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Ground And Aerial Monitoring Protocols For In Shore Special Protection Areas

Alex Banks, Dean Bolt, Ian Bullock, Bob Haycock, Andy Musgrove, Stuart Newson, Nigel Fairney, Bill Sanderson, Richard Schofield, Lucy Smith, Rob Taylor & Siân Whitehead

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Marine Monitoring Project: Ground And Aerial Monitoring Protocols For In Shore Special Protection Areas: Extension.

Common Scoter Surveys in Carmarthen Bay During the Winters of 2002-03 and 2003-04

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EXECUTIVE SUMMARY

- During the winters of 2002-03 and 2003-04, a series of ground and aerial counts of Common Scoters *Melanitta nigra* was undertaken in Carmarthen Bay, South Wales, to continue to develop a monitoring programme and investigating methodological and interpretative issues arising from counts. The ultimate aims were to express targets for Common Scoter numbers and to formulate guidelines for accurate monitoring of scoters wintering in the Carmarthen Bay SPA, to establish and subsequently assess Favourable Conservation Status.

- Ground-based monitoring counts from three vantage points were carried out on four days in 2002-03, and seven days in 2003-04. Further ground-based counts to investigate methodological issues were carried out on another eight days in the first winter and ten days in the second. Eight aerial surveys of the bay were undertaken in the first winter, four each using two separate methods, hereafter described as the ‘census-method’ (birds assigned to 2 x 1 km grid cells) and the ‘distance-method’ (designed to account for missed birds using distance sampling protocols). In the second field season, five distance-method flights and four census-method flights were carried out.

Ground Counts: Monitoring

- The numbers of Common Scoters recorded during the four ground-based monitoring counts in 2002-03 were 16,203 (29/11/02), 23,288 (23/1/03), 19,925 (6/3/03) and 5,678 (31/3/03). Numbers recorded during 2003-04 were 6,853 (27/10/03), 14,427 (27/11/03), 15,446 (30/12/03) and 14,301 (28/02/04).

- Ground counts did not cover the whole of the bay and it is likely that the true peak numbers present in the bay were substantially higher than the peak ground counts of 23,288 and 15,446 in 2002-03 and 2003-04 respectively.

Ground Counts: Methodological Studies

- Ground-based counts were undertaken to investigate the effect of thoroughness on the numbers of scoters counted. The numbers depended very strongly on the time taken by the counter and counts from Carmarthen Bay count stations should take at least an hour, otherwise birds are likely to be overlooked. Counts of two hours often produced increased counts, although this was not always consistent, especially when numbers were low.

- Ground-based counts were undertaken to investigate the effect of the tide on the apparent distribution of scoters, but detected no clear effect in either winter. Peak counts were recorded at high tide for half of the overall surveys performed.

- A simultaneous count by two observers suggested that inter-observer variability in the first winter was potentially high, although it was not possible to test this rigorously. However, other data suggested that intra-observer variation in counting was low. More controlled studies of inter-observer variability in the second winter showed that counts by different observers were often no more than 13% different, although occasionally could differ by as much as 47%. Experience seemed to be a factor in intra- and inter-observer variation, though accomplished surveyors with no specific experience of Common Scoter monitoring could make similar estimates to an expert.

- Anecdotal observations collected during the study confirmed that counts should only be attempted with a light swell at most and that strong sun-glare and other conditions of poor visibility should be avoided. The heavier the swell or poorer the visibility, the longer the time

allowed for the count should be. Wind-speeds should not exceed about 20 mph; additionally, southerly winds may create worse sea conditions than northerly winds.

- Ground counts may be suitable to base an index upon, although the whole of the population within the SPA will not be covered by this method. The 'key' part of the population, foraging on traditional feeding grounds, would likely be monitored.

Aerial Surveys

- The numbers of Common Scoters recorded during the 2002-03 census-method aerial surveys were 8,835 (4/1/03), 10,309 (5/1/03), 7,956 (15/3/03) and 7,572 (16/3/03). To allow for a non-visible area underneath the plane, these counts could be scaled up to estimates of 10,779, 12,577, 9,706 and 9,238, respectively. In 2003-04, Common Scoter numbers totalled 20,271 (25/1/04), 5,234 (28/2/04a), 5,024 (28/2/04b) and 5,431 (27/3/04). These figures could be scaled to 24,731, 6,385, 6,129 and 6,626.

- The estimates derived from the distance-method aerial surveys (with 95% confidence intervals) were 19,909 (10,803-36,390) on 1/12/02, 15,417 (7,840-30,317) on 4/1/03, 13,337 (7,846-22,672) on 15/3/03 and 9,819 (6,071-15,881) on 16/3/03. The same method in the second winter produced estimates of 4,944 (3,097-7,860) on 11/10/03, 11,097 (7,267-16,944) on 23/11/03, 17,999 (11,665-27,774) on 25/1/04, 2,336 (1,550-3,519) on 29/2/04 and 15,086 (8,977-25,353) on 27/3/04. It is proposed that a refined distance analysis should be carried out in the future, although early indications are that additional covariates do not improve the accuracy of the estimates.

- Ground observations confirmed that the aerial survey plane flushed a large proportion of scoters from areas offshore, with a 'trigger effect' disturbing those close to the shore. Moreover, the effect was prolonged with large proportions of birds not returning after the plane left. More than half of the scoters noted during the first winter aerial surveys were detected in flight as opposed to on the surface of the sea. The proportion in flight was higher for the distance-method flights than the census-method flights, perhaps due to the lower altitude of the former. In the second winter, roughly equal numbers of scoters were recorded flying and sitting on the water during aerial surveys (distance-method only).

- One of the suggested advantages of the distance-method over the census-method is that the latter is more likely to involve double-counting of birds between transects. The results suggested that far from inflating the estimate the census-method actually suggested fewer birds than the distance-method in the first winter. However, in the second winter, the opposite was usually the case, apparently because of relatively low point estimates. Therefore the ability of the census-method to detect all birds seems inconsistent, and the respective accuracies of the two surveys would appear to fluctuate.

- Neither aerial survey method accounts for scoters diving upon the approach of the plane. This would appear to be a natural response for a sea duck encountering a perceived threat and some birds are likely missed in this manner by aerial surveys, although ground observers did not commonly record this behaviour. Additionally, neither method accounts for birds that fly well in advance of the arrival of the plane. This is known to occur and mass movement of birds is likely to be the single largest problem in combining ground and aerial counts to derive an overall estimate for the bay. It was not possible to use the aerial counts to describe the decline in detectability by ground counts over distance due to this issue.

- Of the two aerial methods, the distance-method would appear to have most advantages, particularly as it is fast becoming the standard for aerial survey of seabirds, and thus would lead to comparability of results with surveys from other parts of the country. Aerial surveys do not count all birds within the SPA, but do provide useful information on spatio-temporal distribution.

Conclusions

- None of the methods, in isolation or in combination, has yet been able to provide a reliable estimate of the true number of Common Scoters using Carmarthen Bay. Provisional targets for assessing Favourable Conservation Status are proposed, and some rudimentary indices are presented, but future information is required before these targets can be considered wholly reliable.

- Draft Procedural Guidelines for general aerial and ground-based surveying, and Standard Operating Procedures for the same methods in Carmarthen Bay, are presented.

SUMMARY OF RECOMMENDATIONS

- Ground-based counting to continue to monitor ‘key’ proportion of population.
  - Four counts through the winter (November – February) suggested
  - Sea state, cloud cover and optical equipment should all be considered
  - Counts should preferably occur on a high tide and should take 1 – 2 hours

- Distance-method aerial flights necessary to check changes in distribution within the bay
  - Four counts through the winter (November – February) suggested
  - Potential problems to be resolved, but using the method allows comparability with other surveys, as the method is becoming increasingly widespread
  - Disturbance means that the whole population cannot be considered counted

CRYNODEB GWEITHREDOL

- Yn ystod gaeafau 2002-03 a 2003-04 aethpwyd ati ym Mae Caerfyrddin yn Ne Cymru i wneud cyfres o gyfrifau o'r tir ac o'r awyr o'r Fôr-Hwyaden Ddu *Melanitta nigra* fel y gellid parhau i ddatblygu rhaglen fonitro fyddai'n ymchwilio i faterion methodolegol a deongliadol oedd yn codi o'r cyfrifau. Y nod yn y pen draw oedd nodi targedau ar gyfer niferoedd y Fôr-Hwyaden Ddu a llunio canllawiau ar gyfer monitro'n gywir y Môr-Hwyaid Duon oedd yn gaeafu ym Mae Caerfyrddin ACA fel y gellid sefydlu a maes o law asesu Statws Cadwraeth Ffafriol.

- Cafodd cyfrifau monitro eu gwneud o'r tir o dri man ffafriol yn ystod pedwar diwrnod yn ystod 2002-03 a saith diwrnod yn ystod 2003-04. Cafodd cyfrifau pellach eu gwneud o'r tir ar wyth diwrnod arall yn ystod y gaeaf cyntaf a deg yn ystod yr ail gaeaf er mwyn ymchwilio i faterion methodolegol. Cafodd wyth arolwg o'r awyr o'r bae eu gwneud yn ystod y gaeaf cyntaf, pedwar yr un gan ddefnyddio dau ddull ar wahan fydd yn cael eu disgrifio o hyn allan fel y 'dull cyfrifiad' (adar wedi'u neilltuo i gelloedd grid 2 x 1 cm) a'r 'dull pellter' (wedi'i gynllunio i roi cyfrif am adar y methwyd eu gweld ac yn defnyddio protocolau samplu 'distance'). Yn ystod yr ail dymor maes, cafodd pum hediad dull pellter a phedwar hediad dull cyfrifiad eu gwneud.

Cyfrifau o'r Tir: Monitro

- Dyma'r niferoedd o Fôr-Hwyaid Duon gafodd eu cofnodi yn ystod y pedwar cyfrif monitro o'r tir: 16,203 (29/11/02), 23, 288 (23/1/03), 19,925 (6/3/03) a 5,678 (31/3/03). Dyma'r niferoedd gofnodwyd yn ystod 2003-04: 6,853 (27/10/03), 14,427 (27/11/03) 15,446 (30/12/03) a 14,301 (28/02/04).

- Nid oedd y cyfrifau o'r tir yn ymdrin â'r bae cyfan ac mae'n debygol fod y niferoedd uchaf yn y bae mewn gwirionedd lawer yn uwch na'r cyfrifau uchaf o'r tir, sef 23,288 a 15,446 yn 2002-03 a 2003-04 yn y drefn yna.

Cyfrifau o'r tir: Astudiaethau Methodolegol

- Cafodd cyfrifau o'r tir eu gwneud er mwyn ymchwilio effaith trylwyredd ar niferoedd y môr-hwyaid duon gafodd eu cyfrif. Roedd y niferoedd yn dibynnu'n drwm iawn ar yr amser roedd y sawl oedd yn cyfrif yn ei gymryd a dylai cyfrifon o orsafoedd cyfrif Bae Caerfyrddin gymryd o leiaf awr neu fel arall mae'n debygol na fydd pob aderyn yn cael ei weld a'i gyfrif. Roedd cyfrifau o ddwyawr yn aml yn arwain at gyfrifau uwch er nad oedd hyn bob amser yn gyson yn enwedig pan fo niferoedd yn isel.

- Cafodd cyfrifau o'r tir eu gwneud i weld beth oedd effaith y llanw ar ddosbarthiad ymddangosiadol y môr-hwyaid duon ond ni welwyd effaith amlwg yn ystod yr un o'r ddau aeaf. Yn achos hanner yr holl arolygon a wnaethpwyd cafodd y cyfrifau uchaf eu cofnodi ar lanw uchel.

- Roedd cyfrif gafodd ei wneud yr un pryd gan ddau wyliwr yn awgrymu fod cryn amrywiaeth rhwng gwylwyr yn arbennig yn ystod y gaeaf cyntaf er nad oedd yn bosib rhoi prawf llym ar hyn. Roedd data arall, fodd bynnag, yn awgrymu fod amrywiaeth rhwng gwylwyr wrth gyfrif yn isel. Roedd astudiaethau mwy tynn o'r amryiaeth rhwng un gwyliwr a'r llall yn ystod yr ail aeaf yn dangos nad oedd cyfrifau gan wahanol wylwyr yn aml yn amrywio mwy na 13% er bod y gwahaniaeth ar adegau yn gallu bod cymaint â 47%. Roedd profiad i'w weld yn ffactor yn yr amrywiaeth yn y cyfrifau gan wyliwr a rhwng gwylwyr er y gallai arolygwyr profiadol iawn heb unrhyw brofiad penodol o'r fôr-hwyaden ddu wneud amcangyfrifon tebyg i rai arbenigwr.

- Roedd arolygon ancedotaidd a gasglwyd yn ystod yr astudiaeth yn cadarnhau na ddylid ceisio gwneud cyfrif ond pan oedd ar y gorau ymchwydd ysgafn a dylid osgoi golau llachar yr haul ac amgylchiadau eraill lle roedd hi'n anodd gweld yn glir. Po fwyaf yr ymchwydd neu po anodda oedd hi i weld, hwyaf yn y byd o amser ddylid ei ganiatau i wneud y cyfrif. Ni ddylai cyflymder y gwynt fod yn fwy na thua 20mya; dylid nodi hefyd y gallai gwyntoedd o'r de greu gwaeth amgylchiadau ar y môr na gwyntoedd gogleddol.

- Gallai cyfrifau o'r tir fod yn addas ar gyfer sylfaenu indecs arnynt, er na fydd yr holl boblogaeth o fewn yr ACA yn cael ei chynnwys wrth ddefnyddio'r dull yma. Byddai rhan 'allweddol' y boblogaeth oedd yn chwilota yn y lleoedd bwydo traddodiadol yn debygol o gael eu monitro.

Arolygon o'r Awyr

- Dyma'r niferoedd o Fôr-Hwyid Duon gafodd eu cofnodi yn ystod arolygon cyfrifiad o'r awyr 2002-03; 8,835 (4/1/03), 10,309 (5/1/03), 7,956 (15/3/03) a 7,572 (16/3/03). Er mwyn caniatau am y man o dan yr awyren lle y mae'n amhosibl gweld, gallai'r cyfrifau yma gael eu codi i amcangyfrifon o 10,779, 12,577, 9,706 a 9,238 yn y drefn yna. Yn ystod 2003-04 roedd niferoedd y Môr-Hwyaid Duon yn gyfanswm o: 20,271 (25/1/04), 5,234 (28/2/04a) 5,024 (28/2/04b) ac yn 5,431 (27/3/04). Gallai'r ffigyrau yma gael eu codi i 24,731, 6,385, 6,129 a 6,626.

- Dyma'r amcangyfrifon a gafwyd o'r arolygon o'r awyr oedd yn defnyddio'r dull pellter (gyda 95% o bellter hyder): 19,909 (10,803-36,390) ar 1/12/02, 15,417 (7,840-30,317)ar 4/1/03, 13,337 (7,846-22,672) ar 15/3/03 a 9,819 (6,071 –15,881) ar 16/3/03. Bu i'r un dull yn ystod yr ail aeaf roi'r amcangyfrifon canlynol: 4,944 (3,097-7,860) ar 11/10/03, 11,097 (7,267-16,944) ar 23/11/03, 17,999 (11,665-27,774) ar 25/1/04, 2,336 (1,550-3,519) ar 19/2/04 a 15,086(8,977-25,353) ar 27/3/04. Argymhellir y dylid gwneud dadansoddiad pellter gwell yn y dyfodol er mae'n ymddangos yn y dyddiau cynnar yma nad yw cydamrywiaethau ychwanegol yn gwella cywirdeb yr amcangyfrifon.

- Roedd arsylwadau o'r tir yn cadarnhau fod yr awyren oedd yn gwneud arolygon o'r awyr wedi codi canran uchel o'r môr-hwyaid duon o ardaloedd o'r môr gan amharu wedyn ar y rhai oedd yn agos at y lan. Ar ben hynny, roedd yr effaith yn para'n hir gyda chanrannu uchel o'r adar yn peidio dychwelyd wedi i'r awyren adael. Cafodd dros hanner y môr-hwyaid duon gafodd eu gweld yn ystod arolygon o'r awyr yn ystod y gaeafau cyntaf eu gweld yn hedfan o'i gymharu ag ar wyneb y môr. Roedd y garfan oedd yn hedfan yn uwch ar gyfer yr hediadau dull pellter nag ar gyfer yr hediadau dull cyfrifiad a hynny efallai oherwydd fod yna lai o uchder. Yn ystod yr ail aeaf pan wnaethpwyd arolygon o'r awyr (dull pellter yn unig) cafodd tua'r un nifer o fôr-hwyaid duon eu cofnodi yn hedfan ag a gafodd yn eistedd ar y dŵr.

- Awgrymir mai un o fanteision y dull pellter o'i gymharu â'r dull cyfrifiad yw fod yr ail ddull yn fwy tebyg o olygu cyfrif yr adar ddwyaith rhwng trawsluniau. Roedd y canlyniadau yn awgrymu fod y dull cyfrifiad, yn hytrach na chynyddu'r amcangyfrif, mewn gwirionedd yn awgrymu llai o adar na'r dull pellter yn ystod y gaeaf cyntaf. Yn ystod yr ail aeaf fodd bynnag roedd y gwrthwyneb yn wir, fel arfer yn ôl pob golwg oherwydd amcangyfrifon cymharol isel. Mae gallu'r dull cyfrifiad i wled pob aderyn yn ymddangos felly yn anghyson ac mae'n edrych yn debyg fod cywirdeb y ddwy arolwg yn amrywio.

- Nid yw'r un o'r ddwy arolwg o'r awyr ar gyfer y fôr-hwyaden ddu yn rhoi cyfrif am y môr hwyaid oedd yn plymio pan oedd yr awyren yn agosau. Byddai hyn yn ymddangos yn ymateb naturiol i hwyaden fôr fyddai'n dod wyneb yn wyneb â'r hyn fyddai'n edrych fel bygythiad ac mae'n bosibl colli rhai adar trwy wneud arolygon fel hyn o'r awyr, er nid oedd gwylwyr o'r tir fel arfer yn cofnodi ymddygiad o'r fath. Ar ben hyn, nid yw'r un o'r ddau ddull yn rhoi cyfrif am yr adar sydd yn hedfan ymaith ymhell cyn i'r awyren gyrraedd. Gwyddir fod hyn yn digwydd ac mae hediad anferth adar yn debygol o fod y broblem unigol fwyaf wrth gyfuno cyfrifau o'r tir ac o'r awyr er mwyn cael amcangyfrif cyffredinol ar gyfer y bae. Nid oedd yn bosibl defnyddio'r cyfrifau o'r awyr i ddisgrifio'r lleihad mewn detgaladwyedd gan gyfrifau o'r tir dros bellter oherwydd y broblem yma.

- O'r ddau ddull o'r awyr, y dull pellter fyddai i'w weld â'r manteision mwyaf, yn enwedig gan ei fod yn brysur ddod y dull safonol o wneud arolwg o adar môr o'r awyr a byddai felly yn arwain at gymharedd canlyniadau gyda'r arolygon o rannau eraill o'r wlad. Nid yw cyfrifau o'r awyr yn cyfrif yr holl adar o fewn yr ACA ond maent yn darparu gwybodaeth ddefnyddiol ar ddosbarthiad gofodol-amserol.

Casgliadau

- Nid yw'r un o'r dulliau yma ar ei ben ei hun neu mewn cyfuniad â dull arall hyd yma wedi gallu darparu amcangyfrif dibynadwy o'r gwir niferoedd o Fôr-Hwyaid Duon sydd yn defnyddio Bae Caerfyrddin. Mae targedau dros dro ar gyfer asesu Statws Cadwraeth Ffafriol yn cael eu hawgrymu a chyflwynir rhai indecsau dechreuol ond mae angen mwy o wybodaeth yn y dyfodol cyn y gellir ystyried y targedau hyn yn rhai hollol dibynadwy.

- Cyflwynir Canllawiau Drafft ar gyfer gwneud arolwg cyffredinol o'r awyr ac o'r tir a chyflwynir Canllawiau Gweithredu Safonol ar gyfer y dulliau yma ym Mae Caerfyrddin.

CRYNODEB O'R ARGYMHELLION

- Cyfrif o'r tir i barhau i fonitro canrannau 'allweddol' o'r boblogaeth.
  - Awgrymir pedwar cyfrif trwy'r gaeaf (Tachwedd-Chwefror)
  - Cyflwr y môr, pa mor gymylog ydyw a'r offer gweledol i gyd i gael eu hystyried.
  - Dylai cyfrifau ddigwydd os yn bosibl pan fo'r llanw'n uchel a dylai gymryd rhwng 1-2 awr

- Hediadu o'r awyr dull pellter yn angenrheidiol i weld a oes newidiadau mewn dosbarthiad o fewn y bae
  - Awgrymir pedwar cyfrif trwy'r gaeaf (Tachwedd – Chwefror)
  - Problemau posibl i gael eu datrys, ond mae defnyddio'r dull yn caniatau gwneud cymhareb gydag arolygon eraill gan fod y dull yn cael ei ddefnyddio fwyfwy
  - Mae ymyrraeth yn golygu na ellir ystyried fod y boblogaeth gyfan wedi cael ei chyfrif

1. INTRODUCTION

1.1 Common Scoters and Carmarthen Bay

The Common Scoter *Melanitta nigra* is a priority species in the UK Biodiversity Action Plan. Recent aerial and ground-based surveys (*e.g.* L.Smith unpublished, Webb *et al*. 2003, WWT 2003) have confirmed Carmarthen Bay to be one of the most important wintering grounds in the UK and this has led to the bay qualifying for classification as the UK's first marine Special Protection Area (SPA), through regularly supporting more than 1% of the biogeographic population. Such a classification results in an obligation to monitor birds using the bay to determine whether the "favourable conservation status" of the scoters within the SPA is being achieved.

A component of this monitoring is the enumeration either of an absolute population size of Common Scoter or, from sampling, obtaining a reliable estimate or index of this population. However, there remains uncertainty about both the most accurate and most cost-effective methods for monitoring inshore sea ducks. Ground-based surveys are relatively inexpensive, but suffer from limitations on the distance from the shore over which birds can be counted, the technical difficulty of assigning birds to distances from the land and the uncertainty over variation in survey efficiency with weather conditions. In addition, there are only a limited number of suitable vantage points around Carmarthen Bay, and it can be time consuming to visit all count stations. Aerial survey is relatively expensive, but suffers less from the aforementioned limitations. It is also possible to cover the whole bay much more rapidly. There is, however, a pay-off between the desire to count all birds and so gain an absolute population estimate and the amount of disturbance this causes to scoters, which potentially results in double-counting or missed birds. Recent experience in Denmark (Kahlert *et al.* 2000) suggests that lower flights and more widely spaced transects, designed to account for the distance over which scoter fly in response to disturbance from the survey plane, result in a more accurately mapped and counted distribution of a sample of the population. However, this introduces the problem of extrapolation from the sample to the actual population.

The purpose of this project is to maintain a programme of monitoring of Common Scoters at Carmarthen Bay but also to develop the methodology and interpretation of the fieldwork, in order to lead to generic Procedural Guidelines and site-specific Standard Operating Procedures for the monitoring of the species.

1.2 Previous Monitoring

Information on the use of Carmarthen Bay by Common Scoters was relatively sketchy until recent years. Stewart (1995) summarised the historical records, finding little information before the 1970s except that "large numbers" were already clearly recognised. More detailed counts in the 1970s included a peak of 25,000 recorded from a boat between Pendine and Rhossili in March 1974, although the level of precision of this count was not stated. Most other counts in the 1970s, including all of a series of aerial counts made between 1975 and 1977, recorded totals of less than 10,000 scoters. Stewart found no records between 1978 and 1992, after which time more frequent counts were listed, although often only from parts of the bay. A peak count for the early 1990s of 17,650 scoters was recorded for the whole bay on 21/12/94 (Stewart 1995).

Interest in the scoters of Carmarthen Bay was greatly increased following the *Sea Empress* oil spill in February 1996 at the mouth of nearby Milford Haven. Concentrated monitoring was carried out immediately after the spill, and has continued each year since. Stewart *et al.* (1997) summarised counts made between February 1996 and March 1997. It was thought that at least 15,000 birds had been present prior to the spill (Stewart 1995), whereas no counts exceeded 5,000 birds the following winter. Most of the counts were land-based; the aerial counts that were undertaken typically recorded fewer birds although were able to plot the overall distribution of the species more effectively. Cranswick *et al.* (1998) reported upon counts made between April 1997 and March 1998. Land-based counts in the 1997-98 winter peaked at just over 3,200 birds although modified aerial counts found higher numbers than the previous winter. A combination of ground and aerial counts led to a 1997-98 peak count estimate of 6,420 Common Scoter. During the winters of 1998-99, 1999-2000 and 2000-

01, further counts were carried out by Lucy Smith as part of PhD studies for the University of Swansea and CCW (unpubl. data). Peak ground counts of 18,243, 21,592 and 19,506 were recorded in these years. Aerial survey data are partially unavailable, but peak counts of 19,690 in 1998-99, 6,663 in 1999-00 and 11,317 in 2000-01 were recorded (Lucy Smith unpubl. data).

During 2001-02, further ground and aerial counts were carried out as part of an all-Wales study into Common Scoter numbers and distribution (WWT 2003). Seven ground-based counts were made, peaking at 20,078 Common Scoters in February 2002. Additionally, three aerial counts were made, for the first time using a distance-sampling approach to surveying the bay, although half of the data for one of the flights were lost following the theft of equipment from a car. With the change in methods, the actual counts made (up to 12,724 birds) were not comparable with those gathered in previous years. However, analysis of the data (using two slightly different methods) provided estimates of up to 18,578 birds (although with wide confidence limits).

1.3 Objectives

The key objectives of the current project were as follows:

1. Maintain a monitoring programme of ground-based counts.

2. Assess the factors affecting the precision and accuracy of ground-based counts, including weather conditions, tidal state and observer effects.

3. Maintain a monitoring programme of aerial counts.

4. Assess the relative merits of two different aerial survey techniques.

5. Investigate whether ground-based counts consistently provide an appropriate index of overall numbers of scoters.

6. Investigate whether a distance function can be derived using aerial counts to describe the decline in detectability by ground counts over distance

7. Evaluate all extant data to provide possible expressions of targets for scoter numbers and create a draft protocol for how assessments of Favourable Conservation Status should be made.

8. Produce generalised *Procedural Guidelines* for ground-based and aerial assessments of Common Scoter numbers.

9. Produce site-specific *Standard Operating Procedures* for making ground-based and aerial counts of Common Scoters at Carmarthen Bay.

2. METHODS

2.1 Overall Approach

To address the objectives set out in Section 1.3 above, a programme of ground-based and aerial survey events was planned. As anticipated, the programme had to be modified to deal with the eventualities of the weather and plane availability in both winters of monitoring. Ideal conditions for both ground and air counts would be a flat sea (to avoid losing birds amongst waves), no glare on the surface (i.e. cloud cover) and no precipitation (which can reduce visibility). Several planned days of both ground and aerial counts had to be called off at the last minute. However, a total of 20 survey events were achieved in 2002/03 (hereafter ‘first winter’), with a further 23 in 2003/04 (hereafter ‘second winter’), as presented in Tables 2.1a and b.

The personnel involved in each survey are also listed, as observer effects are clearly a major consideration when looking at this type of survey. As such, the observers are frequently identified throughout the report, as follows: AB = Alex Banks, DB = Dean Bolt, IB = Ian Bullock, NF = Nigel Fairney, BH = Bob Haycock, SH = Steve Holloway, LS = Lucy Smith, RS = Richard Schofield, RT = Rob Taylor. AB and SH are BTO staff members; all other fieldworkers were highly experienced in bird survey work, with IB, BH, LS and RS specialising in aerial surveys.

It should be noted that, throughout the report, the state of the tide is often referred to. To ensure a standard approach, a tidal prediction package was used to produce standard high and low tide times for Tenby; tides elsewhere in Carmarthen Bay are generally within 15 minutes of the times at Tenby.

Date	Type of survey	Surveyors
29/11/2002	Ground - monitoring	LS
01/12/2002	Aerial - distance	LS, RS
04/01/2003	Aerial - distance	LS, RS
04/01/2003	Aerial - census	LS, RS
05/01/2003	Ground - methodological - two observers	LS, RS
05/01/2003	Aerial - census	LS, RS
23/01/2003	Ground - monitoring	LS
14/02/2003	Ground - methodological - thoroughness	NF
06/03/2003	Ground - methodological - thoroughness	NF
06/03/2003	Ground - monitoring	LS
12/03/2003	Ground - methodological - tidal	NF
13/03/2003	Ground - methodological - thoroughness	NF
14/03/2003	Ground - methodological - tidal	NF
15/03/2003	Ground - methodological - tidal	NF
15/03/2003	Aerial - distance	LS, RS, SH
15/03/2003	Aerial - census	LS, RS, SH
16/03/2003	Aerial - distance	LS, RS, SH
16/03/2003	Aerial - census	LS, RS, SH
17/03/2003	Ground - methodological - thoroughness	NF
31/03/2003	Ground - monitoring	LS

Table 2.1a Summary of fieldwork undertaken in Carmarthen Bay during the winter of 2002/2003.

Date	Type of survey	Surveyors
11/10/03	Aerial – distance	BH, RS
12/10/03	Aerial – census (training)	SH, RS, AB
27/10/03	Ground – monitoring	NF
28/10/03	Ground – methodological – tidal	NF
29/10/03	Ground – methodological – thoroughness	NF
19/11/03	Ground - methodological – tidal	NF
20/11/03	Ground – methodological – thoroughness	NF
23/11/03	Aerial – distance	BH, RS
27/11/03	Ground – monitoring	NF
28/11/03	Ground – monitoring	NF
29/12/03	Ground – monitoring	NF
30/12/03	Ground – monitoring	NF
24/01/04	Ground – methodological – four observers	AB, DB, NF, RT
25/01/04	Aerial – distance & census	BH, RS
25/01/04	Ground – methodological – three observers	DB, NF, RT
23/02/04	Ground – monitoring	NF
24/02/04	Ground – monitoring	NF
28/02/04	Aerial – census x2	AB, BH
29/02/04	Aerial – distance	AB, BH
28/02/04	Ground – methodological – three observers	DB, NF, RT
29/02/04	Ground – methodological – three observers	DB, NF, RT
23/03/04	Ground - methodological – tidal	NF
24/03/04	Ground – methodological – thoroughness	NF
27/03/04	Aerial – distance & census	AB, RS

Table 2.1b Summary of fieldwork undertaken in Carmarthen Bay during the winter of 2003/2004.

2.2 Methods for Individual Surveys

2.2.1 Ground-based Monitoring Counts

The methodology followed for the ground-based monitoring counts was the same as that used since the winter of 1998-99. Continuity was further ensured by the fact that the same observers (LS, NF) carried out the majority of the counts.

Counts were made on four dates in the winter of 2002-03 (29th November 2002, 23rd January 2003, 6th March 2003 and 31st March 2003), selected by LS as being those likely to provide good viewing conditions. Counts were carried out from three count stations (Figure 2.2.1) along the coast, *i.e.* Pembrey sand dunes (241500, 199190 – 9 m ASL), Dolwen Point near Pendine (223310, 207840 – 25 m ASL) and Merrifields, Amroth (217900, 207350 – 48 m ASL). In some previous seasons, a fourth station at Kitchen Corner, Rhossili (240350, 187500 – 50 m ASL), had been used. This area was favoured by the birds following the *Sea Empress* oil spill, but it appeared that birds had largely ceased to use the area as the effect of the oil spill on other parts of the bay lessened through time. During the 2002-03 season, all available information (confirmed by aerial surveys) suggested that numbers of birds present off Rhossili were relatively insignificant in comparison with the whole bay population and thus effort was concentrated at the other three count stations.

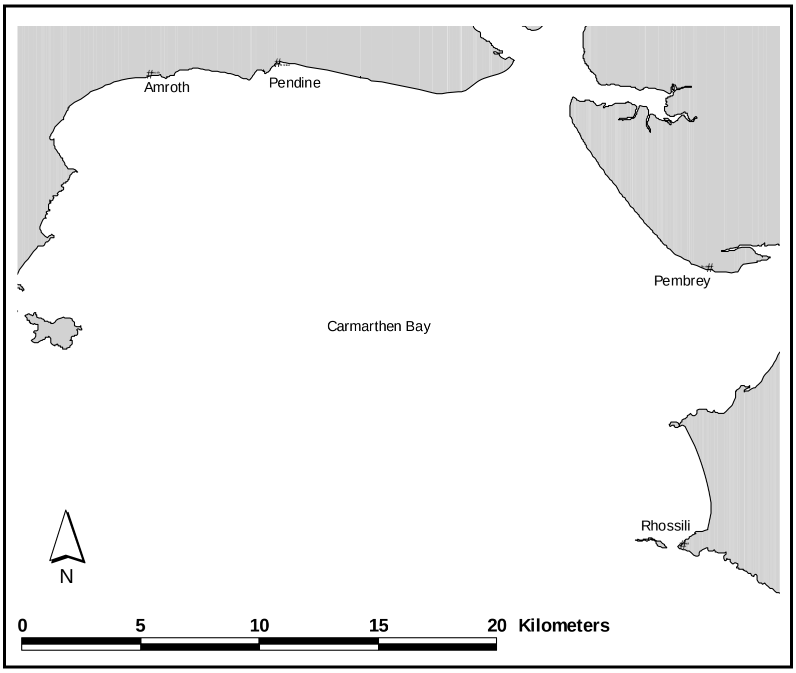


Figure 2.2.1 Map of Carmarthen Bay area illustrating ground count stations.

During the winter of 2003-04, NF undertook four further counts, timed to coincide with aerial counts as far as weather and tide conditions allowed. Counts were made from the same count stations as in the previous winters; however, in three of the months surveyed, counts were also made from Rhossili following unexpectedly low numbers at Pembrey. Because of this extra coverage, monitoring was spread over a two-day period. Surveys took place on 27th October 2003, 27-28th November 2003, 29-30th December 2003 and 23-24th February 2004.

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 telescope (20-60x zoom magnification, 80mm objective). For each bird or flock, the number of birds, their bearing and their distance from shore were recorded. To check the distance estimations, in the first winter a graticule was used which had previously been fixed in the lens and used on a life-size duck model positioned at various known distances from the observer. The graticule was then used occasionally throughout fieldwork to check that distance estimations were reasonable. In the second winter, distance calibrations were made to buoys in the bay, whose offshore distances were calculated from hydrographic charts (Admiralty Standard Navigational Chart #1076, Linney Head to Oxwich Point; UK Hydrographic Office, Taunton). Bearings were taken using a protractor disc centred on the tripod holding the telescope or by needle compass. Recorded bearings were compared with the bearing of a known landmark to enable conversion into actual bearings. 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 ArcView GIS.

2.2.2 Ground-based Methodological Studies

A series of further detailed ground-based counts were undertaken, mainly from the single count station at Dolwen Point, Pendine. These were designed to address a number of questions and each day's survey was not confined to addressing only one question. For convenience, the counts are described in four groups below.

2.2.2.1 Multi-observer Counts

On 5th January 2003, both LS and RS made simultaneous ground-based counts of the numbers of Common Scoters visible from the Pendine count station. RS simply recorded a total figure whilst LS recorded birds to distance and bearing, as described in 2.2.1. As a result, the count made by RS took somewhat less time than that of LS, although it was in no way rushed. The other main difference between the observers was that the telescope used by RS was a 30x wide-angle lens compared to the 20-60x zoom used by LS.

On 6th March 2003, LS carried out a monitoring count from Pendine (as well as the other two stations) whilst NF was also at Pendine carrying out a series of counts designed to assess the effect of thoroughness (see 2.2.2.2). Count numbers six through eight of NF overlapped with those made by LS at the same count station.

On 24th January 2004, DB, NF and RT made simultaneous synchronised counts from one of three count stations (Amroth, Pendine and Rhossili), using the same optical equipment (telescopes with 5-45x zoom and 60mm objective lens). Later that same morning, AB and the three counters mentioned convened at Pendine to carry out four simultaneous 45-minute counts, again using the same optical equipment (with the exception of NF, who used a telescope with a 20-60x zoom and 100 mm objective lens; AB took the telescope used by NF on the first count). This was to compare intra- and inter-observer variability in counts, and so no information on distance or bearings was collected. The following day (25th January 2004), DB, NF and RT undertook three synchronous 60-minute counts of the bay from different count stations (Pendine, Amroth and Rhossili respectively), but again using the same optics. These counts were designed to examine intra-observer variability, and also to provide extended counts of the bay.

On 28th February 2004, DB, NF and RT made three more co-ordinated 60-minute counts of the bay from the three count stations used in the previous month, and a further three simultaneous counts from the same count station on the following day (29th February 2004), always using the same optical equipment.

2.2.2.2 'Thoroughness' Studies

A series of counts was designed to test the effect of the degree of thoroughness with which a count was carried out. On four dates during the first winter, NF attempted to count all Common Scoters in view from the Pendine count station. Search times of varying duration were used. Details of the weather and sea-state were recorded, along with anecdotal observations on the behaviour of the birds. NF used a telescope with a 20-60x zoom magnification and 85mm objective lens. On the first two of these dates, the count regime was that in each hour, three sets of five-minute counts, two sets of ten-minute counts and one 20-minute count would be carried out. Having carried out these first two days of counts at this level, it was decided that the durations were too short to make an adequate assessment of numbers and the count regime was changed. For the last two dates, the count regime was that in each three-hour period, two 20-minute counts, one 40-minute count and one 80-minute count would be carried out.

In the second winter, NF carried out a further three days of counts, from the same count station and with the same optical equipment as in 2002-03, to further investigate the effect of thoroughness. During this season, comparative counts of 60 minutes and 120 minutes were made, with five counts of alternating length throughout the day. A total of nine 60-minute and six 120-minute counts were made.

2.2.2.3 'Tidal' Studies

A further series of counts was designed to assess the degree to which tide-related differences in scoter distribution could be assessed from ground-based counts. In the first winter, on three dates from the Pendine count station, NF made four two-hour counts of all Common Scoters visible, this time assessing the distance and bearing of all flocks recorded in a similar manner to that used by LS for her monitoring counts. NF based his distance estimations upon buoys of known distance. Additionally, NF recorded total counts within a five-degree sector, rather than assigning every flock an individual bearing. As on the other dates, weather and sea-state were also recorded, as were anecdotal observations concerning the behaviour of the birds.

In the second winter, a further three sets of tidal counts were made by NF, using the same methods as in the previous field season. Four counts were made on each survey day: one at high tide, one on a rising tide, one at low tide and one on a falling tide.

2.2.2.4 Behavioural Studies

To assess the behaviour of Common Scoter in response to the activity of the aerial survey aircraft, three ground-based observers (DB, NF and RT) measured disturbance on three dates (25th January 2004 and 28th and 29th February 2004) in the winter of 2003-04. On the first date, observers recorded behaviour during firstly a census-method flight (with transects running from east to west then west to east, beginning in the north and working south), and secondly a distance-method flight (transects running from west to east, beginning in the north of the bay and flying south, then back north on the next transect). On the second date, two census-method flights with alternating transect directions (west to east and south to north in the morning, east to west and north to south in the afternoon) were observed, and on the final date a further distance-method flight (east to west and north to south) took place whilst ground observers watched the scoters in the bay. Situated at Pendine, Amroth and Rhossili respectively, each observer attempted to quantify numbers of Common Scoters affected by the movements of the aeroplane. Also, observers qualitatively recorded changes in behaviour and spatial distribution of the birds, as well as estimating flushing distances of the birds in response to the approaching aircraft. Synchronisation between three ground observers and the aerial surveyors allowed detailed temporal understanding of the birds' movements in response to the plane.

2.2.3 Aerial Census-method Counts

Four aerial surveys of Carmarthen Bay were undertaken in each winter, using the technique hereafter described as the 'census-method'. The aim of this method was to survey the entire area of the bay and count every individual bird. The bay was surveyed using rectangular cells of 2 km x 1 km for the majority of the area and 1 km squares in the south-easterly section, off Rhossili. This was because the lower density of birds off Rhossili enabled a more detailed recording of the distribution. The plane (a Partenavia PN68) was flown at an altitude of 152 m (500 ft) at a speed of approximately 185 kmh^{-1} (51 ms^{-1}), although varying somewhat depending on the strength and direction of the wind. A pair of observers (RS to port and LS to starboard in 2002-03; combinations of AB, BH and RS in 2003-04) looked out of windows on either side and recorded all birds to a distance of 500 m from the transect line. A navigator (IB in all cases but one, replaced by AB), equipped with GPS, assisted the pilot and notified the observers when they were entering the next recording cell. Observations were recorded onto data sheets and initially the birds were recorded as either sitting, flying or flushing; in the latter two cases the direction of travel was also recorded. This practice was not followed in 2003-04; counts were made without assigning behaviour to allow greater precision in estimating numbers. Other species noted during the flights were also noted, as was the presence of sandbanks.

To allow comparability with previous years, the majority of census-method flights were conducted along transects alternating east to west then west to east, starting in the north of the bay and continuing southwards, with each transect 1000 m south of the previous one. In the second winter, two flights took west to east (then east-west, and so on) transects, starting in the south and continuing north. This was to allow comparison in behavioural response to the plane taking different paths. The northernmost transect was flown along the Ordnance Survey national grid northing 207000 and the southernmost along northing 189000, whilst the west and east limits of the survey area were bounded by the eastings 212000 and 240000 respectively. The precise cells covered on each flight varied slightly around the edge of the bay, depending upon tide conditions on the day (the extent of each flight can be seen in plots of bird distribution, Figures 3.9a and b to 3.12 a and b).

In order to provide experience of survey procedure, to improve identification skills and to calibrate counts, various training exercises were incorporated over the course of the two winters. In the first winter, SH occupied a passenger seat to starboard of the plane, and was able to make two counts for comparison with those made by LS. In the second winter, a dedicated training flight on 12th October 2003 allowed SH further training, whilst RS was able to teach AB the methods in detail. AB was also given an introduction to navigating on this flight.

The data were analysed using MS Excel and ArcView GIS.

2.2.4 Aerial Distance-method Counts

In 2002-03, four aerial surveys of Carmarthen Bay were undertaken using the more recently developed 'distance-method' (Kahlert *et al.* 2000), with another five surveys (plus one training flight) in 2003-04. This method is based on distance sampling protocols (Buckland *et al.* 2001). Because the ability to detect a bird decreases with increasing distance from the observer, any counts constitute only a proportion of the total number of birds present in the survey area. If the distance from the observer to the bird is recorded, however, a correction factor may be incorporated. The level of correction may differ according to the flock size, weather conditions / sea-state, observer and behaviour of the birds.

The same plane as for the census-method flights was used but for the distance-method the altitude was 76 m (250 ft). The speed of the plane was again approximately 185 kmh^{-1} (51 ms^{-1}). The position of the plane during the flight was recorded using a Garmin 12XL GPS, which was set to record position at various time periods (usually five or ten seconds). In the second winter, the acquisition of 'WinWedge' software enabled the GPS to live-feed to a laptop, thus allowing the flight position to be recorded to a finer degree of precision. However, it was not always possible to obtain a complete track due to technical difficulties. The transect lines alternated from north to south then south to north, generally running from east to west (but with two running west to east in 2003-04, to investigate potential bias created by transect order) and each transect being located 2000 m west (or east) of the previous one. The approximate line of travel was along eastings of the Ordnance Survey national grid; the first transect was usually south along easting 243000. The start and end times of each transect were recorded.

North-south transects were favoured as they were approximately perpendicular to the major environmental gradient, *i.e.* the depth of water. This is important as it removes a potential source of bias between the two sides of the plane (*i.e.* if scoter distribution is partly dependent upon water depth, as seems likely, then by flying parallel to the depth contour the observer on one side of the plane would be likely to record greatly varying numbers of birds to the observer on the other side).

The same observers as for census flights (RS and LS along with SH as a trainee in 2002-03; AB, BH and RS plus SH as a trainee on one flight in 2003-04) were seated in the same positions as for the census-method flights and dictaphones were used to record observations. For all first winter flights, counts were carried out by RS and LS, whereas in the second winter BH and RS undertook the first three flights. The fourth count was made by AB and BH, whilst AB was joined by RS on the final aerial distance-method flight. Data collected on training flights in 2002-03 and 2003-04 were not included in the analysis.

For distance-method flights, each observation of a flock was recorded as a time, size of flock and distance band, along with species and behaviour (simply as sitting or flying/flushing, with the direction of flight seldom recorded owing to the greater demands on the observers). For both winters of counts, four distance bands were used: Band A = 44-162 m (60^0-25^0 below the horizontal); Band B = 162-282 m (25^0-15^0); Band C = 282-426 m (15^0-10^0); Band D = 426-1000 m (10^0-4.23^0). 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 a clinometer that enabled the measurement of predetermined angles below the horizontal.

The data were transcribed from the dictaphones onto standard paper recording forms and from there into MS Excel. The data collected during both season's flights were analysed using the distance sampling software Distance 4. The analysis is described in further detail in Appendix 1. The GPS tracks were output either as an ASCII text file of northing, easting and time, or as a MS Access file where WinWedge was used. Most of the data analysis and preparation was carried out using Excel. For example, the GPS track was used to derive an estimated position of the plane during every second of the flight (assuming a constant speed in a straight line from one recorded point to the next) and then these positions were assigned to the count data to enable plotting in ArcView GIS.

3. RESULTS

3.1 Ground-based Counts

3.1.1 Ground-based Monitoring Counts

Although ground counts were scheduled to take place on days with optimal viewing conditions, on two dates conditions were sub-optimal. On 31st March 2003, all sites experienced haze and, combined with the sea state and particularly strong glare over a 10˚ arc at Pendine, counts are likely to have been adversely affected. On 23rd and 24th March 2004, light rain and showers were recorded at all four stations visited, and could have had a negative impact on visibility.

The counts for both winters, along with the associated count conditions, are summarised in Tables 3.1a and 3.1b, whilst the distributions of Common Scoters recorded by these counts are mapped in Figures 3.1a – 3.5 and 3.1b – 3.4b, both as graduated symbols showing flock size at a given position and bearing, and as dot density maps where the counts have been assigned to the same recording cells used for the census-method aerial surveys.

The peak count in the winter of 2002-03 reached 23,288 in January 2003. The mean count over the entire winter (based on counts in November, January and two in March) was 16,274 birds. By the time of the first count in November, numbers had already risen to 16,203, increasing for the January count before decreasing to 19,925 at the beginning of March. Less than a month later, numbers dropped to 5,678, presumably as most scoter had departed for the breeding grounds.

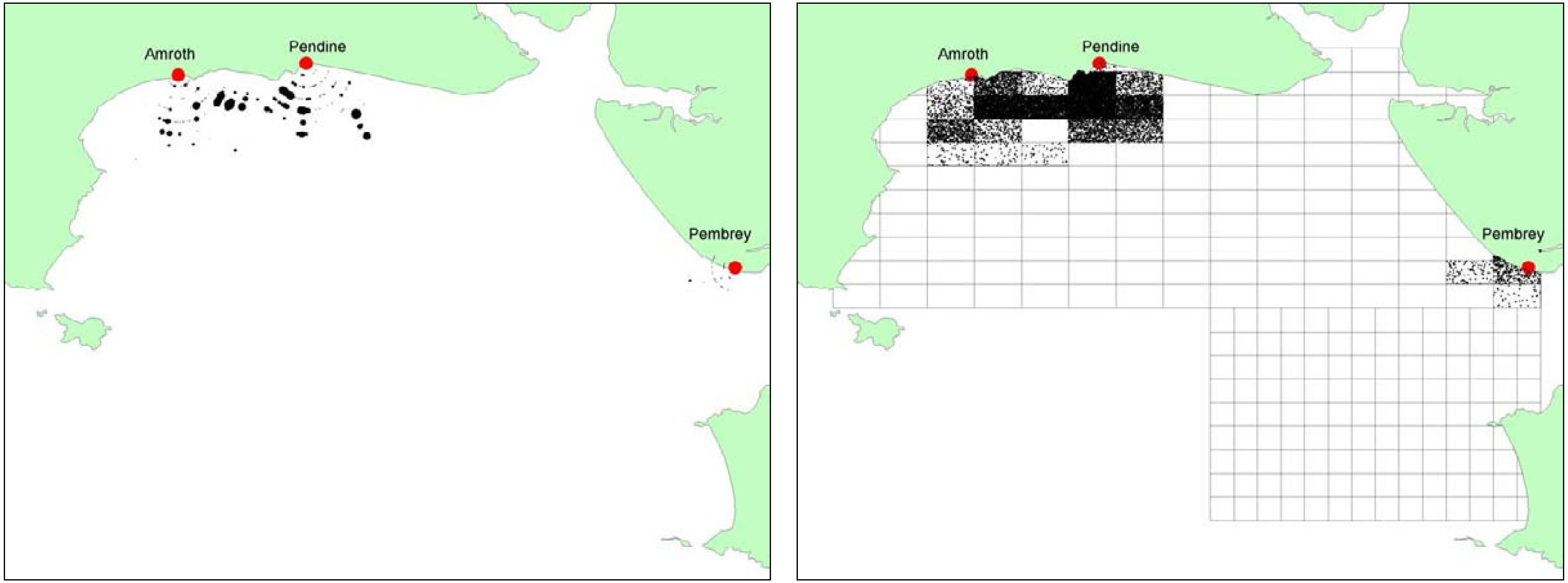
The following winter, peak counts were substantially lower at 15,446 Common Scoter on 30th December 2003. The mean count was also lower at 12,757, although this figure is not directly comparable to the previous winter as surveys occurred in different months (October, November, December and February). Counts built up from 6,853 in October to remain fairly stable over the rest of the winter (14,427 in November, 15,446 in December, and 14,301 in February).

Date & tides	Station	Start time	Count	Approx tidal state	Wind (mph)	Cloud	Sea state	Potential disturbance noted
29/11/2002 (low 0718, high 1336)	Amroth	0900	6663	Rising from low	NW 5	2/8	Small waves, no white horses	None
	Pendine	1100	8942	Rising to high	NW 2	1/8	Small waves, no white horses	Three canoes 500m offshore
	Pembrey	1400	598	Falling from high	WNW 2	1/8	Small waves, some white horses	None
	Total		**16203**					
23/01/2003 (high 0930, low 1554)	Pendine	0945	15159	Falling from high	NW 2	1/8	Small ripples, no white horses	None
	Amroth	1230	6246	Falling to low	NW 2	1/8	Small ripples, no white horses	None
	Pembrey	1530	1883	Low	NW 2	3/8	Small waves, no white horses	None
	Total		**23288**					
06/03/2003 (high 0754, low 1412)	Pembrey	0910	7071	Falling from high	SW 0	1/8	Small waves, no white horses	None
	Amroth	1200	5420	Falling to low	SW 10	5/8	Small waves, no white horses	Two boats within 4 km
	Pendine	1415	7434	Rising from low	SW 20	2/8	Small waves, occ.white horses	None
	Total		**19925**					
31/03/2003 (high 0630, low 1248)	Amroth	1030	3201	Falling to low	SE 5	1/8	Small to medium waves, some white horses	None
	Pendine	1230	1973	Low	SW 10	1/8	Small to medium waves, some white horses	None
	Pembrey	1500	504	Rising from low	SE 5	1/8	Small to medium waves, some white horses	None
	Total		**5678**					

Table 3.1a Ground-based monitoring counts of Common Scoter in Carmarthen Bay during the winter of 2002/2003.

Date & tides	Station	Start time	Count	Approx tidal state	Wind	Cloud	Visibility	Disturbance
27/10/03	Amroth	1030	1,750	Falling	N 2	4/8		None
(high 0700, low 1330)	Pendine	1315	5,097	Low	N 1	5/8		None
	Pembrey	0730	6	Falling from high	N 3	3/8		None
	Total		**6,853**					
27/11/03	Amroth	1330	7,829	Falling to low	N 4	1/8		None
(high 0820, low 1447)	Pendine	1045	6,598	Falling	N 2	0/8		None
	Pembrey	0800	0	Rising to high	N 2	0/8	Excellent	None
	Total		**14,427**					
28/11/03	Rhossilli	0900/1100	767/824	High/falling	S 5	7/8	Excellent	None
30/12/03	Amroth	1330	6,878	Falling	ENE 2	8/8	Excellent	None
(high 1132, low 1759)	Pendine	1100	8,568	High	ENE 2	8/8	Excellent	Herring Gulls
	Pembrey	0830	0	Rising	ENE 3	8/8	Excellent	None
	Total		**15,446**					
29/12/03	Rhossilli	0900/1100	760/808	Rising to high	NE 4	8/8	Excellent	None
24/1/04	Amroth	0800	7,858	High	W 3	1/8	Slight sea state	None
(high 0748, low 1335)	Pendine	COUNT	MISSING					
	Pembrey	0830	83	High				
	Total	N/a	N/a					
23/02/04	Amroth	1330	6,194	Falling to low	WSW 4	5/8	Light rain	None
(high 0806, low 1425)	Pendine	1100	8,107	Falling	SW 3/4	3/8		None
	Pembrey	0800	0	High	WSW 3	2/8		None
	Total		**14,301**					
24/02/04	Rhossilli	0800/1010	176/203	Falling from high	W 3	3/8	Showers	None

Table 3.1b Ground-based monitoring counts of Common Scoter in Carmarthen Bay during the winter of 2003/2004.



i) ii)

Figure 3.1a Distribution of Common Scoters recorded during ground-based monitoring counts on 29/11/02, depicted as i) graduated symbols at measured bearing and distance and ii) dot-density maps of counts assigned to aerial census-method cells.

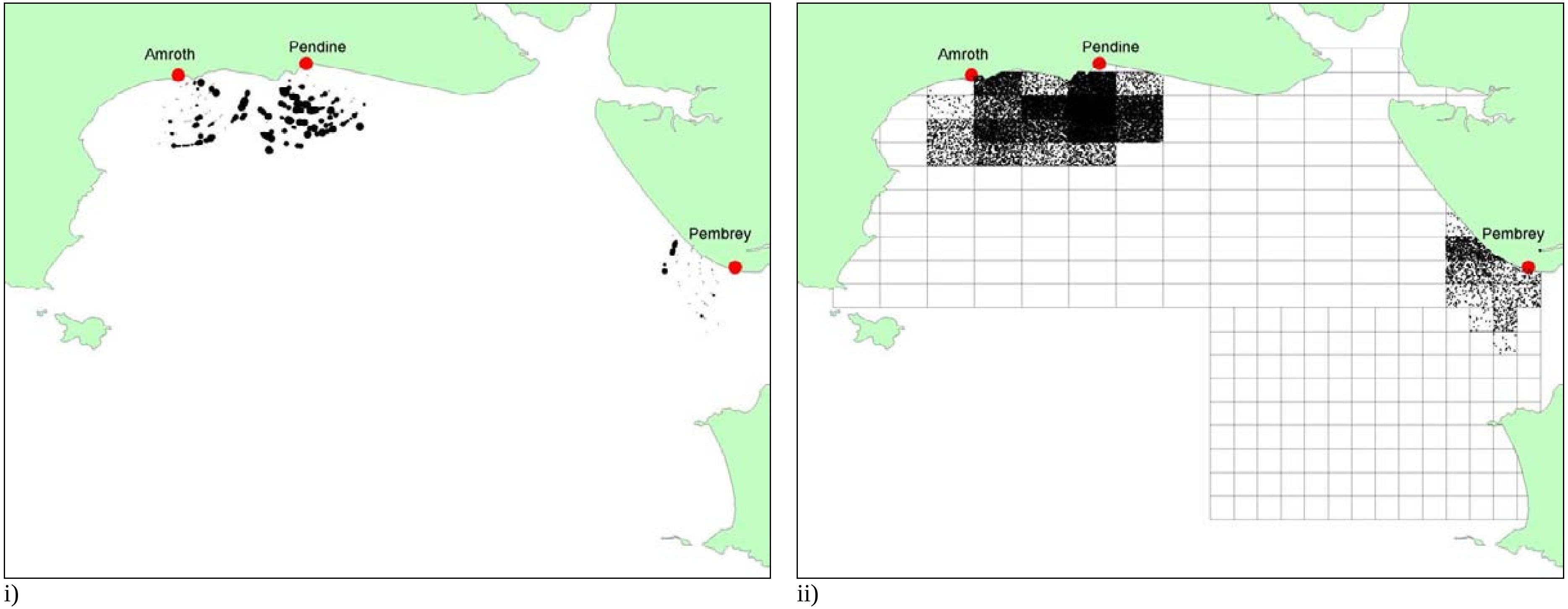
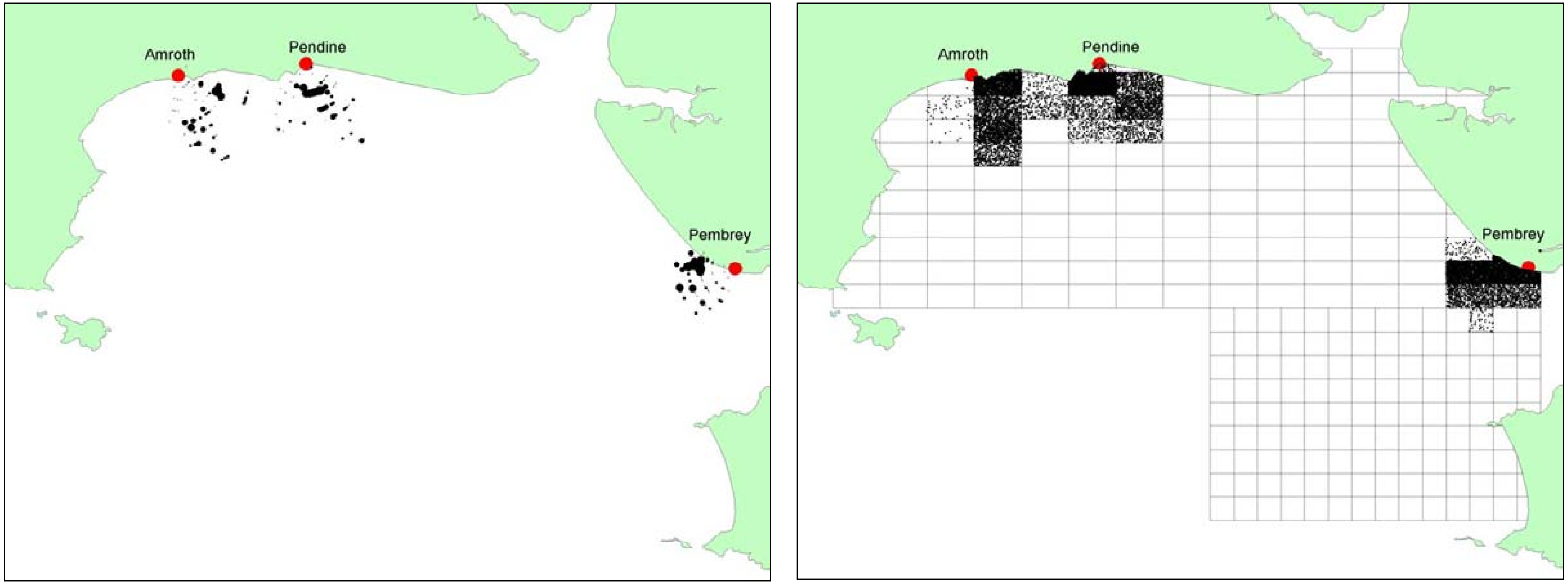
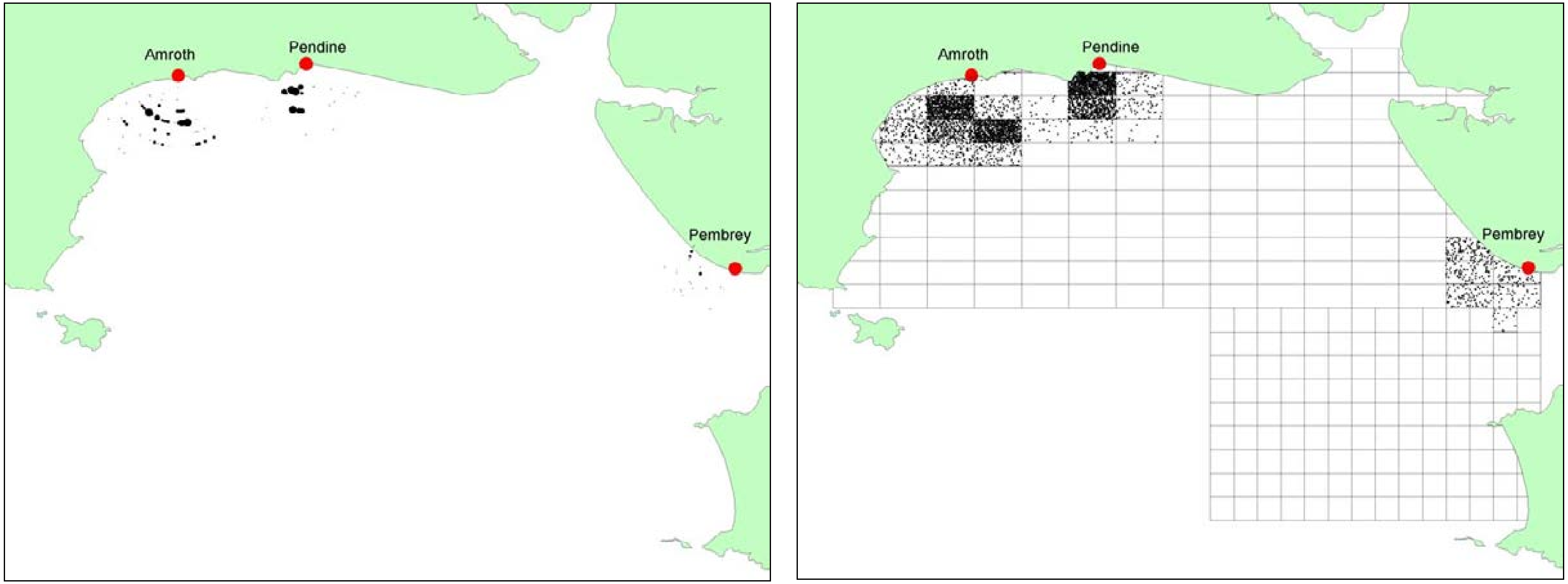


Figure 3.2a Distribution of Common Scoters recorded during ground-based monitoring counts on 23/01/03, depicted as i) graduated symbols at measured bearing and distance and ii) dot-density maps of counts assigned to aerial census-method cells.



i) ii)

Figure 3.3a Distribution of Common Scoters recorded during ground-based monitoring counts on 6/3/03, depicted as i) graduated symbols at measured bearing and distance and ii) dot-density maps of counts assigned to aerial census-method cells.

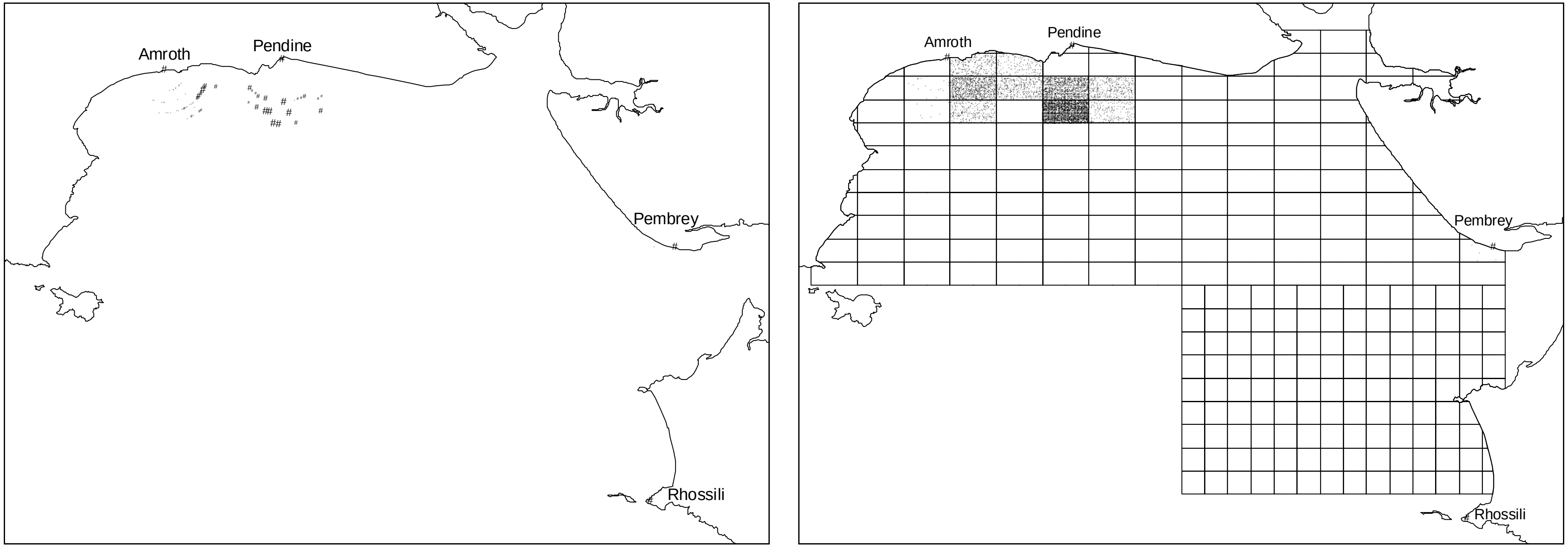


i) ii)

Figure 3.4a Distribution of Common Scoters recorded during ground-based monitoring counts on 31/3/03, depicted as i) graduated symbols at measured bearing and distance and ii) dot-density maps of counts assigned to aerial census-method cells.

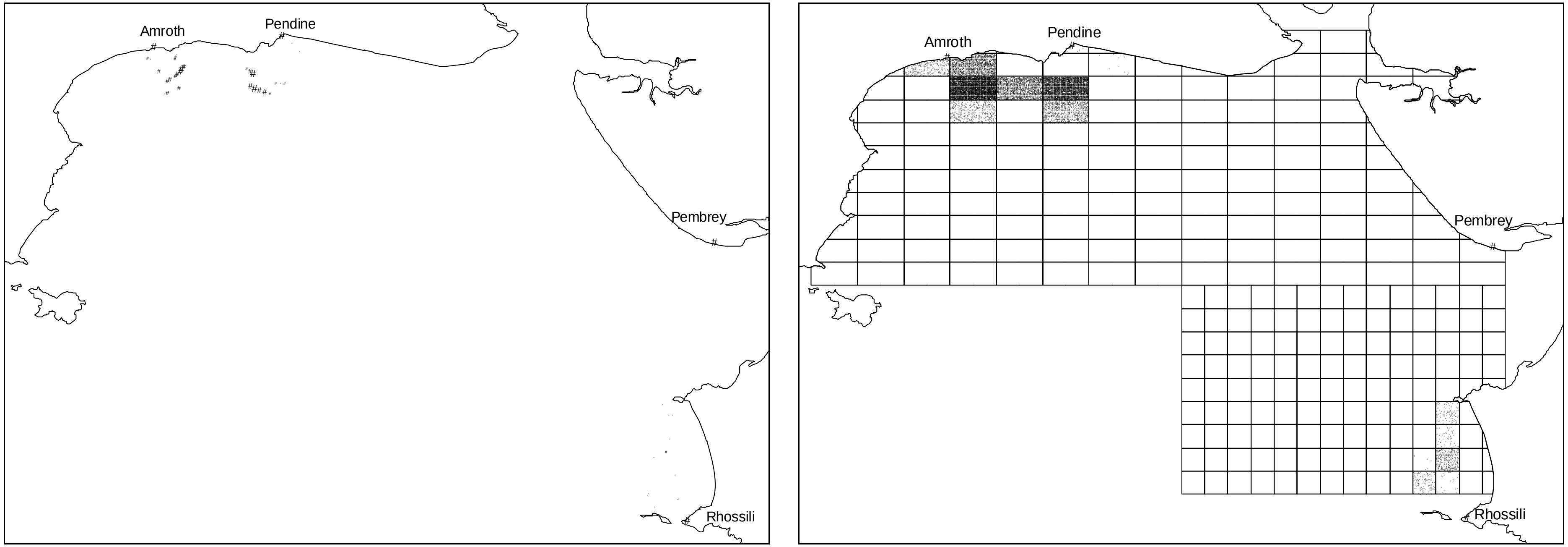
i) ii)

Figure 3.5 Distribution of Common Scoters recorded during ground-based monitoring counts on 5/1/03 (Pendine station only), depicted as i) graduated symbols at measured bearing and distance and ii) dot-density maps of counts assigned to aerial census-method cells.



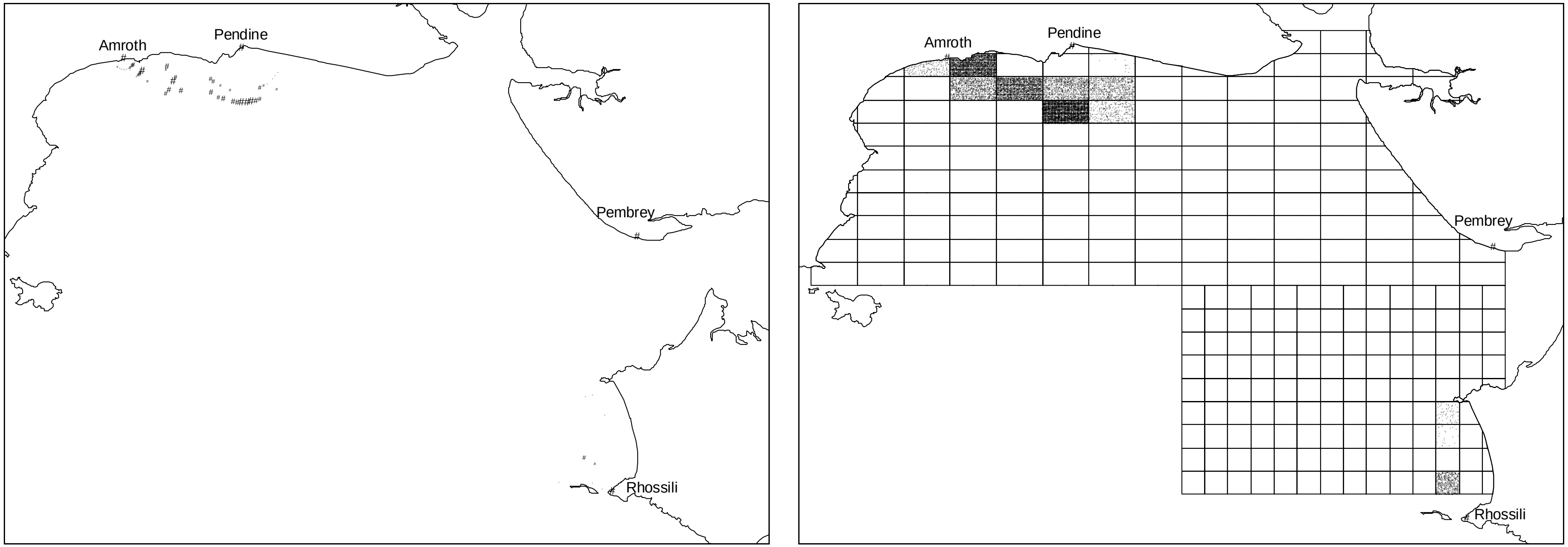
i) ii)

Figure 3.1b Distribution of Common Scoters recorded during ground monitoring counts on 27/10/03, depicted as i) graduated symbols at measured distance and bearing, and ii) dot-density maps of counts assigned to aerial census method cells.



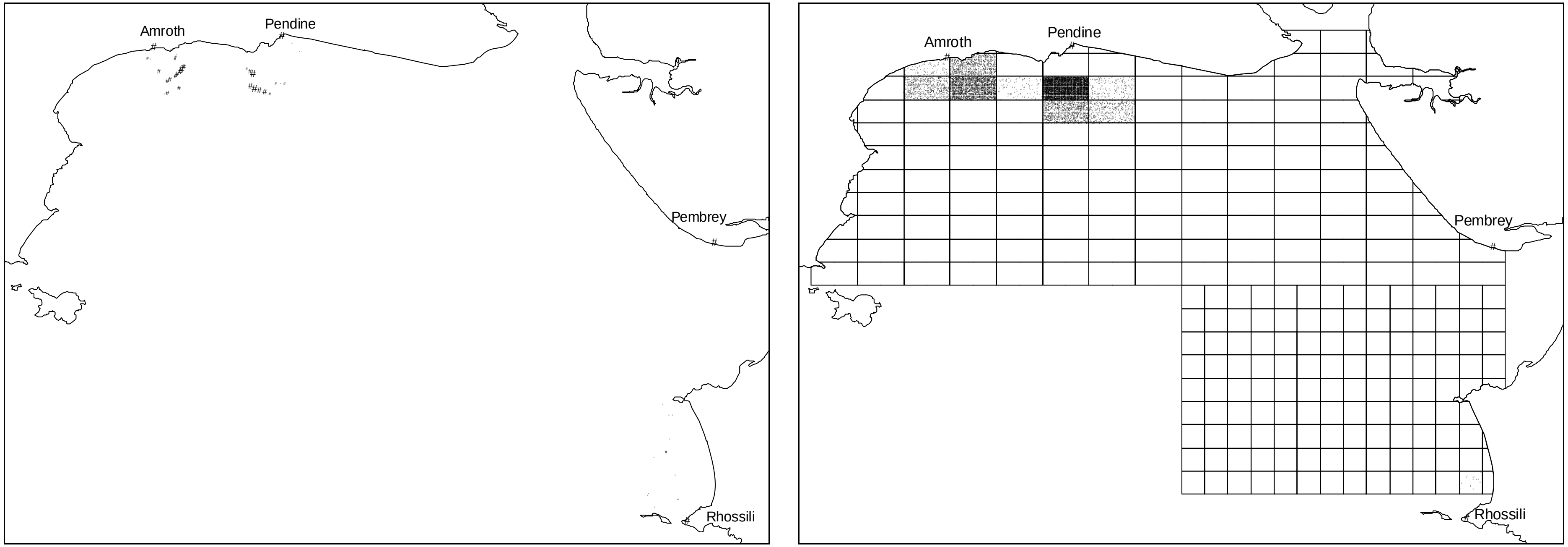
i) ii)

Figure 3.2b Distribution of Common Scoters recorded during ground monitoring counts on 27 and 28/11/03, depicted as i) graduated symbols at measured distance and bearing, and ii) dot-density maps of counts assigned to aerial census method cells.



i) ii)

Figure 3.3b Distribution of Common Scoters recorded during ground monitoring counts on 29 and 30/12/03, depicted as i) graduated symbols at measured distance and bearing, and ii) dot-density maps of counts assigned to aerial census method cells.



i) ii)

Figure 3.4b Distribution of Common Scoters recorded during ground monitoring counts on 23/02/04, depicted as (i) graduated symbols at measured distance and bearing, and (ii) dot-density maps of counts assigned to aerial census method cells.

3.1.2 Ground-based Methodological Studies

The different methodological questions posed by this study were assessed by a variety of surveys which are described below in four groups. However, as mentioned in Section 2.2.2, some questions (e.g. intra-observer variation) were investigated by use of data from more than one of these groups.

3.1.2.1 Multi-observer counts

On the morning of 5th January 2003 (tide falling from high), LS and RS each made a simultaneous ground-based count of the number of Common Scoters visible from the Pendine count station. The wind during the count was south-easterly at Force 1-2, cloud cover was 1/8 and the sea surface was described as having small waves but no 'white horses'.

The totals differed markedly, with 3,740 birds counted by RS compared to 6,318 birds counted by LS. LS carried out her count in the same manner as her ground-based monitoring counts, *i.e.* by recording flocks to bearing and distance. The distribution of birds recorded by LS is shown as Figure 3.5. RS also made a careful count but did not record distance and bearing.

During the afternoon of 6th March 2003, the monitoring count by LS from Pendine overlapped with the 6th to 8th hours of thoroughness counts (see 3.1.2.2 below) being carried out by NF. The former recorded a total of 7,434 birds over approximately two hours. The counts carried out by NF varied with duration. Five-minute counts over these three counts averaged 754 birds, ten-minute counts averaged 1,586 birds and 20-minute counts averaged 2,858 birds.

The comparison of inter-observer variability in 2003-04 revealed interesting differences. On 24th January 2004, DB and NF made counts that tended to be fairly similar, both recording progressive increases with time and with all of DB's counts within 13% of NF's. RT, an experienced bird surveyor, made two counts that represented only 60% and 53% of NF's counts. AB, the least experienced ground counter, fluctuated in comparison to the other counters. The first count was 180% of NF's count, whereas the second stood at 72%. The final two counts were closer to those of NF, at 111% and 97% of his totals (Table 3.2.1 and Figure 3.6).

On 29th February 2004, counts between DB, NF and RT were subject to much less variability. The three counts by RT formed 91%, 90% and 93% of NF's counts. DB's counts were at 88%, 87% and 93% of NF's counts (Table 3.2.2 and Figure 3.7). This was not due to a reduced abundance of birds, as numbers counted peaked at around double those in the previous month. It is unclear why NF's counts should be consistently higher on this survey. This could be an effect of experience, though this was not evident on the January synchronised count.

	Count					
Observer	1	2	3	4	**Mean**	**S.D.**
AB	5010	2759	5339	4877	4496	1174
DB	3026	3649	4189	4533	3849	658
NF	2778	3808	4799	5046	4108	1035
RT	-	3434	2563	3015	3004	436

Table 3.2.1 Comparative 45-minute ground counts of Common Scoters, with means and standard deviations, from Pendine on 24/01/04.

	Count				
Observer	1	2	3	**Mean**	**S.D.**
DB	8754	9234	4875	7621	2390
NF	9978	10674	5237	8630	2959
RT	9070	9640	4870	7860	2605

Table 3.2.2 Comparative 45-minute ground counts of Common Scoters from Pendine on 29/02/04.

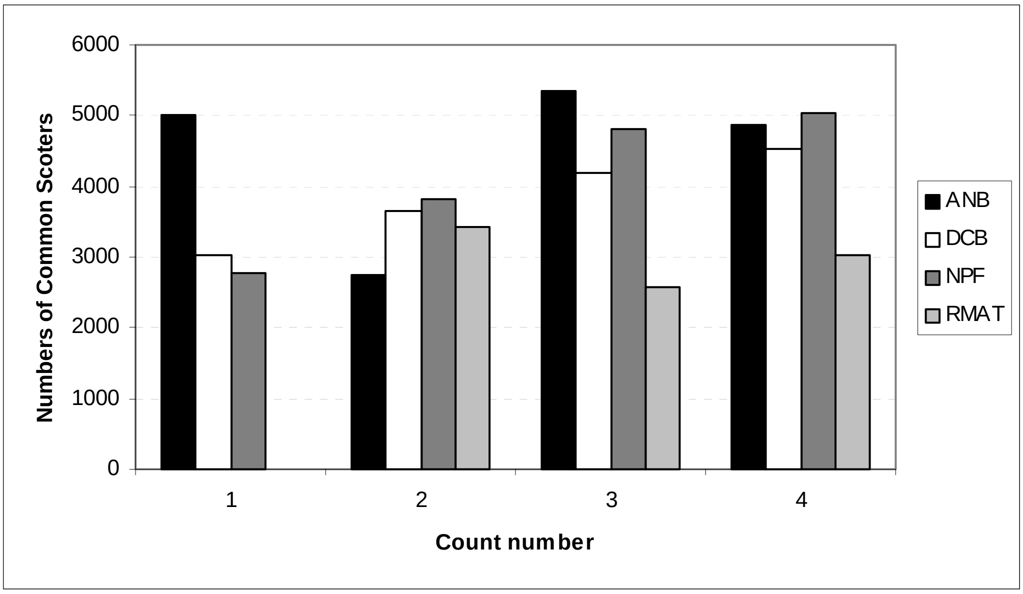


Figure 3.6 Comparative ground counts of Common Scoters from Pendine on 24/01/04. Legend indicates observers.

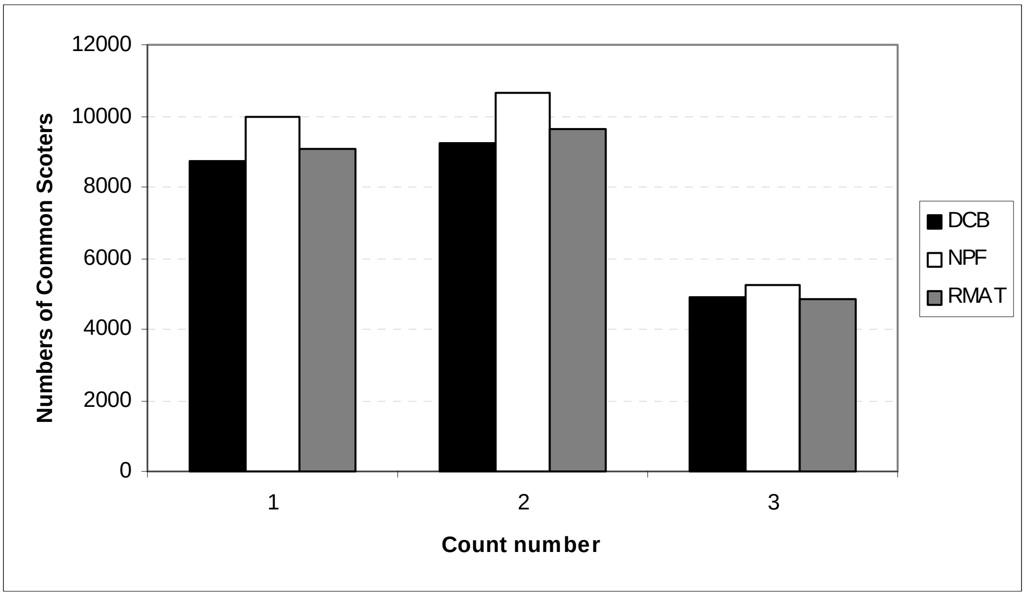


Figure 3.7 Comparative ground counts of Common Scoters from Pendine on 29/02/04. Legend indicates observers.

3.1.2.2 'Thoroughness' studies

Counts of varying durations were carried out during both winter field seasons. The counts and associated conditions are summarised in Tables 3.3 to 3.6 (first winter) and 3.7 to 3.9 (second winter). Further observations pertaining to the counts were recorded by NF and are as follows:

14th February 2003 (Table 3.3)

Counts began at 0745 on a falling tide with low tide at 1036. Counts continued until 1545, ending before high tide at 1642.

The majority of birds were loafing with small groups of males displaying and squabbling. Feeding activity was difficult to ascertain due to distance, especially since it was difficult to determine whether a bird had dived or disappeared amongst the swell. The strong, low sun made observation very difficult. Haze and glare combined such that making out individuals or groups was difficult. The time scales (five, 10 and 20 minutes) did not allow sufficient time to observe birds that may have been lost in even the lightest swell. This was clearer as the time scale increased, when (for example) what may have appeared to be only 20 birds in a scope width became 40 as a group emerged from the trough in a swell.

Relatively little in the way of movements of the scoter was noted, with about 200 flying east during the third hour along with three Velvet Scoters *Melanitta fusca*.

From the fifth hour, as the sun approached due south where most of the scoter were grouped, counting became very difficult and at times near-impossible. During the last three hours, several counts could not be made ('n.c.' in Table 3.3) as a result of extreme sun glare affecting prolonged counts and increasing the need to rest between counts. The conditions could be described as almost a 'white-out', made worse by low tide and glare / reflection from the beach below the count point.

6th March 2003 (Table 3.4)

Counts began at 0825, shortly after high tide which was at 0754. Counts continued past low tide at 1412 until 1655.

Feeding activity was difficult to ascertain due to the distance of the scoter from the watchpoint and the effects of swell. The number of birds counted did not seem to be affected by the rising and falling tide, as they appeared to stay faithful to an area of the sea across which they occupied a band more than 2 km off the watch-point. The apparent decrease in numbers later in the day seemed more likely to be due to the increased swell and the difficultly created with 'losing' birds in the swell, with a limited time period for each scope width count. Indeed, it was the shorter duration counts that decreased by the greatest extent.

During the fourth and fifth hours there were low-flying RAF sorties over Pembrey, with live missile tests and bomb dropping. There were associated large movements of scoters: 1,800 flew west at 1145, 1,500 flew east at 1215, 1,000 flew west at 1315 and 1,100 flew east at 1325. The counts tabulated do not include these flying flocks. Following this time most birds appeared to be loafing and small movements noted were never of more than 15 birds. Squabbling groups of males were commonly observed.

13th March 2003 (Table 3.5)

Counts began at 0830, after low tide at 0730. High tide was at 1348 and the counts continued until 1630.

This was the first of the days during which the count duration was increased. However, even with 20-minute counts, the effect of swell on the number of scoters visible was great, and counts varied greatly for each scope-width dependent on whether the scoters came onto the crest of the swell whilst observing the patch of sea. For example, one scope width could produce 30 scoters at one glance, with a return to the same area showing 130.

Throughout the day, the main impression was of loafing birds, again with squabbling groups of males commonly noted. During the second set of counts, strong sun glare particularly affected the 40 and 80 minute counts, where the 'white-out' was directly over the main body of scoter. By the third set of counts, the main body of scoter was now very distant, but numbers had apparently increased as the flock drifted around on the high tide. Sun glare was less of an issue, but the increased wind speed had increased the swell, particularly as the wind direction was against the incoming tide and drift.

17th March 2003 (Table 3.6)

Low tide was at 1148 and high tide at 1748.

Again, the general pattern was of loafing birds with squabbling groups of males. Although strong glare affected portions of the count, flat sea conditions allowed for easier counting and fewer scoter were lost amongst swell. The scoter were again dispersed, mostly along a band 1.5-2.5 km off the watch-point across the bay although during the third set of counts the rising tide brought the scoter closer inshore (no more than 500 m in places).

29th October 2003 (Table 3.7)

Counts commenced at 0825, just before high tide at 0831. Low tide occurred at 1453, and the final hour of counts began at 1540.

Complete cloud cover meant that visibility was excellent, despite occasional light showers. Birds were widely dispersed, the vast majority loafing and drifting slowly east. Little feeding activity was noted, though such activity was often difficult to detect amongst distant groups; more feeding activity was noted amongst birds along the 1.5-2.0 km band. Many birds were recorded loafing, with some squabbling amongst tighter, more concentrated rafts. As time progressed, the distance from birds increased with the falling tide, making observation, particularly with regard to feeding activity, difficult.

20th November 2003 (Table 3.8)

Low tide was at 0916, so that when counts began at 0830 the tide was falling. The last count session took place at 1514, which coincided exactly with high tide. The northerly wind of around 20 mph created a sea state that at times was judged as moderate. Visibility was considered excellent under complete overcast, despite some light showers.

The general pattern was of loafing birds, most birds drifting or heading west with some feeding activity noted amongst birds at 1.5-2.0 km. As the tide rose, birds appeared around Dolwen Point, drifting west with the rising tide.

24th March 2004 (Table 3.9)

No precipitation was recorded, and cloud cover was partial. The sea state was moderate and there was a moderate northerly breeze (~20 mph). High tide was at 0819, and counts commenced on a rising tide at 0635. The last count session started at 1415, ten minutes before low tide.

Heavy disturbance was recorded between 1000 and 1200, with persistent bombing at RAF Pembrey. This caused at least 360 birds to take flight and fly in a westerly direction to Amroth. At other times, birds were seen loafing and sometimes feeding in small rafts of 5 - 50. Scoters were not seen squabbling throughout the day.

3.1.2.3 'Tidal' studies

Three days of ground counts were also undertaken by NF from the Pendine count station in each winter, with the principal aim being to examine the effect of tidal state on the numbers and distribution of birds noted.

The counts and associated conditions are summarised in Tables 3.10 to 3.15 whilst the distributions of the Common Scoters recorded during these counts are shown in Figures 3.8a and 3.8b. NF recorded further observations pertaining to the counts, as follows:

12th March 2003 (Table 3.10)

Counts began at 0725, following low tide at 0548. High tide was at 1200 and counts continued until 1615 (the next low tide being at 1824).

The offshore distance of the scoters made activity difficult to assess. The birds appeared to be loafing, although feeding could well have been occurring. However, even light swell caused the birds to appear and then disappear very easily. NF wondered whether these birds were diving or just being lost from view, and considered that the latter was most likely in the vast majority of cases. Only occasionally could feeding activity clearly be seen. Small (10-25), tight groups of scoters squabbling were common and when seen at closer range (1 km), these clearly involved groups of males chasing rival males. The majority of flight activity occurred after such 'bouts' when a small number of males would fly away to join other groups. Invariably one or two females were amongst these groups, but again this could only clearly be seen at ranges below 1 km.

14th March 2003 (Table 3.11)

Counts began at 0825 with low tide at 0906. High tide was at 1518 and counts continued until 1655.

Most scoters appeared to be loafing but, as noted on 12th March, activity was difficult to monitor due to the distance and conditions. There were particular problems with sun glare, at its worst during the third count. Otherwise, comments from 12th March also applied.

15th March 2003 (Table 3.12)

Counts began at 0815 with low tide at 1012. Counts continued until 1635, just after high tide at 1618.

Glare was again a major problem, reducing visibility on all counts. Birds were again apparently mostly loafing but, as with the other surveys, actual behaviour was very difficult to monitor in the conditions.

The aerial survey plane passed over the observation point at 1235, resulting in scoter numbers halving on the following count as the bulk of the flock moved too far out to sea to count. Some birds returned but the majority remained well out to sea throughout the rest of the survey period.

28th October 2003 (Table 3.13)

Counts began at 0800, just after high tide at 0746, and continued to 1700, thus including the low tide period at 1408. Cloud cover was complete with light showers from 1300 onwards. Wind was negligible. Visibility was considered excellent, with no glare and the sea 'flat calm'. The light rain did not interfere with counts.

Most birds seemed to be loafing and idly drifting on the water. On the falling tide, birds drifted further from shore, and became increasingly difficult to assess behaviourally beyond 2.5- 3 km.

19th November 2003 (Table 3.14)

Although there was no problem with glare, as cloud cover was near total, a fresh north-easterly breeze (~22 mph) created a moderate sea state. Low tide was at 0832 with high tide at 1428. Counts continued from 0805 to 1655. All behaviour recorded was of loafing or drifting birds, although as many groups of birds were about 3 km from shore it was difficult to assign individual behaviour, as in the previous month.

23rd March 2004 (Table 3.15)

Again, visibility was excellent with minimal glare despite little cloud cover. Wind-speeds were north-westerly at around 18 mph, resulting in a moderate sea state. Counting began at 0715, half an hour before high tide, and ended at 1530, with low tide at 1350. Explosions in the vicinity of RAF Pembrey were noted at around 0930, with prolonged bombing exercises between 1130 and 1215. Approximately 250 scoters were estimated to fly west toward Amroth. Other behaviour predominantly featured loafing, with some feeding birds (including mobbing by Herring gulls) and isolated instances of conspecific squabbling.

Count	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Start time	0745	0845	0945	1045	1145	1245	1345	1445
Precipitation	None	None	None	None	None	None	None	None
Wind speed (mph)	5	5	5	5	5-10	5-10	10	10
Wind direction	NNE	NNE	NNE	NNE	NE	NE	NE	NE
Cloud cover	2/8	2/8	2/8	1/8	0/8	0/8	0/8	0/8
Visibility	4 km	4 km	4 km	4 km	4 km	4 km	4 km	4 km
Sea state	Light swell	Light swell	Light swell	Light swell	Light swell	Light swell	Light swell	Light swell
Disturbance	None	None	None	None	None	None	None	None
5 min (1)	874	945	712	939	627	n.c.	n.c.	n.c.
5 min (2)	796	897	859	821	534	n.c.	n.c.	n.c.
5 min (3)	832	902	958	970	725	638	748	n.c.
10 min (1)	986	1167	1562	1327	1029	955	863	1087
10 min (2)	1024	1390	1483	1322	937	n.c.	n.c.	1235
20 min	1384	1567	1782	1584	1425	1026	1157	1369

Table 3.3 Counts and associated conditions during ‘thoroughness’ counts on 14/2/03.

Count	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Start time	0825	0925	1025	1125	1225	1355	1455	1555
Precipitation	None	None	None	None	None	None	None	None
Wind speed (mph)	10	10	15	15	15	15	15	15
Wind direction	W	W	W	W	W	W	W	W
Cloud cover	0/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8
Visibility	6 km	6 km	6 km	6 km	6 km	6 km	6 km	6 km
Sea state	Light swell	Light swell	White horses	White horses	White horses	White horses	White horses	White horses
Disturbance	None	None	None	See notes	See notes	None	None	None
5 min (1)	1723	1242	1347	819	723	926	832	688
5 min (2)	1685	1310	1202	1112	654	846	743	601
5 min (3)	1791	1139	1289	1011	839	894	632	627
10 min (1)	2343	1663	2316	1839	1846	1682	1563	1466
10 min (2)	2208	1781	1916	1632	1846	1770	1483	1549
20 min	3258	2621	3015	2431	2628	2783	2830	2960

Table 3.4 Counts and associated conditions during ‘thoroughness’ counts on 6/3/03.

Count	**1**	**2**	**3**
Start time	0830	1115	1400
Precipitation	None	None	None
Wind speed (mph)	10	15	15
Wind direction	ENE	ENE	ENE
Cloud cover	1/8	0/8	1/8
Visibility	Worm's Head	Worm's Head	Worm's Head
Sea state	Light swell	White horses	White horses
Disturbance	None	None	None
20 min (1)	1348	1566	2018
20 min (2)	1686	1471	1702
40 min	2356	2015	2839
80 min	3411	2630	3907

Table 3.5 Counts and associated conditions during 'thoroughness' counts on 13/3/03.

Count	**1**	**2**	**3**
Start time	Not reported	Not reported	Not reported
Precipitation	None	None	None
Wind speed (mph)	5	5	10
Wind direction	E	E	E
Cloud cover	0/8	0/8	0/8
Visibility	4 km (hazy)	4 km	4 km
Sea state	Slight swell	Slight swell	Slight swell
Disturbance	None	None	None
20 min (1)	2380	1965	2651
20 min (2)	2634	2106	2367
40 min	4340	4002	2839
80 min	5650	4991	5955

Table 3.6 Counts and associated conditions during 'thoroughness' counts on 17/3/03.

Count	**1**	**2**	**3**	**4**	**5**
Start time	0825	0925	1130	1335	1540
Precipitation	Light showers	Light showers	Light showers	Light showers	Light showers
Wind speed (mph)	2	2	2	2	2
Wind direction	N	N	N	N	N
Cloud cover	8/8	8/8	8/8	8/8	8/8
Visibility	Excellent	Excellent	Excellent	Excellent	Excellent
Sea state	Slight	Slight	Slight	Slight	Slight
Disturbance	None	None	None	None	None
60 min	6,348		5,962		5,655
120 min		7,609		7,398	

Table 3.7 Counts and associated conditions during 'thoroughness' counts on 29/10/03.

Count	**1**	**2**	**3**	**4**	**5**
Start time	0830	0935	1140	1310	1515
Precipitation	Light showers	Light showers	Light showers	Light showers	Light showers
Wind speed (mph)	4-5	4-5	4-5	4-5	4-5
Wind direction	N	N	N	N	N
Cloud cover	8/8	8/8	8/8	8/8	8/8
Visibility	Excellent	Excellent	Excellent	Excellent	Excellent
Sea state	Slight/moderate	Slight/moderate	Slight/moderate	Slight/moderate	Slight/moderate
Disturbance	None	None	None	None	None
60 min	5,527		5,742		6,441
120 min		5,875		6,559	

Table 3.8 Counts and associated conditions during 'thoroughness' counts on 20/11/03.

Count	**1**	**2**	**3**	**4**	**5**
Start time	0635	0745	0955	1105	1415
Precipitation	None	None	None	None	None
Wind speed (mph)	4-5	4-5	4-5	4-5	4-5
Wind direction	N	N	N	N	N
Cloud cover	3/8	3/8	3/8	3/8	3/8
Visibility	Excellent	Excellent	Excellent	Excellent	Excellent
Sea state	Moderate	Moderate	Moderate	Moderate	Moderate
Disturbance	None	None	RAF bombing	RAF bombing	None
60 min	398		749		297
120 min		407		354	

Table 3.9 Counts and associated conditions during 'thoroughness' counts on 24/03/03.

Count	**1**	**2**	**3**	**4**
Start time	0725	0935	1145	1415
Tide state	Rising	Rising	Rising to high	Falling
Precipitation	None	None	None	None
Wind speed (mph)	15	15	15-20	15
Wind direction	NNE	NNE	NE	NE
Cloud cover	2/8	1/8	0/8	0/8
Visibility	Worm's Head	Worm's Head	Worm's Head	Worm's Head
Sea state	Light swell	Light swell	Swell increasing	Light swell
Disturbance	None	None	None	None
Common Scoter total	5309	4302	4027	1597

Table 3.10 Common Scoter totals and associated conditions during 'tidal' counts from Pendine on 12/3/03.

Count	**1**	**2**	**3**	**4**
Start time	0825	1035	1245	1455
Tide state	Falling to low	Rising	Rising	Rising to high
Precipitation	None	None	None	None
Wind speed (mph)	5	5	10	10
Wind direction	SE	SE	SE	SE
Cloud cover	0/8	0/8	0/8	0/8
Visibility	3 km	3 km	2 km	3 km
Sea state	Light swell, mod chop	Light swell, mod chop	Incr swell, chop/surf	Incr swell, chop/surf
Disturbance	None	None	None	None
Common Scoter total	3076	2330	759	3400

Table 3.11 Common Scoter totals and associated conditions during 'tidal' counts from Pendine on 14/3/03.

Count	**1**	**2**	**3**	**4**
Start time	0815	1015	1245	1435
Tide state	Falling	Low	Rising	Rising
Precipitation	None	None	None	None
Wind speed (mph)	5	5	10	10
Wind direction	E	E	E	E
Cloud cover	2/8	1/8	0/8	0/8
Visibility	3 km	3 km	3 km	3 km
Sea state	Light swell, mod chop	Light swell, mod chop	Incr swell, chop/surf	Incr swell, chop/surf
Disturbance	None	None	Survey plane	None
Common Scoter total	3003	2769	1255	1198

Table 3.12 Common Scoter totals and associated conditions during 'tidal' counts from Pendine on 15/3/03.

Count	**1**	**2**	**3**	**4**
Start time	0800	1005	1305	1506
Tide state	High	Falling	Falling to low	Rising
Precipitation	None	None	Light	Light
Wind speed (mph)	1	1	1	1
Wind direction	N	N	N	N
Cloud cover	8/8	8/8	8/8	8/8
Visibility	Excellent	Excellent	Excellent	Excellent
Sea state	Flat calm	Flat calm	Flat calm	Flat calm
Disturbance	None	None	None	None
Total	6,949	5,998	5,928	6,170

Table 3.13 Common Scoter totals and associated conditions during 'tidal' counts from Pendine on 28/10/03. High tide 0746; low tide 1408.

Count	**1**	**2**	**3**	**4**
Start time	0805	1015	1245	1455
Tide state	Low	Rising	Rising	High
Precipitation	None	None	Light	Light
Wind speed (mph)	5	5	5	5
Wind direction	NE	NE	NE	NE
Cloud cover	6/8	6/8	6/8	6/8
Visibility	-	-	-	-
Sea state	-	-	-	-
Disturbance	None	None	None	None
Total	6,008	6,354	6,800	7,277

Table 3.14 Common Scoter totals and associated conditions during 'tidal' counts from Pendine on 19/11/03. High tide 1428; low tide 0832.

Count	**1**	**2**	**3**	**4**
Start time	0715	0925	1225	1435
Tide state	Rising to high	Falling	Falling	Rising
Precipitation	None	None	None	None
Wind speed (mph)	4	5	5	5
Wind direction	NW	NE	NE	NE
Cloud cover	2/8	6/8	6/8	6/8
Visibility	Excellent	-	-	-
Sea state	Moderate	-	-	-
Disturbance	Herring gulls	Explosions	None	None
Total	318	519	525	413

Table 3.15 Common Scoter totals and associated conditions during 'tidal' counts from Pendine on 23/03/04. High tide 0745; low tide 1350.

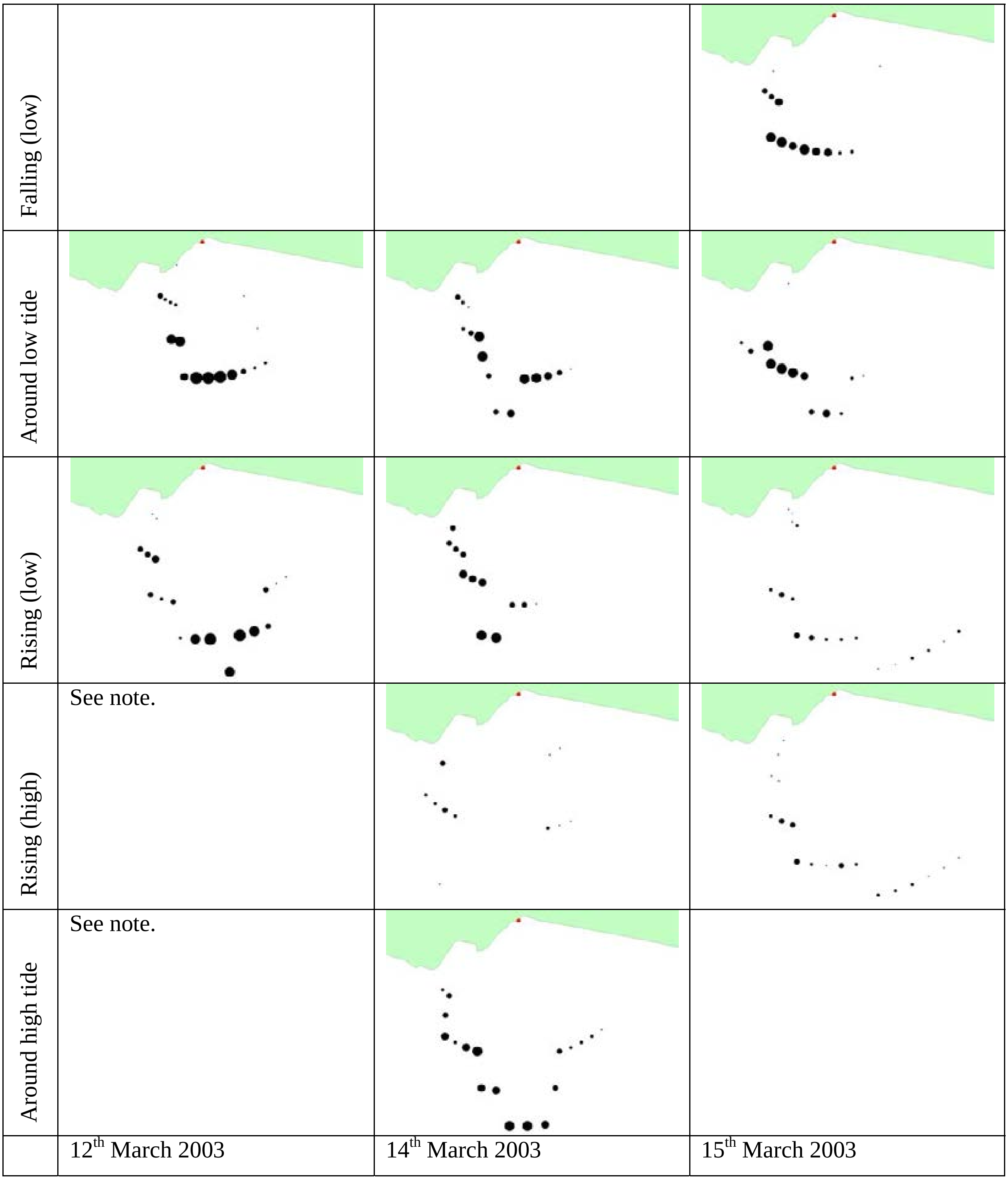


Figure 3.8a Distribution of Common Scoters recorded from the Pendine watchpoint on three dates in March 2003, shown as graduated dots plotted to bearing and distance. Plots have been grouped such that each row of the above 'table' represents an approximate tidal state. Note that data have yet to be fully incorporated for two counts on 12/3/03.

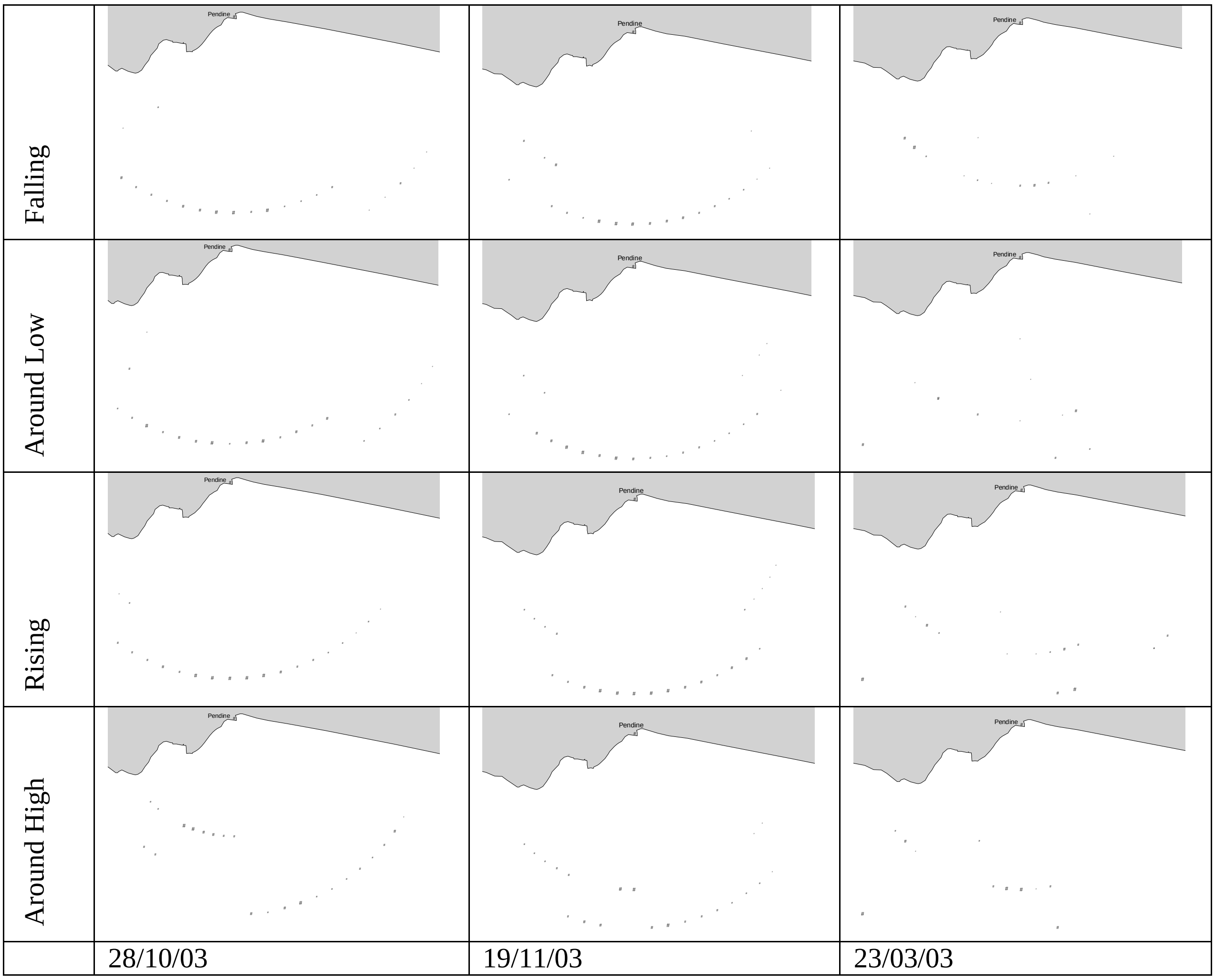


Figure 3.8b Distribution of Common Scoters recorded from the Pendine count station on different tides during three days during the winter of 2003/04.

3.1.2.4 Behavioural studies

The reactions of Common Scoter to the aeroplane were recorded during the two surveys on 25th January 2004 (one distance-method, one census-method), and the three surveys on the 28th and 29th of February 2004 (one distance-method, two census-methods). Tables 3.16 (a and b) – 3.20 (a, b, c) show each observer's qualification of behaviour in response to each pass of the plane.

The overall impression is that the activity of the plane induced widespread disruption amongst the birds in the bay. Movements of thousands of birds were recorded, sometimes up to 1 km in advance of the approaching aircraft. Birds closer to the shore seemed less affected than those further out to sea, although the 'triggering' effect caused by mass movement of scoters often eventually disturbed these smaller flocks. Although some birds usually returned to the areas from which they flushed, large proportions remained out of sight from the ground after the plane had passed. Feeding and loafing behaviour typically resumed a few minutes after the plane departed the bay, but estimated spot counts were usually lower than before the aerial survey. One particularly large disruption seemed to be attributable to a jet plane landing at RAF Pembrey. This type of activity is presumably relatively commonplace when the base is operational, and suggests birds do not routinely habituate to aircraft.

During the January survey, most recordings of movements suggested that birds moved east from Pendine and Amroth, and Table 3.21 suggests that numbers decreased at these stations after both flights. It did not seem to be apparent that birds were being ‘chased’ by the plane, rather that the ducks flew in a generally easterly direction, with some southerly movements further offshore. This pattern applied both to the census-method (east to west transects moving from north to south) and the distance-method (north to south transects moving west to east).

Similar spatial movements were also evident during the February surveys. Again, regardless of survey type, most scoters were recorded flushing in an easterly direction, although some missed counts mean comparisons of movement are difficult. Numbers after the last flight at Amroth did, however, decrease by several hundred (Table 3.22). Interestingly, even though the order of transects was reversed on the second census-method flight (initially west to east transects, later east to west) birds tended to move east, with only a few flocks flushing to the west or south.

Time	**Transect direction**	**Estimated birds affected**	***Reaction to plane***	**Approximate movement**
1120	West	50	Flushed, but ~3,000 birds remained on water	~1,500 birds into area from Amroth direction, settled about 1.8 km offshore
1125	East	2,000	Flushed; ‘widespread panic’ amongst flock	About 1,000 birds scattered locally; another 1,000 flew East until no longer visible from land
1135	West	2,000	Large disturbance	Scattered locally, majority landing South of Pendine but fairly close inshore
1140	East	2,000	Majority of birds that settled closer to shore flushed in response to return of plane	Headed East towards centre of bay, where landed. Offshore, birds scattered but not over any great distance.
1150		>3,000	After plane departed, birds settled and resumed loafing, displaying and chasing	General movement East, scattered over wider area than pre-aerial survey

Table 3.16a Reactions of Common Scoter to census method aerial survey on 25/01/04. Observer: DB; station: Pendine.

Time	Transect direction	Estimated birds affected	Reaction to plane	Approximate movement
1121	West	250	Only those directly under transect path (+/- 100 m) particularly affected	30% of flock moved significant distance, all headed East past Dolwen Point
1125	East	600	Large numbers displaced as plane headed back across bay	Flushed West and South-west, quickly turning and circling once plane had passed, returning to roughly the same area from which they had come
1135	West	Difficult count, but <100 birds left after plane had passed	>95% of birds under the flight path (up to 500 m North of transect path) flushed	Headed East, quickly turning to return to original position on the sea
1136	East	No count possible	Large disturbance: the last birds to settle were at 1144. Birds closest to the coastline (<1 km) less affected, returning to sea after short flight; some showed no reaction. Those further out took flight at both greater distance either side of the transect path and were in flight for much greater periods	Those North of transect headed East, turning quickly towards the coast and settling on the water. Those South also headed East, turning South and continuing for >1 km
1149	West	No count possible	All birds on sea appeared to be sufficiently 'spooked' by the constant disturbance to cause mass movements at some distance to the transect path (up to 1 km)	All headed East; at least 90% quickly wheeled back and return to sea, but some continued East past Dolwen Point toward Pendine
1153	East	No count possible	As the plane passed, birds began to flush wave-like in response to conspecific behaviour, with birds some distance from the transect path being set off by those 'fleeing' the passing plane	70% headed West, with 30% East. Again, the majority quickly 'wheeled' and returned, but increasing numbers (~500) headed West toward Pendine
1205	West	260	Smaller numbers flushed	East, wheeled around after plane had passed
1209	East	90	Few birds seen to react, 'wheeling' quickly	
1219	West	50	Flushed	East
1223	East	200	Flushed	West, quickly returning to sea

Table 3.16b Reactions of Common Scoter to census method aerial survey on 25/01/04. Observer: NF; station: Amroth.

Time	Transect direction	Estimated birds affected	Reaction to plane	Approximate movement
1450	North	~4,000	Flushed; plane audible but not visible to observer	West to East past Pendine from Amroth. Most travelled beyond view into the bay
1500	South	~2,000	Large disturbance, flushing from feeding grounds	Mostly East into the bay; smaller movement West to Amroth
1505	North	Min. 1,000	Large degree of scattering and 'swirling' seen at distance in the bay	Not possible to record
1515		848	Few settled birds remained after plane departure, although tide falling	Further away from shore, into bay

Table 3.17a Reactions of Common Scoter to distance method aerial survey on 25/01/04. Observer: DB; station: Pendine.

Time	**Transect direction**	**Estimated birds affected**	**Reaction to plane**	**Approximate movement**
1434	South	280	Flushed, but small groups near the coastline remained on the water, showing no reaction (30)	Flew East and after 5 minutes had returned, wheeling round and returning to same area from which they had come
1442	North	340	Flushed	Flew East and after 5 minutes had returned, wheeling round and returning to same area from which they had come
1441	South	>1,300	Birds further out to sea flushed in their hundreds, parting in equal numbers East and West away from the transect line/ path of the plane. The 'panic' continued for 5 minutes with fewer birds returning than had left (~70% returning), triggering birds further East to take-off long after the plane had passed	Birds begin to 'wheel' and all then head East toward Pendine
1451	North	>2,500	Birds that were not seen at 3 km from shore, suddenly took flight as the plane passed over them. Only birds <1 km from coastline appeared to be unaffected; however the triggering effect of large numbers flushing eventually affected these birds and they also took flight	All East, then 'wheeling' around and heading West before heading East again. Few birds returned to settle on the water
1452	South	>4,000	The sharp overland turn of the plane meant that birds had not resettled as the plane passed over again. Birds that had yet to be disturbed caused further panic and many thousands of Scoter were seen scattering in all directions	After five minutes, birds began to re-settle on the water, but clearly there was a movement of birds East toward Pendine. Fewer birds were left on the water off Amroth

Table 3.17b Reactions of Common Scoter to distance method aerial survey on 25/01/04. Observer: NF; station: Amroth.

Time	Transect direction	Estimated birds affected	Reaction to plane	Approximate movement
1400	West	3,000	Large-scale movement	West to East, towards Pembrey. Most flew several km and landed beyond view (>3 km)
1405	West	>3,000	Majority of visible birds flushed; mass panic. Few hundred scattered individuals remained ~1 km offshore	East, settling 3-4 km offshore
1410	East	>2,000	Flushed	West, settling 2 km West of Pendine
1419	West	1,000	Flushed	Majority headed East, flying beyond view into the bay (>3 km). Rest circled before landing approx. 1.5 km South of Pendine
1425	East	500	Flushed	Moved 0.5 km East
1435			Within 5 minutes of aircraft departure, birds resumed normal chasing/displaying behaviour	

Table 3.18a Reactions of Common Scoter to first census method aerial survey on 28/02/04. Observer: DB; station: Pendine.

Time	Transect direction	*Estimated* birds affected	Reaction to plane	Approximate movement
1335	East	60	Birds along flight-path flushed off sea	Headed East, wheeling around after plane had passed and resettled on water after 3 minutes in the same area from which they had arisen
1347	West	100s	All flushed off sea as plane approached (600m)	West. 4 VS followed, all returned to roughly the same area after 2-3 minutes in air, wheeling around until the plane had passed
1351	East	1,000	All flushed	East, wheeling around quickly after plane passed and resettling within 2 minutes. ~50% of scoter resettled closer to shore amongst the band of birds already on the water between 1 and 2 km from coast
1405	West	0	None	
1409	East	No count possible	All flushed as plane approached. Birds in open water at >2 km most easily flushed, though birds closer to the shore began to take flight and similarly returned to the sea once plane had passed	East. Once plane had passed the birds quickly 'wheeled' and returned to the water, to the same area from where they flushed. Small number (20) moved West. 13 VS followed, returning to sea after 2 minutes of initially heading East and then 'wheeling' around several times before settling 1.5 km from count station
1421	West	>3,500	All initially flushed. Large numbers of birds in the air (1,000s) as the main band of birds took flight. Generally a scene of mass hysteria as the main body of birds set one another off. The 13 VS targeted to watch (due to the ease with which to pick them out amongst the mass of birds) took flight as the plane approached at 600 m	Initially West, before quickly wheeling and heading East. The VS headed West, then East once the plane overtook the group; then joined by other VS, finally totalling 33 birds. The VS continued to wheel around, briefly settling before the plane returned for its East transect
1424	East	>3,500	Many birds still in the air following the previous pass, the VS take to the air again having spent less than a minute on the sea, but begin actively feeding after ~5 minutes airborne. Many of the CX still in the air wheeling in all directions, unsettled by the quick turn around of the plane. The Scoters finally settle at 1432, though fewer birds appear to be present on the water.	The group of VS were recorded heading East then wheeling West after plane has passed. Continue to wheel around for 5 minutes before settling on the sea at the same location as before disturbance. Many CX headed East and did not return. Birds further out could be seen in the air heading East.

Table 3.18b Reactions of Common Scoter to first census method aerial survey on 28/02/04. Observer: NF; station: Amroth.

Time	Transect direction	Estimated birds affected	Reaction to plane	Approximate movement
1625	East	1,500	Flushed from West of Pendine	Headed East towards Pembrey. Flew several km and landed beyond view
1635	West	~500	Flushed from water 2-3 km offshore	Swirled, landed roughly same area
1640		>10,000	Massive displacement in response to low-flying aircraft (possibly jet landing at RAF Pembrey). Birds swirling everywhere	Most landed East or South-east of Pendine, several km out in the bay

Table 3.19a Reactions of Common Scoter to second census method aerial survey on 28/02/04. Observer: DB; station: Pendine.

Time	Transect direction	Estimated birds affected	Reaction to plane	Approximate movement
1623	East	>500	Birds flush East and West either side of flight-path. Group of 500 causes others to react as they are 'dragged along' with them. Such 'chain reactions' appear to cause large movements away from the locality. After 6 minutes all birds have returned to the water, 140 Scoter return to the sea from further East at 1631	Most wheel and quickly return. 500 head East and past Telpyn Point, toward Pendine.
1638	South-east toward Rhossili	3,000	Mass pandemonium ensued as a plane headed South-east at very low altitude (N.B. this may have been activity at RAF Pembrey). Many thousands of birds in the air, heading in all directions	Birds wheeled around once plane had passed, many headed East and South-east out to sea, and did not return
1653	West	300	Small numbers (~300) flushed	Birds 'wheeling' and returning to the sea from the same area. The VS are followed, returning to near the area from which took-off after 2 minutes in flight
1655	East	No count possible	Flushed	All head East, quickly resettling after 2 minutes of wheeling around two-three times

Table 3.19b Reactions of Common Scoter to second census method aerial survey on 28/02/04. Observer: NF; station: Amroth.

Time	Transect direction	Estimated birds affected	Reaction to plane	Approximate movement
1206	North	2,000	Large-scale movement as plane flew over Cefn Sidan	East to West past Pendine
1217	South	3,000	Large-scale movement as plane flew South from Pendine	Birds moved East from Amroth and into the bay, where majority landed >3 km from shore
1228	South	Few 100	Subsequent transects had lesser effect. Some small movements only	Few hundred birds joined larger flocks ~2 km offshore

Table 3.20a Reactions of Common Scoter to distance method aerial survey on 29/02/04. Observer: DB; station: Pendine.

Time	Transect direction	Estimated birds affected	Reaction to plane	Approximate movement
1206	South	0	None	400 passing birds flying West, flushed from transect further to East
1212	North	0	None	
1217	South	1,000	All scoter in observation area flush	East, continuing East and South-east. ~3,500 head East, comprising those from this and DB's area, joining birds already in the air, into the area observed by RT. ~1,000 (in varying small groups) begin to wheel around after 2 minutes but land on the sea further East of the observation area at >2.5 km; the rest continue East and South East at >3 km
1224	North	0	No Scoter in observation area	
1226	North	550		Scoter heading West at 3 km, wheeling around and heading back East
1227	North	480		Begin to start streaming East from Amroth
1230	South	3,000	Scoters begin to stream out of Amroth, wheeling around for several minutes and then settling on sea at >3 km. Once plane had passed >1,000 headed back toward Amroth	South-east into Carmarthen Bay from Amroth

Table 3.20b Reactions of Common Scoter to distance method aerial survey on 29/02/04. Observer: NF; station: Pendine.

Time	Transect direction	Estimated birds affected	Reaction to plane	Approximate movement
~1205	North	2,850	Large-scale movement as plane flew over Scoter flock. About 95% of flock flushed	East initially, then doubling back to land on the sea. Much more scattered and further offshore when resettled
~1216	North	No count possible	Flushed	Most birds flew a few 100 m West, then returned to area from where flushed
~1220	South	No count possible	Flushed. Joined by ~2,000 birds from West, presumably flushed by plane	Most birds flew a few 100 m East, then again returned to area from where flushed
~1226	North	No count possible	Birds remained on sea, but joined by a few hundred birds from West, presumably flushed by plane	

Table 3.20c Reactions of Common Scoter to distance method aerial survey on 29/02/04. Observer: RT; station: Pendine.

Observer	Count station	Count 1	Count 2	Count 3
DB	Pendine	3000	3257	848
NF	Amroth	5285	4942	2833
RT	Rhossili	218	151	208

Table 3.21 Co-ordinated 60-minute counts of Common Scoter from three count stations in Carmarthen Bay, 25/01/04.

Observer	Count station	Count 1	Count 2	Count 3
DB	Pendine	5843	-	-
NF	Amroth	3147	3438	2764
RT	Rhossili	71	68	54

Table 3.22 Co-ordinated 60-minute counts of Common Scoter from three count stations in Carmarthen Bay, 28/02/04.

3.2 Aerial Counts

3.2.1 Aerial Census-method Counts

Four census-method survey flights were flown to count Common Scoters in Carmarthen Bay in each winter. In all first winter flights, counts were carried out by RS and LS, whereas counters in the second winter were AB, BH and RS, in various combinations (RS and BH for the first flight, AB and BH for the second and third flights, and AB and RS for the fourth flight).

The total counts made are summarised in Table 3.23a and b, whilst the distributions of Common Scoters recorded are shown in Figures 3.9a and b – 3.12a and b. As the figures show, the two March 2003 flights were not carried out as far south as those in January, given that all information suggested relatively few birds present in this area. Also, the flights in February and March 2004 did not include the southernmost cells; the former because of daylight restrictions and the latter because an earlier distance-method survey had revealed negligible numbers of Common Scoter in the area.

In 2002, the observers noted whether scoters were recorded on the sea or in flight (flushed by the plane in the majority of cases), as well as the direction of flight, but in 2003 the observers concentrated on counts alone. Scoters most often flew, where recorded, in a direction away from the plane. The proportions of birds in flight and the direction of flight is summarised in Table 3.24.

Additionally, small numbers of other species were also recorded during the flights, the totals of which are summarised in Table 3.25a and 3.25b.

Census-method counts of Common Scoter in 2002-03 peaked at 10,309 during the month of January. The same month contained the peak count for the following winter, although at 20,271, the peak was almost doubled. Within field seasons, counts on consecutive days in January 2003 were different by nearly 1,500, whereas in March 2003 (consecutive days) and February 2004 (two counts on the same day) numbers varied by just 384 and 256 respectively.

3.2.2 Aerial Distance-method Counts

The counts for the two winters are summarised in Table 3.26a and 3.26b. Tables 3.27a and 3.27b summarise the recorded behaviour of the scoters noted during the flights. Unlike with the census-method aerial surveys, the direction of flushing away from the plane was not consistently recorded, given the greater complexity of the distance-method recording procedure. Tables 3.28a and b summarise the other species recorded during the flight. Figure 3.13 shows the flight path recorded by GPS on 15/3/03, which was essentially the same route followed on each flight in 2002-03. Figures 3.14 – 3.16 show the flight tracks taken on 10th October, 29th of February and 27th March during 2003-04.

Although recording distribution was not the primary aim of the distance-method flights, the distribution of Common Scoters recorded on these flights is depicted in Figures 3.17a and b to 3.21. It should be noted that during the first two flights in the first winter, there were problems with the GPS used by the survey team to record their position. However, the GPS used by the pilot and navigator to fly the plane along the predetermined route was operational and the start and end times of each transect were recorded. Therefore, it was possible to derive approximate, but fairly accurate, positions for the observed clusters of scoters, as mapped in Figures 3.17a to 3.20a, by assuming the same flight path as was flown on 15/3/03.

In the second winter, more flight tracks could be obtained for plotting distribution of scoters, thanks largely to the acquisition of WinWedge software (Taltech; Philadelphia, USA). However, on two flights (23rd November 2003 and 24th January 2004), tracks were either incomplete or unobtainable, and so using the same method as for the previous season, clusters could be plotted fairly accurately on similar flight paths.

Counts estimated by distance sampling in the first winter peaked at 19,909 in December 2002, with confidence limits of 10,803 – 36,690 (Table 3.29a). In the second winter, peak counts were made in January, reaching an estimated 17,999 Common Scoters, with confidence limits of 11,665 – 27,774 (Table 3.29b). No counts were made in December 2003, but the point estimates for January in each year were broadly comparable, as were the 95% confidence limits, totalling 15,417 birds (7,840 – 22,672) in the first winter and 17,999 (11,665 – 27,774) in the second. Comparing March counts between winters, the second winter count was only 391 birds larger than on the 15th March 2003 count, but considerably larger than that on the 16th March 2003. Point estimates for March 2003 were lower than in the same month in 2004, but there is considerable overlap between the confidence limits.

3.2.3 All Aerial Surveys Summary

Early December 2002
A total of 11,004 Common Scoter was recorded during a distance-method flight on 1/12/02, which resulted in an estimate of 19,909 birds (95% CI = 10,803-36,690). The single flight located scoters spread over a wide area. The densest concentration was located well offshore, at least 7 km away from any of the ground stations. A second main cluster was situated closer to shore between Amroth and Pendine. Only small numbers were found off Pembrey.

Early January 2003
A total of 5,408 Common Scoter was recorded during a distance-method flight on 4/1/03, which resulted in an estimate of 15,417 birds (95% CI = 7,840-30,317). Two census-method flights were carried out, on 4/1/03 and 5/1/03, during which totals of 8,835 and 10,309 were recorded respectively. Birds were again scarce inshore off Pembrey but were widespread further west. However, most of the birds were well offshore, with few closer than 3 km and some major concentrations as far as 9 km offshore.

Mid March 2003
Totals of 9,690 and 5,984 Common Scoter were recorded during distance-method flights on 15/3/03 and 16/3/03 respectively, which resulted in estimates of 13,337 (95% CI = 7,846-22,672) and 9,819 (95% CI = 6,071-15,881) birds respectively. Two census-method flights were carried out, on 15/3/03 and 16/3/03, during which totals of 7,956 and 7,572 were recorded respectively. The scoters were grouped into two broad areas. The densest concentrations were found between 2 and 5 km off Pembrey Sands, although substantial numbers were dispersed up to 8 km offshore. The other group was found between about 2 and 5 km off Amroth and Pendine, in an area about 10 km from east to west. These two groupings were separated by a gap of about 4 km where relatively few scoters were located.

Mid October 2003
During this early season flight, 4,796 Common Scoter were recorded, giving an estimate of 4,944 (95% CI = 3,097– 7,860) birds. The greatest concentrations were found between 4.5 km and 6 km off Pendine Sands. Only scattered individuals and small flocks were found off Pembrey and Rhossili.

Late November 2003
Scoter flocks were more widely distributed throughout the bay on the 23/11/03 distance-method flight, although the majority of birds seemed to be within waters <10 m deep. The largest concentrations were recorded in the middle of the bay, between 6 and 7 km from shore, although off Pendine Sands some flocks of over 1,500 were noted at about 2.7 km. The tide at this time was rising from low at 1130. Total numbers counted were 10,058, giving an estimate of 11,097 birds (95% CI = 7,267 – 16,944).

Late January 2004
The distance-method flight on January 25th 2004 produced a total count of 12,471 Common Scoter. This resulted in an estimate of 17,999 scoters (95% CI = 11,665 – 27,774). A census-method survey

on the same day yielded counts of 20,271 scoters, which is within the confidence limits generated on the distance flight. Distributions plotted were largely similar between the two methods, with large flocks between 2 and 4 km from the shore at Pendine. Secondary concentrations were observed off Pembrey.

Late February 2004
Two census-method surveys, on the morning and afternoon of the 28th of February, produced counts of 5,234 and 5,024 respectively. These relatively low counts were coupled with a low count on the distance-method flown on 29th February. On this date, 2,458 scoters were observed, giving an estimate of 2,336 (95% CI = 1,550 – 3,519). This lower figure resulted from a detection function where birds nearest the transect were missed, *i.e.* counters over-estimated distance of flocks. Most birds seemed concentrated close to the coastline between Amroth and Pendine. The morning census flight also revealed some smaller aggregations between 2 and 10 km off the Permbrey coast. These same areas were favoured the following day on the distance-method flight.

Late March 2004
A distance-method flight on the morning of 27th of March resulted in a total of 10,081 Common Scoter recorded, scaled up to a point estimate of 15,086 (95% CI = 8,977 – 25,353). The census-method flight on the same afternoon provided a count of 5,431 individuals. Although there was a discrepancy between the numbers counted, distributions were similar. The north-west corner of the bay was mostly favoured, with highest concentrations from Saundersfoot to Pendine. Another congregation was found further into the bay, about 8 km off the mouth of the Burry Inlet.

Date	**Start**	**End**	**Tide (approx)**	**RS (Port)**	**LS (S'b)**	**SH (S'b)**	**Total LS+RS**
04/01/2003	1033	1314	Rising to high	5860	2975	n.a.	8835
05/01/2003	1246	1540	Low	5724	4585	n.a.	10309
15/03/2003	1432	1710	High	4979	2977	1088	7956
16/03/2003	1008	1219	Low	4140	3432	1047	7572

Table 3.23a Totals of Common Scoters recorded on census-method aerial surveys 2002-03.

Date	**Start**	**End**	**Tide (approx)**	**Starb'd count**	**Port count**	**Total**
12/10/03	1009	1123	Falling	2,302	1,772	4,072
25/01/04	1438	1557	Low	11,912	8,359	20,271
28/02/04	1222	1431	Falling	2,617	2, 864	5,234
28/02/04	1616	1718	Falling to low	2,859	2,165	5,024
27/03/04	1438	1615	Falling to low	2,875	2,538	5,431

Table 3.23b Totals of Common Scoters recorded on census-method aerial surveys 2003-04. Figures in grey indicate training flight.

Date	**On sea**	**In flight**								**Overall total**
		North	**East**	**South**	**West**	**NE**	**SE**	**Unspec.**	**Total flight**	
04/01/2003	4171	3643	205	0	0	816	0	0	4664	8835
05/01/2003	4854	3470	1122	0	0	13	850	0	5455	10309
15/03/2003	2478	2089	27	3346	0	0	0	16	5478	7956
16/03/2003	2575	2123	7	1959	5	0	0	903	4997	7572

Table 3.24 Behaviour and direction of flight of Common Scoters detected during the census-method aerial surveys (first winter). The figures tabulated are the combined totals from LS and RS.

Date	**04/01/03**	**05/01/03**	**15/03/03**	**16/03/03**
Red-throated Diver *Gavia stellata*	0	0	3	2
Great Northern Diver *Gavia immer*	0	0	0	1
Unidentified Diver *Gavia sp.*	0	2	0	1
Cormorant *Phalacrocorax carbo*	0	0	6	2
Eider *Somateria mollissima*	0	0	2	0
Long-tailed Duck *Clangula hyemalis*	0	0	0	2
Velvet Scoter *Melanitta fusca*	0	1	0	9
Red-breasted Merganser *Mergus serrator*	0	0	4	0
Unidentified Auk *Alcidae sp.*	0	0	12	0
Unidentified Seal *Phocidae sp.*	1	0	1	1
Porpoise *Phocoena phocoena*	0	0	0	1

Table 3.25a Other species recorded during the census method flights 2002-03. Totals of two observers shown for each date. Gulls and waders not recorded.

Date	**25/01/04**	**28/02/04a**	**28/02/04b**	**27/03/04**
Red-throated Diver *Gavia stellata*	12	10	11	-
Great Northern Diver *Gavia immer*	1	-	-	-
Cormorant *Phalacrocorax carbo*	7	4	6	7
Shag *Phalacrocorax aristotelis*	-	-	-	1
Eider *Somertaria mollissima*	-	-	-	9
Velvet Scoter *Melanitta fusca*	8	3	4	-
Red-breasted Merganser *Mergus serrator*	-	-	1	-
Auk sp. *Alcidae* sp.	-	30	7	33
Grey Seal *Halichoerus grypus*	-	1	-	-
Harbour Porpoise *Phocoena phocoena*	-	1	-	1
Leatherback Turtle *Dermochelys coriacea*	-	1	-	-

Table 3.25b Other species recorded during the census method flights 2003-04. Totals of two observers shown for each date. Gulls and waders not recorded.

Date	Start	End	Tide (approx)	RS (Port)	LS (S'b)	SH (S'b)	Total LS+RS
01/12/2003	1130	1338	Rising	5947	5057	n.a.	11004
04/01/2003	1350	1545	Rising from low	2695	2713	n.a.	5408
15/03/2003	1123	1311	Rising	7288	2402	n.a.	9690
16/03/2003	1319	1513	Rising	4085	1899	360	5984

Table 3.26a Totals of Common Scoters recorded on distance-method aerial surveys 2002-03.

Date	Start	End	Tide (approx)	RS	AB	BH	SH	Total
11/10/03	1216	1326	Low	3032	N/a	1764	N/a	4796
11/10/03	1504	1622	Rising	N/a	1322	N/a	1330	2,652
23/11/03	1233	1354	Low, rising	5841	N/a	4217	N/a	10,058
25/01/04	1436	1546	Falling to low	7041	N/a	5430	N/a	12,471
29/02/04	1122	1242	Rising to high	N/a	1541	917	N/a	2,458
27/03/04	1134	1249	Falling	5591	4490	N/a	N/a	10,081

Table 3.26b Totals of Common Scoters recorded on distance-method aerial surveys 2003-04. Figures in grey indicate training flight.

Behaviour	01/12/2002	04/01/2003	15/03/2003	16/03/2003	Total	%
Flushing	7073	3271	5383	5146	20873	65
Flying	1249	19	2	620	1890	6
Sitting	2682	2043	3986	208	8919	28
Not recorded		75	319	10	404	1
Total	11004	5408	9690	5984	32086	

Table 3.27a Behaviour of Common Scoters detected during the distance method aerial surveys 2002-03. Totals are combined from two observers.

Behaviour	11/10/03	23/11/03	25/01/04	29/02/04	27/03/04	Total	%
Flying	1,637	1,912	7,252	2,299	6,243	19,343	49%
Sitting	3,159	8,146	5,219	159	3,838	20,521	51%
Total	4,796	10,058	12,471	2,458	10,081	39,864	

Table 3.27b Behaviour of Common Scoters detected during the distance method aerial surveys 2003-04. Totals are combined from two observers.

Species	Date			
	01/12/2002	04/01/2003	15/03/2003	16/03/2003
Red-throated Diver *Gavia stellata*	2	12	2	4
Diver sp. *Gavia sp.*	3	11	4	5
Fulmar *Fulmarus glacialis*	3	1	2	
Gannet *Morus bassanus*		2		
Cormorant *Phalacrocorax carbo*	9	2	21	40
Shag *Phalacrocorax aristotelis*			2	1
Cormorant sp. *Phalacrocorax sp.*			2	
Eider *Somateria mollissima*			2	
Velvet Scoter *Melanitta fusca*	1		2	7
Red-breasted Merganser *Mergus serrator*	3		1	
Kestrel *Falco tinnunculus*			1	
Oystercatcher *Haematopus ostralegus*	2		25	
Wader sp. *Charadrii sp.*	162			
Black-headed Gull *Larus ridibundus*		16		
Common Gull *Larus canus*		19		
Lesser Black-backed Gull *Larus fuscus*	1	1		
Herring Gull *Larus argentatus*	17	34		
Great Black-backed Gull *Larus marinus*		4		
Kittiwake *Rissa tridactyla*	59	17		
Gull sp. *Laridae sp.*	21	363		
Guillemot *Uria aalge*	8		5	
Auk sp. *Alcidae sp.*	82	33	32	34
Grey Seal *Halichoerus grypus*	1			
Seal sp. *Phocidae sp.*			1	1
Porpoise *Phocoena phocoena*	2	6	1	4
Dolphin sp. *Delphinidae sp.*				1

Table 3.28a Other species recorded during the distance method flights 2002-03. Totals of two observers shown for each date. Gulls and waders not recorded.

Species	Date				
	11/10/03	23/11/03	25/01/04	29/02/04	27/03/04
Red-throated Diver *Gavia stellata*	-	10	11	6	3
Great Northern Diver *Gavia immer*	5	-	-	-	-
Cormorant *Phalacrocorax carbo*	35	9	1	1	23
Shag *Phalacrocorax aristotelis*	8	-	1	-	4
Eider *Somertaria mollissima*	-	-	10	4	16
Red-breasted Merganser *Mergus serrator*	-	3	-	-	-
Auk sp. *Alcidae* sp.	35	26	8	52	68
Grey Seal *Halichoerus grypus*	1	-	1	-	-
Harbour Porpoise *Phocoena phocoena*	2	-	1	2	5
Bottlenose Dolphin *Tursiops truncatus*	-	-	2	-	-

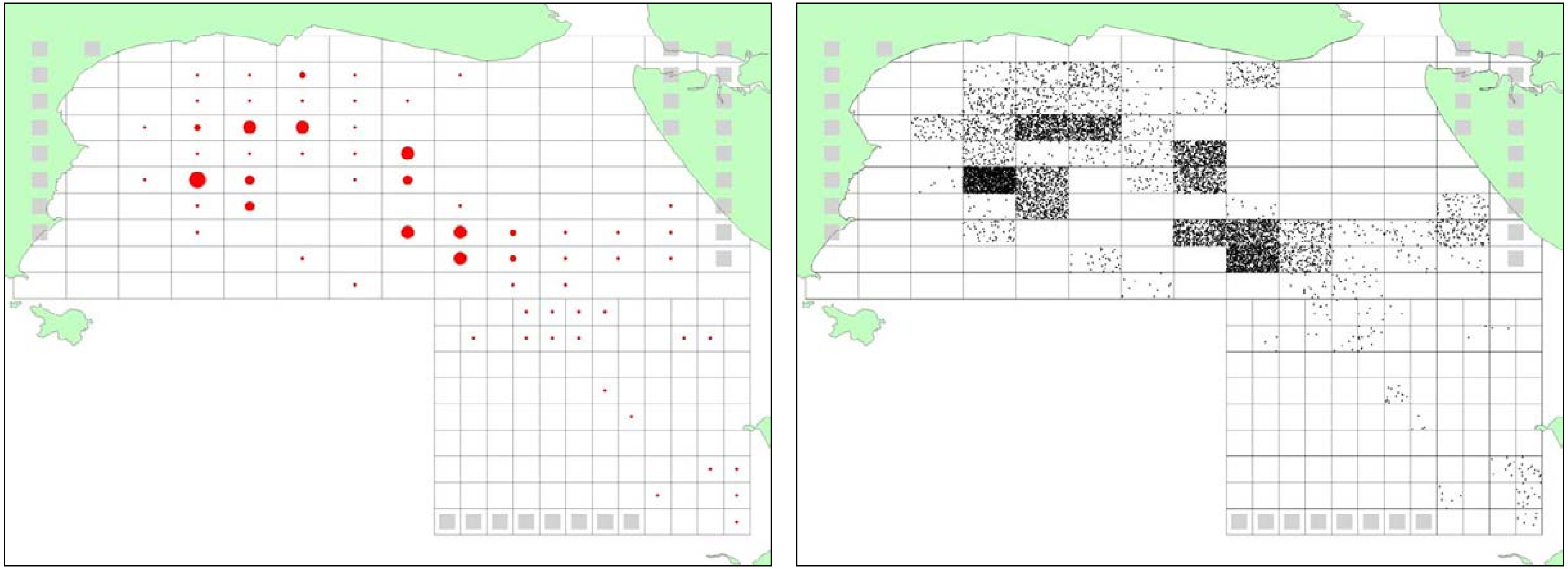
Table 3.28b Other species recorded during the distance method flights 2003-04. Totals of two observers shown for each date. Gulls and waders not recorded.

Date	DS	E(s)	D	N
01/12/2003	1.416 (0.954-2.102)	38.97 (23.78-63.86)	55.19 (29.99-101.70)	**19909** (10803-36690)
04/01/2003	1.074 (0.613-1.880)	40.81 (26.69-62.40)	43.82 (22.28-86.16)	**15417** (7840-30317)
15/03/2003	1.829 (1.160-2.887)	20.60 (15.23-27.86)	37.69 (22.17-64.06)	**13337** (7846-22672)
16/03/2003	1.788 (1.189-2.688)	15.51 (11.70-20.55)	27.73 (17.14-44.84)	**9819** (6071-15881)

Table 3.29a Estimated cluster density DS, cluster size E(s), density of individuals D and total numbers N (with analytical 95% confidence intervals) for each distance-method survey in the first winter.

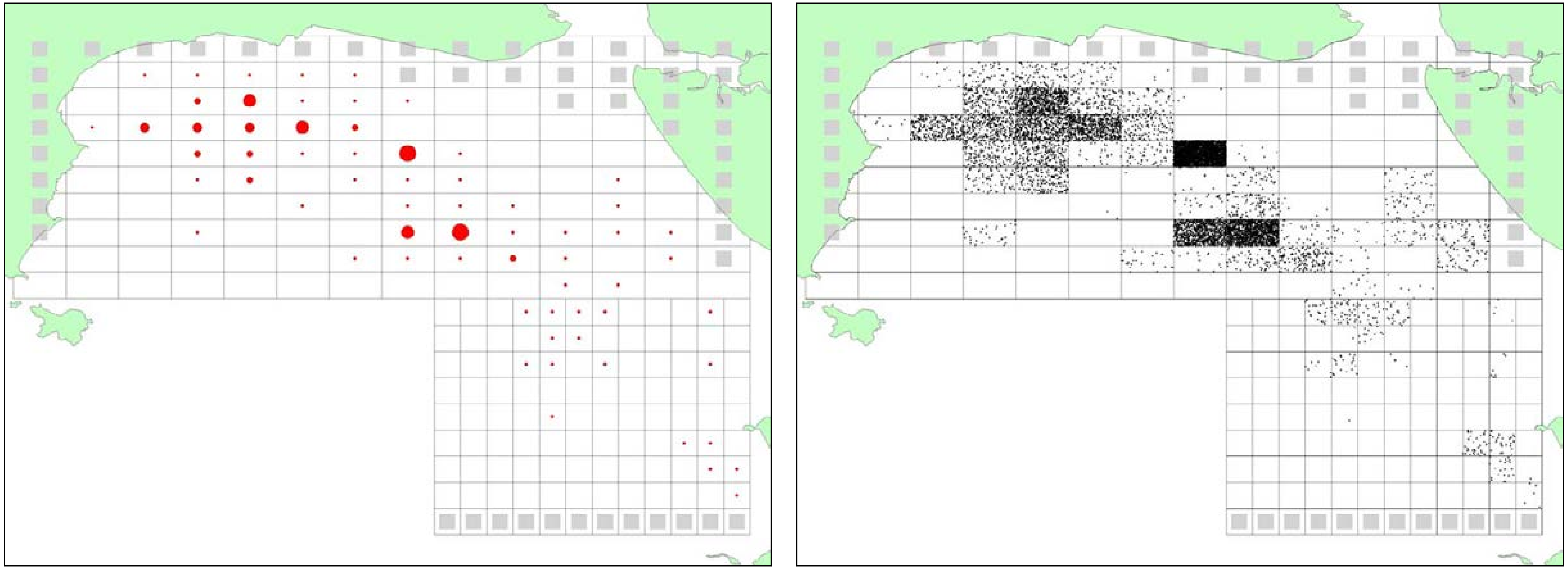
Date	DS	E(s)	D	N
October_1	0.67 (0.47-0.93)	21.14 (15.17-29.45)	14.08 (8.84-22.43)	**4944** (3097-7860)
October_2	0.57 (0.42-0.78)	13.09 (9.76-17.56)	7.50 (4.94-11.39)	**2578** (1698-3915)
November	0.85 (0.64-1.13)	39.31 (28.45-54.31)	33.60 (22.01-51.31)	**11097** (7267-16944)
January	1.12 (0.89-1.57)	52.21 (37.29-74.00)	61.51 (39.86-94.92)	**17999** (11665-27774)
February	0.49 (0.45-0.69)	13.49 (10.65-17.07)	6.57 (4.36-9.89)	**2336** (1550-3519)
March	0.75 (0.54-1.05)	59.87 (39.74-90.20)	45.08 (26.83-75.76)	**15086** (8977-25353)

Table 3.29b Estimated cluster density DS, cluster size E(s), density of individuals D and total numbers N (with analytical 95% confidence intervals) for each distance-method survey in the second winter. Figures in grey indicate training flight.



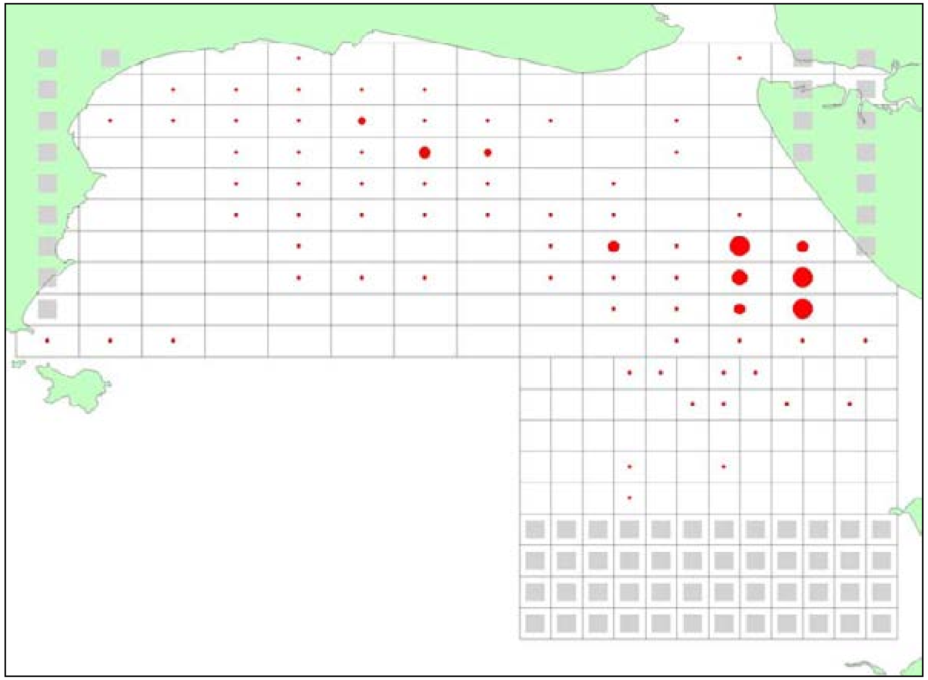
i) ii)

Figure 3.9a Distribution of Common Scoters recorded during aerial census-method counts on 4/1/03. Counts are those of RS and LS combined, depicted as i) graduated symbols centred in each counted grid cell and ii) dot-density maps of counts within grid cells. Grey squares denote non-counted cells.

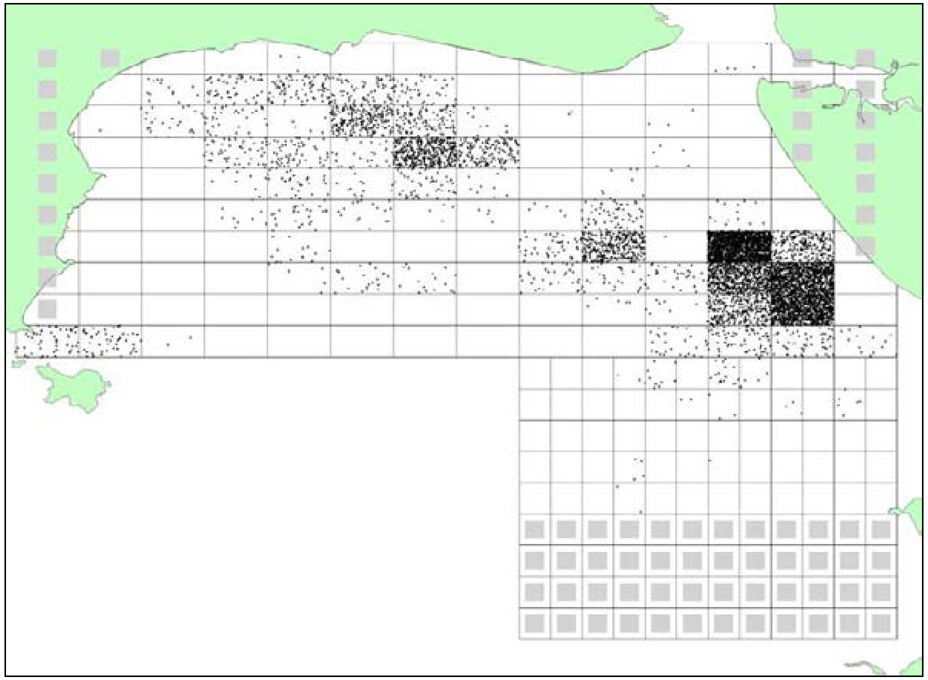


i) ii)

Figure 3.10a Distribution of Common Scoters recorded during aerial census-method counts on 5/1/03. Counts are those of RS and LS combined, depicted as i) graduated symbols centred in each counted grid cell and ii) dot-density maps of counts within grid cells. Grey squares denote non-counted cells.

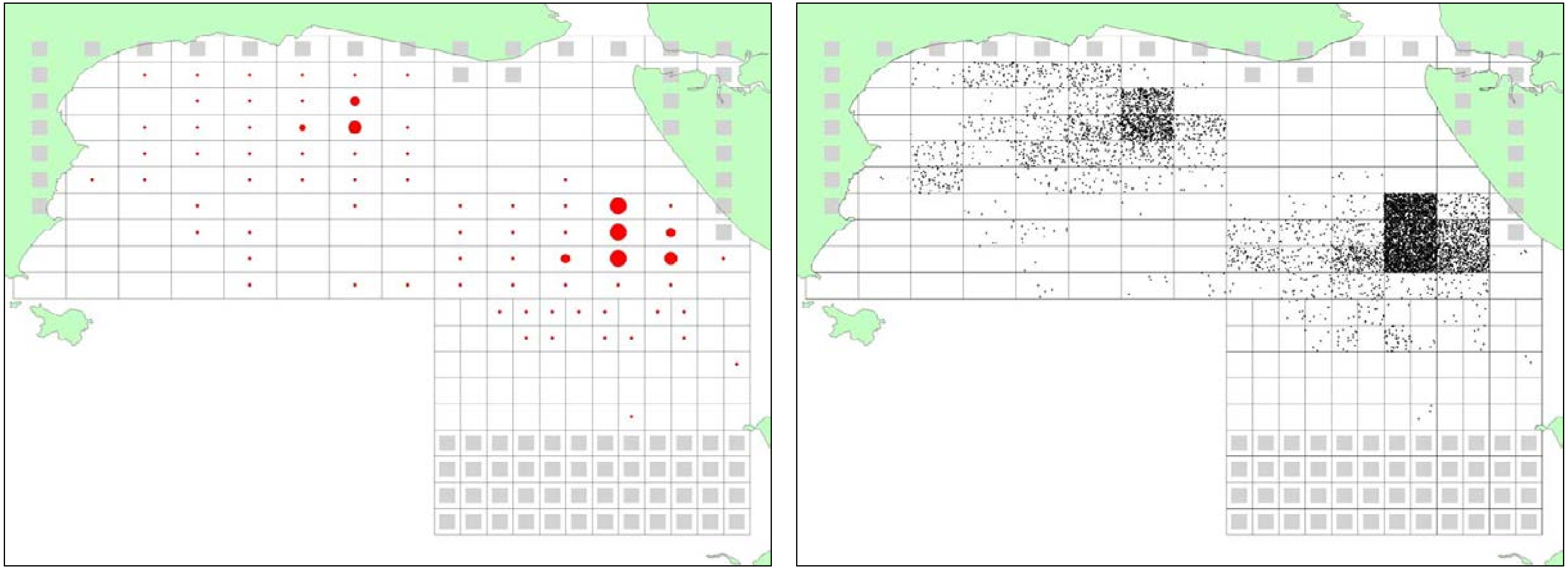


i)



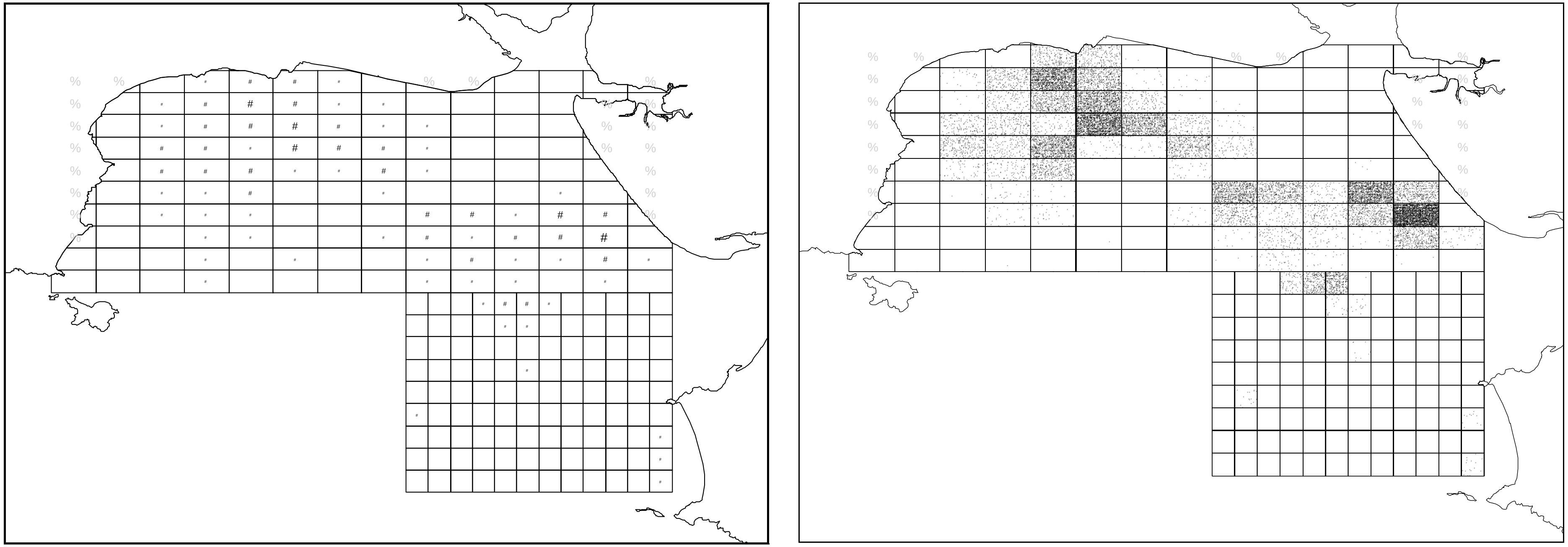
ii)

Figure 3.11a Distribution of Common Scoters recorded during aerial census-method counts on 15/3/03. Counts are those of RS and LS combined, depicted as i) graduated symbols centred in each counted grid cell and ii) dot-density maps of counts within grid cells. Grey squares denote non-counted cells.



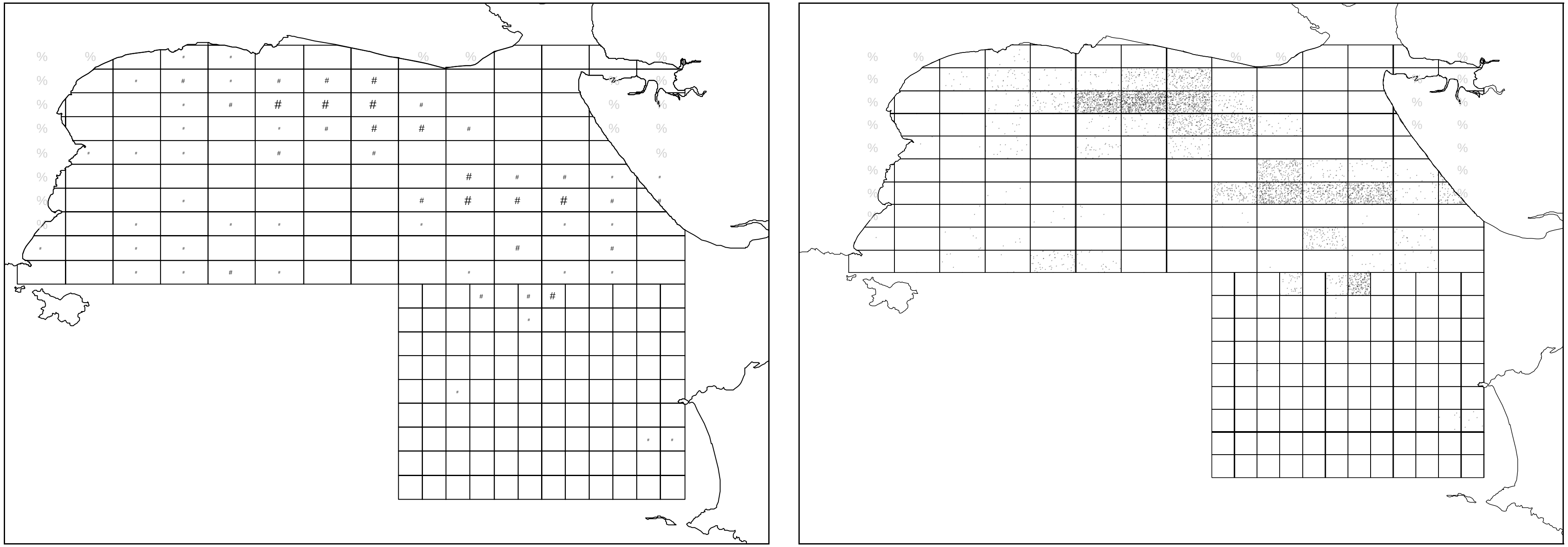
i) ii)

Figure 3.12a Distribution of Common Scoters recorded during aerial census-method counts on 16/3/03. Counts are those of RS and LS combined, depicted as i) graduated symbols centred in each counted grid cell and ii) dot-density maps of counts within grid cells. Grey squares denote non-counted cells.



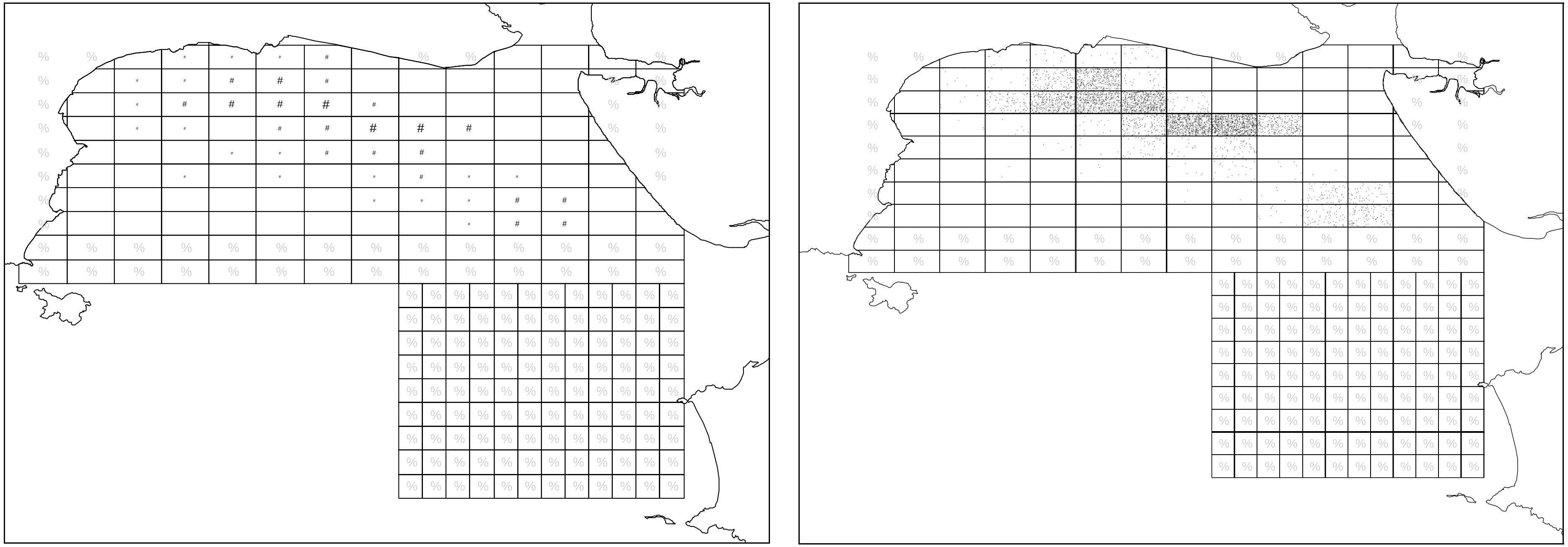
i) ii)

Figure 3.9b Distribution of Common Scoters recorded during aerial census method counts on 24/01/04. Counts are those of RAS and BH combined, depicted as i) graduated symbols centred in each counted grid cell and ii) dot-density maps of counts within grid cells. Grey squares denote non-counted cells.



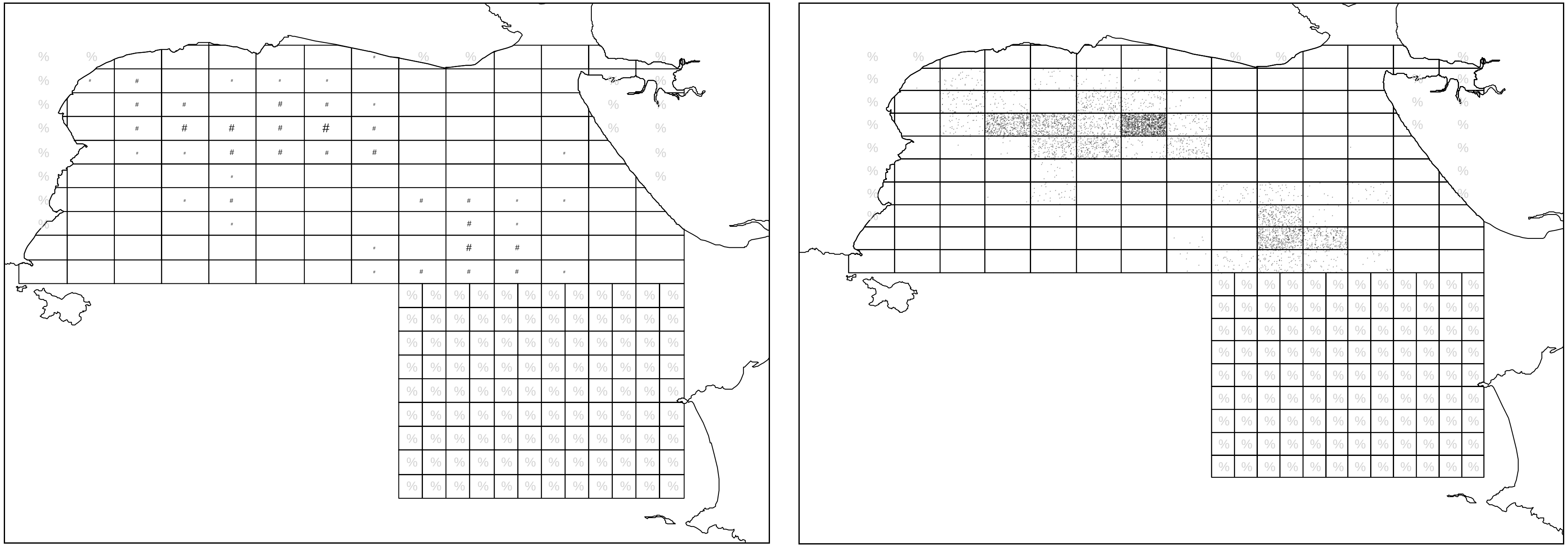
i) ii)

Figure 3.10b Distribution of Common Scoters recorded during aerial census method counts on 28/02/04 (A.M.). Counts are those of ANB and BH combined, depicted as i) graduated symbols centred in each counted grid cell and ii) dot-density maps of counts within grid cells. Grey squares denote non-counted cells.



i) ii)

Figure 3.11b Distribution of Common Scoters recorded during aerial census method counts on 28/02/04 (P.M.). Counts are those of ANB and BH combined, depicted as i) graduated symbols centred in each counted grid cell and ii) dot-density maps of counts within grid cells. Grey squares denote non-counted cells.



i) ii)

Figure 3.12b Distribution of Common Scoters recorded during aerial census method counts on 27/03/04. Counts are those of RAS and ANB combined, depicted as (i) graduated symbols centred in each counted grid cell and (ii) dot-density maps of counts within grid cells. Grey squares denote non-counted cells.

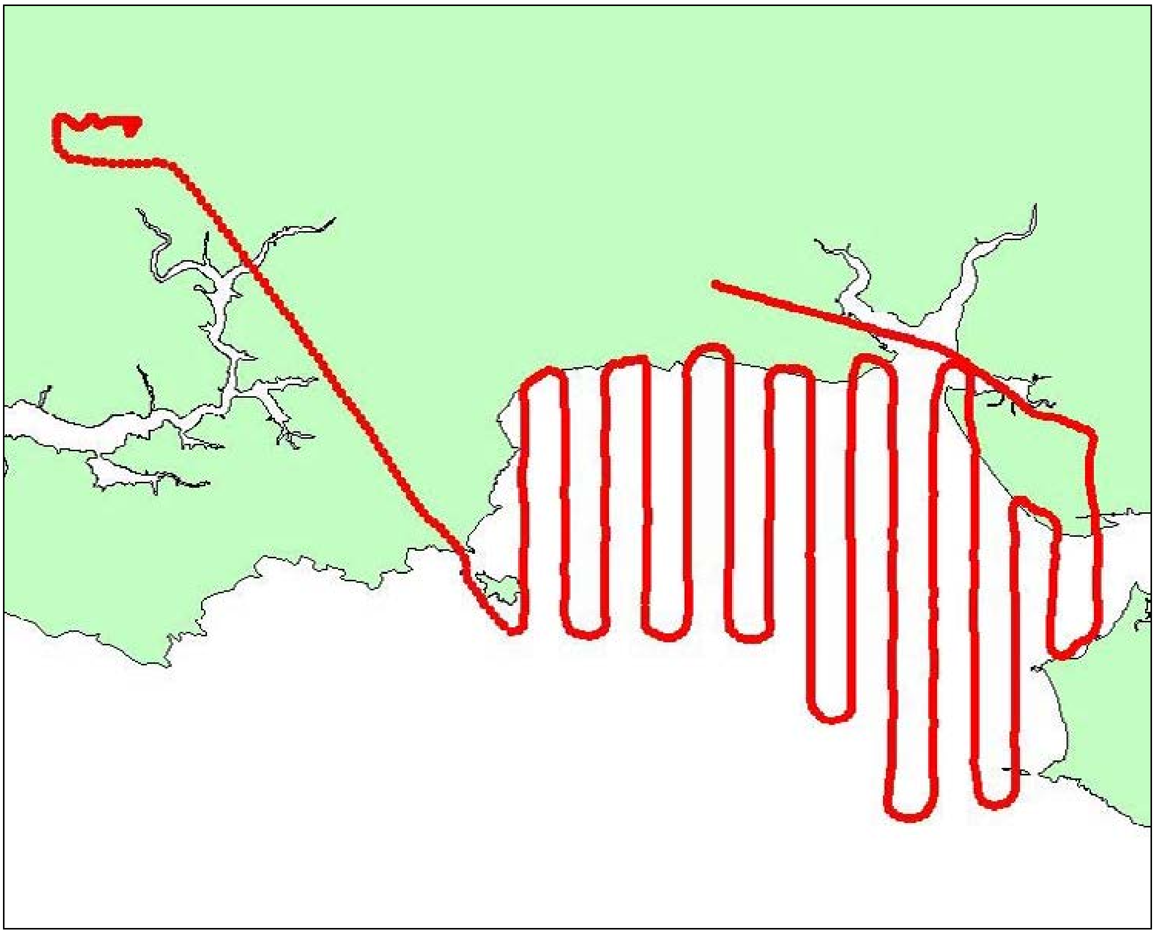


Figure 3.13 Flight path taken during distance-method aerial survey on 15/3/03, as recorded by GPS. The bay was surveyed from east to west.

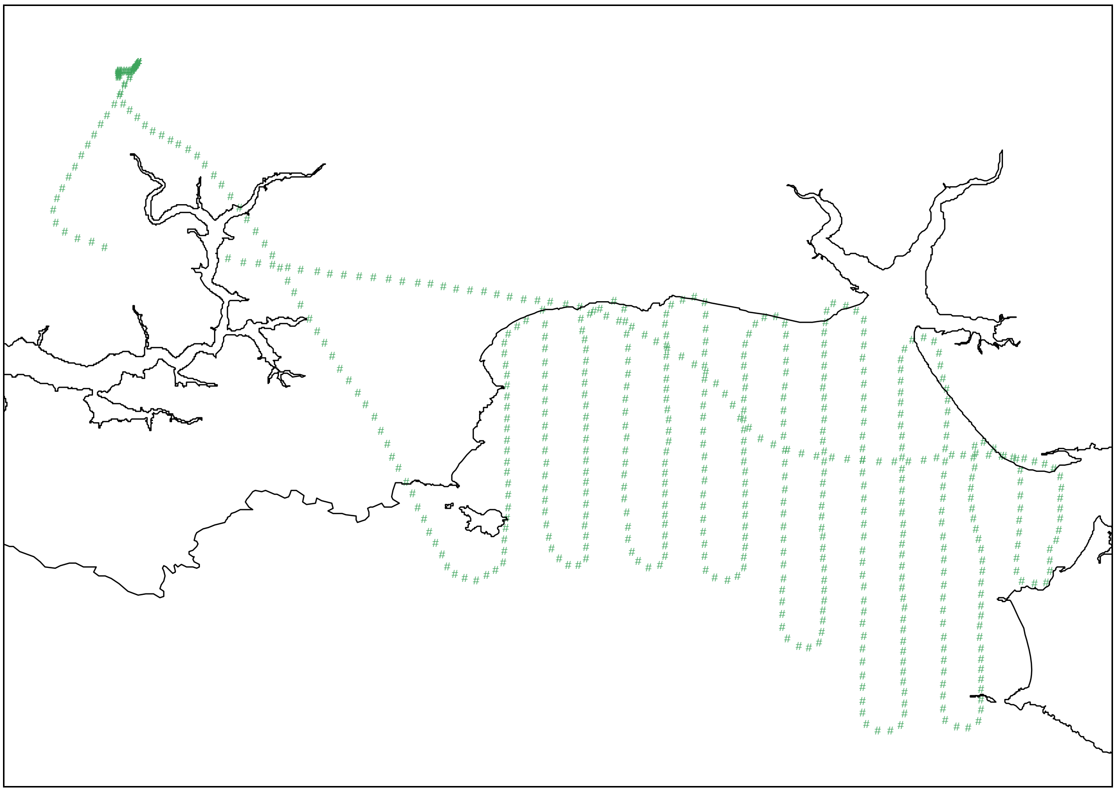


Figure 3.14 Flight track for distance method aerial survey on 10/10/03, as recorded by GPS. The survey began at the South West corner of the bay.

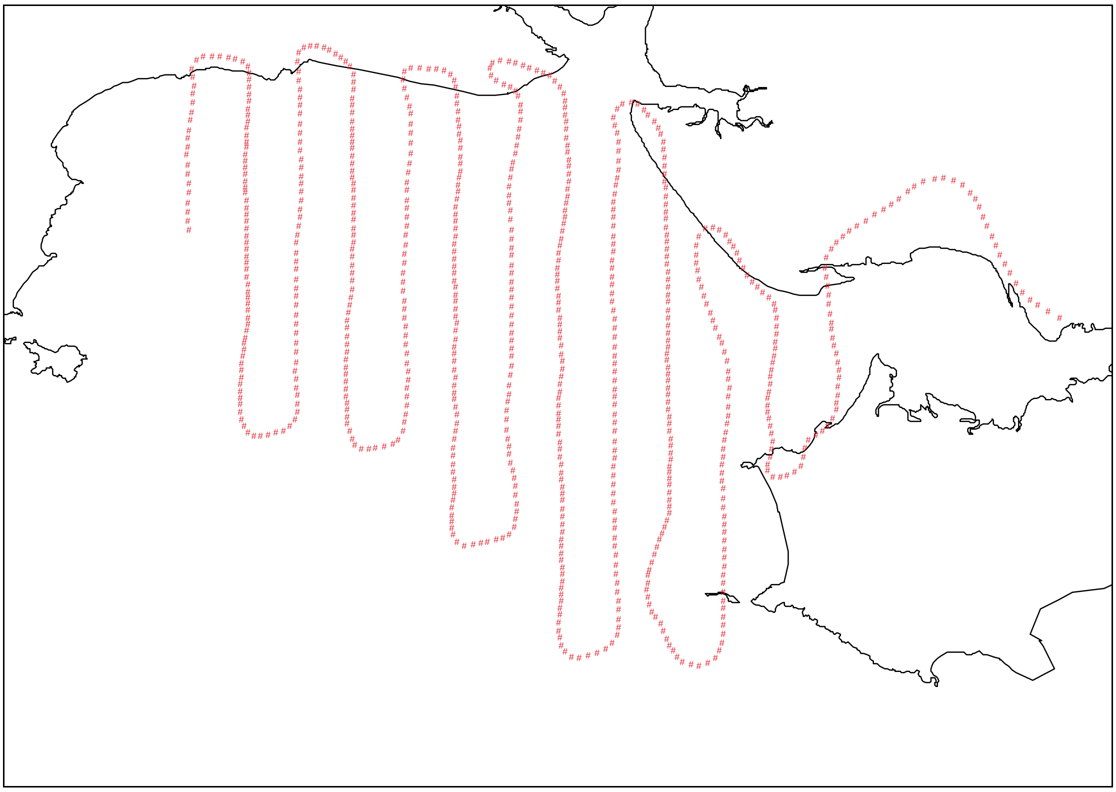


Figure 3.15 Partial flight track for distance method aerial survey on 29/02/04, as recorded by GPS. The survey began in the East of the bay.

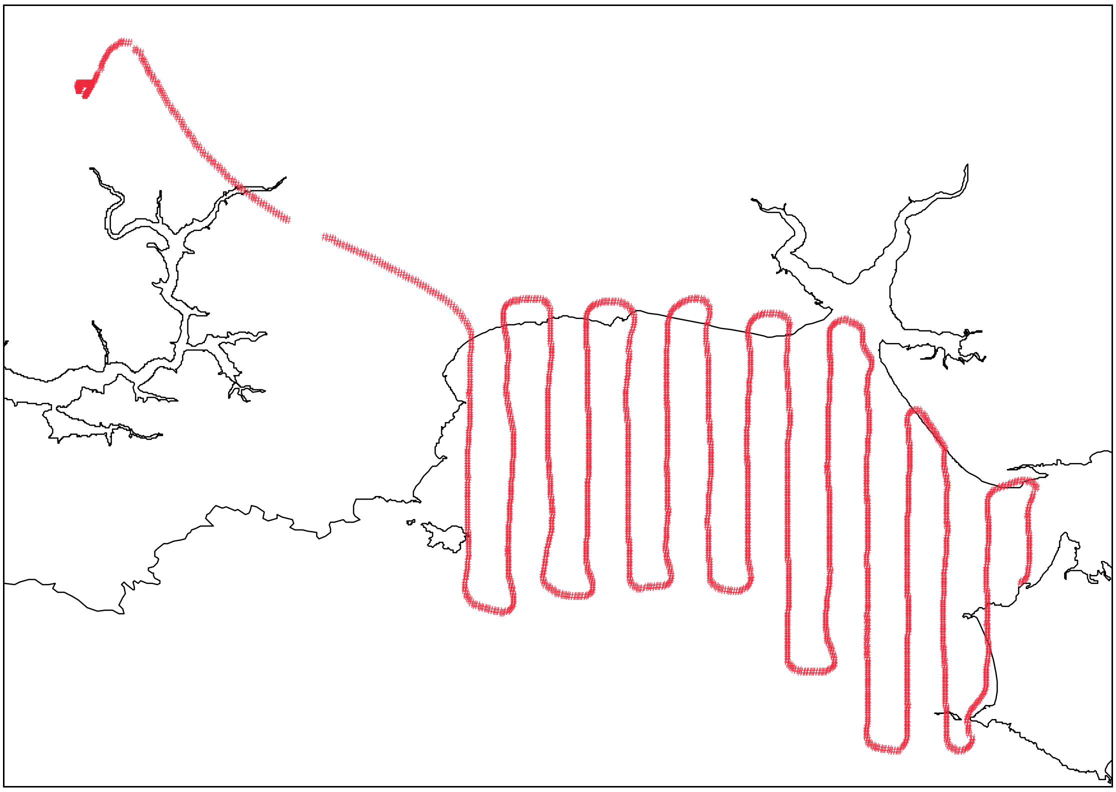


Figure 3.16 Flight track for distance method aerial survey on afternoon of 27/03/04, as recorded by WinWedge. The survey began in the North West corner of the bay.

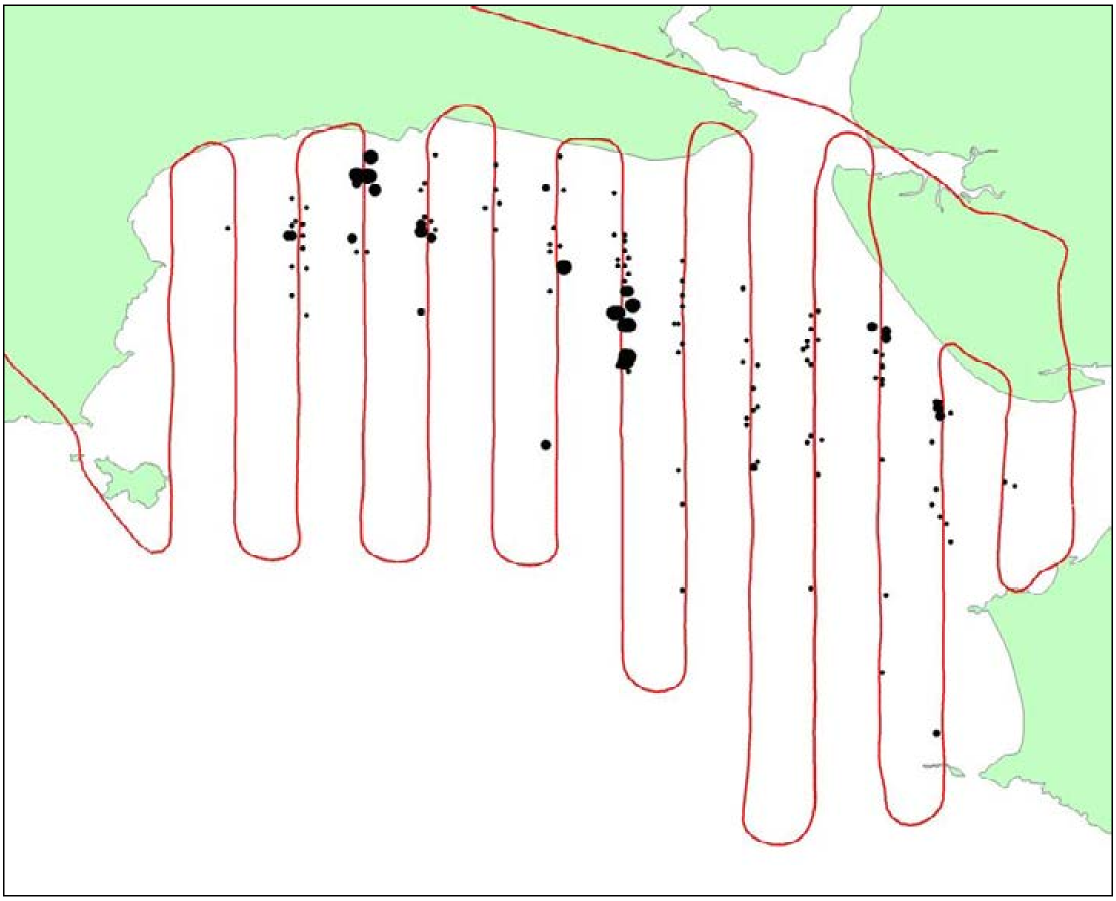


Figure 3.17a Position of Common Scoter flocks recorded during distance-method aerial survey on 1/12/02. Note that due to problems with the GPS, positions are approximate and based on the track flown on 15/3/03 (flight line shown).

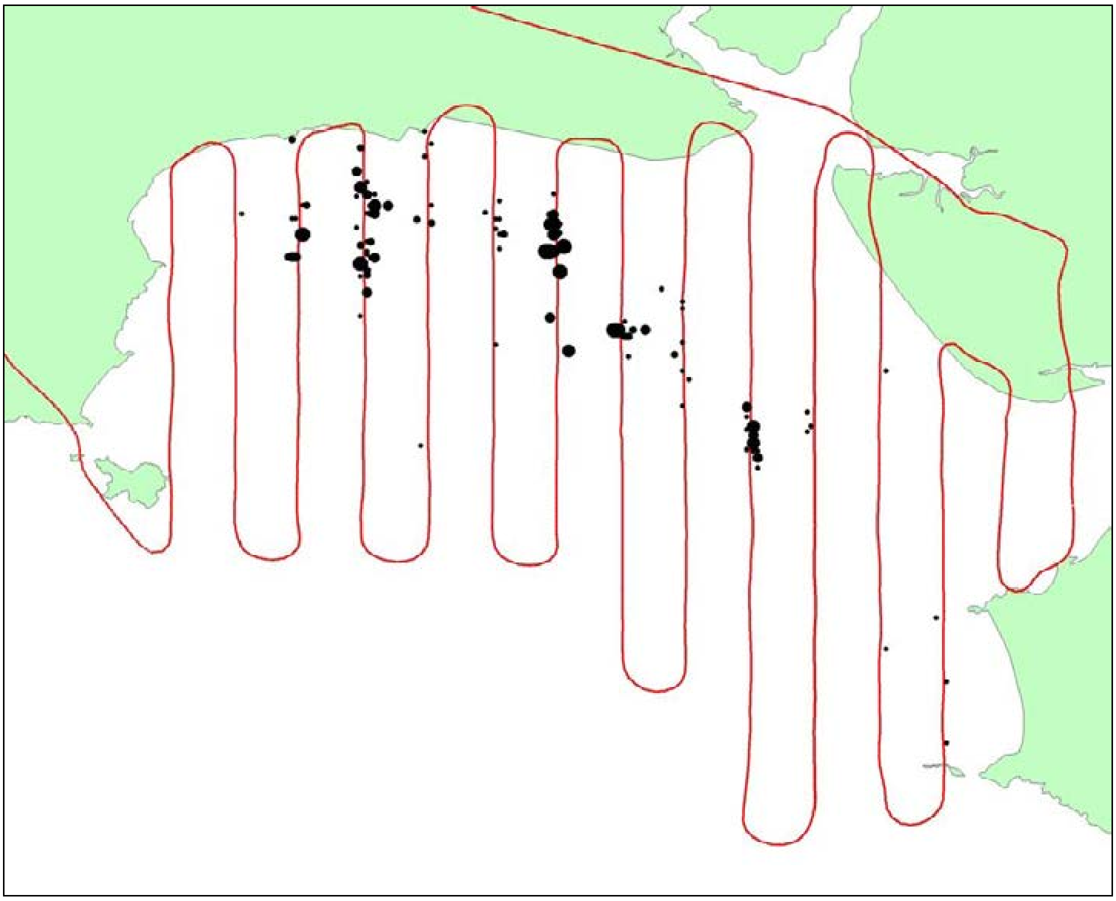


Figure 3.18a Position of Common Scoter flocks recorded during distance-method aerial survey on 4/1/03. Note that due to problems with the GPS, positions are approximate and based on the track flown on 15/3/03 (flight line shown).

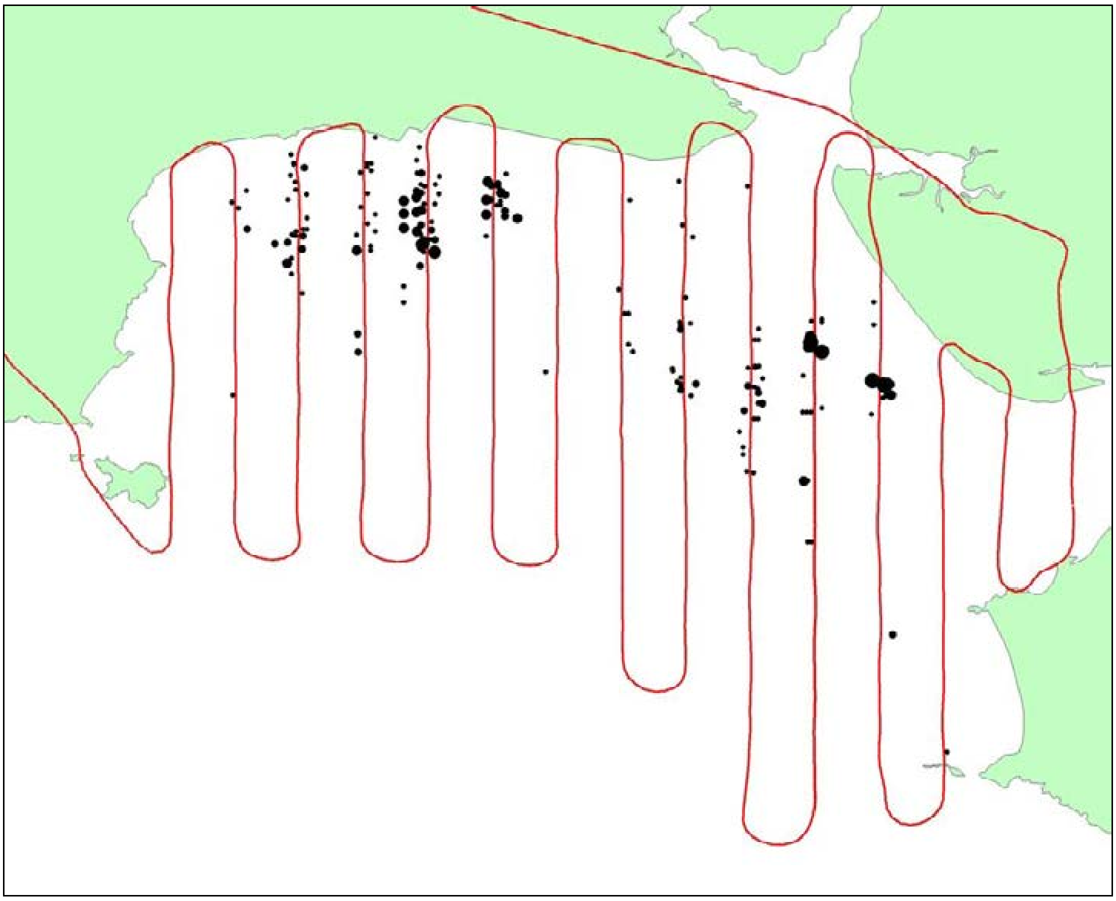


Figure 3.19a Position of Common Scoter flocks recorded during distance-method aerial survey on 15/3/03, with flight line shown.

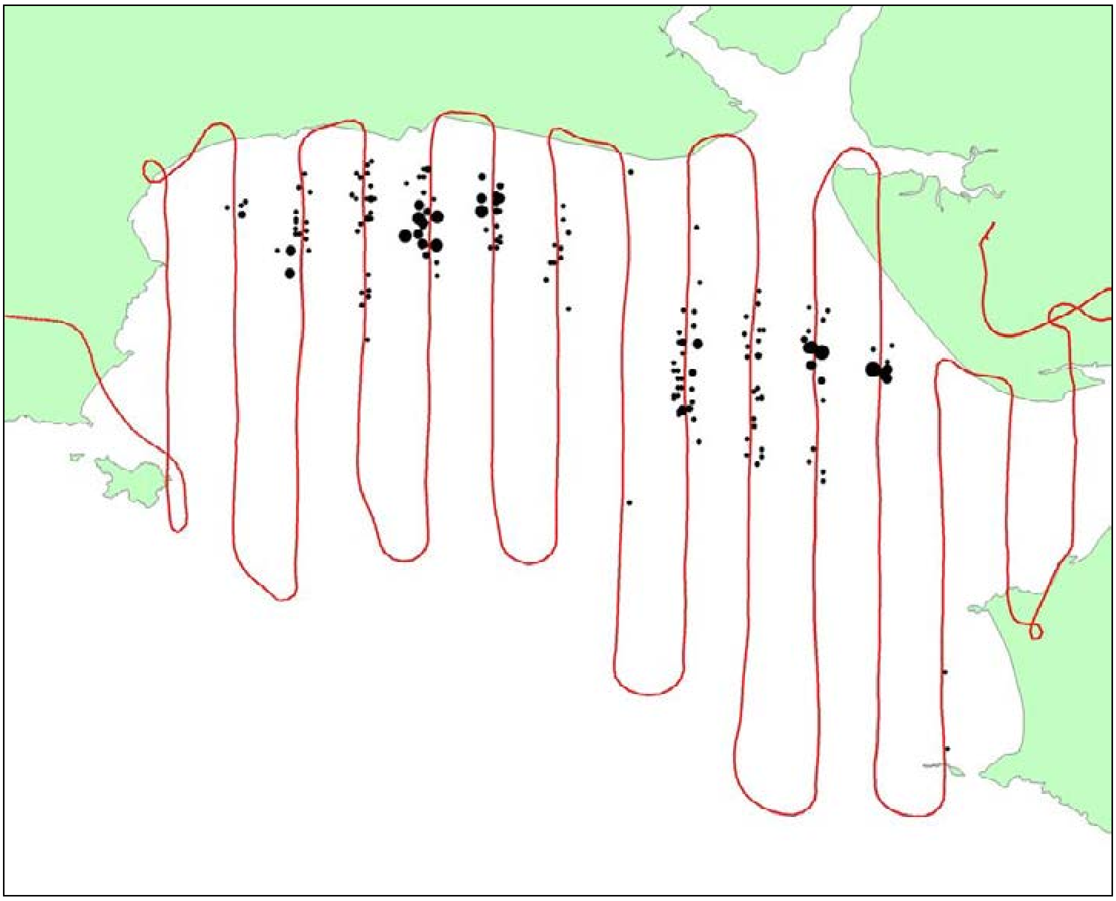


Figure 3.20a Position of Common Scoter flocks recorded during distance-method aerial survey on 16/3/03, with flight line shown.

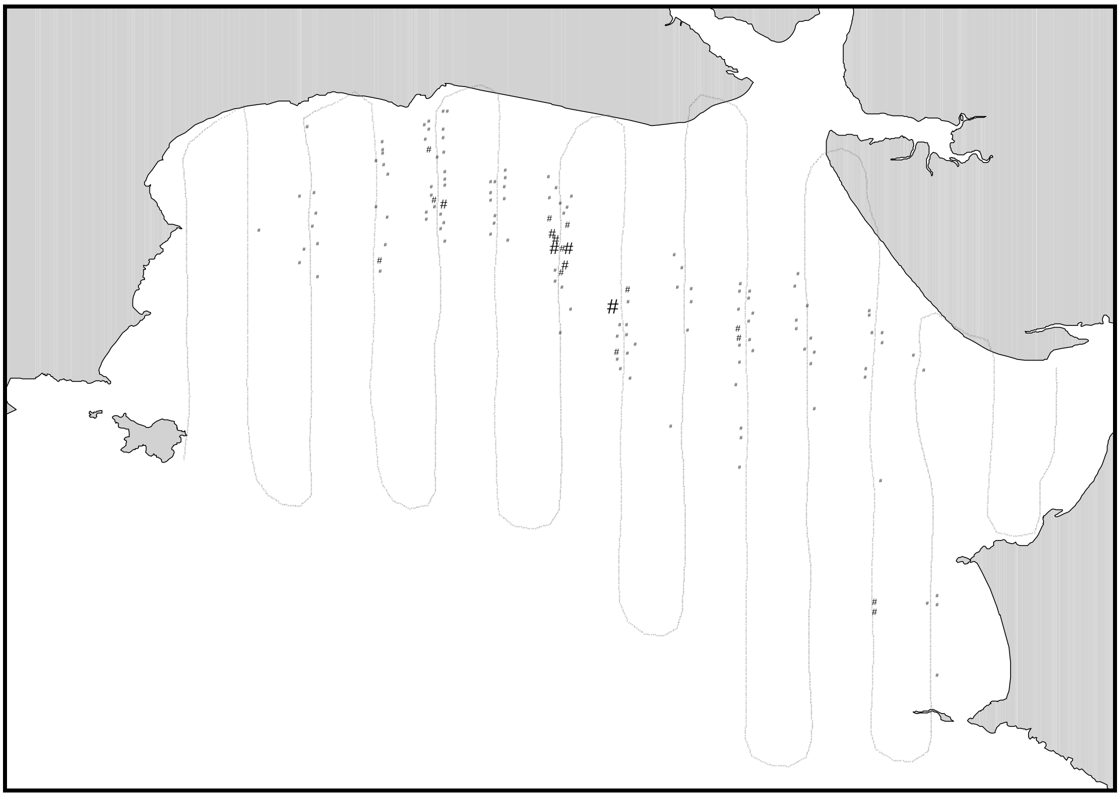


Figure 3.17b Position of Common Scoter flocks recorded during distance-method aerial survey on 11/10/03, with flight line shown.

Figure 3.18b Position of Common Scoter flocks recorded during distance-method aerial survey on 23/11/03, with flight line for October shown.

Figure 3.19b Position of Common Scoter flocks recorded during distance-method aerial survey on 24/1/04, with flight line for March shown.

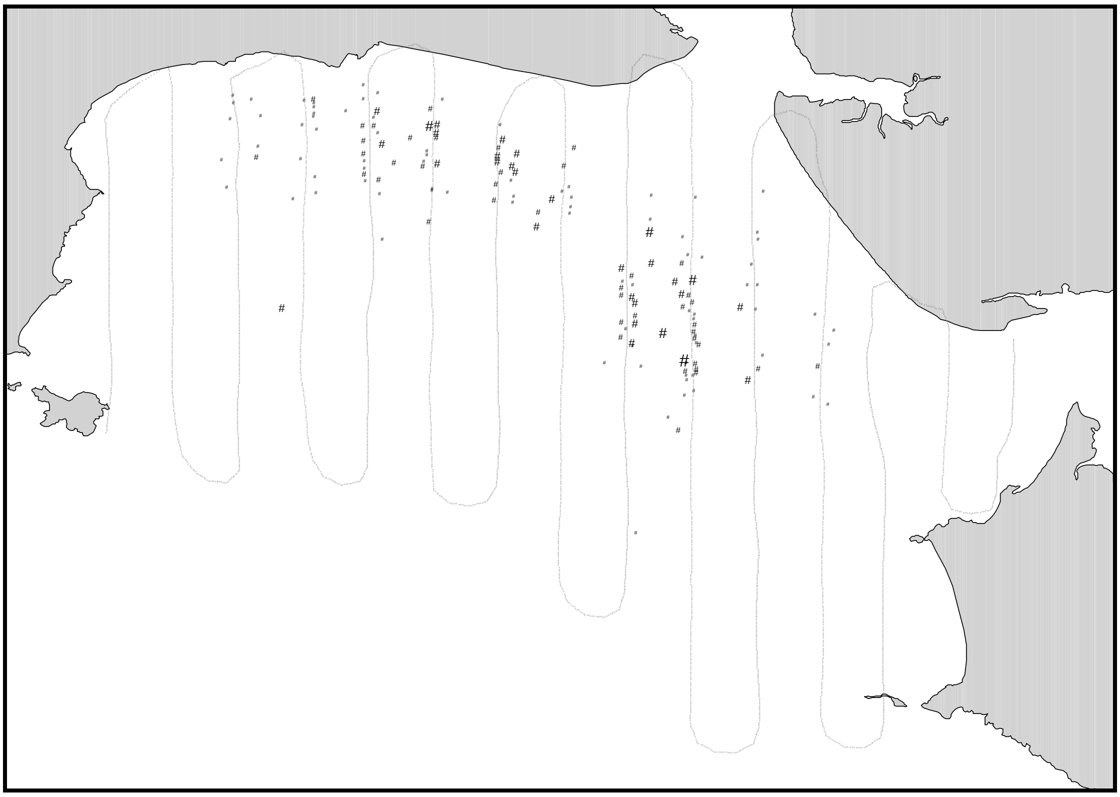


Figure 3.20b Position of Common Scoter flocks recorded during distance-method aerial survey on 29/2/04, with flight line for October shown.

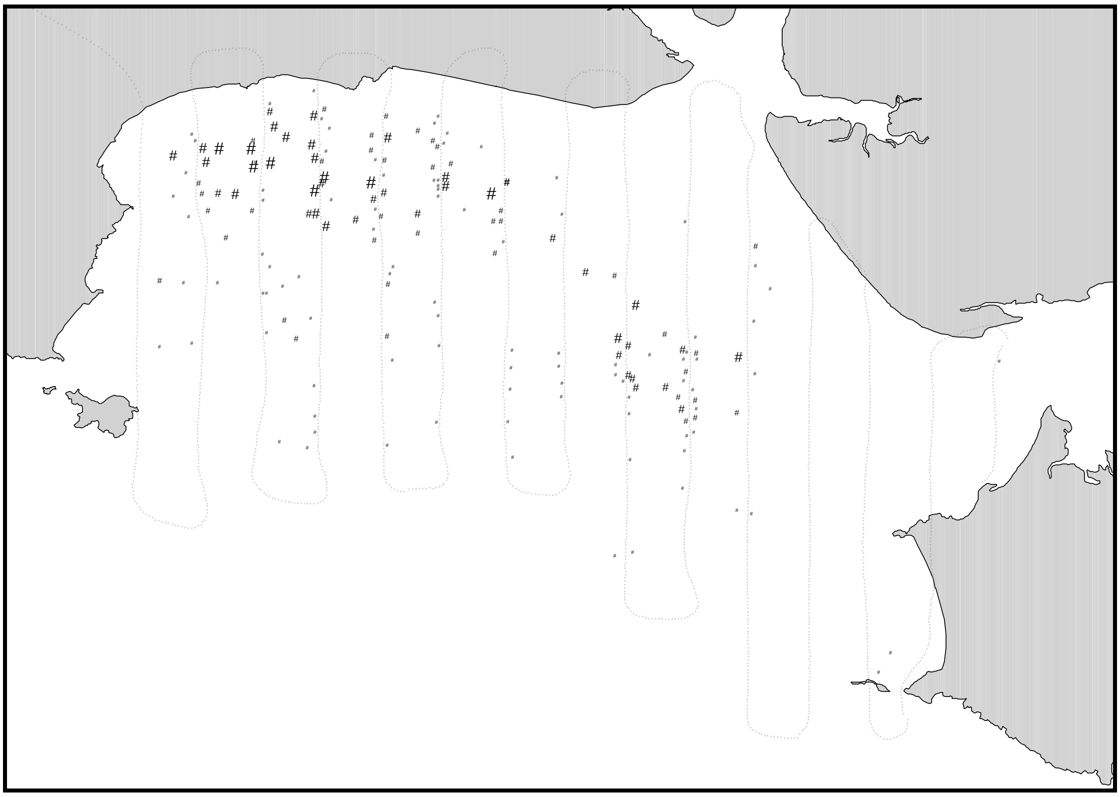


Figure 3.21 Position of Common Scoter flocks recorded during distance-method aerial survey on 24/3/04, with flight line shown.

4. DISCUSSION

The findings of the survey work carried out during the two winters are discussed below in terms of the objectives listed in Section 1.3.

4.1 Maintenance of a Monitoring Programme of Ground-based Counts

A programme of ground-based counts was maintained with four full counts carried out in both 2002-03 and 2003-04, in a consistent manner with the methodology used in previous seasons. The totals recorded are summarised in Table 3.1a and 3.1b.

The general pattern over the two winters, although ground counts were not always undertaken in the same months, was for a low count in October, with rising numbers by the end of November. Peak counts occurred in December or January, as found previously (Cranswick *in press*, L. Smith unpubl. data), although substantial numbers were counted in February. March counts in the first winter suggested that large numbers of scoters were present earlier in the month, but with low counts at the end. This final count may have been affected by other factors, as the observer considered the viewing conditions to be suboptimal. However, the counts are likely to reflect wintering movements of Common Scoters, with a gradual accumulation of birds in the bay during October and November, a peak in December and January before a gradual reduction through February until the end of March, as birds depart for the breeding grounds. Historical data from Lucy Smith reinforces this pattern, with peaks in January. Smith also reports that most birds left Carmarthen Bay by late April.

The most striking feature of the ground counts in 2003-04 was the near total lack of birds counted at Pembrey. In the first winter, numbers counted from this station varied between 504 and 7,071, yet only six individuals were recorded during standard monitoring counts in the second. To account for the possibility that birds may have moved from this area further down the coast, later counts were made at Rhossili. However, although peaks at this station were as high as 824, numbers never approached the peak of over 7,000 birds at Pembrey in the previous winter. Traditionally, this area seems to be used towards the end of the winter, possibly when other areas are depleted of resources.

In comparison with recent historical data, the peak count of 23,288 in January 2003 is potentially the highest figure recorded since 1974. Peak ground counts in the years since recovery from the *Sea Empress* oil spill in February 1996 have consistently shown upwards of 15,000 Common Scoter, with 18,243 in 1998-99, 21,592 in 1999-00, 19,506 in 2000-01 and 20,078 in 2001-02 (all counts by Lucy Smith, with the exception of the latter from WWT (2003)). The peak count of 15,446 in December 2003 is considerably lower than in the previous winter: however, it should be noted that only a partial count could be achieved in January 2004, a month often revealing peak numbers for the season. Taking the peak counts from the past five winters (1999-00 to 2003-04), a five-year peak mean can be generated, producing a figure of 19,982 Common Scoter. This figure is very close to the revised population size of 20,000 earlier estimated by Cranswick (*in press*), although the true value is likely to be higher, as not all birds within the SPA can be counted from shore. This value is well in excess of the 16,000 birds required to fulfil SPA designation criteria.

Upon plotting the ground counts using the recorded distance and bearing measurements, a simple visual comparison with the distribution recorded by aerial surveys over the two winters suggests that the area over which the ground counts were carried out covers only a small part of the distribution of Common Scoters at the site. It is almost certain, therefore, that the true numbers of Common Scoters present in Carmarthen Bay are substantially higher than currently realised, despite ground counts recording tens of thousands of birds. This issue is discussed further in Section 4.7 below.

Ground monitoring counts generally provide higher estimates of bird numbers than aerial surveys, particularly in the north of the bay, as the method is unobtrusive and birds are less likely to depart during counts (Stewart *et al.* 1997, Cranswick *et al.* 1998). However, visibility is not thought to extend past 6 km (Cranswick *et al.* 1998), and realistically counts may not be accurate at this range. As ground monitoring has now been undertaken using the same methods and observers for the past six years, this would seem a sensible platform on which to create a population index for the bay. Although ground counts should not be considered complete in terms of absolute Common Scoter numbers, the method should prove relatively straightforward for indexing at least population minima (see Appendix 6). Factors to consider include sea state, weather, time of year, tidal state, glare and optical equipment; if these can be largely standardised, count accuracy will be greatly improved.

Counts in both winters suggest that the peak count is likely to occur in December or January, a position supported by others (L. Smith, unpubl. data, Cranswick *in press*). Counts in late October 2003 and late March 2003 were below 7,000, and it is likely that most birds have not arrived or have departed for the breeding grounds in these respective months. Therefore, the best period of time for monitoring would seem to be November through to February, with one count of the whole bay in each month. This would allow assessment of the peak count and the mean for the winter.

It should be noted that Carmarthen Bay SPA may also act as an important moulting site for anything up to 2,000 Common Scoter, with the area off Cefn Sidan especially utilised (Cranswick *et al.* 1998). Although birds using the bay for this purpose would be present during July and August, supplementary monitoring of this population is worth considering in terms of favourable management of the SPA.

4.2 Assessment of the Factors Affecting the Precision and Accuracy of Ground-based Counts

4.2.1 Weather

Broad weather conditions were recorded during all ground-based counts, including wind speed and direction, cloud cover and glare and precipitation. Additionally, the state of the sea-surface and visibility were also described. However, although this information can be examined with regard to explaining influences on counts, in reality most counts were made on days where conditions were reasonably favourable. Experienced counters recognise that if sea-state is too rough or visibility too poor then it is effectively pointless attempting to make a count. Most of the following discussion is based on anecdotal observations and a visual inspection of the count conditions; there are too few data to allow a formal analysis.

4.2.1.1 Wind and sea-state

Generally, wind-speed and direction were probably not so important by themselves compared to the effect they had on sea-state, although high winds could affect stability of optical equipment. In general, wind-speed is more critical if the wind is from the south, as winds from the north can have a ‘flattening’ effect as they come off the land, although this varies with position within the bay. Clearly, however, sea-state can also be affected by factors more remote from the survey area itself. Sea-state is one of the most critical factors affecting ground-based counts. The greater the amplitude of the waves, the more likely a flock on the surface will be overlooked from the shore due to its being in a trough. Similarly, the greater the fetch, the larger the resultant wave, which may affect counts of birds further offshore.

Although LS recorded conditions during the first winter monitoring counts, her records were not particularly suited for this question as she was only making one count per station per date. The monitoring counts were carried out with winds from a variety of directions. Most wind speeds were below force 2 although occasionally up to force 5. NF visited three count stations per day, and frequently recorded visibility as ‘excellent’ in 2003-04, despite wind speeds changing strength (though rarely direction) and gusting up to force 5.

During the paired counts undertaken by RS and LS on 5/1/03 from Pendine, even a wind recorded as SE force 1-2 was thought to have contributed to lower counts by RS than by LS, as with a lower powered telescope, he evidently missed many birds behind wave-tops.

During the thoroughness studies, NF recorded multiple counts along with wind-speed and direction. Anecdotally, NF recognised the critical effect of sea-state on his ability to count the birds present and even a light swell readily hid birds from view on less thorough counts. A consideration of the counts on 6/3/03 shows an interesting pattern. On this date, the first two hours of counts were recorded as taking place with westerly winds of 10 mph and a light swell. However, the third to eighth hours of counts had westerly winds of 15 mph with an increasing swell and 'white horses' on the wave tops. Average counts were higher during the first two hours than during the following six hours. However, this decrease was most apparent for the less thorough counts, as set out in Table 4.1. This result is hardly surprising. With any count, scoter flocks can be hidden within troughs. The likelihood of the observer noting the flock is dependent upon both the number and size of the waves and the time taken to observe a particular area of sea.

During the further counts carried out by NF to look at the influence of the tide, the wind and sea-state was again recorded. However, with these counts more time was available (two hours per count) and as expected, sea-state became less significant in comparison to glare.

In summary, the sea-state is a very important factor when making ground-based counts of scoter. However, it becomes less important if more time is available to carry out the count. It has to be stated, however, that all of the counts for this study were in conditions chosen to be suitable for survey work and no counts were made with a wind of more than approximately 20 mph. Above this level, one would expect even rougher seas to become an ever more serious impediment, particularly if the wind is from a southerly direction.

	Hours 1-2	**Hours 3-8**	**% decline with less favourable conditions**
	Wind 10 mph Light swell	**Wind 15 mph Increasing swell**	
Average 5-min count	1482	877	41%
Average 10-min count	1999	1742	13%
Average 20-min count	2940	2775	6%

Table 4.1 Average five-minute, ten-minute and 20-minute counts of Common Scoter from Pendine, with hours 1-2 and hours 3-8 grouped (first winter).

4.2.1.2 Visibility, glare, cloud cover and precipitation

As well as sea-state, the other major weather-related factor affecting ground-based counts was overall visibility, which was contributed to by a combination of glare, cloud cover, precipitation, haze and optical equipment.

Strong sun glare was a serious problem on some counts in 2002-03, although the effect was strongest in a limited part of the sea, *i.e.* that in line with the sun from the observer. Wherever possible, count stations and times should be situated with this fact in mind. The effects of glare were considered particularly pronounced during the monitoring count on 31/3/03 when the numbers of birds recorded were relatively low. However, the true extent of this was difficult to judge as the late date in the season meant that many scoters might have already left the area.

As with sea-state, the effects of strong glare were greatest during shorter duration counts. The effects were particularly severe during the thoroughness counts carried out by NF on 14/2/03 when he experienced near 'white-out' conditions and was even left feeling rather unwell for a time. Again, increasing the time available to carry out the count should reduce any such problems, allowing the counter time to rest their eyes.

For some counts in 2003-04, precipitation was recorded during the count session. Light rain was recorded on the monitoring count on 23rd February 2004, and throughout the 'thoroughness' counts on 29th October and 20th November 2003. NF did not consider the showers an impediment to visibility. Furthermore, on two 'tidal' counts (28th October and 19th November 2003), conditions changed during the day with light rain falling for the afternoon counts. Although potentially confounded by changing tides, numbers were not noticeably reduced in counts during precipitation.

The final factor affecting visibility concerned the optical equipment used by the counters. Section 4.2.1.1 mentioned the lower count made by RS using a low powered telescope in 2002-03. For simultaneous counts in 2003-04, it was important to control for inter-observer bias by using optical equipment that was as similar as possible. BTO provided three Bushnell Spacemaster spotting scopes, which were considered of inferior quality to the fieldworker's personal optics. Direct comparisons are difficult to make, as this was not a project aim, but it is clear that the higher quality the equipment used, the more accurate the count is likely to be.

It is recommended that ground counts should be undertaken when cloud cover is maximal, to avoid problems with sun glare over the sea. Light rain does not appear to impede visibility, though counters may feel discomfort if not properly prepared. Finally, a good quality telescope is desirable, with 20-60x zoom and at least 85 mm objective lens.

4.2.2 Disturbance

Disturbance can affect bird counts in a number of ways, although a real impact on bird populations is usually extremely difficult to demonstrate (Hill *et al.* 1997). Surveys of the type discussed in this study can only really assess immediate disturbance effects, *i.e.* those witnessed at the time. In reality, disturbance events occurring before the survey period may also have a major effect on the numbers of birds present.

During all ground-based counts in this study, disturbance was looked for and recorded when seen. In the event, however, very little disturbance was noted. A number of boats were noted from time to time but no effects were recorded. Herring Gulls were reported to mob feeding scoters, but this should perhaps be considered 'natural' disturbance. The only recorded effects of human disturbance were from aircraft, both military and the aerial survey plane used for this study.

The military use parts of Carmarthen Bay for training flights and weapons practice. This was most apparent during the surveys on 6/3/03, 23/03/04 and 24/03/04 when such activity was noted to cause large flocks of scoter to fly past the Pendine watch-point. However, the effects seemed to be relatively local and short-lived in nature.

More of a problem was the effect of the aerial survey plane on scoter counts. On 15/3/03 the plane passed over NF shortly before his third count. He noted that about half of the birds visible flew further out to sea and his count numbers were affected accordingly. Notably, during the fourth count of the day, two hours later, these birds had apparently not returned. Similar reactions were recorded during the second winter studies. The ground observers on 25/1/04 and 28/2/04 recorded widespread movement of scoters, with flocks of around 3,000 frequently disturbed, sometimes in advance of 1 km from the approaching plane (also noted by Cranswick *et al.* 1998, L. Smith, unpubl. data). Although some birds returned to their original areas, the majority did not and flew out of sight. A general eastern movement was recorded, regardless of survey type or transect order.

Disturbance is a major problem, as the concentration of birds found in the mid-north of the bay, which almost certainly represents a large proportion of the total non-breeding population, is thought to be more 'flighty', and therefore more likely to flush in response to the plane (Cranswick *et al.* 1998).

Census counts on consecutive days in February 2004 showed little variation, suggesting the earlier count did not disrupt the later count. However, numbers were notably low and ground counts suggest the majority of birds may have been missed.

It is recommended, therefore, that if ground and aerial counts are to be made on the same day, the ground counts should be undertaken shortly before the survey plane covers the same area.

4.2.3 Tidal Patterns

NF carried out three days of counts in each winter specifically designed to concentrate on assessing the degree to which the birds moved around on the tide. All observations were made from the Pendine count station. As the tide progressed, different stages of the tidal cycle were covered and the individual counts shown in Figure 3.8a and b could be grouped by approximate stage in the tidal cycle (low, rising (split into two for 2002-03), high and falling (split into two for 2002-03)). These grouped distributions are shown in Figures 4.1a and b.

From a visual inspection, it is difficult to see any clear pattern from these plots. In the first winter, there was no clear evidence of a tidal movement but if anything, birds appeared to be further offshore as the tide rose. To some extent, the overall pattern had been affected by the southwards movement of many birds on 15/3/03 after being flushed by the aerial survey plane.

During the second winter, it was again difficult to discern a pattern. However, there was some evidence that scoters were spotted closer to shore around high tide. This is perhaps unsurprising, as at low tide, new areas which were previously too deep to access become available, meaning that the birds remain near the tide-line. Lower shore type communities can extend into the sublittoral zone approximately 1 km offshore, areas which may be unavailable or unprofitable in deeper waters (A. Woolmer, *pers. comm.*).. Scoters were typically distributed in a wide band across the range of visibility from shore, and although high-density clumps were recorded, these did not appear to fall in a consistent fashion.

It is quite possible that patterns of movement may be diurnal rather than (or as well as) tidal in nature. Unfortunately it is not possible to use the historical data of Lucy Smith to further explore this theme, as her ground counts are not time-stamped. The general impression from at least the second year studied here is that the effect of the tide is to bring the birds closer to shore. A. Woolmer (*pers. comm.*) found dense beds of bivalves and polychaetes around the mean low water spring level at Pembrey, which could explain toward shore movement, as scoters cannot access such areas when exposed. It is interesting to note when the peak counts occurred in each month of tidal studies. For three of the six surveys (14/3/03, 28/10/03, 19/11/03), numbers counted were greatest at high tide, and in each case the timing of high tide was different, implying that tidal state may be more of a determinant of distribution than time of day. For the other three counts, one peak was made on a rising tide and two were made on a falling tide, although bombing at Pembrey heavily disturbed one of these counts. If birds were coming closer to shore during high tide, and were more easily visible, this may help to explain why some counts should be higher at these times.

In light of this evidence, it would seem sensible to suggest that ground counters should aim to conduct surveys on high tides, wherever possible, as has been procedure in some previous studies (Stewart *et al.* 1997, Cranswick *et al.* 1998). Greater numbers of birds should be closer to shore and therefore more readily visible, and a larger proportion of the 'true' population size will be covered.

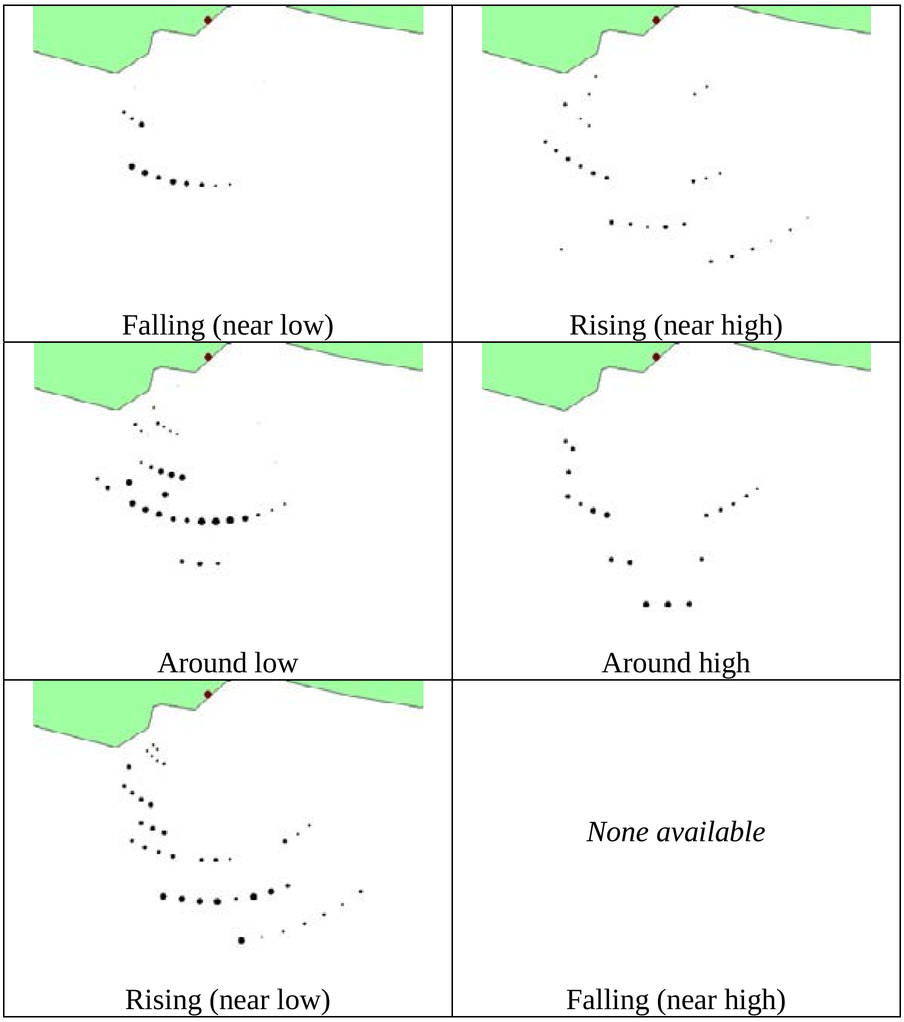


Figure 4.1a Grouped distribution patterns of Common Scoters off Pendine at different stages of the tidal cycle during winter 2002-03. Note that no observations were made on a tide falling from high.

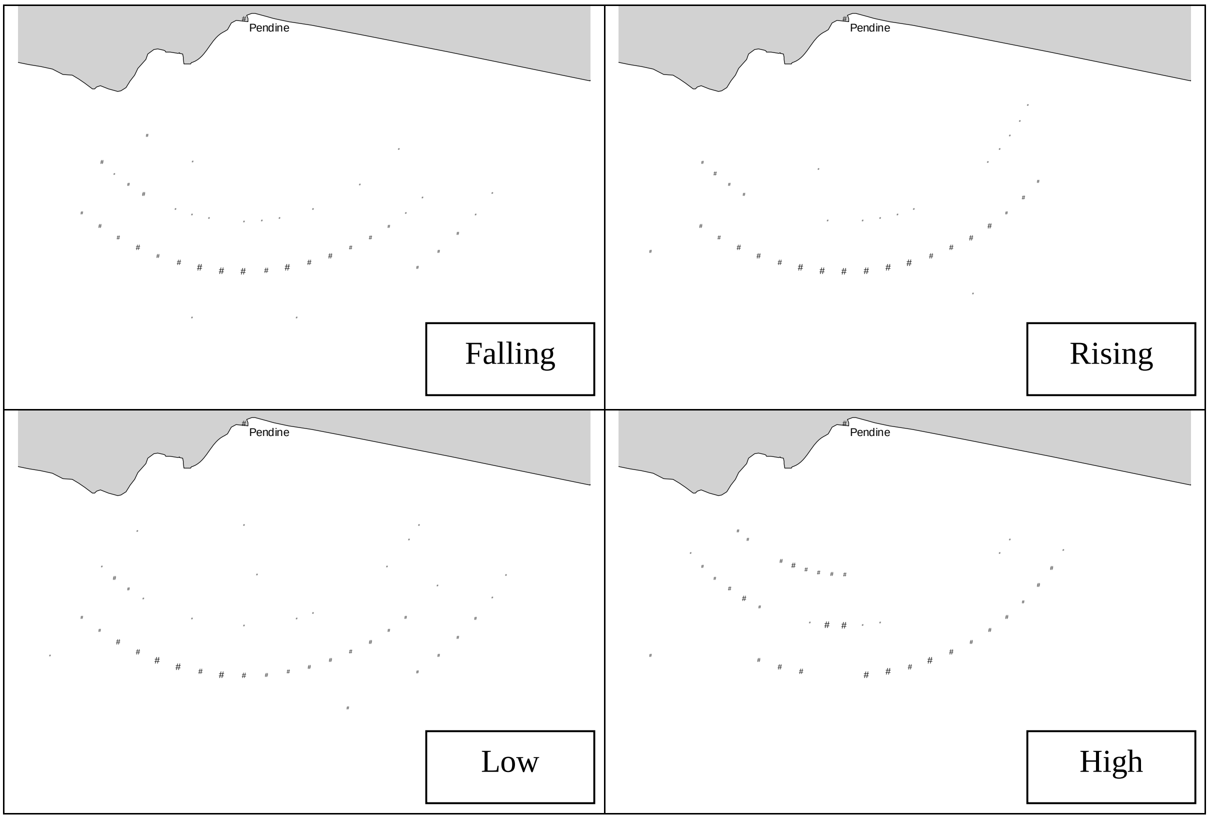


Figure 4.1b Grouped distribution patterns of Common Scoters off Pendine at different stages of the tidal cycle during the winter of 2003-04.

4.2.4 Thoroughness

One of the clearest findings of the study has been the major effect that the degree of thoroughness has on the numbers of scoters counted. Through a series of timed counts of varying duration carried out by NF from Pendine the effect of thoroughness could be seen clearly. Figure 4.2 shows the count totals made from Pendine throughout the first winter, grouped by duration of count. Clearly there is a great deal of variation within each duration grouping, which is linked to count conditions (sea-state and visibility), intra-observer variation and the actual numbers present on different dates. However, the increase in total counted with increasing duration of count is very clear.

The fitted logarithmic trend line for first winter data indicates a levelling-off in counts with increasing duration, although it suggests that increasing the duration of counts above 80 minutes may continue to provide higher counts. Data from the second winter, with counts lasting 60 and 120 minutes, support this proposal, at least where numbers are in the thousands. In March 2004, when few scoters were counted from the ground, the duration spent counting had a comparatively minor effect.

Most of the monitoring counts carried out for this study and in previous years by LS have taken approximately two hours per count station. Figure 4.3 suggests that this is probably a sensible period to count over, but anything less than one hour should probably be regarded as an undercount unless associated with perfect counting conditions or small numbers. In summary, two-hour counts are preferable, although one-hour counts may still provide a reasonable estimate.

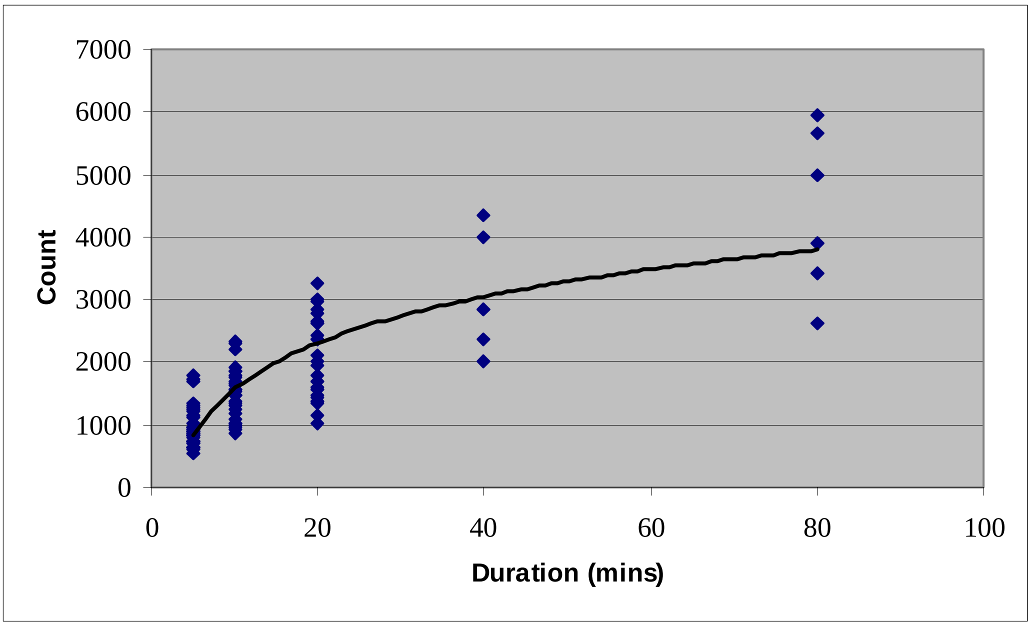


Figure 4.2 Variation in counts made by NF from Pendine with duration of count in first winter.

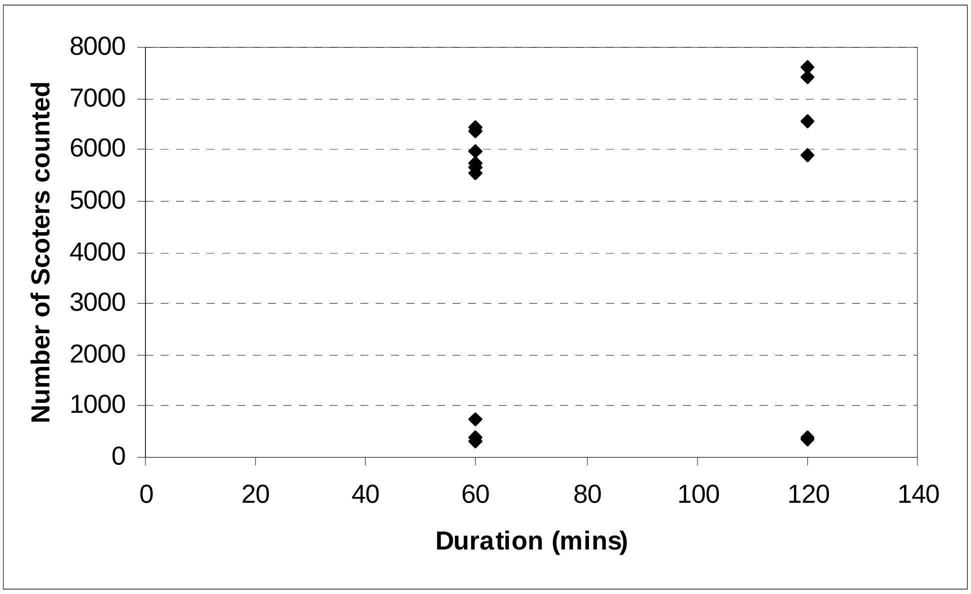


Figure 4.3 Variation in counts made by NF from Pendine with duration of count in second winter.

4.2.5 Intra-observer Variation

Intra-observer variability was investigated by considering the repeated sets of 'thoroughness' counts carried out by NF. On the first two of the four first-winter dates allocated to these counts, NF carried out sets of 3 x 5 min counts and 2 x 10 min counts, whilst on the last two dates sets of 2 x 20 min counts were undertaken. Counts clearly varied over the course of a day, due to factors such as sea-state, glare and overall movement of birds, and so it is not valid to calculate means and standard deviations for these counts. However, the counts can be considered within their own 'sets' to investigate intra-observer variation, making the assumption that during each set of counts, the true number of birds visible did not alter.

For each set of 5 min, 10 min and 20 min counts, the mean was calculated. The percentage difference of each count from its ‘set mean’ was then calculated. Overall, in 58% of cases the count was within 5% of its ‘set mean’ and in 87% of cases counts were within 10% of the ‘set mean’. The maximum percentage difference from a ‘set mean’ was 16%. There was relatively little difference in intra-observer variation between different durations of counts.

In the second winter, the same procedure was followed for the series of 60 and 120 minute counts. 60% of counts were within 6% of the ‘set mean’, with 80% within 10% of the set mean. The only times counts were outside of this bracket was in March 2004, when bombing created disturbance in the bay. Therefore the maximum 56% deviation from the set mean probably reflects a real change in numbers rather than a counting error.

On one day (24/1/04), it was possible for four observers to make four 45-minute counts from Pendine. Observers ranged in experience from AB (no specific experience of sea duck surveys), to DB and RT (some experience of sea duck surveys), to NF (very familiar with sea duck surveys, specifically involving Carmarthen Bay). Table 3.2.1 shows the mean counts with associated standard deviations. Perhaps unsurprisingly, AB showed the highest standard deviation within counts. Interestingly, NF also revealed a large standard deviation, with DB and RT fairly consistent. It should be noted that RT’s counts did not follow the pattern of increasing numbers throughout the day as shown by the other three counters, and made counts that were usually substantially lower. It is difficult to tell which counts were truly representative, and to what extent apparent intra-observer bias was confounded by genuine changes in bird numbers. NF used superior optical equipment to the other counters and was most experienced; it is possible that he was able to detect more of the visible population.

These results suggest that intra-observer variation was generally relatively low and that ground-based counts should be considered to be broadly precise. Experienced observers are clearly preferable to naïve ones, although even NF, a very experienced bird counter, sometimes showed reasonable variation between counts.

4.2.6 Inter-observer Variation

Inter-observer variation in making ground counts of scoters was addressed on two occasions each winter.

On 5th January 2003, both LS and RS made simultaneous ground-based counts of the numbers of Common Scoters visible from the Pendine count station, although using slightly differing methods and, probably more significantly, different optical equipment. The level of discrepancy was great, with LS recording about 70% more birds than RS. There were considered to be a number of reasons why the discrepancy between the counts was so great. LS carried out her count in the same manner as her ground-based monitoring counts, *i.e.* by recording flocks to bearing and distance. Whilst RS also made a careful count he was not recording distance and bearing and thus his count took about half the time. The discrepancy therefore could be partly related to the effects of thoroughness described above in Section 4.2.4. Additionally, the optical equipment used by the two observers varied. RS used a telescope with 30x wide-angle lens whilst LS used a 20-60x zoom lens. This was considered by the counters to be a major factor in explaining the difference in counts. Finally, whilst RS is a very experienced observer, LS has a great deal more specific experience in carrying out ground-based counts from this particular site.

During the afternoon of 6th March 2003, the monitoring count by LS from Pendine overlapped with the 6th to 8th hours of thoroughness counts being carried out by NF. The former recorded a total of 7,434 birds over approximately two hours. The counts carried out by NF varied with duration. Five-minute counts over these three counts averaged 754 birds, ten-minute counts averaged 1,586 birds and 20-

minute counts averaged 2,858 birds. In this case, the difference between observers is confounded by the effects of thoroughness.

Co-ordinated counts in the second winter allowed more precise assessment of inter-observer variation. Again, experience was a factor with AB relatively inexperienced, DB and RT experienced and NF very experienced. AB recorded the highest mean counts on 24/1/04, and was probably over-counting. The problem may have been exacerbated by the lack of a tally counter, used by all other observers. However, within the count-session, AB's estimates became closer to NF's with time, suggesting that it is possible that experience may be gained fairly rapidly. Mean counts between DB and NF were comparable, differing by only 259. RT scored a considerably lower mean. It is possible that this is because this counter was least familiar with the count station, and also because RT usually counted from Rhossili, where few birds were apparent. DB and NF may therefore have both been better attuned to making estimates of numbers and more familiar with the seascape and likely areas of bird concentration. However, the mean of the maximum within-count ranges was still only just over 2,000.

The second co-ordinated count produced much less variation between counters. All counts from DB and RT were within 13% of those by NF. Mean counts differed by no more than 1009, and differences in standard deviation were typically in the order of hundreds (Table 3.2.2). Counts may have been slightly confounded by disturbance caused by the plane, although as all counters were at the same station the effect should have been universal. However, realistically, if birds are flighty and moving frequently, some counters may be more adept at quantifying movements and avoiding repeat counts. High standard deviations probably reflect changes in bird numbers due to re-dispersal during aerial survey, but the low-within counter difference is encouraging, and implies that counters such as DB and RT, with substantial experience of bird-watching but comparatively little specific experience, are able to make counts comparable to an expert (NF).

Future ground counts would benefit from consistent use of personnel, to avoid introducing further inter-observer error. If this is not possible, experienced bird watchers should be used, preferably with direct experience of sea surveys, although this should not be a pre-requisite. In the event that a surveyor does not have such expertise, practice counts would be considered necessary.

4.3 Maintenance of a Monitoring Programme of Aerial Counts

A programme of eight flights was carried out during the 2002-03 winter, using two different count techniques, with an additional nine flights using the same methods in 2003-04. This facilitated comparison of changes in numbers both within and between winters, with the latter supplemented by historical data.

Within-season change

Census-method flights in the first winter showed some changes with time, although the restricted months surveyed are a constraint. January counts recorded most birds in the centre of the bay, in a band roughly stretching from north-west to south-east. By March, many more birds were recorded at Pembrey, with less concentration in mid-Carmarthen Bay. This may reflect movement in response to depletion of food resources (Lucy Smith, unpubl. data). Counts in January were higher than those in March.

The distance-method covered December, January and March of the first winter. Scoters were distributed in an almost continuous band from the north-west of the bay to the mouth of the Burry Inlet on the December count. The greatest concentrations were recorded off Amroth and about 6 km off Pendine. These areas were also favoured in January, with fewer birds found in the east of the bay. By March, two distinct aggregations appeared to have formed, one in the north-west corner of the bay and one off Pembrey in the east. This eastern concentration agrees with the results of the census-method and has been noted previously (Stewart 1995). Numbers of scoters declined with time, the peak point estimate occurring in December.

In the second winter, the census-method in January revealed greatest densities of scoters in the diagonal band from Amroth to Pembrey, with many birds recorded within 4 km of the coast. February counts were remarkably low in comparison to January, and indeed to February 2003. Those birds recorded tended to be off Pendine and Amroth. Counts were higher in March, but the movement to Pembrey evident in the previous winter was not replicated.

Using the distance-method, October counts were fairly low and featured a scattered spread of birds up to 10 km from shore. November counts showed a similar spatial pattern, with transects eight and nine, in the middle of the bay, revealing greatest concentrations, but with a general scatter of scoters. By January, when the peak distance-method counts and estimates occurred, scoters were distributed in the characteristic diagonal band from north-west to south-east. Clumps at Pembrey and off Amroth and Pendine were prominent.

Although counts were unusually low in February, the general spatial distribution was similar to January. By March, most birds were found in the north-west corner of the bay, with some concentration in the middle of the bay. Few birds were seen at Pembrey or Rhossili, despite a count comparable to that in November.

It remains unclear why numbers counted from the plane should have been so low over all three flights in February 2004, as simultaneous ground counts revealed much higher numbers of birds within the bay. One factor that could have influenced bird behaviour and possibly distribution is the weather. Counts at the end of February took place immediately after heavy snowfall (deep enough to close local airports). In such conditions, scoters may have been forced to increase their intake rate to compensate the energetic demands of thermoregulation. This could have led to increased movement between feeding areas within the bay, and also birds could have been missed if they spent longer foraging underwater. Birds are also likely to have experienced higher stress levels, which may have led to more flushing in advance of the plane. It may be advisable to avoid performing aerial surveys during very cold weather, to avoid over-stressing the scoters.

Over the two years of study, the general spatio-temporal pattern appears to be of a scattered distribution early in the season, changing to a more orderly distribution characterised by areas of shallow water (<10 m deep) and therefore likely delimited by suitably accessible prey. Lucy Smith reported a potential feeding area north of the line running east-west from Tenby to 8 km south of Pembrey sands, which would appear to be reflected in scoter distributions recorded here. By the end of the season, birds were more likely to be concentrated in the north-west or south-east corners of the bay. Seasonal movement could be tied to changes in benthic prey, such that depletion of favoured areas results in exploitation of sub-optimal areas of the bay. Common Scoters prefer bivalves, but will also take other taxa (Woolmer 2003). The trade-off between increased foraging times at depleted zones and greater diving depth at sub-optimal but prey-rich areas is a likely factor. Another possibility is that there are behavioural changes throughout the season which affect distribution. However, although pair bonding undoubtedly occurs towards the spring months, it is also likely that feeding is of high priority at both extremes of the winter season: refuelling upon arrival, and for the deposition of fat reserves for the return migration in spring.

Historical context / between-season change

The broad overall distribution of scoters was similar to that seen in previous years, with the mid-north of the bay containing greatest concentrations of birds, with additional aggregations at Rhossili for a time following the 1996 oil spill (Stewart 1995, Stewart *et al.* 1997, Cranswick *et al.* 1998, WWT 2003, Lucy Smith, unpubl. data). The distribution varied between months in this study, as demonstrated (see Figure 4.4), but averaged across the winter the birds could 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 (Appendix 7). Unpublished data from Lucy Smith covers the years 1998-2001, and suggests a comparable spatio-temporal distribution. In 1998-99, she found most birds in the north of the bay, describing a line from Pendine to Pembrey, with some usage of the east of the bay towards the end of the season. The following winter, birds again appeared between Pendine and Pembrey (especially at high tide), although Rhossili Bay was used in January 2000. In 2000-01, Smith again recorded a similar distribution, with most birds in a line between Pendine and Pembrey. Less temporal movement was documented, although early in the season birds appeared at Pembrey. Aerial surveys by WWT (2003) also revealed the majority of scoters in waters less than 10 km deep, particularly around Pendine and Pembrey.

The Rhossili area, to the west of the Gower Peninsula, supported few birds in the two years of study, further supporting the theory that this is a suboptimal area used only following the *Sea Empress* oil spill because the favoured areas became unavailable (Cranswick *et al.* 1998). Additionally, very few scoters were located in the north-east of the bay at the outflow of the three rivers, and this area is not historically favoured.

It is difficult to compare numbers recorded between aerial counts, as methods have changed regularly over the past ten years. The peak count of 18,578 estimated on distance-method flights in 2001-02 (WWT 2003) compares favourably with peaks of 19,909 and 17,999 estimated for the subsequent two winters and is easily within 95% confidence limits for both years. Census method counts can be compared over a longer time period, and seem to be more variable. Peak counts for the period winter 1998 – winter 2000 were 19,960, 6,663 and 11,317 respectively (Lucy Smith, unpubl. data). These compare with 10,309 and 20,271 in the winters of this study. The range is larger than that for the distance method, and also has the disadvantage of no confidence limits.

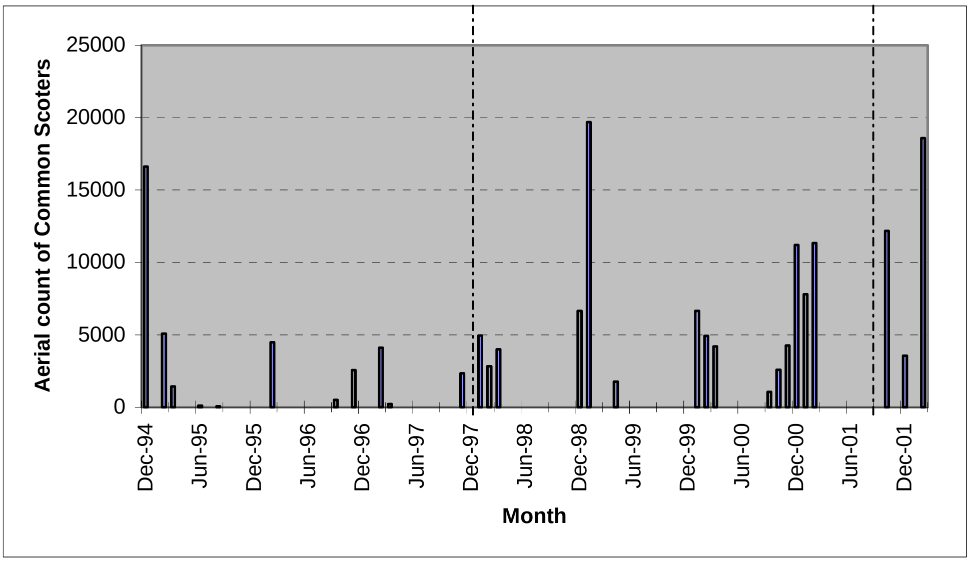


Figure 4.4 Historical counts of Common Scoter by aerial survey in Carmarthen Bay. Dashed vertical lines indicate changes in survey methodology. Where more than one count exists for a month, the largest value is plotted.

Behaviour

During the flights, the behaviour of the scoters was recorded, although only in the broadest of detail, as to have concentrated upon behaviour would have compromised the primary aim of making counts. All that could really be investigated was the reaction of the scoters to the plane. An obvious question is whether the detectability function for birds in the air differs from that of birds on the sea. It seems intuitively likely that they would be different, although it is not clear in what manner: distant birds are likely to be more visible in flight than on the surface but, conversely, birds are perhaps more likely to be in flight nearer the transect due to the effect of the plane. A preliminary attempt was made to separate flying and sitting birds within the distance analysis for first winter data. Perhaps surprisingly, it appeared that the split added little to the model.

During the distance-method counts, the great concentration required of the counters meant that only division of birds into sitting, flying and flushing was possible. For the census-method flights (first winter only), the direction of travel of flying birds was usually also recorded. The distinction between 'flying' and 'flushing' birds is not straightforward as it is not possible to say for certain that a flock of scoters in flight have not been influenced by the approach of the plane. As a result, it is perhaps safest simply to consider whether birds are recorded on the water or in flight.

Overall, during first winter distance-method flights, 71% of birds were noted in flight, compared to 59% in flight during the census-method flights. This difference could perhaps be due to the fact that the distance-method flights were at a lower altitude, causing greater disturbance to the birds. However, it was strongly influenced by the final distance-method survey on 16/3/03 when over 96% of birds were recorded in flight. It is possible that by the time of this flight, which was the fourth covering the bay in two days, the birds had become increasingly 'spooked' by the plane. A comparable effect was noted in the following winter. On the third flight of the weekend (29/2/04), an average of 95% of scoters were recorded in the air, supporting the hypothesis that intensive aerial survey can lead to high levels of flushing and flight in response to the aerial activity.

During the second winter, behaviour during the census-method was not recorded. However, behaviour on the distance-method revealed a near equal split in sitting and flying behaviour. Adding behaviour as a covariate did not improve the precision of point estimates in the distance model.

Observers

Perhaps the most obvious difference between surveys in the two seasons is the change in observer. RS counted in both seasons, but LS was unavailable in the second winter. BH, an experienced aerial surveyor, took part in 2003-04, and AB, with less experience, also participated. Although AB would have counted from a different side of the plane to RS or BH, his counts were not noticeably orders of magnitude different. Also, the birds observed in various distance bands generated for this observer matched closely the detection probability curve, suggesting that distance-method band allocation was accurate. Furthermore, adding separate detection functions for each observer did not increase the precision of count estimates (see Appendix 1). Therefore, it would seem that relative inexperience does not greatly confound counts.

Records of behaviour between observers, however, were sometimes as different as 84%. This suggests inter-observer bias, despite the fact that both observers recorded different birds. It would be worthwhile tightening guidelines on classification of sitting and flying behaviour; for instance, birds which take off from the water may only be detected once in the air, but could have been sitting when first passed. Quantifying this variable is less important than obtaining a valid count, but inaccuracies such as this can easily be controlled with a clearer set of classification rules.

As part of the study, as well as to increase the base of available observers for aerial surveys, a BTO staff member Steve Holloway (a highly experienced field observer but with no prior aerial survey experience) joined the four flights made over the weekend of 15-16/3/03, having been fully briefed on the techniques to be used. For each flight, SH occupied a seat behind LS and made observations to starboard of the plane. However, the visibility afforded to him by this seat was less than that of the two principal surveyors. As expected, the counts made by SH were substantially lower than those of LS; 31% and 37% of her totals for the two census-method counts and 19% of her second distance-method count (the first distance-method count was primarily used by SH to acclimatise to the overall experience of aerial survey). However, it was difficult to assess the extent to which these lower count totals were due to counter experience *vs* the less optimal viewing conditions. It is likely both had an impact. Interestingly, however, the relative distribution of Common Scoters recorded by SH for the two census-method counts are similar to those recorded by the other two observers.

Furthermore, training flights in the second winter supported the above conclusions. AB was required to act as a counter after receiving 12 hours of flight experience, and distance function graphs at least showed that relative inexperience was not a problem, as his observed counts matched well with the detection probability curve. Therefore it was likely that he detected most birds near to the transect line. Results from the two years of survey imply that relative inexperience of aerial surveyors may not be such a problem, especially if the main aim of a flight is to record a broad distribution rather than come up with a population estimate.

It will be especially important to ensure that ground and air counts are as close in time as possible in future, as it appears that aerial activity has a severe effect on scoter distribution. Most birds flushed in response to the approaching plane, and still more were 'triggered' into flying. Although many birds may have returned to their original area, it is very possible that both aerial methods include double or even multiple counts. Conversely, birds that flush in advance of the plane and fly out of the survey area (or back from an area already covered) will not be counted. It would be useful to investigate further whether flushed scoter are likely to be counted on subsequent transects – *i.e.* whether the escape reaction is to fly > 1km. This did seem the case in the second winter, although exact quantification from the ground is difficult. Although counts may be inaccurate when birds flush, it is thought that sufficient numbers of scoters were still present on arrival of the plane to gain a broad picture of spatial distribution.

For future monitoring purposes, it is essential that some aerial surveys be continued, as there are areas of the bay used by scoters that are too far offshore to survey from the land. Furthermore, spatio-temporal descriptions of distributions may only be obtained in this way, and distribution plots between years can be compared to not only investigate long-term change in usage of areas of the SPA, but also changes within seasons. Therefore a series of counts through the winter, from November through to February, is recommended. Transects for both census and distance flights should ideally be flown in a random order. If this is prohibitively impractical, then at least the order of transects should be reversed on consecutive flights. It is also important to continue to train new aerial observers, not only to increase the pool of potential fieldworkers for this type of work but also to confirm the extent to which relative patterns of distribution can be described by relatively inexperienced observers.

4.4 Assessment of the Relative Merits of Two Different Aerial Survey Techniques

Aerial surveys of Common Scoters in Carmarthen Bay have been flown using two quite separate methods in recent years, with the distance-method being introduced in 2001-02 and the census-method used before that. The grid cells used for survey were introduced in 1998-99. However, this study is the first to directly compare counts made using both methods.

The principal reason for introducing the distance-method was to try to improve upon estimates of numbers of scoters in the bay, as it was felt that the census-method involved too great a risk of double-counting birds as they were flushed from one cell to another. With the distance-method, the distance between transects was increased thus potentially lessening the chance of double-counting. Additionally, the distance-method allows the calculation of confidence intervals on the estimates.

The aerial surveys carried out during 2002-03 allow for four sensible comparisons to be made, *i.e.* three pairs of surveys on 4/1/03, 15/3/03 and 16/3/03 and a further comparison of the 4/1/03 distance-method flight with the 5/1/03 census-method flight. The results of these surveys are summarised in Tables 4.2a and b. Overall, the estimates from all of these aerial surveys were relatively consistent, within a range of about 4,000 to 8,500 birds (although the point estimate from the additional non-paired distance-method count on 1/12/02 was almost 20,000 birds).

Surveys		**Distance-method results**			**Census-method results**	
Distance	**Census**	**Count**	**Point estimate**	**95% C.I.**	**Count**	**Adjusted estimate**
04/01/2003	04/01/2003	5408	15417	7840-30317	8835	10779
04/01/2003	05/01/2003	5408	15417	7840-30317	10309	12577
15/03/2003	15/03/2003	9690	13337	7846-22672	7956	9706
16/03/2003	16/03/2003	5984	9819	6071-15881	7572	9238

Table 4.2a Comparison of results from aerial surveys during the 2002/03 winter. Adjusted estimates for the census method count are to allow for a 'dead-zone' underneath the survey plane as discussed in section 4.4.

Surveys		**Distance method results**			**Census method results**	
Distance	**Census**	**Count**	**Point estimate**	**95% C.I.**	**Count**	**Adjusted estimate**
25/01/04	25/01/04	12471	**17999**	11665-27774	20271	24731
29/02/04	28/02/04a	2458	**2336**	1550-3519	5234	6385
29/02/04	28/02/04b	2458	**2336**	1550-3519	5024	6129
27/03/04	27/03/04	10081	**15086**	8977-25353	5431	6626

Table 4.2b Comparison of results from aerial surveys during the 2003/04 winter. Adjusted estimates for the census method count are to allow for a 'dead-zone' underneath the survey plane as discussed in section 4.4.

For the pair of flights on 4/1/03, the adjusted census total was within the confidence limits of the distance-method estimate, although 30% lower than the point estimate. The adjusted census-method total from 5/1/03 was closer to the point estimate but still 18% lower. On 15/3/03, the adjusted census total was again within the distance-method estimate confidence limits (although the non-adjusted census total was only just within these limits) and again the census estimate was lower than the distance point estimate, by 27%. Finally, the estimates from the pair of counts made on 16/3/03 were in closer agreement, with the census-method adjusted total only 6% lower than the distance-method estimate.

In the second winter, flights using the two methods made on the 25/1/04, 28 and 29/2/04, and 27/3/04 were compared. The results were almost the opposite of those in the previous winter. On the first three flights, census-method techniques recorded higher numbers than the point estimates of the distance-method. This highlights some of the problems with aerial survey, as the observers on the January census flight acknowledged the movement of scoters between grid cells, and by their own admission over-counted. Conversely, the very low counts in February (especially with the distance-method) do not reflect the true numbers of birds using the bay at the time, as ground counters observed many thousands of birds flying to escape the plane. The March counts should perhaps have been most accurate, as conditions were perfect for aerial survey. This is reflected in the distance function plot in Appendix 1. On this flight, the distance-method recorded higher numbers of scoters than the census-method, as in the previous winter.

Only one of the four census counts (unadjusted January count) fell within the confidence limits of the distance estimates. It is possible that repeat counts of birds were made on the census-method flights, producing inflated estimates. Further sources of error are likely to have been introduced during the distance-method. Plots of observer detection probability suggest that even very experienced observers saw more birds in the middle distance bands than in the band closest to the transect line. If this is an effect of survey effort, with observers not detecting birds close to the plane, the problem could be rectified by reinforcing the notion that distance band 'A' should be concentrated upon. However, the other possibility, that scoters do not occur at greatest densities in the closest distance band, is more problematic. The escape reaction noted by ground observers could mean that when the plane reaches a point on a transect, the majority of scoters are already flying in the middle distance bands. If this is the case, the assumption that detection rate decreases with distance is violated and the validity of using the distance-method in this case is called into question.

A further relatively minor source of error may result from technical problems with GPS. Accurate GPS tracks for each flight made would allow pinpoint calculation of the actual area surveyed by the plane, a factor necessary in calculating point estimates. Without these tracks, assumptions are made about the area covered. Variables such as wind-speed and direction can affect the course of the plane, and deviations from the transect can never be fully excluded; therefore full GPS tracks, with position recorded at least every two seconds, are desirable. However, this is probably a lesser problem compared to the others.

As mentioned above, one of the principal justifications for using the distance-method is that the census-method is likely to lead to double counting. Therefore, one would expect there to be a tendency for the census-method to lead to higher estimates than the distance-method. This was clearly not the case in the first winter; in all four comparisons the census-method estimate, even after adjusting for a ‘dead-zone’ under the plane (*i.e.* a band of sea below the survey plane that cannot be observed from windows on the side of the plane), was lower than the point estimate from the distance-method survey. However, in the second winter it is possible that repeat counts were made on the census-method. Three of the four comparable flights revealed greater numbers of scoters on the census-method, the exception being in March when count conditions may have facilitated detection at greater distances than usual on distance-method flights.

It seems likely that the census-method can also undercount bird numbers. One reason for this is probably the underlying assumption that counters record all birds out to a distance of 500 m from the transect line. The distance-method results suggest, though, that this assumption is incorrect. For the distance-method flights undertaken during 2002-03, three of the four distance bands were within the 500 m zone and counts were clearly not distributed evenly amongst these bands. However, it should be remembered that the two aerial survey methods were undertaken with the plane at different heights.

One point of note for aerial surveying is that whilst the existence of a ‘dead-zone’ is a well-recognised issue for the analysis of data from distance-method flights, there is also an equivalent ‘dead-zone’ for the census-method flights. As the plane is at twice the height during a census-method flight, the zone is twice as wide, *i.e.* 88m either side of the transect line. The census-method takes as an assumption that the observers cover the whole sea-area. However, the dead-zone means that about 18% of the sea is not being viewed and census-method counts should perhaps be increased by a factor of 1.22. On the other hand, it could be argued that many of the scoters that are in this zone will in fact flush to one side or the other and thus be observed anyway. Whether or not this correction factor is used is probably not too important, as it seems likely that even making this correction the resulting estimate is still far too low, as discussed below in Sections 4.4 and 4.5. The relative distribution is of greater interest.

Although they can give higher estimates and follow a more scientifically rigorous methodology, the distance-method estimates are not ideal, in that the bootstrapped 95% confidence intervals provided around the estimates tend to be very wide. This makes it more difficult to have faith in the point estimate. These wide confidence intervals are largely as a result of a high degree of clumping in the distribution of scoters in the bay. For example, for the distance-method survey on 16/3/03 a total of 176 observations of scoter ‘clusters’ was made, totalling 5,984 birds. However, over half of these birds were present in just two clusters (of 2,200 and 1,100 birds respectively). Given this level of concentration into a few principal concentrations, the accuracy of the counting of these flocks is of great importance. It is well-known that even the most experienced counters can have difficulty in counting larger flocks under the demanding conditions of being in a fast-moving plane, particularly when of uneven density (*i.e.* denser in the centre and more dispersed to the edge). Photographs of the principal clusters encountered during a flight could be advantageous if it were possible to obtain them without undermining the counting effort.

From the aerial surveys during the two winters it has been possible to compare the two methods, but further fieldwork would yet strengthen this comparison. Similar results to either of the winters would need to be consistent if an approximate scaling factor is to be applied to past aerial counts. It is not possible to say which of these two methods is better at estimating the true number of birds present in the bay, since the true number is not known to begin with. It still remains to be proven whether estimates derived from either aerial method are suitable to describe the true numbers of scoters using the bay. The ground-based monitoring counts undertaken over both winters, whilst not always ideally synchronised with the aerial count dates, suggest that aerial counts consistently record lower numbers than ground-based counts. Lucy Smith's data suggests a similar pattern, although some other studies made larger aerial then ground counts (*e.g.* Cranswick *et al.* 1998). This may have been an artefact of birds avoiding feeding areas visible from land that were contaminated during the oil spill of 1996.

Attempts to qualify movements of scoters in response to the plane did not suggest that birds were being 'herded' towards shore on either method. General movements towards the east of the bay were detected, but whether this is a robust behavioural effect is unclear from one year's observation.

The advantage conferred by both aerial methods is that a general picture of wider distribution is formed. The two methods give very similar spatial patterns, implying that the greatest concentrations are recorded close to their actual locations. It would seem that both methods are efficient at mapping scoter dispersal within the bay, and therefore some form of aerial survey is necessary to highlight changes in feeding areas, such as during the *Sea Empress* oil spill. In terms of obtaining accurate counts, the distance-method is fast becoming the standard, having been developed by NERI Denmark and adopted by various organisations such as JNCC and WWT. The advantages of this method are set out in Camphuysen *et al.* (2004), and it is proposed that for scientific rigour and comparability with other surveys, this method be favoured for monitoring Carmarthen Bay SPA. This will allow estimates to be checked against population estimates for other parts of the U.K. If it is decided that annual minimal population estimates from ground counts are acceptable, it may be necessary to carry out aerial surveys only periodically. If flights were (say) every three years, cost would be significantly reduced, and should be sufficient to monitor large, long-term changes in scoter distribution within the bay.

4.5 Investigation of Whether Ground-based Counts Consistently Provide an Appropriate Index of Overall Numbers of Scoters

Both aerial counts and ground-based counts can be used to describe the numbers of scoters in Carmarthen Bay but both have their limitations. As such, neither can be considered to provide a definitive answer to the number of scoters in the bay. Ground-based counts cannot survey birds that are too far away from the shore. Aerial counts by the census-method are limited by the risk of double-counting but probably also, as discussed above in Section 4.4, by the invalid assumption that birds can be completely surveyed to a distance of 500m from the transect line. Aerial counts by the distance-method attempt to account for the risk of double-counting but, in both winters, the confidence limits around the resulting estimates were very wide. Additionally, the assumption that one detects all birds on the transect line is likely to be invalid due to the disturbing impact of the plane.

Even a very cursory visual comparison of the results from the ground and aerial counts strongly suggests that many birds are missed from the air compared to those counted from the ground, which agrees with past survey work at the site (Stewart *et al*. 1997, Cranswick *et al.* 1998). There are two plausible reasons why this should be so. Firstly, neither aerial survey method accounts for birds that fly in advance of the arrival of the plane. This is known to occur, both from observations by observers during this study and also in previous winters by LS. Secondly, neither of the two aerial survey methods accounts for scoters diving underwater upon the approach of the plane. This would appear to be a natural response for a sea duck encountering a perceived threat and some birds at least must surely have been missed in this manner. Anecdotal observations suggest that only a small proportion of scoters appear to adopt this strategy (A. Woolmer, *pers. comm.*), but this may be a significant number when factored over a population of tens of thousands.

The question of whether ground-based counts can consistently provide an appropriate index of overall numbers of scoters is thus not straightforward to address, as the true number present is not known. It could be argued that it is unnecessary to record the true number of birds present so long as one knows what proportion of the whole is being covered by the ground-based counts. For example, if the area known to be visible from the ground count stations can be assumed always to hold a given proportion of the birds, then an appropriate index could indeed be provided.

Whatever the accuracy of the counts and estimates derived from the aerial surveys, the relative distribution is broadly similar throughout all counts, on a band from north-west to south-east, agreeing with the general shallow water pattern found during other recent winters. However, within this band, the relative distribution can vary considerably, as mentioned in section 4.3. Therefore, as birds may shift temporally over the short-term, one could not be sure that the ground counts represented a constant proportion of the overall number of birds in the bay. However, if counts between years took place in the same months so that a yearly average could be used for indexing, this variable should be at least partially controlled for.

As a result, individual ground-based counts should not be considered an index of total population size. However, it is possible that the birds seen from the ground represent the ‘core’ of the population, given that the prime feeding areas appear to lie in a band from the north-west to the south-east of the bay. Areas off Amroth, Pendine and (traditionally) Pembrey frequently hold high densities of scoters, and are often within visible range. Therefore as a population minimum, yearly average ground counts could suffice to produce an index. However, in ‘high’ population years, those birds competitively excluded and forced to forage in sub-optimal areas would not be detected, resulting in a misleading stable index. Similarly, season-long spatial shifts may appear as declines, which relays useful information about the key areas involved, but little about the Favourable Conservation Status of the scoter population within the SPA as a whole.

One point of note is that a potential scaling or cross-calibration factor may be possible to generate. Where available, counts in the same month made from the ground and from the air were compared. For the census-method, aerial counts represented 38%, 40%, 38% and 37% of ground counts. For the distance method, of six survey months across the two years, four were very similar in proportion to the ground counts (66%, 67%, 72% and 76%). The remaining two counts were 49% and 16% of the ground counts, although the latter, in February 2004, recorded very low numbers on the aerial survey.

If a scaling factor based on these differences was found to apply to a larger data set, it should be possible to estimate ground values based on aerial surveys and vice versa. Similarly, cross-calibration between the two surveys could be possible, to check that the same proportions of the population were being monitored. However, as comparable data from Lucy Smith for 1998-99 show that aerial counts exceeded ground counts, further research is necessary before the scaling factor can be considered at all applicable.

In summary, the ground-based counts would ideally be used in conjunction with aerial counts. The latter could provide a relative distribution map to scale up the ground-based counts from the limited area of the bay visible from land to the overall occupied area. A key requirement to providing overall estimates of numbers (as discussed in Section 4.7), therefore, is to know quite precisely the area that is being monitored from the land, as discussed below in Section 4.6. Previous combinations of aerial and ground data (Cranswick *et al*. 1998) assumed that all birds in the north of the bay (Saundersfoot – Pendine) counted from the ground were not counted from the air. However, this approach also makes the assumption that birds flushed did not fly to areas then surveyed by the plane, and would seem inaccurate.

The level of synchronicity between ground and aerial counts should also be improved if possible, although weather and plane availability are significant constraints. Ideally, ground counts from all three vantage points should be carried out simultaneously and immediately followed by aerial survey, with the ground observers recording the reaction of birds to the plane.

4.6 Investigation of Whether a Distance Function can be Derived Using Aerial-counts to Describe the Decline in Detectability by Ground-counts Over Distance

The likelihood of detecting an offshore flock of scoters from a land-based observation station is related to the distance of the flock from the observer and the size of the flock (larger flocks are likely to be detectable over greater distances than smaller ones). Additionally, count-related factors such as sea-state and visibility are also important. In order to interpret ground counts of scoters correctly, it is necessary to develop a distance function to describe detectability. This should also enable counts to be scaled up across the whole of Carmarthen Bay by comparison with aerial counts. The determination of the distance function would be a relatively straightforward matter if the scoters were distributed evenly across the bay. However, this is clearly not the case, as can be seen from both the survey work described in this report and that carried out in previous years. A different approach is thus required. It was initially envisaged that the distance function could be determined by comparing the aerial survey data with the ground count data. Although this approach has proved unsuccessful, as discussed below, it is useful to consider the theory behind it.

Carmarthen Bay is divided into recording cells for the purposes of the aerial census flights. For most of the bay these were 2 x 1 km in size. The south-eastern part of the bay was divided into 1 x 1 km cells, although relatively few birds were recorded here and this area can be largely discounted for the current purpose. The ground counts were recorded to distance and bearing from the three vantage points, enabling plotting of flocks to eastings and northings. Following this, flocks were assigned to the aerial census recording cells. Additionally, the distance from the centre of each cell to the nearest ground station was calculated.

Ideally, one would assume that the distribution between the two surveys was constant, and that both ground and air counts recorded the same number of birds close to shore but that ground counts declined relative to air counts solely with increasing distance. A graph of (ground/air) *vs* distance could then be plotted and the shape of the resulting curve would describe the distance function. A refinement of this method would be to plot separate curves for different sized scoter flocks (perhaps 1-10, 11-100, 101-1000, 1001+) as one would expect detection of small flocks to drop off more rapidly than for large flocks. A further modification would be necessary if, as observed in this study, the overall numbers of birds seen from the air were lower than those counted from land. In this case, one could scale up the aerial counts proportionately and then plot (ground/scaled air) *vs* distance instead. The resulting curve would again be suitable for determination of a distance function.

However, an attempt to use this approach on the data collected for this project was unsuccessful. The reason was that in the nearest cells to the shore, where the ground count would be assumed to be the most accurate, very few birds were recorded by the aerial counts. Although synchronicity between ground and air counts could not often be achieved, a comparison of the mean distribution between ground and aerial census counts (Figures 4.5a and 4.5b) shows that the ground counts reported very much higher numbers of birds close to the shore than were recorded by the aerial census-method counts. The discrepancy is striking; as an example, from the first entire recording cell south of the Pendine vantage point, a mean of 2,666 Common Scoters was recorded during ground-based counts compared to zero from aerial census counts, both in the first winter. This may be because birds in this area are 'flighty' and flush in response to the plane (Cranswick *et al.* 1998). Regardless, it is clearly unrealistic to attempt to scale up such aerial counts. Therefore, the underlying assumption of the approach is violated, *i.e.* that the actual distribution of the birds was constant between the two surveys.

It has to be concluded that it is not feasible to rigorously determine a distance function in this manner. However, it is important to discover why such a discrepancy exists. The possibilities are:

1) There was a real, inherent difference in distribution on the dates of the ground and aerial counts. As the counts could not be synchronised it is not possible to discount this entirely. However, given that analysis has been attempted using data averaged over four winter counts for both methods it seems highly unlikely that this level of discrepancy can be explained entirely in this manner. One possible difference would be if all counts of one method had been at a different state of the tide to all of those by another method. However, examination of the times and tides of the counts shows that each method was carried out over a similar spread of tidal situations. Additionally, visual examination of the maps of distribution by the aerial census-method (Figures 3.9 to 3.12) is instructive. These two pairs of first winter counts on successive dates were carried out at different states of the tide (*i.e.* around high tide for 4/1/03 and 15/3/03 and around low tide for 5/1/03 and 16/3/03). Whilst small differences can be described for the high and low tide distributions there is no large-scale redistribution in the parts of the bay closest to the shore.

2) The distances assigned to flocks during the ground counts were incorrect. If the distance values recorded by LS and NF were lower than they should have been then the aerial and ground counts would suggest more similar distributions. Judging distance over open water is particularly difficult and it would seem quite possible that some distances were not assigned correctly. However, the methods used by the observers had been developed in a rigorous manner. LS felt that if errors did occur then they would be more likely to operate in the opposite direction, *i.e.* it was felt that distances might be over-estimated. NF cross-calibrated his distance estimates using triangulation of buoy positions at compass measurements from the three count stations and values from Admiralty charts, and felt confident in his estimates. Additionally, if there were problems within the distance estimations, these would be more likely for the greater distances, whereas the greatest discrepancy between ground and air counts appears to be closer to the shore. It is not likely, therefore, that this would explain the discrepancy entirely. It should be noted, however, that if this explanation was shown to be correct and distances were being underestimated then this would have further implications as the count zones from the Amroth and Pendine vantage points would overlap and flocks would then be double-counted.

3) The difference in distribution is due to birds moving in response to the approach of the plane. LS felt that this was the most likely explanation and the observations of NF on 15/3/03 back this up, when he noted redistribution out to sea of the scoter flocks off Pendine following the pass of the survey plane. It was also thought that this explained the discrepancy of the distributions noted off Pembrey in the east of the bay, where birds were noted relatively close to shore during ground counts but were located further offshore during aerial counts. LS felt that during the distance-method flights, with north-south transects moving progressively from east to west, it was likely that scoters were 'herded' across the bay in front of the plane. This did not seem to be the case in the second winter, although widespread (easterly) movement of scoters was recorded, with birds close to the shore 'triggered' into dispersing by the wave of flushing birds in advance of the approaching plane. This behavioural response may cause problems for accurate survey, as birds would not always be recorded at their original position (roughly 50% of birds were 'sitting' when recorded in the second winter, and therefore about 50% were already in flight – probably as a result of flushing and possibly through a 'trigger' effect).

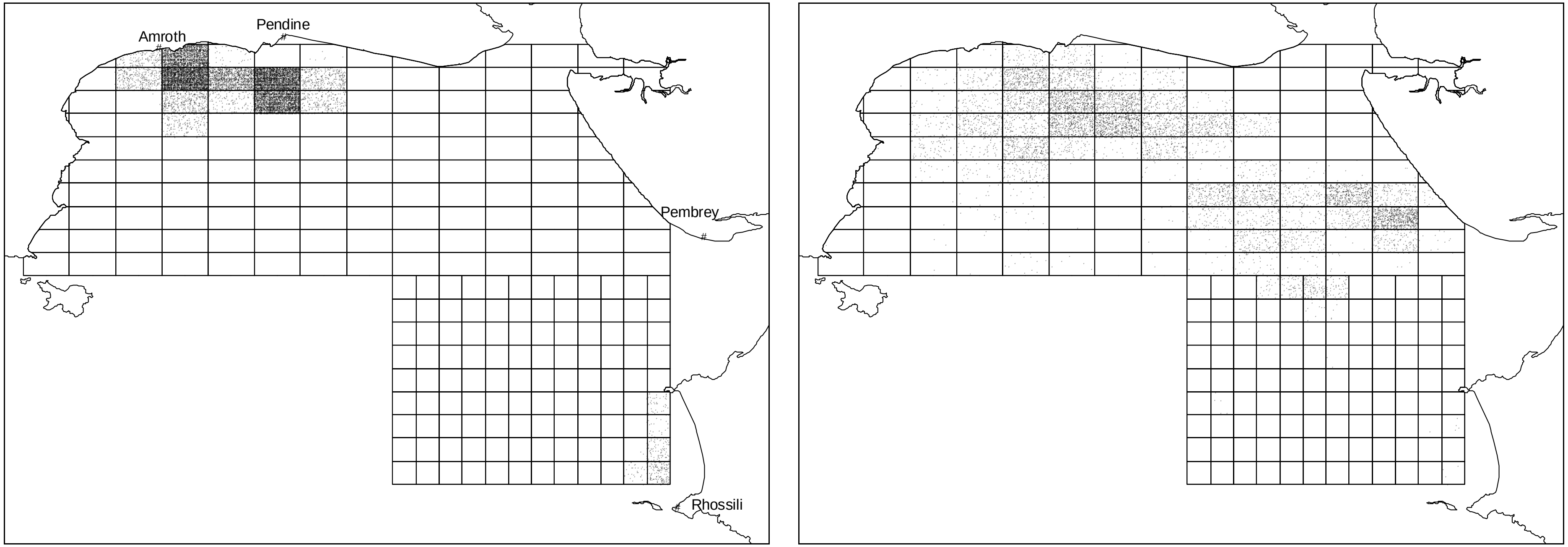
It seems most likely that the third explanation is the most plausible. This has serious implications for the determination of a distance function and thus for the consequent estimation of the overall numbers of scoters within the bay. An exploratory approach to such an estimation resulted in estimates of up to 150,000 scoters, which seems highly unlikely, given that no other counts have ever approached this range.

A much coarser-scale approach was also tried. In this case, it was assumed that all birds seen from the ground within a distance of 4 km from the vantage points were equivalent to all of the birds recorded from the air within that distance of the vantage points. Scaling the ground counts upwards accordingly then resulted in an estimate of about 35,000 scoters, which seems more reasonable. A similar approach comparing the percentage of census counts within view of ground counts in the second winter produced scaled ground estimates of 23,632 for December and 24,312 for February. However, it is felt that there is still too much uncertainty surrounding the counts to rely upon such an estimate yet.

It does not seem feasible to derive an accurate distance function using aerial counts to describe the distance-related decline in detectability with ground counts, for the principal reason that aerial counts do not generally record large numbers of birds close to shore. This is likely to be due to disturbance caused by the plane, with birds flying east or south as an escape response.

(i) (ii)

Figure 4.5a Mean ground (i) and aerial census (ii) distributions of Common Scoters at Carmarthen Bay during the 2002-03 winter. One dot represents one averaged bird.



i) ii)

Figure 4.5b Mean ground (i) and aerial census (ii) distributions of Common Scoters in Carmarthen Bay during the 2003-04 winter. One dot represents one averaged bird.

4.7 Evaluation of all Extant Data to Provide Possible Targets for Scoter Numbers and Creation of a Draft Protocol for how Assessments of Favourable Conservation Status Should be Made

Can a target be derived for the numbers of Common Scoters in Carmarthen Bay that would enable an assessment of Favourable Conservation Status to be made? As has been discussed above, whilst there are a number of ways of arriving at scoter numbers for the site none are ideal and all have associated problems. The most rigorously derived estimates are those from the distance-method flights. However, the width of the confidence intervals around these estimates means that they may not be very suitable for detecting change in the numbers using the site, and as the method has only been used in three winters, it is difficult to construct a useful index (see Appendix 6). It is also seemingly impossible to formulate a scaling factor to convert previous census-method counts to distance-method estimates, as results differed widely between years. An index of census-method counts for the period 1998-99 to 2003-04 is possible, with one year of missing data. The index is also found in Appendix 6.

A ground count index is also feasible for a longer period, 1992-93 to 2003-04 (Appendix 6). Methods were standardised from 1998-99 onwards, and counts shown are peak counts for the winter. Where known, peak counts were made between December and March. The index, as mentioned, probably monitors only the 'key' proportion of the population total. However, if reliable, it shows a fairly stable trend following recovery from the oil spill in 1996. Counts in 2003-04 were lower than in recent times, but this may represent natural population fluctuation. It may of course also reflect temporal shifts within the bay, but associated aerial surveys do not suggest widespread movement from the traditional feeding grounds.

Measures of change in waterbird populations in the UK are becoming standardised around the WeBS Alerts system (Austin *et al.* 2003). This system uses smoothed index values to assess change over three time periods (five, ten and 25 years). Any declines fire an 'alert' if greater than 25% (a medium alert) or 50% (a high alert) over a given time period. Formal application of the Alerts system to the Carmarthen Bay dataset would currently be inappropriate, as the reliability of potential indices has not yet been derived. However, the three time periods (when enough data become available) and the two levels of decline should be adhered to in discussion of change for the purposes of standardisation.

Based largely on data from this study, the following suggestions can be made:

Option A – Ground counts only

Given an adequate degree of thoroughness and favourable count conditions, these provide good minimum estimates. Ground counts are also relatively inexpensive and straightforward to carry out. However, they are not suited to monitoring the whole site. Given that the relative distribution of the scoters within the bay varies through the winter it is not straightforward to use an individual ground count to index the total population. Although it is possible that taking the peak count for the winter might provide a reasonably reliable measure of occupancy, there is a genuine risk that ground-based monitoring may generate an inaccurate index. Given that most birds will preferentially forage in the shallow areas between the north-west and south-east corners of the bay, ground counts could be expected to incorporate a loosely fixed proportion of this distribution. However, any changes that may occur further out to sea would always be missed. Therefore a stable index could be interpreted to mean that the population within Carmarthen Bay SPA was 'healthy', whereas realistically unmonitored changes would greatly affect the index. This may be less of an issue if minimum estimates only are required.

Examination of the recent counts available suggests that peak ground counts over a winter in the order of 20,000 birds should be a reasonable expectation. Using peaks published in Pollitt et al. *(2003), data from Lucy Smith, WWT (2003) and this study, the five-year peak mean for the period 1998-99 to 2002-03 is 20,541 and 19,982 for 1999-00 to 2003-04. It is suggested that if a minimum of four ground counts over the course of a winter, preferably during November to February, fail to* *produce a peak total of 15,000 Common Scoters, this should be considered a provisional medium alert. Likewise, if a minimum of four ground counts over the course of a winter fail to produce a peak total of 10,000 Common Scoters, this should be considered a provisional high alert.*

Option B – Aerial census-method only.

This is a reasonably straightforward way of covering the whole bay, although is clearly logistically more difficult than ground counts (requiring more staff, greater organisation and a plane). This does not appear to be a good method for assessing the overall numbers, as numbers recorded are much lower than those recorded by ground counts. This is probably largely due to birds flying well in advance of the plane and potentially birds diving upon the approach of the plane. However, it is possible that the relative numbers recorded per flight could be as effective an indexing tool as the ground counts. The totals counted by this method during the present study were relatively consistent, averaging 8,668 Common Scoters in the first winter and 8,990 in the second (although counts were much more variable in the latter). During similar aerial census-method flights (although with different routes used) in the winters following the *Sea Empress* oil spill, the peak and average totals were, respectively, 4,500 and 2,382 in the 1996-97 winter and 4,953 and 3,020 in the 1997-98 winter, although totals were somewhat variable between flights. In 1998-99, the average of three flights (December, January and April) was 9,368; the following winter, eight flights (nearly all in March) provided an average count of 3,598, presumably lower due to the later date of survey (Lucy Smith unpublished data). Only data for two flights in September 2000 were available for the subsequent winter; therefore it was not possible to calculate a meaningful average count.

However, using peak counts from this study, plus unpublished data from Lucy Smith, it is possible to obtain a five-year peak mean, albeit with a missing count in 2001-02. For the period 1999-00 to 2003-04, the peak mean count stands at 12,140.

From the recent counts available, it appears that a peak winter count by the aerial census-method of over 10,000 birds should be considered a reasonable expectation. Until further notice, it is suggested that if a minimum of four aerial census-method counts over the course of a winter fail to produce a peak total of 7,500 Common Scoters, this should be considered a provisional medium alert. Likewise, if a minimum of four aerial census-method counts over the course of a winter fail to produce a peak total of 5,000 Common Scoters, this should be considered a provisional high alert.

Option C – Aerial distance-method only.

This is a rigorous and repeatable method and so provides what are arguably the best estimates for between-year comparisons. However, the widths of the confidence intervals arising from the analyses in both years are such that it would be difficult to identify a real decline of 25% or even 50%. It is important to discover whether the method is flawed because of procedural or conceptual inaccuracies. If observers practiced focusing on the nearest distance band, perhaps with additional aids to assign birds to the correct band, and complete GPS tracks could be used to calculate total areas surveyed, estimates could be more accurate. Additionally, further covariates could be investigated to see if the model fit improved. However, if scoters are not recorded in the nearest distance band to the transect because of flushing by the plane, then the fundamental assumptions of distance sampling are violated and the method may not be applicable in this case. However, as the method is becoming standard practice for aerial surveys of seabirds (e.g. Webb *et al.* 2003, WWT 2003), including recommendation by the Crown Estate (Camphuysen *et al*. 2004), there appears to be a consensus in the scientific community that this method is the most accurate.

Dependent on further research and analyses, it is cautiously recommended that aerial distance-method counts could be used to assess Favourable Conservation Status of Common Scoters at Carmarthen Bay. As an interpretative tool for monitoring spatial and temporal distribution, the method is especially useful. Furthermore, three consecutive winters of these type of counts have now been made, and a future index could be partially based on these standardised surveys. From the recent *counts available, it appears that a peak winter count by the aerial census-method of around 18,000 birds should be considered a reasonable expectation. Until further notice, it is suggested that if a minimum of four aerial distance-method counts over the course of a winter fail to produce a peak total of 13,500 Common Scoters, this should be considered a provisional medium alert. Likewise, if a minimum of four aerial distance-method counts over the course of a winter fail to produce a peak total of 9,000 Common Scoters, this should be considered a provisional high alert.*

If four counts a year of this type proves prohibitively expensive, the method should be used on a periodic basis to check the consistency of spatial and temporal distribution within Carmarthen Bay, especially in years where ground counts are low. Interpolation between years of data may be possible for indexing.

Option D – Combination of ground and air counts.

As discussed in Section 4.6, it would be ideal if aerial counts could be used to scale up ground counts to derive an overall estimate of Common Scoters within Carmarthen Bay. It is unclear how this can be achieved without making invalid assumptions about the true population size. Ground counts in the two winters were consistently higher than either census- or distance-method counts, and peak counts historically have generally followed the same pattern (Lucy Smith unpubl. data, WWT 2003). Aerial counts survey only a fraction of the population, but as the scoters assume a very clumped distribution, it is not straightforward to extrapolate numbers counted from the land to the whole bay. It is likely that a significant part of the population is counted from the land, and that birds will be found in generally lower densities within the rest of the bay.

The provisional recommendations for Option A should be followed, except that aerial census flights should be carried out to detect any broad-scale changes in distribution which could explain changes in numbers.

4.8 Procedural Guidelines and Standard Operating Procedures

Procedural Guidelines (PGs) and Standard Operating Procedures (SOPs) are designed to ensure consistent monitoring approaches between sites (PGs) and over time at an individual site (SOPs). It is not felt that sufficient accuracy can be confidently placed on any of the monitoring methods investigated. However, a revised draft PG and SOP for ground counts of Common Scoters have been produced for comment and as a template for future work. These are included as Appendices 2 and 3 respectively.

5 RECOMMENDATIONS FOR FUTURE WORK

This report has identified a number of areas where further work would be beneficial.

Ground-based monitoring counts

It is clearly important that a programme of dedicated ground-based counts is maintained for monitoring purposes. They appear to document consistently higher numbers than do aerial surveys and far higher numbers than would be recorded by casual observations of the bay. For consistency, the same three count stations (Amroth, Pendine and Pembrey) should be used, with consideration given to observing from Rhossili at least once during the winter and more frequently if aerial surveys show there to be reasonable numbers of birds in this part of the bay. At least four counts should be carried out during the period October to March, ideally once a month between November and February. The effect of observer experience could be investigated further, with repeated counts designed to examine how quickly a naïve observer can make counts comparable to an expert.

Ground-based methodological studies

This study has looked into various methodological aspects of ground-based scoter counts. Further work into these aspects would be beneficial, although to a varying degree.

Disturbance has not been a major issue to date with scoter counts at Carmarthen Bay and there is no pressing reason for a more detailed investigation into most types of disturbance, although anecdotal observations should continue to be recorded. However, it is most important to look more closely into the reaction of the scoters to the survey plane in order to learn more about the way the estimates from the ground and air counts can be combined. If consistency of flight direction in response to the approaching plane is confirmed, it may be possible to order transects so that birds fly to areas already surveyed, thus minimising repeat counting. However, transect order did not appear to have a large effect during this study.

The effect of the tide on the distribution and numbers of scoters counted from the ground requires further investigation and this issue would benefit from further days of observation, with continued survey dates selected in such a way that each broad tidal state occurs at different times of the day (although, as always, pre-selection of dates can be hampered by unsuitable weather at the time).

Aerial counts

It is suggested that the comparison of the two methods of aerial survey with ground surveys would still benefit from additional flights.

Of greatest interest is the comparison of aerial and ground counts to attempt to derive, if not a population estimate for the bay, then at least a reliable and repeatable index of the numbers present. Rudimentary indices have not been based on combinations of counts as consistency between years has not been achieved, although some years showed that aerial counts represented a roughly predictable proportion of ground counts for the same month.

To further investigate this issue, ground counts and aerial surveys should ideally be synchronised as closely as possible, at least within the same week if not the same day. However, the ground count should take always place first, before any possible disturbing effects of the survey plane. Ideally, one would have a synchronised count from all ground stations using a team of observers. Immediately following this, an aerial count should take place.

It is also important to continue to train new aerial observers, not only to increase the pool of potential fieldworkers for this type of work but also to investigate the extent to which relative patterns of distribution can be described by relatively inexperienced observers. Similarly, repeating the distance-method with emphasis on the first distance band may be worthwhile; this could be facilitated by taping strips across the plane window to ease decision making. It is very important that the assumptions on which the method is based are tested at Carmarthen Bay.

Further detailed analytical work into the incorporation of observer effects and bird behaviour effects on the distance analysis should also be undertaken. The potential application of power analysis techniques may also inform the ability to detect decline of the various methods. Additionally, it may be worth investigating GIS techniques such as kriging. This is a technique that involves spatial interpolation between concentrations of birds recorded, giving a smoothed spatial distribution for a given area. This method has been successfully used for mapping seabird distribution in the past (e.g. Webb *et al.* 2003), and could serve to inform monitoring of areas favoured within the SPA, whilst also permitting comparison of population estimates derived using different methods.

Additionally, the usage of photographical and video techniques could be explored. If high definition pictures could be obtained of the major flocks, calibration would be possible between aerial counts and ‘actual’ counts from pictures. Digital images would allow quantification of numbers using suitable software. However, placement of equipment, relative expense and precision of images are all issues.

One further recommendation involves a series of flights at high altitude. Comparing bird disturbance with the plane at different altitudes would allow decisions to be made on the trade-off between recording birds in their accurate locations and recording numbers seen. Assuming that detection is more difficult at higher altitudes, it may be necessary to use some optical equipment to detect flocks. Synchronised observations by ground counters would allow assessment of relative disturbance, and count totals could be compared, as they could between these flights at variable altitude. Also, if not prohibitively expensive, flying a second plane above the survey plane could allow the former to further gauge relative disturbance.

Acknowledgments

Acknowledgements are due to Ian Bullock, Nigel Fairney, Richard Schofield and Lucy Smith for carrying out the fieldwork and to Steve Holloway for participating as a new recruit. The staff at Ravenair again ably piloted the plane. Fleur Oliver, Mike Madders and Paul Robinson helped in the initiation and early organisation of the survey. Niall Burton, Mark Rehfisch, Graham Austin and Mike Armitage provided valuable comments and support at the BTO and the report was formatted by Heidi Mellan. Siân Whitehead and Bill Sanderson at CCW provided much help and support throughout the project. Andy Woolmer also deserves thanks for commenting on the draft report and for general advice. Grateful thanks to Ann Hughes for translating the Executive Summary into Welsh.

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Appendix 1 Analysis of distance-method aerial survey data.

As Common Scoter were 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 were of individual flocks (referred to as clusters).

Exploratory analysis of the data suggested that fitting separate detection functions to each survey visit resulted in little gain in model fit in the first winter, and led to a reduction of precision in the resulting estimates when compared with a global detection function applied to counts from each survey visit. This makes the assumption that detectability of scoter was the same across visits (just absolute numbers differed). Analysis of the second-winter data suggested that fitting separate detection functions to each survey visit resulted in a gain in model fit and increase in precision in the resulting estimates compared with a global detection function applied to counts from each survey visit. Detectability of scoter in this case is therefore dependent on detectability during the visit and on the absolute numbers present. Probability detection functions based on hazard rate models gave the best fit of the model to the data (determined by minimum AIC (Akaike's Information Criterion) and goodness-of-fit). To take into account variation in detection of cluster size the model fit using two methods was compared. The first approach was to regress observed cluster size against distance to estimate the average population cluster size (as the expected value at distance of 0). The second approach is to include cluster size as a covariate in the analyses using the multiple covariates detection function (MCDS) analysis engine. We controlled for cluster size to reduce bias if there was a tendency for smaller clusters to be missed more than large clusters at large distances from the track line. Variance was estimated empirically for the first method, whilst bootstrap re-sampling techniques within strata (999 re-samples) were used for the second method. Although there is likely to be some difference in detectability between observers, including this variable as a covariate for the second winter data did not improve the model fit (AIC values of 2611.18 compared with a value of 2605.48 with no covariates). Behaviour of birds (flying or sitting) was *a priori* believed to have an important influence on the probability of detection. For this reason we compared models including and excluding behaviour as covariates in the second-winter model. Including behaviour slightly reduced the fit of the model (AIC value of 2607.40 compared with a value of 2605.48 with no covariates).

Further refinements of the distance analysis part of this project are planned for the future, including improved assessment of the effects of observer, the differences between sitting and flying birds and the length of transect.

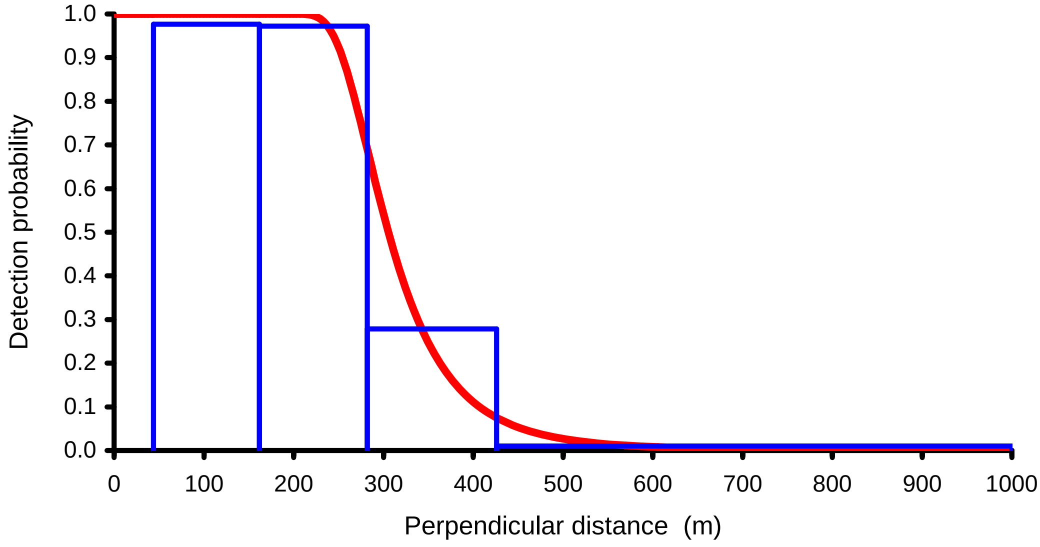
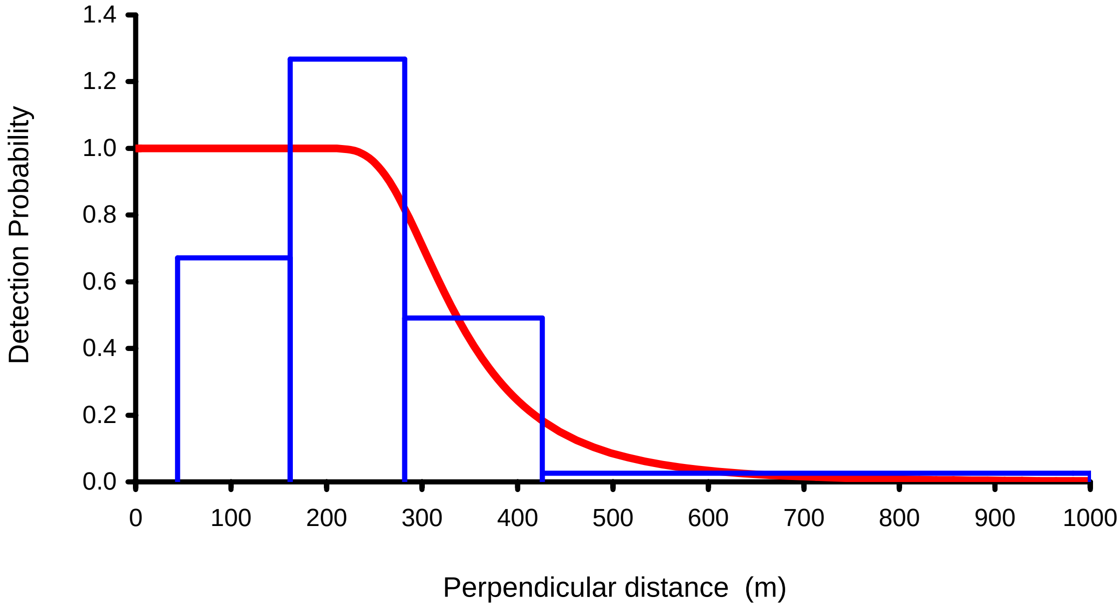
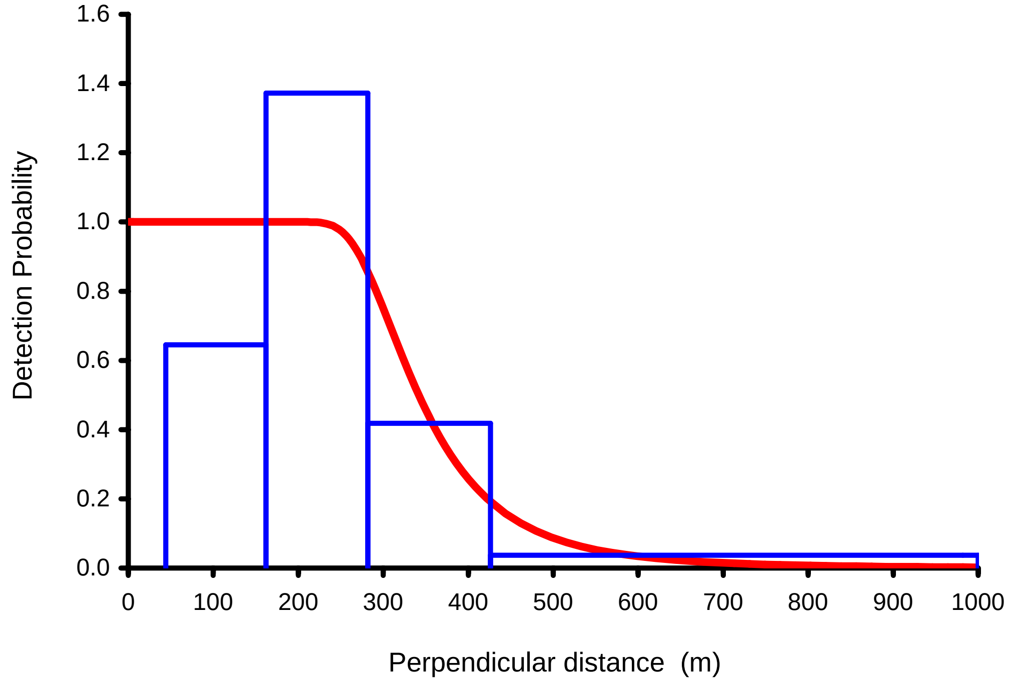


Figure A1.1 Global detection function for winter 2002-03.

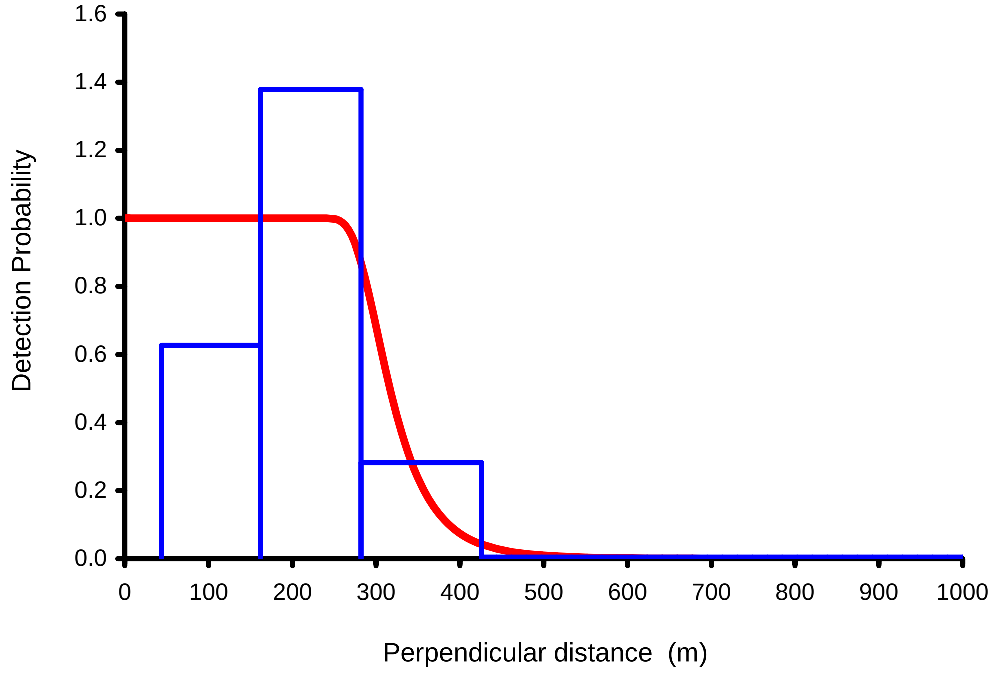
i) October



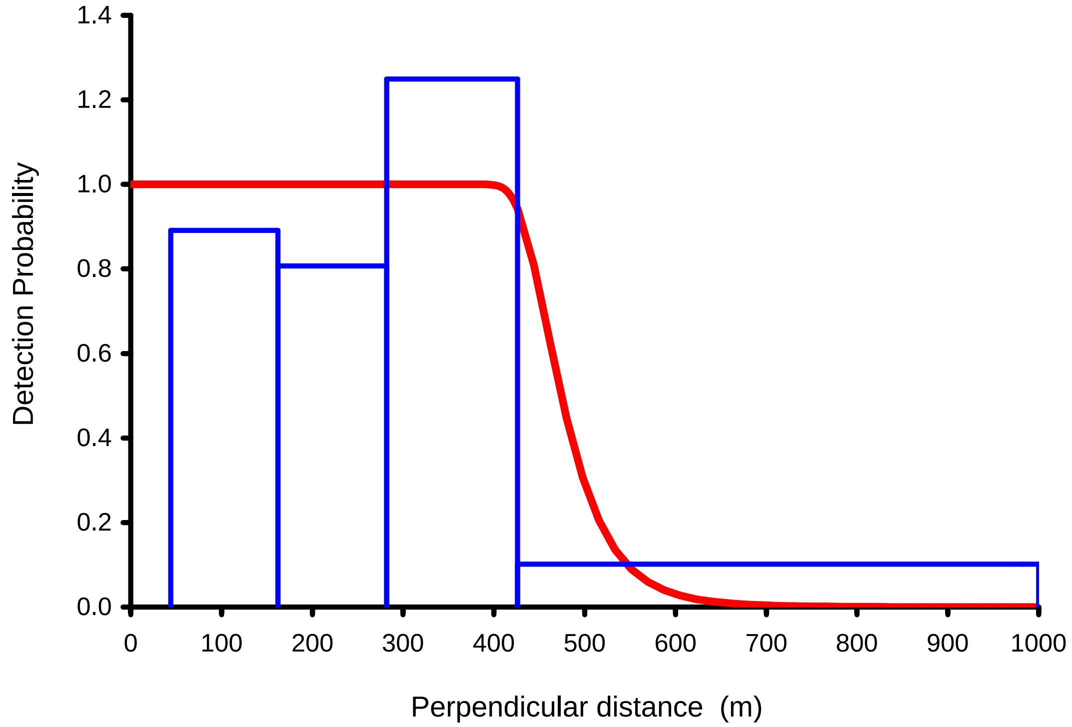
ii) November



iii) January



iv) February



v) March

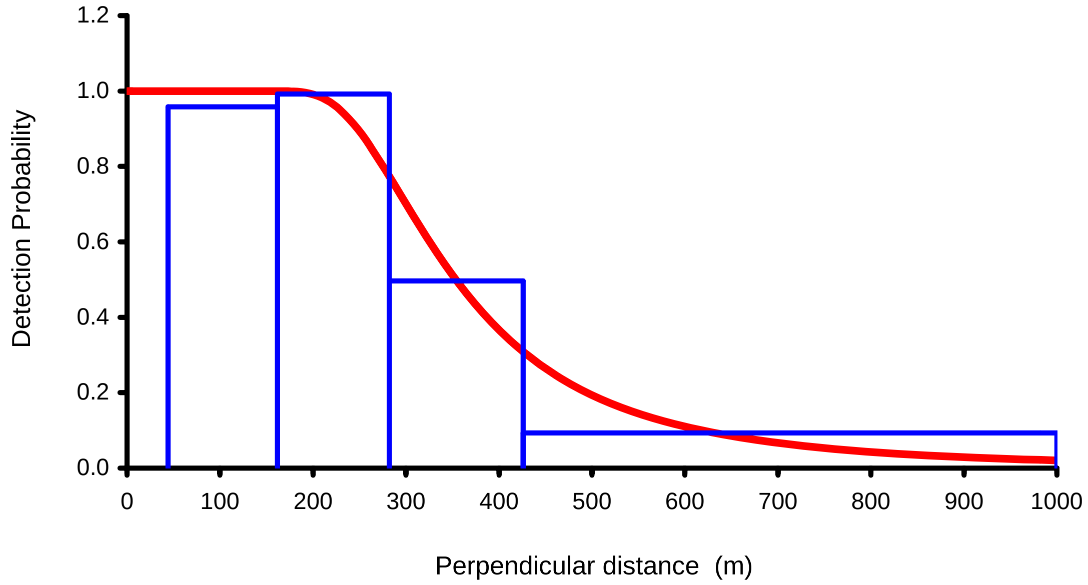


Figure A1.2 (i) to (v) Visit specific detection functions for winter 2003-04

Appendix 2 Draft Procedural Guideline for Ground Counts.

Note:
The following Procedural Guideline is a second draft, based on two 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.

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 report so far 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. The only useful distance measure is one of overall visibility. In the future, however, the guideline might be modified if positional information was considered useful.

Procedural Guideline for making ground-based assessments of numbers of offshore Common Scoter flocks.

Andy Musgrove & Alex Banks

Background
Outside the breeding season, most Common Scoter *Melanitta nigra* concentrate in flocks in shallow 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 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.

Advantages

- Relatively straightforward and in many instances requires little specialist knowledge (although this is dependent upon the occurrence or otherwise of other species in the same area).
- 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.
- There are generally sufficient potential counters in the local area.

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, with general survey experience.
- May be less straightforward at locations where other similar species occur.

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. 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. Furthermore

Logistics

Equipment

A telescope with a zoom eyepiece typically of 20-60 times magnification, with at least an 80mm 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). 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.*

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, although the level of experience required is dependent upon the site and at least some basic ornithological background would be valuable, particularly in counting large numbers of animals. 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, depending 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.

Method

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. Vantage points should be as high 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 made, and these should be spread throughout the winter to gain an impression of seasonal changes in numbers.

Survey methods
Upon arrival at the vantage point, record the date, observer, start time and equipment being used. 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 recorded.

Having positioned the telescope, a preliminary scan should be made to determine any broad patterns of occurrence. Then start at one end of the survey zone, using the telescope 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 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.

Observe each area of sea for at least a minute to check for those 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. Be careful about counting in blocks (*e.g.* count 10, then mental images of sets of 10 or even sets of 100). If doing so then recall that flock density will not be uniform throughout, but generally tends to be densest towards the centre of the flock. If possible, practice beforehand estimating flocks from photographs or using a computer package which generates random flocks. 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 counts.

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.

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 estimate the true 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.

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.

QA/QC

Quality assurance and standardisation of methodology would be assured by ensuring that the same vantage points, count zones 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. 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 are detected. Acceptable weather conditions should be adhered to throughout.

Data products

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

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.

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.

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Appendix 3 Draft Standard Operating Procedure for Ground Counts at Carmarthen Bay.

Note:
The following Standard Operating Procedure is a second draft, based on two 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.

Additionally, the Standard Operating Procedure is currently restricted to the recording of scoter numbers only and not to recording the position of flocks. The evidence from this report so far 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. The only useful distance measure is one of overall visibility. In the future, however, the Standard Operating Procedure might be modified if positional information was considered useful.

Standard Operating Procedure for making ground-based assessments of numbers of offshore Common Scoter flocks in Carmarthen Bay.

Andy Musgrove & Alex Banks

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

Background
Carmarthen Bay is perhaps the most important single site for wintering Common Scoters in Britain and Ireland (Cranswick, *in press*). 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 considerably higher. However, much lower counts were recorded following the *Sea Empress* oil spill of February 1996.

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. During the period following the *Sea Empress* oil spill the south-east of the bay (Rhossili Bay) was used by the birds to a greater extent (Cranswick *et al.* 1998).

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.

Purpose
The purpose of the method described is to record counts of Common Scoters at Carmarthen Bay over the course of a winter for the purposes of comparison 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 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.

Logistics

Equipment
As detailed in Procedural Guideline.

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 this report 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.

Method

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 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 20 mph. Days with clear skies and bright sunshine should also be avoided. 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.

Survey methods
As detailed in the Procedural Guideline.

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 in this report.

Accuracy testing
As detailed in the Procedural Guideline.

QA/QC
As detailed in the Procedural Guideline.

Data products
As detailed in the Procedural Guideline.

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).

Health & Safety
As detailed in the Procedural Guideline.

References

Cranswick, P.A.. (in press). Status and distribution of Common Scoter *Melanitta nigra* and Velvet Scoter *M. fusca* in the United Kingdom. In: *Western Palearctic Scoter Flyway Review; Proceedings of the Seaduck Specialist Group meeting at Fuglesø, Jutland 2000*. NERI technical report: 59-65.

Cranswick, P.A., Stewart, B., Bullock, I., Haycock, R. & Hughes, B. (1998). *Common Scoter* Melanitta nigra *monitoring in Carmarthen Bay following the* Sea Empress *oil spill: April 1997 to March 1998*. WWT Wetlands Advisory Service report to CCW, Contract No. FC 73-02-53A, Slimbridge, 25 pp.

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 Draft Procedural Guideline for Aerial Counts.

Note:
The following Procedural Guideline is a first draft, based on two 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 is based on the proviso that the aerial distance-method is able to generate confidence limits, is potentially less prone to observer bias and is fast becoming the industry standard. The disadvantages (principally problems with disturbance affecting the detection function and ability to detect numerical change) of the method should, however, be borne in mind.

Procedural Guideline for making aerial assessments of numbers of offshore Common Scoter flocks.

Alex Banks & Andy Musgrove

Background
Outside the breeding season, most Common Scoter *Melanitta nigra* concentrate in flocks in shallow offshore areas. 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. The method relies on the assumption that all birds near the transect line will be detected by the observers, and makes allowances for missed birds by calculating point estimates. These estimates carry associated confidence limits, thus allowing a measure of error in the population estimate. 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 escape detection when fleeing from the approaching plane. Therefore this method may be most suitable for providing information on general distribution patterns of large concentrations of scoters.

Advantages
- Scientifically rigorous
- Allows comparability with recent aerial surveys of Carmarthen Bay and also with other areas of the UK (*e.g.* WWT 2003)
- Does not demand the observer to count all birds
- Less time consuming (and therefore cheaper) than the aerial census-method
- Generates 95% confidence limits around population estimates
- Reduces observer bias as transects perpendicular to main determinant of distribution (water depth)
- Provides overview of distribution within the bay

Disadvantages
- Wide confidence limits may preclude accurate detection of population change
- High levels of disturbance created by the aeroplane 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

Purpose
The principal output of the method is a population estimate of Common Scoters over a given area on a given date. Spatial distribution can also be plotted, as GPS data provides accurate 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.

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.

Logistics

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 to inform the counters of start and end times of transects, and to direct the pilot. Also, adjacent passenger seats are necessary, with one observer on the port side and one on the starboard side.

GPS equipment is crucial to direct the pilot along the designated transect route, and to mark the beginning and end of transects. A handheld GPS unit such as a Garmin GPS 12 XL is suitable, and, if possible, a lead connecting the unit to an external lead 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. 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.

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. 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.

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 counters, one on either side of the plane. Counters should have had as much experience of aerial survey as possible.

The method does not call for observers with highly-specialised identification skills, although the level of experience required is dependent upon the site and at least some basic ornithological background would be valuable, particularly in counting large numbers of animals. 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, depending 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.

Method

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, 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 plane 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 ~20 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 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.

Survey methods

The plane should line up with the first transect, as directed by the navigator, and reach the target altitude, speed and bearing. The 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 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. 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, 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 should record the start and end times of each transect, 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, with tapes archived accordingly.

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 4, 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. If possible, synchronised ground counters should record the reaction of birds to the plane. However, where this is not possible, estimates of the number of birds sitting and flying may serve to inform confidence in the spatial distributions recorded. Such information can easily be plotted using GIS packages such as ArcView 3.

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.

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.

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.

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.

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.

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.

References

WWT Wetland Advisory Service. (2003). *All Wales Common Scoter Survey: Report on 2001/02 Work Programme*. CCW Contract Science Report No. 568.

Appendix 5 Draft Standard Operating Procedure for aerial counts at Carmarthen Bay.

Note:
The following Standard Operating Procedure is a first draft, based on two 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 is based on the proviso that the aerial distance-method is able to generate confidence limits, is potentially less prone to observer bias and is fast becoming the industry standard. The disadvantages (principally problems with disturbance affecting the detection function and ability to detect numerical change) of the method should, however, be borne in mind.

Standard Operating Procedure for making aerial-based assessments of numbers of offshore Common Scoter flocks in Carmarthen Bay.

Alex Banks & Andy Musgrove

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

Background
Carmarthen Bay is perhaps the most important single site for wintering Common Scoters in Britain and Ireland (Cranswick, *in press*). As is typical for the species, however, the true numbers present at any time are difficult to ascertain. Aerial count estimates (distance method) have exceeded 15,000 birds on each of the last three occasions surveyed (WWT 2003 and this report) and, given that ground counts are often greater, the true number is thought to be considerably higher.

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. During the period following the *Sea Empress* oil spill the south-east of the bay (Rhossili Bay) was 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.

Purpose

The principal output of the method is a population estimate of Common Scoters wintering in Carmarthen Bay SPA on a given date, allowing assessment of Favourable Conservation Status. Spatial distribution can also be plotted, as GPS data provides accurate positional information, 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. 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.

Logistics

Equipment
As detailed in Procedural Guideline.

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) and two counters, one on either side of the plane. Counters should have had as much experience of aerial survey as possible.

The method does not call for observers with highly-specialised identification skills, although the at least some basic ornithological background would be valuable, particularly in counting large numbers of animals. No formal qualification would be required, and good eyesight and a degree of stamina are more valuable, along with thoroughness and attention to detail.

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.

Method

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. 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 Burry Inlet and moving west at 2 km intervals. 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 ~20 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.

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 as many of the relevant sections of the bay as possible. 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.

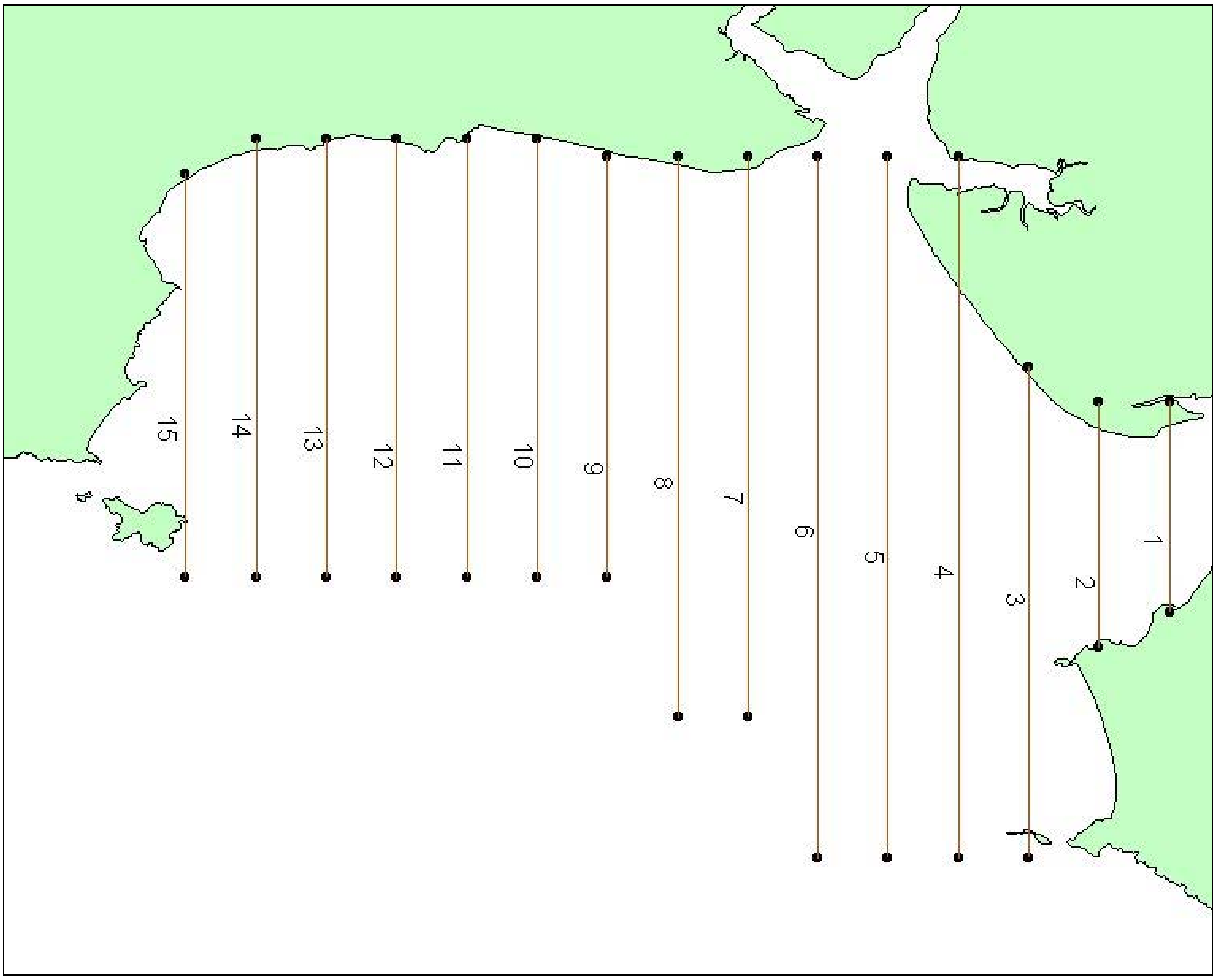

Figure 1 Aerial distance-method survey transects recommended for coverage of Carmarthen Bay SPA

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.

Accuracy testing
As detailed in the Procedural Guideline.

QA/QC
As detailed in the Procedural Guideline.

Data products
As detailed in the Procedural Guideline.

Cost & Time
As detailed in the Procedural Guideline.

Health & Safety
As detailed in the Procedural Guideline.

References

Cranswick, P.A.. (in press). Status and distribution of Common Scoter *Melanitta nigra* and Velvet Scoter *M. fusca* in the United Kingdom. In: *Western Palearctic Scoter Flyway Review; Proceedings of the Seaduck Specialist Group meeting at Fuglesø, Jutland 2000*. NERI technical report: 59-65.

Cranswick, P.A., Stewart, B., Bullock, I., Haycock, R. & Hughes, B. (1998). *Common Scoter* Melanitta nigra *monitoring in Carmarthen Bay following the* Sea Empress *oil spill: April 1997 to March 1998*. WWT Wetlands Advisory Service report to CCW, Contract No. FC 73-02-53A, Slimbridge, 25 pp.

Appendix 6 Potential indices of Common Scoter in Carmarthen Bay.

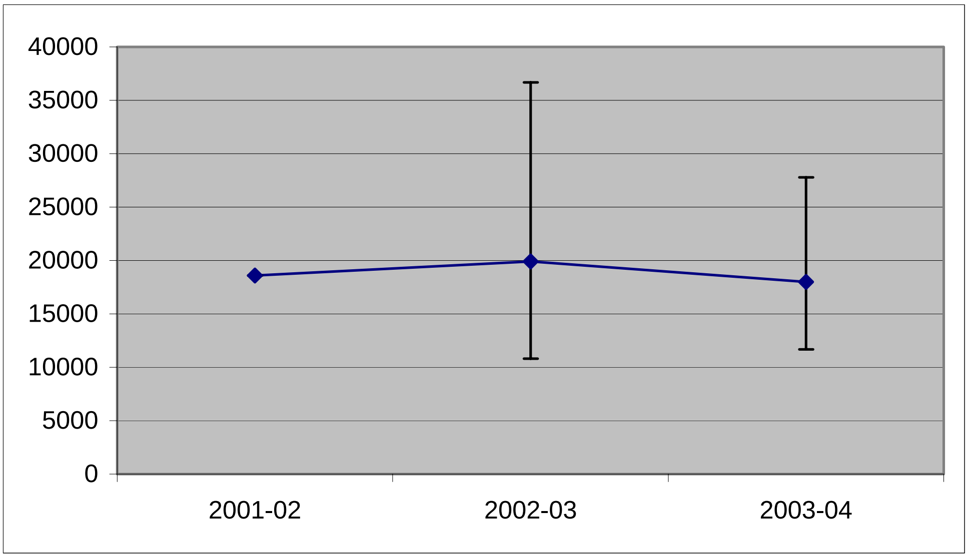

Figure A6.1 Potential index of peak counts of Common Scoter in Carmarthen Bay SPA using the distance-method.

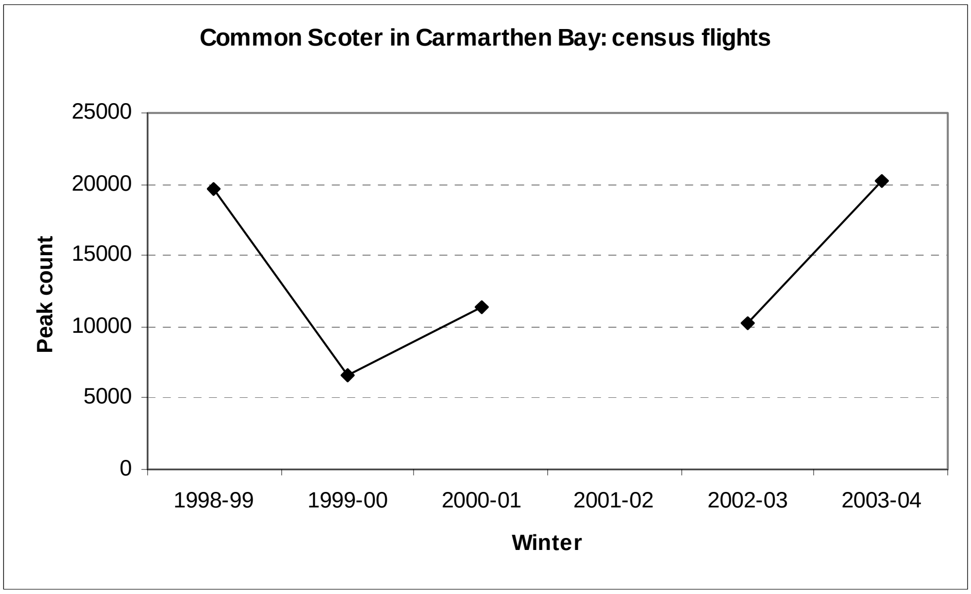

Figure A6.2 Potential index of peak counts of Common Scoter in Carmarthen Bay SPA using the census-method.

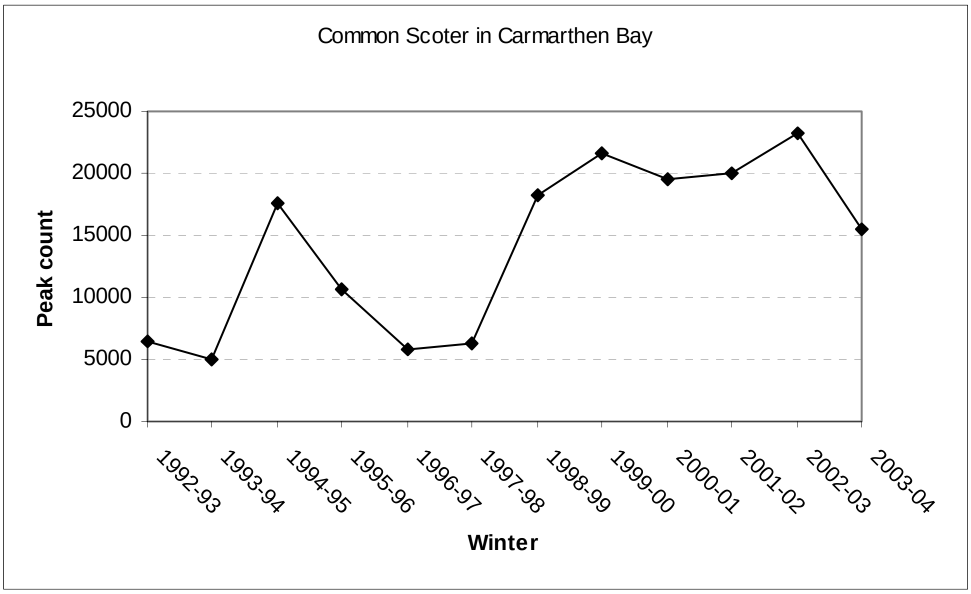

Figure A6.3 Potential index of peak counts of Common Scoter in Carmarthen Bay SPA using the ground count method.

Appendix 7 Historical distributions of Common Scoters in Carmarthen Bay from aerial surveys.

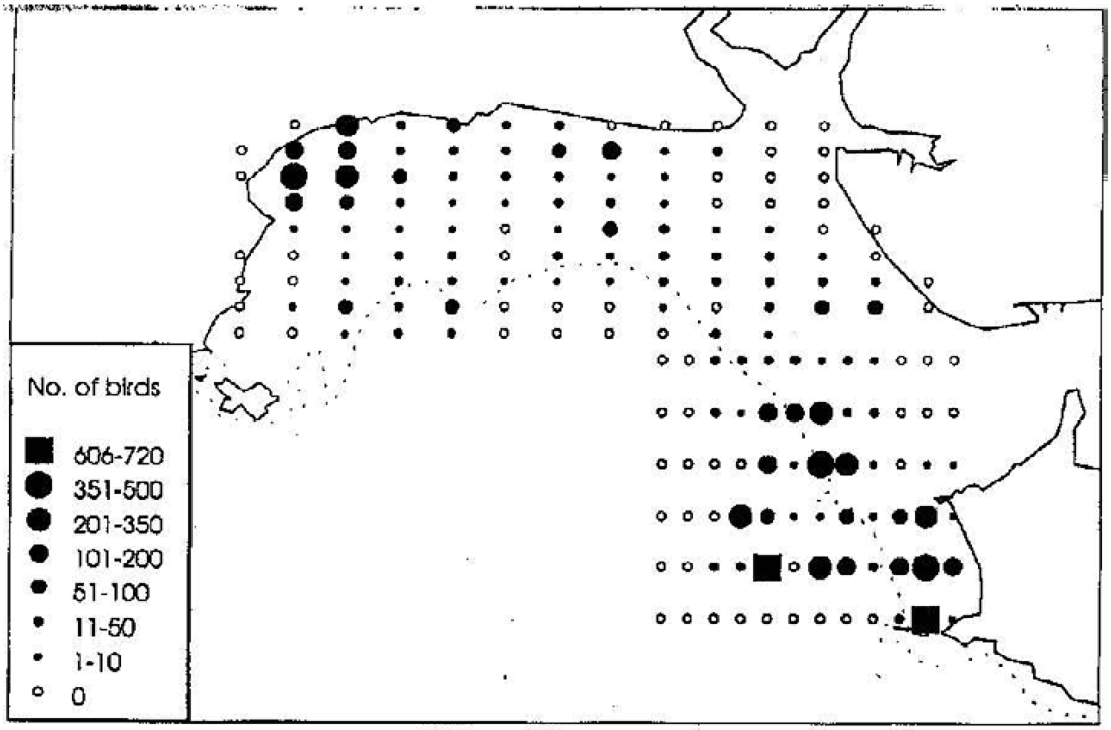

Figure A7.1 Mean density of Common Scoters from counts January-March 1998 (from Cranswick *et al.* 1998)

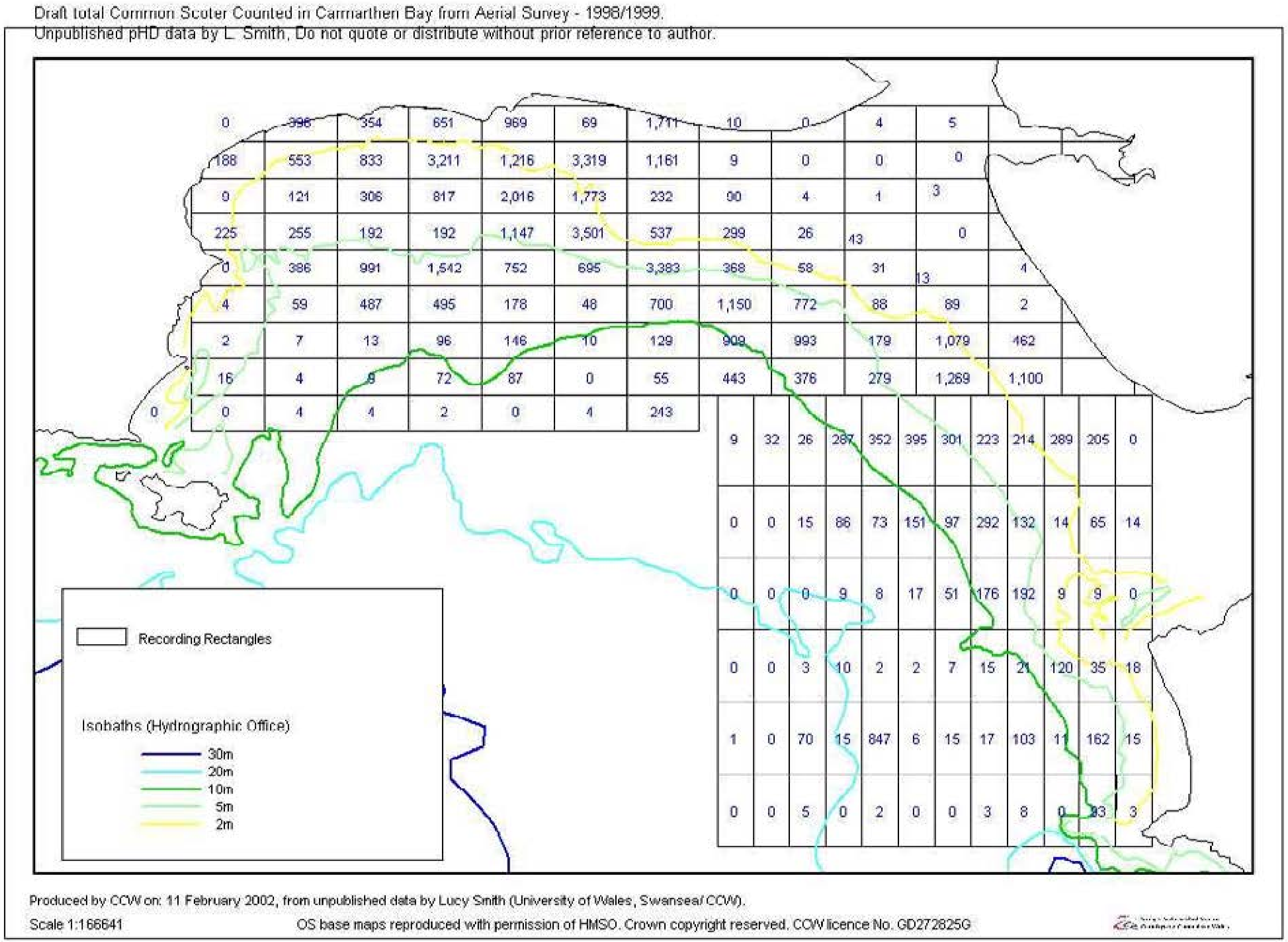

Figure A7.2 Total count of Common Scoters for winter of 1998-1999 (L. Smith, unpubl. data).

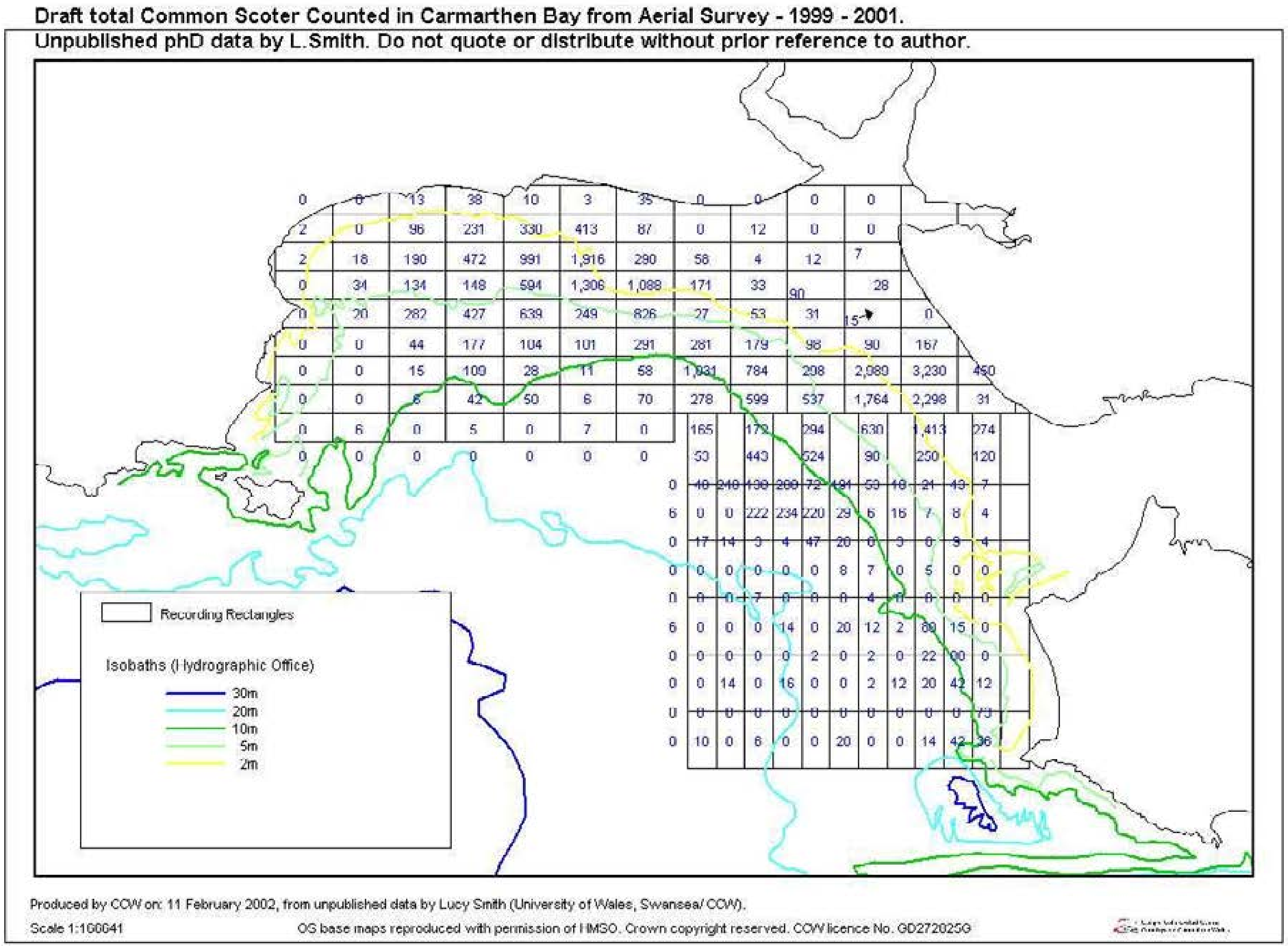

Figure A7.3 Total count of Common Scoters for winters of 1999-2001 (L. Smith, unpubl. data).

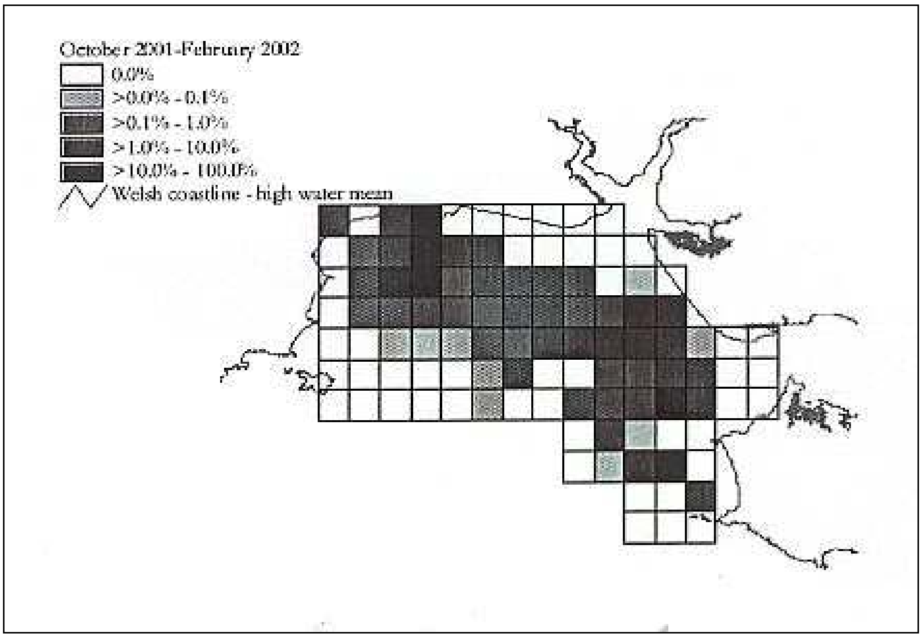

Figure A7.4 Mean relative density of Common Scoters for winter of 2001-2002 (WWT 2003).