laake, J.L. & Thomas, L. 2009. Estimating the encounter rate variance in distance sampling. *Biometrics* 65: 225-236.

- Fox, A.D., Desholm, M., Kahlert, J., Christensen, T.K. & Krag Petersen, I.B. 2006. Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds. *Ibis* 148 (Suppl. 1): 129-144.
- FES (Fulmar Ecological Services). 2006. Seabird and Marine Mammal Monitoring of the Arklow Bank: Interim Report for the period July 2005 to June 2006. Unpublished report for Airtricity Ltd.
- Langston, R.H.W., Fox, A.D. and Drewitt, A.L. 2006. British Ornithologists' Union Conference plenary discussion, conclusions and recommendations. *Ibis*, 148, 210-216.
- Lynas, P., Newton, S. & Robinson, J.A. 2007. The status of birds in Ireland: an analysis of conservation concern 2008-2013. *Irish Birds*; Vol. 8, Number 2. BirdWatch Ireland, Co. Wicklow.
- Macleod, K. 2006. SCANS II: Small Cetaceans in the European Atlantic and North Sea Quarterly Newsletter for Project. Issue 7, June 2006.
- Mavor, R.A., Heubeck, M., Schmitt, S. and Parsons, M. 2008. Seabird numbers and breeding success in Britain and Ireland, 2006. Peterborough, Joint Nature Conservation Committee (U.K. Nature Conservation, No. 31).
- Mitchell PI, Newton SF, Ratcliffe N & Dunn TE. 2004. Seabird Populations of Britain and Ireland. T & AD Poyser, London.
- Morton, A.J. 2001. DMAP for Windows. www.dmap.co.uk
- Newton SF & O Crowe. 1999. Kish Bank: a preliminary assessment of its ornithological importance. BirdWatch Ireland, Dublin.
- Pollock, C.M., Reid, J.B., Webb, A. & Tasker, M.L. 1997. The distribution of seabirds and cetaceans in the waters around Ireland. *JNCC Report*, No. 267.
- Stone CJ, Webb A, Barton C, Ratcliffe N, Reed TC, Tasker ML, Camphuysen CJ, Pienkowski MW. 1995. An atlas of seabird distribution in northwest European waters. JNCC, Peterborough.
- Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47:5-14. DOI: 10.1111/j.1365-2664.2009.01737.x
- Webb A. & Durinck J. 1992. Counting birds from ships. In: Manual for aeroplane and ship surveys of waterfowl and seabirds, eds. J. Komdeur, J. Bertelsen & G. Cracknell, 24-37. Slimbridge, I.W.R.B. Special Publication No.19.

Appendix A

Survey weather conditions in Years 5 to 9

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

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

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

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

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

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

⁴Visibility: - 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

Table A5 Survey conditions for Year 9 (July 2008 to June 2009)

Trip No.	Date	Weather				
		Wind Dir	Wind force ¹	Sea-state ²	Swell ³	Visibility ⁴
1	20/7	NW	3-5	3-5	Slight	Ex
2	21/7	SW	2-3	2	Slight	Ex
3	26/7	S-E	2-3	2-3	Slight	Good
4	8/8	NW-NE	2-4	2-3	Slight	Ex
5	22/8	NW	2-4	1-4	Slight	Good
6	29/8	S	2-3	1-3	Slight	Mod-Good
7	8/9	S	2-4	2-4	Slight	Good
8	13/9	E-S	2-4	1-4	Slight	Good
9	14/9	SE	2-4	1-4	Slight	Good
10	11/10	W-SW	2-3	1-3	Slight	Good
11	12/10	Var-S	1-3	1-3	Slight	Mod-Good
12	17/10	W-SW	2-3	1-3	Slight	Good
13	5/11	N-E	1-3	1-2	Slight	Good-Ex
14	16/11	W-NW	2-4	1-3	Mod-Slight	Mod-Good
15	28/11	SW	2	1	Slight	Ex
16	3/12	W-NW	2-3	2-3	Slight	Ex
17	6/12	NW-NE	2-4	2-4	Slight	Ex
18	7/12	SE-S	2-4	2-4	Slight	Ex
19	11/12	NW	2	1	Slight	Good
20	3/1	SE-S	2-3	2-4	Slight-Mod	Ex
21	4/1	SW-W	3	2	Slight	Good
22	6/1	S-SE	1-2	1-2	Slight	Ex
23	7/1	SW	2-3	2-3	Slight	Ex
24	11/2	SW-NW	2-4	1-2	Slight	Ex
25	12/2	SW	2-4	1-3	Slight	Mod-Good
26	13/2	Var-SE	1-2	0-2	Slight	Ex
27	20/3	SE	3-4	2-4	Slight-Mod	Mod
28	21/3	NW	2	1-2	Slight	Mod-Good
29	30/3	S	2-3	2-3	Slight	Good
30	1/4	N-E	1-3	1-3	Slight	Good-Ex
31	2/4	NE-SE	1-3	1-3	Slight	Good-Ex
32	11/4	SW-S	1-4	1-4	Slight	Ex
33	21/5	SW-SE	2-5	1-3	Slight	Ex
34	24/5	SW-S	1-4	1-3	Slight	Ex-Good
35	25/5	W-SW	2-4	2-4	Slight	Poor-Good
36	2/6	N-NE	0-2	0-2	Slight	Good
37	4/6	SW-SE	1-3	1-3	Slight	Good
38	5/6	N-NE	3-5	3-5	Mod-Slight	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

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

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
Year 9 Statistical analyses tables

Figure 1 Study Area and Zone boundaries, showing bank legs and survey grid



Figure 2 Study area and survey design with actual recording positions superimposed.

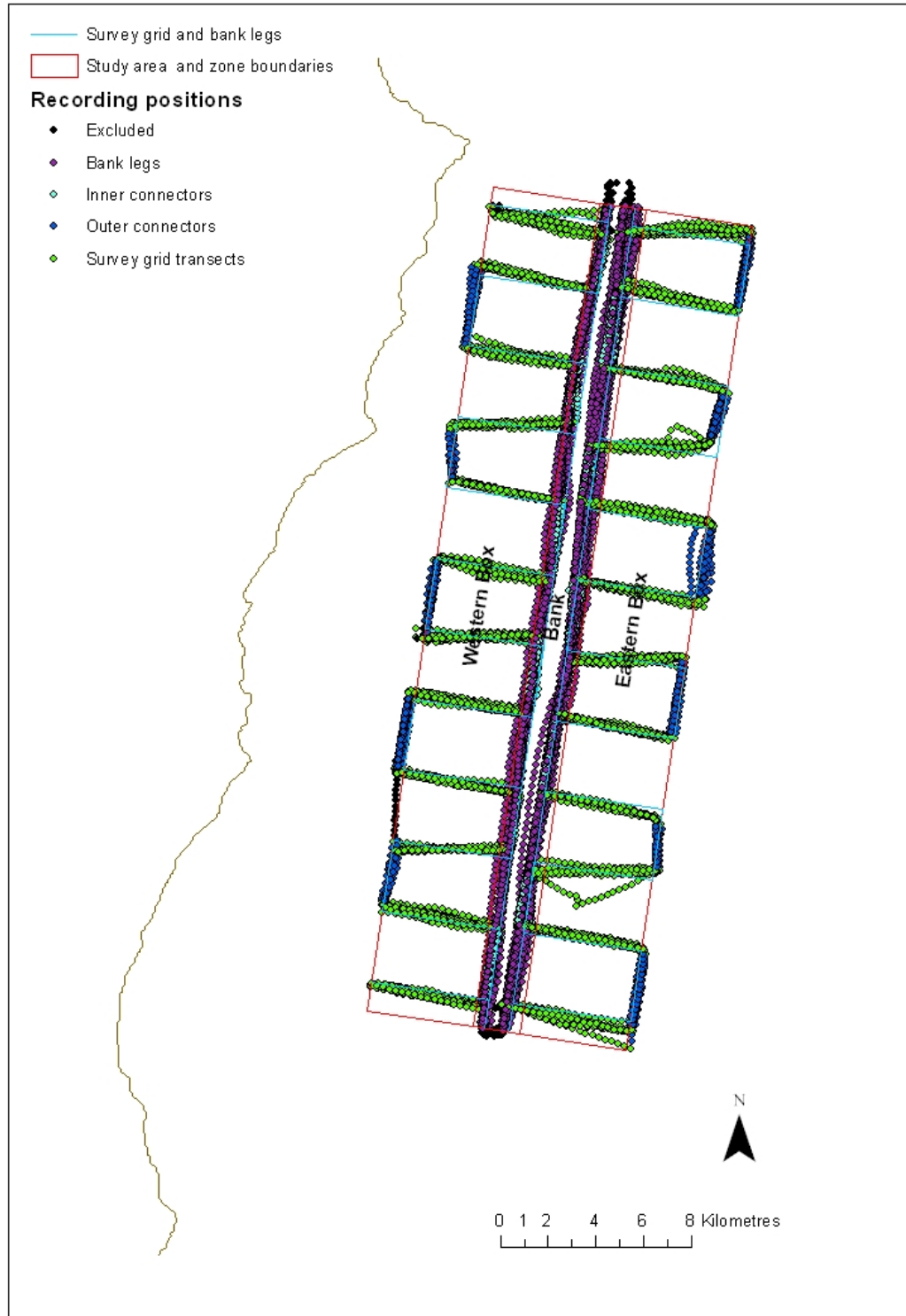


Figure 3 Recording positions on Bank legs used to calculate population size and density estimates for the Bank section, before any data excluded on the basis of sea state.

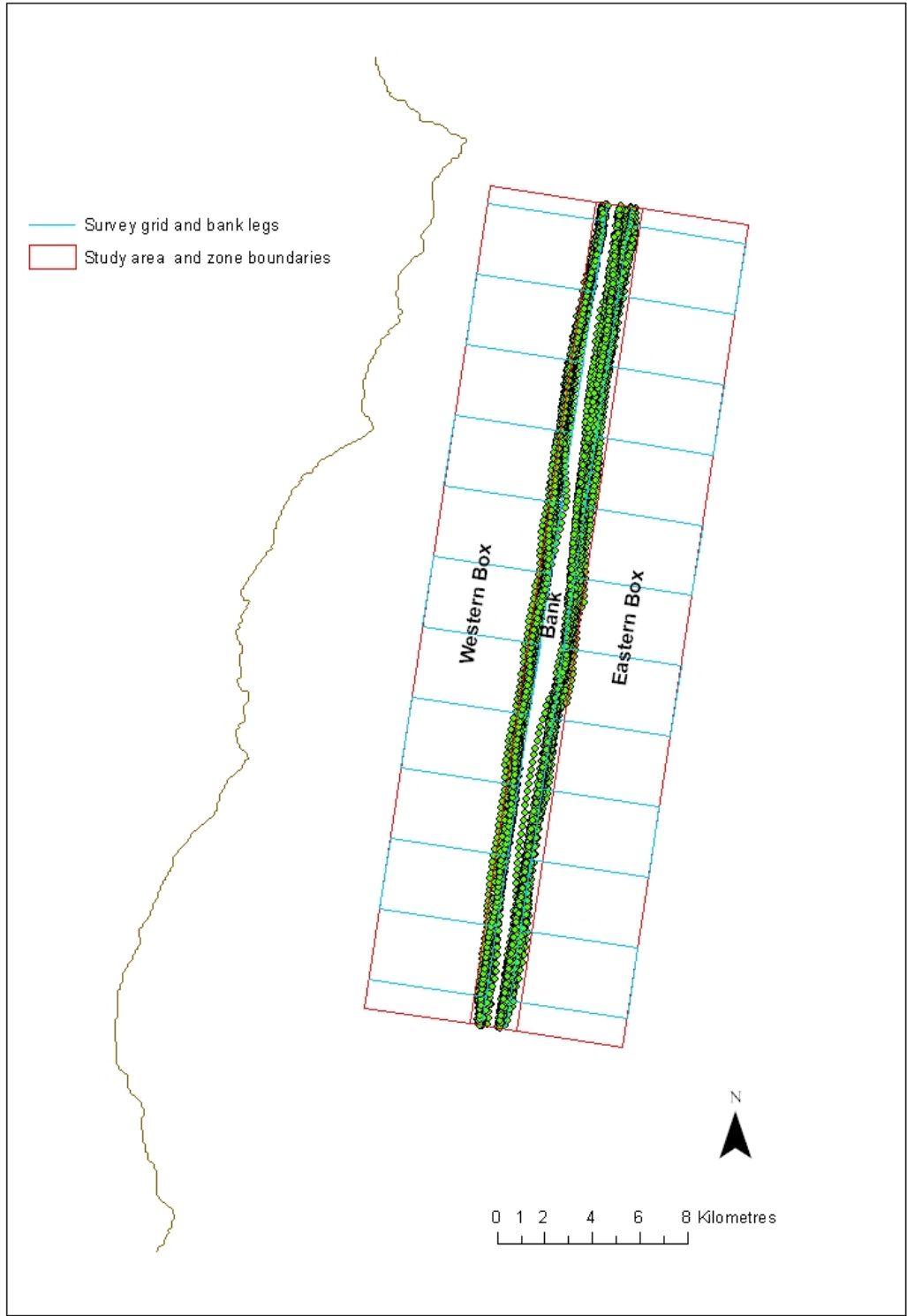


Figure 4 Recording positions on survey grid transects used to calculate population size and estimates for Eastern and Western box, before any data excluded on the basis of sea state.



Table 1 Summary of survey effort by zone and month

Zone	Month	Year	No of transects	Survey effort (km)		
				All sea states	Sea states of 4 or less - Seabirds	Sea states of 3 or less - Marine Mammals
Bank	7	2008	2	137.1	131.8	95.2
	8	2008	2	138.3	138.3	138.3
	9	2008	2	139.0	139.0	126.4
	10	2008	2	140.6	140.6	140.6
	11	2008	2	139.9	139.9	139.9
	12	2008	2	140.9	140.9	124.4
	1	2009	2	139.0	139.0	120.5
	2	2009	2	137.4	137.4	137.4
	3	2009	2	138.7	138.7	108.4
	4	2009	2	139.1	139.1	118.8
	5	2009	2	139.2	139.2	129.1
	6	2009	2	137.4	131.7	92.4
Eastern Box	7	2008	12	54.4	54.4	54.4
	8	2008	12	55.0	55.0	55.0
	9	2008	12	55.8	55.8	55.8
	10	2008	12	53.4	53.4	53.4
	11	2008	12	54.2	54.2	54.2
	12	2008	12	55.2	55.2	41.3
	1	2009	12	53.5	53.5	53.5
	2	2009	12	54.1	54.1	54.1
	3	2009	12	53.4	53.4	53.4
	4	2009	12	53.4	53.4	53.4
	5	2009	12	54.3	54.3	54.3
	6	2009	11	49.5	47.6	40.1
Western Box	7	2008	12	53.8	53.8	53.8
	8	2008	12	54.4	54.4	54.4
	9	2008	12	54.0	27.3	26.8
	10	2008	12	53.9	53.9	53.9
	11	2008	11	54.1	54.1	54.1
	12	2008	12	53.6	53.6	23.4
	1	2009	12	53.4	53.4	53.4
	2	2009	12	54.2	54.2	54.2

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

	3	2009	12	54.3	54.3	45.2
	4	2009	12	53.3	53.3	53.3
	5	2009	12	54.4	54.4	54.4
	6	2009	12	53.0	53.0	53.0

Table 2 Total density and population size estimates for Red-throated Diver for whole study area in each month based upon conventional distance sampling.

Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of animals seen	Density				Population size		
							Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
7	2008	384.9	239.9	26	0	0	0.00	0.00	0.00	0%	0	0	0
8	2008	384.9	247.7	26	0	0	0.00	0.00	0.00	0%	0	0	0
9	2008	384.9	222.1	21	0	0	0.00	0.00	0.00	0%	0	0	0
10	2008	384.9	247.9	26	2	2	0.03	0.00	168.42	87%	11	2	64,830
11	2008	384.9	248.3	25	7	8	0.03	0.02	0.06	19%	13	7	24
12	2008	384.9	249.7	26	4	4	0.02	0.02	0.02	1%	7	6	7
1	2009	384.9	245.9	26	2	16	0.07	0.00	1006.70	88%	27	0	387,523
2	2009	384.9	245.7	26	7	7	0.03	0.00	0.19	15%	12	2	75
3	2009	384.9	246.4	26	9	15	0.11	0.01	4.24	55%	41	3	1,631
4	2009	384.9	245.8	26	9	10	0.04	0.00	14.36	57%	17	0	5,526
5	2009	384.9	247.9	26	5	5	0.02	0.00	25.37	60%	8	0	9,767
6	2009	384.9	232.3	25	0	0	0.00	0.00	0.00	0%	0	0	0

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 3 Total density and population size estimates for Red-throated Diver for each section in each month.

Zone	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
								Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
Bank	7	2008	70.0	131.8	2	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	70.0	138.3	2	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	70.0	139.0	2	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	70.0	140.6	2	1	1	0.02	0.00	925.47	100%	2	0	64,770
	11	2008	70.0	139.9	2	7	8	0.19	0.11	0.34	19%	13	7	24
	12	2008	70.0	140.9	2	4	4	0.09	0.09	0.10	1%	7	6	7
	1	2009	70.0	139.0	2	2	16	0.38	0.00	5537.16	88%	27	0	387,523
	2	2009	70.0	137.4	2	7	7	0.17	0.03	1.07	15%	12	2	75
	3	2009	70.0	138.7	2	8	13	0.31	0.00	21.57	53%	22	0	1,510
	4	2009	70.0	139.1	2	9	10	0.24	0.00	78.96	57%	17	0	5,526
Eastern Box	5	2009	70.0	139.2	2	5	5	0.12	0.00	139.56	60%	8	0	9,767
	6	2009	70.0	131.7	2	0	0	0.00	0.00	0.00	0%	0	0	0
	7	2008	157.5	54.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	157.5	55.0	12	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	157.5	55.8	12	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	157.5	53.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
	11	2008	157.5	54.2	12	0	0	0.00	0.00	0.00	0%	0	0	0
	12	2008	157.5	55.2	12	0	0	0.00	0.00	0.00	0%	0	0	0
	1	2009	157.5	53.5	12	0	0	0.00	0.00	0.00	0%	0	0	0
	2	2009	157.5	54.1	12	0	0	0.00	0.00	0.00	0%	0	0	0
Western Box	3	2009	157.5	53.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
	4	2009	157.5	53.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
	5	2009	157.5	54.3	12	0	0	0.00	0.00	0.00	0%	0	0	0
	6	2009	157.5	47.6	11	0	0	0.00	0.00	0.00	0%	0	0	0
	7	2008	157.5	53.8	12	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	157.5	54.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
Western Box	9	2008	157.5	27.3	7	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	157.5	53.9	12	1	1	0.06	0.01	0.39	100%	10	2	61
	11	2008	157.5	54.1	11	0	0	0.00	0.00	0.00	0%	0	0	0
	12	2008	157.5	53.6	12	0	0	0.00	0.00	0.00	0%	0	0	0
	1	2009	157.5	53.4	12	0	0	0.00	0.00	0.00	0%	0	0	0

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

2	2009	157.5	54.2	12	0	0	0.00	0.00	0.00	0%	0	0	0
3	2009	157.5	54.3	12	1	2	0.12	0.02	0.77	100%	19	3	121
4	2009	157.5	53.3	12	0	0	0.00	0.00	0.00	0%	0	0	0
5	2009	157.5	54.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
6	2009	157.5	53.0	12	0	0	0.00	0.00	0.00	0%	0	0	0

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 4 Separate density and population size estimates for birds on the water and birds in flight for Red-throated Divers

Subset	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
								Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
On Water	7	2008	384.9	239.9	26	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	384.9	247.7	26	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	384.9	222.1	21	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	384.9	247.9	26	2	2	0.03	0.00	168.42	87%	11	2	64,830
	11	2008	384.9	248.3	25	0	0	0.00	0.00	0.00	0%	0	0	0
	12	2008	384.9	249.7	26	3	3	0.01	NA	NA	33%	5	NA	NA
	1	2009	384.9	245.9	26	1	1	0.00	NA	NA	99%	2	NA	NA
	2	2009	384.9	245.7	26	7	7	0.03	0.00	0.19	15%	12	2	75
	3	2009	384.9	246.4	26	7	12	0.09	0.01	0.60	57%	36	6	229
	4	2009	384.9	245.8	26	4	4	0.02	0.00	691.00	100%	7	0	265,996
	5	2009	384.9	247.9	26	1	1	0.00	0.00	173.00	100%	2	0	66,597
6	2009	384.9	232.3	25	0	0	0.00	0.00	0.00	0%	0	0	0	
In Flight	7	2008	384.9	239.9	26	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	384.9	247.7	26	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	384.9	222.1	21	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	384.9	247.9	26	0	0	0.00	0.00	0.00	0%	0	0	0
	11	2008	384.9	248.3	25	7	8	0.03	0.02	0.06	19%	13	7	24
	12	2008	384.9	249.7	26	1	1	0.00	0.00	178.96	101%	2	0	68,888
	1	2009	384.9	245.9	26	1	15	0.07	0.00	2732.82	101%	25	0	1,051,981
	2	2009	384.9	245.7	26	0	0	0.00	0.00	0.00	0%	0	0	0

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

	3	2009	384.9	246.4	26	2	3	0.01	0.00	19.78	106%	5	0	7,614
	4	2009	384.9	245.8	26	5	6	0.03	0.01	0.06	26%	10	4	25
	5	2009	384.9	247.9	26	4	4	0.02	0.00	7.16	50%	7	0	2,755
	6	2009	384.9	232.3	25	0	0	0.00	0.00	0.00	0%	0	0	0

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 5 Total density and population size estimates for Little Gulls for whole study area in each month based upon conventional distance sampling

Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of animals seen	Density				Population size		
							Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
7	2008	384.9	239.9	26	5	15	0.46	0.07	8.61	94%	178	27	3,316
8	2008	384.9	247.7	26	4	5	0.03	0.00	0.85	55%	13	1	329
9	2008	384.9	222.1	21	8	13	0.08	0.03	0.32	31%	30	10	125
10	2008	384.9	247.9	26	20	63	0.62	0.12	111.73	38%	237	45	43,010
11	2008	384.9	248.3	25	28	199	1.48	0.28	8.21	43%	570	107	3,160
12	2008	384.9	249.7	26	7	60	0.26	0.01	12.10	82%	99	2	4,656
1	2009	384.9	245.9	26	12	197	1.41	0.11	1711.46	73%	544	41	658,815
2	2009	384.9	245.7	26	22	40	0.22	0.07	7.26	31%	85	28	2,793
3	2009	384.9	246.4	26	12	23	0.13	0.01	1.96	51%	51	5	756
4	2009	384.9	245.8	26	4	9	0.05	0.00	62.35	84%	21	0	24,001
5	2009	384.9	247.9	26	0	0	0.00	0.00	0.00	0%	0	0	0
6	2009	384.9	232.3	25	0	0	0.00	0.00	0.00	0%	0	0	0

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 6 Total density and population size estimates for Little Gull for each section in each month

Zone	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
								Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
Bank	7	2008	70.0	131.8	2	4	4	0.16	0.00	32.42	55%	11	0	2,269
	8	2008	70.0	138.3	2	4	5	0.19	0.01	4.70	55%	13	1	329
	9	2008	70.0	139.0	2	8	13	0.43	0.14	1.78	31%	30	10	125
	10	2008	70.0	140.6	2	12	52	0.82	0.05	603.22	59%	57	3	42,217
	11	2008	70.0	139.9	2	20	183	5.86	1.11	32.55	55%	410	77	2,278
	12	2008	70.0	140.9	2	7	60	1.42	0.03	66.53	82%	99	2	4,656
	1	2009	70.0	139.0	2	11	171	4.12	0.00	9390.74	104%	288	0	657,219
	2	2009	70.0	137.4	2	22	40	1.21	0.40	39.91	31%	85	28	2,793
	3	2009	70.0	138.7	2	12	23	0.73	0.07	10.81	51%	51	5	756
	4	2009	70.0	139.1	2	4	9	0.30	0.00	342.94	84%	21	0	24,001
5	2009	70.0	139.2	2	0	0	0.00	0.00	0.00	0%	0	0	0	
6	2009	70.0	131.7	2	0	0	0.00	0.00	0.00	0%	0	0	0	
Eastern Box	7	2008	157.5	54.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	157.5	55.0	12	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	157.5	55.8	12	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	157.5	53.4	12	5	7	0.79	0.19	3.37	60%	125	30	530
	11	2008	157.5	54.2	12	3	7	0.43	0.07	2.51	92%	68	12	395
	12	2008	157.5	55.2	12	0	0	0.00	0.00	0.00	0%	0	0	0
	1	2009	157.5	53.5	12	0	0	0.00	0.00	0.00	0%	0	0	0
	2	2009	157.5	54.1	12	0	0	0.00	0.00	0.00	0%	0	0	0
	3	2009	157.5	53.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
	4	2009	157.5	53.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
5	2009	157.5	54.3	12	0	0	0.00	0.00	0.00	0%	0	0	0	
6	2009	157.5	47.6	11	0	0	0.00	0.00	0.00	0%	0	0	0	
Western Box	7	2008	157.5	53.8	12	1	11	1.06	0.17	6.65	101%	167	27	1,047
	8	2008	157.5	54.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	157.5	27.3	7	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	157.5	53.9	12	3	4	0.35	0.07	1.67	65%	55	12	263
	11	2008	157.5	54.1	11	5	9	0.59	0.11	3.09	74%	93	18	487
	12	2008	157.5	53.6	12	0	0	0.00	0.00	0.00	0%	0	0	0

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

1	2009	157.5	53.4	12	1	26	1.62	0.26	10.14	100%	255	41	1,597
2	2009	157.5	54.2	12	0	0	0.00	0.00	0.00	0%	0	0	0
3	2009	157.5	54.3	12	0	0	0.00	0.00	0.00	0%	0	0	0
4	2009	157.5	53.3	12	0	0	0.00	0.00	0.00	0%	0	0	0
5	2009	157.5	54.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
6	2009	157.5	53.0	12	0	0	0.00	0.00	0.00	0%	0	0	0

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 7 Separate density and population size estimates for birds on the water and birds in flight for Little Gulls

Subset	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
								Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
on Water	7	2008	384.9	239.9	26	5	15	0.46	0.07	8.61	94%	178	27	3,316
	8	2008	384.9	247.7	26	4	5	0.03	0.00	0.85	55%	13	1	329
	9	2008	384.9	222.1	21	5	6	0.05	0.02	0.11	29%	19	8	42
	10	2008	384.9	247.9	26	16	43	0.49	0.11	2.37	44%	188	41	912
	11	2008	384.9	248.3	25	14	108	0.77	0.16	3.69	73%	298	63	1,419
	12	2008	384.9	249.7	26	0	0	0.00	0.00	0.00	0%	0	0	0
	1	2009	384.9	245.9	26	1	1	0.01	0.00	154.61	102%	3	0	59,514
	2	2009	384.9	245.7	26	9	14	0.11	0.00	7.07	59%	40	1	2,722
	3	2009	384.9	246.4	26	8	18	0.11	0.01	1.08	60%	43	4	415
	4	2009	384.9	245.8	26	2	6	0.04	0.00	43.63	106%	16	0	16,794
	5	2009	384.9	247.9	26	0	0	0.00	0.00	0.00	0%	0	0	0
	6	2009	384.9	232.3	25	0	0	0.00	0.00	0.00	0%	0	0	0
in Flight	7	2008	384.9	239.9	26	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	384.9	247.7	26	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	384.9	222.1	21	3	7	0.03	0.00	0.21	66%	12	2	82
	10	2008	384.9	247.9	26	4	20	0.13	0.01	109.36	69%	49	3	42,099
	11	2008	384.9	248.3	25	14	91	0.71	0.11	4.52	41%	272	44	1,741
	12	2008	384.9	249.7	26	7	60	0.26	0.01	12.10	82%	99	2	4,656
	1	2009	384.9	245.9	26	11	196	1.41	0.11	1556.85	73%	541	41	599,301
	2	2009	384.9	245.7	26	13	26	0.11	0.07	0.19	22%	44	27	71

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

	3	2009	384.9	246.4	26	4	5	0.02	0.00	0.89	54%	8	0	342
	4	2009	384.9	245.8	26	2	3	0.01	0.00	18.72	106%	5	0	7,207
	5	2009	384.9	247.9	26	0	0	0.00	0.00	0.00	0%	0	0	0
	6	2009	384.9	232.3	25	0	0	0.00	0.00	0.00	0%	0	0	0

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 8 Total density and population size estimates for Kittiwakes for whole study area in each month based upon conventional distance sampling

Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
							Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
7	2008	384.9	239.9	26	8	14	0.11	0.03	132.61	42%	43	11	51,049
8	2008	384.9	247.7	26	15	27	0.30	0.06	2.26	54%	114	22	868
9	2008	384.9	222.1	21	25	39	0.37	0.04	24.06	47%	143	15	9,263
10	2008	384.9	247.9	26	55	817	4.45	0.31	857.11	56%	1,715	121	329,938
11	2008	384.9	248.3	25	91	1138	5.04	2.02	12.81	28%	1,941	778	4,933
12	2008	384.9	249.7	26	48	441	2.60	0.87	7.78	32%	999	336	2,994
1	2009	384.9	245.9	26	38	1148	5.03	1.39	18.30	34%	1,937	534	7,044
2	2009	384.9	245.7	26	134	1203	6.48	0.60	96.08	35%	2,496	230	36,984
3	2009	384.9	246.4	26	122	1035	5.18	1.22	582.41	29%	1,992	468	224,194
4	2009	384.9	245.8	26	97	1337	8.07	1.73	41.03	45%	3,107	664	15,796
5	2009	384.9	247.9	26	58	124	2.66	0.38	36.19	99%	1,025	146	13,929
6	2009	384.9	232.3	25	59	111	1.45	0.60	3.72	20%	558	232	1,430

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 9 Total density and population size estimates for Kittiwake for each section in each month

Zone	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
								Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
Bank	7	2008	70.0	131.8	2	7	13	0.46	0.13	728.44	45%	32	9	50,980
	8	2008	70.0	138.3	2	12	20	0.53	0.10	6.50	36%	37	7	455
	9	2008	70.0	139.0	2	22	34	0.80	0.02	124.57	47%	56	1	8,718
	10	2008	70.0	140.6	2	34	759	17.32	0.34	4619.82	74%	1,212	24	323,322
	11	2008	70.0	139.9	2	63	1108	23.36	9.21	59.73	33%	1,635	645	4,180
	12	2008	70.0	140.9	2	30	415	10.71	3.65	31.43	41%	750	256	2,200
	1	2009	70.0	139.0	2	36	1146	27.39	7.59	98.90	35%	1,917	531	6,921
	2	2009	70.0	137.4	2	127	1137	26.53	1.70	473.89	35%	1,856	119	33,166
	3	2009	70.0	138.7	2	108	1015	24.77	5.55	3190.79	33%	1,734	389	223,310
	4	2009	70.0	139.1	2	78	1192	22.87	5.72	94.91	51%	1,600	400	6,642
Eastern Box	5	2009	70.0	139.2	2	46	97	2.47	1.13	16.14	22%	173	79	1,130
	6	2009	70.0	131.7	2	38	78	2.40	0.96	6.45	26%	168	67	452
	7	2008	157.5	54.4	12	1	1	0.07	0.01	0.44	100%	11	2	69
	8	2008	157.5	55.0	12	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	157.5	55.8	12	1	1	0.06	0.01	0.37	100%	9	2	59
	10	2008	157.5	53.4	12	8	16	0.71	0.21	2.61	44%	112	33	412
	11	2008	157.5	54.2	12	11	12	0.76	0.32	2.07	32%	120	50	325
	12	2008	157.5	55.2	12	12	15	0.87	0.31	2.46	36%	137	49	388
	1	2009	157.5	53.5	12	1	1	0.06	0.01	0.39	100%	10	2	61
	2	2009	157.5	54.1	12	6	6	0.37	0.11	1.21	58%	58	18	191
	3	2009	157.5	53.4	12	4	7	0.68	0.20	2.37	53%	108	32	373
	4	2009	157.5	53.4	12	6	11	1.14	0.12	12.44	95%	180	19	1,960
Western Box	5	2009	157.5	54.3	12	5	8	0.50	0.10	2.62	77%	79	15	412
	6	2009	157.5	47.6	11	17	24	1.84	0.85	3.98	30%	290	135	627
	7	2008	157.5	53.8	12	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	157.5	54.4	12	3	7	0.49	0.09	2.62	78%	77	14	413
	9	2008	157.5	27.3	7	2	4	0.49	0.08	3.09	79%	77	12	487
	10	2008	157.5	53.9	12	13	42	2.48	0.41	39.40	90%	391	64	6,205
Western Box	11	2008	157.5	54.1	11	17	18	1.18	0.53	2.71	28%	186	83	427
	12	2008	157.5	53.6	12	6	11	0.71	0.20	2.58	48%	112	31	407

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

1	2009	157.5	53.4	12	1	1	0.06	0.01	0.39	100%	10	2	62
2	2009	157.5	54.2	12	1	60	3.69	0.59	23.03	100%	581	93	3,627
3	2009	157.5	54.3	12	10	13	0.96	0.30	3.25	49%	151	47	512
4	2009	157.5	53.3	12	13	134	8.43	1.56	45.68	86%	1,327	245	7,194
5	2009	157.5	54.4	12	7	19	4.91	0.33	78.66	131%	773	52	12,387
6	2009	157.5	53.0	12	4	9	0.64	0.19	2.23	53%	100	30	352

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 10 Separate density and population size estimates for birds on the water and birds in flight for Kittiwakes

Subset	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
								Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
on Water	7	2008	384.9	239.9	26	7	13	0.11	0.03	0.45	44%	41	11	173
	8	2008	384.9	247.7	26	12	24	0.28	0.06	1.46	56%	109	21	561
	9	2008	384.9	222.1	21	15	25	0.11	0.00	22.14	62%	41	0	8,522
	10	2008	384.9	247.9	26	20	108	1.02	0.14	16.35	90%	392	53	6,296
	11	2008	384.9	248.3	25	46	840	3.35	1.41	8.11	36%	1,291	542	3,120
	12	2008	384.9	249.7	26	21	99	0.79	0.25	2.50	39%	305	98	963
	1	2009	384.9	245.9	26	3	7	0.01	0.00	0.08	40%	5	1	29
	2	2009	384.9	245.7	26	41	256	0.94	0.12	7.45	42%	360	45	2,867
	3	2009	384.9	246.4	26	89	852	4.31	1.20	15.53	32%	1,660	463	5,979
	4	2009	384.9	245.8	26	56	1145	4.45	0.96	22.59	48%	1,715	371	8,697
	5	2009	384.9	247.9	26	18	37	2.08	0.13	34.42	127%	799	49	13,249
	6	2009	384.9	232.3	25	33	80	1.12	0.47	2.72	25%	430	181	1,048
in Flight	7	2008	384.9	239.9	26	1	1	0.00	0.00	132.17	96%	2	0	50,877
	8	2008	384.9	247.7	26	3	3	0.01	0.00	0.80	33%	5	0	307
	9	2008	384.9	222.1	21	10	14	0.26	0.04	1.93	61%	101	15	742
	10	2008	384.9	247.9	26	35	709	3.44	0.18	840.75	68%	1,323	69	323,642
	11	2008	384.9	248.3	25	45	298	1.69	0.61	4.71	41%	649	236	1,812
	12	2008	384.9	249.7	26	27	342	1.80	0.62	5.28	43%	694	238	2,032
	1	2009	384.9	245.9	26	35	1141	5.02	1.39	18.22	34%	1,932	534	7,015
	2	2009	384.9	245.7	26	93	947	5.55	0.48	88.63	40%	2,136	185	34,117

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

	3	2009	384.9	246.4	26	33	183	0.86	0.01	566.87	78%	332	5	218,215
	4	2009	384.9	245.8	26	41	192	3.62	0.76	18.44	82%	1,392	293	7,099
	5	2009	384.9	247.9	26	40	87	0.59	0.25	1.77	32%	226	97	680
	6	2009	384.9	232.3	25	26	31	0.33	0.13	0.99	22%	128	51	383

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 11 Total density and population size estimates for Guillemots for whole study area in each month based upon conventional distance sampling

Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
							Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
7	2008	384.9	239.9	26	272	466	9.57	5.97	15.77	18%	3,683	2,299	6,069
8	2008	384.9	247.7	26	231	451	6.78	2.69	59.93	21%	2,609	1,034	23,068
9	2008	384.9	222.1	21	278	997	18.14	10.32	32.18	17%	6,982	3,974	12,387
10	2008	384.9	247.9	26	107	227	4.35	2.14	9.25	24%	1,673	824	3,562
11	2008	384.9	248.3	25	87	150	2.01	1.03	4.44	20%	772	395	1,710
12	2008	384.9	249.7	26	113	176	2.54	0.99	7.17	19%	979	382	2,761
1	2009	384.9	245.9	26	132	285	3.30	1.36	8.31	18%	1,271	523	3,199
2	2009	384.9	245.7	26	99	492	5.90	2.03	23.37	40%	2,271	781	8,994
3	2009	384.9	246.4	26	141	253	6.12	3.32	13.51	18%	2,356	1,277	5,201
4	2009	384.9	245.8	26	136	247	4.74	2.47	10.39	18%	1,824	952	3,999
5	2009	384.9	247.9	26	97	185	3.81	1.92	7.98	21%	1,466	741	3,071
6	2009	384.9	232.3	25	138	231	5.67	NA	NA	17%	2,184	NA	NA

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 12 Total density and population size estimates for Guillemot for each section in each month

Zone	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
								Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
Bank	7	2008	70.0	131.8	2	157	263	10.18	8.84	11.73	7%	712	618	821
	8	2008	70.0	138.3	2	144	280	8.15	0.25	271.21	35%	571	17	18,981
	9	2008	70.0	139.0	2	146	621	11.20	5.54	22.63	18%	784	388	1,584
	10	2008	70.0	140.6	2	64	124	3.31	2.34	5.16	13%	232	164	361
	11	2008	70.0	139.9	2	61	117	3.33	2.22	6.56	15%	233	155	459
	12	2008	70.0	140.9	2	80	136	4.60	1.23	18.09	21%	322	86	1,266
	1	2009	70.0	139.0	2	96	226	6.23	2.56	15.37	18%	436	179	1,076
	2	2009	70.0	137.4	2	83	390	9.50	6.32	18.95	17%	665	442	1,326
	3	2009	70.0	138.7	2	51	95	3.33	1.69	9.36	17%	233	119	655
	4	2009	70.0	139.1	2	72	129	4.14	1.90	9.63	18%	290	133	674
5	2009	70.0	139.2	2	63	115	4.36	2.35	8.13	17%	305	164	569	
6	2009	70.0	131.7	2	65	100	4.05	NA	NA	12%	284	NA	NA	
Eastern Box	7	2008	157.5	54.4	12	81	165	15.07	8.56	26.52	27%	2,373	1,348	4,177
	8	2008	157.5	55.0	12	46	124	8.54	4.34	16.81	33%	1,344	683	2,647
	9	2008	157.5	55.8	12	95	292	27.59	16.87	45.10	24%	4,345	2,657	7,103
	10	2008	157.5	53.4	12	20	50	4.61	1.85	11.53	46%	726	291	1,815
	11	2008	157.5	54.2	12	7	9	1.07	0.41	2.80	47%	169	65	441
	12	2008	157.5	55.2	12	23	29	3.03	1.39	6.70	34%	477	218	1,055
	1	2009	157.5	53.5	12	24	45	3.97	1.71	9.73	31%	626	269	1,533
	2	2009	157.5	54.1	12	14	98	9.84	2.09	46.43	58%	1,549	329	7,312
	3	2009	157.5	53.4	12	60	123	9.76	5.32	22.07	26%	1,537	839	3,476
	4	2009	157.5	53.4	12	54	107	8.82	4.87	18.47	23%	1,389	767	2,909
5	2009	157.5	54.3	12	8	16	1.76	0.56	5.56	59%	277	88	876	
6	2009	157.5	47.6	11	32	48	4.78	2.32	9.83	34%	752	365	1,549	
Western Box	7	2008	157.5	53.8	12	34	38	3.80	2.12	6.81	27%	598	333	1,072
	8	2008	157.5	54.4	12	41	47	4.40	2.12	9.14	34%	694	334	1,440
	9	2008	157.5	27.3	7	37	84	11.77	5.90	23.49	31%	1,854	929	3,700
	10	2008	157.5	53.9	12	23	53	4.54	2.35	8.80	33%	715	369	1,386
	11	2008	157.5	54.1	11	19	24	2.35	1.11	5.14	34%	370	175	810
12	2008	157.5	53.6	12	10	11	1.14	0.49	2.79	37%	179	78	440	

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

1	2009	157.5	53.4	12	12	14	1.32	0.47	3.75	44%	209	74	590
2	2009	157.5	54.2	12	2	4	0.36	0.06	2.26	85%	57	9	356
3	2009	157.5	54.3	12	30	35	3.72	2.03	6.79	28%	585	320	1,070
4	2009	157.5	53.3	12	10	11	0.92	0.33	2.64	37%	145	52	416
5	2009	157.5	54.4	12	26	54	5.61	3.10	10.33	28%	883	489	1,627
6	2009	157.5	53.0	12	41	83	7.29	4.47	11.90	24%	1,149	704	1,874

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 13 Separate density and population size estimates for birds on the water and birds in flight for Guillemot

Subset	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
on Water	7	2008	384.9	239.9	26	272	466	9.57	5.97	15.77	18%	3,683	2,299	6,069
	8	2008	384.9	247.7	26	231	451	6.78	2.69	59.93	21%	2,609	1,034	23,068
	9	2008	384.9	222.1	21	278	997	18.14	10.32	32.18	17%	6,982	3,974	12,387
	10	2008	384.9	247.9	26	104	221	4.32	2.14	9.10	25%	1,663	822	3,504
	11	2008	384.9	248.3	25	79	126	1.88	1.00	3.75	21%	724	386	1,445
	12	2008	384.9	249.7	26	103	166	2.40	0.96	6.41	20%	922	368	2,466
	1	2009	384.9	245.9	26	116	242	2.63	1.15	6.09	19%	1,011	443	2,344
	2	2009	384.9	245.7	26	86	389	3.91	1.64	12.88	46%	1,504	631	4,957
	3	2009	384.9	246.4	26	131	183	4.67	2.95	7.49	14%	1,798	1,136	2,884
	4	2009	384.9	245.8	26	118	160	3.41	2.10	5.68	16%	1,311	807	2,187
	5	2009	384.9	247.9	26	91	177	3.75	1.91	7.75	21%	1,444	735	2,983
	6	2009	384.9	232.3	25	134	227	5.66	3.28	9.91	17%	2,177	1,264	3,815
in Flight	7	2008	384.9	239.9	26	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	384.9	247.7	26	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	384.9	222.1	21	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	384.9	247.9	26	3	6	0.03	0.00	0.15	60%	10	2	58
	11	2008	384.9	248.3	25	8	24	0.12	0.02	0.69	54%	48	9	265
	12	2008	384.9	249.7	26	10	10	0.15	0.04	0.77	42%	56	14	295
	1	2009	384.9	245.9	26	16	43	0.67	0.21	2.22	46%	259	80	854
	2	2009	384.9	245.7	26	13	103	1.99	0.39	10.49	76%	767	149	4,037
	3	2009	384.9	246.4	26	10	70	1.45	0.37	6.02	65%	558	141	2,317

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

	4	2009	384.9	245.8	26	18	87	1.33	0.38	4.71	51%	513	145	1,812
	5	2009	384.9	247.9	26	6	8	0.06	0.02	0.23	47%	21	6	89
	6	2009	384.9	232.3	25	4	4	0.02	NA	NA	44%	7	NA	NA

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 14 Total density and population size estimates for Razorbills for whole study area in each month based upon conventional distance sampling

Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
							Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
7	2008	384.9	239.9	26	50	109	2.21	0.74	14.83	38%	851	286	5,710
8	2008	384.9	247.7	26	85	408	5.21	1.80	16.84	30%	2,004	693	6,481
9	2008	384.9	222.1	21	114	775	13.23	7.89	22.52	21%	5,093	3,038	8,669
10	2008	384.9	247.9	26	79	305	7.42	NA	NA	25%	2,857	NA	NA
11	2008	384.9	248.3	25	63	163	3.23	1.60	360.10	24%	1,243	617	138,618
12	2008	384.9	249.7	26	53	137	1.79	0.32	157.79	41%	687	122	60,739
1	2009	384.9	245.9	26	31	266	2.08	0.40	34.11	44%	800	152	13,131
2	2009	384.9	245.7	26	67	626	4.42	0.36	64.76	44%	1,703	137	24,929
3	2009	384.9	246.4	26	103	251	3.85	1.86	171.26	18%	1,482	715	65,924
4	2009	384.9	245.8	26	94	209	2.64	0.88	80.91	22%	1,016	337	31,144
5	2009	384.9	247.9	26	18	26	0.28	0.04	3.12	47%	109	14	1,202
6	2009	384.9	232.3	25	9	12	0.21	NA	NA	50%	80	NA	NA

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 15 Total density and population size estimates for Razorbill for each section in each month

Zone	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
								Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
Bank	7	2008	70.0	131.8	2	28	52	2.13	0.08	56.43	42%	149	6	3,949
	8	2008	70.0	138.3	2	55	197	4.22	0.64	27.97	34%	295	45	1,958
	9	2008	70.0	139.0	2	74	474	11.78	7.85	17.69	17%	824	549	1,238
	10	2008	70.0	140.6	2	40	146	2.92	NA	NA	20%	204	NA	NA
	11	2008	70.0	139.9	2	32	69	1.83	0.23	1950.58	30%	128	16	136,513
	12	2008	70.0	140.9	2	38	103	3.00	0.01	835.78	58%	210	1	58,493
	1	2009	70.0	139.0	2	25	238	7.02	1.43	161.29	61%	491	100	11,288
	2	2009	70.0	137.4	2	58	613	22.26	1.47	347.21	48%	1,558	103	24,300
	3	2009	70.0	138.7	2	76	187	6.77	3.43	909.06	17%	474	240	63,621
	4	2009	70.0	139.1	2	61	150	3.53	0.04	414.38	45%	247	3	29,000
5	2009	70.0	139.2	2	15	21	0.60	0.04	11.43	32%	42	3	800	
6	2009	70.0	131.7	2	5	7	0.19	NA	NA	39%	13	NA	NA	
Eastern Box	7	2008	157.5	54.4	12	22	57	4.46	1.78	11.18	45%	702	280	1,761
	8	2008	157.5	55.0	12	18	156	5.77	2.32	14.31	46%	908	366	2,254
	9	2008	157.5	55.8	12	34	280	25.46	15.21	42.60	26%	4,009	2,396	6,708
	10	2008	157.5	53.4	12	26	88	8.87	4.84	16.41	30%	1,397	762	2,584
	11	2008	157.5	54.2	12	7	21	0.78	0.29	2.11	49%	123	45	332
	12	2008	157.5	55.2	12	6	20	2.07	0.36	11.87	76%	327	57	1,869
	1	2009	157.5	53.5	12	2	22	1.52	0.24	9.51	76%	240	38	1,497
	2	2009	157.5	54.1	12	8	11	0.80	0.20	3.22	51%	126	31	507
	3	2009	157.5	53.4	12	14	32	4.25	2.28	8.31	29%	670	360	1,309
	4	2009	157.5	53.4	12	28	48	4.01	1.96	8.79	26%	631	308	1,384
5	2009	157.5	54.3	12	0	0	0.00	0.00	0.00	0%	0	0	0	
6	2009	157.5	47.6	11	1	1	0.07	0.01	0.45	100%	11	2	70	
Western Box	7	2008	157.5	53.8	12	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	157.5	54.4	12	12	55	5.08	1.79	14.41	53%	801	282	2,269
	9	2008	157.5	27.3	7	6	21	1.65	0.59	4.59	48%	260	93	723
	10	2008	157.5	53.9	12	13	71	7.97	2.79	24.59	46%	1,256	440	3,872
	11	2008	157.5	54.1	11	24	73	6.30	3.53	11.26	29%	993	556	1,773
12	2008	157.5	53.6	12	9	14	0.96	0.41	2.40	38%	150	64	378	

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

1	2009	157.5	53.4	12	4	6	0.44	0.09	2.20	56%	69	14	346
2	2009	157.5	54.2	12	1	2	0.12	0.02	0.77	101%	19	3	122
3	2009	157.5	54.3	12	13	32	2.15	0.73	6.31	49%	338	115	994
4	2009	157.5	53.3	12	5	11	0.87	0.17	4.82	70%	138	26	759
5	2009	157.5	54.4	12	3	5	0.43	0.07	2.55	73%	67	11	402
6	2009	157.5	53.0	12	3	4	0.36	0.07	1.83	69%	56	11	288

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 16 Separate density and population size estimates for birds on the water and birds in flight for Razorbill

Subset	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of birds	Density				Population size		
								Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
on Water	7	2008	384.9	239.9	26	50	109	2.21	0.74	14.83	38%	851	286	5,710
	8	2008	384.9	247.7	26	85	408	5.21	1.80	16.84	30%	2,004	693	6,481
	9	2008	384.9	222.1	21	114	775	13.23	7.89	22.52	21%	5,093	3,038	8,669
	10	2008	384.9	247.9	26	73	287	7.01	3.39	15.10	26%	2,698	1,305	5,811
	11	2008	384.9	248.3	25	62	161	3.22	1.60	7.98	24%	1,240	617	3,073
	12	2008	384.9	249.7	26	51	130	1.61	0.29	156.70	44%	620	111	60,321
	1	2009	384.9	245.9	26	19	57	0.72	0.29	2.37	34%	278	110	911
	2	2009	384.9	245.7	26	59	615	4.19	0.29	63.76	46%	1,613	113	24,546
	3	2009	384.9	246.4	26	98	244	3.69	1.82	7.76	19%	1,422	699	2,986
	4	2009	384.9	245.8	26	74	165	1.96	0.70	76.68	25%	754	269	29,517
	5	2009	384.9	247.9	26	14	22	0.25	0.03	2.17	53%	94	12	837
	6	2009	384.9	232.3	25	6	9	0.17	0.03	0.88	59%	66	13	339
in Flight	7	2008	384.9	239.9	26	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	384.9	247.7	26	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	384.9	222.1	21	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	384.9	247.9	26	6	18	0.41	NA	NA	89%	159	NA	NA
	11	2008	384.9	248.3	25	1	2	0.01	0.00	352.12	100%	3	0	135,546
	12	2008	384.9	249.7	26	2	7	0.17	0.03	1.09	87%	67	11	418
	1	2009	384.9	245.9	26	12	209	1.36	0.11	31.75	65%	522	42	12,220
	2	2009	384.9	245.7	26	8	11	0.24	0.06	0.99	56%	91	24	383

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

	3	2009	384.9	246.4	26	5	7	0.16	0.04	163.50	50%	60	15	62,938
	4	2009	384.9	245.8	26	20	44	0.68	0.18	4.23	43%	261	69	1,627
	5	2009	384.9	247.9	26	4	4	0.04	0.00	0.95	67%	15	2	365
	6	2009	384.9	232.3	25	3	3	0.04	NA	NA	79%	15	NA	NA

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 17 Total density and population size estimates for Harbour Porpoise for whole study area in each month based upon conventional distance sampling

Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total no of animals seen	Density				Population size		
							Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
7	2008	384.9	203.3	26	5	5	0.07	NA	NA	49%	27	NA	NA
8	2008	384.9	247.7	26	4	4	0.02	0.00	7.22	50%	7	0	2,778
9	2008	384.9	208.9	20	1	1	0.00	NA	NA	90%	2	NA	NA
10	2008	384.9	247.9	26	10	12	0.20	0.09	0.45	37%	76	34	175
11	2008	384.9	248.3	25	5	7	0.05	0.00	31.87	73%	20	2	12,266
12	2008	384.9	189.0	18	5	6	0.06	0.01	3.65	63%	22	2	1,405
1	2009	384.9	227.4	26	1	1	0.01	0.00	61.89	86%	2	0	23,825
2	2009	384.9	245.7	26	7	9	0.16	0.04	1.46	48%	63	14	564
3	2009	384.9	207.0	24	5	5	0.09	0.02	1575.04	51%	36	7	606,303
4	2009	384.9	225.5	26	6	7	0.12	0.02	0.76	61%	45	7	292
5	2009	384.9	237.7	26	1	1	0.03	0.00	0.16	100%	10	2	61
6	2009	384.9	185.4	23	8	15	0.33	0.12	24.16	44%	126	46	9,302

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

Table 18 Total density and population size estimates for Harbour Porpoise for each section in each month

Zone	Month	Year	Area (km ²)	Effort (km)	No of transects	No of clusters	Total of animals	Density				Population size		
								Estimate	LCL	UCL	Coeff. of variation	Estimate	LCL	UCL
Bank	7	2008	70.0	95.2	2	3	3	0.11	NA	NA	21%	7	NA	NA
	8	2008	70.0	138.3	2	4	4	0.10	0.00	39.70	50%	7	0	2,778
	9	2008	70.0	126.4	2	1	1	0.03	NA	NA	90%	2	NA	NA
	10	2008	70.0	140.6	2	4	5	0.12	0.06	0.22	20%	8	4	16
	11	2008	70.0	139.9	2	4	6	0.14	0.00	174.40	105%	10	0	12,206
	12	2008	70.0	124.4	2	4	5	0.13	0.00	18.91	64%	9	0	1,323
	1	2009	70.0	120.5	2	1	1	0.03	0.00	340.42	86%	2	0	23,825
	2	2009	70.0	137.4	2	2	3	0.07	0.00	4.50	33%	5	0	315
	3	2009	70.0	108.4	2	2	2	0.06	0.00	8661.07	118%	4	0	606,152
	4	2009	70.0	118.8	2	3	3	0.08	0.01	0.66	16%	6	1	46
Eastern Box	5	2009	70.0	129.1	2	0	0	0.00	0.00	0.00	0%	0	0	0
	6	2009	70.0	92.4	2	2	3	0.11	0.00	128.56	104%	8	0	8,997
	7	2008	157.5	54.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
	8	2008	157.5	55.0	12	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	157.5	55.8	12	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	157.5	53.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
	11	2008	157.5	54.2	12	1	1	0.06	0.01	0.38	100%	10	2	61
	12	2008	157.5	41.3	10	1	1	0.08	0.01	0.52	98%	13	2	82
	1	2009	157.5	53.5	12	0	0	0.00	0.00	0.00	0%	0	0	0
	2	2009	157.5	54.1	12	3	3	0.18	0.04	0.76	71%	29	7	120
Western Box	3	2009	157.5	53.4	12	2	2	0.12	0.03	0.48	67%	20	5	75
	4	2009	157.5	53.4	12	1	2	0.12	0.02	0.78	100%	20	3	123
	5	2009	157.5	54.3	12	1	1	0.06	0.01	0.38	100%	10	2	61
	6	2009	157.5	40.1	9	0	0	0.00	0.00	0.00	0%	0	0	0
	7	2008	157.5	53.8	12	2	2	0.12	0.03	0.48	68%	20	5	75
	8	2008	157.5	54.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
	9	2008	157.5	26.8	6	0	0	0.00	0.00	0.00	0%	0	0	0
	10	2008	157.5	53.9	12	6	7	0.43	0.19	1.01	41%	68	29	159
	11	2008	157.5	54.1	11	0	0	0.00	0.00	0.00	0%	0	0	0
	12	2008	157.5	23.4	6	0	0	0.00	0.00	0.00	0%	0	0	0

Arklow Bank Seabird Monitoring Programme Year 9 Final Report

1	2009	157.5	53.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
2	2009	157.5	54.2	12	2	3	0.18	0.04	0.82	76%	29	7	129
3	2009	157.5	45.2	10	1	1	0.07	0.01	0.48	99%	12	2	76
4	2009	157.5	53.3	12	2	2	0.13	0.02	0.78	100%	20	3	122
5	2009	157.5	54.4	12	0	0	0.00	0.00	0.00	0%	0	0	0
6	2009	157.5	53.0	12	6	12	0.76	0.29	1.93	47%	119	46	304

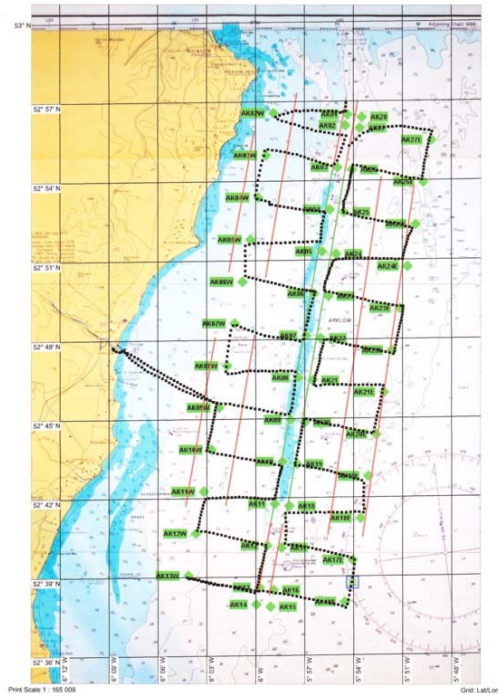
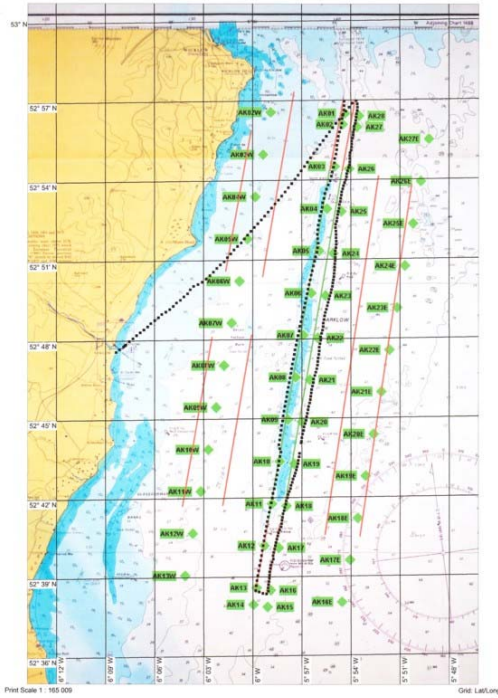
Appendix C

Year 9 Arklow Bank Monthly Survey Tracks

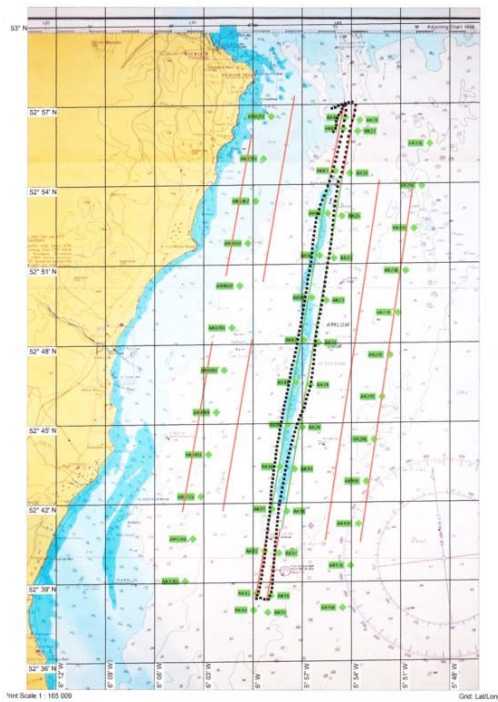
July Survey Tracks

20/7/2008

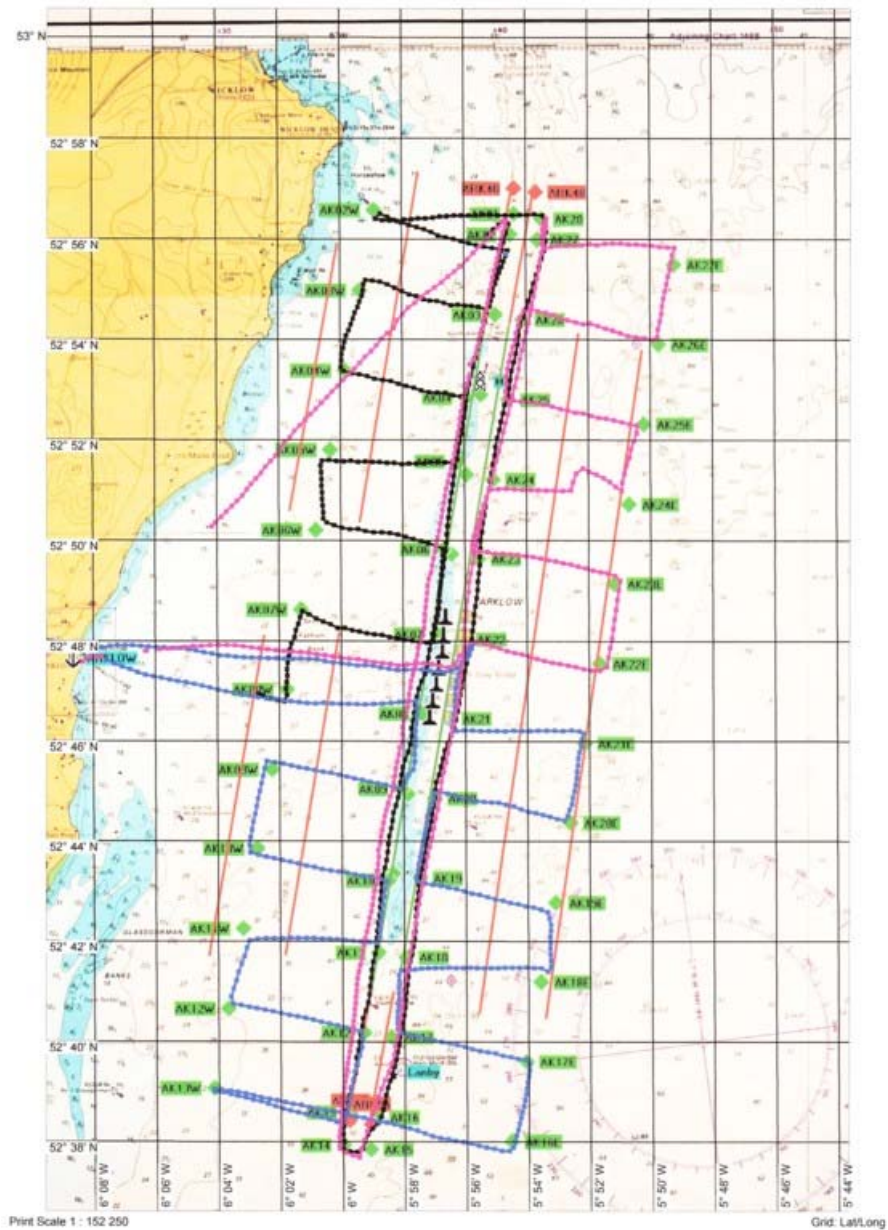
21/7/2008



26/7/2008



September Survey Tracks



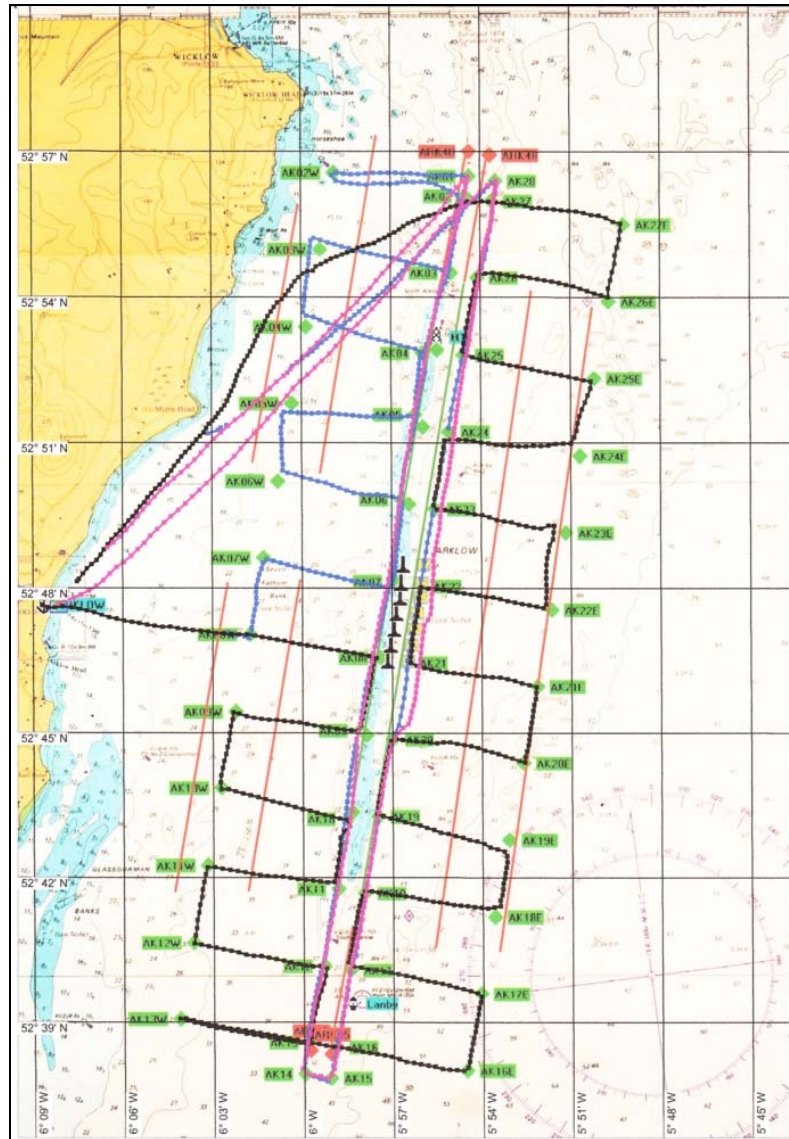
Survey dates:

Black line - 8/9/2008

Blue line - 13/9/2008

Pink line - 14/9/2008

October Survey Tracks



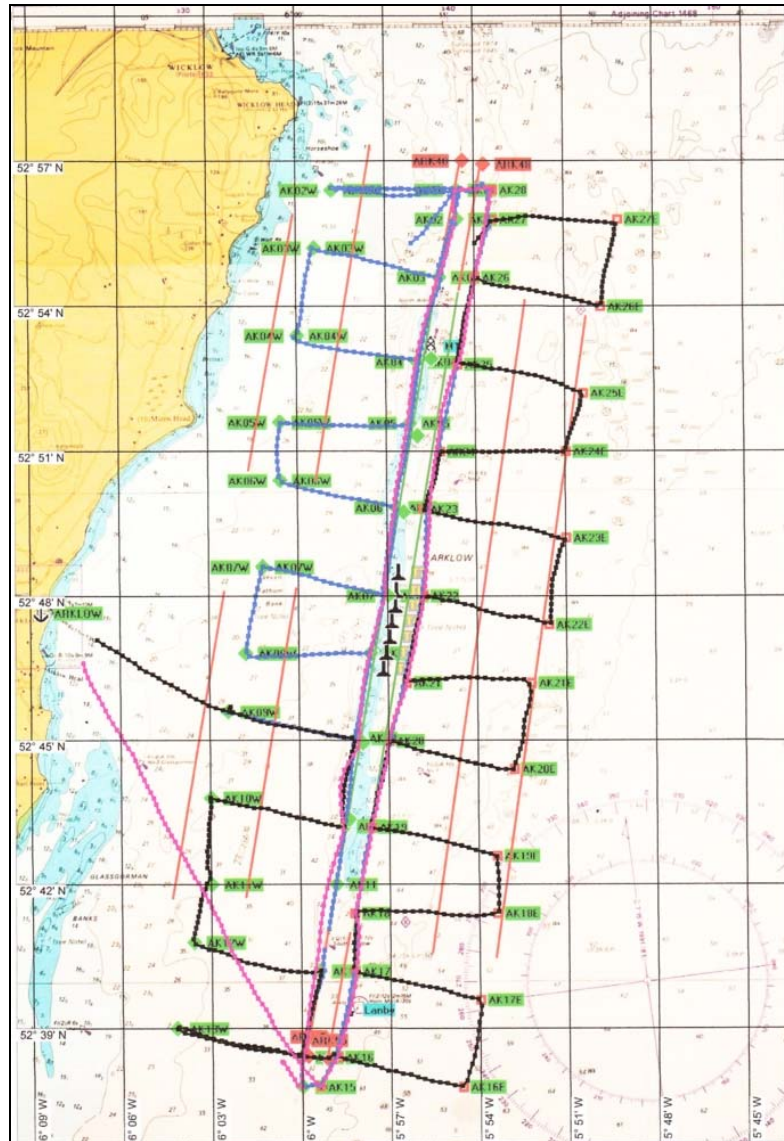
Survey dates:

Blue line - 11/10/2008

Black line - 12/10/2008

Pink line - 17/10/2008

November Survey Tracks



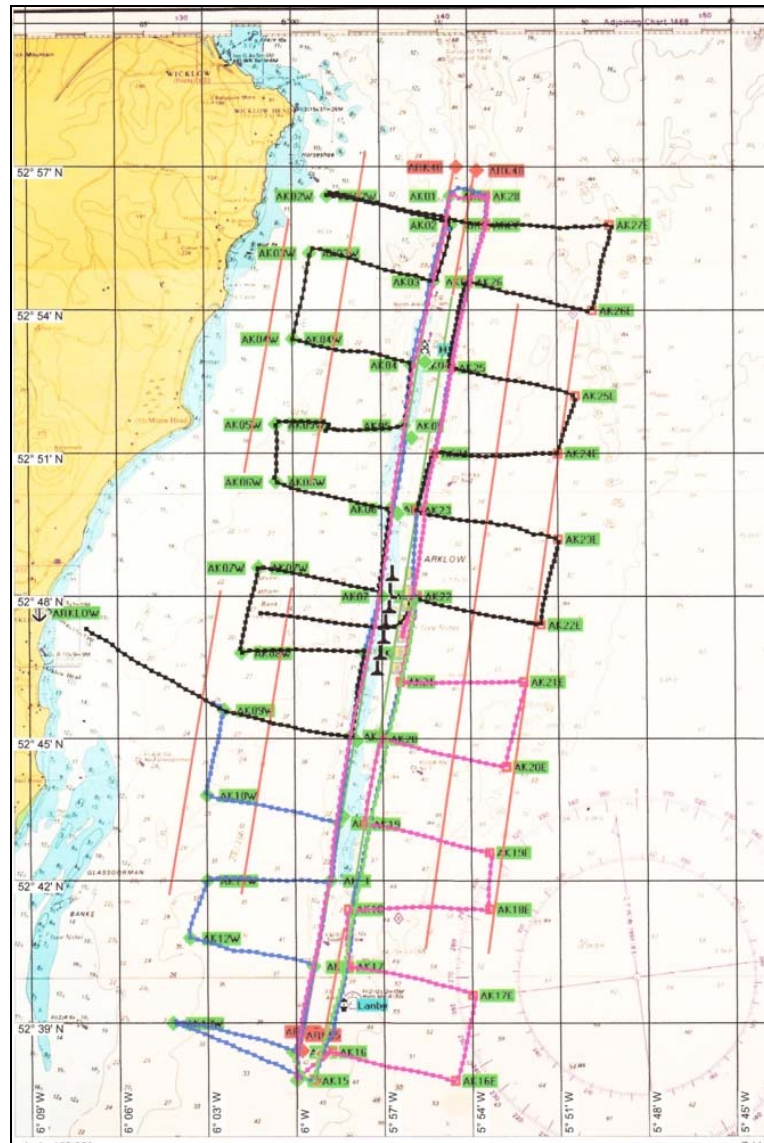
Survey dates:

Blue line - 5/11/2008

Black line - 16/11/2008

Pink line - 28/11/2008

December Survey Tracks



Survey dates:

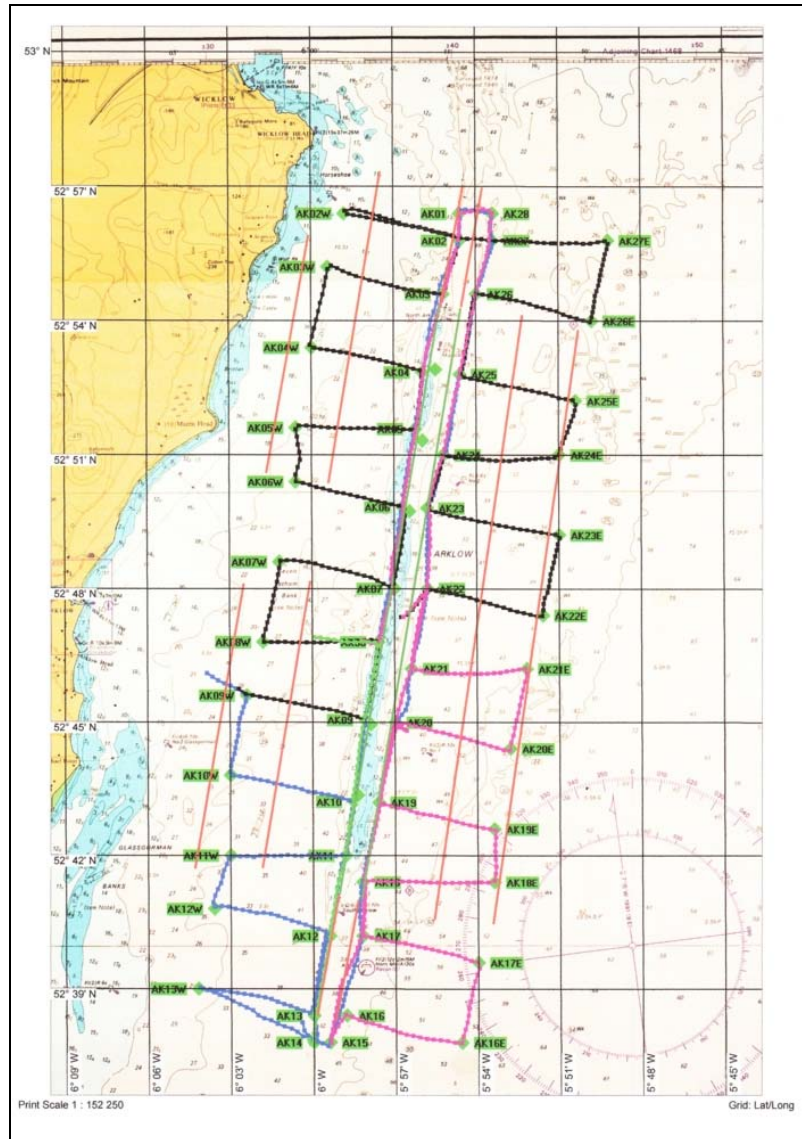
Blue line - 3/12/2008

Black line - 6/12/2008

Pink line - 7/12/2008

Green line - 11/12/2008

January Survey Tracks



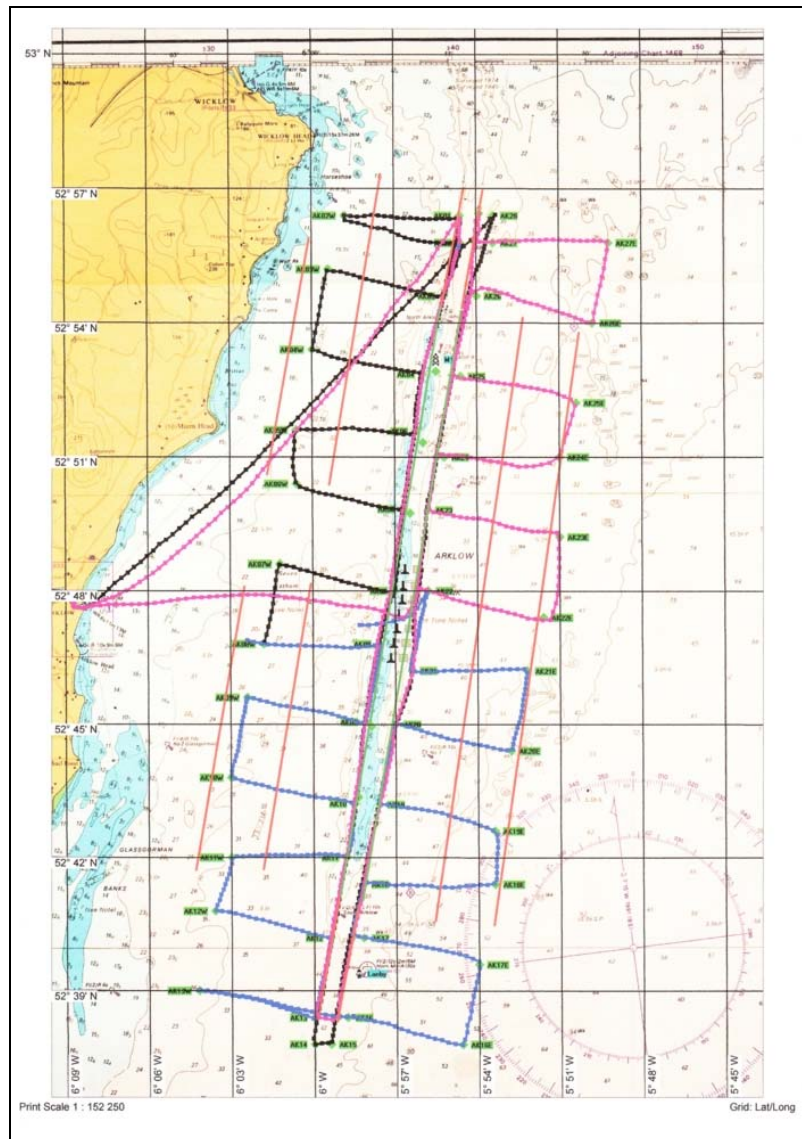
Survey dates:

Blue line - 3/1/2009

Black line - 4/1/2009

Pink line - 6/1/2009

February Survey Tracks



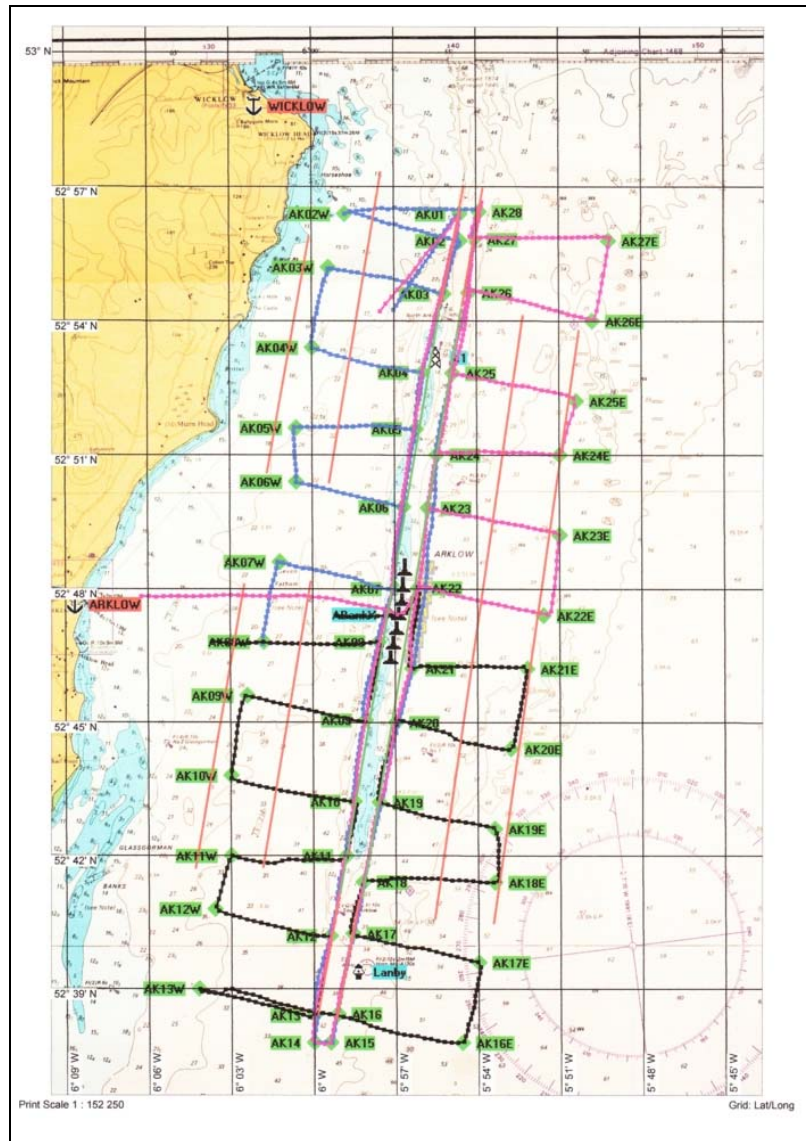
Survey dates:

Blue line - 11/2/2009

Black line - 12/2/2009

Pink line - 13/2/2009

March Survey Tracks



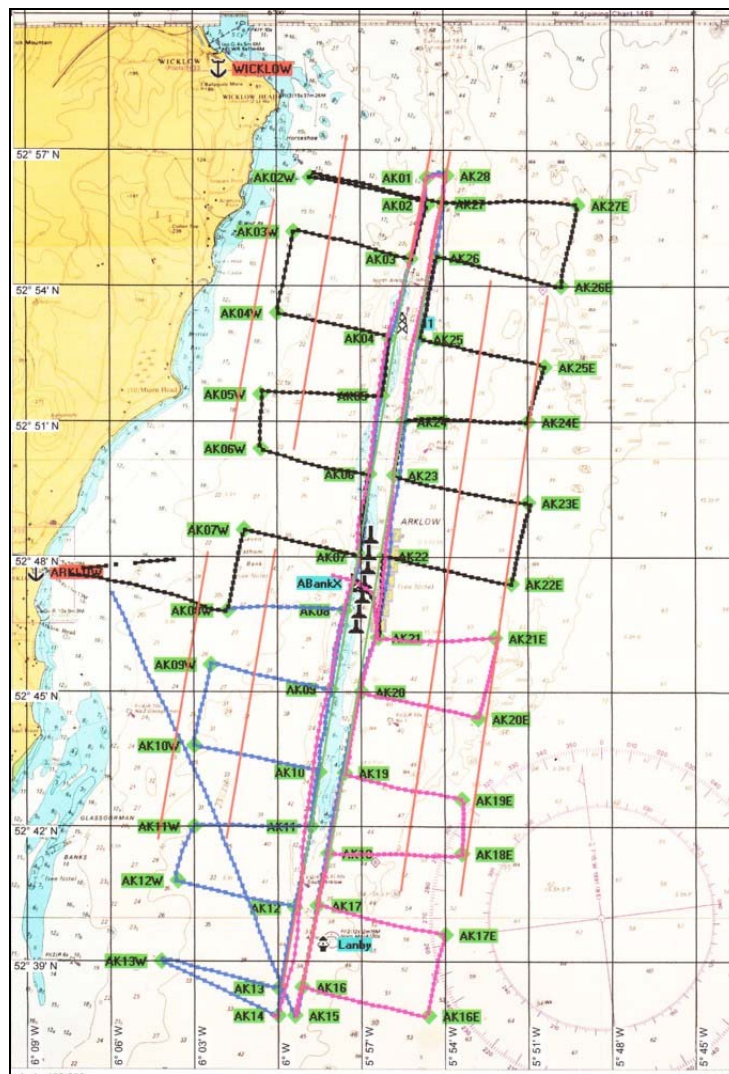
Survey dates:

Blue line - 20/3/2009

Black line - 21/3/2009

Pink line - 30/3/2009

April Survey Tracks



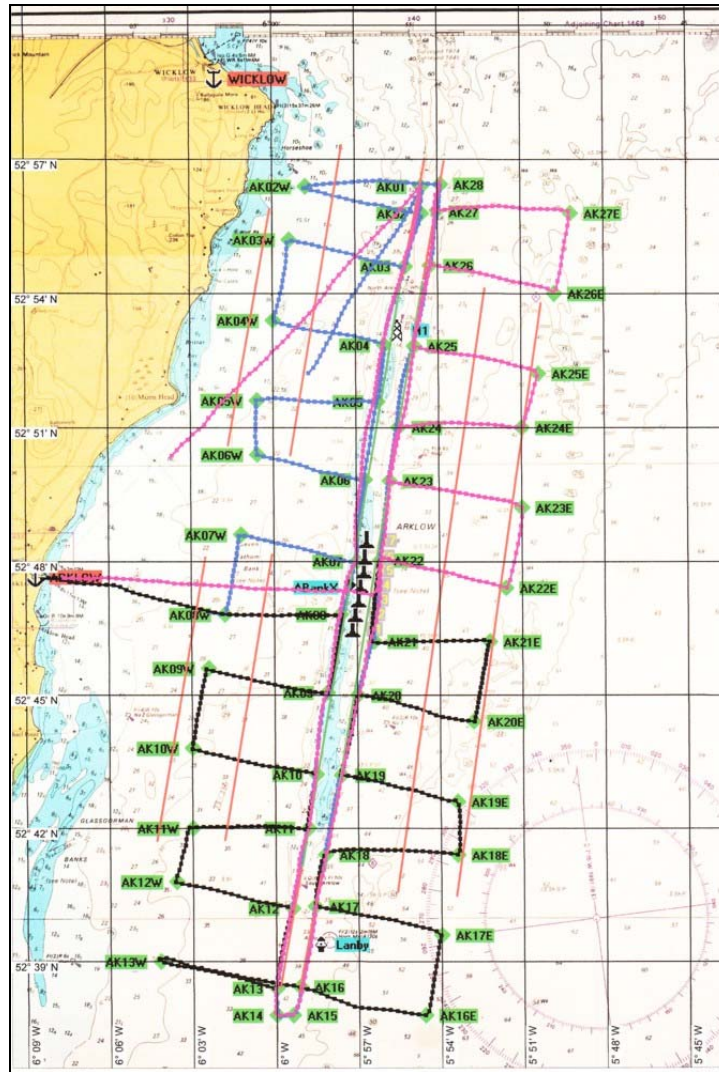
Survey dates:

Blue line - 1/4/2009

Black line - 2/4/2009

Pink line - 11/4/2009

May Survey Tracks



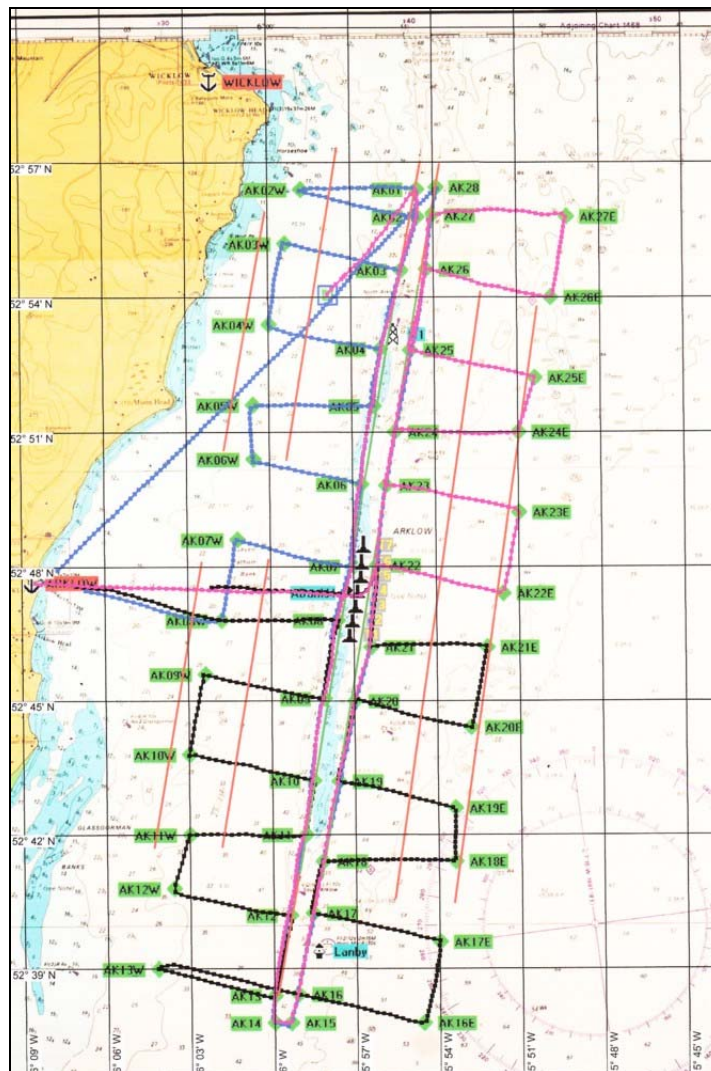
Survey dates:

Blue line - 21/5/2009

Black line - 24/5/2009

Pink line - 25/5/2009

June Survey Tracks



Survey dates:

Blue line - 2/6/2009

Black line - 4/6/2009

Pink line - 5/6/2009

Appendix D

Non-seabird species recorded in the
Arklow Study Area in Year 9

Table C1 Numbers of non-seabirds recorded in the Arklow Study Area in Year 9

Species	Bank	New Route	Total
Mallard	1	0	1
Dunlin	4	0	4
Bar-tailed Godwit	0	12	12
Swift	1	0	1
Swallow	23	27	50
House Martin	0	1	1
Meadow Pipit	1	0	1
Pipit species	0	1	1
Goldcrest	0	1	1
Hooded Crow	2	0	2
Chaffinch	1	0	1
Total no of birds	33	42	75
Total no of species	7	5	10