NATURAL RESEARCH PROJECTS LIMITED

VIKING BIRD REPORT

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Viking Windfarm: Birds Technical Report

Introduction

1. This report details surveys undertaken by Natural Research Projects Ltd (NRP) during the period 2003 to 2008. The report provides a baseline resource for assessment of the potential effects of the proposed Viking Windfarm on birds.

2. The proposed Viking Windfarm site covers a large area (approximately 140 km^2) of the Central Mainland of Shetland. It extends from Weisdale and Tresta Voes in the south to Sullom Voe in the north and straddles the island from the west to east coast taking in the distinctive parallel Kame ridges. This vast area contains a wide variety of habitats for birds which, due to its remoteness, has been the focus of few previous ornithological studies.

3. The report relates to two overlapping areas, known as the Western Survey Area (WSA) and Eastern Survey Area (ESA) (Map 1). The WSA, comprising discrete North and South sections, was surveyed during the period March 2005 to August 2006. The ESA, also comprising discrete North and South sections, was surveyed during the period April 2003 to September 2004, and again during March 2006 to February 2007. Thus, the timing of surveys differs between the WSA and ESA. In 2007 eight small additional areas around the periphery of the site were surveyed in May to July following minor extension to the site boundary(Map 1). In May-July 2008, eight additional small areas around the proposed roads linking the windfarm to the surrounding public road network were surveyed (Map 1).

4. The Viking Windfarm site is split into four natural quadrants with the village of Voe at the centre (Map 2), as follows:

   - Delting - the northwest quadrant bound by Voe - A970 - Brae - B9076 - Mossbank - A968 - Voe.
   - Collafirth - the northeast quadrant bound by Voe - A968 - Dales Voe - Collafirth - Swining - Vidlin - B9071 – Voe. This is the only quadrant not enclosed by a road.
   - Nesting - the southeast quadrant bound by Voe - B9071 - Laxo - B9075 - Catfirth - A970 - Voe.
   - Kergord - the southwest quadrant bound by Voe - A970 - Sandwater - B9075 - Weisdale - A971 - Bixter - B9071 - Voe.

   For consistency with other reports relating to the proposed windfarm, these quadrants are used for descriptive purposes where appropriate. However, the quadrants do not precisely correspond to the division between the WSA and ESA and therefore cannot easily be used as units for aggregated bird survey results.

5. The Central Mainland of Shetland is a stronghold for two notable scarce breeding species, red-throated diver and merlin. In anticipation of particular concerns over the potential effects of windfarm development on these species, considerable effort was devoted to studies of their habits and requirements. Therefore the report is structured into two parts, Part 1 dealing with work

undertaken to describe the overall bird community throughout the year and Part 2 focusing on specialist studies of red-throated diver and merlin during the breeding period.

Overview of Habitats and Birds

6. The Central Mainland of Shetland has a relatively rugged hilly landscape divided by broad sweeping valleys and many shallow sea inlets or 'voes' (Photos 1 and 2). The hills are mainly rounded or flat-topped and formed from a series of three parallel ridges (West, Mid and East Kame) that run north-south down the centre of the island. The hills typically rise to 150-200 m and are covered in blanket peatland.

7. The main marine habitats are the many shallow voes (Photo 1: *all photos can be found later in this report*) with their relatively sheltered shores of rock, shingle and mud that divide up the central mainland and result in a long and convoluted coastline. Most of the area under consideration for the proposed Viking Windfarm site lies inland from the coast itself, though there are notable exceptions, for example where it runs along Dales Voe, Swinning Voe, Gon Firth and Olna Firth. Apart from a few small arctic tern and fulmar colonies there are no notable seabird colonies along this coastline. However, the coast and immediately adjacent sea is of critical importance to birds of high conservation value that breed within the site, for example red-throated diver and arctic tern. Some inter-tidal areas, especially at the head of voes, are important for feeding waders such as dunlin, curlew and oystercatcher.

8. The freshwater habitats comprise hundreds of standing freshwater bodies, numerous burns, and small areas of marsh and fen. Of these it is the lochs, lochans and peatland pool systems that are of greatest importance to birds (Photos 3, 4, 7 and 8). Foremost in importance amongst these is the red-throated diver (Photos 5 and 6) which uses a high proportion of the lochs (hereafter referred to simply as 'lochs') for breeding and social gathering. Some of the lower altitude lochs have a rich growth of water plants and are attractive to wildfowl, including whooper swan and breeding wigeon. The peatland pool systems (Photo 7) are of particular importance for breeding dunlin.

9. The terrestrial habitats split neatly into the more fertile lowland ground around the coast and valley floors, and the upland moors and peatlands (though these extend down to sea level in places). The relatively fertile lowland habitats mostly comprise improved and semi-improved grasslands used for livestock grazing and forage (Photo 1). Some of the few trees in the Central Mainland are also found in these areas, notably in the Kergord Valley and at Tresta. The proposed windfarm mostly avoids areas of fertile farmland. The main ornithological importance of these areas is as feeding habitat for breeding waders, such as golden plover, curlew and oystercatcher, and wintering and passage birds such as golden plover and whooper swan. These habitats also support small songbirds such as skylark, wheatear and starling and this in turn makes them attractive hunting grounds for merlin (Photo 10). The Kergord woodlands are also notable for a large colony of breeding rooks.

10. Upland peatlands cover the bulk of the proposed windfarm site. Most areas are covered in deep peat as a result of thousands of years of peat accumulation and support a varied mix of heather moorland and blanket bog habitats (Photos 2

and 7-9). These habitats support a diverse breeding assemblage of moorland birds including merlin, red grouse, eight species of wader, arctic and great skua, meadow pipit, skylark and (on the peatland lochs) red-throated diver. These habitats are in many ways similar to sub-arctic tundra and it is not surprising that some of the birds found in them are typically found breeding at high latitudes (e.g. golden plover, whimbrel (Photo 11) and artic skua). In addition to providing suitable breeding habitat another important quality of these peatlands is their remoteness and freedom from disturbance. Apart from red grouse nearly all the birds breeding on the peatlands are present in the spring and summer only, and either migrate south or move to lower ground for the rest of the year. Thus, the ornithological interest of the area is greatest in the breeding season (April to August), although some birds of high conservation value occur in the winter months and during spring and autumn migration, notably whooper swan, various goose species and golden plover.

Information Gathering

11. The Royal Society for the Protection of Birds (RSPB; P. Ellis), Scottish Natural Heritage (SNH; J. Uttley) and Scottish Environmental Protection Agency (SEPA; D. Okill[1]) were formally consulted about the proposed development at a meeting in July 2004. However, previous and subsequent to this meeting there has been regular liaison between NRP and the above named individuals throughout the programme of surveys.

12. Ornithological information for the Central Mainland of Shetland was obtained from the Shetland Biological Records Centre (SBRC), initially in April 2003 and thereafter on a regular basis. SBRC is the custodian of bird records gathered by RSPB, SNH and local and visiting ornithologists.

13. Additional information was obtained from the Wetland Bird Survey database (WeBS; 14 August 2003).

14. The above consultations and information sources indicated the presence of the following potentially sensitive species:

- Breeding red-throated diver, merlin, golden plover, dunlin (*C. a. schinzii*) and arctic tern (species listed in Annex 1 of the EU Birds Directive [79/409/EEC] on the Conservation of Wild Birds 1979 ['the Birds Directive']).
- Breeding whimbrel (listed in Schedule 1 of the Wildlife and Countryside Act (WCA) 1981, as amended).
- Breeding snipe, curlew, arctic skua and great skua (important regional breeding species).
- Migratory and wintering whooper swan (listed in Annex 1 of the Birds Directive). No other important populations of migratory or wintering birds were reported.

15. D. Okill provided information from his long-term study of breeding red-throated divers, including annual updates from 2003 onwards. Similarly, P. Ellis,

[1] D. Okill is also the local representative of the British Trust for Ornithology (BTO)

D. Okill and N. Dymond provided historical and contemporary information on breeding merlin.

Scope of Studies

16. The principal objectives of the study were to:

- Determine the distribution and abundance of moorland breeding bird territories.
- Identify the nest locations used by red-throated diver and merlin.
- Quantify the level of bird flight activity throughout the year, with emphasis on the bird breeding period (April – August) and migration periods (March-May and September-November).
- Quantify the flight activity and behaviour of red-throated divers.
- Determine the distribution and abundance of non-breeding birds throughout the year.
- Determine the distribution and abundance of wintering whooper swans.

Part 1: General Ornithology

Survey Methods

17. The field survey team comprised Lauren Jackson, Mark Chapman, Paul Fisher, David Hall, Simon Hulka, Digger Jackson, Steve Minton, Kevin Shepherd and Jon Stirling, with assistance from Craig Robson and Forbes Stewart. Field surveyors received extensive training prior to and during survey work. The training included, but was not restricted to, aspects of navigation, the various survey methods, techniques to minimise fieldworker effects on bird detection, and the recognition of birds and bird behaviour. Training was provided irrespective of the field surveyors' previous experience. Emphasis was placed on the importance of carrying out surveys in a systematic and standardised way to enable direct comparison of data from different sites and survey periods.

Moorland Breeding Birds

18. Breeding bird territories were surveyed using the Brown and Shepherd (1993) method for upland waders. The survey method was modified to provide reliable breeding estimates for most moorland passerines by undertaking surveys during the first few hours of daylight (see below). All species were surveyed with the exception of meadow pipit (see below).

19. The WSA was surveyed in 2005 and the ESA in 2003 and 2006.

20. Eight small additional areas (totalling 13.7km^2) were surveyed in 2007 to accommodate the minor extensions to the site boundary (Map 1: *Maps can be found in Appendix 11.3 of the Viking Wind Farm Environmental Statement..*

Certain non-essential maps mentioned here are available on request). Meadow pipit and skylark were not surveyed in these areas.

21. Following the design of the proposed roads layout in early 2008, eight small areas (totalling 9.6km^2) adjacent to proposed roads linking the core areas to the surrounding public roads network were surveyed in 2008 (Map 1).

22. In order to investigate variation in breeding numbers between years a number of areas were surveyed in two years. Six tetrads (2 x 2 km) within the WSA surveyed in 2005 were re-surveyed in 2006 (Map 3). In 2007 three 6km^2 plots were re-surveyed that had previously been surveyed at least once, in either 2003, 2005 or 2006 (Map 3). Between year changes could also be investigated for the whole of the ESA by comparing the 2003 and 2006 results.

23. To allow for differences in detection rates between early and late breeding species, two survey visits were undertaken; the first during the period 01 May to 05 June and the second during 05 June to 02 July. These survey periods were slightly later than those typically used in Scotland, in recognition of the later timing of breeding in higher latitudes. Fieldwork was undertaken between sunrise and sunrise +6 hrs. In order to reduce the effects of weather on bird detection, surveys were carried out in winds ≤ Force 4. Persistent precipitation or visibility <300 m was avoided.

24. The survey aimed to cover the ground systematically with a constant search effort. All points within the survey area were approached to within 100 m. Survey routes generally followed raised ground in order to maximise ground visibility. Patches of scrub, rocky outcrops, streams and water bodies were investigated closely. Surveyors paused at regular intervals to scan and listen for calling and singing birds

25. Careful attention was given to recording behaviour indicative of breeding. When individuals or pairs of birds were encountered, efforts were made to establish whether, in the fieldworker's opinion, the birds were different from those previously encountered. This involved careful attention to the whereabouts and movements of birds, together with birds' sex and plumage characteristics. Where necessary, surveyors retraced their steps in order to check the continued presence of previously recorded birds.

26. The location and activity of birds were recorded onto 1:25,000 scale maps using standard BTO codes (Marchant 1983). The position of each bird was mapped at the point it was first detected. The flight lines of birds seen flying over the survey area were recorded.

27. At the end of each visit a summary map was compiled showing the location of each identified territory or breeding pair. The following evidence was considered diagnostic:

- Song, courtship or territorial display;
- Territorial dispute;
- Nest building;
- Agitated behaviour by adult birds(s) indicating the presence of a nearby nest or young (e.g. repetitive alarm calling, distraction display);
- Adult(s) carrying food;

- Presence of newly fledged young;
- Adult(s) removing faecal sac.

In the case of skylark, the location of territorial males was taken to represent a territory centre. For red grouse, artic skua and great skua the presence of an adult or pair of adults within suitable habitat was considered sufficient to indicate the location of a breeding territory.

28. Where a number of breeding individuals were present and it was not possible to determine the exact number of breeding pairs, registrations of individual birds were deemed to represent discrete breeding territories / pairs if the distance between them was more than 250 m (500 m in the case of curlew, 200 m in the case of passerines). Whilst it is recognised that these distances are arbitrary and that territory size varies both inter- and intra-specifically, this approach produces a standardised index of abundance based on the distance that members of a breeding pair are likely to move during the survey period. In cases where two individuals were considered to constitute a pair of birds, the location of the pair was placed centrally by convention.

29. Population estimates were derived by comparing the summary maps for the two surveys. Territories plotted during each survey were considered to be separate from one another if they were located more than 1000 m apart (500 m in the case of snipe and skylark, 200 m in the case of passerines other than skylark). These distances were chosen arbitrarily to reflect the distances birds could plausibly move between survey dates. The location of territories mapped in both survey periods was plotted centrally by convention.

Breeding Red-throated Divers

30. Details of this survey are given in Part 2.

Breeding Merlins

31. Details of this survey are given in Part 2.

Generic Flight Activity Survey

32. Generic information on bird flight activity was collected during timed watches from strategic vantage points (VPs) using the methods described by Band *et al* (2007). VPs were selected to maximise visibility of the flight activity survey area, using the minimum number of points.

33. Observers at VPs positioned themselves to minimise their effects on bird behaviour. A viewing arc not exceeding 180 degrees was scanned. Watches were undertaken during daylight hours by a single observer in conditions of good ground visibility (e.g. greater than ~3km) and when the cloud base was higher than the most elevated ground observed. Otherwise a wide range of meteorological conditions was sampled.

34. During each watch, two hierarchical recording methods were used, as follows:

- Focal bird sampling. The viewing arc was scanned constantly until a *Target Species*[2] was detected in flight. Once detected, the bird was followed until it ceased flying or was lost to view. The time the bird was initially detected and the time it spent within the flight activity survey area (to the nearest second) were recorded. The route followed by the bird was plotted in the field onto a 1:25,000 scale map, with the direction of flight indicated. Routes were plotted regardless of whether or not the bird was within the survey area. Within the survey area, the bird's flying elevation above the ground was estimated at the point of detection and at 15 sec intervals thereafter, using a countdown timer with an audible alarm. Flying elevation was classified as <10 m, 10-50 m, 50-100 m, 100-150 m or >150 m.[3]

- Activity summaries. At the end of each 5-min period, flight activity within the survey area by *Secondary Species*[4] was summarised. The number of birds recorded in any one period was the minimum number of individuals that could account for the activity observed. The height, direction and number of individuals involved in notable bird movements (e.g. gull flights) were recorded.

35. Data were entered in the field onto recording sheets and later transferred to Excel spreadsheets. Maps of flight activity by *Target Species* were compiled for each watch. Each flying bout was numbered consecutively and cross-referenced to the relevant flight-path on the map. Summary maps were compiled for each species at the end of the season.

<u>Western Survey Area</u>

- The WSA was surveyed between March 2005 and March 2006. The flight activity survey area measured 101.3 km^2 (North = 39.9km^2, South = 61.4km^2). Thirty-one VPs were initially selected, of which four were subsequently abandoned due to conflicts with breeding bird sensitivities.[5] The area observed from at least one of the remaining 27 VPs (i.e. the cumulative visible area)[6] measured 79.5 km^2, a spatial coverage of 78.4 % (Tables 1 & 2; Maps 4-32).[7] The total area observed (i.e. all areas observed regardless of overlaps) measured 113.4 km^2.

- A summary of generic monthly watches in the WSA is shown in Table 3. Note that the effective observation time is calculated after subtracting 5-min recording periods in which a *Target Species* was recorded. Thus, out of a potential total of 1173 hours spent at VPs,

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[2] Target species were drawn from those listed on Annex 1 of the EU Directive (79/409/EEC) on Conservation of Wild Birds (the Wild Birds Directive 1979) and Schedule 1 of the Wildlife and Countryside Act (WCA) 1981. Other species considered important in a regional context were also included. See Table 59 for a full list.
[3] In 2003 flying height was classified into only three categories: <10 m, 10-100 m, or >100 m.
[4] In practice, these generally include all except the commonest of species (e.g. meadow pipit).
[5] VPs 14, 22, 25 & 28
[6] Visibility of ground + 30 m
[7] Based on visibility being truncated artificially at 2.5 km.

1152.5 hours were spent effectively scanning for birds. Of this time, 836.8 hours was spent observing during the period April to August and 315.7 hours during the period September to March.

- Observational effort during the period April to October was spread across the period 0510 hrs to 2035 hrs BST (Fig. 1: See below). During the period November to March watches covered the period 0815 hrs to 1835 hrs GMT (Fig. 2).

Eastern Survey Area

36. The ESA was surveyed from April to October 2003, April to July 2004, and again from March 2006 to February 2007. The flight activity survey area measured 57.3 km^2 (North = 23.3km^2, South = 34.0km^2). Twelve VPs were selected. The cumulative visible area measured 42.0km^2, a spatial coverage of 73.5% (Tables 4 & 5; Maps 33-46). The total area observed measured 79.7km^2.

37. In 2003, out of a potential total of 412 hours spent at VPs, 399 hours were spent effectively scanning for birds (Table 6a). Watches covered the period 0715 hrs to 1940 hrs BST (Fig. 3). In 2006-07, out of a potential total of 384 hours spent at VPs, 380.4 hours were spent effectively scanning for birds (Table 6b). During the period April to October watches covered the period 0610 hrs to 2215 hrs BST (Fig. 4). During the period November to March watches covered the period 0830 hrs to 1705 hrs GMT (Fig. 5).

38. Additional to the generic VP watches, in 2003 a total of 13.5 hours was spent observing the behaviour of a breeding pair of whooper swan 0.5 km outside the ESA.

Distance-Detection and Diurnal Activity Patterns

39. Additional flight activity watches were undertaken at selected VPs in the 2007 and 2008 breeding seasons. The aim of this work was to quantify changes in the detectability with distance, flight height and changes in flight activity through the day for species of high conservation value. The method employed was the same as that used for generic VPs except that whimbrel, golden plover, dunlin, arctic skua, great skua, merlin, red-throated diver and greylag goose were treated as *Target Species*. For these species details of all flights seen were recorded and mapped. In addition to the details recorded during generic VP watches, observers also recorded the distance to birds at the moment they were first detected. To facilitate accurate estimation of distance and mapping of flight lines a series of markers (white bags filled with peat) were positioned 500 m from the VPs and the exact locations of notable landmarks were determined using GPS and marked on survey maps.

40. In 2007 six VPs (Map 47) were selected to overlook areas known from previous years' survey work to hold above average densities of the *Target Species*. Watches were mostly in bouts of three hours and were spread evenly throughout daylight hours from late May to early August 2007 (Table 7). Each VP was watched for a total of 36 to 40 hours. An additional 18 hours of watches were made in June and July 2008 from three VPs aimed at increasing the sample of dunlin flights.

41. In addition to the detection and diurnal pattern analyses, data for whimbrel and golden plover were examined for evidence that these species flew over some types of landform more than others. The visible area from the six VPs was divided into an array of 200x200 m grid cells and each grid cell was classified as one of four landform-types, as follows:

- hill tops, flat or gently sloping (gradient <0.2);
- steep slopes, (gradient >0.2, 4 or more 10 m contour lines within square);
- gently sloping mid and lower slopes (gradient <0.2);
- near streams, (>50 m length of stream within the square).

The amount of flight activity observed over cells in each landform-type was calculated and compared with the 'availability' of each landform-type in the visible area.

Migratory Movements

42. Additional flight watches were undertaken from Migration Vantage Points (MVPs) during spring (March to May) and autumn (September to November) with the specific purpose of recording migratory movements by geese, swans and waders. These watches aimed to give broad spatial coverage of the area in respect of birds moving on a predominantly N-S axis. A wide range of meteorological conditions were sampled, including wind speeds up to Beaufort F8 and fog, rain, sleet and snow.

Western Survey Area

43. Watches were undertaken from six MVPs within the WSA (Map 48). MVPs 1-5 corresponded to generic VPs 4, 15, 19, 21 and 26. MVP 6 was substituted for MVP 4 in autumn 2005 because it afforded better visibility of potential migration movements. A total of 67 migration watches were undertaken. These complemented the 42 generic VP watches undertaken during migration periods. Overall, observations were undertaken totalling 179.0 hours during the spring migration period in 2005 and 183.0 hours during the autumn period in 2005 (Table 8). A wide range of meteorological conditions was sampled.

Eastern Survey Area

44. Watches were undertaken from four MVPs overlooking the ESA (two in the North section and two in the South; MVPs 1N, 2N, 1S & 2S; Map 49). A total of 25 migration watches totalling 87 hours during the spring migration period, and 25 watches totalling 74.9 hours during the autumn migration period, was undertaken in 2006 (Table 9). A wide range of meteorological conditions was sampled. These watches were independent of the generic VP watches.

Autumn and Winter Surveys

45. Walked transect surveys were undertaken each month during winter 2003-04, 2005-06 and 2006-07 with the aim of recording the distribution and abundance of non-breeding birds. Walk routes meandered to closely examine as much ground as practicable, in particular features of potential ornithological importance.

Observers frequently paused to scan for flight activity. A different route was used on each visit to enable fine-scale coverage of the survey area over time. Surveys were undertaken in conditions of good visibility (> 3km).

46. The walked transects are effectively mobile VP watches except that non-flying birds were also recorded. *Target Species* were the same as those in generic VP watches (see above). The procedure was as follows:

- For *Target Species* the time each individual was first detected was recorded along with details of age, sex and behaviour. These details were cross-referenced to a 1:25,000 scale map where the location and flight route (if applicable) were plotted.
- For all other species, the number of individuals was recorded and locations they were first detected were plotted on the map.

<u>Western Survey Area</u>

47. Walked transect surveys within the WSA were undertaken each month during the period October 2005 to February 2006. A total of 81.2 hours over 20 days were logged (Table 10). Each transect lasted for an average of 3.9 hours (range 2.1 – 6.9 hours). A wide range of meteorological conditions was sampled.

<u>Eastern Survey Area</u>

48. Walked transects within the ESA were undertaken each month during the periods September 2003 to March 2004, March 2006 and September 2006 to February 2007. A total of 171.2 hours over 49 days were logged (Table 10). Transects lasted an average of 3.5 hours (range 1.1 – 6.7 hours). A wide range of meteorological conditions was sampled.

Wintering and Passage Whooper Swans

49. Systematic counts of whooper swans at potential feeding and staging sites were undertaken in winter 2005-06. Counts were made from two driven / walked transect routes covering the northern and southern parts of the surveyed area. All locations considered likely to hold whooper swans, including grassland and inter-tidal habitats, were surveyed (Map 50). The northern transect was undertaken 19 times and the southern transect 15 times, during the period 31 October 2005 to 21 May 2006 (Table 11). Surveys lasted an average of 3.0 hours (range 2.1-4.0 hours) and were undertaken between 0800 hrs and 1900 hrs GMT.

Roosting Hen Harriers

50. In the course of survey work in autumn 2005 it became apparent that a small number of hen harriers were roosting in the vicinity of Sand Water. Therefore supplementary VP observations, focussed on the roost area, were undertaken during winter 2005-06. The aim was to determine the number of harriers using the roost each month, establish the directions from which birds approached the roost and identify any specific areas used for pre-roost gathering activity.

51. Observers selected a variety of vantage points overlooking potential roost sites and surrounding area (Map 51). Decisions on which VP(s) to use on any given watch were made in response to expectations of harrier approach routes and were influenced by factors such as wind strength and direction. Observers positioned themselves inconspicuously to avoid disturbing birds. Observations were undertaken from at least one hour before dusk to one hour after sunset. The number, sex and (where possible) age of roosting harriers was recorded.

52. Watches were undertaken on 11 dates between 17 December 2005 and 27 February 2006, for a total of 43 hours (Table 12). On four dates simultaneous watches from up to three VPs were undertaken in order to ensure comprehensive coverage of the roost environs.

Meadow Pipit and Skylark

53. The locations of territorial male skylark were mapped during moorland bird breeding surveys covering the WSA in 2005 and ESA in 2003 (see above). In late 2005 an internal NRP review of the method concluded that it provided only a crude estimation of the numbers of skylark present, and did not justify the considerable investment of time involved (and potential to distract from mapping other species of conservation importance). Therefore, commencing in 2006, skylarks were recorded from walked transects and the data used to calculate an index of relative abundance that could be compared with other sites surveyed in the same manner. Meadow pipits were also recorded during these surveys.

54. The combined meadow pipit and skylark transect survey involved establishing two straight 5 km transect lines across representative parts of moorland, one in the northern of the ESA and one in the south. Lines were divided into 100 m sections, numbered 1-50. The position of the start, finish and each 100 m waypoint was recorded using a GPS.

55. Transect lines were walked twice, once in May and once in June (Table 13). Surveys took place in fine calm weather between sunrise and sunrise + 6 hrs.

56. Skylarks and meadow pipits were counted within five distance bands, measured perpendicular to the transect line, as follows:

Band 1 = 0-10 m
Band 2 = 11-50 m
Band 3 = 51-100 m
Band 4 = 101-150 m
Band 5 = >150 m

57. Flightless juveniles were excluded. In cases where two transect lines were used birds were recorded regardless of whether or not they had been recorded previously. Before each survey, observers validated their ability to accurately estimate distances by undertaking a simple field test with markers such as bamboo canes or piles of stones.

Survey Results

Moorland Breeding Birds

Year to Year changes and Survey Confidence Limits

58. Surveys of the same area in different years will not give exactly the same answer, partly due to the stochastic effects inherent in field survey work and partly due to actual changes in bird abundance. It is important to remember that the data were gathered during the course of two visits per year to each area and that survey efficiency was dependent on these visits coinciding with the stage of breeding that birds are most detectable (this varies intra-specifically). As a consequence, annual variation in breeding phenology may have caused some species to have been easier to detect in one year than another.

59. Six different year-pair comparisons are possible for areas that were surveyed in two years or more years (Table 14). In most cases the areas compared are different in each year-pair. These comparisons allow estimates to be made of survey repeatability and population trends on the site from 2003 to 2007.

60. A measure of survey repeatability gives an indication of the confidence of the population estimates. For the purposes of evaluating the importance of the Viking site for a particular species the most useful figure would be the mean number of pairs present on the whole area over a series of years. Were such data available, the mean difference from the mean of all years would give a good measure of how reliable, on average, the results from a single year are. Here, because the year to year comparisons cover different areas, the closest to this that could be achieved was to take the percentage difference from the pair mean for each of the six year-pairs, and then take the mean of these six values. To give greater weight to the year-pairs based on the larger areas, the mean difference was weighted by area. This weighted mean percentage difference figure gives the best measure or survey repeatability and is used below to give an indication of the likely range within which the average population level for the site lies. It is assumed that the average population lies within range given by the total survey figures (taken to be WSA 2005, ESA 2006 and the eight 2007 small additional areas) plus or minus the weighted percentage mean difference figure (Table 15).

61. A total of 44 species was recorded in the WSA in 2005, including 36 species that bred (Table 16; Maps 52-57). Six species listed in Annex 1 of the Birds Directive bred (red-throated diver, merlin, golden plover, dunlin, common tern and arctic tern). One species listed in Schedule 1 of the WCA, additional to those above, bred (whimbrel). Two red-listed species of conservation concern (Gregory *et al*. 2002) bred (skylark and starling).

62. A total of 36 species was recorded in the ESA in 2003, including 28 species that bred (Table 17; Maps 58-63). In 2006, a total of 35 species was recorded in the ESA, including 28 species that bred (Table 18; Maps 64-69). Six species listed in Annex 1 of the Birds Directive bred (red-throated diver, merlin, golden plover, dunlin, common tern and arctic tern). One species listed in Schedule 1 of the WCA, additional to those above, bred (whimbrel). One red-listed species bred (skylark).

Additional Small Survey Areas

63. A total of 30 species bred in the eight small additional areas surveyed in 2007 (Table 19; Maps 70-75). Five species listed in Annex 1 of the Birds Directive bred (red-throated diver, merlin, golden plover, dunlin and arctic tern). Two species listed in Schedule 1 of the WCA, additional to those above, bred (whimbrel and black-tailed godwit). Four species were found breeding that are either BOCC red-listed species or UK BAP species, or both (black-tailed godwit, curlew, lapwing and skylark).

64. A total of 34 species bred in the eight areas surveyed in 2008 that are adjacent to the proposed roads that would link the windfarm to the public road system (Table 20; Maps 70-75). Six species listed in Annex 1 of the Birds Directive bred (red-throated diver, merlin, golden plover, dunlin, black-tailed godwit and Arctic tern). In addition one species bred that is listed in Schedule 1 of the WCA but is not Annex 1, namely whimbrel. Six species were found breeding that are either red-listed BOCC species or UK BAP species, namely arctic skua, black-tailed godwit, curlew, lapwing, twite and skylark.

Breeding Birds Summary

65. The Viking Site is of particular importance for breeding red-throated diver and merlin. Detailed information on the distribution and abundance of these species is given in Part 2 of this report.

66. A pair of whooper swan bred approximately 0.5 km outside the ESA in 2003 (see Confidential Annex). Four young hatched between visits made on 26 May and 03 June and remained in the vicinity of the nest site until at least 13 June. Extensive searches of the breeding site and its surrounding area between 18 June and 02 July failed to locate the young birds and the breeding attempt is considered to have failed. In 2004, an adult whooper swan (presumably one of the 2003 birds) paired with an adult mute swan and attempted to breed at the same nest site used in 2003. The adults were seen accompanying two small hybrid young on 06 June but subsequent visits made between 07 and 22 June recorded the pair with no young and the breeding attempt clearly failed. A pair of whooper swan also attempted to breed at the same loch in 2008. A nest was built but was unsuccessful.

67. Whooper swan breeding attempts, located outside the WSA and ESA, occurred in 2005 and 2006 (see Confidential Annex). A pair of whooper swans at Sand Water (Kergord quadrant) on 21 May 2006 was presumed to be local breeders, although they were subsequently displaced by mute swans. A pair of whooper swans, possibly the same birds, was present on Truggles Water (Kergord quadrant) for several days in July 2006.

68. The total number of greylag geese breeding on the Viking survey areas was estimated at 19-57 pairs (Table 15). This represents 15-45% of the most recent published estimate of the Shetland population. However, this species is known to be increasing steadily in Shetland (Pennington et al 2004) and, therefore, the actual proportion is likely to be lower. The comparisons from areas surveyed more than once suggest that between 2003 and 2007 numbers on the Viking site increased two to three fold.

69. The total number of golden plover on the Viking Site was estimated at 176-248 pairs (Table 15). This represents about 12 -17% of the Shetland population and approximately 1% of the UK total. Approximately 131 pairs of golden plover bred in the WSA in 2005, mainly in the Kergord quadrant (Maps 53 and 56). In the

ESA, approximately 60 pairs bred in 2003 and 43 pairs in 2006. (Maps 59, 62, 65 and 68). Approximately 14 pairs of golden plover bred in the eight small additional areas surveyed in 2007 (Table 19, Maps 71 and 74). Approximately seven pairs of golden plover bred in the eight small areas around the proposed access roads surveyed in 2008 (Table 20, Maps 71 and 74).

70. The total number of dunlin was estimated at 63-137 pairs (Table 15). This represents about 3.7-8.0% of the Shetland population and around 0.7-1.4% of the UK total. Approximately 69 pairs of dunlin bred in the WSA in 2005, mainly in the Kergord quadrant (Maps 53 and 56). In the ESA, approximately 27 pairs bred in 2003 and 21 pairs in 2006. Breeding birds were found in both the Collafirth and Nesting quadrants although in 2006 was almost entirely confined to Nesting (Maps 59, 62, 65 and 68)). Approximately 4 pairs of dunlin bred in the eight small additional areas surveyed in 2007 (Table 19, Maps 71 and 74). A single pairs of dunlin bred in the eight small areas around the proposed access roads surveyed in 2008 (Table 20, Maps 71 and 74).

71. The total number of whimbrel was estimated at 45-83 (Table 15). This represents about 9.4-17.4% of the Shetland population and 8.5-15.7% of the most recently published UK total. However, recent surveys of whimbrel strongholds elsewhere in Shetland indicate large declines since the national estimate was made (Forrester and Andrews 2007, RSPB unpublished data) and so the Viking surveys areas probably hold a greater proportion of the national population. Twenty-eight pairs of whimbrel bred in the WSA in 2005, mainly in the Kergord quadrant (Maps 53 and 56). Twenty pairs bred in the ESA in 2003, and 13 pairs bred (mainly in the Nesting quadrant) in 2006 (Maps 59, 62, 65 and 68)). Approximately ten pairs of whimbrel bred in the eight small additional areas surveyed in 2007 (Table 19, Maps 71 and 74). Approximately six pairs of whimbrel were recorded as breeding in the eight small areas around the proposed access roads surveyed in 2008 (Table 20, Maps 71 and 74).

72. The total number of curlew was estimated at 405-507 (Table 15). This represents about 17.6-22% of the Shetland population and around 0.5% of the UK total. Around 248 pairs of curlew bred in the WSA in 2005 and about 127 in the ESA in 2006 (Maps. 52, 55, 64 and 67). Approximately 37 pairs of curlew bred in the eight small additional areas surveyed in 2007 (Table 19, Maps 70 and 73). Approximately 44 pairs of curlew bred in the eight small areas around the proposed access roads surveyed in 2008 (Table 20, Maps 70 and 73).

73. Black-tailed godwit were recorded as probably breeding in the Nesting quadrant in 2006 and definitely breeding (chick seen) on the edge of the 2km buffer zone of the Nesting quadrant in 2004. A pair of black-tailed godwit was seen displaying in suitable habitat in May 2008 (i.e. probably breeding) in one of the small road-access survey areas adjacent to the Nesting quadrant. Typically, less than three pairs of this species breed in Shetland annually so a single pair represents a substantial proportion of the regional population (Table 15). It also represents around 2% of the entire UK population. The birds breeding in Shetland are of the 'Islandica' race, which mainly breed in Iceland.

74. The total number of Arctic skua was estimated at 41-59 pairs (Table 15). This represents 3.6-5.1% of the Shetland population and 1.9-2.7% UK population based on the most recent UK census, made in 1998-2002 (Mitchell et al 2004). However, since this census Arctic skua numbers have undergone declines especially in Shetland, so the actual proportion of the national and regional population on the Viking site is likely to be greater. Approximately 28 pairs of Arctic skua bred in the WSA in 2005 (Maps 54 and 57). In the ESA, approximately 20 pairs bred in 2003 and 16 pairs in 2006 (Maps 60, 63, 66 and

69). One pair of arctic skua bred in the eight small additional areas surveyed in 2007 (Table 19, Maps 72 and 75). One breeding pair of Arctic skua was recorded in the eight small areas around the proposed access roads surveyed in 2008 (Table 20, Maps 72 and 75).

75. The total number of great skua was estimated at 86-122 pairs (Table 15). This represents 1.2-1.8% of the Shetland population and 0.9-1.3% of the UK total. Approximately 68 pairs of great skua bred in the WSA in 2005 (Maps 54 and 57). In the ESA, approximately 42 pairs bred in 2003 and 27 pairs in 2006 (Maps 60, 63, 66 and 69). Only 1 pair of great skua bred in the eight small additional areas surveyed in 2007 (Table 19, Maps 72 and 75).

76. The total number of common tern was estimated at six pairs (Table 15). Five pairs of common tern bred in the WSA in 2005, mainly in the Kergord quadrant ((Maps 54 and 57)). One pair bred in the Nesting quadrant of the ESA in 2003 (Map 63). No pairs of common tern bred in the eight small additional areas surveyed in 2007 (Table 19).

77. The total number of Arctic tern was estimated at 177 pairs (Table 15). This represents about 0.7% of the Shetland population. Approximately 112 pairs of Arctic tern bred in the WSA in 2005, mainly in the Kergord quadrant ((Maps 54 and 57). Approximately 36 pairs bred in the ESA in 2003 (almost exclusively in the Collafirth quadrant; (Maps 60 and 63). However, only two pairs bred in 2006 (again, in the Collafirth quadrant; Map 66), reflecting the tendency of this species to move between breeding colonies from year-to-year. Approximately 18 pairs of Arctic tern bred in the eight small additional areas surveyed in 2007 (Table 19, Maps 72 and 75). Approximately 11 pairs of Arctic tern bred in the eight small areas around the proposed access roads surveyed in 2008 (Table 10), all in the Delting quadrant.

78. The total number of skylark was estimated at least 2183 pairs (Table 15). This is a widespread and very common species throughout Shetland and the numbers found are believed to be approximately directly proportional to the sites relative area. A total of 1612 skylark territories were identified in the WSA in 2005, with more or less equal numbers in the Delting and Kergord quadrants. A total of 429 territories were identified in the ESA in 2003, split evenly between the Collafirth and Nesting quadrants. Skylarks were not surveyed in the eight small additional areas surveyed in 2007 but they were noted to be present in all these areas. Approximately 142 pairs of skylark bred in the eight small areas around the proposed access roads surveyed in 2008 (Table 20).

79. Twenty-two pairs of starling bred in the WSA in 2005. These were concentrated around settlements in the Kergord quadrant. No breeding starlings were detected in the ESA in 2003 or 2006 or the eight small additional areas surveyed in 2007.

80. A pair of fieldfare was located nesting in the Delting quadrant in 2008 (within the WSA) during the course of diver monitoring. A nest with five eggs was found but the attempt subsequently failed. This is very rare breeding species in the UK, and only breeds irregularly in Shetland.

81. A single pair of twite was recorded as probably breeding in 2008 close to one of the proposed roads on croftland in the Nesting quadrant.

82. The surveys suggest that the Viking site might have 12-24% of the common sandpiper, 80% of the woodpigeon, 25-100% of the goldcrest and 42-51% of the red grouse occurring in Shetland (Table 15). The apparent importance of the site for these species may be spurious, and probably largely reflects the detailed level of survey work within the proposed windfarm compared with habitat elsewhere in Shetland.

83. Based on this analysis, breeding species for which the site might be construed as nationally important (i.e. supporting greater than 1% of UK species totals) are red-throated diver, dunlin, whimbrel, arctic skua golden plover and great skua, and in some years black-tailed godwit and whooper swan (Table 15).

84. The Viking survey areas make up about 10% of the land area of Shetland. Therefore, it might be construed as regionally important for a species if it supports more than 10% of the Shetland population. On this basis, the breeding species that are of regional importance are red-throated diver, greylag goose, wigeon, merlin, red grouse, golden plover, lapwing, snipe, whimbrel, curlew, common sandpiper, wood pigeon, and goldcrest, and in some years black-tailed godwit, whooper swan and fieldfare (Table 15).

Generic Flight Activity Survey

Western Survey Area

85. Flight activity by 51 species of bird was recorded in the WSA (Table 21). The species most frequently encountered were gulls, waders, skuas and corvids. Eleven species listed in Annex 1 of the Birds Directive were recorded (red-throated diver, whooper swan, barnacle goose, hen harrier, merlin, hobby, gyr falcon, peregrine, golden plover, dunlin, arctic tern) plus one breeding species, additional to those above, listed on Schedule 1 of the WCA (whimbrel). Of these, eight were *Target Species* where full details of flight behaviour were recorded.

86. A total of 257 red-throated diver flights was observed, all but two of which were during the period 01 April to 15 September (Table 22a). The main concentrations of activity were near Muckla Moor in the Collafirth quadrant and Bratta Field in the Kergord quadrant (Map 76). Most flights were estimated to be 10-100 m above ground. Further information on red-throated diver flight ecology is given in Part 2 of this report.

87. A total of 37 merlin flights were observed, including 21 in the breeding and 16 in the non-breeding periods (Table 22c). Activity was recorded in the Delting, Collafirth and Kergord quadrants and broadly coincided with the locations of known nesting areas (Maps 77 and C7). Most flights were at a low elevation above the ground. Further information on merlin flight ecology is given in the second part of this report.

88. Whimbrel was recorded for almost 1% of observation time (Table 21). Despite this they were quite widespread, with activity recorded from 18/27 (67%) of VPs. Birds were seen during the period 26 April to 27 August 2005, with most records in the Kergord quadrant during June and July.

89. Golden plover was the most frequently encountered Annex 1 species, occurring in 3% of VP observation time (Table 21). Activity was recorded from most (89%) VPs, in the Delting, Collafirth and Kergord quadrants. Sightings peaked in March, presumably as spring passage birds moved through (Fig. 6). There was little or no activity during September to February.

90. Dunlin was recorded in less than 0.1% of observation time (Table 21) and from only 26% of VPs. This was probably due, at least in part, to the difficulty in detecting such small birds when they were flying more than a few hundred metres

distant. Birds were recorded in the Delting, Collafirth and Kergord quadrants, during the period May-July.

91. Arctic tern was recorded for 1% of observation time (Table 21). Birds were seen during the period May to August, with most records in June. Flight activity was logged at 85% of VPs, with most activity observed from VPs 11 and 16.

92. Great skua was recorded for almost 13% of observation time (Table 21). Birds were seen during the period April to October, with consistently high activity from May to August. Records were logged at all 27 VPs. Apart from a single record in April, birds were seen during the period May to August, with more or less equal frequency each month. Flight activity was logged at all but one VP, indicating widespread use of the area.

93. A group of three whooper swan was recorded flying south on 15 March 2006. These birds landed in a field approximately 200 m north of Sand Water (Map 78).

94. Two barnacle geese were observed flying north towards Voe for a total of 26 seconds on 28 March 2005 (Map 78). Both birds were 10-50 m above the ground.

95. A total of eight hen harrier flights were observed (Table 22b). The sightings related to one or more immature females during the period 23-28 March 2005 and November 2005, and an adult male in February 2006. Most activity was in the Kergord (SW) quadrant (Map 77). All flight activity was less than 50 m above the ground, including 80% below 10 m.

96. A single hobby was recorded on 20 August 2005 in the southern part of the Kergord quadrant (Map 78). The bird flew for 20.1 minutes at a height of 50-100 m above ground. Two gyr falcon flights were also observed in the Kergord quadrant, on 24 and 28 March 2005. (Map 78). The total flight time was 1.9 minutes, most of which (84%) was more than 150 m above ground. Similarly, two peregrine flights were observed, on 11 May 2005 and 18 August 2005, in the Kergord and Collafirth quadrants (Map 77). A total of just over one minute was spent flying 10-50 m above ground.

<u>Eastern Survey Area</u>

97. Flight activity by 43 species was recorded in the ESA (33 in 2003 and 40 in 2006-07; Tables 23a & 23b). In common with the WSA, the species most frequently encountered were gulls, waders, skuas and corvids. Ten species listed in Annex 1 of the Birds Directive were recorded (red-throated diver, marsh harrier, hen harrier, merlin, peregrine, golden plover, dunlin, short-eared owl, common tern and arctic tern) plus one breeding species, additional to those above, listed on Schedule 1 of the WCA (whimbrel). Of these, six were *Target Species* where full details of flight behaviour were recorded.

98. Levels of flight activity for 2003 and 2006-07 are not directly comparable, since the latter includes data for the winter period when many species are absent.

99. A total of 207 red-throated diver flights were observed (Table 24a). Activity in the Collafirth quadrant was concentrated over the Muckla Moor – Logie Hill – Yella Moor – Laxo Water area, with a preponderance of flights towards Colla Firth, Swining Voe and Dury Voe (Maps 79 and 81). Activity in the Nesting quadrant

activity was predominantly associated with the area around Gossa Water, with a preponderance of flights towards Dury Voe (Maps 80 and 81). Further information on red-throated diver flight activity is given in Part 2 of this report.

100. Seven merlin flights were observed, in the Collafirth and Nesting quadrants (Table 24b, Maps 82 and 83). In 2003 most activity was estimated to be 10-100 m above the ground (96%, n = 2 flights). Further information on merlin flight ecology is given in the Part 2 of this report.

101. The data indicate relatively high levels of flight activity by curlew, great skua, great black-backed gull, herring gull, common gull, hooded crow and raven throughout much of the site (Tables 23a and 23b). Activity levels by golden plover, snipe and arctic skua were also relatively high, particularly in 2003 when the data were not affected by the inclusion of winter observations. Species of conservation concern that were detected moderately frequently included whimbrel, dunlin, arctic tern and common tern.

102. Whimbrel was recorded during the period April to August, with most records in May and July. Sightings were logged from all 12 VPs, with the greatest number from E3.

103. Golden plover was again the most frequently encountered Annex 1 species. Birds were recorded in all months except September, November and December. Most activity was observed in March (when numbers were presumably augmented by passage birds), May and July. Sightings were logged from all 12 VPs, with the greatest number from E1.

104. Dunlin was recorded during the period May to August. Sightings were logged from 75% of VPs, with the greatest number from VP7.

105. Arctic tern was recorded during the period May to August. Activity was logged from 92% of VPs, with greatest activity from E6 and E12. Common tern was recorded during May and June only from VPs E1 and E12 only.

106. Great skua was recorded during the period April to October, with greatest activity June to August. They were recorded from all VPs. Arctic skua was recorded during the period April to August with greatest activity in May-June. They were recorded from all VPs.

107. A marsh harrier was observed briefly flying low over the ground in the Kergord quadrant on 28 May 2006. Two flights by an adult male hen harrier totalling 4.2 minutes were observed on 04 April 2006 to the east of Voe (Map 83). All hen harrier activity was less than 50 m above the ground, including 96% below 10 m.

108. Three peregrine flights were observed (Map 82 and 83). Birds were recorded for 1.5 minutes in 2003 (all above 100 m) and 1.6 minutes in 2006-07 (of which 65% was at 10-50 m height).

109. A short-eared owl was recorded on 03 May 2006 in the Nesting quadrant (Map 83). The bird flew for a total of 51 seconds at 0-50 m above ground.

Seasonal Patterns in Flight Activity

110. For almost species flight activity was substantially greater in spring and summer than at other times of year. This is unsurprising given that many species were scarce or absent from the study area during the winter months. Thus red-throated divers were active during the period March to August, with a peak during July when they were feeding chicks (Fig. 6a).[8] Whimbrel typified many of the upland breeding waders that visit the site for the summer months, being active over the study area from mid-April to late August (Fig. 6b).

111. Merlin were active over the area in all months except December and January (Fig. 6c). There was some suggestion of greater activity in spring and autumn, perhaps due to the presence of migratory birds.

112. Some breeding species were active earlier in the year than others. For example golden plover flights were observed as early as January, with a substantial increase in early March (Fig. 6d). Many of the individuals seen in March were perhaps passage migrants although others may have been local breeders commuting to moorland habitats in order to secure territories. Conversely, dunlin, a visitor from sub-Saharan Africa, were not recorded until mid-May (Fig. 6e), partly because they were later to arrive on the breeding grounds but also, perhaps, due to an absence of display flights when they first arrive back on the breeding grounds.

113. There was a notable difference in the seasonality of great and arctic skua activity, with the former apparently arriving on the breeding grounds earlier and staying later (Figs. 6f and 6g). Terns were present for a relatively brief period (Fig. 6h).

114. Greylag geese were observed flying over the area for much of the year, the only respite occurring in July when adults moult and become flightless for a few weeks (Fig. 6i). The only species that was conspicuously less active in summer than at other times was raven (Fig. 6j).

Supplementary Information

115. Two flights whooper swan flights were recorded during supplementary watches at the 2003 breeding site (see Field Survey Methods), both during the incubation period. In each case, the non-incubating adult returned to the breeding site, presumably from a feeding foray, from the opposite direction to the ESA.

Distance-Detection and Diurnal Activity Patterns

116. The VP watches undertaken in summer 2007 totalled 221 hours of observation, spread more-or-less evenly across the diurnal period (Table 7). These watches recorded 522 flights by *Target Species*: four by dunlin, 65 by golden plover, 94 by whimbrel, 110 by arctic skua, 185 by great skua, 12 by greylag, one by merlin and 51 by red-throated diver. An additional 18 hours of watches in 2008 recorded 24 flights by dunlin, one each by arctic skua and whimbrel and two by golden plover. Data for the 51 red-throated diver flights were added to the other

[8] Red-throated diver phenology is discussed in more detail in Part 2.

flight data for this species and are dealt with in Part 2. Merlin data from generic VP watches in 2005 and 2006 were also added.

Distance Detection

117. Changes in detectability with distance were examined by comparing the total time spent flying in each of ten 250 m wide zones (centred on the VPs) with the visible areas as of these zones (calculated for each VP using GIS software) Table 25; Figs. 7a-7g). For dunlin (Fig 7a) the 0-250 m zone was split in two, giving a 0-125 m zone and a 125-250 m zone. As the VPs were chosen at random with respect to bird flight activity the amount of flight activity per unit area was expected to be even across all the distance zones. For the purposes of estimating the proportion of flight activity that was seen it was assumed that all activity was observed in the first distance zone (Figs. 7a-7c). For the two skua species and merlin (Figs. 7d-8f) flight activity levels in the second zone (250-500 m) equalled or slightly exceeded that in the first distance zone and therefore for it was assumed that all activity was observed in the first two distance zones. For greylag goose (Fig. 7g) flight activity was similar in the first four zones and so for this species it was assumed that all activity was seen up to 1 km from VP. For each distance zone, the difference between the observed and expected activity was used to estimate the percentage of activity seen. For some smaller species this measure probably overestimates the activity seen because it is unlikely that all flight activity within the closest zone was seen.

118. The rate of decline in recorded flight activity with respect to distance was used to determine a notional distance within which the observer is assumed to detect all activity, and beyond which the observer is assumed to detect no activity. This was achieved by redistributing the observed activity was according to the activity level (flight time per ha) recorded in the closest distance zone(s). This notional distance was termed the 'Effective Total Detection Distance' (ETDD) and has valuable application in estimating the mean level of flight activity (flight time per ha per year) for each species.

119. There was a strong positive relationship between a species' body-size and how far away it could be seen (Table 26, Figs. 7a-7g), although colour and flight height doubtless also affected detectability. The most easily detected species, and also the largest, were greylag goose (Fig. 7g) and great skua (Fig. 7e), with ETDDs exceeding 1200 m. Arctic skua (Fig. 7f) and merlin (Fig. 7d) had ETDDs of around 900 m. Whimbrel (Fig. 7b) and golden plover (Fig. 7c), both medium-sized waders, had ETDDs of 517 and 578 m respectively. For dunlin (Fig. 7a), the smallest wader breeding on the Viking site, the ETDD was only 159 m. Finally, based on a small sample of observations it was estimated that less than 3% of curlew flights beyond 1 km were detected by observers.

Diurnal Activity Pattern

120. The number of flights observed for great skua, arctic skua, whimbrel and golden plover were sufficient to examine how flight activity changed through the day. For these species the amount of flight activity observed was calculated (in terms of bird minutes, i.e. one bird flying for one minute) for each of six time periods through the day. The observation effort in each time period was calculated for each species as the time spent scanning plus the time spent watching that particular species. The time spent watching other species was excluded. The

flight activity in each time period was expressed in terms of flight time per unit observation time (Figs. 8a to 8d).

121. The diurnal activity pattern of great skua (Fig. 8a) showed a slight tendency for greater activity in the latter part of the morning and in the evening. Arctic skua (Fig. 8b) showed relatively low flight activity in the early morning and higher than average activity around mid-morning and in the evening. Whimbrel showed relatively constant flight activity through the day apart from during the mid-morning period (6-9 hours GMT) when activity was nearly twice the average. Similarly, golden plover (Fig. 8d) showed relatively constant activity apart from in the late-morning period (9-12 hours GMT) when flight activity was more than twice the average.

Flying Height

122. Time spent in different categories of flying height was determined from estimates made at each 15-second recording interval (see Field Survey Methods), using data collected in 2007 and 2008. This showed that flying height varied between species with some (e.g. merlin) mainly active below 10 m whilst others (e.g. golden plover) mostly flew above 10 m (Table 26).

Landform Associations

123. The analyses of whimbrel and golden plover flight data provided strong evidence that flight activity by these species was not random with respect to landform. Whimbrel showed a moderate positive association with the proximity of streams (+40%) and a strong negative association for hill tops and steep slopes (-53% and – 90% respectively) (Fig 9a). Golden plover showed a weak positive associations for hill tops and the vicinity of streams (+22% and +19%, respectively) and a strong negative association with steep slopes (-76%) (Fig 9b).

Migratory Movements

124. Flight activity by migratory wildfowl is summarised in Tables 27 and 28. One species listed in Annex 1 of the Birds Directive was recorded (whooper swan).

125. In spring 2005 five flights of greylag geese totalling 24 birds were recorded over the WSA. In autumn 2005 nine flights of greylag geese totalling 144 birds were recorded over the WSA. Five flights (63%) were less than 150 m above the ground. No obvious flight corridors were discernable (Map 84). Two west-east flights of pink-footed geese totalling 52 birds were recorded in autumn 2005. Both flights were approximately 300 m above the ground.

126. In spring 2006 two greylag flights involving nine birds were recorded over the ESA. All birds all flew less than 150 m above the ground. Again, there was no obvious correspondence with site topography (Map 85). In autumn 2006 a group of four whooper swan flew over the ESA (Nesting quadrant) at 15-40 m elevation above ground. In addition, two flocks of greylag geese, totalling 40 birds, and a single pink-footed goose flew across the ESA, all less than 15 m above ground.

127. Several 100 greylag geese now breed in Shetland and at least some of these birds may be resident (Pennington *et al* 2004). Therefore for this species there is

some uncertainty whether the birds seen on migration watches were true migrants or local residents.

Autumn and Winter surveys

128. Forty-four species, including four listed in Annex 1 of the Birds Directive (whooper swan, hen harrier, merlin, golden plover) were recorded from the autumn / winter walked transects within the WSA in 2005-06 (Table 29). Four red-listed BoCC species were recorded (skylark, song thrush, starling and twite).

129. Thirty-six species, including three listed in Annex 1 of the Birds Directive (red-throated diver, whooper swan and golden plover) were recorded from autumn / winter walked transects within the ESA in 2003-04 (Table 30). Two red-listed BoCC species were recorded (song thrush and starling). Ten additional species were recorded from walked transects within the ESA in 2006-07 (Table 31). These included two listed in Annex 1 of the Birds Directive (hen harrier and merlin) and one additionally red-listed as a BoCC species (skylark).

130. Two red-throated divers were present at Sand Water in September 2003.

131. An adult female hen harrier was recorded in the Kergord quadrant on 11 February 2006 and a female / 1st calendar year male was present in the Collafirth quadrant on 31 March 2006 (Map 86). A single bird was reported from Bixter, on the edge of the Kergord quadrant, in winter 2006-07 (per M Chapman), although it was not seen during surveys of the Viking windfarm site. An immature male merlin was recorded chasing a snow bunting in the Collafirth quadrant on 29 October 2005 and a female was seen twice in the Nesting quadrant on 23 March 2006 (Map 86).

132. Golden plover were recorded in the WSA on three occasions, involving between one and 26 birds, in October, November and February. There were 17 sightings in the ESA, involving between one and 26 birds, in the period September to November 2003, February to March 2004, and March 2006. Two of the birds seen in March 2006 were displaying. The records in both the WSA and ESA were loosely associated with the valley separating the Delting and Collafirth quadrants.

133. Skylark was recorded in the WSA on 21 October 2005 and again on 16 February 2006. Small numbers were present in the ESA in March 2006. There were three records of song thrush, in October, November and March. Flocks of 20 to 100+ starling were recorded in the Collafirth and Delting quadrants (especially associated with settlements at Dale) in October and November 2005; small numbers were also recorded January to March. Two twites were seen near Collafirth on 29 October 2005. Grasshopper warbler was recorded on several occasions in autumn 2003, including four records of single birds in November.

134. Small numbers of whooper swans were recorded in both the WSA and ESA. These are detailed under ‘Wintering and passage whooper swans’ below.

135. Other significant sightings included passage flocks of fieldfares (including 14 flocks of 1-140+ birds during November 2005) and redwings (including 18 flocks of 1-300+ birds in October-November 2005 and eight flocks of 1-30+ birds in October-November 2006. Snow buntings were recorded each winter, with 1-2

birds seen on four occasions in 2003-04, 1-28 birds on 11 occasions in 2005-06, and 1-6 birds on three occasions in 2006-07.

136. Unusual records included a little egret and turtle dove in October 2003 and two blackcaps, two mealy redpolls and two waxwings in October 2005.

Wintering and Passage Whooper Swans

137. Whooper swans were recorded at 17 locations during the transect surveys (Map 88). Each location generally held small numbers, with monthly peak counts ranging from one to nine birds (Table 32). The lochs that held greatest numbers were Loch of Benston, Loch of Freester and North Loch. However, the lochs that were most consistently occupied were Loch of Houster and Sae Water.

138. Whooper swans were recorded in all survey months (October to May). However, numbers were greatest in March-April and October-November. Juveniles accounted for 11% of total bird sightings.

139. In addition to the dedicated winter whooper swan transects, this species was recorded in the generic autumn and winter bird surveys of the ESA and WSA. Five whooper swans were present at Black Water (HU 464573) on 13 November 2003 and three there on 05 January 2004. A family group of whooper swans (2 adults + 2 juveniles) were recorded on Mill Loch (Delting quadrant) on 29 December 2005 and two adults were on Sand Water on 16 February 2006.

Roosting Hen Harriers

140. Hen harriers were observed at the Sand Water roost on seven out of 11 survey dates in 2005-06 (Table 33). At least three birds were present during the period December to February (one adult male and two females / 1st calendar year males).

141. Fifteen flights were observed during watches from VPs overlooking the roost area (Map 89). Harriers approached the roost from a variety of directions, including routes that crossed the Kergord and Nesting quadrants. The majority of flights were less than 10 m above ground.

Meadow Pipit and Skylark

142. A total of 133 meadow pipits was recorded from the two 5-km transects walked in the ESA, 2006 (46 in May and 87 in June; Table 34). These totals included 97 birds (26 in May and 71 in June) recorded within 50 m of the transect lines.

143. Similarly, a total of 171 skylark was recorded from the two 5-km transects in the ESA, 2006 (71 in May and 100 in June; Table 35). These totals included 86 birds (30 in May and 56 in June) recorded within 50 m of the transect lines.

144. Thus, numbers of meadow pipit and skylark were greatest in June, presumably because the population included many fledged young birds at this time.

145. Data collected contemporaneously at five other upland UK sites indicated that meadow pipits were relatively scarce and skylark relatively abundant in the Central Mainland of Shetland (Table 36).

Incidental Records

146. During the course of fieldwork various migrant raptors, owls and skuas were seen either during fieldwork activities or incidentally (Table 37). Although merlin is the only species of raptor to currently nest in Shetland these records indicate than at least 11 other raptor species occasionally occur on the Viking site as either migrants or winter visitors, some apparently regularly. In addition to the wintering hen harriers already discussed, notable records include hobby, honey buzzard, red-footed falcon, marsh harrier, osprey. A long-tailed skua was present over moorland for several days in May 2005.

Part 2: Specialist Studies

Red-throated Diver

1. The Central Mainland of Shetland has long been known to be an important area for breeding red-throated divers. From the outset of study it was appreciated that this species was likely to be the bird of greatest concern in relation to the proposed windfarm development. For this reason the species was singled out for detailed studies.

<u>Terms and Definitions</u>

2. In order to report the results some categorisation of sites and pairs is required based on our understanding of the birds' biology. However, it must be borne in mind that this process is limited by the sheer complexity of the number of possible permutations, changes in the status of sites and individuals, the quality of the available data, together with the limitations of our understanding of the birds' biology. For example, the territories of some breeding pairs can cover more than one loch whilst some breeding lochs may support more than one territory or can be used by both breeding and non-breeding birds. Particular difficulty arises when trying to categorise what are termed here as non-breeding birds since in reality this term is a catchall covering a wide spectrum of possibilities. For example, non-breeders may be paired or single, and may or may not hold a territory which may or may not be on a site suitable for breeding. Furthermore, whereas most non-breeders are likely to be inexperienced young birds, some will be birds with breeding experience. It is not possible to distinguish between all these possibilities without studies well beyond the scope of this survey. However, with repeated observations at a site it was possible to assess if any non-breeders present were paired and holding a territory (in which case other divers were generally excluded from all or part of the site). Obtaining a measure of the number of territory-holding pairs present was important because this is the measure used to assess the national and regional importance of the site.

3. Water bodies used for nesting and chick-rearing, are referred to here as breeding lochs, even though, in practice, most are technically lochans. Some breeding pairs (about 20%) have a territory comprising two lochs, the nesting lochan and a nearby 'satellite' loch or lochan. The satellite loch is used by adults for loafing and in many cases adults move part-grown chicks to the satellite loch. Apart from the breeding sites, other freshwater bodies are used as places to gather and loaf, and sometimes feed also. Non-breeding birds, in particular, use these lochs; although breeding adults also visit them. They are referred to here as non-breeding lochs. Whereas most of the water bodies on the site neatly categorise as either breeding or non-breeding sites, a few lochs serve a dual role. It should also be noted that some non-breeding pairs hold territories on non-breeding lochs.

Methods

Diver Abundance and Distribution

4. The objectives of study were to:

- Determine which lochs were used by divers and for what purpose.
- Estimate the number of birds using these sites.
- Measure diver breeding success.
- Investigate year-to-year changes in breeding site occupancy.

Survey Area

5. Red-throated diver surveys were conducted to inform an assessment of the potential effects of windfarm development in 2003 and 2005 to 2008. In 2006 to 2008, the combined ESA and WSA plus 2-km buffer) was surveyed and is hereafter referred to as the Viking Diver Survey Area (VDSA) (Map 90). In 2003 only the ESA plus 2-km buffer was surveyed. In 2005 only the WSA plus 2-km buffer was surveyed.

6. In 2004, a research study unrelated to the windfarm proposal was conducted by Natural Research (NR; Stirling and Hulka 2004). This study monitored breeding red-throated divers throughout the Central Mainland of Shetland. The results from this study corresponding to the VDSA are included in this report. The 2004 survey excluded most lochs not marked on 1:25000 OS maps and generally did not monitor birds on the larger lochs as these were assumed to be non-breeding birds.

7. In all years apart from 2006 the aim was to find and monitor breeding divers only. Fieldwork up to 2005 indicated that many non-breeding birds also used the site and were to a large extent using different lochs to the breeding birds. Therefore, the survey aims in 2006 extended to include detailed monitoring of the non-breeding birds using the VDSA.

Fieldwork

8. The VDSA contains nearly 200 freshwater lochs greater than 15 m long, most of which are situated on upland peatlands well away from roads. Monitoring this many water bodies was a major task, not only because of their remoteness but also because many of the smaller ones are not marked on 1:25,000 OS maps.

9. Divers were monitored by making a series of visits to each water body between early May and late August. In 2006 visits to most lochs continued up to late September. The minimum aim was to visit all apparently suitable lochs at least once between early May and mid June and again at least once between mid June and late July. Breeding sites with chicks were always checked at least once between 30 and 40 days after hatching to estimate chick survival to fledging age (about 42 days). In practice it was possible to check most occupied breeding sites every two weeks or so; the actual number of visits depending on how many was necessary to be confident of a pair's breeding status and final breeding

outcome. Some small lochs not marked on the 1:25000 OS map were overlooked in some years (especially 2003 and 2004), or were not discovered until part way through a season and so lacked earlier monitoring visits. Spells of poor weather (especially hill fog) delayed monitoring visits to some sites.

10. Fieldworkers were acutely aware of the susceptibility of divers to disturbance, particularly at the incubation stage. Great care was taken to minimise disturbance, even if this meant introducing some uncertainties in the data. Where possible, sites were checked from afar using a telescope. Breeding lochs were not approached more closely if an incubating bird or small chicks were seen or suspected. Otherwise, when it was useful to do so, the observer undertook a perimeter walk to check for nests and scrapes (a poorly formed nest). Those that were found were examined for evidence of recent use, such as egg shell remains and other signs that indicated breeding outcome.

11. In most cases, laying dates could be calculated to an accuracy of one week from knowledge of when incubation began or back-estimating from the age of chicks (assuming a 30-day interval between the laying of the first egg and hatching). The age of chicks of unknown hatching date was estimated from the relative size of chicks and parent birds. In 2005 to 2008 estimates were made using measurements of digital photographs and calibrated against photographs of known-age chicks (Natural Research unpublished data).

Classification of Breeding Loch Status and Importance

12. Each water body monitored in a particular year was categorised in respect of diver breeding activity, as follows:

- Occupied, confirmed breeding (eggs laid)
- Occupied, probable breeding (nest built but uncertain if eggs laid)
- Occupied, non-breeding pair (pair present but no evidence of breeding)
- Occupied, satellite site to nesting lochan (i.e. part of a multi loch/lochan territory, in most cases chicks were moved to satellite lochs, see text)
- Vacant breeding site, (not occupied this year but has history of breeding use)
- Vacant site, (not occupied this year and no history of breeding use)
- Unknown (no or insufficient data for year in question)

Although the vast majority of breeding sites held only one pair of divers in a given year, some of the larger sites sometimes held two pairs.

13. Over the six-year monitoring period the differences between lochs in average breeding success and occupancy meant that their overall contribution to maintaining the population varied considerably. This is too short a time period, especially given that most lochs were monitored in only five years and some in just three or four, for this measure to give precise values of each loch's long term importance. However, it was sufficient to make a preliminary classification into four broad categories:

- 'Very High Importance' breeding lochs were those where annual productivity was ≥1.0 fledged chicks per year monitored.

- 'High Importance' breeding lochs had an annual productivity of between ≥0.6 and <1.0 fledged chicks per year monitored.
- 'Medium importance' breeding lochs had an annual productivity of between ≥0.2 and <0.6 fledged chicks per year monitored.
- 'Low importance' breeding lochs had an annual productivity of <0.2 fledged chicks per year monitored.

Importance of Lochs to Non-breeding Birds

14. The importance of the larger water bodies to apparently non-breeding birds was assessed from visits made in 2006 and categorised as follows:

- Major use. Typically more than three non-breeding birds present (including any apparently territorial non-breeding pairs based on the loch). Appeared to be main gathering point for non-breeders in that quarter of the Viking site.
- Medium use. Typically 1-4 birds present, though occasionally up to 10. (including any apparently territorial non-breeding pairs).
- Minor use. Typically 0-2 birds present and not used by any territorial non-breeding pairs.

Measuring Diver Abundance

15. Determining the total number of territory-holding pairs (breeding or non-breeding) on the site was achieved by summing all pairs found, the result being essentially as good as the survey coverage achieved. Determining the number of other birds regularly using the site, i.e. those that do not hold a territory, is more difficult, mainly because these birds appear to move about more between lochs. Without marked individuals their numbers can only be crudely estimated. There is no standardised or recommended way of making such an estimate. The method used here was to consider the Viking Site in three parts, north, south-west and south-east and to separately estimate the numbers of non-territorial birds present in these areas from the peak number seen together on a non-breeding loch in July and August. This approach is likely to underestimate the actual non-breeding population. In contrast, birds on non-breeding lochs may also include failed breeders and this may have inflated the estimate. However, regular, checks at failed breeding sites in July and August showed that in most cases the breeding pair remained in residence and therefore, on balance, it is unlikely that this a serious source of bias.

Breeding Success

16. The breeding outcome of each territory-holding pair was assessed from all the information available for the year in question. The presence of a nest scrape or observations of mating behaviour were not taken as confirmation of breeding because these signs were noted for several non-breeding pairs where follow up observations showed no evidence of egg laying. In five cases, although eggs were not confirmed, a well built nest was found in the main nesting period at lochs where confirmed breeding occurred in the previous year. It was considered most likely that these pairs had short-lived breeding attempts and so they were

categorised as ‘probably bred’. It was assumed that all chicks that survived to at least four weeks age fledged unless it was proven otherwise.

17. The following breeding outcome categories were used:

- Bred, successful, 2 chicks fledged
- Bred, successful, 1 chick fledged
- Bred, failed at chick stage
- Bred, failed at egg stage
- Probably bred, failed (well formed nest found but eggs not confirmed, confirmed breeding in previous year)
- Non-breeding pair present, no evidence of breeding

The study did not consider in great detail why pairs failed, the stage of the breeding cycle at which failure occurred, or whether pairs made multiple breeding attempts.

Diver Flight Behaviour

Objectives

18. Red-throated Divers undertake much flight activity over their breeding grounds. In particular, they fly to and from the freshwater lochs where they breed and socialise to marine feeding areas (in Shetland this is mostly sheltered sea inlets - voes). Flying can also be associated with disturbance, other divers intruding into a bird’s territory, movements between different parts of multi-loch territories and (in the case of non-breeding birds), prospecting for future breeding sites. Flight behaviour studies quantified the spatial and temporal aspects of all types of diver flight activity. The main objectives were to map a sample of flight routes at breeding and non-breeding diver lochs, to determine flight heights, and to quantify how flight frequency changes with the stage of breeding and time of day.

Sampling Strategy and Effort

19. The basic strategy for collecting spatial flight data was to map a sample of flight lines at all frequently used lochs that lie within the core of the site. Flights to and from many of the lochs situated in peripheral part of the VDSA (i.e. the outer 2 km) were also recorded. However, most of these lochs were considered to be of lower priority because it was expected that few flights would cross the proposed windfarm. Also, in those parts of the core site with a high density of breeding divers, some lochs were considered to be of lower priority for study if many flights had been logged for the nearby lochs. Gathering additional flight lines in these areas was unlikely to change the overall picture of flight activity across the site.

20. A minimum of 15 incoming flights (from the sea) for each breeding pair was used as a basis for providing a reasonable sample of flight routes for a given breeding lochan. In practice, as flights of all types were logged during watches, normally at least as many outgoing flights and flights by visiting non-breeders were logged and mapped. Although the aim was always to meet the desired minimum, the

actual number of flight lines obtained for breeding lochs varied between sites. This was due to the deliberate policy of expending greater effort at core sites, variation in the number of incidental flights recorded, and to factors beyond the observers control such as hill fog and the death of chicks.

21. Flight watches were conducted at 40 breeding lochs (Map C1, Table 38). Most were undertaken during the chick-rearing stage (36 lochs, 945 hours) as this is when flight frequency is greatest and so data can be collected most efficiently. Data on the frequency of flights for the other stages of the season were obtained for a sample of lochs in 2004 and 2006. Watches were undertaken at eight lochs during the pre-laying stage (totalling 69 hours), at nine lochs during the incubation stage (totalling 135 hours) and at six lochs after breeding failure / fledging had occurred (totalling 42 hours). On average each of the 40 breeding lochs targeted was watched for 24.3 hours.

22. In 2006 VP watches totalling 259 hours were also conducted at eleven lochs frequented by non-breeding birds (Map C1). The sampling strategy at these lochs was to map and log all flights seen in a series of 3-hour watches undertaken at approximately fortnightly intervals through the breeding season. In addition, all flights associated with these lochs recorded incidentally during other diver work were mapped and logged.

23. In addition to the watches focussed on particular lochs described above, a number of other diver flight watches were made (Map C2). In 2003, 169 hours of observations were undertaken from eight VPs (A1–8) overlooking those parts of the ESA most frequented by breeding divers. In 2006, 188 hours of watches were made from twelve selected vantage points (D1–12) overlooking areas more than 1.5 km away from any lochs frequented by divers. These were designed to fill strategic geographic gaps in coverage of the VDSA. In particular, they either overlooked areas expected to be along the regular flight routes of birds accessing lochs well inland or areas where it was useful to confirm that diver flight activity was very low. In all cases, these additional watches consisted of 3-hour observation sessions approximately fortnightly through the breeding season, though watches at four VPs were terminated early for various reasons.

24. Most data on flight behaviour were collected by undertaking prolonged focal point watches. Watches were made from a vantage point overlooking the loch, typically from 200-400 m away. Vantage points were chosen on the basis of having an adequate view of the loch and surrounding areas, not being so close as to disturb the birds (judged from their behaviour) yet not so far that flights, particularly incoming flights, were difficult to detect. In most cases the topography (mainly rather flat-topped hills) meant there were few, if any, choices in viewpoint location. If it was impossible to find a vantage point that met the above requirements, one was chosen where, although the loch itself was not visible, flights in and out of the loch generally were visible. Watches were made at all times of day, but especially in the five-hour periods following dawn and prior to dusk. For about a third of the watches a small tent was erected at the VP to act as a hide, provide shelter and to sleep in over night; this proved to be very effective and greatly facilitated early morning sessions. Additional data on flights was obtained incidentally to other work on the sites, for example flights seen whilst monitoring lochs.

Fieldwork

25. Watches at breeding lochs with chicks typically lasted between three and eight hours, though a few were shorter. Other flight watches were almost always of three hours duration. Watches were conducted in all weather conditions though some had to be abandoned due to fog. During a watch the observer recorded all diver flights observed to pass within 1 km of the loch and mapped the flight lines onto 1:25,000 scale OS maps. For each flight the following data were recorded: time, the number of birds, type of flight (see below), estimated height above ground (every 15 seconds) and whether the birds vocalised or carried food.

26. During the focal point watches of breeding lochs, non-breeding birds were usually readily distinguishable from the resident and any neighbouring breeding birds by differences in their behaviour. In particular, breeding birds were those that tended eggs and chicks and were typically present on their territory most of the time, whereas visiting non-breeding birds were only present for short periods and evoked territorial behaviour from the residents. Away from a breeding territory, unless carrying food, breeding birds could not be distinguished with certainty from non-breeding birds.

27. In 2006, when the opportunity arose, fog density was determined by measuring the distance at which a pale object (a 0.5 x 0.5 m white bag held up on a stick) or a mast first became visible as it was approached.

Suitability of Lochs for Breeding

28. Although the same lochs tend to be used for breeding each year there is a small amount of variation. Thus, survey work over a period of a few years cannot be guaranteed to identify all the lochs that might be used for breeding in the future. Divers select breeding lochs on the basis of particular characteristics, such as adequate water depth, low profile shorelines for nest location, and unimpeded ‘runways’ of sufficient length for take-off. Therefore, to determine the likely number and distribution of additional lochs that might support breeding in future, the suitability of 56 lochs (each less than 3 ha) with no history of breeding was scored as ‘unsuitable’, ‘low’, ‘moderate’ or ‘high’, based on a subjective combination of the characteristics listed above. In addition, the opportunity was taken to make a visual assessment of peat erosion within ~50 m of each lochan. Evidence of erosion was photographed.

Results

Red-throated Diver Abundance

29. A greater number of breeding birds was found in 2004, 2006, 2007 and 2008 compared to 2003 and 2005 (Table 39). This reflects the much larger areas surveyed in these years and the accruing knowledge of small lochs not marked on OS 1:25,000 maps. Thus, six lochs where breeding birds were found in later years were not checked in 2003, four were unchecked in 2004 and three were unchecked in 2005. The 2005 estimate of non-breeding birds (both territory and non-territory holding) is based on relatively few visits to non-breeding lochs and, therefore, when compared to 2006, is likely to be an underestimate.

30. Allowing for these differences in coverage, the survey data suggest the VDSA supported a more-or-less stable breeding population over the study period comprising approximately 48 breeding pairs. This represents about 12% of the Shetland population (407 pairs) and 4% of the estimated UK total of 1255 pairs. This assessment is based on figures from the 2006 national red-throated diver survey (RSPB unpublished).

31. The estimated percentages of the birds living on the VDSA that were not breeding birds (either paired birds or singles) in 2005 and 2006 were approximately 35% (39/111 birds) and 34% (49/145 birds), respectively (Table 39). This suggests that slightly over one third of the population on the breeding grounds are non-breeding individuals. This proportion of non-breeders is similar to the 38% estimated from the results of the 1994 national survey (Gibbons et al 1997).

Loch Occupancy

32. The breeding lochs and other lochs used by divers were not evenly distributed across the site but all quadrants had substantial numbers (Maps C3 and C4). In the northern half of the site, the greatest concentrations occurred in the Collafirth Quadrant, in particular around Muckla Moor and Logie Hill, and as a band running along the upland ground of the Delting Quadrant. In the southern half, large numbers of diver lochs occur almost throughout the Nesting Quadrant and there were small concentrations in the south and north-west of the Kergord Quadrant.

33. A total of 72 lochs within the VDSA are known to be used for breeding (nesting, chick rearing or both) (Map C3, Table 40). Of these, nesting is known to have occurred at 69, the other three are satellite lochs that are used for chick-rearing lochs where the chicks originated at a different nesting loch. At two of the 69 nesting lochs breeding was not confirmed in the 2003-2008 period but was recorded in the 1994-2002 period (D. Okill pers. comm.).

34. Of the nesting lochs identified, 22% were classed as being of Very High importance, and a further 22% as being of High importance (Table 41). The remainder were either classified as Medium (26%) or Low importance (30%).

35. The 24 lochs used by non-breeding birds and off-duty breeding adults were spread across the site (Map C4, Table 42). Those that were most favoured by

non-breeding divers (i.e. categorised as 'major use' or 'medium use') were the larger lochs closest to the main concentrations of breeding lochs, in particular Gossa Water, Laxo Water, Mill Loch (Muckla Moor), Truggles Water and Marrofield Water. Almost all other lochs larger than 1 ha within the VDSA were regularly used by non-breeding birds to some extent (Map C4, Table 42).

36. Fourteen of the 24 lochs used by non-breeders were also used for breeding activities (nesting, chick rearing or satellite loch) either in the same or a different year.

Year-to-Year Changes in Breeding Loch Occupancy

37. Over the monitoring period the size of the population breeding within the VDSA was approximately stable. However, approximately 14 % of nesting lochs used in the previous year were vacant and a similar number of lochs that were vacant in the previous year were occupied (Tables 43 and 44). Most of this flux occurred on lochs which were marginal in terms of their suitability for breeding (i.e. those rated as 'poor' in the loch characteristics analysis presented later). Most of the better quality sites remained occupied throughout the three-year period. About a third of the flux could be accounted for by three territories where birds used two alternative nesting lochs. The pairs of alternative nesting lochs were separated by between 20 m and 300 m. These three territories were occupied in each year of survey.

38. Two lochs where breeding has been proven in the past ten years did not support confirmed breeding between 2003 and 2008, although both supported non-breeding pairs in at least one season. This suggests that a small number of lochs where no breeding occurred during the survey period might be used in the future. The section on loch characteristics considers in more detail the subject of the flux in site occupancy and how many additional potentially suitable nesting lochs exist on the Viking site.

Breeding Success

39. Breeding success varied over the six years it was measured (Table 45). Success was highest in 2003 and 2005 with means in these years of 1.06 and 1.00 fledged young per breeding pair, respectively. In 2004, 2006, 2007 and 2008 breeding success was relatively poor with 0.61, 0.75, 0.54 and 0.67 fledged young per breeding pair respectively. The two most successful years were characterised by high hatching rates (over 80% of pairs hatched eggs) and high chick survival rates (over 70%).

40. The average 2003-2008 breeding success was 0.77 chicks fledged per breeding pair per year. Productivity per breeding pair on the Viking site was, on average, approximately 10% higher than for pairs elsewhere on Mainland Shetland in the four years (2004 and 2006-2008) for which comparable data are available (Natural Research unpublished data). A comparison can be also be made between the final brood-size of successful pairs on the Viking site with a sample of birds from four other sites in Shetland (Okill 2008). This shows that during the period 2003-2008 final brood sizes on the Viking site were on average 5% greater than elsewhere.

Breeding Phenology

Occupancy

41. Unlike the dedicated diver studies, the programme of generic VP watches covered the whole year and so provides the best indication of when divers were present on the site and how their overall activity changed (Fig. 6a). However, generic VP watches made in early September unfortunately overlooked parts of the site with few divers. Therefore the generic VP data is unhelpful in resolving precisely when the birds departed from the breeding grounds. In 2006 diver survey visits continued at a sample of lochs until late September and so covered the period when birds departed (Fig. 10).

42. The first birds were seen flying over the breeding grounds in late March (Fig. 6a). However, activity levels in late March were very low, either because few individuals had returned or because birds at this time spend most of their time on the sea. Activity levels rose dramatically in April and were more-or-less constant throughout May (Fig. 6a). This suggests that the established breeding birds are back on the breeding grounds from early April onwards. Activity levels again increased at the start of June and continued at a high level until mid August (Fig. 6a). This was a result of increased flight activity by breeding birds as they provisioned their chicks and also an increase in the number of non-breeding birds present on the breeding grounds. Activity recorded during generic VP watches, and the occurrence of adults on the breeding lochs, declined markedly after mid August (Figs. 6a and 10). This marks the start of birds departing from the breeding grounds. The likelihood of birds being present on breeding lochs declined through September and was only 10% during the second half showing that nearly all birds had departed. No divers were seen during generic VP watches in October (Fig. 6a). Divers with exceptionally late broods are occasionally seen on breeding lochs as late as mid October (S Minton pers. comm.).

43. In conclusion, the majority of birds are present on the Viking site from early April until early September.

Timing of Breeding

44. As noted previously, in most cases the laying date of the breeding attempts monitored could be calculated to within a week. When this was not possible it was assumed that clutches were 10-days old when first noted. Results on timing of breeding are presented here in terms of the spread of estimated laying dates for all breeding pairs monitored in 2004 to 2007 (Fig. 11).

45. Egg laying occurred from early May through to mid July (Fig. 11). The plot of laying dates indicates a bi-modal distribution that roughly splits into early season clutches (before mid June) and late season clutches (after mid June). The timing of the onset of early season clutches varied slightly between years, for example in 2006 it was about one week earlier than average and in 2007 it was about one week later. The early season clutches presumably correspond to the first clutches of established breeding pairs. The late season clutches are known to include second (replacement) clutches of pairs whose first attempt failed. It is also likely that some of the late season clutches are first clutches of young birds breeding for the first time.

46. The time period red-throated divers require to complete each breeding stage is relatively constant, although there will be small variations between pairs. Thus, egg laying lasts about 2 days, incubation about 28 days and hatching to fledging (defined as when chicks can first fly) about 42 days (Cramp and Simmons 1978). In addition to these stages, there is a period of nest prospecting and building prior to laying and a post-fledging period in which chicks remain dependent on their parents. The average duration of these stages is unknown. However, observations at the Viking site suggest that the nest-building stage can last up to several weeks and that some diver families continue to use breeding lochs intermittently for two or three weeks after chicks can fly.

47. If a breeding attempt fails at the egg stage and it is not too late in the season (i.e. before July), red-throated divers will usually make a second breeding attempt. Some pairs even make three attempts in a season. The typical time difference between a nest failure and the laying of a replacement clutch is 10 – 20 days (DB Jackson, pers. obs.).

Flight Routes

<u>Summary of Data Collected</u>

48. Over the five years in which flight activity was recorded a total of 2717 diver flights were observed. All except very short flights (less than ~100 m) were mapped (Maps C5, 76, 79, 80 and 81). The majority of flights (1899) were seen during the 1560 hours of diver flight watches undertaken overlooking lochs and other selected VPs (Map C5, Tables 38, 46, 47 and 48). A further 295 flights were seen incidentally during other diver fieldwork. The above figures include data for 233 flights seen during the 2004 Natural Research study (Stirling and Hulka 2004). The remaining 573 flights (177 in 2003, 58 in 2004, 257 in 2005, 30 in 2006 and 51 in 2007) were seen during generic flight activity watches.

49. The number of flights seen from each focal watch point was summed to give an indication of the minimum amount of flight data collected for each loch (Tables 46 and 47). In some cases two lochs positioned close to each other were watched from a single location and data for these lochs were pooled. In most of these cases the lochs were a nesting loch and its corresponding satellite loch. In these cases, flights were simply allocated to the focal loch under observation. However, in many cases a flight, particularly those by apparently non-breeding birds, either took in more than one loch along its route or was equidistant from two or more lochs. Furthermore, the summary does not include 295 flights that were recorded serendipitously during other (non-diver) fieldwork, and 573 flights seen during generic VPs. For these reasons, the amount of flight data recorded that was pertinent to a particular loch is in on average about 10-25% greater than that indicated in Tables 46 and 47.

50. Overall, excellent coverage of the VDSA was achieved with respect to mapping the flight routes of red-throated divers (Map C5, Tables 46, 47 and 48). Nevertheless, for many reasons (see Methods), although there was good geographical coverage, the effort expended was not uniformly spread. In particular, some breeding lochs on the periphery of the site, or in areas containing several other breeding lochs where many flights had already been collected, were either given less attention, were vacant, or were occupied by birds that failed to breed successfully (Table 49).

51. The overall geographical pattern of red-throated diver flight lines gives a good representation of the relative importance of different parts of the Viking site to flying divers ((Maps C5, 76, 79, 80 and 81). However, the maps need to be interpreted with care, taking observational effort into consideration. It should also be borne in mind that despite being based on over 1200 hours of observations, the resulting map represents but a small fraction of the total flights that occur in a single breeding season. As a rough approximation the composite map can be thought of as illustrating the amount of flying activity that occurs in a single typical day in the breeding season (based on 60 lochs, 20 hours day-light). Therefore, the picture for an entire breeding season (typically mid April to end August) would contain roughly 130 times more flights than illustrated. The geographical spread of flight activity is analysed and discussed in greater detail under 'Effort-corrected map of diver flight activity', below.

Flights by Breeding and Non-breeding Divers

52. Approximately half of the flight activity (total flying time) observed during focal watches of the breeding lochs was by breeding birds, and most of the flights by these birds were feeding flights to and from nearby areas of sea. The approximately equal amount of flying activity by non-breeding birds in the vicinity of the breeding lochs is perhaps surprising. Although some of the flights by non-breeding birds were to and from the sea (to feed), most appeared to be prospecting flights that involved birds visiting (flying over or circling around and at times alighting on) breeding lochs occupied by established breeding pairs before returning to the larger lochs where non-breeders gather. These flights often involved several non-breeders and the routes tended to be highly convoluted, covering a relatively large area.

Determinants of Diver Flight Routes

53. The majority of the flights by a given breeding pair were restricted to the relatively discrete geographic area linking the breeding loch and its immediate surroundings (up to ~400 m away) to stretches of nearby coast. Flight routes showed considerable variation due to a number of factors. Typically, there was a tendency for flight activity to be concentrated along particular broad corridors with the rest distributed more widely.

54. Unlike other some areas studied in detail the routes of red-throated diver flights in Shetland tend to be complex. For example, Stirling and Hulka showed that breeding red-throated divers in Lewis made more or less direct flights to and from the nearest area of sea (see Lewis Wind Power ES 2005). In contrast, flight routes on the Viking site were often indirect (a curved route) or convoluted (a series of loops or zigzags). The reasons for these differences appear to be linked to the more complex coastline and topography of the Viking site, resulting in many breeding pairs visiting more than one part of the coast. The relatively complex topographical relief of hills and valleys, compared with the flatter landscape of Lewis, mean that it is probably energetically more efficient to deviate from direct flight lines in order to avoid high ground. It appears that birds often chose routes that minimised the need to gain altitude, for example by following valleys and flying through gaps between hills. Note that the energetically optimum outbound flight route is not necessarily the same as the optimum inbound route and this difference was reflected in the observed flight patterns of some pairs.

55. About 25% of the breeding lochs on the Viking Site were situated both at moderate altitude (>150 m) and relatively close to the sea (<2 km). The divers at these lochs appeared unable to make direct flights from the nearest sea to the nesting loch. This was presumably because red-throated divers are able to gain height only slowly due to their high wing loading (large body weight per unit area of wing). Typically, the inbound flights of these pairs consisted of flying a series of circles of about a kilometre in diameter over the sea and adjacent low ground in order to gain height. Only when sufficient altitude was obtained (typically after several minutes of circling) did the bird take a direct course for its nesting lochan.

56. The breeding territory of at least a quarter of the pairs included a satellite loch or sheltered part of a marine voe where the adult birds spent much of their time. These satellite areas were normally within one kilometre of the nesting lochan. The flights of the pairs that had such loafing areas showed a more complex pattern because their activity had two foci. The flights were between various combinations of breeding site, loafing area and marine feeding area.

Flying Height

57. Divers were recorded in flight 339 times during generic VP watches (see Part 1). These data indicated that most time (87%) was spent 10-100 m above ground, and especially at 10-50 m (Table 26). Similarly, data on 1310 flights gathered during focal watches of diver activity showed that 60% of activity was at an estimated height of 10-50 m, with a further 23% at 50-100 m. The two survey types generated near-identical percentages of time flying at other elevations.

Temporal Patterns in Flight Activity

58. Flight activity by red-throated divers varied greatly according to the time of day, stage of breeding and time of year. This section reports on analyses of the temporal changes in flight activity using focal watch flight data obtained for breeding and non-breeding birds in 2004 to 2006.

59. The aim of the analyses was to quantify patterns that occur at an average breeding loch experiencing average breeding success, and at an average non-breeder loch. As described earlier, the non-breeder gathering lochs held a variable number of individuals and tended to be the larger lochs. At the non-breeder lochs, those that attract more birds (e.g. the 'Major Use' lochs) will experience correspondingly higher levels of flight activity than those attracting less birds, (e.g. the 'Medium Use' and 'Minor Use' lochs) however the temporal patterns can be expected to be similar.

60. At breeding lochs it was possible to distinguish (from the birds' behaviour) between flights made by the resident breeding birds and those of visiting birds, i.e. by intruding non-breeding birds (c. 67%) or by neighbouring breeding birds passing by (c. 33%). Note that the recorded flight events sometimes referred to more than one bird e.g. two birds flying together.

Data Limitations

61. Flight data were collected at all stages of the breeding season and all times of day. Nevertheless, there are some limitations and imbalances in the data that should be borne in mind. In particular, because the focal point watches also served to collect data on spatial patterns (i.e. flight routes) more data were collected during the chick-rearing period than at other times. Few data (41 hours effort) were collected for pairs during the post-fledging or post-failure stages and therefore these data may be less representative (i.e. the recorded activity was probably higher than average). Limited night-time observations (approximately 10 hours over four nights) showed that divers made a negligible number of night flights in mid summer and therefore no attempt was made to quantify them. However, it is possible that a greater number of flights occur on bright moonlit nights in the early and late parts of the season.

Analysis

62. For the purpose of calculating the total number of flights per season it was assumed that an average pair commences undertaking such flights on 15 April and stops on 30 August, a period of 138 days (see 'Breeding phenology'). For breeding lochs the season was split into four stages:

- Pre-laying period.
- Incubation period.
- Chick-rearing period.
- Post-failure/fledging period.

The timing of these periods differs from pair to pair, since divers can lay at any time from late April to late July (see Timing of breeding).

63. For non-breeding gathering lochs, the season was split into four periods:

- April-May.
- June.
- July.
- August.

For each of these periods the mean number of flights per loch per day was calculated and the average daily pattern of activity investigated.

64. Daily temporal patterns in flight activity were investigated in respect of time from dawn (for morning activity), and time from dusk (for afternoon activity) (this accounts for changes in day length through the season). Data were pooled into six periods through the day:

- 0.5 hours before to 3.5 hours after sunrise (4 hrs);
- 3.5 hours to 6.5 hours from sunrise (3 hrs);
- 6.5 hours from sunrise to noon (up to 3.5 hrs depending on time of year);
- noon to 6.5 hours before sunset (up to 3.5 hrs depending on time of year);
- 6.5 to 3.5 hours before sunset (3 hrs);

- 3.5 hours before to 0.5 hours after sunset (4 hrs).

65. For each of these time-periods the mean number of flights per hour was calculated. The statistical significance of any diurnal variations in the hourly flight rate for a particular stage of the season was tested (chi-squared test for heterogeneity based on number of flights observed in the number of 10-minute periods sampled). In some cases, the paucity of data for a particular time-period or stage meant it was necessary to aggregate the data.

66. Seasonal changes in the mean number of birds per flight event were quantified so that flight traffic could be estimated in terms of the number of individual bird movements.

Total Flight Activity

67. The results show that on average there were about 6000 bird flights associated with an average breeding loch during the course of a single season (Table 50). Similarly, there were about 3030 flights associated with an average non-breeder gathering loch, though as noted earlier the actual number will vary according to the importance of the site (the least popular have around half this amount and the most popular more than double) (Table 51).

68. Given the numbers of breeding pairs (about 48 each year) and non-breeding gathering lochs (24), these levels of flight activity indicate that in a typical breeding season there are in the order of 350 000 diver flights over the Viking site and its immediate surrounds.

Seasonal Variation in Flight Activity at Breeding Lochs

69. Flight activity by breeding birds at breeding lochs was not uniform through the season (Table 50). It was much greater during the chick rearing period, when it was approximately double that during the incubation and pre-laying periods. Flight activity by intruder birds visiting a breeding loch also changed through the season. It was low during the pre-laying period (corresponding approximately to mid April to late May) and thereafter increased to levels that were similar to the levels observed for the resident breeding birds (Table 50). For the reasons explained above the results for the post-fledging/failure period are likely to be unrepresentative and may be higher than the true average values, especially for intruders. Despite this uncertainty, it is clear that flight activity at this stage is high.

70. The seasonal variation in overall daily flight activity (i.e. flights by breeders and intruders) at breeding lochs shows that flight activity in the chick-rearing period was approximately twice that observed in the incubation period and nearly four times higher than that observed in the pre-laying period (Fig. 12).

Seasonal Variation in Flight Activity at Non-breeder Gathering Lochs

71. Flight activity at the non-breeder gathering lochs also varied through the season (Table 51, Fig. 13). Activity tended to increase through the season with levels in July and August being approximately twice that observed in April, May and June. The level of flight activity at an average non-breeder gathering loch was about half the overall level estimated for an average breeding loch for any given period.

Diurnal Variation in Flight Activity at Breeding Lochs

72. For breeding lochs there was no statistically significant variation through the day in the frequency of flight events by the residents or intruders during the pre-laying period, or by intruders during the incubation period. However, there were significant diurnal patterns in flight activity by breeding residents during incubation and chick-rearing and a very significant pattern in the activity of intruder flights during chick-rearing (Table 50). During the incubation period flight activity by breeding birds was greater in the morning than the afternoon, especially in the seven-hour period after dawn, when it was approximately twice as high as the rest of the day. During chick-rearing, flight activity by residents was high throughout the day but in the first seven hours and last four hours of the day it was about a third higher than in middle part of the day. The most marked diurnal pattern was shown by intruder birds during the chick rearing period; the hourly flight rates for these was high (averaged >1 flight event per hour) in the four-hour periods after dawn and before dusk, and dropped to a low (of about 0.4 flight events per hour) in the middle of the day.

73. Fig. 14 illustrates changes through the day in the overall flight event frequency for an average breeding loch. The y-axis shows the percentage of the total day's flight events per hour. For the pre-laying stage, where there was no evidence of statistically significant variation in the diurnal pattern of activity, the values through the day are simply the mean hourly rate.

Diurnal Variation in Flight Activity at Non-breeder Gathering Lochs

74. There was statistically significant variation in the diurnal patterns of flight activity at non-breeder gathering lochs in all months except June (Table 51; Fig. 15). In late April/May flight activity was much higher in the late afternoon and evening than at other times of day. In July and August the patterns in flight activity were similar; activity was highest in the hours immediately after dawn and before dusk and was lowest in the hours around middle of the day. On average in July and August flight activity in the middle of the day was about half that observed in the hours immediately after dawn or before dusk.

Flight Behaviour in Fog

75. Foggy conditions (either caused by sea fog or hill fog) are common in Shetland in the summer. Measurements of visibility (Table 52) showed that the distance at which an object first became visible in fog varied from 51 m to 158 m, with a median distance of 97 m. For obvious reasons the amount of diver flight data that could be collected during foggy conditions through direct observations was very limited. On many occasions birds were seen flying into fog banks or clouds, apparently unperturbed. On other occasions, when it was foggy and calm, birds (presumably the resident breeding pair) could be heard coming and going from a loch (either from their distinctive flight calls, or the splashing sounds of take-off and landing) even though they could not be seen. Based on these anecdotal observations, it is considered likely that the feeding flights of breeding birds, at least, continue much as normal during foggy conditions. It was not possible to determine if the fog affected the birds' flight routes, flying height, or ability to navigate.

Distance-Detection

76. The amount of flight activity observed during flight watches is affected by the extent of the visible area (i.e. the viewshed), the visibility conditions (i.e. the weather) and how closely divers approach the observer (i.e. distance). These factors need to be taken into account when interpreting the mapped flight lines.

77. In practice, it is reasonable to assume that nearly all flight activity within 500 m of a VP is seen, but that at greater distances an increasing proportion is missed. Beyond a distance of about 3 km very little activity is recorded. For this reason the analyses that follow are limited to within 3 km from the VP and this is termed the 'potentially visible zone' (PVZ).

78. Divers are unusual in that their flights must start and end on water. Furthermore, in the case of feeding flights the destination is the sea. This means that, with few exceptions (and these can be accounted for) nearly all flights that enter the PVZ either start or terminate, or both, outside it, i.e. beyond 3 km. This also means that it is possible to estimate the amount of flight activity that occurred within the PVZ during watches that went unseen.

79. Outgoing flights from focal lochs seen during conditions of excellent visibility provide a reference sample to compare with other flight types and visibility conditions. Viewshed permitting, these outgoing flights could normally be followed to beyond 3 km (though some reached the sea before this). Comparison against a distance-exceedance-frequency-plot (Fig 16) for outgoing flights observed in excellent visibility provides a means of estimating the amount of flight activity that went unrecorded in different distance zones for the other flight types and in poorer visibility conditions.

80. To estimate how much activity within the PVZ went unseen the different types of flights seen during focal watches of diver lochs need to be considered separately. The five main types considered are:

- Type 1: Inbound flights. Flights that end at focal loch.
- Type 2: Outgoing flights. Flights that start at focal loch.
- Type 3: Local flights. Flights that start at focal loch and end at nearby (<1km) loch or vice versa, or return to same loch.
- Type 4: Visiting flybys. Flights that circle or pass close to (defined as a closest approach <400 m) the focal loch but do not land.
- Type 5: Non-visiting flybys. Flights that do not visit (defined as a closest approach >400 m) the focal loch but are pass over the PVZ.

81. In the case of flights that were directed to or from the loch itself (types 1, 2, 3 and 4), the close proximity of the VP to the loch meant that all flights were detected. Thus, for these flight types any unseen activity within the PVZ was limited to those parts of flights that occurred before first detection or after poor visibility prevented further observation. 'Fly-by' flights (i.e. those that passed through the PVZ but did not come close to the focal loch) were also subject to these influences but also, potentially, might not be detected at all and thus go unrecorded.

82. Many aspects of weather affect an observer's ability to detect and watch diver flights. Weather measures recorded during watches were combined to produce a

four-point ordinal visibility scale: very poor, poor, good and excellent. The definitions of these categories are shown below.

- Very poor. Fog or mist or visibility recorded as <1km, (with or without rain and wind).
- Poor. Rain or recorded as ‘very dull’, and/or wind >=F6, and/or cloud base <350 m.
- Good. Fine or showers, up to 100% cloud, cloud base >350 m and wind <=F5.
- Excellent. Wind <=F4 and <60% cloud and cloud base >500 m and no precipitation.

83. To investigate distance-detection relationships three measurements were calculated for each flight: VP to point of first detection, VP to closest approach point (minimum distance) and VP to most distant observed point of flight (maximum distance).

Distance-Detection Results

84. The aim of the distance-detection analyses is to use the available data to estimate the amount of flight activity that went unrecorded, or, put another way, the reduction in effective watch effort that occurred due to distance from VP and sub-optimal visibility.

85. The maximum distance detection plot for outgoing flights under different visibility conditions (Fig. 16) gives the best indication of the amount of activity that was potentially visible. The fall off with distance in the ‘excellent visibility’ series is mainly due to the limitations imposed by the view shed and the fact that some flights reached the sea before 3 km. The differences between the series of flights in excellent as opposed to poorer visibility are caused by unseen activity due to reduced visibility. The visibility conditions had a marked effect on the amount of activity observed (Fig. 17). For example, under conditions of ‘poor’ visibility the amount of outgoing flight activity recorded at 2 km from the VP was, on average, about half that recorded during ‘excellent’ visibility.

86. The differences between the distance-detection pattern for outgoing flights and that for other types of flight indicates the average amount of unseen activity within the PVZ before these flights were detected. In the case of ‘fly-by’ flights that did not approach closer than 400 m the difference was also caused by some flights going undetected.

87. The difference between the distance detection patterns for inbound and outgoing flights was large (Fig.18). For example, at 1000-1250 m from a VP the average inbound activity recorded was 50% of the outgoing activity and at 1500 m it was only 30% (Fig. 19).

Effort-corrected Map of Diver Flight Activity

88. In order to produce an unbiased picture of the geographic pattern of diver flight activity it was necessary to correct the flight line maps for variation in observer effort. An array of 200x200 m grid squares was used to represent the site, with each square coloured according to its annual flight activity score. Seven levels of

score were defined, each level representing a doubling of activity. Scores were based on the estimated annual distance flown by divers in each square. Separate scores were determined for breeding and apparently non-breeding birds, and the two values summed.

89. The seven flight activity levels used were as follows:

- Very Low, <3km per year, (equivalent to *ca*. <26 passes p.a.).
- Low, 3 - 7.5km per year, (equivalent to *ca*.26 - 50 passes).
- Medium Low, 7.5 - 15km per year, (equivalent to *ca*. 51 - 100 passes).
- Medium High, 15 - 30km per year, (equivalent to *ca*. 101 - 200 passes).
- High, 30 – 60km per year, (equivalent to *ca*. 201- 400 passes).
- Very High, 60 - 120km per year, (equivalent to *ca*. 401 - 800 passes).
- Extremely High, >120km per year, (equivalent to *ca*.>800 passes).

90. The procedure to correct for effort is necessarily relatively complex because account has to be taken of the fact that the visibility from watch points varies considerably and effectively diminishes with distance (see distance detection results). It also needs to take account of the fact that flight activity is temporally uneven, both within a season and within a day, which means that watches at certain times inevitably record more activity than at others.

91. It was assumed that:

- The flight watch data were representative of the flight routes across the areas observed.
- The temporal patterns of activity (calculated separately for breeders and non-breeders) were the same for all birds, i.e. it is fair to apply a single average temporal pattern to all areas.

Stages in Determining Observation Effort

92. Watch effort at each VP was translated from measurements of time (hours and minutes) and calibrated against the percentage of total annual flight activity that was theoretically observed. This was achieved with reference to the analyses on temporal patterns in flight activity presented above. These analyses provide an estimate, both for breeding and for non-breeding birds, of the percentage of the total annual flight activity that occurs on average in each part of a day at each stage of the season. Thus, these analyses enable account to be taken of the variations in the 'value' of watch effort expended at different times of the day and the season. Separate calculations were made of watch effort for flight activity by breeding birds and by non-breeding birds. For ease of reference the measure of effort used is referred to here as 'percentage effort', e.g. '1% effort' means that 1% of the annual flight activity was theoretically observed.

93. The watch effort expended at a given VP only applies to relatively close by where the flights are witnessed. To calculate the effective watch effort beyond this the reduction in flight detectability with distance and viewing conditions (e.g. poor weather) need to be taken into account. This was done with reference to the results from the distance detection analyses. The effective effort from each VP was calculated for a series of four concentric distance zones from the VP. These

were: 0-0.5 km, 0.5-1km, 1-2km and 2-3km. Separate calculations were made for watch effort conducted in ‘excellent’, ‘good’, ‘poor’ and ‘very poor’ viewing conditions (defined above in ‘Distance detection analyses’). For observations from focal watch VPs (but not generic VPs) separate calculations to take account of distance detection effects were required for inbound, outbound and ‘fly-by’ flights, because these had different distance detection functions (Fig. 18).

94. In addition to correcting effort for the effects of distance and weather, the area visible from each VP was also taken into account. The visible area at 20 m elevation above ground level, truncated at 3 km, was calculated using GIS software. All parts of the landscape within 3 km that were not visible from a VP (because they were hidden behind high ground) were treated as receiving zero effort as no flights could be seen in those areas.

95. Incidental effort, (the effort that went into recording incidental flights) was also calculated as far as possible. Incidental flights were recorded during the course of checking lochs. Whilst engaged in this fieldwork observers noted their position along their walk route every ten minutes. For the purposes of calculating incidental effort it was assumed that all flights within a 1 km radius of these positions were seen in that 10-minute period, and that none were seen beyond this distance. It was then a simple matter to calculate the percentage of the annual flight activity that was theoretically witnessed for the time of day and stage of season. Whilst this method this is relatively unsophisticated it nevertheless gives a broadly accurate measure of the effort expended. Given that incidental flights formed only about 11% of all the flights recorded (and thus correspond to about 11% of the total watch effort) any inaccuracies will have a minor influence on the final results.

96. Finally, GIS software was used to calculate the effective watch effort from each watch position and each 10-minute incidental recording location for every 10x10 m square in an array covering the site. The watch effort for all locations combined was then calculated by summing the values for each 10x10 m square. These results were then converted to the mean effort for each 200x200 m square.

Determining Flight Activity

97. Using the mapped flight routes (Fig. C5), GIS software was used to calculate the total observed distance flown by divers in each 200x200 m square. So that separate estimates could be made for breeding and non-breeding birds, all flights were given a probability of being by a breeding bird or non-breeding bird. In most cases this was known in which case the probability was either 1 or 0. If it was unknown (14% of flights) the probability was dependent on the prevailing ratio of breeder to non-breeder flights for the time of year the flight was seen (typically 3B:2NB).

Constructing the Effort-corrected Map of Flight Activity

98. Within each 200x200 m square, the observed total flight distance was divided by the estimated percentage observation effort, and then multiplied by 100 to give an estimate of annual flight distance. Results for flights by breeding birds and non-breeding birds were summed to give a figure for total annual flight distance in each square.

99. The scale of the analysis worked well provided the square had received a reasonable level of effort and several flights were observed there. However, in squares where effort was relatively low and/or no or few flights were observed, stochastic factors meant that the estimated flight activity values tended to be either zero or quite high. This was obviously an artefact of the combination of low effort and few flights and in these areas a 200x200 m resolution was too small. To overcome this problem smoothing was applied to all squares with <1.5% effort. The basis of this smoothing was to take into account in the calculation of the flight activity the values of the eight surrounding squares. Surrounding squares with zero effort were considered invalid and excluded from calculations. Also, if half or more of the surrounding square had zero effort there was considered to be too little information to calculate a reliable smoothed value and in which case the level of flight activity was classified as unknown. Where effort for a square was less than 0.5% the smoothed value of the square was taken to be the mean of the values for the square and it valid neighbours (up to eight). Where effort for a square was between 0.5% and 1.5% the smoothing was centre-weighted. The value was taken to be half the value of the square plus half the mean value of the eight surrounding squares.

100. These procedures effectively smoothed the geographic pattern of activity and helped highlight differences across the site. After this smoothing procedure a few cells (<20) remained that were clearly anomalous compared to their neighbours. These were individually examined and adjusted up or down (mostly down) if there was evidence that this was caused by stochastic effects, for example a single circling flight.

101. Results are presented in Maps C6a – C6b.

Suitability of Lochs for Breeding

102. Of the 56 lochs with no history of occupation by breeding divers that were checked, almost half were classified as unsuitable for breeding and a further 25% were considered to be of low suitability (Table 53; Map C7).

103. Fourteen lochs were classified as moderately suitable. However, many of these were small lochs, barely exceeding 15 m in length. Others were located close (<100 m) to regularly used breeding lochs (which were presumably superior in some respect). Divers may have been unwilling to use one loch because power lines passed directly over it. Despite this, it is likely that some of these lochs occasionally support nesting attempts.

104. The remaining loch was classified as highly suitable.

Merlin

105. The main aim of survey work was to determine the distribution and abundance of merlins by locating all breeding or summering birds. Secondary aims were to determine their breeding success, assess any changes of territory occupancy between years, and obtain information on the birds' flight behaviour, especially in the vicinity of nest sites.

Historical Data

106. Shetland's merlins have received considerable attention from local ornithologists, particularly during the 1980s (Pennington et al 2004). Every year a high proportion of territories are checked for occupancy and to ring young birds. Historical data on the location of breeding territories within and close to the Viking Site were made available to NRP by Pete Ellis and this greatly helped in targeting survey effort in parts of the site particularly likely to hold breeding merlins.

107. Between 1984 (when systematic record keeping began) and 2002 merlin were recorded nesting in 13 territories within the area covered by the recent Viking surveys (see below). Single summering birds were seen in one other territory in several years. Between 1984 and 2002 nesting was not confirmed in five of the territories known to support breeding prior to 1984. However, territories were not checked every year so it is likely that some nesting attempts went undetected.

108. When the historical nest sites were mapped there was a strong tendency for nest sites to form loose clusters. These clusters were in most cases centred at least 2 km apart, and within a cluster nest positions were typically 0.5 – 1 km apart. For convenience, each cluster was interpreted as a nominal traditional territory (Map C8).

Survey Methods

Distribution and Breeding Success

109. The area surveyed for merlin included all parts of the site under consideration for windfarm development (the core site) plus a two kilometre buffer (the peripheral area). In 2003 and 2004 the ESA plus a 2 km wide buffer was surveyed. In 2005 the WSA plus a 2 km buffer was surveyed and in 2006 to 2008 both the WSA and ESA plus 2 km buffer was surveyed. The combined area is referred to as the Viking Merlin Survey Area (VMSA) and was effectively the same as the diver survey area (Map 90).

110. All historical nest locations, together with other areas of apparently suitable breeding habitat (slopes and stream sides with extensive areas of deep heather) were searched in April and May for signs of occupation. Initial searches consisted of systematically walking through suitable nesting areas and watching out for merlin and signs of their activity. Systematic searches were made of grassy knolls and potential lookout rocks etc for prey remains and plucked

feathers, signs that indicate the presence of breeding birds. Merlin have a tendency to return to the same general area to nest, therefore if a search of a historical location was not initially successful, the search was extended to include all apparently suitable habitat within 1 km of that site. Although some merlin pairs are demonstrative and easily located, others can be secretive. Therefore, all traditional territories where birds were not located on the first visit were visited within two weeks and the vicinity around old nest locations watched from vantage points for two hours. Once occupancy of a territory was established no further searches of that territory were made.

111. It was not assumed that merlins would only occur within historical territories. During all the upland bird survey and diver survey fieldwork, surveyors were vigilant for merlin, their signs and areas of heather that looked suitable for breeding. Thus in addition to the dedicated merlin checks described above the whole survey area received considerable additional incidental coverage.

112. Where possible, nests in occupied territories were found and visits made at approximately monthly intervals from May to late July to determine breeding success. Some of these follow-up visits were made by local ornithologists Pete Ellis and Dave Okill to ring chicks.

Flight Behaviour

113. In 2006 information was collected to better understand the typical spatial distribution and height above ground of merlin flight activity in the vicinity of active nests. A sampling programme was devised based on a series of 3-hour focal point watches at seven of the nine occupied territories (Map C9, Table 54), undertaken during the incubation and chick rearing stages.

114. Merlin focal point watches were made from vantage points located at about 500 m from nest sites. Vantage points were chosen that gave a good view of the nest area and as much surrounding ground as possible. Extreme care was taken to avoid interference with the birds' behaviour. To reduce disturbance, most watches were made from a small hide. This necessitated that the observer was accompanied to and from the VP by an assistant. At two sites it was possible to watch from a vehicle.

115. Watches were undertaken between 0600 and 2000 hours BST in conditions of good visibility (> 3km), for periods of three hours. During each watch all flights observed were mapped onto 1:25,000 scale OS maps and details recorded of the number of birds, time, purpose of flight (foraging, displaying, mobbing etc), height above ground (recorded every 15 seconds) and whether the bird was carrying prey.

116. The original aim was to make three 3-hour watches during in pre-laying/incubation and three 3-hour watches again during chick-rearing at each of the seven sample nest site. However, this level of effort was only achieved at one site due to a combination of breeding failure (three sites) and prolonged foggy conditions during the main observation period (July). At two sites watches were discontinued because, despite taking all possible precautions, observers were concerned they were affecting the birds' behaviour.

117. In addition to the focal watches, all merlin flights seen incidentally during other fieldwork were mapped and the same details recorded.

Survey Results

Distribution and Abundance

118. Examination of the survey results for the VMSA from 1984 onwards shows that merlin nested in 17 territories and that single birds summered in one other (Territory N) in several years. These 18 territories are referred to hereafter as 'recently occupied' (Map C8). There are pre-1984 records from several other locations but these appear to be no longer attractive to birds, possibly because of habitat degradation.

119. Between 2003 and 2008 merlins nested in eleven of the eighteen known territories within the VMSA (Map C8, Tables 55 and 56). Nesting is known to have occurred in six additional territories during the period 1984 to 2002 (Table 57). Since 1984 eighteen territories have held either a pair or a single bird in at least one summer. The years with the highest number of occupied territories were 2006 to 2008, when nine or ten territories held nesting pairs and one or two others held single birds. However, these years had the most comprehensive survey coverage (all territories checked).

120. Although survey effort of the recently occupied territories was not uniform (not all sites were checked in all years) the results show several interesting patterns:

- Average annual occupancy rates (years occupied by a pair divided by the number of years checked) have increased with time. For example, from 1984 to 1993 the mean annual occupancy rate was 33%, for 1994 to 2002 it was 44% and for 2003 to 2008 it was 53%. This reflects a recent partial recovery in the population of Central Mainland, though this has not occurred elsewhere in Shetland (P Ellis pers. comm.).
- There was considerable year-to-year flux in territory occupancy. No territory was occupied in all the years it was checked and several were reoccupied after many years proven absence. In one case (Territory E) a territory was vacant for at least eleven years before being reoccupied.
- Some territories were more likely to be occupied than others. The highest occupancy rate (by pairs) was 86% (Territory L, 23 years checked) and the lowest was 0% (Territory N, single birds only, 13 years checked).

121. Because of this flux in territory occupation, it is possible that some of the seven recently occupied territories where no breeding pairs were present between 2003 and 2008 will become re-occupied in the short to medium term.

122. A comprehensive survey of the Shetland population was undertaken in 1992 and 1993, when 30 pairs were located (Rebecca and Bainbridge 1998). However, the most recent estimate, based on monitoring by local ornithologists, is 'below 20 pairs' (Pennington et al 2004). On this basis, ten breeding pairs represent about 50% of the Shetland population, and about 0.8% of the UK population (Pennington et al 2004, Rebecca and Bainbridge 1998). In recent years survey effort within the VMSA has been much better than for most other parts of Shetland and thus the quality of the data for areas outside the VMSA is poorer.

123. The reasons for the apparent decline in Shetland are unclear (Pennington et al. 2004). Habitat quality and prey density appear to be broadly satisfactory, though concerns exist over the current availability of deep heather for nesting. In some

territories, high levels of sheep grazing may have led to deterioration in heather quality. Unlike elsewhere in Shetland, merlin numbers in Central Mainland appear to have recovered slightly in the past few years to levels that are similar to the early 1990s.

124. The 18 recently occupied territories are widely spread across the VMSA. Nine are located in the northern half of the survey area with all these being close (within 500 m) to the survey boundary. Nine territories are located in the southern half of the survey area. These tend to be located deeper within the survey area, with all but three being more than 500 m in from the boundary.

125. At eight territories, the survey data included the locations of at least three nest sites. Mapping the nest sites for these territories gives an approximate indication of the typical geographical spread of nests over time. In all but one case, (Territory B) all the known nest-sites within a territory clustered into a relatively small discrete area, often along a single burn or hillside. At Territory B the nest sites formed two clusters centred 1.6 km apart. The maximum distances between nest sites within a cluster ranged from 255 m to 1500 m and the mean maximum distance was 829 m (n=8).

Breeding Success

126. Breeding success on the VMSA in 2005 and 2007 was very good with averages of 3.0 and 3.6 fledged chicks per breeding pair respectively (Table 58). It was a little lower in 2006 and 2008, with an average of 2.3 and 2.9 fledged chicks per breeding pair, respectively. Comparable data were not available for other parts of Shetland, but the observed rates are thought to be representative (D. Okill pers. comm.).

Flight Behaviour

127. A total of 68 merlin flights were mapped and logged during 33 hours of focal watching (Table 54, Map C10). In addition, 46 merlin flights were recorded during generic VP watches and other fieldwork (not all of these flights could be assigned to a particular territory).

128. Analysis of merlin flight lines seen during the focal watches at six nest sites showed that flight activity per unit area was concentrated close to the nest (<200 m) and declined rapidly with nest distance (Fig 20). Approximately half the flights were less than 10 metres above ground level and the rest were mainly at a height of 10 -50 metres (Table 26).

129. Due to their small size, fast low flight and dark colouration flying merlins are often difficult to detect. Distance detection results for merlin from non-focal point sampling (generic VPs) are presented in Part 1 (Fig. 7d)

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References

Band, W., Madders, M. & Whitfield, D.P. (2007) Developing field and analytical methods to assess avian collision risk at wind farms. *In* de Lucas, M, Janss, G. and Ferrer, M. (eds) *Birds and Wind Power*. Lynx Edicions, Barcelona.

Brown, A.F. and Shepherd, K.B. (1993). A method for censusing upland breeding waders. *Bird Study* **40:** 189-195.

Cramp, S, and Simmons, K.E.L. (eds) 1977. *Handbook of birds of the Western Palearctic. Vol I.* Oxford University Press.

Gibbons, D.W., Bainbridge, I.P., Mudge G.P., Tharme, A.P. and Ellis, P.M. 1997. The status and distribution of the Red-throated Diver *Gavia stellata* in Britain in 1994. *Bird Study* **44**, 194-205.

Gregory, R.D., Wilkinson, N.I., Noble, D.G., Robinson, J.A., Brown, A.F., Hughes, J., Procter, D.A., Gibbons, D.W. and Galbraith, C.A. (2002). The population status of birds in the United Kingdom, Channel Islands and Isle of Man: an analysis of conservation concern 2002-2007. *British Birds* **95:** 410-450.

Forrester, R. and Andrews, I. et al. (eds) 2007. *The birds of Scotland*. Scottish Ornithologists's Club. Aberlady.

Lewis Wind Power 2005 Environmental Statement. LWP.

Marchant, J.H. (1983). *BTO Common Birds Census Instructions*. British Trust for Ornithology, Thetford.

Mitchell, P.I., Newton S.F., Ratcliffe, N. and Dunnn, T.E. 2004. Seabird populations of Britain and Ireland. Christopher Helm, London.

Okill, J.D. 2006. *Report to S.O.T.E.A.G. on Red-throated Divers in Shetland 2005*. Unpublished report.

Pennington, M., Osborn, K., Harvey, P., Riddington, R., Okill, D., Ellis, P., Heubeck, M., 2004. *Birds of Shetland.* Christopher Helm.

Rebecca, G.W., and Bainbridge, I.P. 1998. The breeding status of the Merlin *Falco columbarius* in Britain in 1993-94. *Bird Study* 45, 172-187

Stirling, J and Hulka, S. 2004. *Summary of breeding diver research central Mainland Shetland 2004.* Unpublished Natural Research technical report.

Photo 1. Semi-improved grasslands typical on the more fertile lowland areas. The shallow marine voes around the coast provide fishing grounds for arctic terns, skuas and red-throated divers, and inter-tidal habitat for feeding waders and gulls.

Photo 2. Much of the Viking site consists of remote wide valleys and rounded hills covered in moorland and blanket bog. These areas not only provide suitable habitat for breeding birds such as merlin, golden plover, whimbrel and arctic skua but also a freedom from human disturbance.

Photo 3. A small peatland lochan with ideal characteristics for nesting red-throated divers. In particular, it has high water levels, gently sloping vegetated shorelines, deep water for diving and is of sufficient size for easy take-offs and landings.

Photo 4. Maa Water, one of several relatively large lochs on the Viking Site. Although red-throated divers don't usually nest on the larger lochs they are nonetheless important as places for non-breeding birds to gather and socialise.

Photo 5. A pair of red-throated divers on their breeding lochan. The Viking site and its immediate surrounds annually support nearly 50 breeding pairs, representing about 4% of the UK total.

Photo 6. An adult red-throated divers flying in with a marine fish to feed its chicks on the breeding lochan. Breeding divers make many flights a day over the moorlands to feed in the voes. Considerable numbers of feeding and prospecting flights are also made by non-breeding birds.

Photo 7. Blanket bog pool complex typical of the many flat summit areas of the hills. The marshy ground around such pools provides ideal conditions for breeding dunlin and snipe.

Photo 8. View of plateau peatlands showing a red-throated diver breeding lochan and extensive hag development caused by erosion. Areas such as this are favoured by breeding golden plover and skuas.

Photo 9. Heather moorland covers many of the better drained and more sheltered slopes and provides the preferred nesting habitat of merlin.

Photo 10. A female merlin. Merlins are the only bird of prey that nest in Shetland. The Viking site and its immediate surrounds support up to nine breeding pairs annually, approximately 45% of the Shetland total.

Photo 11. A breeding whimbrel. The moorland and blanket bog habitats of the Viking site and its immediate surrounds support approximately 64 pairs of whimbrel. This represents at least 13% of the UK population and possibly as much as 30% as numbers elsewhere in Shetland are have fallen dramatically over the past two decades.

Table 1. Parts of the WSA visible from each VP within which flight activity was recorded, 2005-06. Visibility was artificially truncated at 2.5 km.

VP	Section	Grid Reference	Area visible (ha)
1	South	HU 34678 53690	276.0
2	South	HU 37935 51572	361.4
3	South	HU 38259 53623	766.4
4	South	HU 36028 54500	588.4
5	South	HU 40936 55490	607.8
6	South	HU 42123 55848	341.7
7	South	HU 37257 56366	449.9
8	South	HU 40560 58571	453.0
9	South	HU 42092 59055	541.4
10	South	HU 38912 58932	320.8
11	South	HU 35450 59166	588.0
12	South	HU 40623 60649	275.6
13	South	HU 37629 60615	369.0
15	South	HU 37350 62882	617.1
16	South + North	HU 39320 63549	164.7
17	North	HU 40469 64366	275.6
18	North	HU 43178 64658	561.3
19	North	HU37086 66701	222.7
20	North	HU39464 66862	555.9
21	North	HU 42002 66328	449.9
23	North	HU 41388 67410	623.0
24	North	HU 40741 69833	290.6
26	North	HU 43185 72140	283.4
27	South	HU 39650 52900	217.7
29	North	HU 38253 69129	224.5
30	South	HU 38320 60270	448.6
31	North	HU 45044 67667	462.7
		Total	11337.2

Table 2. Cumulative parts of the WSA that were visible from VPs and within which flight activity was recorded, 2005-06. The area visible is shown with and without a 2.5km truncation. Data are hectares.

	Area truncated at 2.5km	Area with no truncation
North section	2768.5	3472.9
South section	5179.6	6010.4
Total	7948.1	9483.3

Table 3. Summary of monthly generic observations from VPs overlooking the WSA in 2005-06. Data are hours of observation.

VP	2005										2006		
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	6.0	6.0	5.9	5.9	6.0	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	6.0	6.0	6.0	5.7	6.0	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	5.8	6.0	6.0	6.0	6.0	9.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0
4	5.8	6.0	5.8	6.0	6.0	9.0	2.0	2.0	11.0	1.0	1.0	2.0	2.0
5	6.0	5.9	6.0	6.0	5.8	8.6	1.8	2.0	1.8	1.0	1.0	2.0	2.0
6	6.0	5.9	6.0	6.0	6.0	8.8	2.0	2.0	2.0	1.0	1.0	2.0	2.0
7	5.9	5.8	6.0	6.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	5.8	5.8	6.0	6.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	6.0	6.0	6.0	6.0	5.9	6.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0
10	6.0	6.0	5.8	5.9	5.3	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	6.0	5.9	6.0	5.6	4.9	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	5.9	5.9	6.0	6.0	6.0	6.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0
13	5.8	5.9	6.0	5.7	5.6	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	5.9	6.0	5.8	5.7	5.3	5.8	2.0	2.0	11.0	1.0	1.0	2.0	2.0
16	6.0	5.9	6.0	6.0	5.8	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	6.0	6.0	6.0	6.0	6.0	9.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0
18	5.9	6.0	5.9	6.0	5.8	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	5.9	3.0	5.8	5.8	6.0	8.9	2.0	1.9	2.0	1.0	1.0	1.8	2.0
20	6.0	6.0	6.0	5.7	5.8	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	6.0	5.9	6.0	6.0	5.9	6.0	2.0	2.0	8.0	1.0	1.0	2.0	2.0
23	6.0	6.0	6.0	6.0	5.8	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	6.0	6.0	6.0	5.9	5.9	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	6.0	6.0	6.0	6.0	6.0	5.9	2.0	2.0	13.9	1.0	1.0	2.0	2.0
27	0.0	11.8	6.0	6.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	12.0	12.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	5.7	8.7	11.9	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	11.7	9.9	5.5	5.9	2.0	2.0	2.0	1.0	1.0	2.0	1.6
Total	136.8	145.8	172.3	172.4	163.1	183.2	23.8	23.9	59.8	12.0	12.0	23.8	23.6

Table 4. Parts of the ESA visible from each VP within which flight activity was recorded in 2003 and 2006-07. Visibility was artificially truncated at 2.5 km.

VP	Section	Grid Reference	Area visible (ha)
E1	South	HU 44131 55051	587.9
E2	South	HU 43739 56922	691.6
E3	South	HU 44695 57548	688.3
E4	South	HU 42299 59237	624.8
E5	South	HU 43820 59335	681.5
E6	South	HU 44555 60095	711.5
E7	South + North	HU 42576 60756	775.4
E8	South + North	HU 41902 64077	559.6
E9	North	HU 44863 65099	869.2
E10	North	HU 41895 65595	751.3
E11	North	HU 45227 66944	513.8
E12	North	HU 43659 67782	513.3
		Total	7968.1

Table 5. Cumulative parts of the ESA that were visible from VPs and within which flight activity was recorded in 2003, 2004 and 2006-07. The area visible is shown with and without a 2.5km truncation. Data are hectares.

	Area truncated at 2.5km	Area with no truncation
North section	1439.4	1930.0
South section	2764.2	3094.3
Total	4203.6	5024.3

Table 6. Summary of monthly generic observations from VPs overlooking the ESA. Data are hours of observation.

(a) 2003

VP	Apr	May	Jun	Jul	Aug	Sep	Oct
E1	3.0	5.9	8.8	11.4	3.0	3.0	3.0
E2	3.0	6.0	4.9	11.9	3.0	3.0	2.8
E3	0.0	6.0	9.0	8.9	3.0	3.0	3.0
E4	0.0	8.9	8.8	8.9	3.0	3.0	3.0
E5	2.8	5.8	8.8	8.3	2.8	3.0	3.0
E6	0.0	5.7	8.6	10.7	2.9	3.0	2.9
E7	0.0	6.0	8.9	8.7	2.9	3.0	3.0
E8	0.0	5.7	8.4	9.0	3.0	3.0	3.0
E9	0.0	5.8	7.8	8.3	3.0	2.8	3.0
E10	0.0	6.0	8.9	9.0	2.8	3.0	3.0
E11	0.0	6.0	8.8	9.0	2.9	3.0	3.0
E12	0.0	5.8	8.0	6.5	2.5	3.0	3.0
Total	8.8	73.5	99.8	110.6	34.8	35.8	35.7

(b) 2006-07

VP	2006										2007	
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
E1	3.0	2.0	2.0	2.0	2.0	1.8	3.0	3.0	3.0	3.0	3.0	3.0
E2	3.0	1.9	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0
E3	3.0	3.0	1.9	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0
E4	3.0	2.0	1.8	2.0	2.0	2.0	3.0	3.0	3.0	2.9	3.0	3.0
E5	3.0	1.8	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0
E6	3.0	3.0	2.0	1.6	1.8	1.9	3.0	3.0	3.0	3.0	3.0	3.0
E7	3.0	2.8	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0
E8	3.0	2.9	2.0	2.0	2.0	3.0	2.9	3.0	3.0	3.0	3.0	2.9
E9	3.0	2.0	2.0	2.0	2.0	2.5	3.0	3.0	3.0	3.0	3.0	3.0
E10	3.0	2.0	2.0	1.9	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0
E11	3.0	2.0	2.0	2.9	2.8	2.8	3.0	2.9	3.0	3.0	3.0	3.0
E12	3.0	2.0	2.0	2.8	2.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total	36.0	27.4	23.7	25.2	25.5	27.0	35.9	35.9	36.0	35.9	36.0	35.9

Table 7. Summary of VP watches to investigate distance detection relationships and diurnal flight activity patterns in May, June and July 2007. Data are hours of observation.

VP	Time period (GMT)						Total
	3-6hrs	6-9hrs	9-12hrs	12-15hrs	15-18hrs	18-21hrs	
BF	4.0	6.5	5.7	7.7	9.9	9.1	42.8
FB	4.6	7.0	7.1	3.1	5.3	5.9	32.9
SN	4.8	8.4	7.4	5.3	6.8	2.7	35.3
SS	4.7	6.5	7.8	6.3	4.7	5.3	35.2
TN	4.1	5.5	8.6	9.4	5.3	8.5	41.4
TS	4.6	5.7	7.0	6.5	6.0	3.3	33.0
Total	26.7	39.6	43.6	38.2	38.0	34.7	220.7

Table 8. Summary of VP watches to record migratory movements over the WSA in spring and autumn 2005. Data are hours of observation.

MVP	Mar	Apr	May	Sep	Oct	Nov
1	8.0	24.0	4.0	9.0	18.0	9.0
2	8.0	24.0	4.0	9.0	18.0	11.0
3	8.0	23.0	4.0	9.0	17.0	9.0
4	8.0	24.0	4.0	0.0	0.0	0.0
5	8.0	24.0	4.0	11.0	15.0	12.0
6	0.0	0.0	0.0	9.0	18.0	9.0
Total	40.0	119.0	20.0	47.0	86.0	50.0

Table 9. Summary of VP watches to record migratory movements over the ESA in spring and autumn 2006. Data are hours of observation.

MVP	Mar	Apr	Sep	Oct	Nov
1N	24.0	4.0	9.0	24.0	9.0
2N	0.0	18.0	0.0	0.0	0.0
1S	20.0	3.0	0.0	0.0	0.0
2S	0.0	18.0	9.0	15.0	8.9

Total	44.0	43.0	18.0	39.0	17.9

Table 10. Summary of autumn / winter walked transects, 2003-07. Data are hours of observation

	WSA	ESA
Sep 2003		31.8
Oct 2003		35.0
Nov 2003		11.0
Dec 2003		7.2
Jan 2004		8.2
Feb 2004		9.5
Mar 2004		8.9
Oct 2005	20.4	
Nov 2005	28.3	
Dec 2005	11.1	
Jan 2006	11.6	
Feb 2006	9.8	
Mar 2006		20.2
Sep 2006		7.9
Oct 2006		7.3
Nov 2006		7.2
Dec 2006		6.6
Jan 2007		4.2
Feb 2007		7.1
Total	81.2	171.2

Table 11. Dates of transect surveys of wintering whooper swan, 2005-06.

Area	Day	Month	Year
Southern	31	10	2005
	6	11	2005
	20	11	2005
	19	12	2005
	30	1	2006
	19	3	2006
	25	3	2006
	27	3	2006
	30	3	2006
	11	4	2006
	19	4	2006
	26	4	2006
	3	5	2006
	8	5	2006
	21	5	2006
Northern	31	10	2005
	6	11	2005
	28	11	2005
	31	12	2005
	26	1	2006
	21	2	2006
	17	3	2006
	23	3	2006
	28	3	2006
	30	3	2006
	4	4	2006
	10	4	2006
	14	4	2006
	17	4	2006
	25	4	2006
	30	4	2006
	3	5	2006
	9	5	2006
	16	5	2006

Table 12. Observational effort to record roosting harriers, 2005-06. Watches *in italic* involved simultaneous observations from different VPs.

Date	Obs	VP grid ref.	Start time	Finish time	Duration (hrs)
17/12/2005	MSC	HU 41130 54998	1330	1445	1.25
19/12/2005	SM/DPH	HU 41300 55100	1415	1525	1.67
23/12/2005	*SM*	*HU 40800 55500*	*1325*	*1535*	*2.67*
23/12/2005	*DPH*	*HU 41900 54700*	*1330*	*1530*	*2.00*
24/12/2005	MSC	HU 41130 54998	1300	1520	3.33
31/12/2005	MSC	HU 41130 54998	1400	1445	0.75
02/01/2006	MSC	HU 41130 54998	1400	1515	1.25
24/01/2006	*SM*	*HU 40269 56389*	*1215*	*1600*	*3.75*
24/01/2006	*DPH*	*HU 39612 54717*	*1215*	*1605*	*3.83*
24/01/2006	*MSC*	*HU 41130 54998*	*1215*	*1600*	*3.75*
26/01/2006	MSC	HU 41130 54998	1430	1530	1.00
30/01/2006	*SM*	*HU 42024 55844*	*1400*	*1610*	*2.17*
30/01/2006	*DPH*	*HU 40161 54790*	*1405*	*1605*	*2.00*
09/02/2006	*DPH*	*HU 41130 54998*	*1400*	*1640*	*2.67*
09/02/2006	*SM*	*HU 44162 56511*	*1400*	*1640*	*2.67*
09/02/2006	*MSC*	*HU 43812 54029*	*1300*	*1700*	*4.00*
27/02/2006	MSC	HU 41215 55103	1330	1745	4.25
				Total	43.0

Table 13. Details of transect surveys to record meadow pipits and skylarks in 2006.

Date	Obs	Transect	Start Grid Ref
23/05/2006	SM	1	HU 42250 58800
26/05/2006	MSC	2	HU 45530 64000
09/06/2006	SM	1	HU 42250 58800
28/06/2006	MSC	2	HU 45530 64000

Table 14. Comparisons of the estimated number of breeding bird territories in areas covered by moorland bird surveys in two years.

Species	**Year-pair comparison (area surveyed in both years)**						**Area weighted 'mean % difference from mean'**
	2003 *vs* 2005 (16.2 km^2)	**2003 *vs* 2006 (41.0 km^2)**	**2003 *vs* 2007 (12.6 km^2)**	**2005 *vs* 2006 (24.0 km^2)**	**2005 *vs* 2007 (10.8 km^2)**	**2006 *vs* 2007 (11.8 km^2)**	
Arctic skua	4 > 8prs	16 > 16prs	11 > 6prs	7 > 9prs	12 > 5prs	11 > 5prs	17.7%
Common sandpiper	0 > 0prs	2 > 1pr.	1 > 2prs	3 > 1prs	0 > 0prs	1 > 2prs	33.1%
Curlew	33 > 34prs	94 > 77prs	27 > 19prs	43 > 36prs	12 > 18prs	24 > 17prs	11.2%
Dunlin	14 > 25prs	12 > 21prs	5 > 8prs	14 > 1prs	10 > 8prs	6 > 8prs	36.7%
Golden plover	20 > 22prs	40 > 43prs	13 > 14prs	40 > 17prs	20 > 8prs	9 > 14prs	17.1%
Great skua	22 > 12prs	20 > 27prs	13 > 8prs	15 > 16prs	8 > 5prs	13 > 8prs	17.4%
Greylag goose	1 > 8prs	2 > 8prs	2 > 8prs	5 > 9prs	3 > 7prs	6 > 8prs	50.0%
Lapwing	13 > 11prs	19 > 13prs	6 > 5prs	36 > 22prs	2 > 1prs	6 > 5prs	18.0%
Oystercatcher	11 > 21prs	34 > 41prs	7 > 12prs	55 > 35prs	9 > 7prs	18 > 11prs	18.9%
Redshank	5 > 5prs	6 > 12prs	4 > 5prs	8 > 7prs	1 > 3prs	3 > 5prs	21.8%
Snipe	32 > 33prs	96 > 51prs	21 > 24prs	56 > 51prs	24 > 24prs	16 > 20prs	14.0%
Whimbrel	11 > 2prs	9 > 13prs	8 > 8prs	3 > 10prs	6 > 4prs	9 > 8prs	30.0%
Ringed plover	2 > 8prs	6 > 8prs	1 > 1pr.	5 > 3prs	0 > 0prs	0 > 0prs	23.4%
Red grouse	Not calculated	17 > 14prs	Not calculated	5 > 4prs	Not calculated	Not calculated	10.2%
Common gull	Not calculated	17 > 16prs	Not calculated	5 > 6prs	Not calculated	Not calculated	5.3%
G b-backed gull	Not calculated	13 > 29prs	Not calculated	6 > 5prs	Not calculated	Not calculated	27.4%

Table 15. Summary of the estimated numbers of breeding birds recorded in the Viking survey areas and the regional and national importance. Numbers of red-throated diver, merlin and whooper swan are derived from detailed surveys. Numbers of fieldfare and teal are based on incidental records. For all other species the total is derived from moorland bird surveys made in 2005 (WSA), 2006 (ESA) , 2007 (8 small additional areas) and 2008 (road plots). The indicative range was calculated from the between year comparisons of areas surveyed in two years (Table 14). Birds listed in Annex 1 of the Birds Directive and Schedule 1 of the WCA are shown in bold. Species that are BOCC Red-list and UK BAP species are shown in italic. N.C. indicates value not calculated.

Species	**Number of pairs**						**Indicative range based on repeat surveys (Total +/- MDM)**	**Shetland pop$^{n.}$ estimate**	**Viking site, % of Shetland pop$^{n.}$**	**UK pop$^{n.}$ estimate**	**Viking site, % of UK pop^{n}**
	Quadrant				**2008 road plots**	**All surveyed areas**					
	NW	**SW**	**NE**	**SE**							
Red-thr. diver	13	12	11	12	0	**48**	See Part 2	407	**11.8%**	1255	**3.8%**
Fulmar	6	28	13	4	1	**52**	N.C.	182,105	<0.1%	504756	<0.1%
Wigeon	0	0	0	1	1	**2**	N.C.	10	**20.0%**	400	0.5%
Mallard	0	1	0	0	2	**3**	N.C.	150 - 300	1.3%	88750	<0.1%
Teal	0	1	0	1	0	**2**	N.C.	75-150	1.8%	2000	0.1%
Whooper Swan	0	0	0	1	0	**0-1**	N.C.	3	**0 - 33%**	7	**0 - ca14%**
Eider	1	0	0	0	3	**4**	N.C.	1500 - 2500	<0.1%	31650	<0.1%
Greylag goose	21	14	1	2	0	**38**	19 - 57	>125 (rising)	**15.2 - 45.6%**	34100	0.1 - 0.2%
Merlin	4	2	1	3	0	**10**	See Part 2	ca 20	**50.0%**	1330	0.8%
Red grouse	23	17	10	20	7	**77**	69 - 85	100 - 200	**46.1 - 56.6%**	155000	<0.1%
Oystercatcher	83	141	20	46	41	**331**	268 - 394	3350	8 - 11.8%	113000	0.2 - 0.3%
Ringed plover	9	25	2	8	8	**52**	40 - 64	800 - 1000	4.4 - 7.1%	8540	0.5 - 0.8%
Golden plover	48	92	28	37	7	**212**	176 - 248	1450	**12.1 - 17.1%**	22600	**0.8 - 1.1%**
Lapwing	36	77	11	42	27	**193**	162 - 224	1740	**9.3 - 12.9%**	156000	0.1%
Dunlin	21	49	10	19	1	**100**	63 - 137	1700	3.7 - 8%	9525	**0.7 - 1.4%**
Snipe	96	182	47	93	50	**468**	402 - 534	3450	**11.7 - 15.5%**	59300	0.7 - 0.9%
Bl.-t godwit	0	0	0	1	1	**0-1**	0 - 1	3	**0 - 33.3%**	48	**0 - 2.1%**
Whimbrel	9	24	9	16	6	**64**	45 - 83	479	**9.4 - 17.4%**	530	**8.5 - 15.7%**
Curlew	124	142	44	102	44	**456**	405 - 507	2300	**17.6 - 22%**	107000	0.4 - 0.5%
Redshank	25	37	7	10	26	**105**	82 - 128	1170	**7 - 10.9%**	38800	0.2 - 0.3%
C. sandpiper	0	6	1	1	1	**9**	6 - 12	44	**13.7 -**	12000	0.1 - 0.1%

									27.2%		
Arctic skua	7	22	6	14	1	**50**	41 - 59	1128	3.6 - 5.2%	2136	**1.9 - 2.8%**
Great skua	19	43	20	22	0	**104**	86 - 122	6874	1.2 - 1.8%	9634	**0.9 - 1.3%**
Black-headed gull	0	37	0	10	0	**47**	N.C.	850	5.5%	138014	<0.1%
Common gull	36	98	28	35	7	**204**	200 - 208	3000	6.7 - 6.9%	48720	0.4%
L. b-b. gull	1	4	0	1	0	**6**	N.C.	320	1.9%	112074	<0.1%
Herring gull	2	4	0	0	0	**6**	N.C.	3000 - 3500	0.2%	139309	<0.1%
G. b-b. gull	37	45	24	18	1	**125**	95 - 155	2000 - 2200	4.5 - 7.4%	17160	0.7%
Common tern	1	4	0	1	0	**6**	N.C.	100 - 200	4.0%	11838	<0.1%
Arctic tern	56	74	34	2	11	**177**	N.C.	24716	0.7%	53388	0.3%
Woodpigeon	0	8	0	0	0	**8**	N.C.	10	**80.0%**	2865000	<0.1%
Collared dove	0	4	0	0	0	**4**	N.C.	50 -100	5.3%	298000	<0.1%
Skylark	745	867	204	225	142	**>2183**	N.C.	24000-32000	ca 10%	1785000	<0.1%
Meadow pipit	Common	Common	Common	Common	102	**Common**	N.C.	8000-12500	ca 10%	1680000	<0.1%
Rock Pipit	0	<5	0	0	0	**<5**	N.C.	2000 - 4000	<1%	35650	<0.1%
Wren	53	51	20	35	10	**169**	N.C.	1500 - 3000	7.5%	8512000	<0.1%
Wheatear	77	147	10	24	35	**293**	N.C.	7000 - 10000	3.4%	56000	0.5%
Blackbird	1	6	0	1	1	**9**	N.C.	1000 - 2000	0.6%	4935000	<0.1%
Goldcrest	0	1	0	0	0	**1**	N.C.	1 - 4	**33.3%**	842000	<0.1%
Hooded crow	11	14	0	3	1	**29**	N.C.	500 - 800	4.5%	213900	<0.1%
Raven	1	8	1	1	1	**12**	N.C.	200 - 210	5.9%	12900	<0.1%
Starling	5	17	0	0	0	**22**	N.C.	10000 - 20000	0.1%	804000	<0.1%
Twite	0	0	0	0	1	**1**	N.C.	ca.500	0.2%	11000	<0.1%
Fieldfare	1	0	0	0	0	**0-1**	N.C.	<1	high	<1	High

Table 16. The abundance and nature conservation status of species recorded during the 2005 breeding bird survey of the WSA. Birds listed in Annex 1 of the Birds Directive and Schedule 1 of the WCA are shown in bold.[9] Red-listed birds of Conservation Concern are shown in italic. (B=common breeder, territories not mapped).

(a). Breeding birds

Species	No. of territories		
	North	South	Total
Red-throated diver	See Part 2		
Fulmar	2	26	28
Greylag goose	21	14	35
Merlin	See Part 2		
Red grouse	19	17	36
Oystercatcher	75	139	214
Ringed plover	8	25	33
Golden plover	39	92	131
Lapwing	32	77	109
Dunlin	20	49	69
Snipe	82	180	262
Whimbrel	5	23	28
Curlew	110	138	248
Redshank	19	36	55
Common sandpiper		6	6
Arctic skua	6	22	28
Great skua	15	43	58
Black-headed gull		37	37
Common gull	34	98	132
Lesser black-backed gull	1	4	5
Herring gull	2	4	6
Great black-backed gull	33	44	77
Common tern	1	4	5
Arctic tern	38	74	112
Woodpigeon		8	8
Collared dove		4	4
Skylark	745	867	1612
Meadow pipit	B	B	B
Rock pipit	B	B	B
Wren	36	51	87
Wheatear	66	147	213
Blackbird	1	6	7
Goldcrest		1	1
Hooded crow	9	14	23
Raven	1	8	9
Starling	5	17	22

[9] In the case of Schedule 1 species, only those likely to breed are indicated.

(b). Species present but apparently not breeding

Species	North	South
Mute swan		●
Mallard	●	●
Eider	●	
Red-breasted merganser		●
Teal		●
Black guillemot	●	
Pied/white wagtail	●	●
Twite	●	

Table 17. The abundance and nature conservation status of species recorded during the 2003 breeding bird survey of the ESA. Details as per Table 16.

(a). Breeding birds

Species	**No. territories**		
	North	**South**	**Total**
Red-throated diver	See Part 2		
Fulmar	13	2	15
Greylag goose	1	2	3
Merlin	See Part 2		
Red grouse	10	14	24
Oystercatcher	20	25	45
Ringer plover	2	6	8
Golden plover	28	32	60
Lapwing	11	21	32
Dunlin	10	16	26
Snipe	47	81	128
Whimbrel	9	11	20
Curlew	44	83	127
Redshank	7	4	11
Common sandpiper	1	1	2
Arctic skua	6	14	20
Great skua	20	22	42
Common gull	28	17	43
Great black-backed gull	24	14	38
Common tern	0	1	1
Arctic tern	34	2	36
Skylark	204	225	429
Meadow pipit	B	B	B
Wren	20	33	53
Wheatear	10	7	17
Blackbird	0	1	1
Hooded crow	0	3	3
Raven	1	1	2

(b). Species present but apparently not breeding

	No. territories	
Species	**North**	**South**
Grey heron		●
Red-breasted merganser	●	
Teal	●	●
Mallard	●	●
Black-headed gull		●
Lesser black-backed gull	●	●
Herring gull	●	
Song thrush		●

Table 18. The abundance and nature conservation status of species recorded during the 2006 breeding bird survey of the ESA. Details as per Table 16.

(a). Breeding birds

Species	**No. territories**		
	North	**South**	**Total**
Red-throated diver	See Part 2		
Fulmar	5	1	6
Greylag goose	P	8	8
Mallard	P	1	1
Merlin	See Part 2		
Red grouse	6	8	14
Oystercatcher	7	34	41
Ringer plover	1	7	8
Golden plover	15	28	43
Lapwing	2	11	13
Dunlin	2	19	21
Snipe	18	33	51
Whimbrel	4	9	13
Curlew	15	62	77
Redshank	2	10	12
Common sandpiper	P	1	1
Arctic skua	4	12	16
Great skua	7	20	27
Black-headed gull	32	101	132
Common gull	3	13	16
Great black-backed gull	2	27	29
Arctic tern	2	0	2
Skylark	B	B	B
Meadow pipit	B	B	B
Wren	9	9	18
Wheatear	27	23	50
Hooded crow	P	2	2
Raven	1	1	2

(b). Species present but apparently not breeding

Species	**No. territories**	
	North	**South**
Grey heron	•	
Wigeon		•
Teal	•	•
Kestrel	•	
Herring gull	•	
Starling		•
Twite	•	

Table 19. The abundance (number of territories) and nature conservation status of breeding species recorded during the 2007 breeding bird survey in the eight small additional survey areas. In addition, meadow pipit and skylark were common breeding species but were no surveyed. Birds listed in Annex 1 of the Birds Directive and Schedule 1 of the WCA are shown in bold. Red-listed birds of Conservation Concern and UK BAP species are shown in italic.

Species	Survey Area (Area in ha)								
	Scatsta (617.9)	Voe (159.8)	Laxo (129.4)	Bellister (57.9)	Skellister (71.6)	Catfirth (126.5)	Aith (140.3)	Dales Voe (64.6)	Total (1368.0)
Red-throated diver	1					1			2
Greylag goose	4	2					2		8
Wigeon						1			1
Mallard							1		1
Eider	1								1
Merlin	1								1
Red grouse	4	2		1		3			10
Oystercatcher	3	8	7	2		4	2	5	31
Ringed plover	1				1	1			3
Golden plover	9	1				4			14
Lapwing	2	9	4			8		2	25
Dunlin	1					3			4
Snipe	14	3	2	2	3	2	2		28
Black-tailed godwit						1			1
Whimbrel	4	1		1		3	1		10
Curlew	11	6	4	3	1	5	4	3	37
Redshank	4	1	2			3	1	2	13
Arctic skua	1								1
Great skua	4								4
Black-headed gull						10			10
Great black-backed gull	4		1		3		1		9
Common gull		15	1			2		2	20
Lesser black-backed gull		1							1
Arctic tern								18	18
Wren	16				1	1		1	19
Wheatear	7	5	5	1	1	5		4	28
Hooded crow	2								2

Table 20. The abundance (number of territories) and nature conservation status of breeding species recorded during the 2008 breeding bird surveys of the vicinity of proposed access roads. These birds are additional to those in Table 15. Birds listed in Annex 1 of the Birds Directive and Schedule 1 of the WCA are shown in bold. Red-listed birds of Conservation Concern are shown in italic.

Species	Delting NW, Scatsta access	Nesting SW, Sand Water access	Kergourd S, Hill of Sound access	Nesting SE, Skellister access	Delting SW, Filli Field access	Delting NE, Hill of Swinister access	Kergourd SE, Burn of Weisdale access and Lamba Scord access	Total breeding territories
Area surveyed (km^2)	**1.336**	**0.661**	**1.635**	**1.031**	**1.653**	**1.726**	**1.509**	**9.551**
Red-throated diver	0	(1)	(1 flew over)	0	0	0	0	0
Fulmar	0	0	1	0	0	0	0	1
Greylag goose	0	0	1	0	0	1 (7)	1 (24)	1
Common Eider	3	0	0	(3)	0	0	0	3
Wigeon	0	0	0	1	0	0	0	1
Teal	0	1	0	0	0	0	1	2
Mallard	(6)	0	0	0	0	2	(1)	2
Kestrel	0	(1 pr)	(1 flew over)	0	0	(1 flew over)	0	0
Merlin	single hunting	1	0	0	single hunting	single hunting	0	1
Red grouse	2	3	0	0	0	1	1	7
Oystercatcher	6	3	5	5	7	7	8	41
Ringed plover	2	1	2	2	0	0	1	8
Golden plover	2	0	0	0	5	0	0	7
Lapwing	4	3	1	4	4	2	9	27
Dunlin	(9)	1	0	0	(1)	0	0	1
Snipe	6	5	6	5	9	10	9	50
Whimbrel	0	1	(1 flew over)	1	0	1	3	6
Curlew	7	4	3	2	8	9	11	44
Black-tailed Godwit	0	1	0	0	0	0	0	1
Redshank	5	3	0	3	4	2	9	26
Common sandpiper	0	0	0	0	0	0	1	1
Arctic skua	0	0	0	0	1	0	0	1
Black-headed gull	0	0	0	0	0	(17)	0	0
Common gull	0	0	4	0	3	(20)	(1)	7

Herring gull	0	0	0	0	0	(90)	0	0
Lesser Black-backed Gull	0	0	0	0	0	(11)	0	0
Great black-backed gull	0	0	0	1	0	(6)	(1)	1
Arctic tern	11	(1)	0	0	0	(20)	(1)	11
Meadow pipit	25	9	11	8	16	15	18	102
Wren	1	1	2	1	1	0	4	10
Wheatear	3	4	6	9	7	0	6	35
Hooded crow	1	0	(1)	0	(12)	0	(1)	1
Raven	0	0	1	0	0	0	0	1
Twite	0	0	0	1	0	0	0	1
Skylark	36	14	18	10	19	18	27	142
Blackbird	0	0	1	0	0	0	0	1

Table 21. Species recorded during VP observations of flight activity in the WSA, 2005-06. The number of 5-min recording periods in which each species was encountered during watches from all VPs (n=13829) is shown. Other details as per Table 16.

Species	*Target Species*	Occurrences	
		No.	%
Great-black-backed gull		3255	23.5
Curlew		2571	18.6
Common gull		2192	15.9
Great skua		1772	12.8
Raven		1547	11.2
Hooded crow		1178	8.5
Lapwing		1178	8.5
Herring gull		1137	8.2
Oystercatcher		1011	7.3
Snipe		556	4.0
Golden plover		418	3.0
Black-headed gull		390	2.8
Redshank		283	2.0
Fulmar		243	1.8
Arctic skua		208	1.5
Red-throated diver	●	185	1.3
Greylag goose		167	1.2
Lesser-black-backed gull		146	1.1
Arctic tern		137	1.0
Whimbrel		97	0.7
Mallard		70	0.5
Rock dove		61	0.4
Ringed plover		45	0.3
Merlin	●	38	0.3
Grey heron		12	0.1
Red grouse		12	0.1
Hen harrier	●	10	0.1
Dunlin		10	0.1
Sparrow hawk		9	0.1
Wood pigeon		9	0.1
Hobby	●	5	<0.1
Kestrel		5	<0.1
Teal		3	<0.1
Pink-footed goose		2	<0.1
Gyr falcon	●	2	<0.1
Peregrine	●	2	<0.1
Common sandpiper		2	<0.1
Kittiwake		2	<0.1
Collared dove		2	<0.1
Snow bunting		2	<0.1
Geese sp.		2	<0.1
Cormorant		1	<0.1
Whooper swan	●	1	<0.1
Barnacle goose	●	1	<0.1
Goldeneye		1	<0.1
Buzzard		1	<0.1
Knot		1	<0.1
Green sandpiper		1	<0.1
Guillemot		1	<0.1
Wryneck		1	<0.1
Common Tern		1	<0.1

Table 22. Flight activity within the WSA by selected Target Species in 2005-06. Tables show the number of flights, total bird flying time and time that birds spent within various categories of estimated flying height. Where seasonal sub-totals are shown the data are grouped according to species-specific breeding / non-breeding periods.

(a) Red-throated diver

01 Apr – 15 Sep			**Flying height (s)**				
VP	**No. flights**	**Total fly. time (s)**	**<10 m**	**10-50 m**	**50-100 m**	**100-150m**	**>150 m**
1	4	198	0	61	137	0	0
2	10	511	183	293	35	0	0
4	3	260	0	12	0	179	69
6	2	72	0	72	0	0	0
9	1	12	12	0	0	0	0
10	18	1581	222	352	1007	0	0
11	34	3818	228	2629	845	116	0
13	12	906	0	210	335	338	23
15	24	1428	176	701	551	0	0
16	6	389	23	306	60	0	0
18	4	385	53	194	138	0	0
19	5	264	0	110	154	0	0
20	4	547	0	474	73	0	0
21	2	77	0	41	36	0	0
23	6	392	0	62	330	0	0
24	3	86	30	56	0	0	0
26	2	520	0	0	520	0	0
27	3	70	0	0	0	0	70
30	77	9323	1349	2358	5364	252	0
31	35	3587	220	2056	1016	181	114
Overall	255	24426	2496	9987	10601	1066	276
16 Sep – 31 Mar			**Flying height (s)**				
VP	**No. flights**	**Total fly. time (s)**	**<10 m**	**10-50 m**	**50-100 m**	**100-150m**	**>150 m**
18	1	86	0	14	72	0	0
19	1	16	8	8	0	0	0
Overall	2	102	8	22	72	0	0

(b) Hen harrier

Nov – Mar			**Flying height (s)**				
VP	**No. flights**	**Total fly. time (s)**	**<10 m**	**10-50 m**	**50-100 m**	**100-150m**	**>150 m**
3	1	34	34	0	0	0	0
5	1	125	97	28	0	0	0
7	1	72	43	29	0	0	0
8	2	83	69	14	0	0	0
13	1	214	214	0	0	0	0
19	1	136	136	0	0	0	0
31	1	111	28	83	0	0	0
Overall	8	775	621	154	0	0	0

(c) Merlin

01 Apr – 31 Aug			Flying height (s)				
VP	**No. flights**	**Total fly. time (s)**	**<10 m**	**10-50 m**	**50-100 m**	**100-150m**	**>150 m**
5	3	169	54	98	17	0	0
6	2	36	10	26	0	0	0
7	3	42	34	8	0	0	0
8	2	79	47	32	0	0	0
12	1	18	9	9	0	0	0
15	1	5	5	0	0	0	0
18	1	18	18	0	0	0	0
19	1	33	33	0	0	0	0
20	1	71	14	57	0	0	0
27	1	42	0	28	14	0	0
30	1	16	16	0	0	0	0
31	4	218	38	121	44	15	0
Overall	21	747	278	379	75	15	0
01 Sep – 31 Mar			**Flying height (s)**				
VP	**No. flights**	**Total fly. time (s)**	**<10 m**	**10-50 m**	**50-100 m**	**100-150m**	**>150 m**
3	1	22	22	0	0	0	0
4	1	48	48	0	0	0	0
5	4	127	79	48	0	0	0
13	1	48	24	24	0	0	0
15	1	29	29	0	0	0	0
19	1	182	182	0	0	0	0
22	1	20	20	0	0	0	0
26	1	50	50	0	0	0	0
31	5	136	107	29	0	0	0
Overall	16	662	561	101	0	0	0

Table 23. Species recorded during VP observations of flight activity in the ESA. The number of 5-min recording periods in which each species was encountered during watches from all VPs is shown. Other details as per Table 16.

(a) 2003 (no. of 5-min recording periods = 4788)

Species	***Target Species***	**Occurrences**	
		No.	**%**
Curlew		1144	23.9
Great black-backed gull		1070	22.3
Great skua		738	15.4
Hooded crow		470	9.8
Common gull		466	9.7
Snipe		335	7.0
Golden plover		321	6.7
Arctic skua		275	5.7
Raven		273	5.7
Herring gull		214	4.5
Lapwing		211	4.4
Red-throated diver	●	140	2.9
Oystercatcher		127	2.7
Whimbrel		99	2.1
Arctic tern		46	1.0
Dunlin		38	0.8
Redshank		37	0.8
Fulmar		31	0.6
Greylag goose		19	0.4
Ringed plover		17	0.4
Lesser black-backed gull		16	0.3
Black-headed gull		11	0.2
Red grouse		8	0.2
Common tern		3	0.1
Cormorant		2	<0.1
Goldeneye		1	<0.1
Kestrel		2	<0.1
Kittiwake		2	<0.1
Merlin	●	3	0.1
Peregrine	●	1	<0.1
Red-breasted merganser		1	<0.1
Teal		2	<0.1
Wigeon		1	<0.1

(b) 2006-07 (no. of 5-min recording periods = 4565)

Species	***Target Species***	**Occurrences**	
		No.	**%**
Great black-backed gull		782	17.1
Raven		590	12.9
Hooded crow		500	10.9
Curlew		329	7.2
Great skua		302	6.6
Common gull		217	4.8
Herring gull		139	3.0
Black-headed gull		124	2.7
Oystercatcher		100	2.2
Lapwing		99	2.2
Arctic skua		85	1.9
Snipe		51	1.1
Golden plover		40	0.9
Red-throated diver	●	30	0.7
Greylag goose		26	0.6
Fulmar		22	0.5
Arctic tern		21	0.5
Mallard		17	0.4
Redshank		14	0.3
Whimbrel		13	0.3
Grey heron		10	0.2
Lesser black-backed gull		9	0.2
Merlin	●	5	0.1
Sparrowhawk		4	0.1
Kestrel		4	0.1
Ringed plover		4	0.1
Red-breasted merganser		3	0.1
Hen harrier	●	3	0.1
Cormorant		2	<0.1
Wigeon		2	<0.1
Marsh harrier	●	2	<0.1
Peregrine	●	2	<0.1
Dunlin		2	<0.1
Rock dove		2	<0.1
Teal		1	<0.1
Goosander		1	<0.1
Red grouse		1	<0.1
Short-eared owl	●	1	<0.1
Skylark		1	<0.1
Common tern		1	<0.1

Table 24. Flight activity within the ESA by selected *Target Species*. Tables show the number of flights, total bird flying time and time that birds spent within various categories of estimated flying height.

(a) Red-throated diver

2003			Flying height		
VP	**No. flights**	**Total fly. time (s)**	**<10 m**	**10-100 m**	**>100 m**
E1	6	330	68	262	0
E2	1	112	0	112	0
E3	1	52	0	52	0
E4	5	207	0	207	0
E5	23	1299	242	910	147
E6	31	1656	312	1344	0
E7	7	351	41	310	0
E8	16	1140	98	703	339
E9	35	2774	243	2531	0
E10	5	247	0	234	13
E11	3	216	0	216	0
E12	44	5884	323	5443	118
Overall	177	14268	1327	12324	617

2006-07			Flying height				
VP	**No. flights**	**Total fly. Time (s)**	**<10m**	**10-50 m**	**50-100 m**	**100-150m**	**>150 m**
E1	2	252	0	252	0	0	0
E2	2	418	0	418	0	0	0
E4	2	124	0	100	24	0	0
E5	3	263	26	154	83	0	0
E6	8	606	58	419	129	0	0
E9	6	1030	85	832	113	0	0
E11	4	337	0	248	89	0	0
E12	3	235	0	235	0	0	0
Overall	30	3265	169	2658	438	0	0

(b) Merlin

2003			Flying height		
VP	**No. flights**	**Total fly. time (s)**	**<10m**	**10-100 m**	**>100 m**
E7	1	302	0	302	0
E11	1	12	12	0	0
Overall	2	314	12	302	0

2006-07			Flying height				
VP	**No. flights**	**Total fly. time (s)**	**<10m**	**10-50 m**	**50-100 m**	**100-150m**	**>150 m**
E4	1	28	0	14	14	0	0
E8	2	68	14	54	0	0	0
E9	1	22	11	11	0	0	0
E10	1	124	0	124	0	0	0

Overall	5	242	25	203	14	0	0

Table 25. Estimated percentage of flight activity observed in successive distance zones from VPs during watches in 2007 and 2008. Data for merlin include flights seen during generic VP watches made in 2005 and 2006. To examine dunlin flight activity, the 0-250m zone was divided into two 125m zones. All values are rounded to the nearest whole percent.

Distance Zone	Greylag goose	Great skua	Arctic skua	Merlin	Golden plover	Whimbrel	Dunlin
0-125m	N/A	N/A	N/A	N/A	N/A	N/A	100%
125-250m	N/A	N/A	N/A	N/A	N/A	N/A	19%
0-250m	100.0%	100%	100%	100%	100%	100%	N/A
250-500m	100.0%	100%	100%	100%	39%	44%	2%
500-750m	100.0%	60%	71%	59%	32%	24%	0%
750-1000m	100.0%	54%	42%	39%	15%	8%	0%
1000-1250m	34.7%	42%	15%	21%	7%	2%	0%
1250-1500m	15.6%	28%	5%	10%	1%	1%	0%
1500-1750m	13.9%	19%	2%	6%	0%	0%	0%
1750-2000m	9.7%	19%	1%	3%	0%	0%	0%
2000-2250m	8.9%	15%	1%	0%	0%	0%	0%
2250-2500m	4.4%	8%	1%	0%	0%	0%	0%
ETTD (see text)	1259	1228	894	924	578	517	159
No. of flights	12	185	111	43	67	95	28
Total observed flight time (s)	981	23783	12704	1764	6110	8807	1110

Table 26. Summary of estimated flying heights of birds seen during flight activity watches made from 2005 to 2007. For red-throated diver and merlin data from focal watches at breeding sites and from generic type VP watches are treated separately. Flying heights of waders, skuas and greylag were assessed in 2007 only. Refer to text in Parts 1 and 2.

Species	Height Category					No. of 15 sec intervals assessed	No. of flights
	<10m	10-50m	50-100m	100-150m	150+m		
Red-throated diver (generic VPs)	9.3%	47.2%	39.9%	3.6%	0.9%	2399	339
Red-th. diver (focal watches)	10.7%	60.0%	22.8%	4.6%	1.9%	11953	1310
Merlin (generic VPs, plus incidental)	56.0%	39.7%	3.5%	0.7%	0.0%	141	49
Merlin (nest watches, plus incidental)	50.0%	45.9%	4.1%	0.0%	0.0%	242	75
Hen harrier	85.7%	14.3%	0%	0%	0%	98	13
Dunlin	64.8%	26.1%	9.1%	0.0%	0.0%	88	28
Golden Plover	14.2%	38.3%	31.9%	11.3%	4.2%	379	67
Whimbrel	37.4%	43.7%	17.6%	1.3%	0.0%	602	95
Greylag	14.1%	40.6%	23.4%	14.1%	7.8%	64	12
Arctic Skua	47.9%	36.6%	10.8%	3.3%	1.4%	768	111
Great Skua	20.3%	45.6%	24.1%	6.7%	3.4%	1652	185

Table 27. Summary of flight activity by wildfowl over the WSA during spring and autumn migratory period in 2005. 'Local' times are shown.

Date	Species	Number	Time	Direction	Height (m)
08/03/2005	Greylag goose	4	1249	S-N	30
17/03/2005	Greylag goose	2	1250	S-N	20
17/03/2005	Greylag goose	3	1142	SE-NNW	50-100
17/03/2005	Greylag goose	8	0935	NE-SW	50
15/04/2005	Greylag goose	7	1209	SE-NW	50-100
21/09/2005	Greylag goose	9	1129	W-E	30
24/09/2005	Pink-footed goose	21	1158	W-E	300
24/09/2005	Pink-footed goose	31	1155	W-E	300
11/10/2005	Greylag goose	16	0951	NW-SE	150+
13/10/2005	Greylag goose	24	1100	N-SW	300+
13/10/2005	Greylag goose	12	1120	N-S	100+
13/10/2005	Greylag goose	4	1139	N-S	10-50
27/10/2005	Greylag goose	49	0920	S-N	150+
31/10/2005	Greylag goose	9	0814	W-E	150+
07/11/2005	Greylag goose	14	1403	WNW-ESE	100+
07/11/2005	Greylag goose	7	1122	W-S	100

Table 28. Summary of flight activity by migratory wildfowl over the ESA in 2006.

Date	Species	Number	Time	Direction	Height (m)
05/04/2006	Greylag goose	2	1659	N-S	150
12/04/2006	Greylag goose	7	1320	SE-N	10-50
08/11/2006	Greylag goose	5	1440	SW-ENE	5-10
08/11/2006	Whooper swan	4	1447	SW-NE	15-40
15/11/2006	Greylag goose	35	0957	NW-SE	10-15
15/11/2006	Pink-footed goose	1	0957	NW-SE	10-15

Table 29. Birds recorded during transect surveys in the WSA, autumn / winter 2005-06. The number of times each species was recorded is shown. Species are arranged in descending order of total occurrences. Other details as per Table 16.

Species	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**
Hooded crow	3	15	8	10	6
Raven	6	8	8	2	8
Great black-backed gull		5	6	10	9
Snipe	6	9	1		3
Redwing	12	6			
Curlew	5	5	1	4	2
Fieldfare	4	10			
Greylag goose	4	1	3	1	2
Snow bunting	1	8	1	1	
Wren	3	2		2	2
Common gull	1	3		1	3
Red grouse	1	3	1	2	
Redshank	2	1	1		2
Herring gull	1	1	1		2
Starling	2	1		1	1
Grey heron	2			1	1
Mallard	1	1			2
Oystercatcher	1				2
Golden plover	1	1			1
Lapwing	1	1			1
Blackbird	3				
Rook		1		2	
Fulmar	1			1	
Whooper swan			1		1
Wigeon	1				1
Skylark	1				1
Hen harrier					1
Merlin	1				
Ringed plover	1				
Bar-tailed godwit	1				
Turnstone					1
Black-headed gull	1				
Waxwing	1				
Blackbird		1			
Song thrush	1				
Blackcap	1				
Greenfinch	1				
Twite	1				
Mealy redpoll	1				

Table 30. Birds recorded during transect surveys in the ESA, autumn/winter 2003-04. The number of times each species was recorded is shown. Species are arranged in descending order of total occurrences. Other details as per Table 16.

Species	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Great black-backed gull	10	4	9	9	9	6	7
Raven	5	10	3	4	8	6	8
Hooded crow	8	4	8	5	2	4	3
Red grouse	6	6	5		5	3	4
Snipe	5	10	5	2	1	1	2
Mallard	10	6				4	
Wren		4	6	1	3	2	2
Whooper swan	1	9	2		1		
Golden plover	2	1	1			4	5
Redshank	1	5	2			3	
Teal	2	4		2		2	
Meadow pipit			4	3	1		1
Wigeon	1	5	2				
Lapwing	2	4				1	
Curlew	2	4	1				
Greylag goose	1	3	2				
Fieldfare		2	3				
Goldeneye					1	1	2
Red-breasted merganser	1		1		1	1	
Herring gull	1	1	1	1			
Snow bunting	1			2	1		
Mute swan	3						
Moorhen	1	2					
Red-throated diver	2						
Canada goose	1	1					
Rock dove		2					
Blackbird			2				
Redwing	1	1					
Little egret		1					
Pintail		1					
Great skua	1						
Lesser black-backed gull	1						
Turtle dove		1					
Wheatear	1						
Song thrush			1				
Starling		1					

Table 31. Birds recorded during transect surveys in the ESA, March 2006 and autumn/winter 2006-07. The number of times each species was recorded is shown. Species are arranged in descending order of total occurrences. Other details as per Table 16.

Species	Mar		Sep	Oct	Nov	Dec	Jan	Feb
Raven	17		4	3	3	4	1	2
Great black-backed gull	19		2	3	3	2	1	3
Hooded crow	3		2	6	5	4	2	4
Snipe	3			3	5	3		2
Curlew	6		1	4	1			2
Lapwing	8		1	2	1			
Wren	2			2	2			3
Redwing	1			6	2			
Red grouse	2			1	1	1		3
Skylark	6							
Blackbird	2			3		1		
Greylag goose	1			1	2			1
Golden plover	4							
Mallard					1	1		1
Redshank	2			1				
Meadow pipit	3							
Fieldfare	2			1				
Snow bunting				1		1		1
Grey heron					2			
Merlin	2							
Oystercatcher	2							
Herring gull	1				1			
Wigeon					1			
Teal					1			
Tufted duck					1			
Hen harrier	1							
Woodcock	1							
Black-headed gull						1		
Common gull	1							
Woodpigeon	1							
Robin				1				
Song thrush	1							
Blackcap				1				
Starling	1							

Table 32. Monthly peak counts of whooper swans recorded during driven / walked transect surveys, 2005-06.

Location	Jan	Feb	Mar	Apr	May	Oct	Nov	Dec	Max
Dales Lees								3	3
East Burrafirth			3	3					3
Grunna Water							5		5
Kirkhouse Loch			3	1	1	1			3
Loch of Benston			7	9					9
Loch of Freester					3		8		8
Loch of Houster	1		1	5	4	1	6		6
Loch of Trondavoe	3		4		2		2		4
Loch of Voe	3			1	2				3
Mill Loch (NW quadrant)								4	4
Near Twatt			1						1
North Loch			1			8	3	6	8
Petta Water			3	3			2	2	3
Sae Water		3	3	1	2		3		3
Sand Water			2	5	3				5
South of Voe			3	2					3
Weisdale area	1			1					1

Table 33. Hen harriers recorded during roost watches in 2005-06. Age/sex was recorded as adult male, female, and undifferentiated female / 1st calendar year male (RT = 'ringtail').

Date	Time	No.	Bout	Dur (s)	Age/sex	Notes
17/12/2005	1404	1	1a		RT	
17/12/2005	1404	1	1b		RT	
17/12/2005		1	2		RT	One of above RT joined adult M (bout 3)
17/12/2005	1421	1	3		AD M	
24/12/2005	1456	1	1	130	AD M	
31/12/2005	1426	1	1		RT	
02/01/2006	1421	1	1		RT	Incoming flight + 2 short flights (bouts 2 & 3)
02/01/2006		1	2		RT	See bout 1
02/01/2006		1	3		RT	See bout 1
26/01/2006	1430	1	1		RT	Not same bird as above, watch 1430-1530
30/01/2006	1435	1	1	192	AD M	
09/02/2006	1530	1	1	123	AD M	Sand Water
09/02/2006	1616	1	2	70	F	
09/02/2006	1523	1	1	191	AD M	Same bird as seen earlier
09/02/2006	1605	1	2	105		Same bird as seen earlier

Table 34. Numbers of meadow pipit recorded from 5-km transects in the ESA in 2006.

Transect	Date	Distance band				
		1-10m	11-50m	51-100m	101-150m	>150m
1	23/05/2006	3	1	12	3	1
1	09/06/2006	6	4	8	4	0
2	26/05/2006	8	14	4	0	0
2	28/06/2006	31	30	3	1	0

Table 35. Numbers of skylark recorded from 5-km transects in the ESA in 2006.

Transect	Date of transect	Distance band				
		1-10m	11-50m	51-100m	101-150m	>150m
1	23/05/2006	4	2	12	3	3
1	09/06/2006	4	5	9	12	4
2	26/05/2006	4	20	19	3	1
2	28/06/2006	12	35	9	6	4

Table 36. Mean numbers of meadow pipits and skylarks recorded from transects at Viking and at upland sites A-E elsewhere in the UK, in 2006.

Month	Location	Meadow pipit		Skylark	
		1-50m	Total	1-50m	Total
May	Sites A-E	82.7	104.0	30.7	37.0
	Viking	13.0	23.0	15.0	35.5
June	Sites A-E	61.8	118.7	7.8	30.8
	Viking	30.5	43.5	28.0	33.0
May + June	Sites A-E	144.5	222.7	38.5	67.8
	Viking	43.5	66.5	43.0	68.5

Table 37. Records of migrant raptors, owls and skuas seen during fieldwork on the Viking site 2005-2008.

Species	Dates	Location
Marsh Harrier	several dates May & Jun 2006	Nesting quadrant
Hen harrier	several dates Mar & Apr 2005	Kergord quadrant
	Dec 2005 to Feb 2006	Kergord and Nesting quadrants (2 ringtails and 1 adult male)
	4 Apr 2006	E of Voe, Collafirth quadrant
Osprey	several dates Jul 2005	Nesting and Kergord quadrants
	Seen on many dates, Sep 2008	Sand Water and Kergord quadrant lochs (two birds)
Honey Buzzard	6 Sep 2005	Delting quadrant, (migrating S)
Buzzard	10 May 2005	Kergord quadrant
Sparrowhawk	Several dates Mar to Aug 2005	Delting and Kergord quadrants
	Several dates Apr to Jul 2006	Kergord quadrant
Peregrine	11 May 2005	Kergord quadrant
	18 Aug 2005	Collafirth quadrant
	27 Oct 2006	Kergord quadrant
	13 Dec 2006	Kergord quadrant
	28 Jul 2008	Delting quadrant
Gyr Falcon	Several dates Feb & Mar 2005	Nesting and Kergord quadrants(adult white morph)
Kestrel	Several dates May, Jun & Jul 2005	All quadrants
	17 May 2006	Kergord quadrant
	Two dates Sep 2006	Kergord quadrant
	May 2008	Nesting quadrant, pair apparently attempted to take over an occupied merlin territory
Red-footed Falcon,	12 Jun 2006	Collafirth quadrant (imm. male)
Hobby	20 Aug 2005	Kergord quadrant
	17 Jun 2007	Swinning, Nesting quadrant
Short-eared owl	3 May 2006	Nesting quadrant
Long-tailed skua	18-23 May 2005	Moorland at Sussiter and Skelladale, Collafirth quadrant

Table 38. Summary of watches for red-throated diver flights each year.

Year	Focal point watches (hours)	No. of flights logged during watches.	No. of flights logged incidentally to other fieldwork	Total flights logged
2003	170	50	0	50
2004[1]	178	233	0	233
2005	398	807	128	935
2006	794	792	161	1015
2007	20	17	6	23
All years	1560	1899	295	2256

[1] Data from Natural Research 2004 red-throated diver study.

Table 39. The number of red-throated divers found in each year, 2003 - 2008.

	2003	2004[1]	2005	2006	2007	2008
Confirmed breeding	16 prs	44 prs	37 prs	43 prs	43 prs	41 prs
Probable breeding	0	0	0	5 prs	5 prs	4 prs
Territorial non-breeding pair	*c.*7 prs	No data	10 prs	13 prs	8+ prs	No data
Other non-breeding birds	No data	No data	19+ birds	*c.*23 birds	No data	No data
Estimated total birds	Unknown	Unknown	111 birds	145 birds	No data	No data
Survey coverage	All lochs marked on OS map within ESA plus 2-km	All lochs marked on OS map within VDSA	All lochs within WSA plus 2-km buffer.[2]	All lochs within VDSA, incl. islands	All breeding lochs within VDSA, excl. islands.	All breeding lochs within VDSA, excl. islands and Sullom

	buffer					Voe moors.

[1] Data from Natural Research 2004 red-throated diver study
[2] Some unmarked lochans remained undiscovered in 2005.

Table 40. The number of lochs and lochans in the VDSA used for breeding activities by red-throated divers.

Status	2003	2004[1]	2005	2006	2007	2008	All years
Occupied nesting loch[2]	16	44	41	54	53	46	69[3]
Satellite to a nesting loch[4]	No data	No data	4	4	3	4	4
Vacant nesting loch	No data	No data	12	14	15	19	Not applicable
Survey coverage	All lochs marked on OS map within ESA plus 2-km buffer	All lochs marked on OS map within VDSA. Lochs not covered.	All lochs in within WSA plus 2-km buffer.[2]	All lochs within VDSA incl. islands.	All lochs within VDSA excl. islands.	All lochs within VDSA excl. islands and Sullom Voe lochs	

[1] Data from Natural Research 2004 red-throated diver study
[2] A nesting loch is defined as any loch or lochan where egg laying has been confirmed in past 10 years.
[3] Includes two lochs where nesting not proven during 2003 -2008 but has occurred since 1994.
[4] Satellite lochs are nearby lochs used for loafing and, in some years, for chick-rearing also.

Table 41. The number of red-throated diver breeding lochs (nesting and chick-rearing lochs) in the VDSA, grouped into four categories of importance. Importance was classified on the basis of measures of breeding success and occupancy collected from 2003 to 2008. Full details in text

Importance	No. of lochs	%
Very High importance	15	21.7%
High importance	15	21.7%
Medium importance	18	26.1%
Low importance	21	30.5%
Total	70	100%

Table 42. The number of lochs greater than one hectare within the VDSA used by non-breeding red-throated divers(brief visits by prospecting birds excluded). Insufficient data were available for 2003, 2004, 2007 and 2008.

Status	2005	2006
Major use	3	3
Medium use	4	7
Minor use	9	14
No use recorded	1	3
Unknown (no or insufficient data)	10	0
Total lochs	27	27

Note. In all cases the Major and Medium use lochs supported one territorial non-breeding pair.

Note. Fourteen of these lochs were also used for nesting or chick rearing. In both years, one Major Use and two Minor Use lochs were also satellite breeding lochs, and one Medium use and two Minor Use loch were also used for nesting. Nesting is also known to have occurred at two Medium Use lochs and four Minor Use lochs but not in the year in question.

Table 43. The number of occupied red-throated diver nesting lochs that were vacant the following year.

Year	No. of occupied breeding lochs	No. of these lochs vacant following year[1]	Annual loss
2004	44	7	16%
2005	46	3	7%
2006	53	7	13%
2007	53	10	19%
Total	196	27	14%

[1] Due to difference in survey coverage between years, 2006 occupancy data were used for the five 2004 lochs not monitored in 2005.

Table 44. The number of additional occupied red-throated diver nesting lochs found in the four years following the 2004 survey.

Year	No. of occupied breeding lochs	No. of additional lochs found occupied in following year and known to be previously vacant[1]	Annual gain	No. of additional lochs found occupied in following year that were not previously known about.
2004	44	3	7%	5
2005	46	6	17%	6
2006	53	3	6%	1
2007	53	5	8%	0
Total	196	17	9%	11

[1] Due to difference in survey coverage between years, 2006 occupancy data were used for the five 2004 lochs not monitored in 2005.

Table 45. Breeding success measures for red-throated divers monitored on the Viking site between 2003 and 2008.

Year	No. breeding pairs monitored	% pairs hatching young	% pairs fledging[1] young	Fledged[1] chicks per breeding pair	Fledged[1] chicks per successful pair	Chick survival rate to fledging[1, 2]
2003	16	87.5	81.3	1.06	1.31	0.72
2004	44	65.9	45.5	0.66	1.45	0.58
2005	37	78.4	70.3	0.97	1.38	0.77
2006	48	72.9	52.1	0.75	1.44	0.62
2007	48	58.3	37.5	0.54	1.44	0.58
2008	45	64.4	46.7	0.67	1.43	0.61
Average, all years	**39.7**	**71.2**	**55.5**	**0.78**	**1.41**	**0.65**

[1] Survived to at least 4 weeks old.

[2] In cases where the number of chicks hatching was unknown it was assumed to be 1.5.

Table 46. Summary of red-throated diver focal point watches at breeding lochs within the VDSA. Results for pairs of lochs that were close together and could be watched from a single vantage point are pooled. Flights seen during other fieldwork are excluded. Inbound and outbound flights ended or originated at the focal loch were by the resident pair. Other flights were by intruders (57%), neighbouring pairs (29%) or were short local flights by the resident pair. Flights involving more than one bird were counted as a single flight.

Loch code	Year	Total hours watched	Inbound flights	Outbound flights	Other flights
AX	2004/2006	42.7	18	12	32
AY	2006	10.8	0	2	6
AZ	2006	28.2	11	15	72
BA	2005/2006	21.0	10	8	22
BB	2005	16.0	9	5	21
BC	2004	20.8	21	22	7
BD	2005	49.7	22	17	35
BE	2005/2006	35.5	10	8	0
BG	2005	40.2	19	11	67
BH	2005/2006	37.3	26	21	68
BI	2005	10.8	3	4	22
BK	2004/2006	33.7	13	13	72
BM	2004/2006	20.8	6	3	8
BN	2004	20.7	4	4	0
BO	2005	31.8	14	14	2
BP	2005	33.3	18	20	17
BU	2005	14.5	15	12	4
BV	2005	8.2	2	0	12
BX	2006	4.0	0	0	5
CN	2004/2005/2006	32.0	20	22	30
CO	2005	10.5	3	2	11
CP	2005	23.8	15	10	21
CR	2005	26.8	21	26	26
CS	2005/2006	41.2	22	23	35
CT	2004/2005/2006	43.8	30	26	29
CU	2006	8.0	1	1	3
DU	2004/2005/2006	39.7	14	5	20
DW	2006	21.5	15	6	8
FG	2007	20	7	6	4
FU	2005	38.2	6	8	9
GD	2006	23.7	11	12	29
GH/CQ	2005/2006	22.7	2	4	29
GL	2005	7.8	1	1	0
HM	2006	16.2	12	11	5
HO	2006	21.3	13	11	9
LBE	2006	2.0	1	1	0
LLG/HK	2005/2006	43.3	7	14	38
LMO	2006	7.2	4	4	1
LSW/DV	2006	14.8	11	9	11
Total	All years	944.5	437	393	790

Table 47. Summary of red-throated diver focal point watches at lochs used by non-breeding birds within the VDSA. Results for pairs of lochs that were close together and could be watched from a single vantage point are pooled. Flights seen during other fieldwork are excluded. Flights involving more than one bird were counted as a single flight.

Loch code	Year	Total hours	Flights
LGW	2005/2006	55.0	85
LLV	2006	13.2	1
LLX	2006	27.3	21
LMI	2006	45.8	32
LML (see BK)	2006	5.2	13
LMW (see CT)	2006	1.2	3
LPW	2006	39.3	4
LTW	2006	20.7	24
LMA/LLW	2006	20.7	0
LSK	2006	16.7	12
LWL	2006	13.7	3
Total	All years	258.7	198

Table 48. Summary of red-throated diver flight watches additional to focal watches made at various locations within the VDSA.

Year	Watch point	Total hours	Flights
2003	A1	13	6
2003	A2	28	10
2003	A3	13	5
2003	A4	10	4
2003	A5	24	0
2003	A6	9	5
2003	A7	24	6
2003	A8	49	14
2006	D1	31	2
2006	D2	4	2
2006	D3	9	0
2006	D4	19	6
2006	D5	15	6
2006	D6	3	0
2006	D7	18	0
2006	D8	17	9
2006	D9	5	6
2006	D10	21	0
2006	D11	18	0
2006	D12	27	0
Total		357	81

Table 49. Confirmed red-throated diver breeding lochs within the VDSA at which less than 20 flights were recorded in 2004-2006.

Loch code	Location	No. of flights	Focal watches?	Reason for low no. of recorded flights
BN	Core	11-19	Yes	Breeding failed 2005 & 2006
BV	Core	11-19	Yes	Breeding failed 2006, in high density area
LCW	Core	11-19	No	Breeding failed 2005 & 2006, in high density area
DT	Core	4-10	No	Breeding failed all years, in high density area
DV	Core	4-10	No	Breeding failed or not occupied all years, in high density area
LBE	Core	4-10	No	Outside survey area 2005, failed 2006 and 2007
AY	Core	4-10	Yes	Breeding failed all years
GL	Core	4-10	Yes	Breeding failed or loch vacant all years
HA	Core	<3	No	Breeding failed or loch vacant all years, low priority peripheral site
BF	Core	<3	No	Breeding failed 2005, vacant 2006, high density area
BJ	Core	<3	No	Breeding failed 2005, loch vacant 2006
BL	Core	<3	No	Vacant 2005 onwards
CW	Core	<3	No	Breeding failed 2005 & 2006, high density area
BX	Core	<3	No	Breeding failed or loch vacant all years, high density area
CV	Core	<3	No	Vacant 2005 onwards
GV	Core	<3	No	Breeding failed or loch vacant all years
CU	Peripheral (1 km zone)	4-10	Yes	Breeding failed or loch vacant all years
LMO	Peripheral (1 km zone)	4-10	Yes	Outwith 2005 area, low priority peripheral site
BZ	Peripheral (1 km zone)	<3	No	Outwith 2005 area, loch vacant 2006 onwards, low priority site
CJ	Peripheral (1 km zone)	<3	No	Breeding failed 2006, low priority peripheral site
LLB	Peripheral (1 km zone)	<3	No	Breeding failed all years, low priority peripheral site
LWS (E)	Peripheral (1 km zone)	<3	No	Outwith 2005 area, low priority peripheral site 2006
BQ	Peripheral (2 km zone)	<3	No	Breeding failed 2005 & '06, low priority peripheral site
BT	Peripheral (2 km zone)	<3	No	Breeding failed 2005 & '06, low priority peripheral site
BW	Peripheral (2 km zone)	<3	No	Fail 2006, low priority peripheral site
BY	Peripheral (2 km zone)	<3	No	Outwith 2005 area, loch vacant 2006 onwards
CL	Peripheral (2 km zone)	<3	No	Outwith 2005 area, low priority peripheral site 2006
GN	Peripheral (2 km zone)	<3	No	Vacant 2006, low priority peripheral site
HB	Peripheral (2 km zone)	<3	No	Low priority peripheral site
PL2	Peripheral	<3	No	Low priority peripheral site on offshore

	(2 km zone)			island

Table 50. Summary of red-throated diver flight activity through the breeding season at a hypothetical average breeding lochan with one breeding pair experiencing average breeding success. The flight frequencies for the post-fledge/post failure period are shown in parentheses because they are based on relatively little observation effort at a few lochs only. It is likely that the values for this period are unrepresentative and that a larger sample size would result in slightly lower values.

Bird status	Period	Lochs sampled	Watch effort (hours)	Mean hours daylight (civil twilight)	Mean no. birds/ flight event	Mean no. flight events /day	Mean no. bird flights /day /loch	Daily pattern	Mean duration (days)	Total flights
Resident pr.	Pre-lay	8	69	18	1.66	7.6	12.6	Uniform (not sig)	40	504
Intruders	Pre-lay			18	1.0	2.6	2.6	Uniform (not sig)	40	104
Resident pr.	Incubation	11	135	20	1.21	13.3	16.1	noon low (sig)	30	483
Intruders	Incubation			20	1.57	10.3	16.2	noon low (not sig)	30	486
Resident pr.	Chick rearing	34	695	20	1.31	24.4	31.9	noon low (sig)	35	1116
Intruders	Chick rearing			20	1.75	17.6	30.7	noon low (sig)	35	1074
Resident pr.	Post-fledge/fail	10	41	19	(1.75)	(10.8)	(18.9)	too few data	33	(623)
Intruders	Post-fledge/fail			19	(1.90)	(30.1)	(57.2)	too few data	33	(1887)
All birds	Whole season	39	941						138	6277

Table 51. Summary of estimated red-throated diver flight activity through the breeding season for a typical non-breeding lochan.

Bird status	Period	Lochs sampled	Watch effort (hours)	Mean hours daylight (civil twilight)	Mean no. birds/ flight event	Mean no. flight events /day	Mean no. bird flights /day /loch	Daily pattern	Mean duration (days)	Total flights in period
All birds	April and May	9	73	18	1.50	9.6	14.4	Significant	46	661
All birds	June	9	63	20.7	1.30	12.6	16.4	Uniform (not sig)	30	491
All birds	July	10	82	19.7	1.51	19.2	29.0	Significant	31	899
All birds	August	6	41	17.0	1.77	17.9	31.7	Significant	31	983
All birds	Whole season	12	258						138	3034

Table 52. Measurements of fog density made in July 2006.

Date	Time	Place	Object	Conditions	No. of repeat measurements	Mean 'just visible' distance (m)
05/07/2006	13:00	Loch of Waters	white object	blowing hill fog	2	95
05/07/2006	14:00	Loch of Waters	white object	blowing hill fog	2	115
09/07/2006	14:00	near Lerwick	Radio mast & guys	drizzly hill fog	2	158
17/07/2006	14:00	Sneugie Hill	white/grey Trig Point	blowing hill fog	2	130
18/07/2006	08:45	Weisdale Hill, bottom	white object	hill fog	3	68
18/07/2006	09:00	Weisdale Hill, mid	overhead cables	hill fog	2	51
18/07/2006	09:15	Weisdale Hill, top	Radio mast	hill fog	2	68
21/07/2006	17:30	Midfield	pale grey object	hill fog	2	125
21/07/2006	19:30	Midfield	pale grey object	hill fog	2	99

Table 53. The suitability for breeding of 56 lochs with no history of occupation, based on measures of length, average depth and shoreline.

Suitability score	
Unsuitable (score 0-2)	27 (48%)
Low (score 3-5)	14 (25%)
Moderate (score 6-8)	14 (25%)
Good (score 9-11)	1 (2%)

Table 54. Summary of focal watch effort at each occupied merlin territory in 2006 and the number and duration of flights logged.

Territory	Focal watch effort (hours)	No. of flights	Duration(s)	Additional incidental flights
C	3	5	216	4
D	6	10	537	0
E	6	8	376	3
F	0	0	0	2
G[1]	15.3	37	1602	3
H	0.8	2	74	0
K	0	0	0	0
L	1.8	6	52	1
M	0	0	0	1

[1] Includes 13 flights by juveniles totalling 759 seconds.

Table 55. Summary of status of merlin territories within the VMSA, 2003 - 2008.

Territory status	2003	2004	2005	2006	2007	2008
Area surveyed	ESA+2km	ESA+2km	WSA+2km	ESA+WSA+2km	ESA+WSA+2km	ESA+WSA+2km

Occupied by pair	2	3	7	9	10	9
Single adult present (apparently unpaired)	3	1	1	2	1	2
No. of territories checked	7	7	14	17	18	18

Table 56. The results of survey work at traditional merlin territories within the Viking Merlin Survey Area, 2003 - 2008. (* = data provided by P Ellis)

Territory	2003	2004	2005	2006	2007	2008
A	Not surveyed	Not surveyed	Unoccupied	Unoccupied	Unoccupied	Unoccupied
B	Not surveyed	Not surveyed	Single male	Unoccupied	Unoccupied	Unoccupied
C	Successful	Pair present	Successful: 5 chicks	Successful: 3 chicks	Successful: 4 chicks	Successful: 5 chicks
D	Not surveyed	Not surveyed	Unoccupied	Successful: 4 chicks	Successful: 2 chicks	Successful :4chicks
E	Not surveyed	Successful: 1 chick*	Failed	Failed	Unoccupied	Unoccupied
F	Not surveyed	Not surveyed	Unoccupied	Successful: 2 chicks	Successful at 2nd attempt: 3 chicks	Failed
G	Not surveyed	Not surveyed	Successful: 5 chicks	Successful: 3 chicks	Successful: 5 chicks	Single female
H	Successful: 4 chick	Pair present	Failed	Successful: 4 chicks	Successful: 5 chicks	Failed
I	Not surveyed	Not surveyed	Unoccupied	Single male	Unoccupied	Unoccupied
J	Not surveyed	Not surveyed	Unoccupied	Unoccupied	Unoccupied	Single female
K	Not surveyed	Unoccupied	Successful: 4 chicks	Failed	Successful: 5 chicks	Successful: 5 chicks
L	Pair present*	Successful: 4 chicks*	Successful: 4 chicks	Failed	Successful: 2 chicks	Successful: 5 chicks
M	Pair present	Successful	Not surveyed	Successful: 5 chicks	Successful 1 chick	Successful: 4 chicks
N	Single bird	Single male	Not surveyed	Single female	Single bird	Unoccupied
O	Single female	Unoccupied	Not surveyed	Unoccupied	Successful: 5 chicks	Failed
P	Unoccupied	Unoccupied	Not surveyed	Unoccupied	Unoccupied	Unoccupied
Q	Single female	Unoccupied	Not surveyed	Unoccupied	Not surveyed	Not surveyed
R	Not surveyed	Not surveyed	Not surveyed	Unoccupied	Successful: 4 chicks*	Successful: 3 chicks*

Table 57. Summary of historical merlin survey work of VMSA by local ornithologists between 1984 and 2002.

Territory	No. years surveyed 1984-2002	% years occupied by pair	% years occupied by single
A	16	31%	6%
B	15	53%	7%
C	18	61%	6%
D	16	31%	0%
E	11	0%	9%
F	0	0%	0%
G	2	50%	50%
H	17	41%	6%
I	14	7%	7%
J	11	27%	27%
K	14	57%	7%
L	17	82%	12%
M	19	32%	11%
N	12	0%	17%
O	12	0%	0%
P	9	11%	0%
Q	1	100%	0%
R	0	0%	0%

Table 58. Breeding success of Merlins on the VMSA, 2005-08.

Breeding outcome	2005	2006	2007	2008
Successful pair (chicks fledged)	4 (67%)	6 (67%)	10 (100%)	6 (67%)
Failed pairs	2 (33%)	3 (33%)	0 (0%)	3 (33%)
Total pairs	6	9	10	9
No. chicks fledged	18	21	36	26
Chicks per pair	3.0	2.3	3.6	2.9

Table 59. Target Species in generic VP watches.

Divers (all species)
Whooper swan
White-fronted goose
Barnacle goose
Honey buzzard
White-tailed eagle
Harriers (all species)
Osprey
Hobby
Merlin
Gyr falcon
Peregrine
Dotterel
Terns (all species)
Short-eared owl

Figure 1. Timing of VP watches overlooking the WSA in the months April to October 2005

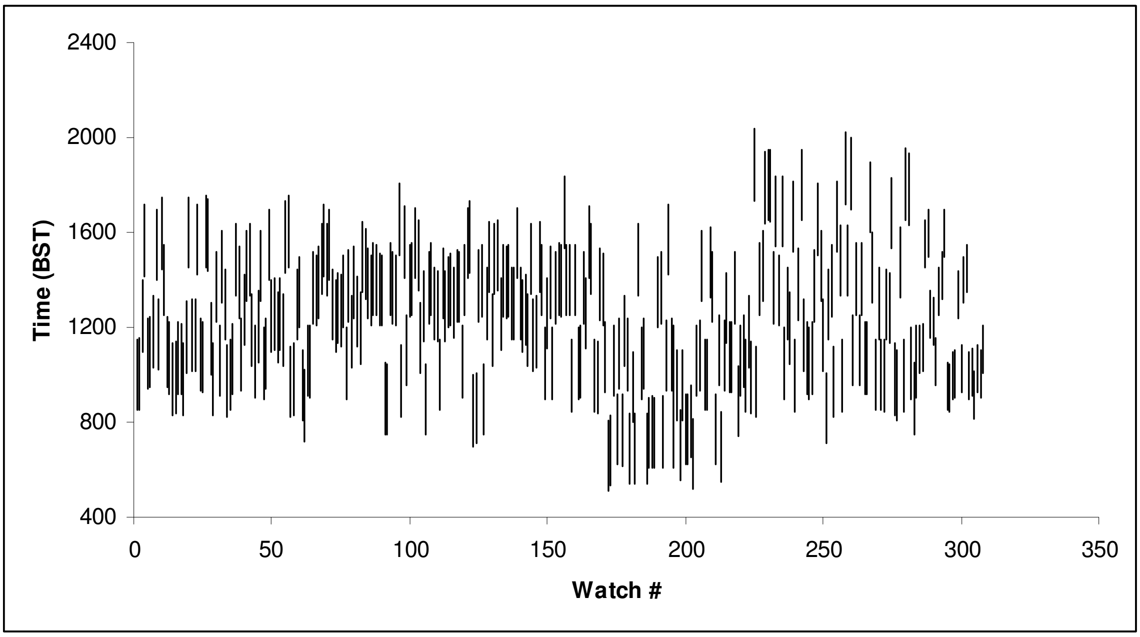


Figure 2. Timing of VP watches overlooking the WSA in the months November to March 2005-06

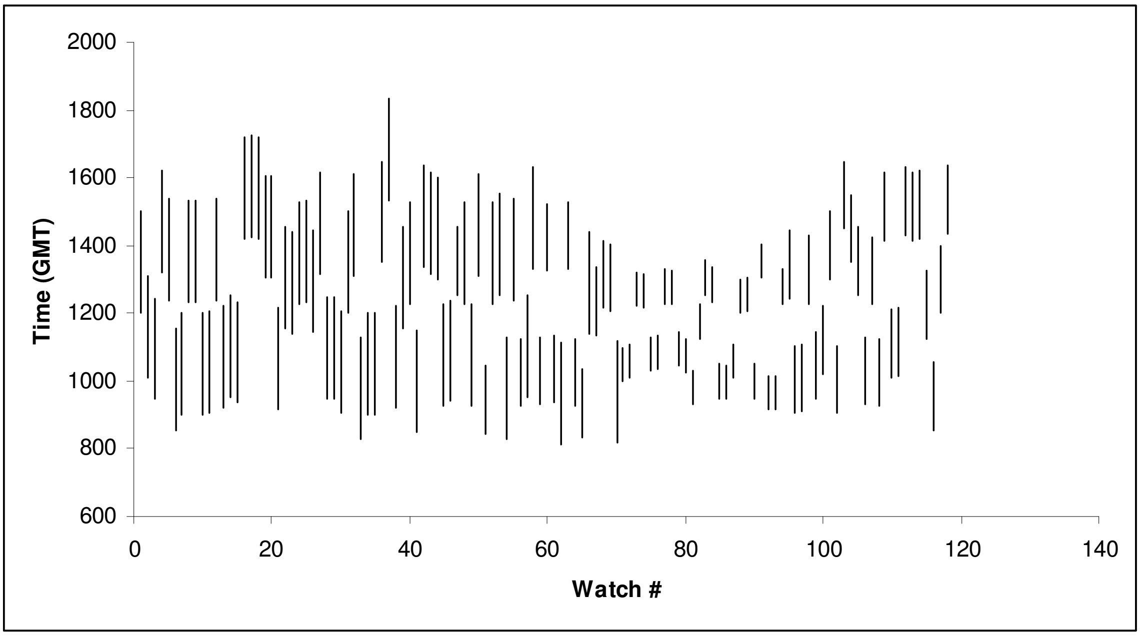


Figure 3. Timing of VP watches overlooking the ESA in the months April to October 2003

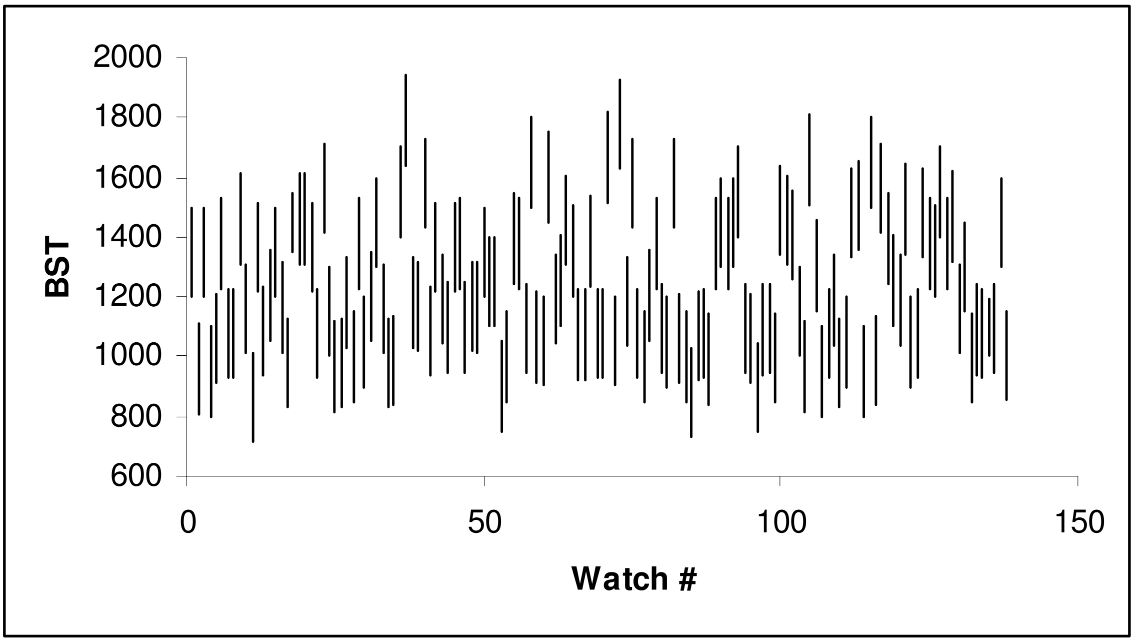


Figure 4. Timing of VP watches overlooking the ESA in the months April to October 2006

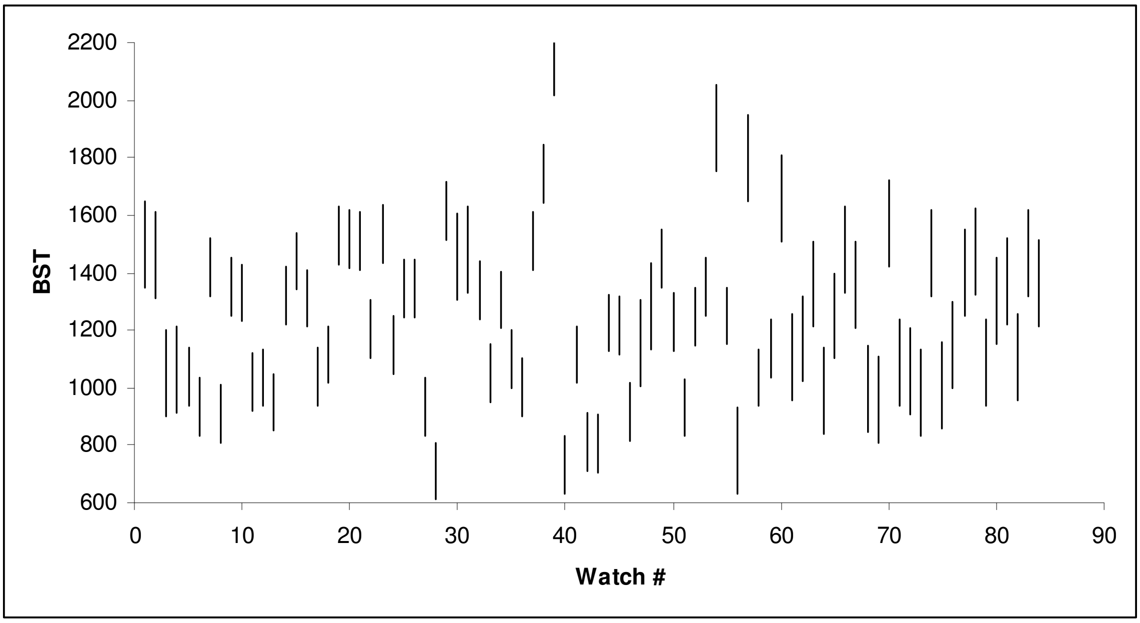


Figure 5. Timing of VP watches overlooking the ESA in the months November to March 2006-07

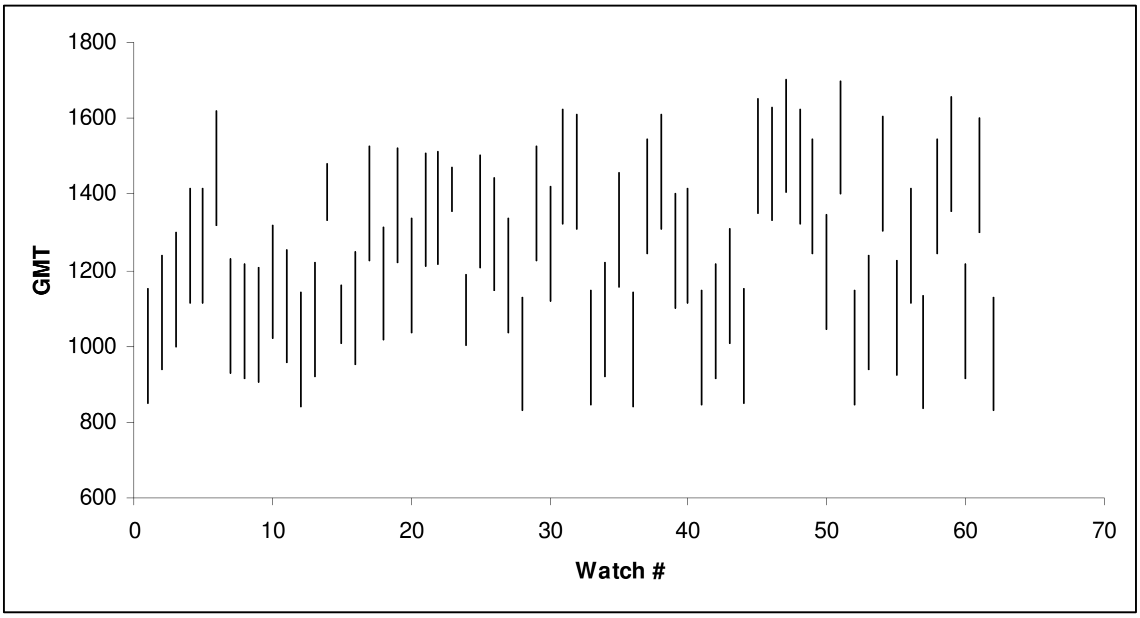
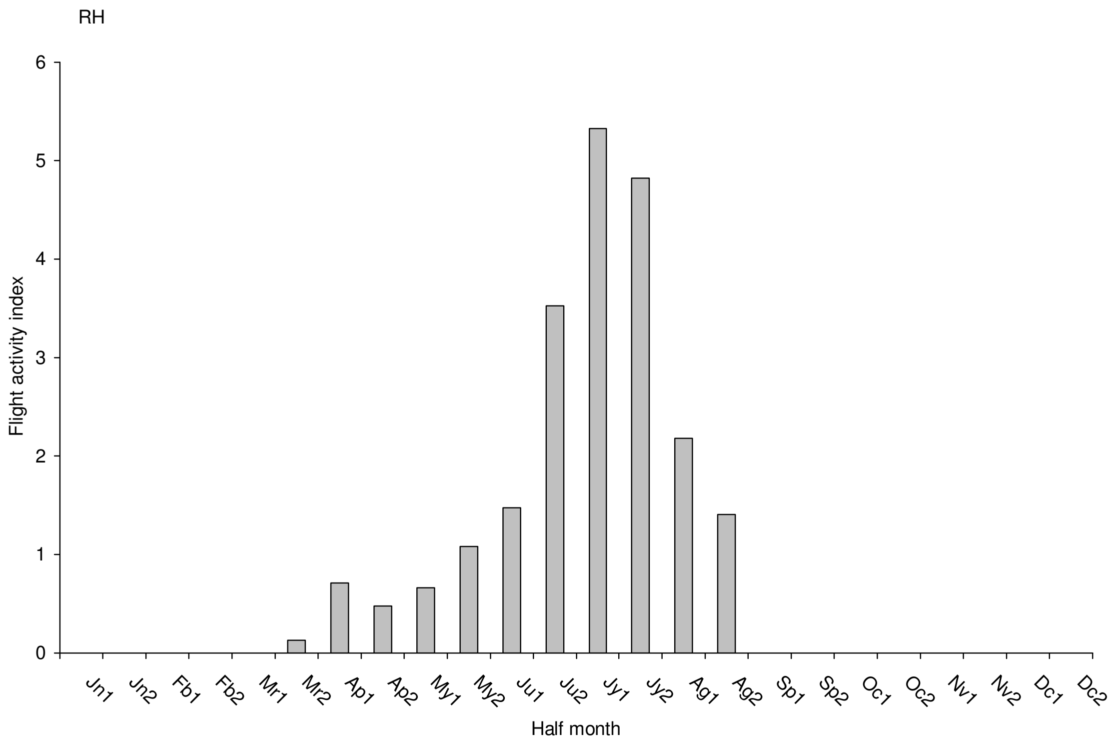
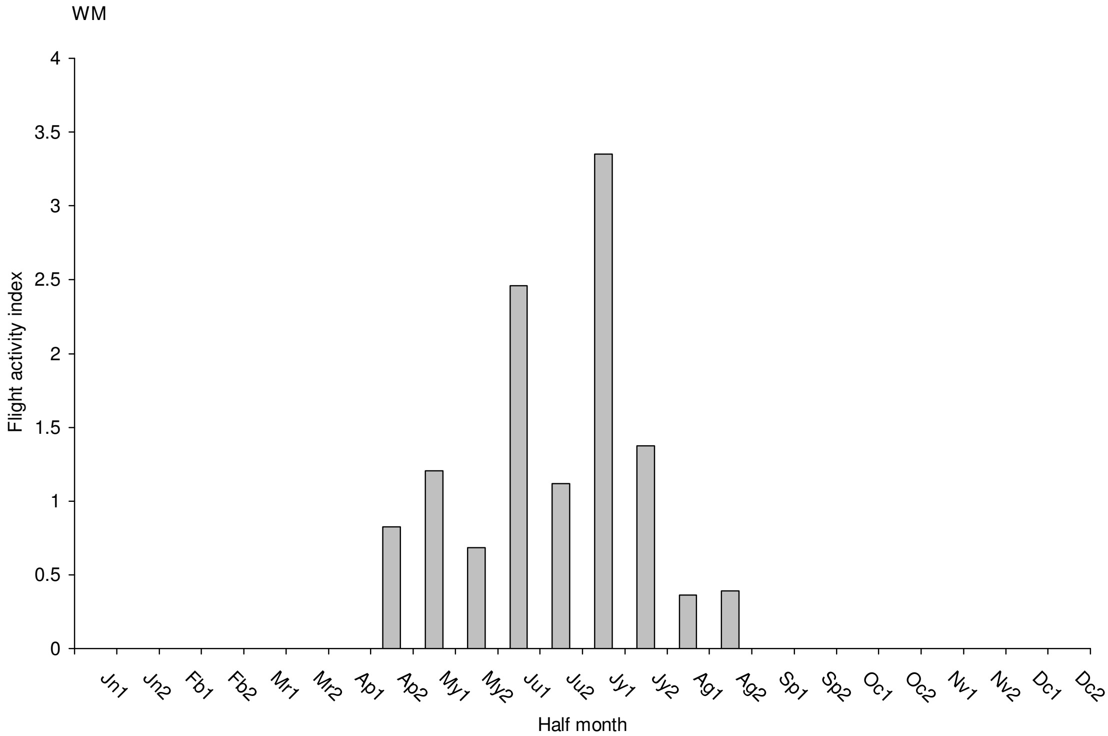


Figure 6. Seasonal variation in an index of flight activity observed at generic VP watches. The graphs show the proportion of 5-minute recording periods in which flights were observed, scaled per 10 hours of observation effort. Data are from generic VP watches in the WSA and ESA during the period March 2005 to February 2007.

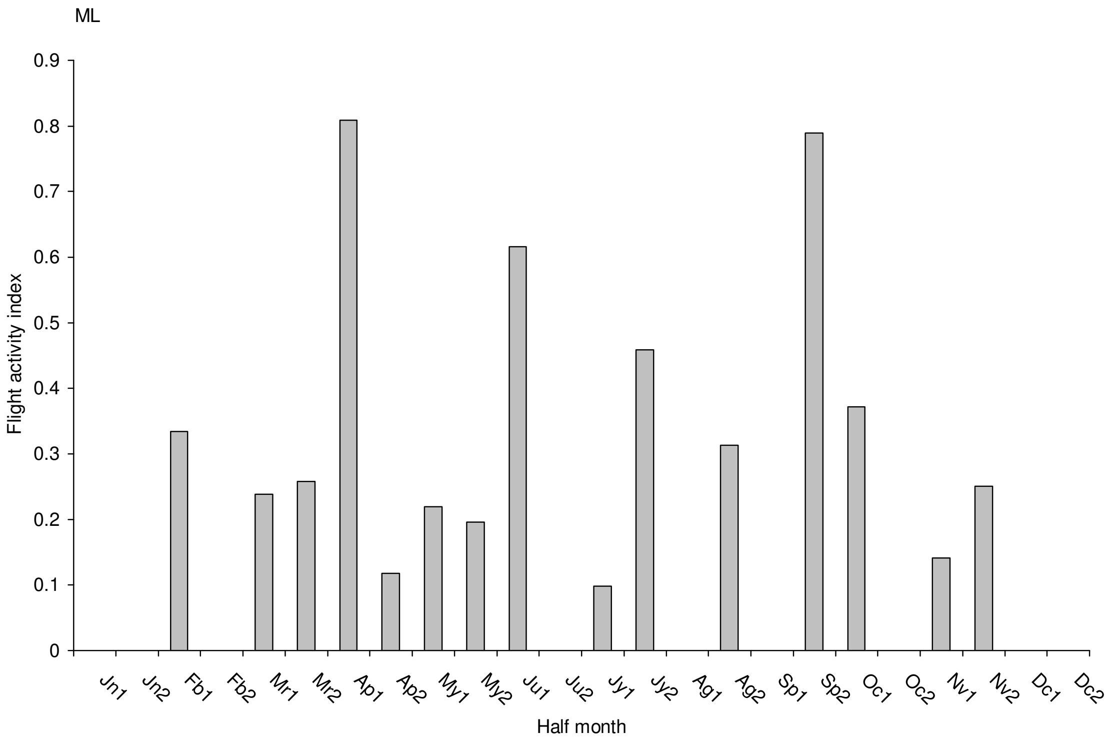
(a) Red-throated diver



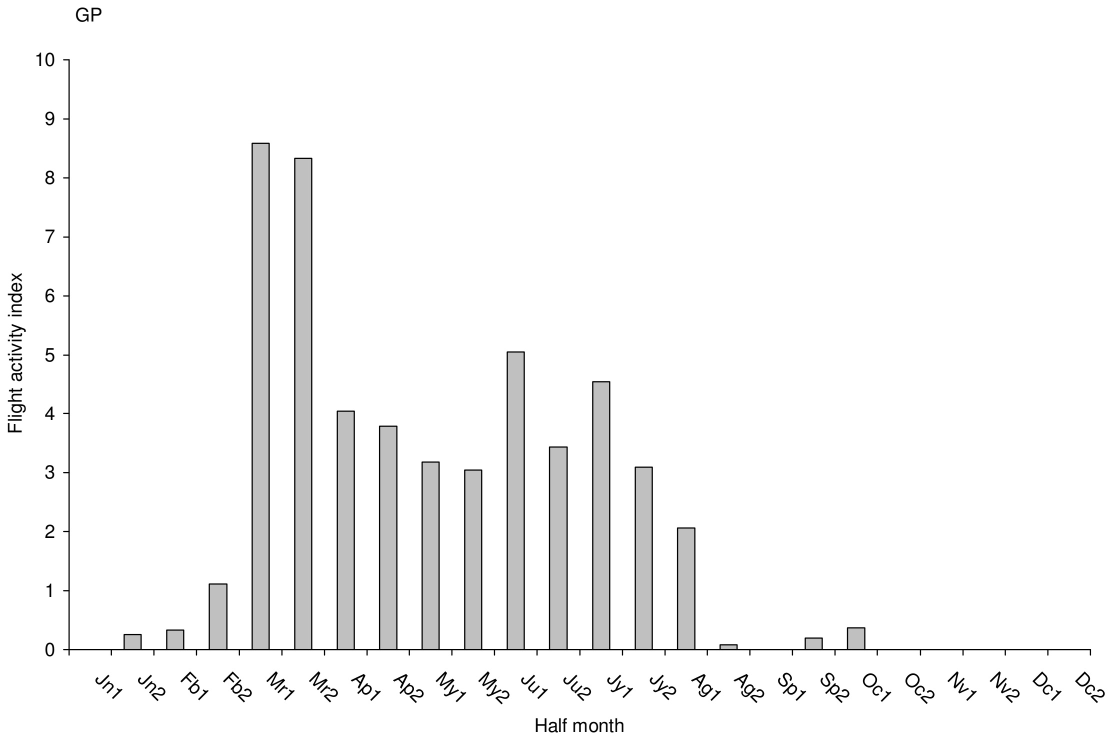
(b) Whimbrel



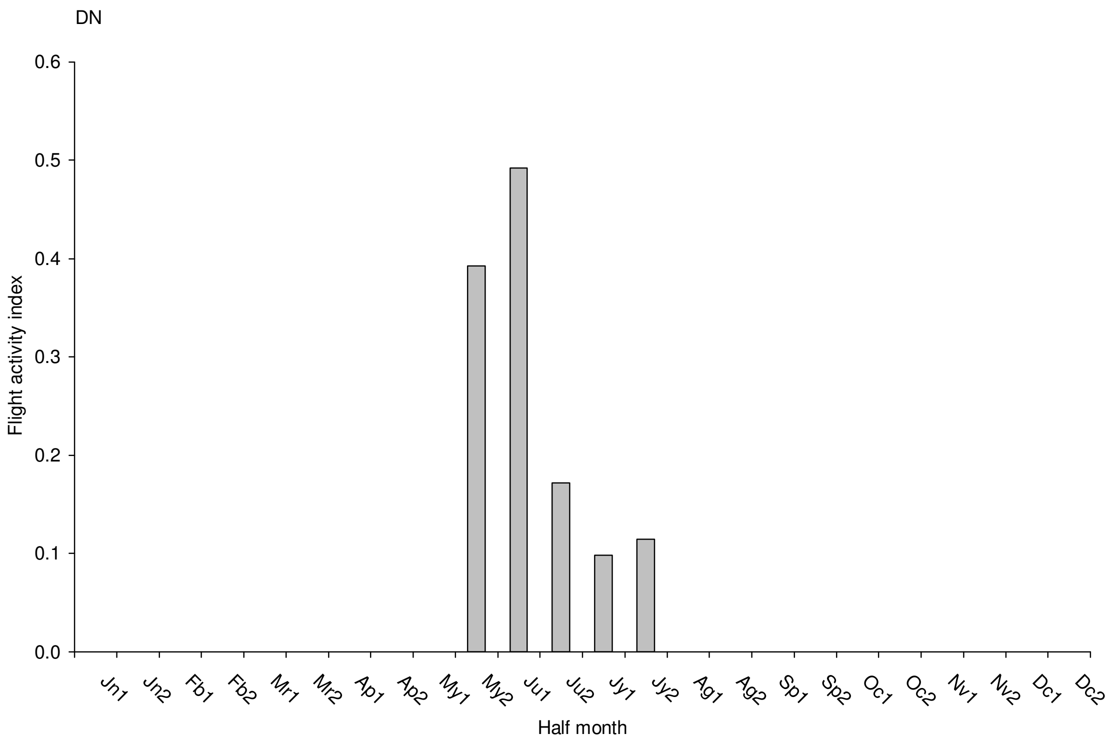
(c) Merlin



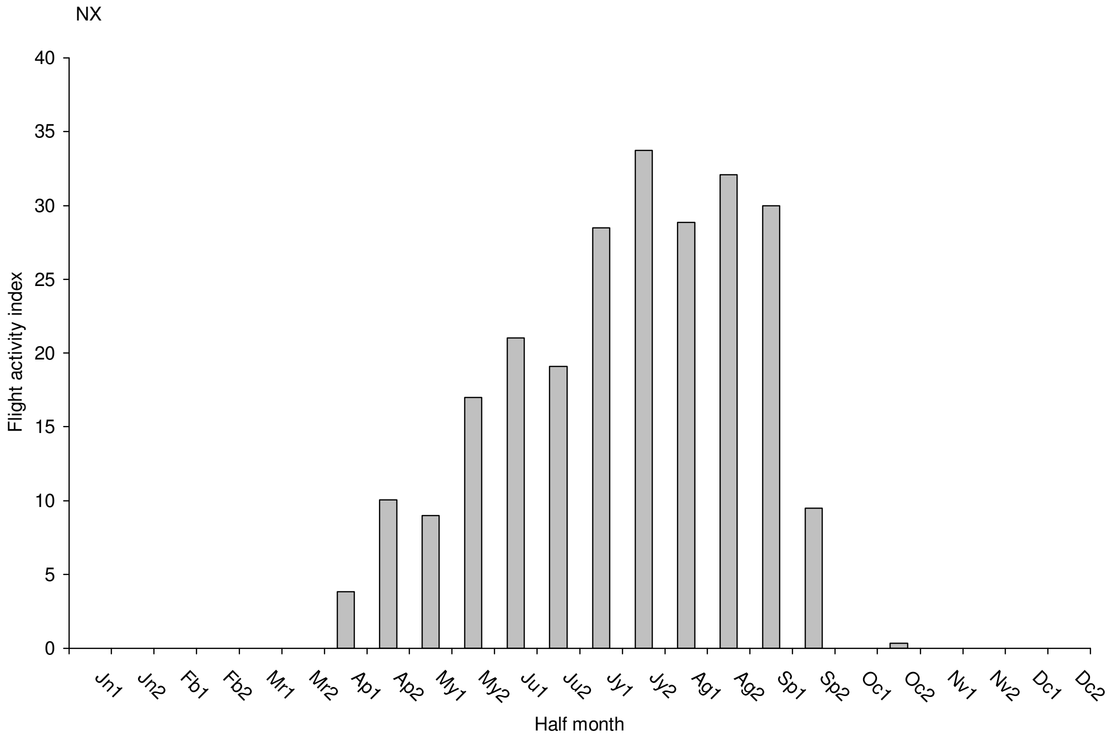
(d) Golden plover



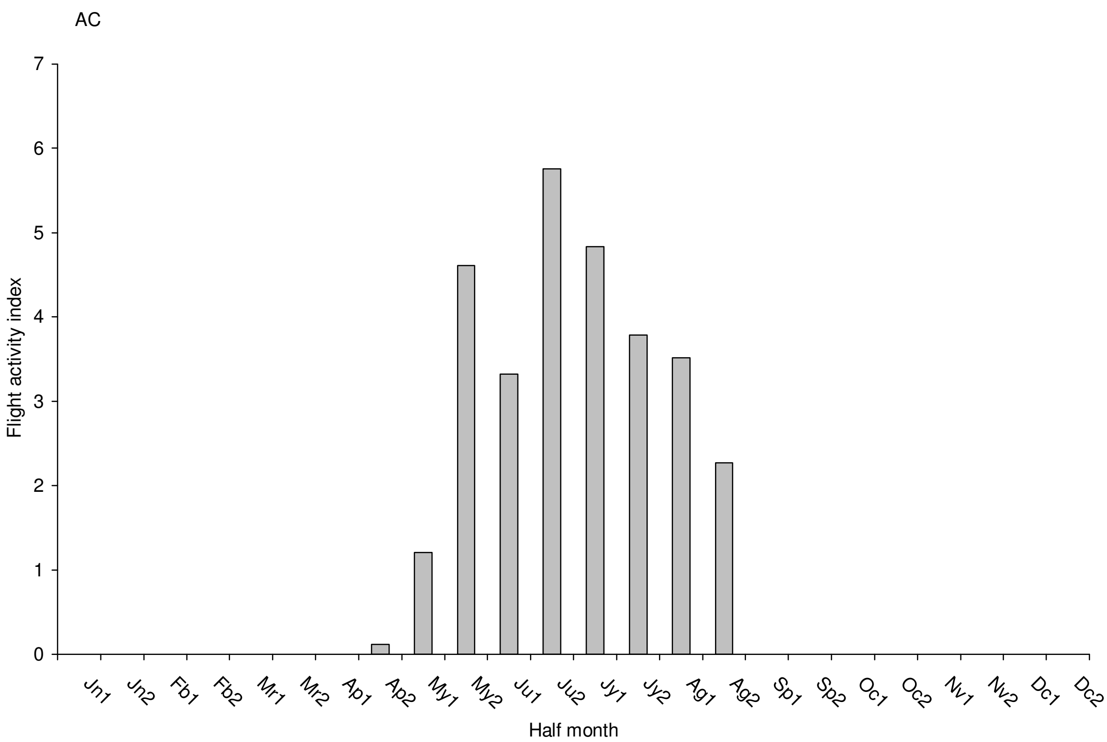
(e) Dunlin



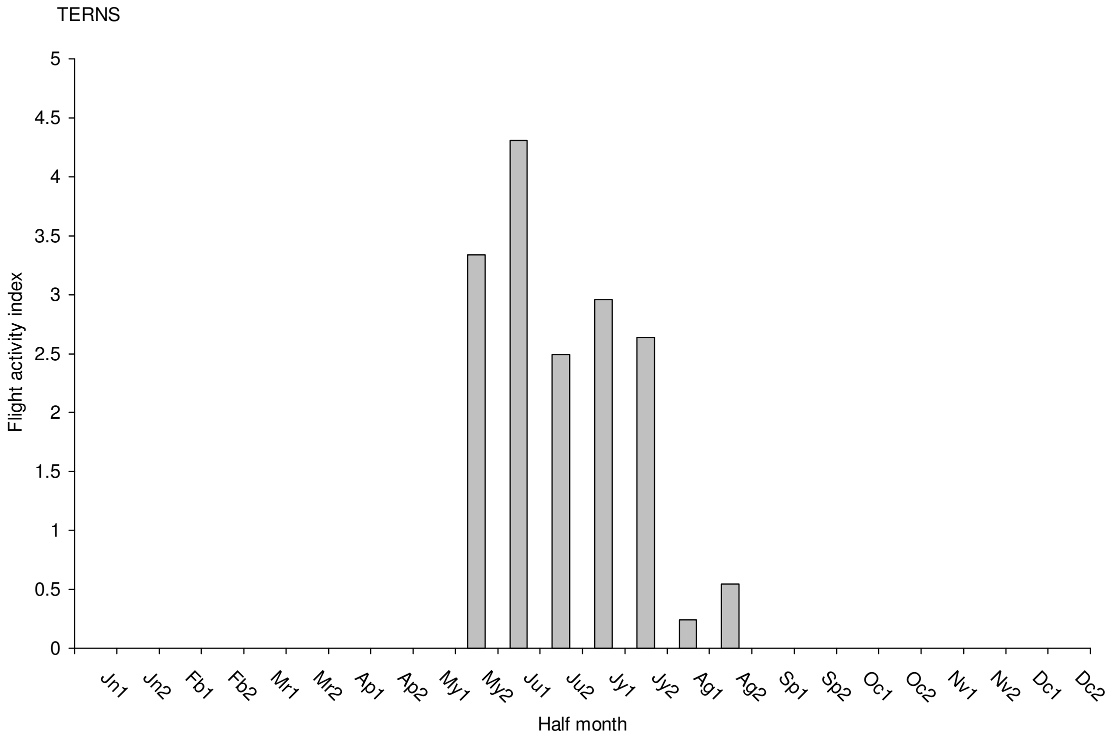
(f) Great skua



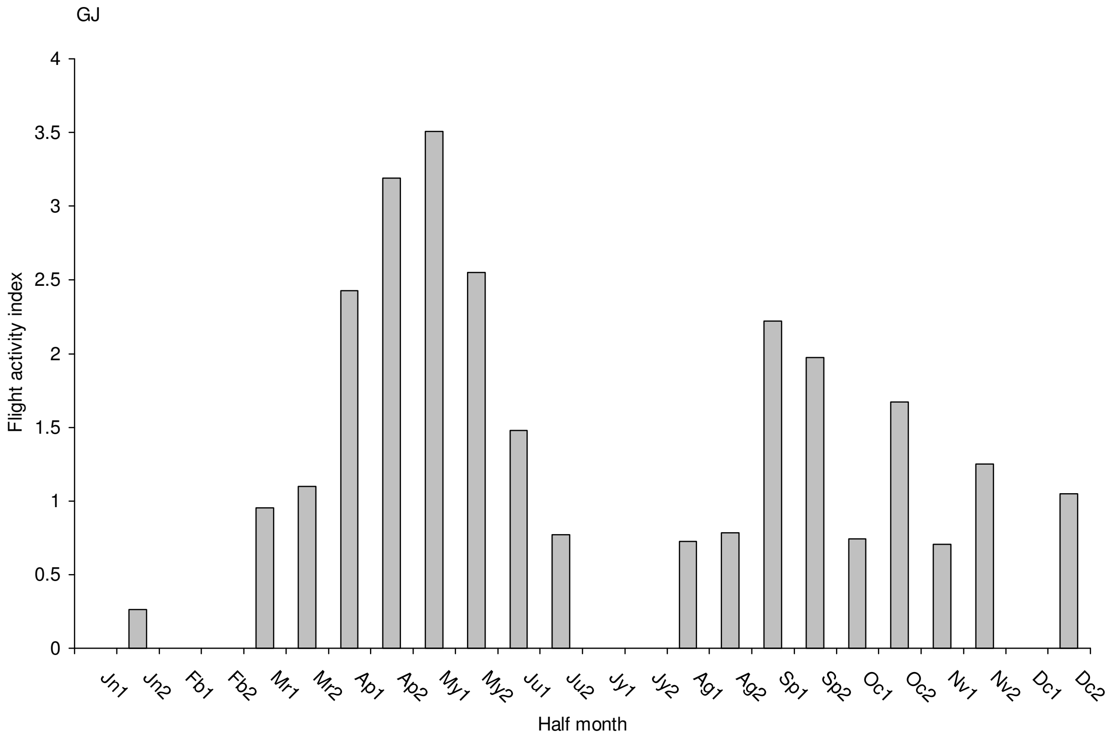
(g) Arctic skua



(h) Common and arctic tern



(i) Greylag goose



(j) Raven

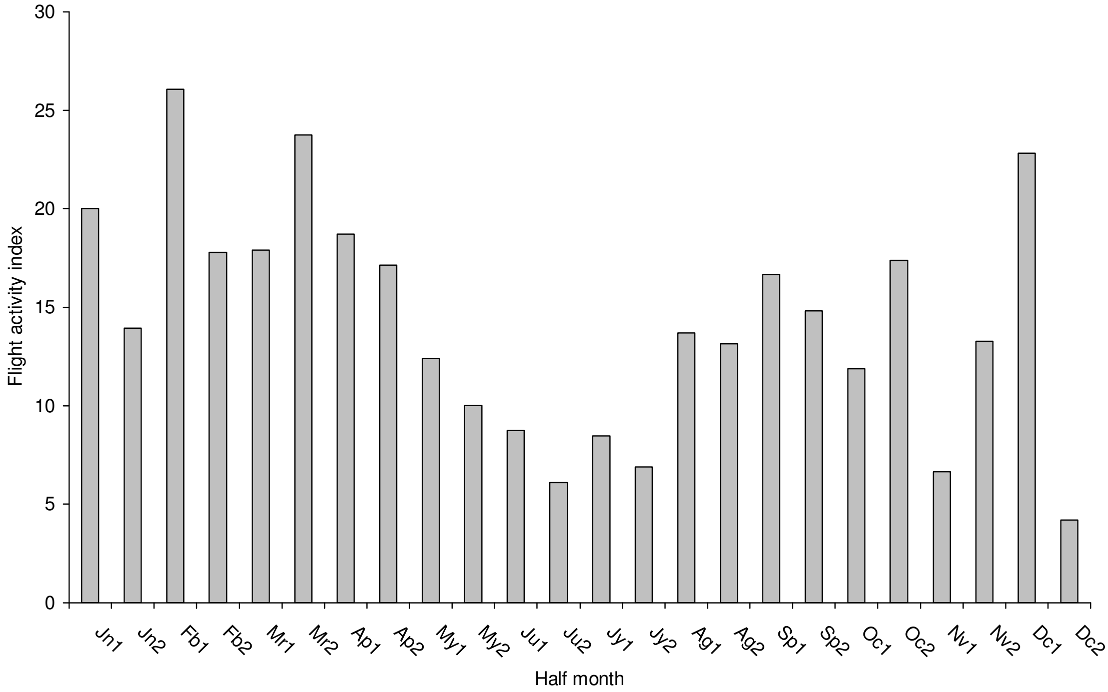
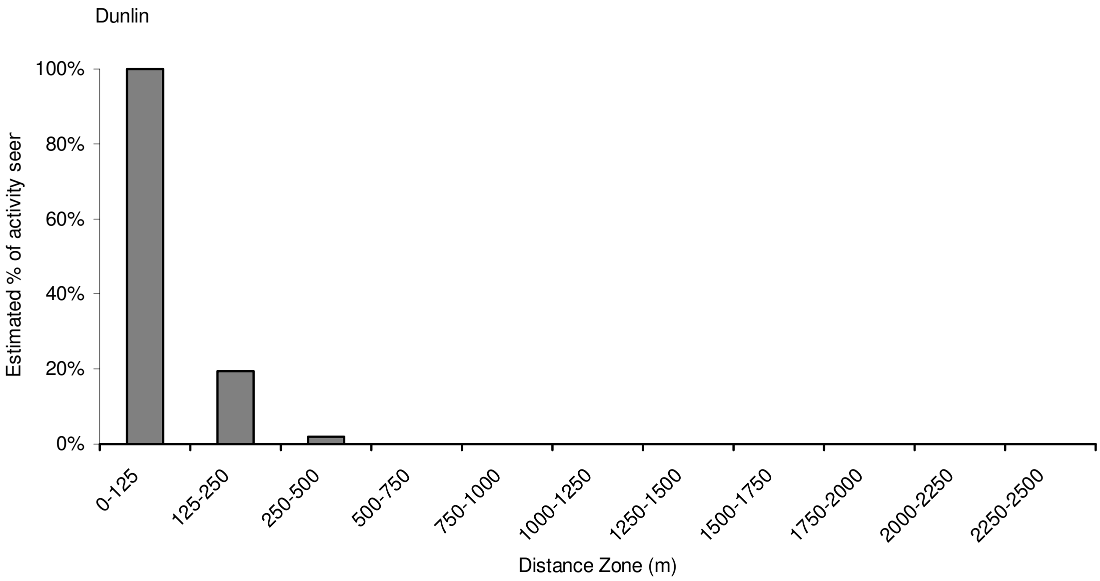
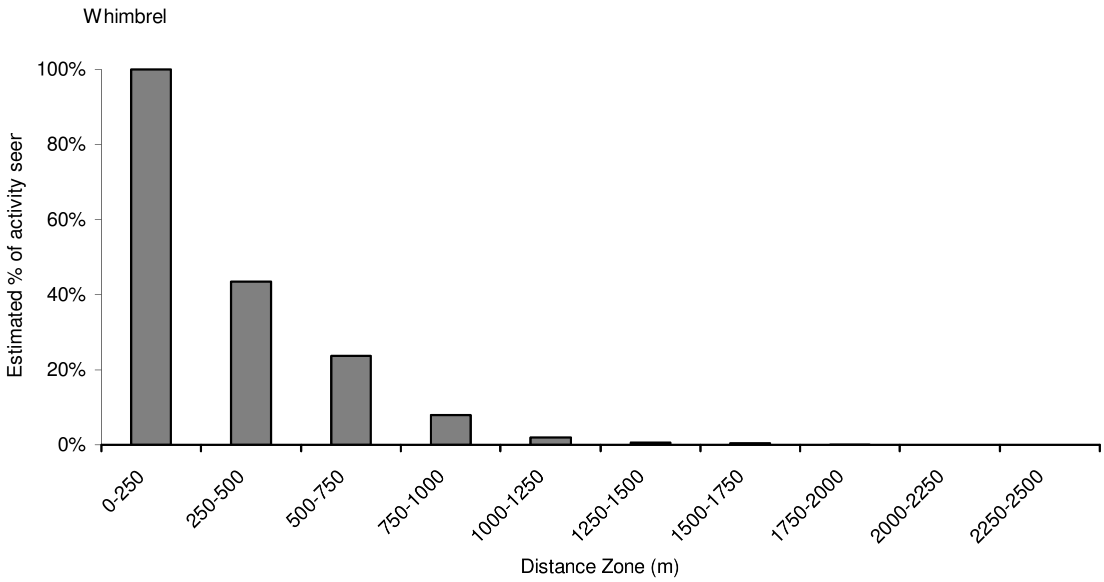


Figure 7. Changes in the estimated percentage of flight activity observed in different distance-zones from vantage points. It was assumed that all activity was seen in the closest zone(s). Data are from 222 hours of watches from 6 VPs in 2007 and 18 hours at 3 VPs in 2008. The results for merlin also include data from generic VP watches conducted in 2005 and 2006.

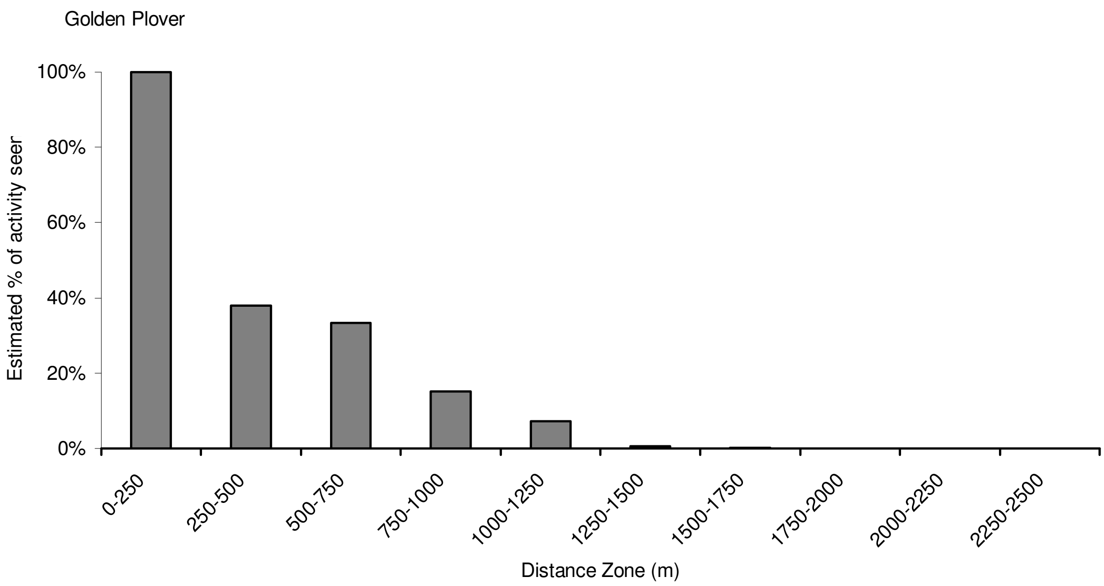
(a) Dunlin



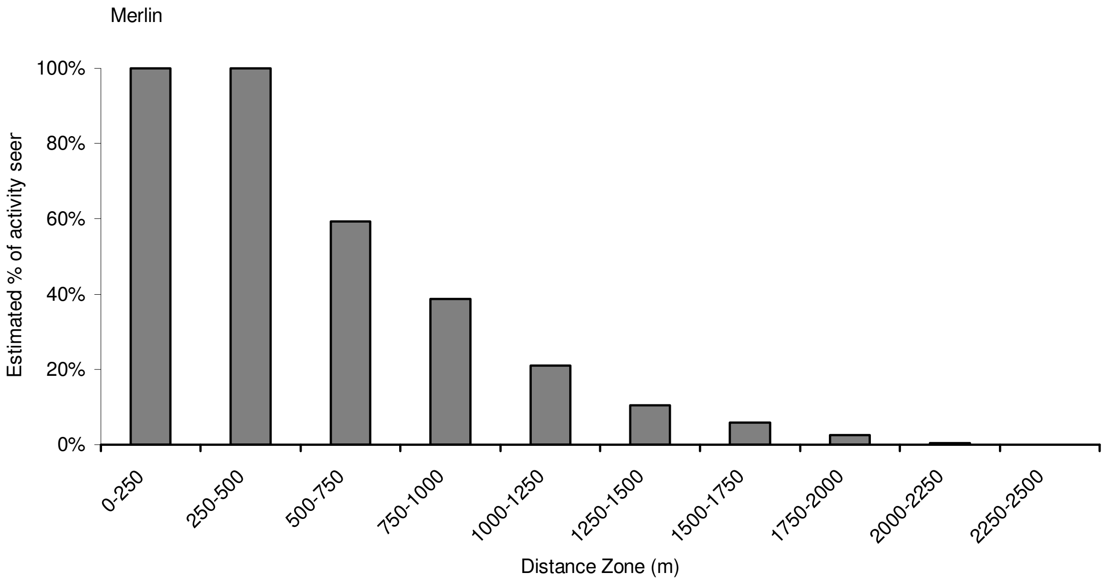
(b) Whimbrel



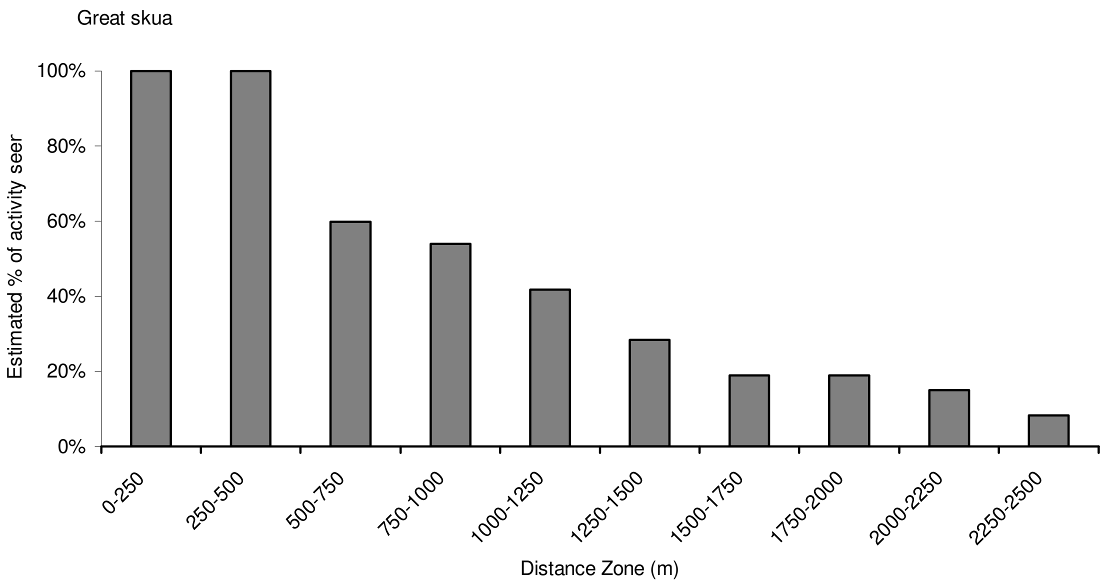
(c) Golden plover



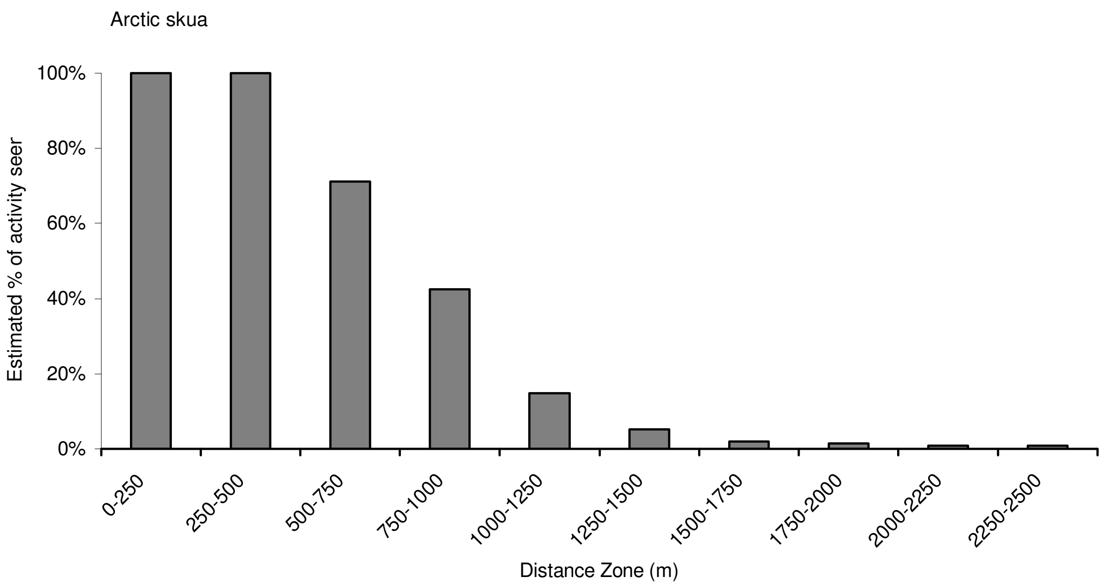
(d) Merlin



(d) Great skua



(e) Arctic skua



(g) Greylag goose

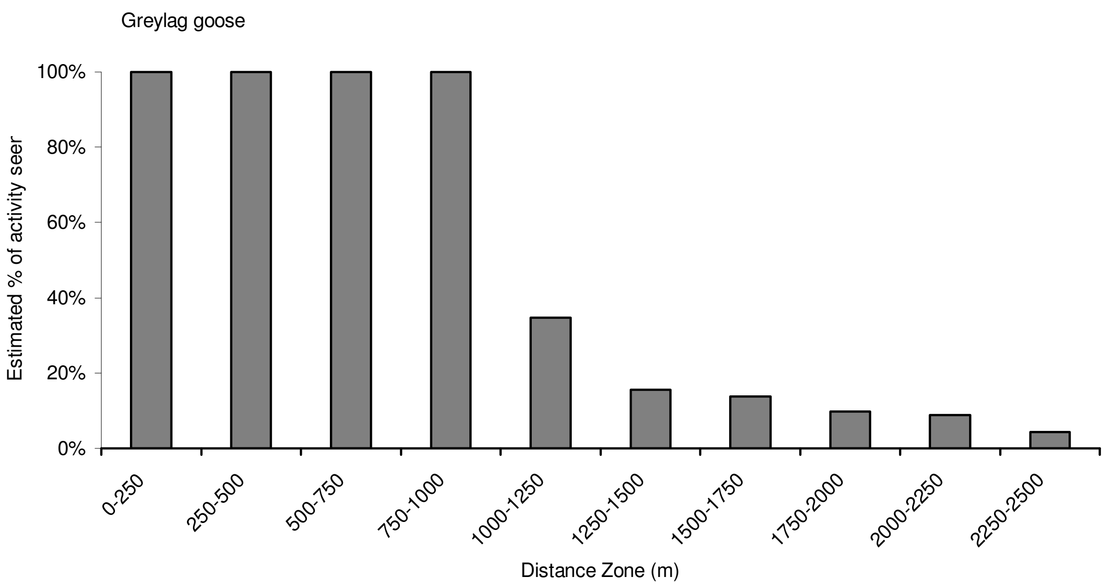
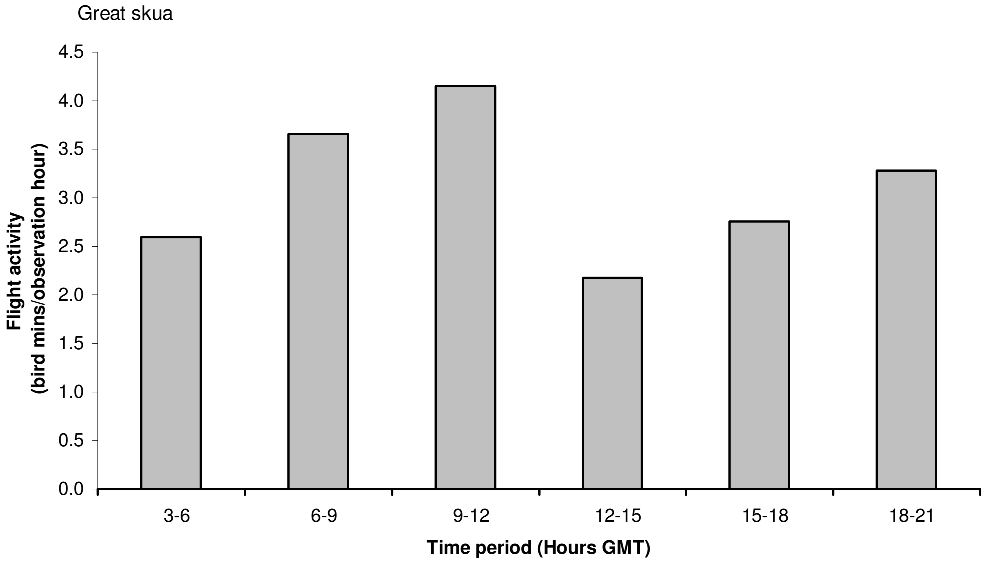
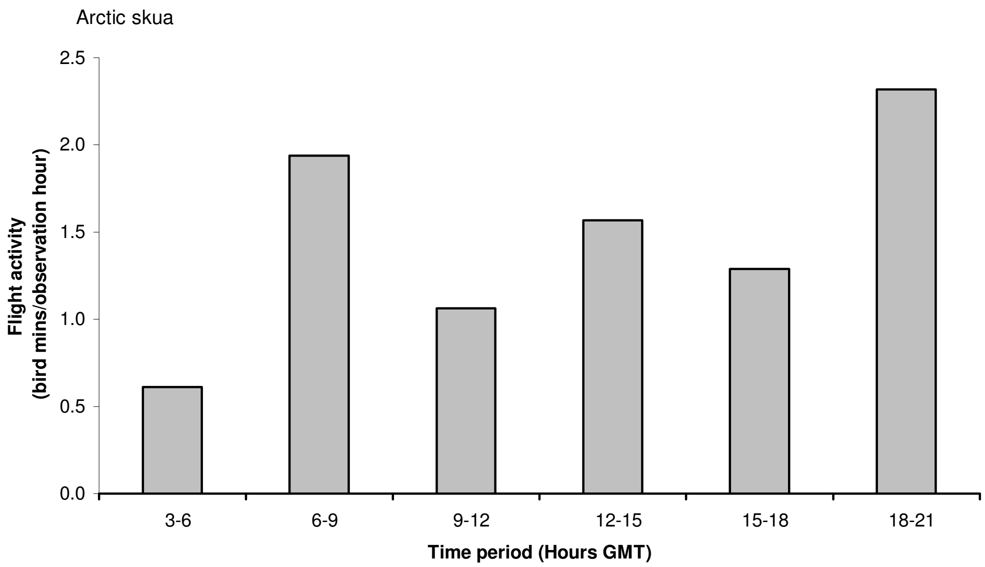


Figure 8. Diurnal variation in the breeding season flight activity based on 220 hours of watches spread evenly through the day during May, June and July 2007.

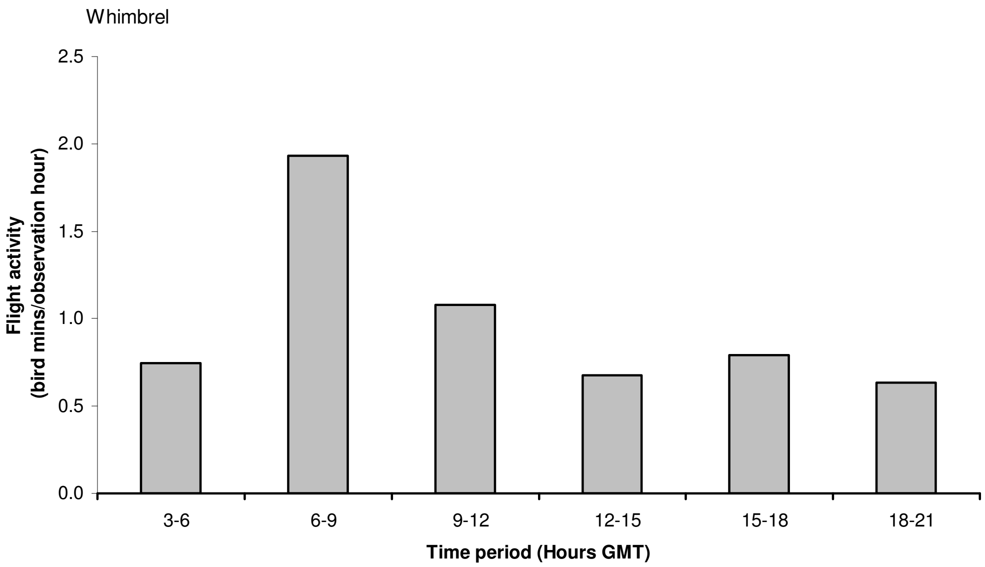
(a) Great skua



(b) Arctic skua



(c) Whimbrel



(d) Golden plover

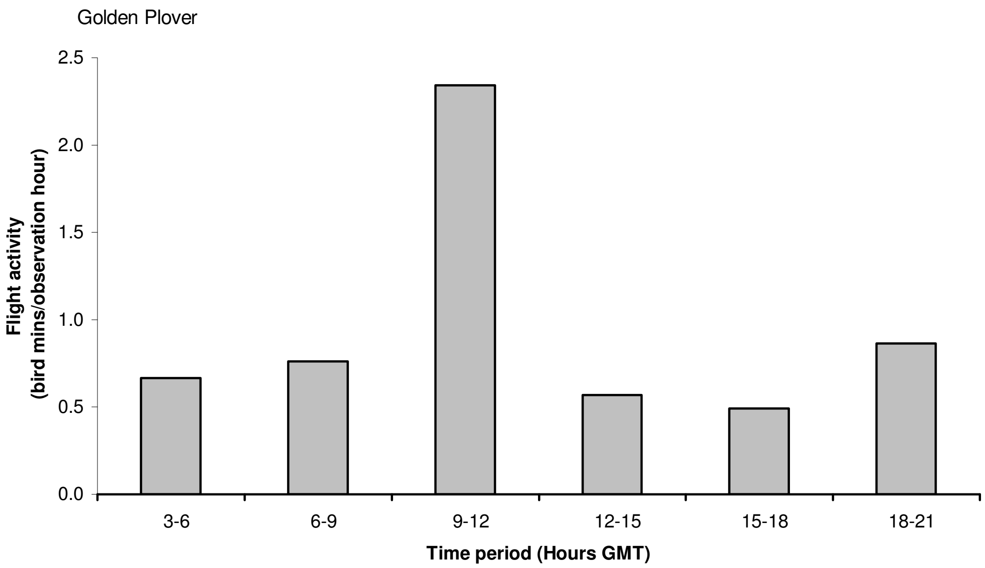
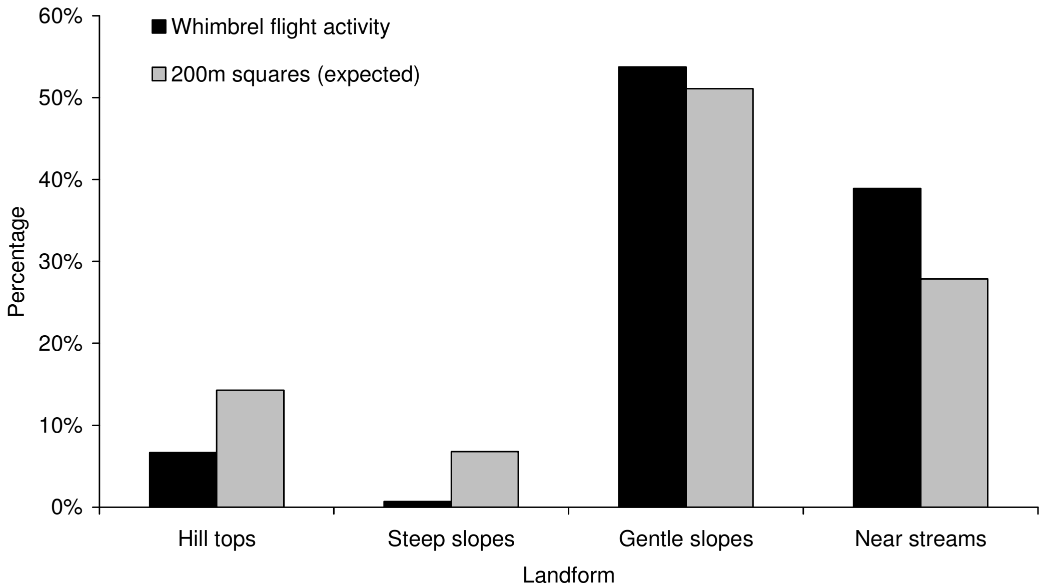


Figure 9. Percentage of flight activity observed over each of four landform types compared to the percentage of 200m squares of each landform type in the study areas.

a) Whimbrel



b) Golden plover

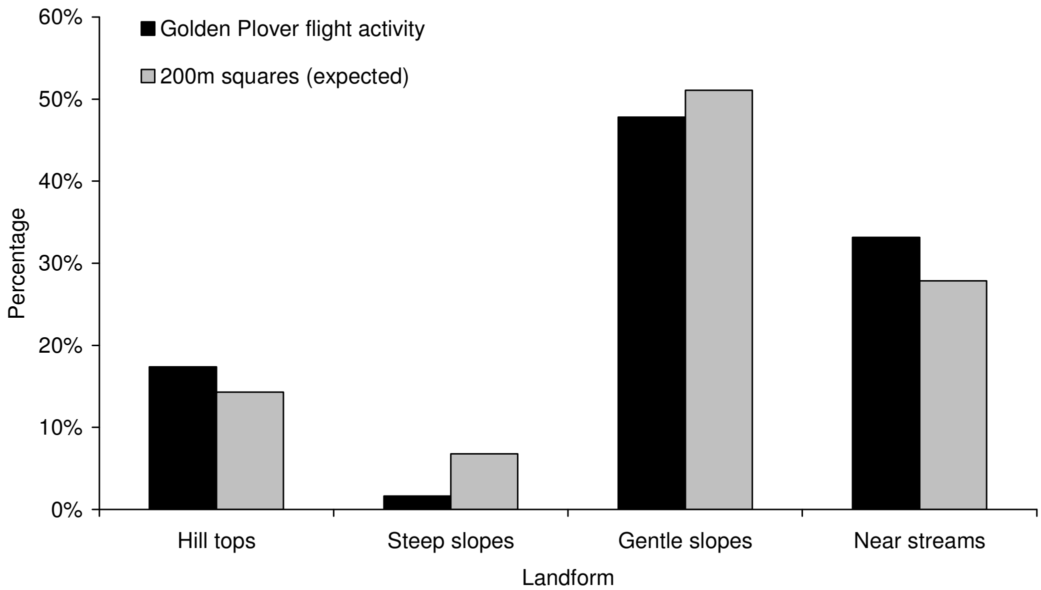


Figure 10. Seasonal change in likelihood of presence during a survey visit of adult red-throated divers at occupied breeding sites. Based on 520 visits to 46 breeding lochs in 2006.

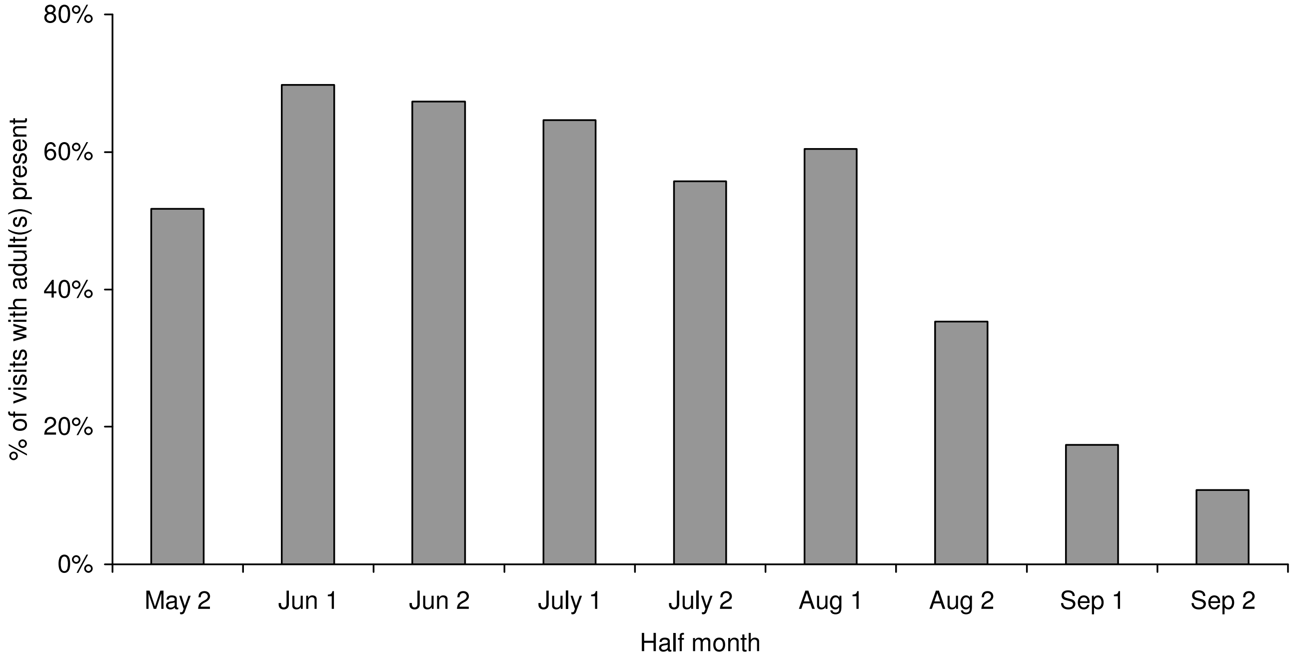


Figure 11. Seasonal pattern of estimated egg laying date for red-throated divers breeding on the Viking site 2004 -2006

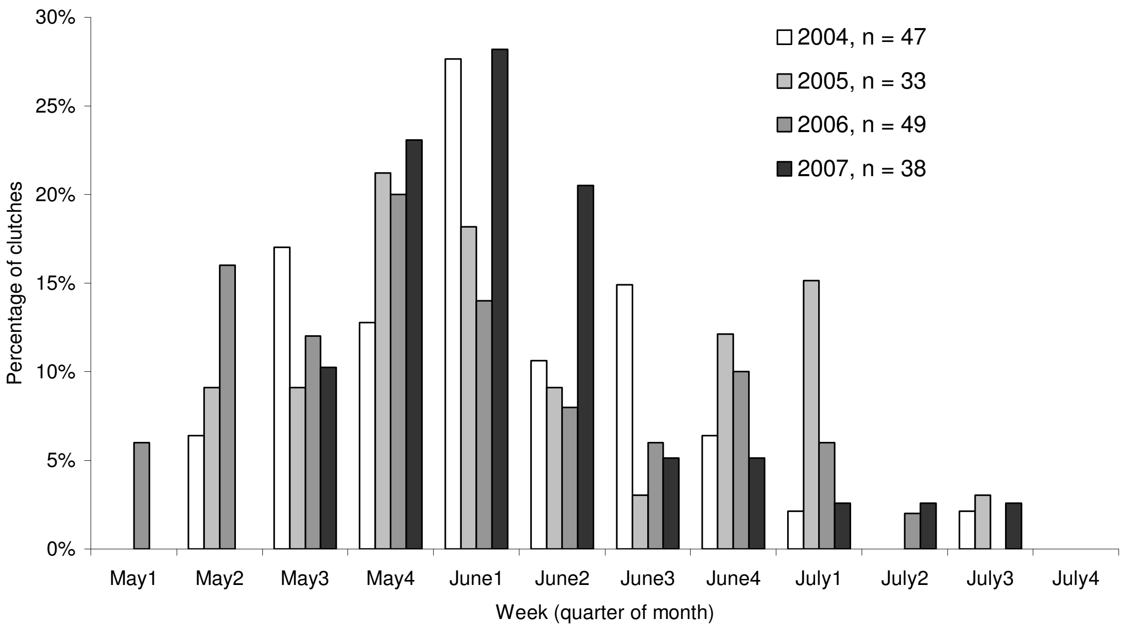
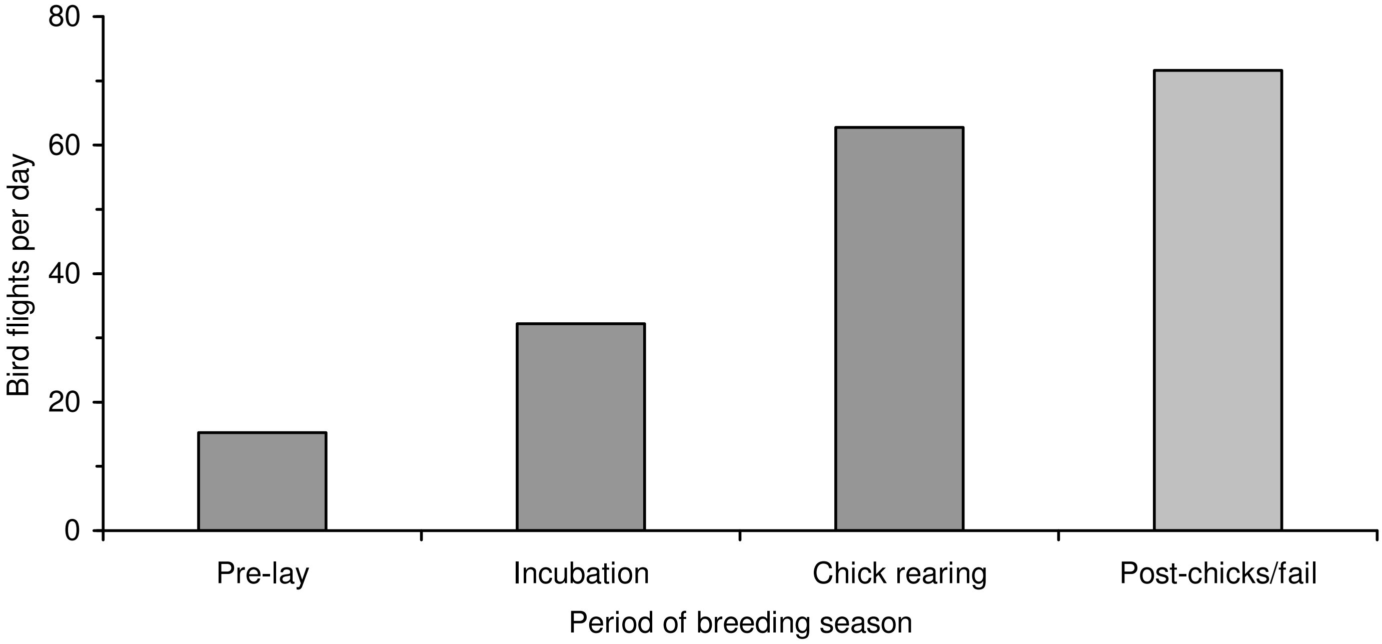


Figure 12. Variation in mean daily red-throated diver flight activity at an average breeding loch (includes flights by residents and intruders). Figures for the post-fledge/fail stage are based on a crude estimate and are likely to be higher than the true



mean.

Figure 13. Seasonal variation in mean daily red-throated diver flight activity at an average non-breeding gathering loch.

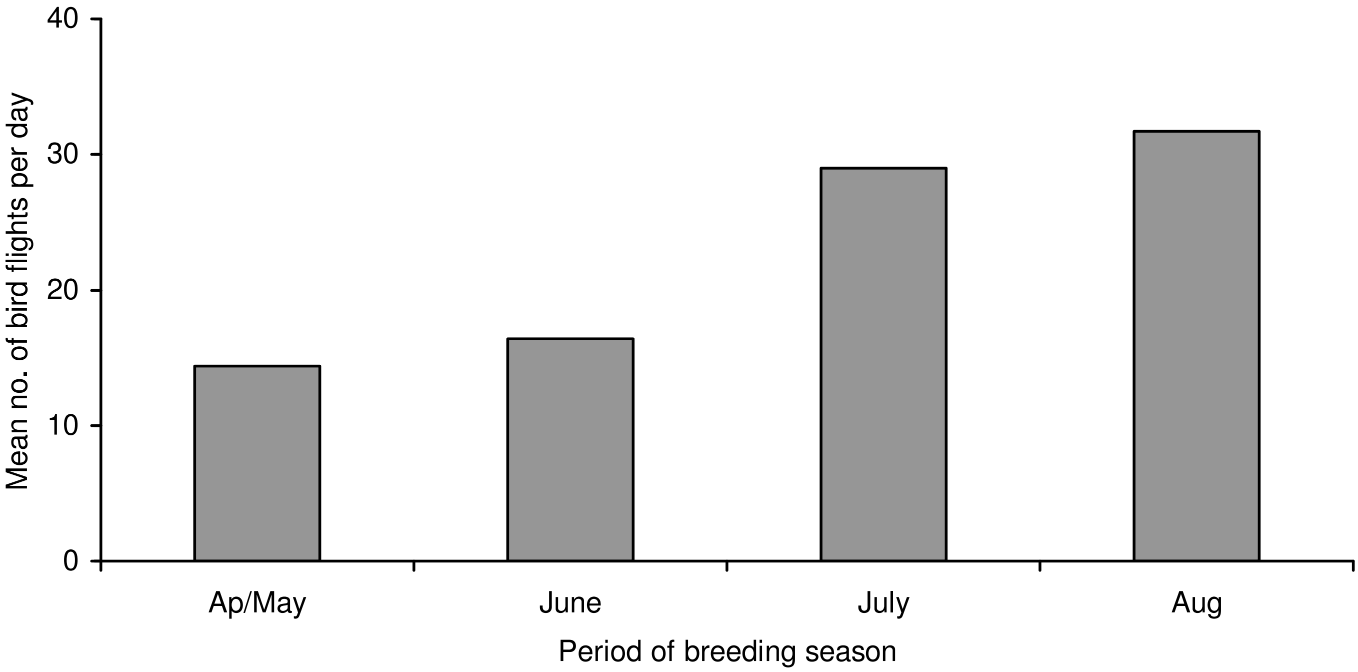


Figure 14 Through-the-day changes in red-throated diver flight activity (residents and intruders) at an average breeding loch during the pre-laying (light grey), incubation (mid grey) and chick-rearing (black) periods

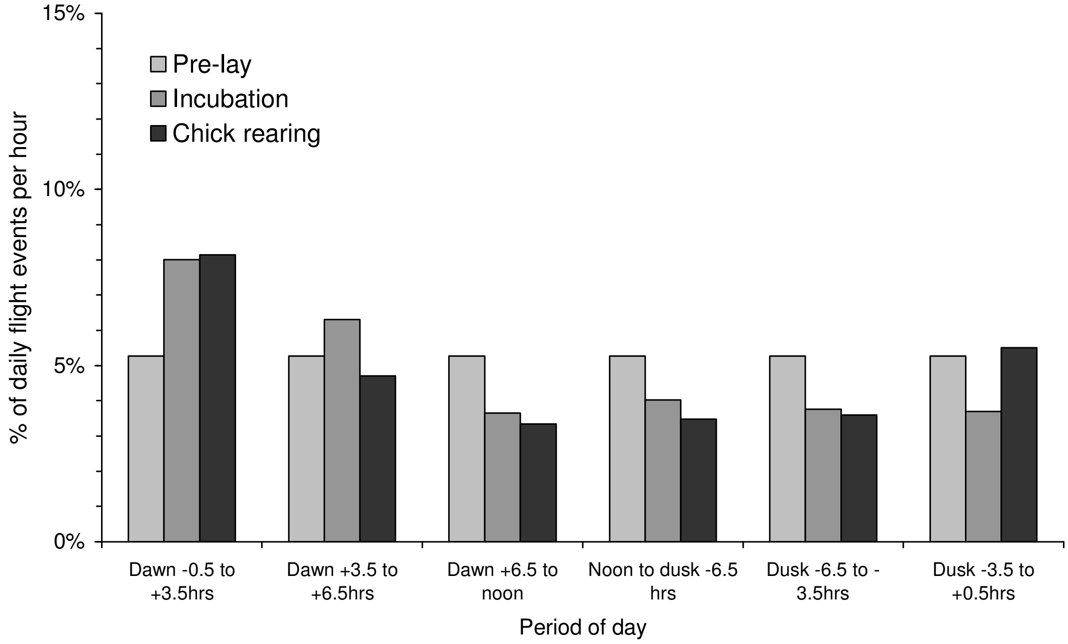


Figure 15. Through-the-day changes in red-throated diver flight activity at an average non-breeder-gathering loch.

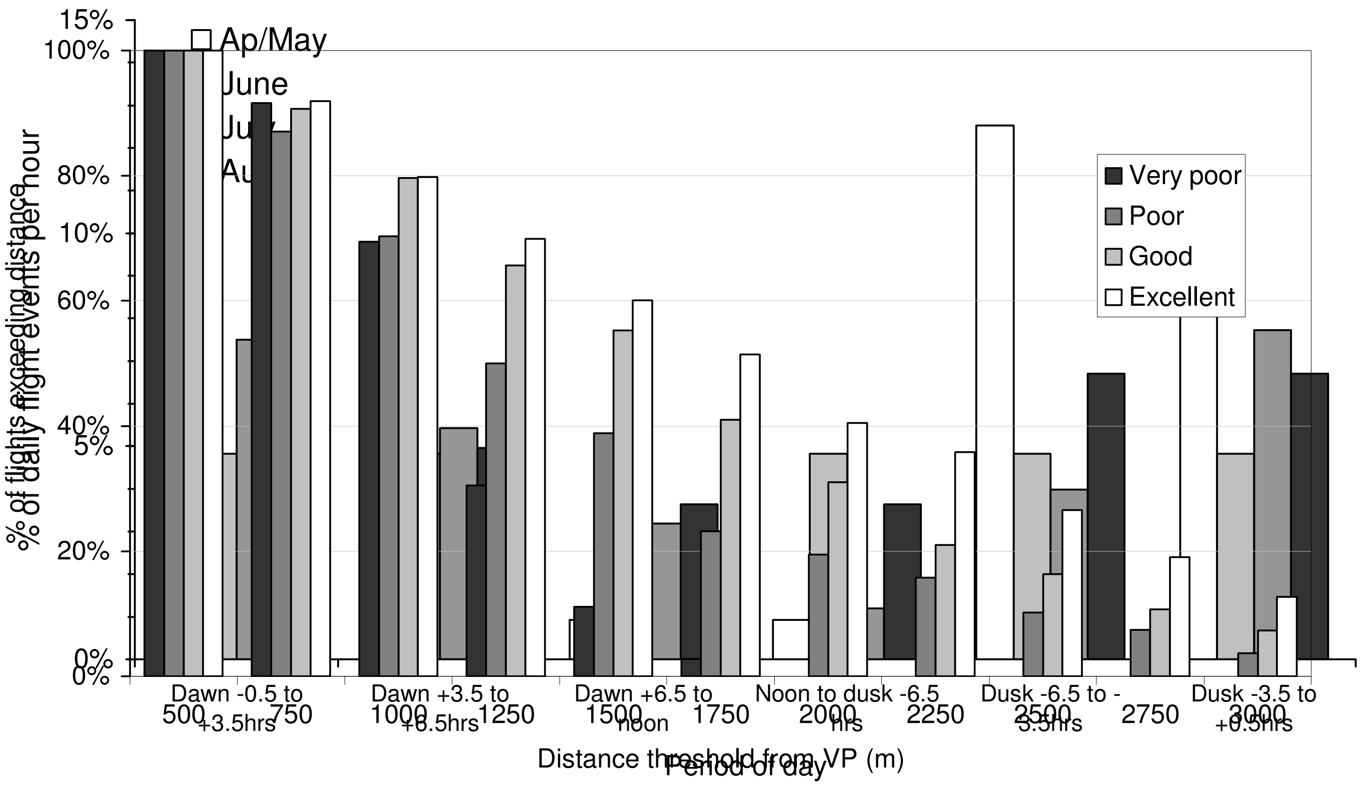


Figure 16. Maximum distance from VP that outbound flights by breeding red-throated divers were observed in different conditions of visibility (n=634).

Figure 17. The effect of visibility conditions on the amount of red-throated diver outbound flight activity observed at different distances from VP relative to amount of activity observed under conditions of excellent visibility. See text for visibility definitions.

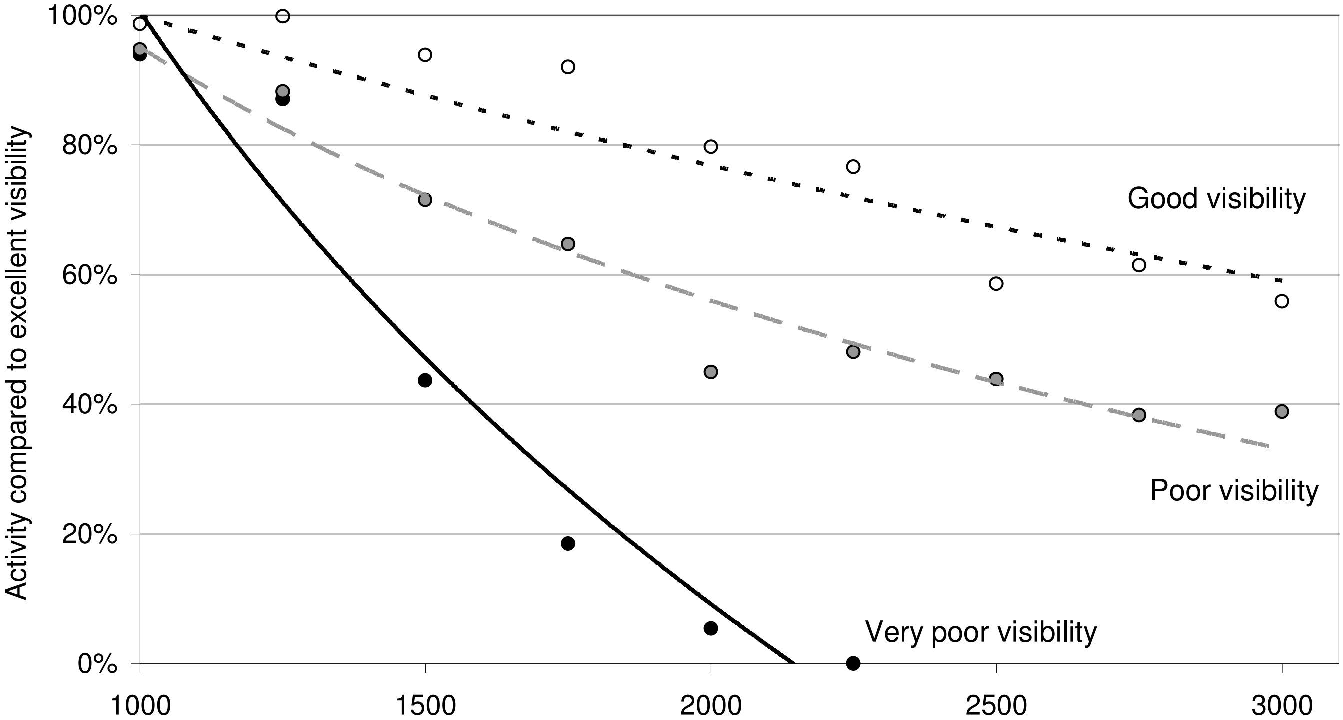


Figure 18. Comparison of the maximum distance from VP that ingoing and outgoing red-throated diver flights were observed (irrespective of visibility conditions).

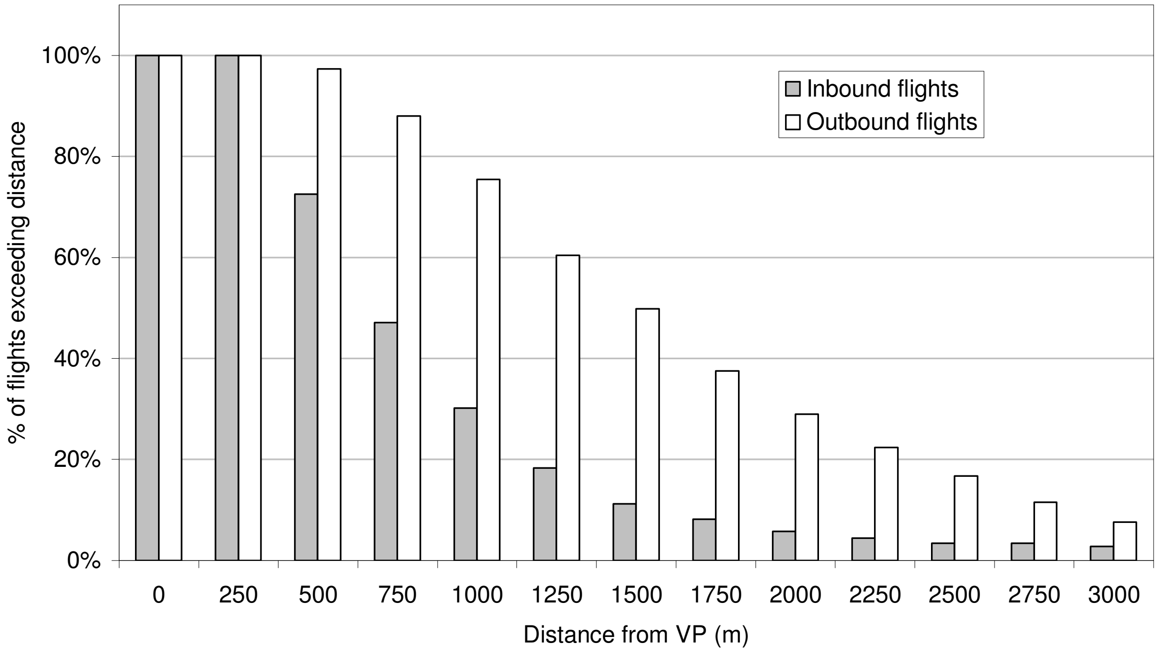


Figure 19. The estimated amount of flight activity seen in 250m-wide distance intervals from vantage points for various types of red-throated diver flights. The estimates are expressed relative to outbound flight activity (i.e. outbound equals 100% in all distance zones). Based on 1670 flights recorded during focal point and generic VP watches during fieldwork conducted from 2004-2006.

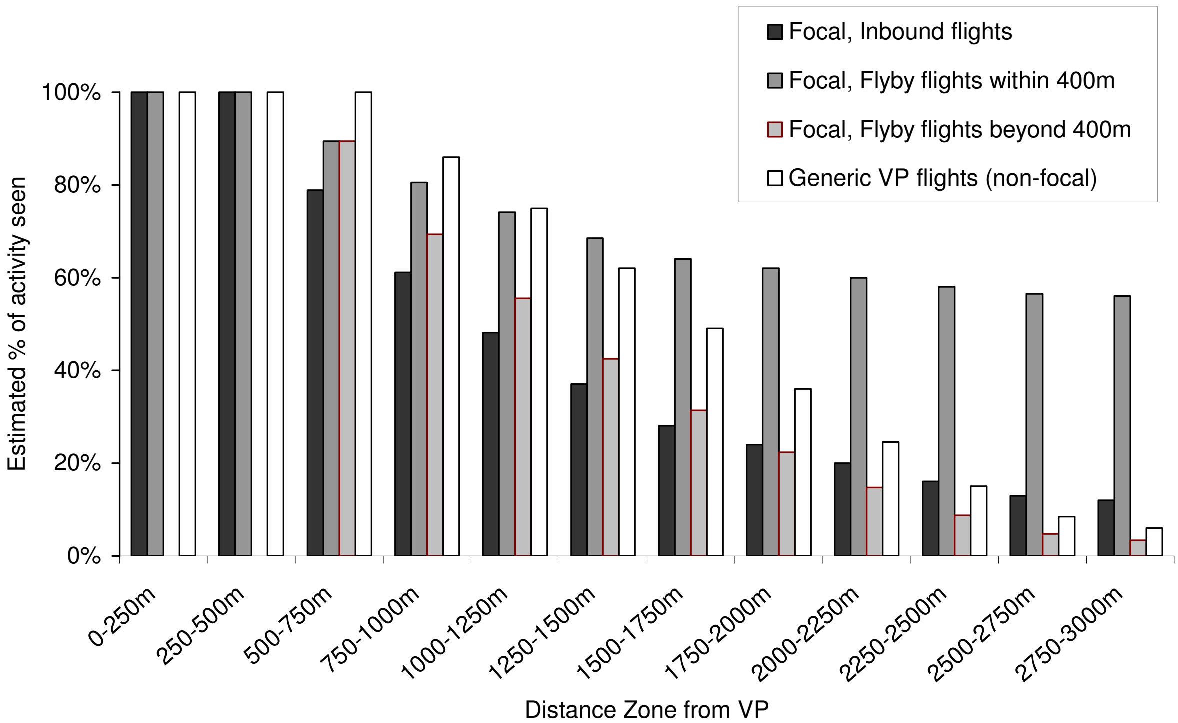


Figure 20. Estimated annual flight activity by adult merlins in the core of nest territories. Based on 33 hours of focal watches at six nest sites spread through the breeding season. Corrected for visible area, assumes 100% detection at all distance bands and a 123 day season (April-July).