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The numbers of inshore waterbirds using the Firth of Forth during the non-breeding season, and an assessment of the area's potential for qualification as a marine SPA

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Contents

Summary

The Firth of Forth is known to support large numbers of inshore waterbirds, particularly over the winter period. Some intertidal areas and islands within the Firth of Forth are already classified as Special Protection Areas (SPAs). The existing SPAs currently afford protection to some species, but these areas do not extend beyond the low water mark. This report describes analyses of data from aerial and boat-based surveys of inshore waterbirds outside the breeding season in the Firth of Forth. These were conducted between 1998 and 2005, mostly in order to determine if the area or part of it might qualify through Stage 1 of the UK Site Selection Guidelines (Stroud *et al.,* 2001*)* as an SPA under the EU Birds Directive (79/409/EEC).

Numbers of divers *Gavia spp*., grebes *Podiceps spp*., seaduck *Aythya marila, Somateria mollissima, Melanitta nigra, M. fusca, Clangula hyemalis, Bucephala clangula*, *Mergus serrator*, and little gulls *Larus minutus* using the waters of the Firth of Forth were estimated and assessed against SPA Stage 1 guideline thresholds. Species distributions using the raw count data are presented here; detailed spatial analyses of bird distributions to define boundary location options for any potential SPA may be conducted in the future.

Data from boat and aerial surveys of the Firth of Forth, carried out over five seasons (winter periods in 1997/98, 2000/01, 2001/02, 2003/04, 2004/05) are described in this report. These data originate from one boat-based line transect survey (1997/98), two aerial strip transect surveys (2000/01) and six aerial line transect surveys (2001/02-2004/05). Results from line transect surveys were analysed, where possible, using distance sampling in order to estimate the total numbers of birds using the area surveyed. Where this was not possible, totals were extrapolated over the survey area based on density of birds. Strip transects, which concentrated on coastal areas where bird abundance was highest, were assumed to represent total counts and were not extrapolated further.

The red-throated diver *Gavia stellata* is listed on Annex I of the Birds Directive. Consequently, an area may qualify as an SPA for this species if more than 1% of the national population regularly use the area (stage 1.1 of the UK SPA guidelines; Stroud *et al.,* 2001). Numbers of red-throated diver exceeded the Stage 1.1 threshold of 170 in two of the five seasons in which surveys were conducted. In December 2004, the estimate was far above the qualifying threshold and the mean peak estimate over the five seasons of surveys also exceeds the threshold. The Firth of Forth therefore meets the Stage 1 guidelines for further consideration as a UK SPA for this species.

The Slavonian grebe *Podiceps auritus* is also listed on Annex I of the Birds Directive. Aerial surveys are not suitable for surveying grebes, as they are very difficult to detect from the air. The species is usually surveyed from land, which consistently produces higher, more accurate counts than other methods. The maximum winter WeBS count for Slavonian grebe was greater than the default qualifying threshold of 50 birds (1% of the current estimate for the GB wintering population is only seven individuals) in every year from 1993/94 to 2004/05 except 2000/01. The Firth of Forth therefore meets the Stage 1 guidelines for further consideration as an SPA for this species. Inshore areas have already been designated as SPAs for this species using WeBS data, but no details of their spatial distribution within the firth have been recorded in the WeBS surveys. Further work would be required to ascertain the

distribution of wintering Slavonian grebes in the Firth of Forth in order to determine the location of the boundaries of any potential SPA for this species.

No accurate estimate of the size of the population of the little gull wintering in Britain exists, so again a default minimum SPA qualifying threshold of 50 individuals applies to this Annex I species. Little gulls were recorded only during the aerial line transect surveys of the Firth of Forth on 5 December 2003. Distance analysis resulted in an estimate that exceeds the qualifying threshold. However, one season of data is insufficient to determine qualification of an area as an SPA; regularity of use must be determined. No birds were recorded during February surveys, suggesting that they are passage birds migrating from their breeding grounds rather than over-wintering birds.

Numbers of regularly occurring migratory species using an area must exceed 1% of the relevant biogeographical populations for the area to qualify as an SPA (stage 1.2 of the UK SPA selection guidelines; Stroud *et al.*, 2001). Population estimates of greater scaup, common eider, long-tailed duck, common and velvet scoter, common goldeneye and red-breasted mergansers failed to meet the Stage 1.1/1.2 guideline thresholds, although they did regularly exceed 1% of the GB wintering populations.

In order to assess possible qualification of the Firth of Forth on the strength of its waterbird assemblage, combined population estimates were calculated for all species. The marine waterbird population (comprising divers, grebes, greater scaup, common eider, common and velvet scoter, long-tailed duck, common goldeneye, red-breasted merganser and little gull) exceeded the 20,000 individuals SPA qualification threshold (stage 1.3 of the UK SPA guidelines) in one season of the surveys undertaken. However, the annual mean of peak assemblage counts of 14,277 individuals over all five seasons fails to meet the SPA site selection Stage 1.3 threshold.

Further work is required to determine a boundary if the area or part of it were to be considered as an SPA.

1 Introduction

1.1 Potential SPA assessment

In 1979, the European Community adopted the Council Directive on the conservation of wild birds (the Birds Directive), which addresses 'the conservation of all species of naturally occurring birds in the wild state in the European territory of the Member States …' (79/409/EEC). It requires European Union Member States to identify and classify in particular the most suitable territories in number and size as special protection areas (SPAs) for the conservation of specified bird species. This refers to rare or vulnerable bird species, which are listed in Annex I of the Directive (Article 4.1) and regularly occurring migratory species not listed in Annex I (Article 4.2).

Although the Directive states that conservation measures should be taken both in 'the geographical sea and land area' (79/409/EEC), most SPAs do not extend further than mean low water mark (or mean low water springs in Scotland). Work to facilitate consideration of SPA at sea below this datum is currently being undertaken by the JNCC in collaboration with the four statutory country conservation agencies: Council for Nature Conservation and the Countryside, the Countryside Council for Wales, Natural England and Scottish Natural Heritage. Four potential ways of addressing marine SPAs (Johnston *et al.,* 2002) in the UK are being currently considered:

1. Marine extensions to existing seabird colony SPAs (e.g. McSorley *et al.,* 2003);
2. Inshore areas used by inshore waterbirds (e.g. seaduck, divers and grebes) outwith the breeding season (e.g. Webb & Reid 2004);
3. Offshore areas used by wide-ranging seabirds, for feeding and for other activities; and
4. Other types of SPA.

This report describes analyses of data from aerial and boat-based surveys of inshore waterbirds, conducted by the Joint Nature Conservation Committee (JNCC) between 1997/98 and 2004/05 in the Firth of Forth, in order to determine whether the area, or a part thereof, qualifies as a SPA. Observations of a number of species were analysed and assessed against UK SPA guideline thresholds. Species distributions using the raw count data are presented here.

1.2 The Firth of Forth

The Firth of Forth, as defined herein, extends east from the River Forth for almost 100 km to a wide estuary mouth, ending at Fife Ness (NO640098) on the northern coast and Dunbar on the southern coast (NT680794; Figure 1). The estuary comprises a diverse range of intertidal habitats from saltmarshes to dune systems and cliffs. The eelgrass *Zostera sp.* beds and high concentrations of invertebrates, particularly associated with the mudflats, that characterise large areas of the inner firth, for example at Torry Bay on the north shore (Figure 2), attract large numbers of passage and wintering waterbirds (Stroud *et al.*, 2001). Further away from the river mouth there are mussel beds and sandy shores providing productive feeding opportunities for waterbirds. Approximately one third of the offshore area is less than 20m deep (Figure 1) and most of the seabed consists of sandy or muddy sediments (Connor *et al.*, 2006).

The Firth of Forth includes existing terrestrial (intertidal) SPAs, including the Firth of Forth SPA, classified in 2001 (Figure 2, www.jncc.gov.uk). These SPAs afford protection for a variety of wintering, breeding and passage waders, seabirds and other waterbirds. They comprise terrestrial and intertidal habitats. However, the open waters of the firth host large numbers of birds outside the existing SPAs (Dean *et al.,* 2004), which were classified on the strength of land-based surveys; such surveys are suitable for species concentrated close to the shore but often significantly underestimate species occurring further offshore, such as divers and seaduck (Webb & Reid 2004). Coastal areas have been designated as SPAs (Figure 2) under Artcle 4.1 of the Birds Directive (79/409/EEC) for Sandwich terns *Sterna sandvicensis* on passage and wintering populations of bar-tailed godwit *Limosa lapponica*, golden plover *Pluvialis apricaria,* red-throated diver and Slavonian grebe. Under Article 4.2 these areas qualify for red knot *Calidris canutus*, pink-footed goose *Anser brachyrhynchus*, redshank *Tringa totanus*, shelduck *Tadorna tadorna* and ruddy turnstone *Arenaria interpres*. The area also qualifies for its important assemblage of 86,067 individual waterfowl (Stroud *et al.,* 2001). Listed as part of this assemblage are a number of additional inshore waterbird species, including greater scaup, great-crested grebe *Podiceps cristatus*, great cormorant *Phalacrocorax carbo,* common eider, long-tailed duck, common scoter, velvet scoter, common goldeneye and red-breasted merganser. Additionally, a small man-made structure at the mouth of the Imperial Dock in the Port of Leith, just north of Edinburgh city has been designated as The Imperial Dock Lock, Leith SPA under Article 4.1 by regularly supporting breeding populations of European importance of the Annex I species common tern *Sterna hirundo.*

There are numerous islands in the Firth of Forth and some of these hold important breeding populations of seabirds and waterbirds. Some of these have been classified in the Firth of Forth Islands SPA, designated in 1990 (Figure 2, www.jncc.gov.uk). These include the Bass Rock, which has an important northern gannet *Morus bassanus* colony and the Isle of May, which has important populations of Atlantic puffins *Fratercula arctica* and European shags *Phalacrocorax aristotelis.* Other species for which the islands are classified include lesser black-backed gull *Larus fuscus,* Arctic tern *Sterna paradisaea*, common tern, roseate tern *Sterna dougallii* and Sandwich tern. The Islands also qualify as a SPA by regularly supporting assemblages of more than 20,000 seabirds. Counts conducted between 2002 and 2005 suggest this figure may be as high as 345,000 individuals, excluding non-breeding birds (Jones 2005). Listed as part of this assemblage are razorbill *Alca torda,* common guillemot *Uria aalge,* black-legged kittiwake *Rissa tridactyla,* herring gull *Larus argentatus,* great cormorant, northern fulmar *Fulmarus glacialis,* Atlantic puffin *Fratercula arctica*, lesser black-backed gull, European shag, northern gannet, Arctic tern, common tern, roseate tern and Sandwich tern.

Of the qualifying species of this SPA there are five which, based on JNCC generic guidance (McSorley *et al.,* 2003, Reid & Webb 2005, McSorley *et al.,* 2008), require a marine extension. These are northern gannet, Atlantic puffin, razorbill, common guillemot and northern fulmar. Northern gannet and northern fulmar require an extension distance of 2 km from the classified terrestrial SPA due to their ecological requirements, therefore a 2 km extension to the site is proposed to support the important breeding seabird populations of the SPA.

The Isle of May Special Area of Conservation (SAC), situated at the outer part of the Firth of Forth (Figure 2), accords protection to its grey seal *Halichoerus grypus* population and reef habitats.

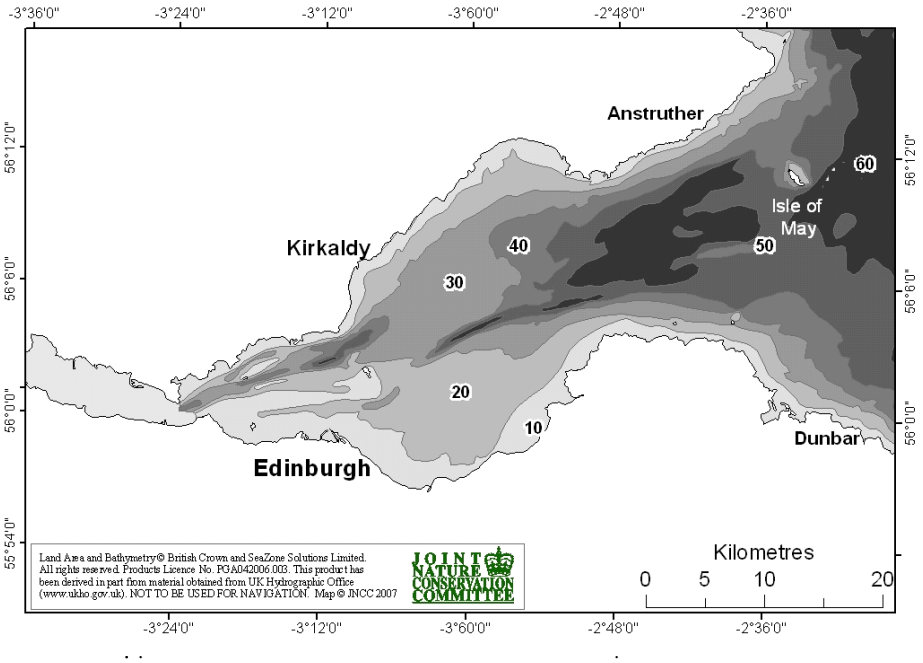

Figure 1. Bathymetry of the Firth of Forth. Maximum depths of areas shaded grey indicated in metres.

There are a number of major ports and industrial areas in the Firth of Forth, including an oil terminal and a refinery. Shipping traffic is therefore substantial. To date, the Forth has not been identified as an area suitable for wind farm development.

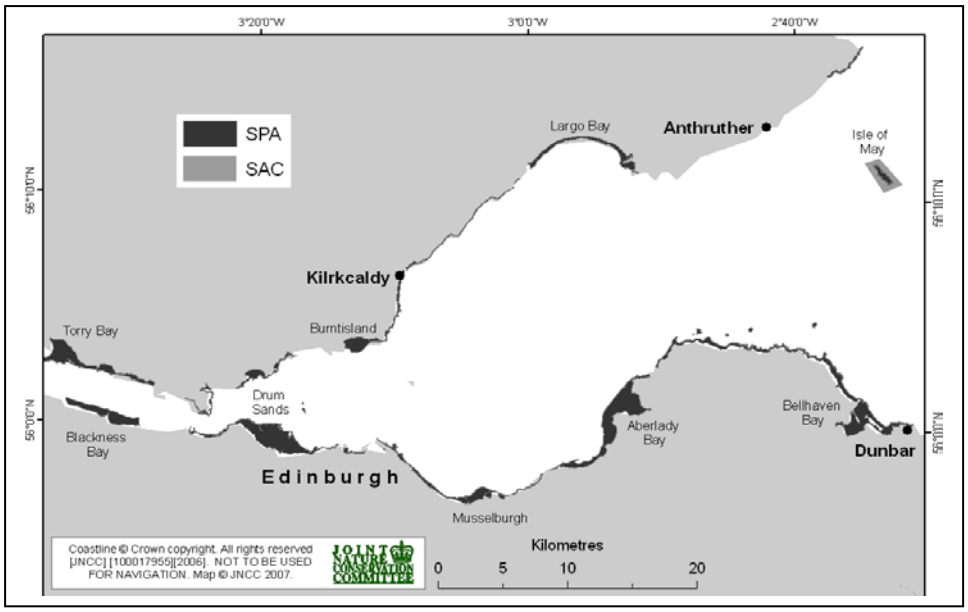

Figure 2. The Firth of Forth survey area showing existing SPAs and SACs

2 Methods

2.1 Data collection

The data used in these analyses originate from one line transect boat survey (1997/98), two strip transect aerial surveys (2000/01) and six line transect aerial surveys (2001/02-2004/05) of the Firth of Forth. All of these surveys were conducted by the JNCC.

Surveys were conducted between November and March to enable estimates of wintering populations to be made. No data were collected during migration periods or for aggregations of moulting birds.

2.1.1 Line transect boat survey 1997/98

A single boat-based survey was carried out using the MV *Chalice*, from 25 to 29 January 1998. The survey was conducted using Seabirds at Sea Team (SAST) methods as described by Webb and Durinck (1992), but with some minor modification (see Cronin & Webb 1998): 10 x 42 binoculars were used to detect seaducks and divers, which tend to take evasive action some distance ahead of approaching boats and cannot be surveyed adequately using the naked eye.

Pairs of observers counted all birds ahead of the ship in a strip transect within which all observations were allocated to one of five distance bands (A = 0-50m, B = 51-100m, C = 101-200m, D = 201-300m and E=300-1000m) based on the perpendicular distance of the bird(s) from the boat's trackline. Where birds were flushed from the water within transect but well ahead of the approaching boat, the perpendicular distance could not be determined accurately. These birds were recorded simply as 'in transect'. Flying birds were counted within a 300m transect using the snapshot method described by Webb & Durinck (1992).

The resulting data were 1-minute sample counts of all birds on the water within a 1000m wide strip transect (split into five distance bands) on one side of the boat, plus flying birds recorded within 300m transects during the snapshots. In total, 39 separate transects were completed. However, overlapping and randomly directed transects were omitted from the analysis. This left a total of 15 transects orientated north-south at approximately 3 km apart and between 6.5 and 26 km long, and 12 roughly east-west transects (Appendix 1, Figure A1).

Analysis of the numbers of birds recorded in different distance bands revealed an atypical pattern of detection, i.e. more birds were detected in the outer distance bands. These analyses suggested that there was either poor distance estimation during the surveys, or more likely, displacement of birds ahead of the ship. Total numbers were therefore estimated by extrapolating the density of birds recorded in transect: i.e. all birds on the sea on one side of the ship were assumed to occur in a Kim wide strip transect, and all flying birds were recorded within a 300m wide strip transect. This probably resulted in an underestimate of numbers, but given the extensive use of binoculars by the observers, a 500m-wide strip transect for birds on the sea would have resulted in an overestimate. The density of birds recorded in these strips was multiplied by the total survey area to give the total estimate.

2.1.2 Strip transect aerial surveys 2000/01

Strip transect aerial surveys were conducted by making sample counts, where observers attempted to detect and count all birds within the survey area. In order to minimise the number of birds that were not detected by the observers and to avoid double counting of birds, this method required intensive and systematic coverage of the survey area; transects extended far enough offshore to cover the target species distribution range in waters of 0-30m depth.

Surveys undertaken by JNCC in December 2000 and February 2001 were carried out from an aircraft flown at 76m (250ft) above the sea, at a speed of 185kmh^{-1} (100 knots). At the beginning of each survey one strip transect was flown along the coastline at a distance of approximately 300-400m from the shore; parallel transects were flown perpendicular to the coastline. Transects were spaced 1km apart and hence were approximately 500m wide on each side of the aircraft. Following Kahlert *et al.,* (2000) this distance was chosen to maximise the detection of birds, or of flocks of birds located between transects, while minimising the risk of double counting.

Two observers recorded bird locations and numbers from both sides of the aircraft, and observations were divided into 1-minute recording periods (see Pihl & Frikke (1992) for a fuller description of methods). The number of birds recorded was either the exact number counted or, where large aggregations were encountered, an estimate of flock size. A Global Positioning System (GPS) recorded the location of the aircraft each 1-minute interval.

2.1.3 Line transect aerial surveys 2000/01

The JNCC conducted two aerial surveys using a small aircraft flown in a systematic pattern of line transects designed to repeatedly cross environmental gradients such as sea depth (Dean *et al.,* 2003). Surveys were flown at an altitude of 76m (250ft) and a speed of approximately 185kmh^{-1} (100 knots). North-south transects were spaced 2' longitude apart (approximately 2km between 55°N and 57°N), running perpendicular to the coast and depth contours, and therefore along the anticipated gradient of bird density. The position of transects was chosen at random from between 10 and 40 options using the random number function on a pocket calculator.

Two observers counted from either side of the aircraft and recorded all observation data onto a dictaphone. Observers determined distances using a fixed angle of declination from the visual horizon, which could easily be measured using a clinometer. All observations were allocated to one of three distance bands (A = 44-163m, B = 164-427m and C = ≥ 428m) based on the perpendicular distance of the bird(s) from the aircraft trackline. This procedure enables application of distance sampling analyses that model the detectability of a bird as a function of its distance from the observer; thereby, account is taken of the decreased probability of detecting a bird at greater distances from the trackline when estimating total numbers of birds actually present (Buckland *et al.,* 2001). *Distance* also allows estimation of confidence intervals associated with total abundance estimates.

Since observers were unable to see birds directly below the aircraft the closest distance band started at 44m from the aircraft's trackline. For each bird, or flock of birds, the time (GMT) at which it was perpendicular to the aircraft, the distance band, the species and number of birds was recorded. Where flocks of birds spanned two bands, numbers present in each band

were assigned accordingly. It was not always possible to assign birds to a species during aerial surveys, and in such cases, birds were assigned to the lowest taxonomic level possible. A GPS recorded the location of the plane every second.

2.1.4 Line transect aerial surveys 2003/04 and 2004/05

JNCC conducted four aerial surveys using a small aircraft flown in a systematic pattern of line transects from December 2003 to February 2005. The methods used were almost identical to the line transects carried out during 2001-2002; however all observations were allocated to one of four distance bands (A = 44-162m, B = 163-282m, C = 283-426m and D = 427-1000m) based on the perpendicular distance of the bird(s) from the aircraft's trackline, and a GPS recorded the location of the plane every 5 seconds. Transects were spaced 2 km apart to ensure coverage of the survey area. Full descriptions of the methods are described in Dean *et al.,* (2004). The survey conducted on 4 December 2003 was terminated after completing six of the planned eighteen transects because of poor weather. A full survey was conducted the following day; data from the former have not been analysed for the purposes of this report.

2.2 Estimating population sizes

Only data on inshore waterbirds such as divers, grebes, seaducks and little gulls are presented here. Numbers of other species were low and of no significance for consideration of the area as a SPA.

Three methods were used to assess population sizes of various species: (1) raw counts where data were collected as strip transects (2000 and 2001); (2) extrapolation of mean density derived from distance sampling; and (3) extrapolation of mean density derived from raw counts if there were insufficient data to apply distance-sampling methods. In carrying out distance sampling, data were analysed using the software *Distance* 5.0 (Thomas *et al.,* 2005). For each species and survey, half-normal models or hazard rate models (with zero adjustments and with the size-bias regression method of cluster size estimation) were selected depending upon which provided the best fit to the data on the basis of minimising the Akaike Information Criterion (AIC) (Burnham & Anderson 2002). Where possible, non-parametric bootstrapping, re-sampling transects as samples with replacements, was used to produce 95% confidence limits for abundance estimates (Cressie 1991).

Where the number of observations for the line transect surveys was too small to permit density estimation using distance sampling, surveys were treated as strip transect surveys and density was estimated directly from raw counts by applying the density for the transect area to the whole survey area. Detection functions generated by *Distance* showed that detection rate was much lower in bands C and D than in bands A and B. These more distant bands were excluded from this analysis to avoid underestimating density. Transect widths were therefore assumed to be either 764m wide, i.e. 2 × (118+264) for aerials surveys before October 2002 or 476m wide, i.e. 2 × (118+120). This was multiplied by the length of the total survey transects flown to give the area over which observers counted. The number of birds observed in bands A and B was then divided by area counted to produce a mean density. This density was extrapolated across the total area surveyed to allow estimation of total population size.

2.2.1 Red-throated diver

Of all divers observed during aerial surveys (154 in total), one bird was identified as a great northern diver *Gavia immer*, whereas the remainder were recorded either as red-throated diver or unidentified diver species. Consequently, unidentified diver observations were assumed to be of red-throated divers and analyses were performed on combined red-throated and unidentified diver data. During the boat survey in 1998, two black-throated divers *Gavia arctica* and one great northern diver were recorded, so unidentified divers were apportioned appropriately.

2.2.2 Long-tailed duck, common scoter, velvet scoter and little gull

Some survey data of common eider and common scoter were not suitable for distance sampling analysis because a small number of very large flocks caused a very high percentage in component variance for cluster size. This created problems with analysis of results for long-tailed duck in December 2003 and February 2004, common scoter in February 2004, velvet scoter in February 2002, all scoters in February 2004 and little gull in December 2003. To overcome this problem all flocks comprising more than a certain threshold of large flock sizes (determined by using a flock size frequency histogram) were removed from the analysis. An estimate for birds within the smaller flocks was made using distance sampling, and the final distance estimate for each survey period was then added to the raw count of birds in the large flocks, which were considered to be accurate counts. This approach assumed that the largest flocks would be equally detectable over all distance bands.

2.2.3 Waterbird assemblage

It was not always possible to identify scoter to species level. In order to include these data in estimating the total size of the waterbird assemblage, common scoter and velvet scoter were pooled along with unidentified scoter records for each survey. The increased sample sizes enabled the application of distance analysis. This pooling of data assumes that the detection functions for all scoter are similar.

3 Results

3.1 Number of birds counted

Data from nine surveys of the Firth of Forth, one in 1997/98 and eight between 2000/01 and 2004/05, were analysed. During the surveys, 14 species of inshore waterbird were recorded, as well as little gulls. Common goldeneye were recorded only in small numbers (11 observations in total) and Eurasian widgeon *Anas penelope* only in one small flock. Black-throated and great northern diver, great-crested, red-necked and Slavonian grebes, greater scaup and surf scoter *Melanitta perspicillata* were, apart from one diver observation, observed only during the boat survey and then only in small numbers. None of the data for these species has been analysed for the purposes of this report. However, intertidal SPAs in the Firth of Forth have been classified for the wintering population of Slavonian grebe. Great-crested grebe, greater scaup and common goldeneye are also included in the list of species that comprise the important assemblage for which the area qualifies. These species may be under-recorded during aerial surveys so land-based counts are important sources of information.

Little gulls were observed in the study area during the December 2003 aerial survey and these data have been analysed for this report. The total number of birds and flocks for each species recorded, in sufficient quantities and for each survey, are presented in Table 1.

Three different survey methods were used so caution should be applied when comparing raw counts of these surveys. Also, the survey area and number of transects surveyed were different between survey dates. Further, during strip transect aerial surveys and the boat survey (which was treated as a strip transect in the analysis), distance information was not collected/used and bird densities were calculated over the entire transect width. The assumption that all birds within the survey area were detected is highly unlikely to be justified so these surveys may underestimate bird density considerably.

Table 1. The total number of birds and flocks (represented in brackets) counted in the Firth of Forth during surveys conducted between January 1998 and February 2005, for selected species. Numbers represent the total (raw) sample counts of all birds recorded on either line transect boat survey (1997/98), strip transect aerial surveys (2000/01) and line transect aerial surveys (2000/01-2004/05).

DATE	Red-throated diver	Common eider	Long-tailed duck	Common scoter	Unidentified scoter	Velvet scoter	Red-breasted merganser	Little Gull
Season 1997/98								
25-29 Jan. 1998	126	3029	636	650		764	289	2
Season 2000/01								
21/22 Dec. 2000	14 (10)	4565 (106)	19 (5)	841 (13)	358 (10)	430 (23)	53 (16)	
15 Feb. 2001	3 (3)	2267 (81)	45 (15)	816 (11)	90 (8)	308 (21)	17 (5)	
Season 2001/02								
14 Dec. 2001	30 (20)	2270 (258)	64 (12)	2557 (63)	276 (29)	196 (30)	22 (9)	
26 Feb. 2002	16 (5)	1582 (267)	48 (25)	379 (42)	129 (23)	132 (28)	34 (15)	
Season 2003/04								
05 Dec. 2003	10 (8)	1331 (199)	62 (16)	24 (5)	33 (5)	13 (4)	12 (9)	75 (28)
16 Feb. 2004	14 (13)	2419 (317)	142 (28)	718 (27)	41 (6)	13 (3)	28 (13)	
Season 2004/05								
12 Dec. 2004	58 (47)	2033 (252)	236 (50)	34 (4)	20 (1)	13 (3)	105 (25)	
03 Feb. 2005	7 (7)	1182 (255)	52 (24)	70 (12)	16 (2)	58 (17)	21 (14)	

3.2 Distribution of bird observation

The distributions of red-throated diver, common eider, long-tailed duck, common scoter, velvet scoter and red-breasted merganser are presented in Appendix 1, Figures A1 to A6. Distribution data is not available for those species assessed using WeBS counts. The great majority of observations of all waterbird species in all surveys occurred in water less than 20m deep, close to the coast.

3.2.1 Red-throated diver

Red-throated divers were recorded during all surveys of the Firth of Forth, albeit in low numbers. There were no clearly consistent hotspots in diver occurrence across surveys but, as expected, divers were recorded mostly in waters less than 20m deep.

3.2.2 Grebes

The only grebes recorded were small numbers of great-crested and red-necked grebes during the 1998 boat survey.

3.2.3 Common eider

Common eiders were recorded during all surveys of the Firth of Forth. Flocks were distributed throughout the length of the Firth of Forth but were slightly more concentrated in the inner firth. Most eiders were located close to the coast in shallow water, with very few flocks recorded in the deeper mid-channel waters.

3.2.4 Long-tailed duck

Long-tailed ducks were recorded during all surveys of the Firth of Forth. The distribution of long-tailed duck was highly variable within the firth and showed no consistent pattern; they were usually recorded at one or more of the following locations: Largo Bay, Aberlady Bay, Musselburgh, and Burntisland. For example, in February 2004, they occurred mostly in Largo Bay but in December 2004 most observations were off the coast at Burntisland.

3.2.5 Common scoter

Common scoters were consistently recorded in two main areas close to the coast: Aberlady Bay and Largo Bay plus the area extending approximately 10 km west. This was the case in every survey with much smaller numbers recorded off Musselburgh in most surveys.

3.2.6 Velvet scoter

Although less frequently recorded than common scoter, the distribution of velvet scoter was similarly confined primarily to areas around Largo Bay and Aberlady Bay, with smaller numbers close to Musselburgh.

3.2.7 Red-breasted merganser

Most red-breasted mergansers were recorded near the south shore of the Firth of Forth between Drum Sands and Musselburgh, with fewer recorded on the north shore close to Largo Bay.

3.2.8 Little gull

High numbers of little gulls were recorded only on the aerial line transect survey in December 2003, all of them in the middle of the firth away from the coast

3.3 Population estimates

Population estimates reported here (Table 2) are derived from total raw counts, extrapolation from raw counts, or distance sampling (see Methods). Line transect distance sampling methods are one of the most robust methods for estimating the total population size (Buckland *et al.,* 2001); 95% confidence limits are presented for distance sampling estimates, but it was not possible to derive confidence intervals for extrapolated counts. Greater detail on estimates, including densities are provided in Appendix 2 for all species analysed.

Table 2. Summary of population estimates (numbers of individuals) in the Firth of Forth during each survey period from 1998 to 2005, for selected species. Counts in December 2000 and February 2001 are based simply on raw counts from observations and those denoted with * have been extrapolated from raw counts. Otherwise, totals are based on distance sampling estimates with 95% confidence limits in parentheses. Highlighted cells indicate that the species threshold for SPA consideration is exceeded (see Baker *et al.*, 2006).

Survey date	Red-throated diver	Common eider	Long-tailed duck	Common scoter	Velvet scoter	All scoter	Red-breasted merganser	Little Gull	Assemblage of all species
SPA Stage 1 selection threshold	170	12850	20000	16000	10000	n/a	1700	50	20000
Season 1997/98									
25-29 Jan. 1998	158*	5363*	874*	1226*	1513*	2744*	427*	15*	9581
Season 2000/01									
21/22 Dec. 2000	14	4565	19	1078	551	1629	53	-	6280
15 Feb. 2001	3	2267	45	881	333	1214	17	-	3546
Season 2001/02									
14 Dec. 2001	150 (63-288)	10996 (7436-16260)	173 (66-310)	5121 (2000-9004)	534*	7498 (4497-12503)	177*	-	18994
26 Feb. 2002	140*	9416 (6679-13274)	455 (222-736)	2066 (817-3986)	680 [640 (224-1062) plus 40]	2849 (1570-4518)	175*	-	13035
Season 2003/04									
05 Dec. 2003	36*	3560 (2277-5567)	225 [195 (67-395) plus 30]	86*	46*	211*	43*	317 [282 (79-563) plus 35)	4392
16 Feb. 2004	144 (72-289)	9771 (6895-13846)	813 [813 (421-1854) plus 55]	1240 [870 (368-2057) plus 370]	55*	1299 [929 (433-1994) plus 370]	119*	-	12146
Season 2004/05									
12 Dec. 2004	512 (361-727)	8767 (6317-12168)	1667 (776-3005)	149*	115*	206*	460*	-	11612
03 Feb. 2005	29*	4304 (2905-6054)	311 (166-534)	294*	262 (67-481)	579 (223-1006)	169 (76-299)	-	5392

3.3.1 Red-throated diver

Of all divers observed during all line transect surveys, two birds were identified as great northern diver and two as black-throated; the remainder were recorded either as red-throated diver or unidentified diver species. Therefore, analyses for red-throated divers were performed on combined red-throated and unidentified diver data, the small amount of potential error (approximately 1%) being deemed acceptable. Monthly WeBS counts of the Firth of Forth support this assumption as counts performed in the same months as aerial surveys recorded a maximum of only three individual black-throated or great northern divers (Cranswick *et al.,* 1999, Collier *et al.,* 2005). Only one record of unidentified diver was made in total for both the February 2004 and December 2004 surveys. In December 2001, 18 of the 30 divers observed could not be identified, but the potential error in this analysis is small and would not affect the potential qualification of the Firth of Forth as an SPA.

Detailed results for each survey are presented in Appendix 2 (Table A1). A summary of maximum seasonal population estimates is presented in Table 3. The Stage 1.1 site selection threshold of 170 birds (O'Brien *et al.,* 2008) was exceeded in one of the five seasons.

Table 3. Maximum seasonal population estimates of red-throated divers in the Firth of Forth. It is important to note that survey method and coverage differ between years. Highlighted cells indicate estimates that exceed the UK SPA Stage 1.1 site selection threshold of 170 birds (O'Brien *et al.,* 2008).

Season	Maximum estimate	Method	Date
1997/98	158	Extrapolation	25 to 29 January
2000/01	14	Raw count	21/22 December 2000
2001/02	150	Distance	14 December 2001
2003/04	144	Distance	16 February 2004
2004/05	512	Distance	12 December 2004
Mean of maximum estimates	196		

3.3.2 Grebe species

It was not possible to generate population estimates from the raw counts of grebes, as there were too few observations (24 in total for all surveys). Grebes are recorded only rarely on aerial surveys. Land-based surveys, which allow time for detection and also more accurate identification of species, are more effective for counting grebes. Regular shore-based counts have been undertaken as part of the Wetland Bird Surveys (Cranswick *et al.,* 1999, Collier *et al.,* 2005). Although WeBS counts are known to underestimate numbers of grebes present (Collier *et al.,* 2005), the most recent counts are presented here (Table 4). The relevant SPA Stage 1.1/1.2 site selection thresholds are 50 birds for Slavonian grebe (Baker *et al.,* 2006) 3,600 for great-crested grebe, and 510 for red-necked grebe (Wetlands International 2006).

Table 4. Summary of WeBS counts for grebe species in the Firth of Forth. Figures are peak counts over the winter period (October – April) from 1993/94 to 2004/05 (Cranswick *et al.*, 1999, Collier *et al.*, 2005). Highlighted cells indicate counts that exceed the SPA Stage 1.1 site selection thresholds of 50 birds for Slavonian grebe (Baker *et al.*, 2006), 3,600 for great-crested grebe, and 510 for red-necked grebe (Wetlands International 2006).

	Great-crested grebe	Red-necked grebe	Slavonian grebe
1993/94	671	44	53
1994/95	627	89	78
1995/96	411	52	108
1996/97	597	44	107
1997/98	491	64	75
1998/99	319	41	57
1999/2000	297	55	67
2000/01	290	29	44
2001/02	224	39	61
2002/03	389	44	80
2003/04	295	16	110
2004/05	313	15	73

3.3.3 Greater scaup

It was not possible to generate population estimates from the raw counts of greater scaup as there were no observations. WeBS counts are a more suitable survey method for this species and the most recent counts are presented in Table 5. All counts are below the Stage 1.2 site selection threshold of 3,100 birds (Wetlands International 2006).

Table 5. Summary of WeBS counts for greater scaup in the Firth of Forth. Figures are peak counts over the winter period (October–April) from 1994/95 to 2004/05 (Cranswick et al., 1999, Collier et al., 2005). No estimates exceed the SPA Stage 1.2 site selection threshold of 3,100 birds for this species (Wetlands International 2006).

Season	Greater scaup
1994/95	77
1995/96	753
1996/97	1031
1997/98	145
1998/99	342
1999/2000	157
2000/01	240
2001/02	189
2002/03	130
2003/04	14
2004/05	22

3.3.4 Common eider

There were sufficient observations to allow distance sampling analysis of all aerial line transects for common eider (Table 6). A summary of maximum seasonal population estimates is presented in Table 6. All estimates were below the Stage 1.2 site selection threshold of 12,850 birds (Wetlands International 2006).

Table 6. Maximum seasonal population estimates of common eiders in the Firth of Forth. It is important to note that survey method and coverage differ between years. No estimates exceed the SPA Stage 1.2 site selection threshold of 12,850 (Wetlands International 2006).

Season	**Maximum estimate**	**Method**	**Date**
1997/98	5363	Extrapolation	25 to 29 January
2000/01	4565	Raw count	21/22 December 2000
2001/02	10996	Distance	14 December 2001
2003/04	9771	Distance	16 February 2004
2004/05	8767	Distance	12 December 2004
Mean of maximum estimates	7892.4		

3.3.5 Long-tailed duck

There were sufficient observations to allow distance sampling of all aerial line transects for long-tailed duck (Table 7). A summary of maximum seasonal population estimates is presented in Table 7. All estimates were below the Stage 1.2 site selection threshold of 20,000 birds (Wetlands International 2006).

Table 7. Maximum seasonal population estimates of long-tailed duck in the Firth of Forth. It is important to note that survey method and coverage differ between years. No estimates exceed the SPA Stage 1.2 site selection threshold of 20,000 individuals (Wetlands International 2006).

Season	**Maximum estimate**	**Method**	**Date**
1997/98	874	Extrapolation	25 to 29 January
2000/01	45	Raw count	15 February 2001
2001/02	455	Distance	26 February 2002
2003/04	813	Distance	16 February 2004
2004/05	1667	Distance	12 December 2004
Mean of maximum estimates	770.8		

3.3.6 Common scoter

Common scoter population estimates were obtained using distance sampling analysis for most surveys (Table 8). However, in December 2003 and December 2004 there were too few observations (five and four respectively) to produce reliable distance estimates, so population estimates were obtained by extrapolating raw count densities. Estimates varied considerably

but all were below the Stage 1.2 site selection threshold of 16,000 birds (Wetlands International 2006, Table 8).

Table 8. Maximum seasonal population estimates of common scoter in the Firth of Forth. It is important to note that survey method and coverage differ between years. No estimates exceed the SPA Stage 1.2 site selection threshold of 16,000 birds (Wetlands International 2006).

Season	**Maximum estimate**	**Method**	**Date**
1997/98	1226	Extrapolation	25 to 29 January
2000/01	1078	Raw count	21/22 December 2000
2001/02	5121	Distance	14 December 2001
2003/04	1240	Distance	16 February 2004
2004/05	294	Distance	3 February 2005
Mean of maximum estimates	1791.8		

3.3.7 Velvet scoter

High variability in flock sizes for observations on 14 December 2001 meant it was not possible to gain reliable population estimates using distance sampling. The estimate was therefore derived from extrapolation. All estimates were below the Stage 1.2 site selection threshold of 10,000 birds (Wetlands International 2006, Table 9).

Table 9. Maximum seasonal population estimates of velvet scoter in the Firth of Forth. It is important to note that survey method and coverage differ between years. No estimates exceed the SPA Stage 1.2 site selection threshold of 10,000 individuals (Wetlands International 2006).

Season	**Maximum estimate**	**Method**	**Date**
1997/98	1513	Extrapolation	25 to 29 January
2000/01	551	Raw count	21/22 December 2000
2001/02	680	Distance	26 February 2002
2003/04	55	Extrapolation	16 February 2004
2004/05	262	Distance	3 February 2005
Mean of maximum estimates	612.2		

3.3.8 Common goldeneye

It was not possible to generate population estimates from the raw counts of common goldeneye, as there were too few observations (a total of 11 in all surveys combined). Common goldeneyes are recorded infrequently on aerial surveys. Land-based surveys are more effective for counting this species and the most recent counts are presented here. The Stage 1.2 site selection threshold of 11,500 birds (Wetlands International 2006) was not met in any season (Table 10).

Table 10. Summary of WeBS counts for common goldeneye in the Firth of Forth. Figures are peak counts over the winter period (October – April) from 1994/95 to 2004/05 (Cranswick et al., 1999, Collier et al., 2005). No counts exceed the SPA Stage 1.2 site selection threshold of 11,500 birds (Wetlands International 2006).

Season	Common goldeneye
1994/95	2369
1995/96	2125
1996/97	2892
1997/98	4864
1998/99	2445
1999/2000	1653
2000/01	2414
2001/02	1113
2002/03	1241
2003/04	753
2004/05	879

3.3.9 Red-breasted merganser

Distance analysis produced unreliable estimates for red-breasted merganser because of the small number of observations (25 was the maximum in December 2004); all estimates reported are extrapolations from raw data with the exception of strip transects in 2000/01, which are raw counts. The Stage 1.2 site selection threshold of 1,700 birds (Wetlands International 2006) was not met in any season (Table 11).

Table 11. Maximum seasonal population estimates of red-breasted merganser in the Firth of Forth. It is important to note that survey method and coverage differ between years. No estimates exceeded the SPA Stage 1.2 site selection threshold of 1,700 birds (Wetlands International 2006).

Season	Maximum estimate	Method	Date
1997/98	427	Extrapolation	25 to 29 January
2000/01	53	Raw count	21/22 December 2000
2001/02	177	Extrapolation	26 February 2002
2003/04	119	Extrapolation	16 February 2004
2004/05	460	Extrapolation	14 December 2004
Mean of maximum estimates	247.2		

3.3.10 Little gull

High numbers of little gulls were recorded only during 2003/04. The only other records were two observations from boat survey in 1998. There were sufficient numbers in 2003/04 to allow a population estimate to be derived using distance sampling (Table 2).

3.3.11 Waterbird assemblage

Results of analyses for all species were added to produce estimates of the size of the waterbird assemblage using the Firth of Forth in each year (Table 12). When compared to the SPA Stage 1.3 site selection threshold for species assemblage (20,000 individuals) the area meets the threshold in only one of the five seasons for which adequate data exist. The mean of the annual maximum estimates over the survey period is 14,277.

Table 12. Maximum seasonal estimates of waterbird assemblage in the Firth of Forth. It is important to note that survey method and coverage differ between years. Estimates for grebes, greater scaup and common goldeneye are taken from peak winter WeBS counts. The single estimate that exceeds the 20,000 SPA Stage 1.3 site selection threshold is highlighted.

Season	**Maximum assemblage from JNCC surveys (see Table 2)**	**JNCC survey date**	**Grebe species**	**Greater scaup**	**Common goldeneye**	**Total waterbird assemblage**
1997/98	9581	25 to 29 January	630	145	4864	15220
2000/01	6280	21/22 December 2000	363	240	2414	9297
2001/02	18994	14 December 2001	324	189	1113	20620
2003/04	12146	16 February 2004	421	14	753	13334
2004/05	11612	3 February 2005	401	22	879	12914
Mean of Maximum estimates	11722.6					14277

4 Discussion

4.1 SPA qualification

The selection guidelines for SPAs in the UK (Stroud *et al.*, 2001) advise that SPAs be selected in two stages. The first stage is intended to identify areas that are likely to qualify for SPA status on the basis of population thresholds. Selection guidelines for SPAs in the UK (Stroud *et. al.*, 2001) advise that SPA qualification should be determined in two stages.

Stage 1: (considered in this report) is intended to identify areas that are likely to qualify for SPA status on the basis of threshold populations, or other ecological considerations.

Stage 2: (not considered in this report) is intended to further consider locations identified under stage 1 to select the most suitable areas.

An area may be considered under any one of four components of Stage 1:

Stage 1.1. Numbers of species listed on Annex I of the EU Birds Directive (79/409/EEC) should exceed 1% of the agreed Great Britain (GB) (or if relevant the all Ireland) population for the species on a regular basis.

Stage 1.2. For migratory species not listed on Annex I of the EU Birds Directive, numbers at a site should exceed 1% of the agreed biogeographical population for the species on a regular basis.

Stage 1.3. For waterbird or seabird species assemblages, more than 20,000 waterbirds (as defined by the Ramsar Convention), of at least two species, should occur regularly in an area (Stroud *et al.*, 2001).

For stages 1.1-1.3, (Webb & Reid 2004) considered definitions of regularity for inshore waterbird aggregations and suggested that the most appropriate definition to use is that of the Ramsar site selection criteria, where “numbers exceed the selection threshold in two out of three seasons” or, when available, the mean peak counts for the five most recent seasons.

Stage 1.4. Finally, where the application of stages 1.1-1.3 does not identify an adequate suite of sites, areas may be selected if they satisfy one or more of various ecological criteria listed under stage 2.

In the later application of stage 2 judgements, a preference should then be given to those areas which contribute significantly to the species’ population viability locally and as a whole, e.g. population size and density, species range, breeding success, history of occupancy, etc. (Stroud *et al.*, 2001).

In order to determine whether the Firth of Forth meets Stage 1.1/1.2/1.3 guidelines for further considerations for SPA status, estimated population sizes for the species it hosts should be compared with either the total estimated GB or total estimated biogeographical wintering populations, depending respectively whether the species is on Annex I of the Directive or whether it is a regularly occurring migratory species.

4.2 Distance sampling analyses

There were sufficient sample sizes for common eider and long-tailed duck to apply distance sampling analyses for each aerial line transect survey. For red-throated diver and common scoter there were sufficient data to allow at least one line transect survey in each of the seasons 2001/02, 2003/04, 2004/05 to be analysed using distance techniques.

For most of the estimates derived from distance sampling, 95% confidence intervals were narrow. In those cases in which a detection function could not be obtained through distance analysis, and this was the case for most velvet scoter and red-breasted merganser data, estimates were calculated by extrapolation of raw counts close to the aeroplane across the entire survey area.

4.3 Red-throated diver

Red-throated divers are listed on Annex I of the Birds Directive and the threshold for SPA qualification is 1% of the GB wintering population. This threshold has recently been revised to 170 individuals (O'Brien *et al.,* 2008). Neither the 1998 boat survey nor the strip transect surveys carried out in 2000 and 2001 resulted in estimates of red-throated divers meeting the Stage 1.1 guideline. Numbers of the species exceeded the site selection threshold in only one of the six line transect surveys conducted between 2001 and 2005; in December 2004, the estimate was 512 individuals or 3% of the Great Britain winter population. Overall the data indicate a mean of peak annual wintering population estimates for the five most recent seasons of 196 red-throated divers in the Firth of Forth, clearly in excess of the threshold of 170. However, when applying the definition of the Ramsar site selection criteria the numbers of red-throated divers did not exceed qualifying thresholds during at least two out of three seasons. Therefore, the data presented here indicate that (part of) the Firth of Forth does not meet the Stage 1.1 site selection guidelines as an SPA based on its red-throated diver population outside the breeding season.

4.4 Grebes

Population estimates for grebes were obtained from land-based WeBS counts in winter (Cranswick *et al.,* 1999, Collier *et al.,* 2005). Great-crested grebe and red-necked grebe are regularly occurring migratory species and SPA Stage 1 site selection thresholds for these species (1% of biogeographical populations) are 3,600 and 510 respectively (Wetlands International 2006). These were not exceeded in any year from 1993/94 to 2003/04.

Slavonian grebe, an Annex I species with a default SPA qualification of 50 birds, occurred in the Firth of Forth in qualifying numbers in every year except 2000/01 (Table 4). In addition, the mean of the peak annual counts for the most recent five winters (2000/01, 2001/02, 2002/03, 2003/04, 2004/05) is 74 birds. WeBS survey totals ranged from 6 to 15% of the estimated GB wintering population.

The Firth of Forth as defined herein therefore meets the Stage 1.1 site selection guidelines as an SPA for its wintering population of Slavonian grebe, but note that the spatial extent of grebe distributions are not recorded in WeBS surveys, and that inshore areas have already been designated as SPAs for this species (Figure 1).

4.5 Greater scaup

Population estimates for greater scaup were obtained from land-based WeBS counts in winter. The greater scaup is a regularly occurring migratory species with an SPA Stage 1 site selection threshold of 3,100 birds (Wetlands International 2006). This threshold was not exceeded in any year from 1994/95 to 2004/05, although WeBS survey totals did represent up to 3% of the estimated GB wintering population of 7,600 (Baker *et al.*, 2006). Historically, up to 15,000 greater scaup have been recorded in the Firth of Forth in winter, but these occurrences were mainly associated with sewage outlets (Milne & Campbell 1973) and numbers appear to have decreased substantially as water quality has improved.

The data presented here suggest that the Firth of Forth does not meet the Stage 1.2 site selection threshold for consideration as an SPA for greater scaup.

4.6 Common eider

Common eider is a regularly occurring migratory species with an SPA Stage 1 site selection threshold of 12,850 (1% of the biogeographical population; Wetlands International 2006). This threshold was not exceeded in any survey during this study. WeBS counts support the conclusion that the species occurs in the Firth of Forth in numbers that do not meet the SP threshold (Cranswick *et al.*, 1999, Collier *et al.*, 2005). Population estimates were lowest for surveys to which distance analysis could not be applied, ranging from 2,267 birds on the 2001 strip transect to 10996 from data collected on the line transect aerial survey in December 2001.

The data presented here suggest that the Firth of Forth does not meet the Stage 1.2 site selection threshold for consideration as a SPA for common eider.

4.7 Long-tailed duck

The long-tailed duck is a regularly occurring migratory species with an SPA Stage 1 site selection threshold of 20,000 (Wetlands International 2006). Population estimates in this study were too low for the Firth of Forth to qualify as an SPA for long-tailed duck. However, numbers were sufficiently great to allow distance sampling.

The data presented here suggest that the Firth of Forth does not meet the Stage 1.2 site selection threshold for consideration as a SPA for long-tailed duck.

4.8 Common scoter

The common scoter is a regularly occurring migratory species with an SPA Stage 1 site selection threshold of 16,000 birds. Population estimates for common scoter in the Firth of Forth varied greatly, ranging from 86 in December 2004 to 5,121 in December 2001. This is not unexpected, as flocks are rarely resident in one area throughout the winter (Milne & Campbell 1973). Estimates were consistently below the selection threshold based on 1% of the biogeographical population (Wetlands International 2006).

The data presented here suggest that the Firth of Forth does not meet the Stage 1.2 site selection threshold for consideration as a SPA for common scoter.

4.9 Velvet scoter

The velvet scoter is a regularly occurring migratory species with an SPA qualification threshold of 10,000 individuals (Wetlands International 2006). Population estimates in this study were too low for SPA qualification.

The data presented here suggest that the Firth of Forth does not meet the Stage 1.2 site selection threshold for consideration as a SPA for velvet scoter.

4.10 Common goldeneye

Winter population estimates for common goldeneye, obtained from land-based WeBS counts, indicate that the SPA qualification threshold of 11,500 birds (1% of the biogeographical population; Wetlands International 2006) for this regularly occurring migratory species was not exceeded in any year from 1994/95 to 2004/05.

The data presented here suggest that the Firth of Forth does not meet the Stage 1.2 site selection threshold for consideration as a SPA for common goldeneye.

4.11 Red-breasted merganser

The red-breasted merganser is a regularly occurring migratory species with an SPA qualification threshold of 1,700 birds (1% of the biogeographical population; Wetlands International 2006). The mean of peak estimates over five seasons was 247 (Table 11).

The data presented here suggest that the Firth of Forth does not meet the Stage 1.2 site selection threshold for consideration as a SPA for red-breasted merganser.

4.12 Little gull

The little gull is listed on Annex I of the Birds Directive and potential qualification is therefore assessed using stage 1.1 of the SPA guidelines. Currently there is no accurate estimate of the size of the GB wintering population of little gulls, so a default minimum SPA Stage 1 site selection threshold of 50 individuals pertains (Stroud *et al.,* 2001).

Little gulls are primarily passage migrants to Britain, although small numbers do over-winter off British and Irish coasts (Stone *et al.,* 1995). With the exception of two birds seen on the 1998 boat survey, little gulls were not recorded during aerial surveys until December 2003 and no observations have been made since that date. A total of 75 birds were recorded. Distance analysis produced an estimate of 317 birds in the Firth of Forth on this date. This exceeds the default SPA site selection threshold of 50. This suggests that, rather than birds which are over-wintering, this may be an irregular occurrence of passage birds on their way from their breeding grounds in Russia and the Baltic, to their wintering grounds in the Irish Sea, and south to Morocco and the Mediterranean (Wernham *et al.,* 2002). During autumn 2003, record numbers of little gulls were reported to be present off the Yorkshire coast (e.g. 10,000 individuals off Spurn, East Yorkshire on 11 September; Hartley 2004). The North Sea is a 'stop-over' area for adult and second-year little gulls in late summer and autumn, when a significant proportion of the Baltic breeding population occurs undergoing their post –breeding moult before dispersing to wintering grounds (Hartley 2004).

Population estimates in this study exceeded SPA stage 1 threshold numbers (50) in only one out of three seasons (2003/04), so the Firth of Forth does not meet the stage 1.1 site selection guideline as an SPA for this species. However, this may be because of the paucity of available data; aerial survey data for little gulls are available only for two seasons at present, so data from at least one more season are required to determine whether the species regularly occurs, and whether in significant wintering numbers.

4.13 Waterbird assemblage

Population estimates derived from distance sampling exceeded the 20,000 threshold in only one season (Table 2). The mean annual peak size of the total waterbird assemblage was 14,277 birds.

The data presented here do not support that the Firth of Forth meets stage 1.3 site selection threshold of the UK SPA selection guideline (Stroud *et al.*, 2001) as a SPA for its assemblage of waterbirds.

5 Conclusions

The Firth of Forth as defined here qualifies as an SPA for the Annex I species Slavonian grebe. Maximum winter WeBS counts exceed the SPA Stage 1.1 site selection threshold of 50 birds in all but one season from 1993/94 to 2003/04. Because of the difficulty in recording grebes from aerial surveys no detailed data on their spatial distribution in the area exists; further land-based survey would be required to ascertain this.

The Firth of Forth does not exceed the Stage 1.2 site selection thresholds as an SPA for great-crested grebe, red-necked grebe, greater scaup, common eider, common scoter, velvet scoter, common goldeneye, long-tailed duck and red-breasted merganser, nor the Stage 1.1 site selection thresholds for little gull. Population estimates in all cases failed to reach the relevant SPA thresholds on a regular basis. In the case of little gull, further surveys are required to determine the degree and regularity of use of the area.

The total number of inshore waterbirds recorded using the Firth of Forth over winter exceeded 20,000 individual waterbirds in one season, but the mean of annual peak estimates over five seasons was less than this (14,277 birds). On this basis, the Firth of Forth does not meet the Stage 1.3 site selection threshold for its waterbird assemblage under the UK SPA guidelines.

Further consideration may be given to inclusion of other species using stage 1.4 of the SPA selection guidelines, e.g. red-throated divers, once a dedicated survey has clarified the relative importance of other potential areas for the various species around the shores of both mainland Scotland and the islands.

In conclusion, the Firth of Forth currently meets Stage 1 site selection thresholds as an SPA for its wintering populations of red-throated divers and Slavonian grebes. Further analyses would be necessary to determine suitable boundaries for an SPA should the area be proposed as such.

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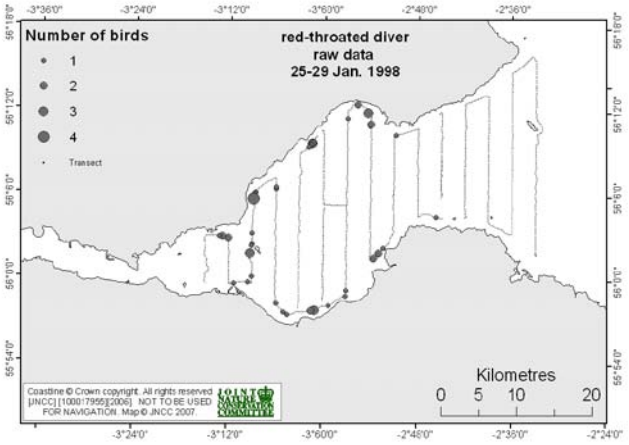
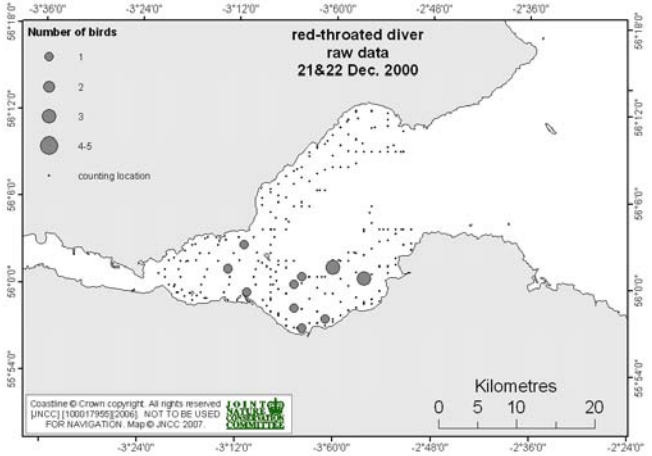
Appendix 1. Distribution of birds recorded during aerial surveys

Figure A1. Distribution of red-throated divers in the Firth of Forth recorded during a) line transect boat surveys conducted in January 1998 b) strip transect aerial survey on 21/22 December 2000 and c) strip transect aerial survey on 15 February 2001.

a)



b)



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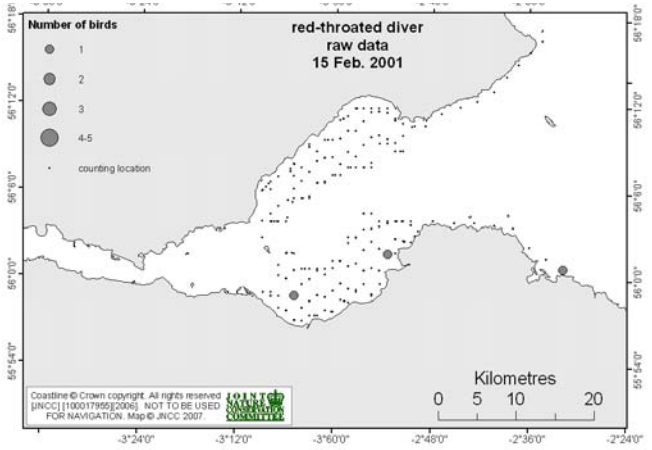


Figure A1 (cont). Distribution of red-throated divers in the Firth of Forth recorded during line transect aerial surveys conducted on d) 14 December 2001 e) 26 February 2002 f) 5 December 2003 and g) 16 February 2004.

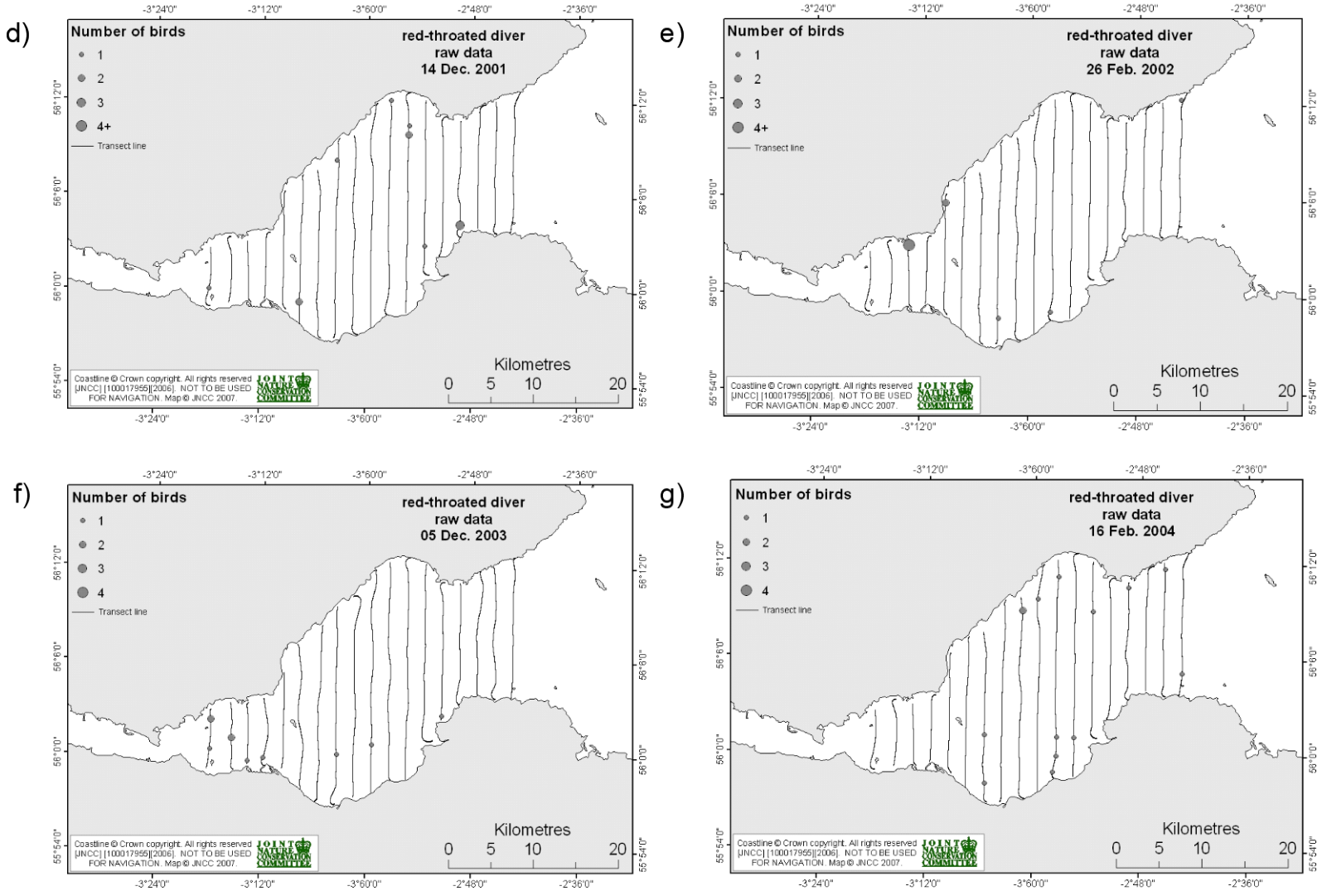
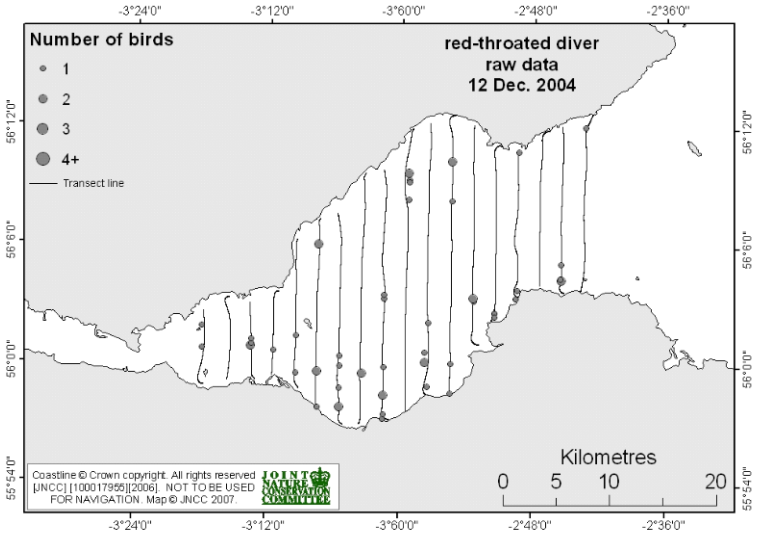


Figure A1 (cont). Distribution of red-throated divers in the Firth of Forth recorded during line transect aerial surveys conducted on h) 12 December 2004 and i) 3 February 2005.

h)



i)

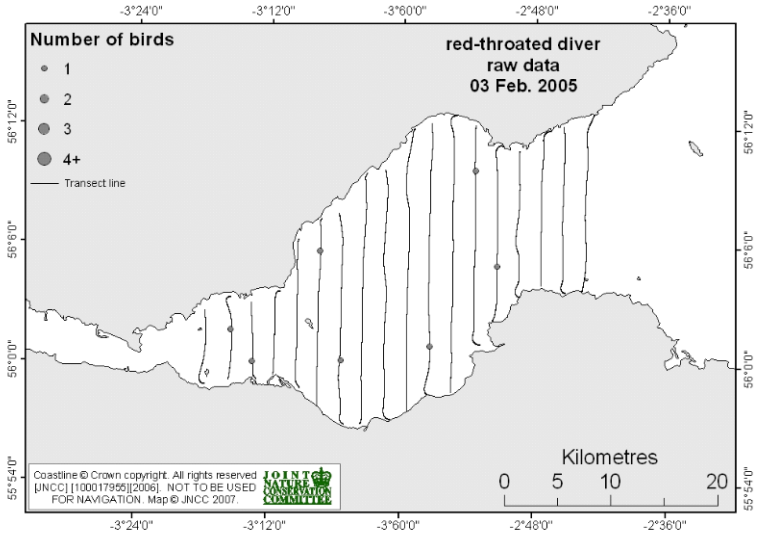


Figure A2. Distribution of common eider in the Firth of Forth recorded during a) line transect boat surveys conducted in January 1998 b) strip transect aerial surveys on 21/22 December 2000 and c) 15 February 2001.

+

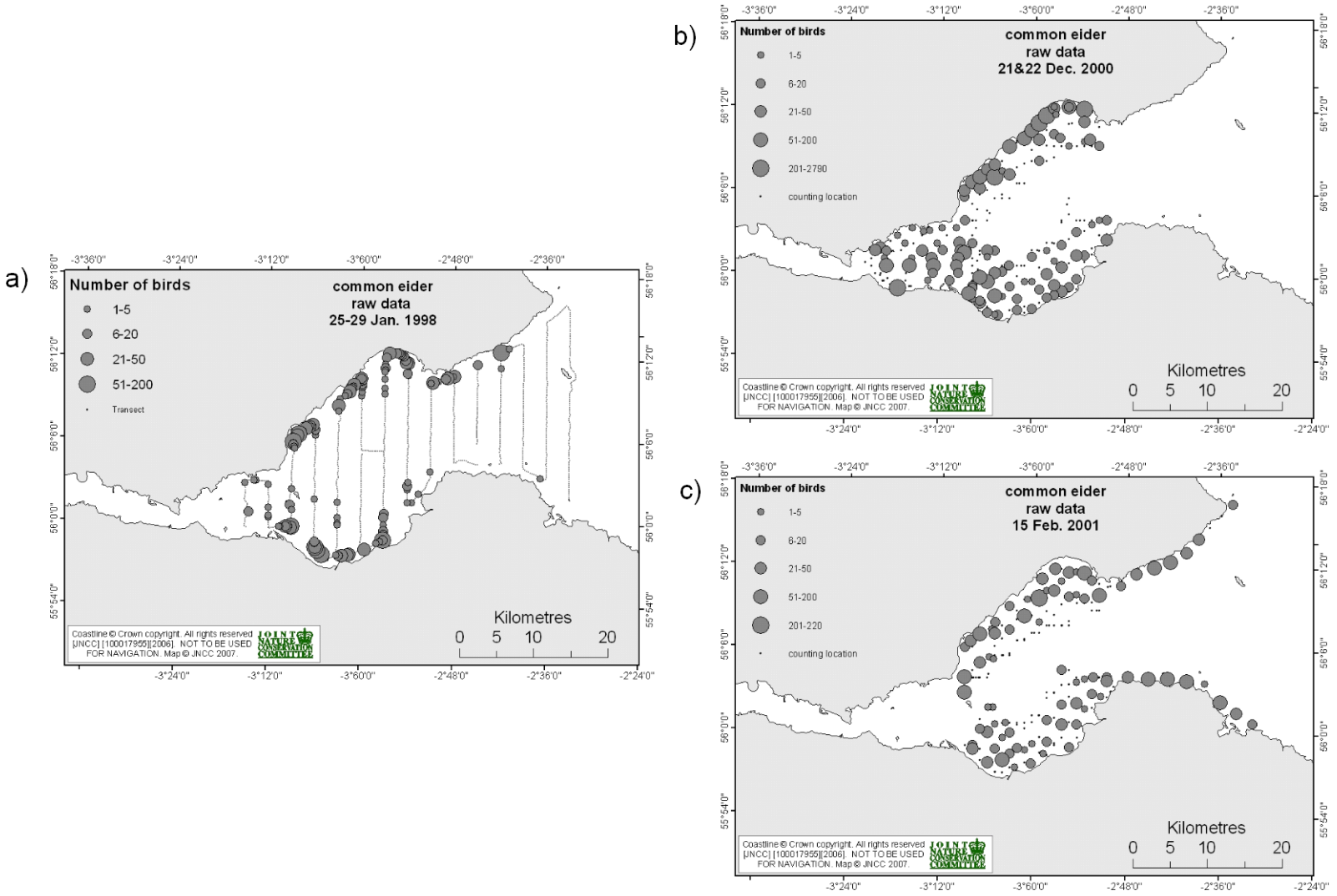


Figure A2 (cont). Distribution of common eider in the Firth of Forth recorded during line transect aerial surveys conducted on d) 14 December 2001 e) 26 February 2002 f) 5 December 2003 and g) 16 February 2004.

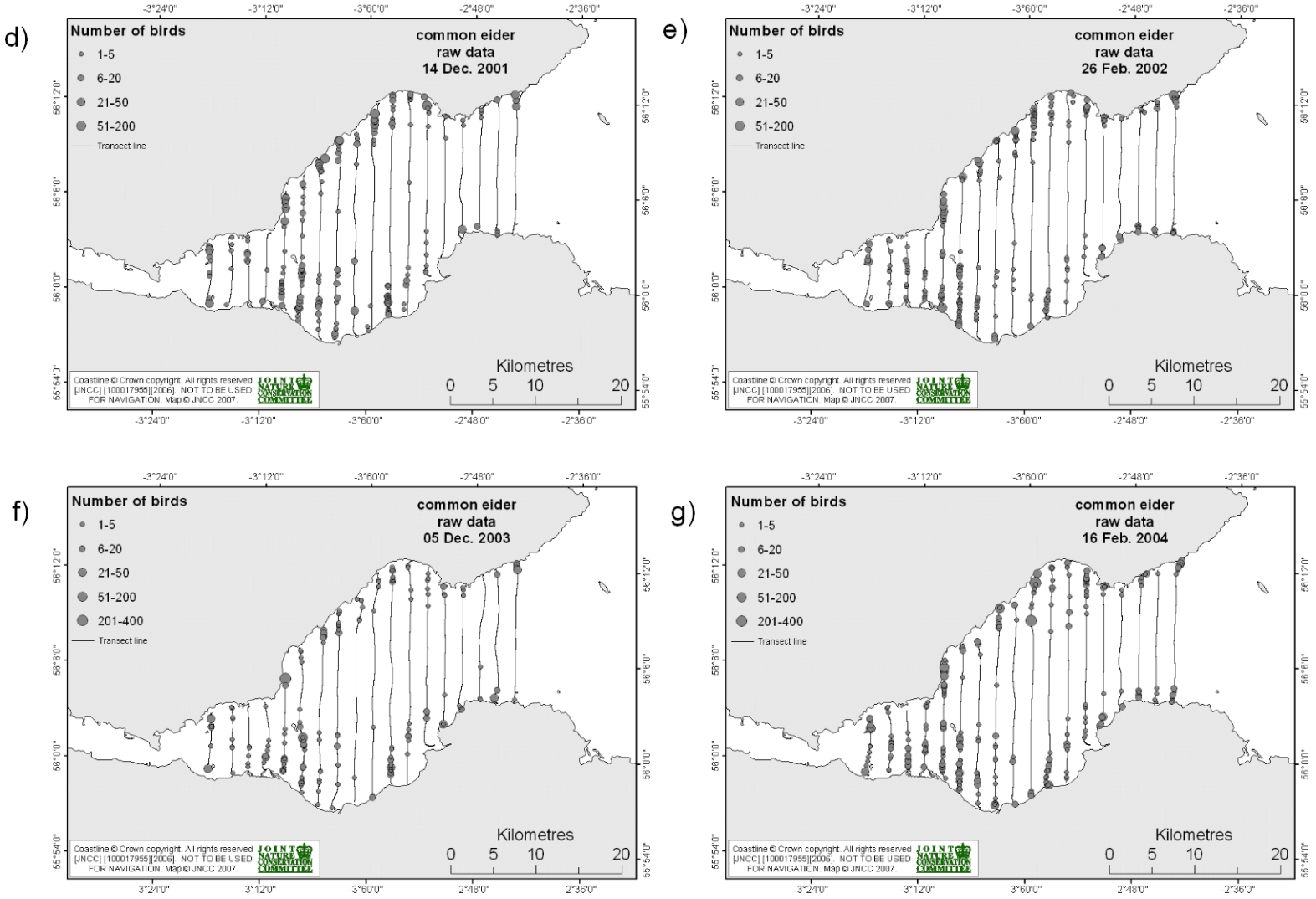
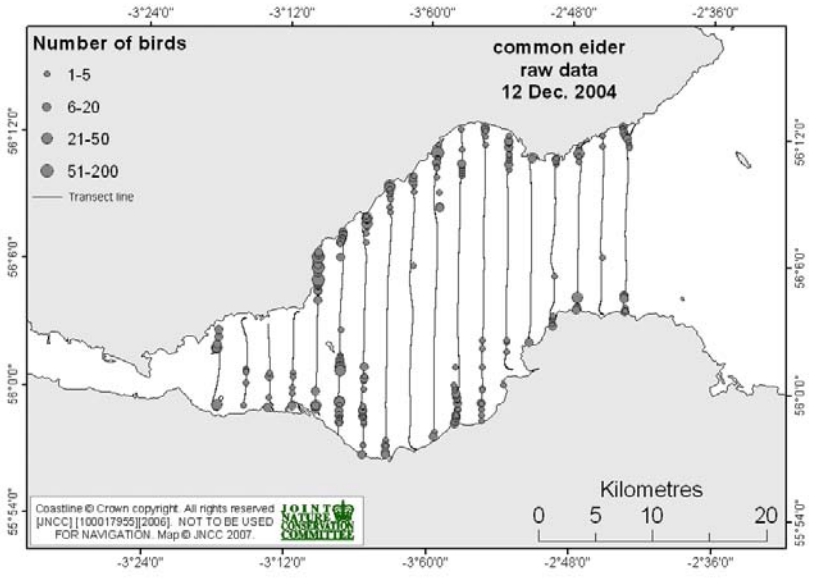


Figure A2 (cont). Distribution of common eider in the Firth of Forth recorded during line transect aerial surveys conducted on h) 12 December 2004 and i) 3 February 2005.

h)



i)

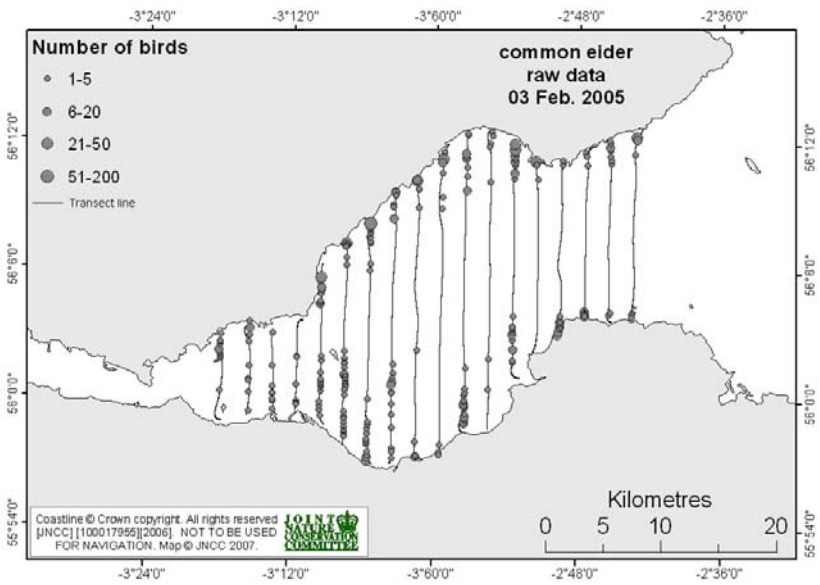


Figure A3. Distribution of long-tailed duck in the Firth of Forth recorded during a) line transect boat surveys conducted in January 1998 b) strip transect aerial surveys on 21/22 December 2000 and c) 15 February 2001.

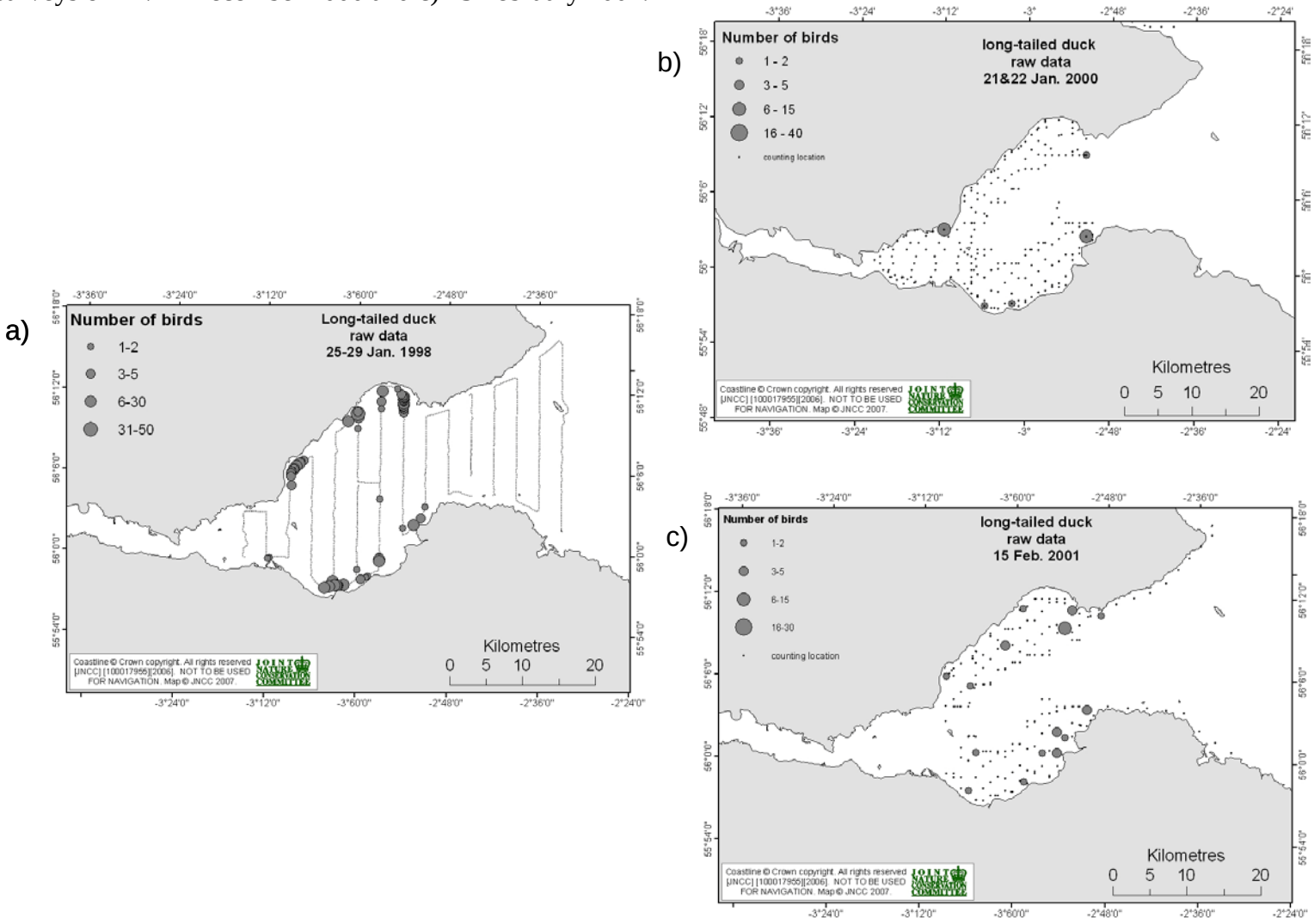
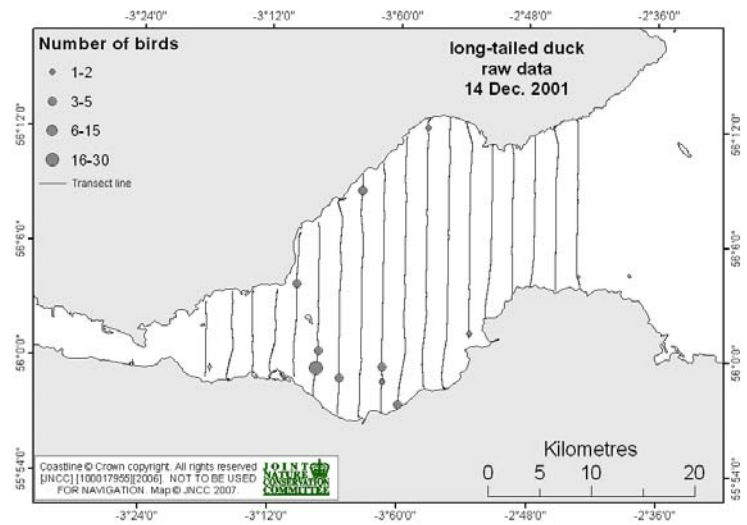
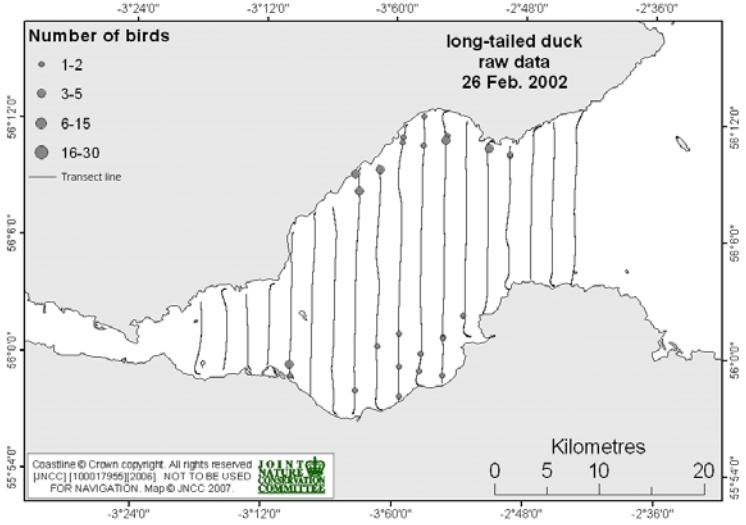


Figure A3 (cont). Distribution of long-tailed duck in the Firth of Forth recorded during line transect aerial surveys conducted on d) 14 December 2001 e) 26 February 2002 f) 5 December 2003 and g) 16 February 2004.

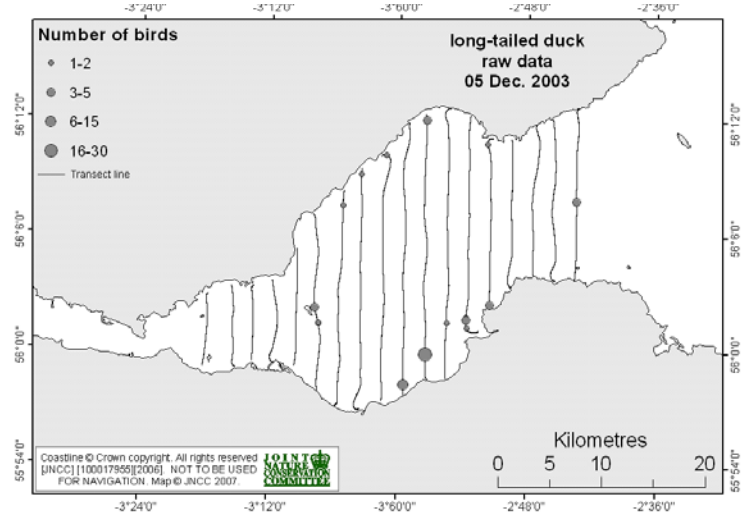
d)



e)



f)



g)

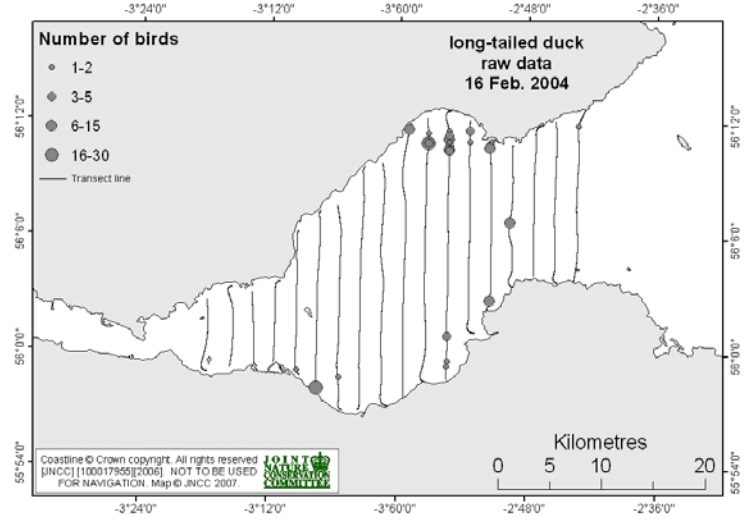
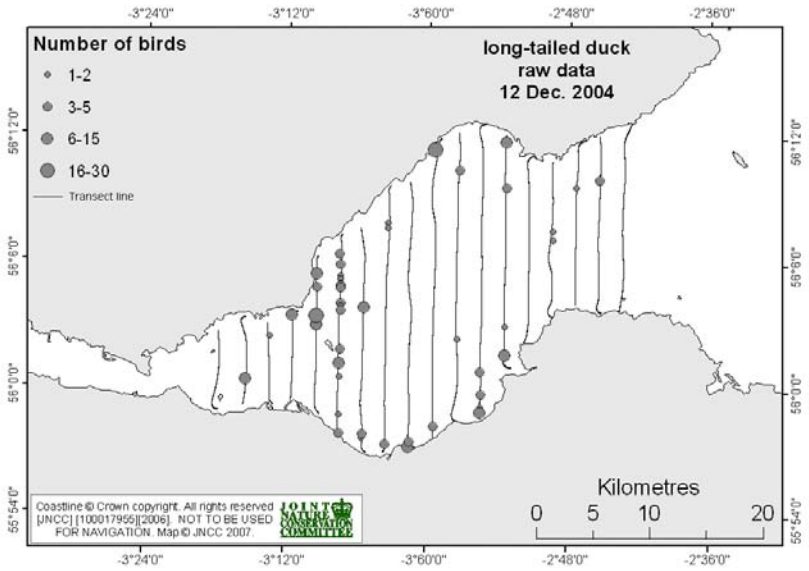


Figure A3 (cont). Distribution of long-tailed duck in the Firth of Forth recorded during line transect aerial surveys conducted on h) 12 December 2004 and February 2005.

h)



i)

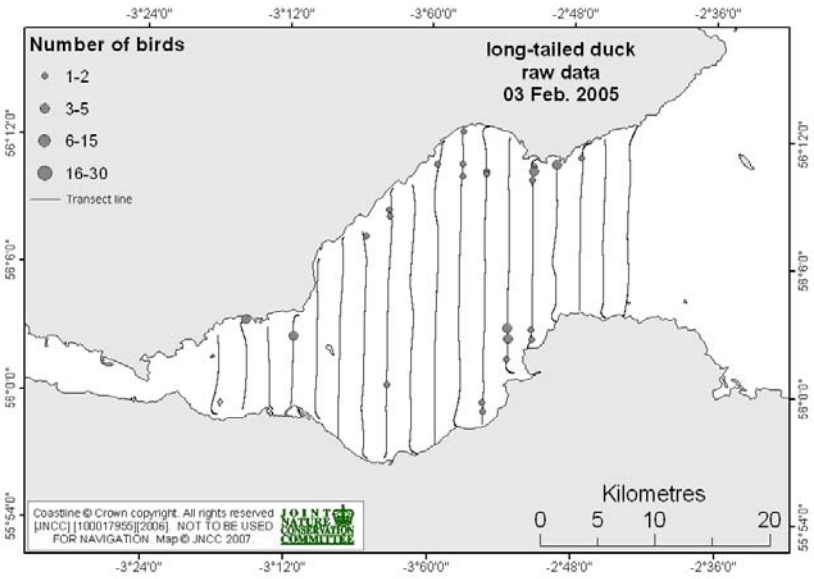


Figure A4. Distribution of common scoter in the Firth of Forth recorded during a) line transect boat surveys conducted in January 1998 b) strip transect aerial surveys on 21/22 December 2000 and c) 15 February 2001.

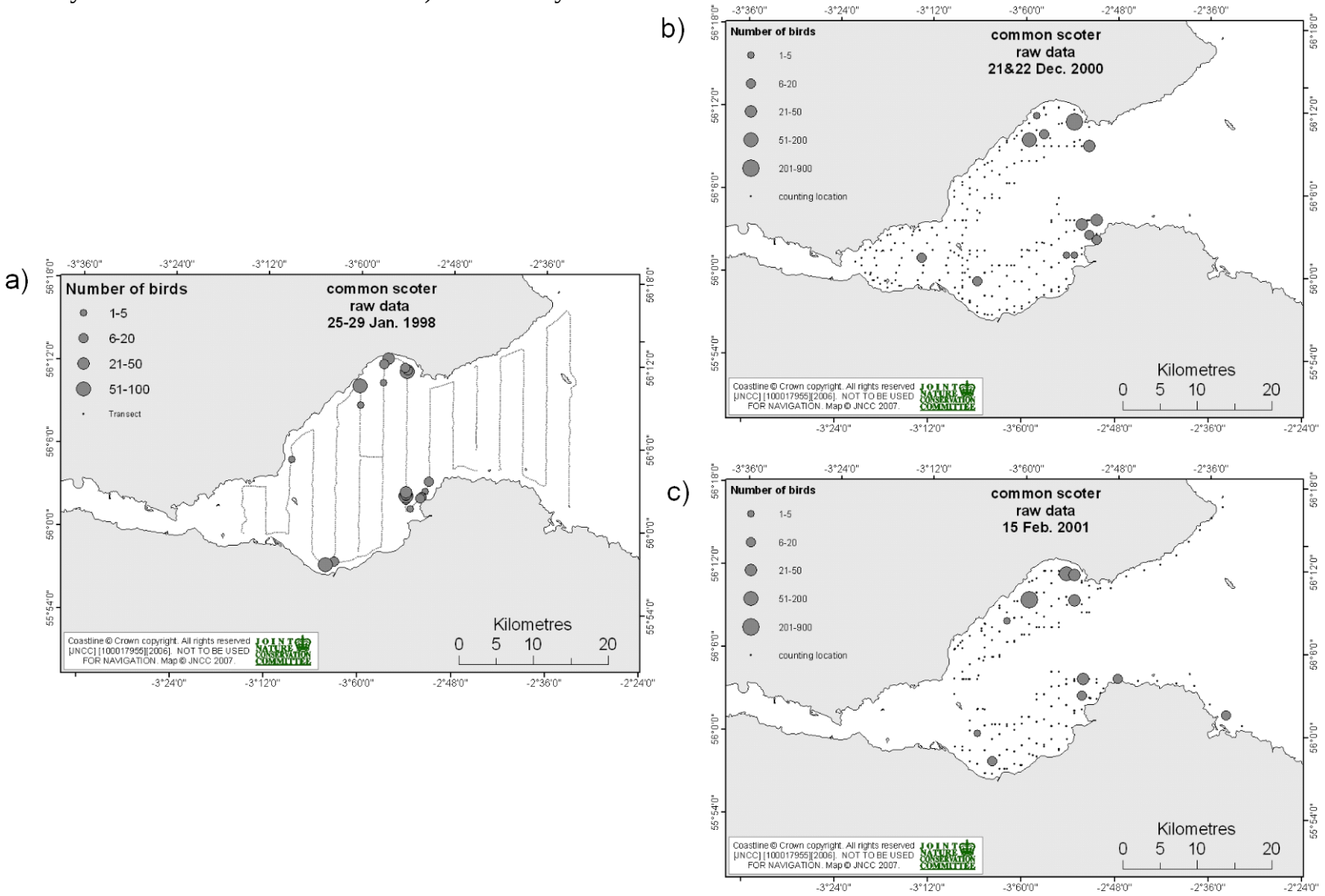


Figure A4 (cont). Distribution of common scoter in the Firth of Forth recorded during line transect aerial surveys conducted on d) 14 December 2001 e) 26 February 2002 f) 5 December 2003 and g) 16 February 2004.

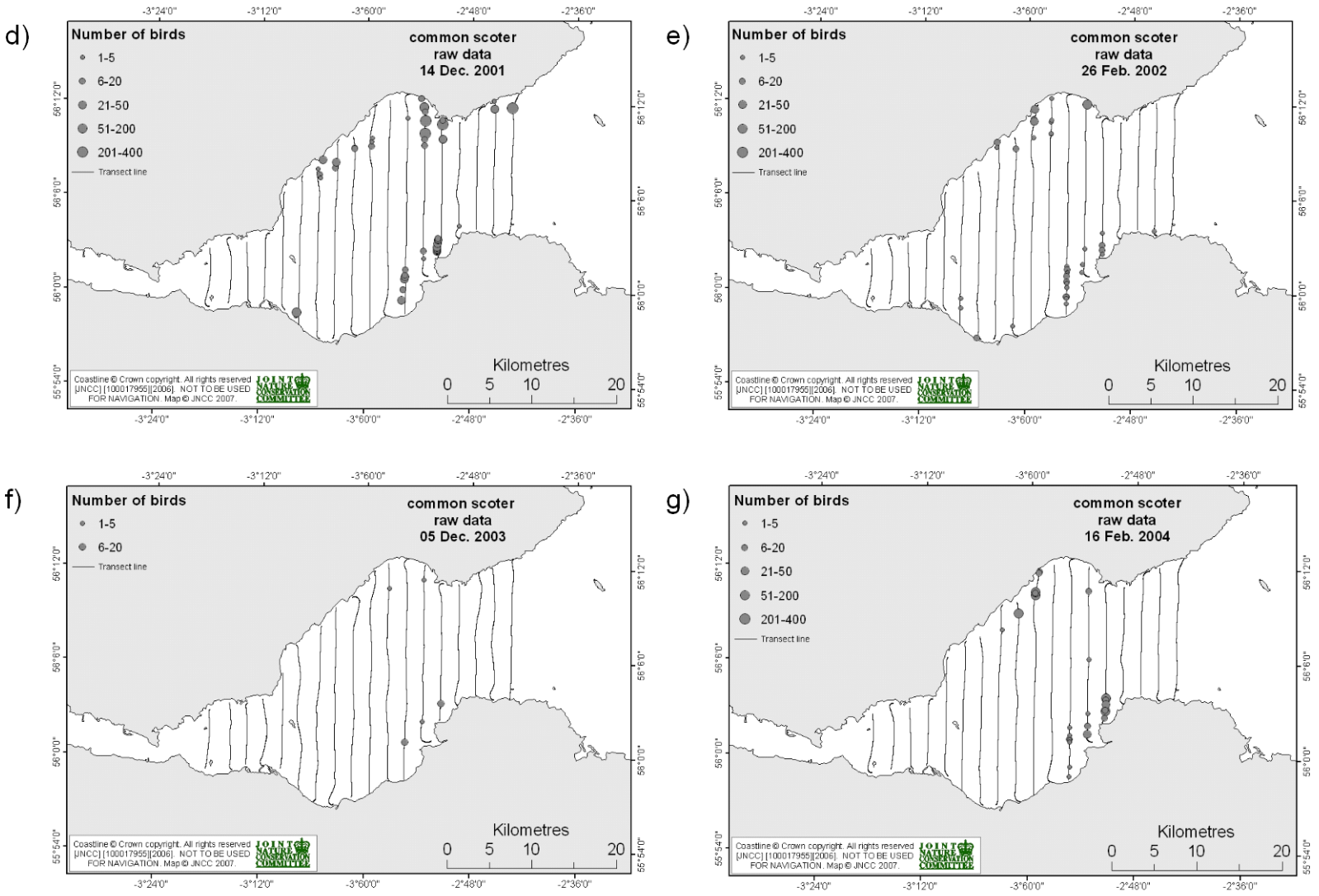
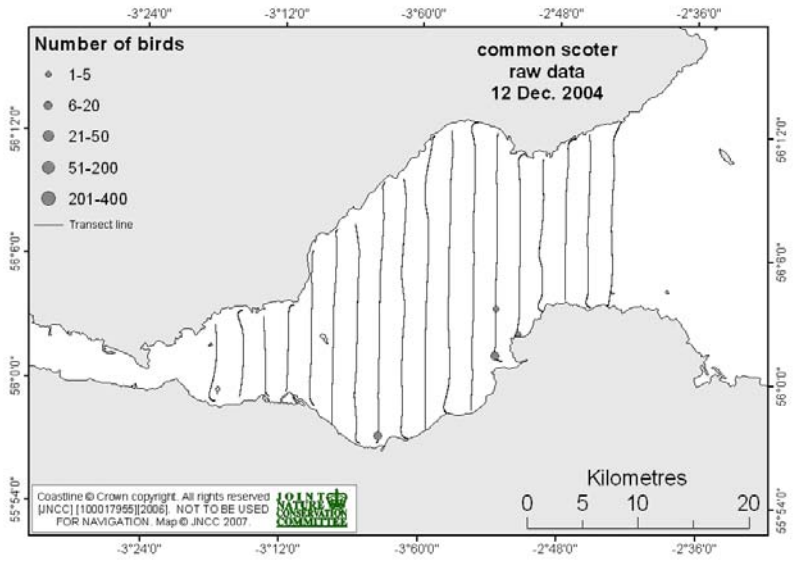


Figure A4 (cont). Distribution of common scoter in the Firth of Forth recorded during line transect aerial surveys conducted on h) 12 December 2004 and i) 3 February 2005.

h)



i)

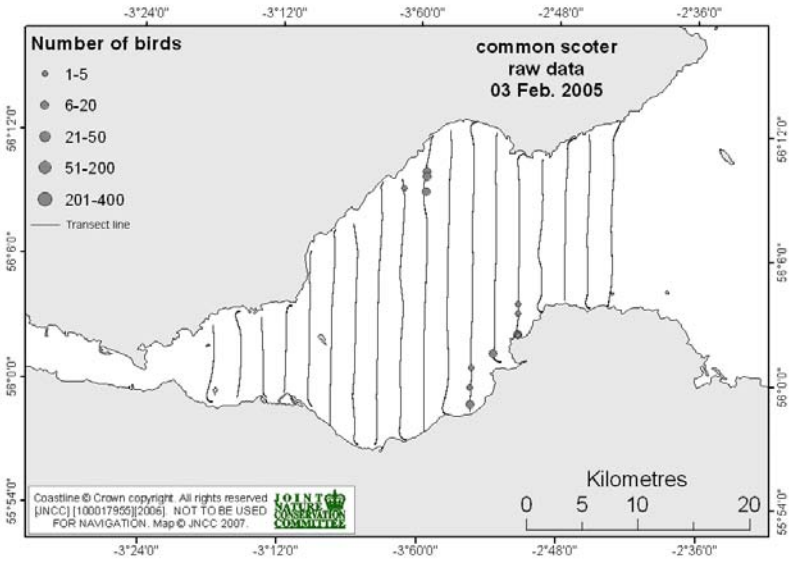


Figure A5. Distribution of velvet scoter in the Firth of Forth recorded during a) line transect boat surveys conducted in January 1998 b) strip transect aerial surveys on 21/22 December 2000 and c) 15 February 2001.

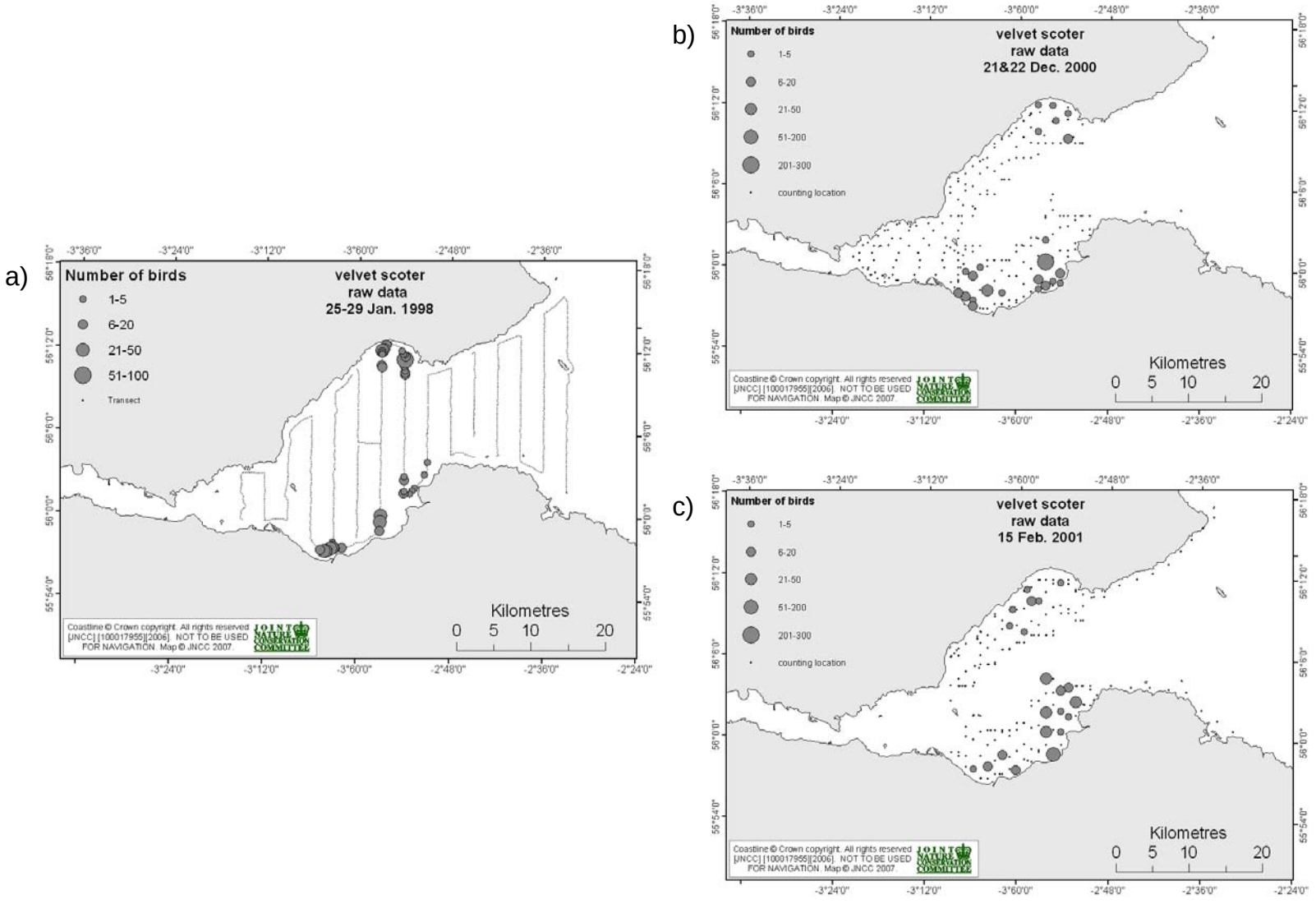
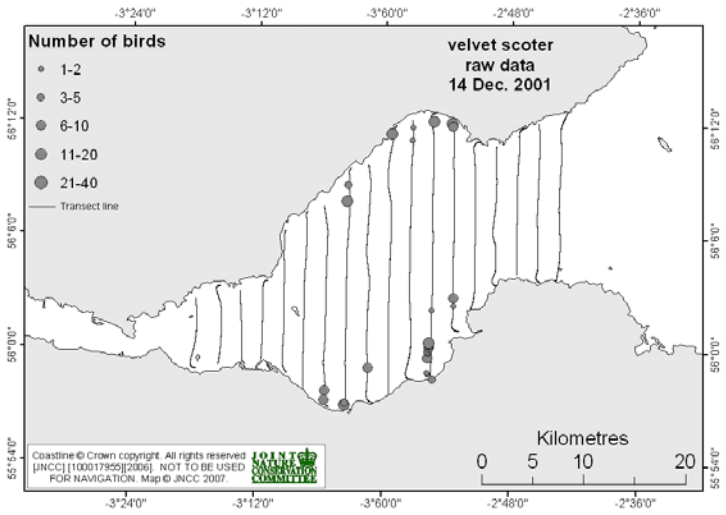
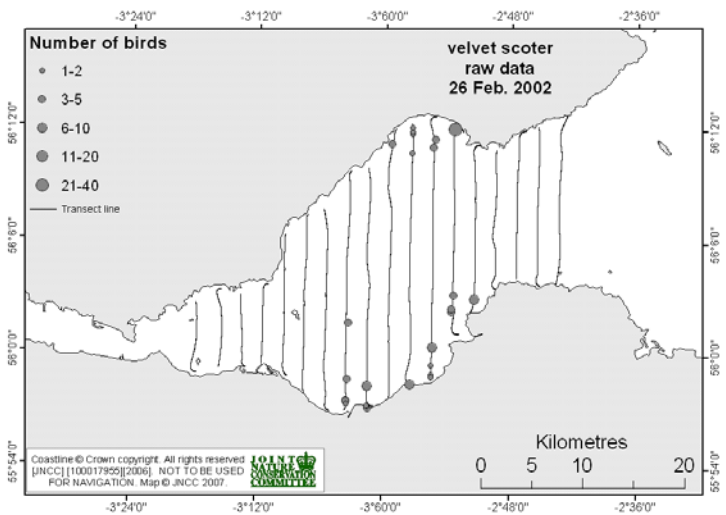


Figure A5 (cont). Distribution of velvet scoter in the Firth of Forth recorded during line transect aerial surveys conducted on d) 14 December 2001 e) 26 February 2002 f) 5 December 2003 and g) 16 February 2004.

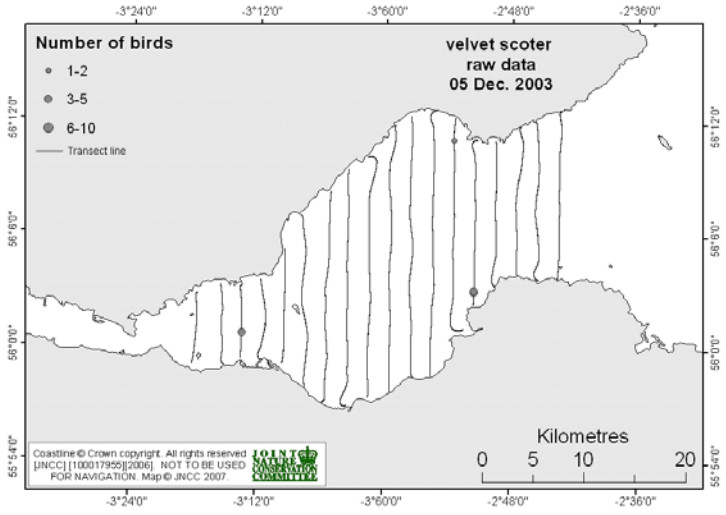
d)



e)



f)



g)

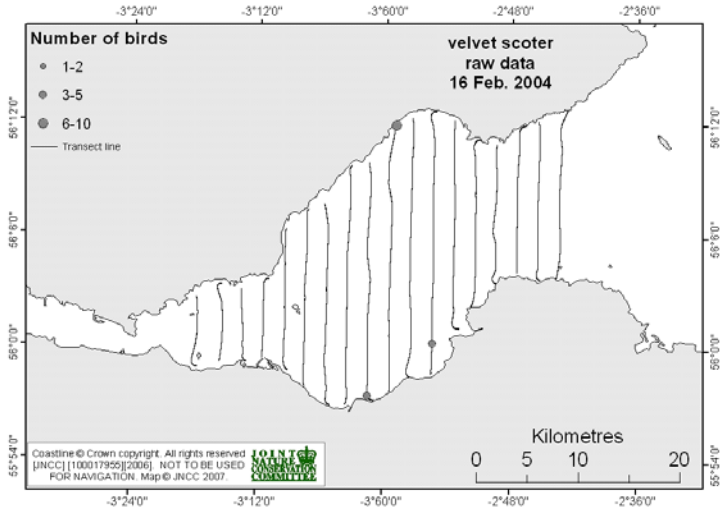
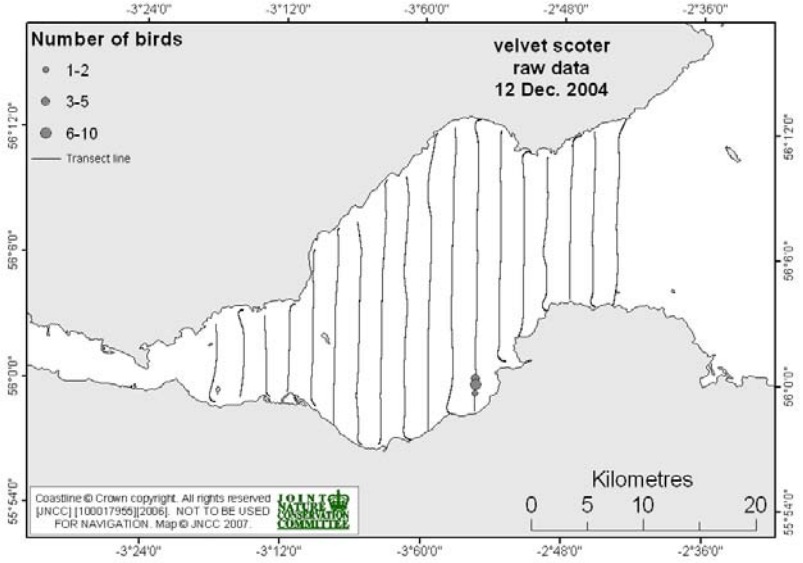


Figure A5 (cont). Distribution of velvet scoter in the Firth of Forth recorded during line transect aerial surveys conducted on h) 12 December 2004 and i) 3 February 2005.

h)



i)

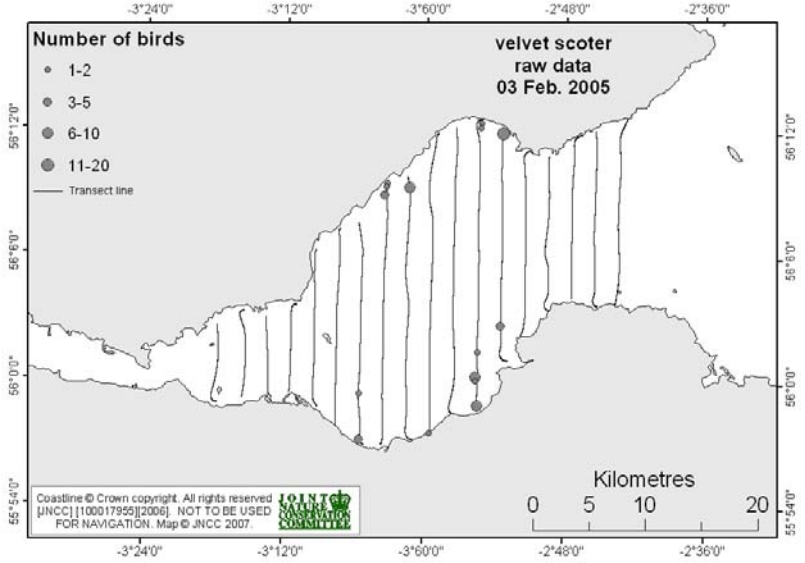
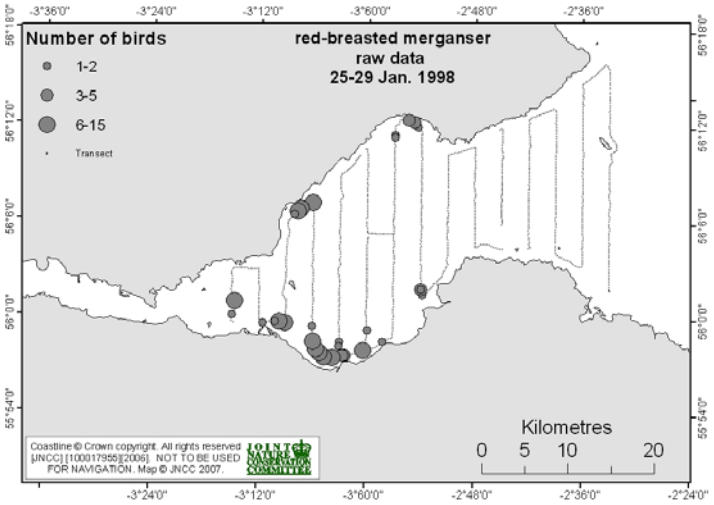
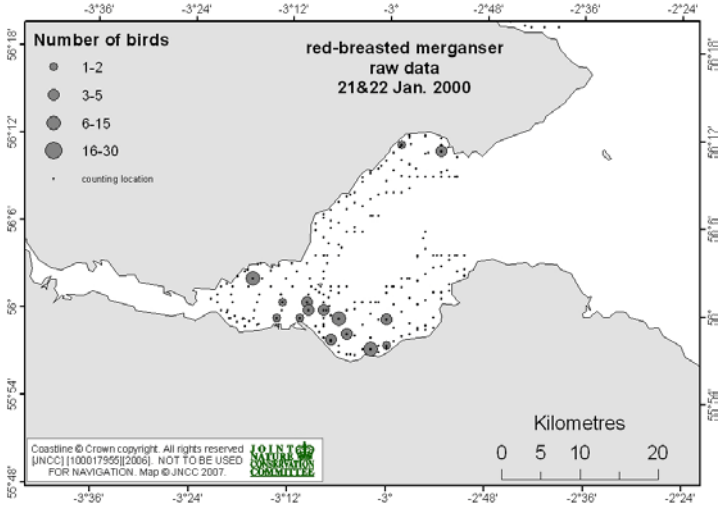


Figure A6. Distribution of red-breasted merganser in the Firth of Forth recorded during a) line transect boat surveys conducted in January 1998 b) strip transect aerial surveys on 21/22 December 2000 and c) 15 February 2001.

a)



b)



c)

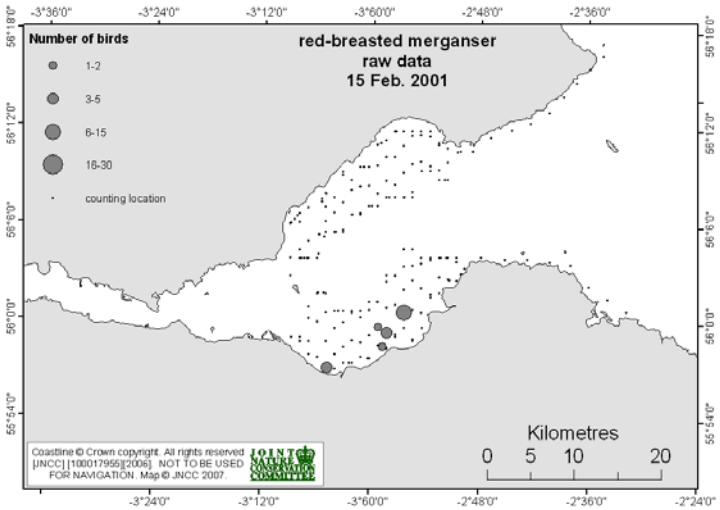


Figure A6 (cont). Distribution of red-breasted merganser in the Firth of Forth recorded during line transect aerial surveys conducted on d) 14 December 2001 e) 26 February 2002 f) 5 December 2003 and g) 16 February 2004.

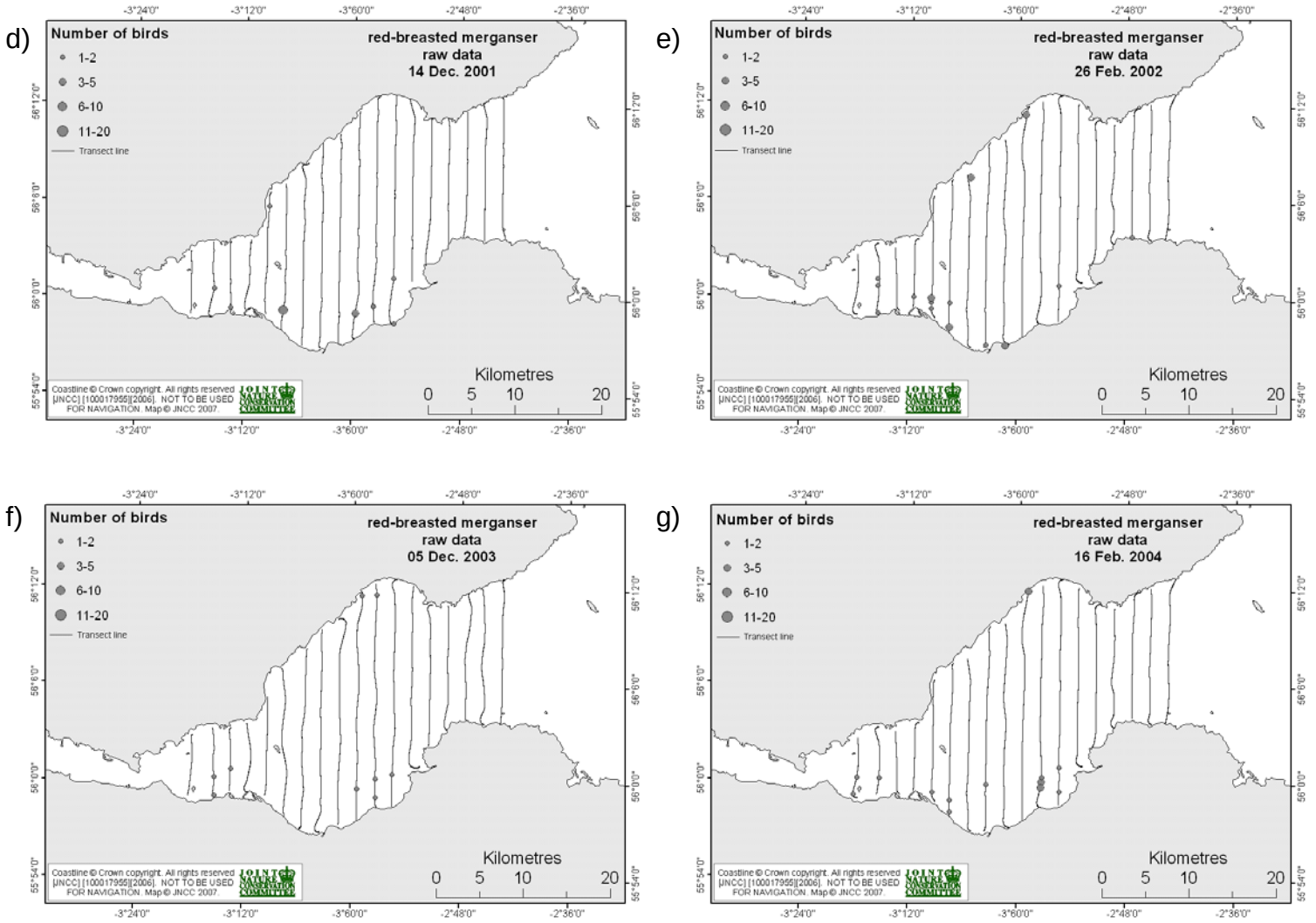
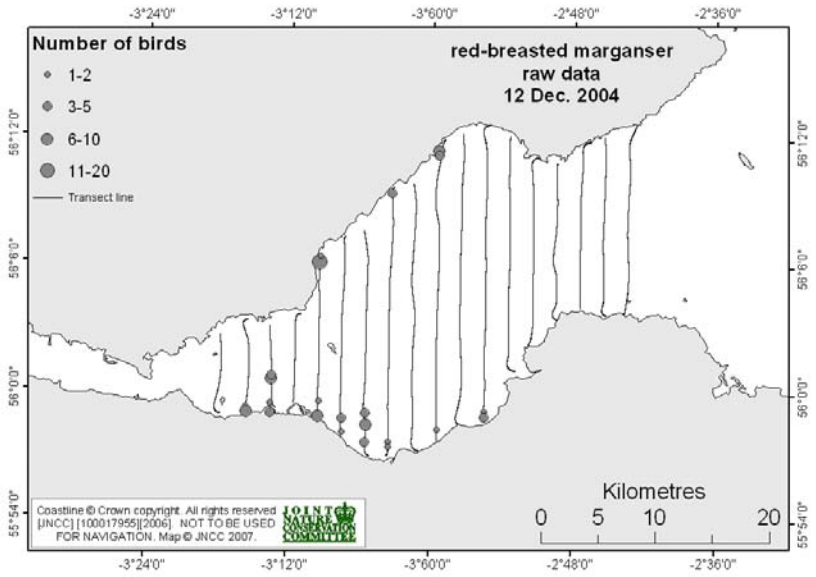
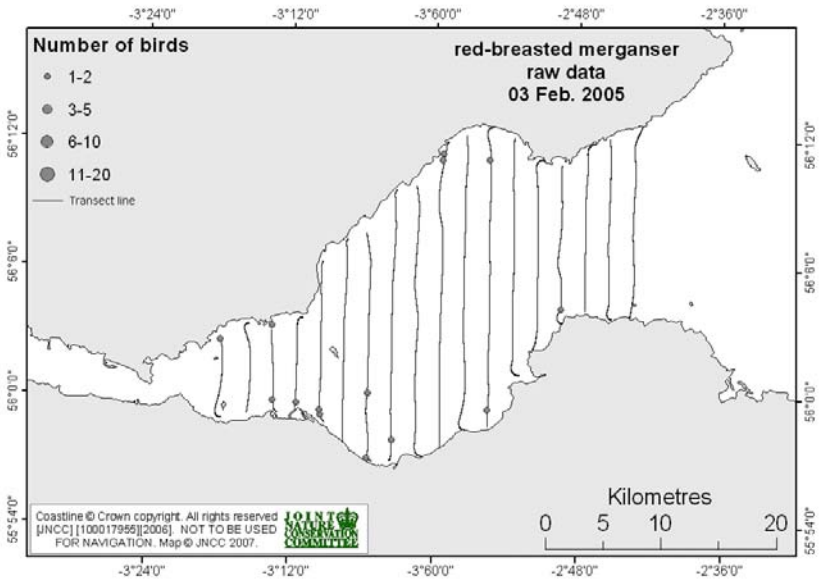


Figure A6 (cont). Distribution of red-breasted merganser in the Firth of Forth recorded during line transect aerial surveys conducted on h) 12 December 2004 and i) 3 February 2005.

h)



i)



Appendix 2: Population estimates

Red-throated diver

Table A1: Density and population estimates for red-throated diver from line transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in the Firth of Forth. Estimates were derived from distance sampling, except for those marked with an asterisk (*), which were derived from extrapolation of raw counts. The 95% confidence intervals (CI) given are empirical ([e]) or bootstrap ([b]) estimates.

Survey date	No. transects	No. observed	No. flocks	Survey area (km^2)	Density [birds/ km^2] (CI)	Total number of birds (CI)
Season 1997/1998						
25-29 Jan 1998	27	126	-	918	0.17*	158*
Season 2001/02						
14 Dec 2001	18	26	17	650	0.23 (0.11 - 0.48)[b]	150 (36 - 288)[b]
26 Feb 2002	18	16	5	650	0.22*	140*
Season 2003/04						
05 Dec 2003	18	10	8	644	0.06*	36*
16 Feb 2004	18	14	13	624	0.22 (0.12 - 0.42)[e]	144 (72 - 289)[e]
Season 2004/05						
12 Dec 2004	18	58	47	669	0.76 (0.54 - 1.08)[e]	512 (361 - 727)[e]
03 Feb 2005	18	7	7	629	0.05*	29*

Common eider

Table A2: Density and population estimates for common eider from line transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in the Firth of Forth. Estimates were derived from distance sampling, except for those marked with an asterisk (*), which were derived from extrapolation of raw counts. The 95% confidence intervals (CI) given are empirical ([e]) or bootstrap ([b]) estimates.

Survey date	No. transects	No. observed	No. flocks	Survey area (km^2)	Density [birds/ km^2] (CI)	Total number of birds (CI)
Season 1997/1998						
25-29 Jan 1998	27	3029	-	918	5.84*	387*
Season 2001/02						
14 Dec 2001	18	2270	258	650	16.93 (11.45 - 25.03)[e]	10996 (7436 - 16260)[e]
26 Feb 2002	18	1582	267	650	14.49 (10.28 - 20.43)[e]	9416 (6679 - 13274)[e]
Season 2003/04						
05 Dec 2003	18	1331	199	644	5.53 (3.53 - 8.64) [e]	3560 (2277 - 5567)[e]
16 Feb 2004	18	2419	317	624	15.66 (11.05 - 22.19)[e]	9771 (6895 - 13846)[e]
Season 2004/05						
12 Dec 2004	18	2033	252	669	13.11 (10.08 - 17.06) [b]	8767 (6740 - 11404)[b]
03 Feb 2005	18	1182	255	629	6.84 (4.75 - 9.87)[b]	4304 (2984 - 6207)[b]

Common scoter

Table A3: Density and population estimates for common scoter from line transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in the Firth of Forth. Estimates were derived from distance sampling, except for those marked with an asterisk (*), which were derived from extrapolation of raw counts. Estimates marked with ($^{+}$) were also derived from distance sampling but based on excluding outliers, which were added as raw counts at the end of the analysis. The 95% confidence intervals (CI) given are empirical (^{e}) or bootstrap (^{b}) estimates.

Survey date	No. transects	No. observed	No. flocks	Survey area (km^2)	Density [birds/ km^2] (CI)	Total number of birds (CI)
Season 1997/1998						
25-29 Jan 1998	27	650	-	918	1.34*	1226*
Season 2001/02						
14 Dec 2001	18	2557	63	650	7.88 (3.89 - 15.95)^{b}	5121 (2000 - 9004)^{b}
26 Feb 2002	18	379	42	650	3.18 (1.754 - 6.55)^{b}	2066 (817 - 3986)^{b}
Season 2003/04						
05 Dec 2003	18	24	5	644	0.13*	86*
16 Feb 2004	18	348	24	624	1.39 (0.59 - 3.29)^{e}	1240^{+} (368 - 2057)^{e}
Season 2004/05						
12 Dec 2004	18	34	4	669	0.22*	149*
03 Feb 2005	18	70	12	629	0.47*	294*

Velvet scoter

Table A4: Density and population estimates for velvet scoter from line transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in the Firth of Forth. Estimates were derived from distance sampling, except for those marked with an asterisk (*), which were derived from extrapolation of raw counts. Estimates marked with ($^{+}$) were also derived from distance sampling but based on excluding outliers, which were added as raw counts at the end of the analysis. The 95% confidence intervals (CI) given are empirical (^{e}) or bootstrap (^{b}) estimates.

Survey date	No. transects	No. observed	No. flocks	Survey area (km^2)	Density [birds/ km^2] (CI)	Total number of birds (CI)
Season 1997/1998						
25-29 Jan 1998	27	764	-	918	1.65*	1513*
Season 2001/02						
14 Dec 2001	18	196	30	650	0.82*	534*
26 Feb 2002	18	192	27	650	0.98 (0.50 - 1.93)	680^{+} (224 - 1062)
Season 2003/04						
05 Dec 2003	18	13	4	644	0.07*	46*
16 Feb 2004	18	13	3	624	0.09*	55*
Season 2004/05						
12 Dec 2004	18	13	3	669	0.17*	115*
03 Feb 2005	18	58	17	629	0.42 (0.17 - 1.02)^{b}	262 (67 - 481)^{b}

All scoter

Table A5: Density and population estimates for all scoters from line transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in the Firth of Forth. Estimates were derived from distance sampling, except for those marked with an asterisk (*), which were derived from extrapolation of raw counts. Estimates marked with ($^{+}$) were also derived from distance sampling but based on excluding outliers, which were added as raw counts at the end of the analysis. The 95% confidence intervals (CI) given are empirical (^{e}) or bootstrap (^{b}) estimates.

Survey date	No. transects	No. observed	No. flocks	Survey area (km^2)	Density [birds/ km^2] (CI)	Total number of birds (CI)
Season 1997/1998						
25-29 Jan 1998	27	1414	-	918	2.99*	2744*
Season 2001/02						
14 Dec 2001	18	3029	122	650	3.85 (2.31 - 6.42)^{e}	7498 (4497 - 12503)^{e}
26 Feb 2002	18	640	93	650	1.46 (0.95 - 2.24)^{b}	2849 (1570 - 4518)^{b}
Season 2003/04						
05 Dec 2003	18	70	14	644	0.33*	211*
16 Feb 2004	18	772	36	624	1.49^{+} (0.69 - 3.19)^{e}	1299^{+} (433 - 1994)^{e}
Season 2004/05						
12 Dec 2004	18	67	8	669	0.31*	206*
03 Feb 2005	18	144	31	629	0.92 (0.43 - 1.99)^{b}	579 (223 - 1006)^{b}

Long-tailed duck

Table A6: Density and population estimates for long-tailed duck from line transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in the Firth of Forth. Estimates were derived from distance sampling, except for those marked with an asterisk (*), which were derived from extrapolation of raw counts. Estimates marked with ($^{+}$) were also derived from distance sampling but based on excluding outliers, which were added as raw counts at the end of the analysis. The 95% confidence intervals (CI) given are empirical (^{e}) or bootstrap (^{b}) estimates.

Survey date	No. transects	No. observed	No. flocks	Survey area (km^2)	Density [birds/ km^2] (CI)	Total number of birds (CI)
Season 1997/1998						
25-29 Jan 1998	27	636	-	918	0.95*	874*
Season 2001/02						
14 Dec 2001	18	64	12	650	0.26 (0.12 - 0.67)^{b}	173 (66 - 310)^{b}
26 Feb 2002	18	48	25	650	0.70 (0.38 - 1.29)^{b}	455 (222 - 736)^{b}
Season 2003/04						
05 Dec 2003	18	32	14	644	0.30 (0.14 - 0.66)^{b}	225^{+} (67 - 395)^{b}
16 Feb 2004	18	87	25	624	1.22 (0.23 - 6.53)^{b}	813^{+} (412 - 1854)^{b}
Season 2004/05						
12 Dec 2004	18	236	50	669	2.49 (1.29 - 4.82)^{e}	1667 (776 - 3005)^{e}
03 Feb 2005	18	52	24	629	0.49 (0.27 - 0.91)^{b}	311 (166 - 534)^{b}

Red-breasted merganser

Table A7: Density and population estimates for red-breasted merganser from line transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in the Firth of Forth. Estimates were derived from distance sampling, except for those marked with an asterisk (*), which were derived from extrapolation of raw counts. The 95% confidence interval (CI) given is a bootstrap ([b]) estimate.

Survey date	No. transects	No. observed	No. flocks	Survey area (km^2)	Density [birds/ km^2] (CI)	Total number of birds (CI)
Season 1997/1998						
25-29 Jan 1998	27	289	-	918	0.47*	427*
Season 2001/02						
14 Dec 2001	18	22	9	650	0.27*	177*
26 Feb 2002	18	34	15	650	0.27*	175*
Season 2003/04						
05 Dec 2003	18	12	9	644	0.07*	43*
16 Feb 2004	18	28	13	624	0.19*	119*
Season 2004/05						
12 Dec 2004	18	105	25	669	0.69*	460*
03 Feb 2005	18	21	14	629	0.27 (0.14 - 0.58)[b]	169 (76 - 299)[b]

Little gull

Table A8: Density and population estimates for little gulls from line transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in the Firth of Forth. Estimates were derived from distance sampling, except for those marked with an asterisk (*), which were derived from extrapolation of raw counts. Estimates marked with ($^{+}$) were also derived from distance sampling but based on excluding outliers, which were added as raw counts at the end of the analysis. The 95% confidence interval (CI) given is a bootstrap (^{b}) estimate.

Survey date	No. transects	No. observed	No. flocks	Survey area (km^2)	Density [birds/ km^2] (CI)	Total number of birds (CI)
Season 1997/1998						
25-29 Jan 1998	27	2	-	918	0.02*	15*
Season 2001/02						
14 Dec. 2001	18	0	0	650	0	0
26 Feb. 2002	18	0	0	650	0	0
Season 2003/04						
05 Dec. 2003	18	40	26	644	0.44 (0.17 - 1.11)^{b}	317^{+} (79 - 563)^{b}
16 Feb. 2004	18	0	0	624	0	0
Season 2004/05						
12 Dec. 2004	18	0	0	669	0	0
03 Feb. 2005	18	0	0	629	0	0