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The numbers of inshore waterbirds using the Greater Wash during the non-breeding season; an assessment of the area's potential for qualification as a marine SPA

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Contents

1 Summary

The Greater Wash is known to support large numbers of inshore waterbirds over the winter period. Three existing SPAs in the area currently afford some protection to some of these species; however these areas do not extend beyond the low water mark. This report describes analyses of data from aerial surveys of inshore waterbirds conducted in the Greater Wash area. Numbers of divers, grebes, scoter and little gulls (*Larus minutus*) using the waters of the Greater Wash are analysed and assessed against guideline thresholds, to determine whether the area or part of it qualifies as an SPA under the EC Birds Directive. Species distributions using the raw count data are presented in this report. Detailed spatial analyses of bird distributions and boundary location options will be required for any potential Special Protection Area, and these will be presented in a separate report if required.

Data from aerial surveys of the Greater Wash carried out over seven seasons (1988/89, 1989/90, 1991/92, 2002/03, 2004/05, 2005/06 and 2006/07) are described in this report. Aerial surveys carried out during the first three seasons were conducted using strip-transect methods, and the data from these are total counts of birds using the area surveyed. Aerial surveys during the latter four 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 (*Gavia stellata*) population that winters around Great Britain was present within the inshore waters of the Greater Wash in all seasons surveyed. The mean of peak counts across seasons was 1,633 birds. The Greater Wash area therefore qualifies for SPA status, for red-throated divers, under stage 1.1 of the UK SPA guidelines. Red-throated divers were distributed throughout the Greater Wash, with the main concentrations being fairly mobile throughout, both within and across years.

Little gulls were present within the inshore waters of the Greater Wash in significant numbers and were particularly concentrated in the area north east of the Inner Wash. On the basis of two seasons' data, and if a 1% (default) threshold level of 50 birds is used, the Greater Wash qualifies at stage 1.1 of the guidelines as an SPA for little gulls. However, additional, comprehensive surveys are required to determine whether this species regularly occurs in this area.

Population estimates for common scoter (*Melanitta nigra*) had very large confidence intervals and were not considered reliable. However, these estimates in conjunction with the raw data and data from other sources, suggest that the common scoter population in the Greater Wash area does not exceed 1% of the biogeographic wintering population. The Greater Wash area does not therefore qualify for SPA status, for common scoters, under stage 1.2 of the UK SPA guidelines.

Based on the available data, fewer than 20,000 waterbirds regularly use the inshore waters of the Greater Wash area; the area does not therefore qualify for SPA status as a waterbird assemblage under Stage 1.3 of the UK SPA guidelines.

2 Introduction

This report describes analyses of data from aerial surveys of inshore waterbirds conducted in the Greater Wash area, to determine whether the area or part of it qualifies as an SPA under the EC Birds Directive (EEC, 1979). These aerial surveys were carried out by the Nature Conservancy Council (NCC) in 1989 and 1991 and the Wildfowl and Wetlands Trust (WWT) from 2003 – 2007. NCC surveys were carried out as part of Phase 3 of the NCC Seabirds at Sea project, whereas WWT surveys were commissioned in response to proposals to develop wind farms in the Greater Wash and in other areas around the UK. The Greater Wash, as defined herein, encompasses the area shown in Figure 1 and stretches from Bridlington Bay (East Riding) in the north, to where the Norfolk coast meets the Suffolk coast in the south. It includes much of the proposed strategic area identified by the Crown Estates and the DTI as appropriate for offshore wind farm development (DTI 2002).

The Wash itself is the largest estuarine system in the UK and comprises very extensive saltmarshes, major intertidal banks of sand and mud, shallow waters and deep channels. It is fed by the rivers Witham, Welland, Nene and Great Ouse that drain much of the east Midlands of England. Several SACs and SPAs have been designated within the Greater Wash area (Stroud *et al,* 2001). The Wash and the North Norfolk Coast both qualify as SACs under the Habitats Directive because of their Annex I habitat types, including coastal lagoons. The Wash qualifies as an SPA on account of its populations of marsh harriers (*Circus aeruginosus*) and a variety of waterbird species. During winter, the area regularly supports around 400,000 individual waterbirds, including little grebe (*Tachybaptus ruficollis*) and Eurasion wigeon (*Anas penelope*), so the area also qualifies as an SPA because of its important assemblage of species. To the north, the coastal habitats of The Wash are continuous with Gibraltar Point SPA (Figure 1). Gibraltar Point SPA consists of a sand-dune system, saltmarsh and intertidal flats and is designated under Article 4.1 of the Directive for its breeding little terns (*Sterna albifrons*) and wintering bar-tailed godwit (*Limosa lapponica*), and under Article 4.2 of the Directive for its wintering grey plover (*Pluvialis squatarola*) and knot (*Calidris canuta*). It also qualifies under Stage 1.3 of the SPA selection guidelines by regularly supporting over 20,000 waterbirds. To the east The Wash adjoins the North Norfolk Coast SPA (Figure 1), which contains some of the best examples of saltmarsh in Europe. The North Norfolk coast supports populations of European importance of hen harriers (*Circus cyaneus*), and a variety of tern and wader species listed in Annex 1. The site also qualifies under Article 4.2 of the Directive by supporting populations of European importance of waders, ducks and geese. It also qualifies under Stage 1.3 of the SPA selection guidelines by regularly supporting over 20,000 waterbirds, including Eurasian wigeon, northern pintail *Anas acuta*, common scoter and velvet scoter (*Melanitta fusca*).

These SPAs have been designated using land-based counts, which provide coverage for species concentrated close to the shore but often significantly underestimates species occurring further offshore, such as divers and seaduck (Webb & Reid 2004). These SPAs offer protection for various waterbirds, but these birds also use the open waters of the Greater Wash area, outside of the existing SPAs. The aim of the analyses described in this report is to determine whether the inshore environment of the Greater Wash, or a part thereof, qualifies for SPA status in respect of the inshore waterbirds it hosts outwith the breeding season, and which occur further offshore than existing SPAs. If the investigated areas of the Greater Wash meet appropriate Stage 1 thresholds under the UK SPA Site Selection Guidelines then it may be considered further for classification, necessitating additional analyses of the data presented herein in order to define site boundaries.

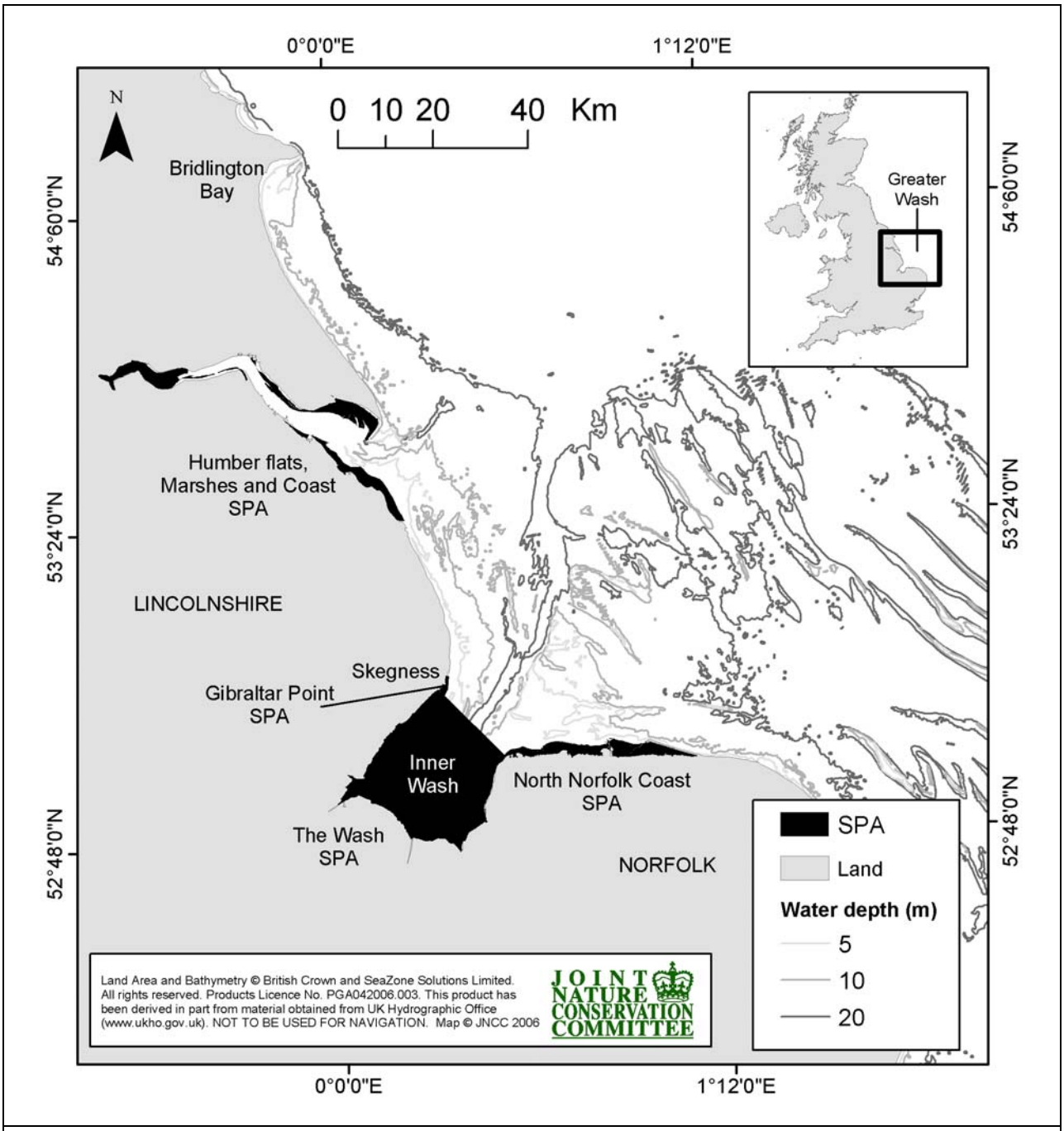

Figure 1. The Greater Wash study area, showing the existing SPAs of The Wash, North Norfolk Coast, Gibraltar Point and Humber Flats, Marshes and Coast.

3 Methods

3.1 Data collection

All surveys were carried out from an aircraft flown at low altitude over the sea, using experienced observers to count all species seen. The following two methods were employed.

3.1.1 NCC Surveys: Strip transects (1989 and 1991)

Surveys by NCC between January 1989 and December 1991 were carried out from an aircraft flown at 60m (200ft) above the sea, at a speed of 185kmh^{-1} (100knots). Two parallel, continuous 180m wide strip-transects were flown at four and nine kilometres from the coast (Figure 2). One observer recorded bird observations from one side of the aircraft, and observations were divided into 1 minute recording periods (see Barton *et al*, 1993 for a fuller description of methods). Although these surveys covered a greater length of coastline than the line-transects described below, the area of coverage was less (Figures 2 – 4).

3.1.2 WWT Surveys: Line transects (2003 – 2007)

Surveys by WWT were carried out from an aircraft flown in a systematic pattern of line-transects, designed to repeatedly cross environmental gradients such as sea depth. A Partenavia PN68 aircraft was used, flying at an altitude of 76m (250ft) and a speed of approximately 185kmh^{-1} (100knots). Two observers counted from either side of the aircraft. All observations were allocated to a distance category based on the perpendicular distance of the observation from the aircraft trackline. This 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 numbers of birds actually present (Buckland *et al*, 2001). All observations were allocated to one of four distance bands (A = 44-162m, B = 163-282m, C = 283-426m and D = 427-1000m). Observers were unable to see birds directly below the aircraft so the closest distance band started at 44m from the aircraft. For each bird, or flock of birds, the time at which it was perpendicular to the flight path of the aircraft was recorded using a dictaphone. 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 5 seconds. Full descriptions of the methods are described in Cranswick *et al* (2003) and Kahlert *et al* (2000). The surveys analysed in this report were carried out over four successive years from February 2003 to March 2007 and spanned the months from October to April. In 2003, transects were spaced 4km apart, whereas between 2004/05 and 2006/07, transects were spaced 2km apart to ensure better coverage. In 2003, surveys were carried out in three blocks; East, Central and West (Figure 3). Between 2004/05 and 2006/07, surveys were carried out in six standardised blocks, GW1-6 (Figure 4), although only GW3 and 4 were not surveyed in 2006/07. In 2005, additional surveys were also carried out during the summer in selected section blocks, which were primarily to record tern distribution during the breeding season.

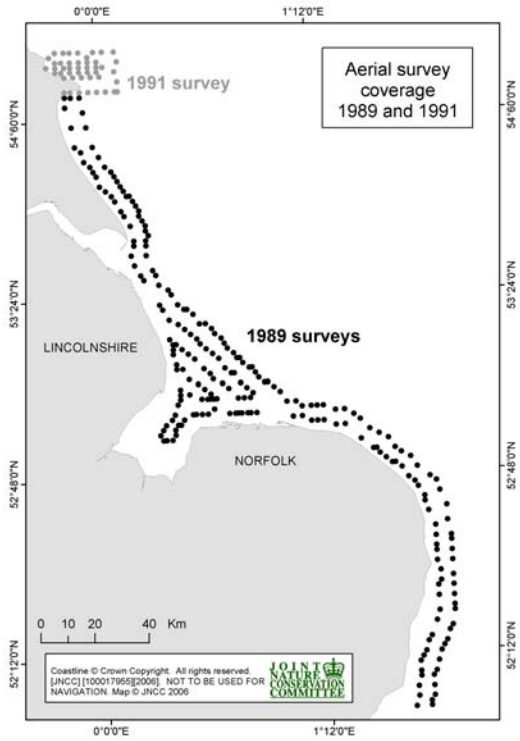

Figure 2. Aerial survey coverage by strip transects in 1989 and 1991.

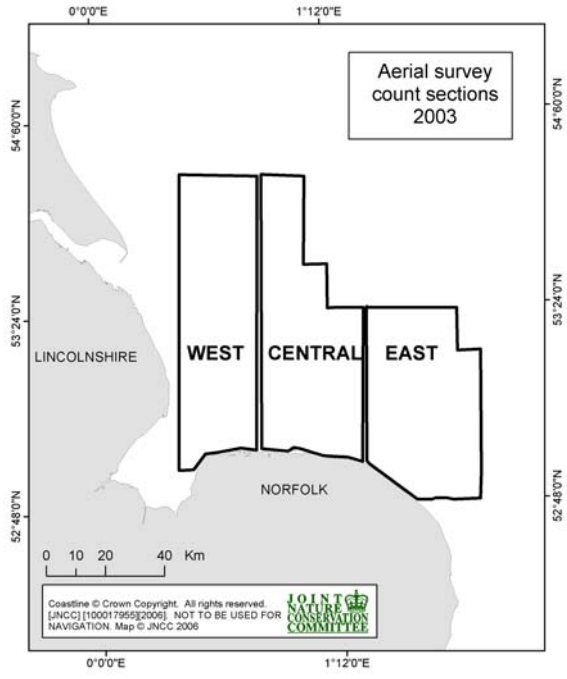

Figure 3. Aerial survey count sections used during 2002/03.

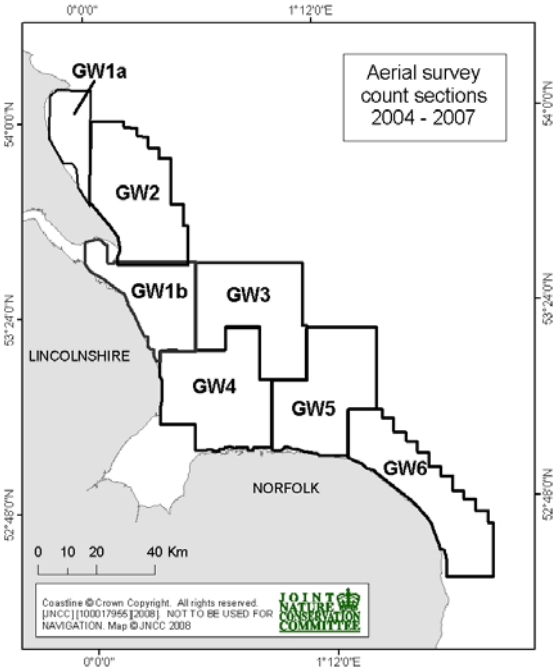

Figure 4. Aerial survey count sections used between 2004/05 and 2006/07.

3.2 Estimating population size

For the purposes of this report, only data on inshore waterbirds (divers, grebes and seaduck) and little gulls are presented. Of all divers observed during line-transect surveys (1,692), 14 were identified as great northern divers (*Gavia immer*), while the remainder were recorded either as red-throated diver or unidentified diver species. Consequently, the majority of unidentified diver observations were assumed to be red-throated divers; the small amount of error (0.8%) was deemed acceptable and analyses for red-throated divers were performed on combined red-throated- and unidentified diver data.

Data were analysed for each survey section individually as well as for the whole of the Greater Wash. 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, either where data were collected as strip-transects (1989 and 1991), or if there were insufficient data to apply distance sampling methods. In carrying out distance sampling, data were analysed using the software *Distance* 4.1.2. (Thomas *et al*, 2004). For each species and survey, half-normal models or hazard rate models, both with zero adjustments and with the size-bias regression method of cluster size estimation, provided the best fit to the data on the basis of minimising the Akaike Information Criterion (AIC). 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. 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. Transects were therefore assumed to be 476m wide, i.e. $2\times(282 - 44)$. This was multiplied by the length of survey transect flown to give the area over which observers counted. The number of birds observed in bands A and B was divided by area counted to give a mean density. This density was extrapolated across the total surveyed area to allow an estimate of population size.

The data for common scoter were not suitable for distance sampling analyses at either the survey section level or for each survey period. This was due to either sample sizes (number of flocks) being too low, or because the data violated distance sampling assumptions, e.g. 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. For the same reasons, extrapolation from raw counts in bands A and B gave spurious results. To overcome these problems, data for all surveys (excluding 2006/07) were pooled for distance analyses and all flocks comprising more than 100 birds were removed from the analysis. A global detection function was generated using all data, and this was used to calculate density estimates for each individual survey period. The final distance estimate for each survey period was then added to the raw count of birds that were in flocks comprising more than 100 birds (and were considered to be accurate counts). The few additional data collected during 2006/07 only became available after this analysis was completed and are simply presented as raw counts.

4 Results

4.1 Numbers of birds counted

Fifty-seven days of survey data in the Greater Wash collected during 1989 and 1991, and between February 2003 and March 2007, were analysed. During the surveys, 10 species and three unidentified species of inshore waterbird were recorded, as well as little gulls. Data for other species that were recorded (e.g. auks, waders, gulls other than little gulls, cetaceans) are not presented here. The total numbers of birds and flocks, of each species and for each survey section are presented in Appendix 1 (which includes survey data collected from May to September 2005; these are not discussed further in this report). Data from line transect aerial surveys carried out from February 2003 to March 2007 are summarised below in Table 1, for particular species of interest.

Table 1. Summary of the total number of birds (and flocks) counted in the Greater Wash during line-transect aerial surveys during each survey period from February 2003 to March 2007, for selected species of interest.

Season	Survey period	Red-throated diver	Great northern diver	Un-identified diver	Great crested grebe *Podiceps cristatus*	Un-identified grebe	Common scoter	Little gull
2003	Feb	14 (10)		25 (25)			2042 (6)	
	Mar	39 (28)		108 (57)			170 (9)	
2004 / 05	Oct /Nov	33 (32)		98 (89)			1141 (30)	330 (250)
	Nov / Dec	32 (28)	10 (7)	113 (101)		1(1)	3217 (28)	95 (82)
	Jan / Feb	20 (20)		106 (100)			2105 (10)	5 (5)
	Feb / Mar	7 (7)		220 (192)	1(1)	7 (2)	3109 (8)	
2005 / 06	Nov			83 (79)			50 (2)	222 (153)
	Nov / Dec	9 (9)		76 (68)		5 (2)	205 (8)	33 (26)
	Jan / Feb	32 (23)	1 (1)	242 (158)			950 (5)	11 (5)
	Feb / Mar	68 (53)	1(1)	280 (215)		3 (2)	1275 (6)	3 (1)
2006/07	Jan/Feb	35 (30)	2(2)	147 (116)			2877 (5)	2 (1)
	Feb/Mar	40 (32)		54 (38)			41 (3)	(1)

4.2 Distribution of bird observations

Distributions of divers, grebes, common scoter and little gull are presented in Appendix 2, Figures 1-4. Numbers of other species were considered insignificant in the SPA context, and were too low to draw any meaningful conclusions on their distribution.

4.2.1 Divers (Appendix 2, Figure 1, a-o)

Divers were observed in all count sections of the Greater Wash. As there were so few great-northern divers recorded, distributions are only described here for red-throated and unidentified divers (assumed to be red-throated divers). In some surveys, red-throated divers appeared to be more concentrated close to shore (e.g. November/December 2004 and January/February 2006), but in others their distribution was more dispersed across the survey area (e.g. January/February 2005 and February – April 2005). Thus, red-throated divers occur in the whole survey area. However, there appeared to be a tendency for birds to be distributed within GW4 and immediate adjacent coasts, as well as close inshore along the Norfolk coast, with fewer birds around the mouth of the Humber estuary and the East Riding coast.

4.2.2 Grebes (Appendix 2, Figure 2, a–d)

The numbers of grebes observed were low, but it is interesting to note that most of them (13 of the 17) were observed along the north Norfolk coast and close inshore.

4.2.3 Common scoter (Appendix 2, Figure 3, a–l)

Common scoters were observed almost exclusively within section GW4, immediately adjacent to the Inner Wash. High numbers recorded during the November/December 2004 survey were very densely aggregated along the Norfolk coast within GW4. Most observations of scoter were within around 3km of the coast, although some of the larger flocks (e.g. 500, 700 and 2800 birds) were around 13km from the coast.

4.2.4 Little gulls (Appendix 2, Figure 4, a–g)

Although little gulls were observed throughout the survey area, the majority of them were recorded in sections GW3 and GW4. Particularly large numbers in these areas were observed during the October/November 2004 and the November 2005 surveys.

4.3 Population estimates

Population estimates reported here were derived from either 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). Confidence intervals are not given for extrapolated counts.

4.3.1 Red-throated diver population estimates

Population estimates for red-throated divers were estimated from red-throated diver and unidentified diver observations combined. Detailed results for each survey section are

presented in Appendix 3 (Tables 1 and 2). Summaries of these results are presented below, in Tables 2 and 3.

Table 2. Summary of red-throated diver population estimates in the Greater Wash, during each survey period between 2004/05 and 2006/07, for each survey section. Note the large confidence intervals associated with these estimates (see Appendix 3, Table 2). GW1 and 2 are considered together as these areas were divided differently between surveys.

Season	Survey period	GW 1 and 2	GW 3	GW 4	GW 5	GW 6	GW1 - 6
2004/05	Oct / Nov	186	32	280	131	46	675
	Nov / Dec	158	16	775	37	163	1266
	Jan / Feb	397	211	170	17	182	963
	Feb - Apr	390	102	385	233	218	1148
2005/06	Nov	124*	4	284	0	418	828
	Nov / Dec	106	35	24	20	345	661
	Jan / Feb	288	16	229	38	786	1641
	Feb / March	615	20	778	319	827	2078
2006/07	Jan / Feb	987	n/a	n/a	218	384	1163
	Feb / Mar	322	n/a	n/a	336	227	804
% (and number) of surveys with qualifying numbers		**70% (7/10)**	**13% (1/8)**	**88% (7/8)**	**40% (4/10)**	**80% (8/10)**	**100% (10/10)**

*This is an estimate for GW2 only as GW1 was not surveyed in Period 1 of 2005/06

Table 3. Maximum seasonal population estimates of red-throated divers in the Greater Wash. The one survey in 1991 (December) is not included due to the small area of coverage. It is important to note that survey coverage differs substantially between seasons.

Season	Maximum estimate	Date
1988/89	409	8/9 January 1989
1989/90	2494	5/6 November 1989
2002/03	1165	13-14 March 2003
2004/05	1266	November / December 2004
2005/06	2078	February / March 2006
2006/07	1163	January / February 2007
Mean of maximum estimates	**1633**	

4.3.2 Grebe species population estimates

It was not possible to generate population estimates from the raw counts of grebes due to the small number of observations.

4.3.3 Common scoter population estimates

There were too few observations in both the March 1989 and the December 1991 strip-transect surveys and the surveys carried out Jan-March 2007, to permit reliable extrapolation of density to the whole survey area. For surveys during 2003-2006, the population estimates

generated by distance analysis for common scoter that were in flocks of 100 or fewer birds (see methods in 3.2) had very large confidence intervals associated with them (Appendix 3, Table 3). Although it is not possible to attach confidence intervals for the final total estimate (which includes birds that were in flocks of more than 100 birds), it is expected that a similar very low level of confidence would apply. For this reason, the population estimates for common scoter are not considered reliable.

4.3.4 Little gull population estimates

Little gulls were only surveyed during the seasons of 2004/05 – 2005/06 and Periods 3 and 4 of 2006/07. No little gulls were observed during Period 4 of 2004/05 or Period 3 of 2006/07. Results for each survey section are presented in Appendix 3 (Table 4) and summarised below in Table 4.

Table 4. Summary of little gull population estimates in the Greater Wash, during each survey period between 2004/05 and 2006/07, for each survey section. Estimates were derived from distance sampling, except from those marked with an asterix (*), which were derived from extrapolation of raw counts.

Season	Survey period	GW 1 and 2	GW 3	GW 4	GW 5	GW 6	GW1 - 6
2004/05	Oct / Nov	13*	1173	433	84	43*	1707
	Nov / Dec	29*	102	305	8*	175	798
	Jan / Feb		16*	4*			
2005/06	Nov			1533	96		
	Nov / Dec	4*	157	95	17*	25*	283
	Jan / Feb			35*	9*		
	Feb / March			13*			
2006/07	Feb/Mar		n/a	n/a	4*		

5 Discussion

5.1 SPA qualification

Selection guidelines for SPAs in the UK (JNCC 1999) advise that SPAs be selected in two stages. Stage 1 selection requires that numbers of species listed on Annex 1 of the EC Birds Directive should exceed 1% of the agreed GB (or if relevant the All Ireland) population for the species on a regular basis (Stage 1.1). For migratory species not listed on Annex 1 of the EC Birds Directive, numbers at a site should exceed 1% of the agreed biogeographical population for the species on a regular basis (Stage 1.2). For assemblages, more than 20,000 waterbirds (as defined by the Ramsar Committee) should occur regularly at a site (with at least two species present with over 1% of the biogeographical or national populations or over 2000 individuals) (Stage 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 stated in *The Convention on Wetlands* (Ramsar, Iran, 1971), where 'the requisite number of birds is known to have occurred in two thirds of the seasons for which adequate data are available' or when available, 'the mean of the maxima of those seasons in which the site is internationally important, taken over at least five years' exceeds the selection threshold.

To determine whether the Greater Wash qualifies 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 1 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 2002). In the case of red-throated diver (which are listed on Annex 1), the GB wintering population estimate in Baker (2006) is known to be a significant underestimate (O'Brien *et al*, 2008). The population estimate of red-throated divers in the Greater Wash was instead compared with the newly revised GB wintering population estimate of 17,000 (O'Brien *et al*, 2008); a qualification threshold of 170 individuals. In addition, there is currently no published estimate of the wintering population of little gulls (also listed on Annex 1), so the default minimum threshold of 50 individuals was applied (as recommended by the SPA Scientific Working Group), following Stroud *et al* (2001).

5.2 Distance analyses

Data were analysed at the individual survey section level, as sections were often surveyed on different days (and hence under different observing conditions) and by different observers, making it likely that detection functions would vary between different survey sections (Buckland *et al*, 2001). Estimates of numbers were produced for each survey section, however, the boundaries of the survey sections were determined only by the logistical demands of the aerial surveys. There is no ecological basis to these sections; therefore only the total estimates for the Greater Wash area as a whole should be compared with the relevant qualifying thresholds to determine qualification as an SPA.

5.3 Divers

Population estimates were calculated for red-throated divers and unidentified divers combined, assuming that almost all unidentified divers were red-throated divers. Of the strip-transect surveys (carried out in 1989 and 1991), three of the five surveys recorded qualifying numbers of red-throated divers. In both line-transect surveys carried out in 2003, and in all ten surveys carried out over the winters of 2004/05 - 2006/07, red-throated diver numbers in the Greater Wash area exceeded qualifying numbers (170), with numbers exceeding 1,000 birds in five of the surveys (see section 4.3.1). Peak numbers of red-throated divers exceeded qualifying levels in six out of six winter seasons, and the mean of peak numbers for the five most recent winter seasons (1,633) greatly exceeds the 1% threshold (Table 3).

Numbers in the March 2003 survey were more than double that of the February 2003 survey, despite the March survey covering a smaller area. Numbers were also particularly high in the February / March survey of 2006. To estimate the actual wintering population of red-throated divers in the Greater Wash, O'Brien *et al* (2008) used peak estimates from only January and February aerial surveys in order to minimise the risk of including passage birds. This resulted in a wintering population estimate of 1,244 red-throated divers in the Greater Wash.

As mentioned above, it is inappropriate to use the survey sections to identify sub-areas of the Greater Wash that contain more birds than others, as the boundaries of these are somewhat arbitrary and have no ecological basis. However, it is useful to look at numbers in each section, in conjunction with the distribution maps presented in Appendix 2 (Figure 1), to get an indication of where higher numbers occur. Population estimates for each section on each survey for the winters of 2004/05 to 2006/07 are summarised in Table 2, and the data indicates that sections GW4 (at the seaward side of the Inner Wash) and GW6 (along the east Norfolk coast) have the most regularly occurring high numbers of red-throated divers. However there is substantial variation in population estimates within each section, both within and across seasons. This supports observations that wintering birds are mobile within their wintering areas in response to weather conditions or food supply (Lack 1986). The high number of birds observed in GW6, which extends south to the Suffolk coast, are likely to represent a continuation of the Greater Thames population, which extends north along the Suffolk coast (O'Brien *et al,* 2008).

5.4 Grebes

Most of the grebes observed during aerial surveys were located close inshore along the North Norfolk coast. A total of only 17 grebes was counted over all the surveys, and, apart from one positively identified great crested grebe, it was not possible to identify which species these were. Because grebes tend to be distributed close to shore, they may be overlooked as the aircraft turns at the beginning and end of transects (Dean *et al,* 2003). Thus, land based surveys are likely to be more effective for counting grebes, which allows more accurate identification of species.

Although Wetland Bird Survey (WeBS: a national land based survey) counts are known to be an underestimate for grebes (Collier *et al,* 2005), it is useful to include the most recent counts for the north Norfolk coast here (Table 5). Results from recent WeBS suggest the north Norfolk coast is a nationally important site for red-necked grebes (*Podiceps grisengena*), as the local population exceeds 1% of the Great British population (200 individuals, Baker *et al,*

2006) (Collier 2005, Table 5). Until 2003 (when the 1% threshold was revised from four to seven birds) the north Norfolk coast was also considered nationally important for Slavonian grebes (*Podiceps auritus*) (Cranswick *et al,* 2005, Table 5). It is important however, to note that 50 birds is usually the minimum threshold value used, so neither The Wash, nor the North Norfolk Coast SPAs include these species as qualifying features (Stroud *et al,* 2001).

Table 5. Summary of WeBS counts for grebe species along the North Norfolk coast. Figures are peak counts over the winter period (October – April) from 2000/01 to 2004/05 and the mean for those winter seasons. (WeBS data supplied by BTO)

Species	2000/01	2001/02	2002/03	2003/04	2004/05	Mean
Black-necked Grebe *Podiceps nigricollis*	1		1			1
Great Crested Grebe *Podiceps cristatus*	38	49	34	32	49	40
Little Grebe *Tachybaptus ruficollis*	69	61	38	60	46	55
Red-necked Grebe *Podiceps grisegena*	3	9	2	2	1	3
Slavonian Grebe *Podiceps auritus*	5	6	4	4	4	5

5.5 Common scoters

Most data for common scoters was characterised by small sample sizes and violated the assumptions required to apply distance analysis, so it was not possible to calculate a detection function for individual survey periods. Instead, a global detection function was generated from all survey data (excluding 2006/07) pooled together. This was then applied to data in each survey period to estimate densities and population sizes for each (see Appendix 3, Table 3). Population estimates for each survey period ranged from 188 – 10,865, with a mean of peaks counts of 5,095. However, it is important to note the extremely large confidence intervals associated with each estimate, indicating that these estimates must be used with extreme caution. For example, the population estimate of 227 birds for February / March 2006 has a 95% confidence interval of between 2 birds and 31,631 birds. Data from 2006/07 only became available after this analysis was completed, and are so few that they would not alter the results, thus are excluded.

Cranswick *et al* (2003) reported land-based observations of a flock of 5,000-10,000 common scoters usually found off the northwest Norfolk coast, with the flock often being highly aggregated into one or two groups. Addition anecdotal observations (Peter Cranswick, *personal communication*) suggest that there might be five sites regularly used by common scoter in the area; off Skegness, the western shore of the Inner Wash, Hunstanton, Titchwell and Holkam Bay, although they are not necessarily all used at once. The birds are reported to usually be present close to shore (within 2-3 km) and in a discrete area, the vast majority usually aggregated into just one or two large flocks at any one site.

The two largest population estimates given in this report (10,865 birds in October / November 2004 and 9,586 birds in November / December 2004) are close to the maximum of the range reported by Cranswick *et al,* 2003. Two of the raw counts for the aerial surveys reported here exceeded 3000 birds (23 November 2004, GW4 and 26 February 2005, GW4) with most birds being found close to shore along the north Norfolk coast, adjacent to the Inner Wash. The North Norfolk Coast SPA protects an estimated 2,909 common scoters as

part of the non-breeding waterbird assemblage selected under Stage 1.3 of the SPA selection guidelines (Stroud *et al,* 2001).

It is difficult to draw conclusions from the common scoter population estimates presented here, because of the low confidence attached to them. However, these population estimates, along with the raw data and anecdotal observations reported in Cranswick *et al,* 2003, suggest that numbers of common scoters were not present in qualifying numbers (>16,000 birds) in any surveys within the Greater Wash. The Greater Wash, therefore, does not qualify as an SPA for common scoter.

5.6 Little gulls

During aerial surveys, little gulls are difficult to distinguish from other small gull species (such as kittiwake *Rissa tridactyla,* black-headed gull *Larus ridibundis* and common gull *Larus canus*), so that many little gulls were necessarily recorded simply as 'small gull species'. It is impossible to estimate what proportion of birds recorded as 'small gull species' were actually little gulls, but the true numbers of little gulls within the survey area may have been at least double that recorded (Pete Cranswick, *personal communication*). For the purposes of this report, analyses and discussion are restricted to those birds positively identified as little gulls, with no account taken of the possible proportion recorded as 'small gull species'. It should therefore be borne in mind that the population estimates presented here are likely to be significant underestimates.

Survey data for little gulls were available for three seasons (2004/05 - 2006/07), although surveys were restricted to Periods 3 and 4 during 2006/07. Observers were not sufficiently trained to identify little gulls in earlier surveys. It was only appropriate to estimate the population size of little gulls across the whole area of the Greater Wash for Period 1 in 2005/06 and Periods 3 and 4 in both 2004/05 and 2005/06, as the other periods contained sections in which no birds were seen, or sections that weren't surveyed. Thus, estimates are only available for two seasons (2004/05 and 2005/06). Estimates for Periods 1 and 2 in 2004/05 and Period 2 in 2005/06 greatly exceeded the threshold of 50 birds, with a peak estimate of 1707 birds during October / November 2004 (Appendix 3, Table 4). The maximum counts for individual sections in each season were 1173 birds on 31 October 2004 in GW3 and 1533 birds on 9 November 2005 in GW4.

Observations of little gulls were concentrated in the area adjacent to the seaward edge of the Inner Wash. During the two seasons of survey which covered Periods 1-4, (2004/05 and 2005/06), there were higher numbers during October and November than during any other period. Little gulls are primarily a passage migrant to Britain, although small numbers over winter off British and Irish coasts (Stone *et al,* 1995). Both seasons (2004/05 and 2005/06) showed peak numbers in the autumn period, followed by a reduction in numbers in November / December, and very few birds during January to March. This suggests that these are 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), rather than birds which are over-wintering. 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). These sightings, from both land and sea suggested that the western North Sea is becoming an increasingly important 'stop-over' area for adult and second-year little gulls in late summer and autumn, when a significant proportion of the Baltic breeding population can be found undergoing their

post –breeding moult before dispersing to wintering grounds (Hartley 2004). Aerial survey data for little gulls are only available for two full seasons at present, with data in 2006/07 being restricted to Periods 3 and 4, so additional autumn (Periods 1 and 2) data is required to determine whether the species is a regularly occurring migratory one in the Greater Wash. However, it seems likely from these observations reported in Hartley (2004) that this is the case. The data presented here show that, if a 1% threshold of 50 individuals is used, the Greater Wash hosts qualifying numbers of little gulls, and that the area north-east of the Inner Wash in particular, is an important area for migrating little gulls.

5.7 Other waterbird species

No other species of inshore waterbird observed in the Greater Wash were recorded in sufficient numbers to reliably estimate total population size. However, they almost certainly do not occur regularly in numbers that would meet SPA qualifying thresholds.

5.8 Waterbird assemblage

For the Greater Wash to qualify as an assemblage at Stage 1.3 of the selection guidelines, total numbers of inshore waterbirds would have to exceed 20,000 individuals (Stroud *et al*, 2001). Summing the peak estimates for divers (2,078), scoters (10,865), little gulls (1,707), and the peak raw counts for other species where population estimates could not be generated, does not result in more than 20,000 individual birds. Therefore, the Greater Wash appears not to qualify as an SPA by virtue of its waterbird assemblage.

6 Conclusion

On the basis of the UK SPA guidelines (Stroud *et al,* 2001) the Greater Wash qualifies as an SPA for red-throated divers at stage 1.1, with a mean of peak counts over the survey period of 1,633 birds. The main areas of red-throated diver distribution appeared to be adjacent to the seaward edge of the Inner Wash, and along the north and east Norfolk coast towards the Suffolk coast. However, divers appeared to be highly mobile within and between seasons. It is likely that the red-throated diver population in the Greater Wash is contiguous with the Greater Thames population (O'Brien *et al,* 2008).

On the basis of two seasons' data, and if a threshold level of 50 birds is applied, the Greater Wash qualifies at stage 1.1 of the guidelines as an SPA for little gull. However, at least one more season of data would be required to determine regularity of use of the area by this species.

Very large confidence intervals were associated with population estimates for common scoters, so these are not considered reliable. However, in conjunction with the raw data and other observations, they suggest that the common scoter population in the Greater Wash area does not exceed the 1% threshold level. On this basis the Greater Wash does not qualify as an SPA for common scoters at stage 1.2 of the guidelines.

Although aerial survey data for grebes were not available at the species level, other data suggest that the north Norfolk coast hosts nationally important numbers of red-necked grebes. However, these numbers do not exceed the minimum threshold value of 50 birds, so the Greater Wash does not qualify as an SPA for this species at stage 1.2 of the guidelines.

The total number of inshore waterbirds recorded using the Greater Wash over winter does not exceed 20,000 individuals. On this basis the Greater Wash does not qualify at stage 1.3 of the guidelines as an SPA on account of its species assemblage.

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Appendix 1. Numbers of birds counted during aerial surveys

Table 1. Total numbers of birds and the number of flocks (in parentheses) counted in each survey (a) or each sub-area (b–d) of the Greater Wash during aerial surveys in the winters of (a) 1989 and 1991, (b) 2002/03, (c) 2004/05, (d) 2005/06 and (e) 2006/07.

(a) 1989 and 1991 (Strip transects)							
Date	Red-throated diver	Unidentified diver	Common eider	Common scoter	Velvet scoter	Unidentified scoter	Red-breasted merganser *Mergus serrator*
Season 1988 / 1989							
8 / 9 Jan 1989	6 (6)	4 (4)					
11 / 12 Mar 1989	4 (2)	1 (1)	5 (3)	300 (1)	20 (1)		1 (1)
Season 1989 / 1990							
1 / 2 Sep 1989		1 (1)					
5 / 6 Nov 1989	61 (36)		40 (1)				3 (1)
Season 1991 / 1992							
3 Dec 1991		1 (1)	3 (1)	160 (1)	2 (1)	1 (1)	

(b) Season 2002/03					
SECTION	DATE	Red-throated diver	Unidentified diver	Common scoter	Unidentified duck
Period 1: February 2003					
East	17 Feb	7 (5)	8 (8)		
Central	14 Feb	2 (2)	6 (6)	4 (1)	
West	13 Feb	5 (3)	11 (11)	2038 (5)	
Period 2: March 2003					
Central	14 Mar	9 (9)	11 (10)		800 (1)
West	13 Mar	30 (19)	97 (47)	170 (9)	7 (1)

(c) Season 2004/05													
SECTION	DATE	Red-throated diver	Great Northern diver	Unidentified diver	Great Crested grebe	Unidentified grebe	Common eider	Unidentified duck	Common scoter	Red-breasted merganser	Common teal	Eurasian wigeon	Little gull
Period 1: October / November 2004													
GW1	20 Nov	2 (2)											3 (3)
GW 2	19 Nov	11 (11)		26 (26)					2 (1)		8 (1)		
GW 3	31 Oct			8 (7)									217 (149)
GW 4	3 Nov	18 (17)		36 (33)			5 (1)		1139 (29)	1 (1)		23 (2)	91 (84)
GW 5	11 Nov	2 (2)		16 (14)								7 (2)	9 (7)
GW 6	17 Nov			12 (9)									10 (7)
Period 2: November / December 2004													
GW 1+2	9 Dec	8 (8)	1 (1)	9 (9)									7 (5)
GW 2+1	9 Dec			7 (7)									
GW 3	23 Nov			4 (4)									11 (11)
GW 4	23 Nov	18 (16)	7 (4)	67 (57)					3217 (28)				53 (45)
GW 5	8 Dec	6 (4)	1 (1)	3 (3)		1 (1)		300 (1)					2 (2)
GW 6	8 Dec		1 (1)	23 (21)									22 (19)
Period 3: January / February 2005													
GW 1+2	2 Feb	6 (6)		16 (15)							9 (1)		
GW 2+1	2 Feb			25 (21)									
GW 3	26 Jan	10 (10)		16 (16)			6 (3)						4 (4)
GW 4	26 Jan	1 (1)		28 (27)			5 (2)		2105 (10)	5 (2)			1 (1)
GW 5	1 Feb	2 (2)		2 (2)				3 (1)					
GW 6	1 Feb	1 (1)		19 (19)									
Period 4: February – April 2005													
GW 1A	19 Mar			37 (28)				4 (1)					
GW 1B	3 Apr			14 (14)									
GW 2	10 Mar			12 (11)									
GW 3	3 Mar			22 (21)									
GW 4	26 Feb	7 (7)		65 (54)	1 (1)	6 (1)	5 (1)		3095 (5)				
GW 5	3 Mar			24 (21)									
GW 6	9 Mar			46 (43)		1 (1)			14 (3)				

(c) Season 2004/05 (Continued)													
SECTION	DATE	Red-throated diver	Great Northern diver	Unidentified diver	Great Crested grebe	Unidentified grebe	Common eider	Unidentified duck	Common scoter	Red-breasted merganser	Common teal	Eurasian wigeon	Little gull
Period 5: May 2005													
GW 3	20 May												
GW 4	18 May								258 (2)				
GW 5	19 May												
Period 6: June 2005													
GW 3	29 June												
GW 4	21 June								41 (2)				2 (2)
GW 5	22 June												
Period 7: July / August 2005													
GW 3	10 Aug												
GW 4	27 Jul								6 (2)				
GW 5	10 Aug								8 (1)				
Period 8: September 2005													
GW 4	9 Sep								67 (2)				

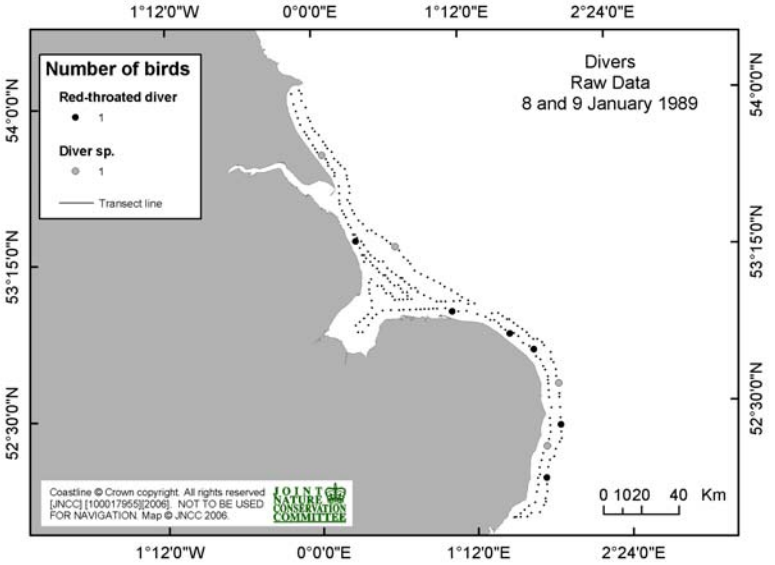
(d) Season 2005/06												
SECTION	DATE	Red-throated diver	Great Northern diver	Unidentified diver	Unidentified grebe	Common eider	Unidentified duck	Common scoter	Velvet scoter	Greater scaup *Aythya marila*	Red-breasted merganser	Little gull
Period 1: November 2005												
GW2	18 Nov			14 (14)			3 (1)	5 (1)				
GW3	7 Nov			1 (1)								
GW4	9 Nov			40 (36)								209 (141)
GW5	15 Nov											13 (12)
GW6	15 Nov			28 (28)				45 (1)				
Period 2: November / December 2005												
GW1	28 Nov	7 (7)		5 (5)		2 (2)	20 (1)					1 (1)
GW2	14 Dec			5 (5)								
GW3	29 Nov			8 (6)								12 (9)
GW4	29 Nov	1 (1)		5 (5)				205 (8)				10 (9)
GW5	30 Nov			5 (5)								4 (3)
GW6	30 Nov	1 (1)		48 (42)	5 (2)		25 (1)			45 (1)	2 (1)	6 (4)
Period 3: January / February 2006												
GW1	19 Jan	3 (3)		24 (14)			3(1)					
GW2	19 Jan			9 (7)								
GW3	12 Jan			4 (4)								
GW4	12 Jan	9 (8)	1 (1)	25 (24)				950 (5)	3 (2)			9 (4)
SECTION	DATE	Red-throated diver	Great Northern diver	Unidentified diver	Unidentified grebe	Common eider	Unidentified duck	Common scoter	Velvet scoter	Greater scaup *Aythya marila*	Red-breasted merganser	Little gull
GW5	18 Jan	4 (3)		6 (6)								2 (1)
GW6part	2 Feb			127 (67)								
GW6part	11 Feb	16 (9)		47 (36)								

Period 4: February / March 2006												
GW1	11 Mar	2 (2)	1 (1)	37 (35)	2 (1)			3 (2)				
GW2	14 Mar	9 (7)		52 (42)	1 (1)							
GW3	19 Feb			5 (5)								
GW4	4 Mar	30 (25)		72 (65)		3 (1)		1272 (4)				3 (1)
GW5	16 Mar	6 (5)		22 (21)								
GW6	10 Mar	21 (14)		91 (46)								
GW6part	11 Mar			1 (1)								

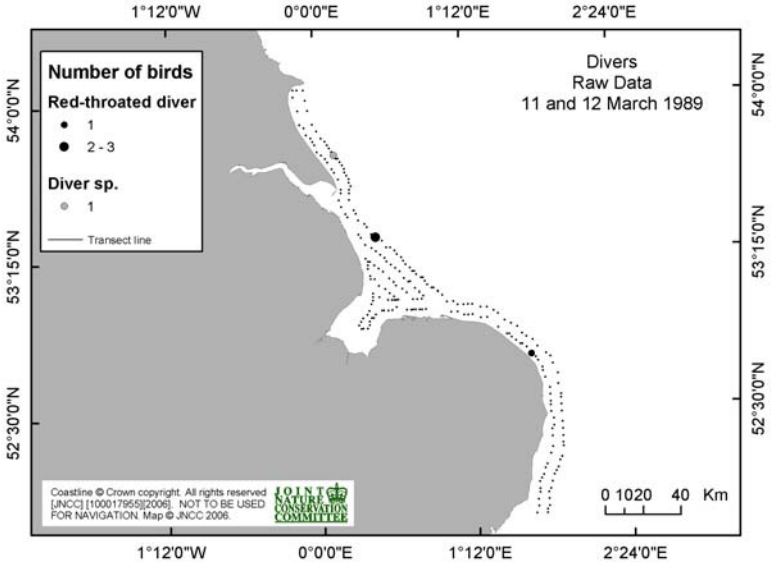
(e) Season 2006/07 (Periods 1 and 2 not surveyed)												
SECTION	DATE	Red-throated diver	Great Northern diver	Unidentified diver	Unidentified grebe	Common eider	Unidentified duck	Common scoter	Velvet scoter	Greater scaup *Aythya marila*	Red-breasted merganser	Little gull
Period 3: January / February 2007												
GW1a	1 Feb	26 (21)	1 (1)	33 (29)				60 (2)			2 (1)	
GW2	16 Jan, 1-2 Feb		1 (1)	50 (31)								
GW5	16 Jan, 19 Feb	4 (4)		16 (13)				2800 (1)				
GW6	17 Feb	5 (5)		48 (43)		82 (3)		7 (1)				
Period 4: February / March 2007												
GW1a	23 Feb	2 (1)		24 (11)				40 (2)				
GW2	23 Feb	7 (6)										
GW5	7 Mar	31 (25)		7 (7)		34 (2)		1 (1)				1 (1)
GW6	7 Mar			23 (20)		37 (2)						

Appendix 2. Distribution of birds recorded during aerial surveys

Figure 1. Distribution of divers in the Greater Wash from aerial surveys conducted in (a) January 1989 and (b) March 1989



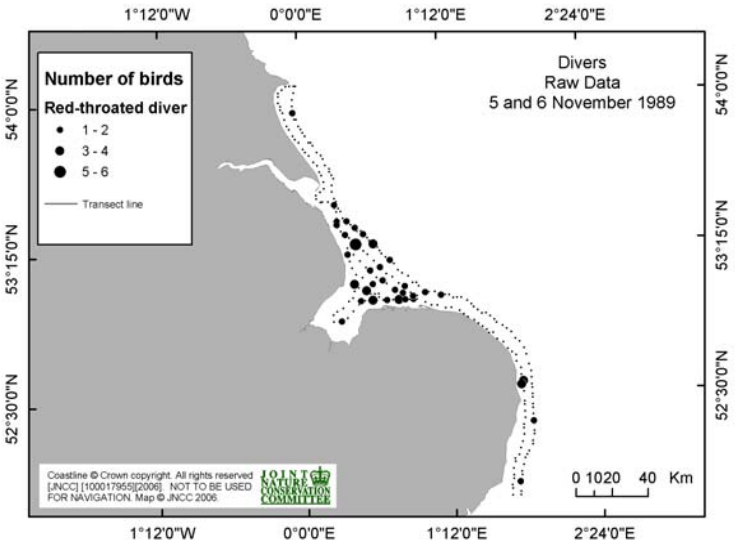
(a)



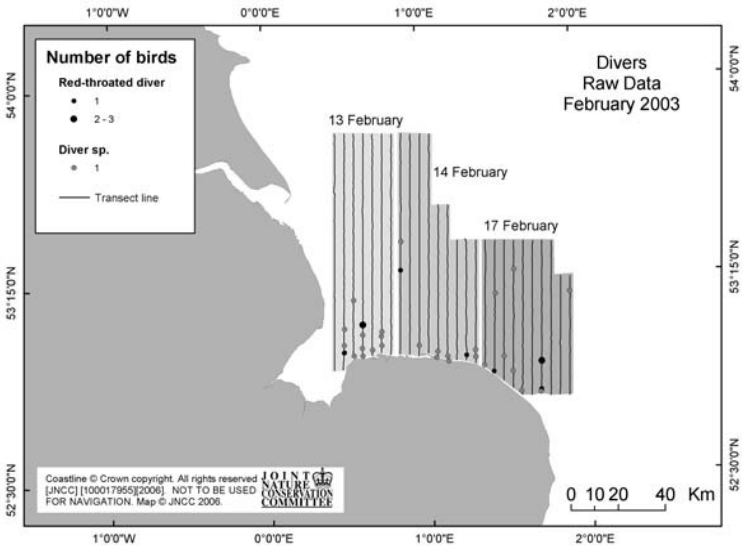
(b)

Figure 1 (cont) Distribution of divers in the Greater Wash from aerial surveys conducted in (c) November 1989, (d) February 2003, (e) March 2003 and (f) October / November 2004

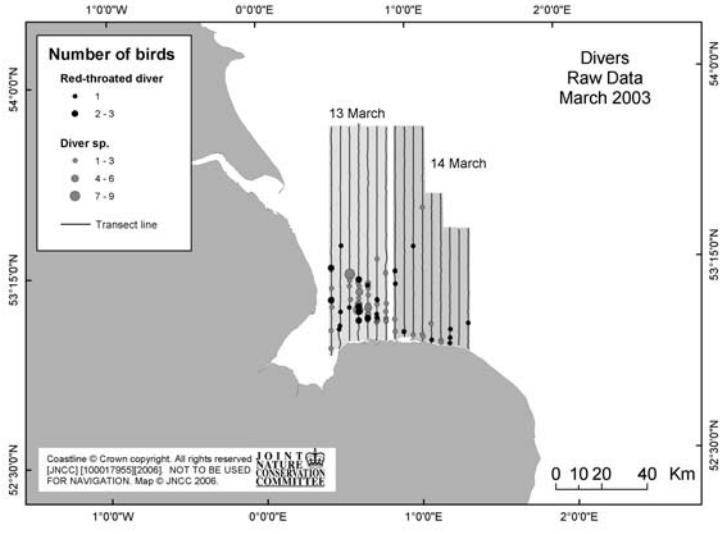
(c)



(d)



(e)



(f)

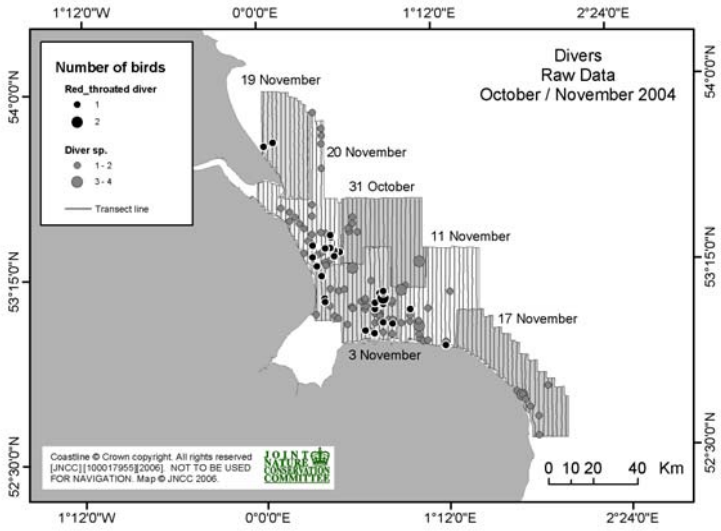
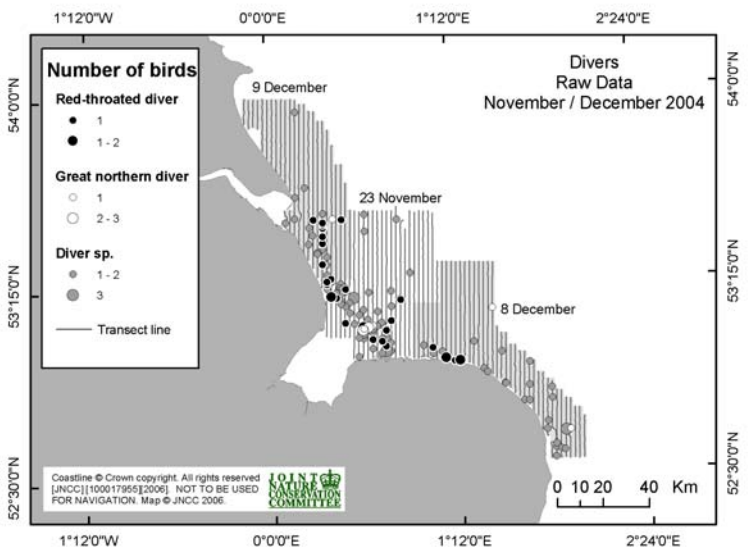
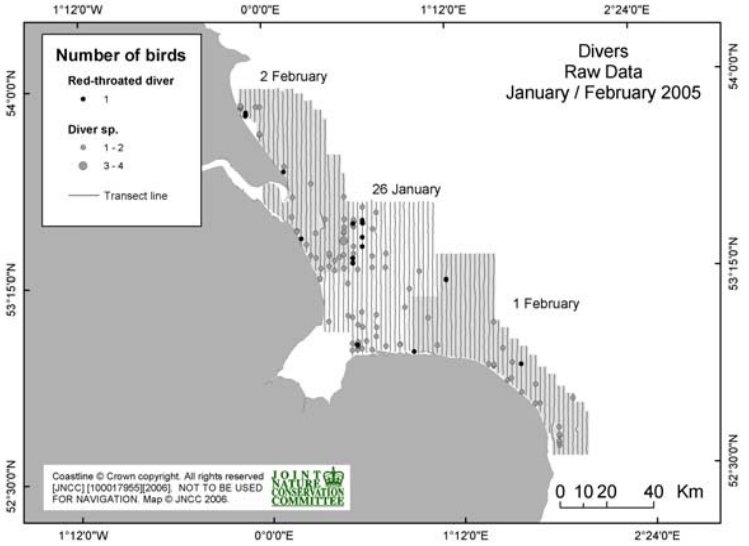


Figure 1 (cont) Distribution of divers in the Greater Wash from aerial surveys conducted in (g) November / December 2004, (h) January / February 2005, (i) February – April 2005 and (j) November 2005

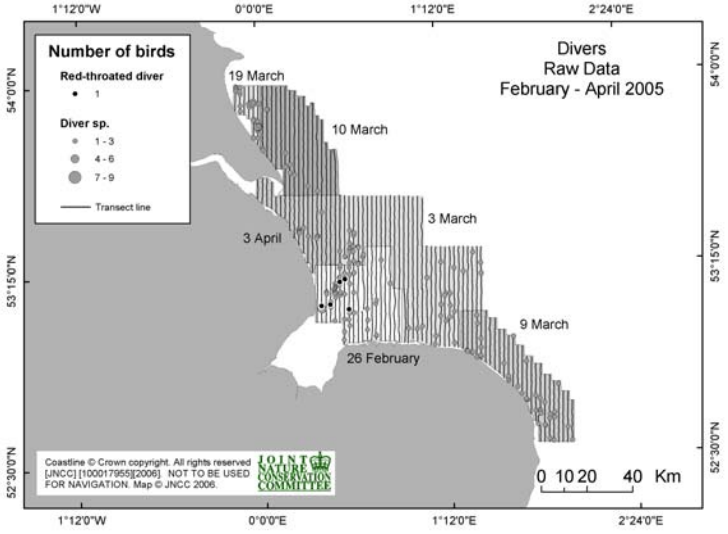
(g)



(h)



(i)



(j)

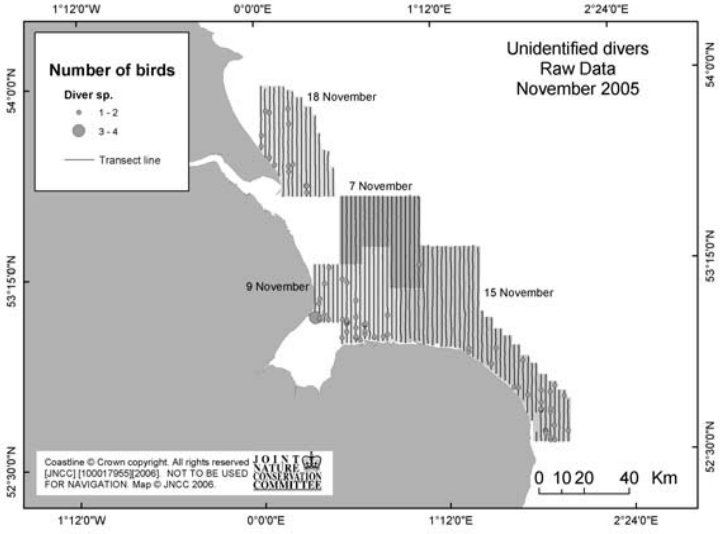
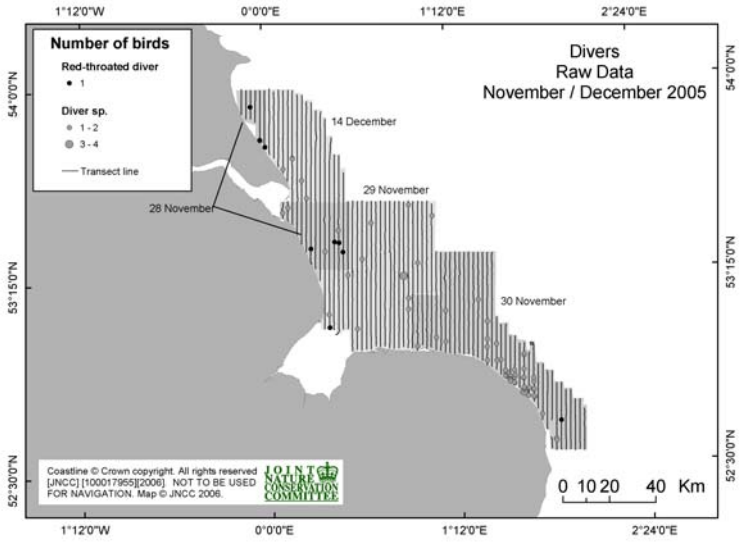
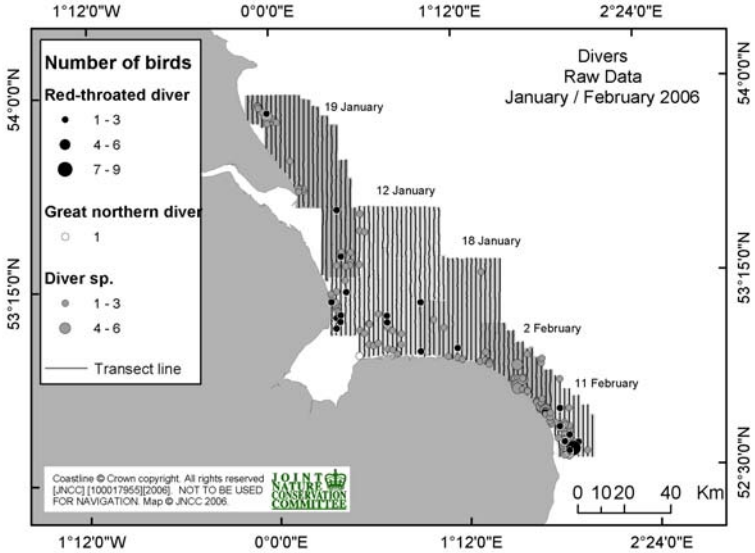


Figure 1 (cont) Distribution of divers in the Greater Wash from aerial surveys conducted in (k) November / December 2005, (l) January / February 2006 , (m) February / March 2006 and (n) January / February 2007

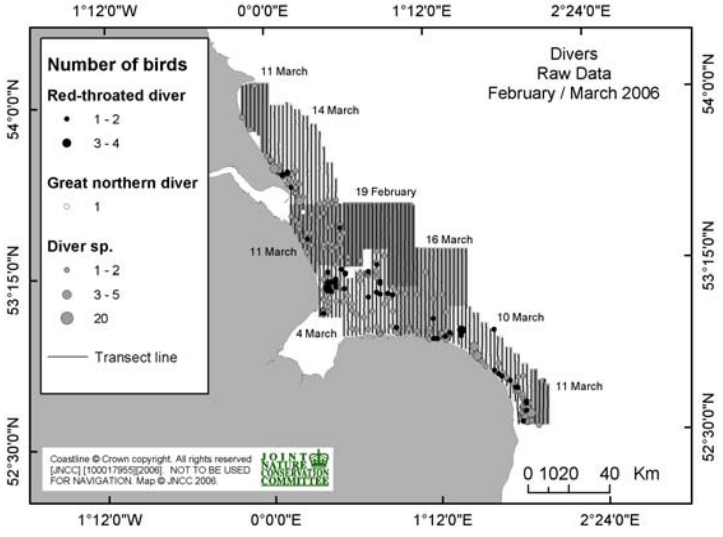
(k)



(l)



(m)



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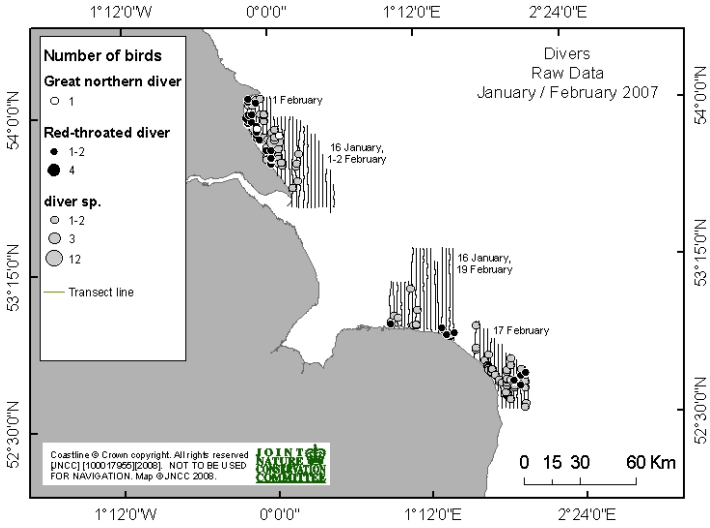


Figure 1 (cont) Distribution of divers in the Greater Wash from aerial surveys conducted in (o) February / March 2007

(o)

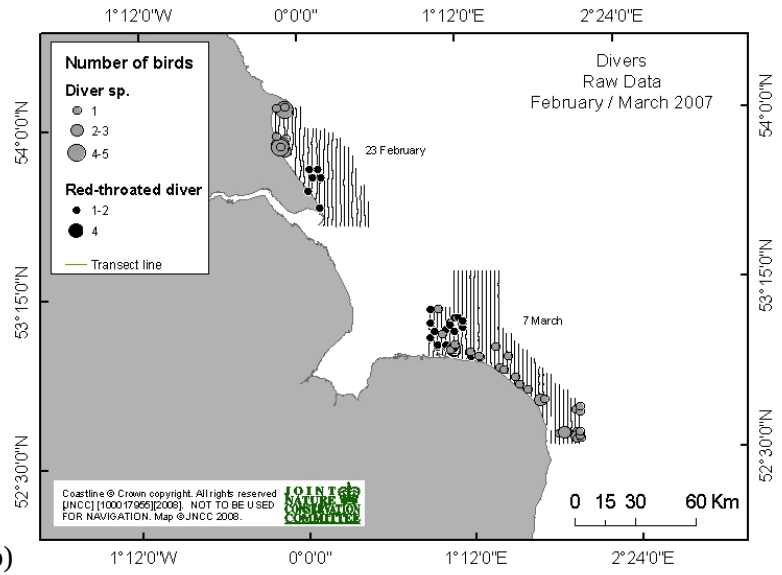
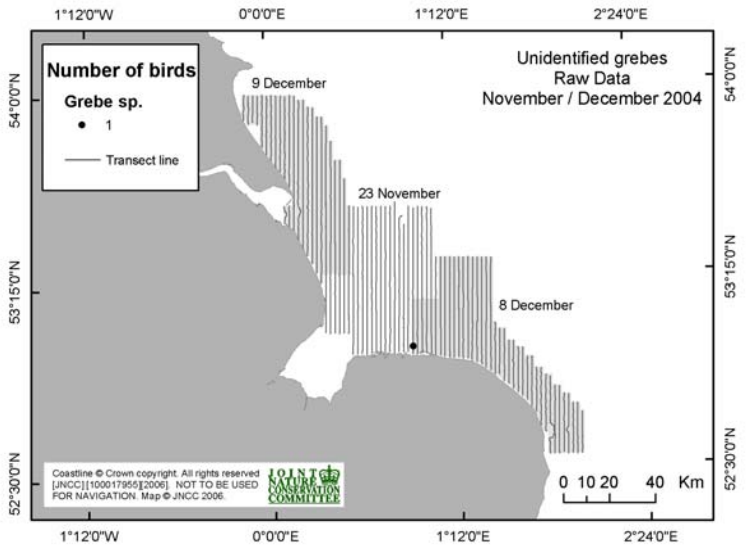
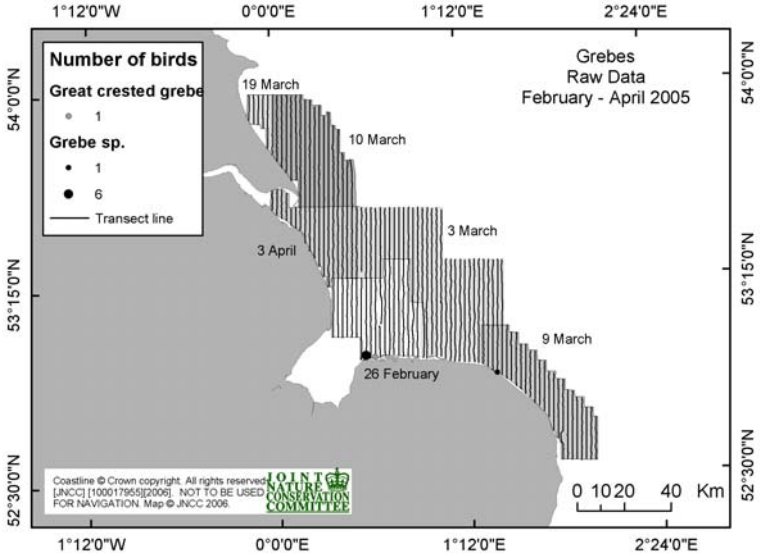


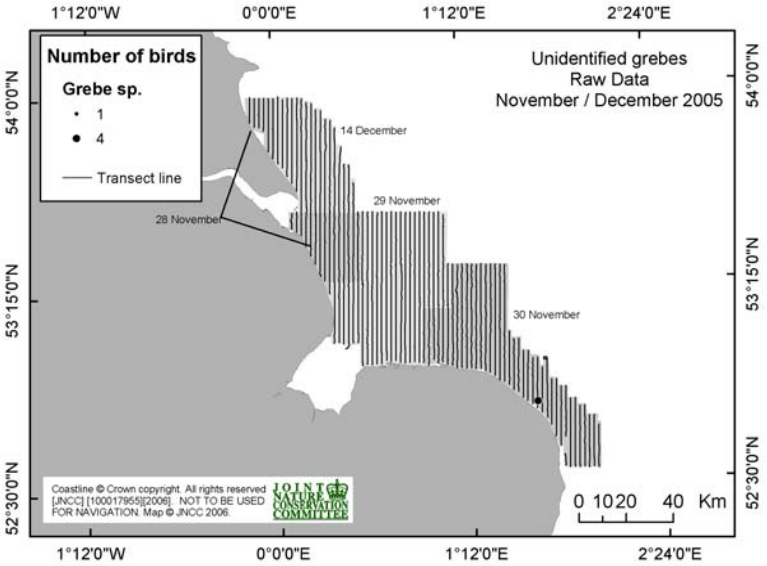
Figure 2. Distribution of grebes in the Greater Wash from aerial surveys conducted in (a) November / December 2004, (b) February – April 2005, (c) November / December 2005 and (d) February / March 2006



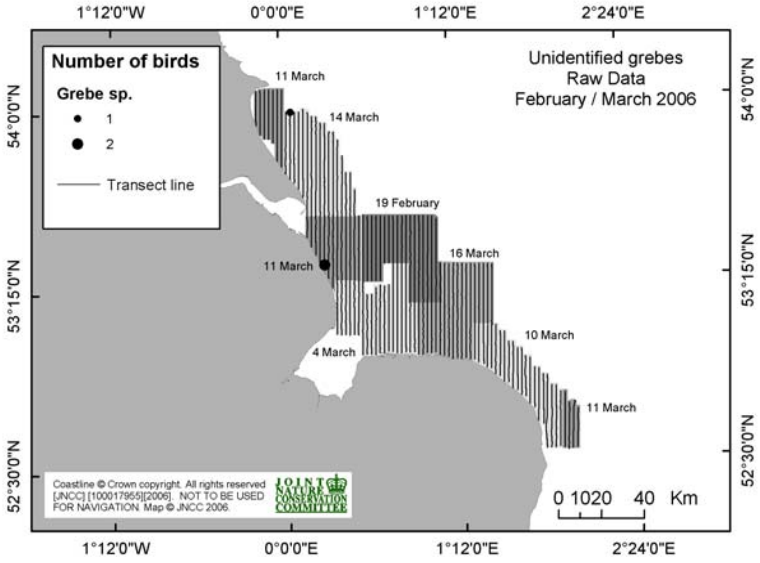
(a)



(b)

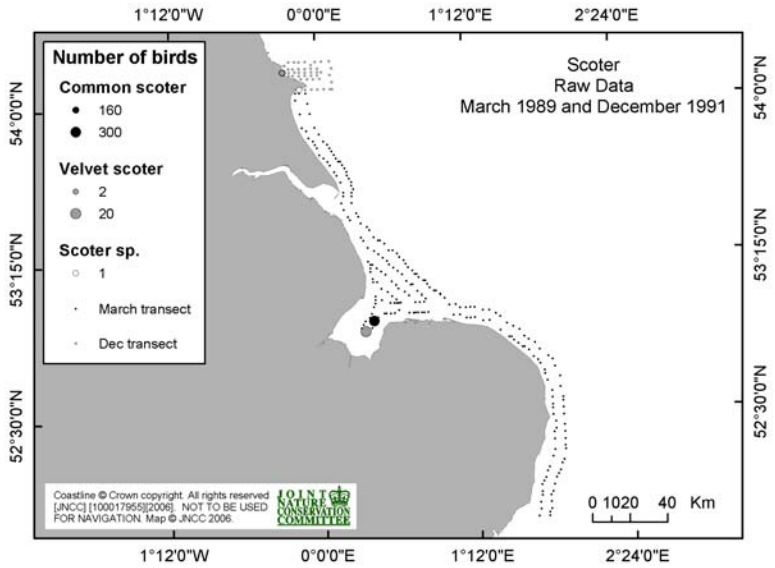


(c)

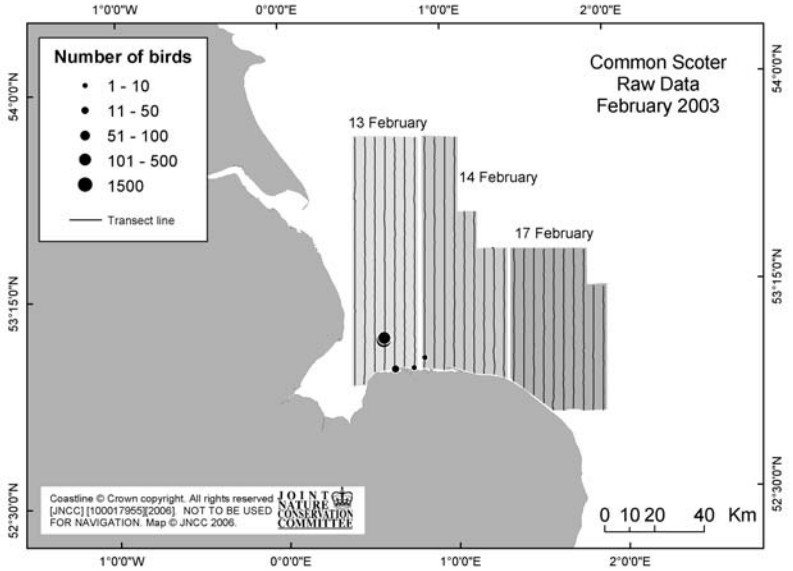


(d)

Figure 3. Distribution of scoters in the Greater Wash from aerial surveys conducted in (a) March 1989 and December 1991, (b) February 2003, (c) March 2003 and (d) October / November 2004



(a)



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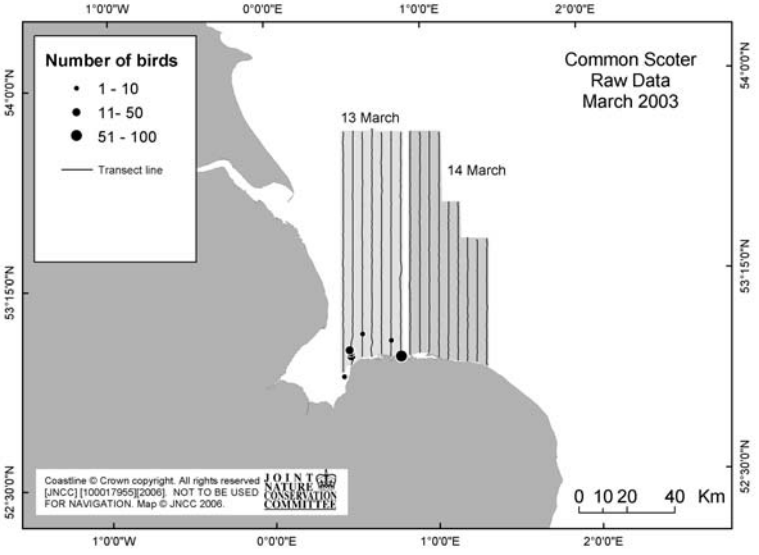
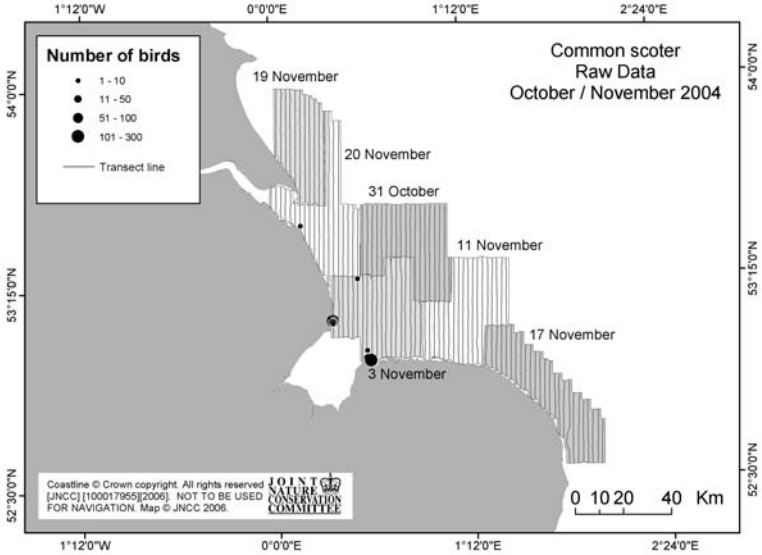
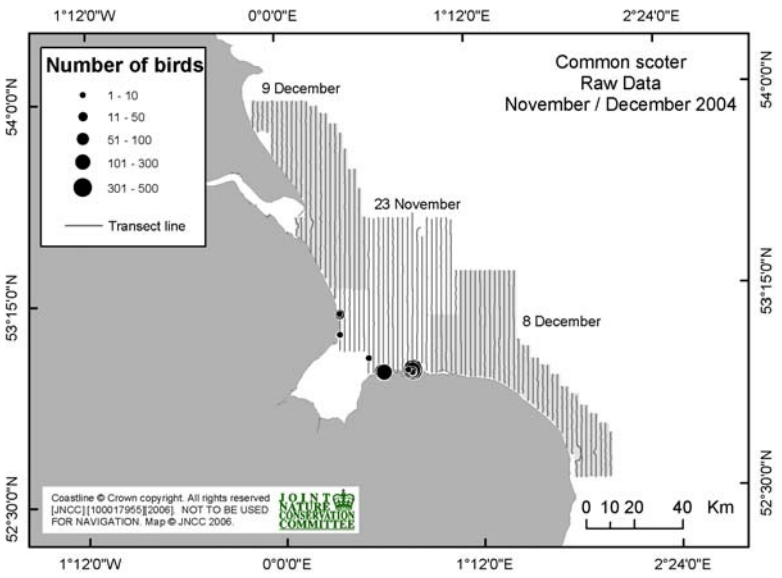


(c)



(d)

Figure 3 (cont) Distribution of scoters in the Greater Wash from aerial surveys conducted in (e) November / December 2004, (f) January / February 2005, (g) February – April 2005 and (h) November 2005



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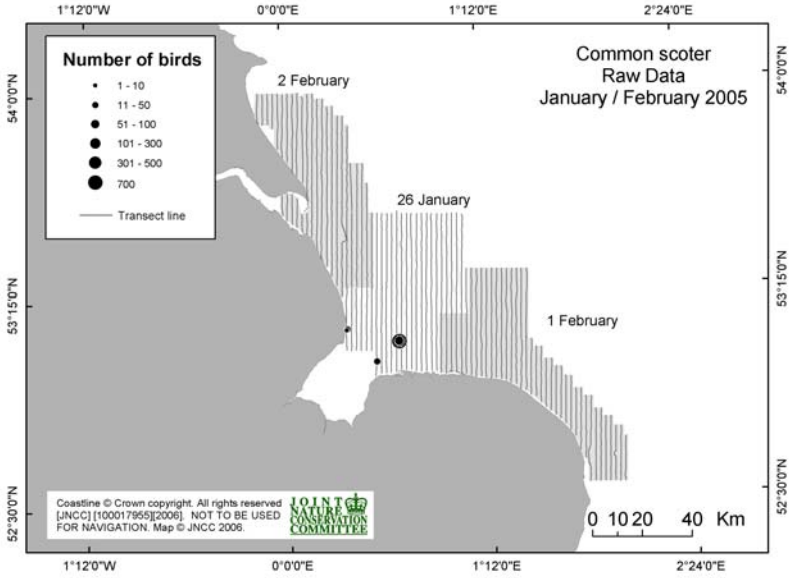
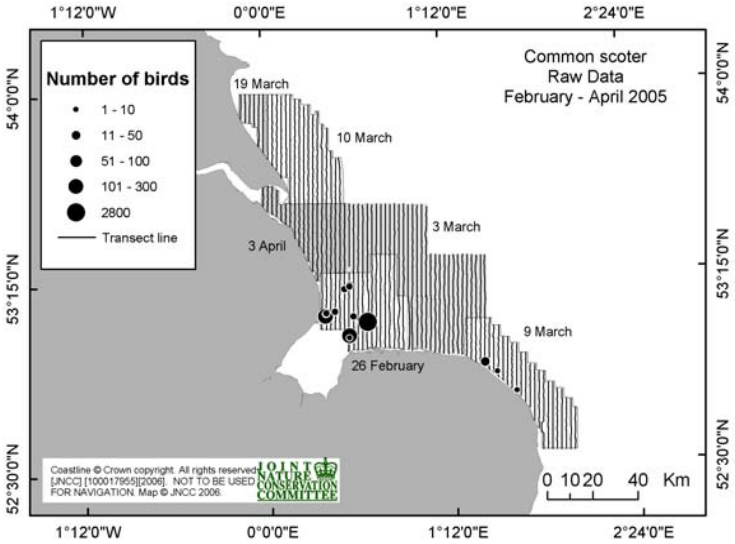
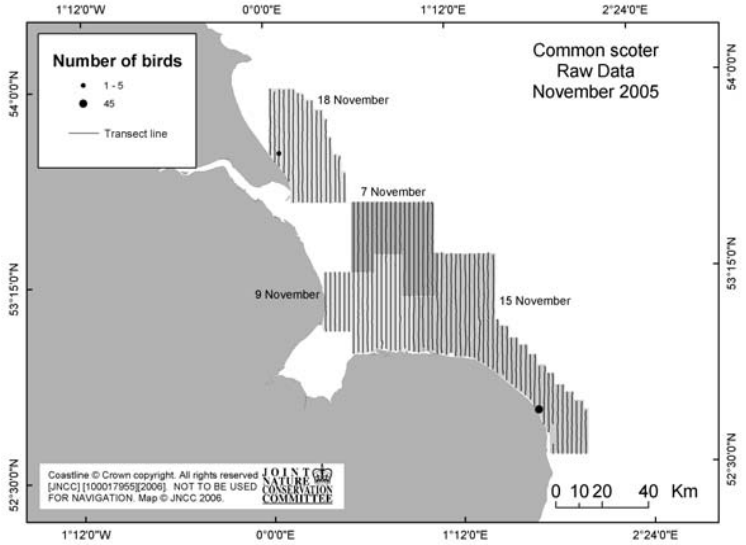


(f)

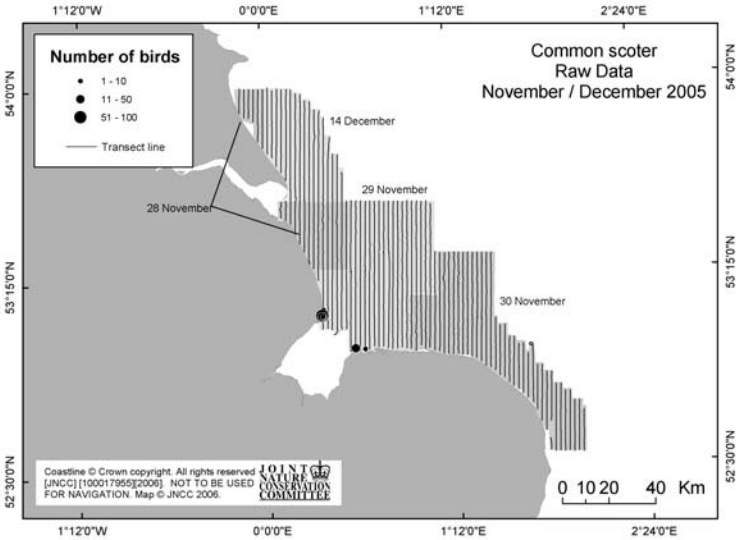


(g)

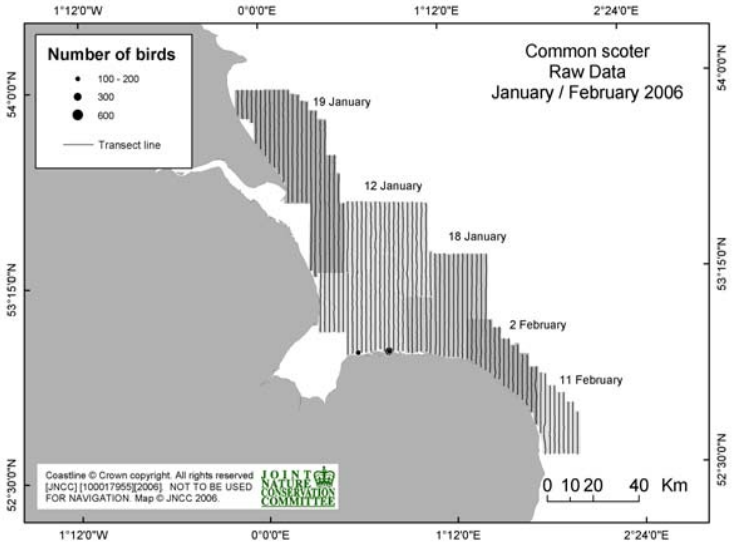


(h)

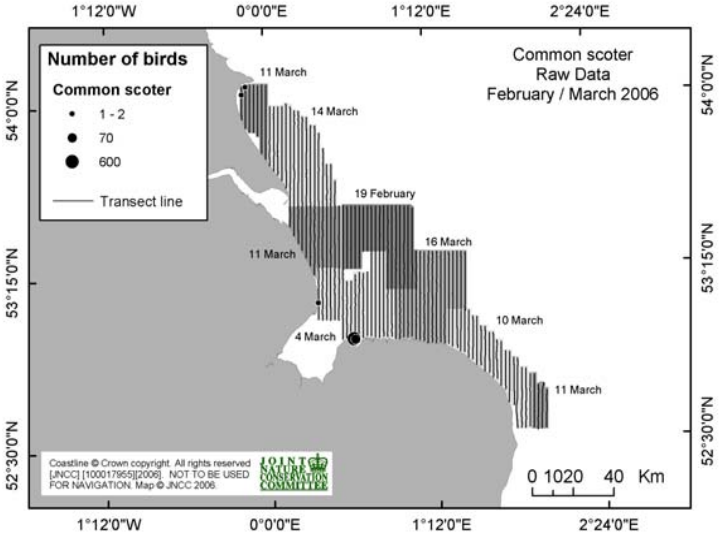
Figure 3 (cont) Distribution of scoters in the Greater Wash from aerial surveys conducted in (i) November / December 2005, (j) January / February 2006, (k) February / March 2006 and (l) January / February 2007.



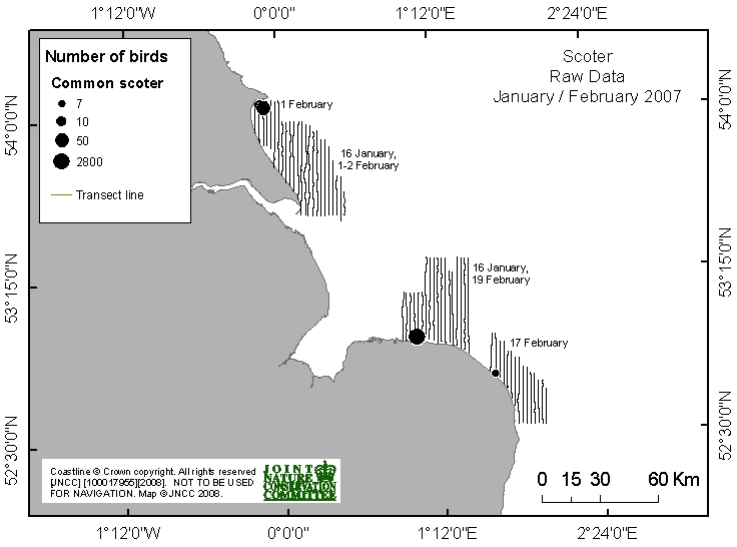
(i)



(j)



(k)



(l)

Figure 4. Distribution of Little gulls in the Greater Wash from aerial surveys conducted in (a) October / November 2004, (b) November / December 2004, (c) January / February 2005 and (d) November 2005

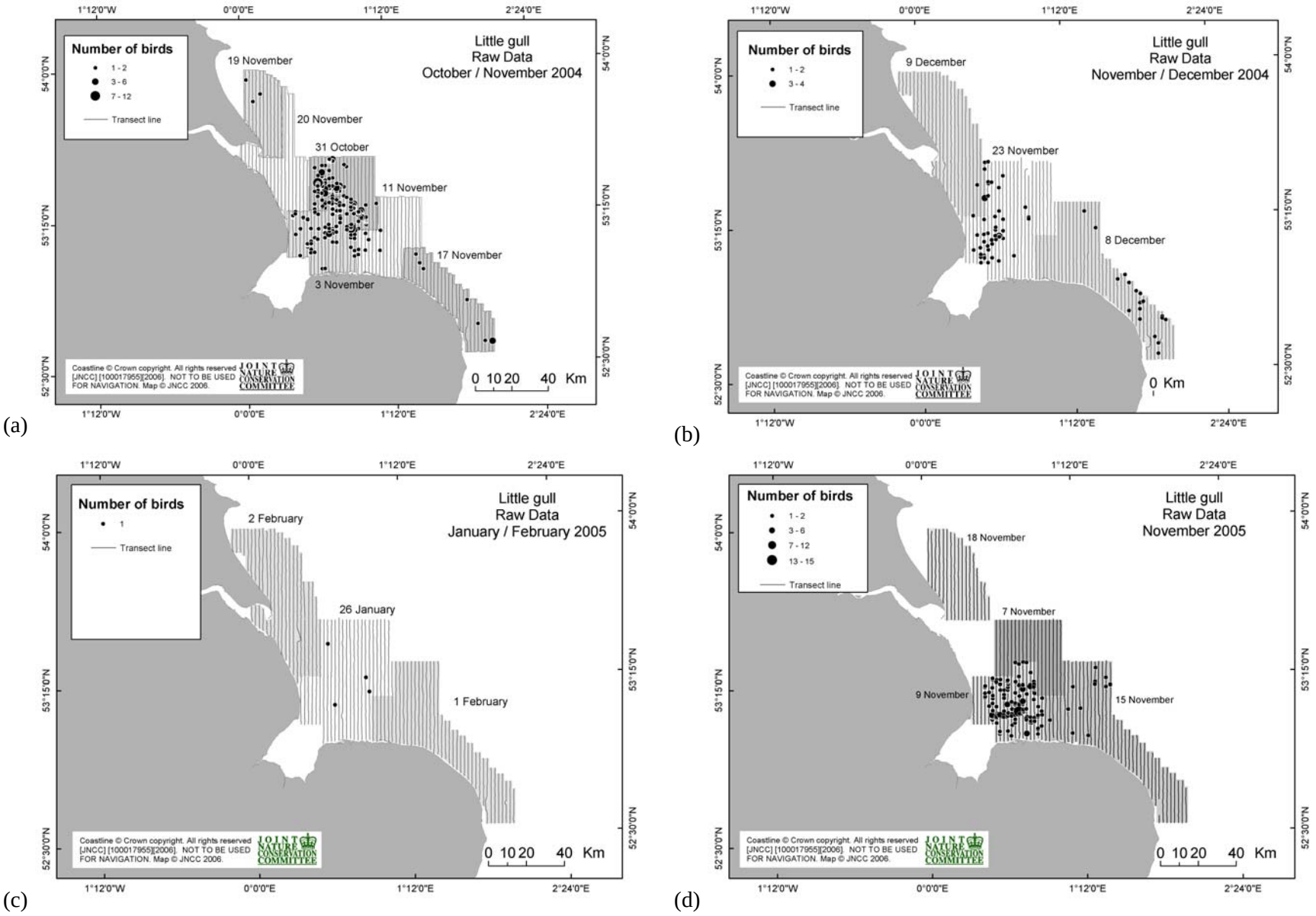
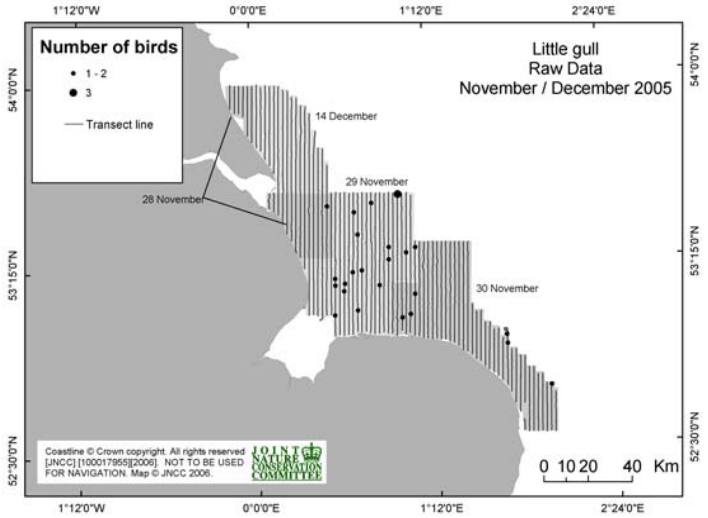
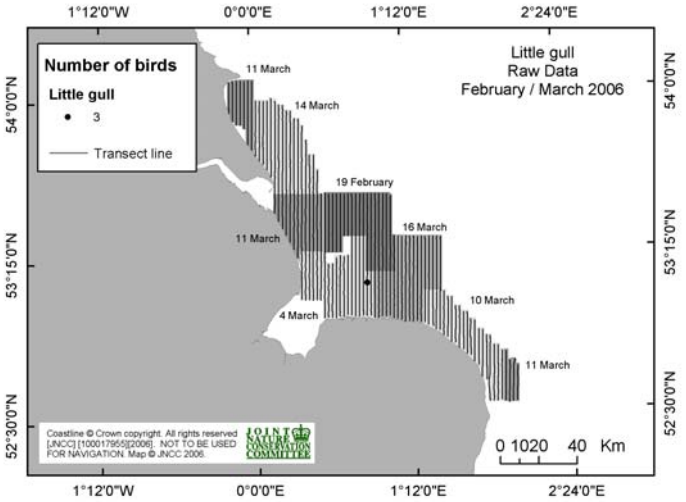


Figure 4 (cont) Distribution of Little gulls in the Greater Wash from aerial surveys conducted in (e) November / December 2005, (f) February / March 2006 and (g) February / March 2007

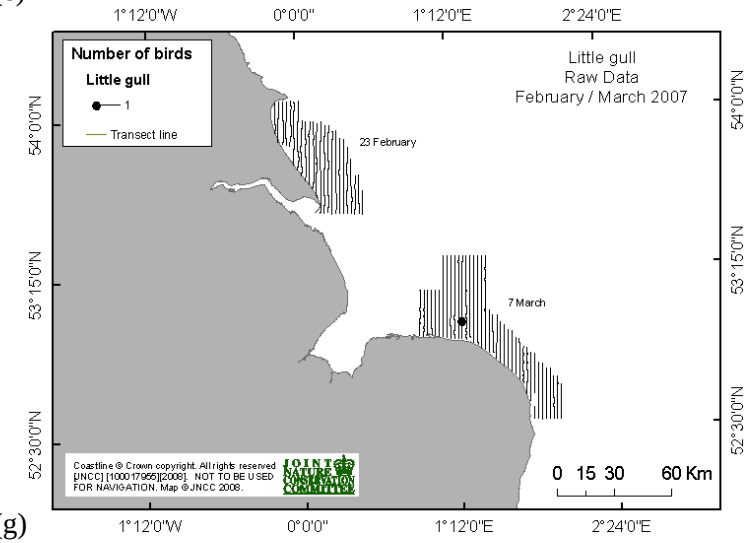
(e)



(f)



(g)



Appendix 3. Population estimates

Red-throated diver population estimates

Table 1. Estimates of red-throated divers extrapolated from total counts from strip-transect aerial surveys carried out in 1989 and 1991 in the Greater Wash. There were not enough observations to extrapolate counts from surveys in March 1989, November 1989 and December 1991.

Date	No. observed	No. flocks	Area searched (km^2)	Density (rounded)	Area represented (km^2) (rounded)	Total number
Season 1988/89						
8 and 9 Jan 1989	10	10	134.72	0.07	5508	**409**
11 and 12 Mar 1989	5	3	123.8	Not enough observations		
Season 1989/90						
1 and 2 Sep 1989	1	1	133.58	Not enough observations		
5 and 6 Nov 1989	61	36	135.40	0.45	5508	**2494**
Season 1991/92						
3 Dec 1991	1	1	25.09	Not enough observations		

Table 2. Density and population estimates of red-throated divers from line-transect aerial surveys carried out in (a) 2002/03, (b) 2004/05, (c) 2005/06 and (d) 2006/07 in the Greater Wash. Estimates were derived from distance sampling, except from those marked with an asterix (*), which were derived from extrapolation of raw counts. 95% confidence intervals given are either empirical estimates ([e]) or bootstrapped estimates ([b]).

(a) Season 2002/03							
Date of survey	Section	No. transects	No. observed	No. flocks	Density (CI)	Area (km^2)	Total number (CI)
Period 1: February 2003							
13 Feb	West	7	16	14	0.092 (0.040 – 0.212)[e]	2529	233 (102 – 536)[e]
14 Feb	Central	9	8	8	0.021	2482	52*
17 Feb	East	10	15	13	0.06 (0.025 – 0.146)[e]	2311	139 (57-338)[e]
13-17 February	**All areas**	**26**	**39**	**35**	**0.06 (0.034 – 0.091)[b]**	**7322**	**442 (249 – 669)[b]**
Period 2: March 2003							
13 March	West	7	127	66	0.416 (0.216-0.802)[b]	2488	1035 (636-1586)[b]
14 March	Central	9	20	19	0.088 (0.222 – 0.055)[b]	2438	215 (134 – 322)[b]
13-14 March	**All areas**	**16**	**147**	**85**	**0.236 (0.132-0.368)[b]**	**4926**	**1165 (650-1814)[b]**

(b) Season 2004/05							
Date of survey	Section	No. transects	No. observed	No. flocks	Density (CI)	Area (km^2)	Total number (CI)
Period 1: October / November 2004							
20 November	GW1	19	37	37	0.162 (0.100-0.261)[e]	1094	177 (109-286)[e]
19 November	GW2	11	2	2	0.01	860	9*
31 October	GW3	19	8	7	0.027	1181	32*
3 November	GW4	19	54	50	0.225 (0.132-0.353)[b]	1243	280 (164-439)[b]
11 November	GW5	18	18	16	0.112 (0.043-0.289)[e]	1175	131 (51-340)[e]
17 November	GW6	25	12	9	0.04	1146	46*
	All areas	**111**	**131**	**121**	**0.101 (0.074-0.138)[e]**	**6699**	**675 (494-928)[e]**
Period 2: November / December 2004							
9 December	GW1+2	9	17	17	0.135 (0.055-0.334)[e]	1006	136 (55-336)[e]
9 December	GW2+1	15	7	7	0.021	1056	22*
23 November	GW3	19	4	4	0.014	1146	16*
23 November	GW4	19	85	73	0.633 (0.397-0.959)[b]	1224	775 (486-1174)[b]
8 December	GW5	18	9	7	0.031	1175	37*
8 December	GW6	25	23	21	0.145 (0.081-0.259)[e]	1127	163 (91-292)[e]
	All areas	**105**	**145**	**129**	**0.184 (0.120-0.260)[b]**	**6734**	**1266 (823-1787)[b]**
Period 3: January / February 2005							
2 February	GW1+2	15	22	21	0.166 (0.052-0.526)[e]	1140	189 (60-600)[e]
2 February	GW2+1	9	25	21	0.211 (0.085-0.524)[e]	985	208 (83-517)[e]
26 January	GW3	19	26	26	0.180 (0.061-0.532)[e]	1173	211 (71-624)[e]
26 January	GW4	19	29	28	0.139 (0.072-0.267)[e]	1220	170 (88-325)[e]
1 February	GW5	18	4	4	0.014	1173	17*
1 February	GW6	25	20	20	0.161 (0.079-0.330)[e]	1130	182 (89-373)[e]
	All areas	**105**	**126**	**120**	**0.141 (0.094-0.206)[b]**	**6821**	**963 (640-1407)[b]**
Period 4: February – April 2005							
19 March	GW1a	6	37	28	0.835 (0.415-0.679)[e]	194	162 (80-326)[e]
3 April	GW1b	19	14	14	0.179 (0.067-0.475)[e]	801	143 (54-381)[e]
10 March	GW2	17	12	11	0.071 (0.032-0.155)[e]	1207	85 (39-187)[e]
3 March	GW3	19	22	21	0.086 (0.216-0.470)[e]	1183	102 (41-255)[e]
26 February	GW4	19	72	61	0.318 (0.1660-0.632)[e]	1213	385 (194-766)[e]
3 March	GW5	18	24	21	0.199 (0.116-0.342)[e]	1168	233 (135-400)[e]
Date of survey	Section	No. transects	No. observed	No. flocks	Density (CI)	Area (km^2)	Total number (CI)
9 March	GW6	25	46	43	0.195 (0.136-0.265)[b]	1123	218 (153-298)[b]
	All areas	**123**	**227**	**199**	**0.167 (0.128-0.213)[b]**	**6889**	**1148 (881-1464)[b]**

(c) Season 2005/06							
Period 1: October / November 2005							
Not surveyed	GW1						
18 November	GW2	17	14	14	0.105 (0.048-0.230)[e]	1184	124 (57-272)[e]
7 November	GW3	19	1	1	0.004	1159	4
9 November	GW4	19	40	36	0.232 (0.112-0.401)[b]	1226	284 (137-492)[b]
15 November	GW5	18	0	0	0	1177	0
15 November	GW6	25	28	28	0.362 (0.193-0.676)[e]	1157	418 (224-783)[e]
	All areas	**98**	**83**	**79**	**0.140 (0.095-0.207)[e]**	**5903**	**828 (561-1224)[e]**
Period 2: November / December 2005							
28 November	GW1	21	12	12	0.094 (0.046-0.191)[e]	918	86 (42-176)[e]
14 December	GW2	17	5	5	0.017	1214	20*
29 November	GW3	19	8	6	0.029	1177	35*
29 November	GW4	19	6	6	0.019	1276	24*
30 November	GW5	18	5	5	0.017	1193	20*
30 November	GW6	25	49	43	0.291 (0.155-0.548)[e]	1181	345 (183-648)[e]
	All areas	**119**	**85**	**77**	**0.095 (0.062-0.136)[b]**	**6959**	**661 (431-946)[b]**
Period 3: January / February 2006							
19 January	GW1	14	27	17	0.386 (0.177-0.841)[e]	665	257 (118-560)[e]
19 January	GW2	17	9	7	0.026	1201	31*
12 January	GW3	19	4	4	0.014	1184	16*
12 January	GW4	19	34	32	0.90 (0.102-0.352)[e]	1210	229 (124-425)[e]
18 January	GW5	18	10	9	0.032	1184	38*
2 February	GW6a	16	127	67	0.774 (0.256-1.478)[b]	683	529 (175-1009)[b]
11 February	GW6b	9	63	45	0.830 (0.386-1.784)[e]	472	257 (118-560)[e]
	All areas	**112**	**274**	**181**	**0.249 (0.150-0.363)[b]**	**6599**	**1641 (991-2398)[b]**

Period 4: February / March 2006							
Date of survey	Section	No. transects	No. observed	No. flocks	Density (CI)	Area (km^2)	Total number (CI)
11 March	GW1	20	39	37	0.248 (0.151-0.409)[e]	368	91 (55-150)[e]
14 March	GW2	17	61	49	0.433 (0.263-0.622)[b]	1210	524 (318-752)[b]
19 February	GW3	19	5	5	0.017	1180	20*
4 March	GW4	19	102	90	0.668 (0.336-1.084)[b]	1165	778 (392-1263)[b]
16 March	GW5	18	28	26	0.265 (0.148-0.474)[e]	1207	319 (178-572)[e]
10 + 11 March	GW6	25	113	61	0.702 (0.374-1.093)[b]	1178	827 (441-1287)[b]
	All areas	**118**	**348**	**268**	**0.329 (0.211-0.515)[e]**	**6308**	**2078 (1331-3246)[e]**
(d) Season 2006/07							
Date of survey	Section	No. transects	No. observed	No. flocks	Density (CI)	Area (km^2)	Total number (CI)
Period 1: Not surveyed							
Period 2: Not surveyed							
Period 3: January / February 2007							
1 February	GW1a	7	59	50	1.10 (0.736-1.649)[e]	369	408 (278-610)[e]
	GW1b	Not surveyed					
16 Jan, 1-2 Feb	GW2	17	50	31	0.482 (0.097-2.396)[e]	1201	579 (117-2877)[e]
	GW3	Not surveyed					
	GW4	Not surveyed					
16 Jan, 19 Feb	GW5	18	20	17	0.160 (0.078-0.329)[e]	1365	218 (106-449)[e]
17 February	GW6	15	53	48	0.519 (0.305-0.884)[e]	740	384 (226-654)[e]
	All areas	**57**	**182**	**146**	**0.394 (0.224-0.677)[b]**	**2955**	**1163 (660-2001)[b]**
Period 4: February / March 2007							
22 February	GW1a	7	26	12	0.855 (0.212-3.455)[e]	370	316 (78-1278)[e]
	GW1b	Not surveyed					
22 February	GW2	17	7	6	0.026*	1201	6*
	GW3	Not surveyed					
	GW4	Not surveyed					
7 March	GW5	18	38	32	0.286 (0.146-0.557)[e]	1175	336 (172-654)[e]
7 March	GW6	25	23	20	0.201 (0.096-0.422)[e]	1130	227 (108-477)[e]
	GW7	Not surveyed					
	All areas	**67**	**94**	**70**	**0.207 (0.125-0.323)[b]**	**3876**	**804 (483-1254)[b]**

Common scoter population estimates

Table 3. Density and population estimates of common scoter from line-transect aerial surveys carried out in (a) 2002/03, (b) 2004/05 and (c) 2005/06. Estimates were derived from distance sampling as follows: Data for all surveys were pooled and all flock sizes of more than 100 birds were removed from the analysis. A global detection function was generated using all data, and this was used to calculate density estimates for each individual survey period. The final distance estimate for each survey period was then added to the raw count of birds which occurred in flocks comprising more than 100 birds (see Methods). 95% empirical confidence intervals are given in parentheses.

Period	**Area surveyed (Km^2)**	**No. transects**	**No. of birds (flocks)**	**No. birds in flocks numbering < 101 birds**	**Density estimate (and 95% CIs) for birds in flocks numbering <101 birds**	**Population estimate (and 95% CIs) for birds in flocks numbering <101 birds**	**No. birds in flocks numbering > 101 birds**	**Total number of birds**
(a) Season 2002/03								
February	7,322	26	2042 (6)	42	0.01 (0.003-0.042)	75 (18-314)	2000	**2075**
March	4,926	16	170 (9)	170	0.059 (0.017-0.196)	288 (86-967)	0	**288**
(b) Season 2004/05								
October / November	6,699	111	1141 (30)	561	1.535 (0.379-6.226)	10,285 (2,536-41,707)	580	**10865**
November / December	6,734	105	3217 (28)	267	0.985 (0.261-3.772)	6,636 (1,757-25,066)	2950	**9586**
January / February	6,821	105	2105 (10)	155	0.187 (0.011-3.275)	1,272 (72-22,335)	1950	**3222**
February – April	6,889	123	3109 (8)	59	0.268 (0.025-2.88)	1,847 (172-19,832)	3050	**4897**

Period	Area surveyed (Km^2)	No. transects	No. of birds (flocks)	No. birds in flocks numbering < 101 birds	Density estimate (and 95% CIs) for birds in flocks numbering <101 birds	Population estimate (and 95% CIs) for birds in flocks numbering <101 birds	No. birds in flocks numbering > 101 birds	Total number of birds
(c) Season 2005/06								
November	5,903	98	50 (2)	50	0.032 (0.003-0.397)	188 (15-2,343)	0	**188**
November / December	6,959	119	205 (8)	205	0.337 (0.051-2.235)	2,346 (354-15,555)	0	**2346**
January / February	6,599	112	950 (5)	100	0.154 (0.028-0.840)	1,013 (185-5,546)	850	**1863**
February / March	6,308	118	1275 (6)	75	0.036 (0.003-5.014)	227 (2-31,631)	1200	**1427**

Little gull population estimates

Table 4. Density and population estimates of little gulls from line-transect aerial surveys carried out in (a) 2004/05, (b) 2005/06 and (c) 2006/07 in the Greater Wash. Estimates were derived from distance sampling, except from those marked with an asterix (*), which were derived from extrapolation of raw counts. 95% confidence intervals given are either empirical estimates ([e]) or bootstrapped estimates ([b]).

Date of survey	Section	No. transects	No. observed	No. flocks	Density (CI)	Area (km^2)	Total number (CI)
(a) Season 2004/05							
Period 1: October / November 2004							
19 November	GW2	11	3	3	0.015	860	13*
31 October	GW3	19	217	149	0.993 (0.626-1.576)[e]	1181	1173 (739-1862)[e]
3 November	GW4	19	91	84	0.349 (0.257-0.472)[e]	1243	433 (320-587)[e]
11 November	GW5	18	9	7	0.072 (0.22-0.233)[e]	1175	84 (26-274)[e]
17 November	GW6	25	10	7	0.038	1146	43*
	All areas	**92**	**330**	**250**	**0.304 (0.212-0.438)[e]**	**5605**	**1707 (1186-2457)[e]**
Period 2: November / December 2004							
9 December	GW1+2	9	7	5	0.029	1006	29*
23 November	GW3	19	11	11	0.089 (0.033-0.242)[e]	1146	102 (38-277)[e]
23 November	GW4	19	53	45	0.249 (0.121-0.515)[e]	1224	305 (148-631)[e]
8 December	GW5	18	2	2	0.007	1175	8*
8 December	GW6	25	22	19	0.155 (0.079-0.305)[e]	1127	175 (89-344)[e]
	All areas	**90**	**95**	**82**	**0.141 (0.227-0.246)[e]**	**5678**	**798 (494-1290)[e]**
Period 3: January / February 2005							
26 January	GW3	19	4	4	0.014	1173	16*
26 January	GW4	19	1	1	0.003	1220	4*

Date of survey	Section	No. transects	No. observed	No. flocks	Density (CI)	Area (km^2)	Total number (CI)
(b) Season 2005/06							
Period 1: October / November 2005							
9 November	GW4	19	209	141	1.251 (0.921-1.699)[e]	1226	1533 (1129-2082)[e]
15 November	GW5	18	13	12	0.082 (0.037-0.182)[e]	1177	96 (43-215)[e]
Period 2: November / December 2005							
28 November	GW1	21	1	1	0.005	918	4*
29 November	GW3	19	12	9	0.134 (0.054-0.330)[e]	1177	157 (64-388)[e]
29 November	GW4	19	10	9	0.075 (0.029-0.189)[e]	1276	95 (38-241)[e]
30 November	GW5	18	4	3	0.014	1193	17*
30 November	GW6	25	6	4	0.021	1181	25*
	All areas	**119**	**33**	**26**	**0.041 (0.022-0.071)[b]**	**6959**	**283 (154-492)[b]**
Period 3: January / February 2006							
12 January	GW4	19	9	4	0.029	1210	35*
19 January	GW5	18	2	1	0.011	1184	9*
Period 4: February / March 2006							
4 March	GW4	19	3	1	0.011	1165	13*

Date of survey	Section	No. transects	No. observed	No. flocks	Density (CI)	Area (km^2)	Total number (CI)
(c) Season 2006/07							
Period 4: February / March 2007							
7 March	GW5	18	2	1	0.004 (0.001-0.018)*	1175	4 (1-21)*