

# **Robin Rigg Offshore Wind Farm**

## **Before and During-construction Marine Mammal Monitoring**

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## **Executive Summary**

This report presents results of monitoring of marine mammals during construction of Robin Rigg offshore wind farm in the Solway Firth. Sixty-two monopile foundations were installed by hammer piling between December 2007 and February 2009.

The programme of marine mammal monitoring commenced with baseline surveys in February 2004 running through to January 2005, supplemented by further pre-construction surveys in July 2007. These were vessel based surveys during which marine mammal observers acquired effort-related sightings data as the survey craft followed set transects within the Solway Firth.

Vessel based monitoring continued during the first 12 months of the construction period and was supplemented in December 2007/January 2008 by land-based monitoring in the upper Solway. In addition, a programme of mitigation involving marine mammal observers, soft start piling and deployment of acoustic harassment devices was operated from the foundation installation vessels.

Surveys immediately before construction supported previous work undertaken for the project Environmental Impact assessment, and earlier baseline surveys, in that harbour porpoise and grey seal were identified as the most commonly encountered marine mammal species in the Solway Firth. Marine mammal sightings in and around the wind farm area itself were relatively rare.

Surveys in the wider Solway Firth showed that harbour porpoise continued to be present within the estuary, and exhibited apparently normal behaviour, over the period of piling activity. There was no evidence of standings and piling was never delayed by presence of cetaceans in close proximity to works.

During the initial period of piling measurements of underwater noise were made which suggested that the likely zone of physical harm for marine mammals was much smaller than expected (approximately 40m, compared to the precautionary 500m monitored zone around piling).

In conclusion, marine mammals are extremely unlikely to have been harmed by the wind farm construction works and any wider disturbance does not appear to have had gross effects, such as displacement from the estuary.

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## 1. Introduction

The 60 turbine Robin Rigg Offshore Wind Farm (OWF) is situated centrally within the Solway Firth, an estuary between the Cumbrian (English) coast and the Dumfries & Galloway (Scottish) coast (Figure 1). Construction of the wind farm commenced on 23<sup>rd</sup> December 2007 and all 62 monopile foundations were installed by 5<sup>th</sup> February 2009. Installation of the 4.3m diameter tubular steel monopile foundations was undertaken by two Jack-Up vessels, namely 'MV Resolution' and 'Lisa A', each utilising cranes and a hydraulic hammer.

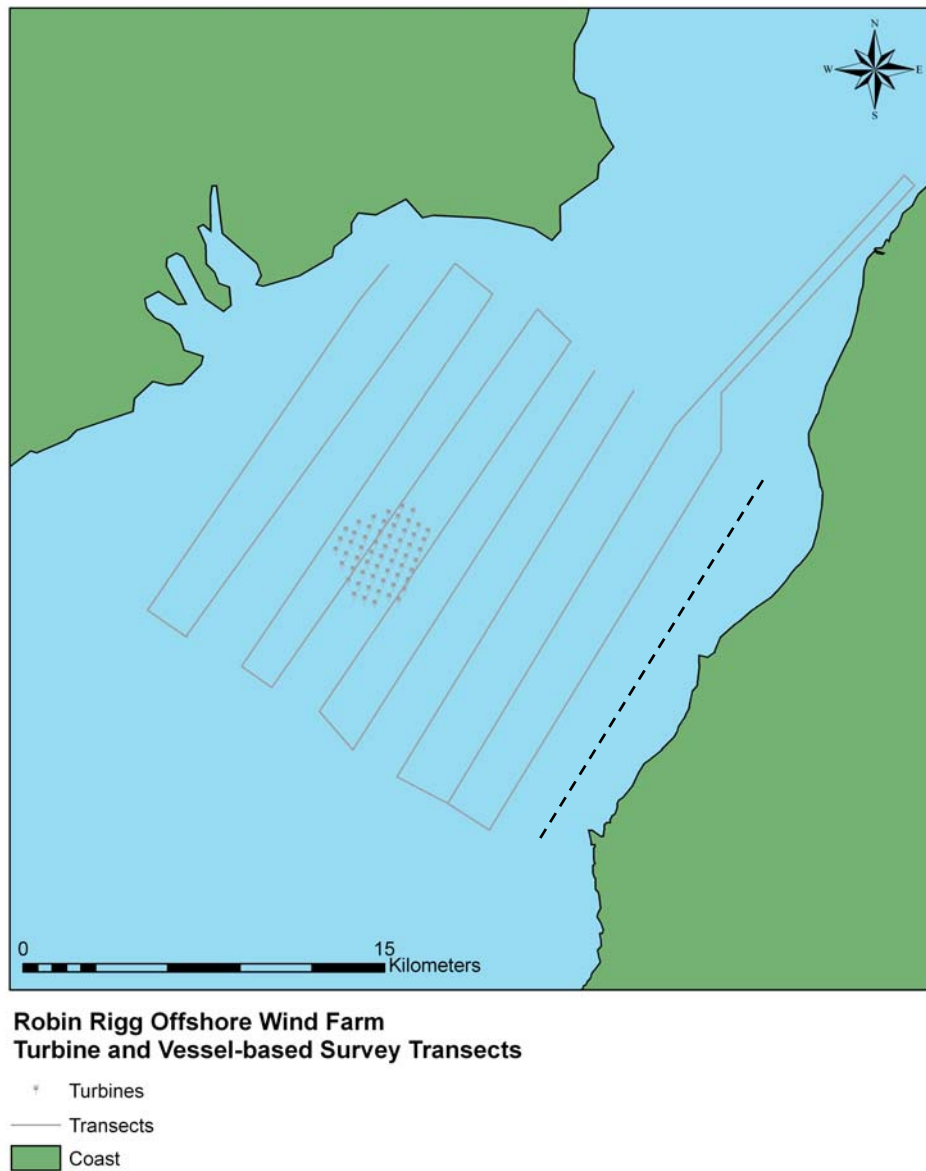
The Environmental Statement (Natural Power 2002) identified that there was a scarcity of information relating to distribution and activities of marine mammals within the Solway Firth. Nonetheless, it did identify harbour porpoise as the most commonly encountered cetacean species in the vicinity of the wind farm, and that the species may use the Solway for calving.

The absence of marine mammal sightings data necessary to provide a baseline for monitoring marine mammals over the construction and initial operation of Robin Rigg resulted in the commencement of monthly vessel-based marine mammal surveys. These surveys were undertaken from February 2004 to January 2005 and in July 2007 in order to acquire effort-related sightings data on the distribution, abundance and activities of marine mammals within the Solway Firth particularly in the vicinity of the site.

The vessel-based marine mammal monitoring continued during the construction period between 1<sup>st</sup> January and 30<sup>th</sup> December 2008. In addition, land-based marine mammal monitoring was undertaken at five sites along the Cumbrian coast by trained Marine Mammal Observers (MMOs) between 25<sup>th</sup> December 2007 and 4<sup>th</sup> January 2008 during periods of piling and non-piling works.

In parallel with the above monitoring surveys, a programme of marine mammal mitigation was developed and operated from the installation vessels. This comprised a Marine Mammal Observer (MMO) onboard the Installation vessel, a soft start procedure to hammer piling, and deployment of an Acoustic Harassment Device (AHD).

This report presents and reviews the results of the above programme of marine mammal monitoring. A review of the mitigation procedures has been undertaken by E.on and is provided as Appendix 3. The main aims of this report are to analyse marine mammal sightings data from the monitoring surveys to determine if any effect from wind farm construction activities is likely.



**Figure 1** Map of the Solway Firth showing the position of the 60-turbine Robin Rigg Offshore Wind Farm and the survey transects (Transect A (dashed line) was dropped in 2006).

## **2. Marine Mammal Survey and Mitigation Methodologies**

### **2.1 Vessel based surveys (pre- and during-construction)**

Pre-construction surveys were undertaken in 2004 (February, March, May, July, August (2), September, October, November December); January 2005; in July, August, September and November 2006, and July 2007 (3 surveys) (total 18 surveys).

The transects worked are shown in Figure 1, these are labelled A-I from the English (southern) to Scottish (northern) coast. The main transects are each between 17 and 19km in length (the workable length varying according to the state of the tide for the most northerly transects).

In 2006 two transects were extended northwards to cover an area of the upper Solway that was believed to be a possible calving area for harbour porpoise. This was based on regular findings of very young harbour porpoise calves dead on local beaches (Natural Power 2002), usually around late summer (peak September). Surveys before 2006 covered only the southern part of the Solway, including the wind farm.

During-construction surveys were undertaken on an approximately bi-monthly basis (total 36 survey days) throughout 2008, starting in February. These surveys included the northern transect extensions where possible (depending on tidal conditions).

An independent survey vessel traversed set transects on a monthly basis (at least bi-monthly during the construction period monitoring). Vessel speed ranged from 6 to 17 knots with a target speed of 10 knots.

The surveys were combined with ornithological work; however, an experienced marine mammal observer (MMO) undertook the dedicated marine mammal visual observation work with no conflicting ornithological responsibility. The MMO generally operated from the front of the survey vessel which permitted approximately a 260° sea view with the field of view behind the vessel obscured by the cabin. Effort data, such as time, position of vessel (latitude and longitude), boat direction and speed, sea state (Beaufort scale), swell height and visibility were recorded at least every 20 minutes along the transect. Transect start and end times were noted to ensure effort per transect line was recorded. Additional data such as water depth and boat activity were also recorded.

All marine mammal sightings (marine mammals visible at the sea surface), including those observed by the ornithologists if not seen by the MMO, were recorded on standard survey proforma in line with standard Sea Watch Foundation survey methodology (Appendix 1).

Three independent survey vessels were utilised as availability allowed: MV Heimdal, MV Tiger and the MV Solway Protector.

This report presents results of all surveys. No adjustments have been made to sighting rates in graphical representations in order to take into account weather

conditions that can affect surveyor efficiency. Therefore these numbers may be underestimated and should not be compared directly with other surveys.

The majority of surveys were undertaken in light seas (0 – 1m swell height). During the 2004/2005 surveys the Beaufort sea state exceeded 3 only once in December, however during the July 2007 survey 34% of total survey effort occurred in Beaufort sea states 4 and 5 and during the 2007/2008 construction period surveys 50% of the total survey effort occurred in Beaufort sea states 4 to 6 (reflecting the reduced ability to select ideal days when monitoring ongoing construction activities).

It is assumed that the surveys are broadly comparable and, since the primary interest is in local distribution and movement patterns rather than absolute numbers, subsequent analyses focus on the position of sightings in relation to the development area, season and tidal state and the relative abundance of animals month to month.

Because it is of particular interest to further understand the movements of harbour porpoise, observations of these animals have been related to tidal state since this is understood to be an important influence on their activity. Each sighting was therefore classified as taking place: during high water (including 1 hour before or after high water); on the ebb (2 - 4 hours after high water); at low water (5 - 7 hours after high water); and on the flood tide (2 - 4 hours before high water).

## **2.2 Land based surveys (during-construction)**

Marine mammal surveys were undertaken by two MMOs at five sites situated along the Cumbrian coast over five survey days between 25<sup>th</sup> December 2007 and 4<sup>th</sup> January 2008, coincident with the start of hammer piling to install wind farm foundations. The sites monitored, namely Silloth, Beckfoot, Mawbray, Alonby and Crosscanonby (from north to south), were chosen due to the presence of harbour porpoise calving grounds believed to extend from subtidal areas near to the Silloth and Alonby sites (Figure 2), although the peak period for calving is believed to be around September which is when dead calves have been found previously (Hammond pers. comm.; Natural Power 2002). In addition, it was considered important that there was monitoring of the upper part of the Solway during the initial period of piling to check that animals were not displaced into the upper estuary and potentially stranded in shallow water on falling tides.

Each site had ease of access and provided suitable visual coverage of ~180° sea view, thus together the five sites ensured good coverage of the southern region of the Solway Firth from Silloth to Crosscanonby. Silloth was designated primary observation site due to both its visual sea coverage and elevation, and therefore achieved the greatest monitoring effort.





**Figure 2: Land based marine mammal monitoring sites (from McCulloch & Travers 2008)**

Sites were monitored during daylight hours when piling works were being performed. Additional effort was achieved during periods of pre- and post-piling works in daylight hours.

MMOs scanned the 180° sea view with the naked eye for presence of marine mammals and utilised 7 x 50 binoculars to occasionally scan the area and to clarify potential sightings. The shoreline and beach area was also scanned during times of exposure to locate any potential strandings.

The position of effort and sightings were recorded using a hand-held Global Positioning System (GPS). Environmental variables such as wind force (Beaufort scale), swell height, sea state and visibility, were recorded continuously on effort data forms, and sightings data were recorded on additional sighting forms in line with standard JNCC guidelines (JNCC 2004).

### **2.3 Installation vessel mitigation**

As detailed in the Environmental Statement, the predominant cetacean species found within the Solway Firth is the harbour porpoise, a European protected species.

Therefore a marine mammal mitigation protocol was developed in order to prevent mortality of marine mammals in the vicinity of the construction area, as a worst case

scenario, and reduce the likelihood of marine mammals incurring non-lethal physical injury.

There were five elements to the marine mammal mitigation:

**1. Marine Mammal Observers (MMOs) based on the Installation Vessel**

An observer, having undertaken suitable training in marine mammal observation, was to implement at least 30 minutes visual observation of a 500m radius 'monitored zone' from the central pile location, following JNCC guidance on disturbance to marine mammals (JNCC, 2004<sup>1</sup>). If marine mammals were observed during this period, piling would be postponed until a 30 minute period had occurred in which marine mammals had not been observed within the 'exclusion zone'. Following a 30 minute period without marine mammals the obligatory Soft Start Procedure would commence. MMO deployment would only be effective during daylight hours and during slight sea states and reasonable visibility.

**2. Deployment of Acoustic Harassment Device (AHD) from the Installation Vessel**

The mitigation protocol included deployment of an AHD 30 minutes prior to commencement of Soft Start Procedure in order to deter marine mammals from the immediate vicinity of the Installation Vessel prior to piling. Such deliberate disturbance requires derogation from the Conservation (Natural Habitats, &c.) Regulations 1994 and a licence (Licence Number: DEROG 068A/2007) was obtained from The Scottish Government, Rural Directorate Landscapes and Habitats Division to allow the disturbance of cetaceans (predominant species, harbour porpoise) by deployment of an Acoustic Harassment Device.

**3. Soft Start Procedure**

Hammer piling was to commence at only 20% of full power and remain at this level for at least 20 minutes.

After 20 minutes at 20%, power was to be ramped up to maximum power (or just below) over at least 60 seconds. These conditions were set out in the Licence to allow disturbance to marine mammals (Licence Number: DEROG 068A/2007) with the stated purpose to provide sufficient time for marine mammals to leave the vicinity prior to full energy levels being reached. The soft start procedure was to be implemented at all times prior to commencement of piling regardless of whether marine mammals were observed or not. If the piling ceased for greater than 15 minutes a full 20-minute soft start was to be implemented upon re-start of piling, including a visual check by an MMO. If marine mammals were seen within the 500m radius monitored zone, re-start of soft start was to be delayed until a period of 30 minutes had passed without a marine mammal sighting.

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<sup>1</sup> These are the guideline for seismic survey which have been adopted by the offshore renewables industry until specific guidelines for that industry are finalised.

4. **Enhanced Vessel-Based Monitoring** (visual observations) was to be employed during the first four daylight piling activities in order to determine the behaviour of any cetaceans that may be disturbed by the piling activities, and to ensure, if necessary, that suitable additional mitigation is applied (for example pause piling) during a period either prior to or during low water, in which previous survey work had suggested animals were most likely to be present in the vicinity of the wind farm.
5. **Noise Measurements** during hammer piling were to be obtained during the installation of the first few monopiles in order to gain further understanding of site specific noise propagation, and to confirm previous predictions. The report, by Subacoustech, is provided as Appendix 4.

### 3. Results

NB data are provided as Appendix 2 (Electronic data appendix- 'Marine mammal effort and sightings raw data.xls').

#### 3.1 Pre- and during-construction vessel-based monitoring

##### 3.1.1 Pre-construction (July 2007) surveys

###### 3.1.1.1 Overview

Three pre-construction vessel-based surveys were undertaken on 15<sup>th</sup>, 16<sup>th</sup> and 23<sup>rd</sup> July 2007 comprising a total of 15 hours 17 minutes effort. Construction had not commenced at this stage; however the Robin Rigg cardinal buoys were in position.

The majority (87%) of the three day survey period was undertaken during a 'light' swell of between 0-1 m swell height, with 13% undertaken during a 'moderate' swell (1-2 m). Similarly a greater proportion of survey effort (66%) occurred during a Beaufort sea state of 0-3 with the remaining effort occurring during Beaufort sea states 4-5. Furthermore 83% of the surveys were carried out during good visibility of 16-20km with the remaining survey experiencing adequate visibility conditions of 11-15km. Therefore environmental conditions on the whole were favourable for marine mammal visual observations.

In terms of effort per survey day, 15<sup>th</sup> and 16<sup>th</sup> July received similar effort of approximately 4 hours 18 minutes whereas 23<sup>rd</sup> July received an additional 2 hours 20 minutes effort (Table 1).

Over the three survey days, Transect E was most frequently surveyed, receiving 15% of total effort, and Transect D was surveyed the least (5% of total effort). The extensions to transects B and C were not covered by the surveys in July 2007.

**Table 1: Effort per survey**

Transect	A	B	C	D	E	F	G	H	I	J	Total	Date
Time Spent Monitoring Each Transect	00:56:00	00:47:00	00:50:00	00:46:00	00:58:00	00:50:00	01:00:00	00:50:00	00:49:00	00:50:00	04:19:00	15/07/2007
	00:43:00	00:45:00	00:43:00	00:00:00	01:20:00	00:24:00	00:58:00	00:35:00	00:35:00	00:38:00	06:41:00	23/07/2007
Total Effort per Transect	01:39:00	01:32:00	01:33:00	00:46:00	02:18:00	01:14:00	01:58:00	01:25:00	01:24:00	01:28:00	15:17:00	Total Effort
Percentage (%) Total Effort per Transect	11	10	10	5	15	8	13	9	9	10	100	Total %

### 3.1.1.2 Marine mammal sightings and distributions

A total of 22 sightings of two marine mammal species were recorded during the three survey days as shown in Figure 3a. Despite receiving over two hours less effort than 23<sup>rd</sup> July, 70% sightings were recorded on 15<sup>th</sup> July in comparison to 26% of sightings on 23<sup>rd</sup> July and 4% sightings on 16<sup>th</sup> July. Harbour porpoise was the most frequently observed species, followed by the grey seal. An additional sighting comprising one to two individuals of a 'dolphin' species was also recorded exhibiting fast swimming behaviour approximately 500m port of the survey vessel.

There were a total of 19 harbour porpoise sightings comprising between 28 and 31 individuals. The majority of sightings (10 sightings, 52.6 %) were of solitary individuals, 31.6 % (6 sightings) were of two individuals and 15.8 % (3 sightings) were groups of at least two possibly three individuals at most. Calves were not recorded.

The species exhibited various behaviours at time of sighting. The majority of sightings (17 sightings) harbour porpoise displayed typical slow/normal swimming behaviour with leisurely surfacing and no splash. Fast swimming with rapid surfacing behaviour was exhibited by a solitary harbour porpoise sighted at approximately 200m distance port to the survey vessel and moving in the opposite direction. On one occasion two adult harbour porpoise were observed 400m ahead of the survey vessel engaged in resting and potential sexual behaviour; the individuals were described as logging (lying motionless) at the sea surface then one individual followed the other in various rotations and directions maintaining close body contact between the pair.

During the July surveys similar numbers of harbour porpoise sightings (of similar total counts of individuals) were recorded around high water, and on ebb and flood tides (Table 2). No sightings were recorded in the three hours around low water.

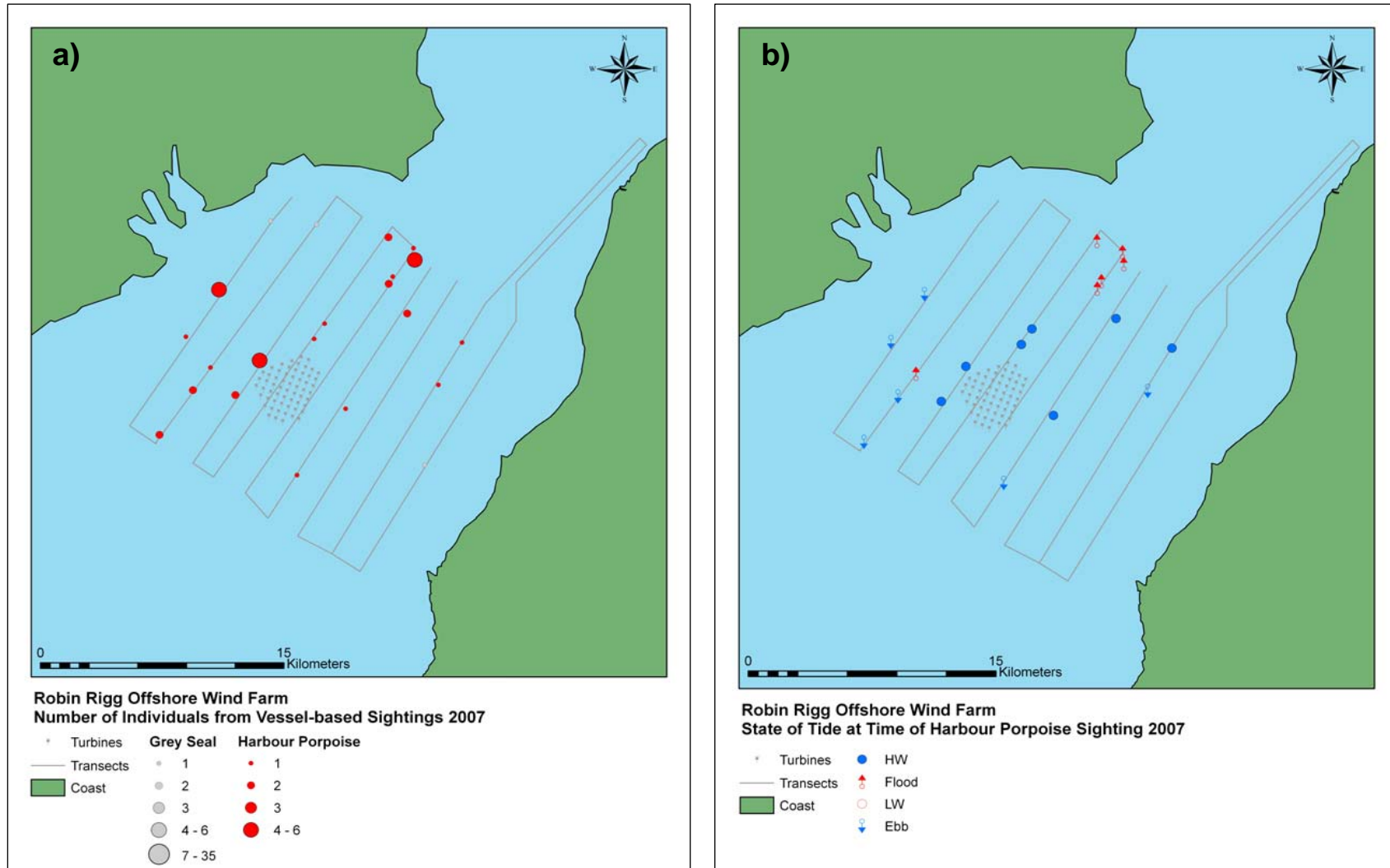
The spatial distribution of sightings in relation to tidal state (Figure 3b) suggests that harbour porpoise were more likely to be present around the north-eastern part of the main transect area (towards the inner Solway) on flooding tides and more likely to be observed around the wind farm nearer high water. This latter observation is in contrast to earlier baseline surveys which showed a clear trend for harbour porpoise to be sighted in the westernmost parts of the survey area, including the wind farm,

around low water. Previous surveys did also report animals towards the north-eastern survey area on flooding tides, however, consistent with animals following the tides into and out of the estuary.

There were no sightings of animals within the actual wind farm area (sightings in the wind farm area were very rare in the previous baseline surveys).

**Table 2 Number of sightings and individual harbour porpoise in relation to state of tide at time of sighting.**

<b>Tidal State</b>	<b>Number of Sightings</b>	<b>Percentage (%)</b>	<b>Number of Individuals (Max)</b>
High Water ( $\pm$ 1 hour)	7	36.8	10 (11)
Ebb (2-4 hours after HW)	6	31.6	9 (10)
Low Water (5-7 hours after HW)	0	0.0	0
Flood (2-4 hours before high water)	6	31.6	9 (10)
Total	19	100	28 (31)



**Figure 3: a) Number of individual harbour porpoise and grey seals observed in vicinity of Robin Rigg OWF in July 2007; b) State of tide in relation to time of harbour porpoise sighting in July 2007**

Three grey seal sightings were of solitary animals (two definite bull males recorded) exhibiting typical spyhopping (periscoping) and slow swimming behaviour.

#### **3.1.1.3 Sighting frequency**

There were 1.2 harbour porpoise sightings (including groups) per hour of effort and 1.8 individual harbour porpoise encountered per hour of effort during the three surveys in July 2007 (Figure 4 and Figure 5), also presenting data for the during construction surveys- see Section 3.1.2). This equates to a sightings frequency (per kilometre surveyed), during July 2007, of 0.059 harbour porpoise sightings and 0.087 individuals.

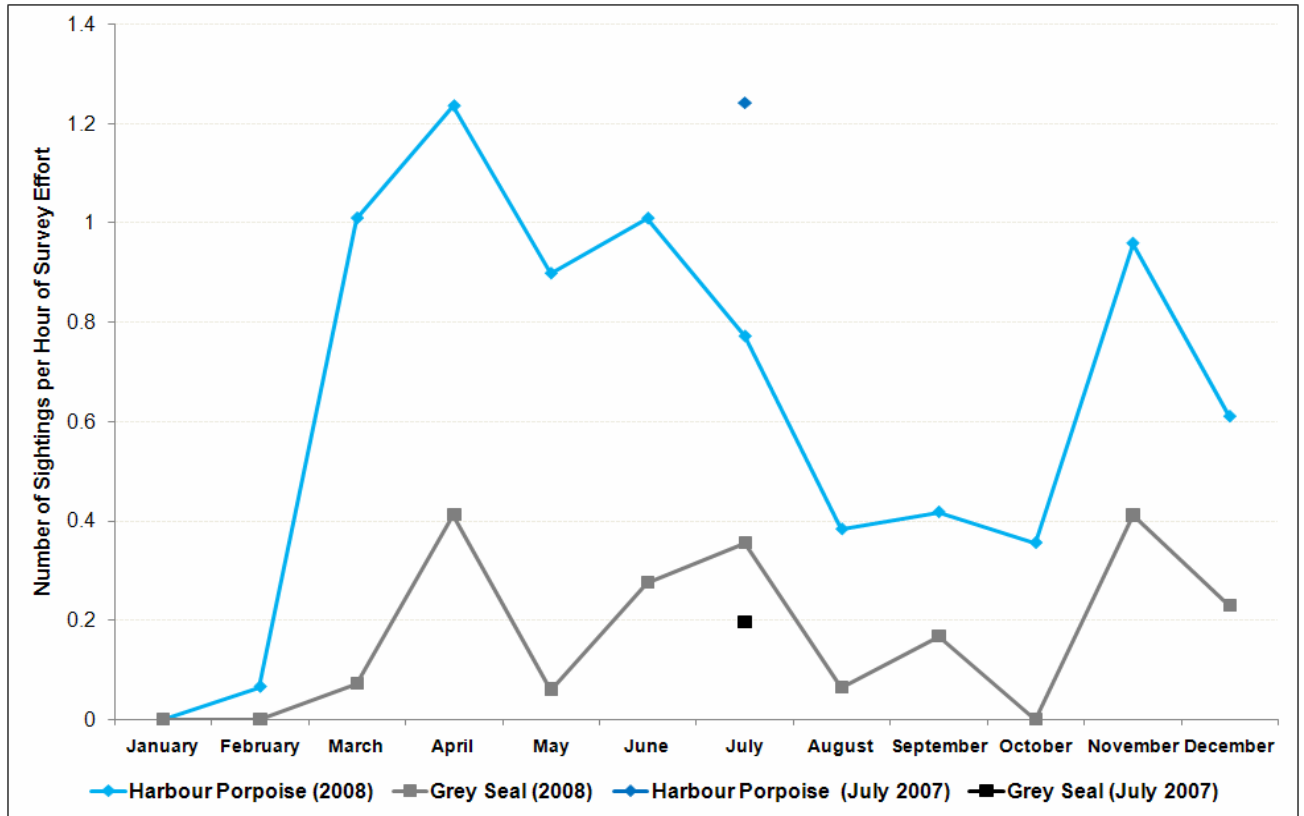


Figure 4: Number of Harbour Porpoise and Grey Seal Sightings per Hour of Survey

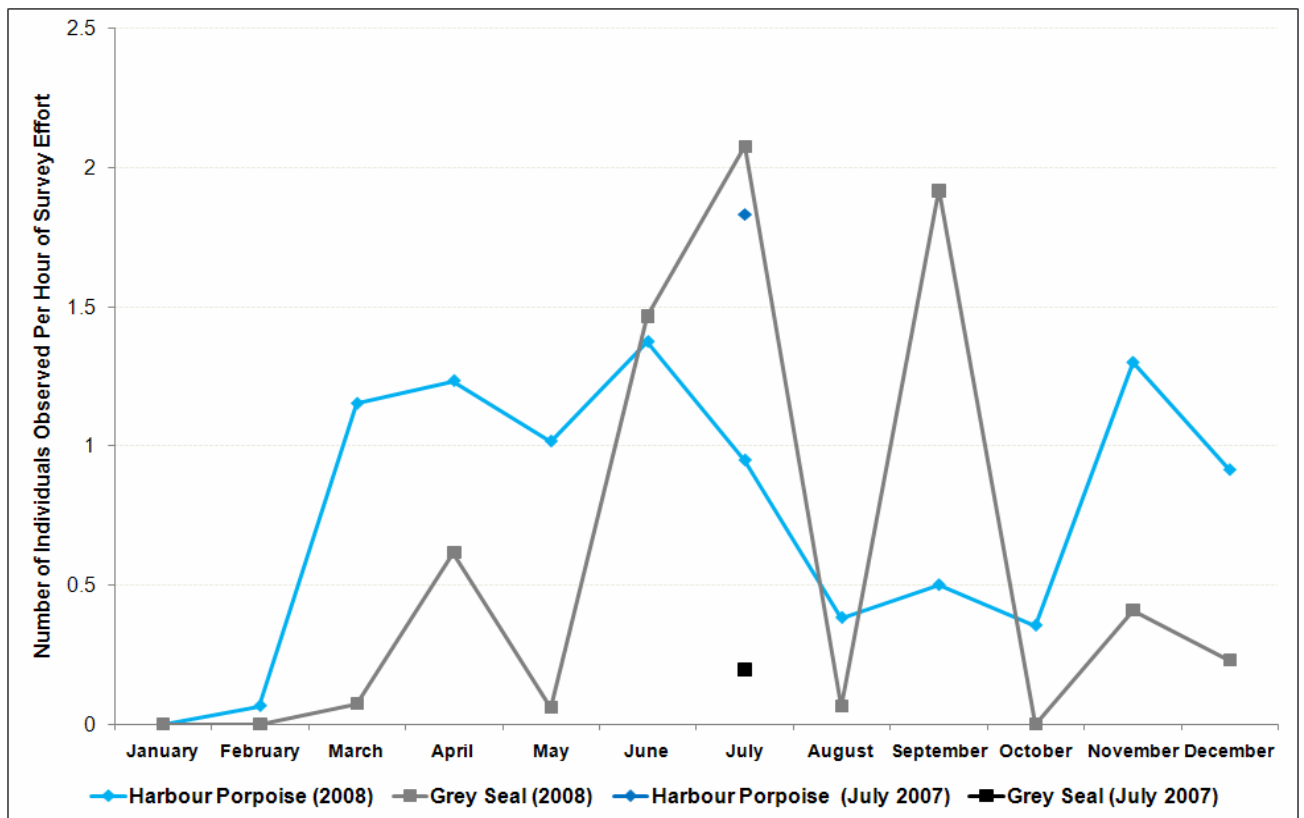
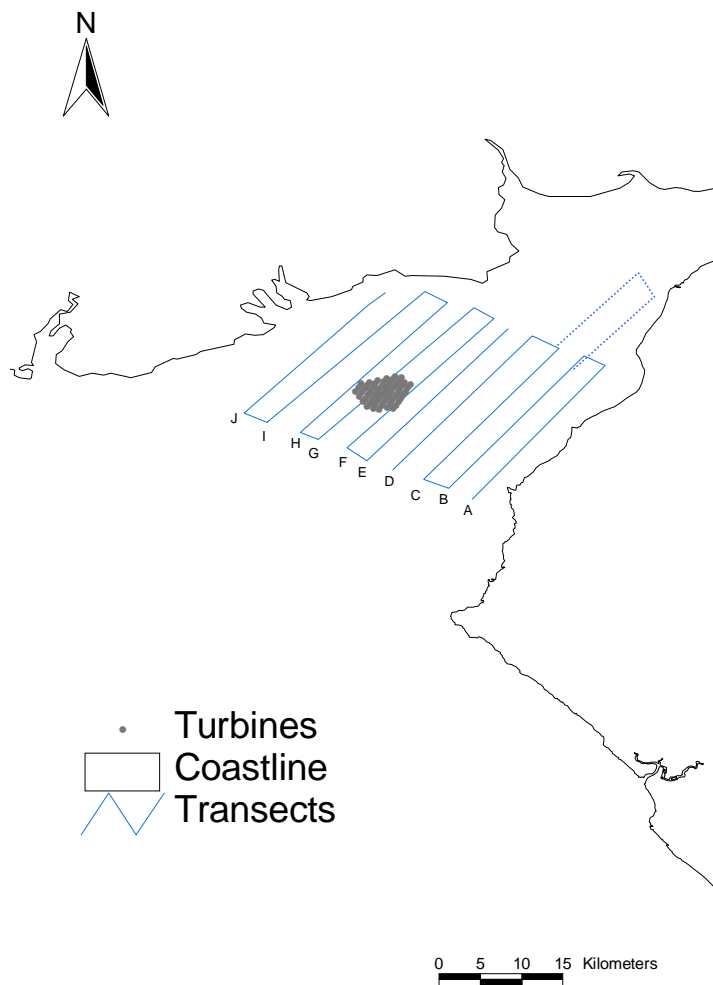


Figure 5: Minimum Number of Harbour Porpoise and Grey Seals Sighted per Hour of Survey





apparent that the majority of harbour porpoise sightings per hour of transect effort occurred along Transect F (left- 3.2 harbour porpoise sightings per hour of effort), followed by Transect I (2 harbour porpoise sightings), transect G (1.5 harbour porpoise sightings), Transect H (1.4 harbour porpoise sightings), Transect J (1.36 harbour porpoise sightings), Transects E and C (1.3 harbour porpoise sightings). In terms of minimum number of individual harbour porpoise encountered per hour of transect effort, Transect F (4.9 individuals) had the most encounters, followed by Transect I (3.6 animals), H (2.8 animals), Transect G and J (2 animals) followed by Transect E (1.7 animals) and finally Transect C (1.3 animals). Harbour porpoise were not observed along Transects A, B and D despite being monitored 11%, 10% and 5% of the total 2008 survey respectively, comparable to transects C and J which had at least 1 harbour porpoise sighting per hour.

When these sightings are broken down into transects (Figure 6 and Figure 7) it is

In contrast, grey seals were only encountered along three of the ten transects surveyed in 2007, namely transects B, I and J, each of which comprised between 9 – 10% of the total survey effort for July. Grey seals were not encountered along transects A, D, E, F, G and H despite a comparable amount of effort per transect line (8 – 15% per transect of total 2007 effort). The majority of grey seal sightings per hour of effort occurred along transects I, J and B (0.7 sightings per hour effort). Approximately 0.7 grey seals were encountered per hour of transect effort for the three transects the species was observed along (three sightings each of one individual).

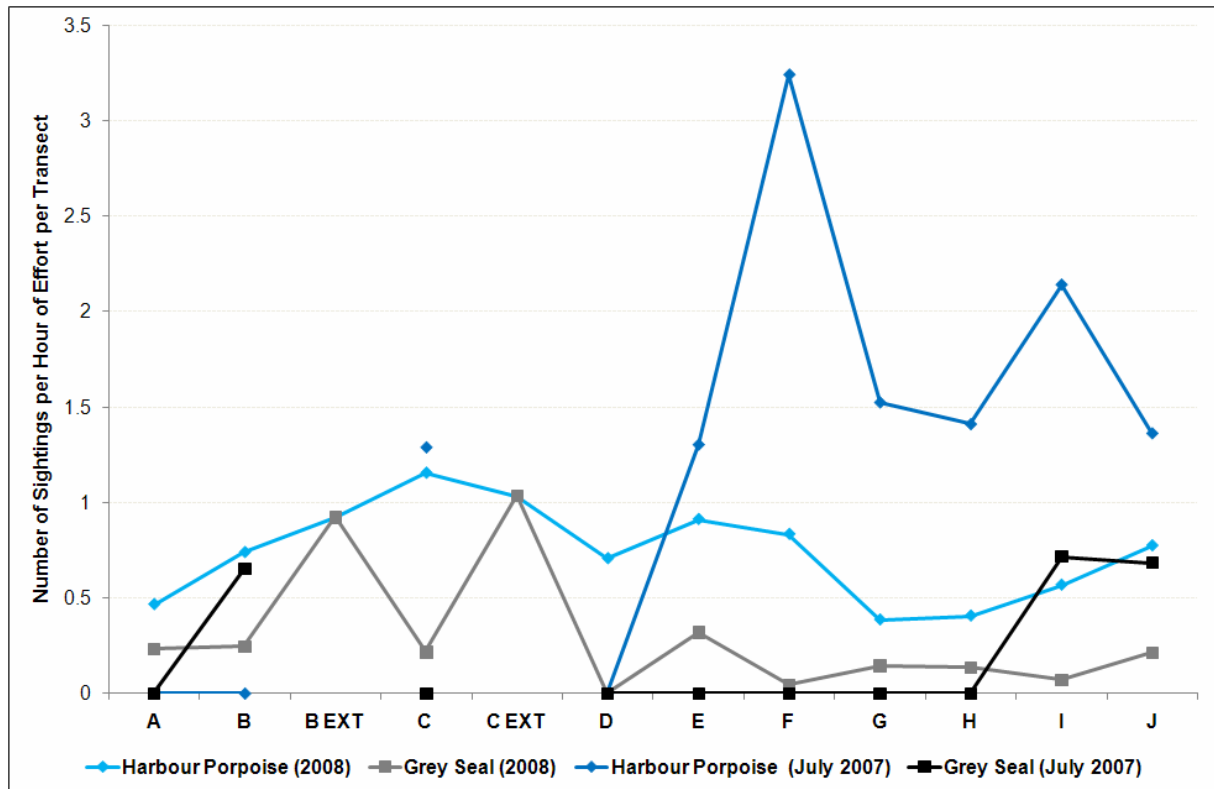
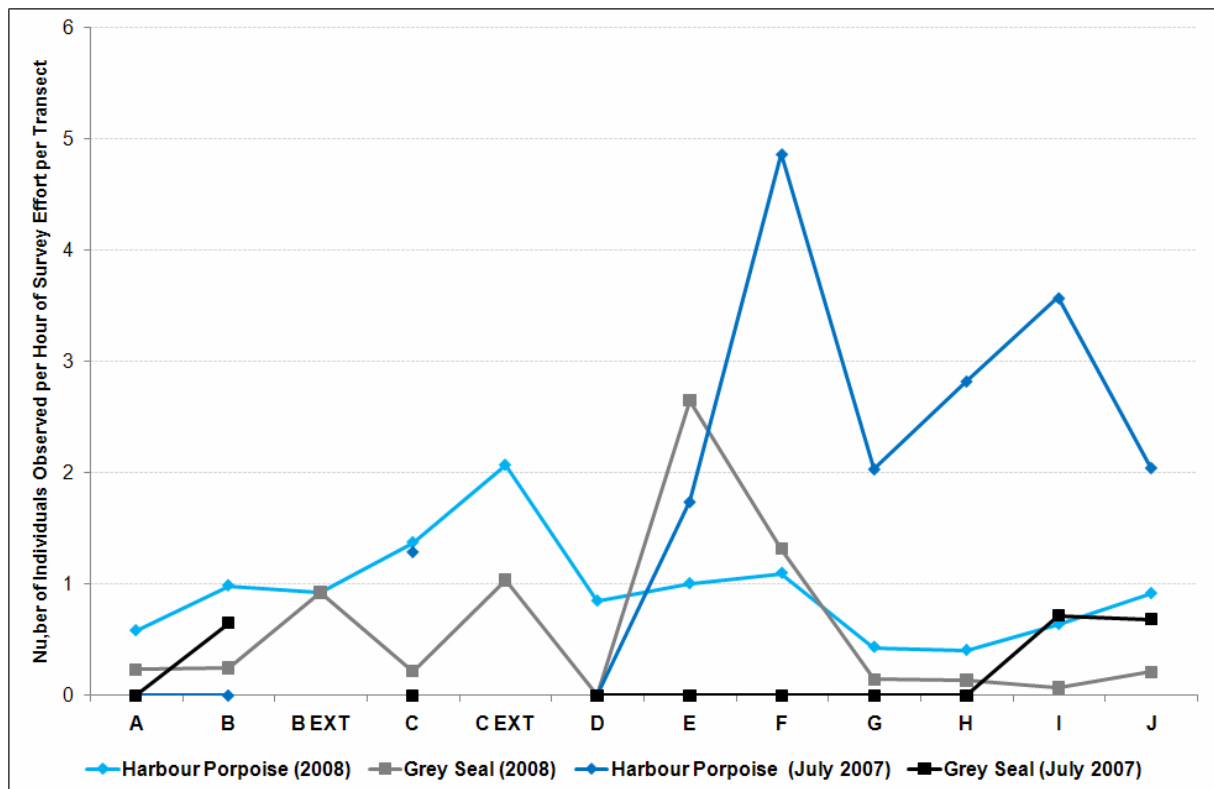


Figure 6: Number of Harbour Porpoise and Grey Seal Sightings per Hour of Survey Effort per Transect Surveyed



**Figure 7: Minimum Number of Harbour Porpoise and Grey Seal recorded per Hour of Survey Effort per Transect****3.1.2 Construction period (December 2007 – December 2008) surveys****3.1.2.1 Overview of data**

Thirty six vessel-based survey days were completed between 1<sup>st</sup> January and 30<sup>th</sup> December 2008 comprising a total of 172 hours 4 minutes of survey effort. June received the greatest survey effort with 21 hours 48 minutes over 4 survey days; 12.7% of the total 2008 effort (Table 3) whereas January was the least surveyed month (3 hours 35 minutes over 1 survey day; 2% of total survey time). The remaining months were surveyed for between approximately 12 and 17 hours each over three to four survey days.

**Table 3: Total survey effort per month for the 2008 construction period surveys**

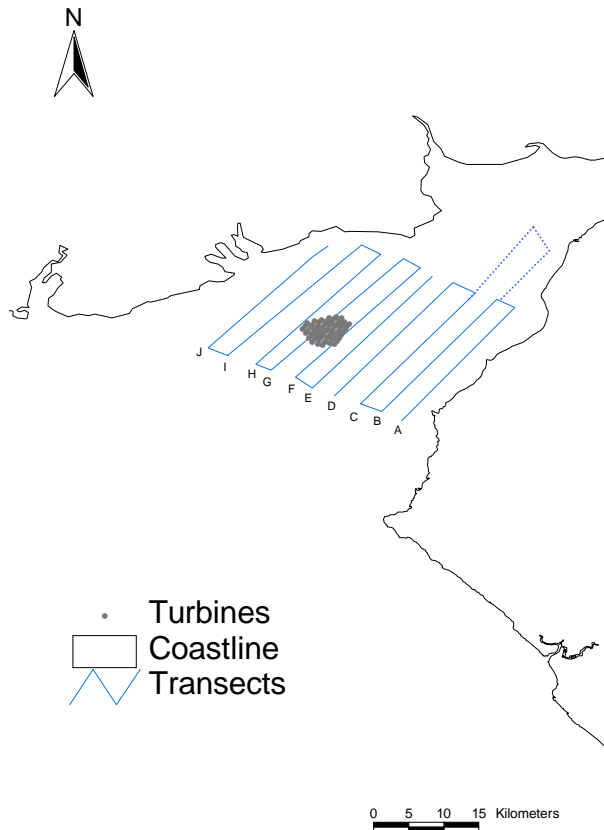
Month	Total Transect Survey Time (Hours:Minutes)	Number of Survey Days	Percentage (%) Survey Transect Effort per Month
January	03:35	1	2.08
February	15:16	3	8.87
March	13:52	3	8.06
April	14:34	3	8.47
May	16:42	3	9.71
June	21:48	4	12.67
July	16:51	4	9.79
August	15:40	3	9.10
September	11:59	3	6.96
October	14:04	3	8.18
November	14:36	3	8.49
December	13:07	3	7.62
<b>Total</b>	<b>172 hours 4 Minutes</b>	<b>36</b>	<b>100</b>

Conditions during each survey and total number of marine mammal sightings are presented in Table 4. Just over half of the surveys (51%) were conducted during Beaufort sea states of 0 – 3; the remaining surveys were conducted in Beaufort sea states 4 – 6 inclusive which are unfavourable conditions for marine mammal observation work. However, the majority of surveys (87%) were undertaken when there was a 'light' swell (0-1m swell height) with only 13% surveys conducted during 'moderate' swell height of 1 – 2m.

**Table 4: Number of sightings and number of individuals estimated per sighting for harbour porpoise and grey seal during 2007 pre-construction and 2008 construction period surveys. (Number) denotes the maximum best estimate was recorded.**

Survey Date	Survey Conditions: Swell (Beaufort Sea State)	Number of Harbour Porpoise Sightings	Number of Harbour Porpoise	Number of Grey Seal Sightings	Number of Grey Seals
15/07/2007	Light (0-1)	13	21 (24)	2	2
16/07/2007	Light (4)	1	1	0	0
23/07/2007	Light (1-3)	5	6	1	1
06/02/2008	Light (1-3)	1	1	0	0
16/03/2008	Light (4-5)	2	2	0	0
26/03/2008	Light (0-1)	10	12	0	0
27/03/2008	Light (3)	2	2	1	1
04/04/2008	Light (3)	0	0	1	1
14/04/2008	Light (1)	14	14 (15)	4	8 (13)
21/04/2008	Light (4)	4	4 (5)	0	0
06/05/2008	Light (2)	7	8 (9)	1	1
08/05/2008	Light (2-4)	5	5 (6)	0	0
14/05/2008	Light (4)	3	4	0	0
02/06/2008	Light (0-1)	14	19 (24)	3	3
04/06/2008	Light (4)	3	4 (5)	0	0
11/06/2008	Light (4)	1	2 (4)	1	8
24/06/2008	Light (2)	4	5	2	21 (26)
03/07/2008	Light (2)	4	5 (6)	3	3
22/07/2008	Light (3-4)	4	5	2	2
28/07/2008	Light (4)	5	6	1	30 (40)
01/08/2008	Light (4)	1	1	0	0
04/08/2008	Light (2-4)	3	3	1	1
28/08/2008	Moderate (4)	2	2	0	0
02/09/2008	Light (3-4)	1	1	0	0
03/09/2008	Moderate (5)	1	1	0	0
08/09/2008	Light (2-3)	3	4	2	23 (26)
08/10/2008	Light (4)	3	3 (4)	0	0
13/10/2008	Moderate (4)	2	2	0	0
06/11/2008	Light (2)	10	14 (17)	5	5
12/11/2008	Light (2)	2	2	0	0
25/11/2008	Light (4)	2	3 (4)	1	1
08/12/2008	Light (2)	6	9	2	2
15/12/2008	Light (2-4)	2	3	1	1
	<b>Total</b>	<b>140</b>	<b>174 (195)</b>	<b>34</b>	<b>114 (137)</b>

Tidal and daylight constraints limit access to some of the transects, especially the extensions to transects B and C in the upper parts of the Solway, and so survey effort is not evenly spread between the transects, although efforts are made to visit all transects on each survey as far as possible. Survey effort for each transect is presented in Table 5. Transects E and F received most attention (13%) during the 2008 surveys, followed by Transect G (12%). Transects A, B, C, D, H, I and J received a comparable level of effort of between 8 and 10% of the total survey effort. The extensions to transects B and C were surveyed minimally (1%) in comparison to the other ten transects.



**Table 5: Total time (hours:minutes) and percentage (%) of survey effort per transect during the construction period marine mammal monitoring form 1st January to 30th December 2008.**

Transect	A	B	B EXT	C	C EXT	D	E	F	G	H	I	J	Total	Date
						00:35	01:15	01:00	00:45				03:35	01/01/2008
								00:40	00:50	00:40	01:53	00:37	04:40	06/02/2008
	00:58	00:48	00:00	00:38	00:00	00:22	00:50	00:48	00:37	00:30	00:26	00:45	06:42	14/02/2008
	00:45	00:30	00:22	00:30	00:21	00:41	00:45						03:54	20/02/2008
	00:53	00:47	00:00	00:34	00:00	00:22	00:50	00:54	00:36	00:22	00:27	00:34	06:19	16/03/2008
	00:56	00:25	00:16	00:50	00:07	00:40	00:48						04:02	26/03/2008
								00:54	00:52	00:30	00:30	00:45	03:31	27/03/2008
	00:47	01:02	00:00	00:22	00:21	00:39	00:42						03:53	04/04/2008
	00:47	00:49	00:00	00:36	00:00	00:25	00:48	00:53	00:52	00:24	00:32	00:34	06:40	14/04/2008
								00:46	00:50	00:52	00:45	00:48	04:01	21/04/2008
								00:45	00:52	00:40	00:37	00:42	03:36	06/05/2008
	00:52	00:47	00:00	00:44	00:00	02:44	00:41						05:48	08/05/2008
	00:47	00:50	00:00	00:29	00:00	00:25	00:41	01:00	00:58	00:59	00:35	00:34	07:18	14/05/2008
								00:50	00:50	00:50	00:33	00:43	03:46	02/06/2008
	00:51	00:51		00:50		00:35	00:48						03:55	04/06/2008
	00:40	00:43		00:30		00:20	00:55	01:59	00:54	00:22	00:28	00:30	07:21	11/06/2008
						00:05	02:04	01:10	01:32	00:35	00:31	00:49	06:46	24/06/2008
								01:00	00:50	00:49	00:45	00:40	04:04	03/07/2008
	00:53	00:44		00:45		00:36	00:48						03:46	22/07/2008
	00:53	00:47		00:32		00:25	00:47	00:55	01:00	00:40	00:26	00:31	06:56	28/07/2008
								00:55	01:10				02:05	29/07/2008
	00:53	00:50		00:48		00:38	00:47						03:56	01/08/2008
								00:58	00:50	00:49	00:45	00:40	04:02	04/08/2008
	00:52	00:56		00:38		00:25	00:45	01:03	00:56	00:50	00:36	00:41	07:42	28/08/2008
								00:47	00:50	00:50	00:41	00:50	03:58	02/09/2008
						00:15	00:43						00:58	03/09/2008
	00:49	00:50		00:42		00:37	00:44	00:51	00:56	00:24	00:31	00:39	07:03	08/09/2008
	00:46	00:46		00:37		00:31	01:44	00:00	00:57	00:22	00:31	00:31	06:45	08/10/2008
	00:50	00:47		00:50		00:34	00:45						03:46	13/10/2008
								00:45	00:55	00:49	00:27	00:37	03:33	15/10/2008
	00:50	00:40		00:45		00:34	00:43	00:53	00:54	00:23	00:30	00:35	06:47	06/11/2008
								00:55	00:50	00:51	00:38	00:35	03:49	12/11/2008
	00:52	00:45	00:15	00:45	00:04	00:36	00:43						04:00	25/11/2008
	00:36	00:44		00:35		00:25	00:39	01:00	00:43	00:23	00:29	00:32	06:06	08/12/2008
	00:42	00:53	00:12	00:50	00:05	00:40	00:44						04:06	15/12/2008
													02:55	30/12/2008
<b>Total Effort per Transect</b>	<b>17:12</b>	<b>16:14</b>	<b>01:05</b>	<b>13:50</b>	<b>00:58</b>	<b>14:09</b>	<b>21:54</b>	<b>22:46</b>	<b>20:49</b>	<b>14:49</b>	<b>14:06</b>	<b>14:12</b>	<b>172 hours 4 minutes</b>	<b>Total Effort</b>
<b>Percentage (%) Total Effort per Transect</b>	<b>10</b>	<b>9</b>	<b>1</b>	<b>8</b>	<b>1</b>	<b>8</b>	<b>13</b>	<b>13</b>	<b>12</b>	<b>9</b>	<b>8</b>	<b>8</b>	<b>100</b>	<b>Total %</b>

During the 36 survey days there were a total of 154 sightings of three identified species, namely: harbour porpoise, grey seal and bottlenose dolphin. One unidentified seal species was also recorded.

Harbour porpoise was the most frequently encountered species with 121 sightings comprising a total estimated 146 to 164 individuals. Group sizes encountered ranged from one to six individuals, with the majority of sightings (76%, 92 sightings) being of solitary animals (Table 6). Pair pairs of animals were observed, although these were not recorded as mother-calf pairs. No calves were recorded.

**Table 6: Group size of harbour porpoise encountered during January to December 2008 vessel-based marine mammal surveys. Note: Where a best estimate range was recorded, the maximum number is presented.**

Group Size	Number of Harbour Porpoise Sightings	Percentage of Harbour Porpoise Sightings
1	92	76.0
2	20	16.5
3	6	5.0
4	2	1.7
5 - 6	1	0.8

Grey seal was the second most frequently encountered species with 31 sightings comprising between 111 and 134 individuals. The majority of sightings (83.9%, 26 sightings) were of solitary animals exhibiting typical behaviour such as spyhopping (periscoping) and slow/normal swimming. One sighting recorded fast swimming behaviour (on the Transect C extension, when no piling was taking place). The remaining 16.1% of grey seal sightings were recorded as groups displaying typical resting behaviour hauled out on a sandbank (situated near transects E and D), which ranged in size from 5 to 40 animals.

One possible bottlenose dolphin was observed breaching 1000m to the port side of the survey vessel when travelling along Transect G on 2<sup>nd</sup> June 2008 (before piling had re-started after the break since January). In addition, during the monitoring of Transect A on 8<sup>th</sup> October 2008 an unidentified seal species exhibiting normal swimming behaviour was observed briefly 300m port of the vessel.

### 3.1.2.2 Harbour porpoise

There was a peak in the number of harbour porpoise sightings per hour of effort events during April (Figure 4; 1.2 harbour porpoise sighting events per hour of effort, a sighting rate similar to that of July 2007). There was a decrease in the number of sightings per hour of effort during the autumn months of August, September and October (0.4 sightings per hour of effort) followed by another peak in November (0.9 sightings per hour of effort). This pattern is reflected in the number of individuals seen (Figure 3a).

Harbour porpoise were encountered throughout the survey area, including the extensions of Transects B and C (although these were surveyed rarely; Figure 6). The highest frequency of harbour porpoise sightings occurred along Transects C, C Extension, B Extension, E and F (1.2, 1.0, 0.9, 0.9 and 0.8 sightings per hour of effort, respectively). Transects G and H yielded the least number of sightings per hour effort (0.4 sightings per hour effort). The greatest number of individual harbour porpoise per hour of effort were encountered along the extension of Transect C with 2.1 animals per hour of effort, followed by Transect C (1.4 animals per hour of effort). Between 0.4 and 1.1 animals were encountered per hour of effort across the remaining ten transects, Transects G and H yielding the least number of porpoise per hour of effort.

Harbour porpoise were widely distributed throughout the survey area but seldom seen within the consented wind farm array area in 2008 (it should be noted that animals were rarely encountered within the array area before construction commenced- further detail on the animals seen in the wind farm is provided below) (Figure 8a). The position of harbour porpoise when sighted in relation to the state of tide is important as it becomes evident that the majority of sightings (and greatest count of animals) were made on flooding tides and around high water (Table 7). During a flood tide animals tended to be inshore to the east of the wind farm construction area within the portion of Solway Firth closest to the English coast. However on high water animals were recorded inshore along both the Scottish and English coasts as well as north of the wind farm construction area (Figure 8b). Fewer sightings were recorded during ebbing tide and around low water; however it is apparent that at such tidal states the porpoises tended to be on the eastern side of the survey area, towards the English coastline.

**Table 7: Number of sightings and individual harbour porpoise in relation to state of tide at time of sighting from January to December 2008.**

Tidal State	Number of Sightings	Percentage (%)	Number of Individuals (Max)
High Water ( $\pm 1$ hour)	35	29.2	43 (49)
Ebb (2-4 hours after HW)	28	23.3	33 (36)
Low Water (5-7 hours after HW)	18	15.0	20 (21)
Flood (2-4 hours before high water)	39	32.5	49 (57)
Total	120	100	145 (163)

Note: one sighting has been omitted from this table since time of sighting was not recorded on sighting form, i.e. total of 121 sightings of at least 146 or at most 164 individuals.

Two sightings of lone harbour porpoise were recorded within the wind farm array. The first, of an animal swimming normally, occurred on 6<sup>th</sup> February 2008 at 08:39 GMT on a flooding tide. At this time, eight monopile foundations had been installed; the previous piling event having occurred 18 days earlier on 17<sup>th</sup> January. The second sighting occurred on 2<sup>nd</sup> June 2008 during an ebb tide and was of an animal swimming fast, apparently away from the survey vessel. At this time no further monopile foundations had been installed, therefore the sighting within the construction area occurred approximately 4 and a half months after the previous piling event (also on 17<sup>th</sup> January 2008) and some three weeks before piling re-started.

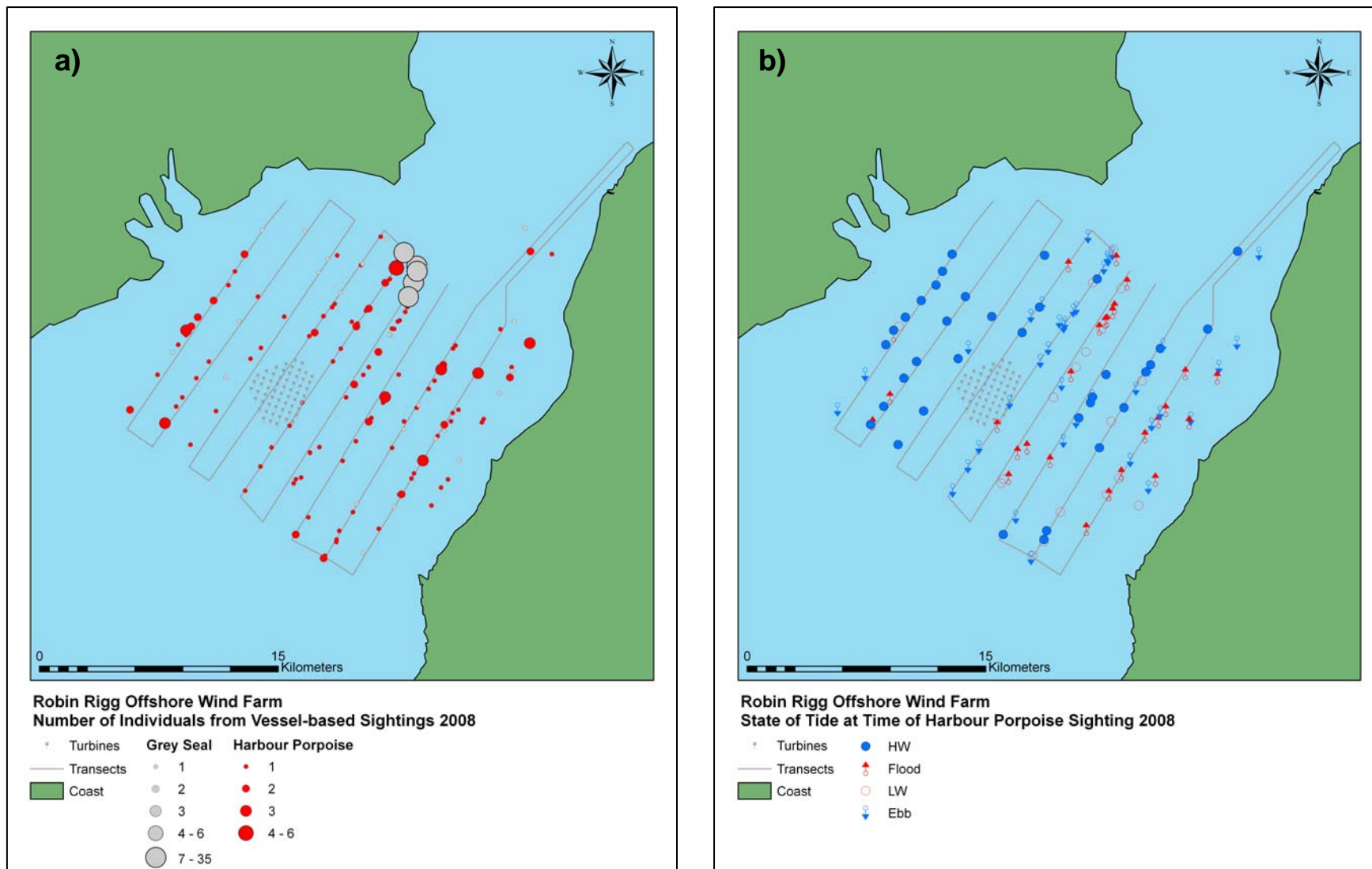


Figure 8: a) Number of individual harbour porpoise and grey seals per sighting during 2008 marine mammal surveys; b) state of tide at time of harbour porpoise sighting during 2008 marine mammal surveys.



### 3.1.2.3 Grey seal

Grey seals were encountered in all months of the year except January, February and October (Figure 4). Peaks in sightings in spring and summer (April-September) are due to the presence of large groups of between 8 and 40 seals hauled out on the exposed Allonsby/Silloth sandbanks to the north-east of the survey area (Figure 3). At other times of the year sightings tended to be of solitary animals rather than groups and were distributed away from the wind farm area.

Transect E yielded the greatest number of grey seals with 2.6 individuals per hour of effort; this peak is attributed to the exposed sandbank in the vicinity of Transect E upon which groups of grey seals were observed to haul out. Transects F and the extensions of B and C provided the next highest numbers of grey seals (1.3 to 0.9 individuals per hour of effort, respectively), despite the extensions of Transects B and C each receiving approximately 1% of the total 2008 survey effort; these latter areas may be more inclined to yield grey seal sightings than transect F since this transect received 13% of the total survey effort yet produced similar sightings rates. The remaining seven Transects yielded relatively lower numbers of grey seals per hour effort (zero to 0.2 animals per hour effort), despite each receiving between 8 and 10% of the total survey effort, considerably more effort than the extensions of Transects B and C.

## 3.2 Land Based Surveys (during-construction)

Effort-related marine mammal monitoring of five sites along the Cumbrian coast was undertaken by two MMOs across five survey days between 25<sup>th</sup> December 2007 and 4<sup>th</sup> January 2008 comprising a total of 16 hours 7 minutes of survey time.

The only daylight piling activity during this period (according to records from the Piling Contractor) was on 1<sup>st</sup> January when Pile G5 was installed between 10:25 and 11:24 (including a 38 minute soft start). Observations were made before, during and after this piling event from 08:30 until 16:15 at Silloth, Beckfoot, Mawbray and Crosscanonby.

Pile G4 was installed on the night of 2<sup>nd</sup> January and Pile H2 early in the morning of 4<sup>th</sup> January. Land based observations were made throughout daylight hours on 2<sup>nd</sup> January and then again on 4<sup>th</sup> January. The observer records from 2<sup>nd</sup> January suggest that piling took place for 18 minutes during their watch between 10:00 and 11:00 on 2<sup>nd</sup> January.

The primary observation site, Silloth, received the greatest attention (approximately 6 hours; 37% of total effort). The four remaining sites received relatively similar proportions of effort, typically between 2 and 3 hours (14 – 16% total effort) each.

Silloth, Beckfoot and Mawbray were the only sites monitored during piling works, where piling comprised 26%, 31% and 43% of the total effort, respectively. Alonby and Crosscanonby were monitored either prior to and/or post-piling events.

Overall the environmental conditions for marine mammal observations in the relatively sheltered upper estuary were good with the majority (81 %) of surveys undertaken during suitable wind conditions of a force 1 – 2 (Beaufort scale). The remaining surveys (19%) were necessarily undertaken during sub-optimal conditions of 3 – 4 (Beaufort scale). All surveys were undertaken during zero swell height but most (77%) during slight sea states. Most (65%) of the surveys occurred during periods of ‘good’ visibility, and only 8% of surveys occurred during ‘poor’ visibility.

Despite the good conditions, marine mammals were not recorded at sea during the entire survey period. One dead unidentified seal species was recorded on Mawbray beach on 25<sup>th</sup> December 2007. The animal was estimated to have been dead for at least a few days and given the extent of decomposition it was considered death certainly occurred prior to commencement of piling activity within Solway Firth.

### **3.3 Installation Vessel-based Marine Mammal Mitigation**

#### **3.3.1 Enhanced vessel-based monitoring**

Of the thirty six marine mammal survey days, seven vessel-based surveys were completed on the same day as a piling event.

The first four monopile foundations that were installed during daylight hours (highlighted in blue, Table 8) were specifically monitored by enhanced vessel-based monitoring as stipulated by condition 18 within the Disturbance License (DEROG 068A/2007). This was undertaken in order to monitor mitigation procedures and record cetacean reactions to pile driving, if observed. The survey vessel followed a selection of the transects close to and passing through the wind farm, attempting to pass close to the wind farm during piling, and an MMO on board the installation Vessel monitored the immediate area around the piling operations.

A summary of events is given below (Table 8).

**Table 8: Enhanced vessel based monitoring**

Date	Pile Location	Start Time of Vessel-Based Survey (GMT)	End Time of Vessel-Based Survey (GMT)	Start Time of Soft Start (GMT)	End Time of Piling (GMT)	Notes
01.01.2008	G5	08:10	12:30	10:25	11:24	Marine mammal survey started 2 hours 15 minutes <i>before piling</i> commenced; piling finished at 11:24 GMT just over one hour before the end of the marine mammal survey. Marine mammals were not observed by independent survey vessel before or during piling although MMO conditions were adequate, i.e. sea state, swell height and visibility predominantly between 1 and 2 (Beaufort scale), light (0-1 m) and up to 5km respectively. Similarly, MMO on installation rig undertook visual observation for 2 hours 49 minutes of which 1 hour 47 minutes occurred directly prior to soft start and marine mammals were not recorded.
24.06.2008	T1/RRW	06:50	17:15	14:23	15:20	Marine mammal survey commenced 7 hours 33 minutes <i>before piling</i> , during which there were 6 marine mammal sightings (1 of which recorded off transect) recorded prior to piling. During the 2 hours 52 minutes of piling works (including 30 minute break) monitored by the independent survey vessel marine mammals were not recorded by the MMOs. Due to mechanical issues on piling rig the marine mammal survey ended at 17:15 GMT and survey vessel returned to port. There were no dedicated marine mammal vessel-based surveys monitoring the piling events later that day, therefore no record of whether marine mammals were observed during the 1 hours 10 minute break between end of initial piling and piling re-start at 18:35 GMT, or during any other breaks in piling works for the remainder of the evening. MMO on piling rig observed between 19:05 and 19:35 GMT and reported no marine mammal sightings.
				15:50	17:25	
				18:35	19:05	
				19:50	19:55	
				20:35	21:05	
				21:25	22:20	
29.07.2008	T2/RRE	18:35	20:55	19:40	22:40	Marine mammal survey started 1 hour 5 minutes <i>before piling</i> commenced; a 1 hour 15 minute period of piling works was also monitored however due to fading light the survey ended at 20:55 GMT. Marine mammals were not observed prior to or during the observed piling works from the independent survey vessel. MMO was also undertaken onboard the installation rig between 18:30 and 22:40 GMT, marine mammals were not recorded however light levels were poor due to fading light to darkness.
28.08.2008	G8	08:06	17:02	04:55	07:04	Marine mammal survey commenced 1 hours 2 minutes <i>after initial piling</i> works had been completed over night. Therefore there are no records of marine mammal sightings during this initial period of piling works from the independent survey vessel however MMO onboard installation rig undertook visual observation for approximately 3 hours during poor light levels (04:00 - 07:04 GMT) and recorded no marine mammal sightings. Marine mammal survey started approximately one hour into the 3 hour 58 minute break in piling works and marine mammals were not observed during this period; from 10:45 GMT and 10:50 GMT vessel was enroute between transect I and J, monitoring of piling began at the north east end of transect J at 10:50 GMT until the south west end of transect J at 11:31. From 11:31 to 11:49 vessel was enroute from transect J to transect F, travelling at 17 knots with no effective monitoring taking place. Monitoring of transect F commenced at 11:49 and vessel passed installation rig 'Resolution' at 11:55, piling was completed and hammer was on deck. Marine mammals were not recorded during the 43 minutes of piling monitored following re-start at 11:02 GMT, however sea state was recorded as Beaufort scale 4 with a 'moderate' swell between 1 - 1.5 m therefore marine mammals were unlikely to have been observed during such conditions. However the independent vessel survey continued for 5 hours 17 minutes after piling ended and recorded two sightings; the first sighting (on transect) was sighted at 15:35 GMT (3 hours 50 minutes after end of piling - 1 x harbour porpoise). A second sighting (on transect) was recorded at 16:41 (4 hours 56 minutes after end of piling - 1 x harbour porpoise).
				11:02	11:45	
08.09.2008	K2	07:54	16:22	21:53	22:48	Marine mammal survey commenced approximately 14 hours <i>before</i> the start of piling works for K2. Installation rig 'Resolution' was grouting a transitional pile when survey started. The survey was 8 hours 17 minutes total duration, ending approximately 5 hours 42 minutes prior to start of piling. During which there were 5 marine mammal sightings (1 sighting off transect) recorded 13 hours 20 mins (Harbour porpoise x 1), 12 hours 43 mins (Harbour porpoise x 1), 11 hours 21 mins (Harbour porpoise x 2), 9 hours 48 mins (Grey seal, 22-25 - off transect) and 6 hours 57 mins (Grey seal x 1) prior to piling works commenced. MMO took place onboard installation rig for 1 hour 48 minutes (21:00 - 22:48 GMT) with no marine mammal sightings recorded prior to or during piling, however light levels were poor.
25.11.2008	B4	07:37	12:12	14:13	17:22	Marine mammal survey commenced 6 hours 36 minutes <i>before</i> the start of piling works. Survey continued for 4 hours 35 minutes during which there were 3 marine mammal sightings (all on transect); 3 hours 45 mins (10:28 GMT, grey seal x 1), 3 hours 27 minutes (10:46 GMT, harbour porpoise x 1), 2 hours (12:13 GMT, harbour porpoise x 2-3) prior to piling works. Independent survey vessel ended survey shortly after 12:12 GMT, approximately 2 hours before piling works commenced. Visual observation by MMO onboard installation rig occurred for 1 hour 23 minutes (13:25 - 14:48 GMT) and recorded no marine mammals prior to or during piling.
08.12.2008	C5	08:53	16:18	22:30	01:31	Marine mammal survey commenced 13 hours and 37 minutes <i>before piling</i> works, for a duration of 7 hours 25 minutes during which there were 8 marine mammal sightings - 7 hours 53 minutes (grey seal x1), 7 hours 20 minutes (Harbour porpoise x 1), 7 hours 13 minutes (Harbour porpoise x 1), 7 hours (Harbour porpoise x 3), 6 hours 46 minutes (Harbour porpoise x 2), 6 hours 37 minutes (Harbour porpoise x 1), 6 hours 36 (grey seal x 1), 6 hours 25 (Harbour porpoise x 1) prior to piling works. An MMO onboard installation rig undertook 3 hours 41 minutes of visual observation and recorded no marine mammal sightings prior to or during piling works, however light levels were poor.

NB there is some ambiguity over use of GMT/BST for timings.

### **3.3.1.1 Enhanced vessel-based monitoring of monopile G5**

The enhanced vessel-based monitoring period for the first monopile installed during daylight (G5) covered a total of 4 hours 20 minutes across transects D, E, F and G (G5 situated between transect F and G) comprising a 2 hour 15 minute period prior to soft start, a 59 minute period of piling works (of which 38 minutes was the soft start procedure as full power was reached at 11:03 GMT) and a 1 hour 6 minute period post-piling. Transects D and E were monitored directly prior to soft start, monitoring of transect F commenced at the same time as soft start, and full power was reached during transect F and piling ended towards the end of monitoring transect F.

Post-piling monitoring covered transect G (passing directly next to the installation vessel).

Marine mammals were not observed before, during or post piling by the independent survey vessel in spite of favourable conditions. Similarly, the installation vessel MMO did not record marine mammals in the vicinity during a 2 hour 49 minute visual observation of which 1 hour 47 minutes occurred prior to soft start (conditions were recorded as slight sea state, low swell height (0-2m) and moderate visibility (1-5km).

### **3.3.1.2 Enhanced vessel-based monitoring of sub-station monopile T1/RRW**

The survey vessel traversed transects E, F, G, H, I and J.

The second monopile installed during daylight (T1/RRW, Sub-Station Pile, situated between transect G and F) was covered by a 10 hour and 25 minute period of marine mammal survey of which approximately 7 hours 33 minutes occurred prior to soft start. There were six sightings comprising a total of 5 harbour porpoise and between 21 and 26 grey seals) in this period of build up to piling.

In a 2 hour 52 minute period of piling works (including a 30 minute break in piling) which no marine mammals were sighted by the MMOs on the independent survey vessel or the installation vessel. Following the 30 minute break in piling, it appears that piling resumed with full power energy levels at 15:50 GMT (as written on Record of Operations form/MTH data spreadsheet. Piling was suspended again at 17:25 GMT due to a repair required to the hydraulic hammer, thus the enhanced monitoring ended at 17:15 GMT to allow MV Tiger to return to port before low water. Consequently there was no further 'enhanced' vessel-based monitoring by the independent vessel for the remaining of the piling works for T1/RRW, neither was there post-piling monitoring to record whether marine mammals returned to the vicinity following completion of piling works. However, the Record of Operations forms completed by MTH for T1/RRW indicate that after all four additional breaks in piling works, piling did recommence on all four occasions with full soft start procedure.

Two visual observation periods by the installation vessel MMO of one hour and 30 minutes (12:45 – 13:45 GMT and 19:05 – 19:35 GMT, respectively) did not record marine mammal sightings.

The six marine mammal sighting events recorded between one and four hours *before* piling commenced are detailed below:

**Table 9: Enhanced vessel-based marine mammal sighting events before piling**

Time (GMT) of Initial Sighting	Species	Minimum Number of Individuals (Maximum)	Time to Soft Start (Hours:Minutes)	Transect	Behaviour Observed
10:40	Harbour porpoise	1 (1)	03:43	E	Slow/normal swim; leisurely surfacing with no splash
10:48	Harbour porpoise	1 (1)	03:35	E	Slow/normal swim; leisurely surfacing with no splash
11:13	Grey seal	1 (1)	03:10	E	Stationary in water, spyhopping
11:22	Grey seal	20 (25)	03:01	E	Hauled out on sandbank
12:31	Harbour porpoise	2 (2)	01:52	OFF TRANSECT	Slow/normal swim; leisurely surfacing with no splash
13:20	Harbour porpoise	1 (1)	01:03	F	Slow/normal swim; leisurely surfacing with no splash

The first two animals sighted were observed on Transect E, adjacent to the wind farm and within a few kilometres of the construction vessel. The remaining animals were present well away from the wind farm array area.

All harbour porpoise observed exhibited slow/normal swimming behaviour. The first two harbour porpoise were reported travelling in the opposite direction to the survey vessel, the third harbour porpoise exhibited variable movement and the fourth harbour porpoise was travelling in a similar (westerly) direction to the survey vessel. Similarly the grey seals observed exhibited normal resting behaviour both in water and on land.

### 3.3.1.3 Enhanced vessel-based monitoring of sub-station monopile T2/RRE

Transects E and F only were covered.

Sub-Station East (T2/RRE) was the third monopile installed during daylight hours; the independent survey vessel employed enhanced monitoring of transects E and F (nearest transects to installation vessel, situated west of transect F) for a total of 2 hours 20 minutes comprising a 1 hour 5 minute period before piling commenced with the soft start procedure and a 1 hour 15 minute period of piling works, 52 minutes of which piling was at full power energy. The soft start lasted 23 minutes in duration.

Due to fading light conditions necessary for effective MMO, the enhanced vessel-based survey ceased at 20:55 GMT at the southern end of transect F. Marine mammals were not recorded prior to or during the monitored piling works by the independent survey vessel MMO. The final 1 hour 45 minute period of pile driving at full power was not monitored by the independent survey vessel and piling continued until completion at 22:40 GMT. Although light levels were poor following sunset at 21:30 GMT, the installation vessel MMO undertook observation between 18:30 and 22:40 GMT and recorded no marine mammal sightings.

### 3.3.1.4 Enhanced vessel-based monitoring of monopile G8

All transects were covered.

Vessel-based monitoring was undertaken for the final stages of piling monopile (G8) since the majority of piling works occurred during the previous night for which independent monitoring was not employed. The independent survey vessel commenced monitoring of the area 1 hour 2 minutes after the initial piling works for G8 had been completed (at 07:04 GMT), therefore monitored transects G, H and I over a period of 2 hours 56 minutes during the 3 hour 58 minute break in piling. Transects J and F (F being closest to installation vessel) were monitored during the 43 minute duration of piling (of which 23 minutes were recorded as a re-start of soft start). Piling of G8 was completed at 11:45 GMT during transect F. Transects E, D, C, B, and A were monitored for the remaining 5 hours 17 minutes representing the post-piling period of 'enhanced' vessel-based monitoring. Marine mammals were not observed by the independent survey vessel MMO prior to or during the second period of piling works; however conditions were not ideal for visual observations (sea state 4, with a moderate swell of between 1 – 1.5m).

Two sightings comprising a solitary harbour porpoise were observed during the post-piling period of monitoring (Table 10) and both exhibited regular swimming behaviour, the first swimming in an easterly direction similar to the survey vessel and the second swimming in the opposite direction to the survey vessel. Neither sighting was close to the wind farm; both sightings were made close to the English coast towards the south-western end of each transect.

**Table 10: Enhanced vessel-based marine mammal sightings post-piling**

Time (GMT) of Initial Sighting	Species	Minimum Number of Individuals (Maximum)	Time since Piling End (Hours:Minutes)	Transect	Behaviour Observed
15:35	Harbour porpoise	1 (1)	03:50	B	Slow/normal swim; leisurely surfacing with no splash
16:41	Harbour porpoise	1 (1)	04:56	A	Slow/normal swim; leisurely surfacing with no splash

### 3.3.2 Other daylight monitoring prior to piling events

A further three vessel-based surveys were undertaken on the same day as piling events (K2, B4 and C5); however the monitoring on all three occasions ceased between two and six hours prior to the initial soft start procedures.

During the pre-piling monitoring periods for K2, B4 and C5 there were 5, 3 and 8 marine mammal sighting events respectively (comprising a total of between 27 – 30 individuals, 4 – 5 individuals and 11 individuals respectively (see table below).

Table 11: Other daylight survey results

Date (Pile Location)	Time (GMT) of Initial Sighting	Species	Minimum Number of Individuals (Maximum)	Time to Soft Start (Hours:Minutes)	Transect	Behaviour Observed
08/09/2008 (K2)	08:33	Harbour porpoise	1 (1)	13:20	G	Fast swim; rapid surfacing possibly with white water around perimeter of circle - moving in diverging direction to survey vessel
	09:10	Harbour porpoise	1 (1)	12:43	H	Slow/normal swim; leisurely surfacing with no splash - moving in opposite direction to survey vessel
	10:32	Harbour porpoise	2 (2)	11:21	J	Fast swim; rapid surfacing possibly with white water around perimeter of circle - moving in same direction as survey vessel
	12:05	Grey seal	22 (25)	09:48	E	Hauled out on sandbank
	14:56	Grey seal	1 (1)	06:57	B	Stationary in water; spyhopping
25/11/2008 (B4)	10:28	Grey Seal	1 (1)	03:45	B EXT	Slow/normal swim; leisurely surfacing with no splash - moving in same direction as survey vessel
	10:46	Harbour porpoise	1 (1)	03:27	B	Slow/normal swim; leisurely surfacing with no splash - moving in opposite direction to survey vessel
	12:13	Harbour porpoise	2 (3)	02:00	A	Slow/normal swim; leisurely surfacing with no splash - moving in diverging direction to survey vessel
08/12/2008 (C5)	14:37	Grey Seal	1 (1)	07:53	C	Slow/normal swim; leisurely surfacing with no splash - moving in same direction as survey vessel
	15:10	Harbour porpoise	1 (1)	07:20	B	Logging on first sight then slow/normal swim; leisurely surfacing with no splash - moving in diverging direction to survey vessel
	15:17	Harbour porpoise	1 (1)	07:13	B	Slow/normal swim; leisurely surfacing with no splash - moving in same direction as survey vessel
	15:28	Harbour porpoise	3 (3)	07:02	B	Slow/normal swim; leisurely surfacing with no splash - moving in diverging direction to survey vessel
	15:44	Harbour porpoise	2 (2)	06:46	A	Fast swim; rapid surfacing possibly with white water around perimeter of circle - moving in same direction as survey vessel
	15:53	Harbour porpoise	1 (1)	06:37	A	Slow/normal swim; leisurely surfacing with no splash - moving in opposite direction to survey vessel
	15:54	Grey Seal	1 (1)	06:36	A	Slow/normal swim; leisurely surfacing with no splash - moving in diverging direction to survey vessel
16:05	Harbour porpoise	1 (1)	06:25	A	Slow/normal swim; leisurely surfacing with no splash - moving in opposite direction to survey vessel	

## 4. Discussion

Both the baseline (2004-2007) and during-construction surveys identified that harbour porpoise and grey seal are the most frequently observed marine mammals in the Solway Firth. These species are present year round but both surveys identified a peak in harbour porpoise sightings in spring and summer months (approximately March to July/August) and in early winter (a distinct peak in November). The summer peak in sightings/numbers is broadly consistent with other European studies which report higher numbers in nearshore waters between approximately May and September (e.g. Evans, 1998a; Northridge *et al.*, 1995). The peak in November is not consistent with these studies but supports the assessment that harbour porpoise use the Solway Firth year-round.

In the earlier pre-construction surveys (2004-06), few sightings were made on or around high water and those that were tended to be around the Scottish coastal areas. Porpoise were most likely to be encountered in close proximity to the wind farm around low water.

The results of the July 2007 pre-construction surveys were not consistent with this pattern; similar numbers of animals were recorded around high water and on ebb and flood tides. No animals were recorded close to the wind farm (or elsewhere) around low water. All harbour porpoise seen near the wind farm (but not inside the array area) were present in the three hours around high water. There was some evidence of animals present at the northern end of transects, towards the upper parts of the estuary, on flooding tides. This is consistent with previous conclusions that harbour porpoise appear to move up and down the estuary with the tide.

It has been a consistent trend throughout baseline and during-construction surveys that harbour porpoise and grey seal are seldom recorded within the wind farm array area. The fact that this area appears to be unfavoured, at least from results of daytime surveys, suggests that the risk of direct injurious effects from pile driving was relatively small, even without mitigation in place. This is discussed further below, along with consideration of a secondary concern that animals might be pushed into the upper estuary by piling activity with associated risk of stranding.

The analysis of harbour porpoise sightings in relation to tidal state suggests that during-construction surveys saw a shift from sightings clustered around the ebb and low water to sightings mainly on flood tides and high water. Most piling started around low water and ebb tides (52 out of 69 piling events up to the end of December 2008); however, sightings over the three July 2007 surveys, all before construction started, also saw most sightings around the low water/ebb period and it would therefore be unreasonable to conclude that the shift could represent avoidance of piling noise.

The survey pro forma request that adults, juveniles (75 - 100% adult size) and calves (50 – 75% adult size) are recorded. However, in the field it is difficult to differentiate age classes of harbour porpoise by size, particularly if the sighting is of a solitary individual since juveniles are more easily identifiable when observed surfacing



alongside an adult within close range of the survey vessel. It is likely that some of the solitary sightings recorded as adults were in fact juveniles. Calves will almost certainly always surface alongside an adult, and differentiation is easier due to the clear size difference and often visible neonatal folds, therefore calves would likely have been recorded if observed, at least during calm sea conditions. However, calves were not recorded during any of the surveys and this may indicate that mother-calf pairs do not utilise the areas surveyed, perhaps remaining closer inshore near the suspected calving grounds along the southern coast of the upper Solway or other areas distant from the wind farm area. However, it must be stressed that this is a tentative suggestion.

As with all distance-sampling surveys there is always the possibility that certain sightings on any particular survey date would be of the same animal(s) in different locations, therefore potentially resulting in an over-estimate of total numbers. In contrast, it is likely that some animals within the survey area were missed since only animals at the sea surface in reasonably close proximity to the survey vessel can be counted. Individuals may have moved away from the survey area with the approach of the survey vessel or a briefly surfacing of an individual could have been missed. The latter is particularly likely during adverse sea conditions, i.e. sea states exceeding Beaufort scale 2 (Evans & Hammond, 2002), high swell heights and/or poor visibility due light conditions or presence of fog. In light of this, it is acknowledged that line transect surveys typically under-estimate numbers of animals since 'missed' individuals are likely to outweigh multiple sightings of individuals.

The quality of the data is improved when surveys are undertaken during conditions when sea state does not exceed Beaufort scale 2 (Evans & Hammond, 2002), this was adhered to as often as possible; however for the 2008 surveys a high proportion of surveys (49%) were undertaken during unsuitable conditions. Therefore, numbers of harbour porpoise can be assumed to be under-estimated for these surveys.

There is no evidence of behavioural reactions to piling from observations based on the Installation Vessel or independent survey vessel. Unfortunately, relatively little of the vessel based survey effort coincided with piling and it is observations over the general period of piling activity which are more informative. At a fundamental level, the fact that animals continued to be observed throughout the survey area over the period of piling, apparently engaged in normal activities, is clear evidence that there was no long term exclusion of marine mammals from the Solway Firth as a result of wind farm construction. Of further relevance are the results of underwater noise measurements by Subacoustech which concluded that animals would be at risk of physical harm from full power piling for surprisingly small distances: up to 3m for lethal effects and 40m for physical injury (Nedwell *et al.* 2009). These are very much smaller than the precautionary 500m exclusion zone and it is highly unlikely that an animal (especially harbour porpoise) would approach so close to the site of works (effectively within the footprint of the foundation installation vessel).

Land based observations were timed to coincide with the early phase of piling activities and at least one piling event (possibly two according to the land based observers) coincided directly with piling in daylight hours. The fact that no animals were seen in the upper Solway during more than 16 hours of surveyor effort suggests

that animals did not actively flee up into the Solway and it is also reassuring that searches of local beaches did not reveal any standings (other than a dead and well decomposed seal which had clearly died before the commencement of piling).

Overall, it is concluded that marine mammals are extremely unlikely to have been harmed by the wind farm construction works and any wider disturbance does not appear to have had gross effects, such as displacement from the estuary.

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## **Appendix 1**

### Survey Proforma

## **Appendix 2**

Electronic data appendix- 'Marine mammal effort and sightings raw data.xls'

## **Appendix 3**

E.on report on marine mammal mitigation

## **Appendix 4**

Underwater noise measurements during piling