Barrow Offshore Wind Farm

Post Construction Monitoring Report

First Annual Report

15 January 2008

This Post Construction Monitoring Report has been prepared by Barrow Offshore Wind Ltd. as part of the environmental monitoring of Barrow Offshore Wind Farm. This report describes the first year of post-construction environmental monitoring in 2006-2007 after construction of the wind farm. The wind farm became operational in July 2006. The report is prepared to comply with the FEPA licence conditions.

Technical surveys and studies are the basis of this Post Construction Monitoring Report. Full unedited copies of the environmental studies and findings can be found in the attached Appendices. They are available on CD only and are attached to this report.

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This report has been written by NIRAS Consulting Engineers and Planners A/S, based on reports and surveys produced by a wide team of consultants.

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1. EXECUTIVE SUMMARY

Barrow Offshore Wind Farm is located in the eastern Irish Sea near Barrow-in-Furness. The transmission cable runs into Morecambe Bay where it is connected to the National Grid transformer station in Heysham.

The construction of Barrow Offshore Wind Farm took place between March 2005 and July 2006. The wind farm became operational in July 2006.

This document describes the environmental monitoring undertaken during the post construction phase in 2006–2007. The environmental monitoring reported in this document should be seen as a continuation of the pre-construction and construction monitoring. Post-construction monitoring activities are made for a period of three years after construction and will be reported annually to the licensing authority, as described in the FEPA licence. This is the first of three post-construction monitoring reports.

The environmental monitoring did not register major or unforeseen environmental impacts during the first year of operation. The following paragraphs summarise the primary results from the monitoring programme.

Fishery: Catches from inside the wind farm were compared to external control sites. No significant differences were obtained between the two sites. The most abundant commercial species caught by otter trawl and beam trawl was dab and shrimp, respectively. Thornback ray and basking shark are electro sensitive and thus of special interest. Both species have been observed in the vicinity of the Barrow site during the surveys undertaken for the Environmental Impact Assessment. At the post construction surveys no basking sharks were detected. Concerning Thornback ray, 20 and 40 individuals were collected at the surveys in December 2006 and March 2007, respectively. They were detected both at the control site and within the wind farm area.

Benthic and Sediment Contaminants Surveys: The grain sizes across both the windfarm site and reference sites have generally increased between 2004 and 2007. Due to relatively consistent changes taking place across the whole survey area, and that some of these changes took place, before construction of the windfarm began, it would appear that they are natural fluctuations and probably influenced by the general sediment movement patterns in the Irish Sea. TOC levels have generally decreased throughout the period 2002 – 2007 across the survey area, again probably with little influence from the construction or operation of the windfarm.

There have been changes in the benthic communities present across the windfarm and its reference sites between the pre- and post-construction surveys. Similarity analysis shows that the sites from 2004 as a group are more similar to themselves than they are to any of the sites sampled in 2007. The main differences in similarity between the groups are probably the high numbers of *Ophiura* present in the post-construction survey and the more frequent occurrence of *Nephtys* and high numbers of *Amphiura* in the pre-construction survey. This result reflects the recorded changes in sediment grain size, with *Amphiura* preferring a finer sediment than *Ophiura*.

There are significant correlations between the concentrations of a number of the metals, but not between metals and the grain sizes or TOC. An analysis of the physical and chemical parameters and the communities present show that grain size and TOC influence the communities present, but no other environmental variables have a significant influence on the communities.

Operational Underwater Noise: The survey results indicate that there is a marginal increase in very low frequency noise around individual wind turbines. This increase is detectable to a range of approximately 600m. The results from measurements taken at ranges of 5 m from an operational wind turbine indicate that the underwater noise is unlikely to cause a behavioural (avoidance) response in marine fish and marine mammals in the region.

Oceanography: In all cases wakes could be traced out to a distance of at least 6–10 diameters distance downstream of each monopile (30–50 m) and often a good deal further, in the order of 100–200 m. Bubble clouds entrained in the wakes forming behind turbine monopiles are traceable over even longer distances, as far as 200 m and possibly further, although there is no evidence to suggest whether there is any flow structure associated with them or whether they simply represent surface slicks. From the flow modelling undertaken prior to construction, it was suggested that due to the separation of 500 m between each monopile, they could be considered as independent in respect of the im-

pact on the currents. On the basis of the wake surveys, it would appear that this may still be the case since no obvious structures were visible in the velocity records extending beyond 300 m from the nearest pile.

Bathymetry, Seabed Morphology and Scour: With the exception of the localised areas of scour around many of the individual turbines, seabed levels across the whole area are very similar to those surveyed during the two previous surveys. Scour surveys were made around 9 turbines in November 2006 and April 2007, respectively. Scours were detected around 7 turbines. The depths of the scours were between 1 and 6 meters. In general, by time, the scours expanded horizontally, but were partially infilled by natural sedimentation processes. Faint remnants of the inter-turbine cable installation were seen around many of the turbines.

Side Scan Sonar Surveys and Archaeology: Side Scan Sonar Surveys were undertaken within the wind farm area and along the associated cable and navigation routes.

For the cable route surveys it should be noted that the position of the cable route centre line was changed between the pre-construction and construction stages.

An archaeological assessment was made of the side scan sonar data. Only two new sites of high archaeological potential have been identified, both of which are located on the cable route. These sites are situated in areas of complex geology and may have natural origin. The exclusion zones defined in earlier studies were re-identified and have shown to be effective in protecting sites of archaeological interest. No sites of high archaeological interest were identified within the navigation route area or outside the exclusion zones within the wind farm area.

Ornithology: In the beginning of 2007 a detailed post construction bird monitoring programme was agreed with Natural England. Aerial surveys as well as boat surveys form part of the monitoring program. In addition, a shore based survey from Walney Island was performed in 2007 to study Whooper Swan or Pink-footed Goose passage. The aerial surveys in the first year of post construction monitoring showed a very similar pattern, to surveys before and during construction, in the abundance and distribution of birds in the vicinity of Barrow Offshore Wind Farm. The results indicate that the establishment of Barrow Offshore Wind Farm did not lead to significant changes in the occurrence and distribution of Common Scoter, divers or other wildfowl in the vicinity of the windfarm.

The bird surveys before, during and the first year after construction of the windfarm have not found bird populations of conservation concern significantly using the site. No collisions have been observed during any of the surveys.

The findings from the Walney Island study indicate that the Barrow Offshore Wind Farm do not constitute a barrier that prevents Whooper Swan or Pink-footed Goose from passing or moving through the site.

2. INTRODUCTION

The construction of Barrow Offshore Wind Farm began in March 2005, and the wind farm became operational in July 2006. The environmental post construction monitoring was initiated on 1 July 2006.

The wind farm is located in the eastern Irish Sea near Barrow-in-Furness. The transmission cable runs into Morecambe Bay where it is connected to the National Grid transformer station in Heysham (Figure 2.1).

This document describes the environmental monitoring undertaken during 2006–2007 to comply with the conditions of the Food and Environmental Protection Act (FEPA) 1985 (as amended), licence reference 31744/07/1 (Appendix 1), latest licence is issued to Barrow Offshore Wind Limited, July 2007.

Furthermore Barrow Offshore Wind Ltd. has received an additional FEPA licence (33069/07/1). The additional FEPA licence has been required for cable protection work on the offshore transmission cable route. The licence was issued in April 2007 and is enclosed in Appendix 2.

The post construction environmental monitoring reported in this document should be seen in continuation of the environmental impact statement, the preconstruction monitoring and the construction monitoring report /ref. 9, 10 and 11/. Monitoring activities continue post-construction and will be reported annually for three years to the licensing authority according to the supplementary condition 9.1 of the FEPA licence (Appendix 1).

As a part of the construction monitoring a survey to monitor cable burial was undertaken in autumn 2006. The survey was followed up by work to secure the protection and burial of exposed or vulnerable offshore transmission cable sections. This work was undertaken from 5 May until 7 May 2007, and Centre for Environment, Fisheries & Aquaculture Science (CEFAS) and Marine and Fisheries Agency (MFA) have been informed about the progress of the cable protection work.

The structure of this post construction monitoring report is divided into two main sections. The first section (chapter 3) provides an overview of the environmental monitoring programme agreed with the authorities. The second section (chapter 4) describes the offshore environmental monitoring.

The presentation of the monitoring results follows the same structure for each theme whenever possible. The presentation includes the conditions based on the licences and subsequent agreements with authorities, the monitoring methods, results and conclusions.

This report covers the environmental monitoring related to relevant themes according to the licence conditions for the post construction period: Fish, benthos, operational underwater noise, oceanography, seabed morphology (scours etc.) and bathymetry, side scan sonar surveys, including archaeology, and ornithology.

Concerning electromagnetic fields (EMF), Barrow Offshore Wind Ltd. has agreed that measurements will be undertaken at the site in spring 2008 as a part of the research programme carried out by COWRIE (Collaborative Offshore Wind farm research into the Environment). A summary of these results will be included in the second post construction monitoring report (November 2008).

Furthermore, the last of the planned post construction fishery surveys was undertaken in October 2007. This report has not been finalised yet and therefore it has been concluded that the result of the last survey as well as the analysis of the pre-construction and post-construction surveys will be presented in the second post-construction monitoring report in November 2008. This has been agreed with the Licence Authority.

Figure 2.1. Location of Barrow Offshore Wind Farm and export cable route to Heysham /ref. 11/.

3. ENVIRONMENTAL MONITORING SPECIFICATIONS

This section provides an overview of the environmental monitoring programme agreed with the authorities.

The licence to construct and operate the Barrow Offshore Wind Farm contained a number of conditions, many of which were environmental monitoring requirements. Since the licence was granted, the specific monitoring activities have been discussed and agreed continuously with the authorities. The most recent adjustments to the monitoring specification were contained within the document submitted to DEFRA in October 2005 (Appendix 3). A revised programme for bird monitoring has been forwarded to Natural England by Barrow Offshore Wind Ltd. in February 2007, and this has been approved by Natural England in March 2007. The bird monitoring programme will be presented in details in chapter 4.7.

Throughout chapter 4 of this document, the agreed specifications for the different monitoring types required during the construction phase are presented where relevant. For summary purposes, Figure 3.1 presents the schedule of surveys that were planned to comply with the licence consent conditions. Table 3.1 lists the licence conditions, together with the timing and any further notes.

The environmental monitoring during the first year of operation of Barrow Offshore Wind Farm (post construction monitoring) include fish, benthos, operational underwater noise, oceanography, seabed morphology (scours etc.) and bathymetry, side scan sonar surveys, including archaeology, and ornithology. Where possible, comparisons between construction monitoring and post construction monitoring are drawn.

Some changes in the monitoring programme have been made according to the planned schedule for the studies:

Ornithology: The boat surveys in 2007 have been postponed for one year. That means the three year boat survey programme will run from 2008-2010 instead of 2007-2009. The contract with the boat surveyors has been cancelled and the work will be tendered in advance of the first survey in May 2008. Natural England and Marine and Fisheries Agency have accepted the changed survey programme.

Epifauna monopile survey: The studies will be undertaken in May 2008. The second post construction monitoring report (November 2008) will encompass these results. Natural England and Marine and Fisheries Agency have accepted the changed survey programme.

Study	Licence Condition No. (FEPA*)	Pre-construction. Completed	During construction. Completed	Post-construction – 1st year of operation. Planned or completed	Notes
Suspended Solids	FEPA 9.4, Annex 1		✓		An alternative approach was agreed with Licence Authority. SSC data was collected during construction and was reported in the Construction Monitoring Report (November 2006)
Seabed Contaminants	FEPA 9.4, Annex 1	✓		✓	
Archaeology	FEPA Supp. Cond 9.22	✓	✓	✓	For the cable route surveys it should be noted that the position of the cable route centre line was changed between the pre-construction and construction stages. Therefore, localised areas of the 2005 survey may not be present, due to deviations between the proposed and as-laid cable routes.
Benthos	FEPA 9.4, Annex 1	✓		✓	
Epi-fauna, monopiles	FEPA 9.4, Annex 1			✓	Survey to be undertaken in May 2008. Results will be included in the second post-construction monitoring report (November 2008).
Fisheries	FEPA 9.6, Annex 1	✓		✓	
Oceanography	FEPA 9.4, Annex 1			✓	
Validation of numeric modelling	FEPA, Annex 1			✓	
Noise and Vibration	FEPA 9.5, Annex 1		✓	✓	Even though no noise monitoring during construction was required by the licence conditions, the COWRIE research programme collected data from the installation of monopiles.
Ornithology	FEPA 9.8, 9.9, Annex 2	✓	✓	✓	Survey programme post-construction (boat based) has been postponed to 2008. The change has been accepted by Natural England.
Seabed Morphology and Scour	FEPA Supp. Conds. 9.17-9.21			✓	
Pre- and post construction bathymetry Monitoring	FEPA Supp. Conds. 9.24	✓		✓	
Marine mammals	FEPA Supp. Cond. 9.10		✓		
Electro-Magnetic Fields	FEPA 9.4, Annex 1			✓	Post-construction monitoring is made as a part of the research programme carried out by COWRIE in spring 2008. Results will be included in the second post-construction monitoring report (November 2008).

* FEPA: Food and Environment Protection Act.

Table 3.1. Outline survey schedule for proposed studies.

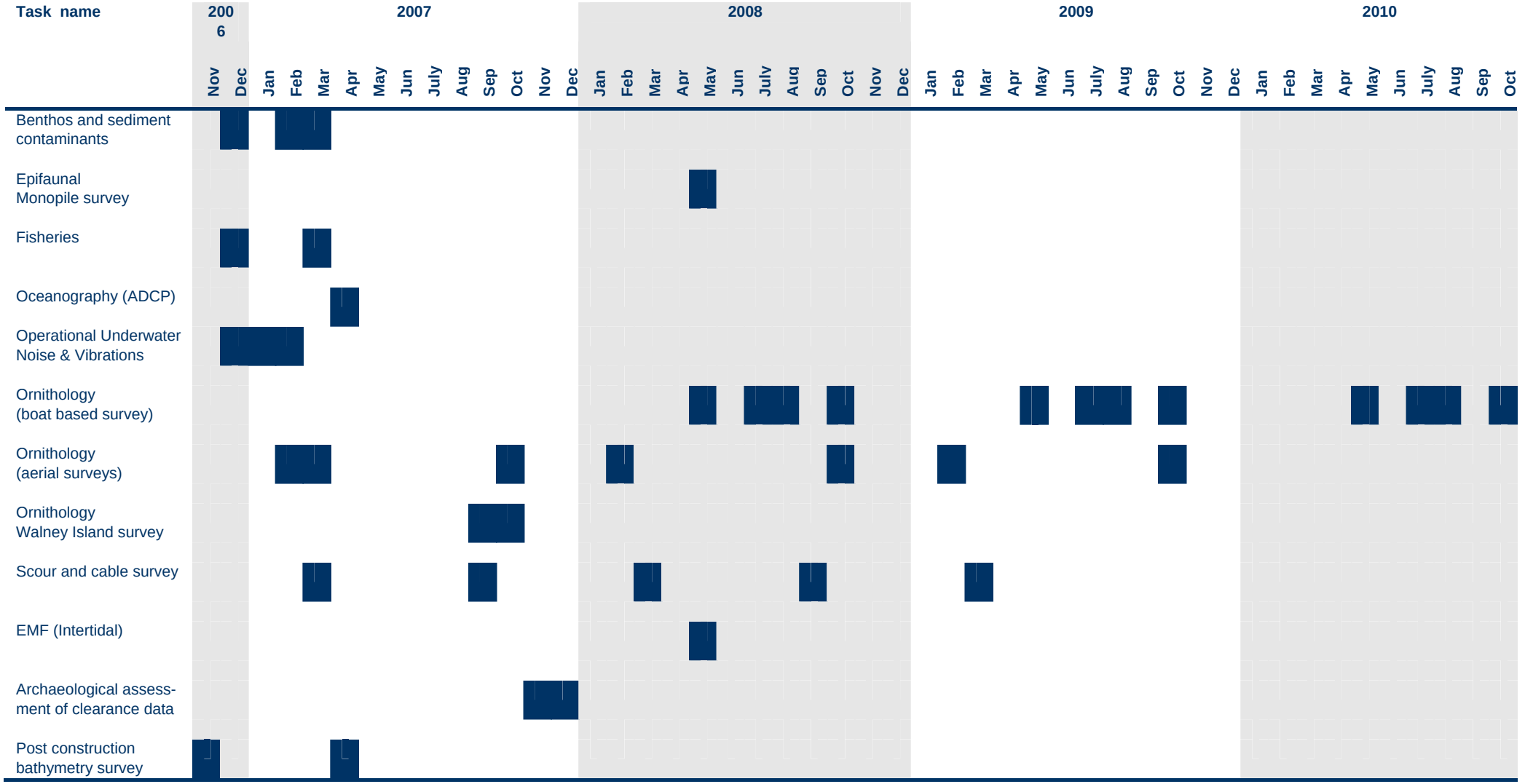

Figure 3.1. Schedule of environmental post construction monitoring for the Barrow Offshore Wind Farm

4. RESULTS, OFFSHORE MONITORING

This section provides the results from the offshore monitoring during the first year of operation of Barrow Offshore Wind Farm (post construction monitoring). The environmental monitoring in this phase includes fish, benthos, underwater noise, oceanography, seabed morphology (scours etc.) and bathymetry, side scan sonar surveys, including archaeology, and ornithology. Where possible, comparisons between pre construction monitoring and post construction monitoring are drawn.

The presentation of the monitoring results follows the same structure for each theme whenever possible. The presentation includes the conditions based on the FEPA licence and subsequent agreements with authorities, the monitoring methods and the results and conclusions.

4.1 Fisheries

4.1.1 Conditions

The FEPA Licence (Appendix 1) states in Supplementary Condition 9.6 that:

Since very little is known about the potential effect of wind farms in terms of enhancing or aggregating fish populations, the Licence Holder must produce proposals for adequate pre-construction baseline and post-construction surveys of fish populations in the area of the wind farm. The Licence Holder shall, in drawing up such proposals, canvas the views of local fishermen. The proposals must be submitted to the Licensing Authority at least one month prior to the proposed commencement of the monitoring work.

The monitoring requirements are described in appendix 1 of the FEPA Licence. The following specification is quoted from the licence:

The Environmental Impact Assessment observed electro sensitive species (e.g. Thornback Ray, Basking Shark) in Morecambe Bay and in the vicinity of the Barrow site. In the absence of any evidence that electromagnetic fields do not pose a risk to such organisms, monitoring work is required to determine the numbers and distribution of such species in the vicinity of the Barrow Offshore Wind Farm (this should include the establishment of a baseline and the use of adequate controls). The results should be presented and discussed in combination with the EMF-studies.

EMF measurements will be undertaken in spring 2008 as a part of the research programme made by COWRIE. The results from the fishery survey are therefore not yet discussed in combination with EMF. This will be presented in the second post construction monitoring report in November 2008.

4.1.2 Monitoring Methods

Titan Environmental Surveys Ltd and has undertaken the post construction fish surveys at the Barrow Offshore Wind Farm. Two post construction surveys have been undertaken in December 2006 and March 2007, respectively /ref. 1 and 2/. The final post construction fishery survey was undertaken in October 2007. The results from this survey will be reported in the second post construction monitoring report with a comparative analysis of the pre and post construction fishery surveys.

At each survey two methods were used. Otter trawling was used to survey adult commercial species, while beam trawling was used to survey juvenile fish and invertebrates. Catches from inside the wind farm were compared to external control sites. The demersal trawl used for the sampling was a multipurpose trawl with an 80mm (stretched) knotted diamond cod end.

Otter trawling

Sampling was undertaken over consecutive days; 19th-21st December 2006 and 21st-22nd March 2007. Figures 4.2 shows the otter trawl towing tracks for the spring survey. Sampling is undertaken inside the wind farm area and at external control site. From the otter trawling the catch rates and species distributions are detected. Further the landing size was measured, sex ratios determined and the principal commercial species were analyzed for spawning conditions.

Beam trawling

The beam trawling was executed 21st December 2006 and 14th March 2007. From the beam trawl species distribution and length distribution by species have been analyzed.

4.1.3 Results and conclusions

Otter Trawling

At the winter survey the otter trawls collected a total of 22 different species and a total number of 2619 individuals. The principle species caught in the wind farm site through otter trawls are Dab, Lesser Spotted Dogfish, Plaice, Whiting and Thornback Ray. The principle species caught in the control sites otter trawls were the same as the wind farm but included also Red Gurnard, Poor Cod and Dragonet. The most abundant species caught in the otter trawls was Dab (Limanda limanda) comprising 71% of the total catch (76% in the wind farm area and 68.3% within the control sites).

Figure 4.1. The Vessel 'Kiroan' /ref. 2/

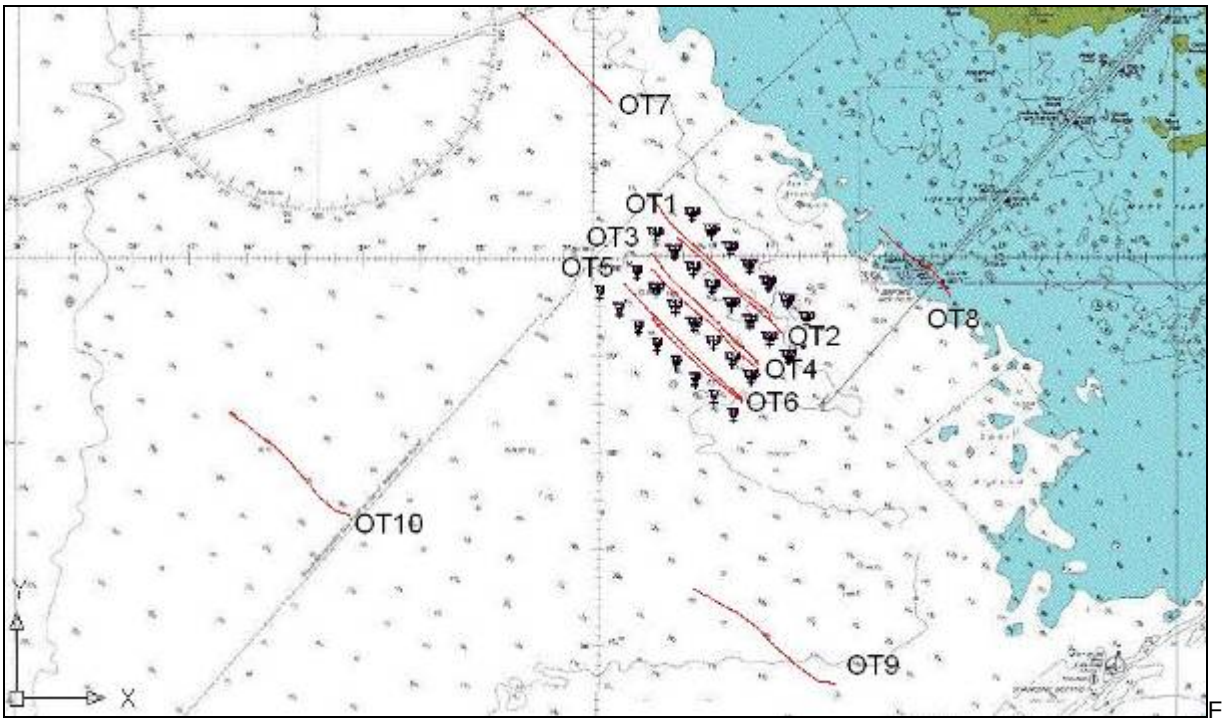

Figure 4.2. Otter trawl towing tracks, Spring 2007 /ref. 2/.

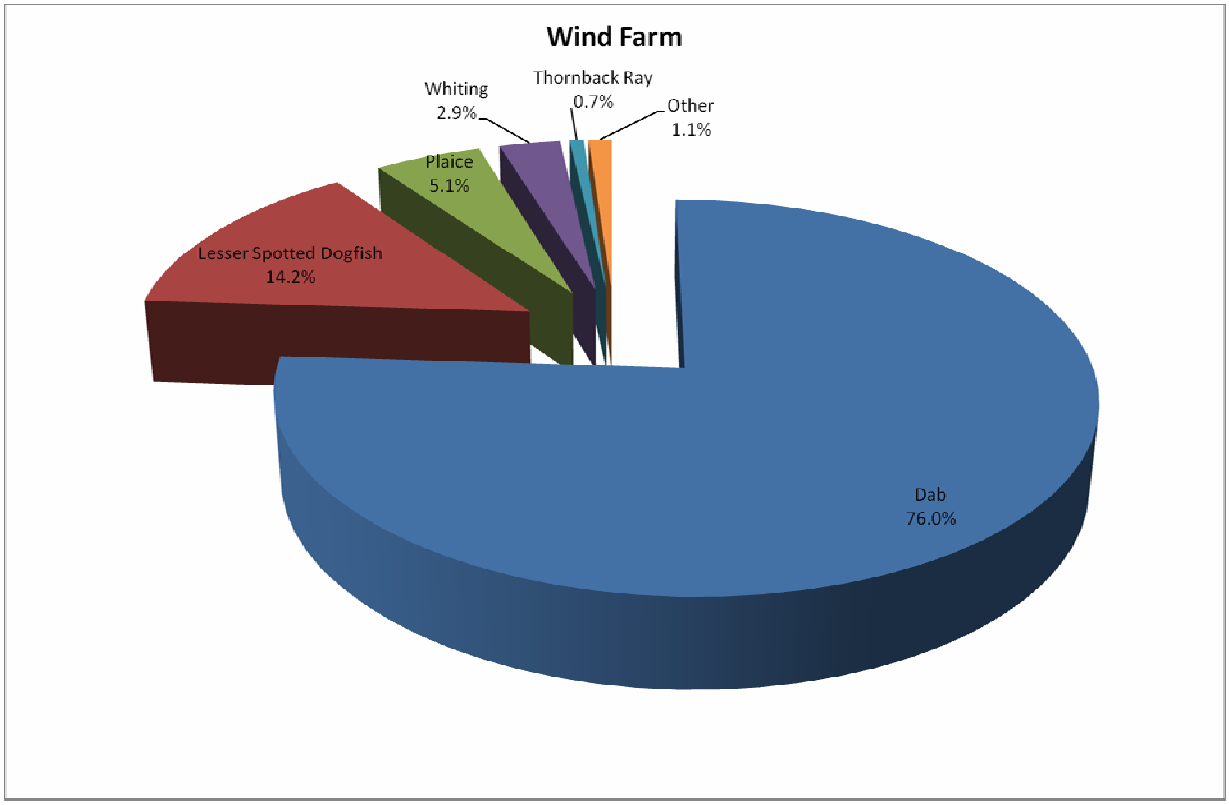

Figure 4.3. Percentage Distribution of species caught within the wind farm site in December 2006 /ref. 1/

During the survey in March the otter trawls collected a total of 19 different species (18 fish species and lobster) and a total number of 844 individuals. The principal species caught in the wind farm site by otter trawl were Plaice, Dab, Lesser Spotted Dogfish, Thornback Ray and Bull-rout. Principal species caught in control sites by otter trawl were the same as the wind farm, although significantly less Dab were caught (half the number caught per hour at control sites compared with wind farm sites). The most abundant species caught in otter trawls was Plaice comprising 43% of the total catch. Dab was comprising 30% of the total catch (36.2% in the wind farm area and 18.5% within the control sites). Table 4.1 shows otter trawl catch rates and total individuals caught during the spring survey.

Species		Individuals per Hour		Number of Individuals Caught		
Common Name	**Scientific Name**	**Wind Farm**	**Control**	**Wind Farm**	**Control**	**Total**
Plaice	*Pleuronectes platessa*	72.1	86.2	220	145	365
Dab	*Limanda limanda*	65.6	32.1	200	54	254
Lesser Spotted Dogfish	*Scyliorhinus canicula*	11.8	14.9	36	25	61
Thornback Ray	*Raja clavata*	5.9	13.1	18	22	40
Bull-Rout	*Myoxocephalus scorpius*	7.5	4.8	23	8	31
Whiting	*Merlangius merlangus*	4.3	8.9	13	15	28
Cod	*Gadus morhua*	2.6	3.6	8	6	14
Lemon Sole	*Microstomus kitt*	3.3	1.2	10	2	12
Flounder	*Platichthys flesus*	3.0	1.2	9	2	11
Poor Cod	*Trisopterus minutus*	1.0	2.4	3	4	7
Pogge	*Agonus cataphractus*	1.6	0.6	5	1	6
Sole	*Solea solea*	0.7	2.4	2	4	6
Lobster	*Homarus gammarus*	0.7	0.0	2	0	2
Bib	*Trisopterus luscus*	0.0	1.2	0	2	2
Grey Gurnard	*Eutrigla gurnardus*	0.0	0.6	0	1	1
Dragonet	*Callionymus lyra*	0.3	0.0	1	0	1
Nurse hound	*Scyliorhinus stellaris*	0.3	0.0	1	0	1
Bass	*Dicentrarchus labrax*	0.0	0.6	0	1	1
Topknot	*Zeugopterus punctatus*	0.3	0.0	1	0	1

Table 4.1. Otter trawl catch rates and total individuals caught during the spring survey /ref. 2/.

Figure 4.4. Otter trawl – winter survey: To the left Lesser Spotted Dogfish /ref. 1/.

Thornback Ray and Basking Shark are electro sensitive species (e.g.) and has both been observed in the vicinity of the Barrow site during the Environmental Impact Assessment. At the post construction surveys, no basking sharks were detected. Concerning Thornback Ray, 20 and 40 individuals were collected at the surveys in December and March, respectively. At both surveys 55% of the catch has been in the control site, and 45% has been in the wind farm area. EMF measurements will be made in spring 2008, and the results from the fishery survey are therefore not yet discussed in combination with EMF

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Figure 4.5. Otter trawl – spring survey: Thornback Ray /ref. 2/.

There are no significant differences in the landing sizes within the wind farm area and the control site; however a higher percentage of the catch in the control area is below the minimum landing size. Both inside the wind farm area and within the control site the majority caught were female.

Beam Trawling

In December 2006 the beam trawls collected a total of 25 different species and a total number of 856 individuals. The principle species caught in the wind farm site through beam trawls are Edible Whelk, Shrimp, Brown Shrimp, Dab, Whiting, Pink Shrimp, Dover Sole and Sprat. The most abundant commercial species caught in the beam trawls was Shrimp (Crangon allmanni) comprising 17% of the total catch (starfish was the most abundant species). Dab comprised 3.4% of the total individuals caught.During the survey in March beam trawls collected a total of 22 different species (9 fish species; 11 motile and 2 sessile invertebrates) and a total number of 1199 individuals. The principal species caught in the wind farm site were Dab, Brown Shrimp, Pink Shrimp, Shrimp and Spider Crab. The most abundant species caught was the Brittlestar comprising 72% of total individuals caught. The most abundant commercial species was Dab, comprising 1.8% of the total catch.

Figure 4.6. Beam Trawl – March 2007 /ref. 2/

4.2 Benthic and Sediment Contaminant Survey

4.2.1 Conditions

The FEPA Licence (Appendix 1) states in Supplementary Condition 9.4 for benthic organisms that:

Sample locations for ongoing monitoring must be determined by factors such as precise monopile locations, locations of cables etc. Sample locations must also take full account of factors such as sensitive areas, coastal processes modelling outputs and geophysical surveys. Samples should be taken to adequately cover the extent and direction of the full tidal excursion. The number and location should be negotiated with the Licensing Authority, CEFAS and English Nature prior to surveys. Colonisation of monopiles and scour protection must be determined by diver operated video observations and analyses with some accompanying sample collection for verification and identification.

Intertidal invertebrate sampling must be undertaken at lower, mid and upper shore sampling stations along three transects running perpendicular to the shore in the area of the cable landfall.

Licence conditions further state that the post-construction surveys will be conducted at the same time each year as the pre-construction survey was carried out and immediately after the end of construction. This schedule should minimise seasonal variation in the results of the pre- and post-construction surveys.

4.2.2 Monitoring Methods

The pre-construction survey was completed in the winter of December 2004. Weather conditions and lack of available vessels at the end of 2006 and early 2007 delayed the completion of the post-construction survey, and the survey was finally completed in March 2007, still considered to be within the winter period (so that seasonal differences in benthic communities should not be an issue when comparing the 2004 and 2007 data).

The following monitoring sites were established:

- Five sites within the wind farm area representing different habitat types and up/down drift conditions
- Four sites within the near-field area of the monopile founda-

tions to determine scour effects, etc.

- Four sites at the eastern boundary of the wind farm, within the area affected by sediment transport and deposition.
- Five sites within the tidal excursion to the north, north-west, west, south-west and south of the turbine array.
- Three sites along the cable route
- Four sites nearby, but remote from the wind farm (controls). These should be outside the tidal excursion and spaced at reasonable distances round the development area.

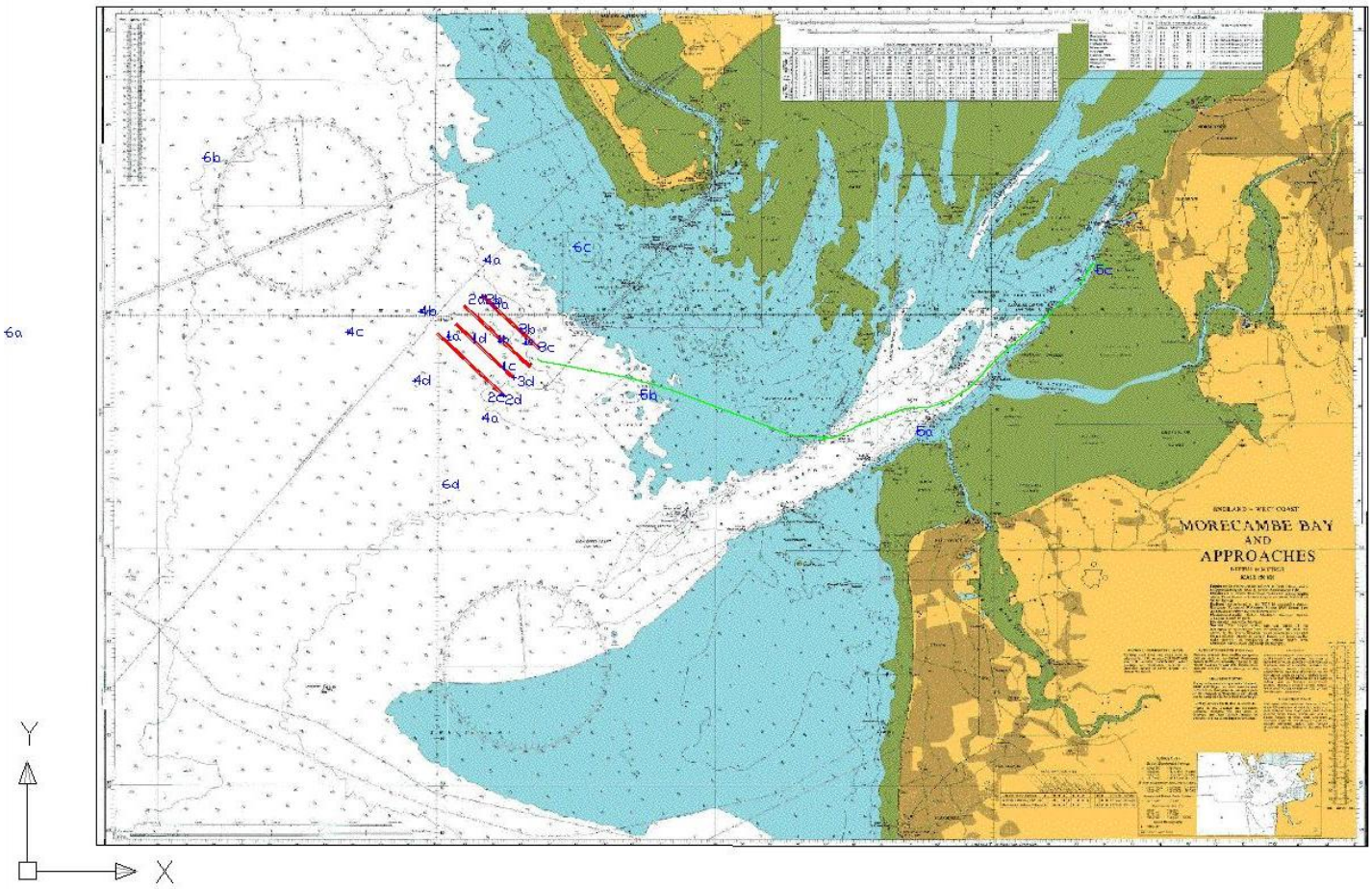

Figure 4.7. Distribution of site locations /ref. 4/.

It should be noted that the 2004 survey locations were agreed with the regulator and these locations were revisited as far as possible in 2007 so that results could be easily compared. Several of the sample positions specified in 2004 were at locations that were sampled in 2002 as part of the baseline benthic survey for the Environmental Impact Assessment. For some locations, therefore, there is a data set stretching over five years.

Due to safety and the location of inter-array cables within the wind farm area some sampling sites (three in total) were relocated in order to secure a 50 m exclusion zone from all cables.

At the selected sites samples of sediment were mostly taken as grab samples, but due to unsuitable ground conditions anchor dredge sampling were used at certain sites. The following analyses were made at selected samples/sites:

- Benthic macro-fauna
- Total Organic Carbon
- Particle Size Analysis
- Trace Metal Analysis (Pb, Cd, Zn, Cr, Cu, Ni, Al, Fe, Hg, Ba, V and Sn)

- Total Petroleum Hydrocarbon Analysis
- Gamma Spectrometry Analysis

4.2.3 Results and Conclusions

Concerning the physical data there have been changes in the grain sizes across both the wind farm site and reference sites in the period between 2002 and 2004 (pre-construction survey), and between 2004 and 2007 (post-construction survey). Due to relatively consistent changes taking place across the whole survey area, and that some of these changes took place before construction of the wind farm began, it would appear that they are natural fluctuations, and probably influenced by the general extensive sediment movement in the Irish Sea.

Station Number	2007				2004	2002
	% Fines (<63µm)	% Sand	% Gravel (>2mm)	Mean (µm)	Mean (µm)	Mean (µm)
Subtidal Sites						
1a	20.5	75.1	4.4	96	172	89
1b	5.8	70.9	23.3	410	125	215
1c	9.2	79.9	10.9	188	90	261
1d	7.6	88.1	4.3	127	192	129
1e	6.8	92.4	0.8	148	126	128
2a	6.8	91.5	1.1	151	165	
2b					177	
2c	11.3	87.8	0.9	106	224	
2d	3.7	80.7	15.3	272	376	
3a					135	
3b	3.3	96.5	0.2	158		
3c	1.4	98.2	0.4	182		
3d	15.5	64.7	19.9	293	77	
4a	2.5	97.2	0.3	152	146	
4b	26.2	73.4	0.4	83	61	92
4c	44.6	55.4	0	39	33	26
4d	15	83.9	1.1	102	65	74
4e	8	87.2	4.8	113	70	103
5a	1.8	15.9	82.3		774	1021
5b	0.1	92.7	7.2	230	106	310
5c	2.8	97.2	0	119	103	121
6a	34.1	65.9	0	53	34	
6b	61.2	38.7	0.1	28	15	
6c	0	100	0	150	116	
6d	47.7	52.3	0	39	54	
Intertidal Sites						
101	8.6	91.4	0	100	85	
102	6.2	93.8	0	101	75	
103	10.2	89.8	0	97	79	
104	5.3	94.7	0	112	104	
105	4.5	95.5	0	106	97	
106	5.4	94.6	0	103	88	
110	33.5	66.5	0	73	93	
112	14.6	85.2	0.2	102	89	

Site moved in 2007 — Site sampled by anchor dredge

Grain size analysis in 2002 and 2004 performed by wet sieving and hydrometry; in 2007, laser diffraction was used

Table 4.2. Comparison of grain size changes at various Barrow Offshore Wind Farm sampling sites, 2002–2007 /ref. 16/.

Chemical surveys consisted of measures of Total Organic Carbon (TOC), metals, Total Petroleum Hydrocarbon (TPH) and radiochemistry. TOC levels have generally decreased throughout the period 2002 – 2007 across the survey area, again probably with little influence from the construction or operation of the wind farm. Metal levels in the samples collected in the post-construction survey were all below the upper OSPAR EAC limits, though some were above the lower EAC limits. Ranges of metal concentrations for which there are provisional EAC limits set are generally similar for the Barrow pre- and post-construction surveys. The range of TPH concentrations measured in 2007 was slightly greater than that recorded from the pre-construction survey, however, all concentrations were below 30ppm, and therefore not of concern. In general, similarity comparisons across the whole site show that there have not been consistent changes in contaminant concentrations between 2004 and 2007.

Location	Cd	Cr	Cu	Hg	Ni	Pb	Zn
				mg/kg			
Barrow Wind farm 2007	<0.1	7.3–16.7	2.1–6.6	<0.05	3.9–9.4	5.6–14.2	12.9–34.5
Barrow Wind farm 2004	0.01–0.07	8.6–17.6	1.8–5.4	0.02–0.09	3.8–9.1	7.1–17.2	25.2–44.4
Barrow Wind farm 2002	0.02–0.1	6.2–25.5	1.76–7.4	0.02–0.17	3.5–11.2	6.82–20.3	30.5–55.7
OSPAR Ecotoxicological Assessment Criteria ranges							
OSPAR EAC	0.1–1.0	10–100	5–50	0.05–0.5	5–50	5–50	50–500
Other Irish Sea areas							
Cirrus Shell Flat Array 2007	<1	9.2–30.6	2.54–13.5	<0.05–0.275	4.58–15.6	10.8–37.2	20.6–81.7
Walney and West of Duddon	0.01–0.17	11.50–38.0	3.74–25.20	0.01–0.37	6.71–19.6	7.61–43.6	24.3–134.0
Ormonde Wind farm 2004	<1.00	3–42	1.2–9.4	0.008–0.22	-	2–26	6.0–79
Other British and European Sea areas							
Tyne	0.06	45	4	0.02	-	12	38
Humber	-	99	17	-	-	22	84
Wadden Sea	-	84	22	0.07	-	37	103
Norwegian Coast	0.08	-	17	0.04	-	26	110

NB: all OSPAR EAC levels are provisional

Table 4.3. Trace metals concentration ranges in samples taken from Barrow Offshore Wind farm in 2007, 2004 and 2002, and a range of other European locations.

There are significant correlations between the concentrations of a number of the metals, but not between metals and the grain sizes or TOC. The correlations between metal concentrations is not unusual, however it would have been expected that grain sizes and TOC were significantly correlated with metal concentrations.

Levels of gamma radiation from ^{137}Cs had reduced between 2004 and 2007 at all sites surveyed. Activity levels of ^{137}Cs are fairly consistent throughout the study area, and are similar to, though generally slightly lower than, levels recorded from the nearby sites.

Benthic surveys were conducted both subtidal and intertidal. The subtidal data show there have been changes in the benthic communities present across the wind farm and its reference sites between the pre and post-construction surveys. Similarity analysis shows that the sites from 2004 as a group are more similar to themselves than they are to any of the sites sampled in 2007. The main differences in similarity between the groups is probably the high numbers of Ophiura (large brittle star) present in the post-construction survey, and the more frequent occurrence of Nephtys (cat worm) and high numbers of Amphiura (brittle star) in the pre-construction survey. This result reflects the recorded changes in sediment grain size, with Amphiura preferring finer sediment than Ophiura. All groupings recorded throughout the surveys are representative of the various wider communities which have been recorded from this area of the Irish Sea /ref. 3/.

Figure 4.8. Sample showing benthic macro-fauna /ref. 4/.

The intertidal surveys show that higher numbers of species and higher numbers of individuals were recorded from the intertidal sites in the post-construction survey than were recorded in the pre-construction work. The similarity of the communities recorded in 2004 and 2007 is low, and this is probably caused by the high abundances of some species in 2007 which were not recorded frequently from the pre-construction survey.

	2007 Species	Total	2004 Species	Total
1	Pontocrates altamarinus	755	Macoma balthica	458
2	Hydrobia ulvae	550	Bathyporeia pelagica	119
3	Nucula nitidosa	511	Hydrobia juv.	73
4	Orchomene nana	114	Corophium arenarium	52
5	Aonides oxycephala	60	Nephtys cirrosa	29

Table 4.4. Most frequently occurring species in intertidal samples, 2007 and 2004.

In general the benthic and sediment surveys show differences in the physical and chemical data as well as the biological data collected in the pre- and post-construction surveys. These differences were not restricted to the sites that could have been impacted by the construction or initial operation of the wind farm, they were also present in the data from sites that were expected to be outside the influence of the wind farm and were regarded as reference locations. The fact that the results from these references sites show a change between the pre- and post-construction surveys suggests that there have been natural changes throughout the area in sediment conditions, and that the changes at

the sites within the area of possible influence are not caused by the construction or operation of the wind farm.

4.3 Operational Underwater Noise

4.3.1 Conditions

The FEPA Licence (Appendix 1) states under Supplementary Conditions – 9.5:

The Licence Holder must make provision during the construction phase of the wind-farm to install facilities to enable subsea noise and vibration from the turbines to be assessed and monitored during the operational phase of the wind-farm.

Following consultation, the above condition has been changed to the specification below:

*Mobile rather than fixed equipment can be used, but several surveys will be required to take account of seasonal variations and fluctuating wind speeds (October, December and March to coincide with the fish surveys should provide sufficient variation). Depending on the results and the results from other wind farms additional data may be required. A good assessment would be to correlate the met mast data with the noise data***.**

The monitoring requirements are stated in appendix 1 to the FEPA Licence. Paragraph 8 concerns noise and states:

Detailed post construction data must be collected on the frequency and magnitude of underwater noise produced by the Barrow Offshore Wind Farm. The choice of sites for installing monitoring equipment should reflect the different conditions such as sediment type, water depth and pile type. This data is required for a variety of purposes, including:

- *In combination with the biological aspects of the monitoring programme, the data would help to elucidate any interactions between noise generation and the provision of new habitat and fish aggregation effects on turbine support structures.*
- *Determining the effects of distance depth and background sources on noise propagation.*

4.3.2 Monitoring Methods

The underwater noise survey at the Barrow Offshore Wind Farm was undertaken on the 30th January 2007 and 1st February 2007, using a hydrophone suspended in the water from a vessel that was floating with engines switched off. Background noise were obtained on 20th December 2006 on a calm day when very few of the turbines were operational, with further measurements taken at a nominal distance of 1000m to 2000m from the closest operational wind turbine on 30th January and 1st February 2007. The surveys were undertaken by Subacoustech Ltd. The subsea operational noise measurements undertaken at the Barrow Offshore Wind Farm were part of a larger programme of work being undertaken for the Collaborative Offshore Wind farm research into the Environment (COWRIE). The procedures and equipment used for the survey were those agreed with authorities and COWRIE as part of the ongoing research programme.

During the subsea noise survey, underwater sound recordings were taken throughout the wind farm array along two drift paths. Furthermore a series of recordings were taken at increasing range from two separate operational wind turbines inside the wind farm (turbine C5 on 30th January 2007 and turbine C2 on 1st February 2007) and four from operational turbines out to approximately 2000 m following orthogonal transect lines.

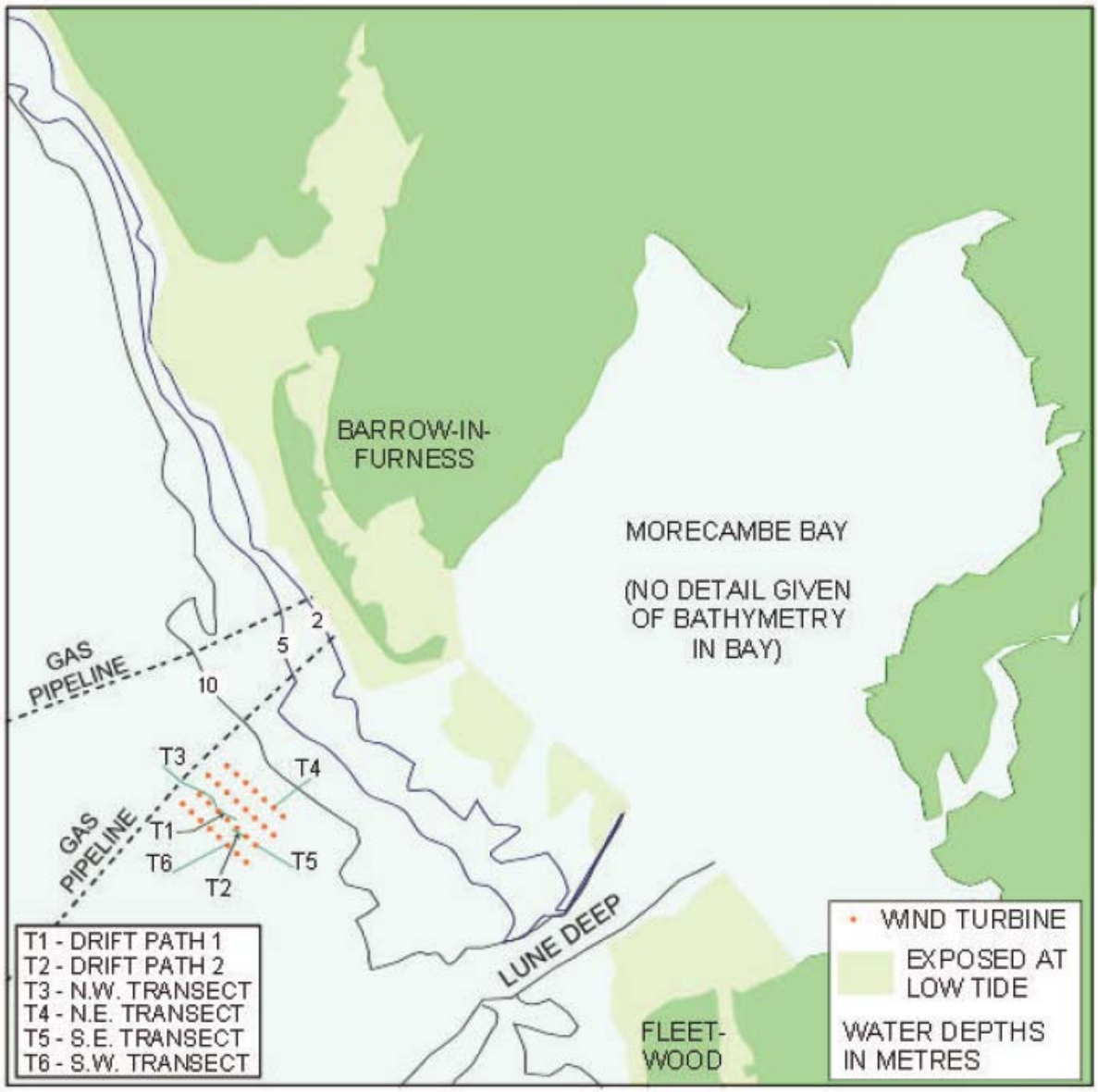

Figure 4.9. Sketch of the wind farm area, and transects lines followed during the subsea operational noise survey /ref. 5/.

4.3.3 Results and Conclusions

The results for the survey were reported by Subacoustech in report no. 753R0109 dated 7 June 2007 /ref. 5/. The report was submitted to Marine and Fisheries Agency, and after consulting CEFAS, Marine and Fisheries Agency responded on 7 September 2007 /ref. 14/. Based on these comments, Subacoustech prepared a clarification note (753R0204) /ref. 15/. All reports/notes are enclosed on the CD in the back of this report, and the results and conclusions below are based on a summary of all the reports/notes.

Along the two drift paths the overall Sound Pressure Level in and around the wind farm array varied from 112.4 to 135.3 dB re. 1 µPa (ie. RMS pressure levels from approximately 1 to 20 Pa) throughout the measurement period.

The survey results indicate that there is a marginal increase in very low frequency noise around individual wind turbines. This increase is detectable to a range of approximately 600m. Beyond this range, the underwater noise is consistent with that for the approximate ambient sea noise level in the region according to Subacoustech.

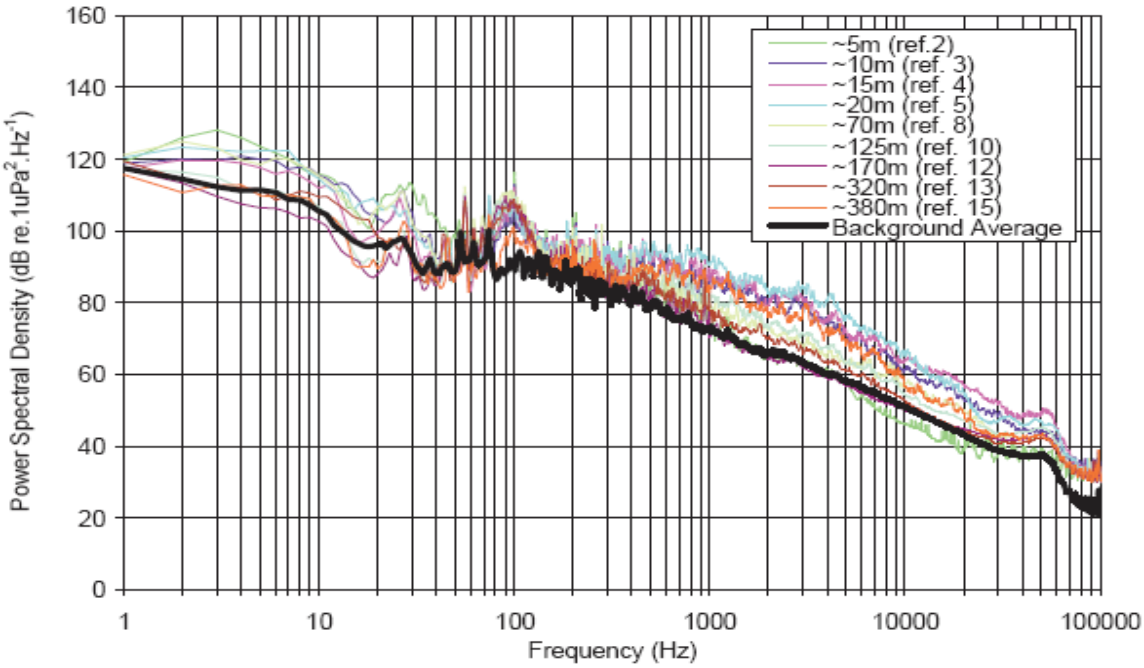

Figure 4.10. Spectral levels of underwater noise at increasing range from a single operational wind turbine (C5) on 30th January 2007 /ref. 5/.

The unweighted noise produced from the operation of BOW is of sufficiently low level that there is no likelihood of direct physical injury to marine species in the form of lethality, injury, nor hearing impairment from long term exposure. Behavioural response to the noise has been assessed by calculating the level of the sound above the hearing threshold (dBht) of marine species in the region. This provides a measure of the perceived loudness. The results from measurements taken at ranges to 5m from an operational wind turbine indicate (according to Subacoustech) that the underwater noise is unlikely to cause a behavioural (avoidance) response in marine fish and marine mammals in the region.

The mean dBht species sound levels in and around the Barrow Offshore Wind Farm site were found to be marginally higher than that measured in other nearby waters. This relatively higher noise level is within the typical variation that would be expected in shallow water regions due to weather sea state and tidal flow conditions.

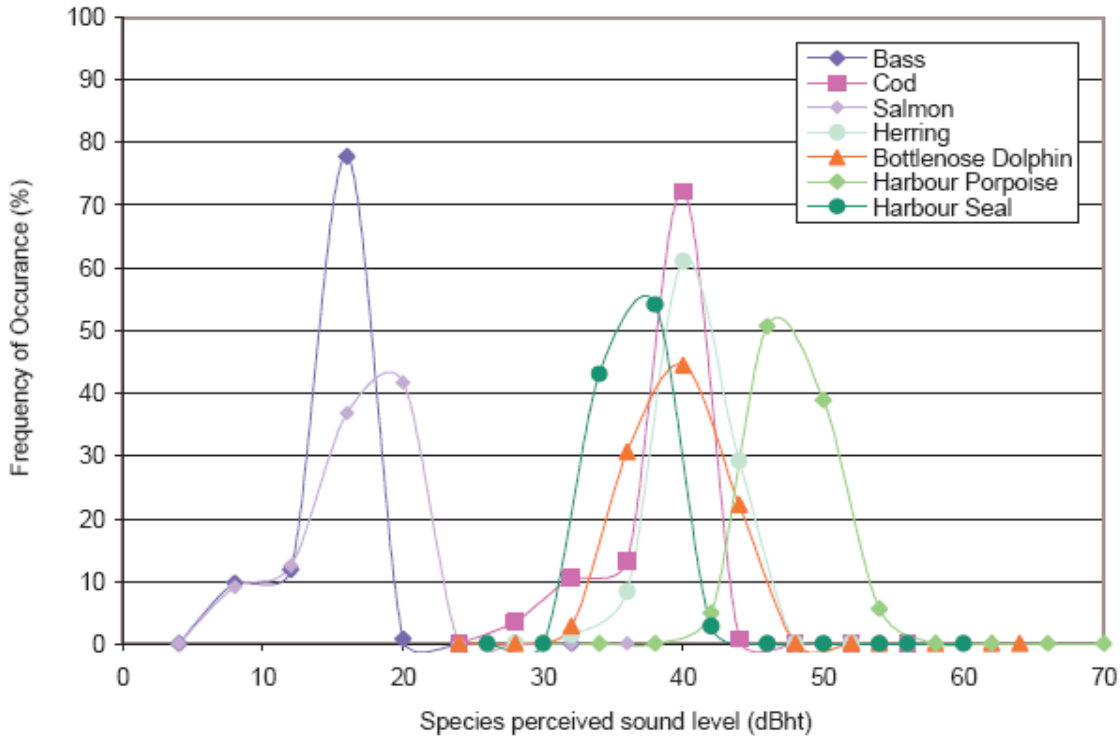

Figure 4.11. Frequency distribution of species perceived underwater sound level (dB_{ht}(Species)) in the waters around the Barrow offshore wind farm /ref. 5/.

4.4 Oceanography

4.4.1 Conditions

The monitoring requirements are stated in appendix 1 to the FEPA Licence. Paragraph 4 concerns current and states:

To monitor predictions made in the Environmental Impact Statement for the Barrow Offshore Wind Farm of a wake effect downstream of each monopole, further investigation is required.

Post construction ADCP monitoring should be undertaken taking transects through the wake region. The results should be compared to the predictions and discussed in the context of possible disruption to coastal processes. If changes in current velocity are significantly greater than predicted, then the consequences for the sediment transport regime will need to be revaluated.

Paragraph 9 states that:

All numerical model computations within the Environmental Impact Statement were completed without any wind forcing. It is suggested that the model be rerun with wind forcing from various directions and strengths. It should also be shown how the model was validated for these directions.

4.4.2 Monitoring Methods

The purpose of the survey has been to assess the extent of hydrodynamic interference imposed by the 4.7m diameter monopiles installed within the Barrow Offshore Wind Farm.

Surveys were carried out by Titan Environmental Surveys Ltd over a 13-hour period on 12th April 2007 /ref. 6/. Tidal diamond information was fundamental in the planning of the field campaign.

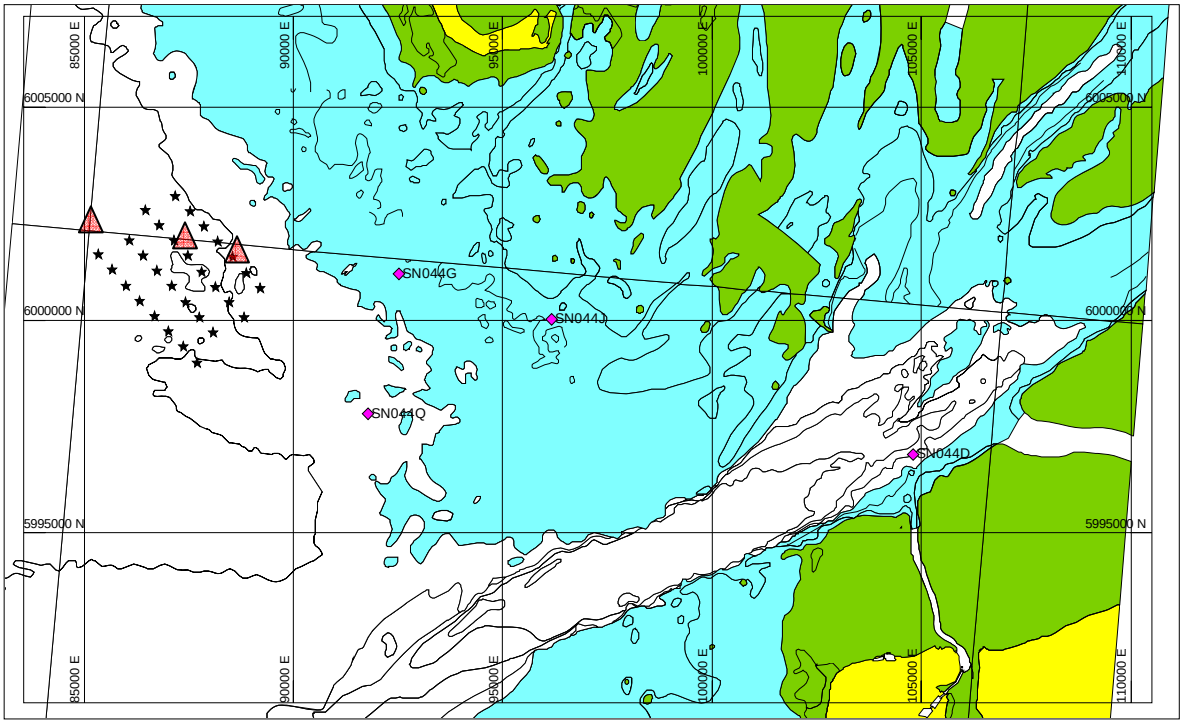

Figure 4.12. Location of Tidal Diamonds (three pink diamonds SN044G, Q, and J inshore of the wind farm). The black stars show the position for each monopole within the wind farm /ref. 6/. Wake studies were made at monopole A1, B4 and D8, marked with red triangles.

An Acoustic Doppler Current Profiler (ADCP) has been utilised to map the spatial extent, orientation and geometry of the wakes along transects, up to 400m from 3 representative turbine towers. Transects cover the whole wake zone.

The wake structure has been mapped in two ways: firstly, by the flow structure itself, i.e. detection of the flow separation zone formed behind each pile; and secondly, by mapping the bubbles entrained in the wake as it passes around the pile.

The survey is conducted during maximum tidal movement during a spring tide (anticipated to be at half tide). The survey vessel has travelled at as low a speed as possible, sufficient to maintain steerage, with the ADCP sampling rate being high enough to resolve any "wake" effects.

The ADCP data generated has then been used to validate the numerical modelling presented in the Environmental Impact Statement. During the revised modelling exercise, wind forcing has been added as a factor in the predicted current changes down current of the monopiles.

It must be borne in mind that ADCP is a new technology to investigate transient processes such as turbulent intensity and wake generation, and it is an area of active academic research; hence, analysis has been limited to qualitative interpretation of the data.

4.4.3 Results and Conclusions

The data collected show that the wake structure can be mapped by both the flow structure itself, i.e. detection of the flow separation zone formed behind each pile, as well as by mapping the bubbles entrained in the wake as it passes around the pile.

From interpretation of the data acquired, it is apparent that in all cases wakes could be traced out to a distance of at least 6–10 diameters distance downstream of each monopile (30–50m) and often a good deal further, in the order of 100–200m. Such distances for wake extent are reported to have been seen when detailed modelling of the wake generation process has been attempted and are probably therefore not unrealistic /ref. 6/.

Bubble clouds entrained in the wakes forming behind turbine monopiles are traceable over even longer distances, as far as 200m and possibly further, although there is no evidence to suggest whether there is any flow structure associated with them or whether they simply represent surface slicks.

From the flow modelling undertaken prior to construction, it was suggested that due to the separation of 500m between each monopile, they could be considered as independent of each other in re-

spect of the impact on the currents. On the basis of the wake surveys, it would appear that this may still be the case since no obvious structures were visible in the velocity records extending beyond 300m from the nearest pile.

4.5 Bathymetry, Seabed Morphology and Scour

4.5.1 Conditions

The FEPA Licence (Appendix 1) states under Supplementary Conditions – 9.17-9.21:

The Licence Holder must undertake a bathymetric survey around a sample of adjacent turbines (minimum of 4) within 3 months of completion of the construction of the wind farm (or sooner if practicable) to access changes in the bathymetry within the array. The number of turbines selected for these works should be sufficient so as to be representative of the different sediment types present at the site (e.g. cohesive, mobile etc.). The survey is to be undertaken immediately after construction is complete and repeated at 6 monthly intervals for a period of 3 years. This shall specifically address the need for (additional) scour protection around the turbine pylons. The Licence Holder must submit the data in form of a report to the Licensing Authority, including proposals for scour measures.

To ensure integrity of the wind farm infrastructure and minimise hazards to mariners this 6 monthly monitoring should also investigate the cable route to ensure that the cable remains buried (such monitoring would need to continue throughout the lifetime of the wind farm although the frequency must be reviewed in discussions with the Licensing Authority at the end of the 3 year monitoring programme). The Licensing Authority recommends that bathymetric surveys are taken of the cable route following any major storm event to ensure that the cable remains buried.

The Licence Holder must ensure that the inter array cables are buried to a depth of 1.5 metres to 2 metres and that the export cables, between the array and the shore, are buried to a depth as specified in the annex 3 to the Licence, to minimise the risk of emergence and reduce the potential effects of electromagnetic fields.

The Monitoring Requirements states for seabed morphology and scour (paragraph 2) that:

4.5.2 Monitoring Methods

The survey was made from a vessel based at Barrow during the survey period. The survey was carried out by Osiris Projects the 25th September to 3rd November 2006 and 4th April to 13th April 2007.

The primary objective of the surveys was to map seabed morphology, seabed features and bathymetry, both within the wind farm area and along the associated cable and navigation routes. Additional lines, run across the faces of the turbines, were carried out to provide detailed scour assessments.

A GeoAcoustics 'GeoSwath', high-frequency (240 kHz) interferometric swath bathymetry system was utilised to map seabed levels and morphology.

The GeoSwath is a high-resolution swath bathymetry system specifically designed for shallow water work. The unit utilises the phase comparison technique (interferometric) to provide high resolution XYZ data. The system has the capability of providing a high-density data set when compared to a beam forming system for a given water depth. A beam forming system must interpolate between data points to achieve high-resolution grids, whereas a phase measurement system can average or statistically filter many real data points within each grid cell for the same resolution grid. The end result is a grid file of the same size with a much higher degree of accuracy.

The GeoSwath system was specifically designed for use in shallow water (<150m) and under optimum conditions, enables bathymetry coverage out to approximately 10 times the water depth.

4.5.3 Results and Conclusions

Surveys were undertaken within the wind farm area and along the associated offshore transmission cable.

As a part of the monitoring programme, a survey to monitor cable burial was undertaken in autumn 2006. The survey was followed up by work to secure the protection and burial of exposed or vulnerable offshore and transmission cable sections. This work was undertaken from 5 May until 7 May 2007, and Centre for Environment, Fisheries & Aquaculture Science (CEFAS) and Marine and Fisheries Agency (MFA) has been informed about the progress of the cable protection work.

Wind farm area

With the exception of the eastern corner of the development site, much of the survey area is relatively flat, with most of the central section lying between -15.5mCD and -17.0mCD. However, localised areas of scour are present around many of the turbines.

Seabed levels across the easternmost corner of the development site are more variable, ranging from -11.5mCD, at the top of one of several small seabed mound/ridge features, to -15.0mCD moving westwards. The ridge/mound features are randomly orientated. There is a slight dip of the seabed towards the west across the whole survey area.

With the exception of the localised areas of scour around many of the individual turbines, seabed levels across the whole area are very similar to those surveyed during the two previous surveys.

Scour

The scour survey results from investigation in autumn 2006 and spring 2007 can be compared in table 4.5. The turbines included in the scour survey can be seen on figure 4.13.

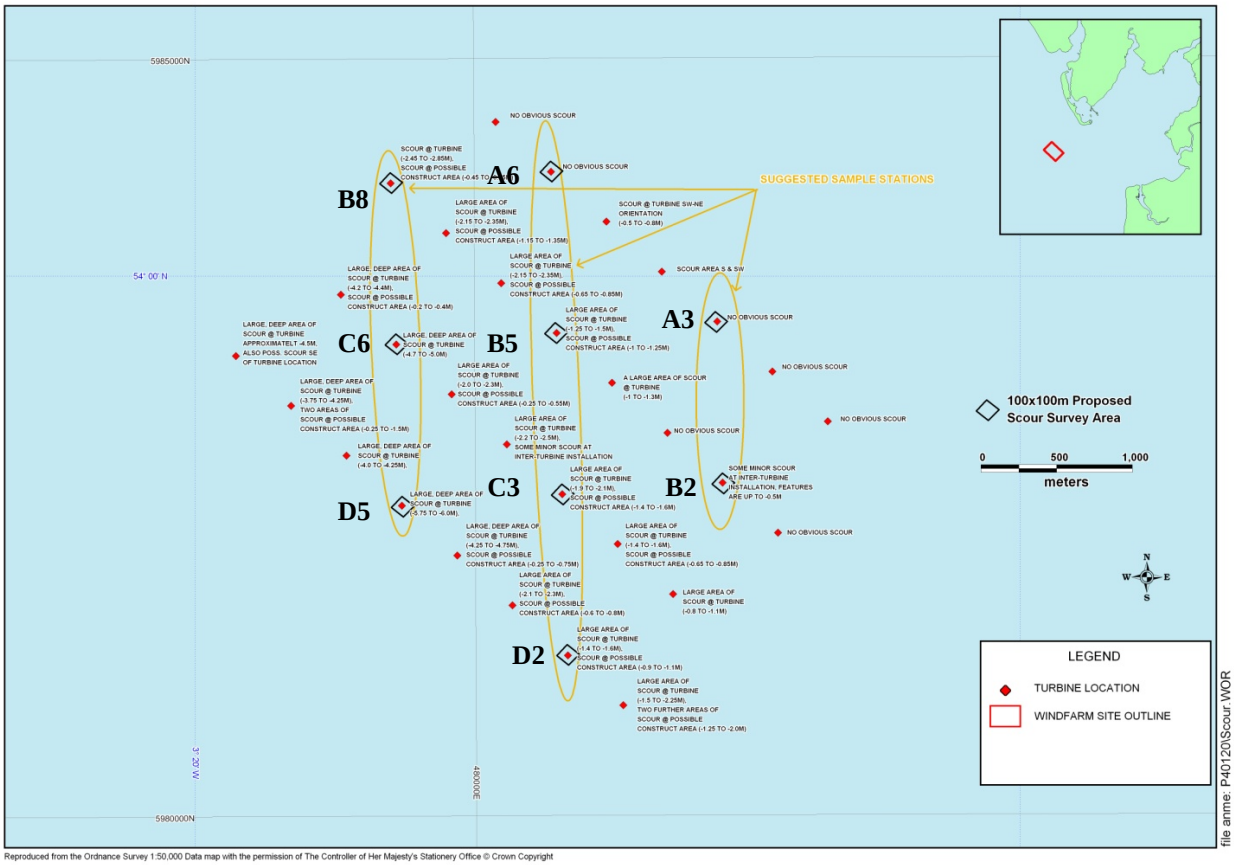

Figure 4.13. The nine turbines included in the scour survey /ref. 12/.

Turbine	Results of Scour Monitoring: September-November 2006	Results of Scour Monitoring: April 2007
A3	Natural seabed levels within the range from -12.25mCD to -13.75mCD. No obvious areas of scour are present and the remnants of the construction works can be seen as a series of faint jack-up leg depressions to the east and north west of the turbine location. These depressions appear to be almost completely in filled, indicating the high mobility of the seabed sediments. A seabed scar is also present to the SSW of the turbine location. This is believed to be a trench remnant from the inter-turbine cable installation.	Natural seabed levels within the from -12.00mCD to -13.50mCD. No obvious areas of scour are present, with only minor variations in levels that can be attributed to the natural movement of sediments across the seabed. Some fill has taken place in the remnants of the jack-up leg depressions to the east of the turbine location.
A6	Natural seabed levels range from -16.00mCD to -16.5mCD. No obvious areas of scour are present, although seabed levels fall to below -17.0mCD to the SE of the turbine location, within the remnants of	Natural seabed levels range from -16.00mCD to -16.30mCD. No obvious areas of scour are present, with only minor variations in levels that can be attributed to the natural movement of sediments

Turbine	Results of Scour Monitoring: September-November 2006	Results of Scour Monitoring: April 2007
	an inter-turbine cable trench.	across the seabed. The inter-turbine cable trench to the south east of the turbine location has been almost completely infilled by natural sedimentation processes.
B2	Natural seabed levels range from -15.0mCD to -15.8mCD. Some scouring is evident from the inter-turbine cable installation, as a series of small seabed depressions to the south east of the turbine location. These features are up to 0.5m deeper than the surrounding seabed.	Natural seabed levels range from -15.00mCD to -15.50mCD. No obvious areas of scour are present, with only minor variations in levels that can be attributed to the natural movement of sediments across the seabed. The seabed depressions related to the inter-turbine cable installation to the south east of the turbine location has been partially infilled by natural sedimentation processes.
B5	Natural seabed levels range from -15.50mCD to -15.75mCD. A large area of scour is developing around the turbine location, with seabed levels falling below -17.25mCD, within this area. A second, roughly circular area of scour is evident to the east of the turbine location, where seabed levels fall to below -17.0mCD. This may be related to seabed disturbances created by the jack-up rig during the installation of the turbine.	Natural seabed levels range from -15.50mCD to -15.75mCD. The circular area of scour to the east of the turbine location has been completely infilled by natural sedimentation processes. Similarly, the data indicates that the original area of scour is expanding, mainly from the north west to the south east, although seabed levels within the central part of the area are also becoming shallower. This may indicate that the main area of scour is gradually being infilled by natural processes.
B8	Natural seabed levels range from -15.65mCD to -16.00mCD. A large, circular area of scour is developing around the turbine location, with seabed levels falling below -18.75mCD, within this area. A second, smaller circular area of scour is evident to the ESE of the turbine location, where seabed levels fall to below -16.75mCD. As for turbines B5, B6 and B7, this may be related to seabed disturbances created by the jack-up rig during the installation of the turbine. The faint remnants of the inter-turbine cable installation can be seen to the SE of the turbine location.	Natural seabed levels range from -15.65mCD to -16.00mCD. The area of scour to the ESE of the turbine location has been completely infilled by natural sedimentation processes. Similarly, the data indicates that the original area of scour is expanding, mainly from the east to the south, although seabed levels within the central part of the area are also becoming shallower. This may indicate that the main area of scour is gradually being infilled by natural processes.
C3	Natural seabed levels range from -15.65mCD to -16.00mCD, although a small seabed mound is evident in the extreme north eastern corner of the survey box, where seabed levels rise to -14.75mCD. A large, circular area of scour is developing around the turbine location, with seabed levels falling below -18.0mCD, within this area. A broader area of scour is evident to the east of the turbine location, possibly caused by seabed disturbances created by the jack-up rig during the installation of the turbine. Seabed levels within this N-S	Natural seabed levels range from -15.70mCD to -15.90mCD. The seabed mound to the north east of the turbine location is still apparent, with seabed levels across this feature rising to approximately -14.5mCD. The area of scour around the turbine location has been partially infilled by natural sedimentation processes, particularly within the original broad area of scour to the east. However, the data also indicates that the general area of scour is expanding, although seabed levels within the central part of the area are not becoming any deeper. This may indicate that

Turbine	Results of Scour Monitoring: September-November 2006	Results of Scour Monitoring: April 2007
	orientated feature fall to -17.50mCD. The faint remnants of the inter-turbine cable installation can be seen to the N and NW of the turbine location.	the main area of scour is gradually being infilled by natural processes.
C6	Natural seabed levels range from -16.25mCD to -16.55mCD, although a seabed mound is evident approximately 40m to the north of the turbine position, where seabed levels rise to approximately -14.5mCD. A large, deep area of scour is developing around the turbine location and elongating to the south east, with seabed levels falling below -21.5mCD within this area. The faint remnants of the inter-turbine cable installation can be seen to the N and NW of the turbine location.	Natural seabed levels range from -15.65mCD to -16.00mCD. The seabed mound to the north of the turbine location is still apparent, with seabed levels across this feature rising to approximately -14.5mCD. The extended area of scour around the turbine location has been partially infilled by natural sedimentation processes. However, the data also indicates that the original area of scour is expanding, apart from the south eastern quadrant, although seabed levels within the central part of the area are becoming shallower. This may indicate that the main area of scour is gradually being infilled by natural processes.
D2	Natural seabed levels range from -15.70mCD to -15.90mCD, although a small seabed mound is evident in the extreme north eastern corner of the survey box, where seabed levels rise to -15.0mCD. A large, circular area of scour is developing around the turbine location, with seabed levels falling below -17.5mCD, within this area. A broader area of scour is evident to the E and NE of the turbine location, possibly caused by seabed disturbances created by the jack-up rig during the installation of the turbine. Seabed levels within this N-S orientated feature fall to -17.0mCD. The faint remnants of the inter-turbine cable installation can be seen to the N and NW of the turbine location.	Natural seabed levels range from -15.70mCD to -15.90mCD. The seabed mound to the north east of the turbine location is still apparent, with seabed levels across this feature rising to approximately -14.5mCD. The extended area of scour around the turbine location has been partially infilled by natural sedimentation processes, particularly within the original broad area of scour to the east and north east. However, the data also indicates that the general area of scour is expanding, although seabed levels within the central part of the area are not becoming any deeper. This may indicate that the main area of scour is gradually being infilled by natural processes.
D5	Natural seabed levels range from -16.50mCD to -16.75mCD. A large, deep area of scour is developing around the turbine location, with seabed levels falling to below -22.50mCD within this area. The faint remnants of the inter-turbine cable installation can be seen to the NW of the turbine location.	Natural seabed levels range from -15.65mCD to -16.00mCD. The data show that the remnants of the inter turbine cable installation have now disappeared. The deep area of scour around the turbine location has been partially infilled, particularly within the central section, where seabed levels have risen from -22.50mCD to approximately -20.25mCD. However, the data also indicates that the original area of scour is more extensive, although this may indicate that the main area of scour is gradually being infilled by natural processes.

Table 4.5. Results of Scour Monitoring around selected turbines. Monitoring is made in autumn 2006 and spring 2007.

In total, scour surveys was made around nine turbines (A3, A6, B2, B5, B8, C3, C6, D2 and D5).

At turbine A3 and A6, no scours were detected during the two surveys.

During the survey in November 2006 some scouring was evident from the inter-turbine cable installation at turbine B2. These features were up to 0.5m deeper than the surrounding seabed. These were infilled by natural sedimentation processes at the survey in 2007.

Around turbine B5 a scour pit with a depth of approximately 1.5-2.0m was detected in November 2006. At the survey in April 2007 the scour has expanded horizontally, but the central part of the area has becoming shallower. This may indicate that the main area of scour is gradually being infilled by natural processes.

At turbine B8 a large scour pit with a depth of approximately 2.5-3.0m was detected in November 2006. A second, smaller circular area of scour was evident to the ESE of the turbine location, with a depth of approximately 1.0m. The smaller may be related to seabed disturbances created by the jack-up rig during the installation of the turbine. At the survey in April 2007 the scour around the turbine has expanded horizontally, but the central part of the area has becoming shallower. The smaller scour has disappeared, caused infilling by natural processes. Scour monitoring details from turbine B8 in April 2007 is showed on figure 4.14

. At both turbines C3 and C6 larger scour pit were detected around the turbines with depths of 2.0-2.5m and approximately 5m, respectively. By time the general area of the scour pit has been expanding, but the depths have not increased. East of turbine C3 a broader area of scour was observed in November 2006, which by time has been partially infilled. At both turbines faint remnants of the inter-turbine cable installation have been seen.

At turbine D2 a large scour pit with the depth of approximately 2-2.5m was observed during the survey in November 2006. This area has by time become larger, but not deeper. East of the turbine a broader area of scour was seen in November 2006, but this was partially infilled at the survey in April 2007. Faint remnants of the inter-turbine cable installation were seen at both surveys.

A large scour pit with the depth of approximately 6m was observed at turbine D5. By time it has been partially infilled, and the survey in April 2007 indicate a depth of approximately 4m. Faint remnants of the inter-turbine cable installation were noticed at the survey in November 2006, but not in April 2007.

Offshore Transmission Cable Route

For the cable route surveys it should be noted that the position of the cable route centre line was changed between the pre-construction and construction stages. Therefore, localised areas of the 2005 survey may not be present, due to deviations between the proposed and as-laid cable routes.

Seabed levels at the wind farm area end of the cable route initially rise from -13.0mCD, and the seabed gradients along the first section are generally very gentle. Moving further to the east, the steep western edge of a very broad channel is encountered, and the seabed levels fall to below -22.0mCD. The deepest level on the cable route is approximately -30.0mCD. Inshore, seabed levels rise gently towards the shoreline, with 'drying' areas (above 0.0mCD).

Cable exposures were seen during the surveys, which are likely caused by natural movement of sediment across the area. Work to secure the protection and burial of exposed or vulnerable offshore and transmission cable sections was made from 5 May until 7 May 2007.

4.6 Side Scan Sonar Survey and Archaeology

4.6.1 Conditions

The FEPA Licence (Appendix 1) states under Supplementary Conditions – 9.24:

The Licence Holder must undertake a pre-construction bottom and side scan sonar survey in grid lines across the area of development (turbine array, cable route, and any vessel access routes from the local service port(s) to the construction site) following discussions with the Licensing Authority as to those parts of operation for which this is deemed necessary. Local fishermen must be invited to send representatives to be present during the survey. All obstructions found on the seabed must be plotted. A post construction survey must be undertaken along the same grid lines (within operational and safety constraints), any new obstructions must be removed on developers expense.

Concerning archaeology the FEPA Licence (Appendix 1) states under Supplementary Conditions – 9.22:

The Licence Holder shall not permit any development to commence as authorised by the Licence until a protocol has been submitted to the Licensing Authority which has been formally agreed with an Archaeologist representing the County Council adjacent to the site of works. This shall detail what action must be taken to protect any archaeological and shipwreck remains that were identified in the Environmental Statement submitted in support of the applications for consent for the works or any such artefacts which may be discovered during the course of progressing the development. Action to be taken to protect any archaeological and shipwreck remains during Geotechnical

Survey are detailed in “Jack up Positioning Procedure for Avoidance of Archaeological Sites and Seabed Obstructions, Seascore” as supplied to the department 23 February 2004.

4.6.2 Monitoring Methods

The survey was made from a vessel based at Barrow during the survey period. The survey was carried out by Osiris Projects the 25th September to 3rd November 2006 and 4th April to 13th April 2007. The survey should has been completed in autumn 2006, but had to be postponed and finalised in 2007 due to severe weather conditions.

The primary objective of the surveys was to map seabed features and anomalies, both within the wind farm area and along the associated cable and navigation routes.

To map the seabed sediments and anomalies side scan sonar surveys were made using a GeoAcoustics SS941 system was used. The system consists of a ballasted tow fish, and is capable of operating in depths of up to 1000 metres. Short, high frequency, high intensity sound bursts are beamed (perpendicular to the direction of travel) from transducers, which are mounted either side of the fish. This results in echoes, which are returned from points on the seabed up to 100 metres abeam of each transducer. Once detected by sensors within the transducers, these echoes are relayed to the transceiver unit, via the tow cable and the signals are processed, line by line, to produce a sonar image. Greater amounts of energy are reflected by harder or denser materials, than by softer seabed types, resulting in images of differing reflectivity or contrast. This enables the geophysicist to delineate areas of differing seabed sediment types, including rock outcrops and isolated contacts/targets.

Comparisons of obstructions found through pre- and post constructions are made. Any new obstructions are analysed by archaeologists. The archaeological assessment was made by Wessex Archaeology. During the assessment side scan sonar data were processed using Coda Geosurvey software. From the form, size and/or extent of the anomalies, each of the anomalies were categorized with an archaeological flag; high, medium, low or very low. High is used, when the anomalies clearly represent a wreck site or were very near to a previously known site. Medium is used for anomalies with no directly corroborating data, but being of a size, shape or amplitude such as to suggest that they possible relate to archaeological sites or features. Low and very low are used for anomalies that are likely to be natural features and of modern origin (e.g. moorings etc.).

Surveys were undertaken within the wind farm area and along the associated cable and navigation routes.

4.6.3 Results and Conclusions

In general the bedrock beneath the site is expected to comprise sandstones and mudstones of Permo-Triassic age. These rocks are overlain, in turn, by glacial deposits comprising mainly stiff clays, with sands and gravels of Pleistocene age. Finally, the glacial deposits are overlain in places by recent deposits comprising silty or clayey sands, with variable gravel content. These glacial deposits are also known to outcrop, close to the existing Cumbrian shoreline.

The geophysical data have by Wessex Archaeology been marked as “good”. This label is used for data which are clear and unaffected by weather conditions or sea state. The dataset is suitable for the interpretation of standing and partially buried metal wrecks and their character and associated debris field. These data also provide the highest chance of identifying wooden wrecks and debris.

Wind farm area

The side scan sonar data indicate that the seabed sediments over much of the eastern and north eastern sections of the wind farm area are granular till deposits comprising sands, gravels, cobbles and occasional boulders. The seabed sediments over the remainder of the site are much finer grained, probably comprising silty fine to medium sands, with frequent small ‘outcrops’ of granular till and/or patchy gravels.

From the assessment made in 2005, 8 exclusion zones were defined in the wind farm area /ref. 12/. During the post construction archaeological assessment the effectiveness of the exclusion zones is commented, and the presence of previously located marine sites is confirmed. Furthermore previously unrecorded sites are identified, located and characterised. /ref. 13/.

In the wind farm area a total of 53 side scan sonar anomalies were identified, and all 8 exclusion zones were re-identified. The exclusion zones have been effective in protecting sites of potential archaeological importance. In total 17 sites/anomalies were identified within the exclusion zones. Only one site, within one of the exclusion zones, was clearly identified as a wreck site. The remaining anomalies in the wind farm area were all interpreted as being of medium or low archaeological potential and therefore were not considered to be of significant archaeological potential. Figure 4.15 shows the identified anomalies within the wind farm area /ref. 13/

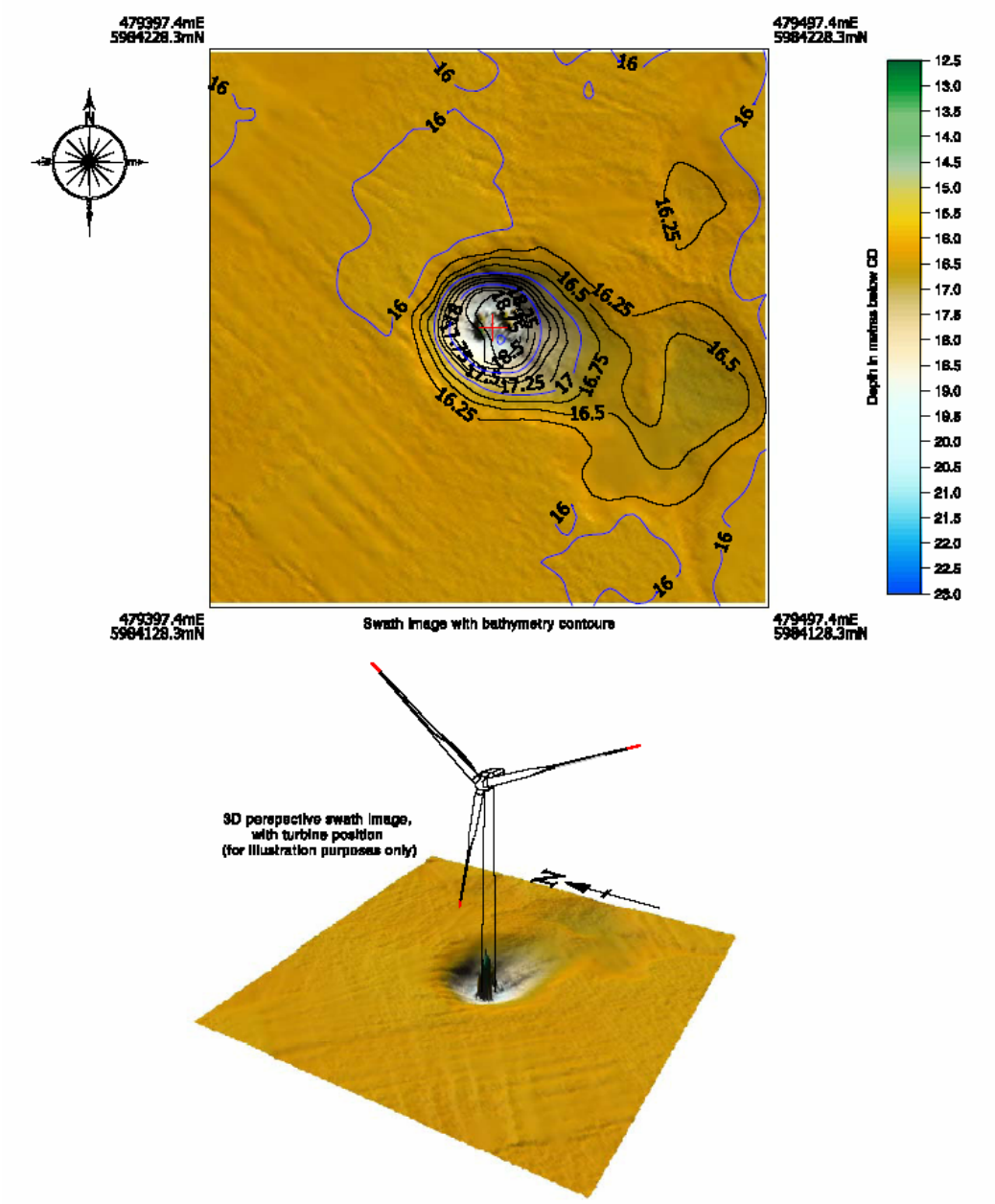

Figure 4.14.. Scour monitoring details of turbine B8 /ref. 8/.

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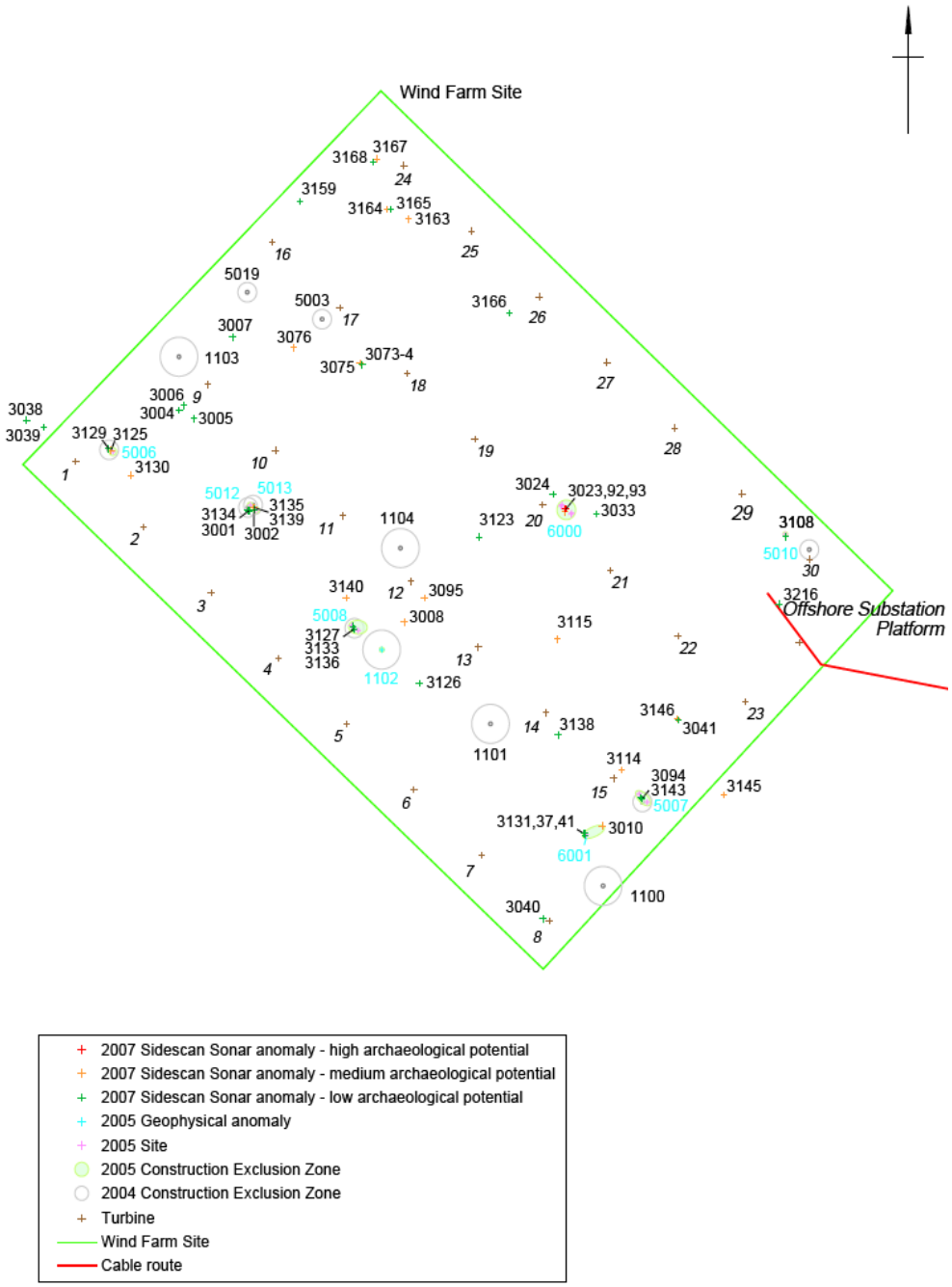


Figure 4.15. Identified site scan sonar anomalies within wind farm area /ref. 13/.

Cable Route

For the cable route surveys it should be noted that the position of the cable route centre line was changed between the pre-construction and construction stages. Therefore, localised areas of the 2005 survey may not be present, due to deviations between the proposed and as-laid cable routes.

Commencing at the wind farm area end of the cable route, the seabed sediments consist of coarsely granular glacial till deposits, comprising sands, gravels, cobbles and boulders. These deposits extend eastwards along the cable route, where till deposits become progressively covered by deposits of fine to coarse sand, with poorly defined megaripple bed forms – see figure 4.16.

These sandy sediments extend eastwards, where granular glacial till is once again evident, together with patchy, finer grained sands.

Later these finer grained sand patches are almost totally absent, leaving a much coarser grained, granular till deposit, with boulders.

Many of these boulders lie on, or very close to the route centreline.

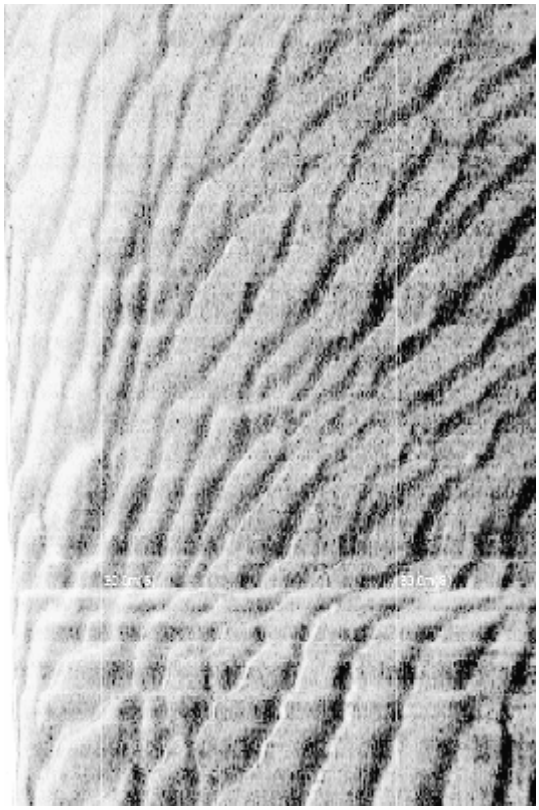


Figure 4.16. Area of megaripples on seabed /ref. 7/

A number of sonar targets and cable trench remnants were seen along the proposed cable route,

together with several sections of recently exposed cable. These

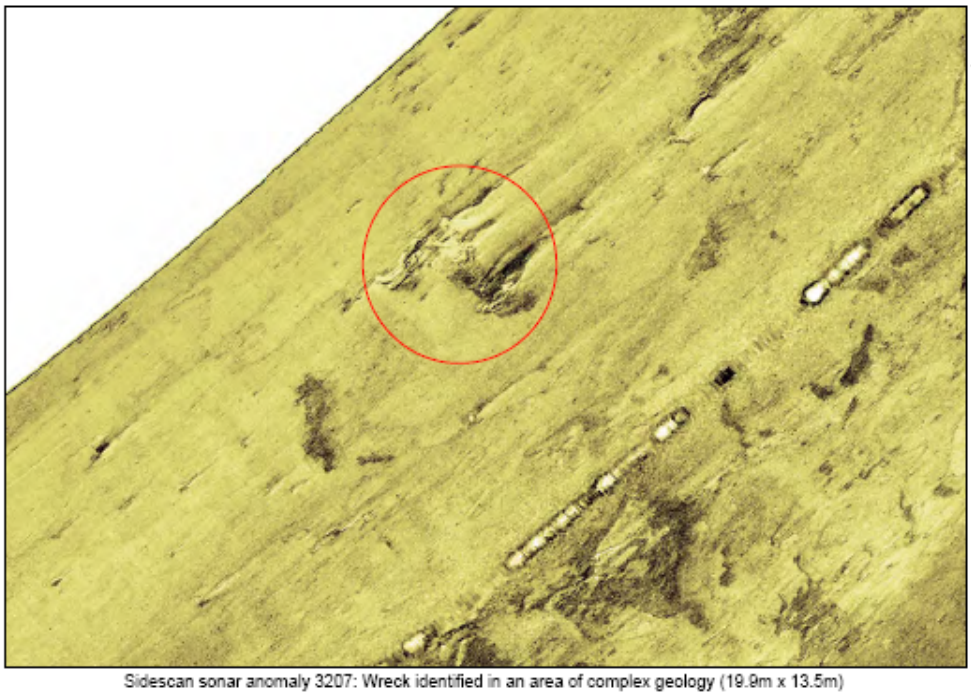
targets from the survey in 2006 are presented in table 4.6 /ref. 7/.

Contact ID	Eastings (m)	Northings (m)	Length (m)	Width (m)	Height (m)	Comments
NT36	486627	5981279	1.5	0.6	1.5	Contact on trench remnant. Likely boulder.
NT37	492091	5979409	1	0.3	0.8	Small linear contact
NT38	494593	5979470	8.4			Thin linear contact
NT39	497910	5980388	45			Linear contact:- possible chain
NT40	498004	5980621	98			Linear contact:- likely scar
NT41	498311	5980709	22			Linear contact
NT42	498523	5980623	78			Linear contact:- possible chain
NT43	498727	5980911	154			Linear contact:- likely scar
NT44	498750	5980897	110			Linear contact:- possible chain
NT45	499283	5981255	96			Linear contact:- possible chain
NT46	499944	5981732	9	7		Rough patch:- possibly natural
NT47	499896	5981886	25			Linear contact:- possible chain
NT48	500313	5982384	77			Linear contact:- possible chain
NT49	500423	5982286	68			Linear contact:- possible chain
NT50	500818	5982635	60			Linear contact:- possible chain
NT51	500854	5982827	5	1.6	1.3	Irregular shaped contact with scour and height
NT52	500934	5982890	3	1.2		Irregular shaped contact with scour

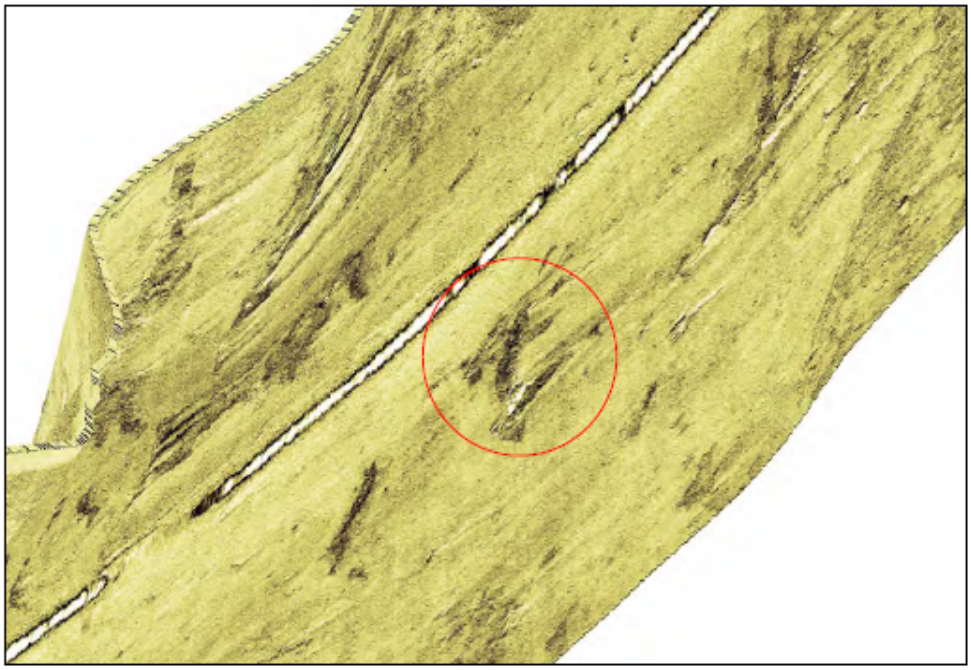
Table 4.6. Cable Route. Sonar contact listing. Survey 2006 /ref. 7/

A total of 47 side scan sonar anomalies were identified within the cable route area during the archaeological assessment in 2007 /ref. 13/. Two exclusion zones were defined in 2005 /ref. 12/. One was re-identified in the post construction survey, and does not appear to have been disturbed. The other was not re-identified, since the cable route has been moved slightly to the north to ensure the un-disturbance of this site.

Two new sites of high archaeological potential were identified on the cable route during the post construction survey /ref. 13/. They are interpreted as being possible wreck sites due to their size and possible evidence of structure – see figure 4.17. However, both anomalies were in area of complex seafloor sediments and may have a geological origin.



Sidescan sonar anomaly 3207: Wreck identified in an area of complex geology (19.9m x 13.5m)



Sidescan sonar anomaly 3214: Wreck identified as a large dark reflector with some signs of structure (22.4m x 20.1m)

Figure 4.17. Two new sites of high archaeological potential on the cable route. They may be possible wreck sites or may have natural geological origin /ref. 13/.

Navigation Route

The seabed sediments along the navigation route are generally finer grained materials comprising sands, or possibly silty sands.

An approximately 100m wide dredged channel is evident (following the course of the navigation route), with coarser grained sands, gravels and occasional boulders present on the seabed at the base of the channel, together with irregular small patches of fine grained sands. Megaripple bed forms are in evidence within the dredged channel and also on the edges of the sand banks.

Numerous objects can be seen along the navigation route. A total of 79 anomalies were identified within the navigation route area. No

sites of high archaeological potential were identified within the navigation route area.

4.7 Birds

This section reports on the findings of the ornithological monitoring the first year post construction. The monitoring programme is designed to meet the objectives set out in the FEPA licence for the Barrow Offshore Wind Farm.

The findings build upon the ornithological analysis and assessments submitted in the Construction Monitoring Report in November 2006. The discussion takes into account the results from baseline EIA preconstruction surveys and the results from the 2005-2006 environmental monitoring during construction.

4.7.1 Conditions

Monitoring will, according to the FEPA licence (Appendix 1), need to fulfil the following objectives:

1. *Determine whether there is change in bird use and passage, measured by species, abundance and behaviour, of the wind farm site and the reference site.*
2. *Determine whether there is a barrier effect to movement of birds through the site.*
3. *Determine the distribution of wildfowl and divers in the Irish Sea, covering the Barrow site and the vicinity. This will include movements of wildfowl to and from Walney Island and Common Scoter.*
4. *If objectives 1 and 2 reveal significant use of the Barrow site by populations of conservation concern, at heights that could incur a risk of collision, a programme of collision risk monitoring will be implemented.*

The monitoring reported here covers the first year of post construction monitoring for Barrow Offshore Wind Farm.

4.7.2 Monitoring methods

In January 2007 a meeting was held with Natural England to agree on a detailed survey programme post construction /ref. 18/. The agreed programme is presented in Table 4.7.

Survey Type	Timing	Comments
Boat based surveys	May, 2008 July, 2008 August, 2008 October, 2008 May, 2009 July, 2009 August, 2009 October, 2009 May, 2010 July, 2010 August, 2010 October, 2010	All surveys cover the wind farm site, 2 km buffer zone and reference site.
Aerial surveys	January 2007 February, 2007 October, 2007 February, 2008 October, 2008 February, 2009	All surveys cover the NW3 survey area.
Walney Island survey	October, 2007	Scope of work agreed with Natural England.

Table 4.7. Post construction bird survey programme. The originally planned 2007 boat surveys have been postponed one year.

The boat based surveys originally planned for 2007 (May, July, August and October) have been postponed one year due to irregularities in the 2007 survey programme. Natural England and the Marine and Fisheries Agency have been informed of the delay in the survey programme and have approved the revised programme. The bird monitoring programme fulfils the FEPA licence requirements and covers a three year period post construction.

Aerial surveys

Aerial bird surveys were undertaken by Wildfowl and Wetland Trust (WWT) through a survey programme coordinated by the Department for Business Enterprise & Regulatory Reform (BERR). The survey area covering Barrow Offshore Wind Farm is named NW3. The survey transects are presented in the figures below (Figure 4.18 and Figure 4.19). The survey on the 21st February did not cover the complete NW3 area. The northwestern corner of the survey area, Danger Area D406, had to be excluded due to military activities, therefore some of the westernmost survey transects were curtailed.

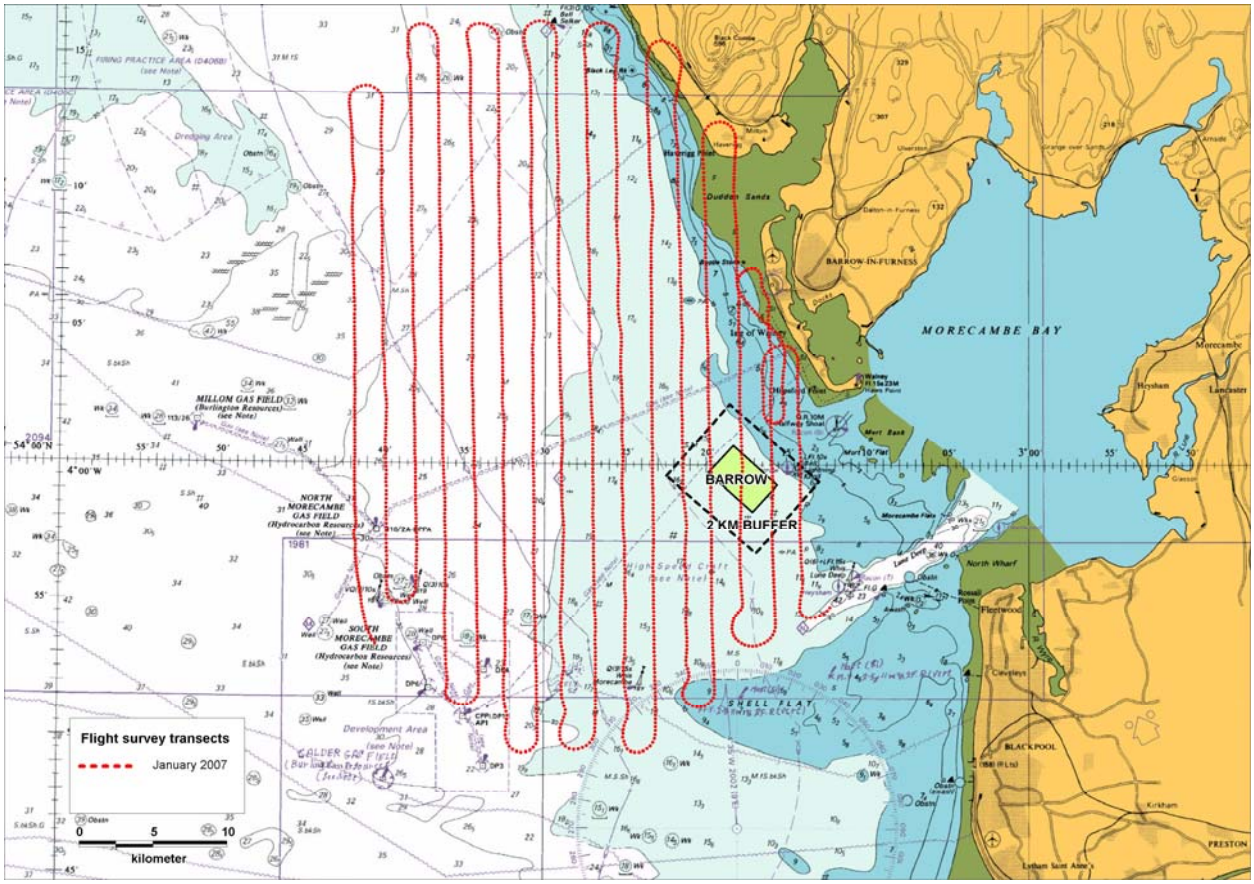


Figure 4.18. Aerial bird survey transects 16th January 2007

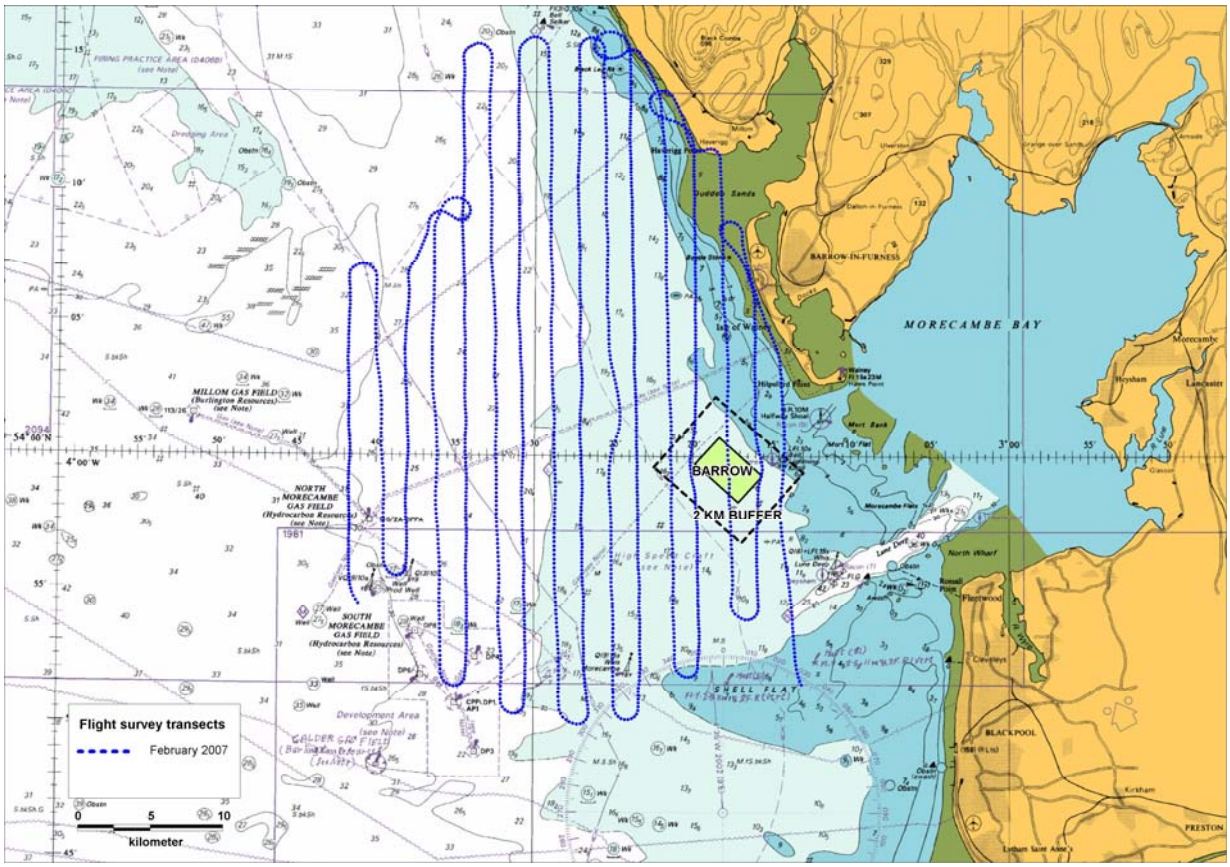


Figure 4.19. Aerial bird survey transects 21st February 2007

The survey transects are flown at 2km intervals. Information on bird species, numbers, distance bands and location through the aircraft GPS is recorded during these surveys. Using a clinometer, birds were located on one of four distance bands covering an area from 44m to 1,000m either the side of the plane (Figure 4.20); birds beyond 1,000m from the flight path of the plane were not recorded.

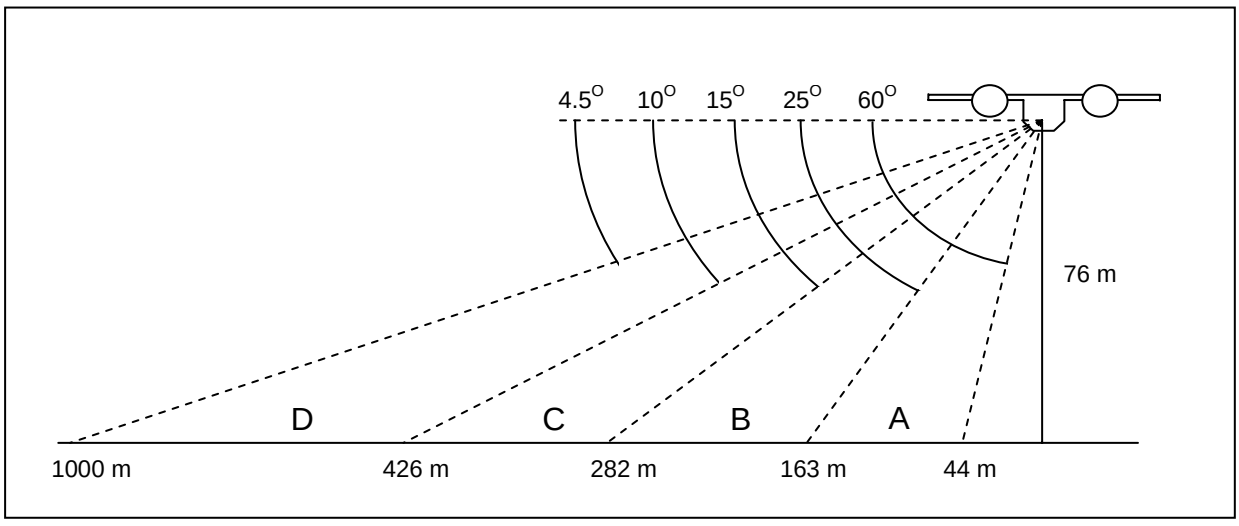


Figure 4.20. Distance bands used for aerial survey (not to scale) /ref. 21/

The aircraft flies at 76m altitude during the surveys. This flight height cannot be maintained at the location of Barrow Offshore Wind Farm, where pilots fly above the wind farm. Bird survey data from the wind farm site and the areas from where the pilot leaves survey height to climb above the turbines are therefore not recorded. The distances at which the aircraft increases flight height varies between the surveys and depends on e.g. wind conditions. In the January and February 2007 surveys the zone without bird counting are approximately within the 2km buffer zone around the wind farm.

Distribution maps were produced for each of the relevant bird species showing the location and relative size of the observed bird flocks. Only birds observed at 76m altitude are included in the Figure 4.27 to Figure 4.32.

Walney Island survey

A land based survey was set up to gain some information on the passage of Pink-footed Goose and Whooper Swan off Walney Island during the autumn 2007.

The survey preformed by the Walney Bird Observatory used Hilpsford Point as observation site. This location holds a purpose built hide for wildfowl and seabird observations. Its geographical position at the southernmost point on Walney Island, allows for uninterrupted view to Barrow Offshore Wind Farm (Figure 4.21). The scope of work for the study has been agreed with Natural England.

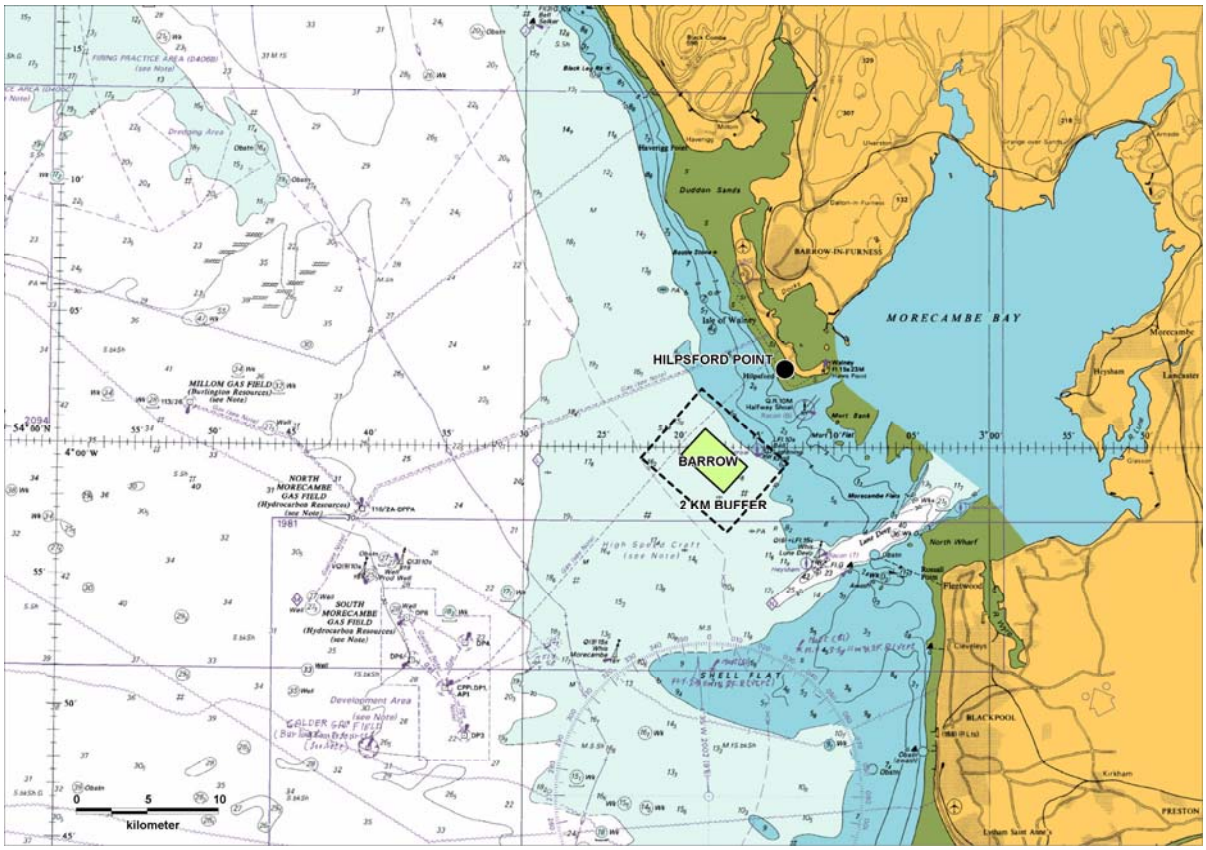


Figure 4.21. Location of Hilpsford Point

Monitoring took place during 21 days in September-October 2007. The timing of the survey initiation was triggered by anecdotal evidence from daily recording activities at Walney Bird Observatory indicating when the migration of the main target species had commenced. The survey periods included 24th September to 7th October (both days included); and 18th October to 24th October (both days included).

Continuous monitoring took place between dawn and dusk each day (c0700-1900hrs). Brief details of weather conditions, wind strength, visibility and sea state were recorded every hour. High powered

telescopes were used by the bird observers.

The target species, agreed with Natural England, were in order of importance Pink-footed Goose, Whooper Swan and other bird species. For each record the following data were registered; species, number of birds, approximate flight direction, approximate distance to the shore (Table 4.8) and approximate flight height (Table 4.9). The distance observation bands are based on the positions of existing buoys in the area close to Barrow Offshore Wind Farm.

The approximate distance of 7km to 9.7km from Walney Island corresponds to the footprint of the Barrow Offshore Wind Farm. If Pink-footed Geese and Whooper Swans were observed passing at 7km to 9.7km distance, flight pattern was registered in addition. This includes birds changing flight height during the passage of the wind farm.

Distance Band	Distance from shore
W	0.0 km
A	0 - 2.5 km
B	2.5 - 4.2 km
C	4.2 - 7.0 km
D	7.0 – 9.7 km

Table 4.8. Approximate distances from the shore for each distance observation band

Height Band	Altitude
A	<20 metres (less than 10m below rotor height)
B	20-130 metres (10m below rotor height to 10m above rotor height)
C	>130 metres (more than 10m above rotors)

Table 4.9. Approximate flight height above sea level

4.7.3 Objective 1

Determine whether there is change in bird use and passage, measured by species, abundance and behaviour, of the wind farm site and the reference site.

This objective leads to the following hypothesis:

1. *The establishing of Barrow Offshore Wind Farm leads to significant changes of occurrence of important bird species at the wind farm site*

Bird use and abundance at Barrow Offshore Wind Farm have been assessed in the Construction Monitoring Report from boat based observations /ref. 17/.

The 2007 boat based bird survey programme was postponed a year. Boat based surveys monitor the use and behaviour of the birds within the wind farm footprint and at the reference site. Assessment of potentially significant changes in the occurrence of important bird species can therefore not be assessed on this monitoring report; instead it will be addressed in the following monitoring reports.

Aerial survey data from January and February 2007 contain some data on the abundance and bird use in the area measured by species. These results are presented and discussed under Objective 3.

4.7.4 Objective 2

Determine whether there is a barrier effect to movement of birds through the site.

This objective leads to the following hypothesis:

2. *The establishing of Barrow Offshore Wind farm constitutes a barrier that prevents important migrating birds from moving through the site*

The land based survey from Walney Island gained information on the passage of birds off Walney Island during the autumn 2007. Detailed data on the passage of the target species Pink-footed Goose and Whooper Swan were collected. Within the 21 days survey period from 24th September to 7th October and 18th October to 24th October a total of 79 Whooper Swans and 4,883 Pink-footed Geese were observed (Table 4.10). By far the majority of the birds were flying south (86% of the Whooper Swans and 97% of the Pink-footed Geese).

The flight distance of the birds from Walney Island was recorded during the survey (Table 4.11). The distance of 7.0 - 9.7km corresponds to the distance from Walney Island to Barrow Offshore Wind Farm.

	Total counts	Flying South	Flying north and other directions
Whooper Swan	79	68 (86%)	11
Pink-footed Goose	4,883	4,732 (97%)	151

Table 4.10. Counts and flight directions of Whooper Swan and Pink-footed Goose from 21 survey days at Walney Island

	0 km	0 – 2.5 km	2.5 – 4.2 km	4.2 – 7.0 km	7.0 – 9.7 km
Whooper Swan	40	24	5	10	0
Pink-footed Goose	1,570	1,141	1,018	578	576

Table 4.11. Bird counts according to distances from Walney Island

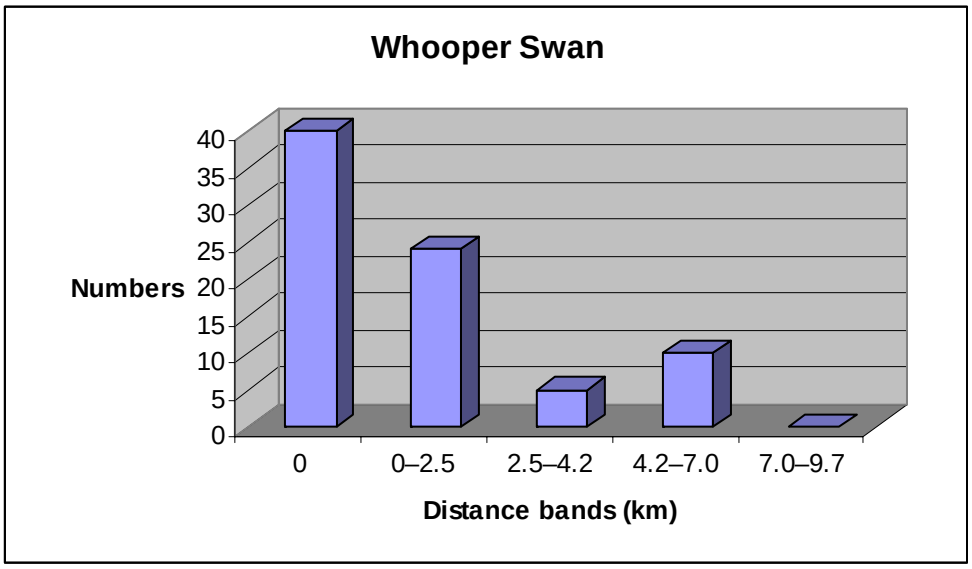


Figure 4.22. Whooper Swan observations within distance bands from Walney Island.

Most of the observed Whooper Swans (81%) were less than 2.5km from the coastline of Walney Island (Figure 4.22). A survey in 2004 found a very similar migration pattern, at that time 135 out of 150 Whooper Swans (90%) were passing less than 2.5km from the coastline of Walney Island /ref. 20/. None of the Whooper Swans were observed further out than 7km and none were passing at distances corresponding to the distance of Barrow Offshore Wind Farm (Table 4.11).

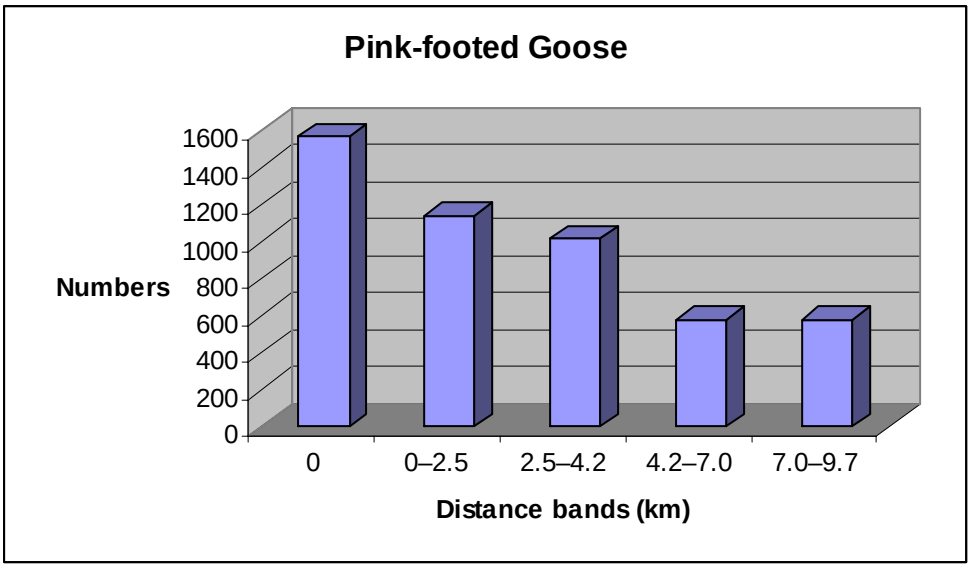


Figure 4.23. Pink-footed Goose observations within distance bands from Walney Island.

The majority of the observed Pink-footed Geese (76%) were passing less than 4.2km from Walney Island (Figure 4.23). About half of the birds (56%) were passing less than 2.5km from the coastline. Some Pink-footed Geese were passing further offshore and 576 birds or 12% were observed passing at the same distance from Walney Island as Barrow Offshore Wind Farm (Table 4.11).

- The flight height of the birds were registered and divided into three height categories:
  - "< 20m": corresponds to the area from the sea level to 10m below the rotor height of the wind turbines at Barrow Offshore Wind Farm.
  - "20 – 130m" corresponds to the height between 10m below the rotors to 10m above the rotors of the wind turbines at Barrow Offshore Wind Farm.
  - "> 130m" corresponds to the area above 10m from the rotors of the wind turbines at Barrow Offshore Wind Farm.

Table 4. presents the approximate flight heights observed for Pink-footed Goose. The first row presents a summary of all the observations from all distance bands between 0 - 9.7km from Walney Island. The last row presents the birds observed at distances from 7.0 - 9.7km, corresponding approximately to the footprint of Barrow Offshore Wind Farm (Table 4.12).

	< 20m	20 – 130m	> 130m
Pink-footed Goose - All observations	467	1,630	2,786
	(10%)	(33%)	(57%)
Pink-footed Goose - At distances between 7.0 - 9.7km from Walney Island	60	9	507
	(10.4%)	(1.6%)	(88.0%)

Table 4.12. Approximate flight height observed for Pink-footed Goose

Considering the flight height of all the observed Pink-footed Geese, approximately half (57%) were registered flying above 130m height, 33% flying between 20-130m and 10% flying below 20m.

The observed flight height of the Pink-footed Geese passing the Barrow Offshore Wind Farm at distances between 7km to 9.7km from Walney Island was different from the flight heights closer to shore (Figure 4.23; Table 4.12). Most of the Pink-footed Geese changed their

flight height when approaching the wind farm.

By far the majority of the geese approaching at flight height above 20m gained height approximately 2-3km before the wind farm and passed the wind farm well above the turbines. A total of 503 out of 512 birds (98.2%) were observed to gain flight height when approaching the wind farm. In Table 4.13 the flight behaviour is summarized from the groups of birds when approaching and passing above the wind farm. The observed birds adjusted their flight height to safely pass the Barrow Offshore Wind Farm and continue their migration.

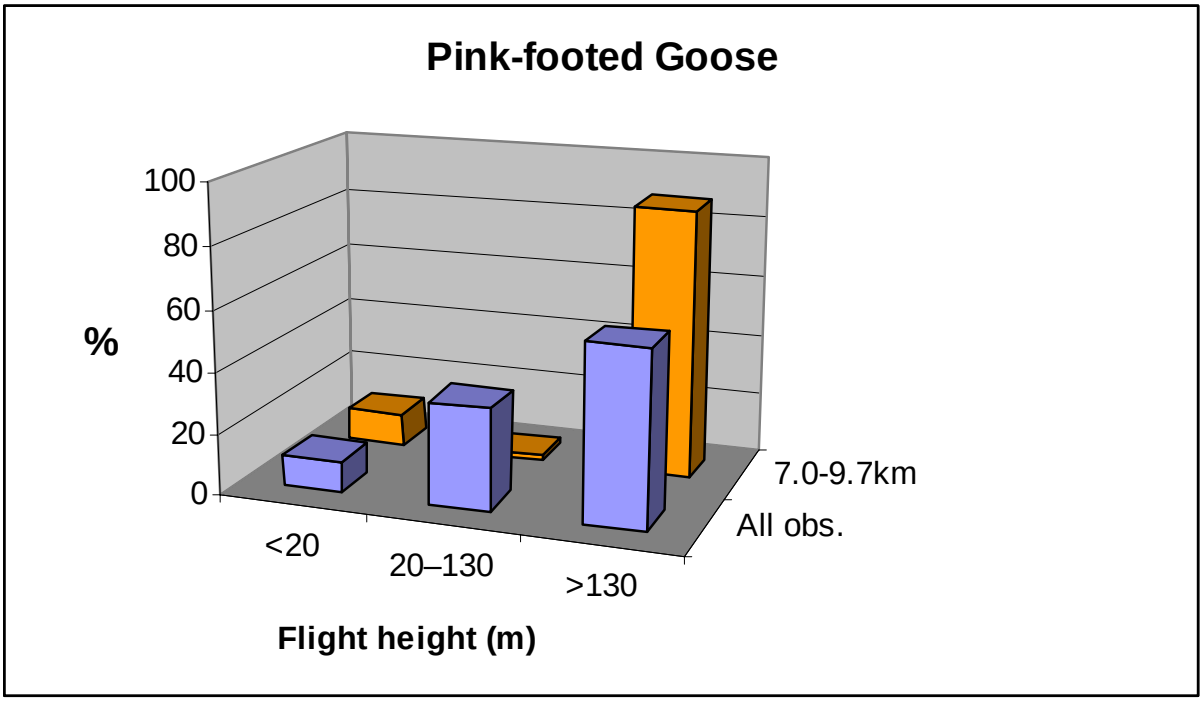


Figure 4.23. Flight height of Pink-footed goose for all observations (blue columns) and at 7.0-9.7 km distance from Walney Island (orange columns).

Birds approaching the wind farm at less than 20m height maintained their flight height through the wind farm.

The flight height of Pink-footed Goose registered in a study in 2004 /ref. 20/ is different from the results in the 2007 study. In 2004 approximately 40% of the birds flew at less than 20m height, 50% at 20-130m height and 10% at more than 130m height.

In the 2007 study some Pink-footed Geese were observed to increase flight height also in the area in between Barrow Offshore Wind Farm and Walney Island when passing by the wind farm. Other birds reacted by increasing flight height when passing fishing boats in the area. It is unknown if the Pink-footed Goose also changed flight height when approaching fishing boats in the 2004 study.

The 9 Pink-footed Geese entering the wind farm at rotor height flew in between the first easterly row of turbines; all birds left the wind farm at the substation in the southern part of the site and continued their flight south.
No collisions were observed from the total of 16,542 observed passing birds during the 21 days survey at Walney Island (Appendix 4).

The findings from this study indicate that the Barrow Offshore Wind Farm do not constitute a barrier that prevents Whooper Swan or Pink-footed Goose from passing or moving through the site.

Date	Flight pattern observations
25-09 2007	15 birds flew in from north in normal skein formation. Approx 2-3km before wind farm they formed a tight group and gained height to fly above wind farm.
25-09 2007	40 birds approached from north. Gained height to fly over wind farm on line and continued south
26-09 2007	13 birds flew in from north in a normal skein. About 2-3km before the wind farm they grouped into a tight flock, gained height then reformed skein to fly over the wind farm at about 200m high.
26-09 2007	A skein of 120 birds approached from north. About 2-3km north of wind farm they grouped together and gained height then flew over the wind farm at about 150m.
27-09 2007	Skein of 55 birds flew from north at a height of 150m but steadily gained more height to clear turbines at a height of 250m.
	A second skein of 160 birds shortly after flew south at a height of 300m and maintained this height as they passed over the wind farm.
27-09 2007	40 birds flew in from the north at a height of 150m. At 2-3km before the wind farm they bunched together and climbed to 300m. They stayed bunched until they had passed the wind farm then reformed the 'V' skein when clear. Soon after a party of four birds crossed the wind farm at a height of 280m.
01-10 2007	A flock of 60 flew from the north at rotor height. At 2-3km north of the wind farm they started to climb above rotor height and flew over the wind farm at 250m.

Table 4.13. Pink-footed Goose flight pattern when approaching Barrow Offshore Wind Farm

4.7.5 Objective 3

Determine the distribution of wildfowl and divers in the Irish Sea, covering the Barrow site and the vicinity. This will include movements of wildfowl to and from Walney Island and Common Scoter.

This objective leads to the following four hypotheses:

I. *The establishing of Barrow Offshore Wind Farm leads to significant changes of occurrence of wildfowl at the wind farm site and its vicinity.*

II. *The establishing of Barrow Offshore Wind Farm leads to significant changes of occurrence of divers at the wind farm site and its vicinity.*

III. *The establishing of Barrow Offshore Wind Farm leads to significant changes of movement of wildfowl to and from Walney Island across the wind farm site and its vicinity.*

IV. *The establishing of Barrow Offshore Wind Farm leads to significant changes of movement of Common Scoter across the wind farm site and its vicinity.*

Results on the relative density of birds recorded in the Irish Sea within the offshore wind farm strategic areas are presented in Figure 4.24 and 4.25 /ref. 21/. The data are based on aerial surveys during the winter 2005/2006 and summer 2006.

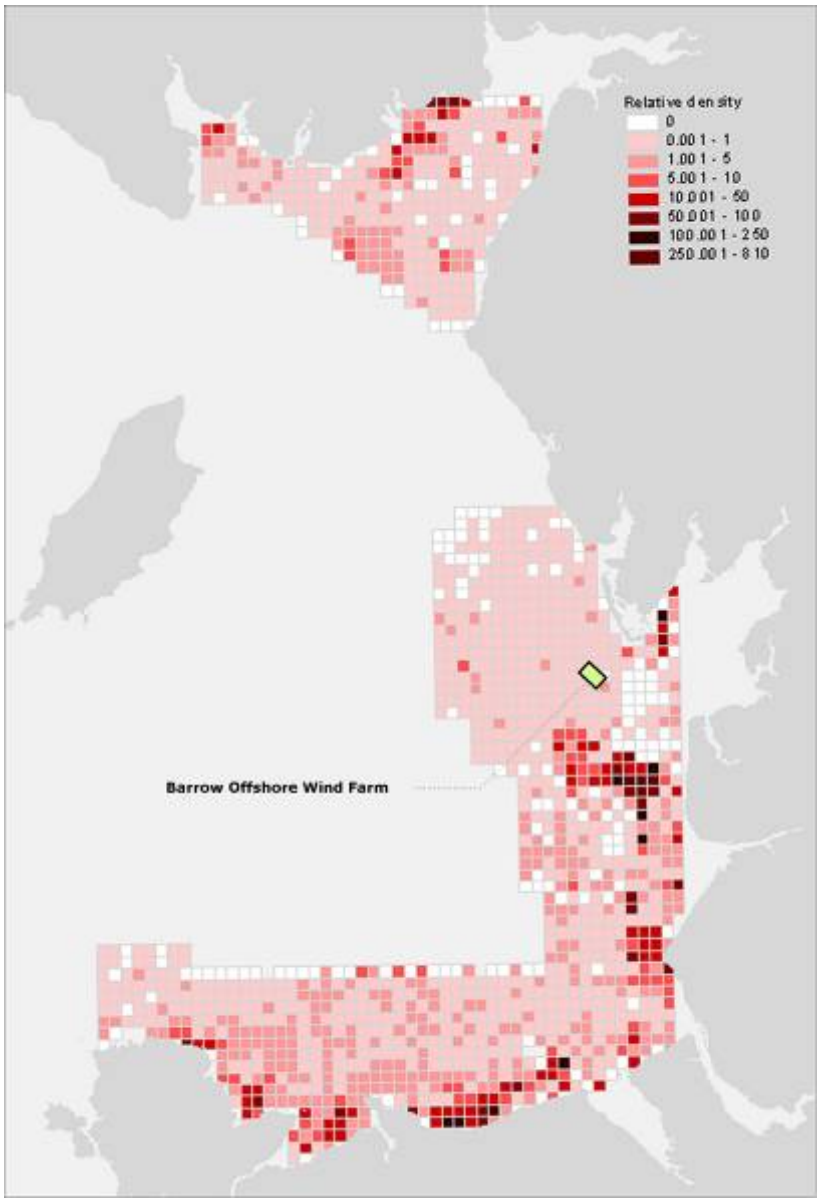


Figure 4.24. Relative density of birds recorded in North West Offshore Wind Farm Strategic Area during aerial surveys, winter 2005/06 /ref. 21/

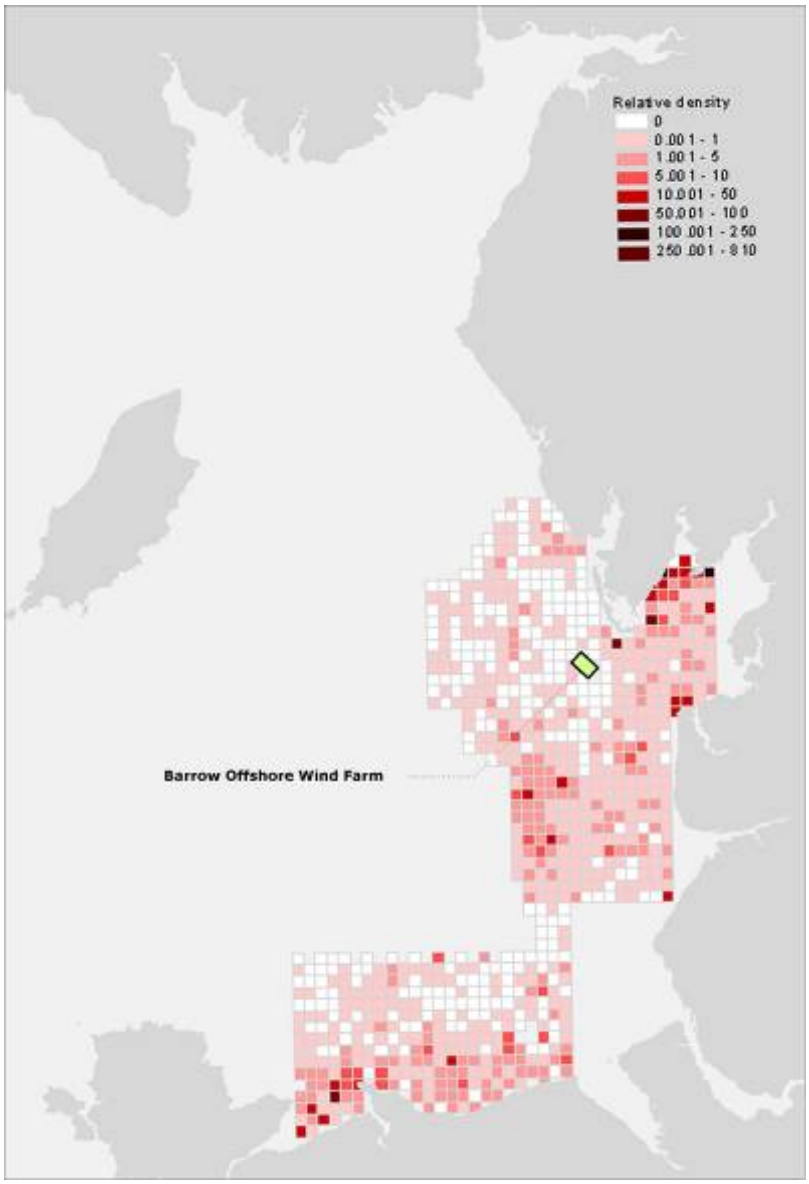


Figure 4.25. Relative density of birds recorded in North West OWF Strategic Area during aerial surveys, summer 2006 /ref. 21/

The results from the two aerial winter bird surveys in the NW3 area are presented in Table 4.14. A blank field in the table means no observations of the species. Due to the increase in survey flight height above the wind turbines, only the amount of birds observed outside the Barrow Offshore Wind Farm and two km buffer zone are included in the list. When the flight height increases above the wind turbines, the bird observations are not comparable with areas flown at lower heights.

Group	Species	January 2007 NW3 (ex. BOW+2km)	February 2007 NW3 (ex. BOW+2km)
Auks	Auk sp.	114	240
Cormorants	Cormorant/Shag		1
Divers	Diver sp.	13	6
	Red-throated Diver	21	
Gulls	Black-backed Gull sp.	6	5
	Great Black-backed Gull	4	5
	Common Gull	4	
	Grey Gull sp. (Herring or Common)	17	7
	Gull sp.	17	2
	Herring Gull	13	3
	Large Gull sp.	2	2
	Lesser Black-backed Gull	2	
	Little Gull	1	2
	Kittiwake	25	45
	Small Gull sp.		6
Seabirds	Guillemot	1	
Seaducks	Common Scoter	56	118
	Eider	27	24
	Red-breasted Merganser	4	
	Sum	**327**	**466**

Table 4.14. Results of aerial bird surveys within the NW3 survey sector. Counts within the Barrow Offshore Wind Farm (BOW) and the 2km buffer zone have been excluded from the total counts. A blank field means no observations of the species.

The aerial surveys presented in Figure 4.26 to Figure 4.31 show the observed distribution of individual bird species in the NW3 area.

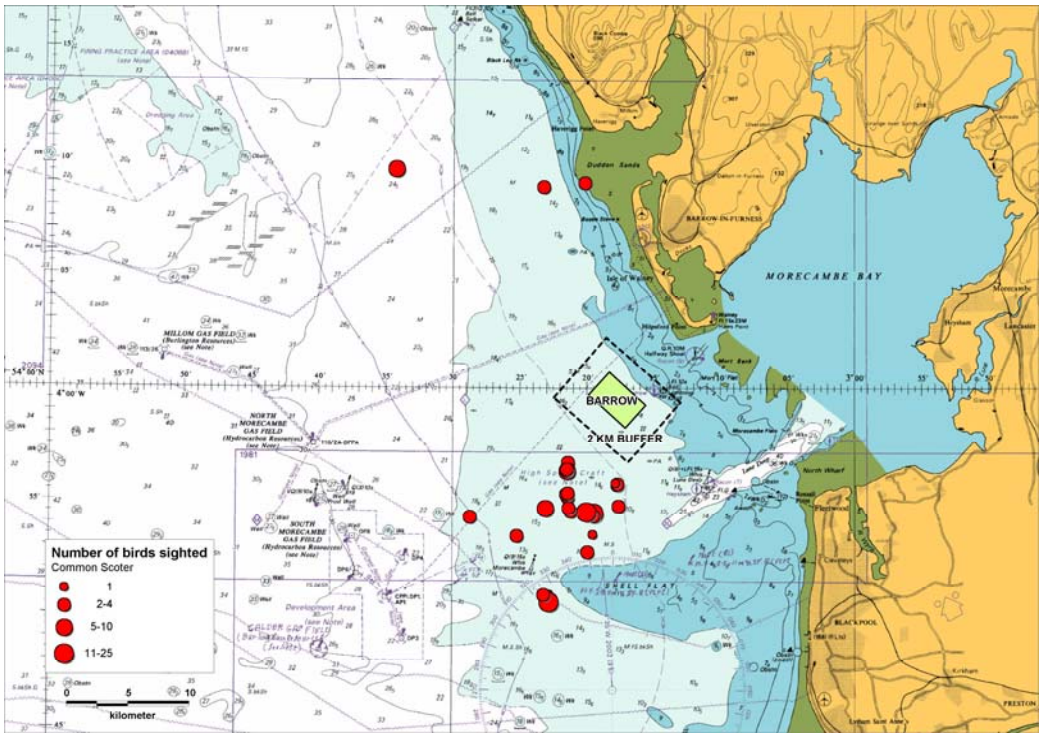


Figure 4.26. Distribution of Common Scoter from two aerial surveys in January and February 2007

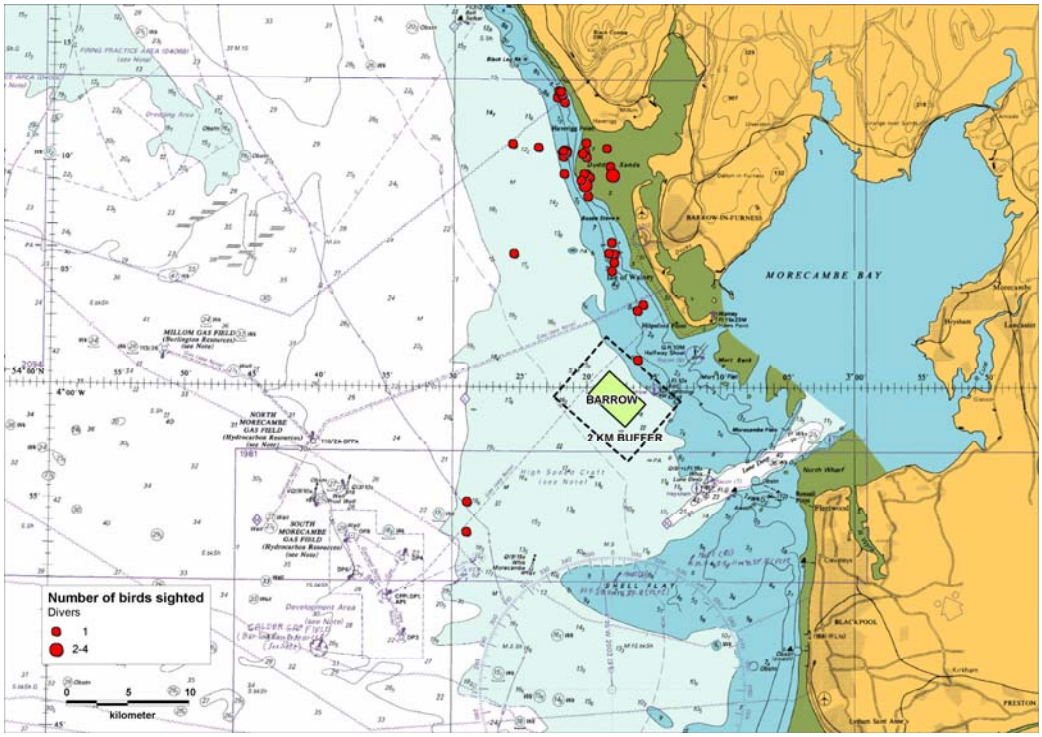


Figure 4.27. Distribution of Diver species from two aerial surveys in January and February 2007

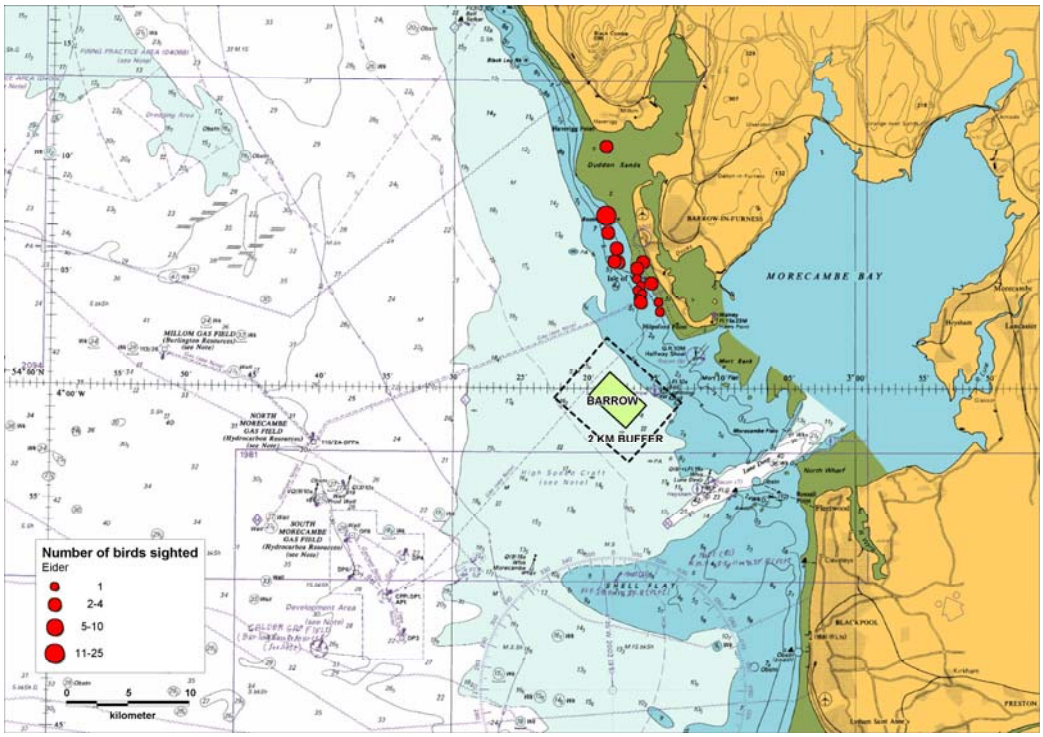


Figure 4.28. Distribution of Eiders from two aerial surveys in January and February 2007

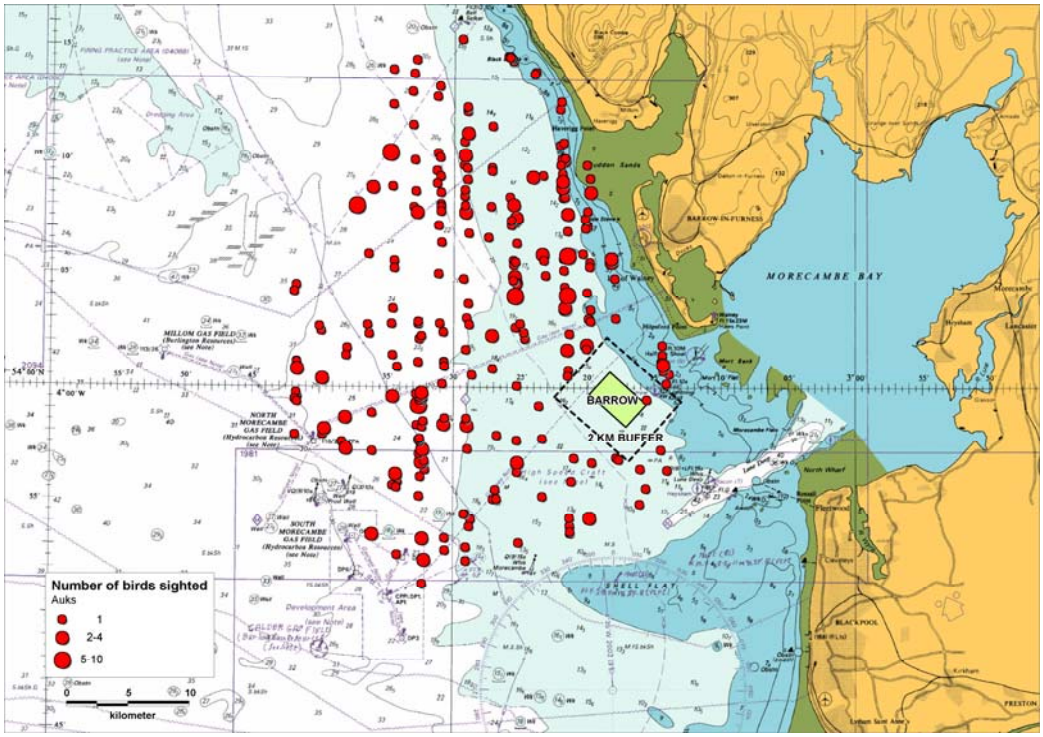


Figure 4.29. Distribution of Auk species from two aerial surveys in January and February 2007

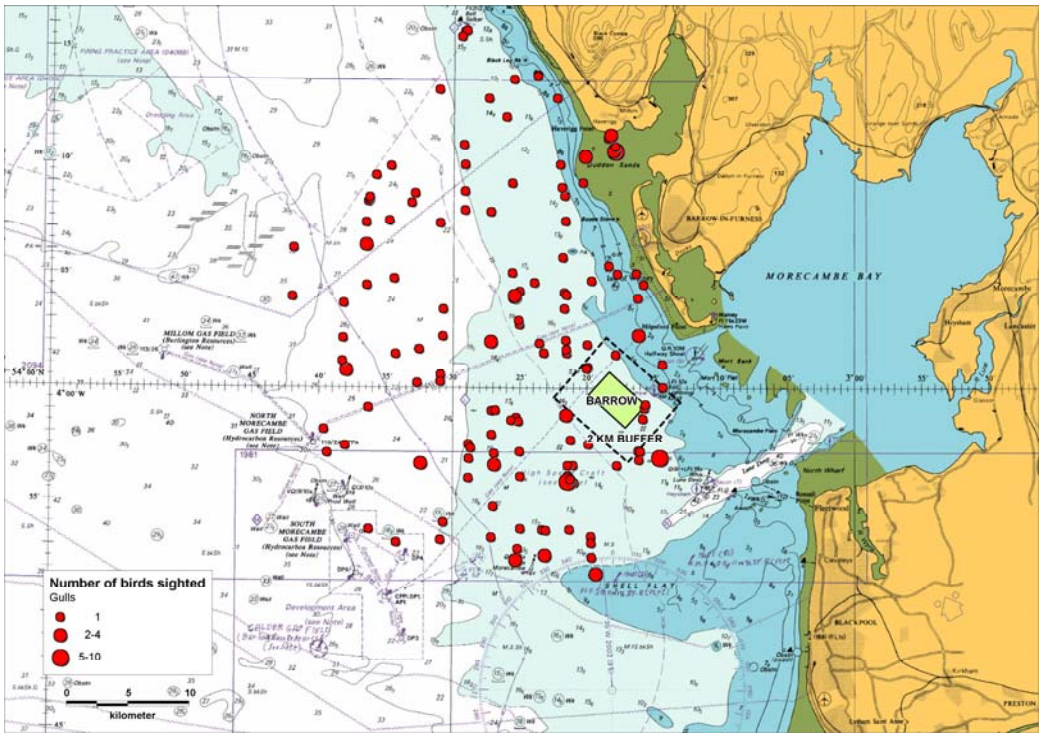


Figure 4.30. Distribution of all Gulls from two aerial surveys in January and February 2007

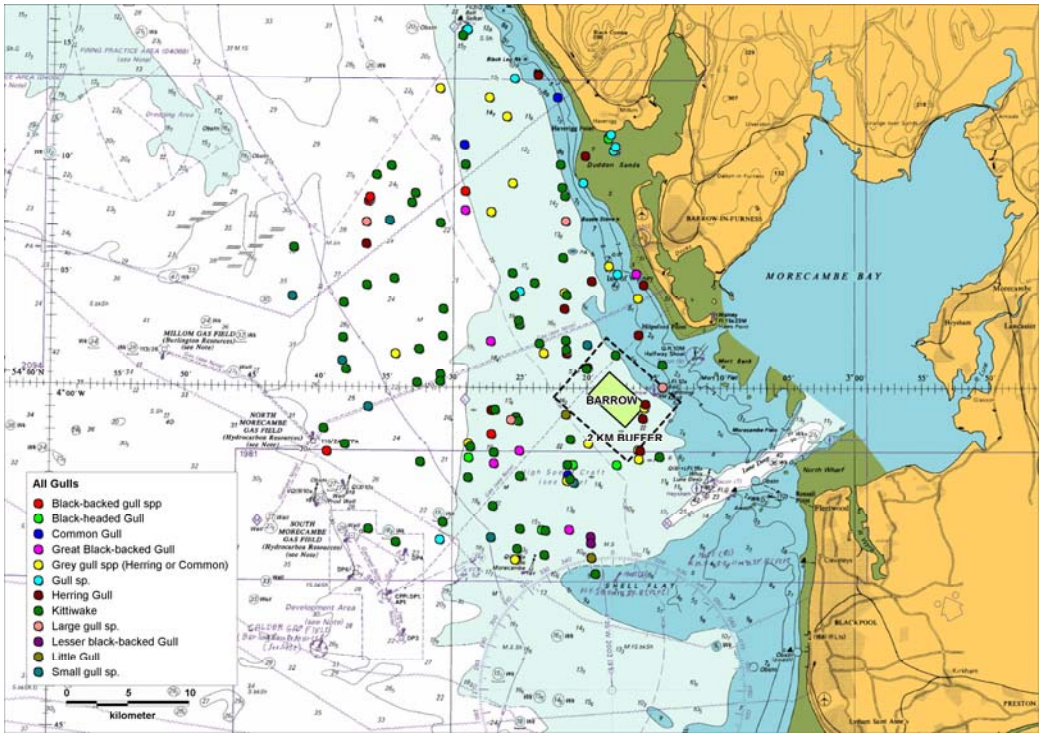


Figure 4.31. Distribution of the Gull species from two aerial surveys in January and February 2007

Common Scoter
The Common Scoter is primarily found south of Barrow Offshore Wind Farm and with a few individuals west of Duddon Sands in the January and February 2007 observations (Figure 4.26). This distribution pattern is very similar to the distribution observed during construction /ref. 17/. It is also similar to distributions observed before the construction of Barrow Offshore Wind Farm, e.g. in January and February 2005 /ref. 19/. The relative density of Common Scoter recorded from aerial surveys in the Irish Sea from January to March 2006 is presented in Figure 4.32 and Figure 4.33.

Divers
The majority of the 40 divers observed in January and February 2007 (Table 4.14) were found along the coast line west of Duddon Sands and Walney Island. Two birds were observed west of Lune Deep. None were observed outside the 20m depth curve (Figure 4.27). The distribution pattern is comparable with the October 2005 and February 2006 surveys, where most birds were found in the same area west of Duddon Sands /ref. 17/.

Eiders
All the eiders observed in January and February 2007 were registered within a few kilometres west of Walney Island (Figure 4.28). The distribution of Eider in the first year of operation of Barrow Offshore Wind Farm is very similar to the distribution during construction /ref. 17/. The amount of birds observed is also similar to the peak counts of 30 birds within the NW3 area from the period between 2002-2005 /ref. 19/.

Auks
Auk species are found more or less regularly distributed in the NW3 area in the January and February 2007 surveys (Figure 4.28). Similar distribution patterns were also observed prior to construction of Barrow Offshore Wind Farm in January and February 2005 /ref. 19/.

Gulls
Gulls can be observed throughout the NW3 area. They are found in shallow water and as far offshore as the survey area extends to the west (Figure 4.29 and Figure 4.30). This distribution pattern is similar to earlier years' observations. The counts of the individual gull species are also similar to the February 2006 observation /ref. 17/.

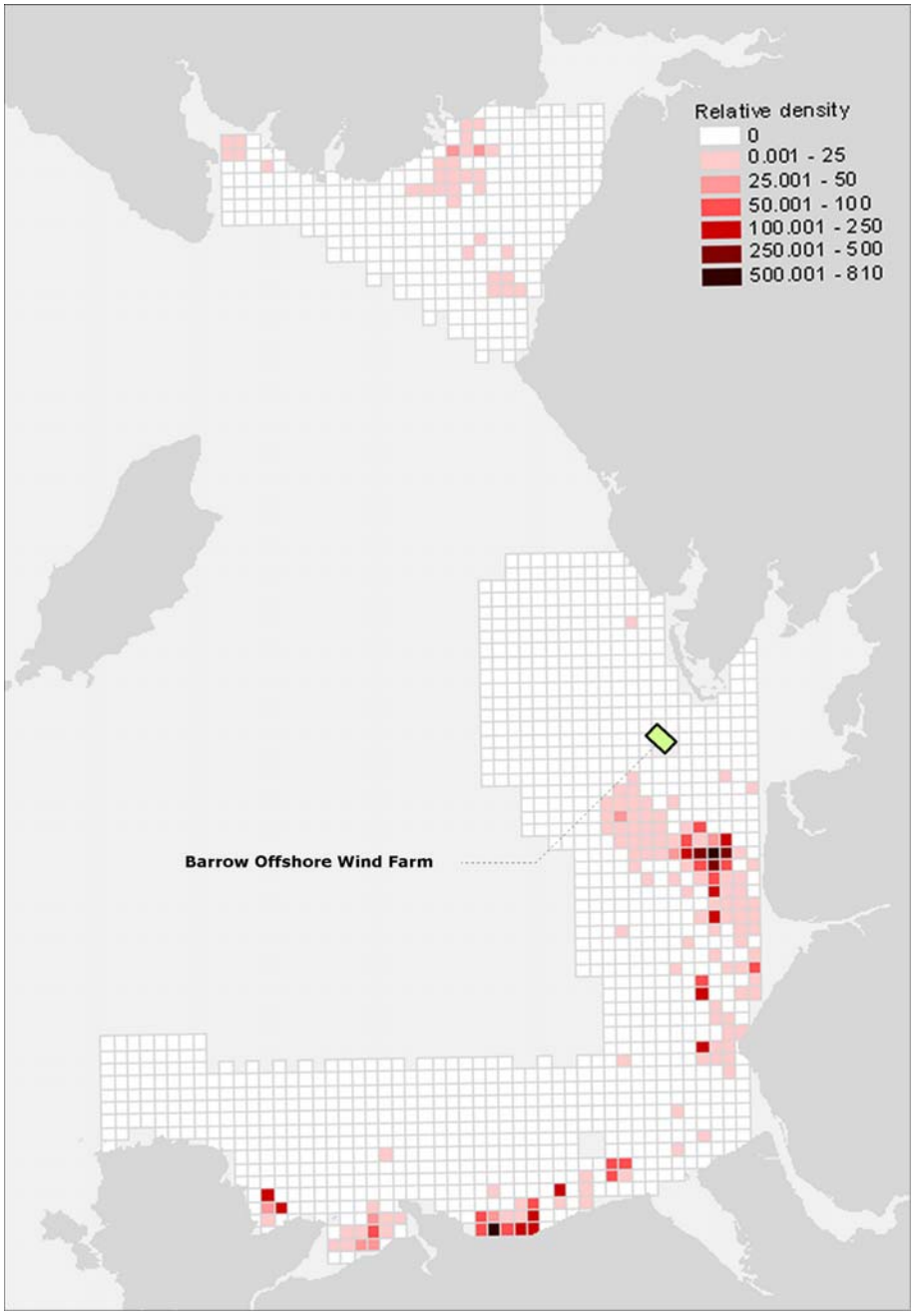


Figure 4.32. Relative density of Common Scoter recorded in North West Offshore Wind Farm Strategic Area during aerial surveys, 1 January – 12 February 2006 /ref. 21/

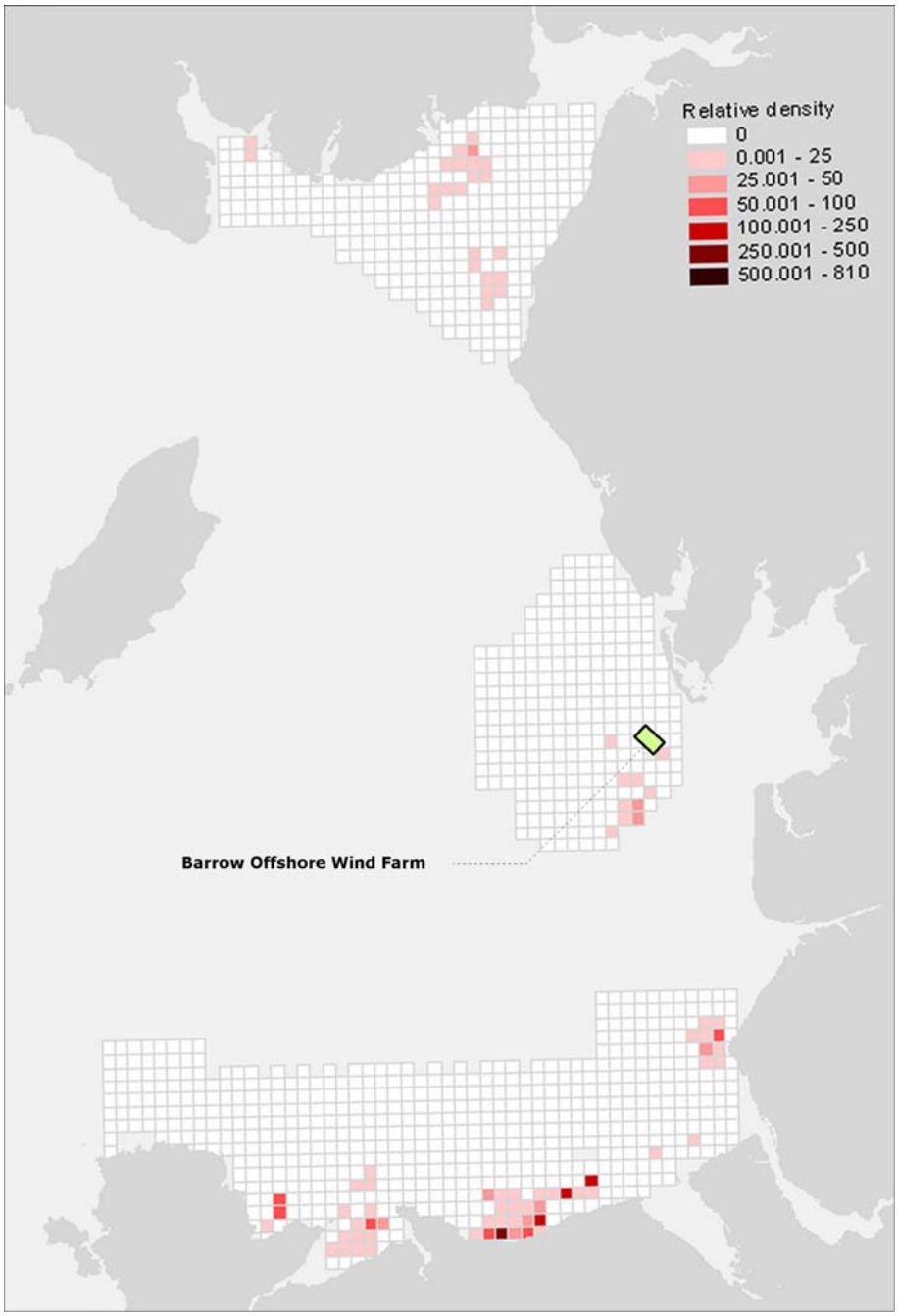


Figure 4.33. Relative density of Common Scoter recorded in North West Offshore Wind Farm Strategic Area during aerial surveys, 13 February – 12 March 2006 /ref. 21/

The aerial survey monitoring indicates that the establishing of Barrow Offshore Wind Farm does not lead to significant changes in the occurrence and distribution of Common Scoter, divers or other wildfowl in the vicinity of the wind farm.

4.7.6 Objective 4

If objectives 1 and 2 reveal significant use of the Barrow site by populations of conservation concern, at heights that could incur a risk of collision, a programme of collision risk monitoring will be implemented.

This objective leads to the following two hypotheses:

V. *Barrow Offshore Wind Farm are being significantly used by populations of conservation concern.*

If this hypothesis is not rejected then:

VI. *The establishing of Barrow Offshore Wind Farm results in a number of collisions [by species name] that significantly affect the population*

No collisions have been observed during any of the environmental monitoring bird surveys.

The bird surveys before, during and the first year after construction of Barrow Offshore Wind Farm have not found bird populations of conservation concern significantly using the site.

No boat surveys were performed in 2007, therefore no flight height from this survey methodology can be taken into considerations of collision risk assessment in this report. Information on flight height will be gathered during future boat surveys.

Data from the survey from Walney Island revealed that approximately 0.18% (9 out of 4,883) of the observed passing Pink-footed Geese were flying in between the wind turbines at rotor height. All 9 birds passed through the wind farm and continued their flight south. None of the observed Pink-footed Geese collided with wind turbines. No Wooper Swans have been observed in between the wind turbines.

Therefore, based on the findings of the bird monitoring so far at Barrow Offshore Wind Farm, it is considered that further collision risk analysis is not required at this stage. This will be reviewed in the next monitoring report based on the following annual bird findings.

5. CONCLUSIONS

Barrow Offshore Wind Farm is located in the eastern Irish Sea near Barrow-in-Furness. The wind farm became operational in July 2006.

This report describes the environmental monitoring undertaken during the post construction phase in 2006–2007. The environmental monitoring reported in this document should be seen as a continuation of the pre-construction and construction monitoring. Post-construction monitoring activities are undertaken for a period of three years after construction, and will be reported annually to the licensing authority, as described in the FEPA licence. This is the first of three post-construction monitoring reports.

This report covers the environmental monitoring related to relevant themes according to the licence conditions for the post construction period: Fish, benthos, operational underwater noise, oceanography, seabed morphology (scours etc.) and bathymetry, side scan sonar surveys, including archaeology, and ornithology.

Some changes in the monitoring programme have been made according to the planned schedule for the studies.

Concerning ornithology, the boat surveys in 2007 have been postponed for one year. That means the three year boat survey programme will run from 2008-2010 instead of 2007-2009. The epifauna monopile survey will be undertaken in May 2008, and the second post construction monitoring report (November 2008) will encompass these results. Furthermore, the last of the planned post construction fishery surveys was undertaken in October 2007. This report has not been finalised yet and therefore it has been concluded that the result of the last survey as well as the analysis of the pre construction and post construction surveys will be presented in the second post construction monitoring report in November 2008. All changes to the monitoring programme have been agreed with the Licence Authority.

Concerning electromagnetic fields (EMF), Barrow Offshore Wind Ltd. has agreed that measurements will

be undertaken at the site in spring 2008 as a part of the research programme carried out by COWRIE (Collaborative Offshore Wind farm research into the Environment). A summary of these results will be included in the second post construction monitoring report (November 2008).

In general, the surveys undertaken during the first year of operation of the wind farm did not register major or unforeseen environmental impacts.

6. REFERENCES

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/ref. 5/	Subacoustech Report No. 753R0109: Subsea operational noise assessment at the Barrow Offshore Wind Farm site. June 2007.
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/ref. 15/	Note prepared by Subacoustech concerning Subsea operational noise assessment at the Barrow Offshore Wind Farm site: Response to comments from the Marine and Fisheries Agency. Report Number 753R0204. Dated 21 November 2007.
/ref. 16/	Benthic and Sediment Survey: Comparative analysis of pre and post construction. Benthic and Sedimentological Data. P40120/25. November 2007. Prepared by RSK Group.
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