

JNCC Report

No. 392

Surveillance of wintering seaducks, divers and grebes in UK inshore areas: Aerial surveys and shore-based counts 2005/06

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November 2006

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ISSN 0963-8091

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This report should be cited as:

Söhle, I., Wilson, L.J., Dean, B.J., O'Brien, S.H., Webb, A. and Reid, J.B. (2006). Wintering sea ducks, divers and grebes in UK inshore areas: Aerial surveys and shore-based counts 2005/06. *JNCC Report*, No. 392

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Summary

From December 2005 to February 2006, and in May 2006 the Joint Nature Conservation Committee (JNCC) conducted aerial surveys of wintering aggregations of seaducks, divers and grebes within a number of UK inshore areas. The aim of the surveys was to collect data on the wintering numbers and distribution of inshore waterbirds in areas of the UK known to be important for this group of species. The surveys were carried out as part of the JNCC annual programme of surveillance of wintering inshore waterbirds in the UK.

The areas covered by aerial surveys were: Aberdeen Bay, the Moray and Dornoch Firths, Scapa Flow and Tankerness, the west coast of the Outer Hebrides, Coll, Tiree and part of the west coast of Mull, the Sound of Gigha and outer West Loch Tarbert, the Firth of Clyde including Loch Ryan and Luce Bay. Surveys were conducted from light aircraft, following a line-transect method designed to collect data that is suitable for both distance sampling (to estimate total numbers of birds by correcting for a decrease in detectability with distance from the transect line) and geostatistical modelling (to identify areas with the highest densities of birds). In addition, monthly shore-based counts were conducted within the Aberdeen Bay area from June 2005 to May 2006 to provide additional data on inshore waterbird numbers.

Ten species of inshore waterbirds were recorded comprising: red-throated diver, black-throated diver, great northern diver, greater scaup, common eider, common scoter, velvet scoter, long-tailed duck, common goldeneye and red-breasted merganser. In addition, birds were recorded that could be identified only as diver species, grebe species or scoter species.

In contrast to the previous two years, no little gulls were observed. One unidentified grebe was recorded but no red-necked, great crested, or Slavonian grebes were observed. Bottlenose dolphins and harbour porpoises were recorded incidentally but are not discussed further in this report.

Within the areas surveyed, several sub-areas were particularly important for inshore waterbird species: Aberdeen Bay between Rockend and north of the Don river mouth, the south of the Dornoch Firth, Spey Bay of the Moray Firth and Firth of Clyde were important areas for red-throated divers, while bays and sounds of Scapa Flow and Tankerness, the west coast of Harris, North Uist, Benbecula, South Uist and Barra, the west coast of Kintyre and Luce Bay were particularly important for great northern divers.

Aberdeen Bay is a key area for common eiders but so are areas in Scapa Flow and Tankerness, and the west coast of Harris, North Uist, Benbecula, South Uist and Barra. Important areas for long-tailed ducks are Spey Bay of the Moray Firth, Scapa Flow and Tankerness, Orkney.

Aberdeen Bay, Spey Bay of the Moray Firth and Luce Bay are key areas for common scoters and the Wide Firth and north of Hoy in Orkney are important for red-breasted mergansers.

Shore-based counts showed that several sub-areas in Aberdeen Bay are particularly important for those waterbird species recorded, namely the Bridge of Don, Balmedie, Nig Bay and Cruden Bay.

1. Introduction

During the winter of 2005/06, the Joint Nature Conservation Committee (JNCC) Seabirds at Sea Team (SAST) conducted aerial surveys of wintering aggregations of sea ducks *Anatidae*, divers *Gaviidae* and grebes *Podicepididae*, hereafter referred to as inshore waterbirds. The surveys were conducted as part of the JNCC annual winter survey programme, which aims to collect data on non-breeding numbers and distributions of these species within UK coastal areas known to be important for inshore waterbirds. In addition, the JNCC conducted shore-based counts of inshore waterbirds within the Aberdeen Bay area. These counts were conducted to collect additional data on the numbers and distribution of inshore waterbirds within this area.

The survey programme, in conjunction with similar surveys by the Wildfowl and Wetlands Trust (WWT), supports two international instruments: the African-Eurasian Migratory Waterbird Agreement (AEWA; established under the Convention on the Conservation of Migratory Species of Wild Animals – also known as CMS or Bonn Convention 1999) and the European Union Birds Directive (Council Directive 79/409/EEC). In support of the first of these, the survey programme aims to address the UK's obligations to monitor important populations of inshore waterbirds. In support of the second, the data collected during these surveys will be used to inform the process of identifying inshore areas as potential marine Special Protection Areas (SPAs) (Johnston *et al.* 2002; Stroud *et al.* 2003; Webb *et al.* 2004a; McSorley *et al.* 2005; O'Brien *et al.*2006).

The aerial survey method used during the 2005/06 surveys has previously been used by both JNCC and WWT for dedicated aerial surveys of coastal waters for aggregations of inshore waterbirds (Cranswick *et al.* 2003, Dean *et al.* 2003; Dean *et al.* 2004a; Dean *et al.* 2004b, Wilson *et al.* 2006). It is a line-transect sampling method, based on that developed by the National Environmental Research Institute (NERI) in Denmark (Kahlert *et al.* 2000), but with minor modification. In 2005/06, the surveys conducted by JNCC were carried out in Scottish inshore waters only; while WWT conducted surveys in the inshore waters of England and Wales (WWT Wetlands Advisory Service 2005).

In the areas surveyed, the method proved to be time and cost effective for surveying large coastal areas for aggregations of some species of inshore waterbirds. The method permits the collection of spatially precise and accurate data on the distribution of inshore waterbirds along sample line-transects. These data may be used to estimate population sizes and to model the density distribution or presence/absence of recorded species using analytical techniques such as distance sampling (Buckland *et al.* 2001) and geostatistical interpolation (Cressie 1991). Examples of these types of analyses can be found in Webb *et al.* (2004a), Webb *et al.* (2004b), McSorley *et al.* (2005); Webb *et al.* (2006).

In addition, shore-based counts were carried out to represent the total numbers of birds present within the survey area. Though aerial surveys are quick and enable the coverage of larger areas per unit time they do have the potential to miss species, e.g. while avoiding flying over ships or cliffs. Also shore-based counts allow for detailed observations on seabird behaviour.

This report outlines the methods used during the 2005/06 aerial surveys and shore-based counts, presents the recorded numbers and diurnal distributions of the species observed in each survey area, and discusses considerations for future surveys.

2. Methods

2.1 Target Species

The target species for aerial and shore-based count surveys were those inshore waterbirds that winter within coastal areas of the UK and are listed in Table 1 of the AEWA Action Plan (Convention of Migratory Species 1999), or in Annex I of the EC Birds Directive (79/409/EEC), or are migratory species that occur regularly in the UK. These species comprise red-throated diver *Gavia stellata*, black-throated diver *G. arctica*, great northern diver *G. immer*, red-necked grebe *Podiceps grisegena*, great crested grebe *P. cristatus*, Slavonian grebe *P. auritus*, greater scaup *Aythya marila*, common eider *Somateria mollissima*, common scoter *Melanitta nigra*, velvet scoter *M. fusca*, long-tailed duck *Clangula hyemalis*, common goldeneye *Bucephala clangula*, goosander *Mergus merganser* and red-breasted merganser *M. serrator*. In addition, little gulls *Larus minutus* and cetaceans were recorded.

2.2 Aerial survey

2.2.1 Survey locations

Aerial surveys were conducted from December 2005 to May 2006 of the following areas:

- Aberdeen Bay
- Moray and Dornoch Firths
- Scapa Flow and Tankerness (Shapinsay and Deer Sounds), Orkney
- West coast of the Outer Hebrides: Traigh Luskentyre, Sounds of Taransay and Harris, west coast of Uists & Barra
- The waters around Coll, Tiree and west Mull
- Sound of Gigha and outer West Loch Tarbert
- The Firth of Clyde and Loch Ryan
- Luce Bay



The locations of each survey area are shown in Figure 1.

Figure 1. Locations of inshore areas surveyed by the JNCC during 2005/06 aerial surveys.

2.2.2 Survey method

The line-transect survey method applied during the 2005/06 surveys was developed in Denmark by the NERI (Kahlert *et al.* 2000) to collect data suitable for analysis using distance sampling (Buckland *et al.* 2001). Distance sampling provides a statistically robust method of describing the rate at which the numbers of birds missed by observers increases with perpendicular distance from the transect line, allowing total population size to be estimated, with confidence limits.

In addition, the survey method applied during these surveys permits the calculation of bird density or presence/absence data at a fine spatial scale, suitable for geostatistical interpolation (Cressie 1991). Geostatistical interpolation methods allow the spatial distribution of a sampled variable (e.g. bird density or presence/absence) to be modelled to identify the most important areas in the distribution.

Previous deployment of the line-transect sampling method (Dean *et al.* 2003; Dean *et al.* 2004a; Dean *et al.* 2004b; Wilson *et al.* 2006, WWT unpublished) has proven to be successful in providing data

suitable for both distance sampling and geostatistical analyses (Webb *et al.* 2004a, 2004b; McSorley *et al.* 2005; O'Brien *et al.* 2006.).

Within each survey area, a regular grid of evenly spaced, parallel transect lines was defined, as described in Dean *et al.* (2004a). East-west transect lines were spaced at 1.85km (1' latitude), except along the west coast of the Outer Hebrides and Coll and Tiree, where transects were spaced at 3.7km (2' latitude) apart. North-south transect lines were spaced at 2km (2' longitude).

The aircraft was generally flown within 50m of the intended transect line, except where ships or offshore platforms necessitated small detours.

2.2.3 Aircraft

Surveys were conducted from a Partenavia (PN-68) and a Britten-Norman Islander (BN2A) aircraft, which have a high-winged design, allowing observers an unobstructed view of the sea. They are capable of relatively low cruising speeds, so maximising observation time, and are twin-engined, so satisfying various legal and safety requirements. Neither aircraft was fitted with bubble windows.

The target altitude and cruising speed were standardised at 76m (250 feet) and 185km h^{-1} (100 knots) respectively. Based on test flights using this type of aircraft in the Kattegat, Denmark, Kahlert *et al.* (2000) suggest that these standards optimise detection and identification of birds, while minimising the flushing of birds from the water by the approaching aircraft.

The lack of bubble windows prevented observers from viewing the strip of water directly below the aircraft. Any birds present within this strip could not be observed. At the target altitude of 76m this strip extended approximately 44m port and starboard of the transect line.

2.2.4 Weather conditions

Survey flights were undertaken during daylight hours (between 07:00 and 18:00 GMT) and in suitable weather conditions. Optimal conditions for survey flights were: excellent visibility (to the horizon), calm seas of sea state 3 or less (wind ≤ 10 knots, swell ≤ 0.6 m), high altitude light cloud cover and little or no precipitation. Some surveys were conducted in sub-optimal conditions, but never in sea state exceeding 4 (wind > 16 knots) or in low cloud (to 500 ft).

2.2.5 Data recording

During each survey flight, time and navigation data to a precision of less than 10 m (including the aircraft's position, altitude and speed) were automatically recorded from two Geographical Positioning Systems (GPSs): data were recorded from a Garmin GPS III Plus using the system described in Dean *et al.* (2004a) and a back-up arrangement logged track data using a Garmin eTrex Legend C.

Observations were made simultaneously by one port observer and one starboard observer, each of whom recorded data directly onto a cassette voice recorder, using the protocols described in Dean *et al.* (2004a). In summary, observers recorded the start and end times of each transect (to the nearest second) directly onto the voice recorder. Observers also recorded the species, number and perpendicular distance of all inshore waterbirds from the transect line. Observed cetaceans were recorded in the same way. The time recorded was the second that the bird/flock passed abeam (at right angles to the length of the aircraft). The perpendicular distance of each observation from the transect line was recorded by assigning observations to one of four distance bands: band A = 44-162m; band B = 163-282m; band C = 283-426m and band $D \ge 427m$. Observers determined these distances using fixed angles of declination from the visual horizon. In addition, visibility, cloud cover and wind speed were recorded at the beginning and at the end of each transect.

2.2.6 Data analysis

Navigation and observation data were entered into separate tables in a Microsoft Access database, linked by a common time field. The position of the aircraft during small gaps in the navigation data (caused by poor GPS signal in some areas) was calculated by interpolation within the Access database, using a program written in Visual Basic for Applications (VBA) code. The total length of transects covered during each survey (Table 1), were calculated from the time and position data in the navigation database tables also using a program written in VBA code.

Using the common time field in the Access database, each observation was assigned a location corresponding to the location of the aircraft at the time (to the nearest 1 second) that the observation was recorded abeam. The database containing the navigation and observation data was linked to a Geographical Information System (ESRI ArcMap v.8.2 GIS) via an ODBC (Open DataBase Connectivity) database connection, to generate the transect maps and distribution maps (Figures 3-10) presented in section 3.1.5.

2.3 Shore-based count survey

2.3.1 Survey area

Twelve shore-based counts of the target species were conducted between June 2005 and May 2006. Within ten sub-sections, 23 count points from Slains Castle (NK1015 3610) in the north to New Doonies Yawns (NJ9680 0370) in the south, along the Aberdeen Bay area were surveyed (Figure 2).

2.3.2 Count method

Locations of count points were chosen on the basis of having sufficient elevation and uninterrupted line of sight to give an optimal all-round view of the coastline to the north and south. To ensure sections were fully covered during each survey count, each section was counted from a minimum of two count points and the observer used landmarks along the coast to determine the boundary of the area. In some cases (sections 1 and 9), count points were placed close together because of the nature of the coastline.



Figure 2. Locations of count points and count sub-sections for shore-based counts conducted within the Aberdeen Bay area, June 2005 – May 2006.

2.3.3 Weather conditions

Counts were undertaken only during daylight hours and in suitable weather conditions which were defined as good to excellent visibility (little or no glare, haze, or precipitation), calm seas (Beaufort Scale 3 or less, wind ≤ 10 knots), and high altitude light cloud cover.

2.3.4 Data recording

Shore-based counts were carried out where possible on a single day during each month from May 2005 to June 2006 (Table 3). Counts were made from each of the 23 count points using a tripod-mounted telescope with a 30x fixed eyepiece, generally working from south to north. The maximum distance from the shore within which birds could be counted was estimated to be approximately 2km in optimal conditions.

All target species observed on the water were counted and recorded. To avoid double counting, flying birds were excluded from calculations, and counts timed to less than 10 minutes.

3. Results/Discussion

3.1 Aerial survey

3.1.1 Survey time and total transect length

Fifteen surveys were completed over 18 days (Table 1). Apart from the Moray and Dornoch Firths and the Outer Hebrides every area was surveyed at least twice. Aberdeen Bay was surveyed three times, including an additional survey taken place in May 2006.

Two surveys (Sound of Gigha, 18 March and Coll, Tiree and Mull, 10 February) were abandoned prematurely due to deteriorating weather conditions, one survey was ended prematurely due to fuel limitations (Firth of Clyde, 31 January 2006) but these were completed on the following day (Sound of Gigha, 20 March 2006) and as soon after as weather condition permitted (Coll, Tiree and Mull, 18 February 2006). Another survey was abandoned prematurely due to military aircraft activity in the region (Moray and Dornoch Firths, 30 January 2006). However, this survey was almost completed and it was considered unnecessary to be flown again. No survey area was covered more than once in any one month.

The approximate total length of transect lines surveyed during the 2005/06 aerial surveys was 6,838km; comprising 427km in December 2005, 1560km in January, 2,621km in February, 2,039km in March and 190km in May 2006. The survey locations, date and time, and total lengths of the transect lines flown during each survey of each area are shown in Table 1.

Trip no.	Area	Date	TF	Start Time (GMT)	End Time	Total length (km)
				. ,	(GMT)	
1	Aberdeen Bay	08 Dec 05	19	10:46:29	12:06:20	190.86
2	Aberdeen Bay	24 Jan 06	17	10:08:25	14:29:00	190.06
3	Aberdeen Bay ⁵	10 May 06	18	10:46:44	12:10:51	189.86
4	Moray and Dornoch Firths ³	30 Jan 06	15	11:37:26	14:12:00	227.92
4	Moray and Dornoch Firths	04 Feb 06	23	09:30:11	12:19:09	448.25
5	Orkney	29 Jan 06	34	10:13:52	14:31:11	352.87
6	Orkney ⁴	22 Feb 06	33	09:39:43	14:40:08	378.81
7	Outer Hebrides	28 Jan 06	34	10:40:34	16:14:39	554.54
7	Outer Hebrides	31 Jan 06	6	11:18:42	12:08:35	103.08
8	Coll, Tiree and west Mull	09 Feb 06	23	11:13:06	15:42:22	375.77
8	Coll, Tiree and west Mull ¹	10 Feb 06	6	09:29:38	10:51:50	126.57
8	Coll, Tiree and west Mull	18 Feb 06	20	09:54:08	15:17:17	515.44
9	Coll, Tiree and west Mull	20 Mar 06	26	14:32:30	16:41:39	280.78
9	Coll, Tiree and west Mull	21 Mar 06	26	09:04:41	14:53:33	585.59
10	Sound of Gigha	12 Dec 05	31	11:20:42	13:41:13	236.42
11	Sound of Gigha ¹	18 Mar 06	9	10:10:58	10:45:14	62.79
11	Sound of Gigha	20 Mar 06	20	09:36:23	11:39:42	206.60
12	Firth of Clyde and Loch Ryan ²	31 Jan 06	9	14:23:06	15:46:35	129.96
12	Firth of Clyde and Loch Ryan	01 Feb 06	12	15:03:39	15:55:52	122.17
12	Firth of Clyde and Loch Ryan	10 Feb 06	12	13:11:33	14:59:10	254.19
13	Firth of Clyde and Loch Ryan	19 Mar 06	34	09:16:22	15:34:08	503.10
14	Luce Bay	01 Feb 06	20	10:51:25	13:25:05	400.29
15	Luce Bay	18 Mar 06	20	11:22:20	16:23:24	400.43

Table 1. Survey trip number, number of transects flown (TF) and total transect length within each area surveyed from December 2005 to May 2006. Start and End Times do not include travel times to and from the survey sites.

¹ Survey terminated due to poor weather conditions

² Survey terminated due to fuel limitations

³ Survey terminated due to military aircraft in the region

⁴ On this survey only starboard observations were recorded

⁵ A training flight was carried out during the afternoon of this day but excluded from the analysis

3.1.2 Species recorded

Ten of 14 target species were recorded at least once during the 2005/06 aerial surveys (Table 2). These comprised red-throated diver, black-throated diver, great northern diver, greater scaup, common eider, common scoter, velvet scoter, long-tailed duck, common goldeneye and red-breasted merganser. Also one unidentified grebe was recorded. In addition, some birds were recorded that could be identified only as diver or scoter species. No little gulls were seen during the surveys. Bottlenose dolphins and harbour porpoises were also recorded but are not further discussed in this report.

3.1.3 Positional accuracy of observations

An assessment of the accuracy of the locations assigned to bird observations was made using a method described by Dean *et al.* (2004a). It resulted in the following conclusions:

- 1. Assuming a cruising speed of 51.38 m sec^{-1} , and an inaccuracy of up to five seconds between the time abeam of an observation and the time recorded onto the cassette, most observations were assigned a position along the transect line within 257 m (5 × 51.38) of their actual position. In a few cases, where visual encounter rates were very high, thereby increasing the inaccuracy between observation and recording to up to 10 seconds, observations may have been assigned a position along the transect line within 514m (10 × 51.38) of their actual position.
- 2. For the purposes of distribution mapping herein, all observations are assumed to be on the transect line and are therefore at least 44m and at most approximately 925 1000m from their true position either side of the transect line.

3.1.4 Numbers of species recorded

In considering the distribution maps (Figures 3-10) it is important to note that there is a degree of error associated with the positions assigned to each observation.

In considering these numbers it is also important to note that:

- 1. The data are samples (recorded along line-transects) of the total numbers present within each survey area. In order to produce total population estimates they must be analysed using distance sampling methods (Buckland *et al.* 2001).
- 2. Comparison of absolute numbers of birds between different survey areas should be avoided due to differences in the size of survey areas and sampling intensity.

Most inshore waterbird species observed during aerial surveys were recorded inshore of the 20m depth contour, this depth being the maximum typical diving depth suggested for these species (Cramp & Simmons 1977). This corresponds with data collected in previous years (Dean *et al.* 2003, 2004a and 2004b, Wilson *et al.* 2006).

Table 2. Total number of target species recorded in each survey area during the 2005/06 aerial surveys. Numbers represent the total sample counts of all birds recorded along line-transects, during each survey.

Unidentified dolphins Harbour porpoise	6 0	5 0	0 0	10 0	0 0	0 0	0 2	0 0	1 0	0 0	0 0	0 0	1 0	0 0	0 0
Bottlenose dolphin <i>Tursiops truncatus</i>	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-breasted merganser Mergus serrator	0	0	1	2	59	36	17	6	11	34	25	2	18	0	0
Common goldeneye Bucephala clangula	0	0	0	5	0	2	0	0	0	3	2	0	1	0	0
Long-tailed duck Clangula hyemalis	1	0	0	524	300	172	75	0	4	35	3	19	3	4	2
Unidentified scoter <i>Melanitta sp</i> .	0	0	0	0	0	0	0	0	0	0	0	0	0	200	0
Velvet scoter Melanitta fusca	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Common scoter Melanitta nigra	22	205	455	205	0	5	0	0	0	0	66	2	19	265	182
Common eider So <i>materia mollissima</i>	191	174	283	393	616	720	948	267	150	623	225	288	589	145	1
Greater scaup A <i>ythya maril</i> a	0	0	0	0	0	0	0	0	6	0	0	161	77	0	0
Unidentified grebe <i>Podiceps sp</i> .	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Unidentified diver Ga <i>via sp.</i>	0	0	0	2	2	0	0	6	0	0	2	0	2	3	1
Great northern diver Ga <i>via immer</i>	0	0	0	14	85	54	188	51	29	203	50	1	11	29	28
Black-throated diver Ga <i>via arctica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Red-throated diver G <i>avia stellata</i>	14	21	39	81	2	6	0	0	1	0	0	4	20	6	2
Date of survey	08 December 2005	24 January 2006	10 May 2006	30 Jan. + 04 Feb. 2006	29 January 2006	22 February 2006	28 + 31 January 2006	09 + 10 + 18 Feb. 2006	20 + 21 March 2006	12 December 2005	18 + 20 March 2006	31 Jan. + 1 + 10 Feb. 2006	19 March 2006	01 February 2006	18 March 2006
Survey area	Aberdeen Bay			Moray and Dornoch Firths	Orkney		Outer Hebrides	Coll, Tiree and west Mull		Sound of Gigha		Firth of Clyde and Loch Ryan	-	Luce Bay	

3.1.5 Distribution of bird observations

3.1.5.1 Aberdeen Bay

During 2005/06 two winter aerial surveys (8 December 2005 and 24 January 2006) and one additional spring aerial survey (10 May 2006) were carried out in Aberdeen Bay (Table 2).

The area has been surveyed from aircraft each winter since 2003/04; in total Aberdeen Bay has been surveyed six times.

The main species recorded in this area during aerial surveys are red-throated divers, common eider and common scoter (Figures 3a-f).

Most red-throated divers were recorded between south of Rockend and north of the Don River mouth, in waters less than 20m depth (Figure 3a-c).







Figure 3b: Distribution of red-throated divers during aerial surveys carried out over Aberdeen Bay on 24 January 2006.







Figure 3d: Distribution of common eiders and common scoters during aerial surveys carried out over Aberdeen Bay on 8 December 2005.



Figure 3e: Distribution of common eiders and common scoters during aerial surveys carried out over Aberdeen Bay on 24 January 2006.



Figure 3f: Distribution of common eiders and common scoters during aerial surveys carried out over Aberdeen Bay on 10 May 2006.

3.1.5.2 Moray and Dornoch Firths

The Moray and Dornoch Firths areas were surveyed only once (30 January and 4 February 2006) during the 2005/06 winter aerial surveys (Table 2).

The Moray and Dornoch Firths have been surveyed by aircraft each winter since winter 2002/03. In total the area has been surveyed seven times however not all surveys were complete. Previous surveys were conducted in different months so a direct comparison of species numbers is not possible.

The main species recorded in this area during aerial surveys were red-throated and great northern divers, common eider, common scoter, long-tailed duck and common goldeneye (Figure 4a-d).

Red-throated divers were present mainly in the south of the Dornoch Firth and concentrated in Spey Bay of the Moray Firth (Figure 4a). Red-throated divers were recorded in equal numbers in waters both deeper and shallower than 20m, while great northern divers were recorded predominantly in waters deeper than 20 metres.

Common eider and long-tailed duck also tend to occur in Spey Bay, Moray Firth (Figure 4c,d) while only a very small number of each species was detected in the Dornoch Firth. For long-tailed ducks the survey area of Spey Bay was recorded as the main congregation area of all areas surveyed.

Common scoter occurred in very low numbers throughout the entire survey area (Figure 4b). Though in low numbers common goldeneye were more common in the Moray and Dornoch Firths compared with any other Scottish survey area (Figure 4b).



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Figure 4a: Distribution of red-throated and great northern divers during aerial surveys carried out over the Moray and Dornoch Firths on 30 January and 4 February 2006.



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Figure 4b: Distribution of common scoter and common goldeneye during aerial surveys carried out over the Moray and Dornoch Firths on 30 January and 4 February 2006.



Figure 4c: Distribution of common eider during aerial surveys carried out over the Moray and Dornoch Firths on 30 January and 4 February 2006.



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Figure 4d: Distribution of long-tailed ducks during aerial surveys carried out over the Moray and Dornoch Firths on 30 January and 4 February 2006.

3.1.5.3 Scapa Flow and Tankerness (Shapinsay and Deer Sounds), Orkney

During 2005/06 two winter aerial surveys (29 January and 22 February 20066) were carried out over Scapa Flow and Tankerness (Table 2).

The Scapa Flow has been surveyed by aircraft five times since winter 2002/03 but in addition to previous surveys the areas of Tankerness, the Wide Firth and parts of the Shapinsay and Deer Sound have not been covered before.

The main species recorded in this area during aerial surveys are red-throated and northern divers, common eider, common scoter, long-tailed duck and red-breasted merganser (Figure 5a-h).

Divers were recorded throughout the area with a small concentration of birds occurring in the northeast of Scapa Bay during the January survey. Whereas divers were sighted mostly in deeper waters, seaducks were observed in inshore areas (Figures 5a,b).

Most common eiders occurred in the Wide Firth, Holm Sound and the bays north and north-west of Hoy (Figure 5c,d). Long-tailed ducks were most common mainly in the Wide Firth and north of Hoy (Figure 5e,f).



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Figure 5b: Distribution of red-throated and great northern divers during aerial surveys carried out over Scapa Flow and Tankerness, Orkney on 22 February 2006.



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Figure 5c: Distribution of common eiders during aerial surveys carried out over Scapa Flow and Tankerness, Orkney on 29 January 2006.



Figure 5d: Distribution of common eiders during aerial surveys carried out over Scapa Flow and Tankerness, Orkney on 22 February 2006.



Figure 5e: Distribution of long-tailed ducks during aerial surveys carried out over Scapa Flow and Tankerness, Orkney on 29 January 2006.



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Figure 5f: Distribution of long-tailed ducks during aerial surveys carried out over Scapa Flow and Tankerness, Orkney on 22 February 2006.



Figure 5g: Distribution of red-breasted mergansers during aerial surveys carried out over Scapa Flow and Tankerness, Orkney on 29 January 2006.



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Figure 5h: Distribution of red-breasted mergansers during aerial surveys carried out over the Scapa Flow and Tankerness, Orkney on 22 February 2006.

3.1.5.4 West coast of the Outer Hebrides

During 2005/06, one winter aerial survey (28 and 31 January 2006) was carried out along the west coast of the Outer Hebrides (Table 2).

This area has been surveyed by aircraft four times since March 2003. Previous surveys were carried out between 17 February and 18 March but not in January.

The main species recorded in this area during aerial surveys were great northern diver, common eider and long-tailed duck (Figure 6a-c).

The most important areas for all species were the Sound of Harris and along the west coast of Benbecula and South Uist. Although a few individual divers and eiders were observed in offshore waters most birds were recorded in waters shallower than 20 metres.



Figure 6a: Distribution of great northern divers during aerial surveys carried out over the Outer Hebrides on 28 and 31 January 2006.



Figure 6b: Distribution of common eiders during aerial surveys carried out over the Outer Hebrides on 28 and 31 January 2006.



Figure 6c: Distribution of long-tailed ducks and red-breasted mergansers during aerial surveys carried out over the Outer Hebrides on

28 and 31 January 2006.

3.1.5.5 Coll, Tiree and west of Mull

The survey area that includes sea areas off Coll, Tiree and the west of Mull was surveyed twice (9, 10, 18 February and 20, 21 March 2006) during the 2005/06 winter aerial surveys (Table 2).

The areas of Coll and Tiree and the western coast of Loch Tuath were first surveyed by aircraft in 2004/05. However, the western coast of Loch Na Keal was added to the survey schedule in 2005/06, thereby extending the survey area towards the north including the northern entrance of the Sound of Mull.

The main species recorded in this area during aerial surveys were great northern diver, common eider and red-breasted merganser (Figure 7a-d).

The areas around the Isle of Tiree are most import for species such as great northern diver (Figure 7a,b) and common eider (Figure 7c,d). Divers were recorded offshore while eiders occurred in inshore areas. Divers and eiders occurred in greater numbers on the north-west coast of Tiree during the March survey (51 and 267 respectively) compared with the February survey (29 and 150 respectively). This could be related to the birds seeking shelter in the calmer waters along the south-east coast during the February surveys.

The extension of the survey area did not result in an increase in the number of species recorded. During a previous survey carried out in March 2005 great northern divers and common eiders were observed using the inshore areas of the northeastern part of the Sound of Mull more extensively. This pattern was not observed during this year's survey.



Figure 7a: Distribution of great northern divers during aerial surveys carried out over Coll, Tiree and west of Mull on 9 and 18 February 2006.



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Figure 7b: Distribution of great northern divers during aerial surveys carried out over Coll, Tiree and west of Mull on 20/21 March 2006.



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Figure 7c: Distribution of common eiders and red-breasted mergansers during aerial surveys carried out over Coll, Tiree and west of Mull on 9 and 18 February 2006.



Figure 7d: Distribution of common eiders and red-breasted mergansers during aerial surveys carried out over Coll, Tiree and west of Mull on 20/21 March 2006.

3.1.5.6 Sound of Gigha and outer West Loch Tarbert

During 2005/06 two winter aerial surveys (12 December 2005 and 18, 20 March 2006) were carried out over the Sound of Gigha and outer West Loch Tarbert (Table 2).

This was the second winter that the Sound of Gigha and outer West Loch Tarbert were surveyed. A single survey was carried out on 9 March 2006.

The main species recorded in this area during aerial surveys were great northern diver, common eider, common scoter, long-tailed duck and red-breasted merganser (Figures 8a-f).

The west coast of Kintyre is a particularly important area for great northern divers (Figure 8a,b), and also for common eiders, which were dispersed in high numbers throughout the area (Figure 8c,d). During the survey on 12 December 2005 as many as 203 great northern divers were recorded - the highest number recorded of this species in any survey area during the 2005/06 survey season. During the 12 December survey common eiders were observed in aggregations mainly around the north and east of the Isle of Gigha (Figure 8c). Their distribution changed during the second survey in March 2006 when birds were recorded mainly south of Gigha (Figure 8d).

On 12 December 2005 (Figure 8c) the amount of long-tailed ducks occurring along the west coast of Kintyre was higher than during the March survey.

During December 2005 red-breasted mergansers were recorded in West Loch Tarbert, whereas during the March 2006 survey a similar number of birds were recorded at the southern end of the Sound of Gigha (Figure 8e,f). Common scoters were present only at the southern end of the Sound of Gigha during the March survey (Figure 8f).



Figure 8a: Distribution of great northern divers during aerial surveys carried out over the Sound of Gigha and outer West Loch Tarbert on 12 December 2005.



Figure 8b: Distribution of great northern divers during aerial surveys carried out over the Sound of Gigha and outer West Loch Tarbert on 18 and 20 March 2006.



Figure 8c: Distribution of common eiders and long-tailed ducks during aerial surveys carried out over the Sound of Gigha and outer West Loch Tarbert on 12 December 2005.



Figure 8d: Distribution of common eiders and long-tailed ducks during aerial surveys carried out over the Sound of Gigha and outer West Loch Tarbert on 18 and 20 March 2006.



Figure 8e: Distribution of red-breasted mergansers during aerial surveys carried out over the Sound of Gigha and outer West Loch Tarbert on 12 December 2005.



Figure 8f: Distribution of red-breasted mergansers during aerial surveys carried out over the Sound of Gigha and outer West Loch Tarbert on 18 and 20 March 2006.

3.1.5.7 Firth of Clyde and Loch Ryan

During 2005/06 two winter aerial surveys (31 Jan., 1, 10 February and 19 March 2006) were carried out over the Firth of Clyde and Loch Ryan (Table 2). These are the first aerial surveys to be carried out in this area. The first survey (30 January, 1 and 10 February 2006) of a rather large area took three days to complete, whereas the second survey (19 March 2006) was completed during one day.

The main species recorded in this area during aerial surveys here were red-throated and great northern divers, greater scaup, common eider, common scoter, long-tailed duck and red-breasted merganser (Figures 9a-g).

Divers occurred in very small numbers in the southern area during the January/February survey; however, numbers increased during the second survey (Figure 9a,b) with concentrations of red-throated divers at Irvine and Ayr Bay.

Common eiders occurred in higher numbers during the March 2006 survey with large concentrations in Loch Ryan, Irvine and Ayr Bay (Figure 9c,d).

Greater scaup and red-breasted mergansers occurred mainly in Loch Ryan (Figure 9e-g).



Figure 9a: Distribution of red-throated and great northern divers during aerial surveys carried out over the Firth of Clyde and Loch Ryan on 31-10 February 2006.



Figure 9b: Distribution of red-throated and great northern divers during aerial surveys carried out over the Firth of Clyde and Loch Ryan on 19 March 2006.



Figure 9c: Distribution of common eiders and long-tailed ducks during aerial surveys carried out over the Firth of Clyde and Loch Ryan on 31-10 February 2006.



Figure 9d: Distribution of common eiders and long-tailed ducks during aerial surveys carried out over the Firth of Clyde and Loch Ryan on 19 March 2006.







Figure 9f: Distribution of greater scaup during aerial surveys carried out over the Firth of Clyde and Loch Ryan on 19 March 2006.



Figure 9g: Distribution of red-breasted mergansers and common scoters during aerial surveys carried out over the Firth of Clyde and Loch Ryan on 19 March 2006.

3.1.5.8 Luce Bay

During 2005/06, two winter aerial surveys were conducted over Luce Bay (1 February and 18 March 2006) (Table 2). These are the first aerial surveys to be carried out in this area by JNCC.

The main species recorded in this area were red-throated and great northern divers, common eider, common scoter and long-tailed duck (Figure 10a-f).

Great northern divers were more common than red-throated divers, which were recorded mostly in waters shallower than 20m (Figure 10a,b).

The small area of Luce Bay might be important for common scoter which was recorded during both surveys (265 and 182 individuals respectively; Figures 10e,f)



Figure 10a: Distribution of red-throated and great northern divers during aerial surveys carried out over Luce Bay on 1 February 2006.



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Figure 10b: Distribution of red-throated and great northern divers during aerial surveys carried out over Luce Bay on 18 March 2006.



Figure 10c: Distribution of common eiders and long-tailed ducks during aerial surveys carried out over Luce Bay on 1 February 2006.



Figure 10d: Distribution of common eiders, long-tailed ducks and an unidentified grebe during aerial surveys carried out over Luce Bay on 18 March 2006.







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Figure 10f: Distribution common scoters during aerial surveys carried out over Luce Bay on 18 March 2006.

3.1.6 Species not adequately surveyed

The following target species were not recorded during these and previous line-transect aerial surveys; red-necked grebe, great crested grebe, and Slavonian grebe (Dean *et al.* 2003; 2004a and 2004b, Wilson *et al.* 2005). Information from shore-based surveys would suggest that red-necked grebes might have been recorded in Scapa Flow, and Slavonian grebes might have been expected in both Scapa Flow and the Moray Firth (Pollitt *et al.* 2003).

It is likely that grebes were not recorded because they are not easily detected on aerial surveys; they tend to be distributed close to shore, where they may be missed as the aircraft turns at the beginning and end of transects. In addition, the small wintering numbers of these species in the UK (Stone *et al.* 1997) reduces the likelihood of grebes being recorded on aerial surveys. Land-based counts or boatbased surveys may be the most suitable methods for surveying or monitoring these species (Dean *et al.* 2003, 2004a and 2004b, Wilson *et al.* 2006).

This was the second winter since 2000/2001 that greater scaup were recorded on aerial surveys. They occurred in each of the 2005/06 aerial surveys of the Firth of Clyde. In land-based surveys, scaup are usually recorded in single, very dense flocks within 50m of the shore (A. Webb, *pers. obs.*; Dean (2003)). The probability of missing such flocks is likely to be quite high and consideration should be given to other survey methods for surveying scaup populations, such as shore-based surveys.

It is vital that alternative methods of monitoring of those species and types of area for which linetransect and/or aerial survey methods are unsuitable be included in any comprehensive inshore waterbird monitoring programme. As more aerial surveys are conducted, it should be increasingly possible to identify the relevant species and types of area here.

3.1.7 Further analyses

The line-transect sample count data for the 2005/06 aerial surveys (the totals of which are presented in Tables 2) are suitable for distance sampling analyses (Buckland *et al.* 2001) aimed at estimating total population sizes in each survey area.

The distribution data collected during the aerial surveys and presented as distribution maps in Figures 3 to 10, offer a good initial representation of the local diurnal distributions of the important species recorded in each survey area. In addition, these data have a high spatial precision and are suitable for geostatistical interpolation (Cressie 1991), depending on their spatial (autocorrelative) structure. Geostatistical interpolation is capable of building fine-scale models of density (hence providing further estimates of population size) or presence/absence distributions (McSorley *et al.* 2005; Webb *et al.* 2006).

3.2 Shore-based counts

3.2.1 Species and numbers recorded

Ten of the 14 target species were recorded on the water during shore-based counts of the Aberdeen Bay area (Table 4). These comprised red-throated diver, red-necked grebe, great-crested grebe, greater scaup, common eider, common scoter, velvet scoter, long-tailed duck, common goldeneye and red-breasted merganser.

3.2.2 Distributions of most common species recorded during shore-based counts

In contrast to the sample counts obtained from aerial surveys, shore-based counts aim to represent total numbers of birds present within the survey area. However, it is possible that a small proportion of the total numbers of some species present within the survey area were not detected during the counts because they were in locations that were obscured by the coastline.

In addition, the maximum offshore extent of the survey area was limited by the maximum distance at which birds could be seen, that is approximately 2km. For this reason, and after consideration of the distributions observed during aerial surveys, it is also possible that a small proportion of the total numbers of some species wintering within Aberdeen Bay may have been missed.

Maps representing the average numbers of the most common species recorded are presented in Figures 11 to 15.

Table 3. Survey trip number,period date, times and total survey time of shore-based counts conductedwithin the Aberdeen Bay area, June 2005– May 2006.

Survey	Survey	Date	Start Time	End Time	Total survey Time
no.	period		(GMT)	(GMT)	(hours)
1		20 Jun. 2005	08:15	17:00	08:45
2	summer	25 Jul. 2005	06:28	13:30	07:02
3		25 Aug. 2005	08:22	16:30	08:08
		18 Sep. 2005	08:55	16:50	08:55
4		20 Sep. 2005	08:20	09:20	
	autumn	26 Oct. 2005	09:30	14:05	08:15
5		27 Oct. 2005	07:40	11:20	
6		17 Nov. 2005	09:15	15:30	06:15
		06 Dec. 2005	09:15	15:00	07:05
7		07 Dec. 2005	10:45	12:05	
	winter	04 Jan. 2006	09:35	14:45	05:40
8		08 Jan. 2006	10:20	10:50	
		03 Feb. 2006	08:55	12:45	05:05
9		04 Feb. 2006	11:50	13:05	
		21 Mar. 2006	08:20	13:05	09:10
10		22 Mar. 2006	10:20	14:45	
	spring	18 Apr. 2006	08:25	13:05	07:49
11		19 Apr. 2006	09:06	12:15	
12		25 May 2006	08:00	16:18	08:18

	Red-throated diver Gavia stellata	Red-necked grebe Podiceps grisegena	Great crested grebe Podiceps cristatus	Greater scaup Aythya marila	Common eider Somateria mollissima	Common scoter Melanitta nigra	Velvet scoter Melanitta fusca	Long-tailed duck Clangula hyemalis	Common goldeneye Bucephala clangula	Red-breasted merganse Mergus serrator
Date of survey										ſ
20 June 2005	14	0	0	0	1548	1840	50	0	0	1
25 July 2005	7	0	0	0	4099	3514	50	0	0	24
25 August 2005	5	0	0	0	5302	1	0	0	0	1
18 + 20 September 2005	83	1	0	0	3543	1091	89	0	0	4
26 + 27 October 2005	116	0	0	0	282	404	2	3	0	4
17 November 2005	84	0	0	4	165	326	0	20	12	5
06 + 07 December 2005	48	0	0	0	426	306	1	27	0	8
04 + 08 January 2006	159	0	0	0	450	19	0	3	0	12
03 + 04 February 2006	156	0	2	0	818	140	0	16	1	28
21 + 22 March 2006	61	0	0	0	999	87	0	29	0	32
18 + 19 April 2006	352	0	0	0	831	50	0	23	0	19
25 May 2006	52	0	0	0	1699	728	0	1	0	0

Table 4. Total numbers of target species recorded on the water during shore-based counts of the Aberdeen Bay area , June 2005 – May 2006.



Figure 11a: Distribution of the average number of red-throated divers recorded during 2005 summer months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 11b: Distribution of the average number of red-throated divers recorded during 2005 autumn months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Shore-based count section

Figure 11c: Distribution of the average number of red-throated divers recorded during 2005/06 winter months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 11d: Distribution of the average number of red-throated divers recorded during 2006 spring months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Shore-based count section

Figure 12a: Distribution of the average number of common eiders recorded during 2005 summer months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 12b: Distribution of the average number of common eiders recorded during 2005 autumn months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 12c: Distribution of the average number of common eiders recorded during 2005/06 winter months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 12d: Distribution of the average number of common eiders recorded during 2006 spring months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 13a: Distribution of the average number of common scoters recorded during 2005 summer months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 13b: Distribution of the average number of common scoters recorded during 2005 autumn months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 13c: Distribution of the average number of common scoters recorded during 2005/6 winter months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 13d: Distribution of the average number of common scoters recorded during 2006 spring months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.

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Figure 14a: Distribution of the average number of long-tailed ducks recorded during 2005 autumn months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 14b: Distribution of the average number of long-tailed ducks recorded during 2005/06 winter months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 14c: Distribution of the average number of long-tailed ducks recorded during 2006 spring months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 15a: Distribution of the average number of red-breasted mergansers recorded during 2006 summer months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 15b: Distribution of the average number of red-breasted mergansers recorded during 2006 autumn months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 15c: Distribution of the average number of red-breasted mergansers recorded during 2006 winter months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.



Figure 15d: Distribution of the average number of red-breasted mergansers recorded during 2006 spring months for shore-based counts along Aberdeen Bay. The bars showing the minimum and maximum range of the average number of birds recorded from a sample of three months.

3.2.3 Important areas in Aberdeen Bay

The survey results show that only certain species used Aberdeen Bay in greater numbers (Table 4). Only the most common species are discussed here.

Red-throated divers used different sections during different parts of the survey year but mostly occurred in high numbers during spring (Figure 11d) and winter (Figure 11c). During spring the main sections were Balmedie and Bridge of Don where birds occurred in average numbers of 35 and 31 individuals respectively (Figure 11d). However during winter months the numbers of red-throated divers where higher and reversed with the Bridge of Don section holding on average more birds (50) than the Balmedie section (27) (Figure 11c).

Common eiders occurred in low numbers during autumn, winter and spring (Figures 12b,c,d). During the autumn survey average numbers went up to a maximum of 489 birds in the Balmedie section and 454 birds in the Bridge of Don section. The most important sections for common eiders during summer months were Nig Bay (1006) and Bridge of Don (945). It should be noted that Nig Bay was a much smaller survey area than the area of Bridge of Don (Figure 2).

Common scoters used the Aberdeen Bay very selectively only being found at certain count sections. The maximum average number of birds recorded was during the summer surveys (1190) (Figure 13a) at Bridge of Don which was also the section in which the highest number of scoters was recorded during the spring (Figure 13d) and autumn surveys (Figure 13b).

Long-tailed ducks were present only in certain count sections and have not been counted at Doonies Yawns. They occurred in low average numbers in Cruden Bay and Bridge of Don sections during spring (Figure 14c), autumn (Figure 14a) and winter (Figure 14b). No long-tailed ducks were recorded during the summer surveys when birds were staying at their breeding grounds in Iceland and northern Norway (Cramp & Simmons 1977).

Red-breasted mergansers were present only in certain count sections and have not been counted at Doonies Yawns and Nig Bay. The maximum average number of birds recorded was during the winter surveys (16) (Figure 15c) at the Bridge of Don and equally during spring surveys (17) (Figure 15d) at Newburgh Bar and the Bridge of Don count section. The Bridge of Don could be identified as the most important area of occurrence for this species throughout the year.

4. Acknowledgements

The success of these surveys was due to the hard work and co-operation of those involved. JNCC would like to thank Richard Schofield and Mark Lewis, who were the observers during these surveys.

The JNCC would also like to thank Ravenair and Hebridean Air Services pilots for making the best use of the unpredictable winter weather, handling air traffic control and flying the surveys with the best possible precision and safety.

We thank the Station Commanders at RAF Lossiemouth, RAF Kinloss, RAF Leuchars, and the Range Controller at Barry Buddon Range, for access into their airspace.

We also thank the various Air Traffic Controllers who provided us with assistance.

These surveys were funded from Grant in Aid by the JNCC and by Scottish Natural Heritage. We would like to thank Nigel Buxton (SNH) and Peter Cranswick (WWT) for their comments on this report.

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