IMPORTANT

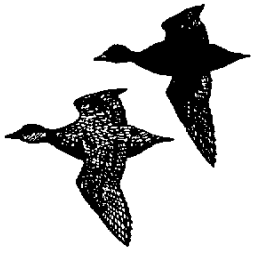
This report is one of a large number commissioned on behalf of the *Sea Empress* Environmental Evaluation Committee. Any views expressed here, however, are not necessarily representative of the views of the committee or its advisory task groups - which will be basing their conclusions on results from the whole programme of studies.

COMMON SCOTER *Melanitta nigra* MONITORING IN CARMARTHEN BAY FOLLOWING THE *SEA EMPRESS* OIL SPILL: APRIL 1997 TO MARCH 1998

CCW CONTRACT NO. FC 73-02-53A

Report to

COUNTRYSIDE COUNCIL FOR WALES



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CONTENTS

1 SUMMARY

Following the grounding of the oil tanker *Sea Empress* on 15 February 1996, oil entered nearby Carmarthen Bay, resulting in the deaths of large numbers of Common Scoter *Melanitta nigra*. Consequently, a programme of land-based and aerial surveys was implemented to monitor numbers and distribution of this species. Counts in summer 1996 and the following winter recorded reduced numbers compared with pre-spill levels, although direct comparison of land with aerial counts was not possible due to survey design; notably, aerial counts employed a 'transect' route providing only an index of numbers over years.

Counts were continued in 1997/98, with a new aerial route used to cover systematically all of the northern and eastern parts of the bay, and thus obtain a total counts of Common Scoter in these favoured areas. With an estimated range of visibility of 500 m from the plane, flight paths were made at 1 km intervals. An aerial count was made using the old route in November, and one in each month from January to March 1998 using the new route. Except in February, a land-based count was made immediately prior to the aerial survey.

As in 1996/97, surveys in 1997/98 recorded much smaller numbers than the pre-spill counts of 10-17,000 birds. Land-based counts peaked at around 2,000 during the late summer moult, and at just over 3,200 birds in late winter. The main moult concentration was again off Pembrey, whilst the traditional areas off Pendine to Saundersfoot and off Rhossili were again favoured during winter.

Aerial counts recorded generally higher numbers compared with land-based counts, with a peak of just under 5,000 birds in January. Distribution was generally similar to that found by land-based observations, though large numbers were located off Rhossili out of range of sight (> 6 km) from land. Small numbers were evenly scattered across the centre of the bay, birds generally occupying most areas of water less than 10 m deep except the area immediately around major river mouths. Some birds were found east of Tenby, where water is greater than 10 m deep, whilst the large flocks offshore from Rhossili were several kilometres beyond the 10 m depth contour. The March count was made at low tide and recorded a similar distribution to those made at high tide in previous months.

Comparison of land-based with aerial counts showed that aerial surveys underestimated numbers in the northwest part of the bay. Birds were very 'flighty' in the presence of the plane in this area and land-based observers noted birds taking to the air well in advance of the advancing plane. It is likely that this resulted in the under-count from the plane. Significantly, birds off Rhossili, which exhibited atypically clumped distribution patterns for scoter, generally remained on the water's surface as the plane flew over.

Recommended count totals were devised by combining the land-based counts in the northwest part of the bay with aerial counts in other parts. Using this approach, the peak count of Common Scoter in Carmarthen Bay in winter 1997/98 is estimated as 6,420.

Common Scoter distribution is described for site protection purposes and recommendations for future standardised monitoring are made. In particular, aerial coverage of the southwest and centre of the bay should be attempted; further land-based observations of the effect of the plane should be made; and at least one full survey should be made using north-south flightlines synchronised with land-based observations of disturbance effects.

2 INTRODUCTION

The Common Scoter *Melanitta nigra* is listed in Annex II/2 of the EC Directive on the Conservation of Wild Birds (79/409/EEC), and occurs on the red list of the UK's Species of Conservation Concern (Gibbons *et al.* 1996). Birds in Britain form part of the population *M. n. nigra* which numbers 1.6 million (Rose & Scott 1997). Its breeds from western Siberia to northern Europe, with small numbers in Scotland and Ireland; it winters principally in the Baltic Sea, with smaller numbers along North Sea coasts, around Britain and Ireland, the Iberian peninsular and northwest Africa (Scott & Rose 1996). Kirby *et al.* (1993) estimated numbers wintering in the UK at 35,000, concentrated at a small number of sites. Carmarthen Bay, southwest Wales, is by far the most important, supporting an average of around 9,000 birds in the mid 1990s, with a peak of 17,650 during that period (Waters *et al.* 1998, Stewart *et al.* 1997). This is around double the number used by Kirby *et al.* (1993), suggesting that the true UK wintering number is nearer 40,000.

On 24 February 1996, large amounts of oil from the stricken *Sea Empress* tanker entered Carmarthen Bay. Some 4,700 Common Scoters were found oiled, mostly between Pendine and Amroth, of which 2,900 were rescued alive (Parr *et al.* 1997). A smaller number were rehabilitated but it is thought likely that most of these will have perished within a year (Hughes *et al.* 1997). Following the oil spill, a monitoring programme was immediately established by the Countryside Council for Wales (CCW) to record numbers and distribution of Common Scoters in Carmarthen Bay. As Common Scoters can only be identified and counted from land up to a range of 6 km (B. Stewart *pers. obs.*), both land-based counts (conducted by The Wildfowl & Wetlands Trust (WWT)) and aerial surveys (conducted by RSPB) were initiated to provided complete coverage of the bay in 1996/97: total numbers were generally much reduced (Stewart *et al.* 1997).

Direct comparison of land-based with aerial counts made in 1996/97 was thought to be limited by the distance between flight lines used by the plane: with an estimated range of 500 m visibility from the plane, flight lines 2-3 km apart will have resulted in areas of 'dead ground' in which birds would have been missed.

Complementary land-based and aerial surveys were continued in 1997/98 by WWT's Wetland Advisory Service under contract to CCW. This report presents results of monitoring between April 1997 and April 1998, makes a qualitative comparison between

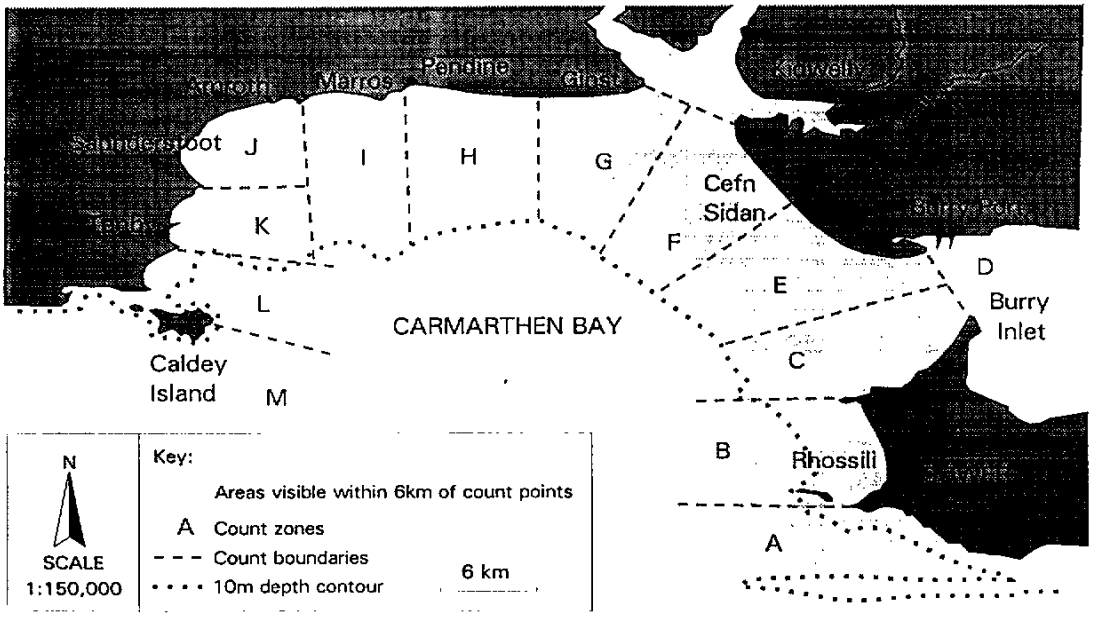
the data obtained using each survey method with particular reference to a new flight path employed in 1997-98, and provides recommendations for future standardised monitoring.

3 METHODS

3.1 LAND-BASED COUNTS

A total of 26 land-based counts were conducted at two week intervals between 21 March 1997 and 14 March 1998. A similar monitoring strategy to that used during the previous year was implemented to ensure compatibility of data: Carmarthen Bay was divided into 13 sectors and each counted from vantage points collectively covering all coastal areas of the bay (Figure 1). Birds were counted as near to high tide as possible and, when possible, the whole bay was covered in the same day. On four occasions, however, counts of different sections of the bay were conducted on separate days, and in these cases birds may have been either double-counted or missed. However, as flocks generally remain within discrete feeding areas, usually for several weeks (B. Stewart *pers. obs.*), such bias is thought to be negligible. On six occasions, a full count was not possible (usually a result of inclement weather). Attempts were also made to locate the positions of scoter flocks from land-based observation points by triangulation. Buoys and physical land features were used as reference points to plot the positions of discrete flocks of birds in the bay.

Figure 1. Count zones and range of land-based observations during Common Scoter monitoring in Carmarthen Bay, 23 February 1996 - 14 March 1998.

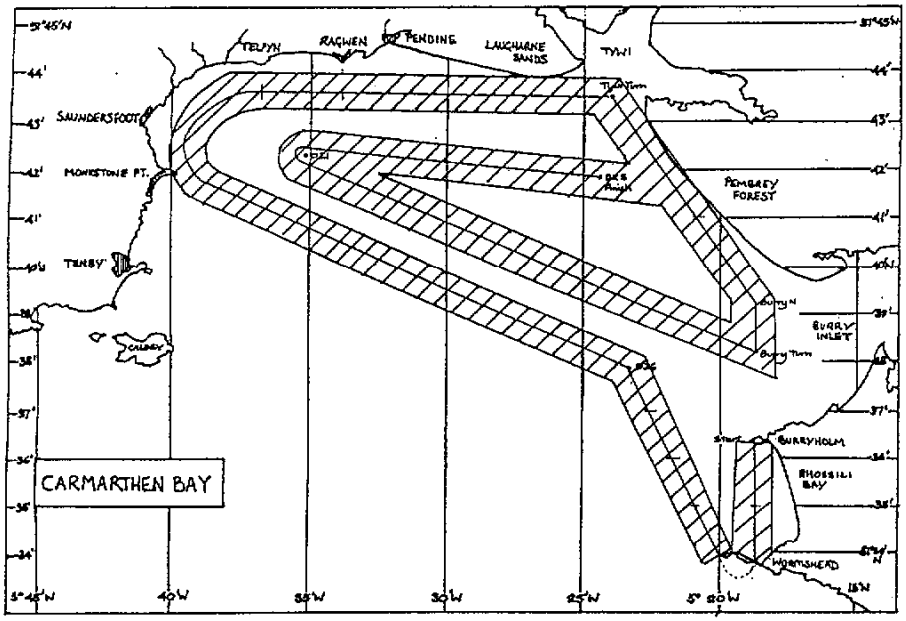


3.2 AERIAL COUNTS

Four aerial surveys of Carmarthen Bay were conducted during 1997/98: on 22 November 1997 and 31 January, 21 February and 14 March 1998. As in the previous winter, a high-winged Cessna 185 was used, flying at 500-550 ft altitude and at 90-100 knots.

The first flight followed the same 'concentric' route as used in previous years (Figure 2). However, after this route was completed, a number of additional east-west passes were made in the area 2-3 km south of Ragwen to survey the 'dead ground' between the flight lines. This resulted in a much greater number of birds being recorded (see Results). As a consequence, a new route was designed and used on subsequent flights (Figure 3).

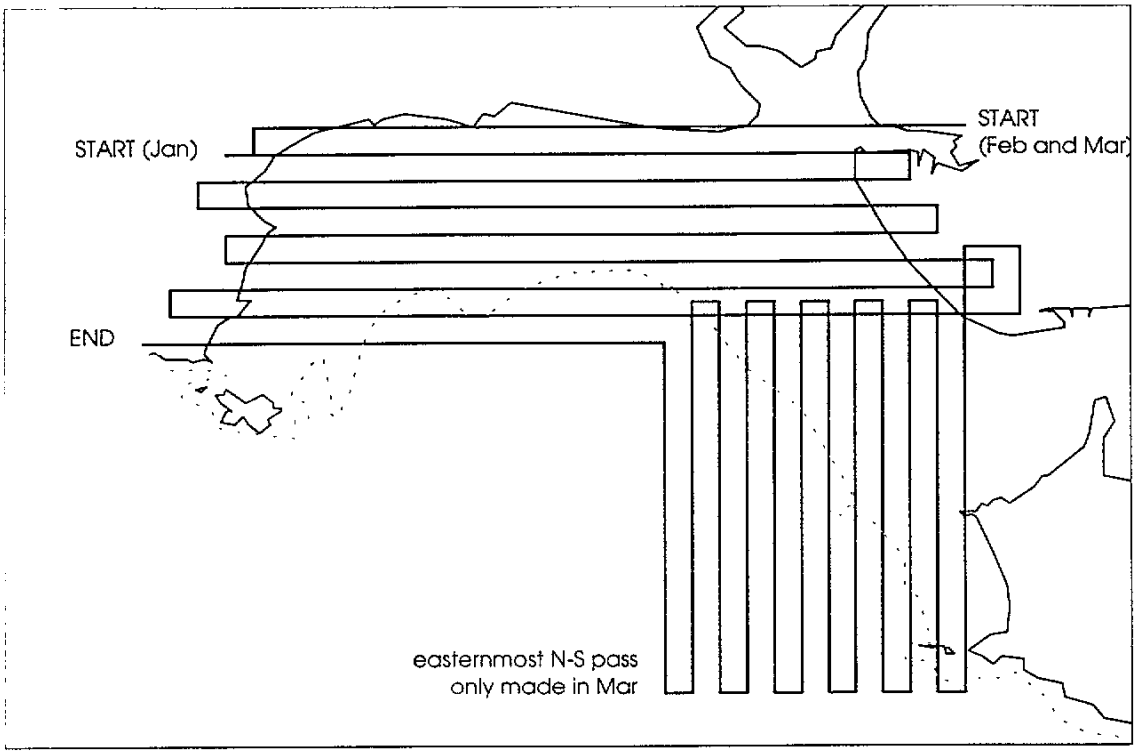
Figure 2. 'Concentric' aerial survey route used during surveys of Common Scoter in 1996-97. The hatched area indicates the approximate range of visibility.



The new 'grid' route involved making seven east-west passes across the northern half of the bay from shore to shore along the OS grid lines, the first running east from Amroth, with each subsequent pass made in the opposite direction 1 km further south, thus covering the area north of a line between Tenby and the southern edge of Cefn Sidan. This was followed by a series of 10 passes running north-south on OS grid lines to cover the area between this line and a line extending west from Worms Head. The first pass was

made running due south directly past Burry Holm and over Worms Head, with subsequent passes, each in opposite directions, 1 km further west. After the last north run, a west running pass was made 1 km to the south of the most southerly east-west pass.

Figure 3. 'Grid' aerial survey route during surveys of Common Scoter in 1997-98. The dotted line indicates the 10 m depth contour.



Flights in February and March started 1 km further to the north, with the first pass heading west from Ginst point. As well as covering possible 'dead ground' between the most northerly pass of the first route and the coast, this was also designed to give birds close to Saundersfoot 'prior warning' to the appearance of the plane; it was thought that the sudden appearance over the bay flying from the area due west of Saundersfoot may have caused birds to take to flight on the first pass. Two additional north-south passes off Rhossili were made during the March count.

The grid route was made using a GPS linked to the OS grid. Whilst many small corrections were made during the flight, this enabled the planned route to be followed accurately.

An observer on each side of the plane counted birds up to a distance of about 500 m from

the plane; although birds a short way beyond this distance were just visible to the naked eye, it was not normally possible to count them accurately (confirmed by use of binoculars). The distance of 500 m for the range of visibility was confirmed by comparison with known landmarks, buoys and on some occasions with distinctive groups of birds, e.g. Eider, between successive passes.

On each of the 'grid' flights, the total number of birds was noted on a recording form upon passing over alternate OS 1-km grid line, producing a distribution map on a 2x1 km grid. In many cases, the birds were observed in flight. Where a large number of birds moved directly away from the plane (i.e. perpendicular to the flight path) a note was made of this on the recording form and the occurrence of an equivalent number of birds in an adjacent pass at the appropriate point (confirmed using the GPS) was treated as the same birds. These numbers were then omitted from the results. Comparison with land-based counts helped confirm the possibility of double-counts.

Land-based counts were made on the same day as two of the three 'grid' flights: land-based observers were positioned at a number of vantage points and made counts directly (less than 1 hour) before the start of the aerial count. In January, observers remained at the Monkstone Point, Ragwen and Telpin count points in the northwest of the bay to observe the reaction of the birds to the presence of the plane. In February, a land-based count was only possible four days after the aerial count.

On most dates, aerial surveys were aimed to start at around high tide, allowing land-based counts to be made during the period just before high tide. Aerial counts generally took 3-3.5 hours, so that the aerial counts off Rhossili were made during mid ebb-tide. In March, the aerial count began at mid ebb-tide, ending at around low tide.

It was not possible to observe the activity of birds during aerial surveys, other than whether they were on the water or flying. Further, it is likely that any observed activity was affected by the presence of the plane, rendering any records of limited value.

4 RESULTS

4.1 CONDITIONS DURING CO-ORDINATED LAND AND AERIAL COUNTS

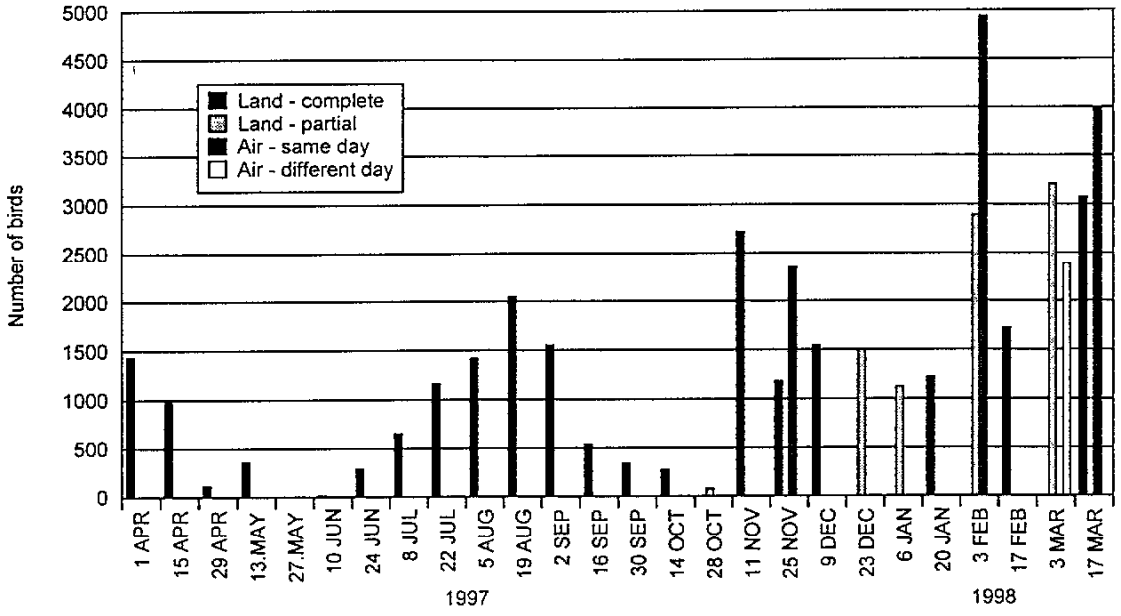
Conditions during November were reasonable, with light winds and partial cloud cover generally preventing glare. Reasonably good conditions were also encountered during the January flight: low cloud prevented glare at most times, although on occasions, low light levels may have reduced the ability of observers to detect birds; winds were light. Conditions in February were not ideal for aerial surveys: partial storm cloud cover and bright sun meant that the south facing observer on east-west passes was often hampered by glare; combined with the moderate wind, it is likely that a proportion of birds were missed in the northern half of the bay. Weather conditions were excellent during the March count: complete, low cloud cover prevented any glare, and with only a slight breeze, the surface of the sea was very calm; even small numbers of birds were easily discernable at a considerable distance from the plane.

4.2 COMMON SCOTER NUMBERS AND DISTRIBUTION

Counts obtained from both land-based and aerial surveys showed that the total number of Common Scoter in Carmarthen Bay in summer 1997 peaked at around 2,000 birds, rising to a maximum of just under 5,000 in winter 1997/98 (Figure 4). The moult concentration rose steadily in number to mid August, and declined steadily thereafter, before a marked arrival of 2,700 birds in early November. Numbers appeared then to fall to less than 1,500 until a sharp increase to 5,000 in late January. Whilst turnover is known to result in large changes in numbers in the bay, e.g. around 10,00 birds arrived shortly after the oil spill, it should also be noted that land-based counts in December and January were either incomplete, or conducted over two or more days. Consequently, it is possible that a number may have been missed and, therefore, that the increase was not as large as at first suggested.

As in 1996, the late summer moult concentration was located primarily off Pembrey, an area generally little used at other times during the last two years (Table 1). The two key areas used during winter 1997/98 were that directly south of Marros Sands, though with large numbers in the Amroth and Pendine sectors immediately adjacent, and Rhossili Bay (Table 1, Figures 5-10). Aerial counts showed large numbers a considerable distance offshore from Rhossili, with smaller numbers distributed thinly over the centre of the bay between Pendine and Rhossili and also east of Tenby.

Figure 4. Counts of Common Scoters in Carmarthen Bay, 21 March 1997 to 14 March 1998, grouped by 2-week periods.



Aerial counts showed that birds occurred in most areas of water less than 10 m deep, with the exception of the those immediately around the river mouths. Birds were consistently found in areas with water depths of greater than 10 m due east of Tenby, and large numbers were located due west of Rhossili Bay, well beyond the 10 m depth contour.

The aerial count in March (Figure 10), made during low tide, suggests that distribution at this point in the tidal cycle is not noticeably different from that at high tide.

4.3 OTHER SPECIES OF WATERFOWL

Only small numbers of other species were recorded during surveys in 1996/97. During land-based and aerial counts, Red-throated Diver, Eider, Velvet Scoter and Red-breasted Merganser were noted, though totals of each from all four counts generally numbered less than ten. Larger numbers have been recorded previously, e.g up to 60 Red-throated Divers, and the bay is used by large numbers of Manx Shearwaters during summer and Gannets and gull spp. (B. Stewart pers. obs.). These species, however, were not systematically recorded during 1997-98 surveys.

Table 1. Common Scoter distribution within Carmarthen Bay, 21 March 1997 to 14 March 1998 (land-based counts only). Sector totals are maxima per two week period. Only sectors holding reasonable concentrations of birds included (see Figure 1). Hyphens represent uncounted sections. Note that, as birds will have moved between sectors within each two week period, totals over all sectors may not correspond to co-ordinated count totals in Figure 4. Sector means are also given for the moult (8 July to 16 September) and winter (11 November to 17 March) periods.

** Indicates an incomplete count.
* Indicates that count of the whole bay was carried out over two or more days.

Fortnight	Actual count	B	C	E	F	H	I	J	K	Total
1/4/97	21-23/3/97	323	6	6	0	140	315	193	452	*1435
15/4/97	6/4/97	0	0	342	109	153	76	286	0	966
29/4/97	22/4/97	0	0	88	19	6	0	0	0	113
13/5/97	11/5/97	0	0	258	74	0	0	22	0	354
27/5/97	20/5/97	0	0	-	-	-	-	-	-	**0
10/6/97	8/6/97	0	0	12	0	0	0	0	0	12
24/6/97	16/6/97	0	0	167	17	36	63	4	0	287
8/7/97	1/7/97	0	0	521	79	12	38	0	0	650
22/7/97	20/7/97	0	0	770	317	7	0	71	0	1165
5/8/97	31/7/97	44	3	1109	74	110	17	61	0	1418
19/8/97	18/8/97	20	0	1610	80	290	12	36	0	2048
2/9/97	21-26/8/97	65	4	1130	55	243	50	2	0	*1549
16/9/97	7/9/97	28	0	173	13	155	164	2	0	535
30/9/97	19-21/9/97	68	0	16	6	104	46	96	0	*336
14/10/97	5/10/97	57	0	46	0	74	31	64	0	272
28/10/97	18/10/97	74	0	-	-	-	-	-	-	**74
11/11/97	31/10/97	132	35	450	40	910	1077	77	0	2721
25/11/97	22/11/97	239	0	88	16	24	377	441	0	1185
9/12/97	9/12/97	229	6	113	32	5	262	896	0	1543
23/12/97	14/12/97	477	-	51	128	12	398	432	0	**1498
6/1/98	2/1/98	382	-	36	25	143	331	210	0	**1127
20/1/98	7-10/1/98	168	100	0	79	237	410	230	0	*1224
3/2/98	31/1/98	625	0	23	67	430	1750	-	0	**2895
17/2/98	9/2/98	171	-	113	12	327	800	300	0	1723
3/3/98	25/2/98	-	-	210	55	550	633	1754	0	**3202
17/3/98	14/3/98	354	23	56	30	299	444	1831	36	3073
	Sum	3456	177	7388	1327	4267	7294	7008	488	
	Mean	138.2	8.0	307.8	55.3	177.8	303.9	304.7	20.3	
	%	11.0	0.6	23.5	4.2	13.5	23.2	22.3	1.6	
	SD	173.3	22.2	428.8	66.3	215.8	418.8	514.1	92.2	
Moult Mean		26	1	886	103	136	47	29	0	1228
Winter Mean		309	28	114	48	294	648	686	4	2131

4.4 SCOTER DISTRIBUTION PATTERN AND BEHAVIOUR DURING AERIAL COUNTS

Although bird activity was not recorded systematically, a large proportion of scoter counted from the plane were observed in flight. This was particularly noticeable in the northwestern part of the bay near Saundersfoot. However, due to the limited time in which birds were visible from the plane, it was not possible to observe closely their precise movements or reaction to the presence of the plane. On several occasions, birds were observed to take to the air, though more usually birds were already in flight as the plane reached them. Land-based counters observed that some birds took to the air a considerable distance (in excess of 1 km) in front of the plane. In most cases, birds flew roughly parallel with and were soon overtaken by the plane, though a proportion veered off at an angle from the path of the plane and some birds flew away from the plane at right angles to the direction of the pass. Land-based observations noted that the majority of birds, once the plane had passed, returned close to the area from which they had been disturbed. Birds off Rhossili Bay were much less prone to take to flight in the presence of the plane.

Common Scoter viewed from the plane were generally reasonably scattered in small groups over a wide area in the Saundersfoot to Pendine sectors; the typical 'Common Scoter pattern' (see Komdeur *et al.* 1992). Although flocks of several hundred birds were observed on a number of occasions, a large proportion of birds were encountered in groups of 50 birds or less. Away from the northwestern corner of the bay, birds were most often encountered in groups of five or less.

The distribution of birds off Rhossili, however, was markedly different: the large majority of birds in this area were found in just a few large flocks, normally of 200-300 birds. In most cases, these birds were in tight, usually circular, well-defined flocks of even density, much more similar to the pattern shown for Scaup in Fig. 2.7C of Komdeur *et al.* (1992).

During most flights, the presence of distinct 'fronts' was noted, where, particularly outside river mouths, there was an obvious interface between brown, muddy water from rivers and clear sea water. The large group of around 1,000 birds noted on the second additional run in November was located in the clear water directly adjacent to (less than 50 m from) the brown water. Whilst no obvious associations such as this were recorded on other flights, it appeared that most birds were located in clearer water; no large flocks were located in turbid areas.

During the four aerial counts, only two birds were seen to dive. Underneath the surface, these were instantly lost from sight. No birds were seen to surface during aerial counts. Similarly, land-based observations did not record birds diving in advance of the approaching plane. However, birds typically dive in the troughs of waves and, when there is a significant swell, this occurs out of sight.

4.5 EFFECTIVENESS OF LAND-BASED AND AERIAL COUNTS

The different recording units used for land-based and aerial counts renders direct comparison of the results problematic: land-based sectors are defined by sightlines to buoys and land marks, compared with a 2x1 km grid used for aerial surveys. An approximate comparison was made by assigning aerial counts to the land-based sector in which the majority of the 2x1 km recording area fell. No attempt was made to divide an individual 2x1 km aerial count between different land-based sectors. Similarly, aerial counts were identified as falling within 4 km and 6 km of shore, where the majority of the 2x1 km recording area fell inside arcs of appropriate distance measured from the count points (see Figure 1).

Table 2. Comparison of land-based and aerial counts of Common Scoter counts by sector and distance from shore. Range indicates the number of birds counted during aerial surveys within 4 km of shore, within 6 km of shore (i.e. including those within 4 km) and those falling within the sector regardless of distance from shore (all). The aerial count totals in November represent the best estimate from the combination of different passes made.

Date	Count	Range	B	C	E	F	G	H	I	J	K	L	Total
22/11/97	land		239	0	88	16	0	24	377	441	0	0	1185
22/11/97	aerial	4 km	536	0	101	60	17	236	1152	122	0	-	2224
22/11/97	aerial	6 km	536	16	101	60	17	298	1152	122	0	-	2302
22/11/97	aerial	all	536	16	101	112	17	298	1152	122	0	-	2354
31/1/98	land		625	0	23	67	0	430	1750	-	0	0	2895
31/1/98	aerial	4 km	1380	20	133	0	38	292	232	386	19	0	2500
31/1/98	aerial	6 km	1389	690	210	68	122	325	303	386	19	6	3518
31/1/98	aerial	all	2218	877	415	89	436	395	412	386	19	6	4953
25/2/98	land		-	-	210	55	0	550	633	1754	0	0	3202
21/2/98	aerial	4 km	896	0	0	7	0	44	47	453	0	0	1447
21/2/98	aerial	6 km	1398	129	22	12	49	52	75	453	87	0	2277
21/2/98	aerial	all	1648	129	189	20	93	126	92	453	87	0	2837
14/3/98	land		354	23	56	30	0	299	444	1831	36	0	3073
14/3/98	aerial	4 km	853	0	1	17	0	105	235	1213	15	-	2439
14/3/98	aerial	6 km	879	317	31	66	92	149	340	1213	17	0	3104
14/3/98	aerial	all	1422	324	242	81	92	209	396	1213	17	0	3996

Note the imprecise match of land-based count sectors with aerial counts and of aerial counts with range from shore (see text); note that land-based counts in January and February were incomplete; that aerial counts in February are likely to have been low due to unfavourable count conditions; that the counts in February were four days apart; and that all of sector J lies within 4 km of shore and that all of K lies within 6 km of shore.

Three of the four aerial counts in 1997/98 recorded markedly more birds than the land-based survey (Table 3). With the exception of the November count, the difference between the land-based and aerial counts was roughly similar to the number of birds out of sight (> 6 km) of land.

Table 3. Aerial and land-based counts of Common Scoters in Carmarthen Bay during 1996/97 and 1997/98. Differences between land-based and aerial counts are expressed as percentages of land-based counts. Percentages of birds not visible from land (>6 km from nearest shoreline vantage point; see Figure 1) are estimated from aerial count totals. The two aerial counts for 22/11/97 represent the unmodified concentric route and the concentric route with the additional passes made off Marros Sands; for this area, at least, the latter figures should equate to those for the grid survey route.

Note the limitations of these comparisons highlighted in Table 2, particularly poor conditions during the February aerial survey.

DATE	LAND COUNT	ROUTE	AERIAL COUNT	DIFFERENCE (%)	BIRDS OUT OF SIGHT OF LAND (%)
22/2/96	-	Concentric	*c* 4,500	-	0
27/2/96	-	Concentric	n/c	-	0
15/9/96	1,001	Concentric	506	495 (-51)	0
10/11/96	4,070	Concentric	2,575	1,495 (-37)	169 (7)
8/2/97	-	Concentric	4,112	-	4 (0.1)
23/3/97	1,352	Concentric	219	1,133 (-84)	0
22/11/97	1,185	Concentric	961	224 (-19)	52 (5)
22/11/97	1,185	Concentric plus additional passes	2,354	1,169 (+99)	52 (5)
31/1/98	2,895	Grid	4,953	2,058 (+71)	1,435 (29)
21/2/98	3,202	Grid	2,837	365 (-11)	560 (20)
14/3/98	3,073	Grid	3,996	923 (+30)	892 (22)

However, comparison of individual sector totals for land-based and aerial counts (Table 2) shows that, whilst the large numbers of birds located considerable distances offshore from Rhossili (Figures 8-10) were clearly not visible from land, land-based counts recorded considerably more birds in the Saundersfoot to Pendine area (sectors J, I and H) than were noted from the plane (with the exception of the November count).

Further, several of the land-based counts were incomplete, those in both January and February missing key sectors for scoter. Whilst, if these counts had been made, the difference between the aerial and land-based totals would have been reduced, it is possible that the discrepancy between counts in the Saundersfoot to Pendine sectors in the January count would have been greater still.

5 DISCUSSION

5.1 COMMON SCOTER NUMBERS AND DISTRIBUTION

Although the overall totals of Common Scoter in Carmarthen Bay in 1997/98 were slightly higher than in 1996/97, numbers remained considerably below peak pre-*Sea Empress* oil spill levels: peak winter counts of between 10,000 and 18,000 were recorded in the previous two winters (Figure 11; Stewart *et al.* 1997). Winter numbers off Rhossili, in particular, remained high, showing this area, which had been used by only small numbers of birds prior to the spill, to be of continued importance.

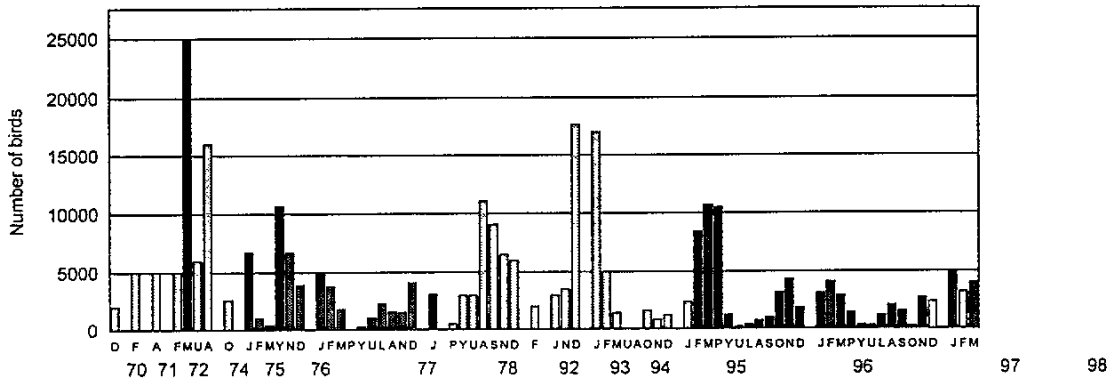


Figure 11. Numbers of Common Scoter in Carmarthen Bay, 1970 - 1998. The maximum count for each month in which a survey was made is given. Note irregular coverage over this period. Letters represent the first month of each year, except for April (P), May (Y), June (U) and July (L). Different shading is used to indicate survey type and coverage: black bars represent land-based counts, complete coverage; dark grey represents aerial, complete; pale grey represents land-based, incomplete; and white represents aerial incomplete.

Of key significance was the discovery of large numbers of birds considerable distances (> 6 km) off Rhossili. At such distances, birds will not be visible from land, even under ideal viewing conditions, and is unlikely that the concentric flight path employed prior to 1997/98 will have encountered flocks in this area. Although detailed data on the distribution of birds before the spill do not exist, the use of the Rhossili area by large numbers of birds appears to have occurred only after the spill (B. Stewart, pers. obs.)

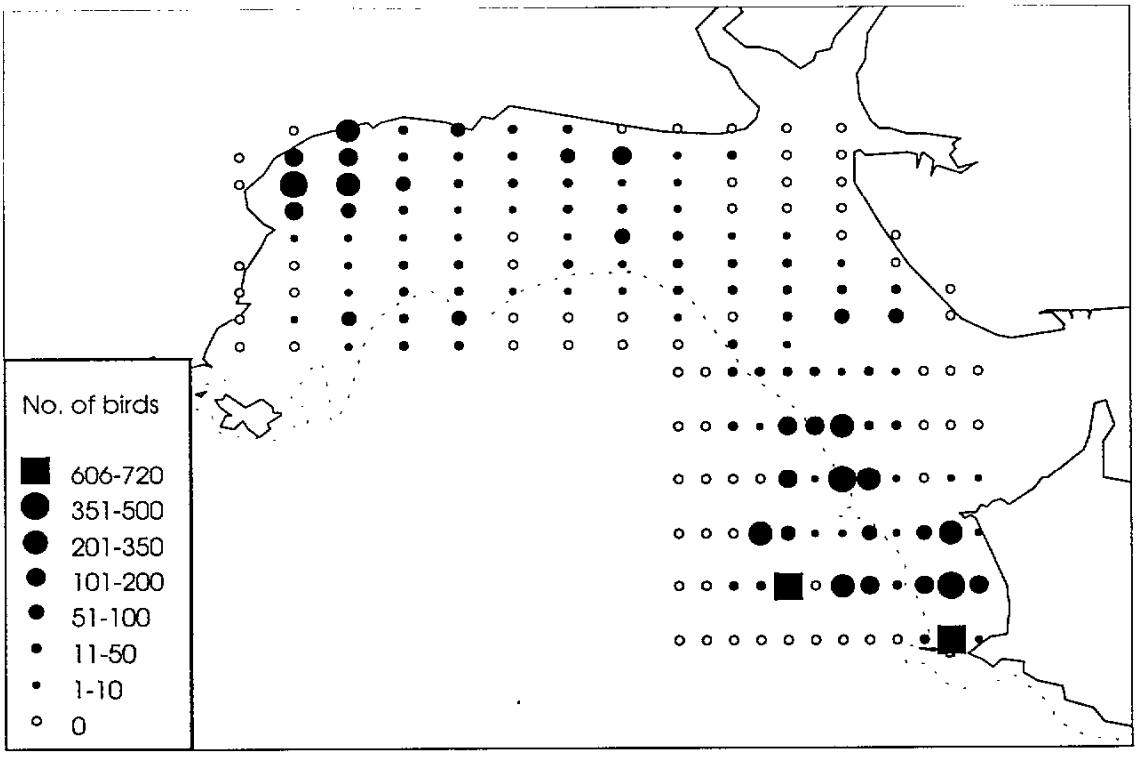
Aerial counts also identified a more or less continuous distribution of small numbers of birds, in a straight line or slight arc, between the two main concentrations in the bay. A proportion of these birds were seen in flight, and it is conceivable that this distribution reflects movement of birds between the Rhossili and Pendine flocks. However, it should also be noted that the presence of the plane caused birds to take to flight on a high proportion of occasions. Alternatively, this distribution corresponds reasonably to the 10

m depth contour, and it may simply represent less preferred feeding areas in shallow waters. Small numbers of birds were also regularly recorded east of Tenby, an area in which birds had not previously been noted, presumably due to the inability of land-based counts to detect birds at this distance from shore.

It is recommended that site protection measures in Carmarthen Bay should extend at least as far as those areas used consistently by Common Scoter, as recorded by aerial counts in 1998 (Figure 12).

The flight range of the plane limited exploration of areas further from shore, and although numbers of birds were smaller towards the limits of the area flown, the possibility remains that additional concentrations of scoter exist in the southern and western parts of the bay.

Figure 12. Key areas for Common Scoter in Carmarthen Bay, based on maximum counts per 2x1 km grid recorded during aerial counts in 1998.



5.2 COMPARISON AND EFFECTIVENESS OF LAND-BASED AND AERIAL COUNTS

Both survey approaches are subject to a number of potential errors. Aerial surveys require considerable experience in order to count or estimate numbers accurately. The two pilots used during the flights had both participated in scoter surveys previously; the navigator and one of the observers had participated in surveys of Carmarthen Bay in previous winters, whilst the other observer had undertaken aerial surveys of sea-duck in the Firths of Forth and Tay. Thus, differences in results between 1997/98 as a result of changes in personnel are likely to have been minimal.

As outlined in the methods, observers for the aerial counts were reasonably confident that birds could be counted up to 500 m either side of the plane, such that passes made at 1 km intervals were likely to record all birds in the area, but with a low probability of birds which remained in the same place being counted on subsequent passes. This distance was confirmed on several occasions during each flight, whilst binoculars were used on occasion to confirm the presence of flocks beyond this distance, and thus that birds were not being missed or double-counted on subsequent passes.

The range at which birds could be counted was reduced when looking south on days with strong glare, and it is likely that small groups of birds were missed as a result, notably in February. The back-light conditions when looking north on the subsequent pass may, however, have enabled some of the missed birds to be noted on the next pass, though it is almost certain that counts in February in the northern half of the bay are undercounts.

The most likely source of error during aerial counts results from the movement of birds due to the presence of the plane. Land-based observers noted that birds forced into flight by the plane often remained airborne for a considerable period (on some occasions, longer than the time for the plane to turn and start the next pass), but that most returned to the same general area of the bay. Thus, these might have been double-counted during the next pass by the plane. However, this is not borne out by comparison of land-based and aerial counts in the Saundersfoot to Pendine area: land-based counts, which should be accurate or at least minima for near shore flocks, were, with the exception of the November count, always considerably higher. Although it is possible that birds that took to flight in the Pendine area moved to Rhossili, though this is thought unlikely: land-based observations did not detect any obvious departure of birds to the southeast.

It is also possible that a proportion of birds were underwater as the plane passed overhead, either because they were feeding, or because they reacted to the presence of the plane in this way. This was not borne out by land-based or aerial observations, although it should be noted, since birds dive in the troughs of waves, this is difficult to observe from land.

Counts from the northern part of the bay suggest that a sizeable proportion of birds were missed during aerial counts in this area. Many birds encountered during aerial counts in the northwest of the bay were already in flight, presumably having taken to the air before the arrival of the plane. Thus, it is likely that some birds had already flown beyond the 500 m viewing distance before the plane arrived and were thus missed. This probably represents the biggest source of error during aerial counts, and probably accounts for much of the discrepancy between land and aerial totals in the northwest part of the bay.

Whilst it is not possible to determine to what degree aerial counts in other parts of the bay underestimate the numbers present, observations from the plane suggest that the tendency of birds to take to flight was markedly strongest in the Pendine area. A much larger proportion of birds were observed on the water in other areas and it is thought that aerial counts in these areas were much more closer to the true figures. It is speculated that the topography of the northwest part of the bay, with land on two sides, may render birds in this area more 'flighty' to the presence of a slow, low-flying plane.

It should be noted that the methodology used in Carmarthen Bay differs in a number of points from that recommended by Komdeur *et al.* (1992). Most notably, 'transects' were made just 1 km apart, compared with the 2-3 km recommended by Komdeur *et al.* The larger separation would certainly have resulted in birds being missed, as noted during the November count. Further, Komdeur *et al.* recommend that total counts be made between 60 and 95 m (180 to 300 ft) altitude. The height of 500 ft was used in Carmarthen Bay to avoid causing birds to take to flight: Common Scoter appear particularly susceptible to disturbance from planes (Komdeur *et al.* 1992). At 600 ft, it became difficult to discern birds, and on some days, discerning small groups at a distance from the plane was difficult at 500 ft. Nevertheless, under good light conditions, males could be distinguished from females at 500 ft. Small numbers of Eider, Red-throated Diver, Red-breasted Merganser and Velvet Scoter were also noted (the last in flight) though, since the vast majority of birds in the bay are Common Scoter, separation of other species, which may be difficult at this

altitude, is not a priority. The higher altitude of 500 ft also allows longer time to view an area of water, particularly useful when assessing numbers of birds flying over large areas, whilst it is likely that birds further from the plane are also viewed more easily at this altitude.

The closer distance between flight lines used during the 'grid' route and the more extensive coverage of the bay during aerial counts in 1997/98 are likely to account for the marked increase in the number of birds observed during aerial counts relative to land-based totals and, in particular, relative to aerial counts in previous years (Table 3). However, a further advantage of the 'grid' route is that all turns in the plane were made outside the area being counted. The concentric route involved making turns over the bay near Saundersfoot and particularly tight turns in the mouth of the Burry and at the buoy DZ1. It is usually not possible for one of the observers to view the water and thus count birds during turns.

Despite the limitations of aerial counts, it retains an obvious advantage over the land-based counts in being able to determine the distribution of birds more accurately. Whilst a 2x1 km grid may at first appear curious, it should be noted that recording counts at 1x1 km proved awkward in the plane. Further, given that a large proportion of birds are in flight before the plane arrives, a smaller grid would give a falsely precise picture of distribution.

5.3 RECOMMENDED COUNT TOTALS

For the reasons given above, it is suggested that the most accurate count totals for the bay can be derived by adding land-based counts in the Saundersfoot to Pendine area (sectors J, I and H) to aerial counts from other sectors; both count methods are likely to record minima even within these areas.

Table 4. Recommended Common Scoter totals in Carmarthen Bay, 1997/98 (note that the February count comprises counts from two different dates)

DATE	RECOMMENDED COUNT
31 January 1998	6,240
February 1998	5,103
14 March 1998	4,752

It is possible that birds observed by plane in sector G represent a double-count of birds in sectors I or H, having flown in front of the plane to sector G. However, many birds in sector G were observed some distance off-shore, whilst aerial counts in other parts of the

bay will tend to be undercounts; thus, these counts are still likely to represent minima. Lastly, no land-based count was made of sector J in January, and thus this figure is a known undercount.

Comparison of land-based with aerial counts in sectors H, I and J combined (see Table 2) could be used to provide a 'correction factor' for aerial counts. Aerial counts (for areas less than 6 km from shore) represented 47% of the land-based count in January (although the land-based count was known to be an underestimate in that month), 20% in February (although counts in this month were not made on the same day), and 66% in March.

However, due to the limitations of coverage in the first two months, it is recommended that no correction factor is calculated using 1996/97 data. Further, given that the behaviour of birds in the Amroth to Pendine area, namely their tendency to take to flight in the presence of the plane, differed markedly from that in other areas, such a correction factor could not be applied uniformly to aerial counts from all areas of Carmarthen Bay.

6 RECOMMENDATIONS

- Future aerial counts should be made using the 'grid' route, recording numbers using a 2 x 1 km grid. This eliminates dead ground during aerial counts and enables detailed distribution to be determined.

- Land-based counts during 'synchronised' aerial and land counts should be made immediately prior to (not during or after) aerial counts, due to the movement of birds when a plane is present.

- Further direct observations of the reaction of birds to the presence of the plane should be made, in particular to observe the distance at which birds react, their direction of flight in front of the approaching plane, and the time and location at which birds re-settle after having flown.

- Coverage of the southwestern part of the bay should be attempted. Whilst few birds were found further west of the main concentrations off Rhossili, small numbers of birds were regularly noted in the area directly east of Tenby and the extent to which this distribution extends further south should be investigated. However, the current route uses the majority of available fuel for a single flight, and some adjustments may need to be made to accommodate a significant extension to flight time.

- Further counts should be made at low tide and other stages of the tidal cycle to determine any differences in distribution at these times.

- Although there appears a tendency for large flocks in the northwest part of the bay to orientate east-west, favouring flight paths to be made in this direction also, at least one flight should be made using purely north-south flightlines. The reasons for this are several fold. Firstly, N-S flightlines are probably the most efficient way to investigate distribution east of Tenby and Caldey Island; secondly, light conditions will be favourable on N-S, rather than E-W, flightlines; and thirdly, the influence of a number of factors, as yet not investigated, may be different using N-S flightlines, e.g. the topography of the site may result in birds being less susceptible to disturbance if approached from a different direction; the orientation of flocks in

favoured feeding areas may lend themselves to passes in a particular direction; observation of the reaction of birds to the plane may appear different when viewed from a different perspective. Whilst it is purely conjecture that using N-S flightlines will affect these results, it is important to ensure that N-S flightlines provide comparable results to E-W passes and that there are no obvious flaws in using either method.

- To enable bird behaviour to be determined objectively, aerial counts should attempt to record whether or not birds are flying and in what direction in relation to the direction of the plane. This may help determine if birds were already flying between two points when encountered by the plane, or whether birds in flight have simply been scared into flight by its presence.

7 ACKNOWLEDGEMENTS

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8 REFERENCES

Gibbons, D.W., Avery, M.I., Baillie, S.R., Gregory, R.D., Kirby, J.S., Porter, R.F., Tucker, G.M. & Williams, G. 1996. Bird Species of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man: revising the Red Data List. *RSPB Conserv. Rev.* 10: 7-18.

Hughes, B., Stewart, B., Brown, M.J. & Hearn, R.D. 1997. *Studies of Common Scoter* Melanitta nigra nigra *killed during the* Sea Empress *oil spill.* WWT Wetlands Advisory Report to *Sea Empress* Environmental Evaluation Committee, CCW Contract No. FC 73-02-58.

Kirby, J.S., Evans, R.J. & Fox, A.D. 1993. Wintering seaducks in Britain and Ireland: populations, threats, conservation and research priorities. *Aquatic conservation: marine and freshwater ecosystems* 3: 105-107.

Komdeur, J., Bertelsen, J., & Cracknell, G. (Eds.). 1992. *Manual for aeroplane and ship surveys of waterfowl and seabirds* IWRB Spec. Publ. 19, Slimbridge, UK.

Parr, S.J., Haycock, R.J. & Smith, M.E. 1997. The impact of the *Sea Empress* oil spill on birds of the Pembrokeshire coast and islands. 1997 International Oil Spill conference, Fort Lauderdale, Florida, April 7-10 1997. American Petroleum Institute Publ. No. 4651, Washington.

Rose, P.M. & Scott, D.A. 1997. *Waterfowl Population Estimates - Second Edition.* Wetlands International Publ. 44, Wageningen, The Netherlands.

RSPB *et al.* 1996. *Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man.* RSPB, Sandy.

Scott, D.A. & Rose, P.M. 1996. *Atlas of Anatidae Populations in Africa and Western Eurasia.* Wetlands International Publication No. 41, Wetlands International, Wageningen, The Netherlands.

Stewart, B., Hughes, B., Bullock, I. & Haycock, R.J. 1997. *Common scoter* Melanitta nigra *monitoring in Carmarthen Bay following the* Sea Empress *oil spill.* WWT Wetlands Advisory Service Report to *Sea Empress* Environmental Evaluation Committee, CCW Contract No. FC 73-02-53.

Waters, R.J., Cranswick, P.A., Musgrove, A.J. & Pollitt, M.S. 1998. *The Wetland Bird Survey 1996-97: Wildfowl and Wader Counts.* BTO/WWT/RSPB/JNCC, Slimbridge.

APPENDIX

Below are a series of questions raised by the monitoring programme to date that cannot adequately be answered using available data. They are identified as aspects which may merit further investigation.

Use of Pendine and Rhossili areas:
Why are these two areas in particular favoured by Common Scoter?
Do these sites serve different functions?
Are the favoured areas consistent between winters?
Why do scoter adopt different flock distribution patterns in the two areas?
Is this distribution similar when very large numbers of birds are present?

Gross distribution presumably reflects food availability and benthic studies should shed some light on this. It is notable that the Rhossili area has only apparently been used by large numbers following the spill. Whilst this may be an affect of oil on food (since oil covered the Pendine area, but did not stretch to Rhossili), it should also be borne in mind that the moult flock has favoured the Pembrey area in recent years, yet this area was relatively little used during the winters. The discrete, dense flocks off Rhossili may be loafing birds, and the fact that many occur in waters 10 m deep or deeper may lend weight to this suggestion. However, it is unclear why birds should use the Rhossili area at all, rather than simply remaining in the Pendine area, and why they should occur so far off-shore. Flocks 2-3 km off-shore are presumably under no greater threat than those 6+ km from the coast. It may be that the prevailing wind or current moves birds sitting on the water, and they have either been moved to this position, or that it represents an area with few currents in which little energy needs to be expended to remain in that area. Disturbance may also have an influence on gross distribution in the bay.

Movement between Pendine and Rhossili:
Does movement between these sites occur to a significant degree?
Is such movement regular, e.g. at certain times of the day or tide, or influenced by other conditions, e.g. wind?
Are birds seen between Pendine and Rhossili simply moving between them or actively using the intervening areas, e.g. for feeding?

If the two sites have different functional uses, then movement should be expected. In this case, the nature of such movements needs to be determined, particularly if there is large scale movement in one direction at a time. Further, care needs to be taken when conducting aerial and land-based surveys, e.g. synchronised over the whole bay, or allowing for the proportion of birds likely to have been missed whilst moving.

Local movements during windy days have been noted, with birds flying into the wind (B. Stewart pers. obs.). It is thought that this may relate to birds returning to the favoured feeding areas from which they have drifted. If so, it might be expected that most movements take place in the morning after windy nights.

Muddy/clear water interface (fronts):
Do fronts influence scoter distribution?
Do fronts influence the distribution of the scoters' prey or affect their ability to detect it?
Do fronts provide additional food washed down from the rivers?