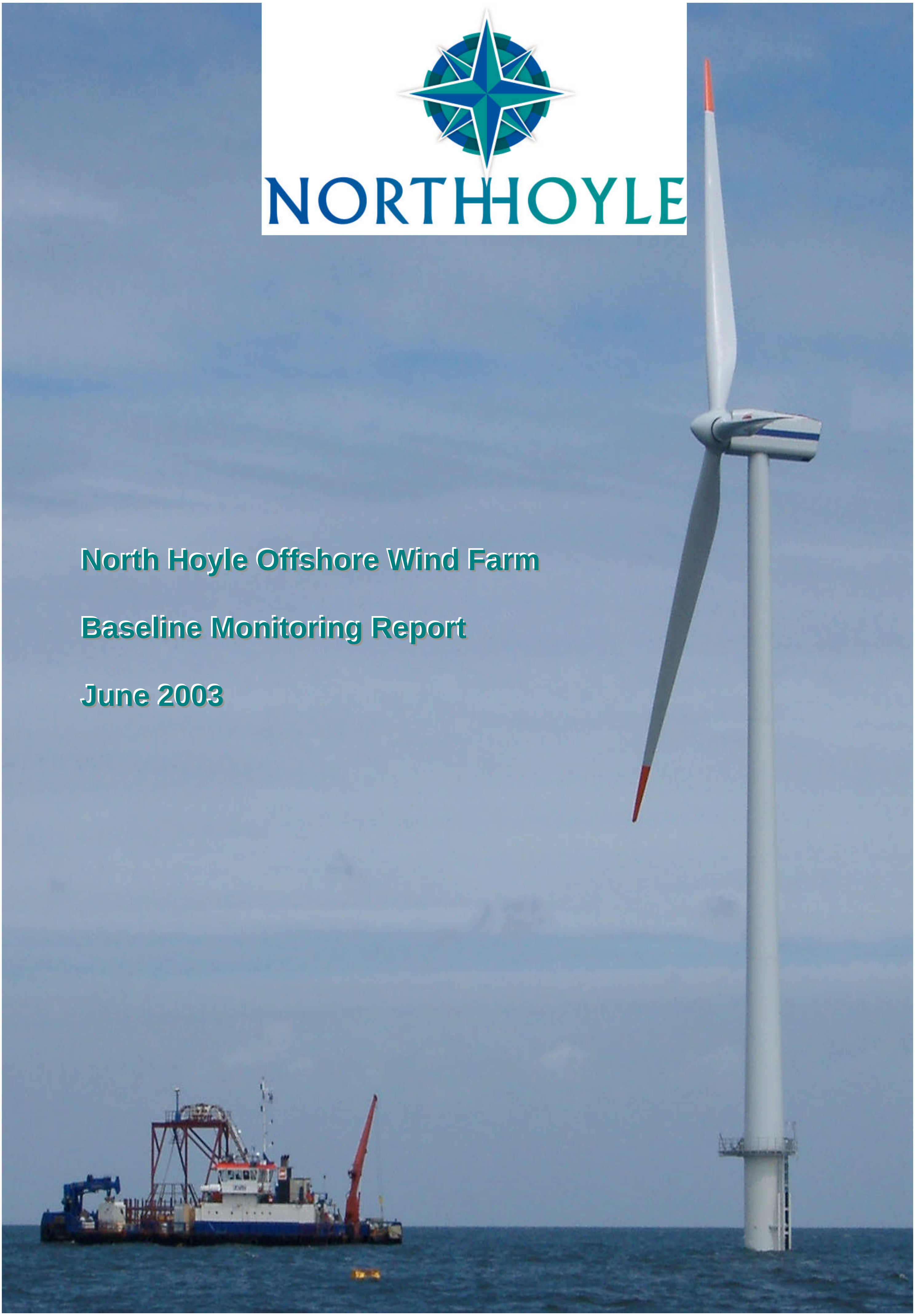
NORTHHOYLE



North Hoyle Offshore Wind Farm

Baseline Monitoring Report

June 2003

Project:	**North Hoyle**
Document Reference:	**NH/MonR/Rev 1**
Date	**June 27, 2003**
Type of Project:	**Offshore Wind Farm**
Owner:	**NWP Offshore Ltd**
Sponsor:	**National Wind Power Ltd** **Riverside House** **Meadowbank** **Furlong Road** **Bourne End** **Buckinghamshire** **SL8 5AJ**
Contacts:	**Neil Birch, Environment Manager [Liaison Officer]**
Project Description:	**Thirty offshore wind turbines, array size 60MW$_e$**
Anticipated Year of Operation:	**2003**
Reference and Date of earlier Environmental Statements	**NH/EA/01: February 2002**
Statement prepared by:	**National Wind Power**

EXECUTIVE SUMMARY

Introduction
This document describes the baseline monitoring undertaken to comply with the conditions of the Food and Environmental Protection Act (FEPA) 1985: Part II (as amended), licence reference 31579/02/0 (as amended), issued to NWP Offshore Ltd. for the North Hoyle Offshore Wind Farm.

Marine sediments
Subtidal (benthic) sediments were sampled from 17 agreed locations in and around the development site using a Day Grab. Additional sites are to be added in the immediate vicinity of a turbine post-construction. Particle size analysis was carried out to allow detection of any future changes in sediment conditions at the sites and, in particular, any influence on benthic invertebrate communities. Inshore and to the east of the development site sediments were a mixture of moderately to well sorted sands. In the region of the sites itself sediments were coarser but more heterogeneous with sands, gravels and varying amounts of pebbles.

Suspended sediments are being monitored to determine any near and far field effects of windfarm construction and post-construction conditions. Pre-construction baseline data were obtained over a period of 1 month (15 February - 17 March 2003) using in-situ turbidity meters calibrated against gravimetrically analysed water samples and compared to tide and weather conditions. Suspended sediments were remobilised during flood and ebb tides, most markedly over higher tides (i.e. a semi-lunar influence) although this was masked closer to the coast by wave action when wind speed increased and shifted to a westerly direction. Baseline data showed expected changes on-offshore and with changes in wave and tidal conditions. Monitoring is therefore expected to show any changes in suspended sediment associated with construction.

Benthic organisms
Three replicate samples were obtained from the 17 locations used for the subtidal sediment sampling by the same methods. Again, additional sites will be established post-construction. Two hundred and eight benthic invertebrate taxa were found and the majority identified to species level. Four major biotopes were identified with no major shifts in community composition since the baseline survey approximately 1 year earlier were detected. There was no clear relationship with particle size as would be expected. One unusual species was found in low numbers, the thumbnail crab *Thia scutellata*. Detailed analysis of monopile colonisation will also be carried out in future surveys.

Fish
Consultation with fisherman and appropriate bodies has been undertaken and is ongoing through the Fisheries Liaison Officer. To date, no vessels have encountered problems, or noticed any apparent fall in the abundance or change in distribution of their catches. In addition to annual analysis of commercial stock assessment, it is proposed that CEFAS can undertake a multi-variate assessment of commercial fish stocks data to include the North Hoyle wind farm site where trawl-surveys shall be undertaken to obtain further baseline data.

Marine mammals
Liverpool Bay is not believed to be an important area for cetaceans. However, to determine any changes, sightings databases are to be interrogated post-construction and combined with site-specific counts being carried out in combination with ornithological surveys. These data will be collated to assist in the determination of any influence of windfarm construction and operation on activity.

Grey seal counts from the Dee estuary haulout near Hilbre Island are being collated to allow for any major influence of windfarm construction and/or operation to be assessed.

Ornithology
5 objectives for ornithological monitoring have been addressed in the report. Power analysis has been undertaken from the results obtained (Appendix 2 and 3).

Boat surveys have shown that a reasonable amount of winter survey effort will result in the ability to detect approximately 50% change with statistical confidence only for two species, cormorant and razorbill. For other key species there is less sensitivity to detect change. This situation would not improve with approximately 20 survey days, which it would be unlikely to achieve in winter in the eastern Irish Sea. Relaxation of the level of significance from 5% to 20%, which results in a higher probability that an incorrect conclusion of "no effect" is accepted, improves the ability of reasonable survey effort to detect change.

From recommendations from the power analysis reports:

- further surveys are concentrated in mid-winter, in practice November to February, to avoid seasonality in the data, rather than an attempt to gather data through a calendar year;
- the transect design, currently being investigated, will as much as possible provide even survey effort for the wind farm and a series of concentric rectangles at 0.5km spacing around the site, out to 2km;
- all surveys are confined to this area; and
- tern foraging surveys for the first post-construction year are undertaken as transects perpendicular to the coast through the wind farm, following RSPB methods being implemented this summer to record little tern foraging activity south of the wind farm. If activity continues to be at the low level recorded in 2003, the summer surveys will cease.

Refinement of methods of flight height measurement will be investigated and reported to CCW.

At the North Hoyle Offshore Wind Farm existing radar systems cannot provide full coverage of the site from land and there are no suitably placed offshore platforms, the test proved the utility of MSR on a boat for the mapping of movement of common scoter. Given concerns over the movement of this species in Liverpool Bay, a practical solution to this data gap for the monitoring of North Hoyle was demonstrated, at least in good weather conditions and a stable marine environment.

Aerial survey methods and survey logistics have been refined during three years of aerial surveying of Liverpool Bay. The data analysis indicates the need to improve the precision of modelled densities of common scoter. Such developments will be incorporated in the North Hoyle monitoring programme to, where feasible, improve the precision of detection of change in common scoter distribution.

The nature of any relationship between common scoter distribution, the location of turbines and change in the benthic fauna that should trigger more intensive benthic sampling and the practicality of such a sampling programme will be under discussion with CCW subsequent to the analysis.

FEPA monitoring to date supports the conclusions of the North Hoyle Offshore Wind Farm environmental statement that the wind farm is outside of potential marine SPAs. Uncertainty remains over the status of a future protected area for red-throated diver in Liverpool Bay, due to a review of the threshold population size for SPA classification and present uncertainty on how to set boundaries for dispersed non-breeding seabirds.

Flight height data is limited in its utility due to the limited range of weather conditions in which visual data can be gathered offshore and the problems of measurement discussed in Objective 1. Practical technologies for the refinement of height measurement will continue to be considered during the future monitoring years.

Future Work

These, and additional studies, will include assessment of:

- colonisation of monopiles (by diver operated video survey)
- the effects of changes in sediment characteristics on fish populations (through fish surveys begun post-construction)
- impact of noise and vibration and electromagnetic field generation on marine organisms (through site-specific measurements of physical conditions, combined with biological surveys)

CONTENTS

1. INTRODUCTION

This document describes the baseline monitoring undertaken to comply with the conditions of the Food and Environmental Protection Act (FEPA) 1985: Part II (as amended), licence reference 31579/02/0 (as amended), issued to NWP Offshore Ltd. for the North Hoyle Offshore Wind Farm.

It should be noted that all relevant baseline monitoring (data collection) has been undertaken although certain aspects of the monitoring cannot be reported at this stage and will be included in subsequent report on construction/post construction monitoring. This Statement therefore documents and consolidates a range of previously submitted and environmental monitoring.

2. MARINE SEDIMENTS

2.1 Subtidal

2.1.1 Introduction

Sediment monitoring is being conducted under a sampling plan agreed with CCW/CEFAS. Pre-construction monitoring was carried out in September 2002, the following describes the sub-tidal sediment monitoring carried out in parallel with benthic organism monitoring.

2.1.2 Methods

Sampling sites

Pre-development benthic monitoring surveys were carried out at 17 locations in and around the North Hoyle development site on 13th and 14th September 2002 (Figures 1 & 2). At each location three replicate Day Grab samples were taken for analysis of benthic fauna, and a further sample was taken for analysis of sediment.

Having been undertaken at the same time of year, results should be broadly comparable with the original baseline surveys undertaken in August 2001.

One small deviation from the sampling protocol agreed with CEFAS, CCW and the client was made. This was because, whilst at sea; it was noticed that site 17, a control site to the south west of the development area, was within 50 m or so of the outfall from the Kinmel Bay sewage works. Site 17 was therefore moved approximately 150 metres offshore away from the main influence of the outfall. It was felt that this was sufficient distance since the influence of the outfall was likely to be predominantly up and downstream, i.e. alongshore.

An additional 3 sites, adjacent to an installed monopile, will be established during the next annual survey, September 2003.

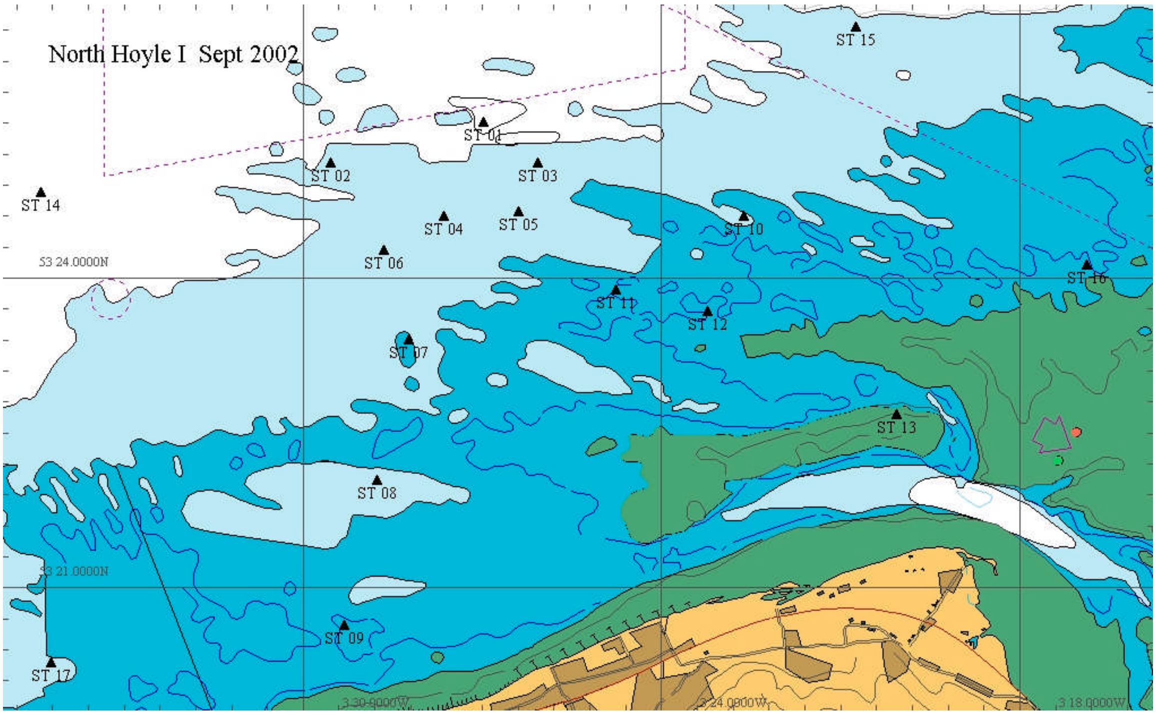


Figure 1. Sample locations overlain onto admiralty chart (image supplied by Aquatec Ltd).

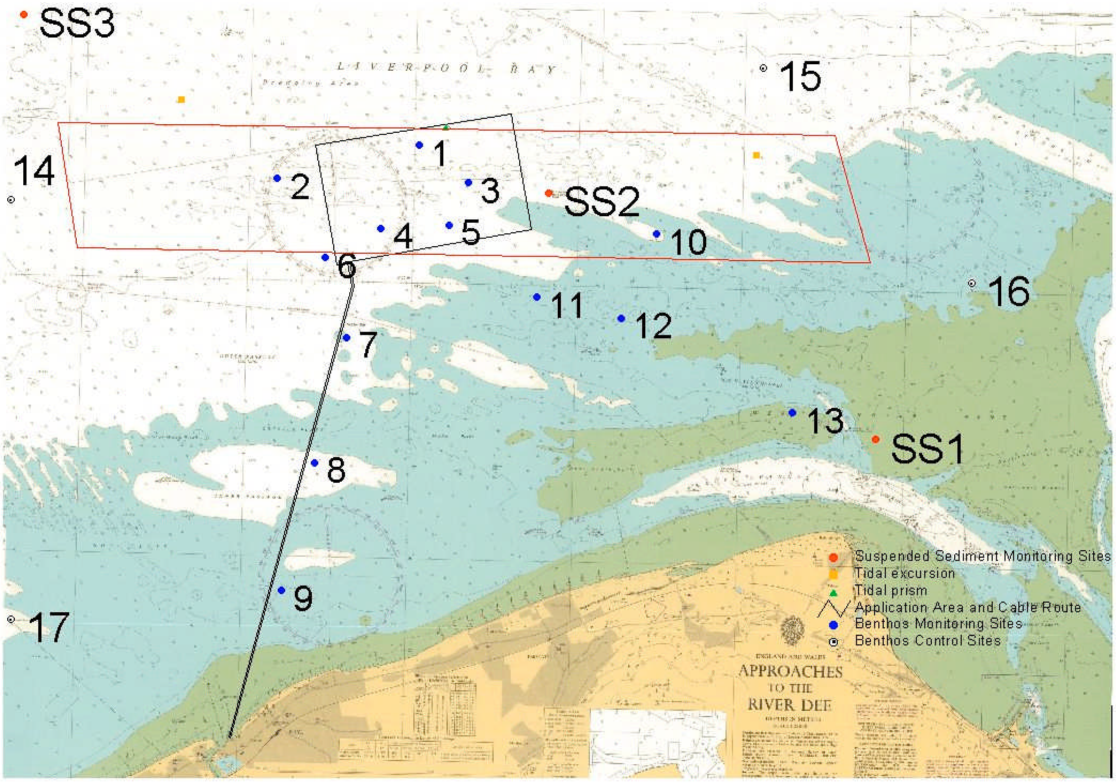


Figure 2. Locations of sampling stations, including monitoring of suspended sediments (SS1, SS2 & SS3) with red parallelogram showing an approximation of the single tidal excursion around the North Hoyle windfarm site.

Detailed methods

All sediment and biota samples were obtained using a 0.1m^2 Day Grab. Where stones, shells or other large objects prevented the jaws of the grab from closing properly, samples were retaken. All samples, including associated benthic infauna samples, were successfully taken over a two day period.

Notes were made whilst at sea of visual appearance of the sediment at the time of sampling.

Excess water was allowed to drain from the grab. Following this, sediment samples were removed from the grab using a stainless steel sampling spoon and deposited in labelled aluminium-lined food trays. In turn, trays were sealed in polythene bags and transported to the laboratory where they were air-dried.

All subtidal sediments were analysed for the following:

- Physical Analysis - Particle size analysis (PSA)
- Chemical Analysis - Total Organic Carbon (TOC), Total Nitrogen (TN)

PSA was carried out on samples from all sampling stations as given in Figures 1 and 2. Sediments were sieved on Endecott BS 410 test sieves using a Retsch AS200 sieve shaker and standard set of sieve sizes (5mm; 2mm; 1mm; 600µm; 425µm; 300µm; 212µm; 150µm; 63µm).

Calculation of mean and median particle sizes and determination of sorting index by calculating standard deviation of Phi, and the classification system used for sediment type and sorting index are were carried out according to the methods of Buchanan et al. (1984), as set out in Tables 1 & 2 below. Further classification was made using JNCC's version of the Folk triangles (unpublished).

Table 1: Classification used for defining sediment type (from Buchanan *et al.*, 1984)

Wentworth Scale (mm)	Phi units	Sediment types
>256 mm	<-8	Boulders
64 - 256 mm	-8 to -6	Cobble
4 - 64 mm	-6 to -2	Pebble
2 - 4 mm	-2 to -1	Granule
1 - 2 mm	-1 to -0	Very coarse sand
0.5 - 1 mm	0 - 1	Coarse sand
250 - 500 µm	1 - 2	Medium sand
125 - 250 µm	2 - 3	Fine sand
63 - 125 µm	3 - 4	Very fine sand
<63 µm	>4	Silt

Table 2: Classification used defining degree of sediment sorting (from Buchanan, 1984)

Standard Deviation of mean Phi	Classification
<0.35	Very well sorted
0.35 - 0.5	Well sorted
0.5 - 0.71	Moderately well sorted
0.71 - 1	Moderately sorted
1 - 2	Poorly sorted
2 - 4	Very poorly sorted
>4	Extremely poorly sorted

Total Organic Carbon (TOC) and Total Nitrogen (TN) Analysis

Small samples of dried homogenised sediment of circa 5-10g were taken prior to PSA sieving for TOC and TN analysis. TOC and TN was determined by use of a Carlo Erba NC2500 analyser. TOC was determined after inorganic carbon (carbonate) had been removed with dilute hydrochloric acid.

2.1.3 Results & Future Analysis

Sediment data is presented in Tables 3a. These have been described in terms of Wentworth scale and JNCC's version of Folk trigons (although it is understood that the JNCC are in the process of changing the criteria used to define the sediments in this classification quite considerably, if so these will be re-assigned in later reports). Field notes are also given for comparison. However, although useful, it should be remembered that these are inevitably more subjective. The sediments are a mixture of moderately to very well sorted coarse, medium and fine sands, particularly inshore of and to the east of the development site, and more heterogeneous coarser sands and gravels, with varying amounts of pebbles, particularly in the region of the wind farm sites itself. These are broadly in line with observations made during the baseline surveys.

Future sampling will determine any discernible and consistent changes in benthic sediment conditions at the sample sites. Sediment types will be used principally to determine influence on benthic invertebrate communities (cf. Section 3).

Table 3a Results of particle size analysis: percentage composition of sediment sample retained on each seive, together with summary statistics.

Site id	% >5.00 mm	% >2.00 mm	% >1.00 mm	% >600 um	% >425 um	% >300 um	% >212 um	% >150 um	% >63 um	% >63 um	Mean (phi units)	Mean (mm)	+/-1 s.d. phi units	Skew-ness	kurtosis
1	0.0	1.7	7.0	15.0	16.4	36.2	21.6	1.7	0.2	0.05	1.212	0.432	0.799	-0.357	1.174
2	18.8	8.9	4.7	2.7	3.2	26.1	32.6	2.7	0.2	0.06	0.325	0.798	1.972	-0.737	0.682
3	1.5	16.4	20.8	15.5	12.9	18.8	11.8	1.3	0.7	0.25	0.354	0.783	1.342	-0.215	0.810
4	37.1	46.0	8.3	1.1	0.5	0.9	2.3	2.1	1.4	0.32	-1.971	3.921	1.371	0.207	1.469
5	15.7	22.3	16.0	11.0	5.1	6.6	17.8	4.9	0.3	0.11	-0.206	1.153	1.895	-0.024	0.668
6	7.5	7.7	6.6	8.1	7.3	17.6	27.3	6.3	6.0	5.64	1.032	0.489	1.946	-0.347	1.669
7	0.0	0.7	1.1	1.0	3.5	70.8	21.1	1.6	0.3	0.02	1.583	0.334	0.318	0.153	1.284
8	75.5	5.2	2.0	0.9	0.5	1.0	7.4	6.6	0.8	0.03	-1.666	3.174	2.030	0.736	2.799
9	0.2	0.7	1.0	0.7	0.4	2.2	48.3	41.0	5.3	0.20	2.219	0.215	0.366	0.091	0.855
10	8.6	26.5	12.9	6.0	2.4	5.7	30.6	6.6	0.8	0.09	0.133	0.912	1.814	-0.135	0.629
11	47.7	27.4	13.6	2.4	1.2	1.2	3.2	2.5	0.7	0.09	-1.920	3.784	1.541	0.416	1.152
12	0.5	1.3	0.8	0.7	0.8	10.9	77.2	7.1	0.7	0.05	1.964	0.256	0.286	-0.093	1.467
13	1.8	1.6	1.4	1.8	3.4	36.6	38.0	12.9	2.4	0.03	1.775	0.292	0.618	-0.176	1.571
14	93.1	0.1	0.1	0.2	0.2	1.4	4.2	0.7	0.0	0.02	-2.934	7.641	1.045	0.380	3.063
15	0.0	1.0	3.1	7.9	13.0	54.1	17.8	2.6	0.4	0.06	1.410	0.376	0.564	-0.245	1.855
16	0.3	2.7	5.2	7.9	7.0	10.0	55.7	10.1	1.1	0.01	1.604	0.329	0.845	-0.584	1.645
17	0.1	1.0	2.0	3.0	5.4	15.7	55.9	14.9	1.6	0.32	1.861	0.275	0.552	-0.317	1.786

Table 3b results of particle size analysis: summary statistics together with interpretation of sediment type after Buchanan (1984) and JNCC's sublittoral sediment trigons, Field descriptions of the sediments in the 3 benthic samples, and results of total organic carbon and total nitrogen analysis.

Site id	Mean (phi units)	Mean (mm)	+/-1 s.d. phi units	Skew-ness	Kurto-sis	Classification after Buchanan	Classification after JNCC trigons	Field descriptions (3 replicate benthic samples); 3 replicate sampls had identical descriptions except where more than one given.	Tot N (%)	Tot. Org. C (%)
1	1.212	0.432	0.799	-0.357	1.174	Moderately sorted medium sand	Sand	Coarse sand and gravel	0.00	0.04
2	0.325	0.798	1.972	-0.737	0.682	Poorly sorted coarse sand	Gravelly Sand	Coarse sand and gravel	0.00	0.06
3	0.354	0.783	1.342	-0.215	0.810	Poorly sorted coarse sand	Sand	Stone gravel and coarse sand	0.00	0.08
4	-1.971	3.921	1.371	0.207	1.469	Poorly sorted granule	Gravel	Stone gravel	0.04	0.55
5	-0.206	1.153	1.895	-0.024	0.668	Poorly sorted very coarse sand	Gravelly Sand	Gravel and coarse sand	0.00	0.07
6	1.032	0.489	1.946	-0.347	1.669	Poorly sorted medium sand	Gravelly Sand	Med-fine sand , much mud, some gravel	0.09	1.02
7	1.583	0.334	0.318	0.153	1.284	Very well sorted medium sand	Sand	Med-fine sand	0.00	0.02
8	-1.666	3.174	2.030	0.736	2.799	Very poorly sorted granule	Gravel	8.1 sand w much stone & gravel; 8.2 muddy sand w stone & gravel; 8.3 muddy sand w stone & gravel	0.01	0.17
9	2.219	0.215	0.366	0.091	0.855	Well sorted fine sand	Sand	Fine sand, shells and some stones	0.00	0.07
10	0.133	0.912	1.814	-0.135	0.629	Poorly sorted coarse sand	Gravelly Sand	10.1 sand & clay; 10.2 gravel; 10.3 sand & clay	0.00	0.07
11	-1.920	3.784	1.541	0.416	1.152	Poorly sorted granule	Sandy Gravel	Gravel	0.00	0.12
12	1.964	0.256	0.286	-0.093	1.467	Very well sorted medium sand	Sand	Sand & clay	0.00	0.02
13	1.775	0.292	0.618	-0.176	1.571	Moderately well sorted medium sand	Sand	Med-fine sand some shell fragments	0.00	0.04
14	-2.934	7.641	1.045	0.380	3.063	Poorly sorted pebble	Gravel	Cobbles with some sand	0.00	0.12
15	1.410	0.376	0.564	-0.245	1.855	Moderately well sorted medium sand	Sand	Coarse sand	0.00	0.03
16	1.604	0.329	0.845	-0.584	1.645	Moderately sorted medium sand	Sand	med-sand & shell frags	0.00	0.05
17	1.861	0.275	0.552	-0.317	1.786	Moderately well sorted medium sand	Sand	med-sand & shell frags	0.00	0.09

2.2 Suspended sediment concentrations

2.2.1 Introduction

The EIA predicted little change in suspended sediments as a result of the proposed works. However, as natural current movements would lead to a net movement of particles towards the Dee Estuary and North Wirral coast, monitoring has been undertaken to confirm the EIA predictions. The monitoring has been based upon the deployment of fixed suspended sediment meters during the pre-construction period.

The suspended sediment datalogger positions have been chosen to permit measurement of near and far-field sediment release and control levels.

2.2.2 Methods

Three independent turbidity monitoring units (Hydrolab DataSonde 4a combined water quality recorders with shuttered optical turbidity sensors) were installed between 15 February and 17 March, 2003 during the pre-construction period. Pre-construction deployment was as close as possible to commencement of construction to enable identification of immediate changes to suspended sediment concentrations (under continuing weather conditions) following the instigation of the construction period.

The locations of the fixed turbidity units are given in Figure 2 (cf. Section 2.1) and described below:

SS1 Towards the Point of Ayr (near mouth of Dee estuary), at a distance of one tidal excursion from the boundary of the licence area and within the predicted suspended sediment plume, to determine far-field levels of SSC (E312,998 N387,079).

SS2 Adjacent to the existing anemometry mast at the south-eastern corner of the proposed North Hoyle Wind Farm licence area to measure near-field effects of sediment release. (E306,398 N392,044)

SS3 At a point outside the predicted area of the sediment plume west of the Licence area, and off-axis of the dominant flood-ebb direction to provide a 'control' measure of natural levels of SSC over the monitoring period (E295,800 N395,655).

The units were mounted on bottom frames deployed from a surface vessel with diver assistance and set to record at approximately 1m above sea bed. The units were marked on the surface using a suitable buoy fitted with radar reflector and strobe light. A mooring arrangement including ground lines to allow easy recovery in the event of surface marker loss was employed. Sensors were programmed to record every 5 minutes over the deployment period.

A notice to mariners was issued as described in the Schedule to Licence No 31579/02/0.

Turbidity sensor readings were calibrated by sampling suspended sediments at each deployment site. Standard techniques for gravimetric analysis were used to enable conversion of results to suspended sediment concentrations (mg/l). Initially, three calibration samples per site were taken over a period of several hours on 28 February from 1m above seabed, the approximate depth of the sensors. A further 2 samples per site were taken on 6 March.

A linear regression equation of the form Y = mx + c (where Y = suspended sediment concentration, m = slope, x = field measured turbidity and c = intercept) was derived and used to transform all field turbidity measurements into mg/l. The performance of the calibration exercise was measured using an R2 statistic.

Suspended sediment levels have been compared with wind speed and direction (as a proxy for wave action) and tidal conditions (i.e. tidal range, an indicator of current strength). Both these factors can have significant effects on suspended sediment levels.

Meteorological data was obtained from Bidston Observatory on the Wirral Peninsula which provides a suitable indication of conditions prevailing at the monitoring sites. Average daily wind speed and direction were calculated from the data provided. Tidal data for February 2003 was obtained from the British Oceanographic Data Centre to compare to suspended sediment fluctuations.

2.2.3 Results & Future Analysis

The calibration exercise was successful for probes deployed at SS2 and SS3 (R^2 0.98 and 0.77 respectively); however, no satisfactory relationship between field measured turbidity and suspended sediment levels was determined at SS1 ($R^2 < 0.1$). The calibration for this site will be undertaken and refined for all sites as further data become available during the ongoing monitoring. In the meantime the regression equation for SS2 has been applied to provide an approximation for these values as suspended sediment characteristics are expected to be similar.

Data for each sampling station are plotted on Figure 3 which also includes an indication of the prevailing wind direction, speed and tidal range throughout the monitoring.

Suspended sediment levels at site SS2, nearest the wind farm site quite closely reflect those at site SS1 near Point of Ayr. Suspended sediment levels at the control site, SS3 were consistently lower than at the other two sites. As anticipated, suspended sediment levels appear to increase with proximity to the coast and the Dee estuary.

Peak suspended sediment levels at SS1 were noticeably higher than at SS2 (max 199.10 mg/l and 155.00 mg/l respectively), the following summarises maximum and mean concentrations for each site:

SS1: MAX 199.10 mg/l, mean 50.10 mg/l

SS2: MAX 155.00 mg/l, mean 39.76 mg/l

SS3: MAX 65.28 mg/l, mean 15.20 mg/l

At all sites a clear relationship is evident, suspended sediment being remobilised during flood and ebb tides and dropping at high and low water. There is also a semi-lunar tidal influence evident over the period 27 February to 13 March, 2003, with suspended sediment levels increasing at all 3 sites with increased tidal range (and hence current strength). The semi-lunar tidal influence did however appear to be masked over the period 27 February to 13 March, 2003 by a change in wind speed and direction. An increase in wind speed and a shift from south-easterly to south to westerly winds (thereby increasing the fetch) led to sustained high suspended sediment levels at sites SS1 and SS2.

Data collected during the construction period will be compared in the next report with this pre-construction data and with independent variables (wind and tides).

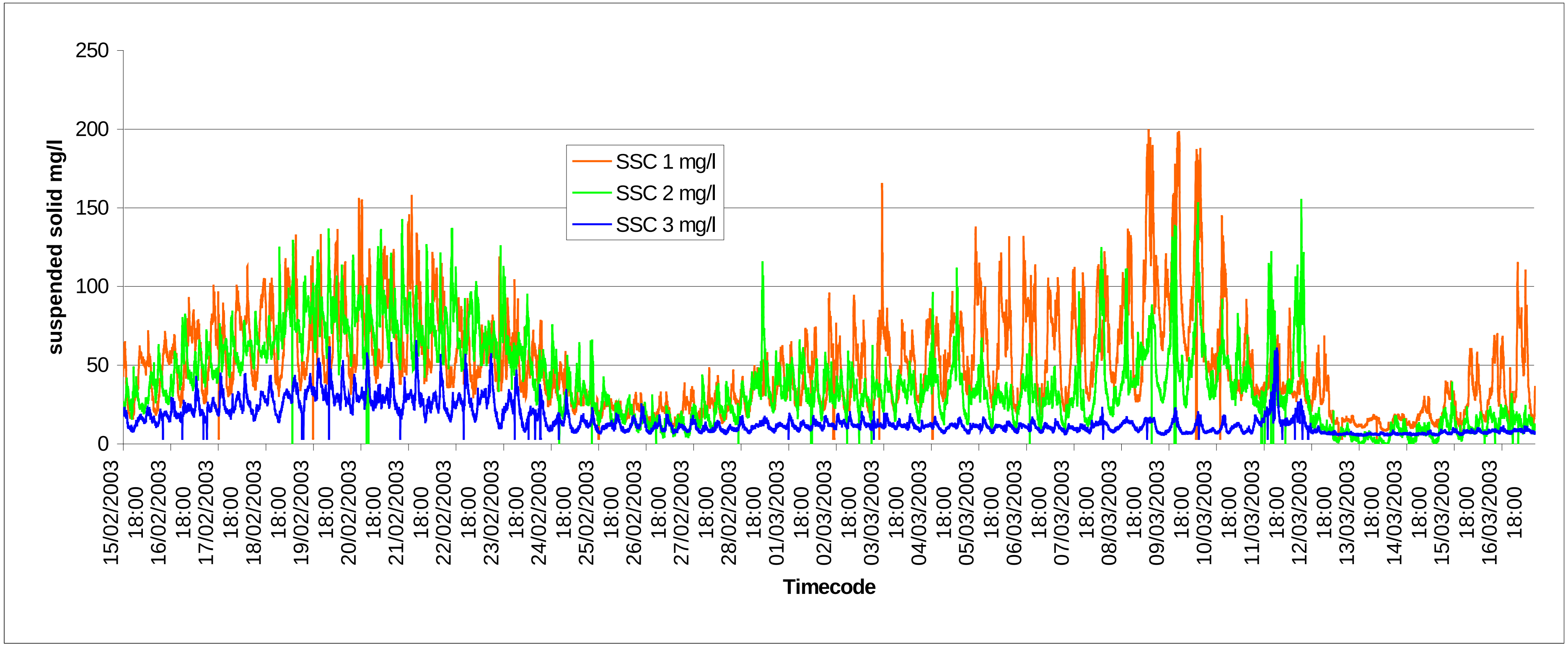


Figure 3. Pre-construction suspended sediment logging at 5 minute intervals between 15 February and 17 March 2003. SSC 1 = Point of Ayr, SSC 2 = Wind Farm, SSC 3 = Control (offshore).

3. BENTHIC ORGANISMS

3.1 Subtidal

3.1.1 Introduction

Benthic invertebrate communities have been surveyed over a large area to provide information on the types and distribution of communities both within and surrounding the North Hoyle Offshore Wind Farm site. For the ongoing monitoring it has been considered more appropriate to take more replicates at fewer sampling sites to more accurately identify the variability in the invertebrate communities present.

3.1.2 Methods

Sampling sites

Three replicate faunal samples were collected, along with a single sediment sample, at each of 17 locations as shown in Figure 4 (Results section).

Detailed methods

All sediment and faunal samples were obtained using a 0.1m2 Day Grab. Where stones, shells or other large objects prevented the jaws of the grab from closing properly, samples were retaken. All samples, including associated sediment samples, were successfully taken over a two day period (Sept 13th and 14th 2002).

The grab contents for faunal analysis were gently washed through a 1mm sieve using a seawater hose. The sieved material was back-washed into labelled containers. A solution of 3.5% w/v magnesium chloride (MgCl) and 0.2% w/v rose bengal was added to the containers in sufficient volume as to just cover the samples. The samples were then left for a minimum period of two hours, following which they were preserved by addition of sufficient 10% solution of formalin to achieve a final concentration of approximately 4-5%. The preserved faunal were transported back to the laboratory for sorting, identification and analysis.

Sorting and identification

Information associated with each grab (e.g. time, site code, and approximate original grab volume) was documented on the sorting sheet. Samples were then washed with filtered seawater over a 0.5mm mesh in order to remove excess formalin. Samples were then gently washed over a white enamel tray and sediments methodically searched. All organisms found were separated according to major taxonomic groups (molluscs; worms; crustaceans; echinoderms; others) and preserved in 70% alcohol.

Quality control was exerted by the chief taxonomist randomly checking one in every ten sorted samples. Under this protocol, if sorting efficiency is less than 95% all ten of the samples have to be resorted by the original sorter.

All the archived sorted organisms from each grab were identified to species level where possible, but in some cases only to genus (mainly juvenile and damaged specimens) or to higher taxa. All organisms were recorded quantitatively where possible but colonial forms (bryozoans, hydroids and sponges) were recorded on a presence/absence basis.

3.1.3 Results & Future Analysis

All raw data are presented in Appendix 1. Two hundred and eight taxa were found, of which one hundred and eighty one were identified to species level. Of these the great majority were also found in the baseline surveys. Of those which were not, none were found in large numbers, and none are unusual or indicative of any unusual or important communities, or of significant changes to existing

communities. All taxa found are known from Liverpool Bay. As in the baseline studies, polychaetes seem to be the dominant taxon in terms of numbers of individuals and species.
Only one unusual species was found. This is the thumbnail crab *Thia scutellata.* This is regarded as a species of concern by the Countryside Council for Wales (Moore, 2002). It was found in the baseline surveys and appears to be widespread in Liverpool Bay, although thought to be limited to certain habitats (well sorted medium sands; Rees, 2001). In this study it appears to have occurred in less well sorted sands than is usual, but the numbers found are fairly low.

Viewed overall, the total numbers of species found per sample are low to moderately high (mean 26.9, range 8 to 61) as are the numbers of individuals (mean 203, range 18 to 857). Diversity indices also appear to be low to moderately high (e.g. Shannon Wiener index mean 0.316, range 2.258 to 3.285) (Table 4). For all of these indicators, the ranges seem to indicate no major shifts compared to the baseline surveys.

The major biotopes found in the baseline surveys were as follows (also shown in Figure 4):

- IGS.Sell (*Spisula elliptica* and venerid bivalves in infralittoral clean sand or shell gravel), thought there was also a similarity to the related biotope IGS.Fab/Mag (*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves in infralittoral compacted fine sand). Parts of this biotope had evidence of stonier sediments although this was more obvious in beam trawl and anchor dredge samples than in Day Grab samples
- CMS.AbrNucCor (*Abra alba*, *Nucula nitida* and *Corbula gibba* in circalittoral muddy sand or slightly mixed sediment)
- IMS.EcorEns (*Echinocardium cordatum* and *Ensis* spp. in lower shore or shallow sublittoral muddy fine sand)
- IGS.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand)

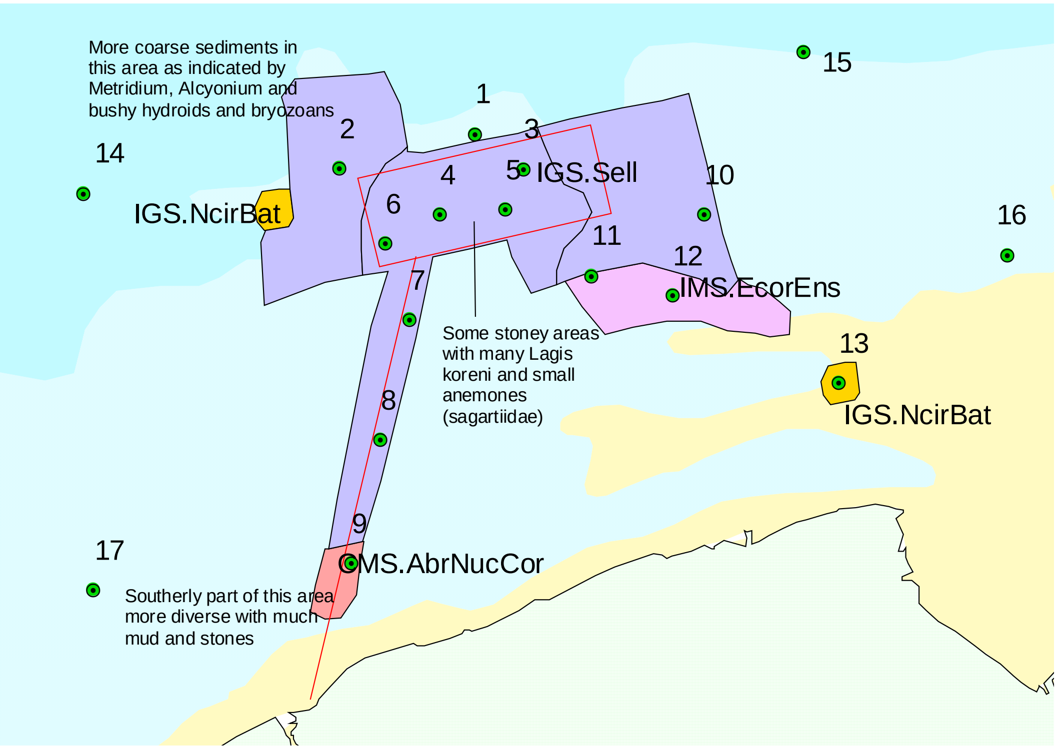


Figure 4. Sites surveyed in September 2002 overlain onto the main biotopes identified during baseline studies, August 2001.

The communities found in the present surveys again seem to be broadly similar to those described in the baseline surveys. Taxa associated with the major biotopes described above, together with some indicators of stonier bottoms such as various sessile hydroids and bryozoans, and anemones (sagartiidae), again as described in the baseline survey, seem to be present. Detailed interpretation and comparisons will be carried out after post –development surveys have been undertaken.

Multi Dimensional Scaling (MDS) analysis and cluster analysis of the samples shows that, in general, the 3 replicates at each site cluster together well indicating that they tend to be much more similar to each other than to samples from other sites. (Figures 5 and 6). The main exceptions are at sites 6 and 10. At site 6, which is in the south west corner of the windfarm site, the three replicates were apparently very different to each other, but observation of the raw data suggests this is to some degree an artefact of the low diversity of the samples, which each have a large number of unidentified cirratulids and small (but to some degree variable) number of other taxa. At site 10 the disparity is caused by sample 10.2, which appears to have hit a coarser sediment than the other two samples, which have communities more typical of sandier areas. This indicates small-scale heterogeneity. Sediment field notes support this (Table 3b), and moreover it appears that the sediment sample taken may have been something in-between the sediment types.

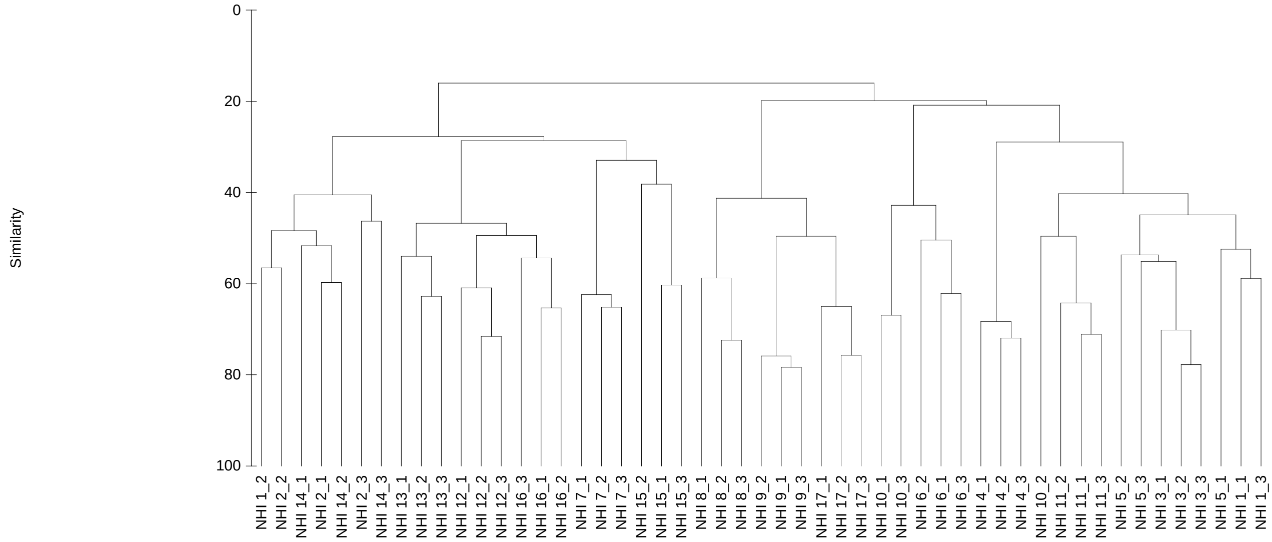
MDS and cluster analysis based on the pooled data shows the overall relationships between the sample sites (Figure 9). Sediment structure is thought to have a very strong influence on benthic infaunal communities. Superimposing major sediment parameters (TOC; mean particle size; sediment descriptions) onto this MDS indicates some influence but it is by no means very clear cut (Figure 7). Site 10 should, of course, be regarded with caution.

Future analysis will include:

- The primary objective is comparison of the communities at the seventeen study sites before and after the development (univariate and multivariate). This analysis is to determine any changes in invertebrate communities in the area which may be related to windfarm construction and/or operation. This information will be specifically interpreted in relation to any changes recorded in common scoter populations in the area.
- More detailed description of the communities, including comparison of communities with the previous North Hoyle surveys of 2001 (univariate and multivariate statistics, and discussion of any differences);
- Incorporation of additional sites adjacent to an installed monopile to determine localised, near-field, effects.
- Investigation of the influence of environmental parameters (including, but not limited to, sediment particle size and total organic carbon) on the above community relationships and changes (if any). Methods may need to be adjusted to take into account small scale heterogeneity (such as at site 10, for example).
- Analysis of spatial distribution of important species e.g. *Thia scutellata,* and indicators, especially if there are any important changes.

Table 4. Univariate statistics (No of taxa, no of individuals, Pilou's diversity index and Shannon Wiener diversity index) for individual samples from North Hoyle, September 2002.

Site	S (No of taxa)	N No of individuals	Pilou's diversity index J'	Shannon Wiener diversity index H'(loge)
NHI 1_1	23	154	0.795843	2.495362
NHI 1_2	18	55	0.781229	2.258043
NHI 1_3	35	152	0.764599	2.718415
NHI 2_1	20	58	0.740748	2.219083
NHI 2_2	26	90	0.801865	2.612554
NHI 2_3	41	181	0.787949	2.926105
NHI 3_1	40	261	0.795269	2.933653
NHI 3_2	40	257	0.768398	2.834526
NHI 3_3	44	244	0.801545	3.033198
NHI 4_1	50	632	0.576416	2.254954
NHI 4_2	61	781	0.62627	2.574516
NHI 4_3	57	857	0.618875	2.502143
NHI 5_1	27	138	0.734234	2.419914
NHI 5_2	36	128	0.830029	2.974423
NHI 5_3	44	152	0.868001	3.284679
NHI 6_1	15	272	0.362424	0.981462
NHI 6_2	20	135	0.402397	1.205474
NHI 6_3	9	274	0.143799	0.315958
NHI 7_1	19	63	0.807268	2.376951
NHI 7_2	16	51	0.866208	2.40164
NHI 7_3	16	55	0.854371	2.368818
NHI 8_1	39	214	0.709514	2.599347
NHI 8_2	38	270	0.706965	2.571647
NHI 8_3	35	254	0.627003	2.229215
NHI 9_1	23	285	0.664623	2.083922
NHI 9_2	26	375	0.629181	2.049932
NHI 9_3	19	289	0.635153	1.870169
NHI 10_1	18	186	0.494273	1.428632
NHI 10_2	40	531	0.701089	2.586231
NHI 10_3	15	151	0.62183	1.683947
NHI 11_1	38	406	0.739354	2.689465
NHI 11_2	46	378	0.738717	2.828283
NHI 11_3	34	339	0.704434	2.484089
NHI 12_1	12	89	0.473083	1.175568
NHI 12_2	14	82	0.7548	1.991961
NHI 12_3	11	86	0.638244	1.530442
NHI 13_1	13	48	0.807538	2.071293
NHI 13_2	8	51	0.667001	1.386989
NHI 13_3	11	51	0.770284	1.84706
NHI 14_1	26	69	0.799992	2.606451
NHI 14_2	26	75	0.809012	2.635838
NHI 14_3	38	109	0.841991	3.062815
NHI 15_1	20	41	0.893771	2.677499
NHI 15_2	9	18	0.780413	1.714743
NHI 15_3	18	38	0.863905	2.497007
NHI 16_1	13	86	0.73095	1.87485
NHI 16_2	12	59	0.826459	2.053673
NHI 16_3	18	82	0.6743	1.948978
NHI 17_1	37	195	0.748713	2.703541
NHI 17_2	25	231	0.697111	2.243914
NHI 17_3	31	290	0.674277	2.315457



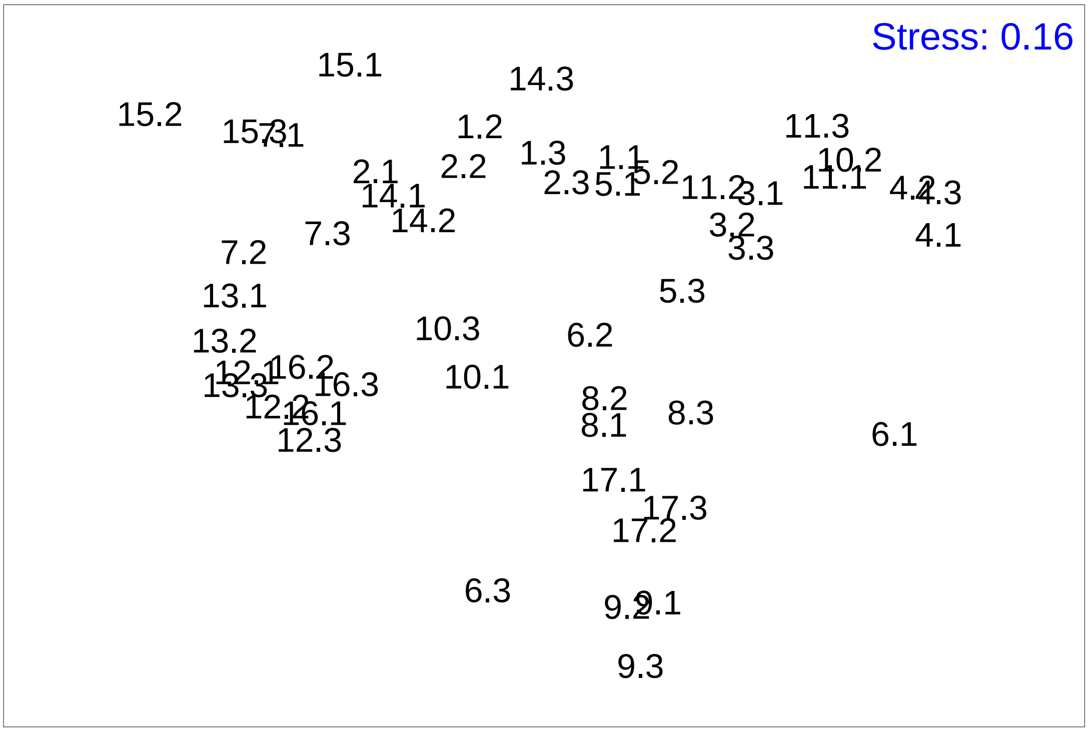


Figure 5. Cluster analysis and MDS showing inter-relationships in the communities from the 51 samples taken at North Hoyle in September 2002.

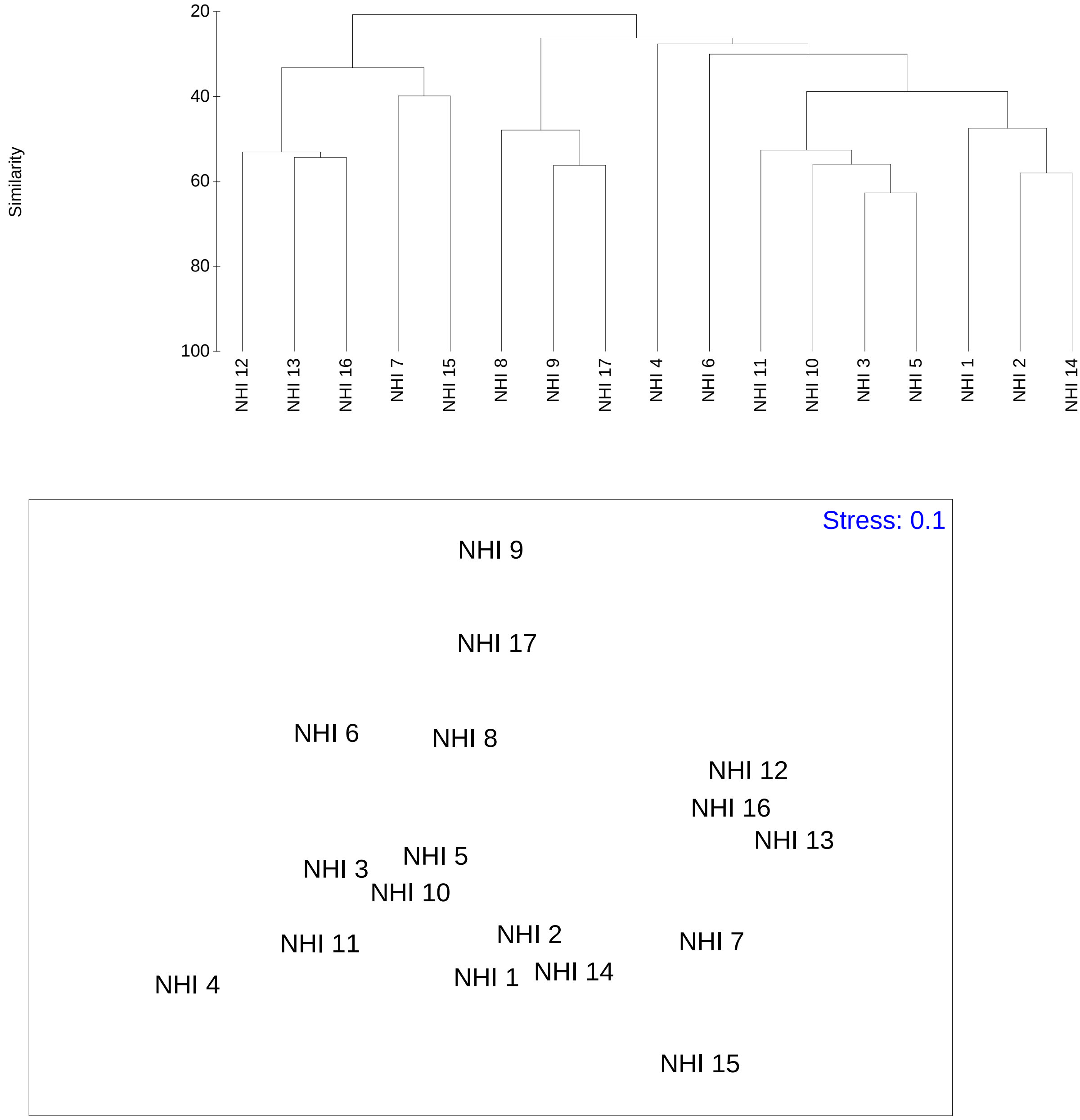


Figure 6. Cluster analysis and MDS showing inter-relationships in the communities from the 17 sites (3 replicates poooled in each case) taken at North Hoyle in September 2002.

A
& mean mm

B
& TOC

C
& sediment
descriptions

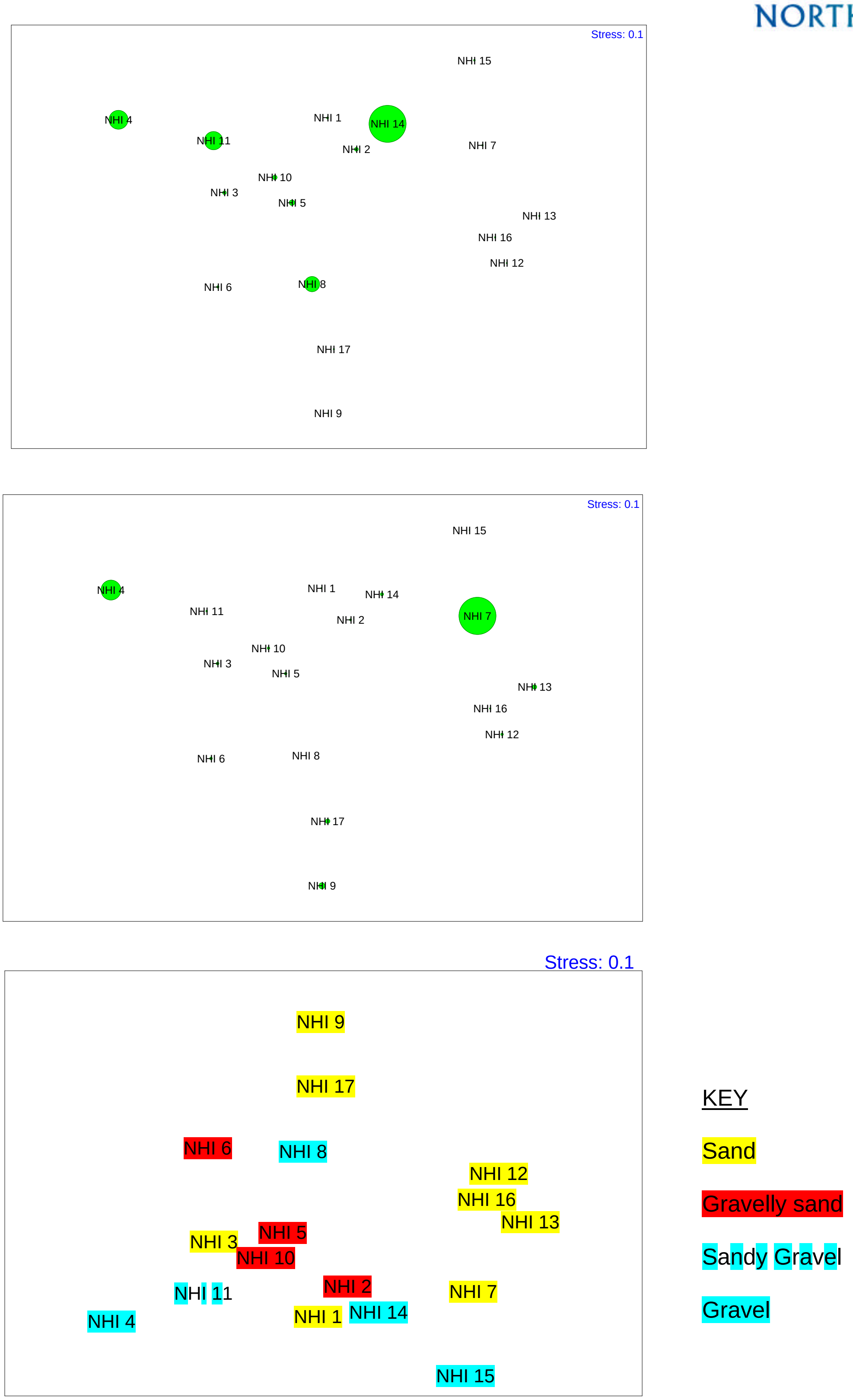


Figure 7 MDS showing the relationship between the seventeen sampled sites (three replicates, pooled data), with A) mean sediment diameter in mm, B) total organic carbon (%) of the fine fraction, and C) broad sediment categories, based on JNCC Folk triangles, superimposed. Note that the MDS process has inverted the image in C).

3.2 Colonisation of monopiles and any scour protection

Monitoring of the colonisation of monopiles and scour protection will be determined by diver-operated video surveys (with some accompanying sample collection for verification of identification).

Video surveys would be carried out annually and will commence in 2004 to allow for installation and colonisation of turbine support structures. The monitoring will involve video surveys of two monopile foundations (remote from one another) over a 2-day period. The survey would start at the bottom of the foundation/scour protection and move up one side continuously capturing the foundation. This would be repeated on the opposite side of the foundation to determine up and down-current effects. Video would be captured digitally and edited for analysis of species present. Samples of species seen will be collected and identified to aid in identification from video footage.

Grid counts (species counts in standard grids, e.g. 0.5m2) will be collected at 3 heights on the turbine foundation by holding a grid against the foundation surface. In addition, the divers will make a skilled eye assessment of percentage cover of the main species present on the turbine foundation. Oceanographic conditions including information on visibility will be recorded on each survey day.

A statutory 4-man diving team will carry out the survey. All diving and diving preparations will be carried out to HSE Regulations and following ACOPS guidelines and dive practices as per the on-going video survey of the North Hoyle Anemometer Mast.

4. INTERTIDAL ORGANISMS

The FEPA licence (Annex 1) states that such intertidal monitoring is only applicable if the cable route along the Clwyd Estuary is pursued. As such a decision on the final cable route had not been made by September 2002, sampling of intertidal areas was undertaken and samples retained for possible future analysis. However, this route has not now been utilised, and so this monitoring has not been pursued further.

5. MARINE FISH

5.1 Monitoring effects of changes in sediment on fish populations

In preparing the monitoring proposals, the views of CEFAS, CCW and local fisherman have been sought through interviews/consultation as described in Section 9.7 of the Schedule to Licence No 31579/02/0 (as amended). NWNW Sea Fisheries Committee are also on the list of consultees. This consultation has been carried out in collaboration with the appointed Fisheries Liaison Officer.

5.1.1 Consultation with commercial fishermen

Fishing activity within Liverpool Bay, and around the North Hoyle site in particular, was reviewed during preparation of the North Hoyle Wind Farm Environmental Statement (Innogy, 2002). The review established that there are only three under-10 m, registered fishing vessels that work regularly in the vicinity of the wind-farm site but a variable number of over 10 m trawlers work in Liverpool Bay but further offshore. The information gathered and the contacts made in preparation of the ES were used to inform the consultation process undertaken in the preparation of this monitoring chapter.

Shortly before construction work began on the wind-farm foundations, National Wind Power Ltd convened a meeting in Rhyl Town Hall to which a wide range of official, trade and leisure bodies and organisations, including fishermen, were invited to discuss navigation-related topics. Although the fishing industry presence was not comprehensive, a small number of fishermen and their representatives did attend. At this meeting National Wind Power Ltd introduced their fishery liaison officer (FLO - Dr S Lockwood) to the industry. Shortly thereafter, and immediately before construction work began on the wind-farm foundations, an information letter was sent by the FLO to more than two dozen individuals and organisations. This letter notified them that work was about to commence and provided contact details should they experience any problems associated with the construction work.

Up to the time of preparing this monitoring report, no individual or organisation has contacted the FLO to report any difficulties associated with construction work at North Hoyle.

In late May-early June, individual meetings were held with the skippers of the (under-10 m) fishing vessels operating from Rhos on Sea and Foryd Harbour, Rhyl, who work the North Hoyle area. Personal meetings were also held with the secretary of the Fleetwood Fishermen's Association (Mr K Moran), the Association's vice-chairman (Mr F Riding) and five other members of the Association who were in harbour at the time of the visit. Fishermen based on the Wirral were contacted by telephone, as were representatives of the offshore beam-trawl fleet from SW England: Cornish Fish Producer's Organisation (Mr P Trebilcock) and South Western Fish Producer's Organisation (Capt. Jim Portus). Regular contact has also maintained with the Deputy Chief Executive of the National Federation of Fishermen's Organisations (NFFO – Mr D Beveridge), although he was not contacted explicitly with respect to this monitoring consultation round.

In total 13 individual skippers and the representatives of three organisations were consulted during this monitoring exercise:

Conwy, Conwy	P Morris
Rhos on Sea, Conwy	A Hunt
Rhos on Sea, Conwy	John Povah
Foryd Harbour, Rhyl, Denbighshire	D Coulsen
Wirral, Cheshire	A Yoxall
Wirral, Cheshire	R Beach
Birkenhead, Merseyside	A Maddock
Fleetwood, Lancashire	F Riding
Fleetwood, Lancashire	C Clark
Fleetwood, Lancashire	R Collinson
Fleetwood, Lancashire	K Maguire
Fleetwood, Lancashire	L Sheard
Fleetwood, Lancashire	G Mitchelson
Cornish Fish Producer's Organisation	P Trebilcock, CEO
Fleetwood Fishermen's Association	K Moran, Secretary
South Western Fish Producer's Organisation	J Portus, CEO

The officers of the three organisations reported that none of their members has reported any problems related specifically to the North Hoyle wind farm site. Mr Moran said that only rarely would any of his Association's members work the North Hoyle area, particularly so early in the year. Messrs Portus and Trebilock said that some of their members' fishing vessels will undoubtedly have fished in Liverpool Bay this year but, generally speaking, they would not work that close inshore.

All six Fleetwood skippers consulted are members of the Fleetwood Fishermen's Association. Five of them are skippers of under 10 m vessels and said that the North Hoyle area is beyond the normal working range of their vessels. Usually they work grounds close to Fleetwood and Morecambe Bay and if they do work towards the south they are unlikely to go beyond the Taylor Bank (north side of the Queen's Channel approach to the Mersey). The one skipper consulted who has a vessel over 10 m said that he only fishes the North Hoyle area towards the end of the year; consequently, he has not been near the site since construction began. Even so, he rarely goes south of the North Hoyle buoy as "the ground is too hard".

Of the non-Fleetwood skippers, only three have been fishing in the vicinity of the North Hoyle site since construction began. Two are working bottom-set nets, the third is trawling. To date, none has experienced any difficulties nor noticed any apparent fall in the abundance or change in distribution of their catches. All have been following their normal pattern of fishing. The netters started their season inshore, working within 2-3 miles of the construction site, and are progressively setting their nets further offshore as their season develops. Even when the pile driver has been active they have only been aware of it if their vessels have been laying with the engine idling and there has been relatively little wind noise. Neither has found that pile-driving noise is intrusive or problematic. The trawler has even worked within one mile of the construction site and not noticed any adverse effect. 1

5.2 Monitoring effect of changes in sediment on fish distribution

CEMACS to contribute

5.2.1 Monitoring the fish fauna of North Hoyle

Monitoring changes to the fish fauna in any one locality is never easy, not least because any index of change must have a robust baseline data-set against which comparisons can be made. In addition, natural inter-annual variations in abundance and distribution can be greater than any change that might be attributed to anthropogenic effects on the marine environment. For these reasons project-based monitoring programmes are rarely satisfactory, particularly so if a long-standing independent survey can be utilised.

In the case of North Hoyle, the CEFAS Laboratory, Lowestoft, has maintained an autumn trawl survey of the eastern Irish Sea, including Liverpool Bay and North Hoyle, since 1991. This survey has core-funding support from the European Commission as it makes a fundamental contribution to the annual assessments of commercially exploited fish stocks in the Irish Sea. It is anticipated, therefore, that the survey will continue on an annual basis for the foreseeable future.

In addition to the annual analysis of samples relevant to the commercial stock assessment exercise, a multi-variate analysis of the total fish fauna has shown that there is a difference between samples taken in depths less than 20 m compared to those from depths greater than 20 m (Ellis *et al*., 2000). It is proposed to use these CEFAS trawl-survey data as baseline data for the North Hoyle monitoring programme and to commission CEFAS to make an annual comparison of sample data from the North Hoyle area with the baseline data and from Liverpool Bay as a whole. It is anticipated that if the development of North Hoyle wind farm results in a significant change in the abundance or distribution of the fish fauna it will be revealed in these data analyses. Conversely, it is assumed that if these data do not reveal any significant change it will be assumed that the wind-farm development is having a negligible effect on the communities of fish.

6. CETACEAN AND SEAL COUNTS

6.1 Cetaceans

6.1.1 Introduction

The only cetacean species that is seen with any regularity in Liverpool Bay and the local area is the harbour porpoise. Due to the fact that numbers of this species are low in Liverpool Bay, and that it is unlikely to be significantly affected by the proposed works, no on-site monitoring was suggested. However, recording of cetaceans is now being undertaken in conjunction with boat-based and aerial bird counts.

For site-specific monitoring, liaison with the Sea Watch Foundation is being maintained to monitor cetacean sightings in Liverpool Bay and the local area through the National Cetaceans Sightings Database. Data has been requested and will be incorporated into the next report.

6.1.2 Methodology

Methods employed during the boat-based and aerial bird counts are detailed in Section 9.

6.1.3 Results and Future Analysis

Observations of cetacean activity in the area of the development collated during the ornithological surveys between November 2002 and March 2003 are provided in Section 9 (Table 4).

The Sea Watch Foundation's sightings database will be used, together with records from the ornithological surveys, to determine inter-annual variation in sightings in the general area of the proposed wind farm to determine any discernible changes in numbers in the area.

6.2 Seals

6.2.1 Introduction

Atlantic Grey Seals (*Halichoerus grypus*) at Hilbre Island are currently monitored by the Hilbre Island Ranger Service and the Hilbre Island Bird Observatory. As such, additional monitoring of seals at this haul-out area is not considered necessary. However, monthly seal count data will be collected annually and compared with the data that has been collected over the past 25 years by the Ranger Service. This would highlight any increase or decrease in the numbers of seals using the sand banks around Hilbre island.

6.2.2 Methods

Monthly seal count data from the Hilbre Island (West Hoyle) haul out was obtained from the Hilbre Bird Observatory Report (2001). We have also included historic data from between 1964 and 1999 from previous Hilbre Bird Observatory Reports. Data for 2000 and 2002 should be available in approximately 2 months and will be included in the next report.

Maximum monthly counts (i.e. highest number of individuals present at any one time) are reported.

6.2.3 Results & Future Analysis

Maximum monthly counts for Atlantic Grey Seal at the West Hoyle haulout between 1964 and 2001 (not including 2000) are provided in Table 5. Numbers peak in summer with over 400 individuals present in recent years. This reflects the importance of this site for Irish Sea Grey Seals which congregate near Hilbre over the summer, swelling the local seal population of over-wintering individuals.

Further data will be collated and used to monitor and impacts of the offshore windfarm development.

Table 5 Maximum grey seal count per month at Hilbre Island

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1964	109	132	80	140	125	1460	125	146	148	80	80	145
1965	90	89	130	150	120	150	178	199	130	70	40	40
1966	50	35	132	93	100	120	196	186	150	70	75	65
1967	103	150	150	97	80	70	160	180	165	125	60	40
1968	75	80	150	130	144	40	153	180	140	30	40	75
1969	70	25	75	120	148	127	217	160	80	80	70	73
1970	55	60	125	107	130	80	160	142	150	80	89	45
1971	48	90	95	80	170	145	200	180	80	90	120	100
1972	60	50	100	111	152	100	105	160	115	75	65	85
1973	80	60	80	120	145	100	95	135	70	90	40	95
1974	70	90	75	100	110	120	130	145	60	60	80	90
1975	84	75	120	100	100	100	85	170	30	70	70	82
1976	86	70	85	95	90	110	100	100	100	85	40	6
1977	73	85	85	89	95	95	110	120	55	90	60	25
1978	85	26	40	73	110	115	110	135	135	135	60	55
1979	78	40	70	90	----	125	114	145	106	60	75	88
1980	45	45	95	80	71	85	116	140	120	75	75	40
1981	50	25	55	85	85	95	125	110	100	80	65	31
1982	45	79	95	107	120	155	107	167	154	146	63	88
1983	79	84	84	95	110	100	140	141	163	133	68	35
1984	64	78	78	110	110	120	148	178	100	115	70	70
1985	65	75	85	165	140	150	200	206	150	120	75	80
1986	70	65	120	150	160	155	212	190	215	120	48	101
1987	80	108	172	140	246	180	250	260	175	146	120	80
1988	102	104	130	135	175	203	173	227	175	170	110	80
1989	85	85	130	150	153	200	200	278	120	120	90	75
1990	75	100	170	110	173	143	227	216	180	100	98	80
1991	75	67	120	200	250	205	342	262	249	110	90	125
1992	98	161	202	225	250	212	283	245	200	100	70	120
1993	107	120	133	225	403	350	275	261	227	190	78	65
1994	130	83	180	269	284	470	210	296	270	172	158	212
1995	120	170	251	186	250	282	401	340	196	146	130	155
1996	78	120	120	273	350	391	318	420	316	250	122	119
1997	70	180	278	285	396	373	424	335	403	206	120	80
1998	90	219	235	220	379	394	310	443	265	175	170	175
1999	143	146	198	350	476	420	477	473	472	212	200	130
2001	165	147	175	325	463	327	477	547	350	215	210	120

7. EMF

The following describes the proposed monitoring of electromagnetic fields required to comply with Section 5, Annex 1 of the Food and Environmental Protection Act (FEPA) 1985: Part II (as amended), licence 31579/02/0 to NWP Offshore Ltd for the North Hoyle Offshore Wind Farm.

Information on the cables, shielding, burial depths and sediment types to be implemented at North Hoyle is appended below.

The COWRIE EMF study currently being undertaken by CMACS is investigating the modelling and measurement of the E (electric) and B (magnetic) emission from as representative a cable geometry as is practicable. This project has now completed and a draft report prepared. The finalised report is to be issues shortly and is to be made available to COWRIE members and windfarm developers.

Notable outputs of the study are that a preliminary model has been developed and results have been verified against the analytical solution. Furthermore, transducers to measure the B and E field of a cable in-situ have been constructed and tested. These may next be applied to working windfarm cables.

Information from other sources would also be considered as part of this analysis. This would include, notably:

- the Westerberg and Begout-Anras (2000) investigation of the orientation of silver eels (*Anguilla anguilla*) in a disturbed geomagnetic field created by the presence of a submarine HVDC power cable.
- an investigation in 2002 of the effect of noise/vibration and electromagnetic fields on fisheries at the Vindeby wind farm, Denmark (Bio/consult 2002)
- SEAS, Denmark intend to repeat the above investigation at the R∅dsand wind farm site. To date, they have collected baseline data on migratory/electrosensitive fish species in the general area of the cable route. Monitoring of fish migration over the cable will be carried out between 2003 - 2005 (Holm Skyt, SEAS, pers. comm.).

The specifications for cables to be used at North Hoyle will be related to these studies on completion of the COWRIE study (expected August 2003). This would allow us to predict whether field strengths are sufficient to have potentially detrimental effects on electrosensitive fish species.

If potentially detrimental effects are determined, the final fish survey methodology would therefore include additional biological monitoring to investigate this effect. This monitoring would be subject to separate agreement by the licensing authority and the interpretation of the COWRIE study is expected to be included in this separate agreement.

8. UNDERWATER NOISE AND VIBRATION

Measurement of underwater noise is being undertaken by the contractor carrying out the current COWRIE study on noise and vibration, Subacoustech. This has included baseline surveys undertaken prior to construction and currently ongoing 'during construction' surveys at the North Hoyle Offshore Wind Farm.

Detailed methodologies have been provided and approved by Subacoustech as part of the COWRIE bidding process (of which we believe CEFAS and CCW are part). CMACS/NWP are in contact with Subacoustech to ensure that biological (particularly fish) and acoustic monitoring can be combined as far as possible and the results of each survey related and the results integrated into annual monitoring reports.

It understood that the baseline data is yet to be reported to COWRIE and will be available in future monitoring reports.

9. ORNITHOLOGY

This chapter summarises the first stage of ornithological monitoring works at North Hoyle, undertaken to meet the FEPA licence requirements. The FEPA Monitoring Statement submitted by National Wind Power Offshore Ltd provides five Objectives for the full duration of the ornithological monitoring of North Hoyle Offshore Wind Farm and specific agreements where dialog with the Countryside Council for Wales, as advisors to the licensing authority, is required. In this chapter progress in the monitoring programme and in agreement on future methods for survey and analysis for each Objective are reported on. For each Objective, background information is provided on the need for the work, the methods summarised, results to date provided and, where useful, compared with those from the baseline data gathered for the environmental statement. The chapter covers data gathered up to the end of March 2003.

9.1 Objective 1: Determine whether there is change in bird use, measured by numbers and behaviour, of the wind farm

9.1.1 Introduction

There is a requirement in this Objective to be able to detect any change in both numbers and behaviour of birds, as birds may move through the wind farm, but be reluctant to feed. The requirement for this behavioural data dictated the use of boat surveys.

Sampling effort, measured by the frequency and size of samples, determines the statistical power of a survey. In an experiment that tests for an effect, there are three related quantities:

- The size of effect. This is the minimum detectable difference between the mean value before and after the treatment (building a wind farm);
- The probability that if such an effect exists, we find it. This is the power of the test. It is common to use 80% or 90%; and
- The number of sampling units used in the experiment (in this case sample days).

If two of these quantities are specified, the third can be estimated. A requirement of this Objective of the monitoring programme was to determine the sample size that would detect a given magnitude of effect for the component species from adjacent designated or potential statutory sites for nature conservation (listed in the Monitoring Statement), except for common scoter, which is dealt with through aerial survey in Objectives 3 and 4, below.

Where possible, time of day and state of tide was to be factored in to the study design.

The boat-based surveys were to provide flight height data to meet the data requirements of Objective 5.

9.1.2 Methods

Boat survey methods for species other than terns followed Komdeur et al 1992. The survey area is shown in Figure 8. Observers recorded as a priority species, number and distance from the boat. Where possible within time constraints on observation, the direction and height of flight and behaviour were noted. For observations of terns, the boat was moored at points to the south of the wind farm and the direction of flight of birds through the wind farm recorded. Survey tracks and points are shown in Figure 8.

Power analysis was undertaken with agreement from CCW on an earlier data set, gathered for the cumulative impact assessment study for the North Hoyle Offshore Wind Farm Environmental Statement in the winter of 2001/02. Dr Alain Zuur of Highland Statistics was contracted to undertake the work. Classical power analysis methods, as described in Zuur 1999, were followed. Subsequent to the findings and further comments from CCW, additional analysis was undertaken; Box-Cox transformation, re-analysis excluding the March data and analysis at 10% and 20% significance levels. March data were clearly excluded due to the notable drop in bird populations as a result of seasonal migration patterns and the onset of the breeding season.

Time of day and state of tide were planned as variables, but with the acceptance that it was necessary to mobilise boats when they were available and weather was suitable, therefore the variables of time of day and state of tide were subject to opportunistic availability and this will remain the same for future analysis.

Flight height was recorded as above and below the horizontal from observer eye height.

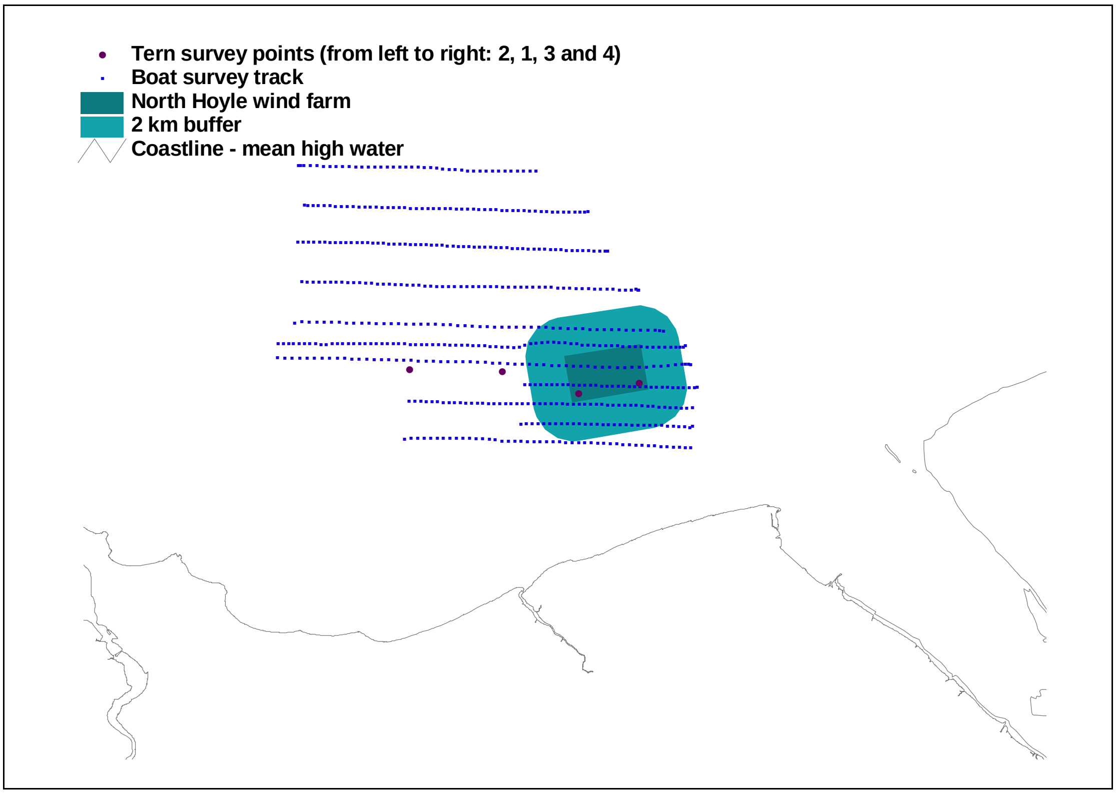


Figure 8: The location of boat transects and survey points for tern surveys 2002-03

9.1.3 Results

Eight transect survey days were achieved between November 2002 and March 2003 and four point surveys of terns in September 2002. The results are presented in Tables 1-4 of Appendix 1.

The power analysis reports are provided in Appendices 2 and 3. Power analysis was not undertaken on the tern observations, due to the very small sample size. For other species of interest, the results follow, with the reasoning provided in more detail for cormorant, as an example.

Cormorant

Sampling took place on 9 days. An observation of cormorants (either 1 or more) was made, on average, 28 times per day. Using the same sampling effort in 2003 (9 days) will result in a detectable difference of 18. This means that if on average, 10 or less times cormorants are observed (or 56 or more) per day, one can statistically prove that there is a difference. A detectable difference of 18 corresponds to a reduction (or increase) of 65%. If the sampling effort in 2003 is doubled, the detectable difference will still be only 50%.

Fulmar

Using the same sampling effort in 2003 will result in a detectable difference (reduction or increase) of 125%. Hence, even if no Fulmar will be detected in 2003, one cannot statistically detect a reduction. If the sampling effort in 2003 is increased to 25 days, the detectable difference will be100%.

Guillemot

Using the same sampling effort in 2003 will result in a detectable difference (reduction or increase) of 51%.

Kittiwake

Using the same sampling effort in 2003 will result in a detectable difference of 100%. Increasing the sampling effort to 12 days will result in a detectable difference of 85%.

Razorbill

Using the same sampling effort in 2003, the detectable difference is 86%.

Red-throated diver

Using the same sampling effort in 2003, the detectable difference is 108%.

Shag

Using the same sampling effort in 2003, the detectable difference is 111%.

Further analysis requested by CCW, fully reported on in Appendix 3, shows that if the rigour is relaxed to 20% significance, meaning the probability that a null hypothesis of no effect is wrongly rejected, is 20%, as opposed to the original 5%, then detectable changes improve. The results of further transformation are biologically unclear. The removal of March data does not improve the ability to detect change and was accounted for as a seasonal effect in the ANOVA for the original analysis.

Table 1. Detectable differences as a percentage of the mean value using total number per days. for 20% significance levels. The column labels refer to species (CO=Cormorant, FU=Fulmar, GU=Guillemot, KI=Kittiwake, RA=Razorbill, RD=Red-throated diver, SH=Shag).

CO	FU	GU	KI	RA	RD	SH
46	127	78	98	83	81	76

9.1.4 Conclusions

Boat surveys have shown that a reasonable amount of winter survey effort will result in the ability to detect approximately 50% change with statistical confidence only for two species, cormorant and razorbill. For other key species there is less sensitivity to detect change. This situation would not improve with approximately 20 survey days, which it would be unlikely to achieve in winter in the eastern Irish Sea. Relaxation of the level of significance from 5% to 20%, which results in a higher probability that an incorrect conclusion of “no effect” is accepted, improves the ability of reasonable survey effort to detect change.

Surveys will continue monthly to the end of 2003. It is proposed, as the outcome of discussion with Alain Zuur, that:

- further surveys are concentrated in mid-winter, in practice November to February, to avoid seasonality in the data, rather than an attempt to gather data through a calendar year;
- the transect design, currently being investigated, will as much as possible provide even survey effort for the wind farm and a series of concentric rectangles at 0.5km spacing around the site, out to 2km;
- all surveys are confined to this area; and
- tern foraging surveys for the first post-construction year are undertaken as transects perpendicular to the coast through the wind farm, following RSPB methods being implemented this summer to record little tern foraging activity south of the wind farm. If activity continues to be at the low level recorded in 2003, the summer surveys will cease.

Refinement of methods of flight height measurement will be investigated and reported to CCW.

9.2 Objective 2: Determine whether there is a barrier effect to movement of birds through the site

9.2.1 Introduction

For the first year's monitoring report, to inform on monitoring methods for this Objective once the wind farm is constructed, National Wind Power Offshore Ltd commissioned a pilot study, formally outside of the FEPA monitoring requirements, to test the utility of land-based and boat-based marine surveillance radar (MSR). The aim was, through overlapping radii of detection of observers with standard optics, land-based MSR and boat-based MSR, to find a best method of monitoring movement of key species, the effectiveness to be measured by the ability of each survey method to record over distance and identify species and flock sizes.

The test of boat-based radar was pertinent given the problems of achieving adequate radii of detection from land, to cover the North Hoyle Wind Farm with any existing radar available in the UK and the absence of suitable placed stable platforms for mounting radars.

The work commissioned by National Wind Power Offshore Ltd will be fully reported on prior to the establishment of methods for monitoring post-construction. Here, the summary findings are presented.

9.2.2 Methods

The study site was off Llandulas in Colwyn Bay. Field work was undertaken over three continuous 24 hour periods in March 2003. Radars were set up on land (6kW and 12kW Furuno S-band) at Llandulas, south of the main common scoter concentration, and using the existing radars of the Prince Madog (Furuno 35 kW S-band and12kW X-band) 1km to 2km north of the main common scoter concentration. On the boat, visual observations were made during daylight hours.

9.2.3 Results

Weather conditions

Weather conditions were uniform during the test.

Species identification

All species could be identified by visual observation. Radar trails and the speed at which they moved enabled identification of common scoter (strictly a duck signal, but no other duck species were observed during the test), auk and gull. Of the key species in Liverpool Bay, no adequate observations were made to test the radar's ability to record divers Gavia spp. The ability to identify trails was not noticeably sensitive to the strength of the radar.

Range of identification

The identification range for species from radar was superior to that from visual observation, for the species that could be distinguished by radar. Range was sensitive to the kW power and signal type, range increasing with power and being superior, measured by the number of signals on the screen at different distances, for the 35kW S-band radar.

Opportunistic observation demonstrated the utility of radar for mapping of the movement of common scoter. On the first two survey days, movements observed from visual observations were followed for longer periods of time on the radar screens, presenting a persistent pattern of movement over a distance that would otherwise have been un-detected.

Flock size

Radar observation could not distinguish flock size, although if flocks were loose, for example with common scoter, then the relative sizes of the flocks could be estimated from the size of the proportion of the screen covered with radar trails.

9.2.4 Conclusions

In a location, such as the North Hoyle Wind Farm, where existing radar systems other than tracking radar cannot provide full coverage of the site from land and there are no suitably placed offshore platforms, the test proved the utility of MSR on a boat for the mapping of movement of common scoter. Given concerns over the movement of this species in Liverpool Bay, a practical solution to this data gap for the monitoring of North Hoyle was demonstrated, at least in good weather conditions.

MSR has the limitations of its range of detection and it is not yet clear how sensitive detection is to the type of radar. Also for some species of interest there is no confirmed ability of MSR to specifically identify the signal. For the radar system of the Prince Madog, range has been demonstrated to be adequate to cover North Hoyle and a 2 km buffer, if the boat was moored at the centre of the wind farm and within this range common scoter movement can be mapped. Therefore there is a practical means for this species of undertaking studies into the effects of North Hoyle on movement patterns, should these occur in or adjacent to the wind farm.

9.3 Objective 3: Determine the distribution of common scoter in Liverpool Bay, through continued contribution to aerial survey co-ordincated by CCW, covering North Hoyle and the vicinity

9.3.1 Introduction

Common scoter is the key non-breeding species in Liverpool Bay in relation to the first round of offshore wind farm applications, due to the population justifying European Site designation and the water depths at which it feeds coinciding with desirable shallows for wind farm development. Aerial survey is demonstrably the appropriate method for mapping the distribution of common scoter, a species that takes flight at considerable distances from boats. The survey methods have been refined through field test in Denmark and are presented in detail in Webb et al 2002 and Robinson & Oliver in prep. The best methods for analysis of the data, which is gathered at sample transects of 2km separation, is under investigation through a collaboration between the National Environmental Research Institute of Denmark and the Centre for Conservation Science University of St Andrews (Fox, Petersen & Helley, 2003).

In order to detect change in distribution, data can be analysed either as point data or, subject to the development of the NERI/St. Andrews model, modelled densities.

9.3.2 Methods

Aerial survey methods will follow those described in Webb *et al* 2002 and Robinson & Oliver *in prep*. Subject to discussion with NERI, observer co-variates will be recorded to allow the option of the data being analysed within their spatial model. A minimum of two flights of the Welsh side of Liverpool Bay for the purpose of the North Hoyle FEPA monitoring will be undertaken between November 2003 and March 2004, subject to discussion with CCW at the planning stage of their 2003/04 aerial survey project and the feasibility of mobilising aerial surveys during that period. The survey track is shown in Figure 9.

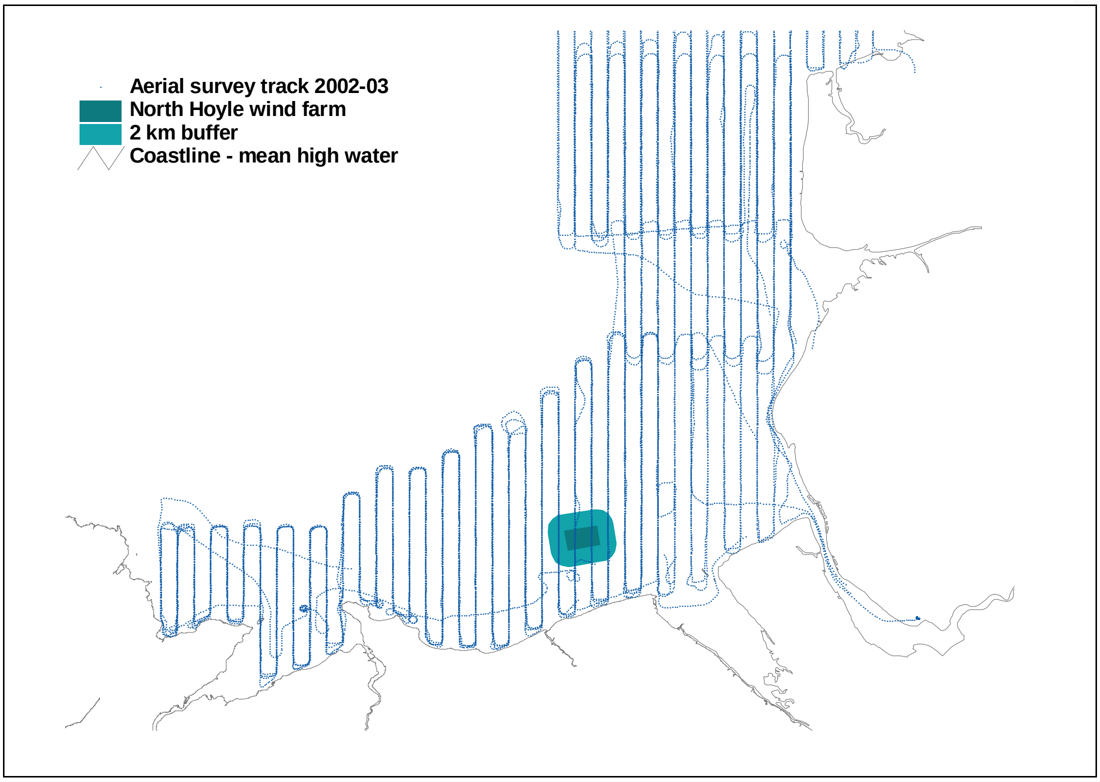


Figure 9: aerial survey track for 2001-2003

Data to analyse change in distribution will be the geo-referenced point data that is the output of the aerial survey. Outline methods of analysis are presented in Objective 4, below. Developments in the precision of spatial modelling will be followed and CCW informed on the utility of this method for the Objectives relating to common scoter.

9.3.3 Results

Unanalysed data for flights within the CCW 2002/03 All Wales common scoter survey to inform the FEPA licence are presented in Tables 5 and 6 of Appendix 1 for August, November and December 2002 and January 2003. Two further flights in February 2003 and May 2003 were undertaken. The data has not yet been made available, but will be incorporated in the analysis and subsequent FEPA monitoring reports. The cumulative distribution map for this data is presented in Figures 10-12, below.

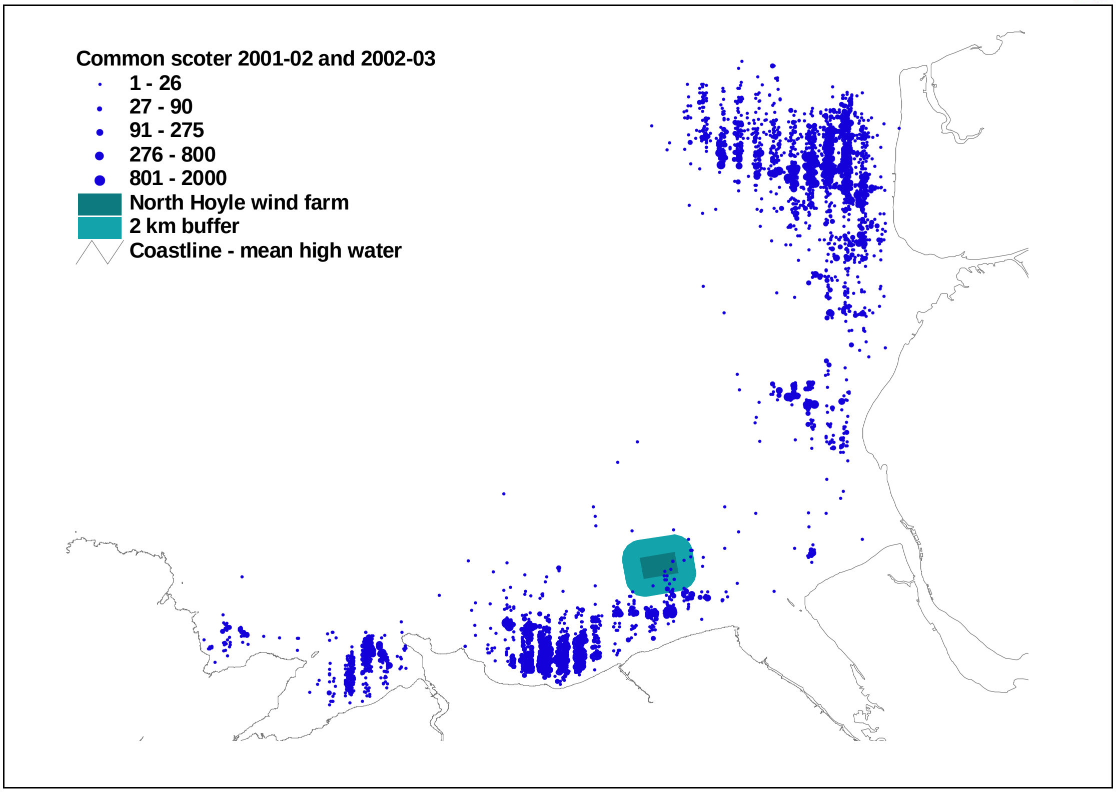


Figure 10: The cumulative distribution of common scoter in Liverpool Bay for 2001-2003

9.3.4 Conclusions

Aerial survey methods and survey logistics have been refined during three years of the CCW aerial survey of Liverpool Bay, in which National Wind Power Ltd has been a partner. The data analysis has pointed to the need for refinement to improve the precision of modelled densities. Such developments will be incorporated in the North Hoyle monitoring programme to, where feasible, improve the precision of detection of change in common scoter distribution.

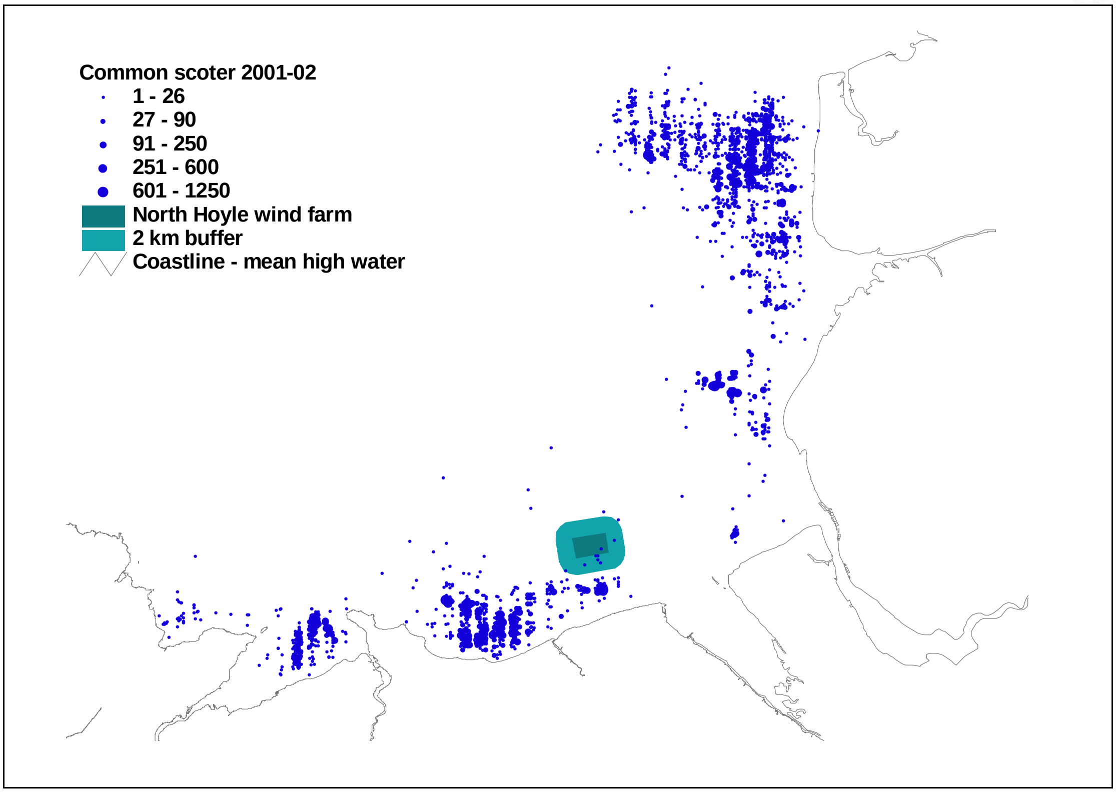


Figure 11: The cumulative distribution of common scoter in Liverpool Bay for 2001-02

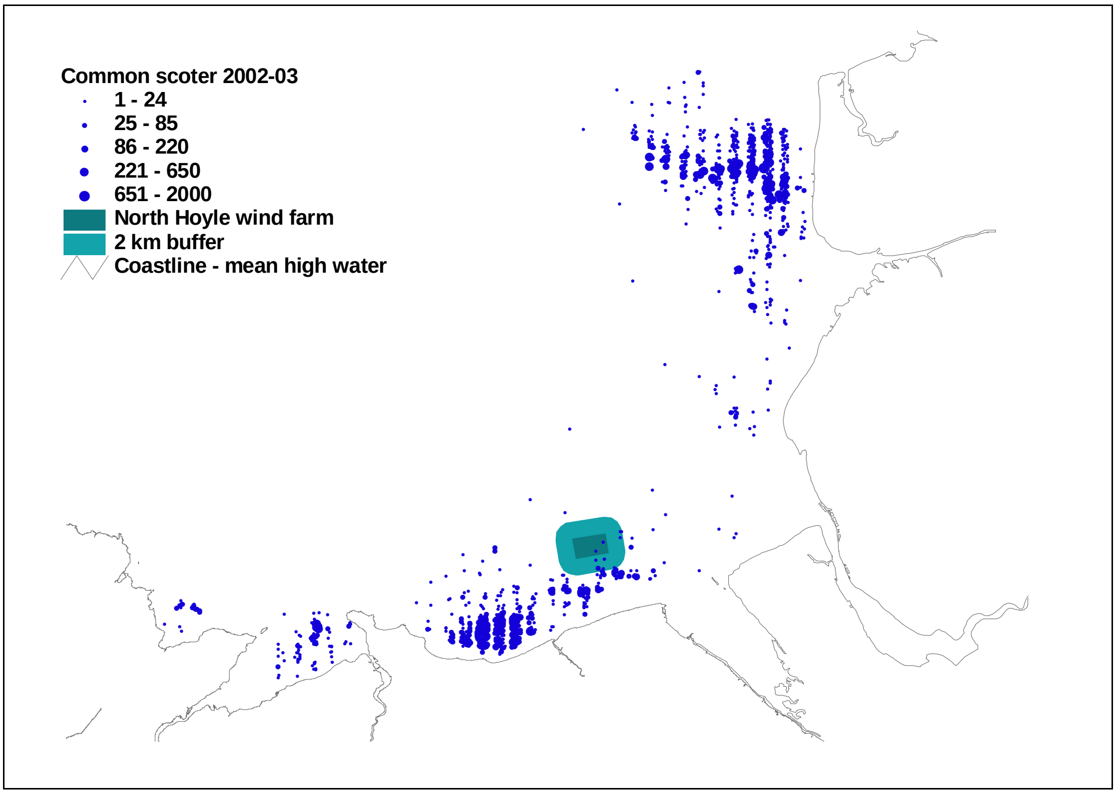


Figure 12: The cumulative distribution of common scoter in Liverpool Bay for 2002-03

9.4 Objective 4: If objective 3 shows change in common scoter population in the vicinity of North Hoyle, monitor the benthos to determine whether the change is a result of change in common scoter food supply

9.4.1 Introduction

This conditional Objective arose from the need to distinguish, should changes occur in the distribution and abundance of common scoter in the vicinity of the wind farm, whether the cause was the presence of the wind turbines, a change in the benthic fauna or independent factors. The change in the benthic fauna could occur as a consequence of a coarse change in sediment type as a result of wind farm construction activity or could be external to the wind farm, for example as a consequence of a change in invertebrate recruitment or predation pressure. Benthic monitoring under the FEPA licence has been agreed to detect gross changes in the benthic community. Changes in settlement or predation pressure could result in a shift in the abundance of age and size classes, at locations favoured by common scoter, which the present monitoring programme would not detect.

A change in the distribution of common scoter in response to avoidance of the wind turbines would be expected to result in a decline in abundance with distance from the turbines, over the distances at which displacement may occur. A change in the benthic fauna that could be implicated in a change in common scoter distribution, if not a gross change in benthic community type, would be detected through a change in the abundance of ages and size classes of the fauna on which scoter feed.

The unravelling of such a relationship is complicated by uncertainty over what common scoter feed on in Liverpool Bay, the poor ability of aerial survey to detect anything other than very large changes in common scoter abundance, the absence of detailed baseline data on the age and size classes of fauna at the scale at which common scoter data is gathered and the very high sampling effort required to detect any relationship between common scoter and benthic fauna (Robinson & Oliver in prep).

Bearing in mind these caveats, the following programme of work is being undertaken or is under discussion.

9.4.2 Methods

Distribution of common scoter

The distribution of common scoter throughout Liverpool Bay continues to monitored under the Countryside Council for Wales aerial survey of the Bay. The survey area is shown in Figure 10. Survey methods are fully described in Robinson & Oliver (in prep). Coverage is discussed under Objective 3. A minimum of one survey of an area to be agreed with CCW will be undertaken in November 2003, within the CCW contract for aerial survey of Liverpool Bay for 2003/04, or as soon as possible after November as is possible within the terms of that contract, survey logistics ad suitable weather conditions.

All common scoter observations are assigned to a six- figure grid reference. The two winters of pre-construction data (2001/02 and 2002/03) and one or more post-construction flights in the last quarter of 2003 will be analysed as point data of location and number of birds against distance from the nearest turbine. At the time of analysis no data will yet be in the public domain on common scoter displacement around turbines. Such data, if this effect occurs, may come out of the monitoring of Horns Rev Offshore Wind Farm, for which reporting is anticipated to be in the spring of 2004. Therefore, it is proposed to investigate the relationship between common scoter distribution, as data points from the aerial survey, and turbine location, separately for all observations at scales of 0-1km from the wind farm application site boundary, 0-1.5km, 0-2km, 0-5km and 0-10km. Where there is both benthic sampling and aerial survey data, a qualitative assessment will be made of the relationship between the two, pre- and post-construction. The timetable for this work is presented in the monitoring statement.

9.4.3 Results

Unanalysed data for flights within the CCW 2002/03 All Wales common scoter survey to inform the FEPA licence are presented in Tables 5 and 6 of Appendix 1 for August, November and December 2002 and January 2003. Two further flights in February 2003 and May 2003 were undertaken. The data is not yet available, but will be incorporated in subsequent analyses.

9.4.4 Conclusions

The nature of any relationship between common scoter distribution, the location of turbines and change in the benthic fauna that should trigger more intensive benthic sampling and the practicality of such a sampling programme will be under discussion with CCW subsequent to the analysis.

9.5 Objective 5: If objectives 1 or 2 reveal significant use of North Hoyle by populations of conservation concern, at heights that couls incur a risk of collision, a programme of collision risk monitoring will be implemented

9.5.1 Introduction

Objective 5 is a conditional Objective. Species of conservation concern are defined in the North Hoyle Monitoring Statement as species that could qualify the wind farm site for inclusion within a Special Protection Area, under Articles 4.1 or 4.2 of the Directive on the conservation of wild birds (79/409/EEC).

Under the criteria presented in the advice document on the implementation of this Directive in UK inshore waters (Johnston *et al.* 2002), parts of the Welsh waters of Liverpool Bay may be classified as marine SPAs for:

- Seawards extensions of breeding colony SPAs beyond the mean low water mark for:
  Little tern *Sterna albifrons* and common tern *Sterna hirundo* from the Dee Estuary SPA; and
  Common tern *Sterna hirundo* from The Mersey Narrows and North Wirral Foreshore SPA; and
- Inshore areas used by birds in the non-breeding season for:
  Sandwich tern *Sterna sandvicensis* from The Dee Estuary SPA;
  Red-throated diver *Gavia stellata*; and
  Common scoter *Melanitta nigra*

This conditional Objective therefore requires two lines of evidence to justify its implementation:

(1) that North Hoyle is included within one or more of the possible marine SPAs listed above; and
(2) that “significant” use of the wind farm site with flight at turbine blade height is recorded for the qualifying population(s) of the SPA(s).

9.5.2 Methods

In the absence of agreed criteria for marine SPA selection, the likelihood of the inclusion of North Hoyle Offshore Wind Farm is based on visual inspection of data gathered for the FEPA licence up to March 2003.

The threshold of significance for flight at turbine blade height is subject to ongoing discussion with CCW.

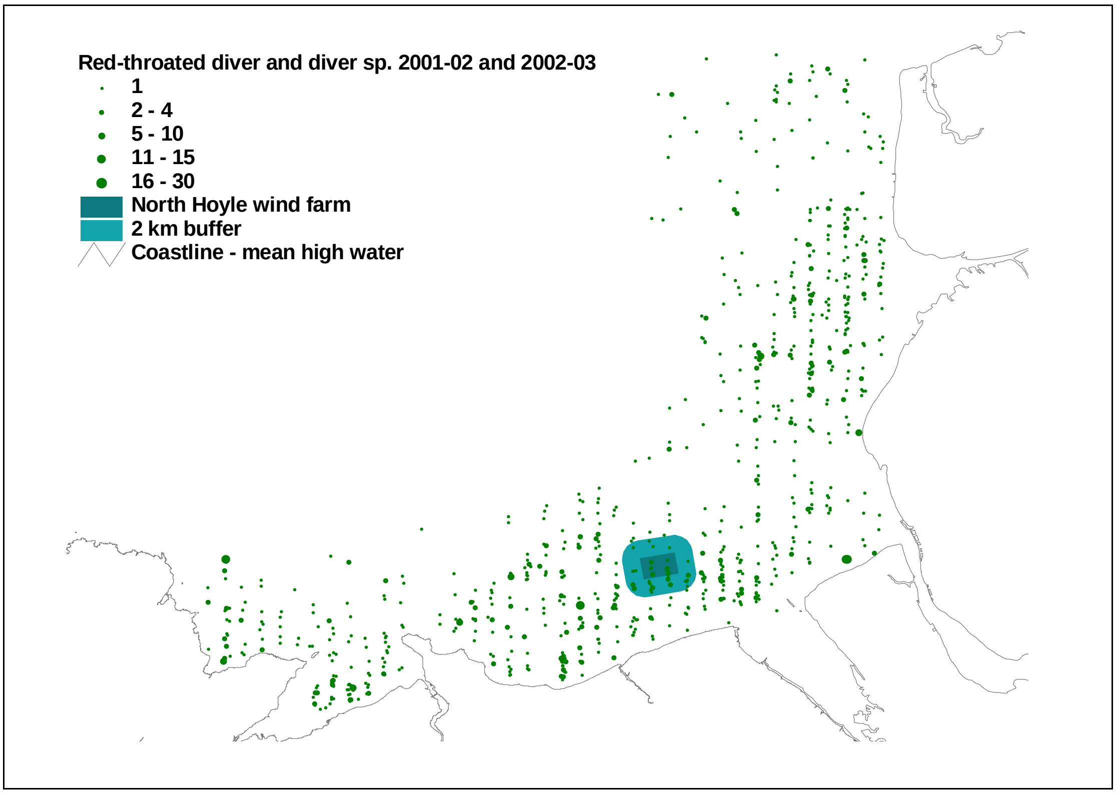
9.5.3 Results

SPA boundaries

Seawards extensions of breeding colony SPAs
The main period of occupancy of the tern breeding colonies on The Dee Estuary SPA and The Mersey Narrows and North Wirral Foreshore SPA is between April and August. FEPA monitoring commenced in September 2003, hence there is no new data to inform the conclusion of the Environmental Statement that North Hoyle would be outside of a breeding colony extension for these species. Pre-construction data will be reported on in the annual FEPA report for 2004.

Non-breeding Sandwich tern
Observations in September 2002 (Table 3 of Appendix 1) confirmed the conclusions of the ES of low usage of the site.

Non-breeding red-throated diver
The size of the Liverpool Bay population for this species is not known, but sample surveys have shown that peak numbers on the Welsh side of the Bay exceed the present threshold (50 birds) for classification of a marine SPA, although that threshold is under review and may be increased. The cumulative distribution for Liverpool Bay, which, as diver distribution is continuous in inshore waters, would probably be the unit for any SPA designation, is only available from aerial survey. This method has lower detection rates than boat survey, but cumulatively provides good distribution data, if not data on actual numbers. The cumulative distribution for the winters of 2001/02 and 2002/03 is shown in Figure 6, below. The distribution is mainly inshore of the 10m lowest astronomical tide and so includes all first round wind farm applications in Liverpool Bay. The low resolution of the data and the absence of guidance on how to define boundaries for dispersed, as opposed to aggregated, species (see common scoter below) makes it unclear how boundary selection would be applied in Liverpool Bay.



Non-breeding common scoter
The cumulative distribution of common scoter for the winters of 2001/02 and 2002/03 from aerial survey is shown in Figures 3-5. Common scoter is a qualifying feature of a marine SPA as the estimated Liverpool Bay population has on occasion exceeded 1% of the biogeographic population, or more than 16000 birds. This is qualification under the so-called Stage 1 criteria.

In addition to Stage 1 criteria, which are clear-cut and deal with numbers, there are a number of less quantitative Stage 2 criteria proposed, imported from the selection of terrestrial SPAs. Amongst these criteria is the need to have a good geographical spread of sites for each species, historically persistent occupancy of a site and unusually high densities of birds, even if the population does not meet the 1% threshold.

Liverpool Bay may be classified as two SPAs for common scoter, one centred on Shell Flat, off Blackpool and the other protecting the Welsh population. Neither SPA would qualify on Stage 1 criteria, therefore stage 2 criteria would have to be used in justification. The Welsh population's SPA status would likely be justified by historical persistence of the population, which is known from the area for more than a century, and geographic spread of sites,

There is unpublished advice (Webb et al. 2002) on how to select a marine SPA boundary for common scoter, applied to the Carmarthen Bay population. Methods of generating distribution maps are described and a number of rules proposed for delineating the boundary. Whilst the analysis is complex, the answer is intuitively simple. Common scoters occur in discrete areas in high densities and the boundary encloses the cluster with some buffer. One boundary rule proposed is that if the distribution is broken into a number of clusters, it must be shown that there is exchange of birds between the clusters, i.e. they are one "population". The absence of evidence of exchange of birds between Shell Flat and Wales will be the main biological justification for the consideration of two SPAs in Liverpool Bay.

Inspection of the common scoter distribution for 2001/02 and 2002/03 (Figures 10-12) shows North Hoyle Offshore Wind Farm to be consistently outside of the main aggregations that are assumed will define the SPA boundary. This qualitative statement will be confirmed once quantitative analysis by the Joint Nature Conservation Committee to propose an SPA boundary is undertaken.

Flight height
The proportion of total observations, during FEPA monitoring up to March 2003, of the key species above that occurred below or above eye height, the latter being the conservative measure of birds being at risk of collision, is shown in Table 4 of Appendix 1.

9.5.4 Conclusion

FEPA monitoring to date supports the conclusions of the North Hoyle Offshore Wind Farm environmental statement that the wind farm is outside of potential marine SPAs. Uncertainty remains over the status of a future protected area for red-throated diver in Liverpool Bay, due to a review of the threshold population size for SPA classification and present uncertainty on how to set boundaries for dispersed non-breeding seabirds.

Flight height data is limited in its utility due to the limited range of weather conditions in which visual data can be gathered offshore and the problems of measurement discussed in Objective 1. Practical technologies for the refinement of height measurement will continue to be considered during the future monitoring years.

10. REFERENCES

Anon (2001) Hilbre Bird Observatory Report. Hilbre Bird Observatory and Ringing Station 45th Annual Report.

Bio/consult AS, (2002) Possible effects of the offshore windfarm at Vindeby on the outcome of fishing. Report to SEAS, Denmark. 23 pages.

Buchanan, J.B. 1984. Chapter 4. Sediment Analysis. In Methods for the Study of Marine Benthos, eds N. A. Holme & A. D. McIntyre, Blackwell Scientific Publications, 41-65.

Ellis, J.R., Rogers, S.I. & Freeman, S.M., 2000. Demersal assemblages in the Irish Sea, St George's Channel and Bristol Channel. Estuarine, *Coastal and Shelf Science*, 51, 299-315.
Moore, J. (2002). An atlas of marine biodiversity action plan species and habitats and species of conservation concern i
n Wales. 2nd Edition. CCW contract science report no 509.

Fox, A.D., Petersen, I.K., & Helley, S.L. (2003) Calculating density estimates for sea birds based upon aerial survey transect counts, Progress report on development of techniques. Report to Energistyrelsen.

Johnston, C.M., Turnbull, C.G & Tasker, M.L. (2002) Natura 2000 in UK offshore waters: advice to support the implementation of the EC Habitats and Birds Directives in UK offshore waters. JNCC, Peterborough. JNCC Report 325.

Komdeur, J., Bertlesen, & Cracknell, G. (eds) (1992) Manual for Aeroplane and Ship Surveys of Waterfowl and Seabirds. IWRB Special Publication No. 19, National Environmental Research Institute Kalo.

Rees, E.I.S. (2001). Habitat specialisation by *Thia scutellata* (Decapoda: Brachyura) off Wales. *Journal of the Marine Biological Association of the U.K.*, 81(4) 697-698.

Westerberg, H & Begout-Anras, M.L. (2000) Orientation of silver eel (*Anguilla anguilla*) in a disturbed geomagnetic field. Advances in Fish Telemetry. Proceedings of the Third Conference on Fish Telemetry in Europe, Norwich, England, June 1999. Eds. Moore, A. & Russel, I. CEFAS Lowestoft 2000.

Robinson, P. & Oliver, F. (in prep) The abundance of common scoter Melanitta nigra in Carmarthen, Cardigan and Liverpool Bays and correlates of the distribution in Liverpool Bay wit the benthic fauna. Draft report to the Countryside Council for Wales.

Webb, A, McSorley, C.A, Dean, B.J. & Reid, J.B. (Unpublished_ Modelling the distribution and abundance of black scoter Melanitta nigra in Carmarthen Bay: a method for identifying potential boundaries for marine Special Protection Areas