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Ground and aerial monitoring for Carmarthen Bay SPA 2004-07

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Authors

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CRYNODEB GWEITHREDOL

1. Yn ystod gaeafau 2004/05, 2005/06 a 2006/07, gwnaethpwyd cyfres o arolygon ar y ddaear ac o'r awyr ym Mae Caerfyrddin o'r môr-hwyaid du *Melanitta nigra.*

2. Bwriad y gwaith yma oedd parhau rhaglen o fonitro oedd yn hanfodol i asesu a oedd y môr hwyaid du o fewn Bae Caerfyrddin Ardal Gwarchodaeth Arbennig yn parhau mewn Statws Cadwraeth Ffafriol.

3. Roedd niferoedd y môr-hwyaid du gafodd eu cyfrif yn ystod yr arolygon ar y ddaear yn cyrraedd hyd at 24,460 yn 2004/05, 20,287 yn 2005/06 a 14,412 yn 2006/07. Cafodd y gwerthoedd cymedrig uchaf dros bum mlynedd eu cyfrifo.

4. Lluniwyd indecs o'r môr-hwyaid du gafodd eu cyfrif yn y dull yma gan ddefnyddio amcangyfrifon paramedr o GLM. Cafodd yr holl ddata oedd ar gael eu cynnwys fel bod yr indecs yn rhychwantu'r blynyddoedd 1994/95 – 2006/07. Yn ystod y tri gaeaf a astudiwyd yma, cododd yr indecs, ac yna gostyngodd dros ddau aeaf yn olynol i lefel oedd yn gwarantu sylw manwl trwy fonitro cyson.

5. Bu i'r niferoedd o fôr - hwyaid du a amcangyfrifwyd trwy samplu o bell ar arolygon o'r awyr gyrraedd uchafbwynt o 9,832 (CIau: 5,670 – 17,051) yn 2004/05, 28,456 (18,127 – 44,669) yn 2005/06 a 13,435 (8,601 – 20,984) yn 2006/07. Cafodd y gwerthoedd cymedrig uchaf dros bum mlynedd eu cyfrifo.

6. Lluniwyd indecs tebyg ar gyfer amcangyfrifon arolygon o'r awyr, yn rhychwantu gaeafau 2001/02 – 2006/07. Roedd y gwerthoedd indecs yn 2004/05 ac yn 2006/07 yn debyg iawn, tra bu i rai 2006/07 godi'n sylweddol.

7. O edrych ar ddosbarthiad y môr-hwyaid du ym Mae Caerfyrddin roedd cyfartaledd dosbarthiadau'r gaeaf yn dangos mai'r parthau bwydo traddodiadol yng ngogledd a gorllewin y bae oedd yn cael eu ffafrio – yn ymestyn o Gefn Sidan a Phembre. Daeth hyn yn amlwg ar waethaf presenoldeb rhai adar mewn lleoliadau anghyffredin yn draddodiadol.

8. Roedd canolfannau cymedrig y dosbarthiadau ar gyfartaledd yn debyg i'r rhai a gofnodwyd cyn hyn mewn blynyddoedd pan dybid fod yr ecosystem wedi'i hadfer yn llwyr ar ôl i'r Sea Empress golli olew.

9. Gwnaethpwyd archwiliad pellach o ffactorau y tybid eu bod yn effeithio monitro cywir, megis profiad yr arsylwr, y llanw, ymyrraeth, a hefyd uchder yr awyren ddefnyddid i wneud yr arolwg.

10. Cafwyd fod profiad arsylwr wrth arsylwi o'r ddaear yn ffactor pwysig o safbwynt cywirdeb wrth gyfrif môr- hwyaid du ym Mae Caerfyrddin. Gydag amser bu i arsylwyr dibrofiad wella trwy ddod yn fwy manwl gywir er bod allosodiadau yn awgrymu y gallai gymryd rhwng 13 a 23 arolwg i arsylwr heb brofiad gyrraedd yr un safon ag arsylwyr profiadol.

11. Roedd ychydig o effaith y llanw ar niferoedd y môr-hwyaid du gafodd eu cyfrif o'r tir, gyda llanw uchel i'w weld yn cael ei gysylltu gyda chyfrifon uwch o fôr-hwyaid du.

12. Cafwyd nad oedd arolygon o'r awyr oedd wedi cael eu hedfan dros is setiau o drawsluniau ar fwy o uchder yn cael dim effaith ar leihau'r aflonyddwch ymhlith y môr-hwyaid du, ac mewn rhai achosion roedd hi'n rhy anodd gweld yr adar i allu'u cyfrif yn gywir.

13. Mae'r *Procedural Guidelines* a'r *Standard Operating Procedures* wedi cael eu diwygio yn seiliedig ar ganfyddiadau'r arolygon yma.

14. Rhoddir argymhellion pellach ynghylch gwaith yn y dyfodol, gan gynnwys cynnal y rhaglen fonitro er mwyn sicrhau nad yw'r gostyngiadau a welwyd yn ddiweddar yn yr indecs arolwg o'r ddaear yn parhau hyd at lefel sy'n achosi pryder.

15. Mae canlyniadau arolwg arbennig o adar sy'n bwrw'u plu hefyd wedi'u cynnwys.

EXECUTIVE SUMMARY

1. During the winters of 2004/05, 2005/06 and 2006/07, a series of ground-based and aerial surveys of common scoters *Melanitta nigra* were undertaken in Carmarthen Bay.

2. The purpose of this work was to continue a program of monitoring, essential as a means of assessing whether the scoters present within Carmarthen Bay Special Protection Area remain in Favourable Conservation Status.

3. Numbers of common scoters counted on ground-based surveys peaked at 24,460 in 2004/05, 20,287 in 2005/06 and 14,412 in 2006/07. Five year peak mean values were calculated.

4. An index of common scoters counted using this method was derived using parameter estimates from a GLM. All data available were included so that the index spanned the years 1994/95 – 2006/07. In the three winters studied here, the index rose, then declined over two successive winters to a level warranting close attention with continued monitoring.

5. Numbers of common scoters estimated by distance sampling on aerial surveys peaked at 9,832 (CIs: 5,670 – 17,051) in 2004/05, 28,456 (18,127 – 44,669) in 2005/06 and 13,435 (8,601 – 20,984) in 2006/07. Five year peak mean values were calculated.

6. A similar index was derived for aerial survey estimates, spanning the winters 2001/02 – 2006/07. Index values in 2004/05 and 2006/07 were very similar, whilst that in 2005/06 rose sharply.

7. Distribution of common scoters in Carmarthen Bay showed that despite the presence of some birds in traditionally unusual locations, average winter distributions showed that the traditional feeding zones to the north and west of the bay, extending off Cefn Sidan and Pembrey, were favoured.

8. Mean centres of average distributions were similar to those recorded previously in years when the ecosystem was thought to have recovered from the *Sea Empress* oil spill.

9. Further investigation was made of factors thought to affect accurate monitoring, such as observer experience, tide, disturbance, and altitude of survey aircraft.

10. Ground-based observer experience was found to be an important factor in precision of counting common scoters in Carmarthen Bay. Naïve surveyors improved in precision with time, though extrapolations suggest it may take between 13 and 23 surveys for such an observer to match experienced counterparts.

11. There was a weak effect of tide on common scoter numbers counted from the land, with high tides seemingly being associated with higher counts of scoters.

12. Aerial surveys flown over sub-sets of transects at increased altitude were found to have no effect on reducing disturbance amongst common scoters, and in some cases made perception of the birds too difficult to count accurately.

13. *Procedural Guidelines* and *Standard Operating Procedures* have been revised based on the findings from these surveys.

14. Further recommendations for future work are suggested, including maintaining the program of monitoring in order to ensure that recent declines in the ground-based survey index do not continue to a level of concern.

15. The results of a special survey for moulting birds are also included.

1 INTRODUCTION

1.1 Common scoters in Carmarthen Bay

The importance of Carmarthen Bay for common scoters *Melanitta nigra* is well established: it was designated in 2003 as the UK's first marine Special Protection Area (SPA) on the basis of holding at least 1% (16,000 individuals: Wetlands International 2006) of the biogeographic population. Common scoter typically feed on bivalves and other invertebrates such as polychaetes and amphipods (Fox 2003; Woolmer *et al.* 2004), which are found in abundance in shallow waters (<10 m) in Carmarthen Bay.

The Countryside Council for Wales (CCW) has supported dedicated land-based counts of common scoter in Carmarthen Bay from 1994/95 (Stewart 1995) to the time of writing. Since 1996, when the *Sea Empress* oil tanker ran aground in Milford Haven and leaked approximately 72,000 tonnes of crude oil into Carmarthen Bay, a sustained program of monitoring common scoters has been in place (Stewart *et al.* 1997; Cranswick *et al.* 1998; Smith *unpubl. data*; WWT 2003; Banks *et al.* 2004). However, owing to the large size of the bay, it is not possible to count all of the birds present from the shore. To combat this problem, periodic aerial surveys have been conducted in an attempt to account for birds out of sight from shore and thus estimate 'true' numbers present. The two approaches have advantages and disadvantages (Banks *et al.* 2004), but in practice it is important to gather information from both methods to fully understand changes in abundance and distribution.

1.2 Recent work

This project aims to build upon the findings of Banks *et al.* (2004). As well as monitoring numbers of scoter, that report aimed to investigate methodological issues and arrive at agreed protocol for monitoring, including:

- Assessment of factors affecting precision of land-based counts;
- Assessment of two different aerial survey techniques;
- Evaluation of extant data to form targets for common scoter numbers;
- Production of *Procedural Guidelines* and *Standard Operating Procedures* for land-based and aerial surveys of common scoter.

Although many of the questions raised were answered satisfactorily, some required further research, whilst other issues arose from the work. Some of these are explored in the current study.

Additionally, a paper summarising all common scoter counts in Carmarthen Bay from 1994/95 – 2005/06 has been prepared (Banks *et al.* in review). This contains the first index of land-based counts generated for common scoters in Carmarthen Bay.

1.3 Objectives of work

The principle objectives of the current project were as follows:

1 Maintain a monitoring / surveillance program using land-based and distance method aerial surveys.

2 Continue to investigate whether land-based counts provide an appropriate index of overall numbers of scoter within Carmarthen Bay or parts of it, and update the current index.

3 Test and, where necessary, update the *Procedural Guidelines* and *Standard Operating Procedures* for land and aerial assessment of common scoter numbers both generally and specifically in Carmarthen Bay.

4 Document observations of disturbance and its apparent effects on the birds.

5 Investigate the effect of observer experience, comparing land-based counts from a naïve surveyor and an expert surveyor.

6 Continue to investigate the effect of the tide on the distribution and numbers of scoters counted from the land.

7 Investigate levels of disturbance caused by aerial survey at different heights.

2 METHODOLOGY

2.1 Overall approach

Methods used to continue the program of aerial and ground-based survey were broadly similar to those reported in Banks *et al.* (2004). Pre-determined optimal weather conditions for counts (both from the ground and air) restricted the number of available survey days, as did the requirement to fly at weekends only owing to MoD operations at Carmarthen Bay. Nonetheless, a total of four survey events were achieved in 2004/05; nine in 2005/06; and 11 in 2006/07, as summarised in Table 2.1.

The survey in September 2005, performed to assess the numbers of moulting birds within Carmarthen Bay, is reported in full in Appendix 4.

The personnel involved in each survey are listed, their names abbreviated to initials commonly referred to throughout the report. ANB: Alex Banks (air); DB: Dean Bolt (ground); NPF: Nigel Fairney (ground); CH: Cathie Hasler (ground); BH: Bob Haycock (air); IMDM: Ilya Maclean (air); NPR: Paul Roberts (ground); RAS: Richard Schofield (air); LS: Lucy Smith (ground); JMS: Julian Swan (ground); RHAT: Rob Taylor (ground).

Where tidal states are referred to throughout the report, a tidal prediction package was used to produce standardised high and low tide times at Tenby. Tides elsewhere within Carmarthen Bay tend to be within 15 minutes of those at Tenby.

Table 2.1 Fieldwork undertaken in Carmarthen Bay between the winters 2004/05 – 2006/07.

Season	Date	**Survey**	Notes	**Surveyors**
Winter 2004/05	09/02/2005	Land	Monitoring	LS
	25/02/2005	Land	Monitoring	NPF
	26/02/2005	Aerial	Monitoring	BH / RAS
	26/03/2005	Land	Monitoring	NPF
Summer 2005	03/09/2005	Aerial	Monitoring	ANB / RAS
		Land	(moulting birds)	NPF
Winter 2005/06	12/11/2005	Aerial	AM: Monitoring	ANB / BH
			PM: Variable altitude	ANB / BH / NPF / NPR / RHAT
	13/11/2005	Land	Monitoring / observer effect	NPF / JMS
	14/11/2005	Land	Through the tide counts / observer effect	NPF / JMS
	10/12/2005	Aerial	AM: Monitoring	ANB / RAS
			PM: Variable altitude	ANB / RAS / NPF / DB / RHAT
	17/12/2005	Land	Monitoring / observer effect	NPF / JMS
	07/01/2006	Aerial	Monitoring	ANB / RAS
	08/01/2006	Land	Monitoring / observer effect	NPF / JMS
	04/02/2006	Aerial	Monitoring	ANB / IMDM
	11/02/2006	Land	Monitoring / observer effect	NPF / JMS
Winter 2006/07	04/11/2006	Land	Monitoring / observer effect	NPF / CH
	18/11/2006	Aerial	Monitoring	ANB / IMDM
	16/12/2006	Land	Monitoring / observer effect	NPF
	16/12/2006	Aerial	Monitoring	ANB / RAS
	17/12/2006	Land	Observer effect	CH
	27/01/2007	Aerial	Monitoring	ANB / RAS
	27/01/2007	Land	Monitoring / observer effect	NPF / CH
	28/01/2007	Land	Through the tide counts / observer effect	NPF / CH
	17/02/2007	Aerial	Monitoring	ANB / IMDM
	17/02/2007	Land	Monitoring / observer effect	NPR / CH
	25/02/2007	Land	Through the tide counts / observer effect	NPR / CH
	17/03/2007	Land	Through the tide counts / observer effect	NPR / CH

2.2 Methods for individual surveys

2.2.1 Ground-based monitoring surveys

Continuing the methodology employed since 1998/99 (Lucy Smith *unpubl. data*; WWT 2003; Banks *et al.* 2004), it was possible to rely largely on the same observers as have surveyed the site from the ground over the previous nine winters (LS, NPF). One count (December 2007) was undertaken by NPR, a skilled seabird watcher with prior firsthand experience of common scoters in Carmarthen Bay from fieldwork in the winter of 2005/06.

Counts were carried out from three count stations (Figure 2.1), long established as most suitable for maximum visibility across the bay in terms of elevation and aspect. These were Pembrey sand dunes (OS British grid reference: 241500, 199190), Dolwen Point near Pendine (223310, 207840) and Merrifields, Amroth (217900, 207350). All three locations were visited within the same day. On two occasions (24/02/2005 and 25/03/2005), a fourth count station at Kitchen Corner, Rhossili (240350, 187500) was also visited. However, as visits to this site could not be made in the same day as visits to the other count stations, and as relatively few common scoters have been detected in this area for some years (Banks *et al.* in review), it was not visited in any subsequent year.

During the winter of 2004/05, counts could not be made until February 2005. In both subsequent winters it was possible for one full count to be made in each month between November and February, as suggested in the *Standard Operating Procedures* (Banks *et al.* 2004). Where possible, these counts were undertaken in close proximity to aerial surveys.

In September 2005, an additional count was made from the land, in conjunction with aerial survey, to assess the numbers of common scoter present within the bay during the moult phase. Methods used were the same as with counts performed in the winter.

At each site and on each date, the time of count, weather (wind-speed, wind direction, precipitation, cloud cover), sea-state and any disturbance was recorded. Full sea scans were then carried out using a tripod-mounted telescope (20-60x zoom magnification, 80 mm objective) and counts recorded using a tally counter. Each survey lasted for approximately two hours. Data were recorded in a notebook in the field and transferred to MS Excel after the count. Further analyses were carried out within Excel and using ArcMap GIS (ESRI: Cal., USA). No attempt to measure distribution of common scoters by assigning distance and bearing to each flock or individual observed was made, in order that full effort could be concentrated on obtaining accurate count figures; spatial data were thus only plotted on a relative broad-scale basis, with count totals displayed for the relevant count station.

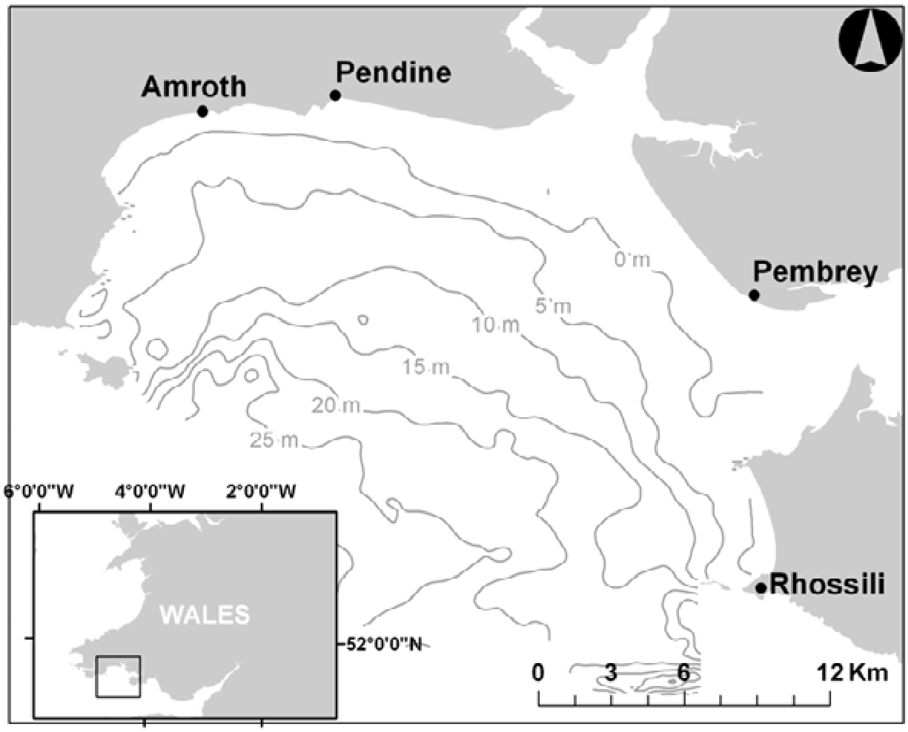


Figure 2.1 Map of Carmarthen Bay showing ground count stations and seabed depth contours.

2.2.2 Ground-based methodological studies

2.2.2.1 'Experience' studies

In the winters of 2005/06 and 2006/07, attempts were made to compare the relative accuracies of counts of common scoter made by experienced and naïve surveyors. The aim of this exercise was to investigate how long it might take a new counter to reach a level comparable with someone with many years experience of surveying Carmarthen Bay (NPF), and avoid potential future problems of the Carmarthen Bay common scoter index fluctuating in response to changes in count personnel. This can also inform recommendations for the *Procedural Guidelines* and *Standard Operating Procedures*. The naïve surveyors were JMS in 2005/06 and CH in 2006/07.

A naïve counter accompanied NPF on each of the surveys (both monitoring and methodological) made through both winters. As far as possible, counters used similar optics (telescope with 20-60x zoom magnification, 80 mm objective) and were positioned in similar locations. Counters visited the same count locations and recorded the same variables as described in 2.2.1. Counters were asked not to confer over count totals, to avoid biasing results.

Surveys from different count stations within the same day were considered as distinct count events, as the *a priori* assumption was that counter precision would increase with time.

2.2.2.2 'Tidal' studies

To assess the influence of tidal state on numbers of common scoters counted, a series of 'through the tide cycle' counts was undertaken. Regrettably, poor weather restricted the number of counts that occurred, with one count performed in 2005/06 and two the following winter. All counts were made from the Pendine count station (Figure 2.1) and lasted for a two-hour period. During the course of one visit, four counts of two hours were made; one at high tide, one on a falling tide, one at low tide, and one on a rising tide.

Observers used a tripod-mounted telescope with 20-60x zoom magnification and an 80 mm objective lens. As well as the variables listed in 2.2.1, observers recorded the distance and bearing to each flock of common scoter seen. Distance estimates were calibrated against buoys situated in the bay, the offshore position of which was determined from hydrographic charts. Bearings were taken in relation to the observer using a needle compass and categorised to within 5°. Anecdotal records of bird behaviour and sources of disturbance were also recorded.

2.2.2.3 Behavioural studies

On two occasions in 2005/06, three ground-based observers (a combination of NPF, DB, NPR and RHAT) were positioned around the bay, in order to assess the effect of the aerial survey aircraft on common scoter behaviour and distribution. Pre-flight counts were made from each location (Amroth, Pendine, Pembrey), and observers recorded quantitative changes in numbers during aerial surveys. Observers also attempted to qualitatively describe common scoter behaviour in response to the aircraft.

See also section 2.2.4.

2.2.3 Aerial monitoring surveys

Following the recommendations in Banks *et al.* (2004), all aerial surveys were performed using the 'distance' method (Komdeur *et al.* 1992; Dean *et al.* 2003; Camphuysen *et al.* 2004), based on the statistical principles of distance sampling (Buckland *et al.* 2001). This method is accepted as the standard for surveying birds in offshore locations (Camphuysen *et al.* 2004). The total survey area covered was designed to encompass the whole of Carmarthen Bay Special Protection Area (SPA).

In the winter of 2004/05, only one monitoring survey was possible. A further survey to investigate numbers of birds using Carmarthen Bay as a moulting site was undertaken in September 2005, and thereafter the requisite four surveys, one in each month between November and February, were performed in the winters of 2005/06 and 2006/07.

Surveys utilised a transect design, with the aircraft moving north – south and south – north along pre-determined transect lines (Figure 2.2). Surveys began in the north west corner of the bay and ended in the south east of the bay. The orientation of transects was selected to run perpendicular to the major environmental gradient, *i.e.* the depth of the sea bed. This can help to eliminate bias introduced by observers experiencing differing count conditions (Camphuysen *et al.* 2004). Transects varied in length depending on the southward extent of the SPA, but were always spaced 2 km apart.

All surveys were carried out in a Partenavia PN68 aircraft (Figure 2.3), piloted by Ravenair (Liverpool). The aircraft is suitable as it has fixed high wings, twin engines and five seats (four typically occupied by pilot, navigator (where present) and two counters). The aircraft was flown at a constant ground speed (185 kmh^{-1}) and altitude (76 m). No surveys took place in wind speeds of greater than 24.1 kmh^{-1} (15 mph), and all surveys took place at weekends when MoD operations in the bay were inactive.

The aircraft was equipped with an onboard GPS system, into which the waypoints forming the start and end of each transect were entered prior to takeoff. In this way, the pilot could follow a straight-line track on the GPS screen between start and end points. It was also possible for the pilot to announce the start and end of transects to the surveyors, who then recorded these (in addition to all other data collected) on digital voice recorders. In some instances, it was possible to include a designated navigator amongst the crew, and in such cases this person recorded the start and end times of the transects, additionally keeping track of position, altitude and speed.

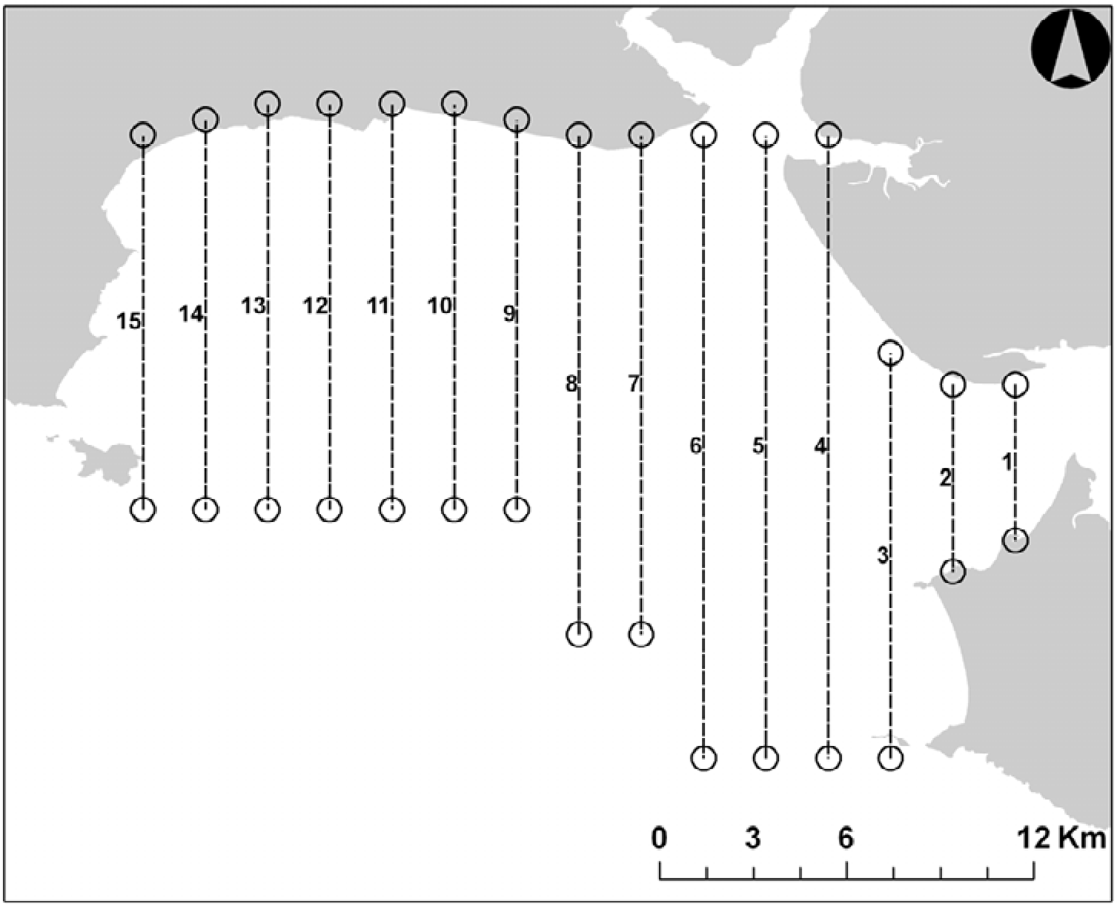


Figure 2.2 Map of aerial survey transects flown in Carmarthen Bay. Circles denote waypoints.

Figure 2.3 Partenavia PN68, Ravenair, Liverpool. (*Alex Banks*)

Each flock or individual bird seen was recorded. Observers recorded the time of observation, the number and species of birds (and cetaceans when seen). Behaviour of the birds was determined as sitting or flying / flushing, with the direction of flight seldom recorded owing to the greater demands on the observers. Each observation was allocated to one of four distance bands used as standard (Camphuysen *et al.* 2004): Band A = 44-162 m (600-250 below the horizontal); Band B = 162-282 m (250-150); Band C = 282-426 m (150-100); Band D = 426-1000 m (100-4.230). There was a 'dead-zone' below the plane where observations could not be made, which extended out from the transect line to a distance of 44 m. The limits of each band were determined using an inclinometer that enabled the measurement of predetermined angles below the horizontal.

The position of the plane during the flight was recorded using a Garmin 12XL GPS, which was linked to a laptop computer running WinWedge. This allowed continuous recording of position to a Microsoft Access database. Where satellite reception was broken, position was inferred from known start and end points, assuming a constant speed between the markers. The clock of the GPS was synchronized before each flight with the stop-clocks used inside the plane.

All surveyors were experienced aerial surveyors, and were familiar with the target species and the methods used. Across the three winters, five surveys were carried out by ANB and RAS, three by ANB and IMDM, one by ANB and BH, and one by BH and RAS (Table 2.1).

Data were transcribed from digital voice recorder files into MS Excel, and then analysed using distance sampling software (Distance 5.0; Research Unit for Wildlife Population Assessment, University of St. Andrews).

2.2.4 Aerial methodological surveys

Using the same aircraft as detailed in the previous section, two attempts were made in the winter of 2005/06 to investigate the effect of altitude on the trade-off between reducing disturbance to the birds and accuracy of counting. With the hypothesis that birds may be less disturbed at higher altitudes, a subset of five transects (15 – 11: Figure 2.2) known to overlap with typically high concentrations of common scoters was selected. The plane was then flown along these transects at various altitudes (375 m, 300 m, 225 m). Inclinometers were adapted to fit the distance bands used on standard monitoring counts.

In an attempt to measure the effect on disturbance, ground surveyors were positioned around the bay to record responses of the birds to the aircraft (see section 2.2.2.3).

2.3 Data analysis

2.3.1 Ground-based counts

Generalised Linear Models (GLMs: McCullagh and Nelder, 1989) were used to investigate temporal changes in the ground-based count data, using all available and comparable information from 1994/95 to the last winter of survey, 2006/07 (Stewart *et al.* 1997; Cranswick *et al.* 1998, Lucy Smith unpubl. data; WWT 2003; Banks *et al.* 2004). Only data collected during the winter period (November – February) were considered, as year-round data were not available for every year. Furthermore, peak numbers of scoters in Carmarthen Bay consistently appear in these months. Counts were modelled in relation to month and year class variables. An index of population change was derived from the exponential of estimated model parameter values for the year factor, as has been applied to other bird trends (Robinson *et al.* 2005), indicating the variation of counts each winter in relation to 2006/07. The model assumed a Poisson distribution for the number of birds, specified a log link function and treated year and month as categorical variables. The problem of overdispersion caused by a combination of several low counts and several very high counts, typical of flocking species, was addressed by applying a scale factor estimated from the square root of the Pearson's χ^2 statistic divided by its degrees of freedom.

Because data collected between 2004/05 and 2006/07 were not assigned distance and bearing information, relative abundances of common scoter counted at each count station were displayed cartographically. All maps were created using ArcMap GIS.

To analyse the effect of observer experience, the proportion of the count of the experienced surveyor achieved by the naïve surveyor was taken as the measure of precision. Owing to extremely low numbers of common scoters at Pembrey in both winters, data from this count station were not used; this avoided confounding outliers resulting from small absolute differences (*e.g.* counts of 12 and 18 common scoters by the experienced and naïve surveyors respectively produced a precision value of 150%). Precision was then plotted for all count events in one winter (*i.e.* for one naïve observer) and linear regression lines were added. It was not possible to add exponential curves, which may have better modeled surveyor's learning curves, in the package used. Linear regression lines were extrapolated to obtain a value at which the naïve surveyor's accuracy could be said to match the experienced counterpart.

Separate plots, without lines, were created to illustrate the effect of count site and survey type on accuracy levels.

To investigate the possible effects of tide on common scoter counts, data from experienced surveyors only were used. Tidal heights at the time of counts were derived by linear extrapolation from known high and low tide times. These were then plotted with count totals, the mid-point of each two-hour count being used for the x variable. Tidal height ten minutes after this mid-point was plotted for clarity.

Additionally, distribution of common scoters on these counts was plotted using ArcMap GIS. Flocks were plotted at the mid-point of the 5° arc to which they were assigned in the field.

2.3.2 Aerial survey

To generate estimates of abundance from aerial monitoring surveys, the program Distance 5.0 was used. All data available from the period of analysis (2004/05 – 2006/07) were treated, including data collected in September 2005, as there was no *a priori* reason to believe that detection functions in different months should have been affected by month-specific factors. Data were, however, stratified by month to allow this hypothesis to be tested. Total survey areas and transect lengths were derived from GIS. Covariates read into the software included observer, side of plane, bird behaviour and state of tide at the mid-point of the survey.

Various conventional distance models and multi-covariate distance models were run; models were selected between on the basis of lowest AIC values (more details appear in Appendix 1).

An index of common scoter numbers recorded on 'distance method' aerial surveys was generated using the same procedure as described for ground-based counts. Data were restricted to those collected between November and February in any given winter, and thus the index reflects changes in wintering estimates only. Point estimates were used as input values and analytical 95% confidence intervals obtained from distance sampling were not treated.

All spatial data were plotted using ArcMap GIS. As the aim was to examine relative distribution, no correction was made to raw count data, other than to correct the x-coordinate for the distance band in which the observation was made. For ease of visual interpretation, a 1 km grid encompassing the Carmarthen Bay SPA and any part of any transect outside of this boundary was overlaid, with observations falling inside grid cells attributed to those cells. Thus the distribution for an individual survey was presented as a summed point at the central location of the relevant 1 km OS grid square. Mean winter distributions were calculated by taking the average count for the square recorded between November and February of the relevant winter.

Additionally, the weighted mean centroid, a spatial measure of central tendency, was determined for each average winter distribution. The centre of the distribution was then weighted by average count using ArcMap GIS. This enabled a visual interpretation of spatio-temporal changes in common scoter distribution within the bay and comparison with previous distributions.

3 RESULTS

3.1 Ground-based surveys

3.1.1 Ground-based monitoring surveys

Results from all monitoring counts made from the land are presented in Tables 3.1 – 3.3. Only three such counts were possible in 2004/05, all occurring in February or March. During 2005/06 and 2006/07, four counts were made from the land, one in each of the months November to February.

Peak and mean counts for the various winters are presented in Table 3.4.

The counts were fed into the model producing the ground-based index of common scoter counts (Banks *et al.* in review). The index thus shows changes in scoter numbers visible from the standard count stations around Carmarthen Bay (Figure 3.1).

Relative distribution of common scoters counted from the three (or four) count stations are shown in Figures 3.2 – 3.4. Mean relative distributions for these counts for each of the winters 2004/05, 2005/06 and 2006/07 are also shown (Figure 3.5).

Table 3.1 Ground-based monitoring counts of common scoter in Carmarthen Bay 2004/05. All counts by NF, except 09/02/05 counts by LS.

Date	Station	Start	Count	Tidal State	Wind (mph)	Cloud	Sea state	Visibility	Notes
09/02/2005	Pendine	0915	13,825	Falling	SW 3	7/8	Small waves, occasional white horses		Birds ranging from 1.5 to 4 km from shore. Large proportion feeding.
09/02/2005	Amroth	1115	6,995	Falling to Low	SW 3 – 4	7/8	Small wavelets, few white horses		Birds ranging from 1 to 5 km from shore.
09/02/2005	Pembrey	1530	3,640	Rising	SW 3 – 4	8/8	Medium waves, regular white horses	3 km	Slight mist and drizzle.
	TOTAL		24,460						
24/02/2005	Rhosilli	1000	27	Falling	ENE 4	4/8	Calm	6 km +	Loafing, feeding.
25/02/2005	Pembrey	0800	274	Falling from High	ENE 4	6/8	Calm	6 km +	Loafing, feeding.
25/02/2005	Pendine	1100	10,117	Falling	ENE 5	4/8	Calm	6 km +	Loafing, limited feeding observed. Many in flight (west to east), though no disturbance noted, other than Herring Gulls mobbing feeding birds.
25/02/2005	Amroth	1330	682	Low	ENE 5	6/8	Calm	6 km +	Loafing, limited feeding observed.
	TOTAL		11,100						
25/03/2005	Rhosilli	0830	264	Falling	SSE 4	4/8	Calm	5 km +	Widely dispersed across bay, typically very distant (3 km +). Loafing / displaying / chasing / squabbling parties noted. Limited feeding activity noted amongst closer parties (<2 km).
26/03/2005	Amroth	0630	217	High	ESE 5	5/8	Calm	5 km +	Several small parties displaying / chasing and diving but the majority loafing. The birds were closer to shore with a few only approx. 200 m offshore. The birds usually present in larger numbers toward Telpin Point were apparently absent.
26/03/2005	Pendine	0915	8,320	Falling	ESE 4	3/8	Calm	5 km +	Majority of birds following a distinct line 1-2 km offshore from the buoys off Telpin Point across the bay toward Cefn Sidan / Pembrey. Most of the birds loafing but many small groups of about 20 chasing and diving, often taking flight but only for a few hundred metres. Very little evidence of feeding. Only a few small flocks were flying any noticeable distance and then approx. 2 km; these flocks rarely exceeded 30 individuals. A few small parties were noted in flight at a distance of 3-4 km indicating the presence of more birds not visible from land.
26/03/2005	Pembrey	1245	344	Low	SE 4	5/8	Calm	5 km +	Loafing, small parties (<15), some squabbling / chasing / courtship noted.
	TOTAL		9,145						

Table 3.2 Ground-based monitoring counts of common scoter in Carmarthen Bay during the winter of 2005/06. All counts by NF.

Date	Station	Start	Count	Tidal State	Wind (mph)	Cloud	Sea state	Visibility	Notes
13/11/2005	Pembrey	0800	67	Falling to Low	NNE 4	2/8		Good	Loafing.
13/11/2005	Pendine	1130	10,941	Rising	NNE 3	2/8		Good	Mainly loafing, small numbers squabbling and occasional feeding observed. 2,800 were counted in flight heading east from Amroth through count sector and into recording area. No disturbing influence was observed to produce this flight.
13/11/2005	Amroth	1345	7,345	Rising	NNE 2-3	0/8		Good	Loafing / feeding / squabbling.
	TOTAL		18,353						
17/12/2005	Pembrey	0830	140	Falling	N 2	8/8		Good	Loafing.
17/12/2005	Pendine	1100	5,391	Falling to Low	N 2	7/8		Good	Mainly loafing, small numbers squabbling and occasional feeding observed.
17/12/2005	Amroth	1330	14,756	Rising from Low	N 1-2	7/8		Good	Loafing / feeding / squabbling. Jet-ski west-east through the main raft of birds at 13:58 and on its return at 15:38 caused great disturbance.
	TOTAL		20,287						
08/01/2006	Pembrey	1400	13	Falling	E 3-4	3/8		Moderate: strong sun glare	Loafing.
08/01/2006	Pendine	1100	4,545	Rising to High	ENE 3	2/8		Moderate: strong sun glare and wispy sea mist	Mainly loafing, small numbers squabbling and occasional feeding observed.
08/01/2006	Amroth	0830	1,210	Rising	E 3-4	3/8		Moderate: some sea mist and sun glare (4 km)	Loafing / feeding / squabbling.
	TOTAL		5,768						
11/02/2006	Pembrey	1400	148	Rising	SSE 4	6/8		Good	Loafing.
11/02/2006	Pendine	1100	9,237	Falling to Low	S 3-4	8/8		Good	Mainly loafing, small numbers squabbling and occasional feeding observed.
11/02/2006	Amroth	0830	4,238	Falling	S 4	8/8		Good	Loafing / feeding / squabbling.
	TOTAL		13,623						

Table 3.3 Ground-based monitoring counts of common scoter in Carmarthen Bay during the winter of 2006/07. All counts by NF, except 17/02/2007 by NPR.

Date	Station	Start	Count	Tidal State	Wind (mph)	Cloud	Sea state	Visibility	Notes
04/11/2006	Pembrey	0930	118	Falling to Low	NE 0-1	1/8	Calm	5 km + with sun glare affecting 25% of view	Widely dispersed across bay, small rafts <10, loafing.
04/11/2006	Pendine	1230	8,670	Rising	SW 1-2	2/8	Calm	5 km + with sun glare affecting visibility	Loafing, squabbling groups and feeding activity noted in the flock of 1,220 between 400 m and 1.3 km offshore. At 2.5 km, feeding not noted due to distance but squabbling and loafing groups (6,090). At 5 km distance too great to note behaviour (1,360). Disturbed by fishing boat at 12:32 and 13:40 but disturbance brief and birds soon relocated after short flight.
04/11/2006	Amroth	1500	627	Rising to High	SW 0-1	1/8	Calm	5 km +, with low setting sun glare affecting only the most westerly portion (<15%) of the recording area	Loafing, some squabbling amongst distant rafts (1.5 km). Very few birds present. Most (440) at 1.3 km. Viewing beyond this difficult due to low setting sun causing dark peaks to wave crests.
	TOTAL		9,415						
16/12/2006	Pembrey	1445	237	High	SW 3-4	3/8	Calm, slight chop	5 km + with sun glare affecting 25% of view	Dispersed across western end of extent of scan (1.5 km + offshore); appeared to be mostly loafing.
16/12/2006	Pendine	1145	2,175	Rising	SW 2 increasing to SW 3-4	1/8 later 3/8	Calm, chop worsening with wind	5 km + with sun glare affecting visibility directly south	Increasing 'chop' on water reduced visibility around 1.6 km, but relatively few scoters, widely dispersed across whole bay. Squabbling and loafing, with feeding birds noted closer in (<1.5 km).
16/12/2006	Amroth	0930	2,970	Rising from Low	WSW 2	1/8	Calm	5 km +, sun glare south of count station	Loafing, feeding activity noticeable amongst closer groups (<1 km), largest raft (760) about 850 m offshore. More birds than on other counts in the western portion of the bay (1,100).
	TOTAL		5,382						
27/01/2007	Pembrey	1000	673	Rising	N 2-3	8/8	Calm	5 km +	Mainly loafing with some feeding activity noted. Gulls mobbing scoters where feeding taking place.
27/01/2007	Pendine	1200	7,932	Rising	N 3-4	7/8	Calm	5 km +	Loafing, drifting west on tide, some feeding activity

				to High					noted. At 12:05 a plane flew east across study site causing typical reaction with birds in flight then returning to approx. same area as alighted from.
27/01/2007	Amroth	1430	3,620	Falling	N 2-3	5/8	Calm	5 km +	Loafing, feeding activity noticeable amongst closer groups, rafts widely dispersed across the sea from this site.
	TOTAL		12,225						
17/02/2007	Pembrey	1020	12	Falling to Low	NW 3	3/8	Fairly calm	3 km with sun glare affecting 25% of view	Loafing. No aggression / fighting observed, tide well out.
17/02/2007	Pendine	1445	8,430	Rising	NW 4	8/8	Fairly calm	5 km +, light rain starting at end of count	Mostly loafing, some feeding.
17/02/2007	Amroth	1245	5,970	Rising from Low	NW 3	4/8	Fairly calm	5 km + with sun glare affecting visibility	Feeding, loafing, no squabbling noted, groups arriving into study area from the west- some double-counting?
	TOTAL		14,412						

Table 3.4 Count totals, winter mean counts and winter peak counts of common scoter from land-based surveys 2005 – 2007.

Date	Total	Winter mean	Winter peak
09/02/05	24,460		
25/02/05	11,100	14,902	24,460
26/03/05	9,145		
13/11/05	18,353		
17/12/05	20,287	14,508	20,287
08/01/06	5,768		
11/02/06	13,623		
04/11/06	9,415		
16/12/06	5,382	10,359	14,412
27/01/07	12,225		
17/02/07	14,412		

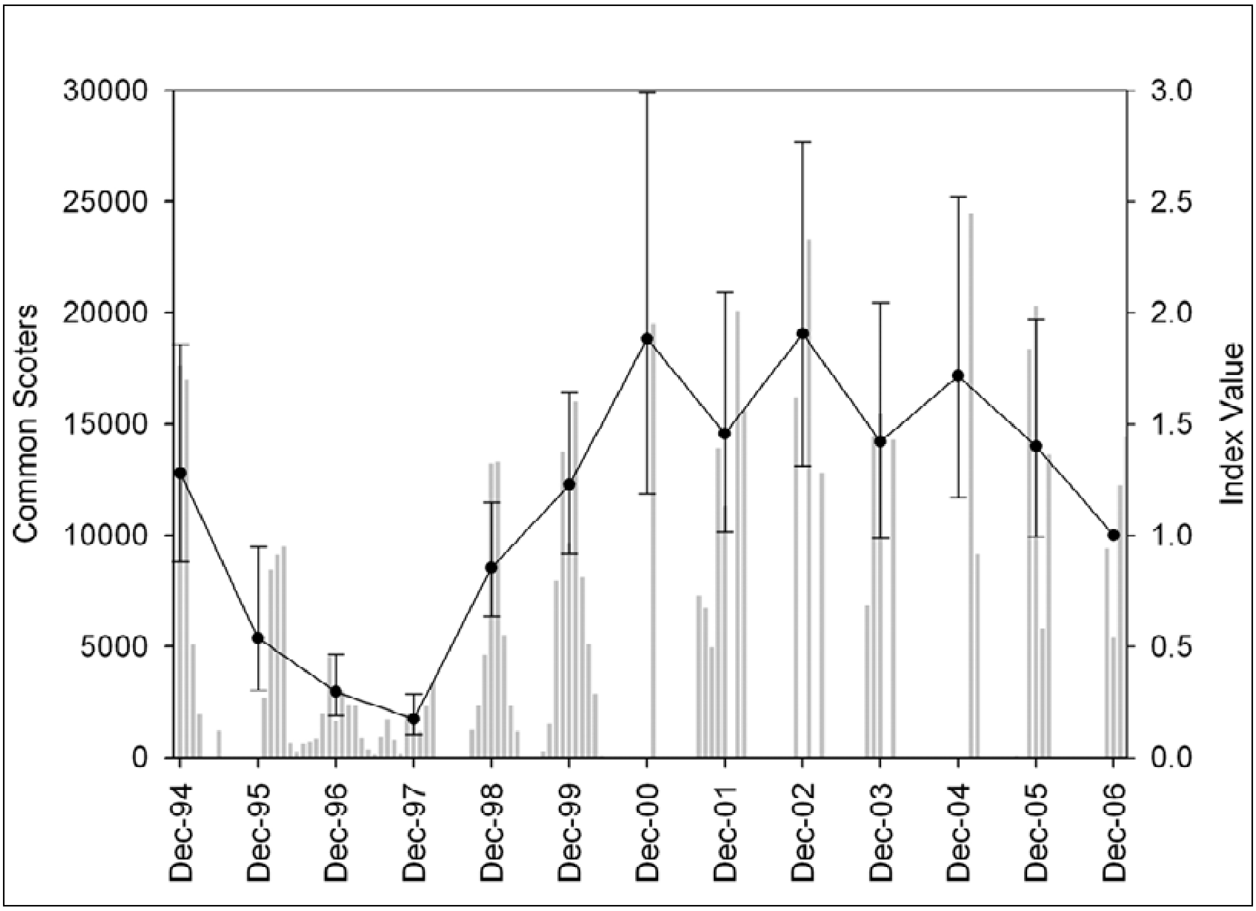


Figure 3.1 Index of common scoter numbers in Carmarthen Bay from ground-based surveys 1994 – 2007.

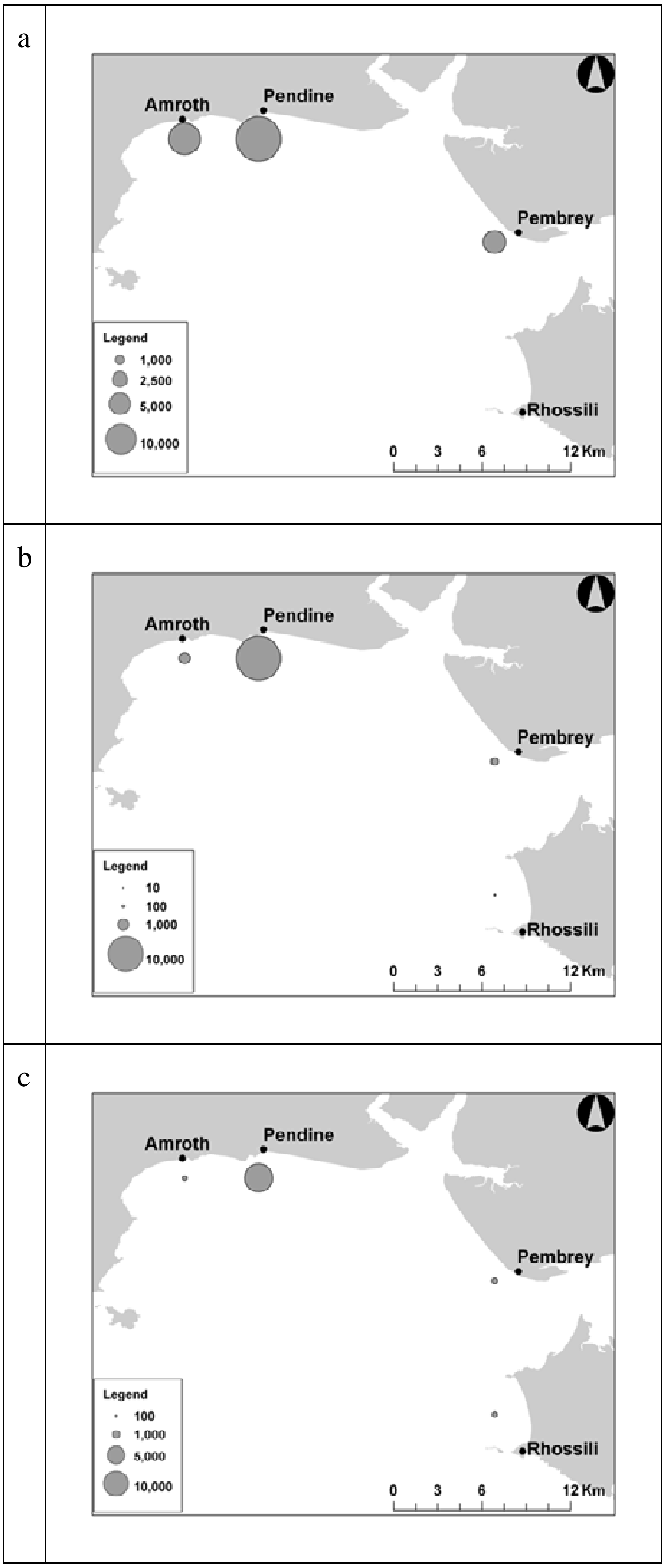


Figure 3.2 Relative distribution of common scoters recorded on land-based counts 2004/05. **a.** 09/02/2005; **b.** 20/02/2005; **c.** 26/03/2005.

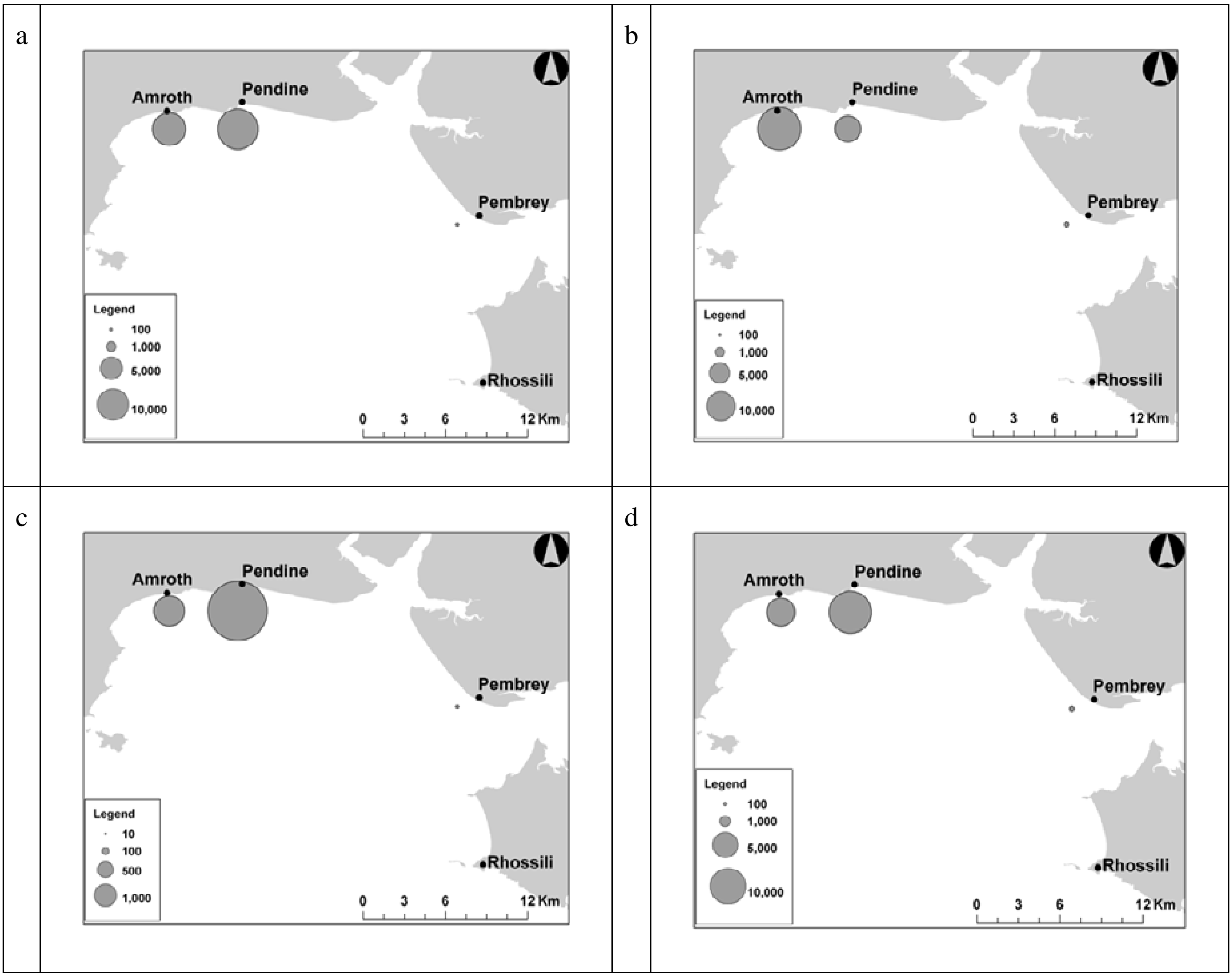


Figure 3.3 Relative distribution of common scoters recorded on land-based counts 2005/06. **a.** 13/11/2005; **b.** 17/12/2005; **c.** 08/01/2006; **d.** 11/02/2006.

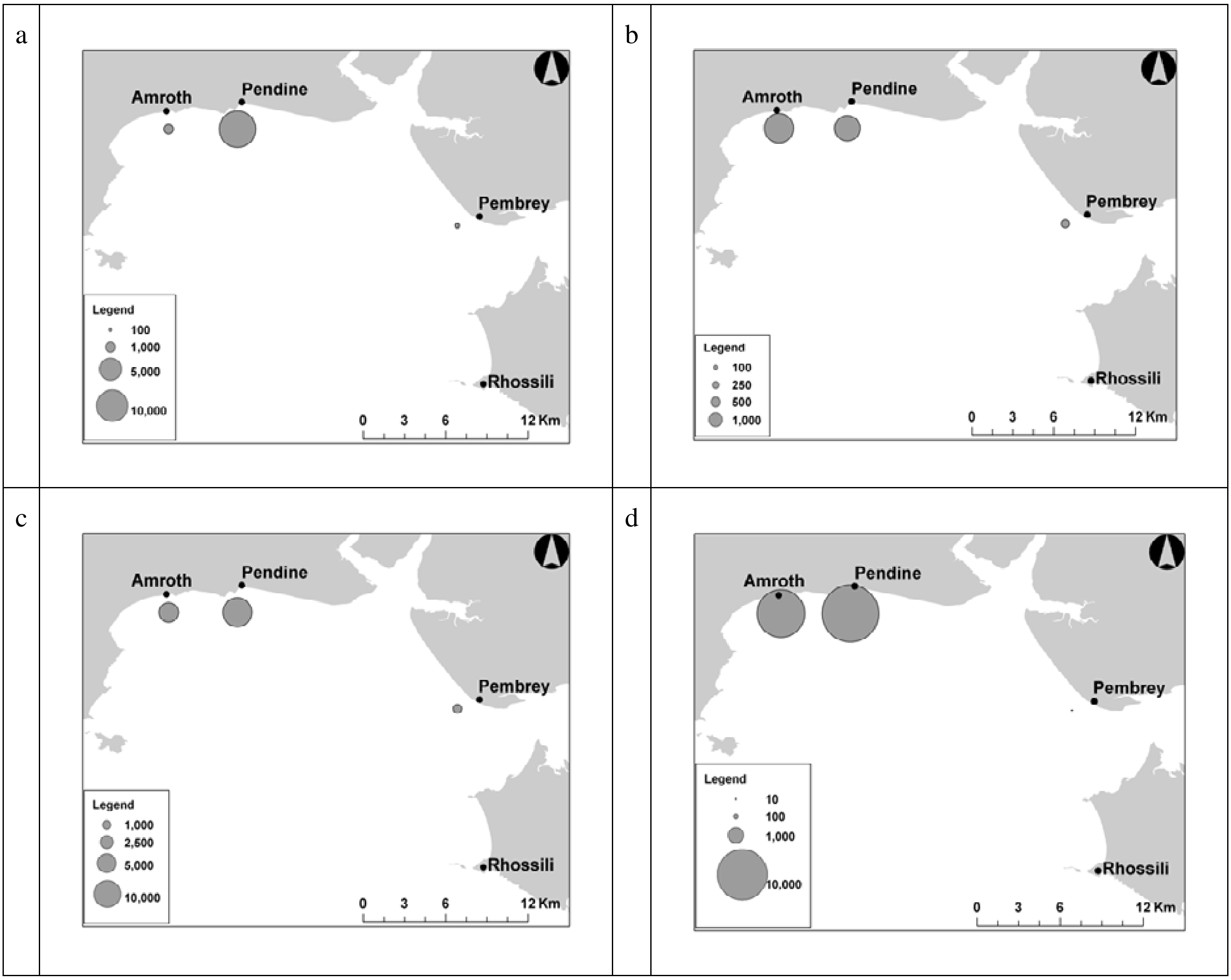


Figure 3.4 Relative distribution of common scoters recorded on land-based counts 2006/07. **a.** 04/11/2006; **b.** 16/12/2006; **c.** 27/01/2007; **d.** 17/02/2007.

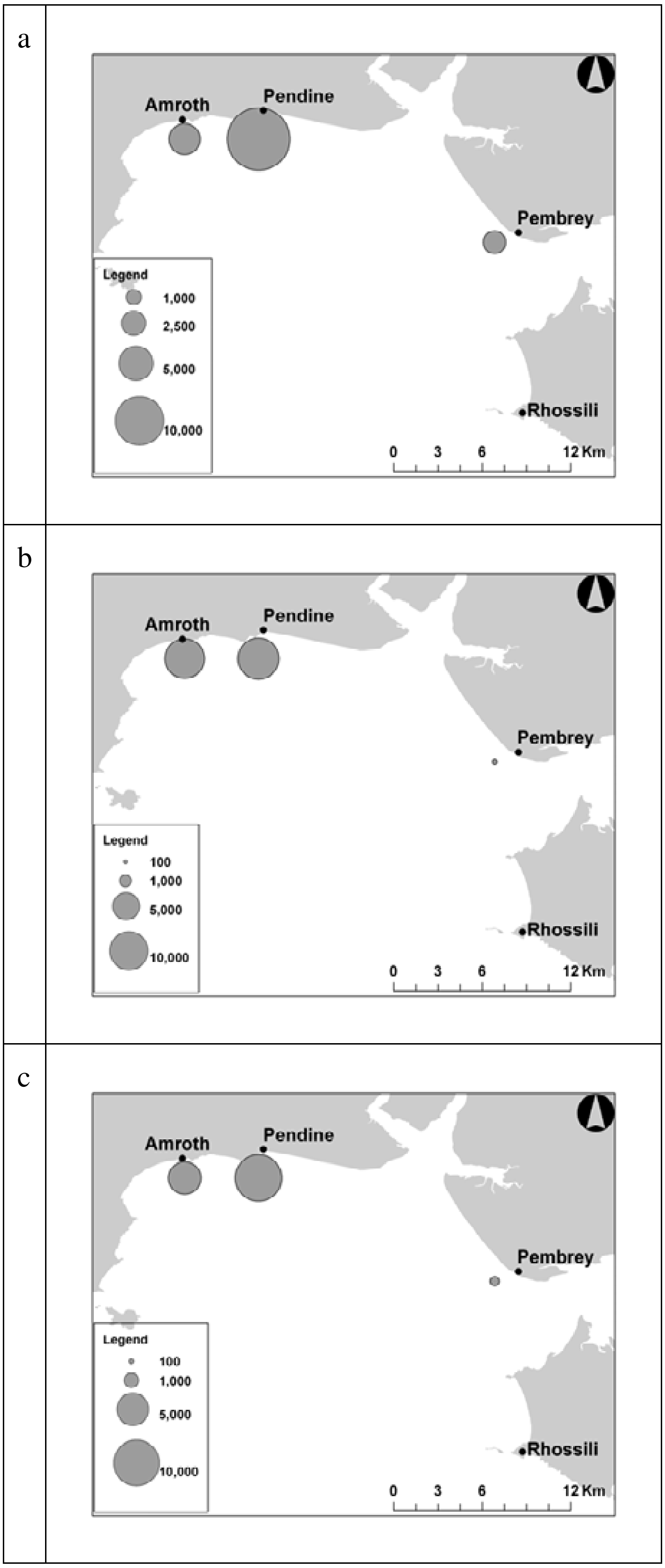


Figure 3.5 Mean relative distribution of common scoters recorded on land-based counts 2004-2007. **a.** 2004/05; **b.** 2005/06; **c.** 2006/07.

3.1.2 Land-based methodological surveys

To attempt to further understand the effects of experience and tide on land-based counts of common scoter, two groups of surveys were analysed as below. However, counts made on 'tidal' surveys also contributed to results regarding counter experience.

3.1.2.1 Experience studies

Naïve surveyors counted alongside an experienced surveyor on 12 occasions in 2005/06 and 13 occasions in 2006/07. As expected, naïve surveyor precision was much lower than that of their experienced counterpart to begin with, and increased over time. There were differences in the rate of increase of precision between surveyors (Figure 3.6), though for four of the first six visits surveyors' precision levels were very similar. It should be noted that an additional two counts (which would have been counts three and four) made by CH could not be compared to an experienced surveyor as counts occurred on different days. Counts 9 –13 by CH were alongside a different experienced surveyor, but it is assumed that differences between experienced surveyors are not substantial (Banks *et al.* 2004). One more additional count (which would have been count 14) was excluded for CH owing to missing counts resulting from mass disturbance during the count.

To provide an estimate of the number of counts necessary to approach the proficiency of an experienced observer, the linear regression lines were extrapolated over an extended set of visits (Figure 3.7). Although this approach should not be considered definitive (see Discussion), a rough approximation of the number of visits necessary to achieve the precision of an experienced surveyor lies between 13 and 23 visits.

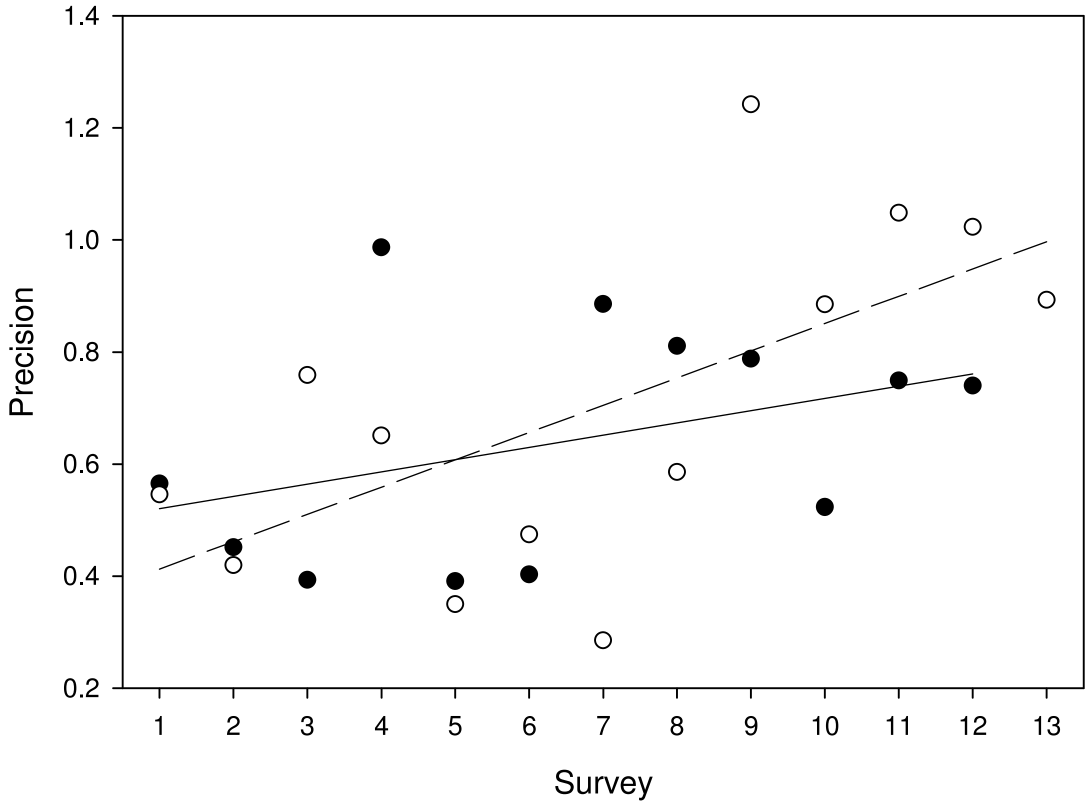


Figure 3.6 Precision of naïve counters as fraction of count compared to experienced counter across all surveys. Lines are linear regression. Filled circles (solid line): observer = JMS; open circles (dashed line): observer = CH.

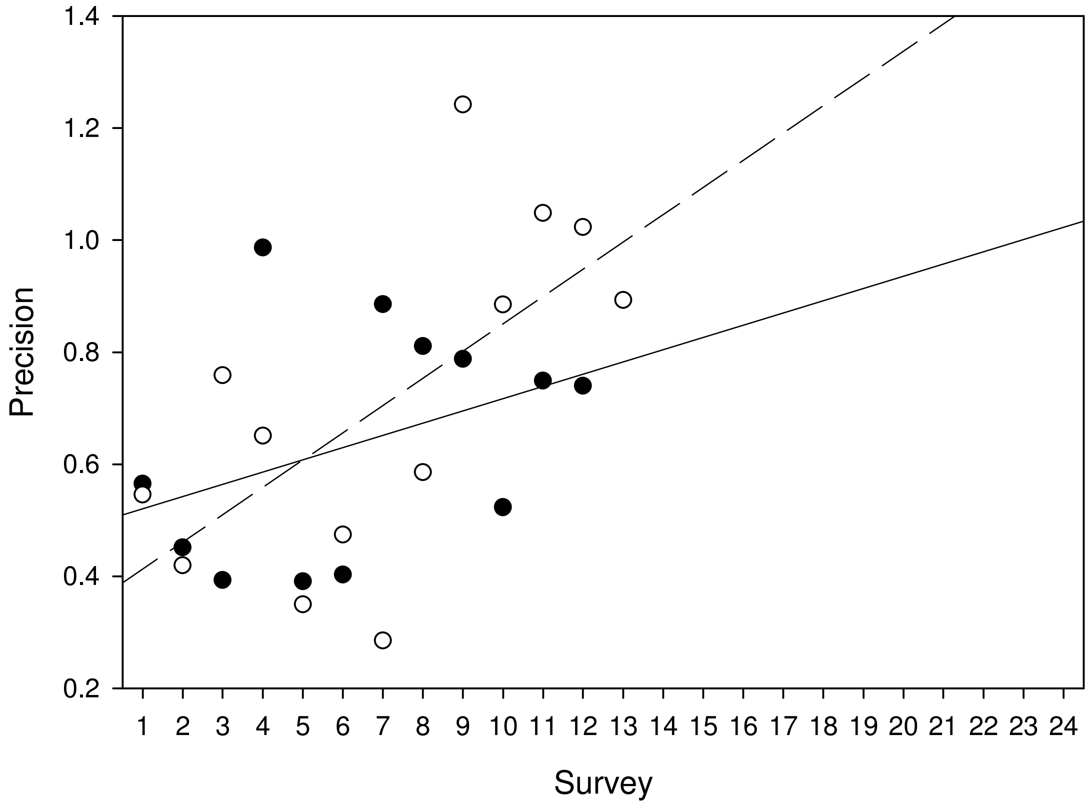


Figure 3.7 Extrapolated counter precision. Lines are linear regression. Filled circles (solid line): observer = JMS; open circles (dashed line): observer = CH.

An additional plot was created using data only from standard monitoring surveys, to see if count station had an effect on naïve surveyor precision. Precision was generally greater at Pendine than Amroth (Figure 3.8). Where comparisons between counters was possible, naïve counters showed the same patterns in these site differences, in some cases (1st and 3rd counts) notably so.

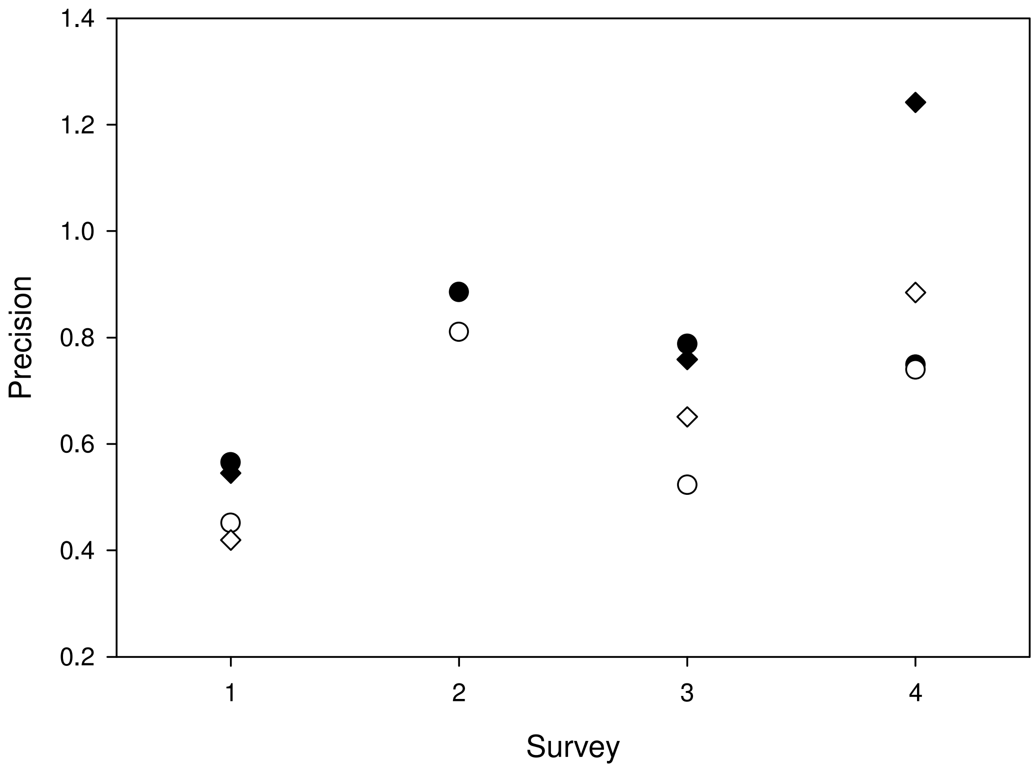


Figure 3.8 Precision of naïve counters as fraction of count compared to experienced counter on monitoring surveys. Circles: observer = JMS; diamonds: observer = CH. Open symbols = Amroth; filled symbols = Pendine.

3.1.2.2 Tidal studies

In the winter of 2005/06, one day of through-the-tide counts was possible. The following winter, the surveys occurred on two separate dates. All three counts featured a naïve and an experienced counter.

The totals recorded on the various surveys differed with tide and observer, as expected (Tables 3.5 – 3.7). Although not a universal pattern, there is some evidence that highest counts are made on high or rising tides. This is best illustrated by Figure 3.9, which shows tidal height in relation to the total number of common scoters counted (experienced surveyors only).

Further results from these counts are presented below.

14th November 2005 (Table 3.5)

High tides: 04:36, 16:54. Low tides: 10:54, 23:12. The count was undertaken in perfect conditions, and on the first survey the vast majority of birds recorded were loafing (90%), with some squabbling behaviour noted. This pattern persisted until the final survey of the day, when up to 15% of scoters recorded were engaged in some feeding behaviour. The final survey was affected by deteriorating sea state, restricting visibility beyond around 1.6 km.

28th January 2007 (Table 3.6)

High tides: 01:12, 13:54. Low tides: 07:36, 20:24. Count conditions began favourably, with only a slight chop on the water; however, by the time of the last count this had increased and is likely to have affected visibility to some extent. On the first count (lowest tide), loafing was the predominant behaviour, with 95% of observations exclusively assigned to this category. Groups including at least some feeding individuals were more common as time progressed, with 25% and 28% of scoters observed in such flocks on the second and third surveys. On the last count, 31% of birds observed were recorded as including feeding flocks, with the additional comment that these birds were less dispersed.

25th February 2007 (Table 3.7)

High tide: 11:54. Low tides: 05:42, 18:18. Despite isolated light showers, the sea state was moderate to begin and not thought to greatly reduce visibility; however, sun glare was an issue when looking in certain directions and the sea became increasingly choppy as the survey progressed. Windsurfers caused disturbance to the birds on the third and especially the fourth survey. The majority of common scoter flocks were noted as feeding, figures ranging from 75%, 64%, 73% and 59% through the four counts. Other flocks of loafing birds were also frequently recorded as containing feeding individuals. It is possible that increased feeding reflected pre-migratory behaviour at the late stage of the season, or alternatively differences in counter interpretation of bird behaviour.

Table 3.5 Common scoter totals from Pendine on 14/11/05 at different tidal states. Naïve surveyor's estimate in brackets.

Count	1	2	3	4
Start time	07:45	09:45	12:00	14:00
Tidal state	Falling	Falling to low	Rising	Rising near high
Precipitation	None	None	None	None
Wind strength	1	1	2 –3, increasing to 4	4
Wind direction	NE	NE	NE	NE
Cloud Cover	4/8	4/8	4/8 increasing to 6/8	6/8
Visibility	Excellent	Excellent	Worsening through count	Poor (1.6 km)
Sea state	Flat calm	Flat calm	Calm	Deteriorating
Disturbance	None	None	None	None
Total count	10,879 (4,279)	11,038 (10,892)	13,667 (5,347)	11,113 (4,478)

Table 3.6 Common scoter totals from Pendine on 28/01/07 at different tidal states. Naïve surveyor's estimate in brackets.

Count	1	2	3	4
Start time	08:00	10:00	12:15	14:15
Tidal state	Rising from low	Rising	Rising to high	High, falling
Precipitation	Minor	Minor	None	None
Wind strength	3	3	2	2-3
Wind direction	SSW	SSW	WNW	S
Cloud Cover	8/8	8/8	8/8	8/8
Visibility	Ok	Ok	Ok; glare	Ok
Sea state	Slight chop	Slight chop	Slight chop	Increasing chop
Disturbance	None	None	None	None
Total count	6,069 (2,005)	8,924 (4,230)	9,174 (2,490)	6,440 (3,480)

Table 3.7 Common scoter totals from Pendine on 25/02/07 at different tidal states. Naïve surveyor's estimate in brackets (*some counts missing due to disturbance).

Count	1	2	3	4
Start time	09:00	11:15	13:45	15:45
Tidal state	Rising	Rising to high	Falling	Falling near low
Precipitation	Light showers	Light showers	None	None
Wind strength	2-3	2-3	2	2
Wind direction	SW	SW	SW	SW
Cloud Cover	5/8	4/8	7/8	7/8
Visibility	Some glare	Ok	Some glare	Some glare
Sea state	Moderate	Some chop	Some chop	Increasing chop
Disturbance	None	None	Windsurfers	Windsurfers
Total count	4,835 (5,068)	6,675 (6,829)	5,138 (4,589)	5,774 (3,124*)

The effect of tide on common scoter counts is best represented in Figure 3.9b, and to a lesser extent Figure 3.9c. As the tidal height rises, so does the number of scoters counted. Some factors of note will have affected these counts: for instance, in Figure 3.9a the final count was undertaken in restricted visibility and may have been higher otherwise. Similarly, the final two counts in Figure 3.9c were affected by disturbance and there is the possibility of inflation from double-counting.

The distribution of common scoters in Figures 3.10 – 3.12 does not clearly indicate a spatial tendency for more birds to move closer inshore on high or rising tides, nor does it greatly reflect closer aggregation of the birds present.

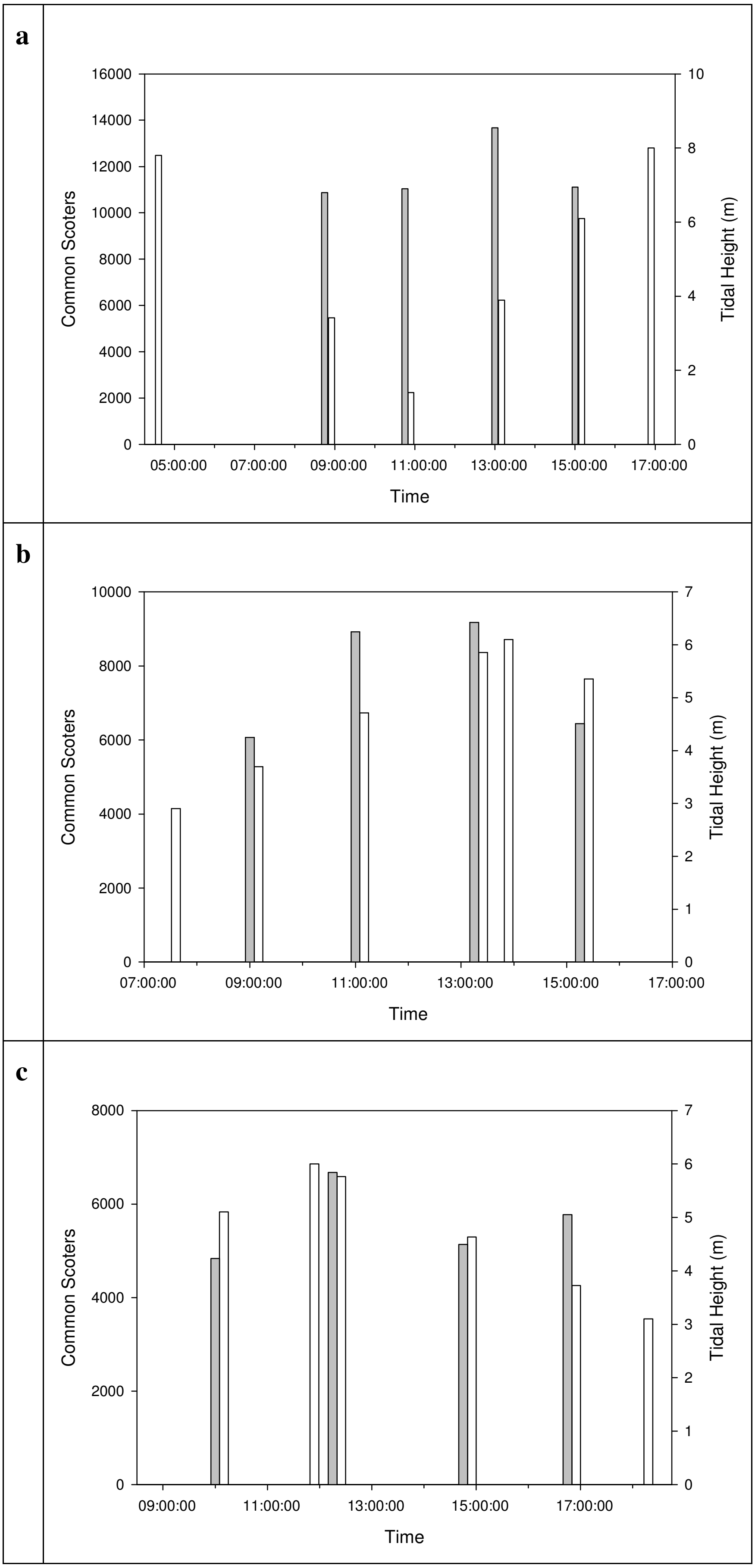


Figure 3.9 Common scoter counts in relation to tidal height. **a.** 14/11/05. **b.** 28/01/07. **c.** 25/02/07. Grey bars show numbers counted, open bars tidal height in metres at Tenby.

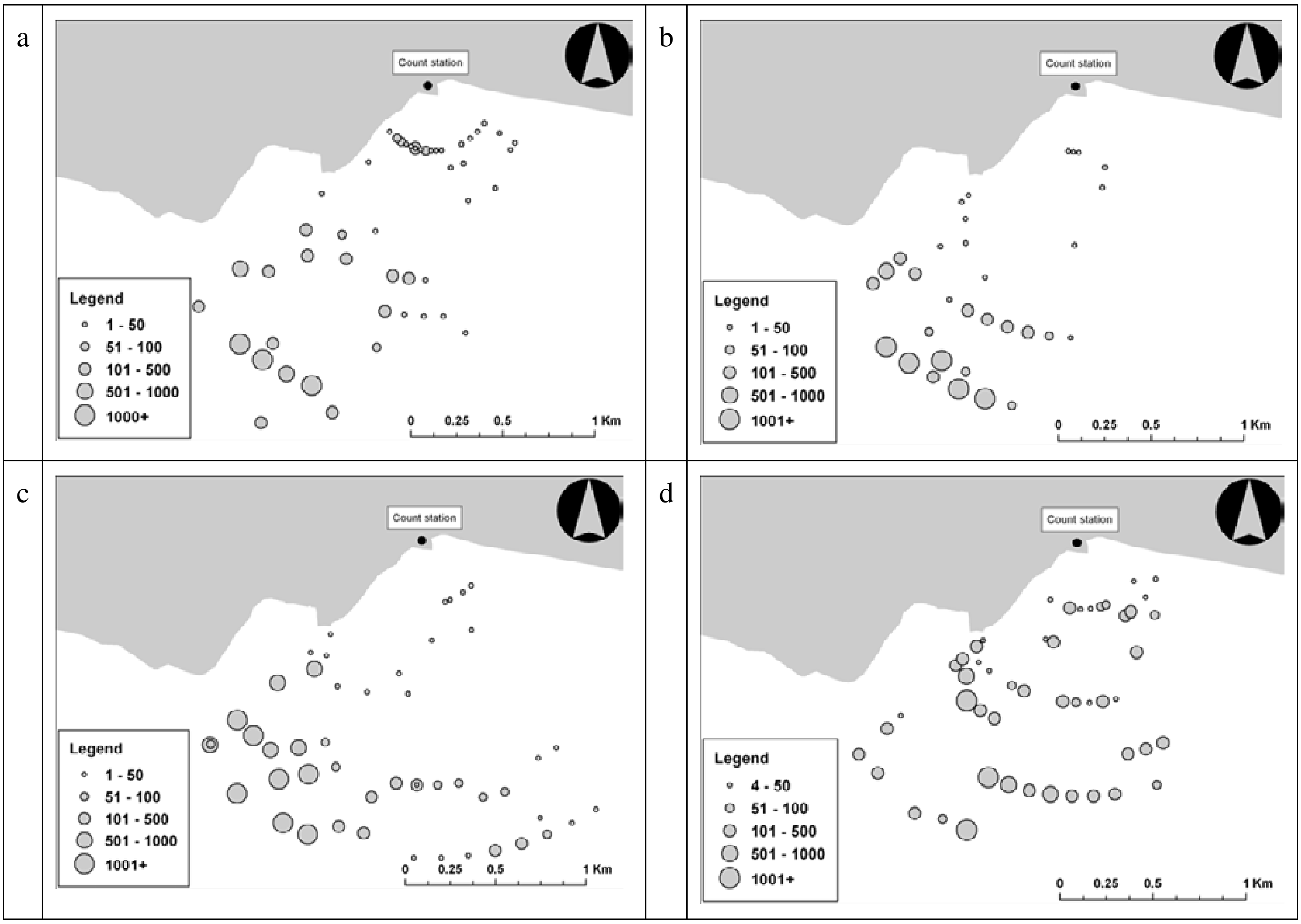


Figure 3.10 Distribution of common scoters recorded at various tidal stages on 14/11/05. **a.** Falling. **b.** Low. **c.** Rising. **d.** Rising to high.

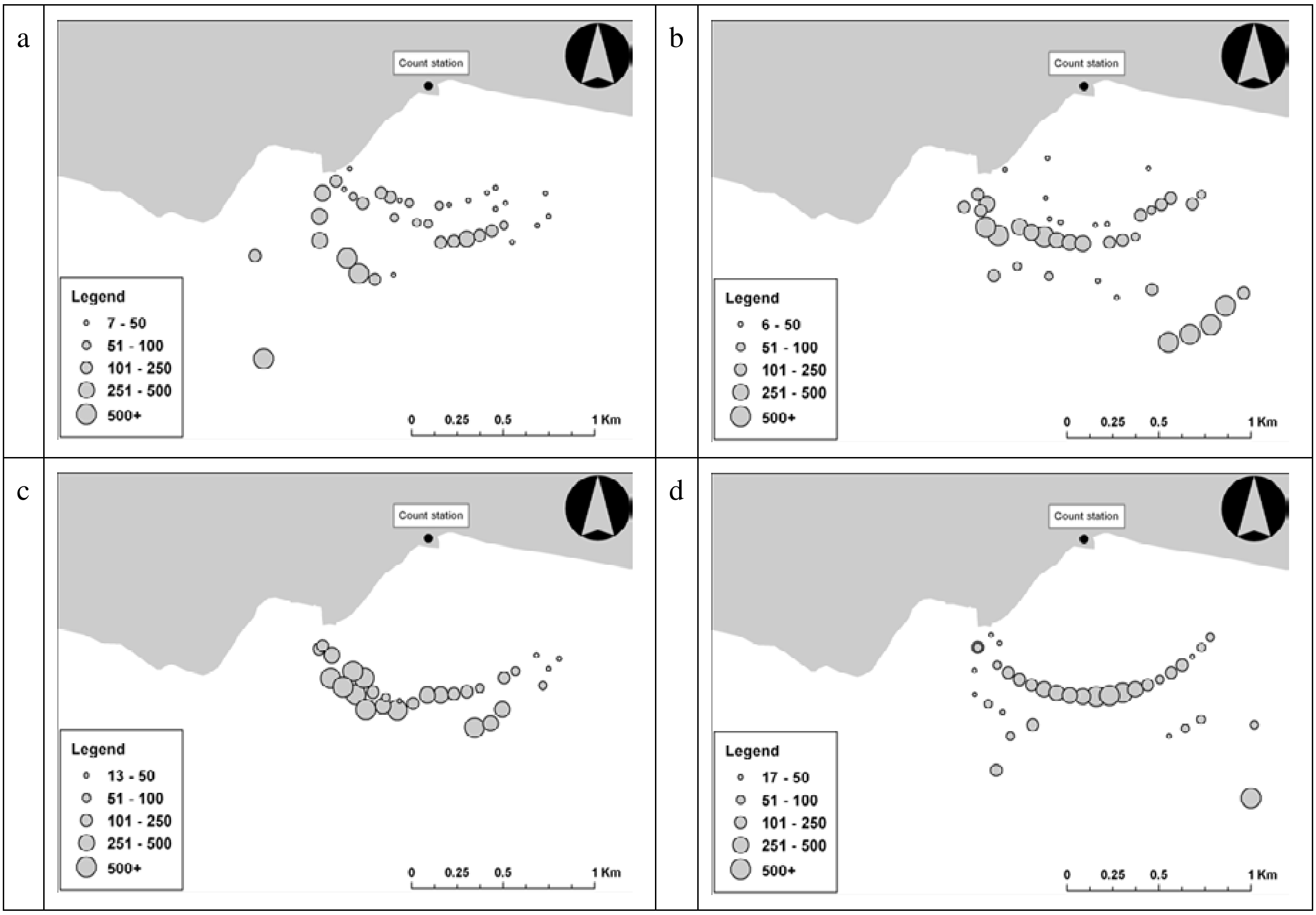


Figure 3.11 Distribution of common scoters recorded at various tidal stages on 28/01/07. **a.** Rising from low. **b.** Rising. **c.** Rising to high. **d.** High, falling.

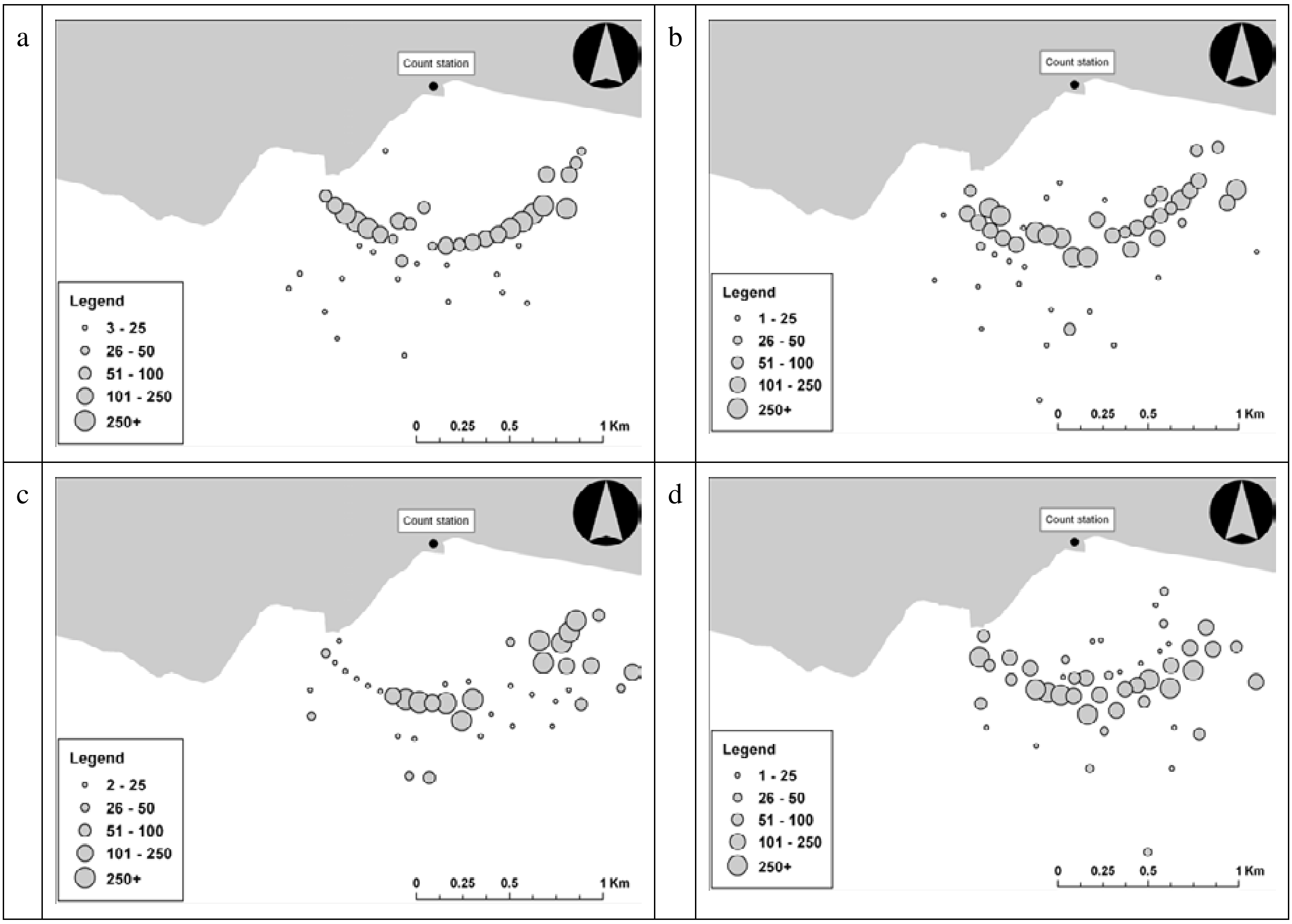


Figure 3.12 Distribution of common scoters recorded at various tidal stages on 25/02/07. **a.** Rising. **b.** Rising, high. **c.** Falling. **d.** Falling near low.

3.1.2.3 Behavioural studies

Surveyors situated on the land recorded the responses of common scoters to the activity of the aircraft on aerial surveys, in order to assess the degree of disturbance created. This type of survey was possible on two occasions (Tables 3.8, 3.9).

In general, the aircraft was found to create often large amounts of disturbance, but this disturbance was usually short lived and localised (Table 3.10, 3.11). Where flushing distances were estimated, these were in the range 200 – 400 m, suggesting that common scoters responded to the aircraft when it was fairly close. However, at other times, the aircraft was known to be at a distance of approximately 1 km when disturbance was noted.

Table 3.8 Survey conditions and pre-flight common scoter counts 12/11/05.

Count station	Amroth	Pendine	Pembrey
Observer	NPF	RHAT	NPR
High tide	15:03	15:03	15:03
Low tide	08:57	08:57	08:57
Cloud cover	4/8	4/8	4/8
Time	09:00-10:00	09:00-10:00	09:00-10:00
Extent of scan	180	180	180
Visibility	5 km+	5 km+	Misty, later 5 km+
Precipitation	0	0	0
Wind strength / direction	W 1-2	W 1-2	W 1-2
Pre-flight count	9,160	7,267	38
Notes	Majority loafing, with squabbling groups and occasional feeding birds observed	Majority loafing, some feeding birds observed	Majority loafing
	7,120 in large raft between 145-166 degrees from north, at a distance in line with the second buoy.	All birds quite closely grouped to west of watch point.	

Table 3.9 Survey conditions and pre-flight common scoter counts 10/12/05.

Count station	Amroth	Saundersfoot	Pendine
Observer	NPF	RHAT	DB
High tide	13:36	13:36	13:36
Low tide	07:24	07:24	07:24
Cloud cover	8/8	8/8	8/8
Time	09:00-10:00	09:00-10:00	09:00-10:00
Extent of scan	180	180	180
Visibility	5 km+	3-4 km	5 km +
Precipitation	0	0	0
Wind strength / direction	S 3	S 3	W 2
Pre-flight count	5,700	7,000	8,980
Notes	Majority loafing, with squabbling groups and occasional feeding birds observed	Majority loafing, some feeding birds observed	Majority loafing 1 – 2 km offshore. Small parties of 10+ chasing around. Very little feeding with only occasional birds diving.
	80% in a raft at around 1325 m	Difficult to count accurately, on extreme range of visibility. Birds c.4 km offshore	The total includes a flock of 380 unusually close to the shore just beyond the surf line.

Table 3.10 Behaviour and spatial change of common scoters in response to aerial survey aircraft on 12/11/05. Flush distance: approx. distance of aircraft when birds responded.

	No. affected	Behaviour	Spatial Change	Flush Distance (m)
Amroth	1	Took flight	Circled & returned to same area	200
	27	Took flight	Those in flight headed east settling 500 m from original area	200
	700	Took flight, but majority remained on water in an alert posture with small numbers (~30) seen to dive in avoidance	Those in flight east for 500 m away from plane transect before settling on water	250
	820	Took flight but majority remained on water in an alert posture with small numbers seen to dive in avoidance. Distance made latter observations difficult	Those in flight heading west for a short distance before landing or circling back to their previous position	-
	0	No change	Cloud cover inc. to 100%, the sun became obscured by cloud; possibly contributed to no reaction.	-
	500	Not observed	500 from east heading west into the main raft of scoter. Presumably birds displaced by transects over Pendine	-
	300	Not observed	300 from east into main raft. Presumably birds displaced by transects over Pendine.	-
Pendine	6,500 (?)	Took flight	70% of birds moved 200 - 300m west. Rest circled and returned to original area	250
	500 (?)	Birds remained on sea	None	-
Pembrey	0	No reaction	None	-

Table 3.11 Behaviour and spatial change of common scoters in response to aerial survey aircraft on 10/12/05. Flush distance: approx. distance of aircraft when birds responded.

	No. affected	Behaviour	Spatial Change	Flush Distance (m)
Amroth	80	Flushed and headed east	Birds circled before resettling in same area	300
	3,500	Flushed and headed east and west from the transect path	Birds circled and resettled closer to the count station at around 950 m	200-400
	1,300	Flushed both east and west of plane transect	Birds circled and returned to same area	200-400
	1,000	Flushed west	Birds circled and returned to original area	200-400
Saundersfoot	?	Took flight (100% of flock)	Birds moved c.500 m south	150
	?	Took flight (100% of flock)	Birds circled before resettling in same area	200
	?	Took flight (100% of flock)	Birds circled before resettling in same area; large number of birds remained circling	300
	?	Took flight (30% of flock)	Birds circled and moved south 300 m and landed on sea	300
Pendine	600 +	Small movement of birds from east; most landed in main flock.	-	-

3.2 Aerial Surveys

3.2.1 Monitoring surveys

3.2.1.1 Flight tracks

Where possible, flight tracks were recorded from a GPS (Figures 3.13, 3.14). Where tracks cross the bay, these show the path of the plane after completion of the survey at which time the aircraft would have climbed to around 500 m. As the figures show, there was some variation between flight tracks (dependent on factors such as wind speed, pilot, etc.) but these are generally no greater than in the order of metres. On the one flight in 2004/05 and on two occasions in 2005/06, GPS tracks were either not obtained or were incomplete. In 2006/07, the GPS was typically attached to an external aerial made available on a new aircraft used for surveys and the signal was not lost.

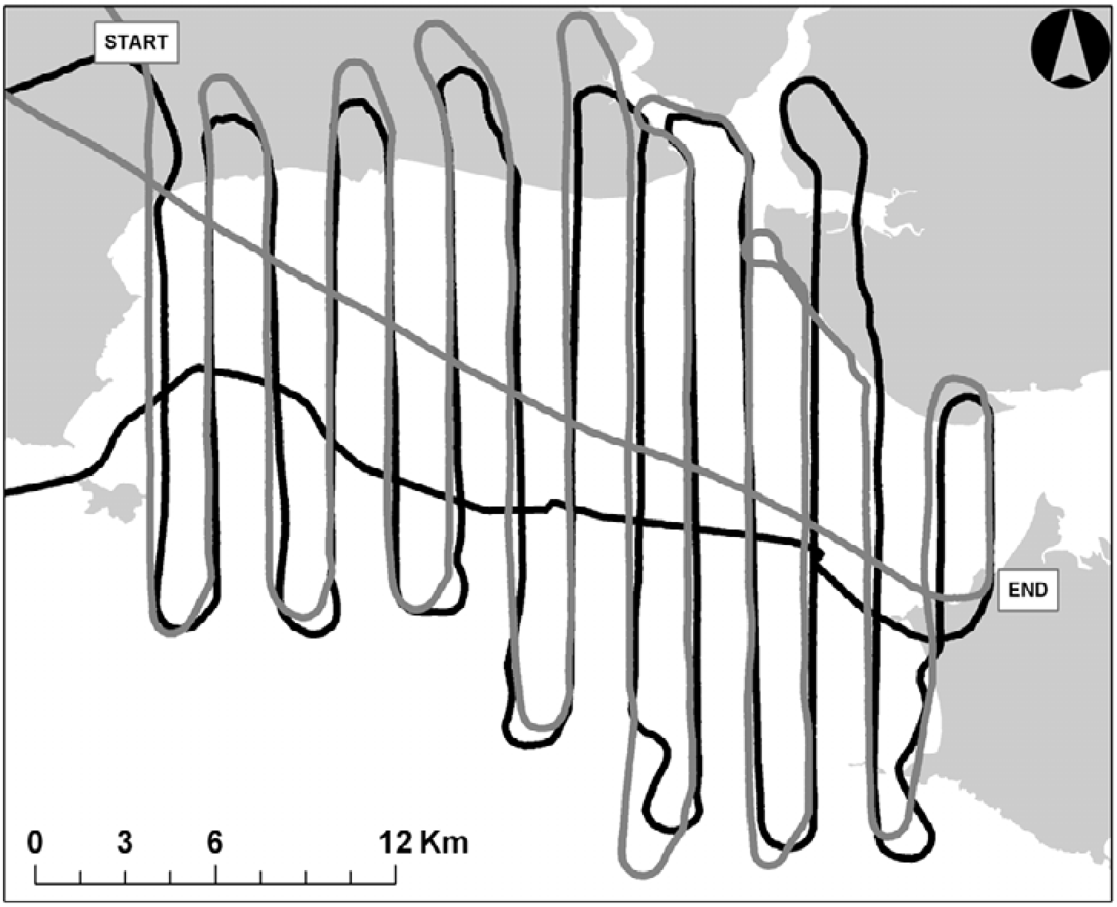


Figure 3.13 Flight tracks for aerial surveys in the winter of 2005-06. Black line: 12/11/05; grey line: 07/01/06.

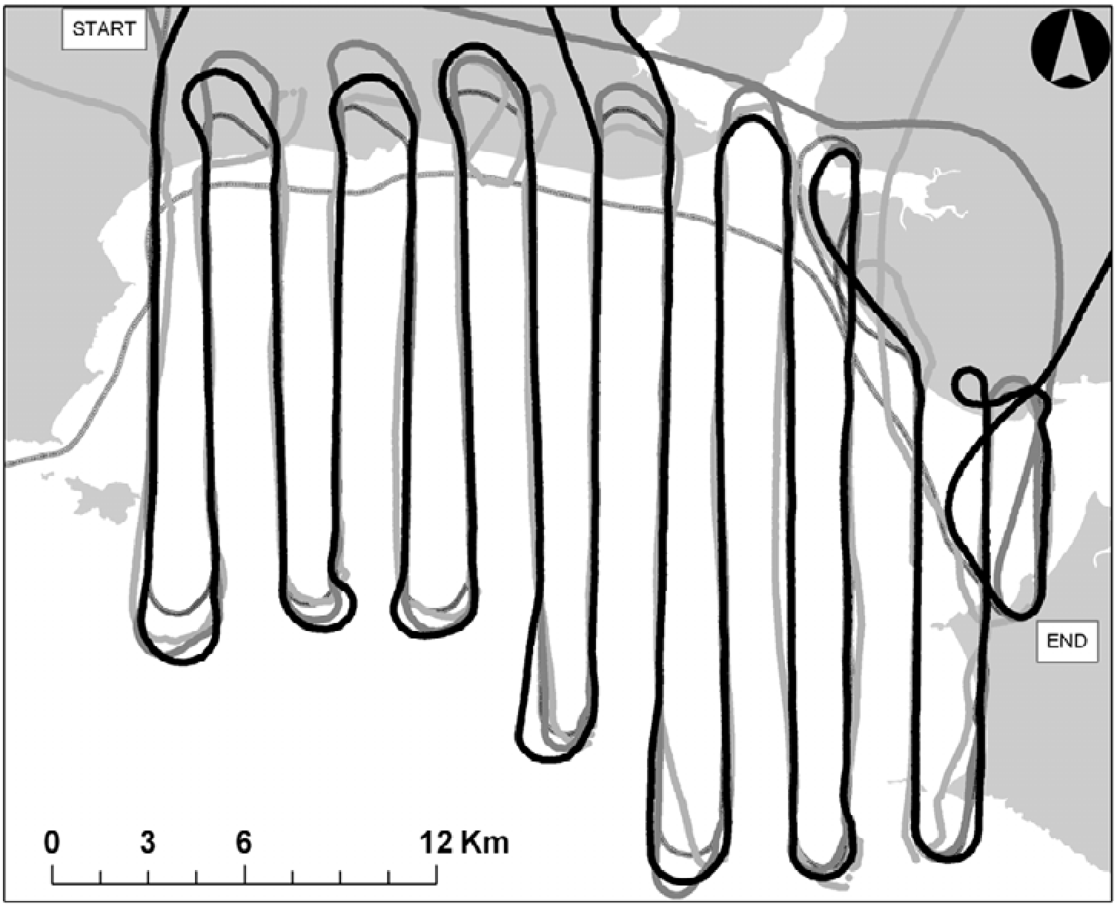


Figure 3.14 Flight tracks for aerial surveys in the winter of 2006-07. Black line: 18/11/06; dark grey line: 16/12/06; light grey line: 27/01/07; grey dotted line: 17/02/07.

3.2.1.2 Distance estimates

Detailed results of the parameters used in obtaining distance estimates can be found in Appendix 1. Lowest AIC values were obtained for models with a global detection function, with probability of detection modelled at the stratum (=survey) level and with observer included as a covariate factor; these were used to generate density and abundance estimates (Table 3.12).

Table 3.12 Distance estimates of common scoters on aerial surveys 2004/05 – 2006/07. DS=estimated cluster density; E(s)=estimated cluster size; D=density of individuals (km^2); N=total abundance estimate. Confidence intervals are analytical 95%. Survey for moulting birds shown in grey.

Date	DS	95% CIs	E(s)	95% CIs	D	95% CIs	N	95% CIs
25/02/2005	0.98	(0.66 - 1.46)	27.30	(18.24 - 40.86)	26.74	(15.42 - 46.36)	**9,838**	(5673 - 17062)
03/09/2005	0.60	(0.31 - 1.16)	8.35	(6.06 - 11.52)	5.02	(2.48 - 10.15)	**1,871**	(925 - 3784)
12/11/2005	0.73	(0.46 - 1.15)	29.32	(17.77 - 48.37)	21.47	(11.19 - 41.22)	**8,444**	(4399 - 16206)
10/12/2005	1.52	(1.01 - 2.28)	22.09	(16.22 - 30.08)	33.54	(20.47 - 54.96)	**12,900**	(7872 - 21139)
07/01/2006	1.69	(1.16 - 2.45)	31.81	(24.12 - 41.96)	53.63	(34.21 - 84.05)	**21,152**	(13495 - 33154)
04/02/2006	2.83	(1.88 - 4.28)	26.18	(21.25 - 32.27)	74.18	(47.25 - 116.44)	**28,498**	(18154 - 44736)
18/11/2006	1.48	(0.98 - 2.25)	10.55	(8.08 - 13.76)	15.66	(9.69 - 25.3)	**6,305**	(3903 - 10186)
16/12/2006	0.85	(0.66 - 1.1)	22.12	(15.28 - 32.02)	18.87	(12.16 - 29.29)	**7,780**	(5012 - 12077)
27/01/2007	1.59	(1.08 - 2.33)	20.92	(16.28 - 26.89)	33.18	(21.25 - 51.83)	**13,447**	(8609 - 21004)
17/02/2007	1.43	(0.98 - 2.09)	20.46	(15.48 - 27.03)	29.27	(18.54 - 46.19)	**11,802**	(7478 - 18628)

Table 3.12 suggests that numbers were highest on surveys undertaken in January and February 2006, with 21,139 and 28,456 estimated respectively. Estimates for the 2006/07 winter were considerably lower, the peak reaching 13,435 in January 2007.

Using data previously published (WWT 2003; Banks *et al.* 2004) plus these new estimates, it was possible to generate the first wintering index from aerial survey distance estimates (Figure 3.15). The index suggests that using this method results in a fairly stable trend, with occasional fluctuations (2002/03; 2005/06).

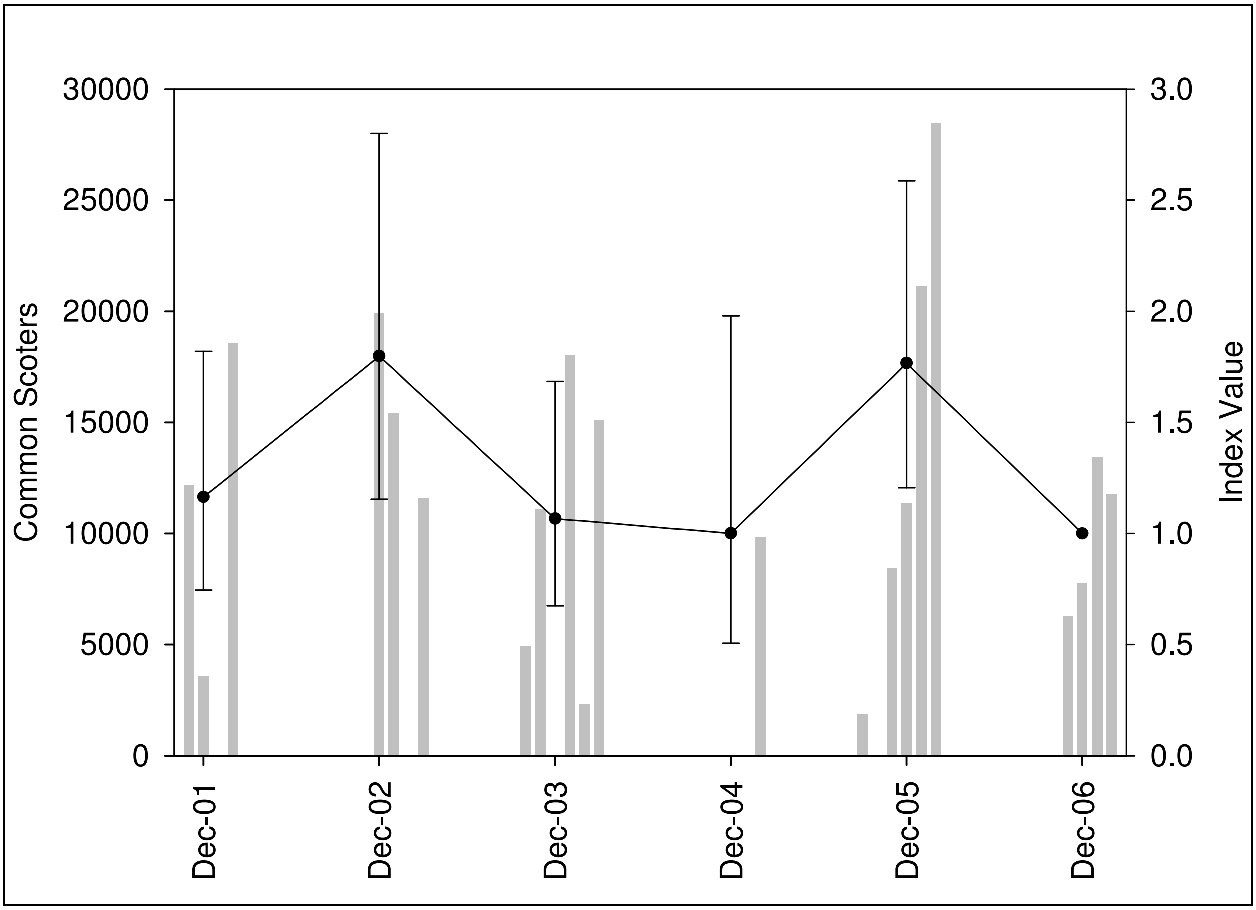


Figure 3.15 Index of distance estimates of common scoters in Carmarthen Bay 2001/02 – 2006/07.

Although the inclusion of behaviour was not found to improve model fit (Appendix 1), it is worth considering the relative numbers of birds recorded in flight and sitting on the water (Table 3.13) as this may influence counts. For instance, it is possible that birds in flight are more easily detectable, or that the risk of double-counting is increased when large numbers of scoters are put to flight.

Other species (of birds and mammals) were recorded on aerial surveys; raw numbers of these are presented in Appendix 5.

Table 3.13 Behaviour of common scoters detected during aerial surveys 2004/05 – 2006/07.

Behaviour	25/02/05	12/11/05	10/12/05	07/01/06	04/02/06	18/11/06	16/12/06	27/01/07	17/02/07	Total	%
Flying	10,047	1,292	8,717	10,222	13,286	3,002	1,600	6,611	3,026	56,356	84%
Sitting	57	4,122	1,405	402	1,366	292	1,141	417	1,831	11,134	16%
Total	10,104	5,414	10,122	10,624	14,652	3,294	2,741	7,028	4,857	67,490	

3.2.1.3 Distribution of common scoters

Observations of common scoters were summed by 1 km grid cell to facilitate comparison of distributions between winters. Figures 3.16 – 3.18 show summed (uncorrected for distance) distributions for each month of winter survey, plotted to the same scale and grouped by winter period. Typically, the majority of flocks observed were recorded within the 10 m bathymetry contour (not shown for clarity), consistent with distributions recorded in recent previous winters (Banks *et al.* 2004). Favoured areas were again mostly in the north of the bay, especially close to the north west shore; birds were often seen at lower density off Pembrey. In November and December 2006/07, fewer large flocks of common scoters were recorded in these areas, distributions instead being thinly spread. There were notable concentrations recorded in all months of 2006/07 between Pembrey and Rhossili (Figures 3.18a, 3.18b).

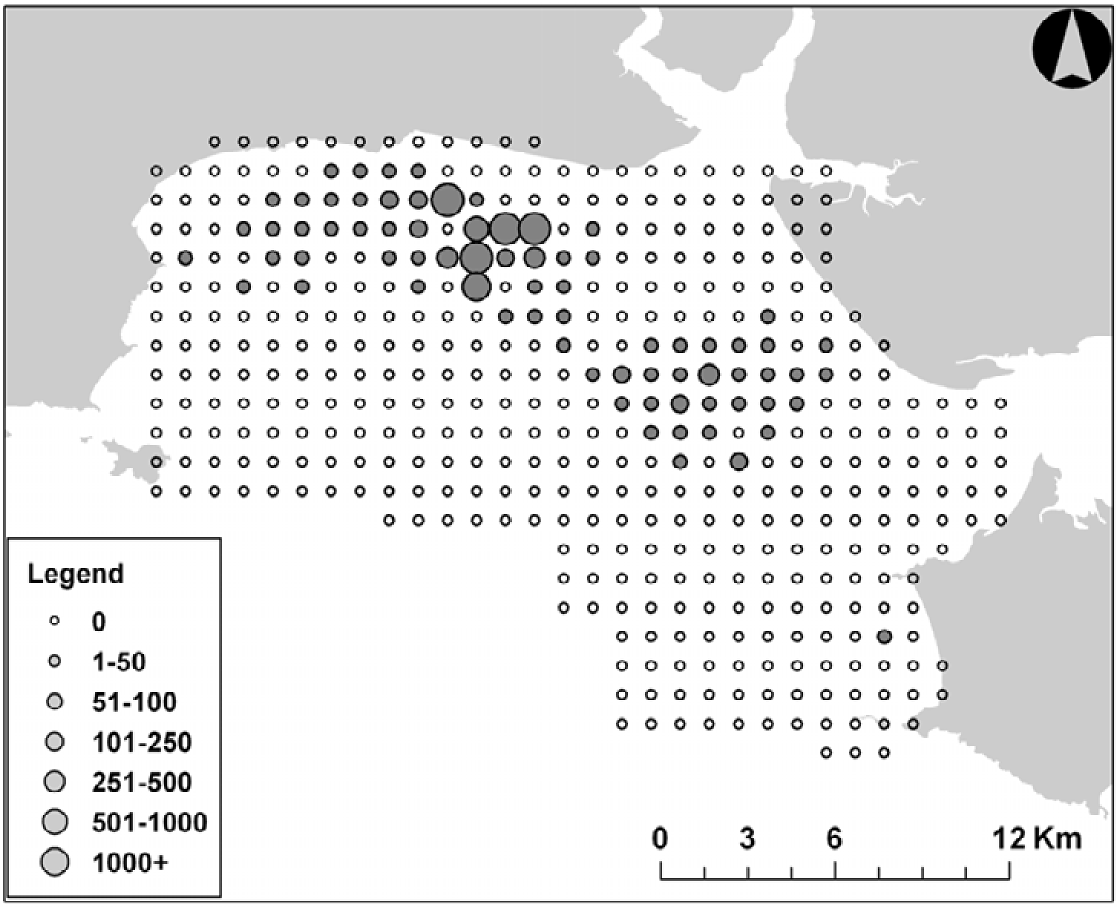
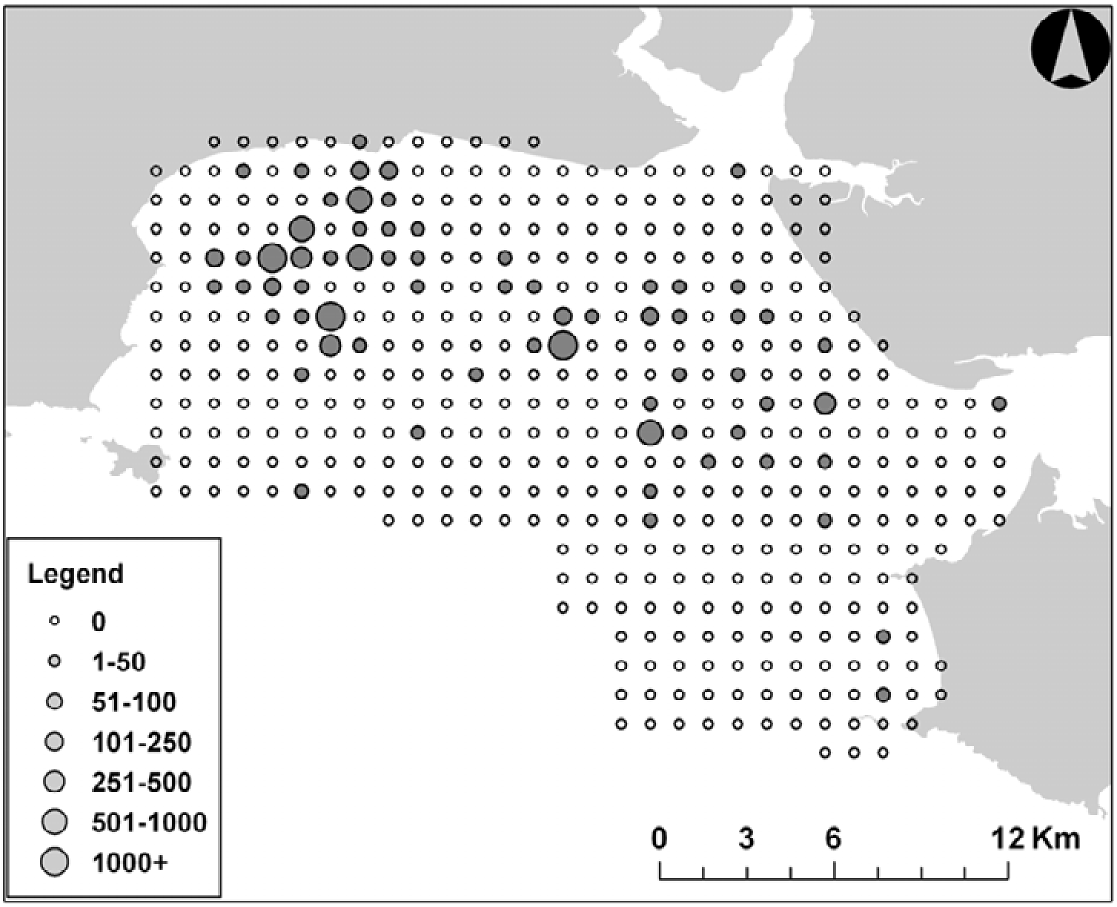
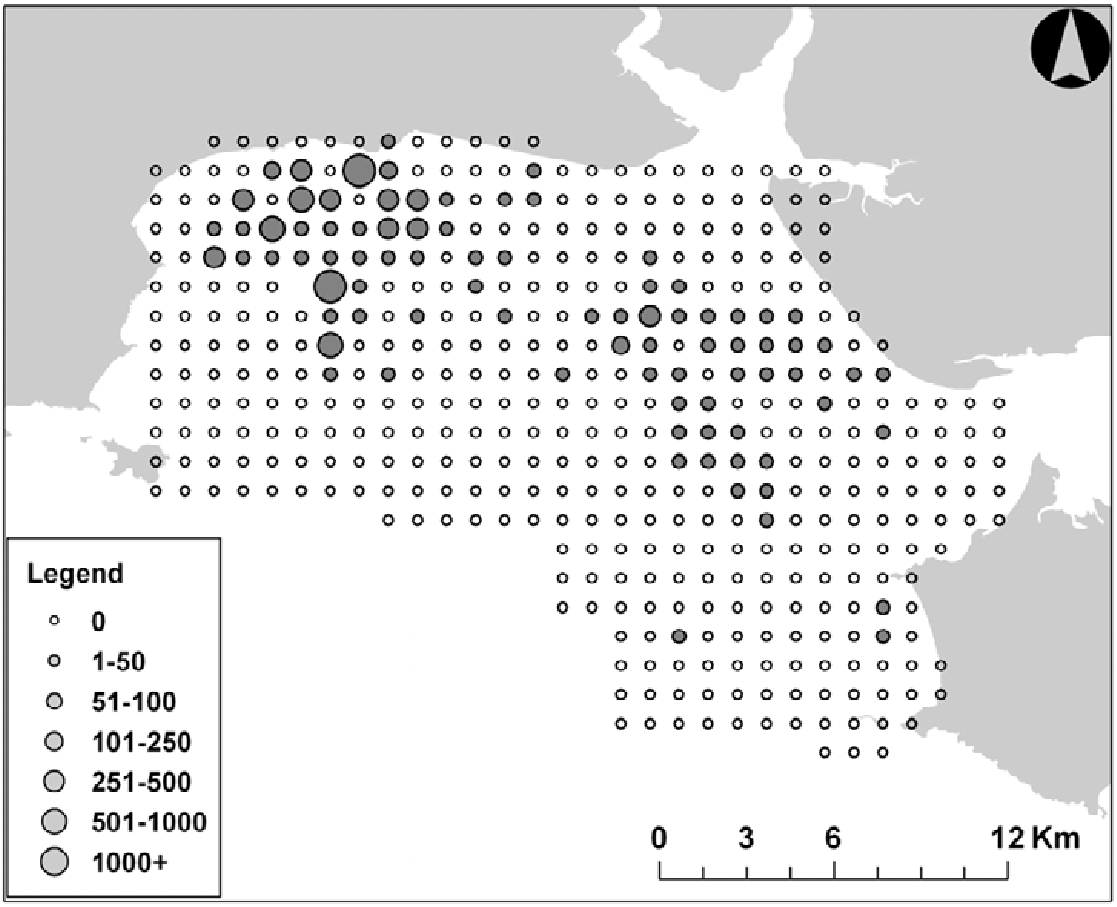


Figure 3.16 Summed distribution of common scoters from aerial survey on 26/02/05.

a


Legend
0
1-50
51-100
101-250
251-500
501-1000
1000+
0
3
6
12 Km

b


Legend
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251-500
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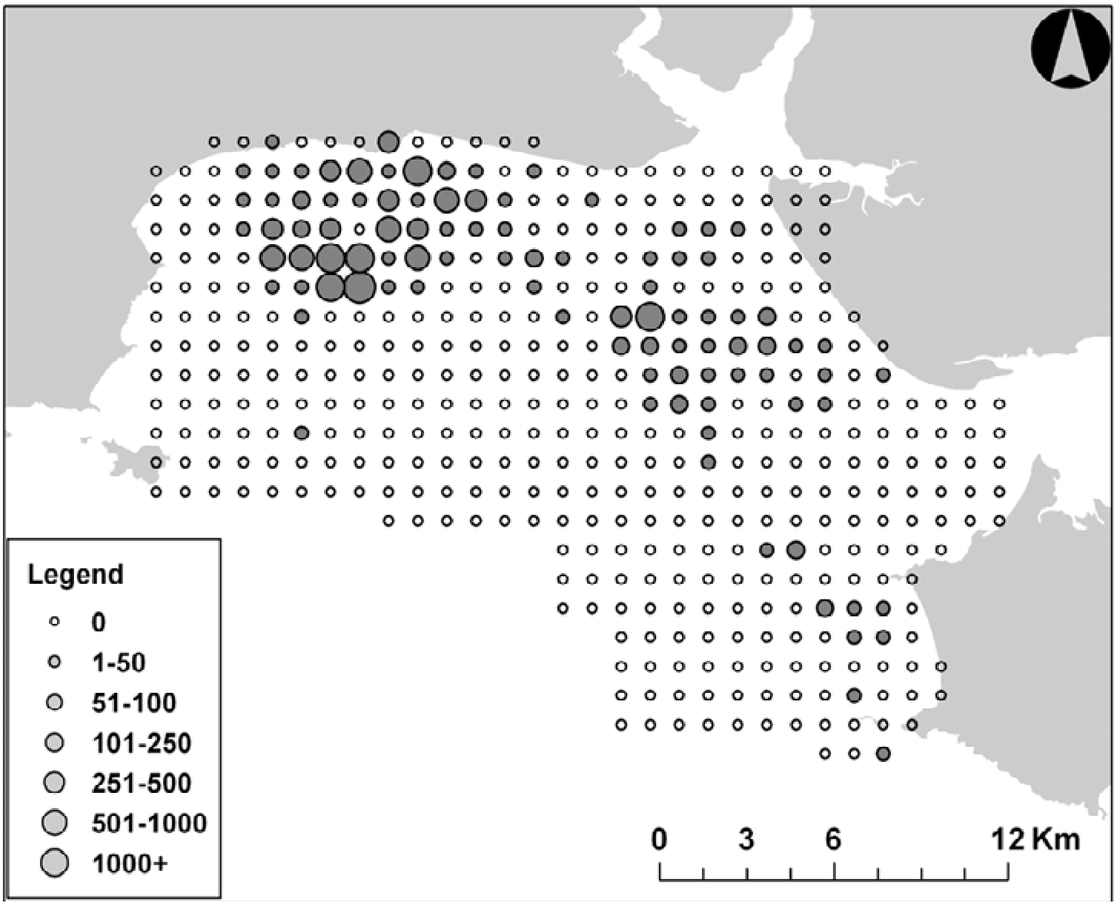


d

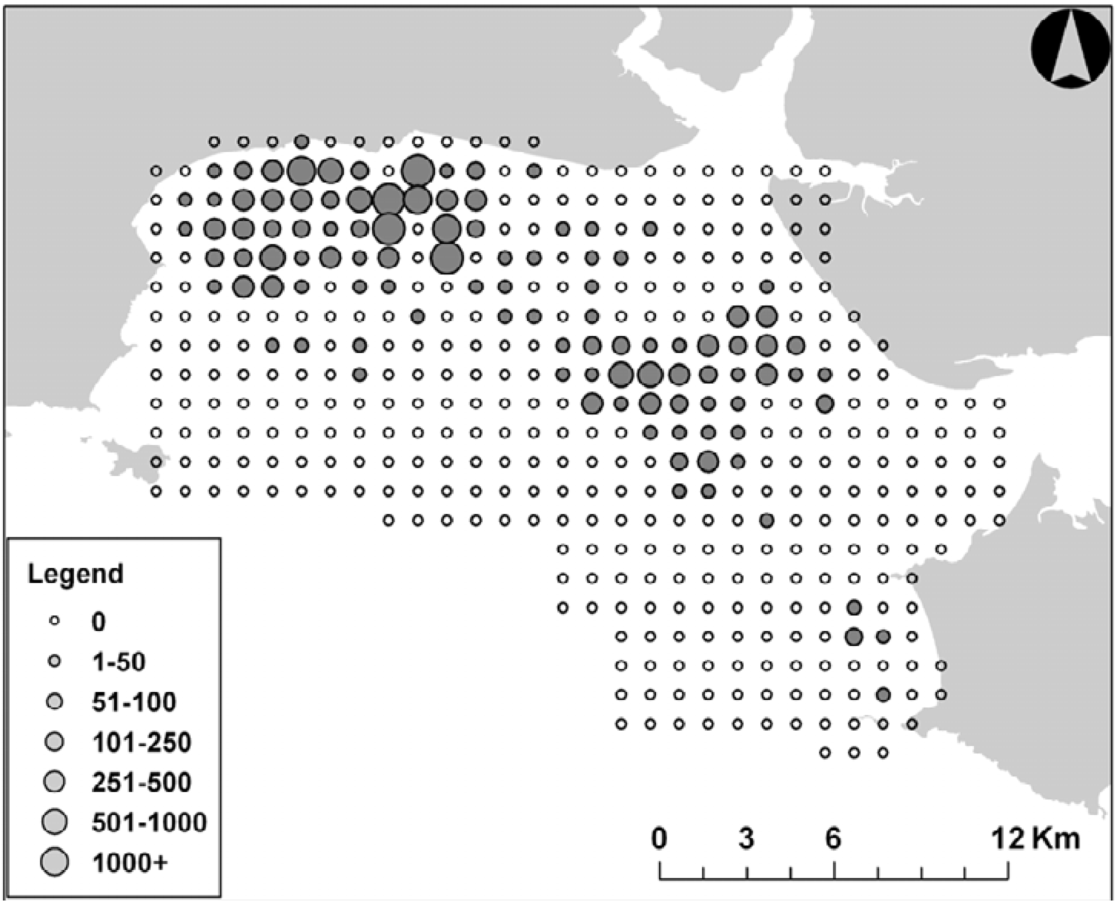
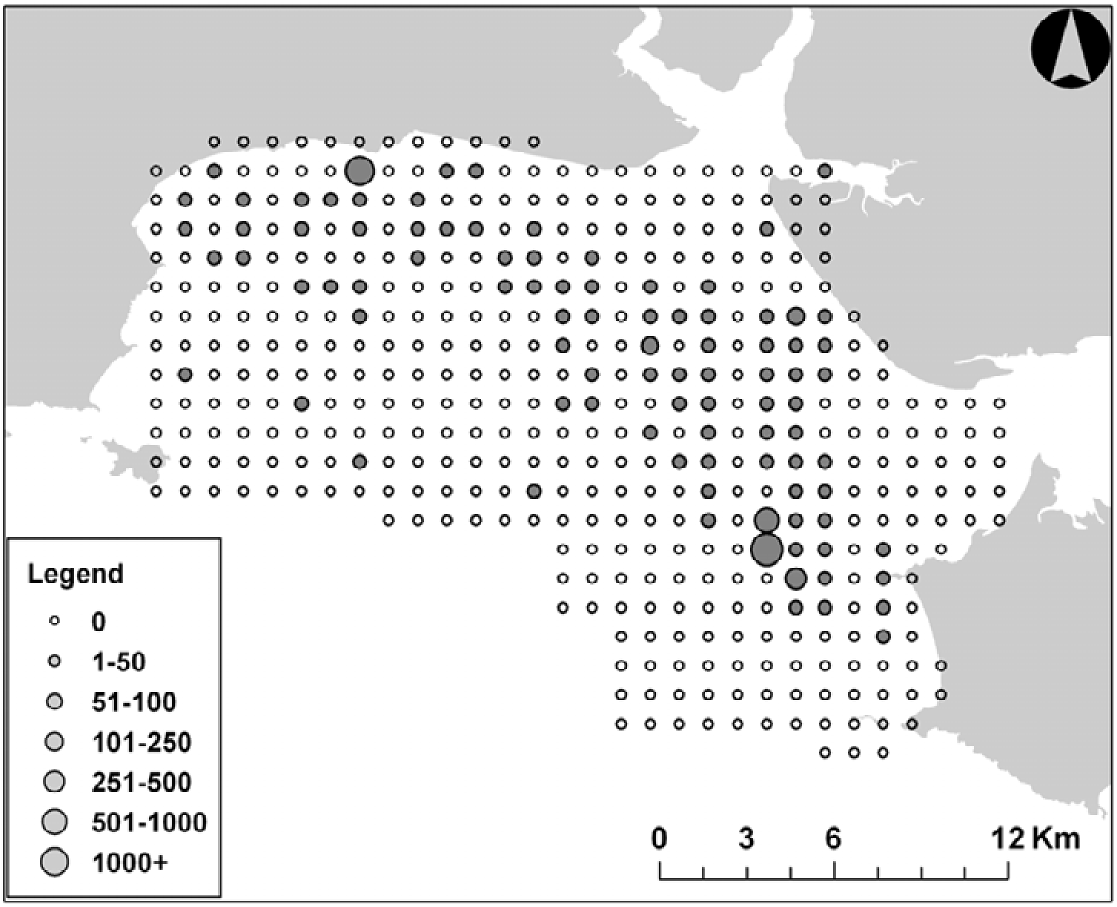


Figure 3.17 Summed distribution of common scoter for winter 2005/06. **a.** 12/11/05; **b.** 10/12/05; **c.** 07/01/06; **d.** 04/02/06.

a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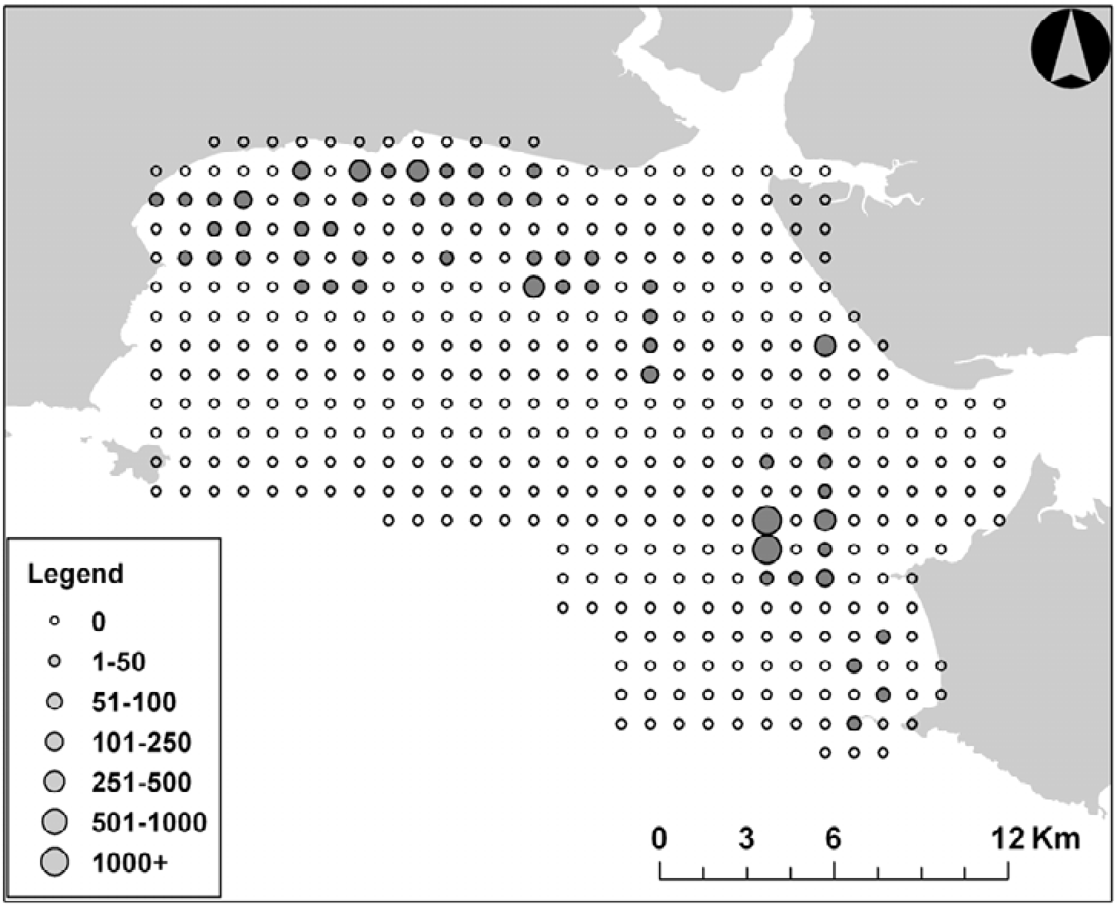
12 Km

b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12 Km

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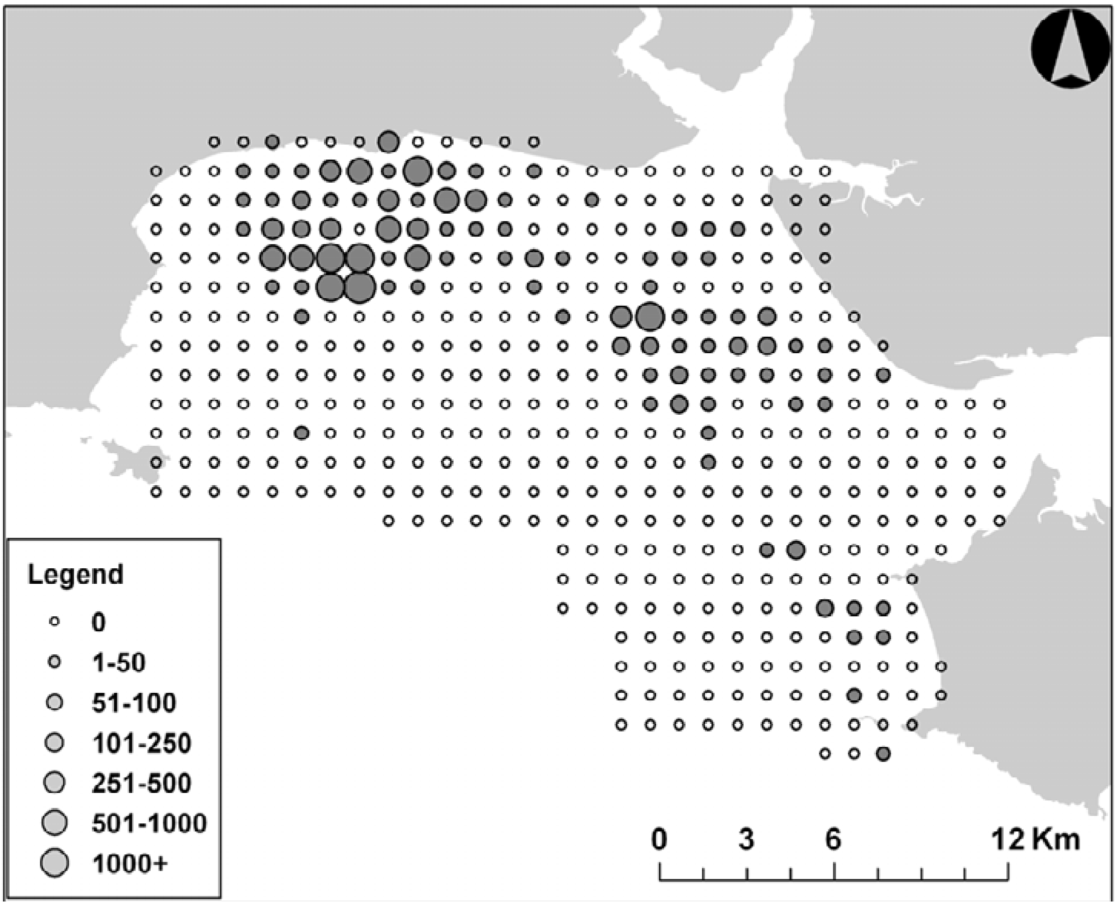

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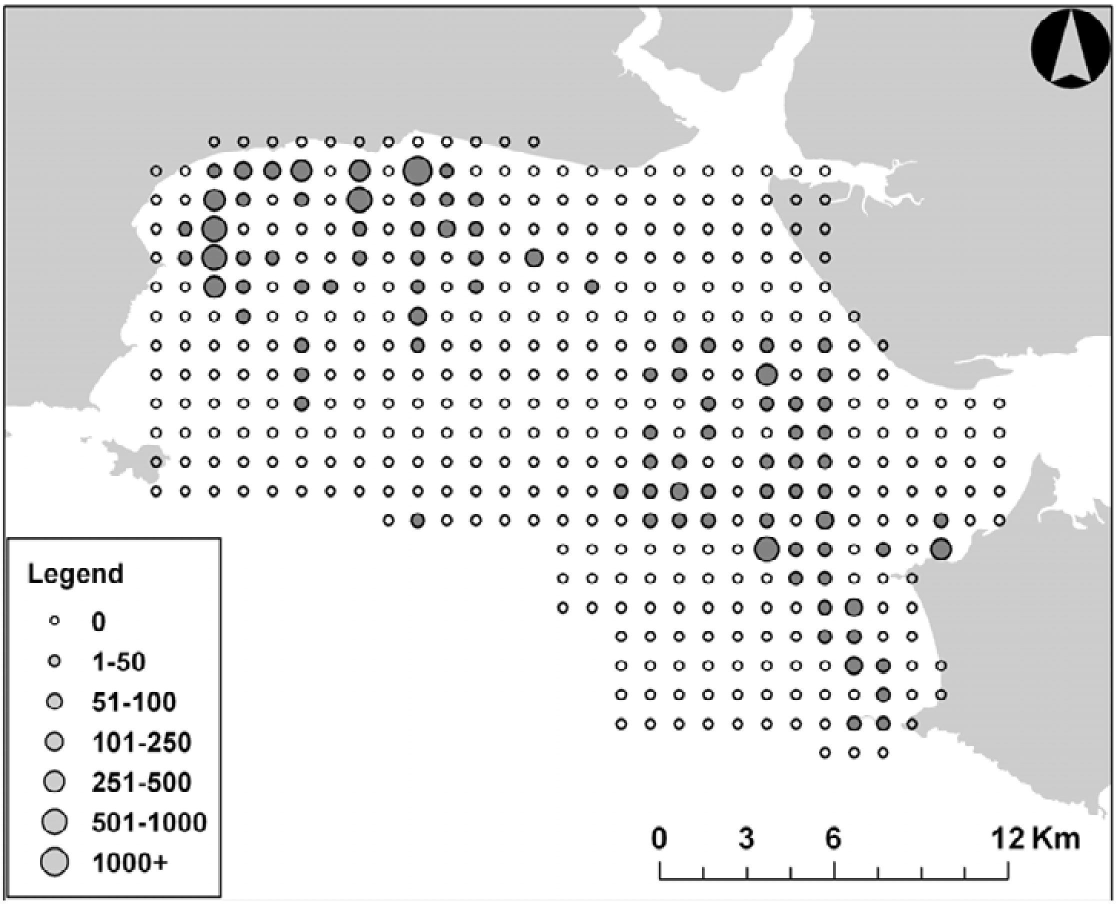
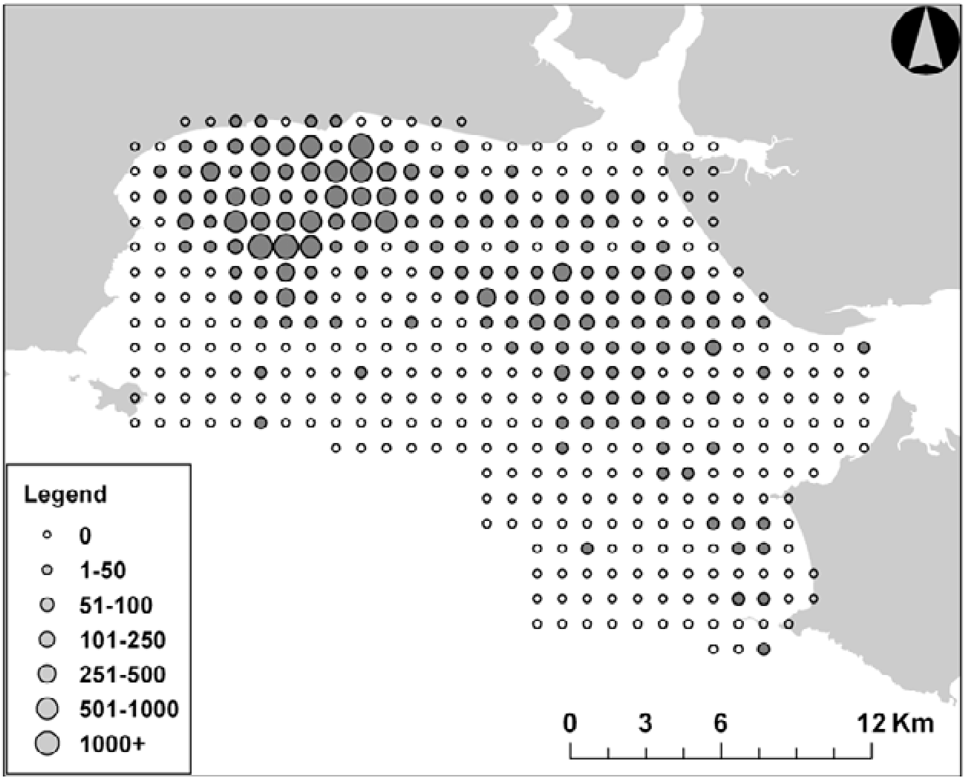


Figure 3.18 Summed distribution of common scoter for winter 2006/07. **a.** 18/11/06; **b.** 16/12/06; **c.** 27/01/07; **d.** 17/02/07.

The mean winter distribution of common scoters in 2005/06 was heavily biased to the north west corner of the bay, with lesser concentrations off Pembrey. Numbers in the south east corner, off Rhossili, were low (Figure 3.19a). The distribution was similar in 2006/07, though with a less obvious concentration in the north west corner, and more birds to the south of the mouth of the Burry Inlet (Figure 3.19b). The unusual presence of common scoters in these areas is discussed elsewhere.

a



b

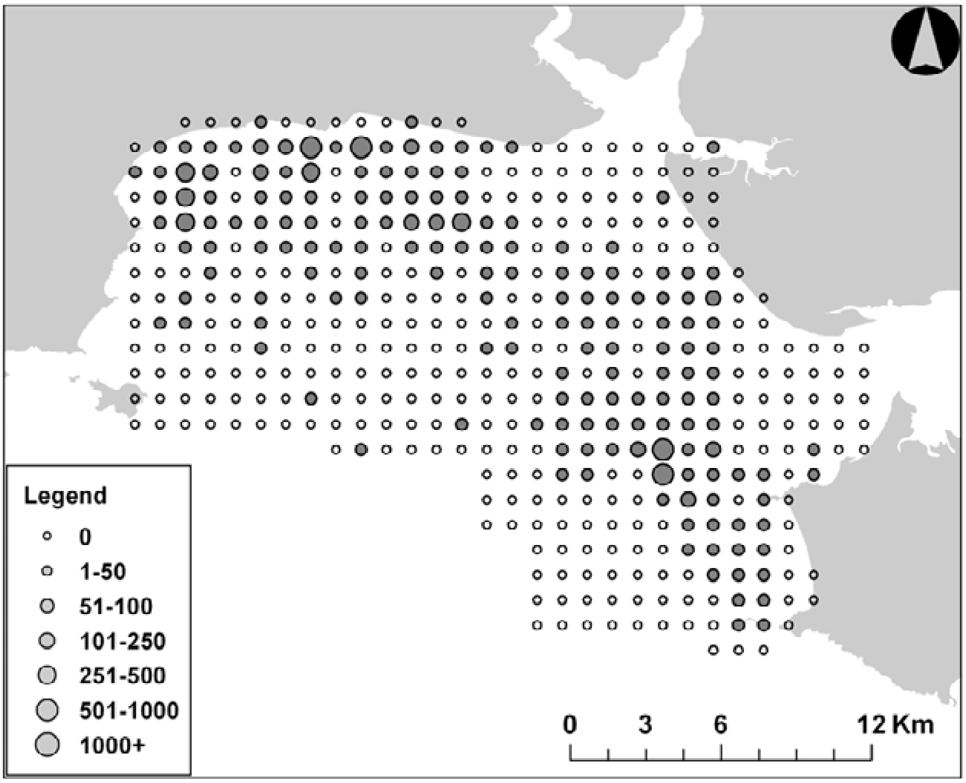


Figure 3.19 Mean winter distribution of common scoters. **a.** 2005/06. **b.** 2006/07.

Despite the apparently different distribution observed in 2006/07, when the mean centre of this distribution, weighted by average count, is plotted against similar mean centres for 2004/05 and 2005/06, the difference appears smaller. The mean centre for 2006/07 was further south and east of those for 2004/05 and 2005/06, but comparable with mean centres obtained (albeit from a slightly different aerial survey method) for other winters.

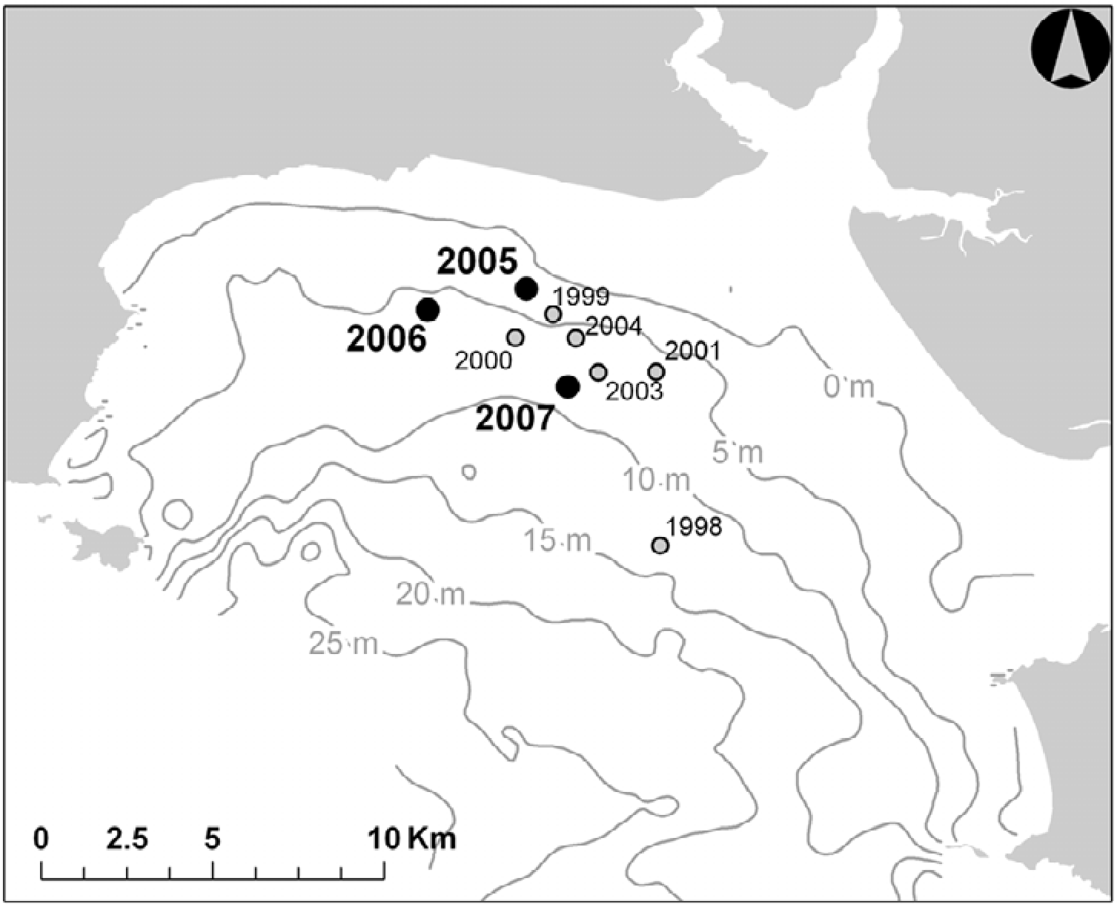


Figure 3.20 Mean weighted centres of common scoter distribution 1997/98 – 2006/07. Symbols show weighted mean centres by winter (later year of winter used as label); black symbols show winters considered in this report; grey symbols show weighted centres from Banks *et al.* (in review), calculated from a different but similar aerial survey technique.

3.2.2 Variable altitude surveys

The limited results achieved by flying a subset of transects at varying altitude indicated that expectations about the trade-off between detectability (decreasing with increasing altitude) and disturbance (reduced with increasing altitude) were unsupported. Neither ground nor aerial surveyors noted subjective changes in the level of disturbance caused to common scoters at any altitude flown.

At the lowest altitude (225 m), it was possible to make counts of common scoters without the perception that large groups of birds were overlooked. Counts of 5,559 compare with the raw total of 4,902 recorded for the same transects earlier on the same day. However, there was no indication that disturbance was at all reduced, either from the aircraft or from the land. Observers on the land recorded scoter behaviour consistent with that seen on flights at 76 m; namely, thousands of birds flushing and circling, either resettling nearby or returning to the area from which they were disturbed.

A similar pattern of disturbance was recorded by land-based observers when the aircraft was at 375 and 300 m, but even at the lower of these altitudes detection of common scoters from the aircraft was felt to be poor in comparison to that at lower altitudes. Moreover, the impression was formed that at 375 m more birds were prone to disturbance than at the standard operating altitude of 76 m, justifying the use of the method outlined by Camphuysen *et al.* (2004).

4 DISCUSSION

4.1 Maintenance of monitoring program

4.1.1 Ground-based monitoring

After some problems establishing the survey program in the winter of 2004/05, a full suite of four counts was carried out using previously drafted *Standard Operating Procedures* (Banks *et al.* 2005) between November and February in each of the winters of 2005/06 and 2006/07.

Counts from ground-based monitoring varied considerably and in part this might reflect the imperfections of this method. However, despite the lack of surveys in 2004/05, the peak of 24,460 common scoters recorded in February 2005 exceeded the peak of 23,288 in January 2003 (Banks *et al.* 2004), which itself was the highest recorded in the bay since 1974. It should be noted that this peak count was recorded by LS, and inter-observer differences between LS and NPF cannot be ruled out. However, as LS is a fieldworker with vast experience of counting common scoters in Carmarthen Bay, there is no undue reason to suspect the accuracy of the figure and thus this new peak count for common scoter numbers in Carmarthen Bay should be recognised.

However, at the opposite extreme, on three occasions (January 2006, November 2006, December 2006) the count returned less than 10,000 birds, which had not happened in the months November to February since February 2000. Although this may represent genuinely low numbers of birds within the bay, factors affecting count totals warrant further examination.

Observations from the surveyor (NPF) indicated that in January 2006, the sea state was ‘moderate’ and that there were also problems with sun glare, which could have influenced count totals. During observations in November and December 2006, birds may have been feeding further east and offshore than ‘usual’, as many birds not visible with even a slight swell on the water were revealed at distance when the sea was flat calm. This opinion is supported by aerial survey distributions, though numbers on these surveys were also comparatively low. The reasons for this change are not clear. It is possible that particularly turbulent weather in late 2006 affected common scoter distribution; however there is no evidence that this explanation should be the case.

Large numbers of common scoters were only recorded at Pembrey on one of the surveys. The largest total was 3,640 in February 2005, but the next largest reached only 673 in January 2007. Some aerial survey distributions (summarised in Figure 3.19) appear to indicate that some scoters were feeding further offshore in this area, with some common scoters also further south in 2006/07. Such changes indicate the imperfections of ground-based surveys and the importance of associated aerial surveys to explain changes visible from the land.

The index of ground-based counts (Figure 3.1) appears to show a decline in 2005/06 and 2006/07, at least partially owing to the enormous peak in February 2005 and associated lack of counts in the winter of 2004/05. However, heeding the possibility that scoters may have been beyond visible range on surveys, it will be important to continue monitoring in 2007/08 and beyond to ensure that data are available to determine whether there is any lasting threat to the Favourable Conservation Status of common scoters in Carmarthen Bay. The current index value is near the lowest confidence limits of ‘recovered’ Carmarthen Bay counts (*i.e.* counts since 2000/01 returning to levels comparable with those prior to the *Sea Empress* oil spill; Banks *et al.* in review) and a further decline may be of concern.

Banks *et al.* (2004) contended that a peak total of 20,000 common scoters over the course of a winter should be a reasonable expectation. This criterion was reached in both 2004/05 and 2005/06, but not 2006/07. Under the guidelines in Banks *et al.* (2004), a winter peak total of 15,000 common scoters should be considered a provisional medium alert. However, it is possible that conditions in 2006/07 were anomalous and it is too early to assume that a new decline is beginning in Carmarthen Bay. Furthermore, it should be remembered that counts made from the land are unlikely to census the entire population within Carmarthen Bay and so the alert status is dubious. Examining the five year peak means, the standard measure used to assess site totals by (*e.g*) the Wetland Bird Survey (Banks *et al.* 2006), the site still comfortably holds in excess of the 1% threshold value of 16,000 birds (Table 4.1) and appears to fluctuate very little.

Table 4.1 Five year peak mean ground survey values for common scoters in Carmarthen Bay

Winter	2004/05	2005/06	2006/07
Five year peak mean	20,556	20,712	19,579

4.1.2 Aerial monitoring

In common with this program of ground-based surveys, the first aerial monitoring surveys were carried out in February 2005. Thereafter, one survey was possible in each of the months November – February in both of the winters 2005/06 and 2006/07.

4.1.2.1 Abundance estimates

Banks *et al.* (2004) suggested a provisional peak target of 18,000 common scoters was a reasonable expectation over a winter of four surveys. At the time of the only survey in 2004/05, in late February 2005, estimated numbers in Carmarthen Bay were found to be fairly low at 9,832, though upper confidence limits were as high as 17,051. The estimate produced was lower than the total number of birds counted, resulting from a less than ideal detection function; it was apparent that more birds were recorded in the middle distance bands B and C, which is contrary to the assumptions of distance sampling (namely, that more birds are detected close to the track line). In the following winter, estimates were again low in November 2005 (8,345), rising throughout the winter to a peak estimate of 28,456 in February 2006. In 2006/07, despite a series of four counts the peak estimate reached only 13,435, in January 2007. Estimates in November and December 2006 were comparatively very low, consistent with results from ground-based surveys. The peak estimate of 13,435 would be considered a provisional medium alert according to Banks *et al.* (2004), although upper confidence limits in November and February 2007 exceeded the figure of 18,000 considered to be a reasonable expectation of numbers of scoter.

However, analysing the five year peak mean figures for 2005/06 and 2006/07 (the only winters possible given that the first distance flights were carried out in 2001/02), the figure of 18,000 is exceeded or approached in both cases (Table 4.2).

Table 4.2 Five year peak mean aerial survey values for common scoters in Carmarthen Bay

Winter	2004/05	2005/06	2006/07
Five year peak mean	N/A	18,955	17,926

It should be remembered that on each transect, there is a dead zone of 88 m width under the plane which observers cannot view physically (Figure 4.1). It is possible that birds present in this area are not recorded, meaning that count totals and thus distance estimates are lower than reality, but given that the behaviour of common scoters in Carmarthen Bay is to flush in response to the plane, it is not considered that there has been any appreciable underestimation of numbers.

However, this behaviour can potentially influence estimates at a wider scale. An obvious risk is that birds may move around and be counted more than once, although the method is designed to minimise this bias. Whilst this is probably not a major problem for birds in the furthest distance bands, where transect lines happen to bisect large scoter flocks the circling behaviour found to be typical of the species in response to an aircraft at Carmarthen Bay may result in some birds flying under the plane and thus entering distance bands of two observers. In practice, there is relatively little that can be done in the field, as the demands on observers are already high. One solution could be to announce that birds have crossed the transect line, but estimating the sizes of these flocks as well as those away from the aircraft may be too many tasks to achieve at once. It may be safe to assume that double-counting is minimal but it cannot be ruled out entirely.

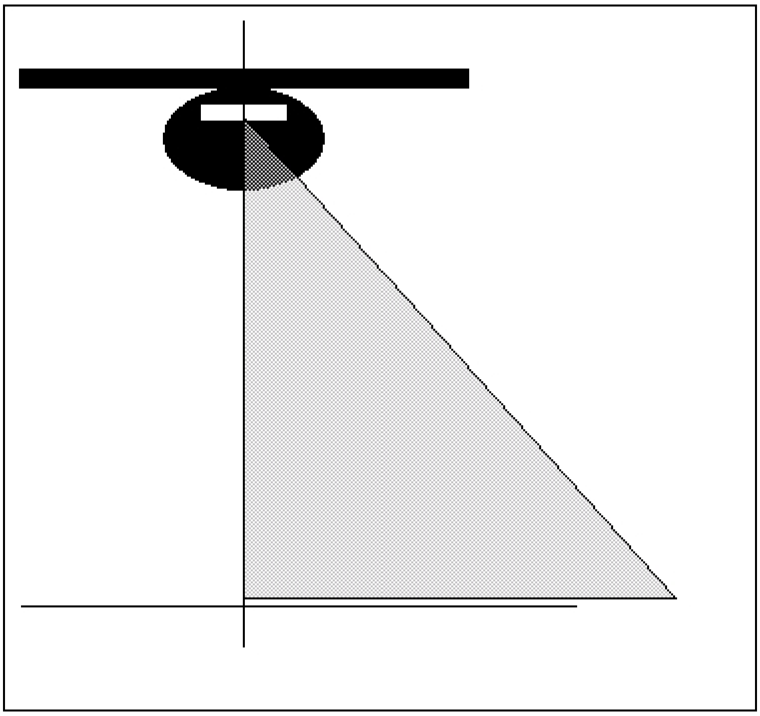


Figure 4.1 Dead zone effect of aerial surveys. Grey area represents that area not seen by observers and extends to both sides of aircraft.

Abundance estimates may also be affected by observer bias, though including this factor as a covariate in the distance model will have controlled for the effect to some extent. Although all aerial surveyors are experienced at the task, inevitably there is some variation between them. Using a computer simulation such as “Wildlife Counts” (Lucid Reverie LLC: Juneau, Alsaka) can help to test the biases of surveyors and further explain changes in abundance estimates generated (Banks 2006).

Regardless of these caveats, an attempt was made to formulate an index of distance-sampled abundance estimates from aerial surveys (Figure 3.15). The results from this index indicate a trend that is stable over time, with occasional high peaks (2002/03 and 2005/06). The standard errors around the ‘year’ parameter estimates tend to be fairly wide, meaning that it is possible to form a linear trend through all estimates with error bars. Comparisons of this index with that derived from the ground-based surveys are discussed elsewhere (section 4.4).

4.1.2.2 Distribution

Perhaps the greatest benefit of aerial surveys is the resulting ability to plot the distribution of common scoters seen. It is assumed that such distributions are likely to be fairly accurate, as observed movement of scoters tends to be localised in response to the aircraft, meaning that there is not large-scale redistribution around the whole site. Furthermore, although it is likely that aerial surveys underestimate the total number of birds present (Frederick *et al.* 2003; Banks *et al.* 2004), relative distribution should remain broadly precise.

In most years studied, the majority of common scoters detected on aerial surveys in Carmarthen Bay have occurred at some point along a line from Amroth in the north west to off the coast of Pembrey in the east (Stewart 1995; Banks *et al.* 2004; Banks *et al.* in review). In these years, the largest proportion of the distribution was found within the 10 m bathymetry contour, suggesting, as scoters are typically distributed to match their prey (Kaiser *et al.* 2006), that birds were feeding on shallow water prey; Woolmer *et al.* (2004) further linked common scoter distribution to distinct prey communities with the bay. The exception to this ‘typical’ distribution was in the years immediately following the *Sea Empress* oil spill, when large groups of common scoter were recorded in deeper water off Rhossili in the south east of the bay (Cranswick *et al.* 1998), as a likely result of pollution to favoured food resources in the north (Law & Kelly 2004; Banks *et al.* in review).

The survey in February 2005 conformed to the typical distribution (Figure 3.16), as did the patchier distributions from the first three surveys of 2005/06 (Figure 3.17). In February 2006, when distance estimates peaked, the distribution observed reflected large flocks of scoters in an almost unbroken sweep from Amroth to Cefn Sidan, all within the 10 m bathymetry contour, and smaller flocks off the Gower Peninsular. This is reflected in the average distribution for the winter (Figure 3.19a).

At the beginning of the following winter (2006/07), there was an unusual absence of large concentrations of scoters in the north of the bay (Figure 3.18a, b). Distance estimates were low, and this was reflected in the distribution observed. Furthermore, in both November and December, the largest flocks were recorded some distance off the Gower Peninsular. It is unclear why this area was favoured; however, the end of 2006 saw particularly turbulent weather, and much debris was noted on the sea especially in December, perhaps affecting scoter distribution. By January 2007, large flocks had returned to the areas in the north off Amroth and Pendine, though other aggregations remained further south (off the mouth of the Burry Inlet) than typically observed, a pattern persisting in February 2007 (Figure 3.18c, d).

Because of this apparent southward tendency in 2006/07, the mean centre of the average winter distribution was found to be some 3 km south of that for 2004/05 and 4.5 km south east of that for 2005/06 (Figure 3.20) (note that the average distribution for 2004/05 is based on one survey only). However, in comparison to mean centres calculated for the post-oil spill winters 1998/99 – 2003/04 (albeit using a slightly different aerial survey method: Banks *et al.* in review), 2006/07 was not anomalous, and certainly did not resemble the immediate post-spill winter of 1997/98 when distribution radically changed (Cranswick *et al.* 1998). 2004/05 and 2005/06 showed particular westward bias in comparison to other winters, suggesting that the largest average concentrations were found away from the Pembrey / Gower area.

4.2 Assessment of factors affecting ground-based count precision

4.2.1 Experience

Investigation of the effects of experience proved to be instructive, although without stringent statistical analysis should be interpreted cautiously. As expected, naïve surveyor precision was poor compared to an experienced counterpart on the first set of surveys. This is unsurprising, as there will always be an element of familiarisation when beginning a task such as this. However, in both winters, precision improved as more counts were achieved, and it was possible to derive a linear relationship between count number and precision.

Depending on individual differences, the number of counts necessary to achieve 100% precision (in comparison to an experienced surveyor) may lie between 13 and 23. Evidently such a figure is reasonably high, and resources may not be available to pay someone to fulfil that number of surveys. However, it may be possible for intended future surveyors to make a number of independent visits to practice counting, and that such activity be required before their counts are considered acceptable. Alternatively, it may be acceptable to make a lesser number of visits, for instance so that precision is within 10% of an experienced surveyor. This would have an effect on the index, but possibly would not lead to large artefactual increases or declines caused by change of count personnel.

To further this approach, it would be worth exploring the use of exponential curves to describe improvement in surveyor precision. Learning rates typically describe a curvilinear relationship, with an exponential growth phase followed by a levelling off at some ceiling level. Employing such statistics could lead to more precise estimates of the number of counts necessary for a surveyor to be considered accurate enough to take on common scoter counts at Carmarthen Bay.

4.2.2 Tide

As suggested in Banks *et al.* (2004), there is some evidence, albeit not derived from statistical testing, that high tides can return higher counts of common scoter, at least at the Pendine count station. On both counts in 2007, highest counts were returned on the highest tides (Figure 3.9). Such an effect might be expected, as birds move closer to shore to exploit newly inundated prey resources, although there was little evidence of this from the distribution maps obtained (Figures 3.10 – 3.12).

If the recommendation should be that counts are performed on high tides, then there is an obvious dilemma; at present, three count stations around the bay are visited during the course of one survey day. It is therefore impossible for one person to survey from each location on a high tide. The best approach may be to visit each count station so that each is surveyed on a high tide through the course of the winter. The effect of the tide may therefore be averaged out across the winter if it is logistically practical to use this approach.

4.2.3 Disturbance

The effects of disturbance to common scoters from the survey aircraft are now well established. Both in this study and Banks *et al.* (2004), scoters were observed to flush in response to the oncoming aircraft, both when the aircraft was some distance away and when in close proximity. The birds are likely to respond to a number of different disturbing cues: aural, visual (including the silhouette cast when the sun is behind the aircraft) and physical, the latter likely to result from the draught produced by flying at low level.

However, all observations thus far obtained suggest that the majority of disturbance caused is fairly short-lived and spatially restricted, with only local redistribution or return to areas from which the birds were flushed. Therefore we can be fairly confident that the degree of double-counting caused by disturbance is likely to be low; also, that distributional data are thought to be representative of the actual distribution of birds, as birds that flush are viewed typically as they flush or shortly afterward. It is very unusual to record a flock of scoter in flight that have not obviously just left the water.

It is not considered necessary to investigate the effects of disturbance at Carmarthen Bay further. Although there may be differences in scoter behaviour at different sites around the country, at Carmarthen Bay it would appear to be fairly consistent. The only further consideration is the implications of high proportions (84%) of scoters flushing (Table 3.13) on the relevant outputs from distance sampling models.

4.3 Assessment of effect of varying altitude on aerial surveys

Results from the subset of transects flown at different altitudes universally suggested that there is little to be gained from pursuing the investigation of this methodology. No discernible difference in disturbance was detected either by observers on the ground, or in the aircraft. Disturbance occurred when flying at 76 m, 150 m (Banks *et al.* 2004), 225 m, 300m and 375 m. Furthermore, those in the aircraft found visibility to be too poor to reliably count scoters once altitude increased above 225 m. In conclusion, behaviour of common scoter in Carmarthen Bay in response to a survey aircraft appears to be similar regardless of altitude: widespread flushing from the water, with the general tendency to return to areas previously occupied.

The implications for results from aerial surveys are debatable; as birds tend to return to the same areas when flushed it does not seem likely that there is widespread redistribution of birds in response to the aircraft. However, the disturbance itself may influence resulting abundance estimates, detectability, and distance estimates. These findings justify the adoption of the standard aerial survey method (Camphuysen *et al.* 2004).

4.4 Indexing common scoters and assessment of Favourable Conservation Status

The principal aim of survey work in Carmarthen Bay is to ensure that monitoring of common scoters is standardised and produces results of the highest precision, so that the conservation status of the SPA features (*i.e.* the birds) can be continually assessed. In order to facilitate this task, three analytical tools are proposed:

1. The ground-based survey index to track changes in key visible feeding areas
2. The aerial survey index to track changes in estimates of abundance
3. The aerial survey mean centre distribution to track changes in average winter distribution

4.4.1 Abundance changes

It is suggested that indices of both ground-based surveys and aerial surveys are adopted. The former has the advantage of recording generally greater numbers of common scoters, as the method is unobtrusive and involves finer-scale observation. The latter has the advantage of encompassing all available habitat within the SPA, though is prone to disturbance and often wide confidence limits around point estimates of abundance. Both indices proposed make use of GLMs, which have been used in other indexing applications (Burton *et al.* 2006).

A sensible approach would seem to be to compare relative changes in the two indices from year to year. Where both indices agree on direction and scale of change, this would appear to provide strong evidence of actual change. Table 4.3 shows this approach, with year-to-year index value changes expressed as percentages of the base year. In three of the changes analysed, aerial survey and ground-based survey indices agree in terms of direction, though not always in scale. This is also shown in Figure 4.2 where both indices are plotted together.

Table 4.3 Relative change in ground-based and aerial indices

Winter	**Ground change**	**Aerial change**	**Difference**
2001/02 - 2002/03	0.308	0.544	0.236
2002/03 - 2003/04	-0.254	-0.407	-0.153
2003/04 - 2004/05	0.208	-0.062	-0.27
2004/05 - 2005/06	-0.184	0.765	0.949
2005/06 - 2006/07	-0.286	-0.434	-0.148

It is clear from both Table 4.3 and Figure 4.2 that the indices derived from the two methods agree in some winters but not others. Prior to 2004/05, the indices appear in step before diverging for two winters; both then record a decline in 2006/07.

It is important that the indices are viewed in conjunction with absolute estimates obtained. It may be acceptable for declines to occur if the local population is at an extremely high level, for instance, but not if absolute estimates suggest numbers are below the 1% threshold of 16,000. It is also advisable to regularly update the five-year peak mean values in order that anomalous years may not have an undue effect and to incorporate the most recent data. Furthermore, if the WeBS Alerts model is to be followed as occurs for most SPAs in the UK (Maclean & Austin 2006), it may be possible for regular calculation of alerts status, by comparison of index values with those in previous years.

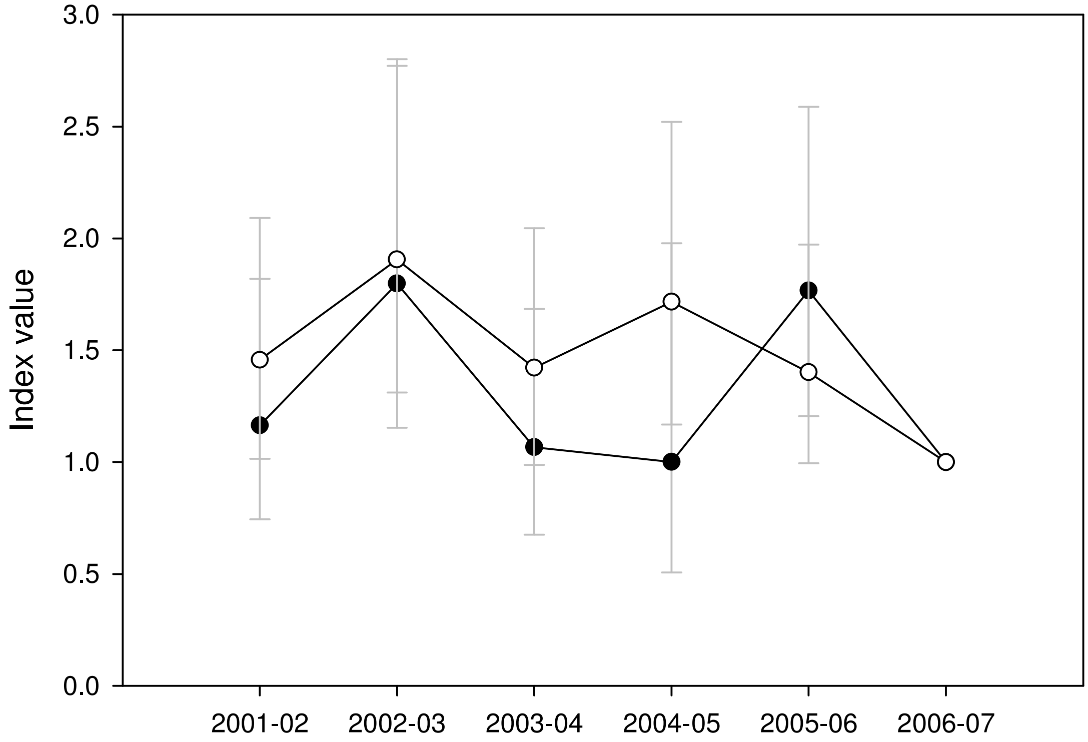


Figure 4.2 Indices of wintering common scoter numbers in Carmarthen Bay derived from aerial surveys (filled symbols) and ground-based surveys (open symbols). Bars are standard error.

4.4.2 Distribution changes

Ground-based counts, although useful in counting common scoters in areas visible from shore, are very limited in their ability to detect changes in distribution over anything but the very gross scale. In order to obtain full information on scoter distribution throughout the bay and changes therein, it is imperative to maintain a program of aerial surveys, at least until a method of remote imaging is readily available.

It has been suggested that a lesser number of aerial surveys could be performed throughout a winter, and some distributions (*e.g.* 2005/06) would suggest that changes are small enough to warrant this approach. However, those of 2006/07 illustrate that this may not be wise, especially if mean centres of distribution are to be used as a measure of change. If, for example, surveys had only been performed in November and December, the resulting average distribution would have indicated a relative absence of scoters in the traditional feeding zones in the north west of the bay, areas which were used during the January and February surveys. Where a lesser number of surveys is unavoidable, it would be advisable to target two periods for surveys to occur: one between 01 November and 31 December; and, crucially, one between 01 January and 28/29 February. It is this latter period in which the majority of peak estimates have been collected at Carmarthen Bay since this method was introduced. A minimum of two weeks between surveys should be aimed for.

The use of mean centres to describe changes in distribution would seem a neat and intuitive method of summarising complex spatial information. It has been used in other ecological studies aiming to show patterns of a similar nature (Jensen & Miller 2005), and is straightforward to run in a GIS. The changes presented in this study are slightly open to interpretation given that between 1997/98 and 2003/04 a different aerial survey method was employed. It may be possible to resample the data at a common level, but past attempts have been problematic. Alternatively, it would be possible to analyse all data collected using the same approach (from 2001/02 onwards) and plot these centres; this is, however, beyond the scope of the current project.

4.5 Revised Procedural Guidelines and Standard Operating Procedures

Procedural Guidelines and Standard Operating Procedures are designed to ensure consistent monitoring approaches between sites and over time at individual sites respectively. A revised draft for each of these has been drawn; these are presented in Appendices 2 and 3.

5 RECOMMENDATIONS FOR FUTURE WORK

Of primary importance is the requirement to continue a full suite of ground-based and aerial monitoring, especially given that the ground index currently illustrates a negative trend, recommencing in the winter of 2007/08. Where possible, four ground surveys and four aerial surveys should be performed between November and February.

Ground-based surveys

- Protocol for ground-based counts is now fairly well established, and monitoring surveys should continue as before, preferably with at least one visit to Rhossili in the course of a winter (or more if aerial surveys suggest it is worthwhile). This is especially pertinent given that the index suggests a negative trend.

- Although weather conditions can restrict the number of days available for counting, surveyors should be encouraged to perform counts only when conditions are ideal. Therefore allowance may need to be made for partially completed counts terminated because of weather deterioration.
- Given what has been suggested about the number of surveys necessary for naïve counters to achieve acceptable precision, only sufficiently experienced surveyors should be used.
- The effect of tide highlighted by this study and Banks *et al.* (2004) could be investigated further. As mentioned, it is impossible for a single surveyor to move between count stations quickly enough to record three counts all at high tide. The only possible method of examination would be for one surveyor to perform the three standard counts, whilst three other surveyors simultaneously counted from each of the three stations. This would then allow comparison of count totals obtained in the routine fashion and those obtained on the same high tide.
- It is not considered necessary to further investigate the effects of disturbance on ground-based surveys.

Aerial surveys

- The method employed for aerial surveys is standard (Camphuysen *et al.* 2004) and appears to work in Carmarthen Bay, so there appears little need to adjust it. It is important, however, that organisations involved in aerial surveys maintain a pool of trained aerial surveyors, all of which should be given a number of training flights and tested against an experienced observer using a computer simulation such as "Wildlife Counts". It may also be worthwhile marking distance bands on the aircraft windows to familiarise new counters with the method, and ensure that detection functions are sensible. However, there are also desk-based studies that could inform analysis and interpretation of results.
- Maclean *et al.* (2006) recently analysed a large dataset in connection with the ability to detect changes in numbers of seabirds wintering offshore. The implications of this study, a power analysis which showed that some aerial survey regimes may be insufficient to detect population changes, should be considered for aerial surveys at Carmarthen Bay, potentially with a new power analysis using all available data for the bay. This may support the conclusion that using an aerial survey index to track numerical change may not detect the sort of differences that may be of interest. On a related theme, the distance analysis of count totals may benefit from the additional collection of data from variables suggested by Maclean *et al.* (2006); the practicality of this should be investigated. Also, a wider analysis should consider the possible violation of distance sampling assumptions inherent in the scoter data. Predominantly, the assumption that all birds are detected near the track line is perhaps debatable, as there is likely to be some short distance movement away from the transect if the aircraft passes overhead.
- Refinement of the aerial survey index would be worthwhile, perhaps basing the index on raw counts rather than distance estimates. The use of these estimates as point values may not be entirely valid given that they are derived themselves from modelling and represent only a likely estimate from a range of values.
- Regardless of such research, it is important to continue aerial surveillance for distributional analysis. A small project could aim to produce mean distribution centres from previous distance method flights, thus giving a consistent set of points from 2001/02 – 2006/07 against which future changes could be measured. It may also be worth considering whether methods of kriging – spatial interpolation of distribution data – could be introduced to further enhance interpretation of spatial data (Webb *et al.* 2003).

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APPENDIX 1: DISTANCE SAMPLING DETAILS

Exploratory analysis of the data suggested that fitting separate detection functions to each survey visit did result in a small gain in model fit (and thus increased precision of abundance estimates) using conventional distance sampling, compared to a global detection function applied across all surveys.

However, when covariate analysis was undertaken using multi-covariate distance sampling (MCDS), a combination of a global detection function and observer as a covariate was found to produce the best model fit using hazard rate models, based on lowest AIC values and parameter numbers. Figure A1.1 shows the global detection function used.

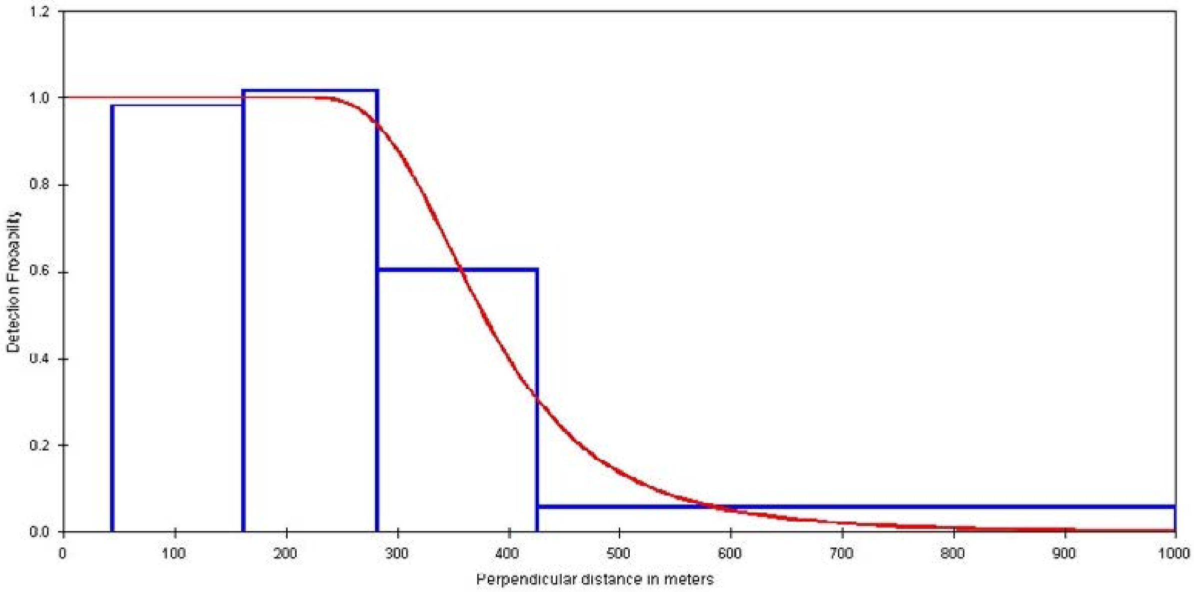

Figure A1.1 Global detection function

Various other covariates were modelled, including side of plane, tide, scoter behaviour, winter and cluster size, none of which were found to improve model fit.

As detection functions differed between observers, it is possible to draw these to the attention of the people involved and feedback this information to improve accuracy of distance estimates generated in future surveys.

APPENDIX 2: DRAFT PROCEDURAL GUIDELINES

The following Procedural Guidelines are based on five years of monitoring and methodological studies by the BTO, taking into account work by Lucy Smith towards a PhD in conjunction with Swansea University, WWT and CCW. These guidelines were drafted by Alex Banks and Andy Musgrove [BTO].

Procedural Guideline for making ground-based assessments of numbers of offshore common scoter flocks

1.1 Background

Outside the breeding season, most common scoter *Melanitta nigra* concentrate in flocks in shallow (typically <10 m deep) offshore areas. This Procedural Guideline recommends a technique to be used to assess common scoter numbers by ground-based observers (as opposed to aerial survey) and is based largely upon experience gained from surveying birds at Carmarthen Bay in south west Wales. The method is straightforward but its interpretation is less so, being highly dependent upon both site-specific factors (*e.g.* vantage points and distance to offshore flocks) and count-specific factors (*e.g.* weather conditions). The applicability of the methods will depend to a large extent on the physical characteristics of the site in question and the ease of offshore visibility. The method will provide minimum estimates of the numbers of birds present but will seldom be able to provide a reliable estimate of total numbers, as some birds are always likely to be beyond the visible range from the coast. Therefore this method may be suitable for producing a species index of the 'core' sample of the population, but not an overall population estimate.

Additionally, the Procedural Guideline is currently restricted to the recording of scoter numbers only and not to recording the position of flocks. The evidence from this and the previous report (Banks *et al.* 2004) suggests that there is little to be gained in recording the position of flocks as the resulting distribution cannot be combined with the aerial distribution and offers limited assessment of spatial patterns. The only useful distance measure is one of overall visibility. In the future, however, the guideline could be modified if positional information was considered useful.

Advantages

- Relatively straightforward.
- Relatively inexpensive.
- Does not require specialised equipment, beyond standard optics.
- Requires little last-minute organisation.
- Does not rely on (*e.g.*) plane or pilot availability.
- Potential counters can likely be sourced from CCW staff or the local birdwatching community.
- Creates little or no disturbance to the target species.

Disadvantages

- Can be used over only a limited range from the shore.
- Dependent on suitable vantage points.
- Highly dependent upon weather conditions.
- Relatively time-consuming (in comparison to aerial survey), especially if >1 count station.
- Requires a careful and thorough observer.
- Observer may need 10 – 20 practice visits to achieve acceptable precision if inexperienced.
- May be less straightforward at locations where other similar species occur.

1.2 Purpose

The principal output of the method is a count of common scoters over a given area on a given date. This count (or a series thereof) can then be compared against pre-determined threshold values or historical counts using the same method to monitor the condition of the area in question. The count obtained, however, must be considered carefully in relation to site-specific and count-specific factors when comparing against threshold values before firm conclusions can be drawn.

Making slight modifications of the method could also provide additional information. The distribution of common scoters over the surveyed area could also be recorded with an extra investment of effort if it was deemed useful to obtain fine-scale spatial information. Also, other offshore waterbird species could be surveyed at the same time. In some situations, bird behaviour and sex ratios could also be recorded, although these are even more strongly limited by site-specific and count-specific factors.

1.3 Logistics

1.3.1 Equipment

A telescope with a zoom eyepiece typically of 20-60 times magnification, with at least an 80 mm objective lens. The telescope must be mounted on a sturdy tripod.

A map and compass, to determine accurately both the location of the vantage point and the extent of the surveyed area. Admiralty charts of the area may also be useful to estimate distances from shore, if such a variable is to be recorded. Distances to buoys at sea may inform estimates of proximity, though it should be noted that these can change. Distances to headlands or other fixed landmarks could also be deduced and used to instruct estimates of distances to bird flocks.

Suitable recording media. A pre-prepared form is the most suitable to ensure that all relevant supplementary information is recorded but in wet weather a dictaphone may be more suitable (although counts should be transferred to paper as soon as possible afterwards, to avoid uncertainty). Alternatively a commercially available ‘Weather Writer’ should be used; this allows written recording of results without damage to the page from rain. Some counters may like to use a tally counter.

Warm and waterproof clothing, suitable for an observer working from a fixed, exposed position for about two hours at a time.

Suitable health and safety equipment, such as a mobile phone with relevant contact numbers (*e.g.* local coastguard and police), emergency rations, *etc.*

1.3.2 Personnel / time

The number of staff required depends upon the size and nature of the particular site and the perceived necessity of avoiding double-counting. For example, it may be more critical to have multiple observers carrying out simultaneous counts from different vantage points at a highly disturbed site than at a relatively undisturbed site where distribution may alter much less over the course of a day. The work should be planned taking into account any prior knowledge of daily movements of scoters. Some organisations or situations may require paired observers for safety purposes and this should be considered at an early stage.

The method does not call for observers with highly-specialised identification skills, as common scoters are easily recognisable. If possible, counts from new observers should be compared to those of an observer with specific experience of common scoter counting, to ensure that results are not unduly affected by any change in count personnel. New counters without any seawatching experience should have undertaken at least 10 surveys before participating in ‘formal’ surveys; those with experience of counting seabirds need make only one or two visits to familiarize themselves with the site and procedure. No formal qualification would be required, and good eyesight and a degree of stamina are more valuable, along with thoroughness and attention to detail.

The preferred time of year for sampling is dependent upon the site, relying on both the occupancy by the species and the requirement for the survey (*e.g.* if investigating a seasonal disturbance factor or estimates of birds in moult). Common scoters do occur in UK waters throughout the year but overall the highest numbers are in the winter, particularly November – February. Existing datasets for the site in question should be investigated in advance of the survey to determine what is already known about occupancy patterns.

1.4 Method

1.4.1 Pre-survey considerations

The target area should be clearly defined. Vantage points covering as much of the site as possible should be selected, although care should be taken to avoid double-counting through overlapping zones. It may be useful to fix predetermined lines of sight marking the edge of count sectors on previous surveillance visits; this may help to reduce the risk of repeat counting of areas of sea from different vantage points. Vantage points should be as elevated as possible to increase visibility. Ideally, vantage points should also be readily accessible, reducing the walk-in time. Where possible, vantage points should also be in sheltered situations; a more comfortable counter will produce a more thorough count. Consideration of travelling times between vantage points should also be made.

Survey dates should be selected in advance but may vary at short notice. If the sea-state has any more than a slight swell or if visibility is hampered through haze, fog or precipitation, postponing the survey until a day with more suitable conditions should be considered. The time of day, where possible, should be selected to minimise the extent to which observations need to be made in line with the sun, and to try to coincide counts with high tides. A target number of counts should be set, and these should be spread throughout the winter to gain an impression of seasonal changes in numbers.

1.4.2 Survey methods

Upon arrival at the vantage point, the date, observer, start time and equipment being used should be noted. Weather conditions (wind speed and direction, cloud cover, precipitation and sea-state) should be recorded before the count and at the end of the count, along with any clear changes throughout. An assessment of the range of visibility should also be included.

Having positioned the telescope (in a fixed location consistent between surveys), a preliminary scan should be made to determine any broad patterns of occurrence. Then, starting at one end of the survey zone, the telescope should be scanned across the sea at a low magnification. It is critical that the sea is scanned very slowly, particularly when the sea-state is less than ideal. If there is the possibility of poor visibility (*e.g.* fog) it may be worth speeding up the count to cover the whole area in less time, but the fact that this was done should be carefully recorded. If a quick count is carried out and the visibility remains satisfactory then the observer should attempt to repeat more slowly.

Each area of sea should be observed for at least a minute to check for any birds that are under water. When birds are encountered a higher magnification should be used as necessary. A flock should be observed for at least a minute to check both for birds behind waves and birds diving. The observer should not necessarily expect to see all of the birds in a flock at the same moment as with a swell this is unlikely to occur. Instead, a combined impression of the numbers present should be arrived at after watching the flock for a period. It should be noted that birds will drift if watched for too long, however.

If large flocks (more than 100) are encountered, particular care should be taken not to rush to a total. Care with counting in blocks should be taken (*e.g.* count 10, then mental images of sets of 10 or even sets of 100). Flock density will not be uniform throughout, but generally tends to be densest towards the centre of the flock. If possible, prior experience of estimating flocks from photographs or using a computer package (such as the program 'Wildlife Counts' available at www.wildlifecounts.com) which generates random flocks, should be sought. A tally counter can be used if preferred, clicking once for each bird viewed or advancing the counter by factors of ten.

A count of each flock should be recorded separately. Whilst it may not be considered critical to assign birds to a particular position, it may be useful to record each flock to a compass bearing as a check in case of accidental movement of the tripod during the count, to ensure that the count can be resumed from a known point. This would be most useful in areas of higher density.

The count should aim to take at least one, and preferably two, hours. Where there are small numbers of birds, a count of one hour should suffice. It is important that the length of time spent counting is standardised across other counts during the same and subsequent winters, as this factor can affect count totals.

The target species is an all-dark duck and, within the UK at least, at its main sites it is usually the dominant species with relatively little scope for confusion. The related velvet scoter *Melanitta fusca* is difficult to distinguish within flocks of swimming common scoters. However, at most UK sites (including all Welsh sites), velvet scoters are scarce and likely to be so heavily outnumbered by common scoters that they will not affect the results in any significant manner. Only in Scotland (especially from the Firth of Forth to the Moray Forth) are velvet scoters likely to be a significant issue. The presence of substantial numbers of velvet scoters would become apparent to an observer carrying out an intensive survey of a site as the species is very apparent in flight or when flapping its wings on the surface, revealing white secondary feathers (not shown by common scoters). The other main possible source of confusion would be eider *Somateria mollissima* and perhaps transient flocks of dabbling ducks *Anas* that can sometimes rest offshore, particularly on migration.

At the end of the count, the time and the weather conditions should again be recorded. If the time is available then the observer should consider carrying out repeat counts.

1.5 Data analysis

The level of data analysis required is very much dependent upon the nature of the site and survey. At the simplest level, counts from all vantage points are summed and a total is produced for the site. Depending upon the selection of vantage points, the synchronicity of multiple counts and the degree of movement of flocks observed, it may be necessary to take account of potential double-counting. When required, it is useful for the counters themselves to be involved in this, ideally as soon after the survey as possible.

If a single observer has made multiple repeated counts then, unless there is a good reason otherwise, the maximum count should be taken. This is because the nature of the environment involved means that it is always far more likely that birds will be missed than that additional birds will be introduced into the count total. The level of variation amongst repeats, however, should be kept under review and if particularly variable then a modification of the site-specific procedures should be considered.

The interpretation of whether or how the ground count can be used to improve estimates of the number of scoters present depends greatly upon the other resources available and this subject is discussed elsewhere in this report. As a bare minimum, an assessment should be made at the time of the count of the distance over which scoters are thought to be visible on the day. This may be by reference to objects of known distance, such as buoys or other landmarks, but it may be necessary to estimate the distance by comparing the perceived size of the most distant scoter with an object visible on the land which can be positioned on a map. It is important that this assessment is available, however approximate, to estimate likely count completeness.

1.6 Accuracy testing

Accuracy can be tested by making repeat counts using the same observer or by carrying out counts, ideally simultaneously, using more than one observer. Counts should also be considered with regard to the sea-state, visibility and duration of count.

1.7 QA/QC

Quality assurance and standardisation of methodology would be assured by ensuring that the same vantage points, count zones, tidal states and approximate count dates were repeated between years. Consistency of optical equipment would be important. Where possible, the same observer should be used but if this is not possible the level of thoroughness (*i.e.* the duration of the count) should be the same over time. New personnel could have their field skills tested at interview, for example by comparing practice counts with those of a surveyor of known experience, and should carry out a number of practice visits if found to make estimates varying greatly from the experienced counter. Periodic validation of counters could also prove effective in maintaining quality control. In such cases, experienced surveyors would accompany counters, and counts made at the same time and location could be compared. Cross-calibration or re-training could then be employed if consistent differences were detected. Rules on acceptable weather conditions should be adhered to throughout.

1.8 Data products

The method described in this guideline generates estimates of numbers of scoters only. Modifications of the method to record distribution would result in positional data which could be mapped or analysed using GIS.

1.9 Cost & Time

The main cost involved is that of staff time. Travel time and expenses (and perhaps overnight accommodation) should be taken into account. Consideration should also be given to potential standby costs, *i.e.* having planned to carry out a survey but then postponing at the last moment due to weather. Equipment costs are largely restricted to those for the telescope, tripod and compass.

1.10 Health & Safety

All standard procedures set out by CCW or other involved organisations and/or landowners should be followed. Particular attention should be paid to the following issues:

Have suitable warm and waterproof clothing. Vantage points may be exposed and suitable footwear should also be used if vantage points are accessed along paths with hazardous terrain. Observers should not walk out onto intertidal substrates. In remote areas, a survival blanket, whistle, first aid kit, torch and emergency rations should also be carried along with mobile phone with relevant contact details. Always make it clear with someone else where you are going and when you should be expected back and instruct this person to notify the emergency services if you do not return as expected. Some coastal areas are used as military firing ranges and in such cases make sure you are aware of the times the ranges will be active.

Procedural Guideline for making aerial assessments of numbers of offshore common scoter flocks

2.1 Background

This Procedural Guideline recommends a technique to be used to assess common scoter numbers and distribution by aerial survey, and is based upon experience gained from surveying birds at Carmarthen Bay in south west Wales, and recent agreements on offshore survey methodology related to wind farm development (Camphuysen *et al.* 2004). The method is based on the principles of distance sampling, and relies on the assumption that detectability of birds decreases with distance from the observer. It assumes that all birds near the transect line will be detected by the observers, and makes allowances for missed birds by calculating point estimates based on detection functions. These estimates carry associated confidence limits, thus allowing a measure of error in the numerical estimate. The method will provide minimum estimates of the numbers of birds present, but is susceptible to disturbing the target species. However, disturbance is thought to be short lived (see elsewhere in this report), and localized. As large areas of sea can be surveyed in a relatively short time period, this method may therefore be most suitable for providing information on relative broad-scale distribution patterns of large concentrations of scoters.

Advantages
- Scientifically rigorous.
- Allows comparability with other aerial surveys (*e.g.* DTI 2006).
- Does not demand the observer to count all birds but to focus on a transect line.
- Generates 95% confidence limits around numerical estimates.
- Allows modeling of covariates such as observer, tide, sea-state, etc.
- Provides overview of distribution over wide area.

Disadvantages
- Wide confidence limits may preclude accurate detection of population change.
- High levels of disturbance created by the aircraft may give low estimates of population size.
- Risk of double counting higher than on ground counts as disturbance more likely.
- Aerial survey more costly and logistically more difficult than ground counts.
- Allows fairly limited historical comparisons.
- Requires experienced personnel for surveying.

2.2 Purpose

The principal outputs of the method are an estimate of common scoter numbers over a given area on a given date, and comprehensive spatial distribution data (obtained from GPS positional information). The estimate (or a series thereof) can then be compared against pre-determined threshold values or historical counts using the same method to monitor the condition of the area in question. The count obtained, however, must be considered carefully in relation to site-specific and count-specific factors when comparing against threshold values before firm conclusions can be drawn. Distributional patterns can be compared at different stages of the same year, or between years.

Other offshore waterbird species can be surveyed at the same time. In some situations, bird behaviour can also be recorded, and although the additional demands placed on classifying this variable may sacrifice precision of the count data, it is a useful factor to include in the distance sampling procedure.

2.3 Logistics

2.3.1 Equipment

The most obvious factor is the demand for an aeroplane, preferably an aircraft such as a Partenavia PN-68 with high wings and good visibility from the side windows. The aircraft should be fitted with an internal communication system (headphones, personal microphones) to allow the navigator (or pilot) to inform the counters of start and end times of transects, and to direct the pilot where necessary. Also, adjacent passenger seats are required, with one observer on the port side and one on the starboard side.

GPS equipment is crucial to record the position of the aircraft during the survey and subsequently link records of scoter flocks to correct locations. A handheld GPS unit such as a Garmin GPS 12 XL is suitable, and, if possible, a lead connecting the unit to an external aerial is useful to maximise reception. Although such a GPS system can record position to definable time periods using the 'memory log' function, software such as 'WinWedge' allows more precise recording and should be favoured. A laptop, with a database program such as MS Access installed, is necessary to take on board the plane and receive a live feed from the GPS. Most aircraft now have on-board GPS systems for pilot navigation, and waypoints of transect end and start points should be entered and checked prior to take-off.

A clinometer is highly desirable to facilitate determination of distance bands, although the same effect can be achieved using strips of tape across the window, or with a card with ruled lines designed to correspond to fixed angles in comparison to the horizon. Dictaphones are needed for observers to record counts on; these should be of high quality to pick up records above engine noise from the plane, and spare batteries should always be available. Digital Dictaphones are preferable to avoid problems with tapes and to provide an easily stored log of flight details. Electronic stopwatches, synchronised with the GPS and between all members of the survey team and taped to the inside of the plane for easy reference and to keep hands free, are also crucial. A map of the area is also useful, particularly for navigating unfamiliar terrain. A pre-made schematic map of the transects to be flown would also benefit navigators.

2.3.2 Personnel / time

The number of staff required is unlikely to vary from site to site; each aerial survey team should consist of a pilot (preferably with experience of wildlife survey and transect methods), a navigator (with experience of GPS and ideally the local area) and two observers, one on either side of the plane. Navigators are not required where pilots are experienced enough to navigate by on-board GPS; in such instances, the pilot announces the start and end of transects. However, where financial constraints and availability permit, a navigator is desireable to ensure accuracy of flight lines, altitude and flight speed, and to allow pilots to concentrate fully on piloting.

The method does not call for observers with highly-specialised identification skills, as the target species is not easily confused, although it is essential that some experience of aerial survey is gained before observer's counts can be considered reliable and observers should have had as much experience of aerial survey as possible. Although it may not be necessary or realistic for observers to have experienced 30 hours of flights as recommended for aerial surveys related to wind farms (Camphuysen *et al.* 2004), at least four flights (equating to 10 hours) should have been experienced to familiarize with the method and to compare counts with those from experienced observers.

The preferred time of year for sampling is dependent upon the site, relying on both the occupancy by the species and the requirement of the survey (*e.g.* if investigating a seasonal disturbance factor or estimates of birds in moult). Common scoters do occur in UK waters throughout the year but overall the highest numbers are in the winter, particularly November-February. Existing datasets for the site in question should be investigated in advance of the survey to determine what is already known about occupancy patterns.

2.4 Method

2.4.1 Pre-survey considerations

Survey aircraft should be reserved well in advance, and the pilot should make arrangements to take off and land from the airfield nearest the target area, if this is far from where the plane is based. Any potential disturbance to the flight should be taken into account, with particular reference to airspace restrictions. This factor should also be considered in planning transects and approaching the survey area; it is advisable to avoid any restricted airspace to reduce flight time, but also the area of survey should not be entered if possible before the first transect begins, as the aircraft can significantly disturb birds on the water. The order of transects should also be predetermined, to factor in bias created from directional factors and geographical factors (*e.g.* it may be impossible to turn at the end of some transects if there is a sharp cliff face).

Survey dates should be selected in advance but may vary at short notice. If the sea-state has any more than a slight swell or if visibility is hampered through haze, fog or precipitation, postponing the survey until a day with more suitable conditions should be considered. Wind – speeds should not exceed ~15 mph to avoid sea swell and to facilitate accurate flight lines, altitudes and speeds. Extreme cold weather should perhaps be avoided to prevent disturbance to potentially stressed birds.

The time of day, where possible, should be selected to minimise the extent to which observations need to be made in line with the sun, and to try to coincide counts with high tides. A target number of surveys should be made, and these should be spread throughout the winter to gain an impression of seasonal changes in numbers and distribution.

2.4.2 Survey methods

The plane should line up with the first transect and reach the target altitude, speed and bearing. The pilot or navigator should use the GPS to monitor position and announce when the starting co-ordinates are reached. During the flight along the transect line, the navigator (where present) should fine tune plane movements through constant communication with the pilot, also checking the speed and altitude.

Distance bands should be pre-assigned, for instance into four bins A, B, C and D (Camphuysen *et al.* 2004). The first band is suggested to range from 44 m up to 162 m, to allow for a 'dead-zone' beneath the plane. Other suggested bandwidths are 163 – 282 m (B), 283 – 426 m (C) and 426 – 1000 m (D). These bands can be converted into relevant angles from the plane in relation to the horizon, and a clinometer produced. Observers should practice estimating these bands before beginning the first survey.

Upon announcement of the start of the survey by the navigator or pilot, counters should sweep the sea with the naked eye, concentrating most heavily on those birds found within the first distance band, as the statistical model applied factors those birds likely to be missed. Upon spotting a bird or flock, the observer should turn on the Dictaphone and record time, distance band, species and number of birds seen. Where large flocks span more than one distance band, the approximate centre of the flock should be estimated, and the appropriate band selected on this basis. An additionally useful variable to record is behaviour; this can be merely a distinction between flying birds and those on the water.

The target species is an all-dark duck and, within the UK at least, at its main sites it is usually the dominant species with relatively little scope for confusion. The related velvet scoter *Melanitta fusca* is difficult to distinguish within flocks of swimming common scoters. However, at most UK sites (including all Welsh sites), velvet scoters are scarce and likely to be so heavily outnumbered by common scoters that they will not affect the results in any significant manner. Only in Scotland (especially from the Firth of Forth to the Moray Forth) are velvet scoters likely to be a significant issue. The presence of substantial numbers of velvet scoters would become apparent to an observer carrying out an intensive survey of a site as the species is very apparent in flight or when flapping its wings on the surface, revealing white secondary feathers (not shown by common scoters). The other main possible source of confusion would be Eider *Somateria mollissima* and perhaps transient flocks of dabbling ducks *Anas* that can sometimes rest offshore, particularly on migration.

The navigator, where present should record the start and end times of each transect, as should the observers, and also record the start and end grid co-ordinates on pre-fabricated recording forms. Counters may rest between transects (*i.e.* when the plane is turning). All information recorded to Dictaphone should be transcribed to recording forms or input into a program such as MS Excel after landing. Electronic voice files and GPS track files should be backed up immediately after landing and eventually archived accordingly.

2.5 Data analysis

As common scoter are encountered in flocks, where the detection of an individual within a flock cannot be considered independent of the detection of other individuals within that flock, models of detectability are made for individual flocks (referred to as clusters).

Analysis of the data uses the software package DISTANCE 5, and point estimates are made based on counts, area surveyed and estimates of bird density. Bootstrapped re-sampling techniques, with 999 re-samples, are used to generate variance estimates and 95% confidence limits. Various covariates can be included in the model to examine effects of observer, weather (detectability), behaviour and so on.

The interpretation of whether or how aerial counts can be used to estimate the true number of scoters present depends greatly upon the other resources available and this subject is discussed in detail elsewhere in this report. Estimates of the number of birds sitting and flying may serve to inform confidence in the spatial distributions recorded, though evidence suggests that disturbance does not change common scoter distribution over a large scale (Banks *et al.* 2004 and this report). Such information can easily be plotted using GIS packages such as ArcView 3.

2.6 Accuracy testing

Carrying out simultaneous counts using more than one observer can test accuracy, as long as the plane has a seating arrangement permitting more than one person to sit on the same side as at least one counter. Counts should also be considered with regard to the sea-state, wind-speed, degree of disturbance and visibility during the count.

It is also worthwhile investing in a computer simulation such as 'Wildlife Counts' (www.wildlifecounts.com); this allows observer accuracy to be measured and compared, and is useful in determining when new observers are competent enough to begin formal surveys.

2.7 QA/QC

Quality assurance and standardisation of methodology would be assured by ensuring that the same transects were flown in repeat surveys. Using the same counters would also promote consistency. If finances allow, one or more practice flights could be flown for new counters, for calibration with an experienced surveyor sitting on the same side of the plane (although 30 hours of aerial count experience is suggested to guarantee quality of counts (Camphuysen *et al*. 2004), and something approaching this figure would be desired at interview stage). Periodic validation (*e.g.* every third flight) using an experienced counter sitting on the same side of the plane would introduce a quality control regulation. Acceptable weather conditions should be adhered to throughout.

2.8 Data products

The method described in this guideline generates numbers and distributions of scoters. Spatial information could be mapped or analysed using GIS, with the possibility of 'kriging' techniques being applied for spatial interpolation. Point estimates from distance sampling can be taken as estimated population size, with appropriate confidence limits.

2.9 Cost & Time

The main cost involved is that of renting the aeroplane and hiring the pilot. Travel time and expenses (and perhaps overnight accommodation) should be taken into account for fieldworkers living away from the area in which the plane is based. Consideration should also be given to potential standby costs, *i.e.* having planned to carry out a survey but then postponing at the last moment due to weather or plane unavailability. Equipment costs are largely restricted to those for the GPS, laptop, Dictaphones and stopwatches.

2.10 Health & Safety

All standard procedures set out by CCW or other involved organisations and/or the plane company must be followed. Particular attention should be paid to the following issues:

The pilot's instructions should be obeyed at all times. Life jackets should be worn during the survey and not kept beneath the seat. In case of emergency, the pilot's orders should be carefully adhered to. Pilots should be allowed a minimum hour's rest between flight events. Bags for air sickness should be made readily available at all times.

Always make it clear with someone else where you are going and when you should be expected back and instruct this person to notify the emergency services if you do not return as expected. Some coastal areas are used as military firing ranges and in such cases make sure you are aware of the times the ranges will be active.

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APPENDIX 3: DRAFT STANDARD OPERATING PROCEDURES

The following Standard Operating Procedure is based on five years of monitoring and methodological studies by the BTO, taking into account work by Lucy Smith towards a PhD in conjunction with Swansea University, WWT and CCW. It was drafted by Alex Banks and Andy Musgrove [BTO].

Standard Operating Procedure for Ground-based Counts of offshore common scoters at Carmarthen Bay

This Standard Operating Procedure should be read in conjunction with the associated Procedural Guideline. Only site-specific issues are covered below.

1.1 Background

Carmarthen Bay is one of the most important single sites for wintering common scoters in Britain and Ireland (Banks *et al.* 2006). As is typical for the species, however, the true numbers present at any time are difficult to ascertain. Ground counts have certainly exceeded 20,000 birds on a number of occasions and, given that only a part of the bay can be surveyed from the land the true number is thought to be higher. However, much lower counts were recorded following the *Sea Empress* oil spill of February 1996 (Banks *et al.* in review).

The distribution of common scoters within the bay varies, but overall birds can be found throughout a band approximately 5 km wide running from the north-west of the bay off Amroth and Saundersfoot to the east off Pembrey Sands, where the seabed is at 10 m or less. During the period following the *Sea Empress* oil spill, deeper waters in the south east of the bay (Rhossili Bay) were used by the birds to a greater extent (Cranswick *et al.* 1998; Banks *et al.* in review).

Whilst not covering the whole of Carmarthen Bay, ground-based counts of the scoters are relatively straightforward to carry out and can provide a good assessment of the numbers of birds present, at least for those birds feeding in the traditionally key areas of the bay that lie within visible range.

1.2 Purpose

The purpose of the method described is to record counts of common scoters at Carmarthen Bay over the course of a winter, for comparison between months within a winter and with totals from previous winters. Comparison with national and international threshold values can also be made.

The method could be modified to record the distribution, as well as abundance, of common scoters seen from the land. Additionally, other inshore species could also be noted, although at Carmarthen Bay there are seldom large numbers of other sea-duck present, except for a small flock of Eider at Whiteford Sands at the mouth of the Burry Inlet (which are probably well monitored by standard WeBS Core Counts at the site). Recording of behaviour and sex ratios of common scoters at Carmarthen Bay is not likely to be easy, due to the distance of most of the birds from the shore.

1.3 Logistics

1.3.1 Equipment

As detailed in Procedural Guideline.

1.3.2 Personnel / time

Ground counts of common scoter at Carmarthen Bay have traditionally been carried out by a single observer over the course of a day, with three or four vantage points visited consecutively, depending largely on duration of counts and daylight hours. It is thought that the degree of movement between sites is relatively small over the course of an average day (Stewart *et al.* 1997). Clearly, however, the option exists to carry out counts concurrently from all vantage points, if the observers were available to do so. The added value of synchronicity could, however, be outweighed by the differences in survey technique used by individual observers (although Banks *et al.* (2004) suggests that inter-observer variation can be relatively low, giving high internal validity). Similarly, if sufficient resources were available then consideration should be given to carrying out simultaneous counts from vantage points by multiple observers. Given that there are few sea-duck other than common scoters within Carmarthen Bay, the observers would not be required to possess highly-developed identification skills.

Common scoters can be seen in Carmarthen Bay throughout the year but post-breeding arrivals occur first in August and then again later in the autumn. The largest numbers appear to be present from November to March, although birds start to leave the site later in March and numbers are typically low from April. Ideally, the numbers in the bay would be monitored throughout the year. However, for an assessment of peak numbers the minimum requirement would be four counts during the period November to February.

1.4 Method

1.4.1 Pre-survey considerations

The four vantage points to be used for consistency are (positions using Ordnance Survey of Great Britain co-ordinates):

Pembrey sand dunes (241500, 199190 – 9 m ASL)

Dolwen Point near Pendine (223310, 207840 – 25 m ASL)

Merrifields, Amroth (217900, 207350 – 48 m ASL)

Kitchen Corner, Rhossili (240350, 187500 – 50 m ASL)

The Rhossili vantage point should be visited at least once during the winter. However, as mentioned above, this area is generally not used by large numbers of birds and survey efforts should be concentrated at the other three vantage points.

In general, the count zones visible from the vantage points can be assumed to be mutually exclusive. However, if count conditions are absolutely ideal then there may be a danger of double-counting between Pendine and Amroth, at ranges of more than 3.5 km to the south-east of the latter. However, the topography of the bay is such that the line of sight south-west from Pendine is likely to exclude most birds counted at Amroth. It is worth considering tidal movements and expected drift of birds between counts from these stations, as this may affect the likelihood of double counts.

Carmarthen Bay is used by the military for training purposes during weekdays, which can cause movements of scoters from one part of the bay to another. It would be sensible to select count dates when it was known no training exercises would occur, such as at weekends. However, recreational disturbance may be higher at the weekend, and so perhaps caveats should be added when disturbance is large (although there is no evidence to date that recreational disturbance presents a large problem).

Counts should ideally only take place if visibility exceeds 4 km and the sea-swell is light. Southerly winds in particular should be avoided, along with any winds greater than 15 mph. Days with clear skies and bright sunshine should also be avoided where possible. Light precipitation is acceptable, though observers should be well protected from the rain, and optical equipment should also be rain proof. If raindrops are large enough to form on the objective lens of the telescope, the counter should make note of this.

1.4.2 Survey methods

As detailed in the Procedural Guideline.

1.5 Data analysis

As detailed in the Procedural Guideline. However, it should be noted here that ground counts at Carmarthen Bay are known to underestimate the numbers of birds present as the range over which counts can be made appears to be only a part of the total occupied range recorded by aerial survey. Further discussion of this issue can be found elsewhere (Banks *et al.* 2004; Banks *et al.* in review).

1.6 Accuracy testing

As detailed in the Procedural Guideline.

1.7 QA/QC

As detailed in the Procedural Guideline.

1.8 Data products

As detailed in the Procedural Guideline.

1.9 Cost & Time

The minimum cost for a winter's fieldwork would be for four days of observer time, plus travel and expenses as required. In addition, one or two days of standby time would be a sensible provision to account for weather-related problems at short notice. Time should also be made available for data transfer from recording form to spreadsheet (one day) and analysis and reporting (time dependent upon the level of detail and supplementary information required). If a telescope, tripod and compass are not available then these need to be budgeted for (up to £1000).

1.10 Health & Safety

As detailed in the Procedural Guideline.

Standard Operating Procedure for making aerial-based assessments of numbers of offshore common scoter flocks in Carmarthen Bay

This Standard Operating Procedure should be read in conjunction with the associated Procedural Guideline. Only site-specific issues are covered below.

2.1 Background

Carmarthen Bay is perhaps the most important single site for wintering common scoters in Britain and Ireland (Banks *et al.* 2006). As is typical for the species, however, the true numbers present at any time are difficult to ascertain. Aerial count estimates (distance method) regularly exceed 10,000 birds during the winter (WWT 2003; Banks *et al.* 2004; this report) and, given that ground-based counts are often greater, the true number is thought to be towards the higher end of associated confidence limits.

The distribution of common scoters within the bay varies, but overall birds can be found throughout a band approximately 5 km wide running from the north-west of the bay off Amroth and Saundersfoot to the east off Pembrey Sands, where the seabed is at 10 m or less. During the period following the *Sea Empress* oil spill, deeper waters in the south-east of the bay (Rhossili Bay) were used by the birds to a greater extent (Cranswick *et al.* 1998).

Aerial surveys cover the whole of Carmarthen Bay SPA, and can provide an estimated population size, but also an idea of spatio-temporal distribution.

2.2 Purpose

The principal outputs of the method are an estimate of common scoter numbers wintering in Carmarthen Bay SPA on a given date, allowing assessment of Favourable Conservation Status, and spatial distribution data, allowing within- and between-year changes in areas of concentration to be plotted, whilst also permitting analysis of, for instance, spatial correlation with benthic organisms, seabed depth variables, etc. The population estimate (or a series thereof) can then be compared against pre-determined threshold values or historical counts using the same method to monitor the condition of the SPA. The count obtained, however, must be considered carefully in relation to site specific factors (tidal range, suspected areas prone to disturbance, monitoring of known ‘key’ areas) when comparing with threshold values before firm conclusions can be drawn.

Other offshore waterbird species could be surveyed at the same time. In some situations, bird behaviour could also be recorded, and although the additional demands placed on classifying this variable may sacrifice precision of the count data, it is a useful factor to include in the distance sampling procedure.

2.3 Logistics

2.3.1 Equipment

As detailed in Procedural Guideline.

2.3.2 Personnel / time

The aerial survey team should consist of a pilot (preferably with experience of wildlife survey and transect methods), a navigator (with experience of GPS and ideally the local area), where financial constraints and availability allow, and two observers, one on either side of the plane. Navigators are not required where pilots are experienced enough to navigate by on-board GPS; in such instances, the pilot announces the start and end of transects. However, a navigator is desirable to ensure accuracy of flight lines, altitude and flight speed, and to allow pilots to concentrate fully on piloting.

The method does not call for observers with highly-specialised identification skills, as the target species is not easily confused, although it is essential that some experience of aerial survey is gained before observer's counts can be considered reliable and observers should have had as much experience of aerial survey as possible. Although it may not be necessary or realistic for observers to have experienced 30 hours of flights as recommended for aerial surveys related to wind farms (Camphuysen *et al.* 2004), at least four flights (equating to 10 hours) should have been experienced to familiarize with the method and to compare counts with those from experienced observers.

Common scoters can be seen in Carmarthen Bay throughout the year but post-breeding arrivals occur first in August and then again later in the autumn. The largest numbers appear to be present from November to March, although birds start to leave the site later in March and numbers are typically low from April. Ideally, the numbers in the bay would be monitored throughout the year. However, for an assessment of peak numbers the minimum requirement would be four counts during the period November to February.

2.4 Method

2.4.1 Pre-survey considerations

Survey planes should be reserved well in advance, and the pilot should make arrangements to take off and land from the airfield nearest the target area, either Swansea or Haverfordwest: alternatively, the bay can be surveyed in one flight, routing Liverpool – Liverpool (assuming that Ravenair Liverpool are used as the aircraft provider). Any potential disturbance to the flight should be taken into account, with particular reference to airspace restrictions around RAF Pembrey. The base is operational during weekdays and survey effort may be restricted to weekends. Fifteen transects should be flown, beginning over the north west corner of the bay (*i.e.* transect 15) and moving east at 2 km intervals. It is preferable to begin here as typically large concentrations of common scoters are found here; therefore disturbance may be minimized by encountering the aircraft at the beginning of the survey. The length of each transect should vary in accordance with the southernmost boundary of the SPA to ensure it is encompassed entirely. The order of transects should be predetermined, either moving west to east or east to west and south to north or north to south. Approaches to the first transect should be made overland to avoid disturbance to the scoters present.

Survey dates should be selected in advance but may vary at short notice. If the sea-state has any more than a slight swell or if visibility is hampered through haze, fog or precipitation, postponing the survey until a day with more suitable conditions should be considered. Wind-speeds should not exceed ~15 mph, particularly if southerly, to avoid sea swell and to facilitate accurate flight lines, altitudes and speeds. Extreme cold weather should perhaps be avoided to prevent disturbance to stressed birds.

The time of day, where possible, should be selected to minimise the extent to which observations need to be made in line with the sun, and to try to coincide counts with high tides. A target number of counts should be made, and these should be spread throughout the winter to gain an impression of seasonal changes in numbers and distribution, preferably encompassing the months November - February.

2.4.2 Survey methods

As detailed in the Procedural Guideline.

The flight path taken by the aeroplane should be agreed with the pilot before take-off. Depending on in which order the transects are to be surveyed, the plane can approach from the west or east, although flying over the bay should be avoided in reaching the first transect, to avoid disturbing birds before surveying begins.

The transects recommended for aerial survey are illustrated below (Figure 1). The transects are designed to cover the entire SPA. Turns between transects, where over land, may need to be made at different altitudes. The pilot evidently assumes full control, and if he or she needs to adjust altitude to avoid cliffs, land-based wind turbines or other obstacles, this must occur, dropping to survey-level altitude when it is safe to do so.

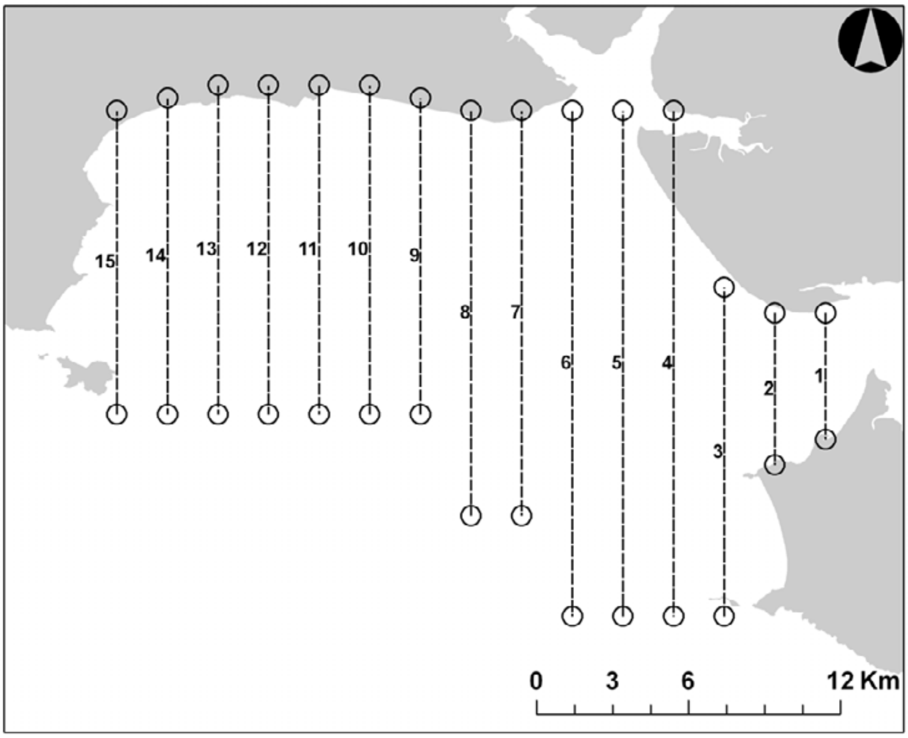

Figure A3.1 Aerial distance-method survey transects recommended for coverage of Carmarthen Bay SPA

2.5 Data analysis

As detailed in the Procedural Guideline. It should be noted here that aerial counts at Carmarthen Bay are known to underestimate the numbers of birds present as disturbance causes many birds to be missed. Further discussion of this issue can be found elsewhere in this report.

2.6 Accuracy testing

As detailed in the Procedural Guideline.

2.7 QA/QC

As detailed in the Procedural Guideline.

2.8 Data products

As detailed in the Procedural Guideline.

2.9 Cost & Time

As detailed in the Procedural Guideline.

2.10 Health & Safety

As detailed in the Procedural Guideline.

References

Banks, A.N., Bolt, D., Bullock, I., Haycock, B., Musgrove, A., Newson, S., Fairney, N., Sanderson, W., Schofield, R., Smith, L., Taylor, R. & Whitehead, S. 2004. Ground and aerial monitoring protocols for in shore Special Protection Areas: Common Scoter in Carmarthen Bay 2002-04. CCW Marine Monitoring Report No: 11, 138pp. CCW: Bangor.

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Stewart, B., Hughes, B., Bullock, I. & Haycock, R. (1997). *Common Scoter* Melanitta nigra *monitoring in Carmarthen Bay following the* Sea Empress *oil spill.* WWT Wetlands Advisory Service report to CCW.

APPENDIX 4: MOULTING COMMON SCOTERS IN CARMARTHEN BAY

Abstract

It has been suggested that Carmarthen Bay, designated as a marine Special Protection Area (SPA) on the numbers of wintering common scoters *Melanitta nigra*, may also prove to be important for the same species during the moulting period (typically August to September). As such, we undertook a combined aerial and ground survey of the area in September 2005 to examine the hypothesis. Results suggested that there were relatively few common scoters within the bay on that day. Although this may reflect a more general lack of use during this phase of the annual cycle, it is also possible that temporal and spatial variations in site use may have led to our low totals.

1. Method

Land-based counts were made between 0600 and 1230 on Saturday 3rd September 2005. Counts were carried out from four count stations along the coast. These were Pembrey sand dunes (British Grid co-ordinates 241500, 199190 – 9 m Above Sea Level), Dolwen Point near Pendine (223310, 207840 – 25 m ASL), Merrifields, Amroth (217900, 207350 – 48 m ASL) and Kitchen Corner, Rhossili (240350, 187500 – 50 m ASL). Counts were made by an extremely experienced observer using high quality optics. At the beginning of the counts, the tide was high, falling during the morning.

An aerial survey took place on the same day as ground counts, between 1145 and 1330. This survey was timed so that the area over which the plane passed had already been surveyed from the ground, thus avoiding ground counts being disturbed. The plane flew at an altitude of 76 m (250 ft). The speed of the plane was approximately 185 kmh^{-1} (51 ms^{-1}). The position of the plane during the flight was recorded using a GPS. Two observers allocated all counts to 'distance bands', thus allowing post hoc statistical estimation of the number of birds likely to have been missed during counts. For fuller explanation of the application of 'distance sampling' to this type of data, see Banks *et al.* (2004).

2. Results

2.1 Ground-based counts

The number of common scoter recorded from the ground was exceptionally low (Table 1). Given that peak counts in the wintering period typically reach in the order of 16,000 birds, the grand total of 75 was comparatively very small. It is possible that disturbance recorded may have led to some birds moving further offshore, but it is notable that at Amroth, where no disturbance was recorded, no birds were also recorded. In the winter, this site alone can hold upwards of 6,000 scoters (Banks *et al.* 2004).

Table A4.1 Ground counts of Carmarthen Bay 3/9/05

Site	Common scoter	Behaviour	Disturbance
Amroth	1	Loafing	None
Pembrey	74	Loafing	Single jetski and fishing boat
Pendine	0		Fishing boats 1 km from shore
Rhosilli	0		None

2.2 Aerial surveys

Raw counts, presented in Table A4.2, were low, reflecting ground-based survey results. Starboard and Port refer to sides of the aircraft on which counters were positioned.

Table A4. 2 Aerial counts of Carmarthen Bay 03/09/05.

	Common scoter
Starboard	205
Port	289
Total	494

After distance sampling, estimates of common scoters increased to 1,870, with confidence limits of 925 and 3,781.

Table A4.3 Distance estimates of common scoter 03/0905

Date	DS	95% CIs	E(s)	95% CIs	D	95% CIs	N	95% CIs
03/09/2005	0.60	(0.31 - 1.16)	8.35	(6.05 - 11.51)	5.01	(2.48 - 10.14)	1,870	(925 – 3,781)

Distributional data presented in Figure A4.1 show the location of all common scoter recorded, with adjustment away from the transect line according to the distance band the birds were assigned to. The distribution was similar to that seen during the winter, although the typically large flocks seen in the north west corner of the bay were absent.

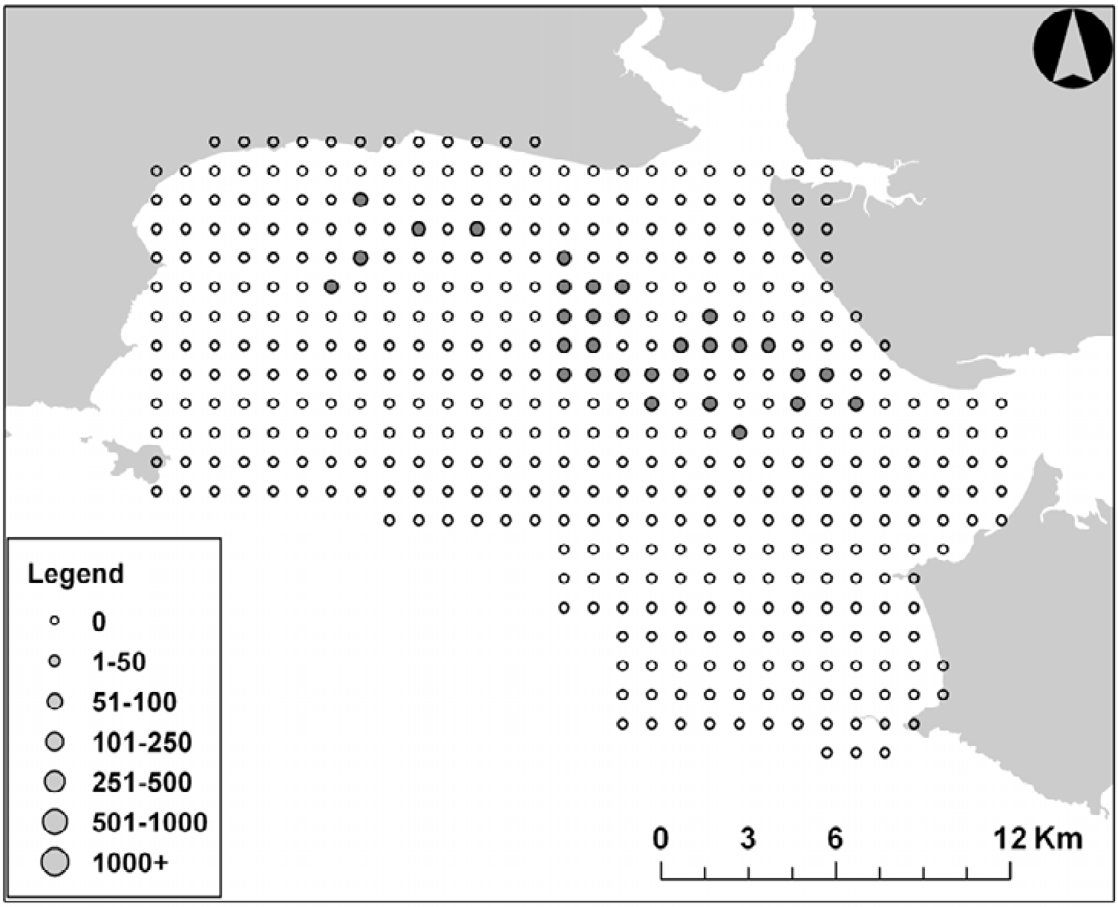

Figure A4.1 Relative distribution of common scoters within Carmarthen Bay, 03/09/05.

3. Conclusions

Both aerial and ground surveys detected comparatively few common scoters within Carmarthen Bay at the time of survey. Even allowing for an increase in numbers from distance correction, the totals of birds recorded are fractional in relation to the numbers present during winter (*e.g.* Banks *et al.* 2004), although the distribution of birds that were present appeared similar to a typical wintering distribution.

The numerical results from ground surveys are at odds with those found in some previous years. For instance, ground counts in 1997 were as high as 1,549 in late August, although by the end of the first week of September, numbers were as low as 535 (Cranswick *et al*. 1998). In terms of distribution, the same authors cited the area "off Pembrey" as important, and this would seem to be supported from our survey.

It should not necessarily be concluded that Carmarthen Bay is no longer of importance to common scoter during the moult cycle. It is possible that there are movements between Carmarthen Bay and other sites in South Wales, although evidently these will be limited by the birds' flightless state. Also, it may be that there is weak site fidelity to moulting sites and that some sites may be favoured in some years but not others. Finally, it is perhaps more likely that the surveys conducted in September happened to coincide with a period when few birds were within the bay, and that performing the surveys a few weeks earlier could have produced different results. Peak numbers of birds during the moulting period were recorded on the 18th August 1997 by Cranswick *et al*. (1998).

References

Banks, A., Bolt, D., Bullock, I., Haycock, B., Musgrove, A., Newson, S., Fairney, N., Sanderson, W., Schofield, R., Smith, L., Taylor R., & S. Whitehead (2005). Ground and aerial monitoring protocols for in shore Special Protection Areas: *Common Scoter in Carmarthen Bay 2002-04*. CCW Marine Monitoring Report No: 11, 89pp.

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APPENDIX 5: ADDITIONAL SPECIES RECORDED ON AERIAL SURVEYS

It should be noted that other species (particularly gulls) were only counted where this did not interfere with counting common scoters. It should also be noted that most cetaceans seen were assumed to be Harbour Porpoise; few aerial surveyors had more than cursory experience of cetacean identification, however.

Species such as Dark-bellied Brent Goose, Shelduck, Cormorant, Shag, Oystercatcher and Curlew were recorded on substrate (sand and mud) bordering the water.

Relatively large numbers of Red-throated Diver recorded in February 2005, November 2005 and January 2006 is potentially of interest.

Table A5.1 Summary of species, other than common scoter, recorded on winter aerial surveys 2004/05 – 2006/07.

Species	Scientific name	Feb-05	Nov-05	Dec-05	Jan-06	Feb-06	Nov-06	Dec-06	Jan-07	Feb-07
Birds										
Dark-bellied brent goose	*Branta bernicla*						4			4
Common shelduck	*Tadorna tadorna*			3						
Common eider	*Somateria mollissima*		2	4		6			3	
Velvet scoter	*Melanitta fusca*	5		1	4		7	1	1	7
Red-breasted merganser	*Mergus serrator*	2	4							
Black-throated diver	*Gavia arctica*					1				
Red-throated diver	*Gavia stellata*	43	33	5	20	4	1	6	11	10
Great crested grebe	*Podiceps cristatus*					4				1
Northern fulmar	*Fulmarus glacialis*						7			1
Great cormorant	*Phalacrocorax carbo*	5	11	12	3	7	3		1	48
European shag	*Phalacrocorax aristotelis*	2		7	1				2	2
Eurasian oystercatcher	*Haematopus ostralegus*	700		120			6			230
Northern lapwing	*Vanellus vanellus*									15
Eurasian curlew	*Numenius arquata*									30
Black-headed gull	*Larus ridibundus*						6			4
Lesser black-backed gull	*Larus fuscus*		1	1			1			12

Species	Scientific name	Feb-05	Nov-05	Dec-05	Jan-06	Feb-06	Nov-06	Dec-06	Jan-07	Feb-07
Herring gull	*Larus argentatus*		6	1			25			3
Great black-backed gull	*Larus marinus*		1	1			3		1	1
Black-legged kittiwake	*Rissa tridactyla*		1	2						43
Guillemot	*Uria aalge*	99	301	5		13	50		3	
Razorbill	*Alca torda*	2	17							
Unidentified diver				1				1	6	4
Unidentified small wader							5			
Unidentified gull			1	23	50		125	1	80	1,135
Unidentified large gull				25			9	5	6	35
Unidentified small gull							35	8	5	533
Unidentified auk		45	51	39	63	20	62	39	75	22
Mammals										
Harbour porpoise	*Phocoena phocoena*	1	14	18	5	3		2		
Unidentified cetacean										3
Unidentified dolphin										4
Unidentified seal										1

APPENDIX 6: DATA ARCHIVE APPENDIX

The report and data collected under CCW contract FC 73-02-316 is archived as Media xxxx and is stored in fire-proof storage facilities at CCW headquarters on optical media. This archive is also maintained on backed-up server based storage at CCW headquarters.

The data archive for this project builds on earlier studies of Common Scoter usage of Carmarthen Bay, in particular data collected using the Census and Ground based methodologies in survey seasons 1998 - 2004. Data from these studies is archived as Media 219 & 221 and is also maintained on backed-up server based storage at CCW headquarters.

The data archive consists of:

[A] Digital versions of the contract report: Microsoft Word document(s); and an equivalent Adobe Portable Document Format version:

[B] Data (counts, meteorological and sea state) from the ground based methodological studies is incorporated into the tables and text of the report itself, as detailed in the table below.

	Bird count data	**Meteorological**	**Sea state**
Multi-observer counts	Tables 3.1 to 3.4 (pages 12 to 16)	Tables 3.1 to 3.3 (pages 12 to 15)	Tables 3.1 to 3.3 (pages 12 to 15)
Tidal studies	Tables 3.5 to 3.7 (page 24) and in text section 3.1.2.2 (page 23)	Tables 3.5 to 3.7 (page 24) and in text section 3.1.2.2 (page 23)	Tables 3.5 to 3.7 (page 24) and in text section 3.1.2.2 (page 23)
Behaviour studies	Tables 3.8 & 3.9 (page 29)	Tables 3.8 & 3.9 (page 29)	Not recorded

[C] Data on the incidental sighting of other species observed during aerial surveys is incorporated into the tables and text of the report itself as Tables A5.1 on pages 77 & 78. N.B. locational data relating to the distribution of these incidental sightings was not recorded, i.e. only the date and number of individuals observed is noted.

[D] A series of Microsoft Excel spreadsheets:

- ***air20050226.xls; air20050903.xls; air20051112.xls; air20051210.xls; air20060107.xls; air20060204.xls; air20061118.xls; air20061216.xls; air20070127.xls; air20070217.xls***: contain information on the number and distribution of Common Scoter counted during aerial surveys in the survey seasons 2004/05 – 2006/07. In total data from ten surveys are present. Data are tagged against a derived position based on aircraft position and distance and direction estimates. The transect, recorder, recorder's position in aircraft, distance band and time of observation for each sighting are also recorded alongside the number of Common Scoter observed.

- ***air20050226.csv; air20050903.csv; air20051112.csv; air20051210.csv; air20060107.csv; air20060204.csv; air20061118.csv; air20061216.csv; air20070127.csv; air20070217.csv:*** contain information on the number and distribution of Common Scoter, plus other animals, counted during aerial surveys in the survey seasons 2004/05 – 2006/07. In total data from ten surveys are present. Data are tagged against a derived position based on aircraft position and distance and direction estimates. The transect, recorder, recorder's position in aircraft, distance band and time of observation for each sighting are also recorded alongside the number of Common Scoter observed.

- ***IndividualVantagePointCounts04_07.csv***: contains information on ground-based surveys from up to four count stations around Carmarthen Bay in the survey seasons 2004/05 – 2006/07. Date, time and observer are recorded as well as number of Common Scoter observed.

- ***SiteEstimates04_07.csv***: summed Common Scoter counts for the whole of Carmarthen Bay 2004/05 – 2006/07. Date and time of count are recorded with estimate of bird numbers.

- ***ground20050209.xls; ground20050225.xls; ground20050326.xls; ground20051113.xls; ground20051217.xls; ground20060108.xls; ground20060211.xls; ground20061104.xls; ground20061216.xls; ground20070127.xls; ground20070217.xls:*** contain additional data from ground-based surveys 2004/05 – 2006/07, including information on weather and disturbance.

[E] A series of MapInfo GIS layers in MapInfo Native format (Tables):

- ***air20050226; air20050903; air20051112; air20051210; air20060107; air20060204; air20061118; air20061216; air20070127; air20070217:*** equivalent data to those held in the .xls files for the 2004/05 and 2006/07 survey seasons. Records are tagged to point spatial objects as well as those attributes identified above.
- ***Siteestimates04_07:*** aggregated data for aerial surveys 2004/05 – 2006/07; data tagged to spatial polygon object.
- ***flight20050226; flight20050903; flight20051112; flight20051210; flight20060107; flight20060204; flight20061118; flight20061216; flight20070127; flight20070217:*** A series of layers recording the flight path taken during each of the ten aerial survey events. These record: the aircraft location in metres east and north of the origin of the British National Grid, the date and the time of each location.
- ***ground20050209; ground20050224; ground20050325; ground20050903; ground20051113; ground20051217; ground20060108; ground20060211; ground20061104; ground20061216; ground20070127; ground20070217:*** equivalent data to those held in the .xls files for the 2004/05 and 2006/07 survey seasons. Records are tagged to point spatial objects as well as those attributes identified above.
- ***ground04_07:*** aggregated data for aerial surveys 2004/05 – 2006/07; data tagged to spatial polygon object.
- ***ground0405[inclrhossili]:*** aggregated data for aerial surveys 2004/05 with inclusion of count station at Rhossilli; data tagged to spatial polygon object.

Translations from the above MapInfo Tables are retained in ESRI Shapefile and MapInfo Interchange formats.

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