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Scroby Sands Seal Monitoring:

Analysis of 2003 aerial surveys and summary of baseline data

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Final Report

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EXECUTIVE SUMMARY

Powergen Renewables Development Ltd[1] are in the process of constructing a wind farm comprised of 30 x 2MW turbines on Scroby Sands, a dynamic sand bar system approximately 3 km offshore from Great Yarmouth, Norfolk.

The Schedule to Licence required that a monitoring programme should be carried out to determine the impact of the wind farm on the seals. This was specified as two aerial photographic surveys from fixed wing aircraft per month at low water for the six summer months (April to September) pre, during and post construction. This report is concerned with analysing the second year of pre-construction data from 2003 in relation to the 2002 data, and establishing a baseline against which the potential impacts of the wind farm may be measured.

The mean survey count for 2002 was 150, whereas for 2003 it was only 116 (a 23% decline). However, this difference was not found to be statistically significant within the context of the naturally high levels of variation associated with haul out counts. However, it is reasonable to suggest that this variation might be masking a genuine decline resulting from the 2002 Phocine Distemper Virus (PDV) outbreak. It would be highly unlikely for the seals on Scroby not to have been affected by PDV since it is highly contagious, and the seals nearby in the Wash were the most affected group in the country with an estimated mortality rate of 35% (SCOS 2003).

Although no statistically significant inter-annual changes in abundance could be detected, the pattern of peaks identified in 2002, namely the rise in Common seals seen in late July and the increase in Grey seals in September, did not occur in 2003. Therefore it must be concluded that these peaks are not related to life cycle events (as discussed in the 2002 report) but are instead more likely to be due to stochastic factors such as local prey abundance, height of the sand bank exposed, and the timing of low tide.

The Common seals pupped on Scroby again in 2003, although it appears that the surveys fell just outside of the peak breeding week. Since pups can swim almost from birth, it was likely that they were out at sea when the surveys took place. The peak number of pups hauled out in 2003 occurred in August (42), in comparison with 2002 when a much higher peak count occurred in early July (67). Unfortunately it was not possible to test whether there was a significant difference between these counts. Other studies have also found that peak pup counts vary both inter-annually and between colonies, to such an extent that comparison is often impossible (Anderson 1981, Warner 1983, *op. cit.* Thompson & Harwood 1990). This is due to changes in dispersal patterns thought to be associated with local foraging conditions. It is likely that this is the case at Scroby; in 2002 the pups dispersed during August, whereas in 2003 they remained present throughout the summer. However, pup counts can be an important means of detecting change, since changes in seal populations can take a long time to become apparent because they are long-lived annually breeding animals. Pup counts can be a more sensitive indicator of change, and may be a useful tool in assessing any impacts resulting from the wind farm. Therefore it is recommended

[1] A wholly owned subsidiary of Powergen Renewables Holdings Limited

that more surveys be undertaken during the pupping period in order to improve the accuracy of the pup counts.

The distribution of haul out sites also changed between years, although both in 2002 and 2003 the seals hauled out in preferred areas. This is likely to be connected with changes in the shape of the sandbank; locals have reported a large sandbar appearing parallel to Scroby, which would indicate that sand distribution has changed. The seals may have chosen different haul out sites in 2003 because, as a consequence, the sandbank was highest in different areas, or because the prevailing wind direction made certain haul out sites more or less attractive. Another possibility is that the seals prefer hauling out on some substrate types more than others, and that the distribution of these substrates changed between years. This example highlights an important point: whilst aerial surveys can provide an effective means of monitoring the abundance, distribution and breeding success of seals, these counts cannot explain the reasons for any changes identified (Hammond 2002). Other factors such as noise, disturbance, mortality, emigration, immigration, feeding habits or environmental processes would need to be investigated separately, and if any significant changes occur during the monitoring programme, potential causes will need to be investigated independently. However, it is possible to improve the scope of the data currently being gathered so that the identification of such factors is facilitated. Therefore the following measures are recommended:

- Several surveys to be carried out each year during the pupping period so that an accurate index of pup production can be obtained;
- Use of GPS points so that seal distribution may be related to a definable physical area, and also so that changes in the shape of Scroby can be monitored more effectively;
- Tide condition, time of day, and weather to be recorded at the time of each survey, especially during the pupping period;
- Although not required by the consent, we would recommend one aerial survey to be undertaken in November, December, January and February, which would enable a fuller understanding of seasonal trends.

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1. INTRODUCTION

Powergen Renewables Development Ltd[2] are in the process of constructing a wind farm comprised of 30 x 2MW turbines on Scroby Sands, a dynamic sand bar system approximately 3 km offshore from Great Yarmouth, Norfolk.

The Schedule to Licence states that a monitoring programme for the seals, as agreed with the Sea Mammals Research Unit (SMRU) should be carried out to determine the impact of the wind farm. This is specified in the licence as 2 fly-overs per month at low water for the six summer months (April to September) pre, during and post construction. Data collected prior to construction in 2002 and 2003 were to establish the baseline conditions against which the potential impacts of the wind farm could be measured. The licence states that the data collected during each fly-over should be copied to SMRU and a written report provided to the Licensing Authority at three monthly intervals (Condition 9.14 of DEFRA Licence 31272/02/0).

ECON were first approached to analyse the 2002 data in April 2003, since SMRU were unable to provide reports required by the licencing authority due to ongoing committments . ECON's historical review of the colony and analysis of the 2002 aerial survey data revealed the following:

- Both Common seals (*Phoca vitulina*) and Grey seals (*Haliochoerus grypus*) regularly haul out on Scroby.
- Common seals have been on Scroby for at least a century, and still breed there with haul-out counts typically numbering about 100 (although the actual colony size will be much greater).
- Grey seals were first identified on Scroby in 1958. Whilst they still use Scroby as a haul out site they no can longer breed there as the bank is covered at high tide and unlike Common seal pups, Grey seal pups cannot swim for their first month.

The following recommendations were made to improve the monitoring programme, although the timescale of the project meant that not all of these were incorporated into the 2003 monitoring:

- Winter surveys to establish general seasonal patterns
- Greater consistency in the frequency of surveys
- Improvement of photograph quality to identify species-specific trends
- dGPS points to be taken so that distributional changes can be more accurately quantified

2. AIMS

The aims of this report were:

1. To analyse the data from the 2003 aerial surveys.
2. To use the data from both pre-construction surveys (2002 and 2003) in order to establish a baseline against which the impacts of the wind farm may be determined.

[2] A wholly owned subsidiary of Powergen Renewables Holdings Limited

3. METHODS

3.1 Aerial survey specifications

The 2003 monitoring constitutes the last year of the pre-construction baseline survey. As stipulated in the licence requirements, monitoring took place in the form of aerial surveys conducted at approximately fortnightly intervals throughout the summer months (08/04/03 – 06/10/03).

The aerial surveys were undertaken by Air Images Ltd using a Cessna 150 aerobat aircraft, flying at a height of approximately 1000 ft and at a speed of 80 knots. Positioning was judged on a purely visual basis, due to the natural variation in the position of the Sands. The intervals between surveys and the time taken to carry them out varied according to weather conditions. Surveys were conducted at low tide, when the sandbank was most visible, and the greatest number of seals was present.

The first four surveys and the last four surveys were carried out in the same manner as in 2002; that is, a series of photographs were taken with a Mamiya 645 camera held out of the side window. The photographs, measuring 20 cm x 15 cm, were taken with a 150 mm lens on traditional medium format colour negative film. Each survey included enlargements of most sections containing seals, which had been taken at the lower height of 500 ft using a more powerful 300 mm lens. The sequences of photographs, when pieced together provided a map of Scroby, with enlarged sections where the seals were hauled out. The photographs were also provided on CD in digital form, scanned at a resolution of 300 dpi for the standard photos and 600 dpi for the enlargements. Table 1 shows the programme of surveys and the specifications of the equipment used (data supplied by Air Images Ltd).

The surveys from 30/5/03 – 14/07/03 were taken using a digital camera in order to establish whether this would improve quality, although otherwise the methodology was the same. The camera used was a Niklon DXI. Various lenses were used, depending on the angle at which the photographs were taken. The dates of the surveys and the cameras used are shown below in table 1.

The trial surveys using the digital camera were of extremely high quality and were an enormous improvement on the 2002 surveys. On these four surveys it was frequently possible to identify the species, gender and age of the seals. However, this level of identification was not possible throughout the rest of the surveys, which again means that the output was not of consistent quality. The intervals between surveys were more consistent than in 2002, although the intervals between the last three surveys were longer than they might have been (19 and 26 days respectively). It is understood that this was a result of the constraints of unsuitable weather.

Table 1. The aerial survey programme.

Date	Interval between surveys (days)	Camera specifications	Other comments
8/04/03		Mamiya 645 camera, 150 mm lens (with 300mm lens for enlargements)	
18/04/03	10		Carried out 90 minutes after low tide (even though very little sand is exposed, perhaps due to a strong north-easterly wind).
04/05/03	16		Photographed 17:30
15/05/03	11		Photographed approximately 30 minutes after low tide.
30/05/03	15	Niklon DXI digital camera	
12/06/03	13		
30/06/03	18	Niklon DXI digital camera	
14/07/03	14		
28/07/03	14	Mamiya 645 camera, 150 mm lens (with 300mm lens for enlargements)	
19/08/03	22		
13/09/03	25		
06/10/03	23		

3.2 Analysis of data from aerial surveys

3.2.1 Abundance

The seals were classified and counted on Adobe Photoshop using the zoom function. Each individual was marked with a specific colour code. Table 1 shows the colour codes used, and Plate 1 shows how the seals were marked on Photoshop. The photographs themselves were also examined thoroughly with a hand lens to confirm that identification had been carried out correctly.

Table 2. Colour codes used in classification of seals, according to species, sex (in the case of Greys) and age (adults, pups, and young-of-the-year in the case of Greys)

Classification	Colour code
Common seal adult	Yellow
Common seal pup	Orange
Grey bull seal	Pink
Grey cow seal	Light blue
Grey YOY	Red
Unidentified 1	Green
Unidentified 2	Blue

The Unidentified 1 category was used for seals that could either have been Common seal pups or small Common seal cows, whilst the Unidentified 2 category was used for seals that could either have been Grey bulls or Grey cows.

For the photographs taken using the traditional Mamiya 645 camera, the most effective means of identifying seals was by a combination of size and haul-out pattern. Common seals are smaller and have a more dispersed haul out pattern, whilst Grey seals are bigger and haul out in more densely packed groups (see Plates 2-4). On several occasions in both 2002 and 2003 the Grey seals hauled out in a densely packed cluster in a completely different area to the Common seals (Plates 3 and 4). In these instances the Grey seals are easily identified. However, there are also occasions when the situation is not so clear. Judging the size of the animals is difficult if the aircraft height varies, or even if the shadows are very dark (Plates 5 and 6). This is exacerbated when both species of seal are hauled out together (Plate 7). Since Grey seals are sexually dimorphic size is not a reliable means of identification in these circumstances, so it is necessary to look at muzzle shape in order to make confident identifications. However, this was only visible on the better quality photographs. Colour is also not a reliable indicator; although Common seals are typically lighter and browner in colour than Grey seals, there is a high level of individual variation within each species. Correct identification of young-of-the-year (YOY) Grey seals is impossible in mixed haul out groups if survey quality is too poor to show muzzle shape.

For the photographs taken with the digital camera, identification to species level was straightforward, since muzzle shape was always clear. Furthermore, it was possible to classify Grey seals into bulls, cows and YOY seals (Plate 1). These categories have been included in the results for the surveys when this information was available.

3.2.2 Breeding success

Pup counts were recorded when identification was possible (Plate 8). When a seal was small, but was not obviously a pup (which frequently occurred later in the year) they were counted under the Unidentified 1 category.

When possible (ie. when the digital camera was used) Grey YOY seals were also identified and counted (Plate 1).

3.2.3 Distribution

In order to map the distribution of seal haul outs it was necessary to select the best of the two photographic sequences i.e. the most complete, taken in the best light and at the lowest state of tide and thus containing the maximum number of seals. This was then traced onto graph paper and the haul out areas were mapped (Figs 3-14). This process was more problematic than for the 2002 data since the photographs from the surveys 30/05/03 and 12/06/03 were considerably larger (20 cm x 20 cm). This not only caused printing issues, but also meant that the surveys as a collection were difficult to compare since the scale throughout was so variable. There were also several instances (30/6, 14/7, 21/6 and 30/5) when it was difficult mapping Scroby in its entirity because the aerial photographs did not show the edges of the Sands.

IDENTIFICATION OF SEALS FROM AERIAL PHOTOGRAPHS

Plate 1. Identification of Grey seals from digital survey pictures.

Pink = bull
Light blue = cow
Red = YOY

Plate 2. Dispersed haul out pattern of Common seals

Plates 3 and 4. Grey seals hauled out in a separate cluster.

Plates 5 and 6. Difficulties with using haul out pattern to identify species. These seals are dark in colour and have a dense distribution pattern. However, it is simply a trick of the light and their muzzle shape (in the enlargement on the right) identifies them as Common seals.

Plate 7.
Mixed haul out group.

Plate 8.
Pup suckling

4. RESULTS

4.1 Analysis of 2003 aerial survey data

4.1.1 Abundance

The number and classification of seals from the 2003 aerial surveys are shown in Table 4 and Figure 1. Table 4 compares statistics from the 2002 and 2003 surveys.

Table 3. Abundance and classification of seals from the 2003 aerial surveys.

Date (2003)	Common seal adult	Common seal pup/YOY	Grey bull	Grey cow	Grey YOY	Unidentified 1*	Unidentified 2**	TOTALS
08/04	87	0	0	0	0	5	0	**92**
18/04	77	0	0	0	0	1	0	**78**
04/05	56	0	0	0	0	18	22	**96**
15/05	100	0	0	0	0	1	0	**101**
30/05	14	0	13	14	16	1	8	**66**
12/06	45	0	9	10	0	0	13	**77**
30/06	37	16	10	4	1	0	2	**70**
14/07	43	16	7	23	4	0	7	**100**
28/07	76	23	2	4	0	0	7	**112**
19/08	113	42	0	0	0	0	4	**159**
13/09	92	13	0	0	0	0	0	**105**
06/10	48	32	0	0	0	0	0	**80**

*Either small Common seal adult or large pup
**Either Grey cow or Grey bull seal

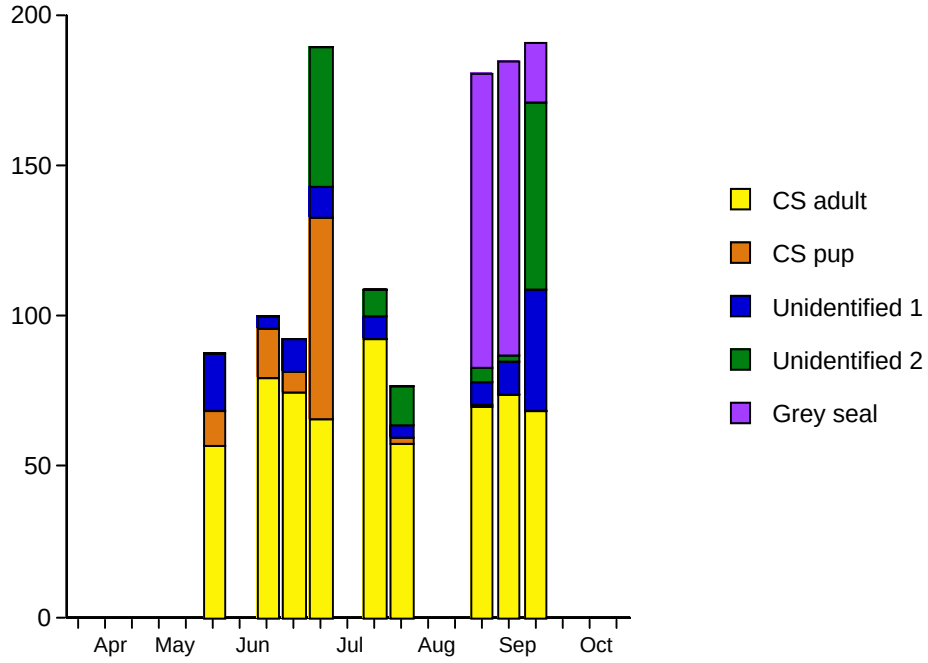
Table 4. Comparison of abundance statistics from 2002 and 2003.

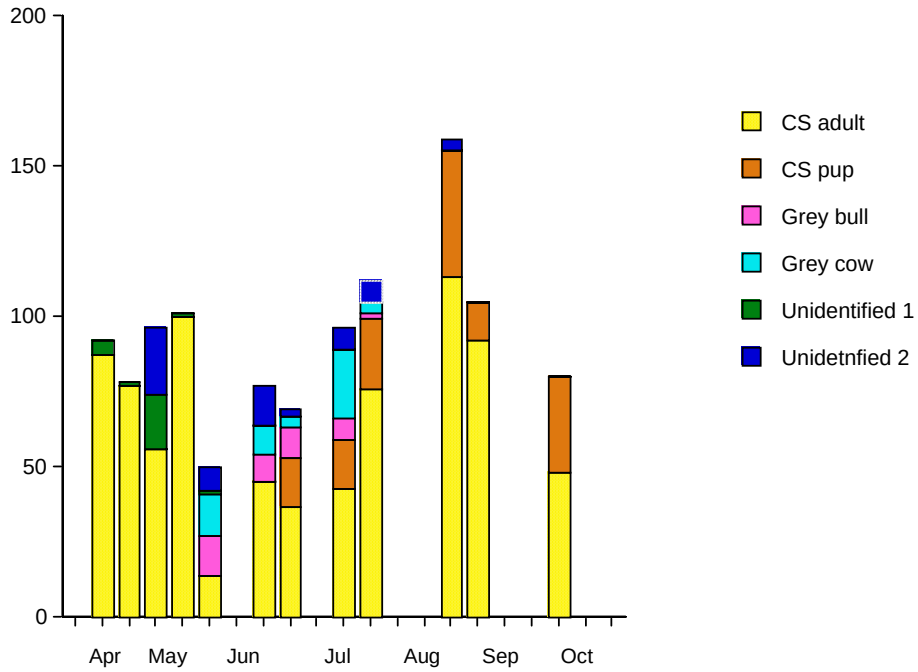
	2002	**2003**
Mean haul-out count	150	116
Maximum count	203	159
Minimum count	77	66
Range	126	93
Maximum pup count	67 (on 4 July)	42 (on 19 Aug)
Maximum Grey seal count	98	51
Common to Grey ratio	5:1	5:1

The maximum and mean seal counts decreased by 22% and 23% respectively between 2002 and 2003. Minimum counts were also 10% lower. In contrast the ratio of Common to Grey seals was the same in both years. In the 2003 surveys 100% of seals were identified to species level in contrast to 2002 when 20% remained unidentified. There appeared to be less seasonal variation in seal numbers in 2003 than in 2002, and the peaks seen in 2002, both in mid-July for Common seal adults and in September for Grey seals did not occur. However, in 2003 the Grey seals were present throughout much of the summer, as opposed to 2002 when they were often absent.

Figure 1 (above). Number and type of seals hauled out on Scroby Sands throughout the 2002 surveys

Figure 2 (below). Number and type of seals hauled out on Scroby Sands throughout the 2003 surveys





4.1.2 Breeding success

The pup counts from 2003 were lower, with a maximum of 42 (in comparison with 62 on 4 July 2002). Moreover, the peak count was much later in the season (mid August) and far later than the typical peak pupping period in early July. It is plausible that the 2003 surveys missed the peak pupping period and that many of the pups were at sea when the surveys took place, since Common seals are able to swim almost from birth.

4.1.3 Distribution

Figures 3-14 show the distribution of seals mapped on each of the twelve surveys. The key and data relating to these maps is included as Appendix 3.

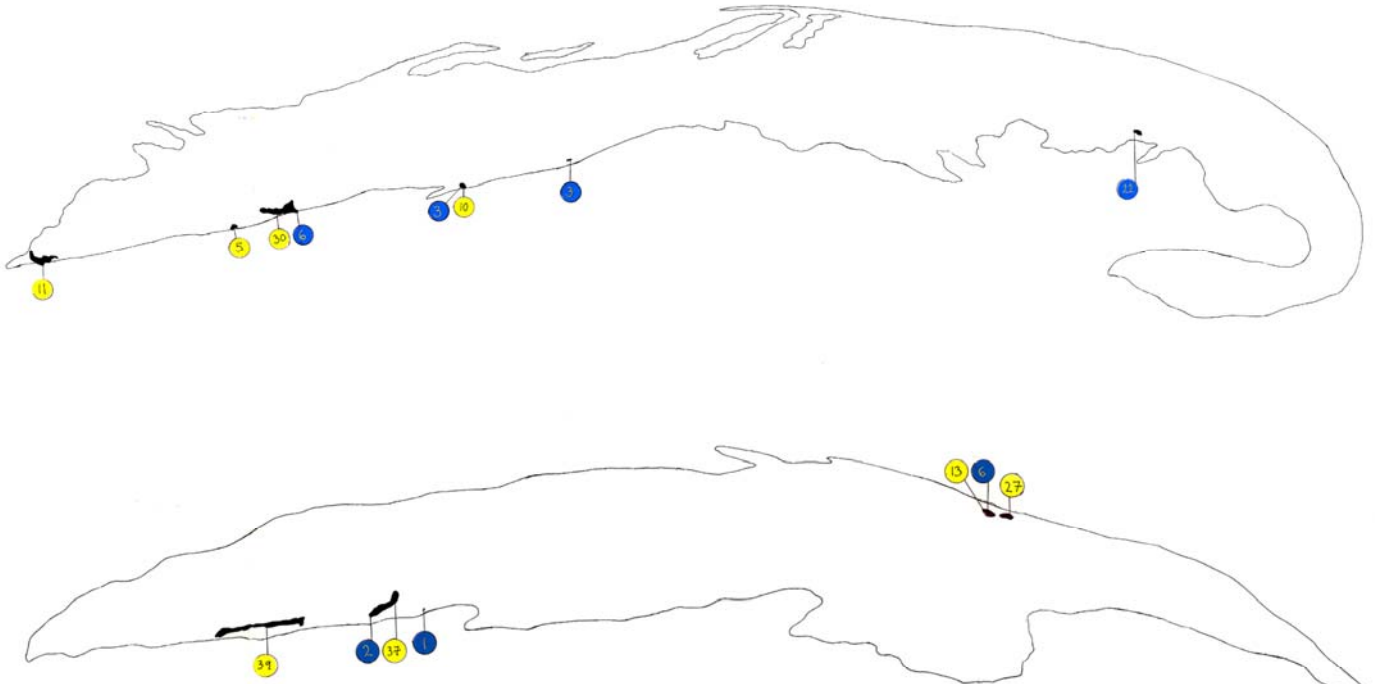
The area of Scroby exposed at low tide appears to have changed considerably since 2002 when there was a sizeable and unbroken strip of sand showing at each low tide. Whereas in 2003 the sections of sand exposed were completely fragmented on three occasions, and partially so on several others. In short, there was much less of Scroby appearing at low tide, although this was impossible to quantify since the surveys are not linked to dGPS points.

The haul-out areas used in 2003 differed from those used in 2002, although the seals still selected particular areas (Figure 15). In 2003, the seals no longer used the SW haul out that was the most popular in 2002, but instead used an area on the NE of Scroby. Haul out areas on Scroby are not fixed, and choice of haul out site is likely to be related to a number of factors including weather and area of Scroby exposed. This may explain the discrepancy in the location of the haul-out areas described in the Environmental Statement and the observations from the 2002 data.

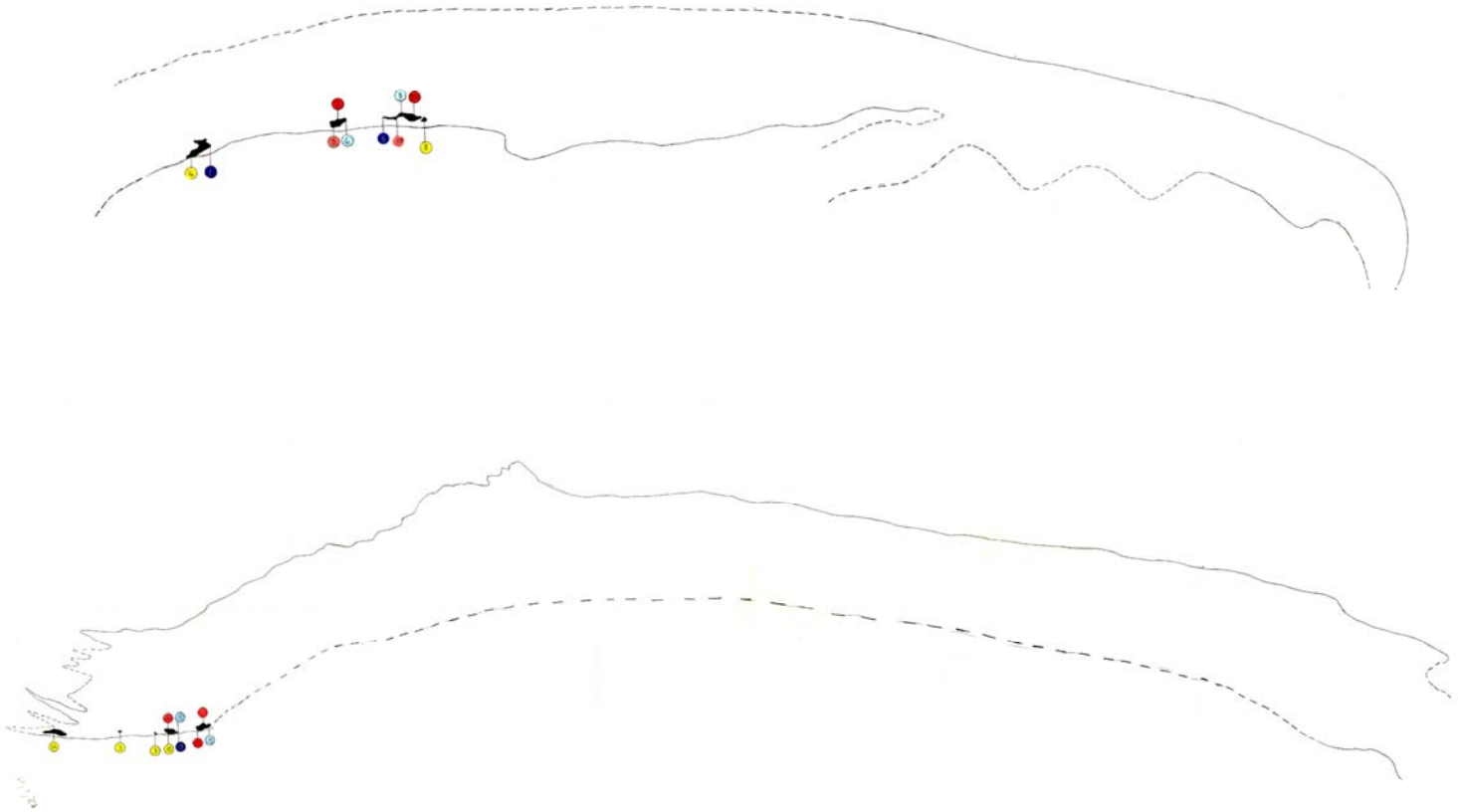
Furthermore, there did not appear to be any species-specific trends in haul out distributions. Grey seals sometimes hauled out separately from Commons, although both species often hauled out in mixed groups (See plates 3, 4 & 7). This does not appear to be related to season, although in both 2002 and 2003 Grey seals hauled out separately from Common seals around the time of the latter species' breeding season.

Figures 3 and 4

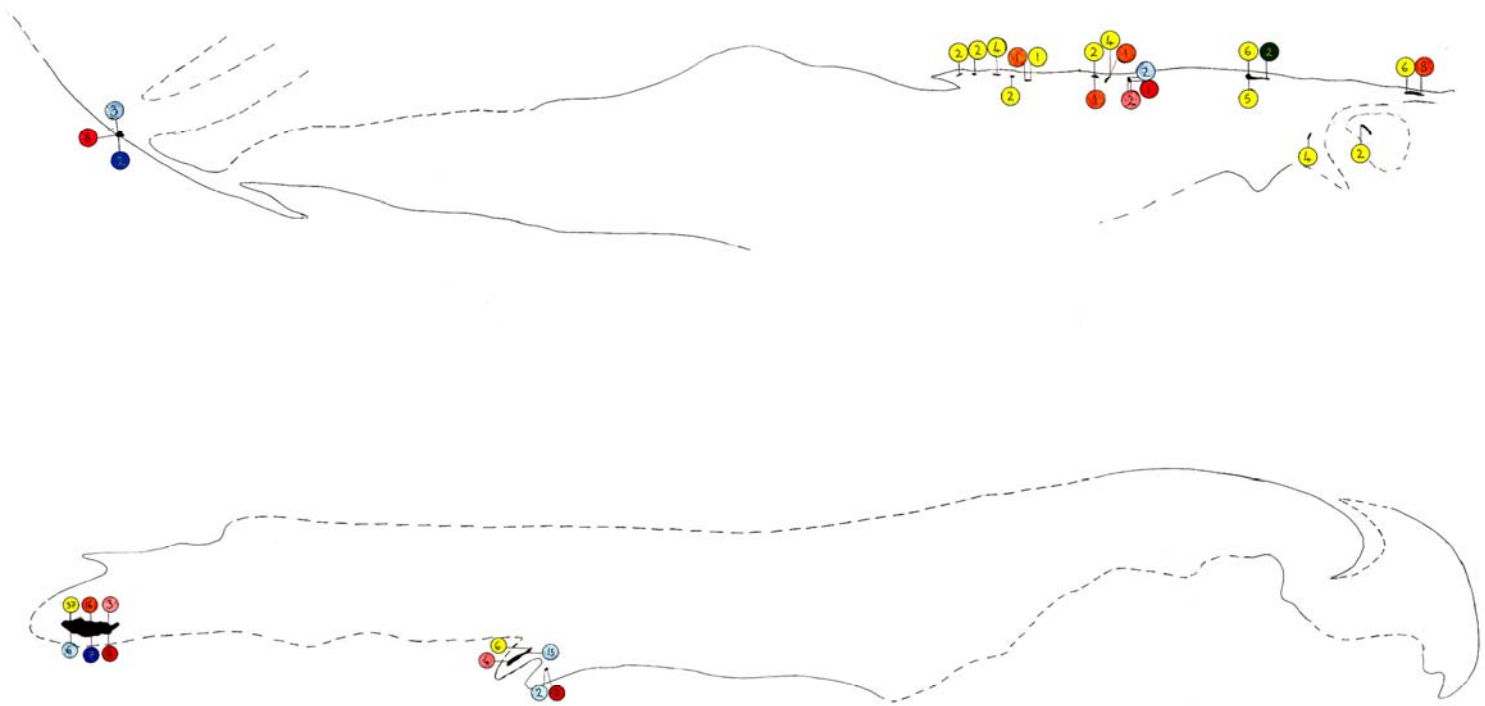
Figures 5 and 6



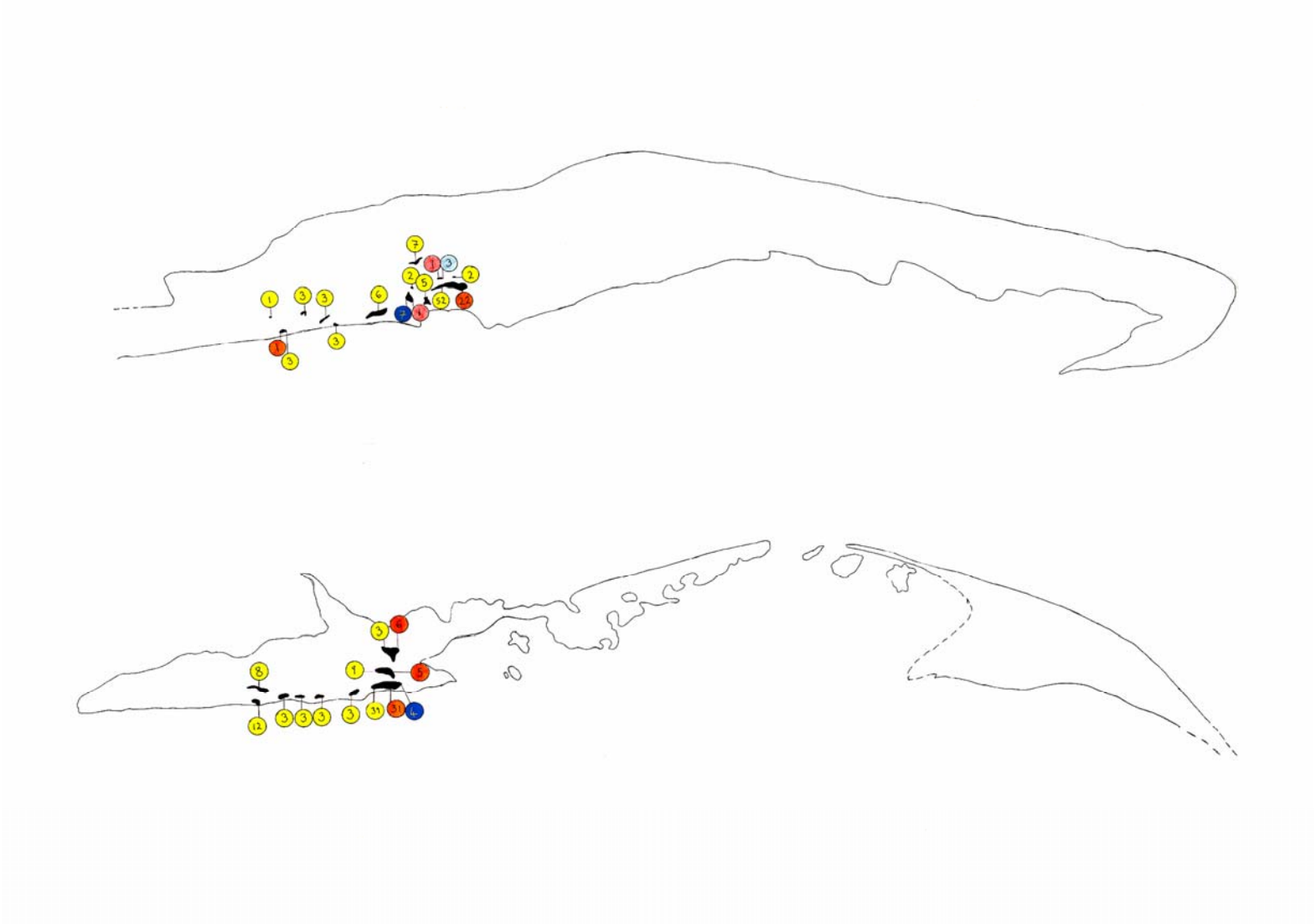
Figures 7 and 8



Figures 9 and 10



Figures 11 and 12



Figures 13 and 14

Figures 15 & 16. Haul out sites used by seals in 2002 and 2003. The hatched area represents the wind farm, the red area represents the part of Scroby visible at low tide, and the blue areas represent seal haul-out areas. The numbered crosses are the Little Tern monitoring sampling stations, whilst the stars show the stations from which large numbers of seals were recorded during the ornithological monitoring.

The seal counts obtained during the little tern monitoring are included as Appendix I.

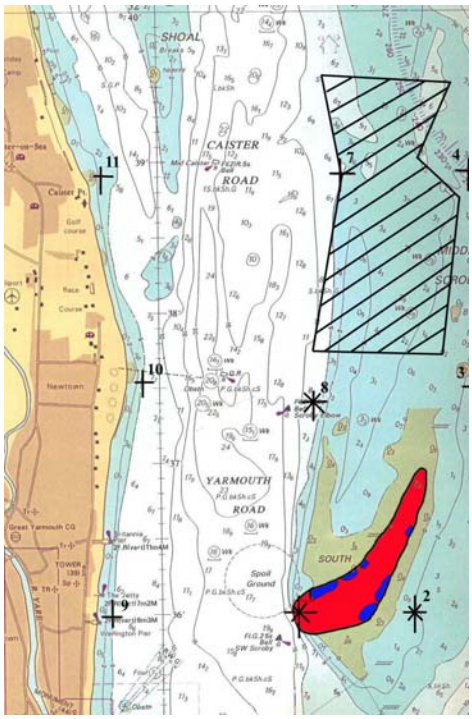


Figure 15. Seal haul out sites used in 2002

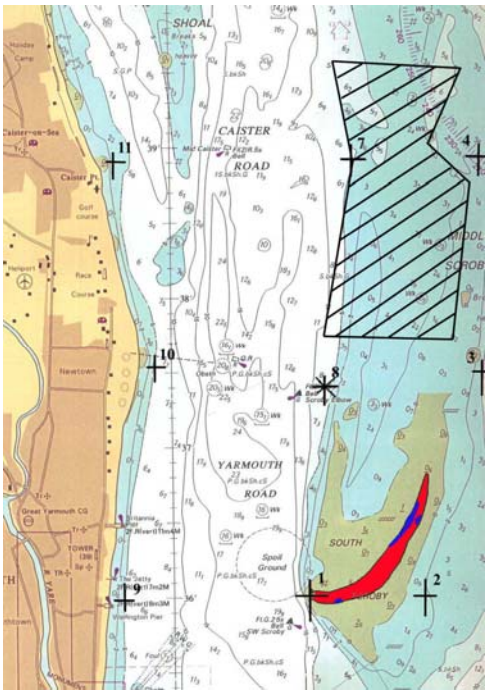


Figure 16. Seal haul out sites used in 2003

4.2 Statistical treatment

The sign test was used in order to establish whether the variation in seal counts between 2002 and 2003 were significant. For the purposes of comparison and to account for seasonal variation, the surveys carried out on similar dates were paired together (Table 5). The seals in the Unidentified 1 category (either large Commons or small Greys) were counted as Greys for the purpose of this test to ensure that any patterns would not be masked by identification uncertainties.

Table 5. Paired survey dates

Pair	2002	2003
1	25/05	30/05
2	11/06	12/06
3	25/06	30/06
4	04/07	14/07
5	27/07	28/07
6	21/08	19/08
7	16/09	13/09
8	26/09	06/10

The sign test is based on the direction of differences between two measures rather than quantitative measures. The null hypothesis tested by the sign test was that:

$$P[X_i > Y_i] = P[X_i < Y_i] = ½$$

Where X_i is the haul out count from 2002 and Y_I is the haul out count from 2003. If the null hypothesis is true, we would expect the number of pairs which have $X_i > Y_i$ to be equal to the number of pairs which have $X_i < Y_i$. The null hypothesis is rejected either if too few differences of sign occurs. A two-tailed test was used as there was no prediction of the direction of any difference, so the prediction was simply that either the seal counts for 2002 or for 2003 would be significantly different.

The sign test was carried out on the total number of seals (Table 6), Grey seals only (Table 7), and Common seals only (Table 8). The results are shown below.

Table 6. Sign test 1: Total number of seals counted in 2002 and 2003

Pair	**2002**	**2003**	**Direction of difference**	**Sign**
1	88	66	$X_{2002} > X_{2003}$	+
2	100	77	$X_{2002} > X_{2003}$	+
3	93	70	$X_{2002} > X_{2003}$	+
4	190	100	$X_{2002} > X_{2003}$	+
5	112	112	$X_{2002} + X_{2003}$	0
6	77	159	$X_{2002} < X_{2003}$	-
7	185	105	$X_{2002} > X_{2003}$	+
8	191	80	$X_{2002} > X_{2003}$	+

Number of most signs (positive) = 6
Number of fewer signs, x (negative) = 1
Number of matched pairs (N) = 7 (Note that if a matched pair shows no difference, it is dropped from the analysis and N is reduced accordingly)
Significance (α) = 0.062

Table 7. Sign test 2: Grey seals counted in 2002 and 2003

Pair	2002	2003	Direction of difference	Sign
1	19	51	$X_{2002} < X_{2003}$	-
2	4	32	$X_{2002} < X_{2003}$	-
3	11	17	$X_{2002} < X_{2003}$	-
4	10	41	$X_{2002} < X_{2003}$	-
5	7	13	$X_{2002} < X_{2003}$	-
6	4	4	$X_{2002} = X_{2003}$	0
7	109	0	$X_{2002} > X_{2003}$	+
8	60	0	$X_{2002} > X_{2003}$	+

Number of most signs (negative) = 5
Number of fewer signs (positive) = 2
Number of matched pairs (N) = 7
Significance (α) = 0.227

Table 8. Sign test 3: Common seals counted in 2002 and 2003

Pair	2002	2003	Direction of difference	Sign
1	69	15	$X_{2002} > X_{2003}$	+
2	96	45	$X_{2002} > X_{2003}$	+
3	82	53	$X_{2002} > X_{2003}$	+
4	180	59	$X_{2002} > X_{2003}$	+
5	105	99	$X_{2002} > X_{2003}$	+
6	73	155	$X_{2002} < X_{2003}$	-
7	76	105	$X_{2002} < X_{2003}$	-
8	131	80	$X_{2002} > X_{2003}$	+

Number of most signs (positive) = 6
Number of fewer signs (negative) = 2
Number of matched pairs (N) = 8
Significance (α) = 0.145

In summary, there were no significant differences between seal counts from 2002 and 2003 either in terms of the total seal counts, Grey seal counts, or Common seal counts.

5. DISCUSSION

5.1 Abundance

There was no statistically significant difference between the number of seals hauled out on Scroby in 2002 and in 2003 even though the mean count for 2002 was 23% higher than for 2003. Haul out counts are inherently subject to very high levels of variability, the extent of which is illustrated by some experiments in Eilsgay where a camera was left running taking photographs every hour. The number of Common seals hauled out on a single day was found to range from 48 to 158 (Thompson & Harwood, 1990). It is also important to remember that haul out counts are not a direct indicator of abundance, and can only be regarded as a minimum population estimate, since a large number of the seals will always be at sea. This has been demonstrated

by mark-recapture studies in the Wash where hauled out seals were sprayed with paint from an aeroplane. Subsequent surveys compared numbers of marked and unmarked animals in order to estimate the proportion of seals likely to be hauled out at any one time, and thus establish population size. Whilst maximum haul out counts totalled 1722, the population was calculated to be 6575 (Bonner *et al*. 1991). In the case of Scroby, it is impossible to provide a population estimate of the seals using the area around Scroby as there is not enough historical scientifically collected data relating to the colony. However, a better understanding of the factors influencing haul out patterns can help to establish the optimal survey period (i.e. when the maximum numbers of seals are hauled out), and minimize count variation. Seals occur in groups, so if a large group is not present when the surveys are undertaken then counts can be disproportionately small (Hammond 2002). Factors that can influence seal haul out patterns include:

- Tidal and circadian cycles
- Prey availability
- Seasonal patterns
- Moult behaviour
- Site fidelity

Despite the lack of significant change in seal numbers between 2002 and 2003 the seasonal pattern of abundance of seals hauled out on Scroby was clearly different. Analysis of the 2002 data revealed two distinct peaks that did not occur in 2003:

- A peak in the number of Common seal males seen on 19/07/02. Interpreted as an influx of bulls attempting to mate with post-partem oestrus females.
- A marked increase in Grey seals seen in September 2002 (01/09/02 and 16/09/02). Interpreted as a pre-breeding assemblage.

Incidentally, the changes in Grey seal patterns are unlikely to be related to uncertainties in identification, since the differences in numbers are still marked when all the Unidentified 1 category seals are counted as Greys.

Since the peaks seen in 2002 were not repeated in 2003, then it must be concluded that they were not related to annual life cycle patterns (mating and pre-breeding assembly respectively), but must have been due to other factors, for example local variations in prey abundance. Inter-annual changes in local prey abundance could also explain why Grey seals were present throughout the summer in 2003 and not in 2002. During the summer Grey seals need to forage extensively in order to put on enough weight for the breeding season when they fast. As a consequence they usually frequent the areas where prey is most abundant (Hewer 1974). Therefore it is possible that in 2003 Scroby was a comparatively better foraging area than it had been in 2002. Unfortunately, it was not possible to use the prey surveys from the Little tern monitoring to establish whether patterns of prey abundance differed between years, since seals are benthic foragers and have different prey requirements.

Since haul out counts are so variable, it is difficult to establish the extent to which both Common and Grey seals at Scroby interchange with other colonies. Common seals are known to forage locally (mostly <10 km from their regular haul out site), so

in this respect they are faithful to a single haul out site. However, Grey seals predominantly forage upto 60 km from their regular haul out sites, and will frequently utilize a number of different sites outside of the breeding period (Hewer 1974). Therefore, it is likely that changes in counts resulting from variation in site fidelity would only be apparent in Grey seals, and certainly use of an alternative haul out site near better foraging grounds could account for the lack of Grey seals seen on Scroby throughout summer 2002.

Since Common seals are generally site faithful (although there will always be some degree of interchange between sites), neither prey availability nor changes in haul out site can adequately explain the peak of Common seals seen in late July 2002. Since this peak was largely the result of a highly elevated count on the survey carried out 19/07/02 and slightly elevated numbers on 21/08/03, the perceived peak may simply be the result of one unusually high count. This could easily be attributed to a combination of other factors. For example, peak counts from sites which remain continuously exposed occur most frequently in the afternoon (Stewart 1984, *op. cit.* Thompson 1989), and studies from tidal haul out sites result in higher absolute numbers when low tide occurs at this time (Allen *et al*. 1980; McConnell *et al.* 1985 *op. cit.* Thompson 1989). It may be no coincidence that on this particular survey Air Images observed that it was a particularly low tide occurring at 17:30. Seals usually haul out at the highest point and follow the water as the tide recedes leaving characteristic tracks (Plate 9) (Anderson 1991). Therefore, it is possible that the seal count was high firstly because the site was available for longer, and secondly, because once hauled out the seals would have spent longer waiting to be washed back to sea again.

There is one further factor that may account for the changes in seal counts, in particular the 23% reduction in overall numbers in 2003, and that is the 2002 outbreak of the Phocine Distemper Virus (PDV) which caused the death of 21,000 seals throughout Europe between August and late October (SCOS 2003). It is unlikely that the seals would have escaped the outbreak since PDV is highly contagious and the nearby colony in the Wash, the worst affected in the UK, had an estimated mortality of 35% (this figure cannot be confirmed until the SMRU's summer surveys have been analysed) (SCOS 2003). It is likely that the tagged seal shown in Plate 9 comes from the Wash, since this is the nearest major colony where animals are tagged. Although it has not been possible to detect a statistically significant decrease in the abundance of seals counted in 2002 and 2003 this does not necessarily mean that they were not affected. It seems reasonable to suggest that that the naturally high variation associated with haul out counts has masked the impact of PDV to some extent. Another possibility is simply that when seals died they were replaced by others who came into the area and took their place (Brasseur, *pers. comm.).*

Plate 9.
Characteristic marks left by seals as they are washed down the banks when tide rises

Plate 10.
Grey seals moulting (note orange colouration)

Plate 11. Common seal with an orange tag (right flipper) indicates that the seals on Scroby interchange with other colonies. It is likely that this animal was tagged in the Wash.

5.2 Breeding success

Since Common seal pups are able to swim almost immediately after birth and the Common seal breeding season typically lasts about a month, pup counts (like haul out counts) can only be seen as an index of abundance since there is no time when all pups will be hauled out. However, peak pup counts do provide a measure of the productivity of the colony, and can be used as another indicator for monitoring change, although pup counts are frequently so variable that it is difficult to compare counts between years or areas (Anderson 1981, Warner 1983, *op. cit.* Thompson & Harwood 1990). In 2002, the peak pup count occurred on 04/07/02 (67), whereas in 2003 it occurred on 19/08/03 (48). Both the historical records (NBMR 1960, 1961, 1962, 1963 – see Appendix II) and the 2002 data indicate that the seals pup in early July, so it is just possible that the 2003 counts missed peak numbers (in 2003, surveys were carried out 30/06/03 and 14/07/03). In order to obtain a reliable peak count in 2004, it is recommended that several surveys be carried out during early July to minimize the risk of a disproportionately low count and to improve accuracy. This is with the aim of obtaining a reliable measure of breeding success because pup counts can provide a more sensitive indicator of population changes than general abundance counts. This is because seals are long lived annually breeding animals, and so changes in the population as a whole take time to show (Thompson *et al.* 1999). Pup counts could therefore be useful in the early detection of impacts associated with the wind farm.

In general, it appears as though there were fewer pups in 2002 than 2003, although this could not be tested statistically. It is possible that the weather decreased pup survival in 2003, since in this year storms occurred during the pupping period. (Data from the BBC Weather Centre, http://www.bbc.co.uk/weather/). Indeed, the historic literature often cites storms in early July as a major influence on the success of the Common seal breeding season (NBMR 1960, 1961).

Pup dispersal patterns also differed between 2002, when they dispersed rapidly, and 2003, when they remained throughout the summer. This is not unusual, since variability in the amount of time that pups spend ashore post-weaning is commonly seen both between populations and between years, and is usually explained in relation to other factors, such as prey abundance. This would account for Harwood's suggestion in the Environmental Statement that Scroby might represent an important resting place for young animals rather than a breeding colony, which he based on the observation that there were more pups seen on Scroby in August (Harwood 2001). However, the obvious pupping peak in the 2002 data and the cows suckling young in the 2003 photographs (Plate 8) further indicates that annual pupping occurs on Scroby, and the large numbers of pups sometimes present in August can instead be explained by changes in pup dispersal patterns.

Since Grey seals pup during the winter on the mainland beaches, it is not possible to obtain peak annual pup counts from the survey data. However, counts were made from the mainland beaches both in 2002 and 2003 during breeding period (Table 9).

Table 9. Seal counts from Horsey-Winterton beaches during Grey seal breeding season

Type of seal	2002/2003		2003/2004	
	27 Dec	*5 Jan*	*6 Dec*	*26 Dec*
Bull	12	7	14	28
Cow	23	14	48	23
Pup	29	12	51	32
Total	**64**	**33**	**113**	**83**

Comparing the counts from 27/12/02 with those from 26/12/03 show that more seals were present in 2003. However, the difference between years is largely attributable to the presence of more bulls in 2003 and does not represent any significant increase in recruitment, which appears to be more or less stable.

5.3 Distribution

The distribution of haul out sites has changed substantially since 2002. This is reinforced by the increase in sightings of seals from Site 8 during the 2003 Little tern monitoring, in contrast to 2002 when seals were mainly sighted from Sites 1 and 2 (Perrow *et al.* 2003). The sites used during the little tern monitoring are shown in Figures 15 and 16, and the seal counts are included as Appendix I. Changes in the height of the sandbanks exposed at high tide is one possibility; locals have observed a large sandbar appearing parallel to Scroby, so it is possible that the sand in the area has re-distributed in some way (P.Lines, *pers. comm.*). However, the surveys carried out when Scroby was very fragmented do not have reduced counts, and indeed the maximum count for 2003 occurred when Scroby was in this state (19/08/03 – Figure 12). It could be that the seals are utilizing different haul out sites because of other factors associated with sand re-distribution, for example changes in wind strength and direction. Some types of substrate may be more preferable to others, and it is possible that the distribution of preferred material has changed in some way. This is speculative, and it is not possible to establish whether either changes in bank height or substrate distribution are responsible from the aerial photographs, so these factors may need to be investigated at a later date if the drivers behind these distribution changes need to be ascertained. However, in both years seals clearly exhibited a strong preference for particular haul-out sites.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Review of monitoring programme

The quality of the aerial photographshas greatly improved since 2002. The four surveys carried out using the digital camera were extraordinarily clear, and it is strongly recommended that this equipment is used in 2004.

Furthermore, in order to improve the scope of the data gathered, the following measures are also recommended:

- At least one set of surveys to take place during the winter months (October-March), which would enable a fuller understanding of seasonal trends;
- Several surveys to be carried out each year during the pupping period so that an accurate index of pup production can be obtained;
- Use of GPS points so that seal distribution may be related to a definable physical area, and also so that changes in the shape of Scroby can be monitored more effectively;
- Tide condition, time of day, and weather to be recorded at the time of each survey, especially during the pupping period;
- Regular surveys in August, firstly to ascertain whether there is an increase associated with Common bulls hauling out to moult, and also to further elucidate pup dispersal patterns.

Whilst aerial surveys can provide an effective means of monitoring the abundance, distribution and breeding success of seals, these counts cannot explain the reasons for any changes identified (Hammond 2002). Other factors such as noise, disturbance, mortality, emigration, immigration, feeding habits or environmental processes would need to be investigated separately. If any significant changes in seal abundance and distribution occur during the monitoring programme, potential causes will need to be identified and investigated independently.

6.2 Conclusions from baseline data

From the analysis of the 2002 and 2003 data, the following conclusions can be made:

i) There are over 159 seals using the area (this was the maximum count for 2003 and should therefore be regarded as a minimum population estimate);
ii) Both Common and Grey seals haul out regularly on Scroby (species ratio 5:1);
iii) Common seals pup annually on Scroby (peak count 67 in 2002 and 48 in 2003), although pup dispersal patterns vary
iv) Seals haul out in preferred areas, although these are subject to change

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APPENDIX I

Seals recorded during the little tern monitoring around Scroby

APPENDIX I

Seals recorded during the little tern monitoring around Scroby

The Site numbers refer to the survey sites from the little tern monitoring programme. These are shown in Figures 15 & 16.

Records from the 2002 monitoring programme

SITE 1

Date	Common seal	Grey Seal
12/06/02	2	3
26/06/02	3	
10/07/02	1	
07/08/02		
05/09/02	5	6
Total	13	11
Mean	2.17	1.83
SE	0.70	0.98

SITE 2

Date	Common seal	Grey seal
21/06/02	12	38
26/06/02	2	1
10/07/02	1	4
26/07/02		1
07/08/02		
05/09/02	3	13
Total	18	57
Mean	3.00	9.50
SE	1.86	6.03

SITE 8

Date	Common seal	Grey seal
12/06/02		
26/06/02		
10/07/02		
26/07/02		
07/08/02	27	
05/09/02		
Total	27	
Mean	4.50	
SE	4.50	

SITE 10

Date	Common seal	Grey seal
12/06/02		1
26/06/02		
10/07/02		
26/07/02		
07/08/02		
05/09/02		
Total		1
Mean		0.17
SE		0.17

SITE 12

Date	Common seal	Grey seal
12/06/02		
26/06/02		
10/07/02		
07/08/02		
05/09/02		1
Total		1
Mean		0.17
SE		0.17

Records from the 2003 monitoring programme

SITE 1

Date	Common seal	Grey seal	Unid. Seal
06/05/03			
02/06/03			
11/06/03			
03/07/03			
14/07/03			
31/07/03			1
07/08/03			
21/08/03			

SITE 2

Date	Common seal	Grey seal	Unid seal
06/05/03			
02/06/03			
11/06/04			
03/07/03			2
14/07/03			
31/07/03			
07/08/03			
21/08/03			2

SITE 8

Date	Common Seal	Grey seal	Unid seal
06/05/03			20
02/06/03			
11/06/03			
02/07/03			
14/07/03			
31/07/03			54
07/08/03	1		70
21/08/03			

SITE 10

Date	Common seal	Grey seal	Unid seal
06/05/03			
02/06/03			
11/06/03			
03/07/03			
14/07/03			
31/07/03			
07/08/03	1	1	
21/08/03			

SITE 11

Date	Common seal	Grey seal	Unid seal
06/05/03			
02/06/03			
11/06/03			
03/07/03			
14/07/03			
31/07/03			
07/08/03		3	
21/08/03			

Appendix II

Seal counts for Scroby taken from the historic literature

Table to show the numbers of Common and Grey Seals recorded on Scroby Island

Year and date (if known)	Number of seals at Scroby		Comments
	Grey	Common	
1958 Oct	6-7	No records.	The 8 pups found on Scroby on 7 Dec were tagged by Prof Hewer from Imperial College.
29 Nov	100 (nr sandbank)		
7 Dec	4 pups, 1 bull, several cows in with common herd		
1959 7 June	No records	Breeding season described as 'very good'	
1960 6 June		150	The sands changed little during the winter, the highest parts lying at the north-east and south-east corners of the island (3 feet above high water). Visit to monitor little terns on 23 July (after storms had come and covered these banks) describes greater black-backed gulls quarrelling over the carcasses of common seal pups. Report of a tail-tagged animal seen on May 15th, although impossible to approach closely.
16 June		40	
end June		25 pups	
3 July		200 (seeking shelter from gales)	
16 Aug		132	
24 Nov	4 pups seen by RAF.		
16 Dec	12 pups		

1961 2 July		80 adults, 6 pups (all under 1 wk old)	North-westerly gales and abnormally high tides reported July 4th. Unsettled weather prevented landing until July 14th (i.e. during the Common Seal breeding season.).
14 July	18	2 herds; 150 adults in total with 16 pups (most under 1 wk old, 2 later found dead)	By end July large numbers of black gulls were devouring the carcasses of common seal pups. Stranding of pups/young seals occurred at Horsey, Cley, Yarmouth South Denes, Caister, Winterton, Hopton and West Runton.
21 July	47 (one herd of 27 and another of 20)	3 herds, but total no adults still 150. Only 2 pups ashore, rest at sea.	
19 Nov	3 pups; 2 male, 1 female		Later in November 3 Common Seals hauled out on a knoll below Breydon bridge and spent the winter there in spite of considerable human activity on the railway, bridge and barges.
26 Nov	5 pups; 4 male, 1 female		
3 Dec	2 pups; 1 male, 1 female		
10 Dec	1 female pup		
1962 18 June		60 adults; about half on NE corner, the rest offshore	Bad weather from during late June until 8th July (breeding season). Abnormally high tides and strong winds prevented visits prior to Dec 4th. Bad weather after this visit doubtless had a serious effect on the survival of these

8 July		30 pups (less than a few days old). A few dead/very weak	pups, one was washed ashore at Yarmouth on 12 Dec.
28 July	18 resting on NW corner	100 adults, 20 pups	
4 Dec	10 pups		
1963 30 June	Small groups of 10-20 Greys seen during summer.	200 adults (peak no seen during summer)	
14 July		17 pups found (all less than a few days old)	Bad weather reported June 18th, however seals seem to have bred successfully in spite of this.
30 July		6 pups found dead	
27 Dec	7 live pups, 2 dead pups		Some of these were already in moult.
1964 June		120-200 seen throughout month	The report mentions that the colony has a high mortality rate (no figures given). This can again be explained by high tides that occurred end June and mid July.
25 June		9 pups	
'Winter' (no date given)	12 pups seen for certain. Population of adults estimated at 300		Some attempts at shooting Common Seals on Scroby (for skins), but only shot 6 animals. They were deterred by naturalists and boatmen who take visitors to see the seals.

1965 19 July	27	100	Also reliable sightings of Greys on beaches at Weybourne and Winterton.. One Common Seal ringed at Scroby was found 5 weeks later in a Norwegian fjord, and another was recovered from West Africa. Scroby Island decreases in size by at least 50% between mid-summer 1964 and 1965. The original island had become circular by July 1965 and a sandbank had formed to the north-west with a quarter mile channel between the 2 islands. This new section was about 3.5 miles long at low tide, extending from Yarmouth to California.
1966	Did not breed due to adverse weather and changes in the shape of Scroby	Described as having a 'difficult year'	Throughout the year Scroby was completely submerged long before each high tide.
1967 27 June	15 (though did not breed)	80	Scroby remained below high water level. At low tide a new island a mile long appeared a quarter of a mile to the north.
1968 Winter	200 seals present with some 80-100 estimated to be at sea. Ratio of common to Grey 5:3		Scroby cull, authorized by the Ministryof Agriculture and Fisheries, started 16 May with the intention of killing 75 seals. Only 9 were killed in the first week, and subsequently the cull was called off. The Grey seals were tagged by the Seal Research Division (then in Lowestoft) to determine whether the pups could survive now the island is inundated by high tides. During the third week of December only 75 seals were counted on Scroby, and some of the tagged seals were washed up on the beaches between Yarmouth and Caister. This seems to indicate survival chances were slim.
1969	No mention of numbers at Scroby, although there were reports of individuals spotted as several points on the north and east coasts	Numbers described as 'same as last year'	No comments given as to the state of Scroby itself.
1970 No date given		200-250 adults, 20-30 pups.	Scroby reported to be making up again following its disappearance in 1966.

3 Dec	50-70 adults, 18 pups (2 of which were later washed ashore at Yarmouth)		
1971 7 June	10	200+ 20-30 pups born	Further sand continues to build up leaving a small area completely dry on most tides. This improved breeding success. One Grey pupped on the beach at Hopton. There were other reports of single individuals, dead and alive, from many other places along the coastline.
9 Sept	47		
11 Dec	5 pups; 3 new born, one 2 weeks old, and one offshore.		
1972	100+ with 20 pups born Dec/Jan	Described as about the same as 1971	
1973 – 1974	No data available		
1975	Described as producing about 25 pups annually	Numbers described as 'remaining constant'	
1976	No data available		
1977	Some cow pupped, but they were all lost.		Scroby Sand disappeared under water during the Grey Seal breeding season. Several Greys pupped on the mainland beaches, but again all the pups were lost.
1978			Large numbers of Grey seal pups washed ashore on beaches
1979			Grey seal pups washed ashore on beaches again, although not to the same extent as 1978.
1980	Bulls established territories for breeding but as the cows began to arrive the sands washed away.	'Reasonably good season'	Commons from Scroby picked out later at Morston, Blakeney and in the Wash. The Grey bulls displaced from Scroby set up alternative territories on mainland beaches and cows ended up pupping near fishermen, and then deserting their pups. A number were also shot, and severely wounded seals then had to be destroyed. It was reported that some went to Holland instead.
1981	Greys did not stay this year.		The island was very unstable, so they Greys did not stay; some pupped on the mainland beaches but fewer than in 1980.
1982	No data		

1983	Scroby submerged; seals unable to breed	'Average successful year'	5 Grey seal pups found deserted on beach – however seals unable to pup at Winterton because of the construction of the sea wall. It is assumed that they carried on to Morston.
1984	No data		
1985	Bulls set up territories, but sands were covered by the time the cows arrived.	120	Some Grey cows dropped pups at sea; several cows pupped on beach, but all the pups were deserted. Some of these seals were marked and later found at Morston.
1986	Scroby submerged. Several cow dropped pups at low tide, which were then lost when the waters rose. Others came ashore but all the youngsters died or had to be put down.	Common seals hauled out and pupped at Winterton with greater success than the Greys (since their pups were able to take to the sea and avoid people, dogs and other animals). However 6 of the 18 pups died, bitten by dogs.	
1987	28 Greys seen at Horsey on 21 April – reputedly the most seen there for years.		
1988	The Grey seals did not come to Scroby or Horsey this year.	30 (reduced from 120, poss due to PDV outbreak)	
1989-1991	No data		
1992	No references to seals		
1993	15-20. Attempted to give birth on mainland beaches. 2 pups sighted.	60	
1994	200 (on Scroby).	90	One report mentions 6 pups born on beach between Horsey and Winterton, though none survived. Another conflicting report mentions that 4 pups had been born by 1 Dec, of which 3 survived.
1995		120 adults, 15 pups successfully reared.	Tidal surge reduced area of sand from 20 to 5 km^2. Greys bred at the Horsey-Winterton site: 2 pups sighted 25 Noc, and 3 pups fatally shot Boxing Day.
1996 10 Jan	Bred at Horsey Winterton: 6 pups (one dead), 2 bulls, 3 cows		

1997	Bred at Horsey-Winterton: 15 pups (1 dead, 1 with bite wound), also 6 bulls and one Common seal.		No mention of number of Grey cows.
1998	Bred at Horsey-Winterton: 17 pups (2 died). 5 bulls seen.		
1999			
2000			
2001			
2002 27 Dec	Bred Horsey-Winterton: 30 pups (1 dead), 23 cows (inc 8 non-breeders), 12 bulls *(pers obs)*		
5 Jan	12 pups, 14 cows (inc. 8 non-breeders), 7 bulls *(pers obs)*		
2003 6 Dec 26 Dec	Bred Horsey-Winterton: Cows: 48, Pups: 51, Bulls: 14. Total: 113 (*Pers obs)* Cows: 23, Pups 32 Bulls 28, Total 82 (*pers obs)*		

Appendix 3

Key and data relating to Figures 3-14

Key

	Common seal adult
	Common seal pup
	Grey seal bull
	YOY Grey seal
	Grey seal cow
	Unidentified 1 (Grey cow/bull)
	Unidentified 2 (small common adult/large common pup

Figure 3. Abundance and distribution of seals hauled out 08/04/03

Type of seal	**Number**
Common seal adult	87
Common seal pup	0
Grey seal bull	0
Grey seal cow	0
YOY Grey seal	0
Unidentified 1	5
Unidentified 2	0
TOTAL	**92**

Figure 4. Abundance and distribution of seals hauled out 18/04/03

Type of seal	**Number**
Common seal adult	77
Common seal pup	0
Grey seal bull	0
Grey seal cow	0
YOY Grey seal	0
Unidentified 1	1
Unidentified 2	0
TOTAL	**78**

Figure 5. Abundance and distribution of seals hauled out 04/05/03

Type of seal	Number
Common seal adult	56
Common seal pup	0
Grey seal bull	0
Grey seal cow	0
YOY Grey seal	0
Unidentified 1	18
Unidentified 2	22
TOTAL	**96**

Figure 6. Abundance and distribution of seals hauled out 15/05/03

Type of seal	Number
Common seal adult	116
Common seal pup	0
Grey seal bull	0
Grey seal cow	0
YOY Grey seal	0
Unidentified 1	1
Unidentified 2	0
TOTAL	**117**

Figure 7. Abundance and distribution of seals hauled out 30/05/03

Type of seal	Number
Common seal adult	14
Common seal pup	0
Grey seal bull	13
Grey seal cow	14
YOY Grey seal	16
Unidentified 1	1
Unidentified 2	8
TOTAL	**66**

Figure 8. Abundance and distribution of seals hauled out 12/06/03

Type of seal	Number
Common seal adult	45
Common seal pup	0
Grey seal bull	9
Grey seal cow	10
YOY Grey seal	0
Unidentified 1	0
Unidentified 2	13
TOTAL	**77**

Figure 9. Abundance and distribution of seals hauled out 30/06/03

Type of seal	Number
Common seal adult	40
Common seal pup	14
Grey seal bull	8
Grey seal cow	3
YOY Grey seal	0
Unidentified 1	2
Unidentified 2	2
TOTAL	**69**

Figure 10. Abundance and distribution of seals hauled out 14/07/03

Type of seal	Number
Common seal adult	43
Common seal pup	16
Grey seal bull	7
Grey seal cow	23
YOY Grey seal	4
Unidentified 1	0
Unidentified 2	7
TOTAL	**100**

Figure 11. Abundance and distribution of seals hauled out 28/07/03

Type of seal	Number
Common seal adult	87
Common seal pup	23
Grey seal bull	2
Grey seal cow	3
YOY Grey seal	0
Unidentified 1	0
Unidentified 2	7
TOTAL	**122**

Figure 12. Abundance and distribution of seals hauled out 19/08/03

Type of seal	Number
Common seal adult	113
Common seal pup	42
Grey seal bull	0
Grey seal cow	0
YOY Grey seal	0
Unidentified 1	0
Unidentified 2	4
TOTAL	**159**

Figure 13. Abundance and distribution of seals hauled out 13/09/03

Type of seal	Number
Common seal adult	92
Common seal pup	13
Grey seal bull	0
Grey seal cow	0
YOY Grey seal	0
Unidentified 1	0
Unidentified 2	0
TOTAL	**105**

Figure 14. Abundance and distribution of seals hauled out 06/10/03

Type of seal	**Number**
Common seal adult	52
Common seal pup	29
Grey seal bull	0
Grey seal cow	0
YOY Grey seal	0
Unidentified 1	0
Unidentified 2	0
TOTAL	**81**

Filename: Report 2003 for pdf final
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