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

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Summary

Tay Bay is known to support large numbers of inshore waterbirds over the winter period. The intertidal areas of the Firth of Tay and Eden Estuary are included within an existing terrestrial Special Protection Area (SPA), while the inshore areas of the Firth of Tay and Eden Estuary comprise a marine Special Area of Conservation (SAC). The area is also designated as a Ramsar site under the International Convention on Wetlands of International Importance, especially as habitat for waterfowl. However, the current SPA and Ramsar site do not extend beyond the low water mark. This report describes analyses of data from boat and aerial surveys of inshore waterbirds conducted in the Tay Bay area. The numbers of red-throated diver (*Gavia stellata*), common eider (*Somateria mollissima*), common scoter *(Melanitta nigra), velvet scoter (Melanitta fusca), long-tailed duck (Clangula hyemalis), red-breasted merganser (Mergus serrator*), and little gulls (*Larus minutus*) using the waters of Tay Bay were analysed and assessed against the appropriate Stage 1 guideline thresholds, to determine whether the area or part of it might meet the site selection requirements under Stage 1 of the UK Site Selection Guidelines, as an SPA under the EU Birds Directive (79/409/EEC). 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 Tay Bay carried out over five winter seasons (1997/98, 2000/01, 2001/02, 2003/04 and 2004/05) are described in this report. One boat survey carried out during 1997/98 was conducted using line transect sampling techniques; for this survey, the data were analysed using extrapolation of raw counts to estimate the total numbers of birds using the survey area. Two aerial surveys carried out during 2000/01 were conducted using strip-transect methods, and the data from these are total counts of birds using the area surveyed. Seven aerial surveys during the latter three seasons were conducted using line-transect sampling techniques; for these, the data were analysed where possible, using distance sampling, to estimate the total numbers of birds using the area surveyed.

More than 1% of the red-throated diver population that winters around Great Britain (O'Brien *et. al*, in press) was present within the inshore waters of Tay Bay in three of the five seasons surveyed. The mean of peak estimates across seasons was 437 birds. The Tay Bay therefore meets the site selection threshold for SPA status for red-throated divers under stage 1.1 of the UK SPA guidelines (Stroud *et. al* 2001). Red-throated divers were distributed throughout Tay Bay, with the main concentrations being fairly mobile throughout, both within and across years.

Numbers of common eider (20,333) exceeded 12,850 (site selection threshold for common eider) in only one out of five seasons in Tay Bay. Neither did the maximum seasonal population estimates across seasons (8,433 individuals) exceed the threshold. Tay Bay therefore does not meet the Stage 1.2 site selection threshold for SPA status for common eider under the UK SPA guidelines. Similarly threshold numbers of common scoter, velvet scoter, long-tailed duck and red-breasted mergansers were not exceeded in any season in Tay Bay. Neither did the mean of peak estimates of 2,166 for common scoter, 877 for velvet scoter, 679 for long-tailed duck and 106 for red-

breasted merganser exceed the relevant thresholds. On this basis Tay Bay does not meet the Stage 1.2 site selection thresholds as an SPA for common and velvet scoter, long-tailed duck and red-breasted merganser under the guidelines.

Numbers of little gull (216) exceeded appropriate threshold numbers in only one out of five seasons in Tay Bay. Although the maximum seasonal population estimates across seasons (92 individuals) exceeded the default threshold level of 50 birds, Tay Bay does not meet the Stage 1.1 site selection threshold for SPA status for little gull under the UK SPA guidelines.

Based on the available data, more than 11,703 individual waterbirds regularly use the inshore waters of Tay Bay; the area does therefore not meet the site selection threshold for SPA status as a waterbird assemblage under Stage 1.3 of the UK SPA guidelines.

1. Introduction

1.1 Background

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 Member States to identify and classify in particular the most suitable territories in number and size as special protection areas (termed Special Protection Areas or SPAs by Member States) 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) which are protected through a range of conservation and management measures.

Although this Directive states that conservation measures should be taken both in ‘the geographical sea and land area’, most SPAs in the United Kingdom (UK) 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 Joint Nature Conservation Committee (JNCC) in collaboration with the four statutory country agencies: Council for Nature Conservation and the Countryside, the Countryside Council for Wales, Natural England and Scottish Natural Heritage.

Three potential ways of addressing marine SPA in the UK (Johnston *et al.*, 2002) are currently being considered:

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

The inshore areas of the Firth of Tay and Eden Estuary include an existing terrestrial SPA and a marine SAC which were designated in 2000 (Stroud *et al.*, 2001) and 2005 (SNH 2006) respectively. The SPA was designated using land-based counts, a method that provides coverage for species concentrated close to the shore but often significantly underestimates species occurring further offshore, such as divers and seaducks (Webb & Reid 2004). The SPA offers protection for various waterbirds, but divers and seaducks also use the open waters of the Tay Bay area, outside of the existing boundaries.

The aim of this report is to determine whether the inshore area of Tay Bay, or a part thereof, hosts numbers of inshore waterbirds outwith the breeding season which meet site selection thresholds, and therefore could be considered for selection as an SPA under the EU Birds Directive.

If Tay Bay meets appropriate Stage 1 thresholds under the UK Site Selection Guidelines as an SPA and is to be taken forward to classification, then a second report will follow describing analyses aimed at defining a site boundary.

1.2 Tay Bay

Tay Bay, as defined herein, encompasses the marine area stretching from Red Head in the north, to Fife Ness in the south, including St Andrews Bay (Figure 1). It is a shallow (0-30m deep) inshore area, located on the east coast of Scotland, UK. Two large rivers provide freshwater input: the River Tay (Scotland's largest river) leading into the Firth of Tay, and the River Eden leading into St Andrews Bay. The sediments of Tay Bay and St Andrews Bay are predominantly sandy and muddy, with bedrock outcrops between Red Head and Buddon Ness and around Fife Ness (Connor *et al.*, 2006). The Wee Bankie, a sand bank much favoured by seabirds as a feeding ground (Wanless *et al.*,1998, Wanless *et al.*, 2004), is located around 40km offshore to the north-east of Fife Ness outside the study area.

The tidal mudflats of the estuaries have high-abundance, low-diversity populations of intertidal fauna and flora. Blue mussels (*Mytilus edulis*) are dense and plentiful along the southern shore of the Firth of Tay and south to the Eden Estuary rendering these areas highly attractive to wintering wildfowl (Information sheet on Ramsar Wetlands (RIS): UK13018). Potential human activities including discharge of commercial effluent/sewage, aggregate extraction such as subtidal sand and gravel, windfarm development and commercial fishing could have serious effects on wintering wildfowl in the outer Tay Bay (SNH 2006).

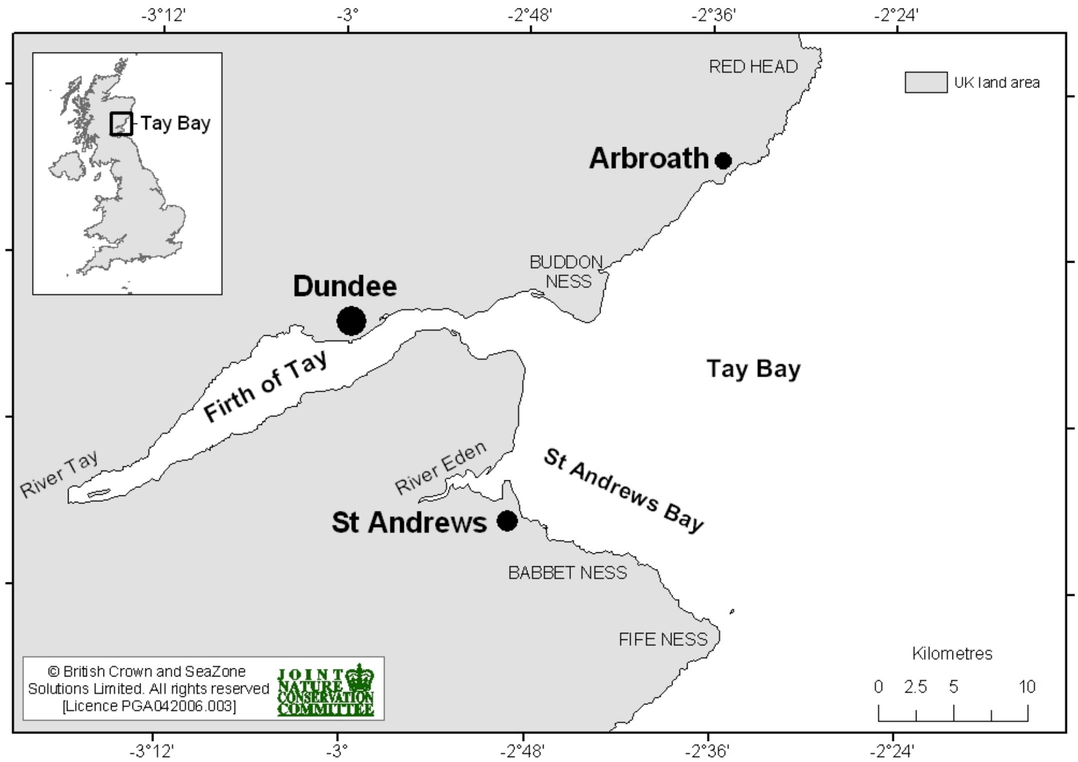

Figure 1. The Tay Bay area, showing towns, rivers, and landmarks.

The inshore areas of the Firth of Tay and Eden Estuary include an existing terrestrial SPA and a marine SAC. The area is also designated as Ramsar site under the International Convention on Wetlands of International Importance especially as Waterfowl Habitat (the Ramsar Convention).

The existing terrestrial SPA in the Tay Bay provides protection for the bird species that occur here: the Firth of Tay and Eden Estuary SPA (56°24’30N, 03°05’00W; SPA EU Code UK9004121). This estuarine site covering 6,923.29ha (Figure 2), qualifies under Article 4.1 of the Birds Directive, by supporting qualifying numbers of Annex I species, including breeding little tern (*Sterna albifrons*), Eurasian marsh harrier (*Circus aeruginosus*) and wintering bar-tailed godwit (*Limosa lapponica*) (Stroud *et al.*, 2001).

In addition, the site qualifies under Article 4.2 of the Birds Directive by (1) supporting internationally important concentrations of regularly occurring migratory species, including, greylag goose (*Anser anser*), pink-footed goose (*Anser brachyrhynchus*) and common redshank (*Tringa totanus*); and (2) regularly supporting an assemblage of more than 20,000 waterfowl. This assemblage of 34,074 waterfowl individuals (five year peak mean 1991/2 – 1995/6 – UK9004121) includes the following species:

- great cormorant *Phalacrocorax carbo*
- pink-footed goose *Anser brachyrhynchus*
- greylag goose *Anser anser*
- common shelduck *Tadorna tadorna*
- common eider *Somateria mollissima*
- long-tailed duck *Clangula hyemalis*
- common scoter *Melanitta nigra*
- velvet scoter *Melanitta fusca*
- common goldeneye *Bucephala clangula*
- goosander *Mergus merganser*
- red-breasted merganser *Mergus serrator*
- Eurasian oystercatcher *Haematopus ostralegus*
- grey plover *Pluvialis squatarola*
- sanderling *Calidris alba*
- dunlin *Calidris alpina alpina*
- black-tailed godwit *Limosa limosa islandica*
- bar-tailed godwit *Limosa lapponica*
- common redshank *Tringa totanus*

The existing marine Firth of Tay and Eden Estuary SAC is made up of the Tay Estuary and the Eden Estuary (56°22’00N, 02°57’00W; Site Code UK003011). This estuarine site covering 15,412.53ha (Figure 2), qualifies under Article 3 of the Habitat Directive (92/43/EEC), by supporting qualifying areas of Annex I habitats, including estuaries, mudflats and sandflats not covered by seawater at low tide, sandbanks that are slightly covered by sea water all the time and common seals *Phoca vitulina*.

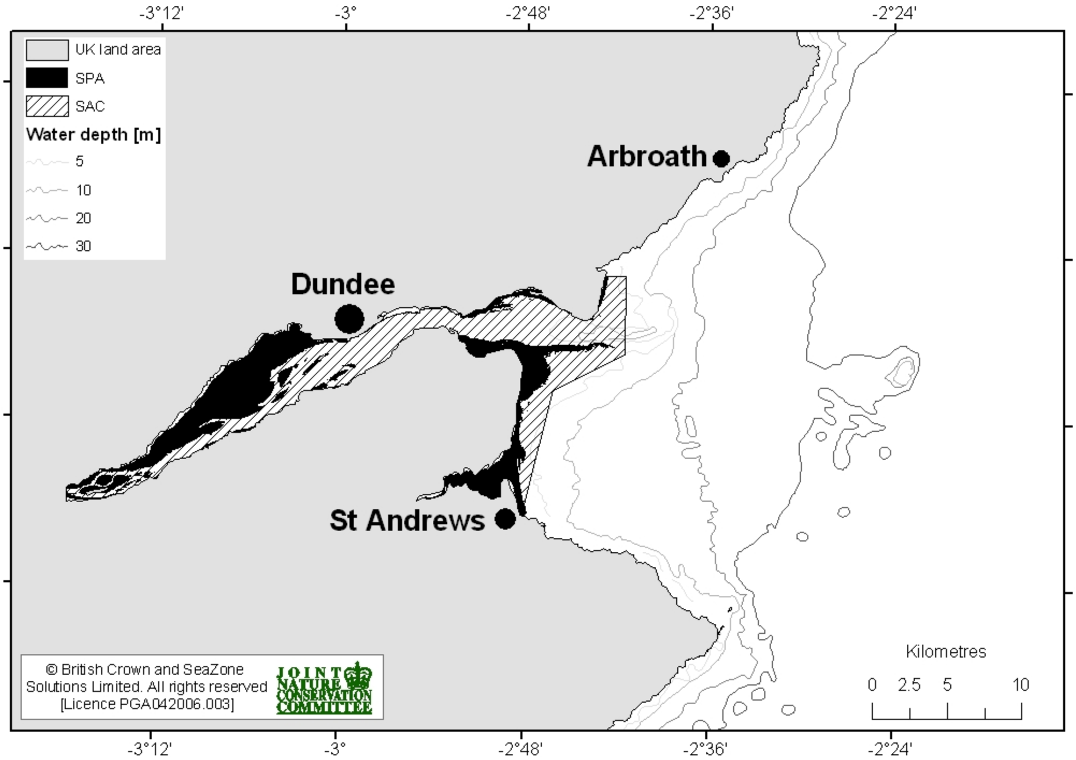

Figure 2. Location of the Firth of Tay and Eden Estuary SPA and SAC boundaries.

2. Methods

2.1 Data collection

The data used in these analyses originated from one line transect boat-based survey (1998), two strip-transect aerial surveys (2000-2001) and seven line transect aerial surveys (2000-2005) of Tay Bay all 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 *M.V. Chalice*, on 24 and 25 January 1998. The survey was conducted using standard Seabirds at Sea Team (SAST) methods as described in 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 adequately surveyed using the naked eye. A pair of observers counted all birds ahead of the ship, but most efficiently in a strip transect on one side of the ship, 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 the 300m transect but well ahead of the approaching boat, the perpendicular distance from the observer could not be accurately determined. These birds were recorded simply as 'in transect'. Flying birds were recorded within a 300m transect using the snapshot method described in 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. Overlapping and randomly directed transects were omitted from the analysis. This left a total of 13 transects which orientated east-west at approximately 3km intervals and between 3.5 and 15km in length, with 11 roughly north-south transects in between (Appendix 1, Figure 1.1a).

2.1.2 Strip-transect aerial surveys (2000/01)

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. Therefore the positioning of transects was designed by using Admiralty charts, and transects extended far enough offshore to cover the target species distribution range in waters of 0-30m depth.

Surveys by JNCC between December 2000 and February 2001 were carried out from a small 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 then flown perpendicular to the coastline. These transects were spaced 1km apart and were approximately 500m wide on either 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, whilst 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 Barton *et al.,* 1993 for a full 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 in one minute intervals.

2.1.3 Line transect aerial surveys (2001/02)

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). East-west transects were spaced 1' latitude apart (approximately 1.85km), running perpendicular to the coast and depth contours, and therefore along the anticipated gradient of bird density. The positions of transects were selected at random from between 10 and 40 options using a pocket calculator's random number function.

Two observers counted from either side of the aircraft and recorded all observation data onto a dictaphone. Observers determined distances using fixed angles of declination from the visual horizon, which was 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's trackline. This procedure enables the application of distance sampling analyses that models 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 sampling also allows estimation of 95% 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.

For each bird, or flock of birds, the time at which it occurred (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 positively identify a bird 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 at one second intervals.

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

The JNCC conducted five aerial surveys using a small aircraft flown in a systematic pattern of line-transects. Methods used were 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 five seconds. Full descriptions of the methods can be found in Dean *et al.*, (2004).

2.2 Estimating population size

For the purposes of this report, only data on inshore waterbirds such as divers, seaducks and little gulls are presented.

Three methods were used to assess population size: (1) raw counts; (2) extrapolation of mean density derived from distance sampling; and (3) extrapolation of mean density derived from raw counts, where data collected were either too few to apply distance sampling methods or distance sampling methods indicated an unsatisfactory detection function based on either poor distance estimation, or a displacement of birds ahead of the ship. In carrying out distance sampling, data were analysed using the software *Distance* 5.0. (Thomas *et al.*, 2004). For each species and survey a model was chosen that provided the best fit to the data on the basis of minimising the Akaike Information Criterion (AIC). Mostly half-normal models or hazard rate models, both with zero adjustments and with the size-bias regression method of cluster size estimation were generated. Where possible an analytical technique called 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. Detection functions generated by distance sampling analysis 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 aerial 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 the area surveyed to give a mean density. This density was extrapolated across the total surveyed area to allow an estimate of total population size.

2.2.1 Boat survey data

Even though there were sufficient numbers of birds observed during line transect boat survey on 24/25 January 1998, it was not possible to fit an appropriate detection function for each individual species using sampling analysis. The reason for this is likely to be displacement of birds ahead of the boat and possibly inaccurate assignment of birds to distance bands during surveys. For this reason, it was necessary to use a simpler method of extrapolation, in which all birds on the sea on one side of the ship were assumed to occur in a 1km wide strip-transect, and all flying birds were recorded within a 300m wide strip-transect. This method probably underestimated numbers of birds, 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 over-estimate.

Density of birds was multiplied by the area of 1.5’ latitude x 3’ longitude rectangles, and these were summed to give the total estimate within the surveyed rectangles.

Where there is a clear linear pattern to bird distribution, it is advisable to align transects perpendicular to the line of the bird distribution. The estimate of common eider in the Tay Bay was problematic, because the transect and the birds were all aligned parallel along the edge of the estuary, giving a far from satisfactory sampling strategy. A very high number of common eiders occurred on the transect side of the ship, and these represented most of the population within the Tay estuary (Appendix 1, Figure 1.2a). For this reason, a hybrid estimate for common eiders was calculated for Tay Bay, in which a total count was used for within the estuary using the first method, and numbers outwith the estuary are estimated by extrapolation from observed density. The result is a more realistic estimate for the numbers of common eiders in Tay Bay.

2.2.2 Common eider and common scoter

Some survey data for 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 (4 Dec. 2003, 29 Feb 2004 and 12 Dec. 2004). Also some survey data were not suitable for distance sampling analyses because observations in band A were lower than those in other bands. A likely reason for the latter is that scoter can occur in large flocks, which are easily detected, even at greater distances. 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 as outliers. A detection function was generated, and this was used to calculate an abundance estimate for the survey with 95% confidence intervals. The number(s) of the very large flock(s) were then added as raw counts to supply total abundance estimates, but 95% confidence intervals could not be adjusted. This approach assumed that the largest flocks would be equally detectable over all distance bands.

2.2.3 Waterbird assemblage

For this analysis common scoter, velvet scoter and unidentified scoters were combined to give estimates for ‘all scoter’. First the total population estimates for each survey were calculated (Table 2), second the peak total for each season (maximum estimate) was determined and then divided by the number of survey seasons (in this case five) to give the mean peak estimate. This mean peak estimate calculation takes account of the regularity of exceeding 20,000 birds.

3. Results

3.1 Number of birds counted

Ten surveys were conducted during 13 days in Tay Bay. These surveys comprised data from one line transect boat survey in 1989, two strip-transect aerial surveys in 2000 and 2001 and seven line transect aerial surveys carried out between December 2001 and March 2005. The line transect aerial survey carried out on 12 December 2004 was not completed due to fading light conditions. Data were collected for 12 and analysed for a total of seven species because they were recorded in sufficient numbers: red-throated diver, common eider, common scoter, velvet scoter, long-tailed duck, red-breasted merganser and little gull (Table 1). Additionally, some divers, scoters and seaducks could not be identified to species level and therefore were recorded as unidentified diver, unidentified scoter, or unidentified seaduck species. Data for other species that were recorded during the *MV Chalice* boat survey (e.g. geese, other gull species, etc.) are not presented here.

Three different survey methods were used and caution should be applied when comparing raw counts of these surveys. Also the survey area and number of transects surveyed was different for each survey. Furthermore, during strip-transect aerial surveys and the boat survey (which was treated as a strip-transect in the analysis) distance information was not collected 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 have been met and these surveys may therefore underestimate bird density considerably.

Table 1. Total number (raw counts) of birds and flocks (represented in brackets) counted in Tay Bay during survey periods from January 1998 to March 2005. Numbers represent the total sample counts of all birds recorded on the line transect boat survey (1997/98), strip-transect aerial surveys (2000/01) and line transect aerial surveys (2001/02, 2003/04, 2004/05).

Date of survey		Red-throated diver	Great northern diver	Unidentified diver	Unidentified grebe	Common eider	Common scoter	Velvet scoter	Unidentified scoter	Long-tailed duck	Red-breasted merganser	Unidentified seaduck	Little gull
		Season 1997/98											
24/25 Jan. 1998	Strip-transect boat survey	216		8		5294	1116	206		111	3		217
		Season 2000/01											
21 Dec. 2000	Strip-transect aerial survey	1 (1)				3861 (18)	1416 (13)		36 (2)	53 (4)			
15/16 Feb. 2001		98 (22)				1518 (54)	1687 (25)	4 (2)	16 (4)	546 (36)	5 (1)		
		Season 2001/02											
13 & 15 Dec. 2001	Line transect aerial survey	10 (10)		2 (1)		260 (50)	547 (24)	3 (1)		69 (16)	27 (3)		
26 Feb. 2002		9 (7)		3 (3)	1 (1)	1018 (108)	865 (43)	6 (3)	295 (14)	116 (36)	4 (1)		
		Season 2003/04											
04 Dec. 2003		57 (29)		13 (7)		5974 (67)	717 (18)	69 (3)	105 (5)	159 (17)	12 (1)	16 (2)	4 (4)
29 Feb. 2004		137 (88)			1 (1)	3017 (148)	487 (29)			159 (36)	38 (12)	50 (1)	13 (12)
		Season 2004/05											
12 Dec. 2004		20 (14)				4378 (58)	1085 (11)		500 (1)	21 (11)	6 (2)		4 (3)
02 Feb. 2005		33 (22)				3432 (97)	305 (34)			32 (17)	6 (3)		
18 Mar. 2005		20 (18)	1 (1)			992 (176)	448 (64)	3 (1)		27 (11)			

3.2 Bird distributions

Distributions of diver species, common eider, scoter species, long-tailed duck, red-breasted merganser and little gull are presented in Appendix 1, Figures 1.1-1.6. Numbers of other species were not significant in the SPA context, and were too low to draw any meaningful conclusions on their distribution.

3.2.1 Divers (Appendix 1, Figure 1.1, a – j)

Red-throated divers were recorded during all surveys of Tay Bay. Red-throated divers were observed over the whole survey area, with no clearly consistent hotspots in recorded occurrence across different surveys.

3.2.2 Common eider (Appendix 1, Figure 1.2, a – j)

Common eiders were recorded during all surveys and they were observed mainly in the inshore areas of the survey area. Large numbers of Common eider were regularly recorded in the entrance to the Firth of Tay; during many surveys, the majority of the eider population within the Tay Bay was recorded here. Smaller numbers of eider were regularly recorded between Babbet Ness and north of Fife Ness, St Andrews Bay.

3.2.3 Scoter species (Appendix 1, Figure 1.3, a – m)

Common scoter were present in all surveys, mostly occurring in water less than 20m deep. During many surveys common scoters were regularly occurring near the entrance of the Firth of Tay.

Velvet scoter were observed on six out of ten surveys in low numbers and occurred also mainly in water shallower than 20m, with no clearly consistent hotspots in recorded occurrence across different surveys.

3.2.4 Long-tailed duck (Appendix 1, Figure 1.4, a – j)

Long-tailed ducks were present in all surveys. Although birds were recorded throughout the survey area, most were recorded regularly just outside the entrance of the Firth of Tay.

3.2.5 Red-breasted merganser (Appendix 1, Figure 1.5, a – h)

Red-breasted mergansers were present during eight out of 10 surveys. The numbers of red-breasted merganser observed were low, but most birds occurred close inshore and near to the entrance of the Firth of Tay.

3.2.6 Little gull (Appendix 2, Figure 1.6, a – d)

Little gulls were present in low numbers during four out of 10 surveys and occurred throughout the survey area, with no clearly consistent hotspots in recorded occurrence across different surveys.

3.3 Population estimates

Population estimates reported here (Table 2) were derived from raw counts, extrapolation from raw counts, or distance sampling analysis (see Methods). Line-transect distance sampling is 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, Table 2.1-2.8, for red-throated diver, common eider, common scoter, velvet scoter, all scoter, long-tailed duck, red-breasted merganser and little gull.

Table 2. Summary of population estimates in Tay Bay during each survey period from 1998 to 2005, for selected species. Counts in December 2000 and February 2002 are raw counts and those denoted with (*) have been extrapolated from raw counts. Otherwise, totals are based on distance sampling estimates with 95% confidence limits presented in brackets. The number in shaded cells exceeded the 1% threshold for stage 1 SPA qualification and figures in bold show the peak population estimates of assemblies per season.

Date of survey	Red-throated diver	Common eider	Common scoter	Velvet scoter	All scoters	Long-tailed duck	Red-breasted merganser	Little gull	Assemblage of all species
SPA qualification threshold	170	12,850	16,000	10,000	n/a	20,000	1,700	50	20,000
Season 1997/98									
24/25 Jan. 1998	387*	5300*	1474*	280*	1754*	111*	3*	216*	7771
Season 2000/01									
21 Dec. 2000	1	3861	1416	n/a	1452	53	n/a	n/a	5367
15/16 Feb. 2001	98	1518	1687	4	1707	546	5	n/a	3858
Season 2001/02									
13 & 15 Dec. 2001	54 (20-101)	1804 (956-3406)	3049 (732-7123)	23	2984 (758-6515)	1254 (466-3376)	206	n/a	6302
26 Feb. 2002	55 (24-123)	4486 (2451-8211)	3634 [3334 (1583-7025) plus 300]	15	5336 (2606-10923)	722 (216-1362)	32	n/a	10631
Season 2003/04									
04 Dec. 2003	517 (256-1045)	20333 [18133 (5191-63347) plus 2200]	1028 (235-1186)	566	999 (478-2086)	705 (253-1964)	98	16	22668
29 Feb. 2004	1589 (1127-2240)	16180 (8634-30319)	2165 [1945 (768-4923) plus 220]	n/a	2165 [1945 (768-4923) plus 220]	1436 (605-3407)	287 (0-817)	44	21701
Season 2004/05									
12 Dec. 2004	115 (57-231)	10398 [8698 (3271-23127) plus 1700]	360 (63-2068)	n/a	1270 (233-5330)	235 (101-546)	46	15	12079
02 Feb. 2005	258 (114-421)	3665 (1788-7511)	1134 (479-2685)	n/a	1134 (479-2685)	293 (128-673)	25	n/a	5375
18 Mar. 2005	126 (58-275)	2270 (1343-3836)	1647 (764-2654)	4	1654 (819-2681)	272 (111-671)	n/a	n/a	4322

3.3.1 Red-throated diver

Results for each line transect survey are presented in Appendix 2, Table 2.1. Table 3 shows the mean maximum seasonal population estimates for red-throated divers in the Tay Bay from 1997/98 to 2004/05.

Red-throated diver was the dominant diver species present throughout the survey period. Of all divers observed during line transect surveys (394), one bird was identified as a great northern diver; the remainder were recorded either as red-throated diver or unidentified diver species. Consequently, unidentified diver observations were assumed to be red-throated divers; the small amount of error (0.3%) was deemed acceptable and analyses for red-throated divers were performed on combined red-throated and unidentified diver data.

Season	Analysis used to derive estimate	Maximum estimate	Date
SPA qualification threshold		**170**	
1997/98	extrapolation	387	24/25 Jan. 1998
2000/01	raw count	98	15/16 Feb. 2001
2001/02	Distance Sampling	55	26 Feb. 2002
2003/04	Distance Sampling	1589	29 Feb. 2004
2004/05	Distance Sampling	258	02 Feb. 2005
Mean of maximum estimate		**477**	

Table 3. Maximum seasonal population estimates for red-throated divers in the Tay Bay from 1997/98 to 2004/05. Estimates are either raw counts from observations, extrapolated from raw counts or based on distance sampling analysis estimates. Shaded cells exceeded the 1% threshold (170 individuals) for the stage 1 SPA guideline which is based on O'Brien *et al.*, (in press).

3.3.2 Common eider

Results for each survey are presented in Appendix 2, Table 2.2. Table 4 indicates the mean maximum seasonal population estimates for common eider in Tay Bay from 1997/98 to 2004/05.

Common eiders were the most numerous species present except in winter 2001/2002. Total population numbers varied enormously over the survey period. For two surveys (4 December 2003 and 12 December 2004), distance sampling population estimates for common eider had very wide confidence intervals associated with them. Variance in cluster size due to small numbers of very large flocks contributed to very large proportions of the total estimates of variance (Distance Sampling 5.0). To avoid possible bias these large flocks were treated in the same way as for very large flocks of common scoter, and as described in the methods. Consequently it was not possible to calculate confidence intervals for those final estimates that included birds in very large flocks (4 December 2003 and 12 December 2004).

Results for each survey are presented in Appendix 2, Table 2.2. Table 4 indicates the mean maximum seasonal population estimates for common eider in Tay Bay from 1997/98 to 2004/05.

Season	**Analysis used to derive estimate**	**Maximum estimate**	**Date**
SPA qualification threshold		**12,850**	
1997/98	extrapolation	5300	24/25 Jan. 1998
2000/01	raw count	3861	21. Dec. 2001
2001/02	Distance Sampling	4486	26 Feb. 2002
2003/04	Distance Sampling	20,333	04 Dec. 2003
2004/05	Distance Sampling	10,398	12 Dec. 2004
Mean of maximum estimate		**8876**	

Table 4. Maximum seasonal population estimates for common eider in the Tay Bay from 1997/98 to 2004/05. Estimates are either raw counts from observations, extrapolated from raw counts or based on distance sampling analysis estimates. Shaded cells exceeded the 1% threshold (12,850 individuals) for the stage 1 SPA guideline which is based on Wetlands International (2006).

3.3.3 Scoter species

Common scoter

Results for each survey are presented in Appendix 2, Table 2.3. And Table 5 presents the mean maximum seasonal population estimates for common scoter in the Tay Bay from 1997/98 to 2004/05.

Common scoter were the second most numerous species in most surveys although estimating their density and population estimates of common scoter (13 & 15 December 2001, 04 December 2003, 29 February 2004, 12 December 2004 and 02 February 2005) cannot be considered reliable. Estimates were either based on small sample sizes or were derived from distance sampling but based on excluding outliers (large flocks) which were added as raw counts at the end of the analysis. However, they are the best estimates possible using these data, but should be treated with caution.

For one survey (29 February 2004), the distance sampling density and population estimates for common scoter had very large confidence intervals associated with them. Variance in cluster size due to one flock (150) contributed to very large proportions of the total estimates of variance. To avoid possible bias this large flock was treated in the same way as for large flocks of common eider, and as described in the methods. It was not possible to calculate confidence intervals for the final estimate that included birds in one large flock (29 February 2004).

Results for each survey are presented in Appendix 2, Table 2.3, and Table 5 presents the mean maximum seasonal population estimates for common scoter in the Tay Bay from 1997/98 to 2004/05.

Season	Analysis used to derive estimate	Maximum estimate	Date
SPA qualification threshold		**16,000**	
1997/98	extrapolation	1474	24/25 Jan. 1998
2000/01	raw count	1646	15/16 Feb. 2001
2001/02	Distance Sampling	3634	26 Feb. 2002
2003/04	Distance Sampling	2165	29 Feb. 2004
2004/05	Distance Sampling	1647	18 Mar. 2005
Mean of maximum estimate		**2113**	

Table 5. Maximum seasonal population estimates for common scoter in the Tay Bay from 1997/98 to 2004/05. Estimates are either raw counts from observations, extrapolated from raw counts or based on distance sampling analysis estimates. The 1% threshold for stage 1 SPA qualification (16,000) is based on Wetlands International (2006).

Velvet scoter

There were insufficient observations on all surveys to generate population estimates using distance sampling analysis for velvet scoters. Density and total population estimates were therefore extrapolated from raw counts.

Results for each survey are presented in Appendix 2, Table 2.4 and Table 6 shows the mean maximum seasonal population estimates for velvet scoter in the Tay Bay from 1997/98 to 2004/05.

Season	Analysis used to derive estimate	Maximum estimate	Date
SPA qualification threshold		**10,000**	
1997/98	extrapolation	280	24/25 Jan. 1998
2000/01	raw count	4	15/16 Feb. 2001
2001/02	extrapolation	23	13 & 15 Dec. 2001
2003/04	extrapolation	566	04 Dec. 2003
2004/05	extrapolation	4	18 Mar. 2005
Mean of maximum estimate		**175**	

Table 6. Maximum seasonal population estimates for velvet scoter in the Tay Bay from 1997/98 to 2004/05. Estimates are either raw counts from observations, extrapolated from raw counts or based on distance sampling analysis estimates. The 1% threshold for stage 1 SPA qualification (10,000) is based on Wetlands International (2006).

All scoter population estimates

Results for each survey are presented in Appendix 2, Table 2.5. And Table 7 indicates the mean maximum seasonal population estimates for all scoter in the Tay Bay from 1997/98 to 2004/05.

All scoter population estimates were generated only for the purpose of calculating the waterbird assemblage (section 3.3.7). Velvet scoters were recorded too infrequently to derive a reliable distance sampling estimate of numbers. These observations, along with records of common scoter and unidentified scoter species, were used to derive ‘all scoter’ estimates. The 29 February 2004 and 2 February 2005 surveys resulted in no observations of velvet or unidentified scoters so overall density and population estimates for ‘all scoter’ was equal to the values calculated for common scoter.

Season	Analysis used to derive estimate	Maximum estimate	Date
1997/98	Extrapolation	1754	24/25 Jan. 1998
2000/01	raw count	1707	15/16 Feb. 2001
2001/02	Distance Sampling	5336	26 Feb. 2002
2003/04	Distance Sampling	2165	04 Dec. 2003
2004/05	Distance Sampling	1654	12 Dec. 2004
Mean of maximum estimate		**2223**	

Table 7. Maximum seasonal population estimates for all scoter in the Tay Bay from 1997/98 to 2004/05. Estimates are either raw counts from observations, extrapolated from raw counts or based on distance sampling analysis estimates.

3.3.4 Long-tailed duck

Most density and population estimates for long-tailed duck are reliable. However, for one survey (04 December 2003), distance sampling analysis generated very high, unacceptable cluster size variance and the density and population estimates for long-tailed duck had very large confidence intervals associated with them. The sample size of 17 observations did not allow for many adjustments when using distance sampling analysis (truncation, post stratification or exclusion of very large flocks), so this is the best possible estimate but it should be treated with caution.

Results for each survey are presented in Appendix 2, Table 2.6. Table 8 presents the mean maximum seasonal population estimates for long-tailed duck in the Tay Bay from 1997/98 to 2004/05.

Season	Analysis used to derive estimate	Maximum estimate	Date
SPA qualification threshold		**20,000**	
1997/98	extrapolation	111	24/25 Jan. 1998
2000/01	raw count	546	15/16 Feb. 2001
2001/02	Distance Sampling	1254	13 & 15 Dec. 2001
2003/04	Distance Sampling	1436	29 Feb. 2004
2004/05	Distance Sampling	293	02 Feb. 2005
Mean of maximum estimate		**728**	

Table 8. Maximum seasonal population estimates for long-tailed ducks in the Tay Bay from 1997/98 to 2004/05. Estimates are either raw counts from observations, extrapolated from raw counts or based on distance sampling analysis estimates. The threshold for stage 1 SPA qualification (20,000) is based on Wetlands International (2006).

3.3.5 Red-breasted merganser

There were insufficient observations during all but one survey (29 Feb. 2004) to generate population estimates using distance analysis for red-breasted merganser. However, the estimates derived should be used with caution, as the sample sizes were low.

Results for each survey are presented in Appendix 2, Table 2.7. Table 9 indicates the mean maximum seasonal population estimates for red-breasted merganser in the Tay Bay from 1997/98 to 2004/05.

Season	Analysis used to derive estimate	Maximum estimate	Date
SPA qualification threshold		**1,700**	
1997/98	extrapolation	3	24/25 Jan. 1998
2000/01	raw count	5	15/16 Feb. 2001
2001/02	extrapolation	206	13 & 15 Dec. 2001
2003/04	Distance Sampling	287	29 Feb. 2004
2004/05	extrapolation	46	12 Dec. 2004
Mean of maximum estimate		**109**	

Table 9. Maximum seasonal population estimates for red-breasted merganser in the Tay Bay from 1997/98 to 2004/05. Estimates are either raw counts from observations, extrapolated from raw counts or based on distance sampling analysis estimates. The exceeding 1% threshold for stage 1 SPA qualification (1,700) is based on Wetlands International (2006).

3.3.6 Little gull

Little gulls were recorded only in four out of eight line transect surveys. All population estimates were generated using extrapolation of raw counts.

Results for each survey are presented in Appendix 2, Table 2.8. Table 10 presents the mean maximum seasonal population estimates for little gull in the Tay Bay from 1997/98, 2003/04 and 2004/05. During 2000/01 and 2001/02 no observations of little gulls were made using aerial surveys.

Season	Analysis used to derive estimate	Maximum estimate	Date
SPA qualification threshold		**50**	
1997/98	extrapolation	216	24/25 Jan. 1998
2003/04	extrapolation	44	29 Feb. 2004
2004/05	extrapolation	15	12 Dec. 2004
Mean of maximum estimate		**92**	

Table 10. Maximum seasonal population estimates for little gulls in the Tay Bay from 1997/98 to 2004/05. Estimates are either raw counts from observations, extrapolated from raw counts or based on distance sampling analysis estimates. Little gull is listed on Annex I of the EU Birds Directive, therefore qualification should be assessed at stage 1.1 of the SPA selection guidelines (Stroud *et al.*, 2001). However, to do so requires that there be a suitable GB population estimate for this species; no such population estimate is available.

3.3.7 Waterbird assemblage

Summing the peak population estimates of red-throated divers, common eiders, all scoter species, long-tailed ducks, red-breasted mergansers and little gulls per season results in a total of 11,703 individual birds. Population estimates taken from distance sampling analysis exceeded the 20,000 threshold in only two surveys undertaken on 04 December 2003 and 29 February 2004 (Table 2).

4. Discussion

4.1 SPA qualification

Selection guidelines for SPAs in the UK (Stroud *et. al* 2001) advise that SPA qualification be determined in two stages. The first stage (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. The second stage (not considered in this report) is intended to further consider sites selected under stage 1 to select the most suitable areas. Under Stage 1, there are four guidelines under which an area may be selected:

Stage 1.1. Numbers of species listed on Annex I of the EU Birds Directive (79/409/EEC) should exceed 1% of the agreed 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 Committee), of at least two species, should occur regularly at a site.

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 "numbers exceed the selection threshold in two out of three seasons" or when available, the mean of 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 areas, sites may be selected if they satisfy one or more of the ecological criteria (e.g. 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) 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. (Webb & Reid 2004).

In order to determine whether Tay Bay meets Stage 1.1/1.2/1.3 guidelines for further consideration for SPA status, estimated population sizes should be compared with either the total estimated GB or total estimated biogeographical wintering populations. For species listed on Annex I of the Birds Directive, the appropriate population for comparison is the GB population (Baker *et al.,* 2006); for regularly occurring migratory species, the appropriate population for comparison is the biogeographical population (Wetlands International 2006).

In the case of red-throated diver (which are listed on Annex I), the GB wintering population estimate in Baker *et al.,* (2006) is known to be a significant underestimate (Webb *et al.,* 2005; O'Brien *et al.,* in press). The population estimate of red-throated divers in the Tay Bay area was instead compared with the newly revised GB wintering population estimate of 17,000 (O'Brien *et al.*, in press); a qualification threshold of 170 individuals, agreed as the operational threshold by the UK Inter-Agency Ornithological Working Group. In addition, there is currently no suitable published GB population estimate of the wintering population of little gulls which is also listed on Annex I and therefore qualification should be assessed at stage 1.1 of the SPA selection guidelines (Stroud *et al.*, 2001). Consequently the default minimum threshold of 50 individuals was applied (as recommended by the SPA Scientific Working Group), following Stroud *et al.*, (2001) and applied in Webb *et al.*, (2005).

4.2 Distance sampling analysis

Most species estimates were characterised by sufficient sample sizes and did not violate the assumptions required to apply distance sampling analysis, consequently it was possible to generate a detection function for each survey apart from the line transect boat survey in January 1998 and the two strip-transects flown during 200/01. The small 95% confidence intervals associated with these density and total population size estimates indicated high confidence in these numbers. However, where it was impossible to acquire a detection function either raw counts or extrapolation of mean density derived from raw counts were calculated.

4.3 Red-throated diver

The Tay Bay population estimates were calculated for red-throated divers and unidentified divers combined, assuming that all unidentified divers were red-throated divers. Other diver species do not commonly occur in significant numbers in Tay Bay (Lack 1986). Aerial and boat surveys from 1997/98 to 2005 of the area support this assumption with only one great northern diver out of 598 divers recorded.

During the line-transect boat survey carried out in 1998, and in three line-transect aerial surveys carried out over the winters of 2003, 2004 and 2005, red-throated diver numbers in Tay Bay exceeded the stage 1 site selection threshold of 170 individuals, with numbers exceeding 1,000 birds in one of these surveys (see section 3.3.1). Population estimates for each survey of red-throated divers ranged from 1 to 1,589, with a mean of peak counts of 477. The line transect aerial survey on 12 December 2004 could have potentially exceeded the qualifying numbers for red-throated divers if the survey had been completed. Peak numbers of red-throated divers exceeded the stage 1 threshold in three out of five winter seasons, and the mean of peak numbers for the five winter seasons (477) greatly exceeds that 1% threshold (Table 3). Numbers of birds were particularly high during the February 2004 survey (1,589). In estimating the actual wintering population of red-throated divers in Great Britain, O'Brien *et al.*, (in press) where possible, used only peak estimates from only January and February aerial surveys since 1999. This resulted in a lower mean wintering population estimate for the four most recent seasons (2001-2005) of 449 red-throated divers in Tay Bay; also well in excess of the 1% threshold of 170 birds.

The data presented here suggest that the Tay Bay area meets the Stage 1.1 site selection threshold of the UK SPA Selection Guidelines (Stroud *et al.*, 2001)as an SPA for red-throated diver.

It is useful to look at numbers of each survey in conjuction with the distribution maps presented in Appendix 1 (Figure 1.1a-j), to obtain an indication of where higher numbers occur. Peak population estimates of line transect surveys for seasons 1997/98, 2000/01, 2001/02, 2003/04 and 2004/05 are summarised in Table 3. The data indicate that there is substantial variation in population estimates during each survey, both within and across seasons. This supports observations that wintering birds are highly mobile within their wintering areas, probably in response to weather conditions and/or food supply (Lack 1986).

4.4 Common eider

Population estimates for each survey of common eider ranged from 1,804 to 20,333 individual birds (in December), with a mean of peak counts of 8,876. This indicates that there is substantial variation in population estimates during each survey, both within and across seasons (Appendix 2, Table 2.2). Only one (2003/04) out of five seasons exceeded qualifying numbers of common eider (12,850 – 1% of biogeographical population) in Tay Bay but it is important to note the extremely large confidence intervals associated with the estimate on 4 December 2003, indicating that the estimate may not be reliable. All other survey densities and population estimates had narrower 95% confidence intervals but never exceeded qualifying numbers.

In 1996, Scott & Rose described the Tay Estuary as an internationally important area for common eider in winter with an average count of 25,150 individuals (five or more counts available between 1984 and 1993 with an average of the last five counts exceeding 1% of the population size). In 2003, Kershaw & Cranswick revised the population estimate of common eider in Tay/St Andrews Bay to 11,000 individuals. These estimates were based on WeBS mean Core Counts from 1994-1999. Since then the Tay Estuary has shown some considerable variation in numbers during the last 10 years but the five year mean (since 1998/99) never exceeded 7,500 individuals (Politt *et al.,* 2003, Collier *et al.,* 2005, Cranswick *et al.,* 2005, Banks *et al.,* 2006), indicating a considerable decline in numbers of common eiders in the Tay region.

During JNCC aerial survey counts the last two seasons (2003/04 and 2004/05) showed higher counts of individual birds than previous years. The reason for this could be that JNCC surveys are conducted only in optimal weather conditions, e.g. low wind speed, no rain and lower than seastate three. The WeBS Core Counts however are made once per month, counted on the same day within each month and generally undertaken during the morning (Banks *et al.,* 2006). This methodology can result in varying weather conditions which can effect counting results and underestimates bird numbers.

While WeBS Core Counts are understaken normally at high tide on estuarine sites (Banks *et al.,* 2006), no account is taken of the influence of tides on the distribution of the birds during JNCC aerial surveys. The WeBS counts data and JNCC aerial surveys in Tay Bay do only scarcely overlap with JNCC covering a much larger survey area including an area further offshore. This fact makes comparison of population estimates with Tay Bay WeBS Core Counts difficult. More detailed WeBS Core Counts are needed for the inner Tay estuary in order to make a full estimate for common eider.

The contemporary data presented here do not suggest that the Tay Bay area currently meets the Stage 1.2 site selection threshold of the UK SPA Selection Guidelines (Stroud *et al.,* 2001) as an SPA for common eider.

Bird numbers recorded on each survey, in relation to the distribution maps presented in Appendix 1, Figure 1.2, indicate where high numbers of common eider occur. The line transect aerial survey on 12 December 2004 could have potentially exceeded the threshold numbers of common eider if the survey had been completed. This would have increased the numbers of common eider for the 2004/05 maximum estimate but it is doubtful that this would have changed the mean of maximum estimates for qualification as SPA. The peak population estimates are summarised in Table 4.

4.5 Scoter species

4.5.1 Common scoter

Population estimates for each survey of common scoter ranged from 360 (based on small sample size) to 3,634, with a mean of peak counts of 2,113. The majority of estimates of common scoters, although the best available that can be obtained, have large 95% confidence intervals associated with them, indicating low reliability in these numbers. During the line-transect boat survey and all line transect aerial surveys common scoter numbers in the Tay Bay area never exceeded the Stage 1 site selection threshold numbers of 16,000 (1% of the biogeographical population).

The data presented here do not suggest that the Tay Bay area meets the Stage 1.2 site selection threshold of the UK SPA Selection Guidelines (Stroud *et al.,* 2001) as an SPA for common scoter.

The bird numbers of each survey, in relation to the distribution maps presented in Appendix 1, Figure 1.3, provide an indication where high numbers of common scoter occur.

St Andrews Bay and recently Tay Estuary have been recognised as sites of national importance for common scoter in GB by the Wetland Bird Survey (WeBS) (Cranswick *et al.,* 1999, Politt *et al.,* 2000, Musgrove *et al.,* 2001, Politt *et al.,* 2003, Collier *et al.,* 2005). St Andrews Bay supports a five season mean of 1,514 individuals for 1999/00 to 2003/04 while 511 birds can be found on average during the same period in the Tay Estuary. Though our surveys covered a larger area with most birds occurring in inshore areas these counts are comparible to population estimates of common scoter in this report. Peak population estimates of line transect surveys for all seasons can be found in Table 5.

4.5.2 Velvet scoter

Population estimates for each survey of velvet scoter ranged from 4 to 566 individuals, with a mean of peak counts of 175. These estimates were derived from extrapolation of raw counts, which should be interpreted with caution. Although there is low confidence attached to these densities and population estimates presented here, none of the velvet scoter numbers in the Tay Bay area exceeded qualifying numbers (10,000 – 1% of biogeographical population).

The data presented here do not suggest that the Tay Bay area meets the Stage 1.2 site selection threshold of the UK SPA Selection Guidelines (Stroud *et al.,* 2001) as an SPA for velvet scoter.

Figures 1.3 in Appendix 1, show the distribution in Tay Bay and give an indication of where velvet scoter occur. Almost all of the birds recorded during WeBS are found on just a few sites, generally between the Moray Firth and the Firth of Forth (Collier *at el.* 2005). St Andrews Bay has been recognised as site of national importance for velvet scoter in GB by WeBS and supports a five season mean of 721 individuals for 1999/00 to 2003/04 (Collier *et al.*, 2005). Our estimates for a larger survey area in comparison is lower. The reason for this might be that several birds were recorded as unidentified scoter species which potentially could have been velvet scoters. The peak population estimates of line transect surveys for all seasons are summarised in Table 6.

4.5.3 All scoters

Population estimates for each survey of 'all scoter' ranged from 999 to 5,336, with a mean of peak counts of 2,523. Observations of common, velvet and unidentified scoters were combined in order to gain better density and population estimates and smaller confidence intervals for 'all scoters' but no improvement occurred as only a small number of flocks with low numbers of individuals were added to the already existing data. Density and population size were estimated in order to determine if the area met stage 1 site selection guidelines as an SPA on account of its species assemblage (see section 4.9). Peak population estimates of line transect surveys for all seasons are summarised in Table 7.

4.6 Long-tailed duck

Population estimates for each survey of long-tailed ducks ranged only from 111 to 1,254 with a mean of peak counts of 728. The narrow 95% confidence intervals associated with density and total population size estimates for long-tailed duck indicate high confidence in these estimates. During the line-transect boat survey and all line transect aerial surveys, long-tailed duck numbers in the Tay Bay area never exceeded qualifying numbers of 20,000 (1% of biogeographical population).

The data presented here do not suggest that the Tay Bay area meets the Stage 1.2 site selection threshold of the UK SPA Selection Guidelines (Stroud *et al.*, 2001) as an SPA for long-tailed duck.

The bird numbers during each survey, in relation to the distribution maps presented in Appendix 1, Figure 1.4, provide an indication where high numbers of long-tailed duck occur. St Andrews Bay and Tay Estuary have shown some considerable variation in numbers during the last 10 years but the five year mean (1999/00 to 2003/04) never exceeded 237 and 134 long-tailed ducks respectively (Cranswick *et al.*, 1999, Politt *et al.*, 2000, Musgrove *et al.*, 2001, Politt *et al.*, 2003, Collier *et al.*, 2005). JNCC aerial survey counts were higher, probably because they covered a larger survey area and also surveyed further offshore. Therefore the results are different compared to population estimates of long-tailed ducks from WeBS counts. The peak population estimates of line transect surveys for all seasons are summarised in Table 8.

4.7 Red-breasted merganser

Population estimates for each survey of long-tailed ducks ranged only from 3 to 251 individuals, with a mean of peak counts of 109. For red-breasted merganser, most population estimates were derived from extrapolation of raw counts, which should be interpreted with caution. Line transect aerial survey conducted on 29 February 2004 did result in a large enough sample size, so distance sampling analysis was applied. However, large confidence intervals were generated. Although there is low confidence attached to the density and population estimates presented here, no red-breasted merganser numbers in Tay Bay exceeded qualifying numbers (1,700 – 1% of biogeographical population).

The data presented here do not suggest that the Tay Bay area meets the Stage 1.2 site selection threshold of the UK SPA Selection Guidelines (Stroud *et al.*, 2001) as a SPA for red-breasted merganser.

The bird numbers of each survey, in relation to the distribution maps presented in Appendix 1, Figure 1.5, provide an indication where red-breasted merganser occur. Red-breasted mergansers are a widespread species and birds from the Icelandic and Greenland populations are thought to winter in large numbers off the north coast of Scotland (Collier *et al.*, 2005).

Any sites covered by WeBS in the UK only holds insignificant numbers of this species however Tay Estuary has been recognised as site of national importance for red-breasted merganser (Collier *et al.*, 2005). It supports a five season mean of 127 individuals for 1999/00 to 2003/04. Though our surveys covered a larger area with most birds occurring in inshore areas these counts are comparible to population estimates of red-breasted merganser in this report. The peak population estimates of line transect surveys for all seasons are summarised in Table 9.

4.8 Little gull

During aerial surveys, little gulls are difficult to distinguish from other small gull species (such as black-legged kittiwake *Rissa tridactyla*, black-headed gull *Larus ridibundis* and common gull *Larus canus*), so that many small gulls were necessarily recorded simply as ‘small gull species’, or were not recorded at all during aerial surveys. For the purposes of this report, analyses and discussion are therefore restricted to those birds positively identified as little gulls, with no account taken of their classification as ‘small gull species’. It should therefore be borne in mind that the population estimates presented here may be underestimates.

For the little gull, population estimates were derived from extrapolation of raw counts, which should be interpreted with caution. The line transect boat survey conducted on 24/25 January 1998 generated a large total population estimate without confidence intervals. The population estimates for each survey of little gulls ranged from 15 to 216 individuals. There were few data for little gulls in Tay Bay and only one (1997/98) out of five seasons surveyed exceeded qualifying numbers based on a default of 50 individuals. During two seasons of aerial surveys no observations of little gulls were made in Tay Bay. Little gulls are primarily passage migrants to Britain, although small numbers over-winter off British and Irish coasts (Stone *et al.,* 1995). They occasionally occur in large numbers along the east coast of the UK (pers. comm. Andy Webb), so the number estimated here probably reflects actual numbers present in the area.

The data presented here do not suggest that the Tay Bay area meets the Stage 1.1 site selection threshold of the UK SPA Selection Guidelines (Stroud *et al.*, 2001) as a SPA for little gulls. Little gull distributions during the survey seasons are displayed in Appendix 1, Figure 1.6. Peak population estimates of line transect surveys for all seasons are summarised in Table 10.

4.9 Other waterbird species

No other species of inshore waterbird observed in the Tay Bay (such as grebes) were recorded in sufficient numbers to reliably estimate total population size. However, probably none occurs regularly in numbers that would meet SPA stage 1 site selection thresholds.

4.10 Waterbird assemblage

For Tay Bay to meet the threshold as a waterbird assemblage at Stage 1.3 of the SPA selection guidelines, total numbers of, at least, two species of inshore waterbirds would regularly have to exceed 20,000 individuals, (a) either in two out of three seasons of total species mean peak estimates or (b) the total species mean peak estimates of five seasons. Regularity is assessed as for single species guidelines (1.1 and 1.2) and as described in Webb and Reid (2004).

The peak estimates resulted in a total of 11,703 individual birds. The data presented here do not suggest that the Tay Bay area meets the Stage 1.3 site selection threshold of the UK SPA Selection Guidelines (Stroud *et al.,* 2001) as a SPA for the water bird assemblage.

5. Conclusion

When the complete suite of marine SPAs including, those for inshore areas has been determined, then Tay Bay should be considered for inclusion. On the basis of the UK SPA guidelines (Stroud *et al.*, 2001) Tay Bay meets the UK SPA Site Selection Guidelines only as a potential marine SPA for red-throated divers at stage 1.1. However, further consideration may be given to inclusion of other species using stage 1.4 of the SPA selection guidelines once 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.

If Tay Bay is then selected for SPA classification, further analysis may be required of the data presented here in order to define a marine site boundary.

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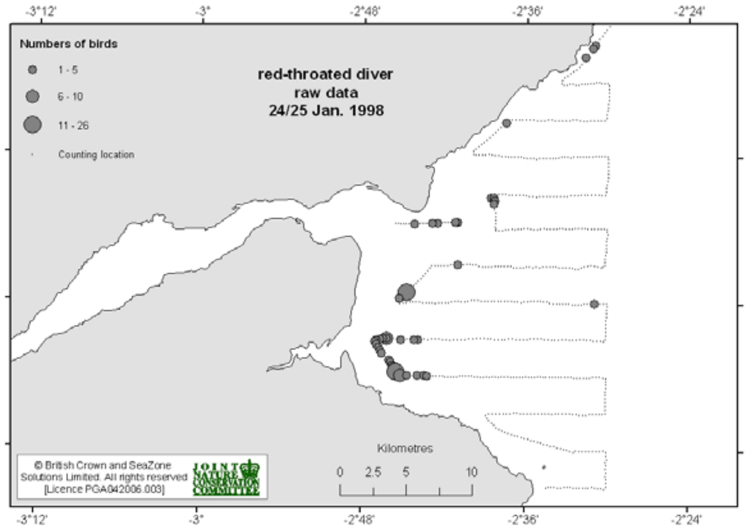
APPENDIX 1: Birds recorded during surveys

Figure 1.1: Distribution of all divers in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line-transect aerial surveys (d-j)

(a)



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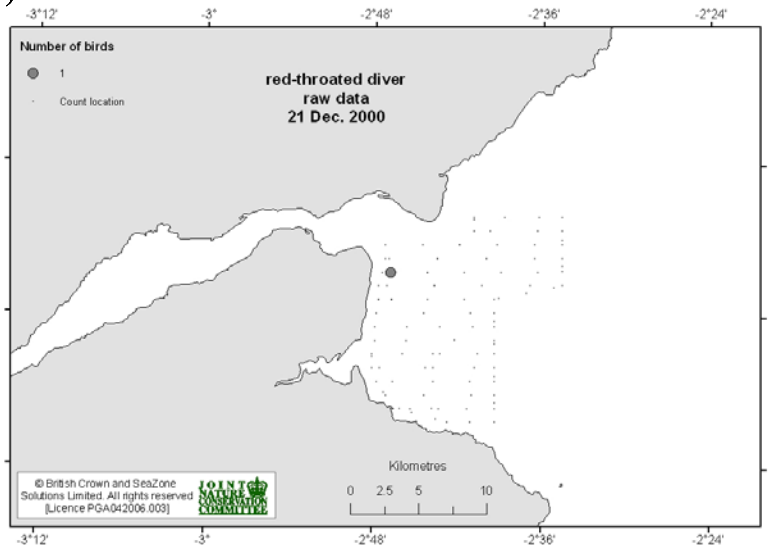
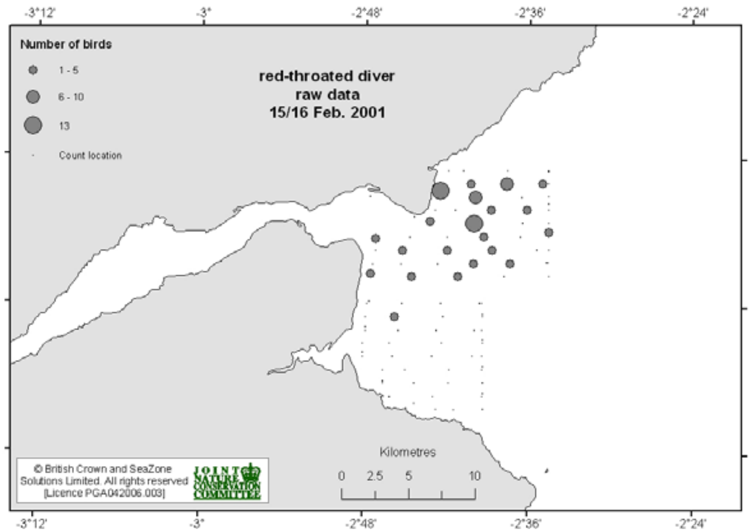


(c)



(d)

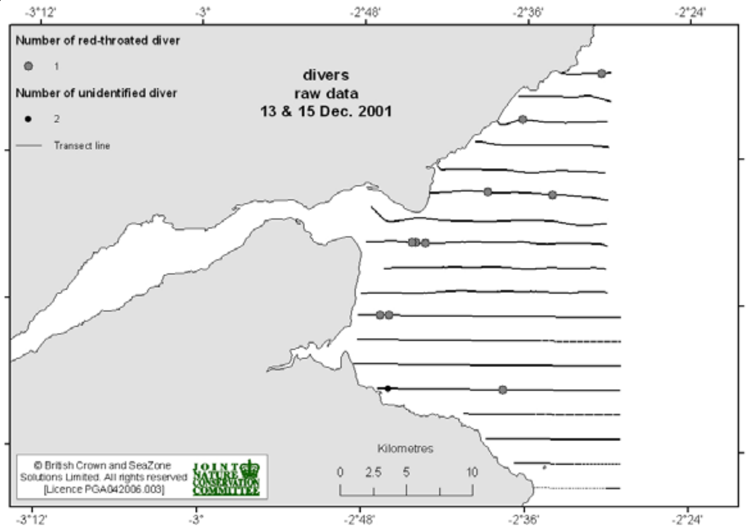
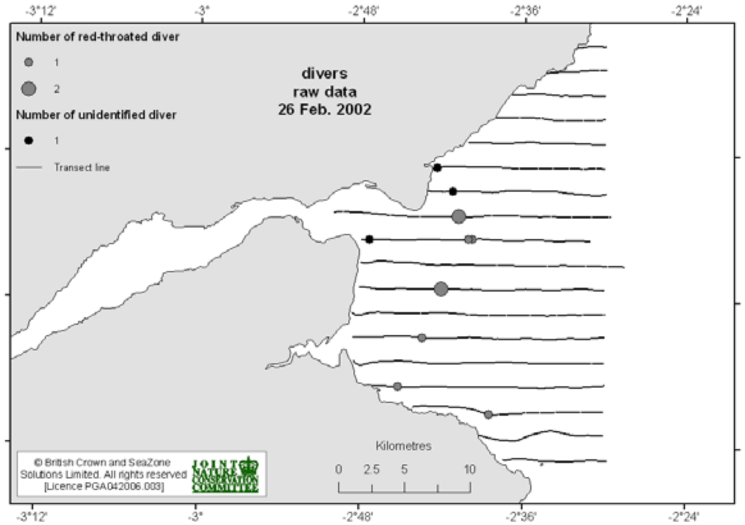
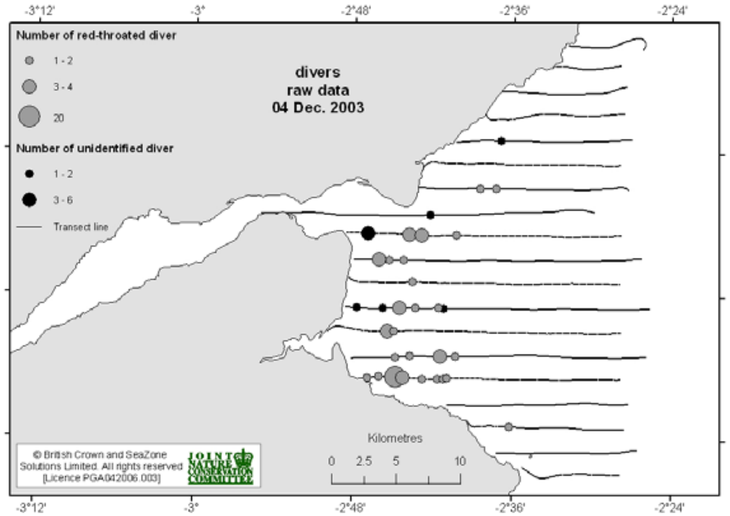


Figure 1.1 (cont): Distribution of all divers in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line-transect aerial surveys (d-j)

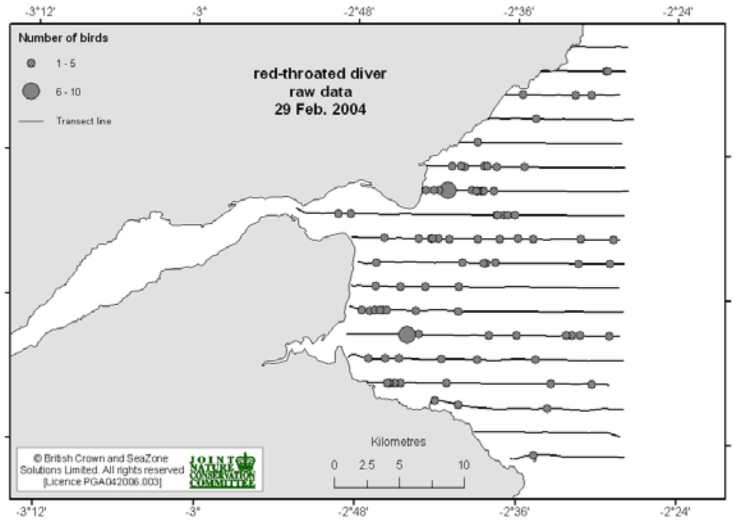
(e)



(f)



(g)



(h)

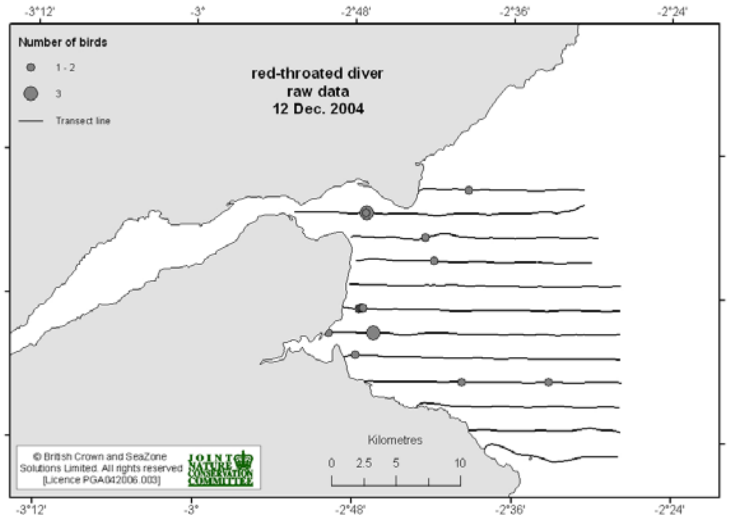
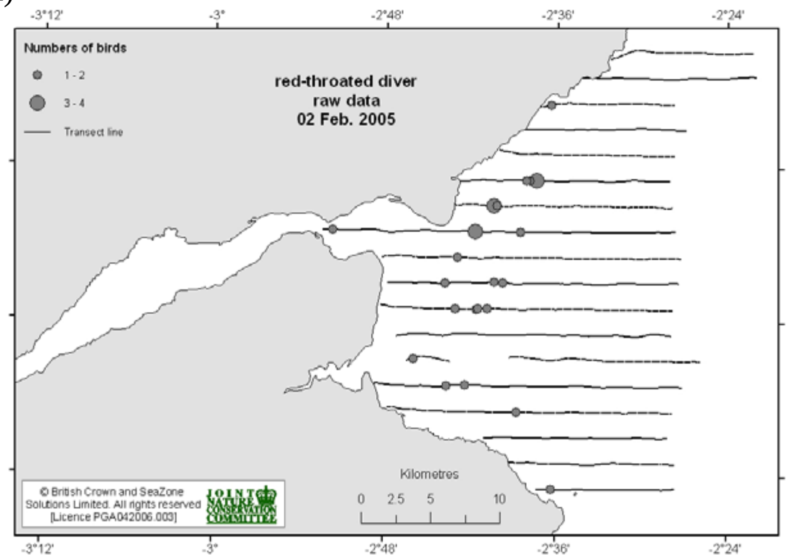


Figure 1.1 (cont): Distribution of all divers in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line-transect aerial surveys (d-j)

(i)



(j)

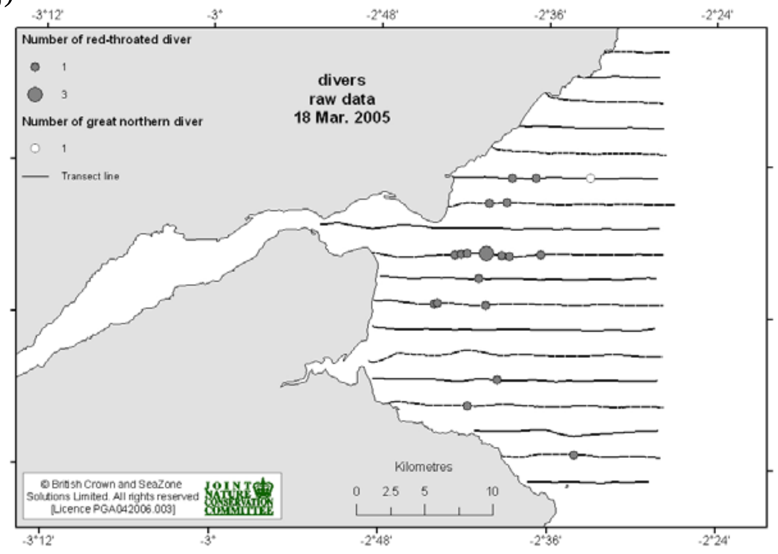
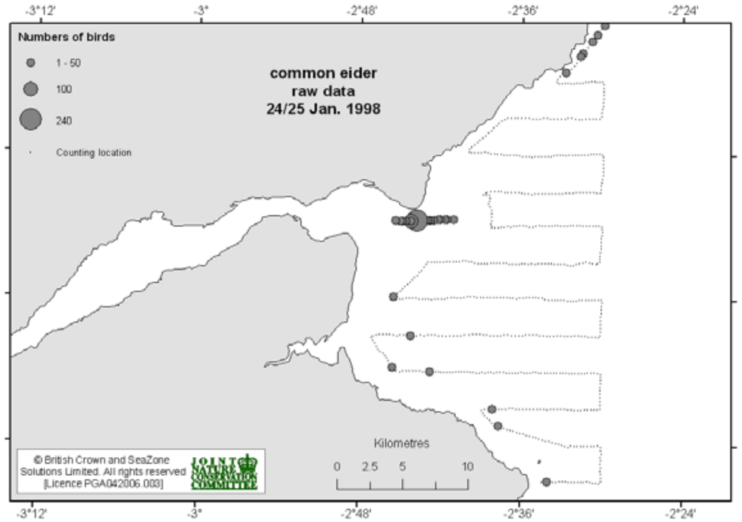
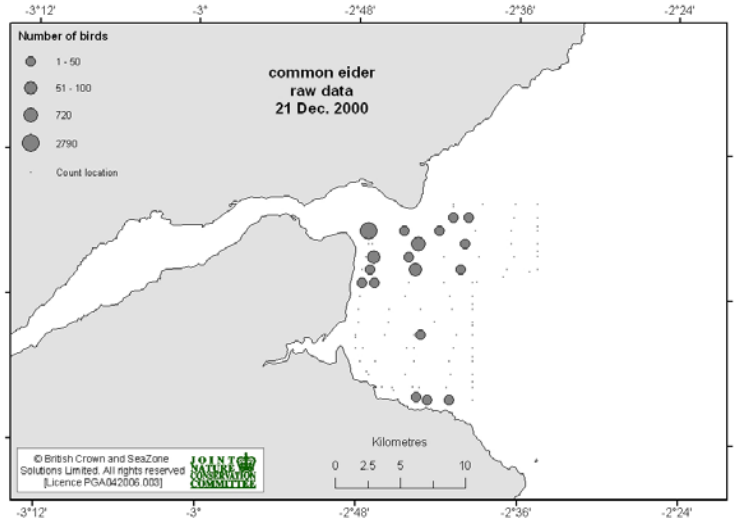


Figure 1.2: Distribution of common eider in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line- transect aerial surveys (d-j)

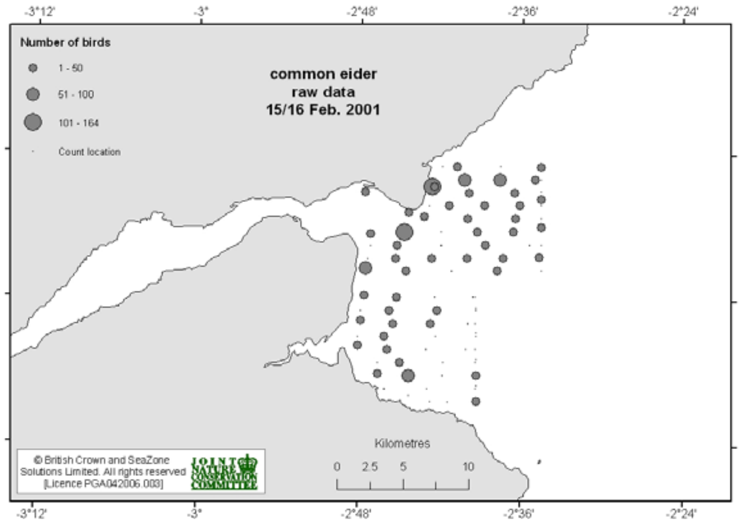
(a)



(b)



(c)



(d)

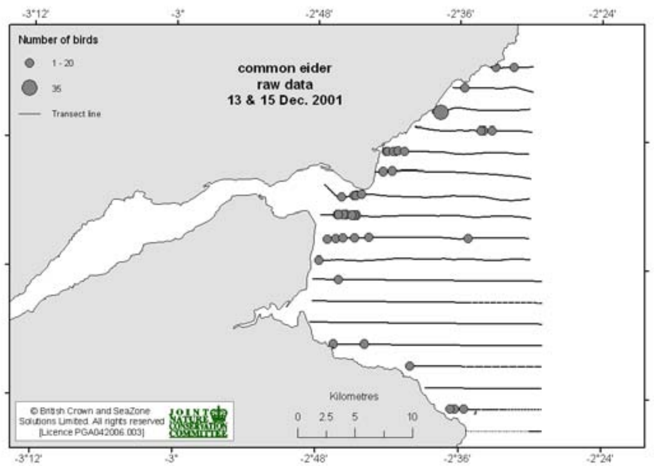
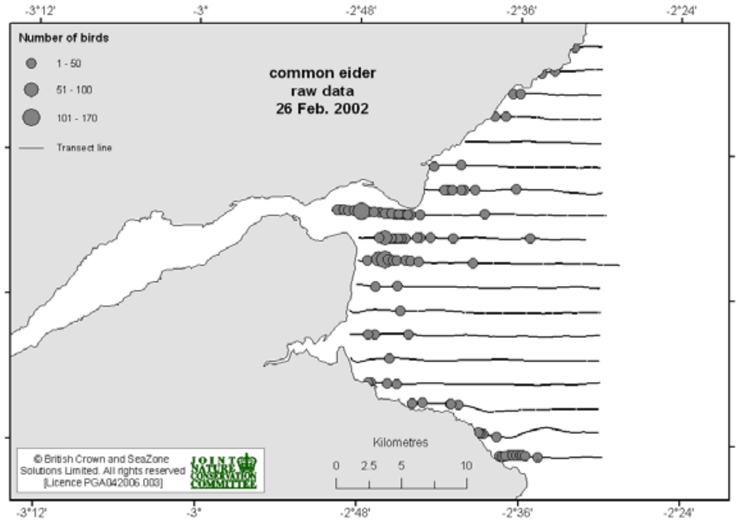
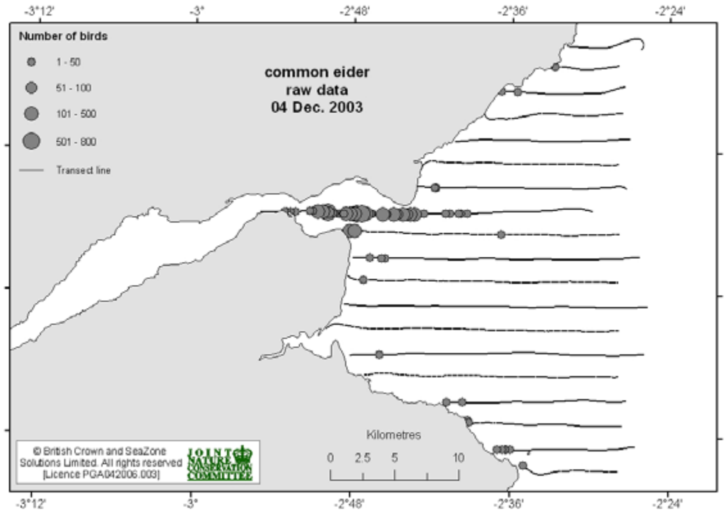


Figure 1.2 (cont.): Distribution of common eider in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line-transect aerial surveys (d-j)

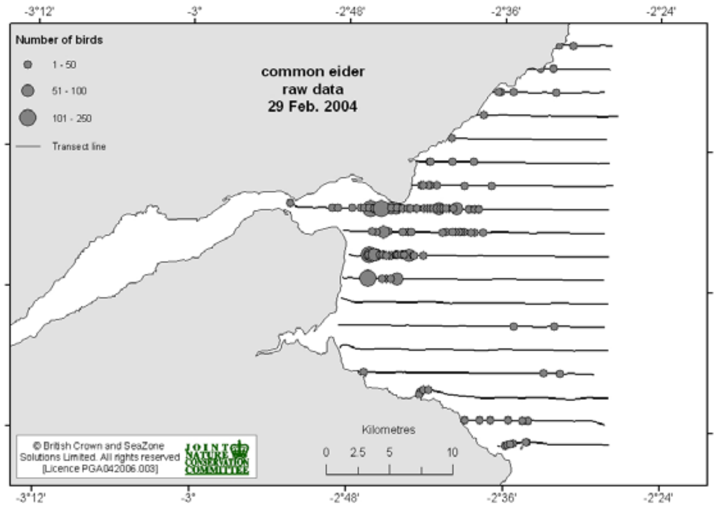
(e)



(f)



(g)



(h)

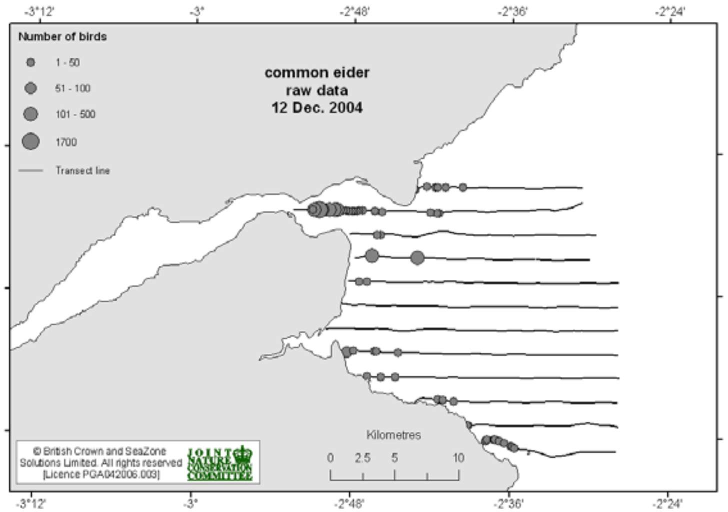
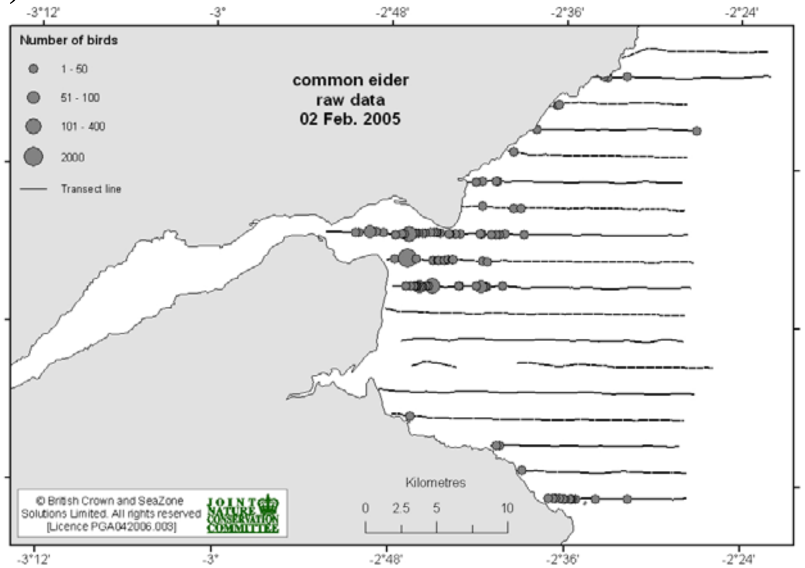


Figure 1.2 (cont.): Distribution of common eider in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line-transect aerial surveys (d-j)

(i)



(j)

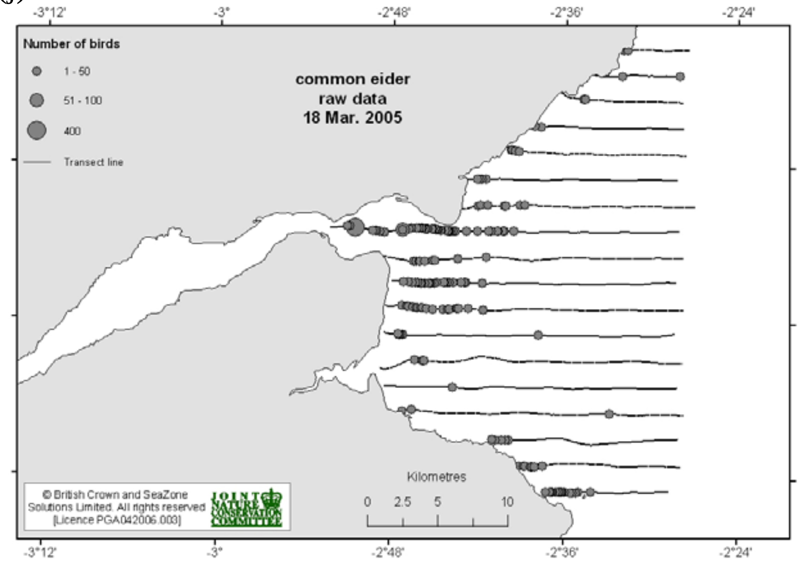
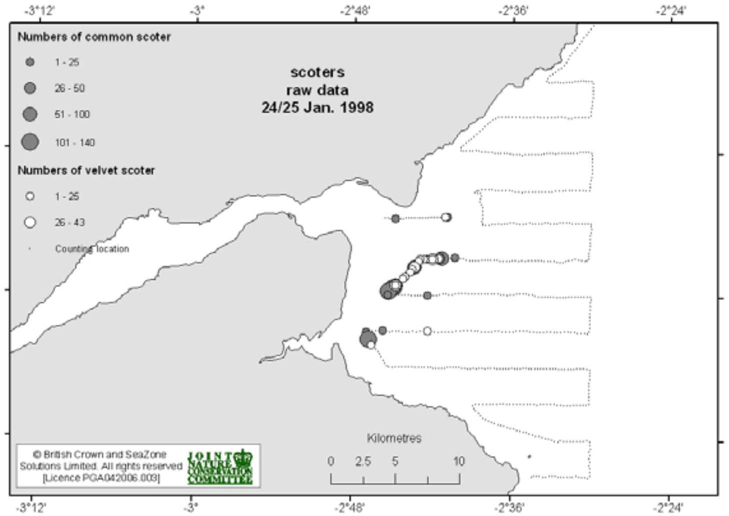
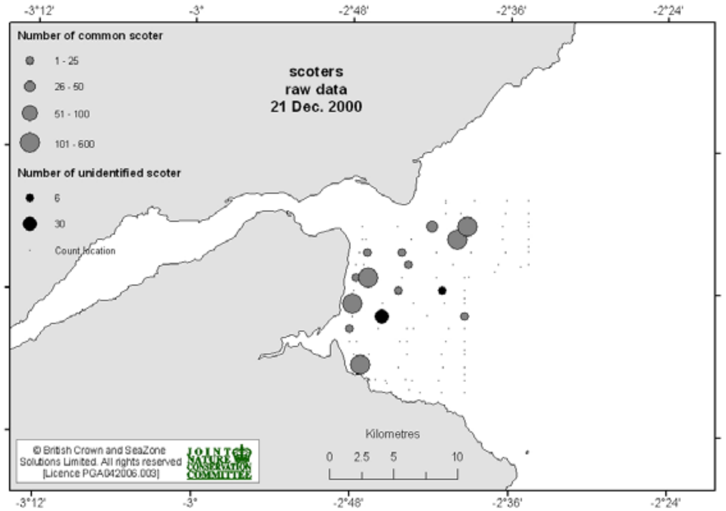


Figure 1.3: Distribution of scoters in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b-d) and line-transect aerial surveys (e-m)

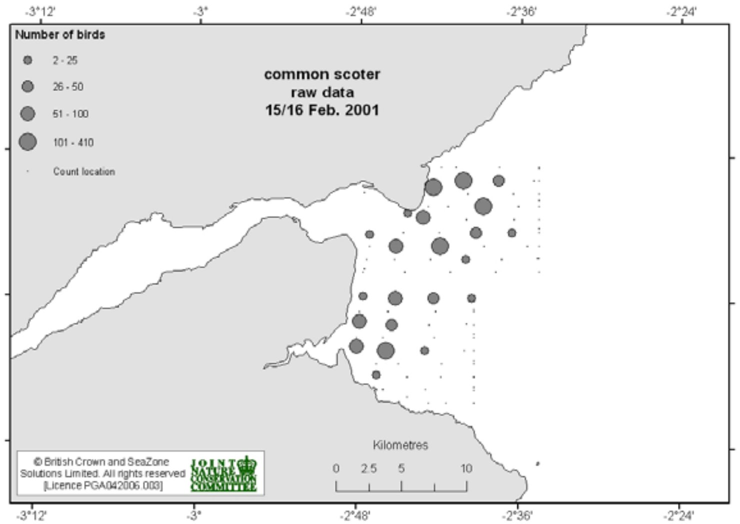
(a)



(b)



(c)



(d)

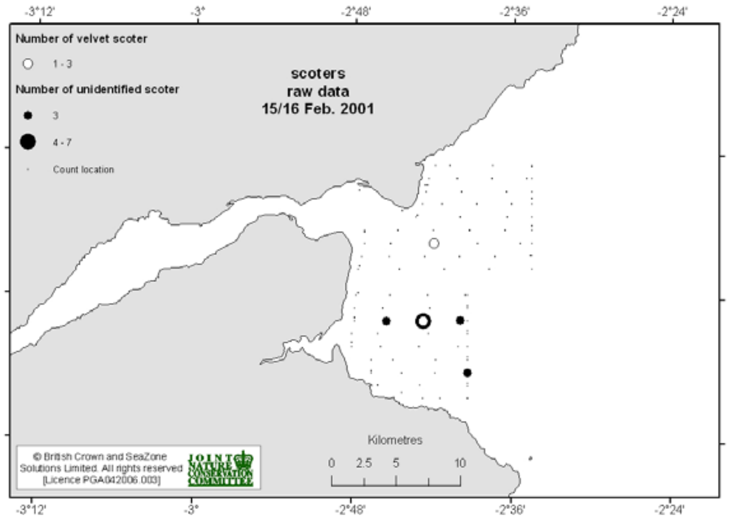
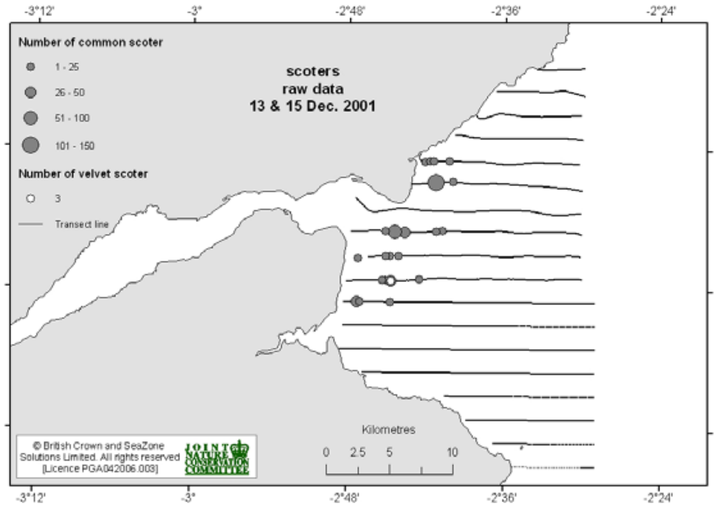
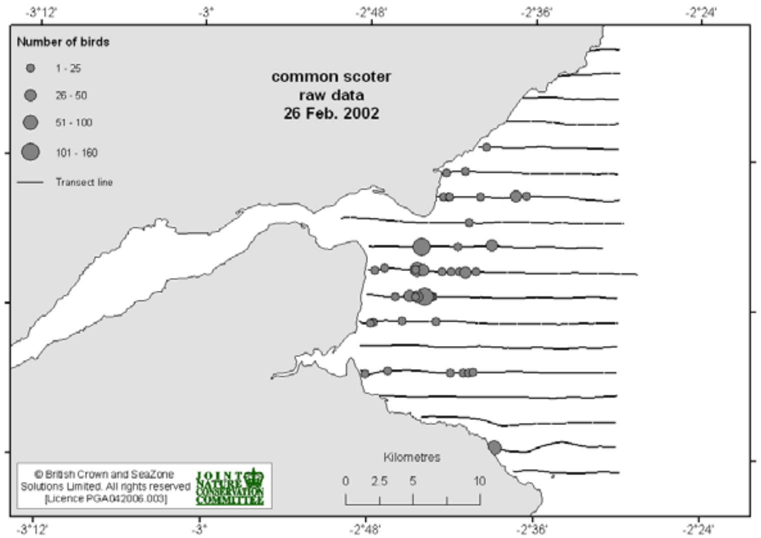


Figure 1.3 (cont.): Distribution of scoters in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b-d) and line- transect aerial surveys (e-m)

(e)



(f)



(g)

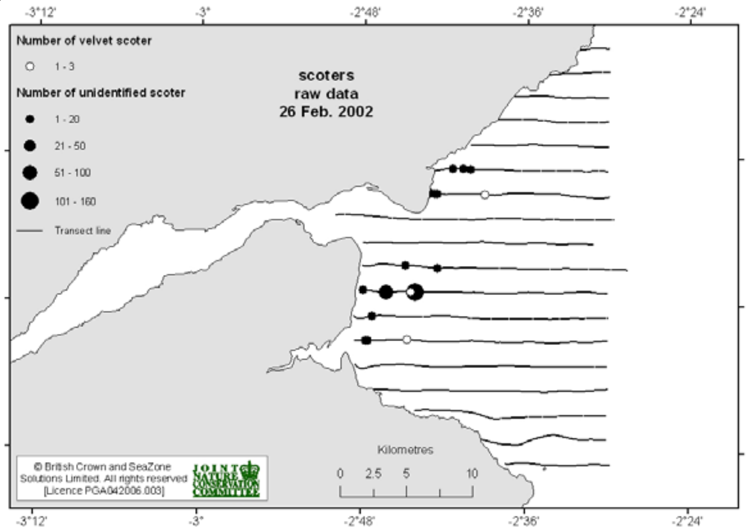
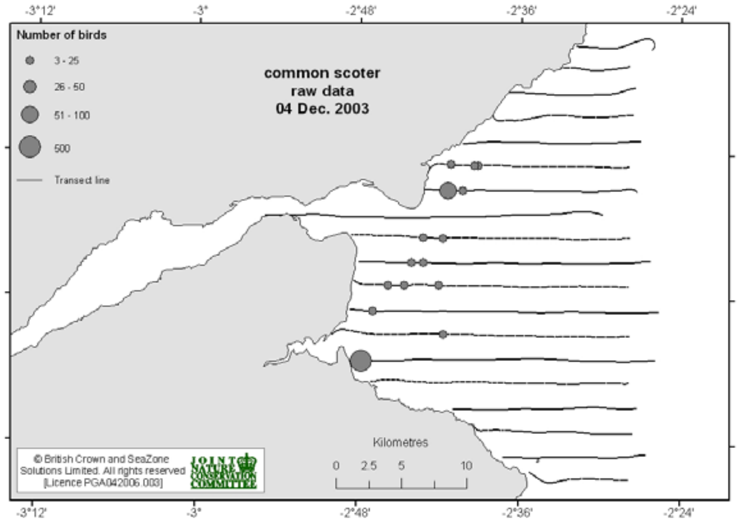
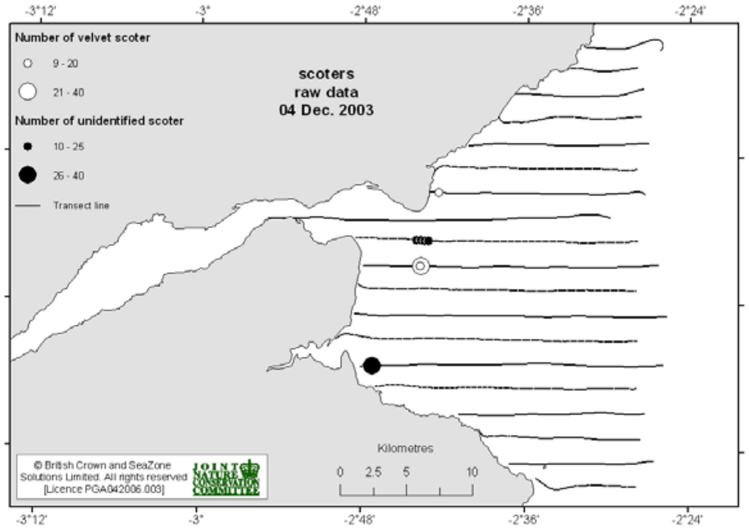


Figure 1.3 (cont.): Distribution of scoters in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b-d) and line- transect aerial surveys (e-m)

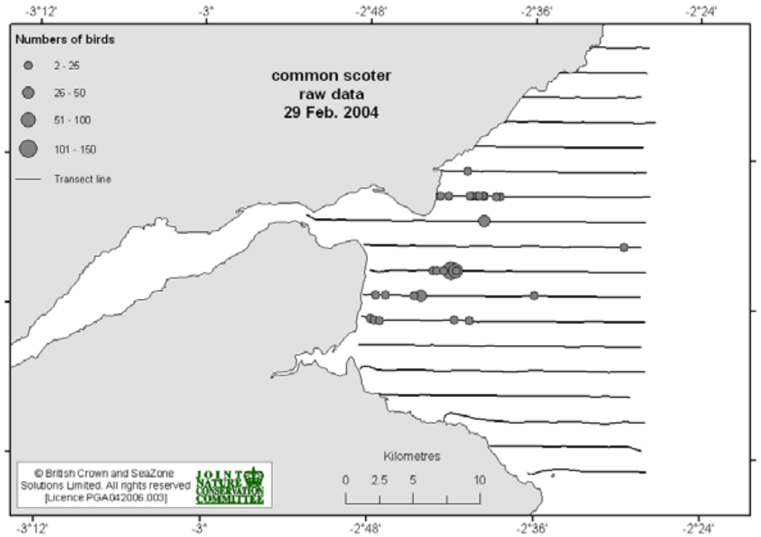
(h)



(i)



(j)



(k)

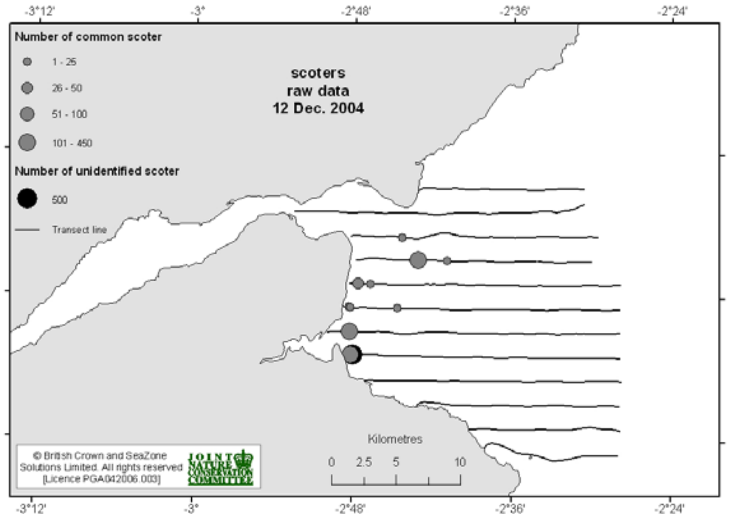
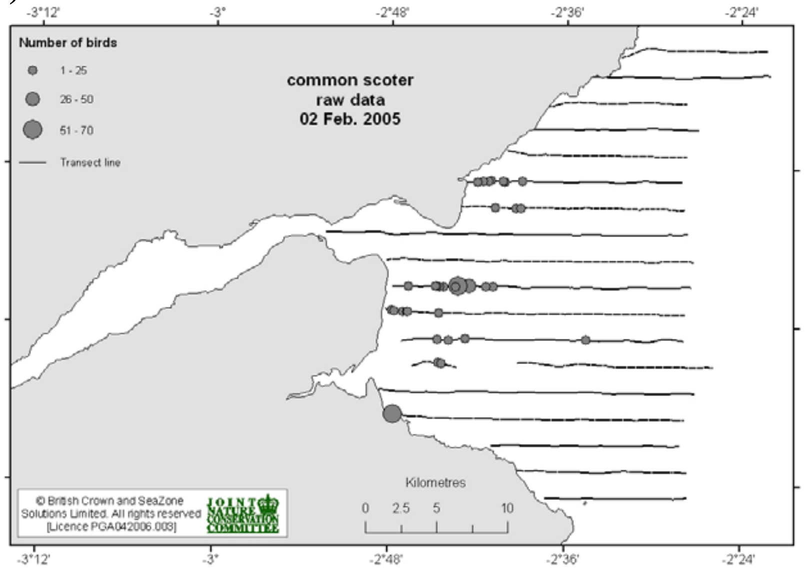


Figure 1.3 (cont.): Distribution of scoters in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b-d) and line transect aerial surveys (e-m)

(l)



(m)

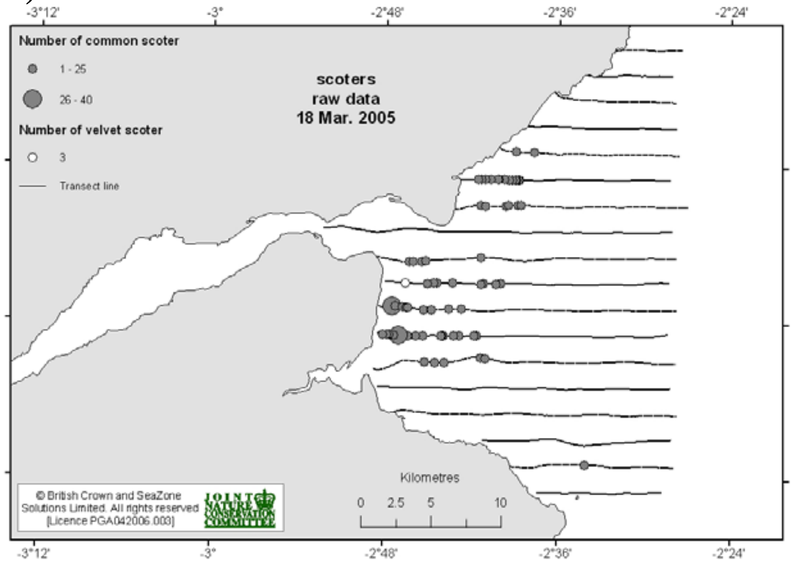
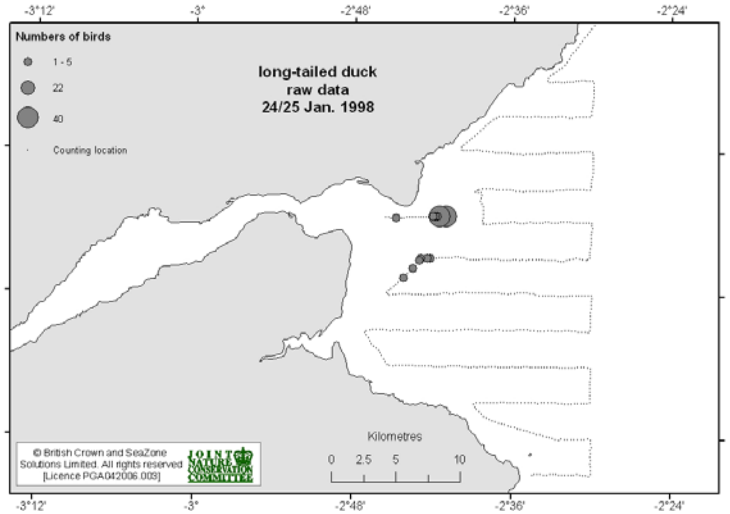
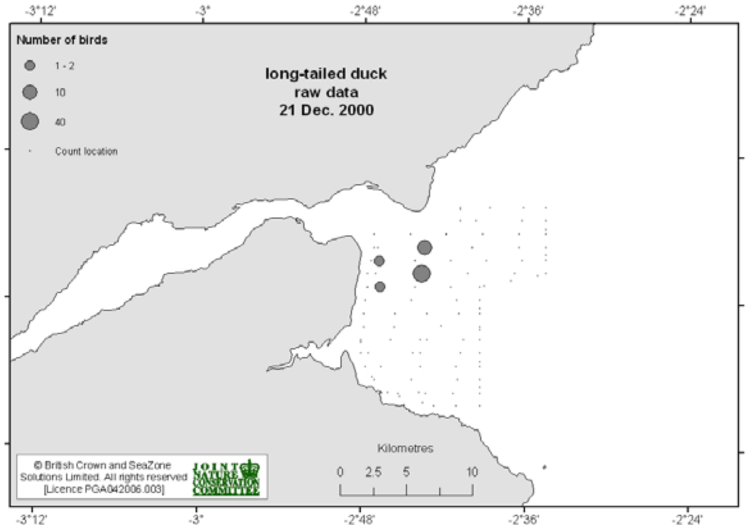


Figure 1.4: Distribution of long-tailed duck in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line transect aerial surveys (d-j)

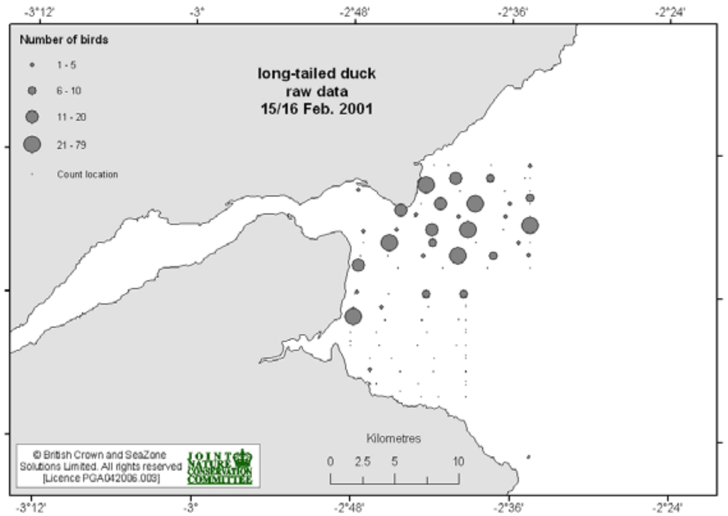
(a)



(b)



(c)



(d)

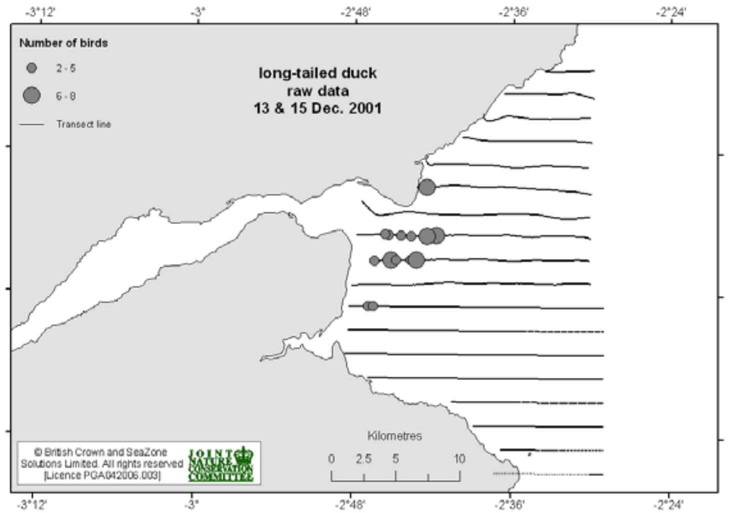


Figure 1.4 (cont.): Distribution of long-tailed duck in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line transect aerial surveys (d-j)

(e) (f) (g) (h)

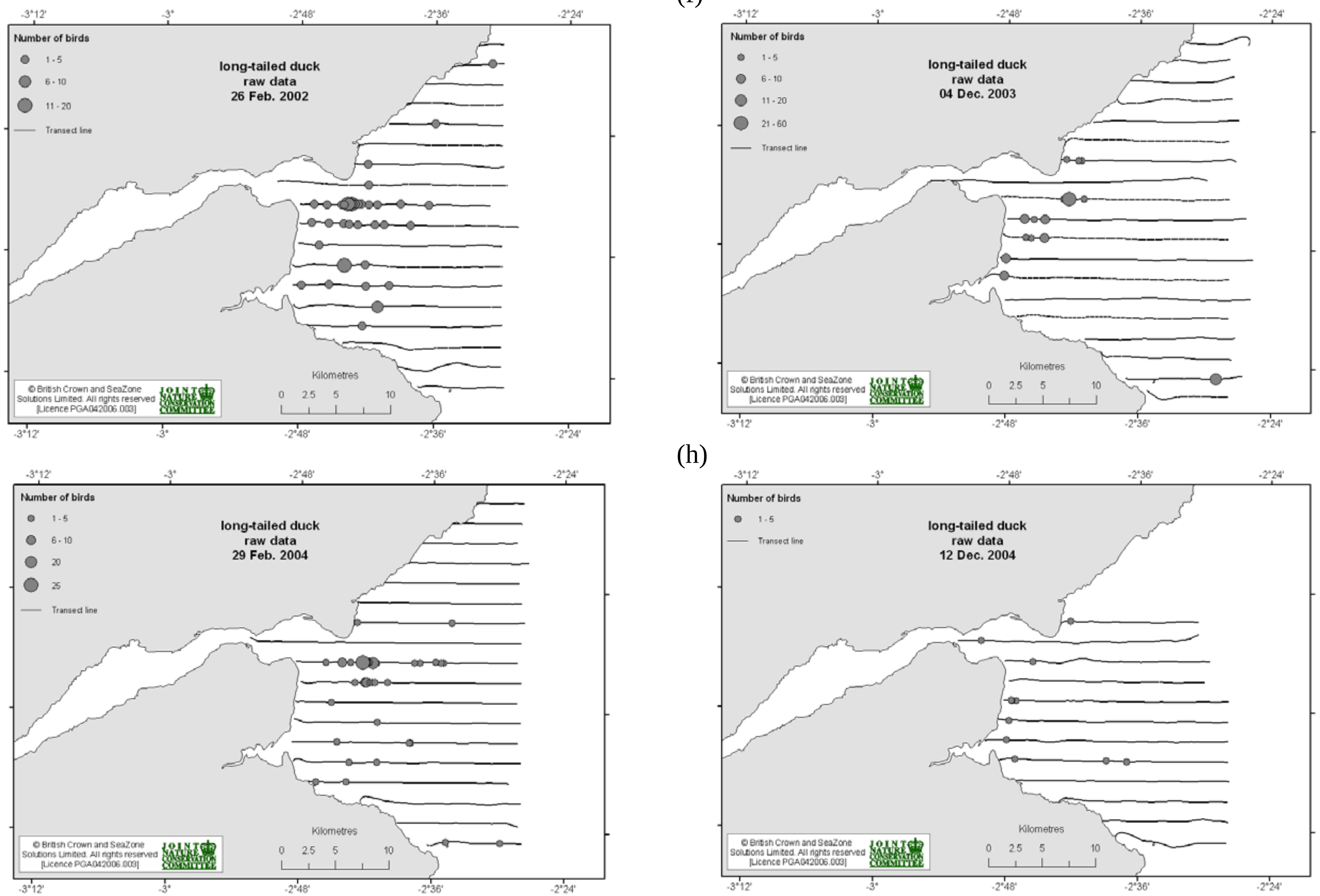
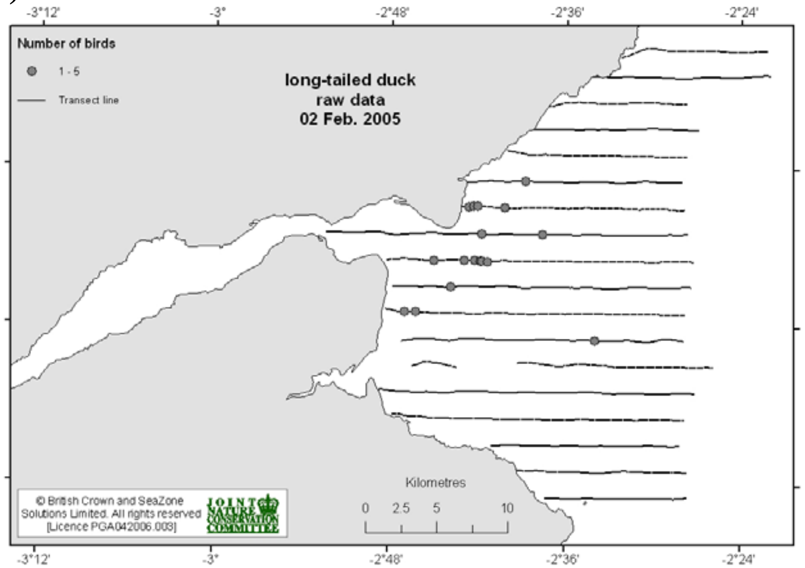


Figure 1.4 (cont.): Distribution of long-tailed duck in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line transect aerial surveys (d-j)

(i)



(j)

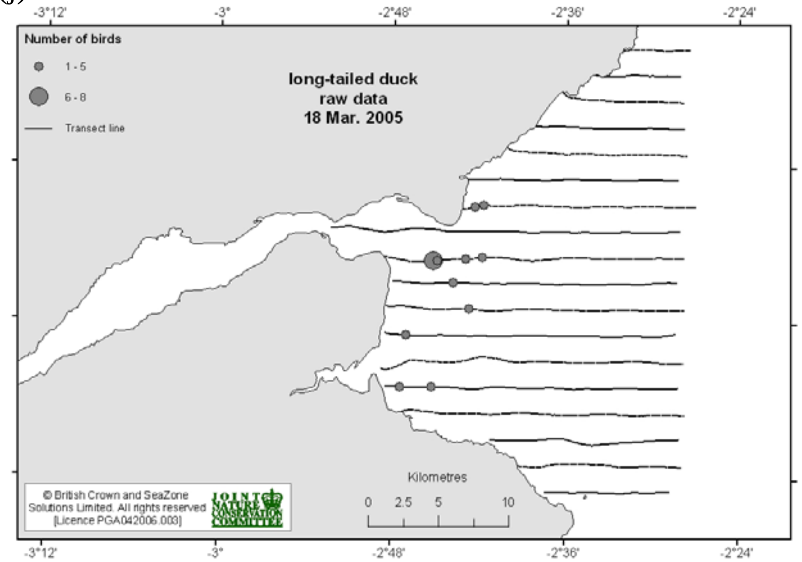


Figure 1.5: Distribution of red-breasted merganser in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line transect aerial surveys (d-h)

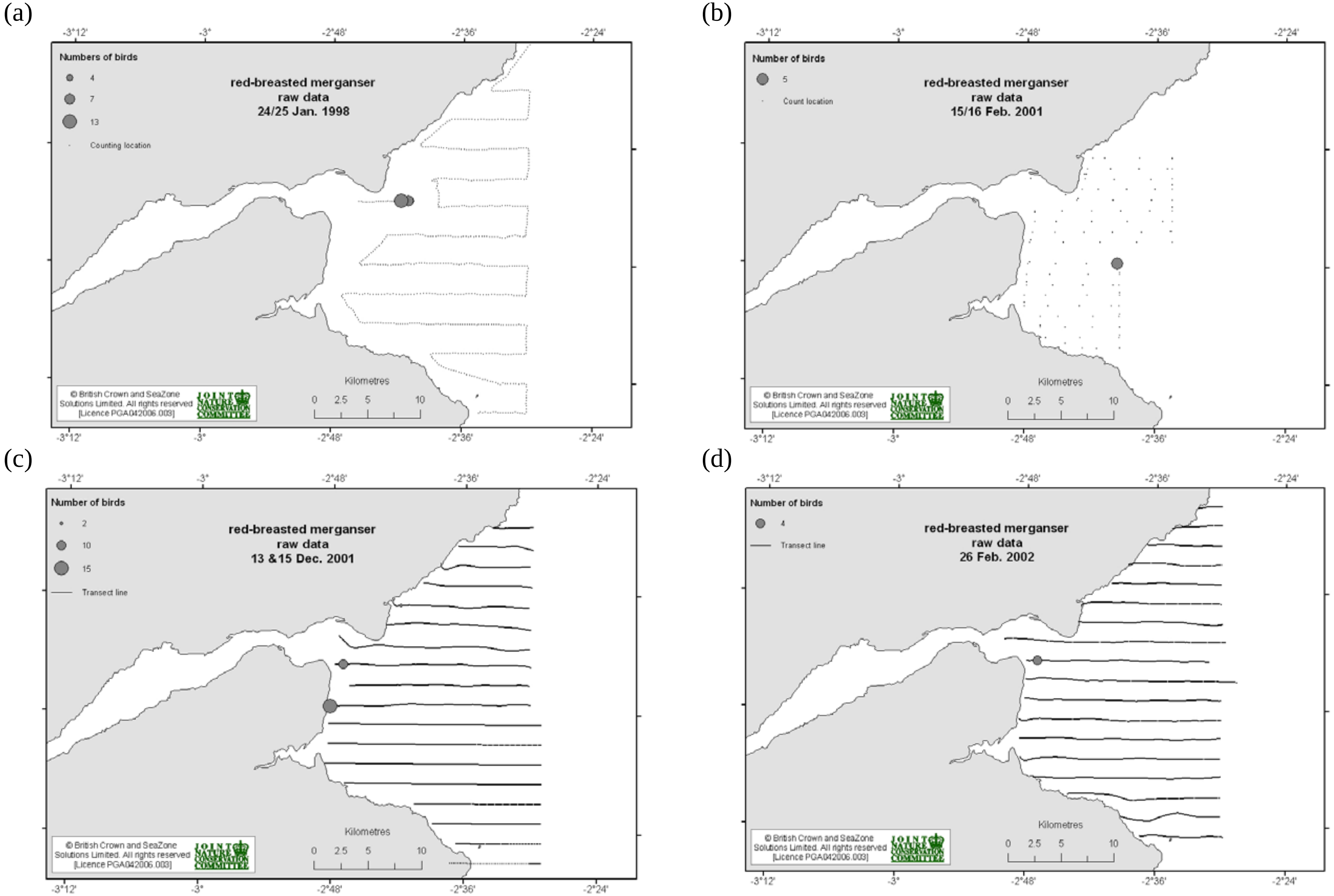
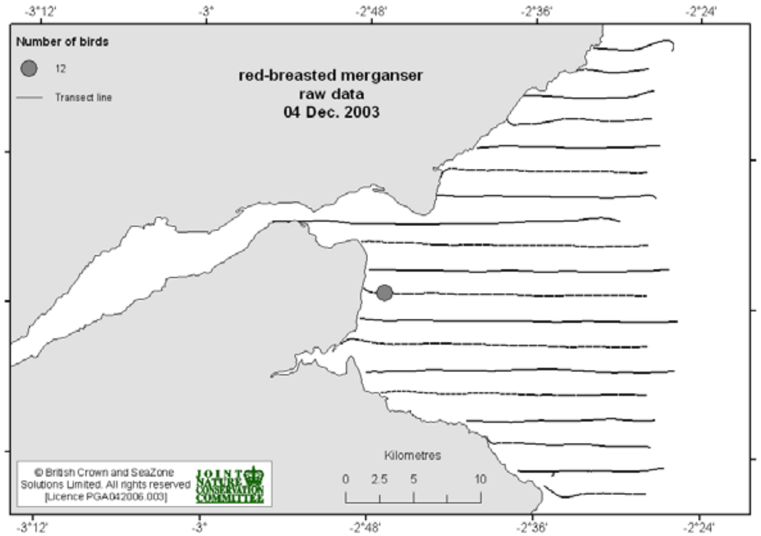
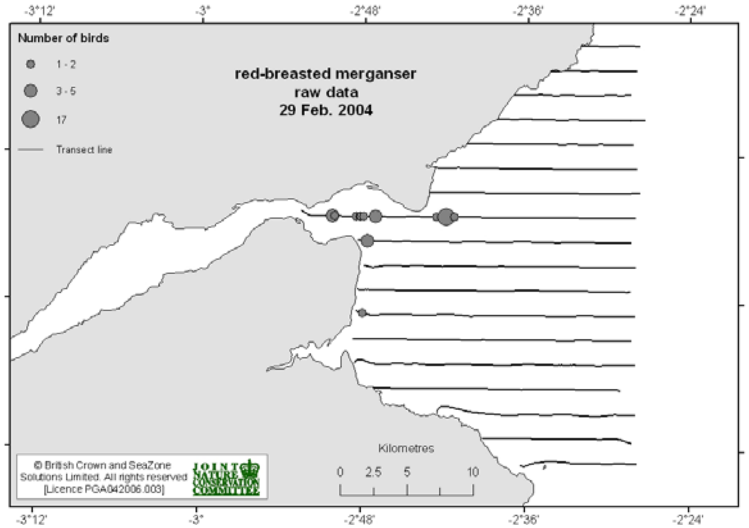


Figure 1.5 (cont.): Distribution of red-breasted merganser in Tay Bay observed during line transect boat survey (a), strip transect aerial surveys (b, c) and line transect aerial surveys (d-h)

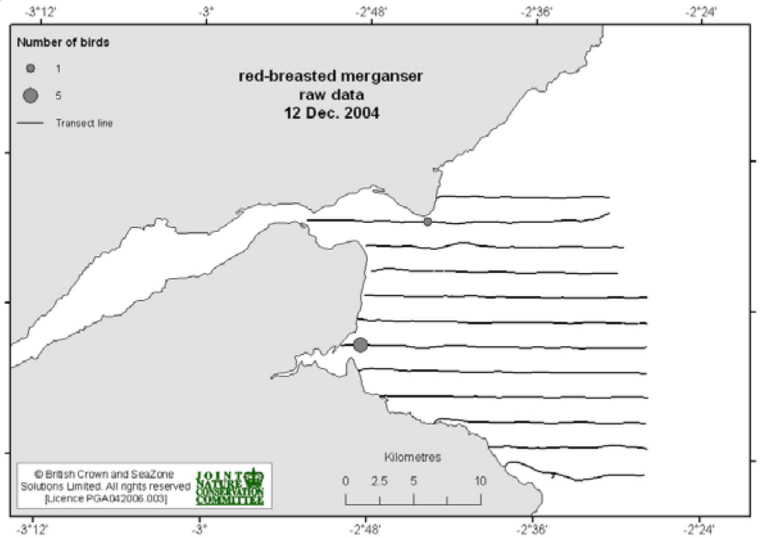
(e)



(f)



(g)



(h)

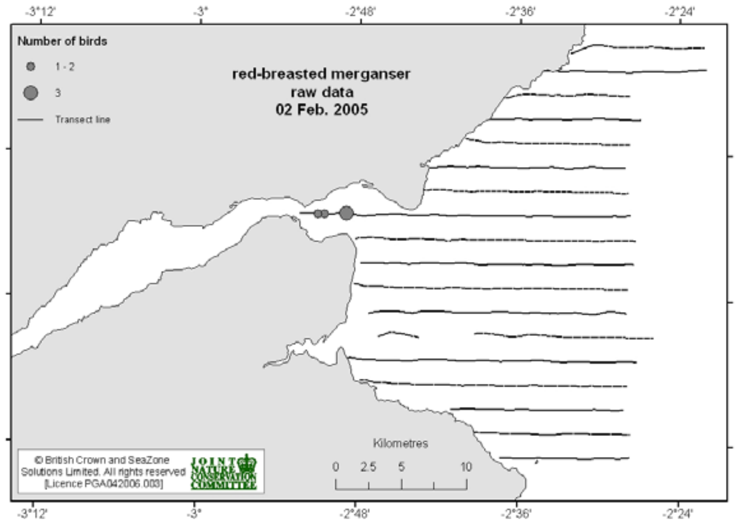
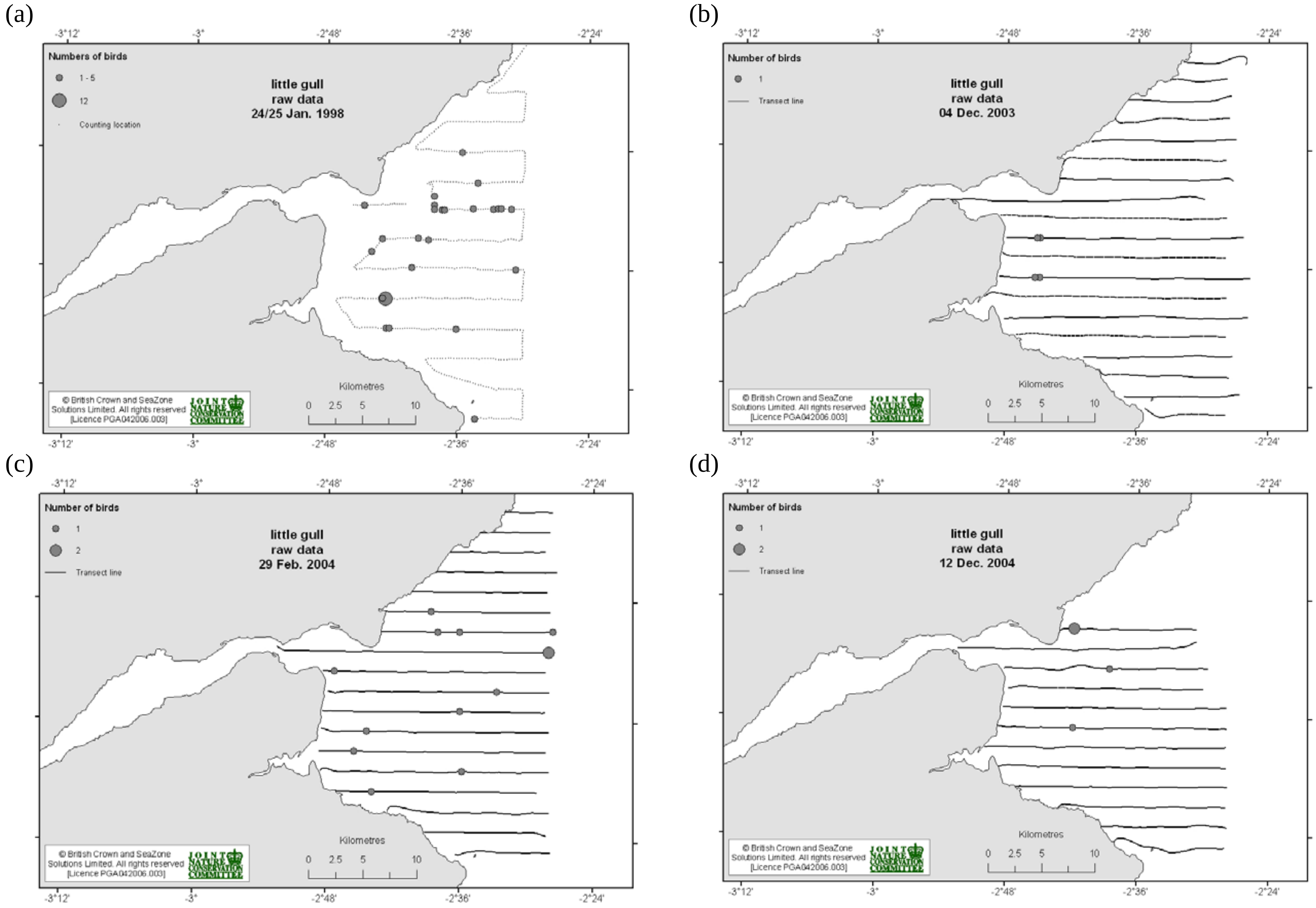


Figure 1.6: Distribution of little gull in Tay Bay observed during line transect boat survey (a) and line transect aerial surveys (a-d)



APPENDIX 2: Detailed population estimates

Red-throated diver

Table 2.1: 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 Tay Bay. 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 (CI)
Season 1997/1998						
24/25 Jan. 1998	24	216	-	428.36	0.903*	387*
Season 2001/02						
13&15 Dec. 2001	18	12	11	447.17	0.122 (0.050-0.296)[b]	54 (20-101)[b]
26 Feb. 2002	18	12	10	457.28	0.120 (0.054-0.269)[b]	55 (24-123)[b]
Season 2003/04						
04 Dec. 2003	18	57	29	574.19	0.901 (0.446-1.819)[e]	517 (256-1045)[e]
29 Feb. 2004	18	137	88	520.84	3.0499 (2.163- 4.300)[e]	1589 (1127-2240)[e]
Season 2004/05						
12 Dec. 2004	12	20	14	400.74	0.288 (0.143-0.578)[e]	115 (57-231)[e]
02 Feb. 2005	18	33	22	553.41	0.466 (0.260-0.837)[b]	258 (114-421)[b]
18 Mar. 2005	18	20	18	509.77	0.248 (0.114-0.539)[e]	126 (58-275)[e]

Common eider

Table 2.2: Density and population estimates for common eider from line-transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in Tay Bay. 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) estimates.

Survey date	No. transects	No. observed	No. flocks	Survey area (km^2)	Density [birds/ km^2] (CI)	Total number (CI)
Season 1997/98						
24/25 Jan. 1998	24	5294	-	428.36	12.373*	5300*
Season 2001/02						
13&15 Dec. 2001	18	260	50	447.17	4.035 (2.139-7.618)[e]	1804 (956-3406)[e]
26 Feb. 2002	18	1018	108	457.28	9.811 (5.361-17.956)[e]	4486 (2451-8211)[e]
Season 2003/04						
04 Dec. 2003	18	3774	64	574.19	31.580[+] (9.0399-110.32)[e]	20333[+] (5191-63347)[e]
29 Feb. 2004	18	3017	148	520.84	31.065 (16.577-58.212)[e]	16180 (8634-30319)[e]
Season 2004/05						
12 Dec. 2004	12	2678	57	400.74	21.704[+] (8.163-57.709)[e]	10398[+] (3271-23127)[e]
02 Feb. 2005	18	3432	97	553.41	6.622 (3.231-13.572)[e]	3665 (1788-7511)[e]
18 Mar. 2005	18	992	176	509.77	4.452 (2.634-7.526)[e]	2270 (1343-3836)[e]

Scoter species

Table 2.3: Density and population estimates for common scoter from line-transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in Tay Bay. 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 (CI)
Season 1997/98						
24/25 Jan. 1998	24	1116	-	428.36	3.441*	1474*
Season 2001/02						
13&15 Dec. 2001	18	547	24	447.17	6.819 (2.591-17.942)^{b}	3049 (732-7123)^{b}
26 Feb. 2002	18	565	41	457.28	7.292^{+} (3.461-15.362)^{e}	3634^{+} (1583-7025)^{e}
Season 2003/04						
04 Dec. 2003	18	717	18	574.19	0.920^{+} (0.410-2.066)^{e}	1028^{+} (235-1186)^{e}
29 Feb. 2004	18	267	27	520.84	3.733^{+} (1.475-9.451)^{e}	2165^{+} (768-4923)^{e}
Season 2004/05						
12 Dec. 2004	12	1085	11	400.74	0.898 (0.156-5.161)^{b}	360 (63-2068)^{b}
02 Feb. 2005	18	305	34	553.41	2.050 (0.866-4.852)^{b}	1134 (479-2685)^{b}
18 Mar. 2005	18	448	64	509.77	3.231 (1.498-5.206)^{b}	1,647 (764-2654)^{b}

Velvet scoter

Table 2.4: Density and population estimates for velvet scoter from line-transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in Tay Bay. Estimates were derived from extrapolation of raw counts.

Survey date	No. transects	No. observed	No. flocks	Survey area (km^2)	Density [birds/ km^2] (CI)	Total number (CI)
Season 1997/98						
24/25 Jan. 1998	24	206	-	428.36	0.654	280
Season 2001/02						
13&15 Dec. 2001	18	3	1	447.17	0.051	23
26 Feb. 2002	18	6	3	457.28	0.032	15
Season 2003/04						
04 Dec. 2003	18	69	3	574.19	0.985	566
29 Feb. 2004	18	0	0	520.84	No observations	
Season 2004/05						
12 Dec. 2004	12	0	0	400.74	No observations	
02 Feb. 2005	18	0	0	553.41	No observations	
18 Mar. 2005	18	3	1	509.77	0.007	4

All scoters

Table 2.5: Density and population estimates for all scoters from line-transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in Tay Bay. 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 (CI)
Season 1997/98						
24/25 Jan. 1998	24	1322	-	428.36	4.095*	1754*
Season 2001/02						
13&15 Dec. 2001	18	550	25	447.17	6.674 (2.585-17.231)[b]	2984 (758-6515)[b]
26 Feb. 2002	18	1166	60	457.28	11.669 (5.699-23.893)[e]	5336 (2606-10923)[e]
Season 2003/04						
04 Dec. 2003	18	891	26	574.19	1.739 (0.833-3.634)[e]	999 (478-2086)[e]
29 Feb. 2004	18	267	27	520.84	3.733[+] (1.475-9.451)[b]	1945[+] (768-4923)[b]
Season 2004/05						
12 Dec. 2004	12	1585	12	400.74	3.169 (0.667- 15.044)[b]	1270 (233- 5330)[b]
02 Feb. 2005	18	305	34	553.41	2.050 (0.866-4.852)[b]	1134 (479-2685)[b]
18 Mar. 2005	18	451	65	553.41	3.244 (1.692-6.217)[b]	1654 (819-2681)[b]

Long-tailed duck

Table 2.6: 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 Tay Bay. 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 (CI)
Season 1997/98						
24/25 Jan. 1998	24	78	-	428.36	0.259*	111*
Season 2001/02						
13&15 Dec. 2001	18	69	16	447.17	2.804 (1.041-7.549)[e]	1254 (466-3376)[e]
26 Feb. 2002	18	116	36	457.28	1.579 (0.674-3.700)[b]	722 (216-1362)[b]
Season 2003/04						
04 Dec. 2003	18	159	17	574.19	1.227 (0.440-3.420)[e]	705 (253-1964)[e]
29 Feb. 2004	18	159	36	520.84	2.757 (1.162-6.542)[e]	1436 (605-3407)[e]
Season 2004/05						
12 Dec. 2004	12	21	11	400.74	0.585 (0.252-1.362)[e]	235 (101-546)[e]
02 Feb. 2005	18	32	17	553.41	0.529 (0.230-1.216)[e]	293 (128-673)[e]
18 Mar. 2005	18	27	11	509.77	0.534 (0.217-1.315)[e]	272 (111-671)[e]

Red-breasted merganser

Table 2.7: 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 Tay Bay. Estimates were derived from extrapolation of raw counts, except for 29 February 2004, which was derived from distance sampling. 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 (CI)
Season 1997/98						
24/25 Jan. 1998	24	0	-	428.36	0.007	3
Season 2001/02						
13 & 15 Dec. 2001	18	27	3	447.17	0.460	206
26 Feb. 2002	18	4	1	457.28	0.069	32
Season 2003/04						
04 Dec. 2003	18	12	1	574.19	0.171	98
29 Feb. 2004	18	38	12	520.84	0.550 (0.139-2.172)[b]	287 (0-817)[b]
Season 2004/05						
12 Dec. 2004	12	6	2	400.74	0.115	46
02 Feb. 2005	18	6	3	553.41	0.044	25
18 Mar. 2005	18	0	0	509.77	0	0

Little gull

Table 2.8: Density and population estimates for little gulls from line-transect boat and aerial surveys carried out during 1998 and from 2001 to 2005 in Tay Bay. 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 1997/98						
24/25 Jan. 1998	24	49	-	428.36	0.524*	216*
Season 2001/02						
13 & 15 Dec. 2001	18	0	0	447.17	No observations	
26 Feb. 2002	18	0	0	457.28	No observations	
Season 2003/04						
04 Dec. 2003	18	4	4	574.19	0.028	16
29 Feb. 2004	18	13	12	520.84	0.085	44
Season 2004/05						
12 Dec. 2004	12	4	3	400.74	0.038	15
02 Feb. 2005	18	0	0	553.41	No observations	
18 Mar. 2005	18	0	0	509.77	No observations	