



**JNCC Report**

**No. 434**

**Aerial surveys of aggregations of seabirds, divers and grebes in  
UK inshore areas outside the breeding season in  
2007/08**

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## Summary

From December 2007 to March 2008, the Joint Nature Conservation Committee (JNCC) conducted aerial surveys of non-breeding aggregations of seaducks, divers and grebes within a number of Scottish inshore areas. The aim of the surveys was to collect data on the numbers and distribution of inshore waterbirds in areas of the UK known to be important for these groups of species. The surveys were carried out as part of the JNCC annual programme of surveillance of non-breeding populations of inshore waterbirds in the UK.

The areas surveyed by aircraft were: Luce Bay; the Firth of Clyde; the Sound of Gigha; Loch Indaal (Islay); Coll and Tiree; Wester Ross Inner Sound and sea lochs; north Orkney; and east Unst, east Mainland and south-west Mainland areas of Shetland. Surveys were conducted from light aircraft, following a line-transect method designed to collect data that are suitable for both distance sampling (to estimate total numbers of birds by correcting for a decrease in detectability with increased distance from the transect line) and spatial modelling (to identify areas with the highest densities of birds).

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 that could be identified only as diver species were recorded.

In contrast to some previous winter surveys, no little gulls were observed. No red-necked, great crested or Slavonian grebes were observed, despite surveying areas with known concentrations of some of these species. It is not known whether these species are overlooked during surveys, or whether their behaviour renders them difficult to observe from the air. Bottlenose dolphins and harbour porpoises were recorded incidentally but are not discussed in this report.

Great northern divers were recorded mainly in the north and west, with the highest numbers being in Orkney (March), Luce Bay (March) and the Sound of Gigha (February). Red-throated divers were recorded in the highest numbers in Luce Bay in March. Common eiders were numerous in all areas, but were recorded in the highest numbers in Orkney (March) and the Firth of Clyde (December). Common scoters were recorded in the largest numbers in Luce Bay (March). The largest numbers of long-tailed ducks were recorded in Orkney (March).

# 1 Introduction

During the winter and spring of 2007/08, the JNCC Seabirds at Sea Team (SAST) conducted aerial surveys of non-breeding aggregations of sea ducks *Anatidae*, divers *Gaviidae* and grebes *Podicepsidae*, 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 2007/08, the winter survey programme comprised: aerial surveys of Scottish inshore waters conducted by JNCC (presented in this report), aerial surveys of inshore waters of England and Northern Ireland (WWT Consulting, unpublished data), shore-based surveys of Scottish inshore waters conducted by JNCC (JNCC, unpublished data), and boat based surveys of inshore waters around Shetland conducted by Shetland Oil Terminal Environmental Advisory Group (SOTEAG) and Shetland Amenity Trust (JNCC, unpublished data). The survey programme supports the process of identifying inshore areas as potential marine Special Protection Areas (SPAs) (Stroud *et al*, 2001) under the requirements of the EC Birds Directive (EEC 1979).

Aerial surveys are only a component of the winter survey programme because in some cases, aerial survey methods may miss some species, eg species that avoid aircraft, or species that are close inshore and are missed by observers while the aircraft is banking at the coastline. Shore-based counts can potentially collect data on some species that might be missed by aerial surveys, although the offshore extent of such counts can be limited. Boat-based surveys can potentially collect data on some species that might be missed by aerial surveys, while retaining the ability to survey the offshore extent of aggregations. In addition to aerial surveys, the JNCC winter survey programme included shore-based counts of inshore waterbirds within the upper Firth of Clyde, selected areas of the Outer Hebrides, and the inshore waters north of Orkney Mainland. These counts collected additional data on the numbers and distribution of inshore waterbirds and attempted to count the total numbers of birds present within the survey areas. Several boat surveys were also conducted around Shetland by an external contractor to collect additional data on the numbers and distribution of great northern divers and Slavonian grebes in the area.

Only the aerial surveys conducted by JNCC in Scottish waters are considered in this report. This report outlines the methods used during the 2007/08 winter aerial surveys and presents the recorded numbers and distributions of the species observed in each survey area.

## **2 Methods**

### **2.1 Target species**

The target species for aerial surveys were those inshore waterbirds that winter within coastal areas of the UK and are listed in Annex I of the EC Birds Directive (79/409/EEC), or are migratory species that occur regularly in the UK. These species are 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*, red-breasted merganser *M. serrator*, 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*, and Slavonian grebe *P. auritus*. Cetaceans were also recorded.

### **2.2 Aerial surveys**

#### **2.2.1 Survey locations**

Aerial surveys were conducted from December 2007 to March 2008 of the following areas:

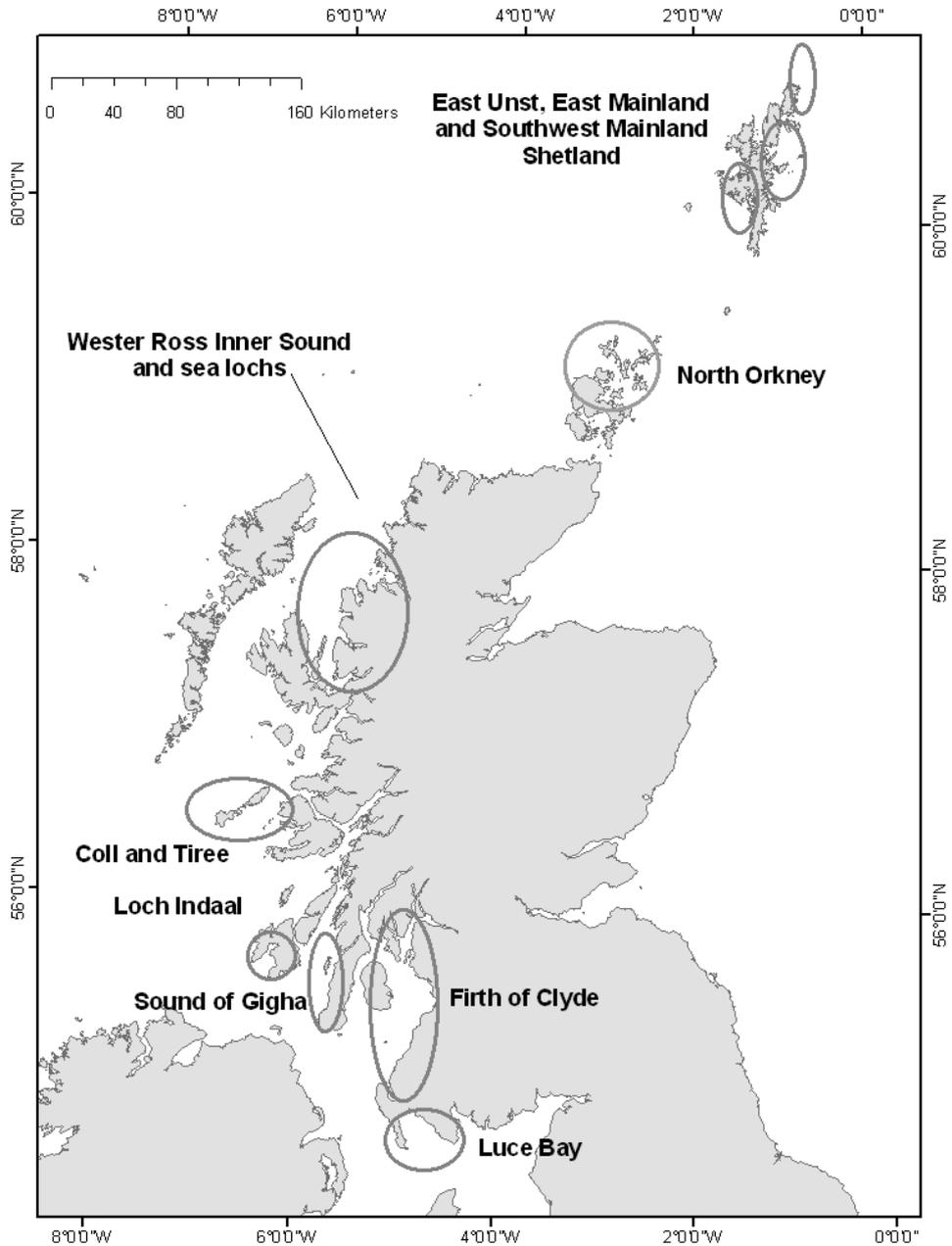
- Wester Ross Inner Sound and sea lochs (x2)
- Loch Indaal, Islay (x1)
- North of Mainland Orkney (x1)
- The waters around Coll and Tiree (x1)
- Sound of Gigha and outer West Loch Tarbert (x1)
- The Firth of Clyde(x1)
- Luce Bay (x1)
- East Unst (Shetland) (x1)
- East Mainland, Shetland (x2)
- South-west Mainland, Shetland (x1)

#### **2.2.2 Survey time and total transect length**

A total of 12 completed surveys were achieved out over 11 days, with a total transect length of approximately 3,435km (Table 1). All areas were surveyed once, apart from Wester Ross Inner Sound and sea lochs, and East Mainland, Shetland, which were both surveyed twice. 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. The locations of each survey area are shown in Figure 1.

**Table 1.** Survey trip number, area, date, times, the number of transects flown and total transect length within each area surveyed from December 2007 to March 2008. Start and end times do not include travel times to and from the survey sites. These data do not include any transects flown parallel to the coast

<b>Trip no.</b>	<b>Area</b>	<b>Date</b>	<b>Start time (GMT)</b>	<b>End Time (GMT)</b>	<b>No. transects flown</b>	<b>Total transect length(km)</b>
1	Firth of Clyde	19/12/2007	10:18:21	15:22:23	30	446.88
2	Wester Ross	20/12/07 and 21/12/2007	10:12:58	15:22:23	53	564.61
3	Loch Indaal	11/02/2008	10:23:39	11:33:31	11	117.89
4	Sound of Gigha	11/02/2008	12:44:54	15:11:27	35	269.4
5	East Mainland, Shetland	13/02/2008	10:23:39	12:17:22	18	176.6
6	West Mainland, Shetland	13/02/2008	13:08:21	14:31:44	22	117.6
7	North Orkney	15/03/2008	12:10:51	14:06:57	18	203.66
8	Wester Ross	16/03/2008	09:47:41	17:22:20	44	461.3
9	Coll and Tiree	17/03/2008	10:55:25	16:32:01	22	473.46
10	Luce Bay	18/03/2008	10:39:22	13:17:01	20	382.49
11	East Unst, Shetland	26/03/2008	10:32:13	11:02:55	10	54.29
12	East Mainland, Shetland	26/03/2008	11:19:20	12:37:45	17	167.04



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**Figure 1.** Locations of inshore areas surveyed by the JNCC during 2007/08 aerial survey season

### 2.2.3 Survey method

Winter surveys were originally planned from November 2007 to March 2008. However, due to logistical reasons (weather conditions and aircraft availability), no surveys were carried out before December 2007.

The aerial survey method used during the 2007/08 surveys has previously been used by both JNCC and WWT during 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; Söhle *et al*, 2006; Lewis *et al*, 2007). 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.

Within each survey area, a regular grid of evenly spaced, parallel transect lines, running approximately perpendicular to the coastline was defined, as described in Dean *et al* (2004a). East-west transect lines were spaced at 1.85km (1° latitude), while north-south transect lines were spaced at 2km (2° longitude). Transects in the Wester Ross survey were spaced at 2km, and set at bearings of either 57 or 117 degrees. This was to allow the transects to run as far as possible into the many sealochs in the area. In some survey areas, a further transect was flown parallel to the coast (approximately 1 km offshore), in order to collect additional data to aid future spatial analyses. The data for these parallel transects are not included in this report because they include repeat records of birds.

The line transect method has 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 McSorley *et al* (2005), Webb *et al* (2004), Webb *et al* (2006a) and Webb *et al* (2006b). This report presents only the raw sample count data and does not include any distance sampling or spatial statistical analyses.

#### **2.2.4 Aircraft**

Surveys were conducted from either a Partenavia (PN-68), or a Britten-Norman Islander (BN2A) aircraft. Both aircraft have a high-winged design, allowing observers an unobstructed view of the sea. Both aircraft are capable of relatively low cruising speeds, thus maximising observation time, and are twin-engined, so satisfying legal and safety requirements. Neither aircraft was fitted with bubble windows. Any birds present within the strip of water directly below the aircraft could not be recorded; at the target altitude of 76m this strip extended approximately 44m port and starboard of the transect line.

The target altitude and cruising speed were standardised at 76m (250 feet) and 185km h<sup>-1</sup> (100 knots) respectively to minimise the flushing of birds from the water by the approaching aircraft (Kahlert *et al*, 2000).

#### **2.2.5 Weather conditions**

Survey flights were undertaken between 09:00hrs and 18:00hrs GMT. Optimal conditions for survey flights were: excellent visibility (to the horizon), calm seas of sea state 3 or less (wind ≤ 10 knots, swell ≤ 0.6m), high altitude light cloud cover and little or no precipitation. Some surveys were conducted in sub-optimal conditions, but never in sea states exceeding 4 (wind > 16 knots) or in low cloud (below 500 ft).

### 2.2.6 Data recording

During each survey flight, time and navigation data (including the aircraft's position, altitude and speed) were automatically recorded by Global Positioning Systems (GPS) at a precision of 10m or better. Data were recorded with a Garmin GPSMap 276C GPS and a Garmin eTrex Legend C GPS. The pilot used either the onboard GPS (in the PN-68) or the handheld Garmin GPSMap 276C (in the BN2A) to maintain the aircraft's position along the transect line. Transect route waypoints were pre-loaded into the GPS prior to the survey. The aircraft was generally flown within 50m of the intended transect line, except where ships or offshore platforms necessitated small detours.

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 (assigned in bands) of all inshore waterbirds from the transect line. Cetaceans were recorded in the same way. The time recorded was to the nearest second that the bird/flock passed abeam (perpendicular to the survey track). 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  $\geq$  427m. Observers determined these distances using fixed angles of declination from the visual horizon. In addition, visibility, cloud cover, sea state and wind speed were recorded at the beginning and at the end of each transect.

### 2.2.7 Data analysis

Observational data were entered, and navigation data uploaded from the GPS, into Microsoft Access database tables. 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 database routine 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 using VBA code.

The observation and navigation data tables were then linked using common time and date fields. Using these common fields, each observation was assigned a location corresponding to the location of the aircraft at the time (to the nearest 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.9 GIS), to produce the transect maps and distribution maps (Figures 2-26) presented in section 3.1.5.

## **3 Results/Discussion**

### **3.1 Species recorded**

Ten of the 14 target species were recorded at least once during the 2007/08 aerial surveys (Table 3). These comprised greater scaup, common eider, common scoter, velvet scoter, long-tailed duck, common goldeneye red-breasted merganser, red-throated diver, black-throated diver and great northern diver. In addition, some birds were recorded that could be identified only as diver species. No grebe species or little gulls were recorded on any surveys. Bottlenose dolphins and harbour porpoises were also recorded but are not further discussed in this report.

**Table 2.** Numbers of each species recorded on each aerial survey, December 2007 to March 2008. These data do not include any transects flown parallel to the coast

<b>Date</b>	<b>Area</b>	<b>Greater scaup</b>	<b>Common eider</b>	<b>Long-tailed duck</b>	<b>Common scoter</b>	<b>Velvet scoter</b>	<b>Common goldeneye</b>	<b>Red-breasted merganser</b>	<b>Red-throated diver</b>	<b>Black-throated diver</b>	<b>Great northern diver</b>	<b>Unidentified diver</b>	<b>Total</b>
19/12/2007	Firth of Clyde	0	389	16	0	0	1	26	20	0	0	1	<b>453</b>
21/01/2008	Wester Ross	0	28	0	0	0	0	19	0	0	27	4	<b>78</b>
11/02/2008	Sound of Gigha*	0	338	8	0	1	16	38	0	0	85	1	<b>487</b>
11/02/2008	Loch Indaal	350	29	0	0	0	0	0	0	0	17	0	<b>396</b>
13/02/2008	West Shetland Mainland*	0	250	2	0	0	0	0	0	0	9	0	<b>261</b>
13/02/2008	East Shetland Mainland*	0	45	32	0	0	0	0	0	0	13	0	<b>90</b>
15/03/2008	North Orkney	0	405	159	0	0	0	17	0	0	30	2	<b>613</b>
16/03/2008	Wester Ross	0	30	2	0	0	0	10	0	1	11	0	<b>54</b>

<b>Date</b>	<b>Area</b>	<b>Greater scaup</b>	<b>Common eider</b>	<b>Long-tailed duck</b>	<b>Common scoter</b>	<b>Velvet scoter</b>	<b>Common goldeneye</b>	<b>Red-breasted merganser</b>	<b>Red-throated diver</b>	<b>Black-throated diver</b>	<b>Great northern diver</b>	<b>Unidentified diver</b>	<b>Total</b>
17/03/2008	Coll and Tiree	0	285	0	0	0	0	0	1	0	60	0	<b>346</b>
18/03/2008	Luce Bay	0	73	0	430	0	0	18	44	0	87	30	<b>682</b>
26/03/2008	East Unst, Shetland	0	0	0	0	0	0	0	0	0	3	0	<b>3</b>
26/03/2008	East Shetland Mainland	0	29	19	0	0	0	5	2	0	49	1	<b>105</b>
	<b>Totals</b>	<b>350</b>	<b>1901</b>	<b>238</b>	<b>430</b>	<b>1</b>	<b>16</b>	<b>133</b>	<b>67</b>	<b>1</b>	<b>388</b>	<b>39</b>	<b>3564</b>

\* During these surveys, observers felt that they may have missed some birds due to unfavourable observing conditions, as flight height was generally higher than usual for safety reasons.

Figures 2-26 show the distributions of birds recorded during aerial surveys of each area. 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 agrees with data collected by JNCC in previous years (Dean *et al*, 2003, 2004a and 2004b; Wilson *et al*, 2006; Söhle *et al*, 2006; Lewis *et al*, 2007).

### **3.2 Positional accuracy of observations**

In considering the distribution maps (Figures 2-26) it is important to note that there is a degree of error associated with the positions assigned to each observation. An assessment of the accuracy of the locations assigned to bird observations was made using a method described by Dean *et al* (2004a). In summary it resulted in the following conclusions:

1. Most observations were assigned a position along the transect line within 257m 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, although this degree of error is unlikely as very few birds were observed this far from the transect line.

### **3.3 Interpreting the raw data**

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 should 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.

### **3.4 Distribution of bird observations**

#### **3.4.1 Coll and Tiree**

One survey of Coll and Tiree was carried out on 17 March 2008 and recorded three species; common eider, red-throated diver and great northern diver. Great northern divers were recorded in moderately high numbers, favouring the western end of the survey area; common eider showed a similar pattern, whereas only a single red-throated diver was recorded.

This is the sixth complete survey of the area to be carried out over a 5 year period. Although great northern diver numbers have varied, the observations from this survey are typical in both number and distribution. Likewise, the numbers of common eider and the distribution, favoured areas being to the north and west of Tiree, are consistent with previous years' observations.

### **3.4.2 East Mainland Shetland and East Unst**

This was the first winter that east Mainland Shetland was surveyed by JNCC. It was surveyed twice, on 13 February 2008 and on 26 March 2008. Three species were recorded on both surveys, with common eider, great northern diver and long-tailed duck all recorded in small numbers, although larger numbers (49) of great northern divers were observed during the March survey. All three species were widespread throughout the survey area. In addition, two red throated divers were observed on the March survey.

An unknown number of birds may have been missed on the March 2008 survey, because flight height was generally higher than usual for safety reasons.

One survey off the east coast of Unst was carried out on 26 March 2008, the first survey to be undertaken in this area. Only three great northern divers were observed.

### **3.4.3 South-west Mainland, Shetland**

The south-west Shetland Mainland was surveyed once, on 13 February, with small numbers of great northern diver, and moderately high numbers of common eider recorded. This was the first survey to be carried out in the area. Most birds were concentrated in the northern part of the survey area, north of the islands of East and West Burra.

An unknown number of birds may have been missed on the March 2008 survey, because flight height was generally higher than usual for safety reasons.

### **3.4.4 Firth of Clyde**

This was the third winter that the Firth of Clyde was surveyed and was the fifth completed survey of the area. The area was surveyed once, on 19 December. Due to access restrictions, the most southerly transects from this survey, including those in Loch Ryan, could not be completed. Four species were recorded, comprising common eider, long-tailed duck, red breasted merganser, and red-throated diver. In addition, one unidentified diver was recorded.

High numbers of common eider were recorded, the northernmost part of the survey area being favoured. Long-tailed duck were also aggregated here. Ayr and Irvine bays contained a few observations of both long-tailed duck and red-breasted merganser, and almost all of the moderately high numbers of red-throated diver that were recorded.

### **3.4.5 Loch Indaal**

This was the first year that a survey of Loch Indaal was carried out by JNCC, with one survey completed on 11 February 2008. Three species were recorded: common eider, greater scaup and great northern diver. Common eider and great northern diver were recorded in small numbers mainly in the inner, more northerly part of the loch. Large numbers of greater scaup were recorded in the most northerly part of the loch, two flocks comprising 350 birds.

### **3.4.6 Luce Bay**

This was the third winter that Luce Bay was surveyed in the JNCC survey programme, and was the fifth completed survey of the area. The area was surveyed once, on 18 March 2008.

In total, five species were recorded, comprising common eider, common scoter, red-breasted merganser, red-throated diver, and great northern diver. In addition, 30 unidentified divers were recorded.

Common eider and red-breasted merganser were recorded in small numbers, but large numbers of common scoter were observed, mainly in the more northerly part of the surveyed area. Both red-throated and great northern divers were recorded in high numbers, favouring the more northerly part of the survey area, in the inner part of the bay.

### **3.4.7 North Orkney**

One survey was carried out on 15 March 2008, which recorded high numbers of great northern diver, common eider, long-tailed duck, with smaller numbers of red breasted merganser and two unidentified divers. This is the second season of survey for Sounds of Wyre, Rousay and Gairsay but the third season of survey of the Shapinsay and Deer Sounds area. The largest concentrations of all birds were observed around the islands of Wyre and Gairsay and in Wide Firth, a similar distribution to that found on the 2007 survey. In contrast to that survey, neither common scoter nor red-throated diver was recorded. Numbers of common eider and great northern divers were much lower than those observed last year, whereas long-tailed duck and red-breasted merganser were higher.

### **3.4.8 Sound of Gigha**

The Sound of Gigha was surveyed on 11 February 2008, and this represents the fifth winter survey and the fourth season of survey of this area. A total of six species were recorded, including common eider, long-tailed duck, velvet scoter, common goldeneye, red-breasted merganser, and great northern diver. In addition, one unidentified diver was recorded.

Common eider were observed in fairly large numbers and in common with other seaduck, were recorded mainly in the waters around the island of Gigha and West Loch Tarbert. As in other years, large numbers of great northern divers were observed, again favouring the area around Gigha and West Loch Tarbert. The raw count of 85 birds was low compared with other surveys of this area. An unknown number of birds may have been missed on the March 2008 survey, because flight height was generally higher than usual for safety reasons.

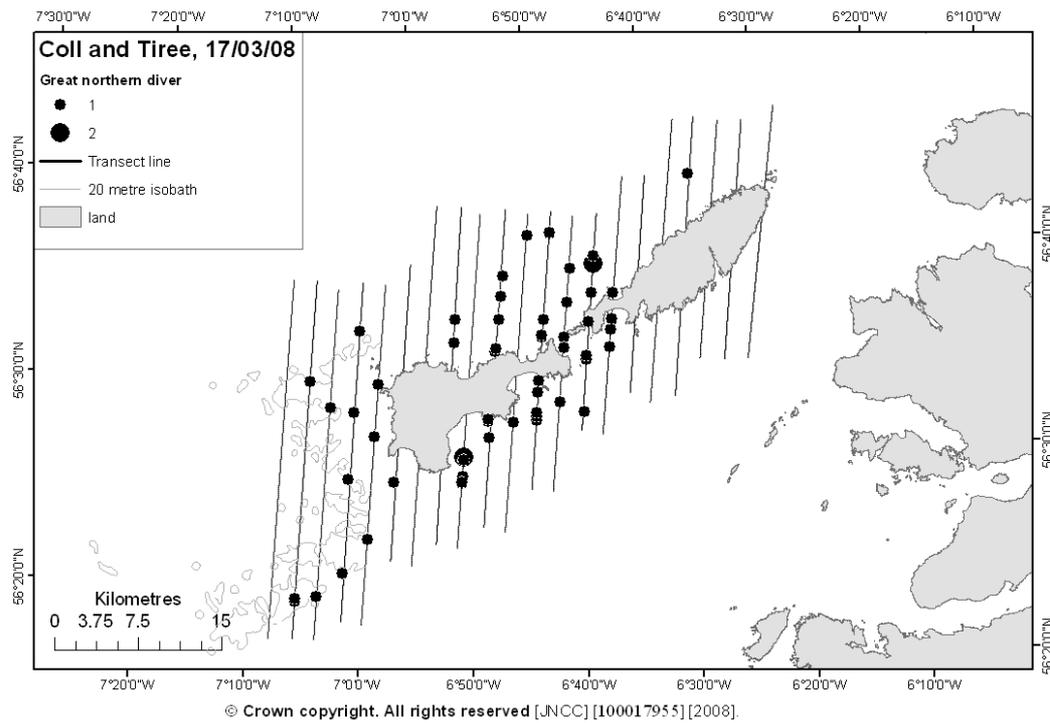
### **3.4.9 Wester Ross Inner Sound and sea lochs**

This year was the first time that the Inner Sound and sea lochs of Wester Ross were included in the JNCC survey programme. Two complete surveys were conducted, on 20/21 January 2008 and on 16 March 2008.

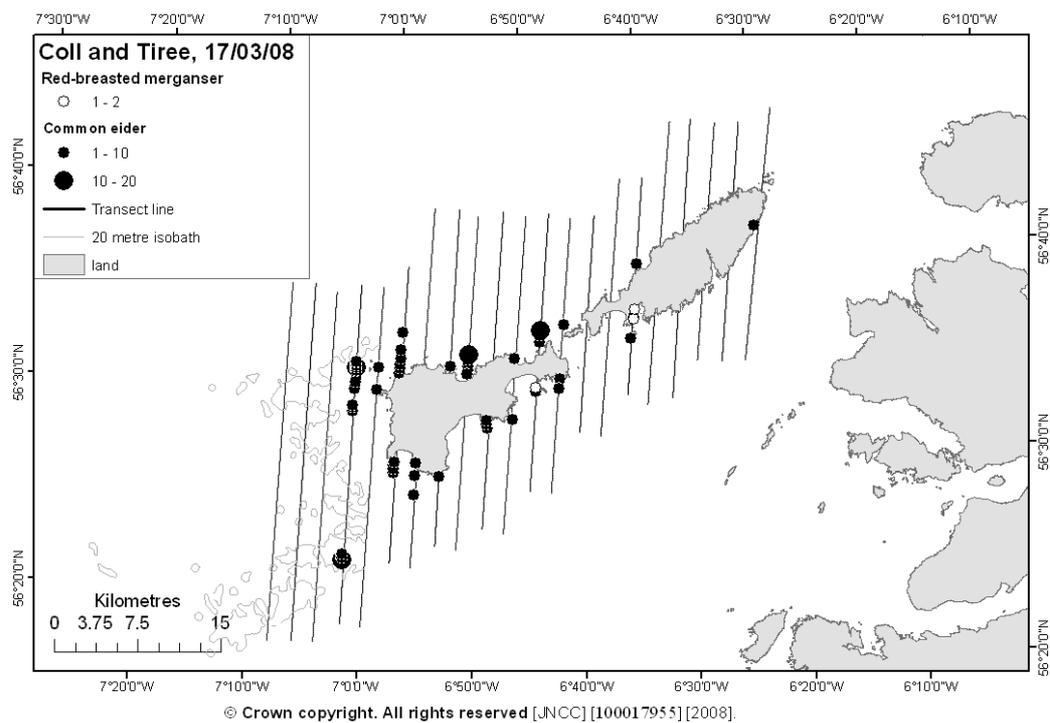
Birds were rather sparsely distributed in the area. On the January survey, small numbers of common eider, red-breasted merganser, long-tailed duck and great northern diver were observed throughout the area, with small concentrations in Loch Gairloch, Loch Ewe, and Loch Carron.

The March survey yielded a similar variety of birds but in smaller numbers, and with no notable aggregations of birds. In addition, a single black-throated diver was observed. This was the only observation of this species over the entire survey season.

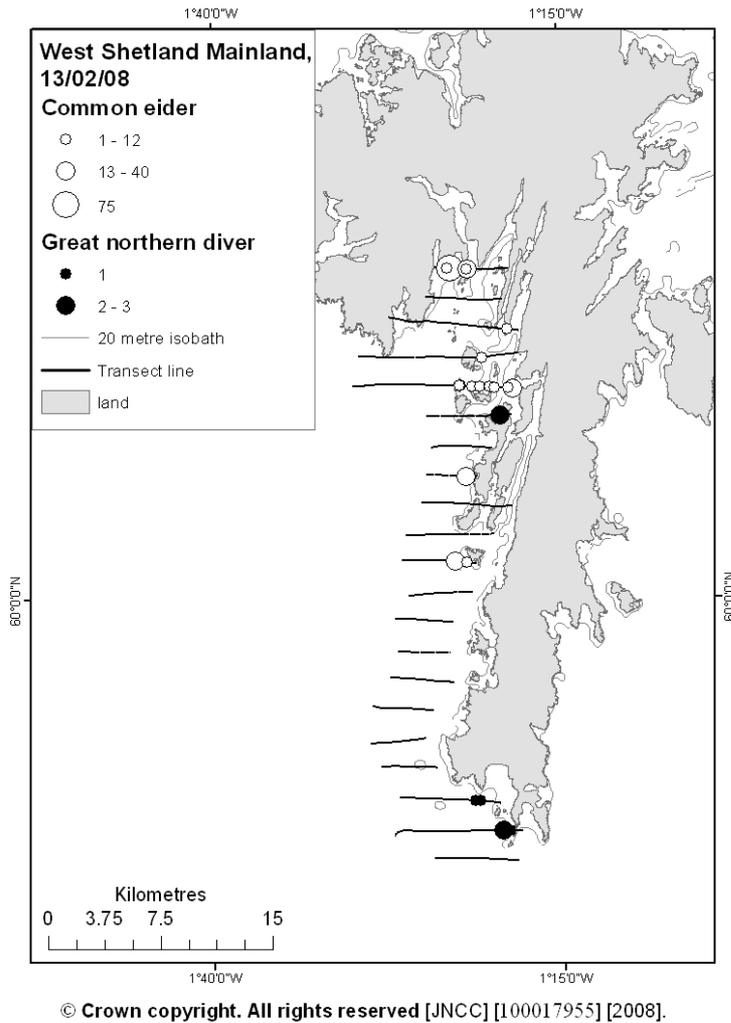
### 3.5 Maps showing distributions of observations



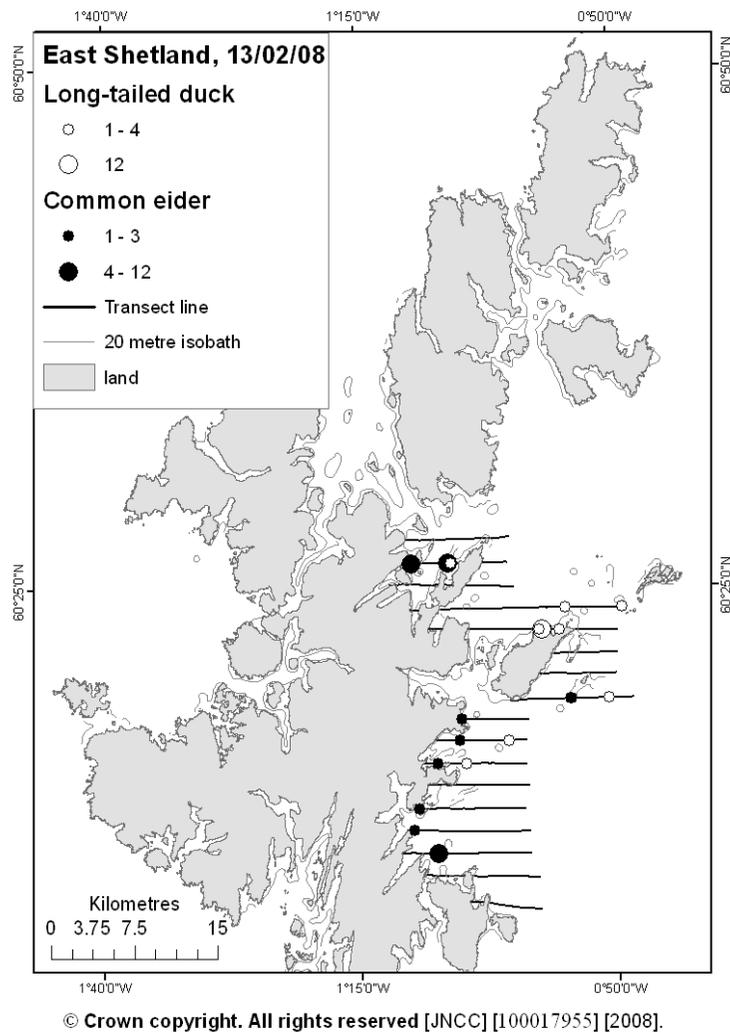
**Figure 2.** Distribution of great northern diver, Coll and Tiree, 17 March 2008. Bathymetry data are not available for the whole area



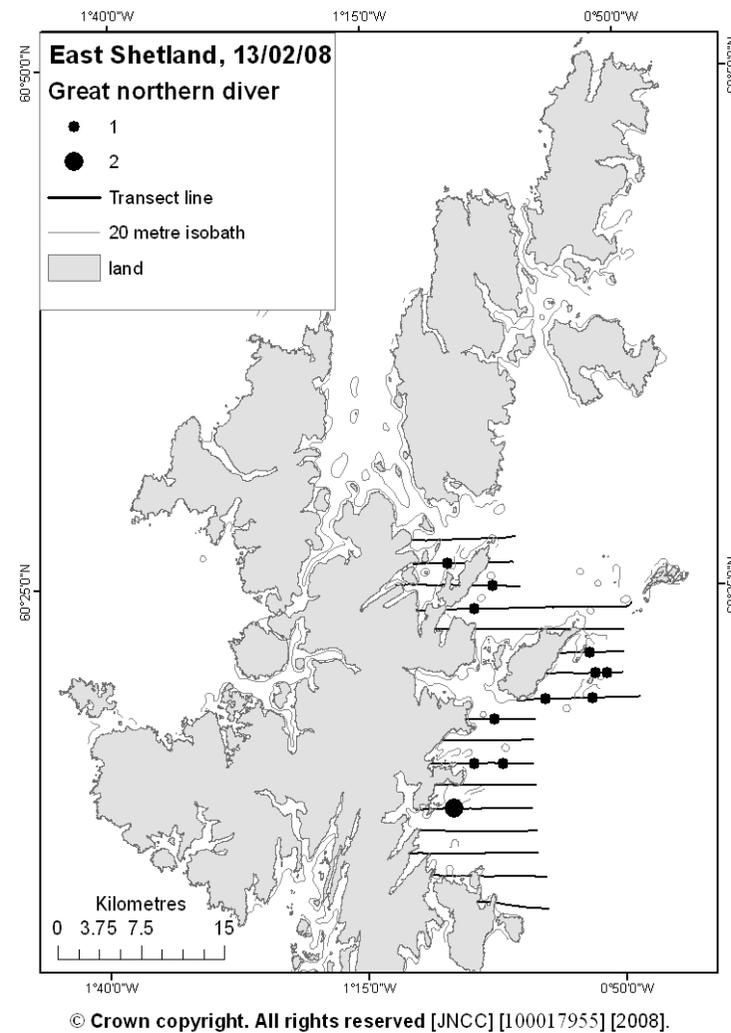
**Figure 3.** Distribution of red-breasted merganser and common eider, Coll and Tiree, 17 March 2008. Bathymetry data are not available for the whole area



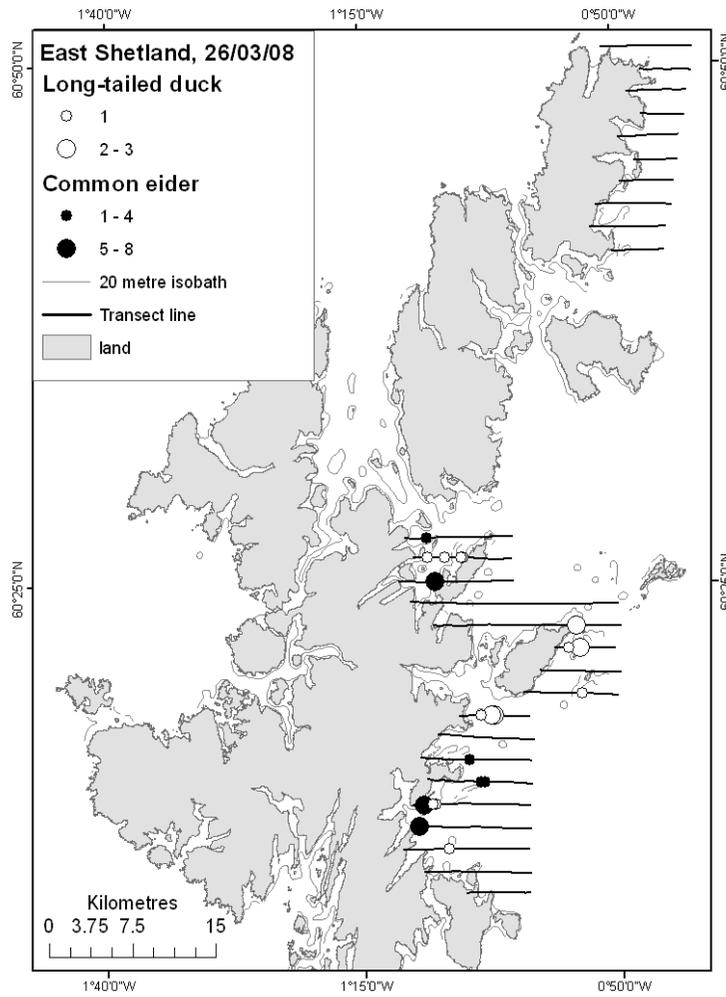
**Figure 4.** Distribution of common eider and great northern diver, west Shetland, 13 February 2008



**Figure 5.** Distribution of long-tailed duck and common eider, east Shetland, 13 February 2008

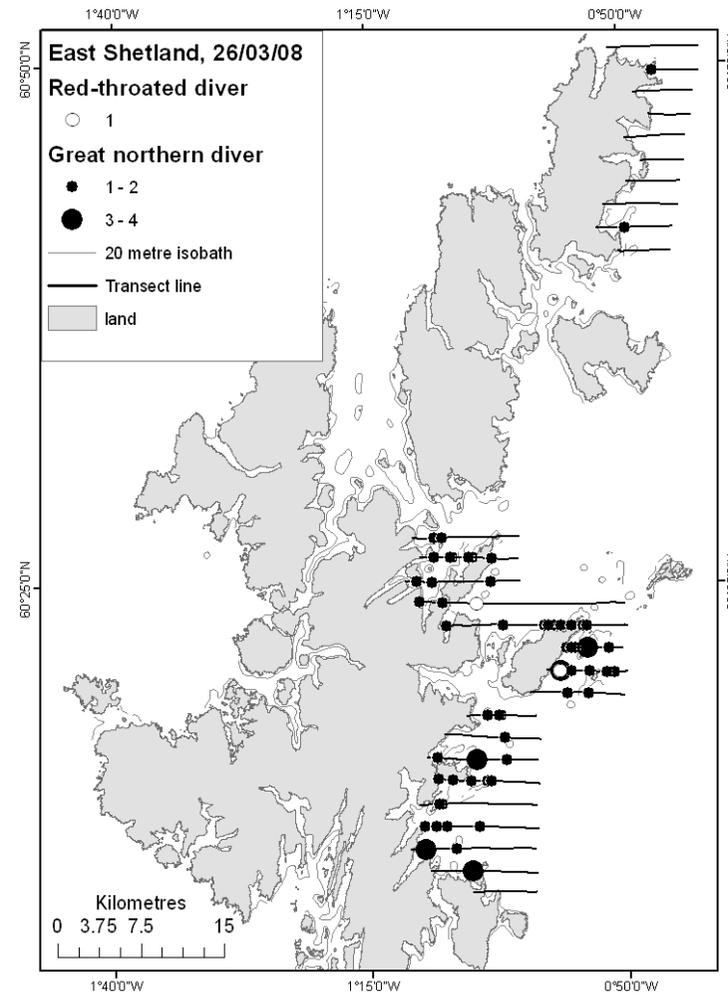


**Figure 6.** Distribution of great northern diver, east Shetland, 13 February 2008



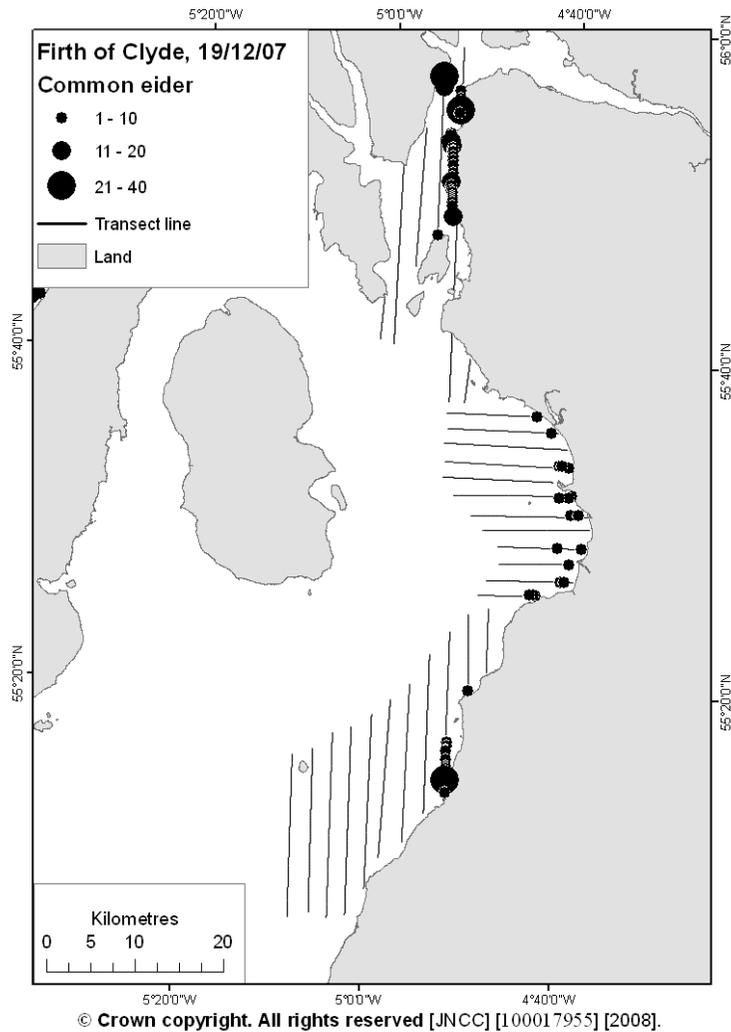
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**Figure 7.** Distribution of long-tailed duck and common eider, east Shetland, 26 March 2008

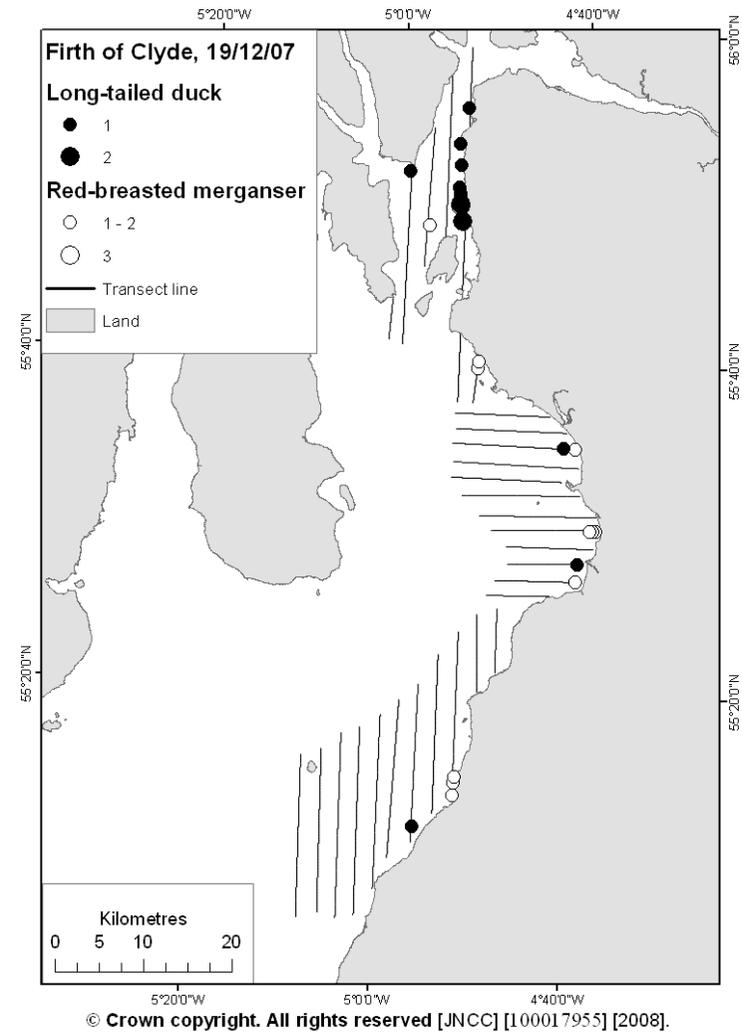


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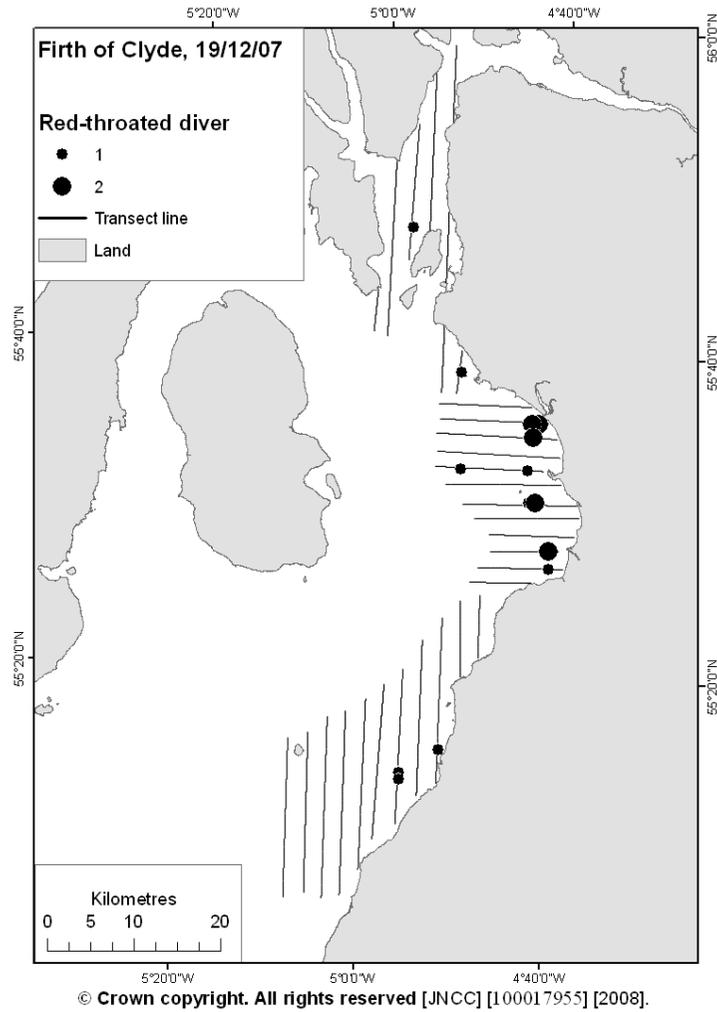
**Figure 8.** Distribution of red-throated and great northern diver, east Shetland, 26 March 2008



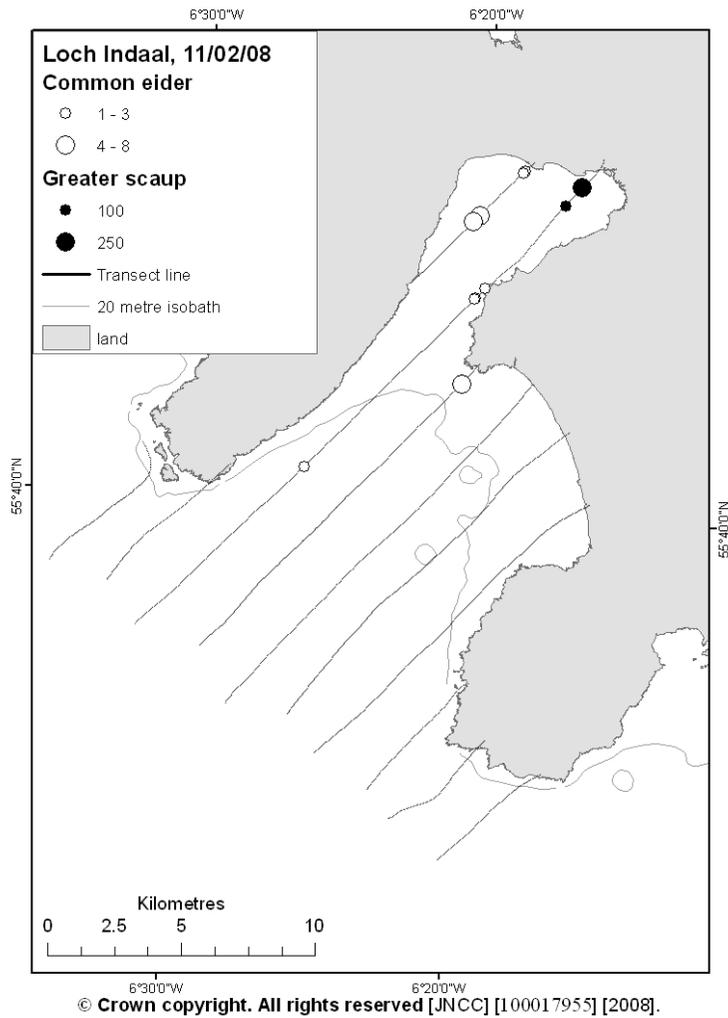
**Figure 9.** Distribution of common eider, Firth of Clyde, 19 December 2007. Bathymetry data unavailable



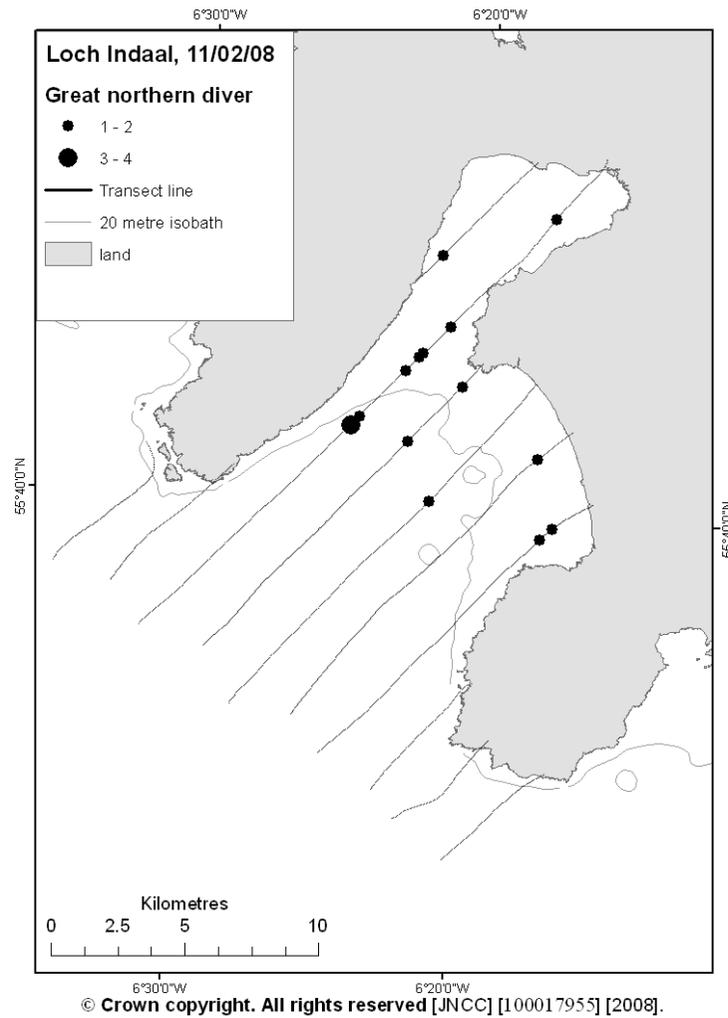
**Figure 10.** Distribution of long-tailed duck and red-breasted merganser, Firth of Clyde, 19 December 2007. Bathymetry data unavailable



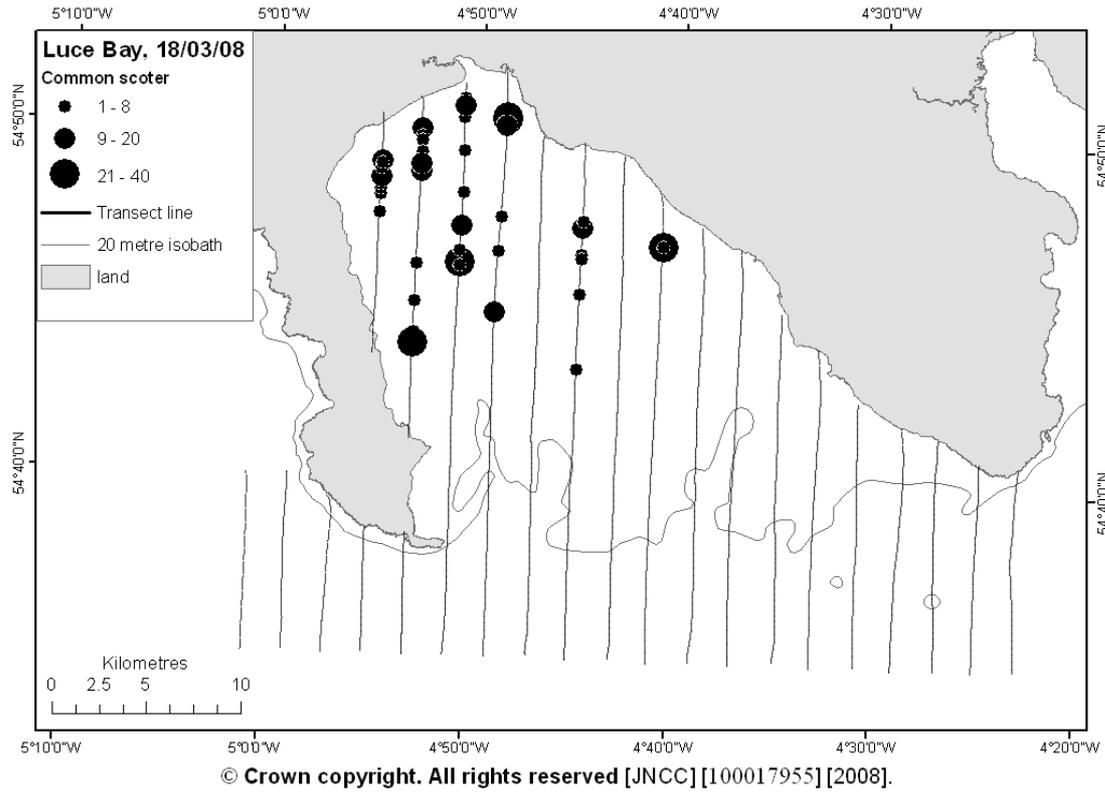
**Figure 11.** Distribution of red-throated diver, Firth of Clyde, 19 December 2007. Bathymetry data unavailable



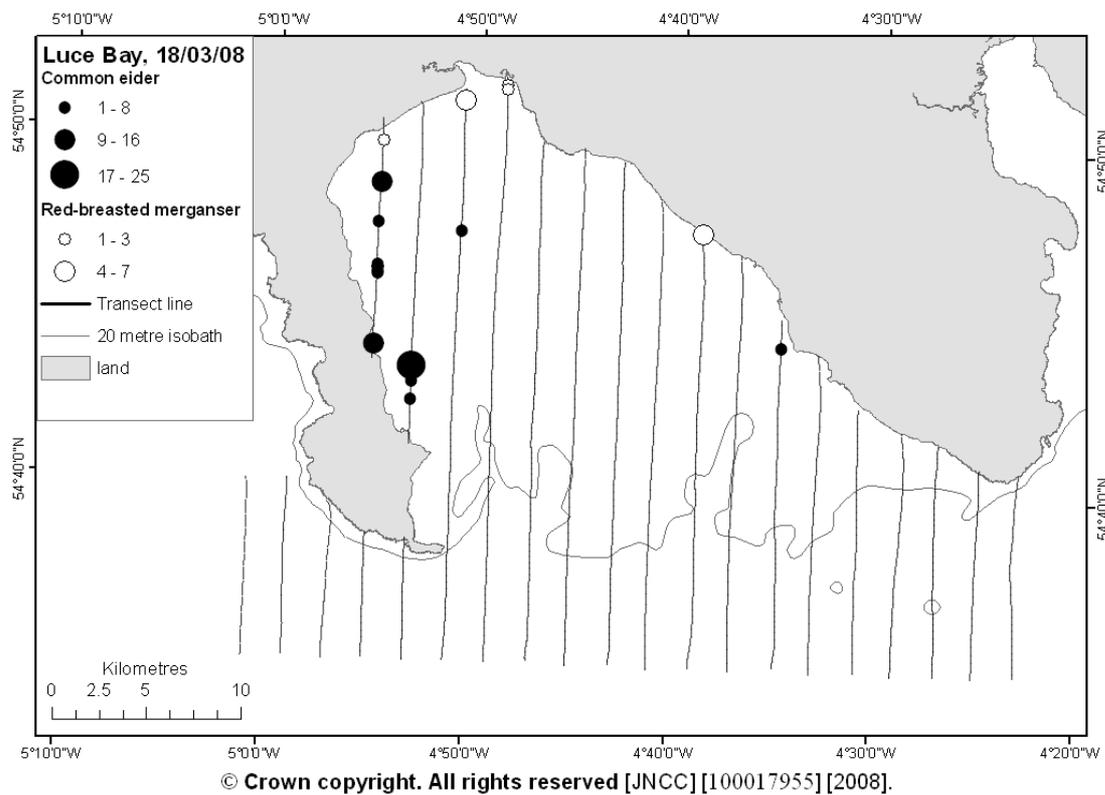
**Figure 12.** Distribution of common eider and greater scaup, Loch Indaal, 11 February 2008



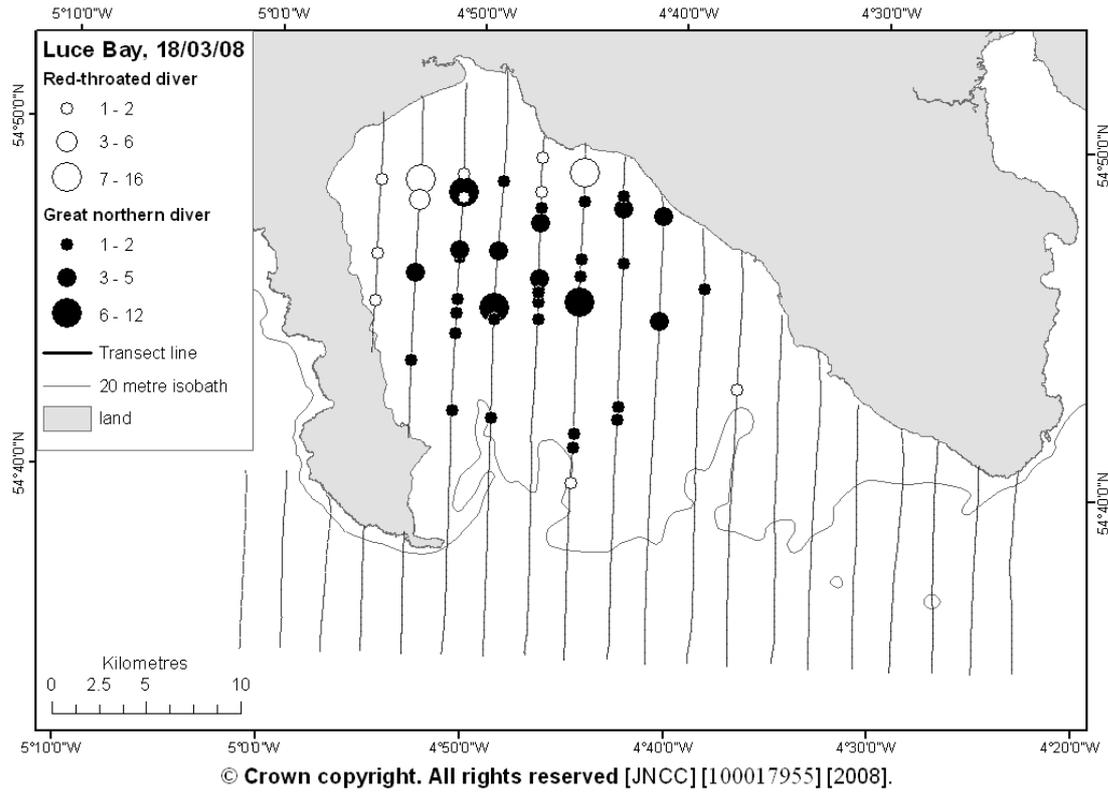
**Figure 13.** Distribution of great northern diver, Loch Indaal, 11 February 2008



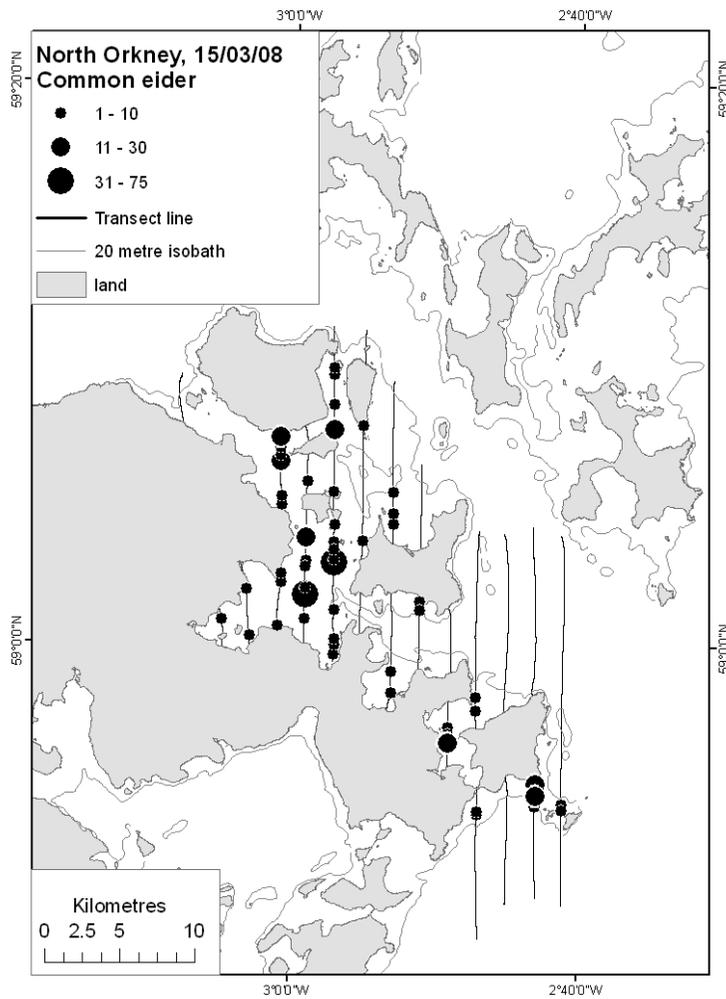
**Figure 14.** Distribution of common scoter, Luce Bay, 18 March 2008



**Figure 15.** Distribution of common eider and red-breasted merganser, Luce Bay, 18 March 2008

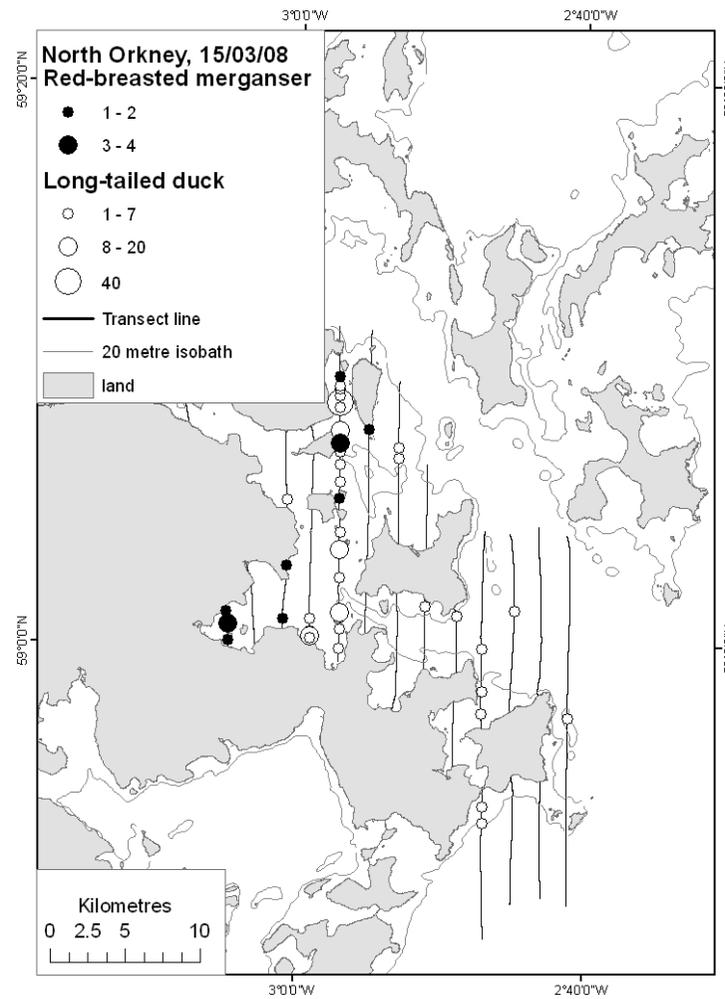


**Figure 16.** Distribution of red-throated and great northern divers, Luce Bay, 18 March 2008



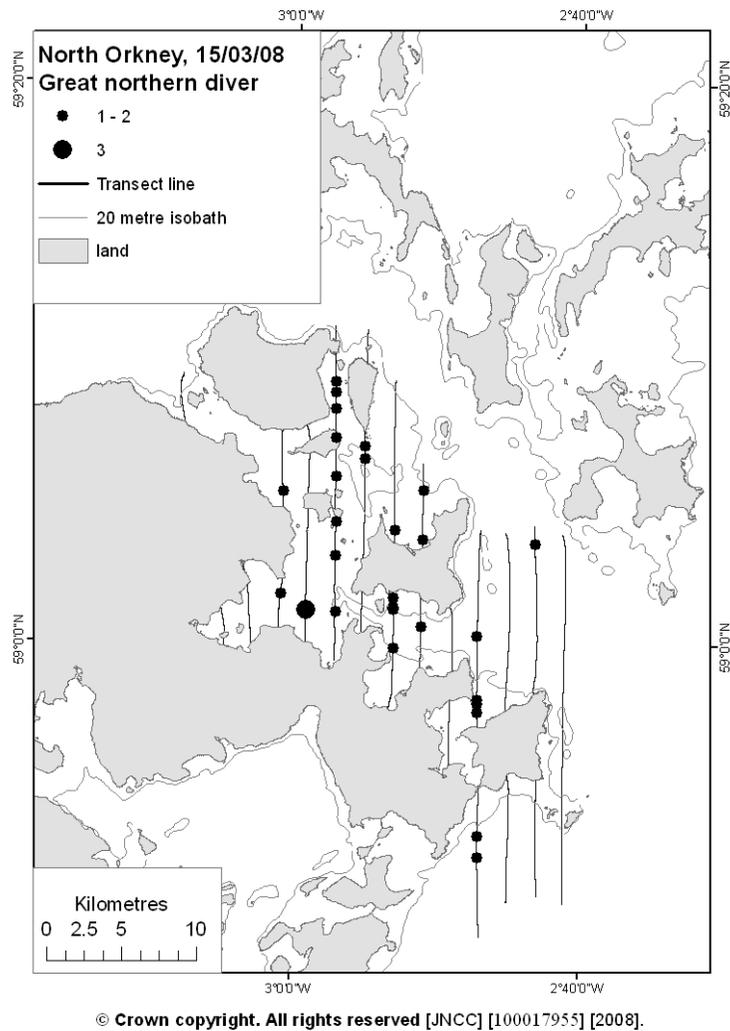
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**Figure 17.** Distribution of common eider, north Orkney, 15 March 2008

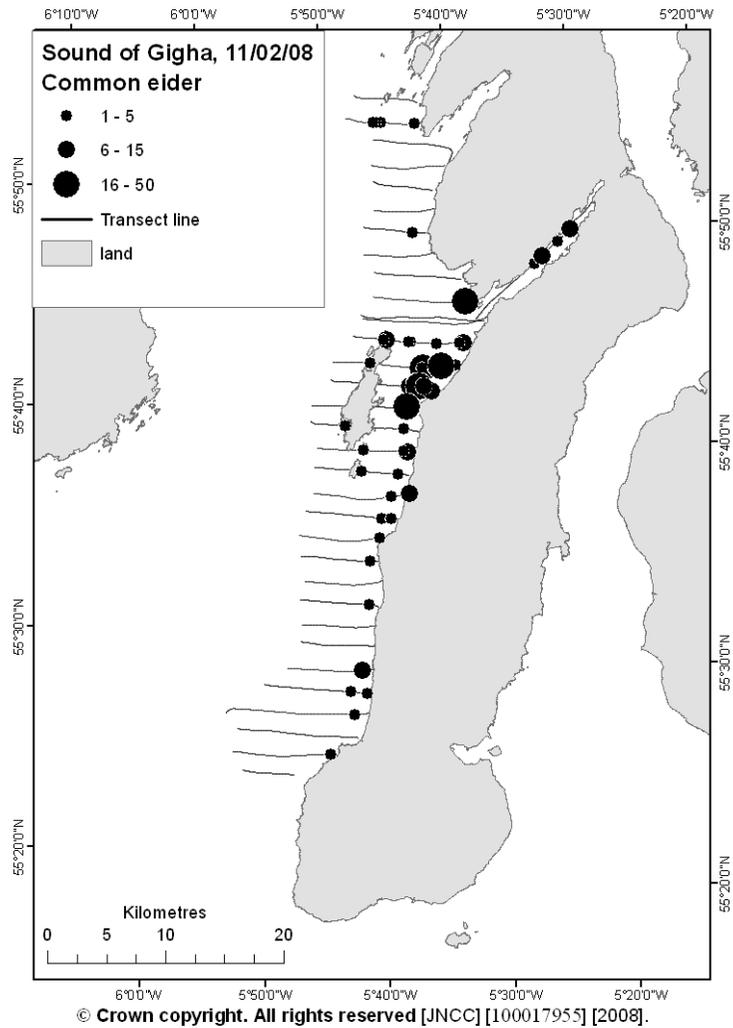


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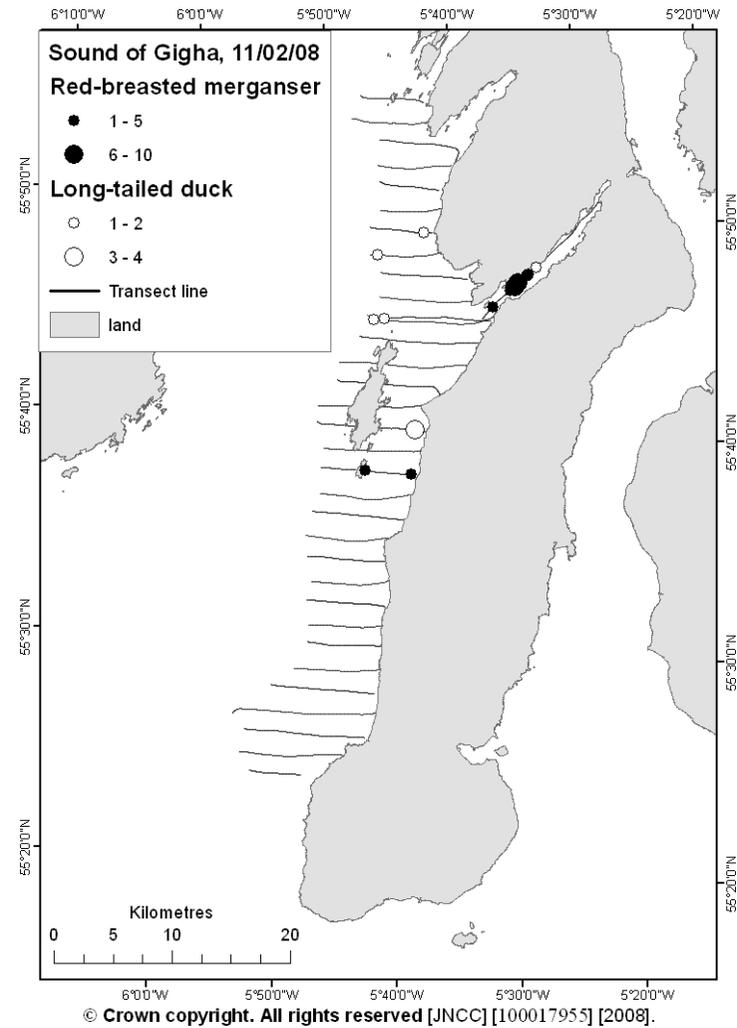
**Figure 18.** Distribution of red-breasted merganser and long tailed duck, north Orkney, 15 March 2008



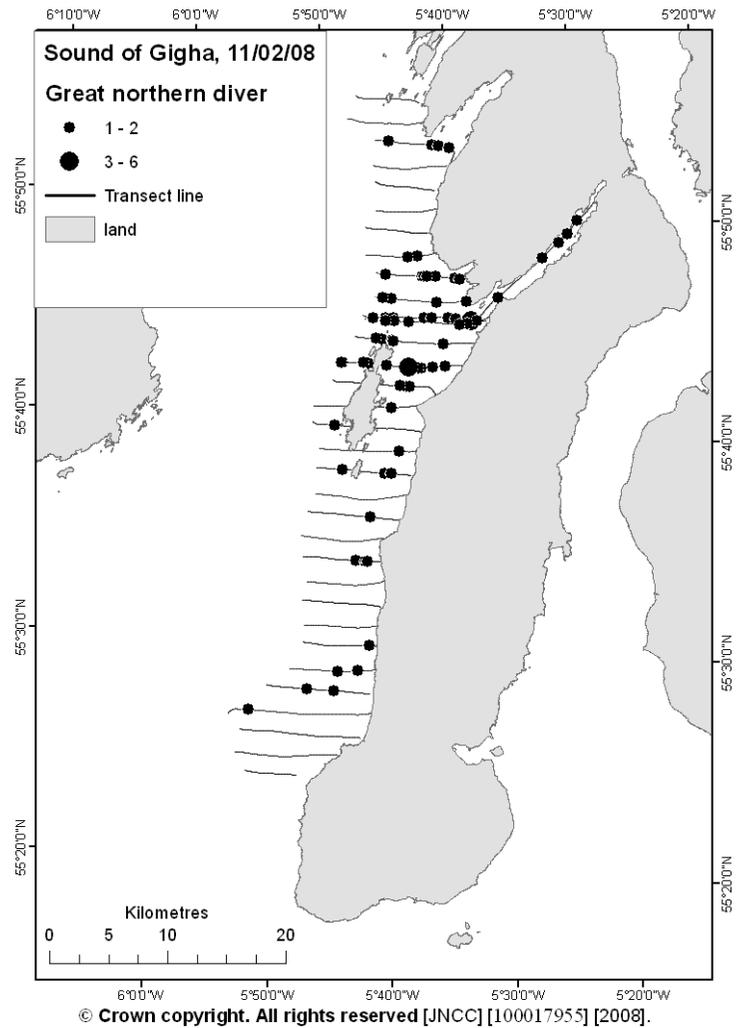
**Figure 19.** Distribution of great northern diver, north Orkney, 15 March 2008



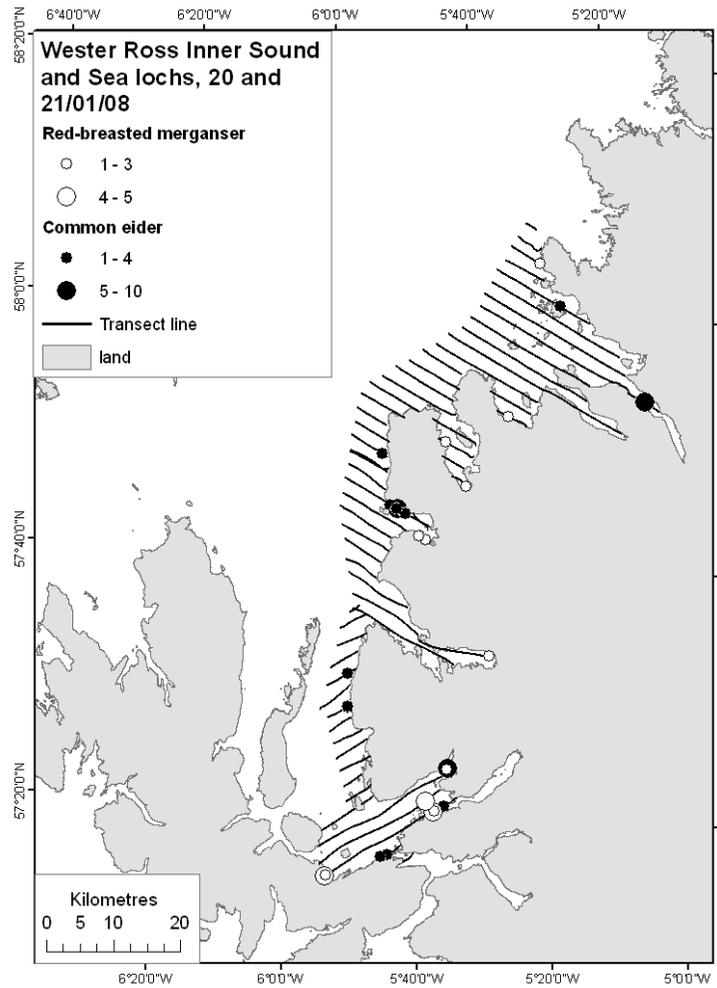
**Figure 20.** Distribution of common eider, Sound of Gigha, 11 February 2008. Bathymetry data unavailable



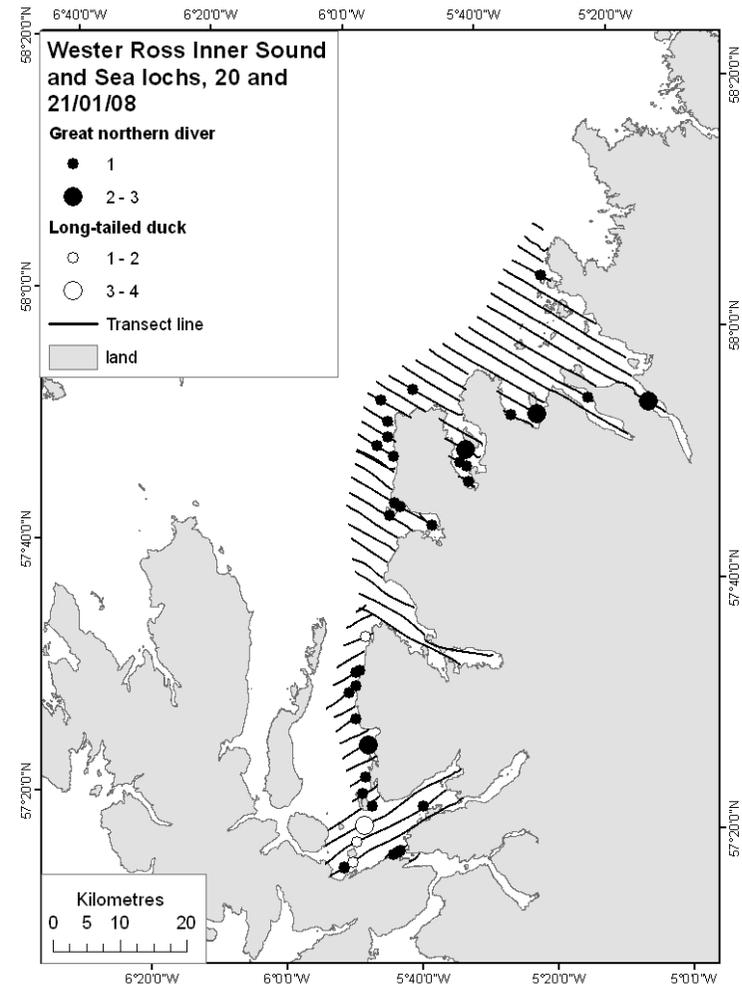
**Figure 21.** Distribution of red-breasted merganser and long-tailed duck, Sound of Gigha, 11 February 2008. Bathymetry data unavailable



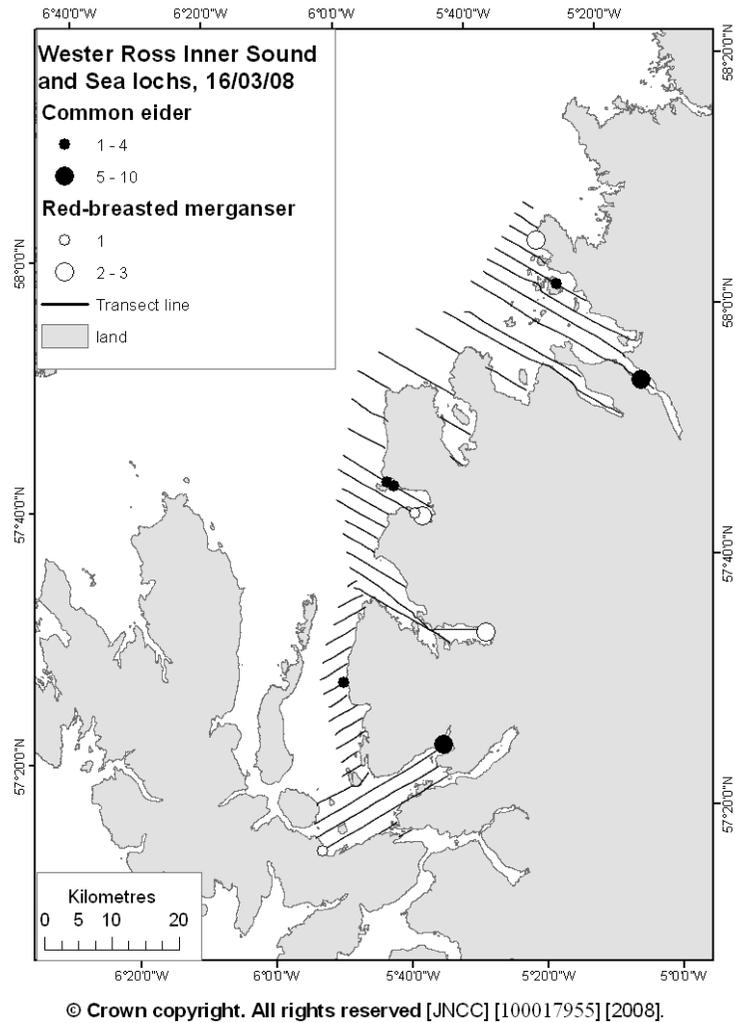
**Figure 22.** Distribution of great northern diver, Sound of Gigha, 11 February 2008. Bathymetry data unavailable



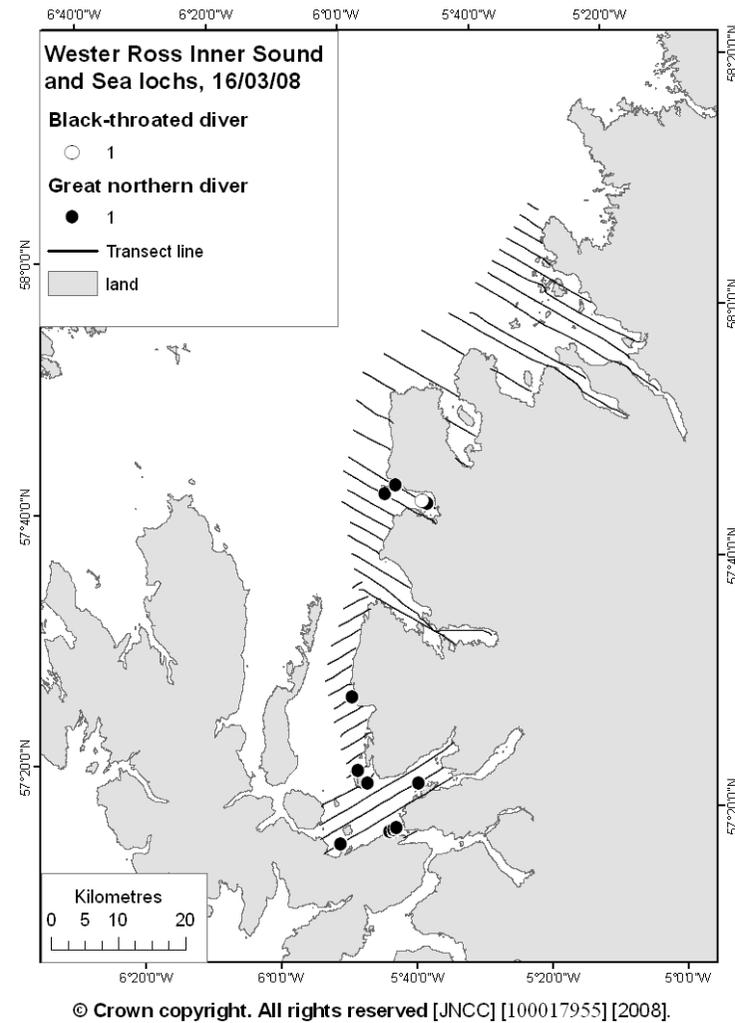
**Figure 23.** Distribution of common eider and red-breasted merganser, Wester Ross, 20 and 21 January 2008. Bathymetry data unavailable



**Figure 24.** Distribution of great northern diver and long-tailed duck, Wester Ross, 20 and 21 January 2008. Bathymetry data unavailable



**Figure 25.** Distribution of common eider and red-breasted merganser, Wester Ross, 16 March 2008. Bathymetry data unavailable



**Figure 26.** Distribution of black-throated and great northern diver, Wester Ross, 16 March 2008. Bathymetry data unavailable

### 3.5.1 Species not adequately surveyed

The following target species were not recorded during these, and previous line-transect surveys: red-necked grebe, great crested grebe, and Slavonian grebe (Dean *et al*, 2003, 2004a and 2004b; Wilson *et al*, 2006; Söhle *et al*, 2006; Lewis *et al*, 2007). Information from shore-based surveys suggests that Slavonian grebes might have been expected in north Orkney, Shetland and Loch Indaal (Austin *et al*, 2008).

It is likely that grebes were not recorded because they are not easily detected on aerial surveys; grebes tend to be distributed close to the 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 boat-based surveys may be the most suitable methods for surveying or monitoring these species (Dean *et al*, 2003; 2004a and 2004b, Wilson *et al*, 2005, Söhle *et al*, 2006; Lewis *et al*, 2007).

This was the third winter since 2000/2001 that greater scaup were recorded on aerial surveys. Previously they have been recorded in each of the 2005/06 surveys in Loch Ryan, during surveys of the Firth of Clyde. In 2008, they were observed in large numbers in Loch Indaal. In land based surveys, greater scaup are usually recorded in single, very dense flocks within 50m of the shore (A. Webb *pers. obs.*; Dean *et al*, 2003). Using a randomly placed systematic survey grid with a 2km transect spacing, the probability of missing such flocks is likely to be quite high, and consideration should be given to other survey methods for surveying greater scaup populations, such as shore based surveys.

It is important that alternative methods of monitoring those species and areas, for which line transect and/or aerial survey methods are unsuitable, be included in any comprehensive inshore waterbird monitoring programme. The JNCC winter survey programme for 2007/08 included shore-based and boat-based counts of selected areas (in the upper Firth of Clyde, Orkney and Shetland) where it was thought that some species may not be adequately surveyed. Data from these surveys are not presented here.

### 3.6 Further analyses

The line transect sample count data for the 2007/08 aerial surveys (the totals for which are presented in Table 2) are potentially 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 (Figures 2-27) offer a good initial representation of the local daytime distributions of the important species recorded in each survey area. In addition, these data have a high spatial precision, and may be suitable for geostatistical interpolation (Cressie 1991), depending on their spatial structure (degree of autocorrelation). Interpolation is potentially capable of building fine scale density surfaces (hence providing further estimates of population size) or presence/absence distributions (McSorely *et al*, 2005; Webb *et al*, 2004; Webb *et al*, 2006a, 2006b).

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The continued success of these aerial surveys is due to the dedication and hard work of everyone involved. The JNCC would like to thank Richard Schofield and Micky Maher for their work as observers during these surveys, and Genevieve Leaper who acted as navigator for some surveys.

The JNCC would also like to thank the pilots and staff at Ravenair and Hebridean Air Services for dealing with air traffic control, unpredictable winter weather, changes of schedule at short notice, and for flying the surveys with the best possible precision and safety.

We would also like to thank all the Air Traffic Controllers and airport staff who provided us with assistance.

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## 5 References

- AUSTIN, G.E., COLLIER, M.P., CALBRADE, N.A., HALL, C. & MUSGROVE, A.J. 2008. Waterbirds in the UK 2006/07: The wetland bird survey. BTO/WWT/RSPB/JNCC, Thetford.
- BUCKLAND, S.T., ANDERSON, D.R., BURNHAM, K.P., LAAKE, J.L., BORCHERS, D.L. & THOMAS, L. 2001. *Introduction to Distance Sampling*. Oxford University Press, London.
- CRAMP, S. & SIMMONS, K.E.L. (Eds.). 1977. Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic. Volume I. Ostrich to Ducks. Oxford University Press, Oxford, 722pp.
- CRANSWICK, P.A., HALL, C. & SMITH, L. 2003. Aerial Surveys of Birds in proposed strategic areas for offshore windfarm development, Round 2: Preliminary Report, Winter 2002/03. The Wildfowl and Wetlands Trust, Slimbridge.
- CRESSIE, N.A.C. 1991. *Statistics for Spatial Data*. John Wiley & Sons, Inc., New York.
- DEAN, B.J., WEBB, A., MCSORLEY, C.A. & REID, J.B. 2003. Aerial surveys of UK inshore areas for wintering seaduck, divers and grebes: 2000/01 and 2001/02. *JNCC Report No. 333*, Peterborough, UK.
- DEAN, B.J., WEBB, A., MCSORLEY, C.A. & REID, J.B. 2004a. Surveillance of wintering seaduck, divers and grebes in UK inshore areas: Aerial surveys 2002/03. *JNCC Report No. 345*, Peterborough, UK.
- DEAN, B.J., WEBB, A., MCSORLEY, C.A., SCHOFIELD, R. A. & REID, J.B. 2004b. Surveillance of wintering seaducks, divers and grebes in UK inshore areas: Aerial surveys and shore-based counts 2003/04. *JNCC Report No. 357*, Peterborough, UK.
- EUROPEAN ECONOMIC COMMUNITY. 1979. Council Directive 79/409/Eec of 2 April 1979 On the Conservation of wild birds. Official Journal L103 (25.4.1979).
- JOHNSTON, C.M., TURNBULL, C.G. & TASKER, M.L. 2002. Natura 2000 In UK offshore waters: Advice to support the implementation of the EC habitats and Birds Directives in UK offshore waters. *JNCC Report No. 325*, Peterborough, UK.
- KAHLERT, J., DESHOLM, M., CLAUSAGER, I. & PETERSEN, I.K. 2000. Environmental impact assessment of an offshore wind park at Rødsand. *Technical Report on birds*. Neri, Rønde.
- LEWIS, M., WILSON, L.J., SOHLE, I., DEAN, B.J., WEBB, A. & REID, J.B. 2007. Wintering sea ducks, divers and grebes in UK inshore areas: Aerial surveys and shore-based counts 2006/07. *JNCC Report No. 414*. Peterborough, UK.

MCSORLEY, C.A., WEBB, A., DEAN, B.J. & REID, J.B. 2005. UK Inshore Marine Special Protection Areas: a methodological evaluation of site selection and definition of the extent of the interest feature using line transect data. *JNCC Report* No. 344, Peterborough, UK.

O'BRIEN, S.H., WEBB, A., DEAN, B.J., WILSON, L.J., REID, J.B. & SÖHLE, I. 2006. An assessment of the numbers and distribution of inshore waterbirds using the Moray Firth during the non-breeding season. *JNCC Report* No. 384, Peterborough, UK.

POLLITT, M.S., HALL, C., HOLLOWAY, S.J., HEARN, R.D., MARSHALL, P.E., MUSGROVE, A.J., ROBINSON, J.A. & CRANSWICK, P.A. 2003. *The Wetland Bird Survey 2000-01: Wildfowl and wader counts*. BTO/WWT/RSPB/JNCC, Slimbridge.

SÖHLE, I., WILSON, L.J., DEAN, B.J., O'BRIEN, S.H., WEBB, A. & REID, J.B. 2006. Surveillance of wintering seaducks, divers and grebes in UK inshore areas: Aerial surveys and shore based counts 2005/06. *JNCC Report* No. 329, Peterborough, UK.

STONE, C.J., WEBB, A., BARTON, C., RATCLIFFE, N., REED, T.C., TASKER, M.L., CAMPHUYSEN, C.J. & PIENKOWSKI, M.W. 1995. *An atlas of seabird distribution in north-west European waters*. Joint Nature Conservation Committee and Nederlands Instituut voor Onderzoek der Zee, Peterborough.

STROUD, D.A., CHAMBERS, D., COOK, S., BUXTON, N., FRASER, B., CLEMENT, P., LEWIS, P., MCLEAN, I., BAKER, H. & WHITEHEAD, S. 2003. *The UK SPA Network: Its scope and contents*. Vols 1-3.

WEBB, A., MCSORLEY, C.A., DEAN, B.J. & REID, J.B. 2004. Modelling the distribution and abundance of common scoter *Melanitta nigra* in Carmarthen Bay in winter 2001/02: A Method for identifying potential boundaries for a marine Special Protection Area. Unpublished *JNCC Report* No. 330, Peterborough, UK.

WEBB, A., MCSORLEY, C.A., DEAN, B.J., REID, J.B., CRANSWICK, P.A., SMITH, L. & HALL, C. 2006a. Dispersion patterns of inshore waterbirds in Liverpool Bay in the non-breeding season. *JNCC Report* No. 373. Peterborough, UK.

WEBB, A., MCSORLEY, C.A., DEAN, B.J. & REID, J.B. 2006b. Recommendations for the selection of and boundary options for an SPA in Liverpool Bay. *JNCC Report* No. 388, Peterborough, UK.

WILSON, L.J., DEAN, B.J., WEBB, A., MCSORLEY, C.A. & REID, J.B. 2006. Wintering seaducks, divers and grebes in UK inshore areas: Aerial surveys and shore-based counts 2004/05. *JNCC Report* No. 371, Peterborough, UK.