Burbo Offshore Wind Farm

Construction Phase
Environmental Monitoring Report

Document: J3034 Construction phase summary v3 (04-08)

Version	Date	Description	Prepared	Checked	Approved
1	12-07	First Draft	LG/IGP	THS	
2	02-08	Reviewed by SeaScape	IGP	LG	IGP
3	04-08	Final Version	IGP		IGP

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Cover photograph: transition piece of turbine 27 before turbine tower installation.

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1 Introduction

1.1 Environmental Monitoring

Burbo Offshore Wind Farm is a twenty-five turbine, 90MW development located in Liverpool Bay approximately 6km from the coastline of Wirral, Crosby and Liverpool.

Centre for Marine and Coastal Studies Ltd (CMACS) was appointed by SeaScape Energy Ltd in April 2005 to develop and undertake pre and during construction environmental monitoring to meet the requirements of the Food and Environment Protection Act (FEPA) licence issued to the wind farm developer. The current version of the FEPA licence is 31864/07/0 (Appendix 1.

The Environmental Monitoring Methods have been developed in consultation with statutory and non-statutory consultees. Monitoring is being undertaken through a series of discrete surveys covering various environmental and ecological components in response to the requirements of the FEPA licence. The current version of the Methods Statement is provided here as Appendix 2. These are the v1.5 methods which were also referred to in the pre-construction report; monitoring methods for the post-construction/operational phase are currently being updated following issue by SeaScape Energy of a proposed Post-construction monitoring programme (Doc No. 283521) in July 2007.

The purpose of this report is to bring together the various technical reports which present results of the different strands of the environmental monitoring. An overview of the results is provided in an Executive Summary (Section 3) and inter-related elements of the monitoring are considered in Section 4. Detailed information is provided in the technical reports within Appendix 3.

Information reported in the project Environmental Statement (SeaScape Energy 2002) and the first year FEPA report (CMACS 2006) provide the benchmark against which change can be assessed.

1.2 Wind Farm Construction Schedule

A summary of the construction schedule is provided in Table 1.

For the purposes of environmental monitoring the construction period is considered to have commenced on 21st May 2006 when a filter layer was placed to stabilise sediments in advance of hammer piling of the first monopile foundations the following month. Horizontal directional drilling works to install a conduit for power export cables under the sea wall commenced in April 2006 but these onshore works are not considered relevant to any of the offshore or intertidal monitoring. Three electricity export cables were installed in July/August 2006 and intra-array cabling continued into 2007. Dumping of rock armour around monopile foundations to protect against scour took place between September and November 2006.

Table 1 Overview of construction schedule.

	2006								2007											
	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Scour protection																				
filter layer																				
rock armour																				
Monopile Installation																				
hammer piling																				
Turbine installations																				
Cabling																				
export route																				
array cables														*1						

*1 Array cabling was largely complete by May 2007 but post-lay burial and other remedial works have been ongoing since.

2 Overview of Environmental Monitoring Work

All surveys set out in the Method Statement (Appendix 2) that were required to be undertaken during the wind farm construction period are included in this report as technical reports within Appendix 3.

The technical reports are appended in the original order set out in the FEPA license annexes which was reflected in the Method Statement. The relevant text from the FEPA licence is detailed in the Method Statement.

Table 2 provides a summary of progress with the environmental monitoring programme in relation to each main area of monitoring.

Table 2 Overview of Monitoring Programme.

Monitoring reports (in relation to FEPA Licence Sections)	Pre-construction	During construction	Post-construction
Annex 1(1) Suspended Sediment Concentrations- SCC		●	
Annex 1(2) Seabed Morphology and Scour		●	⦿
Annex 1(3) Contaminants	●		
Annex 1(4) Current monitoring			○
Annex 1(5) Benthic Organisms- Subtidal benthic organisms	●	●	⦿
Annex 1(5) Benthic Organisms- Colonisation of monopiles/scour protection			○
Annex 1(5) Benthic Organisms- Intertidal Invertebrates	●	●	
Annex 1(6) Electromagnetic Fields		●	
Annex 1(7) Marine Fish- 4m Beam Trawls	●	●	○
Annex 1(7) Marine Fish- 2m Beam Trawls	●	●	⦿
Annex 1(8) Operational Noise and Vibration			○
Annex 1(9) Numerical models			○
Annex 2 Ornithology	●	●	⦿

○ = planned activity; ● = survey and report completed; ⦿ = programme commenced, report to follow in the Post-construction (first Operation Phase) report.

Pre-construction: CMACS (2006) Burbo Offshore Wind Farm. Year 1: Pre-construction Environmental Monitoring Report. Version 1.1 September 2006.
Doc ref: J3034 Pre-construction summary v1.1 (09-06)

During-construction: This report (Construction Phase Environmental Monitoring Report).
Doc ref: J3034 Construction phase summary v2 (02-08)

The following section provides an overview of each aspect of the environmental monitoring, including: programme status, results to date, ongoing and/or proposed future work. The overview of results provides the Executive Summary required by the FEPA Licence. Where the Marine and Fisheries Agency (MFA) have commented on aspects of the monitoring in their reply to the Pre-construction monitoring report (letter to SeaScape dated 20th December, 2007) their comments are reported. In relation to suspended sediment monitoring this includes comments on the technical report appended here which was issued to consultees in advance of this report.

3 Summary of Discrete Monitoring Elements

Annex 1(1) Suspended Sediment Concentrations- SSC

Two discrete monitoring surveys were undertaken during power cable installation works, one during export cable installation work, the other during intra array cable installation. This monitoring is reported in a single document (J3034 suspended sediments v1.0 Dec 06) which is provided here in Appendix 3 (now v2 as an Executive Summary has been added; the document is otherwise unchanged).

The aim of the monitoring was to validate and confirm predictions made in the project Environmental Statement (SeaScape Energy 2002) that:

> *some effects (on SSC) may arise during installation from localised increased suspended sediments concentrations for released disturbed fine sediments. …any effects will be short term and relatively small resulting in little impact on coastal processes.*

The monitoring was also undertaken to confirm that suspended sediments remained within parameters that were agreed with regulators before construction. The agreed suspended sediment threshold was:

> *not more than 5 times background (control area), or 3,000mg/l throughout the water column (measured as close as safely possible to construction activity), whichever is greater*

The three export cables were installed to a target depth of approximately 3m by vertical injector ploughing (Figure 1) while array cables were installed to a similar depth by jetting assisted ploughing.

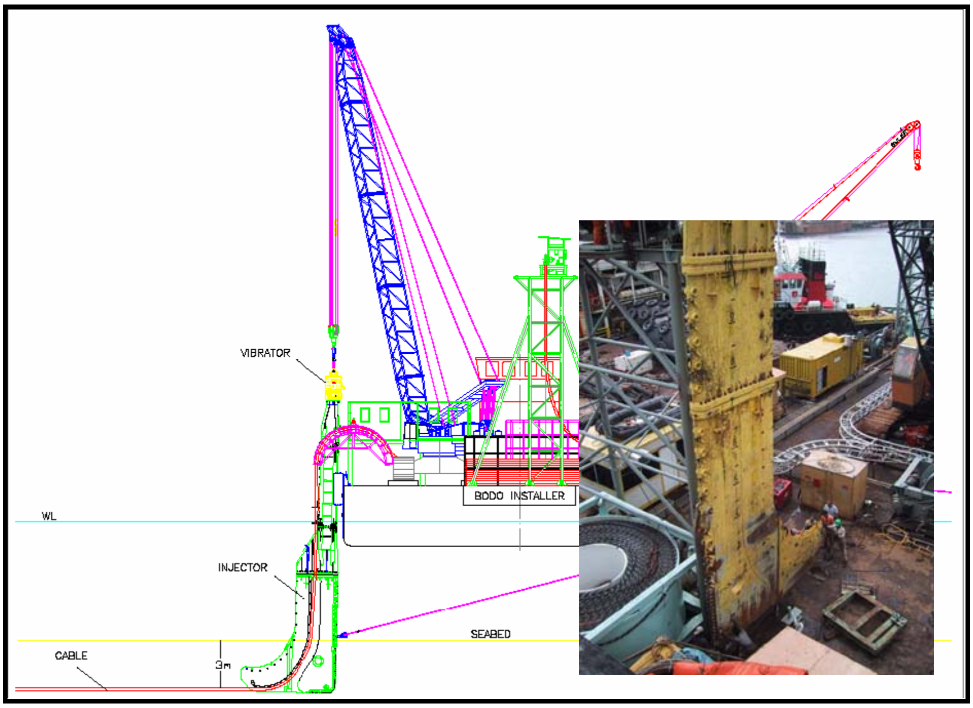


Figure 1. Vertical injector apparatus (inset, injector in dry dock)

Suspended sediment monitoring was undertaken from a small survey vessel using a hand deployed suspended sediment probe (Hydrolab Quanta) calibrated against local sediments. This was a mobile, responsive technique that allowed the monitoring team to measure sediment mobilisation both up and down-tide of works; the former provided control data against which the impact of the works could be compared.

The monitoring demonstrated clearly that both cable installation techniques had only small scale impacts on localised suspended sediment concentrations. Effects were measurable to a few hundreds of metres only and suspended sediment levels were not elevated more than five times background. Suspended sediment levels never approached the threshold level (3,000mg/l) agreed with regulatory authorities beforehand, even in very close proximity to the works (< 50m). Typical results, obtained by allowing the survey vessel to drift immediately down-tide of works when there was no wind, are represented by Figure 2. This shows the local effect on suspended sediments over a relatively fine sediment seabed area which is likely to represent close to a 'worst-case' scenario for cable installation at Burbo.

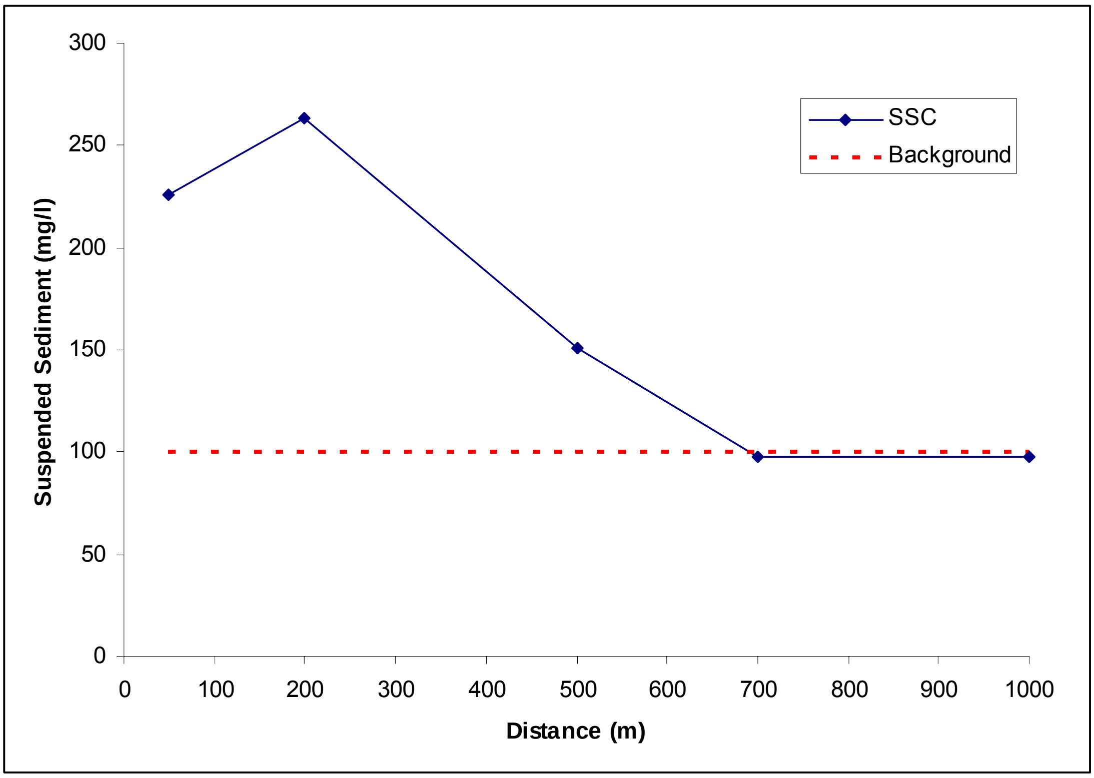


Figure 2. Suspended sediment concentration at 2m water depth down-tide array cable installation works.

The report concludes that the predictions of the Environmental Statement are fully supported in relation to effects on suspended sediments.

MFA provided the following comment on suspended sediment monitoring after reviewing the technical report (J3034 suspended sediments v1.0 Dec 06 in Appendix 3):

> *An appropriate level of monitoring was undertaken with no adverse effects identified. The licence condition has been fulfilled and no further work or reporting is necessary.*

This aspect of the monitoring programme is therefore concluded. The Technical Report is appended here as it has not been included in any other annual monitoring report.

Other parts of the monitoring programme, covering various potential marine ecological receptors, are interrelated. The monitoring is focused upon identifying broader scale impacts and the relevance of the suspended sediment monitoring results described here for other aspects of the marine environment is considered in Section 4.

Annex 1(2) Seabed Morphology and Scour

The FEPA licence calls for a suite of monitoring to confirm that the presence of the wind farm does not lead to unacceptable physical impacts on the environment and that scour does not compromise the integrity of the wind farm or pose a danger to mariners by exposing cables.

The monitoring is part of the Post-construction programme and results will therefore be included in the first Post-construction monitoring report. Detailed information on monitoring methods will be presented in the next iteration of the Monitoring Method Statement.

It is currently anticipated that Post-construction seabed morphology and scour surveys will be conducted at bi-annual intervals for a period of 3 years to provide up to 6 survey points in total.

Annex 1(3) Contaminants

Monitoring work was reported in Pre-construction environmental monitoring report where it was concluded that construction of the wind farm would not lead to any increased mobilisation of existing contaminants into the marine environment.

MFA have advised that:

> *An appropriate level of monitoring was undertaken with no adverse effects identified. The licence condition was fulfilled and no further work or reporting is necessary.*

This aspect of the monitoring programme is therefore concluded.

Annex 1(4) Current Monitoring

The FEPA licence calls for monitoring to validate predictions made in the Environmental Impact Statement for the Burbo Offshore Wind Farm of the magnitude of the wake effect downstream of each monopile.

The monitoring is part of the Post-construction programme and results will therefore be included in the first Post-construction monitoring report. Detailed information on monitoring methods will be presented in the next iteration of the Monitoring Method Statement.

Annex 1(5) Benthic Organisms

Annex 1(5) a Sub-tidal Benthic Ecology

The Construction Survey was undertaken in September 2006. This was the same time of year as the 2005 Pre-construction (Baseline) survey. A characterisation survey was completed to inform the EIA in April 2002 and was subsequently used to refine the approach to monitoring. This also provides a useful set of pre-construction reference data.

MFA provided the following comment after reviewing the Pre-construction subtidal benthic ecology survey report:

> *The benthic monitoring programme indicates broadly similar communities as in 2002. Initial comments are that sampling to date has been fit for purpose and the licence conditions will be fulfilled once detailed analysis of biotopes and communities has been carried out.*

The report of the Construction monitoring in September 2006 (Appendix 3) draws comparisons between the results of the Baseline and Construction monitoring surveys in terms of seabed sediments and associated subtidal benthic ecological communities.

There were considerable changes in benthic fauna at most survey stations between 2005 and 2006, with marked reductions in numbers of many of the more abundant species. These changes were most noticeable in the central area of the wind farm site, where there was also an increase in the proportion of mud in seabed sediments. Overall community types at each station are relatively unchanged, however.

There is considered to be a strong likelihood that the observed variability in seabed sediments and benthic invertebrate communities are natural features of the marine environment around Burbo. Importantly, changes in sediment conditions resulting from construction activities are not expected to have had time to cause significant effects on benthic organisms given that the survey took place only a few months into the construction programme. This is supported by evidence from the scientific literature which reports large fluctuations in several of the most abundant species in this area and by similarities between the results of the 2006 during construction survey and EIA characterisation survey of 2002.

The first Post-construction subtidal benthic ecology survey was completed in September 2007 and will be reported in the first Post-construction environmental monitoring report. These samples were collected after the wind farm became operational (though not fully commissioned) and benthic invertebrates would be expected to have responded to any major influences of the wind farm construction by that stage.

The intention is to review the ongoing monitoring after completion of this report.

Annex 1(5) b Colonisation of Monopiles and Scour Protection

A desk study is proposed to meet this FEPA licence condition. The approach will be outlined in the next iteration of the Monitoring Method Statement for discussion with the Licensing Authority and consultees.

Annex 1(5) c Intertidal Invertebrates

A number of interrelated surveys have been undertaken to monitor the effect of cable installation works across the intertidal area of the electricity export route on the North Wirral foreshore at Wallasey on invertebrates and physical habitat (sediments). Three separate reports are included in Appendix 3:

Annex 1(5) c.1
Baseline biotope survey shortly before works in summer (July) 2006, supported by sediment core samples. Followed by repeat sediment core sampling after final cable landfall works in November 2006 (baseline and rapid assessment report).

Annex 1(5) c.2
A photographic survey in July 2006 immediately after Pre-Lay Grapnel Run (PLGR) works to record physical recovery of beach sediments along part of the route (photographic survey report).

Annex 1(5) c.3
Repeat biotope survey in summer 2007 (post-construction intertidal biotope survey report), including photographic survey of remedial works on horizontal directional drill pits (HDDP) at the top of the beach.

Biotopes and sediments on the North Wirral foreshore were very similar before and after cable burial works (Figure 3). The dominant biotope on both occasions was LS.LSa.FiSa.Po.Ncir - *Nephtys cirrosa* dominated littoral fine sand. Some small changes in the beach infauna were identified but these were not specific to the cable burial area and were indistinguishable from natural variations.

The photographic surveys showed that there had been good recovery of beach sediments following disturbance by PLGR and HDDP works.

The surveys therefore demonstrated that there has been no significant effect on intertidal invertebrate communities or sediments; the importance of this conclusion for other trophic groups, including birds and fish, is considered in Section 4.

This aspect of the monitoring is concluded and no further surveys are planned, pending comments from the Licensing Authority and consultees.

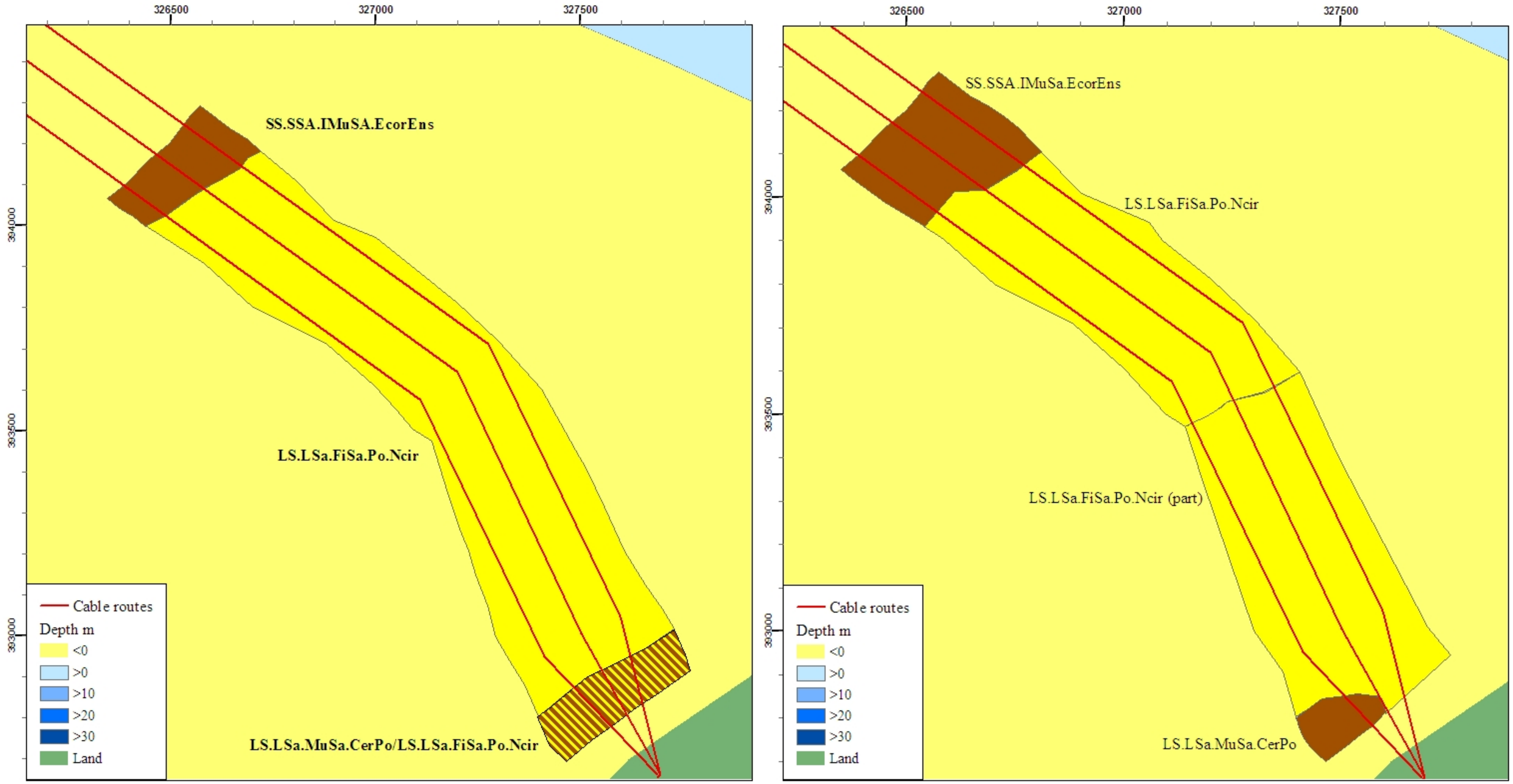


Figure 3 Intertidal biotope map before cable installation (summer 2007, left) and 12 months after installation works (right).

Annex 1(6) Electromagnetic Fields

A technical report is provided in Appendix 3. This provides information on predicted electromagnetic field (EMF) strengths and the likely significance for marine ecology.

The cables in use at Bubo are of a design used widely across the UK and elsewhere. They are all tri-core (copper), XLPE insulated, copper screened and steel armoured and carry current at 50 Hz AC.

The cable manufacturer provided a calculation of the maximum anticipated magnetic field strength (B field). This is estimated to be approximately 0.54 μT, a figure which agrees well with independent estimates for similar cables elsewhere.

An electrical field (E) will be generated by the cable but will be fully retained by the shielding; however, the B field is present outside the cable and because of the nature of the alternating current around each of the three conductor cores a second electrical field will be induced outside the cable (iE field). Based on the magnitude of the B field and experience of measurement and modelling of iE fields at other wind farms it is determined that the maximum induced electrical field at Burbo will be above 0.5 μV/m but are not anticipated to exceed 100 μV/m. Such fields would be propagated for distances of metres to tens of metres around cables.

The report concludes that the prediction in the Environmental Statement (SeaScape Energy 2002) of no more than a low magnitude impact to elasmobranchs (sharks, skates and rays) is still considered to be a justified conclusion; however, additional monitoring of elasmobranchs has been incorporated into the fish monitoring programme because of the uncertainties regarding EMF effects. This monitoring is ongoing (see Annex 1(7), below). The first survey to take place while the wind farm is generating power will be in spring 2008.

The FEPA licence requirement to provide information on attenuation of field strengths associated with the cables, shielding and burial has been addressed by the report referred to above and a judgment made on likely ecological significance made using best available information. Any advances in understanding of the ecological significance of EMF for elasmobranchs, or requirement to amend EMF predictions, following ongoing COWRIE funded research will be included in future monitoring reports. This aspect of the monitoring programme is otherwise complete, pending comments from the Licensing Authority and consultees.

Annex 1(7) Marine Fish

Two marine fish surveys are undertaken annually. A scientific (2m) beam trawl survey is carried out in autumn immediately after the benthic grab survey to provide information on epibenthic invertebrate communities and smaller demersal fish. A commercial (4m) beam trawl is undertaken in spring to survey larger benthic fish species and to provide information on elasmobranch foraging in and around the wind farm.

MFA provided the following comment after reviewing the Pre-construction marine fish reports:

> *Survey work was compliant with the licence condition, although until the post construction survey is completed few conclusions can be made and a further report is expected.*

Separate technical reports of the spring 2007 4m beam trawl and autumn 2006 2m beam trawl are provided in Appendix 3. These are during construction monitoring reports. The current programme envisages that each survey will be repeated annually up to three years of post-construction monitoring; however, the need for continued surveys beyond one year of full wind farm operation (2008 survey) will be reviewed as data become available.

4m Beam Trawls

The spring 2007 survey was the second annual commercial fish survey. As with the baseline survey in 2006 it was undertaken in May, this was after the majority of wind farm infrastructure had been installed but before power generation commenced. Works were ongoing around the time of the survey to complete installation of array cabling.

Relatively high numbers of fish were caught in 2007, including at sites in close proximity to the wind farm. The composition of catches was similar, for example dab was a dominant species in both 2006 and 2007, but significant numbers of a range of other species including rays and flatfish were captured in 2007 that were not recorded in 2006. No specific conclusions are yet drawn as this will be a focus of the 2008 survey report.

In spring 2008 the first commercial fish survey during wind farm operation will be undertaken. This will be of particular interest in relation to the investigation of elasmobranch foraging activity within the wind farm. Stomach contents have been retained and analysed from dogfish caught during the surveys and these data will be used to review foraging behaviour of individuals caught within and around the wind farm with those outside it.

2m Beam Trawls

The autumn 2006 survey was the second scientific beam trawl survey. Multivariate statistical analyses have been performed on both sets of data which have revealed trends in composition of both invertebrate and fish communities that are expected to be related to natural variability. It is too soon to state this with confidence, however, and it is hoped that analysis of the third set of data, collected in autumn 2007, will confirm the extent, if any, to which wind farm construction has influenced benthic communities.

In addition, information during the operational phase of the wind farm during power production will become available after surveys in 2008. This is of interest since the 2m beam trawls did capture several elasmobranch species (rays and dogfish) that may be sensitive to electromagnetic fields produced by the wind farm. This point was recognised by MFA in their comments to the Pre-construction FEPA report:

> *Species liable to be impacted caught by the trawls include thornback ray, spotted ray (one individual) and lesser spotted dogfish.*

Annex 1(8) Operational Noise and Vibration

No site specific underwater noise survey is currently planned as the wind farm industry has supported collaborative research on underwater noise generated by offshore wind turbines during the operational phase. Data have been collected at nearby North Hoyle wind farm and it is hoped that the report will be made available by COWRIE in time for the results to be considered in relation to Burbo offshore wind farm in the third FEPA monitoring report in 2008.

Annex 1(9) Numerical Models

This aspect of the monitoring programme is currently under review. Proposals will be set out in the next version of the environmental monitoring Method Statement.

Annex 2 Ornithology

A technical report is provided in Appendix 3. This details results of ornithological monitoring between May 2006 and July 2007, during the construction phase of the wind farm, and compares these with baseline data from the pre-construction monitoring between September 2005 and April 2006.

Boat based ornithology surveys were undertaken at approximately monthly intervals. The aim of the surveys was to monitor the effects of the construction phase of the wind farm on bird use of the wind farm site and adjacent areas by recording the distribution of bird species in and around the wind farm.

Survey methodology followed pre-construction studies. Ornithologists recorded bird observations along seven transect routes. Three transects passed through the wind farm wind farm area and buffer areas north and south, two transects covered buffer areas either side of the wind farm and the final two transects were in a reference area to the west of the wind farm. All birds sighted, other than common gull species, were recorded. Analysis focused on species of interest, namely common scoter, red-throated diver, cormorant and common tern which are interest features of local protected sites such as the proposed Liverpool Bay SPA and Mersey Narrows and North Wirral Foreshore SSSI/pSPA.

Baseline surveys had shown that the survey area holds few bird species, and those that do occur are present in low numbers. In general, construction period survey results were similar to those from pre-construction surveys. Given these low numbers, it was generally not possible to determine any difference in abundance and distribution between construction and pre-construction periods for the wind farm area, the buffer area and the reference area; the notable exception was cormorant *Phalacrocorax carbo* which regularly used the recently built wind turbines as roosting sites. Records for this species therefore increased within the wind farm area during the construction period.

The distributions of two target species, common scoter *Melanitta nigra* and red-throated diver *Gavia stellata*, did show some bias towards the buffer and reference areas; however, neither species was recorded from the wind farm area before construction started and the low numbers of birds involved were predominantly recorded in flight. It is therefore considered unjustified to relate this distribution to construction activity. The final target species, common tern *Sterna Hirundo*, appeared unaffected by the construction activity and distribution remained relatively constant for the small numbers recorded.

Of the other noteworthy species recorded, auks *Alcid* spp. also showed a bias towards the buffer and reference areas, but this may relate to existing disturbance from the Queen's Channel shipping lane, which lies adjacent to the wind farm area.

The overall effects of construction activity on birds are considered likely to have been limited since only small numbers of birds were recorded, which is consistent with pre-construction surveys. Given these low numbers and the existing levels of disturbance in the area, it is considered likely that construction of the wind farm has had no significant effect on the favourable conservation status of the bird population in its natural range.

SeaScape have proposed that boat based ornithological surveys continue for two years post-construction in winter months (November to March). Detailed proposals will be submitted in the next version of the environmental monitoring Method Statement.

4 Interrelated Monitoring

The environmental monitoring at Burbo covers a range of physical and biological subject areas, these are reported as discrete elements in the technical reports[A]; however, all are interrelated to varying degrees and some of the more important interrelationships are considered here. Such issues will be drawn out further in future reports once operational phase data become available and the marine ecosystem has had opportunity to respond to construction of the wind farm.

4.1 Intertidal Sediments, Invertebrates, Birds and Fish

A number of discrete surveys have investigated the physical impacts of cable laying activities in both offshore and intertidal areas. In the intertidal zone photographic monitoring has demonstrated that the visible effects of cable installation works are very short term and barely detectable after a single tide has covered the site. Even more intrusive pit digging during repair works at the position of three horizontal directional drill pits towards the top of the shore when clay sediments were exposed did not leave visible effects for more than approximately 1 month. Sediment particle size analyses from samples collected during intertidal invertebrate surveys also support the conclusion that the physical effects of cable laying across the intertidal zone in this sandy environment have been trivial.

It is not surprising, therefore, that intertidal invertebrate monitoring did not reveal any significant effects on biota, in line with predictions made in the Environmental Statement. This conclusion has important consequences for other trophic levels, notably birds and fish which utilise intertidal areas for foraging when tidal conditions permit. There is no monitoring to evaluate short term disturbance to birds during construction work in the intertidal; however, this is expected to represent a trivial displacement effect and there is no apparent mechanism for any long term impact to intertidal foraging during wind farm operation.

4.2 Offshore suspended sediments and marine ecology

High levels of suspended sediments can lead to smothering of benthic habitats and clogging of fish gills. Suspended sediment monitoring during cable installation works demonstrated that the sediment plume occurring was both small in scale (detectable for a matter of a few hundred metres) and not very dense (the maximum value measured at Burbo was just over 600mg/l, more typically suspended sediment levels were elevated to just over 200mg/l within approximately 50m of works). Such magnitude impacts are of no concern to marine ecology in a dynamic environment such as Burbo near the

[A] Note, however, that some interrelationships, notably sediments and benthic invertebrates, are considered in detail within technical reports.

mouth of the Mersey where suspended sediments of approximately an order of magnitude greater can be expected through natural events.

References

CMACS (2006) Burbo Offshore Wind Farm. Year 1: Pre-construction Environmental Monitoring Report. Report to SeaScape Energy, Doc ref: J3034 Pre-construction summary v1.1 (09-06).

SeaScape Energy (2002) Burbo Offshore Wind Farm. Environmental Statement.

Appendix 1 FEPA Licence

FOOD AND ENVIRONMENT PROTECTION ACT 1985 : PART II (AS AMENDED) - DEPOSITS IN THE SEA IN CONNECTION WITH MARINE CONSTRUCTION WORKS

Licence 31864/07/0

The Secretary of State for Environment, Food and Rural Affairs (hereinafter referred to as "the Licensing Authority") hereby authorises:

SEASCAPE ENERGY LTD
THE GATEHOUSE
WHITE CROSS
SOUTH ROAD
LANCASTER
LA1 4XQ

Company Registration No: **4129545**

(hereinafter referred to as "the Licence Holder") to deposit in the sea the substances or articles the particulars of which are set out at paragraph 1.1 of the attached Schedule. The Licence is subject to the conditions of use set out, or referred to, in the said Schedule.

This licence shall be valid from the beginning of the day of **23 July 2007**, (hereinafter referred to as the start date of this licence) to the end of the day of **31 August 2008**, (hereinafter referred to as the end or expiry date of this licence), and replaces licence 31864/06/1 and all the terms and conditions in the schedule associated with that licence.

For the purposes of this licence and attached schedule and unless indicated otherwise:-

(i) all times shall be taken to be Greenwich Mean Time (GMT), and,
(ii) all co-ordinates shall be taken to be latitude and longitude degrees and minutes to two decimal places.

Signed:

Marine Environment Team

for and on behalf of the Licensing Authority

Date of issue: 23 July 2007

The Licence Holder is urged to read carefully all the conditions and requirements of this Licence which are set out in the Schedule. You should acknowledge receipt of this licence and confirm that you have understood its term by signing and returning Form FEP 14 within 28 days of the date of issue of this licence

1. Particulars of the deposit

1.1 The type of works for which the deposit of the substances or articles as specified in paragraph 1.4 of this Schedule are :

Windfarm

1.2 Details of the works requiring the deposit of the substances or articles as specified at paragraph 1.1 of this Schedule are:-

The construction of a 90MW offshore wind farm and associated infrastructure at Burbo Bank, approximately 7km from the coast of North Wirral and Crosby , and subsea cables between the turbines the cables to shore, as described in SeaScape Energy Ltd's application dated 26 September 2002 to the Marine Consents and Environment Unit.

1.3. Such works are as detailed in the drawing(s) and sectional plan(s) detailed below which were submitted in support of your application to the Licensing Authority of 26 September 2002

As shown in the Environmental Statement (submitted 26 September 2002) and the Provisional Method Statement (submitted 11 February 2003).

1.4 The substances or articles authorised for deposit at sea are:

Iron / Steel – monopile foundations and turbine support structuires
Stone / Rock – scour protection material (subject to further agreement in accordance with supplementary conditions 9.17 and 9.21)
Grouting – subject to further agreement with MFA
Cables – single core 125mm diameter insulated and armoured cables

1.5. The Licence Holder and any Agent and Contractor acting on their behalf is permitted to deposit the substances or articles specified at paragraph 1.4 of this Schedule, at the following location(s):

BURBO BANK: TURBINE ARRAY

53 30.110 N	**03 13.240 W**
53 30.120 N	**03 11.170 W**
53 28.550 N	**03 08.550 W**
53 28.140 N	**03 10.450 W**
53 29.380 N	**03 13.240 W**

(Turbine Locations at Annex 3)

BURBO BANK - METEOROLOGICAL MAST

53 28.290 N 03 10.220 W

BURBO BANK: CABLE ROUTE

53 28.290 N 03 10.220 W

1.6. The works shall be carried out in accordance with the works schedule and method statement as detailed in the following:

The construction of an offshore wind farm located approximately 7km from the coast of North Wirral and Crosby. Works include the installation of up to 30

wind turbines in five rows, regularly spaced, a meteorological mast and associated cabling. Offshore construction is expected to commence in summer 2005.

Installation of the monopile foundations (turbine support structures) will be through drilling or driving into the seabed using a jack-up barge. The foundations will comprise tubular steel monopiles, 4m in diameter and with a penetration into the seabed of 20-30m.

Any material removed through drilling will either be disposed of onshore or, if deposited in situ (within the area of the turbine array), will be subject to this licence, or, if deposited off-site, will be subject to disposal under a separate FEPA licence.

If scour protection material is required, it will consist of graded sandstone rock placed around the base of each turbine. The extent of scour will be monitored post-construction and reviewed in accordance with Supplementary Conditions 9.17and 9.21.

Cables will be entrenched in the seabed using an offshore trenching machine underwater and onshore equipment when crossing the North Wirral foreshore. Backfilling of the trenches will be subject to the requirements of conditions 9.29 and 9.31. Cables will be buried as deep as possible (up to 3m depending on seabed conditions (minimum depth of 1 metre) - in accordance with condition 9.19 - to minimise electromagnetic effects and the risk of re-exposure. Offshore cables will be directionally-drilled under the sea wall at North Wirral into the interconnection chamber location to avoid disturbance to coastal defences.] (NB. The onshore cabling is covered by consent under the Electricity Act 1989 and planning permission under the Town and Country Planning Act 1990, as appropriate).

2. Persons Responsible for the Deposit of the Substances or Articles

2.1. The Agents and Contractors permitted to engage in activities subject to the terms and conditions of this licence are:-

Name of Agent or Contractor	Function
RPS HYDROSEARCH	**Other Agent**
EDF ENERGY CONTRACTING LTD	**Construction Agent**
SIEMENS WIND POWER A/S	**Construction Agent**
ABB POWER TECHNOLOGIES AB	**Construction Agent**
MCNICHOLAS CONSTRUCTION SERVICES	**Construction Agent**
SUBMARINE CONSTRUCTION SERVICES KG	**Construction Agent**

2.2 The following operators and vessel(s) or vehicle(s) are permitted to engage in activities subject to the terms and conditions of this licence are:

Name of Vessel or Vehicle Registration	Operator	Type

THE LICENCE HOLDER IS NOT PERMITTED TO COMMENCE THE DEPOSIT OPERATION SPECIFIED BY THIS LICENCE 31864/07/0 UNTIL THE LICENSING AUTHORITY HAS IN WRITING VARIED THE LICENCE TO INCLUDE DETAILS OF ALL VEHICLE(S), VESSEL(S) ETC. TO BE EMPLOYED IN THE OPERATION.

2.3 All vessels employed to perform the deposit operation permitted by this Licence **31864/07/0** shall be so constructed and equipped as to be capable of the proper performance of these operations in compliance with the conditions set out in the Schedule to this licence **31864/07/0** . Details of the vessels that may operate under this Licence **31864/07/0** are set out in sub-paragraph 2.2, and the standard equipment to be on all vessels operating under this Licence **31864/07/0** are set out in paragraph 10.

3. Distribution of copies of this Licence 31864/07/0

3.1 The Licence Holder is required to ensure that a copy of this licence **31864/07/0** and attached Schedule, any special conditions and any subsequent revisions or amendments thereto is given to:

3.1.1. All Agent(s) and Contractor(s) as detailed at paragraph 2.1; and

3.1.2 The Masters of all vessels and transport managers responsible for the vehicles employed in the pursuance of this Licence **31864/07/0** and detailed at paragraph 2.2.

3.2 Copies of this Licence **31864/07/0** shall also be available at the following locations :

3.2.1 at the address of the Licence Holder;

3.2.2 at any site office, located at or adjacent to the site of the works, used by the Licence Holder, agent(s) or contractors(s) responsible for the loading transportation or deposit of those substances or articles detailed at paragraph 1.2.1 of this Schedule; and,

3.2.3 on board each vessel or at the office of any transport manager with responsibility for vehicles from which licensed deposits are to be made.

4. Inspection of the Operation

4.1 The documents referred to in paragraph 3 shall be available at all reasonable times for inspection by an authorised Enforcement Officer at the locations stated in that paragraph.

4.2 The Licence Holder must advise the Licensing Authority and District Inspector of Fisheries (being a designated officer responsible for enforcement of this Licence) 5 working days before the licensed operation, or an individual phase of the operation is expected to commence.

5. Returns to be made to the Licensing Authority

5.1 The Licence Holder is required to acknowledge receipt of this licence **31864/07/0** and confirm that you have understood its term by signing and returning Form FEP 14 within 28 days of the date of issue of this Licence. No operations permitted under the terms of this licence **31864/07/0** shall commence until the FEP 14 form has been signed and returned to the Licensing Authority.

5.2 All persons referred to at paragraph 2.1 and 2.2 of this Schedule shall provide an acknowledgement, using Form FEP 13, of their receipt of this licence **31864/07/0** and their understanding of all the conditions specified therein to the Licensing Authority within 28 working days of the start date of this Licence **31864/07/0** or prior to engaging in any activity to which this Licence relates, whichever is the sooner.

5.3 Only those Agent(s) or Contractor(s) whose names appear at paragraph 2.1 and the vessel(s) and operator(s) whose names appear at paragraph 2.2 may operate under the terms of this Licence **31864/07/0** . Any changes must be notified to and be approved by the Licensing Authority in writing prior to operating under this Licence **31864/07/0** .

6. Contacts

6.1 Except where otherwise indicated, the primary point of contact with the Licensing Authority and the address for returns and correspondence shall be:-

Marine and Fisheries Agency
Marine Environment Team
Area 6B,
3-8 Whitehall Place
London SW1A 2HH

Tel: 020 7270 8696

6.2 For the purposes of this Licence **31864/07/0** any references to the Local District Inspector of Fisheries shall mean the relevant District Inspector in the area(s) located at:-

Marine Fisheries Agency,
Fisheries Office,
Bradley's Chambers,
26 London Street,
Fleetwood,
Lancashire
FY7 6JG

Tel: 01253 873515

6.3 For the purposes of this Licence **31864/07/0** any references to the Centre for Environment, Fisheries, and Aquaculture Science (CEFAS) shall mean:-

Centre for the Environment, Fisheries, and Aquaculture Science (CEFAS),
The Laboratory
Remembrance Avenue
Burnham-on-Crouch
Essex CM0 8HA

7. Force Majeure

7.1 If, by reason of "force majeure" the substances or articles specified at sub-paragraph 1.4 of this Schedule, are deposited otherwise than in the area authorised by this licence at paragraph 1.5, full details of the circumstances shall be notified to the Licensing Authority within 48 hours of the incident occurring.

"force majeure" may be deemed to apply when, due to stress of weather or any other cause, the master of a vessel determines that it is necessary to deposit the substances or articles because the safety of human life and/or of the vessel is threatened.

8. Changes to this licence

8.1 In the event of the Licence Holder becoming aware that any of the information on which the granting of this licence **31864/07/0** was based has changed or is likely to change, he/she shall notify the Licensing Authority at the earliest opportunity of the details.

8.2 Similarly in the event that the Licence Holder wishes any of the particulars set down in the Schedule to be altered he/she shall inform the Licensing Authority at the earliest opportunity. The terms and conditions of this Licence apply until such time as they may be varied by the Licensing Authority.

9. Supplementary Conditions

The Licence Holder must submit the reports of monitoring activities set out in the following Supplementary Conditions to the Licensing Authority at the appropriate time in order to allow the Licensing Authority to consider if any action may be required to mitigate or correct any adverse effects which may be identified.

The Licensing Authority reserves the right to vary or attach additional conditions to this Licence in the event that:

i. the results of monitoring studies required under the terms of the Schedule to this Licence,
or
ii. any other observed effects considered to be directly associated with the works permitted by this Licence suggest a risk of significant adverse environmental impact.

9.1 Pre-construction monitoring must be carried out in 2004 to provide a baseline for subsequent monitoring of the effects of the windfarm. NB The Licence Holder will need agreement from the Licensing Authority that the pre-construction monitoring programme has generated adequate baseline data to support the construction and post construction monitoring. Assuming that the construction of the windfarm is completed as scheduled during the summer months of 2005, a post-construction monitoring programme must commence in late summer/autumn to follow the completion of the works. Monitoring must be carried out at the same time each year for comparative purposes in 2006, 2007 and 2008. Therefore, the initial monitoring schedule is as follows:-

Pre-Construction	late summer/autumn 2005
Construction	late summer/autumn 2006
Post Construction/Operation	late summer/autumn 2007/2008/2009

The ornithological monitoring will be subject to a specific timetable as detailed in Annex 2.
Further monitoring requirements may be imposed by the Licensing Authority in the light of the results of each phase of the monitoring programme.

9.2 If the period of construction varies from that described in 9.1 above, or where unavoidable problems occur in meeting this schedule, the Licence Holder must notify the Licensing Authority and seek instruction on the monitoring schedule. The Licence Holder is not permitted to commence any construction works specified by this licence 31864/07/0 until the Licensing Authority has in writing agreed and varied the licence to include specific milestones for all deliverables associated with the monitoring programme

9.3 The monitoring reports must be forwarded to the Licensing Authority & Natural England on an annual basis, or more frequently if the results trigger further monitoring work. Each report must be forwarded to the Licensing Authority within 3 months of the completion of the analyses. The Licence Holder should advise the Licensing Authority if circumstances suggest that there will be a delay in the submission of reports.
The reports should include assessment, conclusions and an executive summary and the data within all reports should be presented in its processed and unprocessed forms.

The various components of the monitoring programme and resultant reports, as described in conditions 9.6 to 9.10 of this Licence, should be integrated so as to compare related environmental parameters eg the bird monitoring should address the conclusions of the benthic studies which should similarly draw on the sedimentary studies.

Monitoring of Sedimentary and Hydrological Processes, Benthic Ecology, Electromagnetic Fields and Noise & Vibration

9.4 The Licence Holder must carry out a programme of sedimentary, hydrological, benthic and other monitoring, as outlined in Annex 1 attached to this Schedule. The full specification for the monitoring programme must be drafted by the applicant and submitted to the Licencing Authority at least three months prior to the proposed commencement of the monitoring work. The Licensing Authority will issue separate written agreement following consultation with CEFAS and Natural England at least one month prior to the commencement of the monitoring work.

9.5 The Licence Holder must make provision during the construction phase of the windfarm to install facilities to enable subsea noise and vibration from the turbines to be assessed and monitored during the operational phase of the windfarm. Before completion of the construction phase the Licence Holder must supply specification to the Licensing Authority of how it proposes to measure subsea noise and vibration - at various frequencies across the sound spectrum at a selection of locations immediately adjacent to, and between turbines, within the array and outside the array at varying distances - in order to fulfil the monitoring requirement outlined in Annex 1 attached to this Licence. Such a study would need to reflect differences in foundation/tower type, water depths and sediment types within the site and would need to be supported by adequate baseline data. Collaborative studies could be an acceptable means of fulfilling this condition.

Fish Monitoring

9.6 Since very little is known about the potential effect of windfarms 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 windfarm giving strong consideration to non-destructive methods of monitoring. The Licence Holder shall, in drawing up such proposals, canvas the views of local fishermen, North West and North Wales Sea Fisheries Committee. The proposals must be submitted to the Licensing Authority at least three months prior to the proposed commencement of the monitoring work. Written agreement from the Licensing Authority is required at least one month prior to the commencement of the monitoring work. (See also Annex 1 in relation to monitoring of electro-sensitive species).

9.7 The Fisheries Liaison Officer (see condition 9.15) shall pay due regard during the conduct of any fisheries surveys to the need to safeguard the safety of any persons engaged in fishing operations on the site of the windfarm

Ornithological Monitoring

9.8 Ornithological monitoring must be carried out as outlined in Annex 2 attached to this schedule. The full specification for the monitoring will be subject to separate written agreement with the Licensing Authority following consultation with CEFAS, Natural England and the Countryside Council for Wales prior to the proposed commencement of the monitoring work.

9.9 Post-construction monitoring must be undertaken annually for three years. The level of any subsequent ornithological monitoring, during the lifetime of the windfarm's operation, will be determined, in consultation with Natural England and the

Countryside Council for Wales, having regard to the magnitude of any change in bird populations observed during the initial monitoring period.

9.10 Cetacean, Pinnepeds and Basking Sharks. During construction the Licence Holder must ensure that disturbance to cetaceans, seals and basking sharks is minimised by operating a soft start procedure for all drilling and/or piling operations.

Timing

9.11 As there are internationally important numbers of protected species of overwintering estuarine and coastal birds in the vicinity of the windfarm the Licence Holder must ensure that works are undertaken within the following times: -

- March to March 2007 inclusive for works within the array
- March to October inclusive for works from the array to land

so as to minimise disturbance to over-wintering birds. Any specific requirement for works outside these times shall only take place after written approval from the Licensing Authority (following consultation with CEFAS and Natural England). In so far as is practicable, the majority of the piling or drilling works shall only be undertaken during the months of April to June.

Interference

9.12 The Licence Holder must ensure that a Notice to Mariners is issued at least 10 days prior to works commencing warning of the start date for the construction of the windfarm and the expected supply/construction vessel routes from the local service ports to the array. A second Notice to Mariners must be issued warning of the timing and route of laying the submarine cable. These Notices to Mariners must be updated and reissued at appropriate intervals and supplemented by VHF radio broadcasts as deemed appropriate and agreed with the Maritime and Coastguard Agency.

9.13 The Licence Holder must ensure that a suitably qualified and experienced liaison officer or officers are appointed (for fisheries and environmental liaison) and the Licensing Authority notified before any work commences, to establish and maintain effective communications between the Licence Holder, contractors, fishermen, conservation groups and other users of the sea during the project.

9.14 The Licence Holder must ensure that information is made available and circulated in a timely manner through the liaison officer(s) to minimise interference with fishing operations and other users of the sea.

9.15 The Licence Holder must ensure that the liaison officer's environmental remit includes:

- Monitoring compliance with the commitments made in the Environmental Statement and the Environmental Management Plan.
- Providing a central point of contact for the monitoring programme described in Annexes 1 and 2.
- Liaison with fishermen, conservation groups and other users of the sea concerning any amendments to the method statement and site environmental procedures.
- Inducting site personnel on the site/works environmental policy and procedures.

9.16 The Licence Holder must submit a copy of a Project Environmental Management Plan for the approval of the Licensing Authority, in consultation with CEFAS and Natural England, prior to the proposed commencement of construction work to ensure that satisfactory arrangements are in place for liaison on environmental issues (as such the plan should provide names and contact details for the environment liaison officer(s)). This must be submitted to the Licensing Authority at least three months prior to the proposed commencement of works. Written agreement is required from the Licensing Authority at least one month prior to the commencement of works.

Seabed Morphology and Scour

9.17 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 windfarm to assess 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 (eg 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 the form of a report to the Licensing Authority, including proposals for scour protection measures.

9.18 To ensure the integrity of the windfarm 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 windfarm although the frequency must be reviewed in discussions with the Licensing Authority at the end of the 3 year monitoring programme).

9.19 The area for the windfarm and cable route is very dynamic therefore all of the associated cabling should be buried both to minimise the risk of emergence and reduce the potential effects of electromagnetic fields. Where practicable, the Licence Holder must ensure that the cable is buried to a depth of 3 metres.

9.20 If the monitoring results carried out under condition 9.17 indicate that scour protection is not required, or if the Licence Holder's plans for scour protection differ substantively from the measures detailed in the Provisional Method Statement (submitted 11 February 2003) or in the Environmental Statement, the Licence Holder must seek approval from the Licensing Authority for the change in the works previously notified to the Licensing Authority.

Should additional cable protection be required (eg rock armour) a separate Food and Environment Protection Act/Coast Protection Act application must be submitted.

9.21 Any scour protection placed around the monopile foundations should be inert material with minimal fines and the Licensing Authority's prior approval is required for the nature and origin of the material. The Licence Holder must provide evidence to the Licensing Authority that consideration has been given to the use of fronded mattresses for scour protection.

General

9.22 The Licence Holder must ensure that any debris or temporary works placed below MHWS are removed on completion of the works authorised by this Licence. (NB Drill cuttings, if drilled with water-based muds, can be left on the seabed within the area leased from the Crown Estate for the construction of an offshore windfarm. However, should these need to be removed and sea disposal considered an application for a separate FEPA licence will be required).

9.23 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 the 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 at the developers expense.

9.24 All chemicals utilised in the drilling operation must be selected from the List of Notified Chemicals assessed for use by the offshore oil and gas industry under the Offshore Chemicals regulations 2002 (this list can be viewed/downloaded at www.cefas.co.uk). Should any system other than a water-based mud be considered for use in the drilling operation, written approval and guidance on disposal of any arisings will be required from the Licensing Authority.

9.25 The Licence Holder must ensure that any chemical agents placed within the void of the monopile, eg biocides, corrosion inhibitors etc. are selected from the List of Notified Chemicals (see condition 9.24). The use of any chemical not contained on this list will require prior consent from the Licensing Authority following a comparable ecotoxicological hazard/risk assessment undertaken at the Licence Holders own expense.

9.26 The Licence Holder must ensure that all protective coatings; paints etc. used are suitable for use in the marine environment and, where necessary, are approved by the Health and Safety Executive.

9.27 The Licence Holder must ensure that storage, handling, transport and use of fuels, lubricants, chemicals etc. during construction on vessels and equipment should prevent releases to the marine environment, ie bunding should be 10% total volume of all reservoirs, containers etc.

9.28 The Licence Holder must produce a Marine Pollution Contingency Plan for spills, collision incidents during construction and operation, and this must be adhered to. The Contingency Plan must have regard to plans for Liverpool Bay, River Mersey, River Dee & offshore installations. The plan should include Natural England's emergency contact details - Marine Pollution Officer, pager number: 07626 419491. Practices used to refuel vessels at sea must conform to industry standards.

9.29 Directional drilling equipment should be utilised in preference for cable laying but, if this can be shown to be an inappropriate technique, the Licence Holder must ensure that all reasonable care is taken to minimise disturbance and resuspension of seabed sediments. Water jetting will be permitted within the wind farm array. If jetting is required outside this area, the Licensing Authority must be informed so that an assessment can be made of the potential impacts prior to any jetting being undertaken.

9.30 The Licence Holder must ensure that all reasonable care is taken to prevent the accidental release of wet concrete/grout into the marine environment.

9.31 In the event that directional drilling techniques are not utilised the Licence Holder must ensure that the top layers of sediment are separated from the sub-surface sediments during works in the intertidal zone (where practicable) and replaced in the trench in the appropriate sequence to assist recolonisation of benthic organisms.

9.32 All the above conditions are also applicable to the meteorological mast which must be considered as an integral part of the development.

9.33 The Licence Holder is not permitted to commence the deposit operation specified by this licence 31864/07/0until the Licensing Authority has in writing varied the licence to include specific timings of the works and inserted descriptions of the chosen working methodologies.

9.34 In addition to the initial licence charge paid with the application (or application for extension) relating to this Licence, the Licence Holder shall pay a further annual instalment of the licence charge in respect of the second period of twelve months of the licence (equivalent to the extension charge in force at the due date). Payment of the annual instalment shall be due and be made to the Licensing Authority 28 days prior to the anniversary of the original start date of this licence.

9.35 The Licence shall be deemed to become invalid and shall be liable to be revoked in the event that the Licence Holder fails to make full payment of each annual instalment of the licence charge within a period of 28 days following the respective due date for payment.

9.36 The Licensing Authority reserves the right to seek a further variation charge in the event that the Licence Holder requests any significant change to the work or the working methods to which this licence applies, or to its terms and conditions. Should the Licence Holder seek to make changes to the terms and conditions of this licence or to the work to which it relates which in the opinion of the Licensing Authority will require it to be substantially re-assessed, the Licensing Authority may seek to revoke this licence and request a revised application.

9.37 In addition to the powers of variation or revocation set out in sections 8(10) and (11) of the Food and Environment Protection Act 1985, the Licensing Authority may suspend this Licence if it appears to the Licensing Authority that there has been a breach of any of its provisions or if it appears to the Licensing Authority that this Licence ought to be suspended because of a change in circumstances relating to the marine environment, the living resources which it supports or human health or because of increased scientific knowledge relating to any of those matters or for any other reason that appears to the Licensing Authority to be relevant. Any such suspension may apply to some or all of the activities permitted by this Licence (as specified in the notice of suspension) and may be imposed either for a period of time specified in the notice of suspension or for an indefinite period until the Licensing Authority is satisfied that conditions specified in the notice of suspension have been met.

10. Conditions relating to the Construction, Equipment and Operation of the Vessels engaged upon Deposit Operations

10.1. All motor powered vessels engaged in operations to which this licence **31864/07/0** relates must be fitted with the following equipment:

10.1.1 Electronic positioning aid to provide navigational data e.g. GPS, etc.

10.1.2 Radar

10.1.3 Echo sounder

10.1.4 Multi-channel VHF

10.2. All vessels' names or identification shall be clearly marked on the hull or superstructure.

10.3. All communication on VHF working frequencies shall be in the English Language.

10.4. Under no circumstances shall a vessel engage in the deposit operations until all equipment specified in this paragraph is fully operational.

EXPLANATORY NOTES

This page does not form part of this licence **31864/07/0** or its associated schedule but the licence holder is recommended to read the following guidance notes.

1. The granting of this licence **31864/07/0** does not absolve the Licence Holder from obtaining such other authorisations, consents and approvals which may be required under any other legislation, controls or regulations.

2. Under Section 8 of the Food and Environment Protection Act 1985, the Licensing Authority may vary or revoke this Licence **31864/07/0** if it appears to the Authority that the Licence Holder is in breach of any conditions in it or for any other reason that appears to the Authority to be relevant.

3. A person who makes a deposit, or causes a deposit to be made, at sea in contravention of the conditions specified in this licence 31864/07/0 may be found guilty of an offence under Section 9(1) of the Food and Environment Protection Act. It is a defence under Section 9(3) of the Act for a person charged with such an offence to prove that the operation was carried out for the purpose of securing the safety of the vessel or of saving life ("force majeure") and that he/she took steps within 48 hours following the incident to send full details of the incident including those relating to the operation, the locality and the circumstances in which it took place and the substances or articles concerned, to the Licensing Authority (see paragraph 6 of the schedule).

4. If the works authorised by this Licence **31864/07/0** are unlikely to be completed by the expiry date of this licence, the Licence Holder should apply for a replacement licence at least 10 weeks prior to the expiry date of this Licence

Annex 1

This is an annex to the schedule of Licence 31864/07/0

MONITORING REQUIREMENTS

This Annex summarises the minimum physical and biological (excluding birds) monitoring requirements that must be undertaken to comply with the conditions of Licence 31864/03/0. Full details of the proposed survey specifications to meet these requirements are to be set out in a separate report to be agreed by the Licensing Authority, in consultation with CEFAS and Natural England - see licence condition 9.3 Agreement from the Licensing Authority must be received prior to the commencement of any survey works.

1. Suspended Sediment Concentrations (SSC)

The following monitoring must be undertaken to validate and confirm predictions. Monitoring must be based on the deployment of three suspended sediment meters over a period of at least 4 weeks during pre-construction, construction (during drilling, piling and cabling) and post construction periods.

These would need to be deployed as follows:

- At a representative point identified by the modelling and within the sediment plume to measure near-field effects of sediment release.
- At a representative point identified by the modelling and within the sediment plume to measure far-field effects
- At a point outside the predicted area of the sediment plume to provide a 'control' measure of natural suspended sediment levels over the respective monitoring periods.

Alternative approaches may be acceptable but the methodologies would have to be submitted to the Licensing Authority for review and agreement at least one month prior to the proposed commencement of the monitoring work.

In line with the second paragraph of the supplementary conditions at section 9 of this Licence, should suspended sediment levels associated with the construction works be shown to be at unacceptable levels (ie above threshold) works may need to be suspended while a less disruptive methodology is investigated. Background levels from the monitoring programme will be used to set suitable threshold levels.

2. Seabed Morphology and Scour

(See Supplementary Licence Conditions 9.17 and 9.21)

Monitoring of seabed morphology should include the cable route (both between the turbines and to shore) to assess sediment movements in relation to the cable burial depth and the long term integrity of the cable.

3. Contaminants

The Environmental Impact Statement predicted that sediment redistribution during construction would be low. To assist in validating this prediction in addition to the suspended sediment concentration monitoring described above further sediment samples for contaminant analyses are required from within and adjacent to the turbine array and the cable route. The outcome of the pre-construction monitoring may necessitate the addition of mitigation measures to minimise and control the release of sediments during the cable laying operation. Samples are required from a representative number of locations at the following at 0.5 metre intervals (the first being a surface sediment sample) to provide a profile of the unconsolidated sediments.

4. Current Monitoring

To monitor predictions made in the Environmental Impact Statement for the Burbo offshore windfarm of a wake effect downstream of each monopile further investigation is required.

Post construction Acoustic Doppler Current Profiler (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 re-evaluated.

5. Benthic Organisms

Sample locations for ongoing monitoring must be determined by factors such as precise monopile locations, location of cables etc. Sample locations must also take full account of factors such as sensitive areas, coastal processes modelling outputs (for sediment transport/deposition information) and geophysical surveys (to ensure adequate coverage of seabed habitats). The following samples should be taken to adequately cover the extent and direction of the full tidal excursion. The number and location of the sample points needs to be submitted to the Licensing Authority along with a plan and rationale and agreed with CEFAS and Natural England at least one month prior to the survey works commencing.

The survey should be designed in line with the approach described in the CEFAS publication 'Guidelines for the conduct of benthic studies at aggregate dredging sites, May 2002'. Copies of this document are available from CEFAS or can be downloaded from www.cefas.co.uk/publications/files/02dp1001.pdf

Colonisation of monopiles and scour protection must be determined by diver-operated video observations and analyses with some accompanying 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. The precise details of the monitoring for the cable route and the reinstatement works are dependent on the methodologies used. The Licence Holder must therefore provide the details of the methodology used for cable laying at least 2 months prior to works commencing so that recommendations on the benthos monitoring specifications can be made.

NB. The sedimentary and benthic data sets must be closely related and the resultant reports should include quality assurance, statistical analyses and full species lists.

6. Electromagnetic Fields

The Licence Holder must provide the Licensing Authority with information on attenuation of field strengths associated with the cables, shielding and burial described in the Method Statement (to be submitted to the Licensing Authority as a matter of urgency) and related to data from the Rødsand windfarm studies in Denmark and any outputs from the COWRIE tendered studies in the UK (where appropriate). This is to provide reassurance that the cable shielding and burial depth(s), both between the turbines and along the cable route to shore, given the sediment type(s) at the Burbo site are sufficient to ensure that the electromagnetic field generated is negligible. Should this study show that the field strengths associated with the cables are sufficient to have potential detrimental effect on electrosensitive species, further biological monitoring to that described in Section 7 of this Annex may be required to further investigate the effect.

7. Marine Fish

(See also Supplementary Licence Condition 9.6)

The Environmental Impact Assessment observed electrosensitive species (eg Thornback Ray) in in this area of Liverpool Bay and in the vicinity of the Burbo site (although frequency and abundance were not quantified). 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 Burbo offshore windfarm (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 described in the preceding section (6).

8. Noise and Vibration

(See also Supplementary Licence Condition 9.5)

Detailed post construction data must be collected on the frequency and magnitude of underwater noise produced by the Burbo offshore windfarm. 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 proposed in Annexes 1 and 2, the data would help to elucidate any interactions between noise generation and the provision of new habitat and fish aggregation effects of the turbine support structures.
- Determining the effects of distance depth and background sources on noise propagation.

9. Numerical Models

Calibration of the hydrodynamic model for speed and direction at BB1 and BB2.

-------------------------------------- This is the end of this Annex --------------------------------------

Annex 2

This is an annex to the schedule of Licence 31864/07/0

ORNITHOLOGICAL MONITORING

Monitoring will commence with at least a year of baseline, pre-construction data gathering and monitoring during the year of construction. Post-construction monitoring will be undertaken annually for three years. The level of subsequent monitoring, during the lifetime of the windfarm's operation, will be determined, in agreement with Natural England, by the magnitude of change in bird populations observed in the initial monitoring period. The ornithological monitoring programme may have to be adapted and amended as new technologies and research findings become available.

Monitoring should be linked, where appropriate, with the benthic monitoring.

Monitoring reports will be provided to Natural England annually, or more frequently where the results of the data may trigger further monitoring work. Monitoring of an agreed reference site will also be carried out in parallel to the windfarm site.

Monitoring will need to fulfil the following objectives:

To be developed in consultation with NE

-- **This is the end of this Annex** --

Annex 3

THIS IS AN ANNEX TO THE SCHEDULE OF LICENCE 31864/07/0

Turbine foundations will be located at the following co-ordinates.

Turbine Number	Latitude	Longitude
01	53 28.480 N	03 11.110 W
02	53 28.680 N	03 11.470 W
03	53 28.880 N	03 11.850 W
04	53 29.080 N	03 12.220 W
05	53 29.300 N	03 12.580 W
06	53 29.500 N	03 12.970 W
07	53 29.700 N	03 13.330 W
08	53 28.700 N	03 10.520 W
09	53 28.900 N	03 10.900 W
10	53 29.100 N	03 11.300 W
11	53 29.300 N	03 11.650 W
12	53 30.500 N	03 12.020 W
13	53 29.720 N	03 12.380 W
14	53 29.290 N	03 12.770 W
15	53 30.120 N	03 13.130 W
16	53 28.700 N	03 09.580 W
17	53 28.900 N	03 09.950 W
18	53 29.120 N	03 10.320 W
19	53 29.320 N	03 10.700 W
20	53 29.520 N	03 11.070 W
21	53 29.720 N	03 11.430 W
22	53 29.920 N	03 11.820 W
23	53 30.120 N	03 12.180 W
24	53 29.920 N	03 09.000 W
25	53 29.120 N	03 09.370 W

-- **This is the end of this Annex** --

Appendix 2 Environmental Monitoring Methods

Centre for Marine and Coastal Studies Ltd

Burbo Bank Offshore Wind Farm
FEPA Monitoring Methods

Document: J3034 Burbo FEPA Methods v1.5 (08-06)

REVISION RECORD

Version	Date	Description	Prepared	Checked	Approved
1.0	01/07/05	Draft for consultation	IGP/TH		
1.1	10/08/05	Internal amendments	IGP		
1.2	13/08/05	Internal amendments	IGP	TH	
1.3	19/08/05	Submitted methods	IGP	TH	TH
1.4	12/04/06	Updated methods and progress updates.	IGP/TH	TH	IGP
1.5	15/08/06	Updated construction schedule and methods	IGP	LG	IGP

CONTENTS

INTRODUCTION

FEPA Monitoring

Centre for Marine and Coastal Studies Ltd (CMACS) has been appointed by SeaScape Energy Ltd to devise and undertake the pre and post-construction surveys to fulfil requirements for environmental monitoring under the Food and Environment Protection Act (FEPA) licence (Ref 31864/03/0, see Appendix 2) for Burbo Offshore Wind Farm in Liverpool Bay.

Version 1.3 of this document, issued in August 2005, set out the survey methods proposed by CMACS on behalf of the wind farm developer. These methods incorporated comments received from consultees following distribution of draft (v1.0) methods in July 2005. Version 1.4 provided the following information:

1. a report on progress of pre-construction surveys thus far, in advance of the first annual FEPA monitoring report;
2. provided further detail and sought consultee support and approval for certain aspects of the environmental monitoring where this had been firmed up following confirmation of engineering solutions and the project construction timetable;
3. identified proposed changes to the previous (v1.3) survey methodology and programme and to seek consultee support and approval for these changes.

Our proposed approach to meeting the requirements of the FEPA licence, including scheduling of the environmental surveys (Appendix 1) is presented in this document. Each section relates to numbered sections of the FEPA licence and contains a summary of relevant text from the Licence followed by our proposed survey approach.

We have provided in Table 1, below, a summary of the current wind farm construction schedule as this is central to the timing of environmental surveys. A split installation period is planned, with cables and wind turbine foundations installed in 2006 and turbines in advance of wind farm commissioning in 2007. This schedule is subject to change and surveys would be re-scheduled accordingly should timings vary.

We also provide in Table 2 a summary of changes to survey methods proposed since the previous (v1.4) document. Updates on progress where monitoring has either commenced or is imminent is provided at the end of each section.

Wind Farm Construction Schedule

Table 1 Outline construction schedule for major offshore works

	2006									2007			
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Apr	May	Jun	Jul
Work Element													
Foundations		■	■	■									
Scour Protection	■	■	■	■	■								
Cables to shore				■	▒								
Array Cables					▒	▒	▒						
Wind Turbines										▒	▒	▒	▒

■	completed
▒	ongoing/scheduled

NB 1 For the purposes of environmental monitoring the construction period is considered to have commenced on 21st May 2006 when scour protection placement in advance of hammer piling of the first monopile foundations began. Horizontal directional drilling works to install a conduit for power export cables under the sea wall commenced in April 2006 but these onshore works are not considered relevant to any of the monitoring.

NB 2 Works that affect the foreshore (beach) were originally to be completed by the end of August, in line with Town and Country Planning consent. Following construction delays an application was made to Wirral Borough Council to extend these works through September. English Nature have provided advice in support of this request.

NB 3 Condition 9.11 of the FEPA licence states that '*As there are internationally important numbers of protected species of overwintering estuarine and coastal birds in the vicinity of the windfarm the Licence Holder must ensure that works are undertaken in the months of March to October (inclusive) so as to minimise disturbance to over-wintering birds.*' An application is being made to DEFRA to extend the period of offshore works from the end of October until the end of December 2006. Works are anticipated to pause at the end of November (Table 1) with December available as a buffer for any overrun.

Summary of Key Changes in Methods Since Previous Version

Table 2 Proposed Changes in Monitoring Methods

Monitoring Element	Summary of proposed changes
Annex 1(1) Suspended Sediments	Following discussion with Adrian Judd (CEFAS), monitoring of both export cable and array cable installation works (previously only array cable installation was to be monitored).

Timetable changes have been made throughout the document as necessary.

FEPA Licence Requirements and Proposed Monitoring: ANNEX 1

Annex 1(1) Suspended Sediment Concentrations- SSC

FEPA Licence, Annex 1(1)

The following monitoring must be undertaken to validate and confirm predictions. Monitoring must be based on the deployment of three suspended sediment meters over a period of at least 4 weeks during pre-construction, construction (during drilling, piling and cabling) and post construction periods.

These would need to be deployed as follows:

- *At a representative point identified by the modelling and within the sediment plume to measure near-field effects of sediment release.*
- *At a representative point identified by the modelling and within the sediment plume to measure far-field effects*
- *At a point outside the predicted area of the sediment plume to provide a 'control' measure of natural suspended sediment levels over the respective monitoring periods.*

Alternative approaches may be acceptable but the methodologies would have to be submitted to the Licensing Authority for review and agreement at least one month prior to the proposed commencement of the monitoring work.

In line with the second paragraph of the supplementary conditions at section 9 of this Licence, should suspended sediment levels associated with the construction works be shown to be at unacceptable levels (i.e. above threshold) works may need to be suspended while a less disruptive methodology is investigated. Background levels from the monitoring programme will be used to set suitable threshold levels.

NB No further guidance on suspended sediment levels was found in the supplementary conditions.

Proposed Approach

Deployment of suspended sediment meters at fixed locations will provide broad scale information about impacts on suspended sediments during construction but is unlikely to provide useful information on sediment settlement rates and the zone of any impact. Fixed loggers would monitor at a single depth only (most likely 1m above the sea bed) and would therefore be unable to detect effects throughout the entire water column. Fixed loggers are vulnerable to damage by trawls, anchors etc. and can also be covered by sediments or fouled by marine organisms/debris. A final drawback is that if any threshold level were exceeded we would not be aware of this until the equipment was recovered and data uploaded.

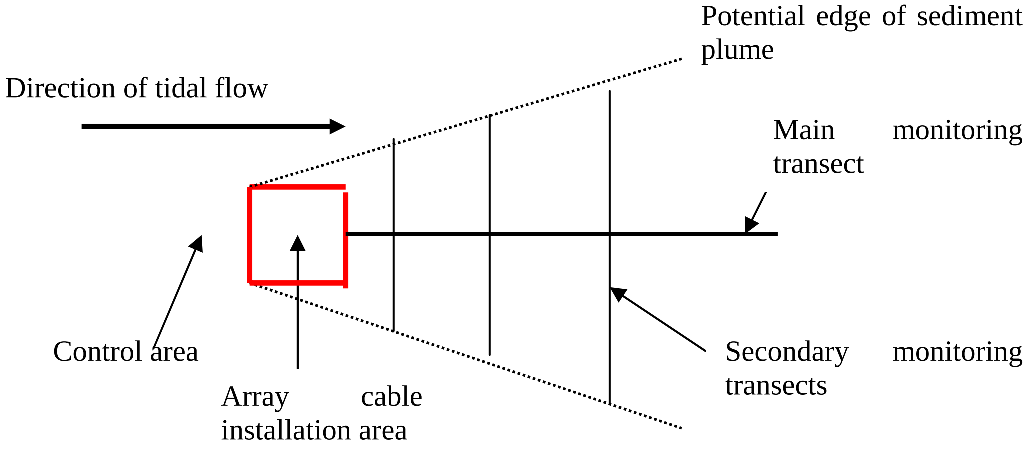
The FEPA licence does state that alternative approaches may be acceptable. We believe that the following approach would provide for better monitoring of SSC.

SSC survey would be undertaken using a hand deployed probe from a boat. The survey would take place over 1-2 days (covering at least one full tidal cycle) immediately before and during initial **export cable** installation works and be repeated for the array cable works. Cables to shore are to be installed using a plough and we anticipate very limited sediment mobilisation whereas array cable installation will be facilitated by jetting which has higher potential to mobilise fine sediments. We do not consider that hammer piling to install monopile foundations has significant potential to mobilise sediments into the water column and therefore propose to focus monitoring on both cable installation works.

Measurements would be made throughout the water column (e.g. bottom plus 1, 2, 4, 6, 10 and surface minus 1m) uptide of works and at varying distances downtide until no impact was detectable. The measurements uptide of works would provide an accurate local control measure of natural suspended sediment levels.

Measurements would also be taken at limited depths (potentially bottom plus 1m and a mid-water reading) at positions perpendicular to the main survey transect to allow an estimation of the width of any plume to be determined.

The following schematic outlines the anticipated approach:



The licence indicates that a threshold value for SSC is required against which monitored levels can be compared. Suspended sediment concentrations near large estuaries such as the Mersey are highly variable, showing predictable variability in relation to tidal action (both diurnal and semi-lunar patterns being evident) and less predictable variability in relation to wave action and riverine sediment inputs.

In the case of the Mersey, natural suspended sediment levels can be very high. The environmental statement identified that natural near-bed suspended sediment levels in the Mersey estuary could approach 1500mg/l (HR Wallingford 1982, cited in Burbo ES), although it is likely that higher levels are reached naturally on occasions.

We propose that a threshold of not more than 5 times background (control area), or 3,000mg/l throughout the water column (measured as close as safely possible to construction activity), whichever is greater, be adopted during works.

Update on Progress

Suspended sediment monitoring is programmed to take place upon commencement of export cable installation works in August/September 2006. The survey will be repeated for array cable installation works in September/October 2006.

Annex 1(2) Seabed Morphology and Scour

FEPA Licence, Supplementary Conditions 9.17-9.21

9.17 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 windfarm to assess 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 the form of a report to the Licensing Authority, including proposals for scour protection measures.

9.18 To ensure the integrity of the windfarm 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 windfarm although the frequency must be reviewed in discussions with the Licensing Authority at the end of the 3 year monitoring programme).

9.19 The area for the windfarm and cable route is very dynamic therefore all of the associated cabling should be buried both to minimise the risk of emergence and reduce the potential effects of electromagnetic fields. Where practicable, the Licence Holder must ensure that the cable is buried to a depth of 3 metres.

9.20 If the monitoring results carried out under condition 9.17 indicate that scour protection is not required, or if the Licence Holder's plans for scour protection differ substantively from the measures detailed in the Provisional Method Statement (submitted 11 February 2003) or in the Environmental Statement, the Licence Holder must seek approval from the Licensing Authority for the change in the works previously notified to the Licensing Authority.
Should additional cable protection be required (eg rock armour) a separate Food and Environment Protection Act/Coast Protection Act application must be submitted.

9.21 Any scour protection placed around the monopile foundations should be inert material with minimal fines and the Licensing Authority's prior approval is required for the nature and origin of the material. The Licence Holder must provide evidence to the Licensing Authority that consideration has been given to the use of fronded mattresses for scour protection.

FEPA Licence, Annex 1(2)

Monitoring of seabed morphology should include the cable route (both between the turbines and to shore) to assess sediment movements in relation to the cable burial depth and the long term integrity of the cable.

Proposed Approach

There will be six bathymetric surveys over 3 years at a minimum of 4 turbines and including the cable route to shore to assess sediment movements in relation to cable burial depth and the long term integrity of the cable. The first survey will be within 3 months of completion of construction of the wind farm (specifically, wind turbine foundations and power cables). This is anticipated to be between October and December 2006 (subject to ongoing construction works and may be delayed).

Annex 1(3) Contaminants

FEPA Licence, Annex 1(3)

The Environmental Impact Statement predicted that sediment redistribution during construction would be low. To assist in validating this prediction in addition to the suspended sediment concentration monitoring described above further sediment samples for contaminant analyses are required from within and adjacent to the turbine array and the cable route. The outcome of the pre-construction monitoring may necessitate the addition of mitigation measures to minimise and control the release of sediments during the cable laying operation. Samples are required from a representative number of locations at the following at 0.5 metre intervals (the first being a surface sediment sample) to provide a profile of the unconsolidated sediments.

Proposed Approach

Contaminants sampling has been completed using a methodology agreed with CEFAS and outlined below:

> The depth of the surface sand layer on site averages 12 metres. CMACS and RPS (who are the geotechnical consultants to Seascape and Elsam Engineering) assess that the unconsolidated surface layer that has been subject to mobilisation and deposition in recent history, and might therefore show anthropogenic contamination, is 2-3 metres deep. We suggest that an appropriate survey approach would be to sample contaminants at 0.5 metre intervals to a similar depth and analyse for the same suite of determinands covered by the EIA. We would anticipate obtaining up to 6 cores (up to 6 samples each) from the array and up to 3 cores (5 or 6 samples each) from the cable route.

Update on Progress

The resultant data were reported by CMACS in October 2005 (Doc ref: J3034 Contaminants v1.0, 25 October 2005) as an additional item in advance of the annual FEPA report.

This will also be incorporated into the first annual FEPA report.

Annex 1(4) Current Monitoring

FEPA Licence, Annex 1(4)

To monitor predictions made in the Environmental Impact Statement for the Burbo offshore windfarm of a wake effect downstream of each monopile further investigation is required. Post construction Acoustic Doppler Current Profiler (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 re-evaluated.

Proposed Approach

A one-off post construction ADCP survey will be completed and results compared to predictions in the ES.

Annex 1(5) Benthic Organisms

FEPA Licence, Annex 1(5)

Sample locations for ongoing monitoring must be determined by factors such as precise monopile locations, location of cables etc. Sample locations must also take full account of factors such as sensitive areas, coastal processes modelling outputs (for sediment transport/deposition information) and geophysical surveys (to ensure adequate coverage of seabed habitats). The following samples should be taken to adequately cover the extent and direction of the full tidal excursion. The number and location of the sample points needs to be submitted to the Licensing Authority along with a plan and rationale and agreed with CEFAS and English Nature at least one month prior to the survey works commencing. The survey should be designed in line with the approach described in the CEFAS publication 'Guidelines for the conduct of benthic studies at aggregate dredging sites, May 2002'. Copies of this document are available from CEFAS or can be downloaded from www.cefas.co.uk/publications/files/02dp1001.pdf. Colonisation of monopiles and scour protection must be determined by diver-operated video observations and analyses with some accompanying 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. The precise details of the monitoring for the cable route and the reinstatement works are dependent on the methodologies used. The Licence Holder must therefore provide the details of the methodology used for cable laying at least 2 months prior to works commencing so that recommendations on the benthos monitoring specifications can be made. NB. The sedimentary and benthic data sets must be closely related and the resultant reports should include quality assurance, statistical analyses and full species lists.

Proposed Approach

Sub-tidal Benthic Ecology

The approach is based on the recommendations of the environmental statement, taking into account the FEPA licence conditions. In the ES it was recommended that approximately 20 benthic stations be established with triplicate samples obtained from each station.

Surveys would be undertaken annually in late summer to coincide as closely as possible with completion of the main elements of construction. The following sample stations have been selected to provide good coverage in relation to known seabed habitats which are based on previous biological and geophysical surveys. As far as possible sites surveyed in the original characterisation survey for the EIA have been chosen to provide maximum long-term data[1].

Site positioning in relation to known seabed habitats is described in Figure 1. There are 17 sites on Fig.1 , numbered to reflect site numbers in the original EIA survey to aid comparisons. Triplicate grab samples would be obtained from each site. A total of 20 sites will exist once the positions of 3 stations near to a wind turbine monopile are finalised (see below).

A control site has been positioned outside of one tidal excursion from the development. The finalised control site will be in the same region that will provide the control area for ornithological monitoring.

We have included at least two sites at each of the identified biotopes: FfabMag; NcirBat; and an area with an unclassified community that had similarities to the other biotope types, especially NcirBat, but was richer than NcirBat.

Outside the array the survey again covers all the biotopes: AbrNucCor, a muddier biotope immediately west of the array; Ffabmag, including quite rich versions of this biotope to the north; and Ncir Bat, to the south. In covering the latter it has been ensured that one site (65) was a repeat of a site where we previously found the thumbnail crab *Thia scutellata*, a nationally scarce species according to Rees (2001).

In order to fulfil requirement to consider sites out as far as the tidal excursion the survey includes one of the previously surveyed sites within the Rock Channel, and also a previously unsurveyed area well to the north west of the site. It is not clear what community this will lie on, but likely to be either an Abra dominated or shallow Venus type of community (now thought equivalent to the biotopes FfabMag or MoeVen).

To the south there are also three sites on the cable route (two within the FfabMag community and one within the less rich NcirBat community; the latter (64) is another site where *Thia scutellata* was previously found.

Once precise turbine positions are confirmed it is intended that an investigation of the effects of any scour is undertaken by placing sites at circa 30 to 50 m (or as close as is practical to the edge of any scour protection), 100 m and 150 m from any one of the turbines. It is intended that these sites will be aligned approx NW / SE i.e. in the direction the currents are expected to run. We will also need to take into account which side of the towers the cables enter/exit as we would like to work on the opposite side for safety reasons.

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[1] It should be noted, however, that the characterisation survey was completed in late spring/early summer and can not be directly compared with a late summer survey.

If precise turbine positions are known in time for pre construction (baseline) surveys these sites will be included at that stage. This is highly preferable, and so every effort should be made to ensure this is the case. However, it must be recognised that it is possible that actual turbine locations will differ from expected and this might necessitate slight movements of the locations for post development surveys. It is here suggested that the three sites close to a turbine will be placed near a turbine in the FfabMag area in the northern half of the area since this community is the most prevalent in the array area and this would also even up coverage of the array area geographically.

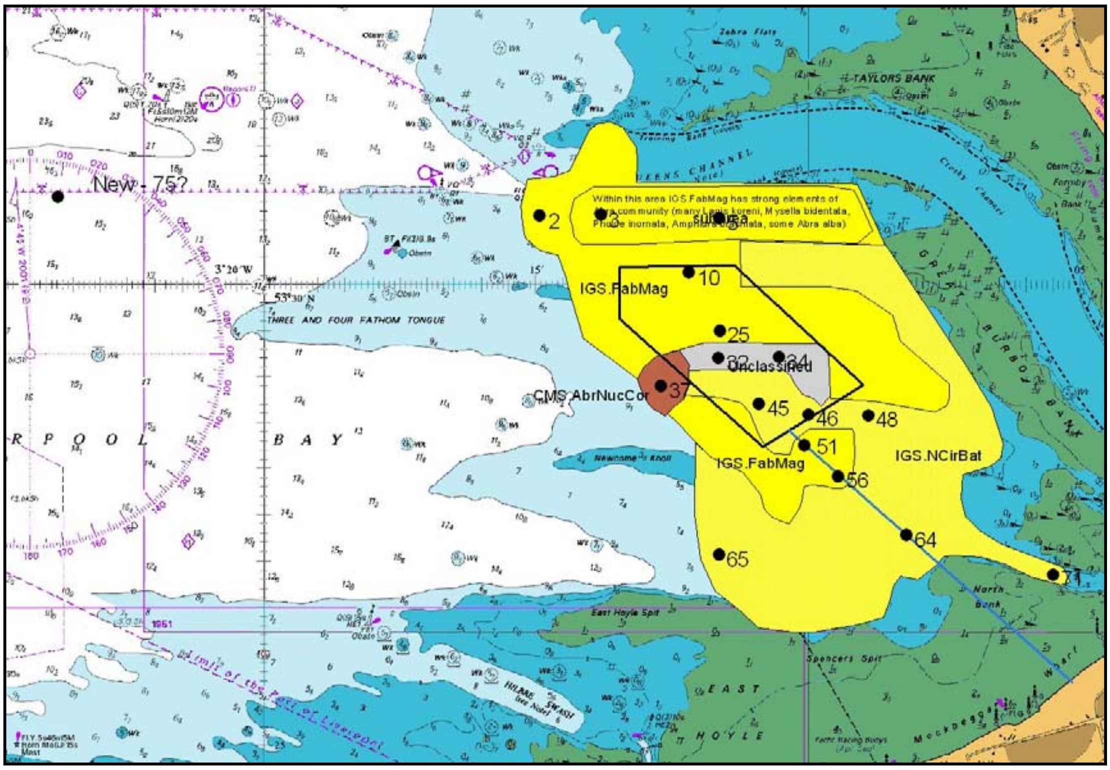

Figure 1 Sub-tidal Benthic Ecology Stations

The subtidal benthic ecological survey will be undertaken in line with DTLR best practice guidelines[2].

A 0.1 m^2 Day grab would be deployed (as per the characterisation survey).

Boat crew would operate the grab in line with safety procedure detailed in the site specific Risk Assessment (to be prepared). The survey vessel will be positioned to within 10m of the target point using DGPS with actual sample position recorded with sub-2 metre accuracy. Positional format will be Lat/Long WGS84.

CMACS will provide a scientific officer to ensure that benthic samples are taken and processed in the appropriate manner as described below.

After retrieval of the grab, the CMACS scientific officer will take a circa 200g sub-sample[3] of material for particle size and total organic carbon analysis which will be placed into a foil tray and labelled (cf. standard coding below) in line with CEFAS requirements. Sub-samples will be stored in a cool location on board (e.g. cool box) and transferred to a freezer as soon as possible once onshore.

The remaining contents of the grab will then be transferred to a 1 mm rocker sieve and the surface of the sample photographed (with sample code clearly visible).

The balance of the sample will then be washed through a 1mm mesh sieve, finer sediments discarded and material retained on the sieve transferred to a labelled bucket and fixed with buffered 20% formalin solution to at least 5% final concentration as soon as the boat is back on shore. A separate waterproof label will be added to the sample bucket duplicating the main external label.

Standard sample coding will comprise the following:

Site Description (e.g. Burbo)
Station ID/replicate a, b or c and date

The following Quality Control safeguards will apply for field sampling:

Digital photographs will be taken of all samples.

DGPS derived locations will be provided for all sample locations.

Visual descriptions of sediment type will be made at the time of sampling, together with estimates of sample volume (as a measure of sampler efficiency). Sample containers will be clearly marked externally with date, sample id and project name. There will also be an internal plastic tag carrying the same information, marked using a suitable material.

Samples will be rejected where objects such as stones or shells are suspected to have kept the jaws open or where for any other reason loss of finer fractions of the sediment is suspected.

[2] CEFAS (2002) Guidelines for the conduct of benthic studies at aggregate dredging sites.

[3] 200g or at least ten times the mass of the largest particle present, whichever is greater.

Samples will be rejected where depth of sediment is less than 5cm unless the sediment is very hard and/or coarse and it is clear that better samples can not be obtained.

> If during the first survey the first three samples at any site are rejected or no sample is obtained the site will be moved approximately 50m and further attempts made to obtain samples. Repeat surveys in subsequent years will then be undertaken at the position of the successful site.

PSA and TOC samples will be taken as a subsample of the faunal sample in each case in line with DTLR guidelines for the conduct of benthic studies at aggregate dredging sites.

The following QC safeguards will apply for laboratory analyses:

Analysis will be undertaken by an NMBAQC accredited laboratory as follows:

All sorting to be carried out by experienced operatives with low power microscopes available for use. A proportion of samples (minimum 10%) (typically one sample randomly selected from each batch of ten recently sorted samples) to be re-sorted by an experienced sorter other than the person who carried out the original sorting. In the case that the number of animals found in the original sorting was less than 95% of the total found (sorting plus re-sorting) all of the other samples in the appropriate batch sorted by that person would have to be re-sorted.

All identification to be carried out by experienced marine invertebrate taxonomists using appropriate up to date identification guides and papers, appropriate range of stereo and monocular microscopes etc. Nomenclature to follow MCS species directory unless more up to date names exist. A labelled reference collection of all taxa found will be preserved in alcohol.

Systems must be in place to ensure correct labelling of all samples throughout the process.

Sediment residues to be kept for a period of up to five years in phosphate buffered formalin unless a further QC check (for example, resorting by a company different to that doing the original sorting) has been carried out and accepted by the client.

CMACS will use the PRIMER multivariate statistical package to analyse benthic macrofauna and environmental data sets. Macrofauna community data will be related to environmental variables such as depth and sediment characteristics, including TOC.

A variety of indices to represent the benthic macrofauna will be calculated for each site. These will include numbers of taxa, faunal abundance, diversity indices etc..

GIS (ArcView) will be utilised in the analysis and reporting to represent the data, including our assessment of biotope types, in a spatial manner. This will be important to provide a visual template against which any future changes in benthic macrofaunal communities can be compared.

NB The benthic grab surveys will be supported by data from 2m scientific beam trawls which will provide additional information on epibenthic communities (Annex 1(7) Marine Fish).

Update on Progress

The baseline subtidal benthic survey was completed in September/October 2005. The survey will be reported in the first annual FEPA report.

Colonisation of Monopiles

A one-off survey of colonisation of monopile (and scour protection, if relevant) by diver-operated video is required. It is likely that two representative monopiles will be selected for survey, potentially one deep and one shallow or, if initial inspection reveals very little colonisation of shallow monopiles, two deep. The objectives of the survey will be as follows:

To study colonisation of two wind turbines.
To carry out Phase 2 habitat and community descriptions at each depth zone on each turbine base.
To take specimens of species where necessary for further identification
To video the underwater communities at each site.

It is likely that water clarity will frequently be poor and so it will be important to identify a suitable period in which to undertake this work. This will most likely be high water slack after a settled spell of dry weather with low plankton and suspended sediment levels. The indicative survey date in Appendix 1 (September 2007) may well need to be fine-tuned so that survey conditions are suitable.

Intertidal Invertebrates

Monitoring will assess the impact of cable installation on intertidal invertebrates and, therefore, on food resources for shorebirds.

The biotope map drawn from the characterisation survey in May 2002 (Figure 2) was developed according to standard MNCR methodologies (Wyn et al. 2000). This was based upon a walk-over survey supported by hand searching and sediment cores taken from observed biotopes.

The works associated with bringing the three main power cables to shore from the wind farm are expected to take place during June-July 2006. The final cable landfall positions will be within the area assessed during the EIA and are expected to be between the eastern and western cable route positions shown in Figure 2.

The monitoring approach will be as follows:

1. baseline biotope survey immediately (1-2 weeks) before landfall works in 2006, supported by sediment core samples;
2. photographic survey to show recovery of the cable route;
3. repeated sediment core samples two weeks and one month after landfall works;
4. repeat biotope survey during same month as landfall works in 2007 if a detectable impact is revealed by step 3.

NB the above strategy has been developed to meet a request from English Nature (Michael Young) for additional intertidal work following submission of an appropriate assessment of cable landfall works in relation to Liverpool Bay pSPA.

The baseline and post-construction surveys will involve sampling lower, middle and upper shore stations along 3 shore-perpendicular transects in the area of the cable landfall. One transect will be within the cable landfall corridor, the other two spaced away from this area but within the area mapped in Figure 2.

The photographic survey will provide perspectives across the cable landfall route with photographs taken on low tide immediately before works, during works and on daylight low tides for up to three low tides following works, or until no evidence of the works can be detected.

There will be triplicate faunal samples and a single psa sample at each station. It is therefore estimated that 27 sediment core samples will be required for faunal analysis and 9 for sediment particle size analysis.

Intertidal invertebrate fauna will be fully worked up and new biotope maps produced according to current MNCR methodology. Additional sediment core samples collected 2 weeks and 1 month after landfall works will be worked up semi-quantitatively; in particular, total abundance and biomass of major invertebrate taxonomic groups of importance to shorebird species will be assessed. These additional sediment cores will be taken from a sub-set of stations sampled during the baseline and post-construction surveys.

Biotopes will be assigned using the most up to date statutory guidance (existing maps will be re-drawn where necessary to facilitate comparisons). Indices of intertidal invertebrate populations (e.g. abundance and diversity) from before and after cabling works will be compared.

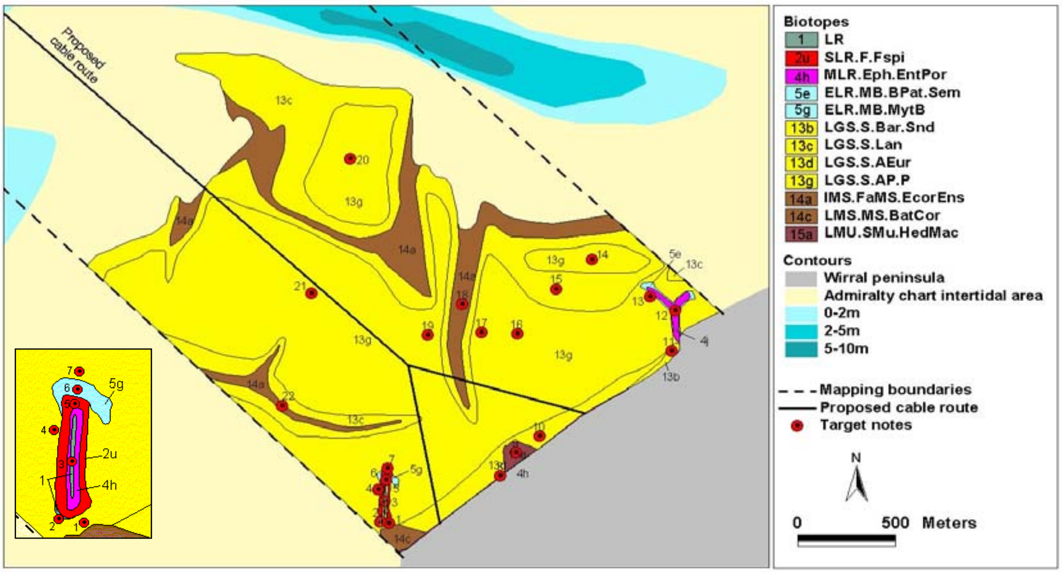

Figure 2 Intertidal Biotopes at Cable Landfall (from characterisation survey)

Update on Progress

The baseline re-survey of intertidal biotopes took place over July/August 2006. The main biotope monitoring will be reported in the second annual FEPA report in 2007 and will include post-construction monitoring surveys that are yet to be undertaken.

The photographic survey was completed following trial plough work on the beach in July 2006.

Annex 1(6) Electromagnetic Fields

FEPA Licence, Annex 1(6)

The Licence Holder must provide the Licensing Authority with information on attenuation of field strengths associated with the cables, shielding and burial described in the Method Statement (to be submitted to the Licensing Authority as a matter of urgency) and related to data from the Rødsand windfarm studies in Denmark and any outputs from the COWRIE tendered studies in the UK (where appropriate). This is to provide reassurance that the cable shielding and burial depth(s), both between the turbines and along the cable route to shore, given the sediment type(s) at the Burbo site are sufficient to ensure that the electromagnetic field generated is negligible. Should this study show that the field strengths associated with the cables are sufficient to have potential detrimental effect on electrosensitive species, further biological monitoring to that described in Section 7 of this Annex may be required to further investigate the effect.

Proposed Approach

CMACS and Canfield University have recently completed a COWRIE study into electromagnetic fields and their significance for marine organisms. We will provide information on the magnetic and induced electrical field strengths likely to be produced by Burbo Bank offshore wind farm to the Licensing Authority along with our best interpretation of the significance of such fields.

It must be stressed that further research work is planned, by CMACS and others, to investigate the environmental significance of, in particular, anthropogenic induced electrical fields in the marine environment. This is likely to be collaborative work undertaken by the offshore wind farm industry as a whole. The results of such work will feed into the reporting on electromagnetic fields at Burbo.

Annex 1(7) Marine Fish

FEPA Licence, Supplementary Condition 9.6

Since very little is known about the potential effect of windfarms 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 windfarm giving strong consideration to non-destructive methods of monitoring. The Licence Holder shall, in drawing up such proposals, canvas the views of local fishermen, North West and North Wales Sea Fisheries Committee. The proposals must be submitted to the Licensing Authority at least three months prior to the proposed commencement of the monitoring work. Written agreement from the Licensing Authority is required at least one month prior to the commencement of the monitoring work. (See also Annex 1 in relation to monitoring of electro-sensitive species).

FEPA Licence, Annex 1(7)

The Environmental Impact Assessment observed electrosensitive species (eg Thornback Ray) in this area of Liverpool Bay and in the vicinity of the Burbo site (although frequency and abundance were not quantified). 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 Burbo offshore windfarm (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 described in the preceding section (6).

Proposed Approach

There will be several strands to the fish monitoring:

1. Annual 4m beam trawl survey (targeting larger benthic and demersal species) in spring
2. Annual 2m scientific beam trawl (small and juvenile benthic species) in autumn
3. Review of fisheries data from other (e.g. CEFAS) surveys and anecdotal information obtained via the Fisheries Liaison Officer and other sources

4m Beam Trawls

A variety of fish can be caught in this area but sole and roker (thornback rays) are the main species repeatedly mentioned by local fishermen. The first survey was carried out in late April/early May 2006 when sole and roker can both be expected to be present. Since construction will be carried out in May, the first survey and seasonal repeats can not be carried out any later. The survey has been designed with the following requirements in mind: to sample locally abundant commercial fish species; to include elasmobranches which may conceivably be affected by EMF; and to provide an adequate baseline including suitable control areas.

In order to achieve these aims consideration was given to use of a number of techniques including otter trawls, longlines, gill nets, and beam trawls, all of which are used commercially in the area (although beam trawls are probably the commonest). After considering a variety of factors, including availability of suitable boats and local knowledge, ease of future repeatability etc. we have selected to use 4m beam trawls. The first survey will be from the 23.9 m fishing vessel Admiral Grenville which regularly fishes the area and regularly does survey work with CEFAS.

The proposals for an annual 4m beam trawl survey have been developed through direct discussion with Jim Ellis of CEFAS.

Note that juvenile fish have been sampled by 2m scientific beam trawl (undertaken in conjunction with benthic surveys- see below) and this will probably give the more important information on possible aggregation of fish in the vicinity of the wind farm, although additional information will be provided by video surveys of the turbines themselves once installed (see Annex 1(5) Colonisation of Monopiles).

Survey gear is a pair of commercial 4m beam trawls (total swept area 9 metres). Cod end mesh is 80 mm. There will be up to thirteen tows (Figure 3), each up to a maximum one thousand metres long (see Figure 1) but shorter if hauls are very large. Sites have been selected with comments from local fishermen in mind. Tow positions may be amended slightly in light of additional information on obstructions etc. and whilst four sites have initially been selected within the wind farm array area a minimum of two will be sampled. Four control sites have been selected; sites 3 and 4 are on comparable ground to the wind farm site but since these are only around five km from the wind-farm site an additional two (sites 1 and 2) were added further west, although here the ground/depth is not quite so comparable. It is not sensible to place controls further west due to the proximity to North Hoyle offshore wind farm.

All fish species will be counted and, so far as time allows, all fish lengths will be measured.

Where large numbers of shoaling fish such as whiting, poor cod, herring etc. are caught a representative selection will be measured if time becomes a limiting factor. However, with two scientists on board and the experienced crew to help this is unlikely to be necessary except with particularly heavy catches. All fish will be processed as quickly as possible and returned alive where possible, prioritising elasmobranches.

We will consider storing of fish stomachs from a representative selection of dogfish if caught, with the aim of analysing the contents to see how well, and on what, they have been feeding. This could form a useful baseline for future so that we can compare with feeding efficiency of dogfish (as a representative elasmobranch) in future within and outside the wind farm.

The baseline survey will be replicated as closely as possible in subsequent years.

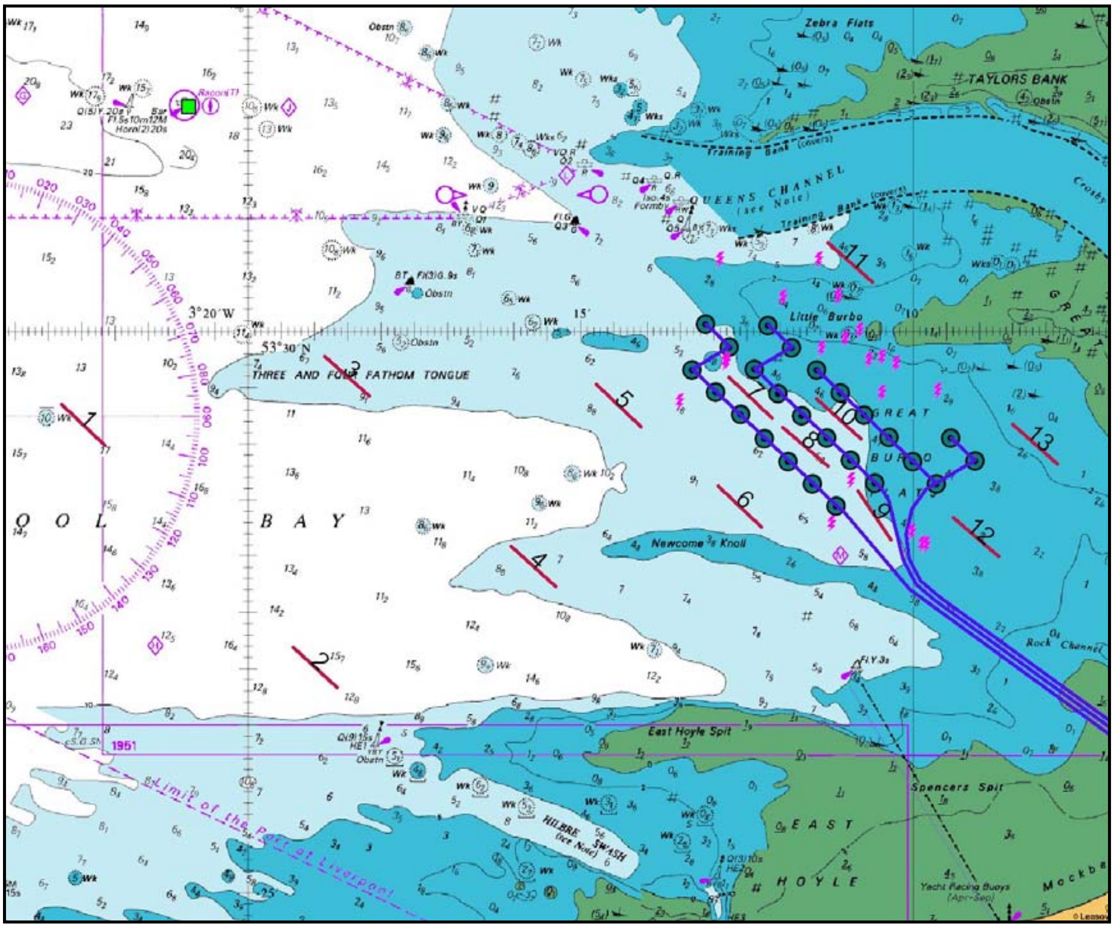

Figure 3 Locations of 4m beam trawls

2m Beam Trawls

There would be 12 beam trawls, proposed positions are indicated in Figure 4. The beam trawl sites cover the range of biotopes identified by previous study and include a control site to the west of the wind farm. Most sites have been positioned to support the grab survey by providing additional information on epibenthic communities (grab site positions are visible in Figure 4) Beam trawl sites will be off-set from grab sites by approximately 100m to avoid results being influenced by trawling over grab sample sites. Where possible, sites sampled during the original beam trawl surveys undertaken in 2002 to support the environmental assessment will be re-visited so that long-term trends may be detected.

Each beam trawl will be approximately 300m in length (2 knots for five minutes = 309 metres). Gear to be used: 2m beam trawl with 4mm square cod end mesh, with a chain matrix between the beam and foot-rope. Warp to be sufficiently long to ensure gear fishes the bottom properly. Tows will be into the current, at approximately 2 knots over ground.

All animals, including fish and macroinvertebrates, to be identified and counted on board where possible. Commercial fish species will be measured, elasmobranchs will also be sexed. Very numerous organisms such as brittle stars to be counted by sub sampling where necessary. Samples of difficult organisms, or large samples which cannot be dealt with in time on board, would be preserved and taken to the laboratory for subsequent identification. A photograph of each beam trawl haul will be taken. As far as possible all captured organisms will be returned to the sea.

DGPS fixes will be taken for beginning and ends of tows so they can be repeated later.

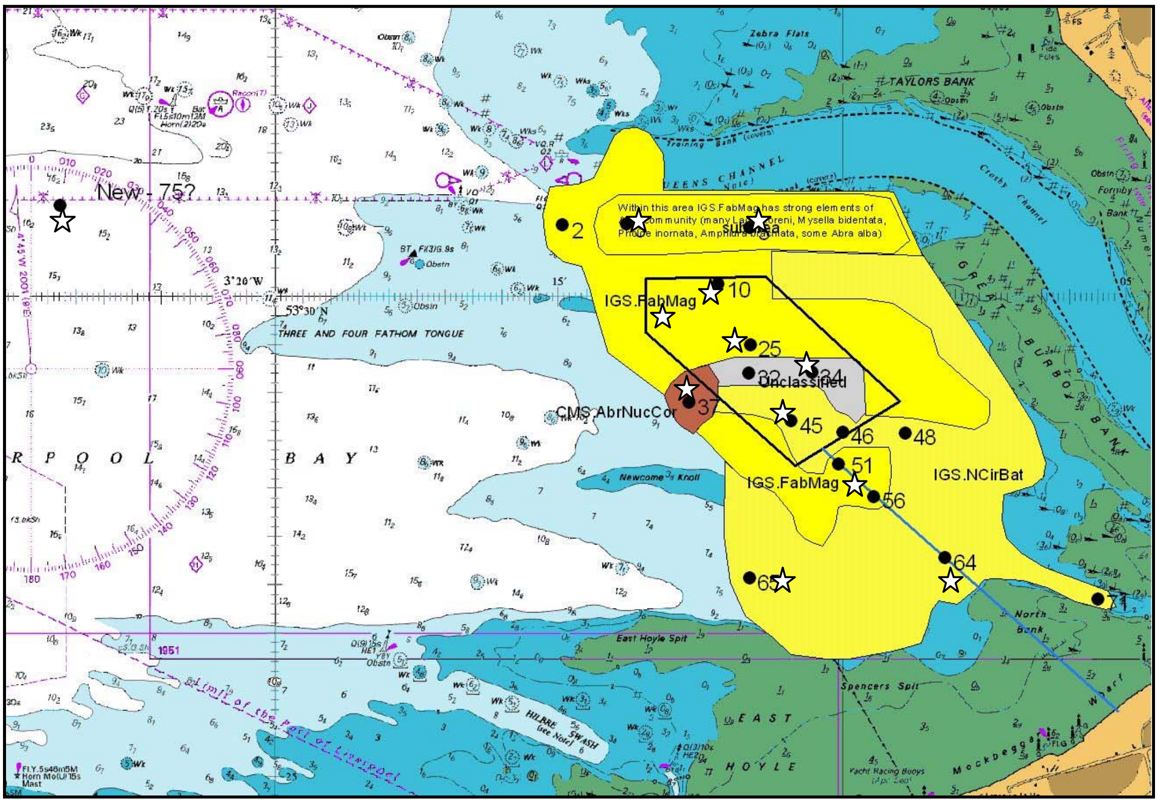

Figure 4 Locations (☆symbols) of 2m beam trawl sites

Other Information

We will compile information from other surveys and local information obtained from local fishermen, anglers etc. and interpret in relation to the construction and operation of the wind farm.

Update on Progress

The pre-construction baseline 2m beam trawl survey was completed in September 2005 and will be reported in the first annual FEPA monitoring report. The pre-construction baseline 4m beam trawl survey was completed in May 2006 and will also be reported in the first annual FEPA report.

Annex 1(8) Operational Noise and Vibration

FEPA Licence, Supplementary Condition 9.5

The Licence Holder must make provision during the construction phase of the windfarm to install facilities to enable subsea noise and vibration from the turbines to be assessed and monitored during the operational phase of the windfarm. Before completion of the construction phase the Licence Holder must supply specification to the Licensing Authority of how it proposes to measure subsea noise and vibration - at various frequencies across the sound spectrum at a selection of locations immediately adjacent to, and between turbines, within the array and outside the array at varying distances - in order to fulfil the monitoring requirement outlined in Annex 1 attached to this Licence. Such a study would need to reflect differences in foundation/tower type, water depths and sediment types within the site and would need to be supported by adequate baseline data. Collaborative studies could be an acceptable means of fulfilling this condition.

FEPA Licence, Annex 1(8)

Detailed post construction data must be collected on the frequency and magnitude of underwater noise produced by the Burbo offshore windfarm. 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 proposed in Annexes 1 and 2, the data would help to elucidate any interactions between noise generation and the provision of new habitat and fish aggregation effects of the turbine support structures.

Determining the effects of distance depth and background sources on noise propagation.

Proposed Approach

Since the FEPA licence was drafted a considerable amount of work has been completed to address the issue of underwater noise[4] in relation to offshore wind farm construction and operation. This includes work by Subaccoustech on both construction and operational noise at the North Hoyle and other offshore wind farms and measurement of operational noise at existing wind farms as part of FEPA licence monitoring. Operational noise data will therefore be in the public domain within a short space of time (anticipated by 2006).

Given that the FEPA licence states that collaborative studies could be an acceptable means of fulfilling the obligations of the licence, we propose to discharge this FEPA obligation by reference to these existing studies.

CMACS will therefore re-interpret the COWRIE and other available studies study in relation to the Burbo development.

[4] NB ‘noise and vibration’ is equivalent to underwater sound, i.e. the pressure variations produced by the vibrating source (turbines).

Annex 1(9) Numerical Models

FEPA Licence, Annex 1(9)

Calibration of the hydrodynamic model for speed and direction at BB1 and BB2.

Proposed Approach

In order to meet the requirements of the FEPA licence it is necessary to undertake post-construction validation of the hydrodynamic model (Delft –3D model of Liverpool Bay) used in the environmental assessment. This is to be assessed by comparison of current speed and direction data obtained at BB1 and BB2 (Table 3).

Table 3 Location of Physical Measurements at Burbo

Site	Latitude	Longitude	Approx. Depth (m DC)
BB1	**53º29.20**	**03º12.55**	**7.53**
BB2	**53º29.42**	**03º10.60**	**5.65**

Current speed and direction data will be collected through depth at each of the sites for a spring and neap tide condition. The data collected will be compared with the post construction model predictions for spring and neap tide conditions, as has already been carried out with the "tidal diamond" data. The environmental statement (ABP Technical Report, ES Volume 4.A) provides typical performance criteria for estuaries that were used in the original model validation, and these criteria will be used to confirm whether model predictions are within the specified limits of recorded speed and directions.

A CMACS associate, Alan Williams of Coastal Engineering UK Ltd, will provide technical support to CMACS and ensure that appropriate data are collected and that the validation exercise is thorough.

FEPA Licence Requirements and Proposed Monitoring: ANNEX 2

Annex 2 Ornithology

FEPA Licence, Supplementary Conditions 9.8 and 9.9

9.8 Ornithological monitoring must be carried out as outlined in Annex 2 attached to this schedule. The full specification for the monitoring will be subject to separate written agreement with the Licensing Authority following consultation with CEFAS, English Nature and the Countryside Council for Wales prior to the proposed commencement of the monitoring work.

9.9 Post-construction monitoring must be undertaken annually for three years. The level of any subsequent ornithological monitoring, during the lifetime of the windfarm's operation, will be determined, in consultation with English Nature and the Countryside Council for Wales, having regard to the magnitude of any change in bird populations observed during the initial monitoring period.

FEPA Licence, Annex 2

Monitoring will commence with at least a year of baseline, pre-construction data gathering and monitoring during the year of construction. Post-construction monitoring will be undertaken annually for three years. The level of subsequent monitoring, during the lifetime of the windfarm's operation, will be determined, in agreement with English Nature, by the magnitude of change in bird populations observed in the initial monitoring period. The ornithological monitoring programme may have to be adapted and amended as new technologies and research findings become available.

Monitoring should be linked, where appropriate, with the benthic monitoring. Monitoring reports will be provided to English Nature annually, or more frequently where the results of the data may trigger further monitoring work.

Monitoring of an agreed reference site will also be carried out in parallel to the windfarm site.

Monitoring will need to fulfil the following objectives:

To be developed in consultation with EN.

Proposed Approach and Update on Progress

Hyder Consulting (Project Manager Stewart Lowther) have been appointed to undertake the ornithological monitoring through CMACS. The methodology has been sent to the appropriate consultees and comments incorporated into the ongoing surveys. A full report will be incorporated into the first annual FEPA report.

OTHER FEPA REQUIREMENTS

Pre and Post Construction Clearance Surveys

Sidescan sonar survey before and after construction (cf. FEPA condition 9.23).

Proposed Approach

Single beam bathymetrical survey of development site, export cable route (2 survey lines) and 4 survey lines to working port. Plus data processing and presentation of high resolution side scan sonar mosaic.

Update on Progress

OSIRIS Projects have completed pre-construction clearance survey. This is being co-ordinated directly by Elsam as the work is being undertaken in conjunction with other geophysical survey work on site.

Reporting

Reporting will be annually in August with reports provided to consultees approximately 1 month later (after internal auditing). The aim will be to produce an integrated report to identify the impacts of construction and operation of Burbo offshore wind farm on the environment, meeting FEPA requirements covered by CMACS's works. We will endeavour to link various elements of the report, e.g. birds, benthos and fish; fish and noise etc..

Detailed data will be provided as appendices.

Appendix 1 Schedule for Environmental Monitoring

Pre and during-construction (solid fill = completed; grey fill = planned)

	Year	1													2														
	Development Phase	Pre-construction													Construction-1											C-2			
		Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07
	Initial consultations/method development	■	■	■	■	■												■	▒										
1	SSC (vessel based survey option)																	■	▒										
2	Seabed morphology & scour																				▒							▒	
3	contaminants						■																						
4	current monitoring (ADCP)																											▒	
5.1	sub-tidal benthic ecology						■												■										
5.2	colonisation of monopiles																												
5.3	Intertidal invertebrates																■	■	▒									▒	
6	EMF																							▒					
7	Marine fish						■								■				■								▒		
8	Operational noise and vibration																									▒			
9	Numerical models																											▒	
10	Ornithology (transect survey work)						■	■	■	■	■	■	■	■	■	■	■	■	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
10	Ornithology (point survey- if required)																				▒	▒	▒	▒					
11	Clearance surveys													■															▒
12	Reporting (internal- external 1 month later)																	■									▒		

NB this schedule is subject to change should the construction period differ from that indicated.

Pre and during-construction (solid fill = completed; grey fill = planned)

	Year	3										4												5											
	Development Phase	Post-construction																																	
		Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10
1	SSC (single survey option)																																		
2	Seabed morphology & scour					■							■							■							■								
3	contaminants																																		
4	current monitoring (ADCP)																																		
5.1	sub-tidal benthic ecology		■												■												■								
5.2	colonisation of monopiles		■																																
5.3	Intertidal invertebrates																																		
6	EMF																																		
7	Marine fish		■								■				■								■				■								
8	Operational noise and vibration																																		
9	Numerical models																																		
10	Ornithology (transect survey work)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10	Ornithology (point survey- if required)				■	■	■	■									■	■	■	■									■	■	■	■			
11	Clearance surveys																																		
12	Reporting (internal- external 1 month later)										■												■												■

NB this schedule is subject to change should the construction period differ from that indicated.

Appendix 3 Technical Reports

Annex 1(1) Suspended Sediments Concentrations- SCC

SeaScape
Energy

Burbo Offshore Wind Farm

Suspended Sediment Concentration Monitoring

Document: J3034 Suspended sediments v2 (04-08)

Version	Date	Description	Prepared by	Checked by	Approved by
1	12-06	First Draft	Ian Gloyne-Phillips	Ken Neal	IGP
2	04-08	Executive Summary added	IGP	LG	IGP

This report has been prepared by Centre for Marine and Coastal Studies Ltd (CMACS) on behalf of SeaScape Energy.

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Cover photograph: from Survey vessel 'Halcyon Days' during SSC monitoring of array cable installation works in November 2006

Contents

1 Executive Summary

Burbo Offshore Wind Farm is a twenty-five turbine, 90MW development located in Liverpool Bay approximately 6km from the coastlines of Wirral, Crosby and Liverpool.

A licence was issued to the wind farm developer, SeaScape Energy Ltd, which allows them to construct and operate the wind farm providing certain conditions are met. The licence (31864/07/0) was issued under the Food and Environment Protection Act (FEPA) and contains a specific requirement to monitor suspended sediment mobilisation during construction work to ensure that no significant adverse environmental effects occur. The specific aim of the monitoring was to validate and confirm predictions made in the project Environmental Statement (SeaScape Energy 2002) that:

> *some effects (on SSC) may arise during installation from localised increased suspended sediments concentrations for released disturbed fine sediments. …any effects will be short term and relatively small resulting in little impact on coastal processes.*

The monitoring was also undertaken to confirm that suspended sediments remained within parameters that were agreed with regulators before construction. The agreed suspended sediment threshold was:

> *not more than 5 times background (control area), or 3,000mg/l throughout the water column (measured as close as safely possible to construction activity), whichever is greater*

The three export cables were installed to a target depth of approximately 3m by vertical injector ploughing while array cables were installed to a similar depth by jetting assisted ploughing.

Suspended sediment monitoring was undertaken from a small survey vessel using a hand deployed suspended sediment probe calibrated against local sediments. This was a mobile, responsive technique that allowed the monitoring team to measure sediment mobilisation both up and down-tide of works; the former provided control data against which the impact of the works could be compared.

The monitoring demonstrated clearly that both cable installation techniques had only small scale impacts on localised suspended sediment concentrations. Effects were measurable to a few hundreds of metres only and suspended sediment levels were not elevated more than five times background. Suspended sediment levels never approached the threshold level (3,000mg/l) agreed with regulatory authorities beforehand, even in very close proximity to the works (< 50m).

The report concludes that the predictions of the Environmental Statement are fully supported in relation to effects on suspended sediments.

2 Introduction

This report describes monitoring undertaken by Centre for Marine and Coastal Studies Ltd (CMACS) on behalf of SeaScape Energy Ltd towards meeting the requirements of the Food and Environment Protection Act (FEPA) 1985 (as amended) Licence No 31864/06/0 in respect of Suspended sediment concentration (SSC) monitoring.

The licence requires monitoring to validate and confirm predictions made in the Environmental Statement (SeaScape Energy 2002). The specific licence requirements are as follows:

FEPA Licence, Annex 1(1)

The following monitoring must be undertaken to validate and confirm predictions. Monitoring must be based on the deployment of three suspended sediment meters over a period of at least 4 weeks during pre-construction, construction (during drilling, piling and cabling) and post construction periods.

These would need to be deployed as follows:

- *At a representative point identified by the modelling and within the sediment plume to measure near-field effects of sediment release.*
- *At a representative point identified by the modelling and within the sediment plume to measure far-field effects*
- *At a point outside the predicted area of the sediment plume to provide a 'control' measure of natural suspended sediment levels over the respective monitoring periods.*

Alternative approaches may be acceptable but the methodologies would have to be submitted to the Licensing Authority for review and agreement at least one month prior to the proposed commencement of the monitoring work.

In line with the second paragraph of the supplementary conditions at section 9 of this Licence, should suspended sediment levels associated with the construction works be shown to be at unacceptable levels (i.e. above threshold) works may need to be suspended while a less disruptive methodology is investigated. Background levels from the monitoring programme will be used to set suitable threshold levels.

CMACS has developed a programme of environmental monitoring on behalf of the wind farm developer in response to the FEPA licence conditions. The proposed approach to SSC monitoring was originally outlined in FEPA monitoring methods submitted to consultees in August 2005 (CMACS ref: J3034 Burbo FEPA Methods v1.3 (19 August 2005)). An alternative approach to the deployment of three suspended sediment meters at fixed locations over 4 week periods was proposed; this comprised mobile SSC monitoring from a survey vessel using a hand-deployed probe.

In the subsequent version 1.4 Methods Statement CMACS proposed that SSC monitoring should focus on cable laying as the activity with the greatest capacity to mobilise suspended sediments since wind turbine monopile foundation installations were to be completed by hammer piling without the need for any drilling. Following discussions with one of the consultees (Adrian Judd, CEFAS) it was agreed that SSC monitoring would be undertaken during installation of power export to shore and intra array cables (hereafter termed export and array cables respectively). The outline monitoring methodology was described in the current FEPA monitoring Method Statement (CMACS ref: J3034 Burbo FEPA Methods v1.5 (08-06)) and is reproduced here in Section 3.1.

In relation to cable installation works, the Environmental Statement for Burbo Offshore Wind Farm predicted that:

some effects (on SSC) may arise during installation from localised increased suspended sediments concentrations for released disturbed fine sediments. …any effects will be short term and relatively small resulting in little impact on coastal processes.

This report focuses solely on SSC monitoring during cable installation works. Other parts of the monitoring programme are interrelated but will be reported separately and/or incorporated into annual monitoring reports, these include:

- an additional walk-over survey that was undertaken by CMACS to check for recovery of beach sediments following installation of the first export cable across the foreshore;
- intertidal benthic invertebrate and sediment particle size monitoring that has been undertaken around foreshore works and is currently ongoing;
- a planned Acoustic Doppler Current Profiler (ADCP) survey to assess the significance of wake effects due to the presence of turbine foundations on coastal processes. This survey could lead to follow up investigations into the sediment transport regime if changes in current velocity are significantly greater than predicted.

3 Methods

3.1 Outline methods statement and rationale for selection of monitoring methods

A number of factors underpinned the decision to propose an alterative approach to SSC monitoring to the fixed loggers technique suggested in the FEPA licence and to focus on cable installation rather than monopile foundation works. These factors are summarised as follows:

- Deployment of suspended sediment meters (loggers) at fixed locations provides broad scale information about impacts on suspended sediments during construction but is unable to provide useful information on sediment settlement rates and the zone of any impact.
- Fixed loggers would monitor at a single depth only (most likely 1m above the sea bed) and would therefore be unable to detect effects throughout the entire water column.
- Fixed loggers are vulnerable to damage by trawls, anchors etc. and can also be covered by sediments, especially in softer sediment areas such as are present in parts of the array area at Burbo, or fouled by marine organisms/debris.
- CMACS has previous experience in both fixed logger and mobile approaches to SSC monitoring, notably through our experience at the nearby North Hoyle offshore wind farm. A campaign of SSC monitoring by CMACS at North Hoyle on behalf of the wind farm developer there (National Wind Power 2003 and Npower Renewables 2005) used three fixed loggers to monitor near and far field plus control suspended sediments in relation to the installation of three monopile foundations by a combination of drilling and piling in April 2003. This work found no detectable increase in suspended sediment load due to wind turbine installation and showed the overriding influence of natural processes, notably tide, wind and riverine inputs, in driving suspended sediment processes.
- Finally, if agreed threshold levels were exceeded this would not be known until after the equipment was recovered and data uploaded, by which time constructions activities would have continued without review for upwards of one month.

The following alternative approach was outlined in the v1.5 FEPA monitoring Methods Statement:

> SSC survey would be undertaken using a hand deployed probe from a boat. The survey would take place over 1-2 days (covering at least one full tidal cycle) immediately before and during initial **export cable** installation works and be repeated for the array cable works. Cables to shore are to be installed using a plough and we anticipate very limited sediment mobilisation whereas array cable installation will be facilitated by jetting which has higher potential to mobilise fine sediments. We do not consider that hammer piling to install monopile foundations

has significant potential to mobilise sediments into the water column and therefore propose to focus monitoring on both cable installation works.

Measurements would be made throughout the water column (e.g. bottom plus 1, 2, 4, 6, 10 and surface minus 1m) uptide of works and at varying distances downtide until no impact was detectable. The measurements uptide of works would provide an accurate local control measure of natural suspended sediment levels.

Measurements would also be taken at limited depths (potentially bottom plus 1m and a mid-water reading) at positions perpendicular to the main survey transect to allow an estimation of the width of any plume to be determined.

The following schematic outlines the anticipated approach:

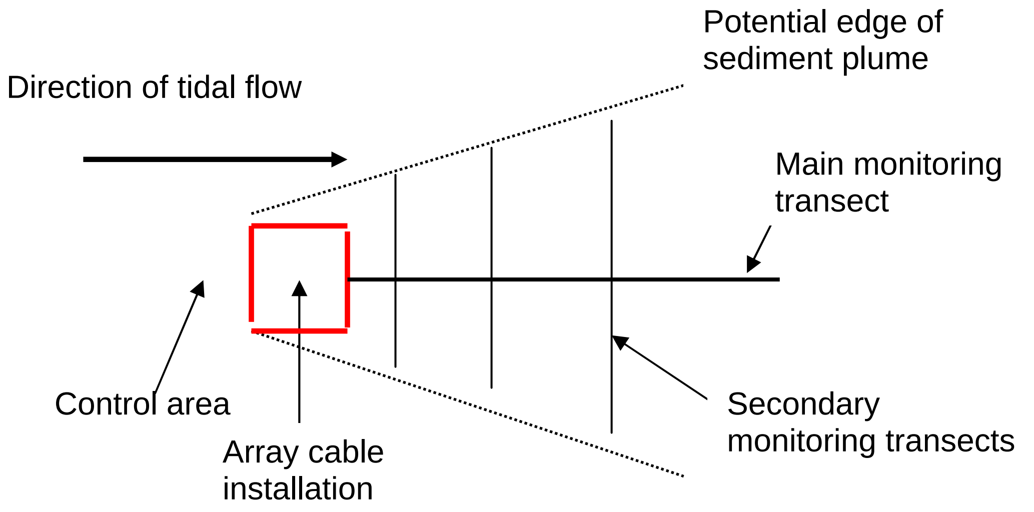


Figure 1. SSC monitoring strategy

The licence indicates that a threshold value for SSC is required against which monitored levels can be compared. Suspended sediment concentrations near large estuaries such as the Mersey are highly variable, showing predictable variability in relation to tidal action (both diurnal and semi-lunar patterns being evident) and less predictable variability in relation to wave action and riverine sediment inputs.

In the case of the Mersey, natural suspended sediment levels can be very high. The environmental statement identified that natural near-bed suspended sediment levels in the Mersey estuary could approach 1500mg/l (HR Wallingford 1982, cited in Burbo ES), although it is likely that higher levels are reached naturally on occasions.

We propose that a threshold of not more than 5 times background (control area), or 3,000mg/l throughout the water column (measured as close as safely possible to construction activity), whichever is greater, be adopted during works.

3.2 Cable installation methods

Export cables were installed using a vertical injector ploughing technique. A detailed method statement is provided as Appendix 1. In outline, power cable installation to a depth of approximately 3m was accomplished through a two-stage process: 1, a pre-lay grapnel run (PLGR) using the Vertical Injector (VI) shown in Figure 2 and Plate 1 equipped with an open face designed Ripper and top-mounted vibrator; 2, simultaneous laying and burial of the cables using the Vertical Injector equipped with an Injector Foot and Vibrator in exactly the same trench as cleared with the Ripper.

The forward facing nozzles of the VI were blocked during export cable installation so that no jetting was done during the ploughing operation. On the bottom part of the VI some horizontal, downwards facing nozzles were left to provide under heel lubrication. The under heel lubrication used low water pressure to lubricate the lower part of the injector foot in order to reduce the required pulling force.

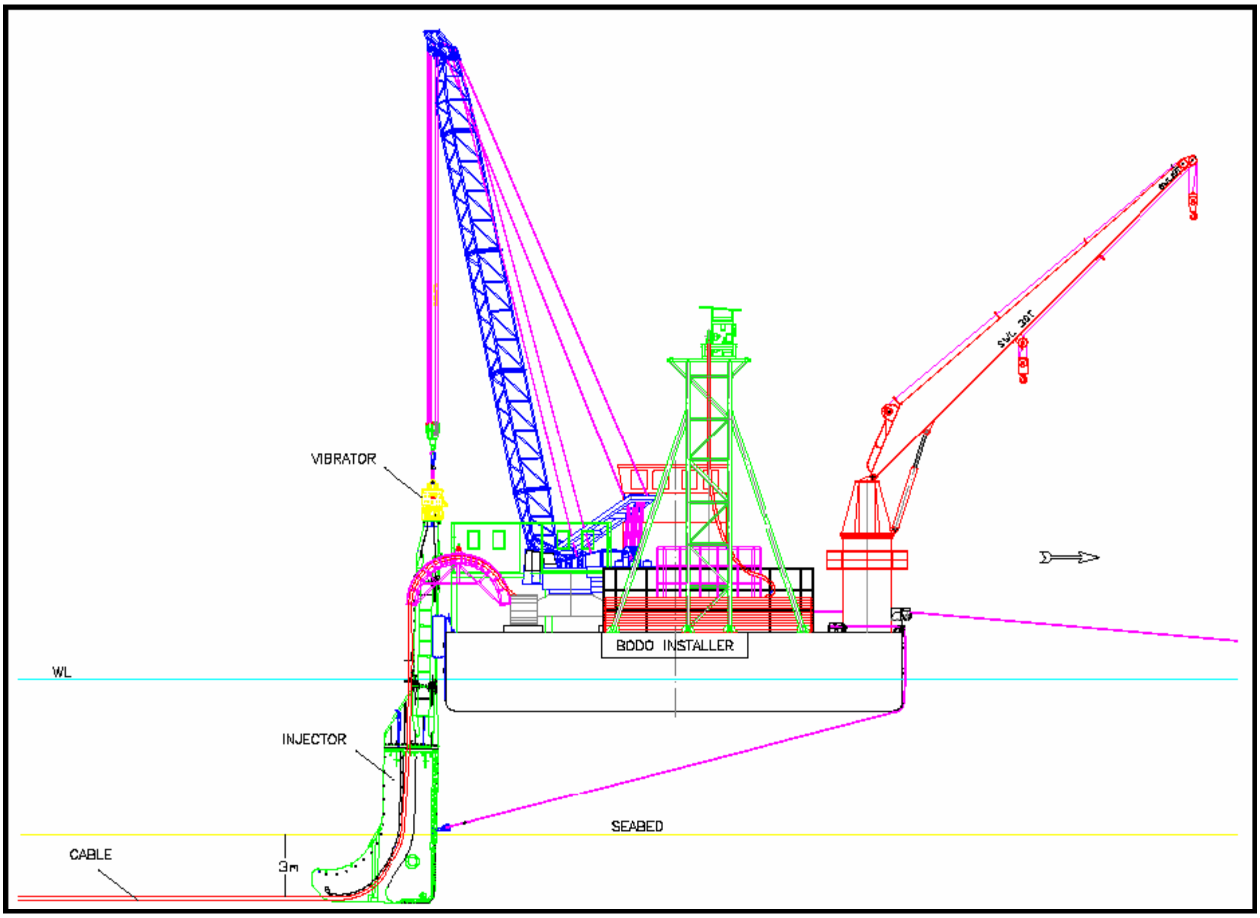


Figure 2. Simultaneous cable laying and burial using vertical injector equipped with injector foot and vibrator (from Submarine Cable and Pipe 2006, see Appendix 1).

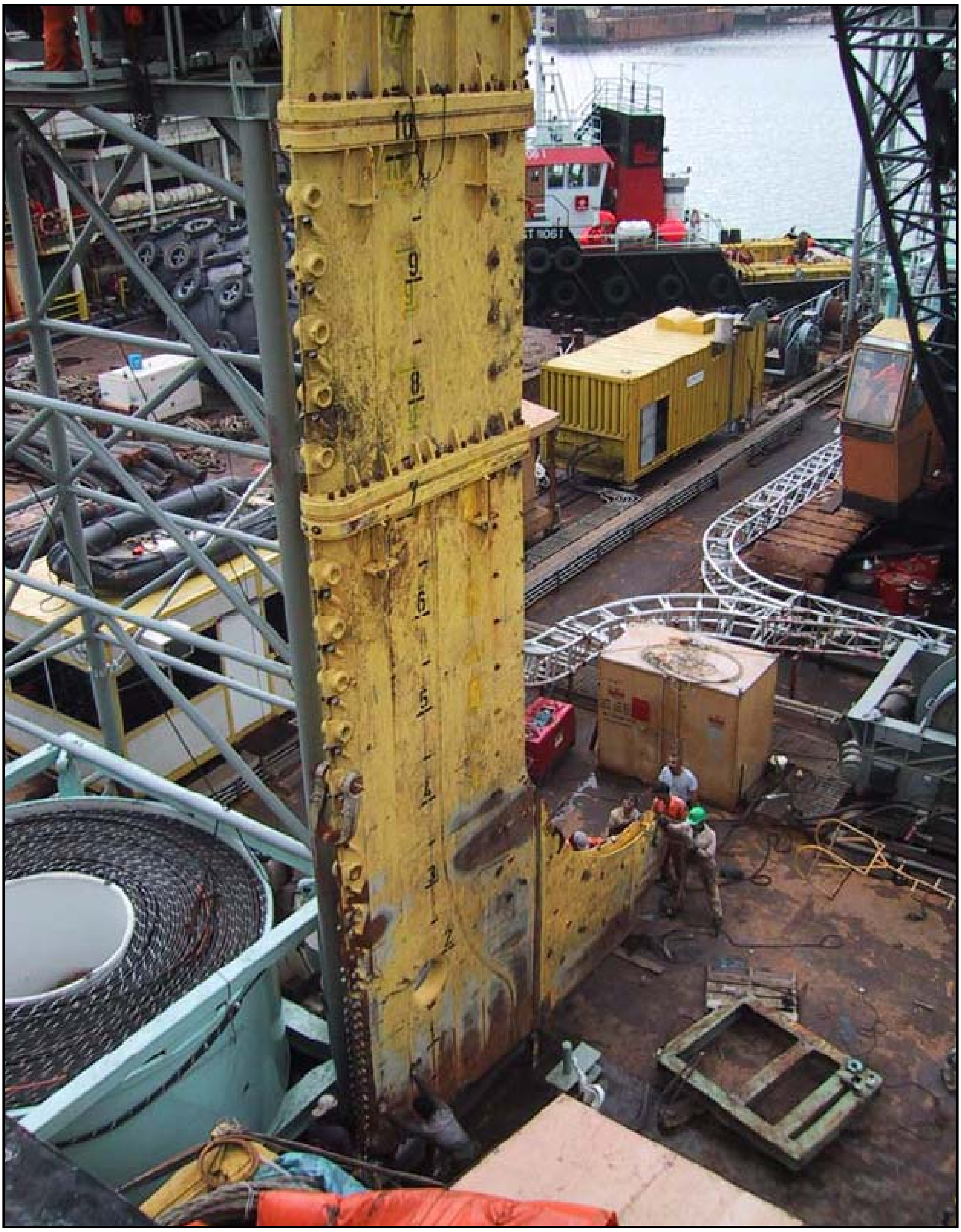


Plate 1. Vertical Injector (from Submarine Cable and Pipe 2006, see Appendix 1).

Plate 2. Burbo export cable installation in progress on 31st August 2006.

Installation of the first of three power export cable commenced on 25th August 2006 at the offshore (wind farm) end of the route, working towards the cable landfall on the beach off Wallasey. The trenching operation took place during suitable weather windows over the next week or so, and was completed on September 2nd. The total route length was just over 8km; during suitable weather conditions the trenching proceeded at a rate of approximately 250m per hour with pauses of 30 minutes or so to re-position anchors when required.

Array cables were installed using a jetting technique, i.e. the nozzles that were closed during installation of the export cables were left open to facilitate sediment fluidisation and cable installation. A PLGR was still performed before each cable lay to check for any debris and to loosen sediments in advance of cable laying to reduce the required tow tension.

The rate of installation of array cables was similar to the export cable; however, as array cables are very much shorter than the export cables (typically only 600 to 800m in length), the jetting process for each cable was completed in a matter of hours. This very much increased the need to carefully co-ordinate the monitoring to ensure that the operation of interest, i.e. jetting, was taking place while the survey vessel was present.

3.3 Detailed monitoring methods

The SSC monitoring methods were developed and applied specifically to:

1. evaluate the conclusions of the Environmental Statement by determining the density and spatial extent of any sediment plume resulting from the construction activity anticipated to have the greatest capacity to mobilise bed sediments (cable installations);
2. measure absolute suspended sediment levels in relation to the agreed threshold levels.

3.3.1 Export cable installation monitoring

The first export cable to be installed was Cable C (westernmost cable in Figure 3) and monitoring was planned for the earliest practical opportunity during daytime operations. This was 31st August when the cable installation barge (Bo-Do Installer) was approximately 3km from the end of the route (Figure 3).

A team of two surveyors worked from the survey vessel ‘Halcyon Days’ operating out of Liverpool. The vessel was on site at 13:30 when cable laying had been paused for almost 3 hours while a new pennant wire was fitted on the main tow anchor. Cable laying operations recommenced at 14:28 and took place continuously until monitoring ended at 16:45. Because the Bo-Do Installer was operating in relatively shallow water it was necessary to work over the high water period and to depart before the ebb as works approached the beach. Monitoring therefore commenced on a flooding tide and ended at high water slack. Tide times and heights for Liverpool on 31st August were:

	Time (BST)	Height (m)
HW	04:03	8.0
LW	10:33	2.8
HW	16:27	7.7
LW	22:49	3.0

The survey team used a hand-deployed probe (Hydrolab Quanta, Appendix 2) equipped with depth and turbidity sensors on a 50m umbilical. Turbidity readings were taken at 1m intervals throughout the water column starting at bottom plus 1m. Each set of readings was accompanied by a GPS waypoint from a hand held GPS unit (Garmin GPS 60Cx, accurate to ±5m). The first set of readings obtained were controls from areas at least 100m uptide of works and away from any other vessel activities or anchors. Regular control samples were obtained at appropriate intervals thereafter; we always ensured that control samples were taken away from any areas that had been subject to recent disturbance. It was considered important to update the control readings at intervals since the Bo-Do Installer was working into shallower waters, over varying seabed conditions and under the influence of steadily decreasing tidal flows so background turbidity could be expected to be variable.

The survey strategy in Section 3.1 was followed. Turbidity measurements in Normalised Turbidity Units (NTU) were available instantaneously and noted for each sample depth so that the surveyors were able to determine the number of transects necessary to track any plume in real time. Up to 10 seconds were allowed for readings to settle at each new sample depth; where fluctuating readings indicated that turbidity was variable the range of values was noted. In all cases the maximum value has been used in follow up analyses and is reported here.

A Niskin type sampler was used to obtain five 2 litre seawater samples of varying turbidity for follow up laboratory analysis by filtration for total suspended solids so that the turbidity readings could be converted into suspended sediment values (mg/l) for reporting. The calibration exercise is described and data provided in Appendix 3.

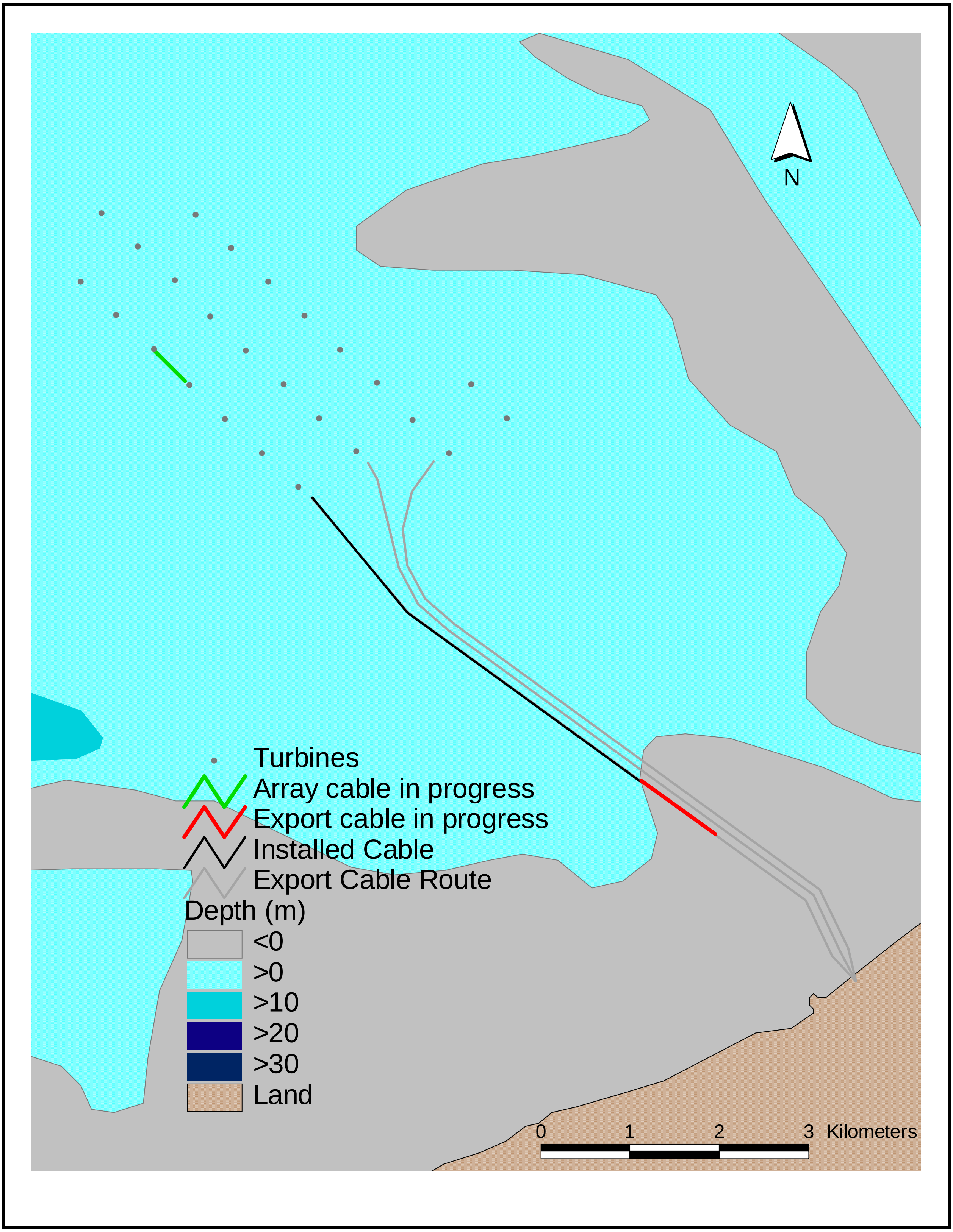


Figure 3. Representation of cable installation works during SSC monitoring surveys on 31st August (export cable) and 2nd November (array cable). For clarity, only the array cable installed during survey is shown

3.3.2 Array cable installation monitoring

Because jet-assisted ploughing works for each array cable were completed in a matter of hours it was not possible to be on site for installation of the first array cable. The first opportunity to monitor array cable installation works during favourable weather in daylight hours when a survey vessel could be mobilised in time came on 2nd November during installation of a cable between turbines 18 and 17 on the western edge of the array (Figure 3).

A single surveyor worked from the survey vessel 'Halcyon Days' operating out of Liverpool. The vessel was on site at 11:20 having been slightly delayed by shipping while leaving Liverpool docks. Cable laying operations had commenced at 10:24 and continued until 11:50. Monitoring continued until 13:16 when it was deemed that sufficient data had been collected.

Tide times and heights for Liverpool on 2nd November were:

	Time (BST)	Height (m)
HLW	04:03	8.0
LW	10:33	2.8
HW	16:27	7.7
LW	22:49	3.0

Monitoring therefore took place during a flooding tide.

Because it was realised that there was relatively little time to obtain data it was decided to reduce the number of sample intervals through the water column in the deeper water found offshore in the array area. Readings were taken at bottom plus 1m, 2m and then at 2m intervals to surface minus 1m. Sampling techniques were otherwise as described in Section 3.3.1. A Niskin type sampler was again used to obtain several 2 litre seawater samples of varying turbidity to verify the previous calibration (Appendix 3).

4 Results

4.1 Export Cable Monitoring

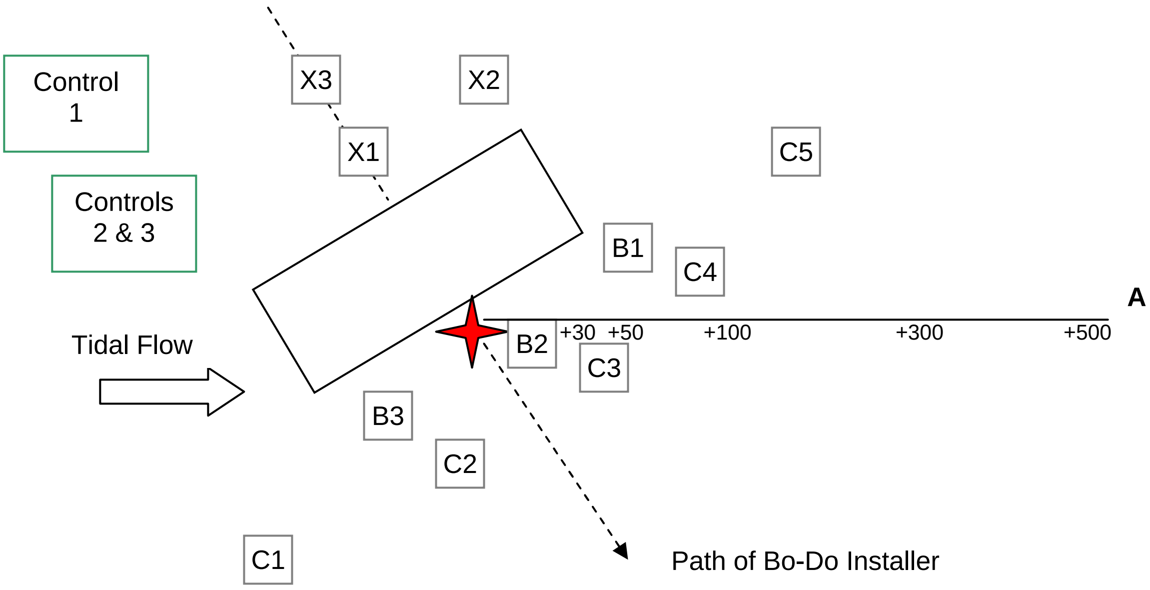
Cable laying operations had been temporarily suspended since 10:43 when the survey team arrived on site. Control samples were still taken uptide of works to ensure that there was no disturbance from anchors or prop-wash, particularly as water depth was only around 6m. The first set of controls were taken from a position approximately 500m uptide of the Bo-Do Installer; these data are reported in Table 1. The relative position of all samples is represented in Figure 4.

While the survey team awaited the resumption of cable laying several additional readings were taken immediately downtide of the Bo-Do Installer so that the effect of wash from the barge's thrusters could be measured in the absence of ploughing. Suspended sediment concentrations within 20m of the Bo-Do Installer's thrusters at 14:10 were a maximum of 124.2mg/l one metre above the seabed and 120.4mg/l one metre below the surface, i.e. approximately 2.5 times background levels.

Table 1. Suspended sediment measurements along transect A (a straight line downtide of cable installation works). Position A+30 was sampled 9 minutes after cable laying operations recommenced after a 2hr:45min pause.

Position		control 1	A+30	A+50	A+100	A+300	A+500
Time		13:47	14:37	14:45	14:50	14:55	15:00
Distance from cable laying (m)		100	30	50	100	300	500
Suspended sediments (mg/l) at bottom (B) plus Xm and surface (S) minus 1m	B+1	48.2	207.0	86.6	188.2	86.6	90.3
	B+2	48.5	79.4	94.1	94.1	69.6	71.5
	B+3	48.2	68.9	96.0	69.6	69.2	67.0
	B+4	48.2	60.2	97.9	72.6	64.7	62.1
	B+5			96.0	59.5	60.2	60.2
	B+6						
	S-1	47.4	56.8	82.8	67.7	50.4	45.2

Transect A ran directly downtide from the Vertical Injector. Within 30m of cable laying SSC ranged from 207mg/l (4.3 times background) one metre above the seabed to 56.8mg/l just below the surface. Control levels were approached in surface waters within 300m of cable laying but remained elevated (around 2 times background) in bottom waters up to 500m. We did not extend Transect A further as it was felt that the influence of the coast was likely responsible for elevated turbidity closer to shore compared to the control station.



NOT TO SCALE

Figure 4. Diagrammatic representation of positions of SSC sample stations in relation to the Bo-Do Installer. In reality, the Bo-Do Installer was moving constantly in a south easterly direction throughout the survey and so the sample positions are representative.

A second control station approximately 100m uptide of works was sampled at 15:10 (Table 2). These control levels were slightly higher than the first control although we are confident that this was not due to any effects of the cable laying works or other vessel disturbance. Subsequent repeat samples along Transect A revealed that SSC was very similar to control levels at most depths up to 200m from the cable laying works. There were two small peaks in SSC (30m along the transect at B+5 and at B+2 at 200m) but these were only slightly (approximately 15%) above control levels.

By 15:30 cable laying had been underway for just over 1 hour following the re-start at 14:28. There was no visible sediment plume; surface boiling could be seen within approximately 10m of the Vertical Injector and there was surface disturbance associated with prop-wash from Bo-Do Installers thrusters but no visual indication of any major effect on seabed sediments. There was still some water movement due to the flooding tide at this stage although this was reducing down towards high water slack.

Table 2. Repeat suspended sediment concentrations along transect A.

Position		control 2	A+30(2)	A+50(2)	A+200
Time		15:10	15:16	15:22	15:26
Waypoint		10	11	12	13
Distance from cable laying (m)		100	30	50	200
Suspended sediments (mg/l) at bottom (B) plus Xm and surface (S) minus 1m	B+1	71.5	67.7	65.9	75.3
	B+2	71.5	67.7	67.7	82.8
	B+3	54.6	67.7	67.7	50.8
	B+4	41.4	67.4	65.9	45.2
	B+5		84.7	64.0	45.2
	B+6				
	S-1	41.4	51.2	64.0	30.1

The second survey along Transect A was followed immediately by three measurements along Transect B. This transect was approximately 20m downtide from the Bo-Do Installer, sample positions were as follows: B1 was opposite the port side (east), immediately downtide of a thruster; B2 was central and in line with the Vertical Injector; B3 was in line with the starboard side thruster. These readings were taken almost on high water slack and so there was very little current; the skipper used his judgment to estimate the direction of flow.

All data are provided in Table 3 where the most recent control samples are reproduced for convenience. SSC at BB2 was similar to control levels at all depths (slightly elevated at B+1 and below control at S-1). SSC was however 2 to 2.5 times background at B+1 off the sides of the Bo-Do Installer in the areas influenced by that vessel's thrusters.

Table 3. Suspended sediment measurements along transect B (perpendicular to the tide, 20m off Bo-Do Installer).

Position		control 2	B1	B2	B3
Time		15:10	15:34	15:40	15:45
Waypoint		10	14	15	16
Distance from cable laying (m)		100	20	20	20
Suspended sediments (mg/l) at bottom (B) plus Xm and surface (S) minus 1m	B+1	71.5	180.6	90.3	143.0
	B+2	71.5	109.1	62.1	101.6
	B+3	54.6	67.7	58.3	79.0
	B+4	41.4	58.3	58.3	73.4
	B+5		58.3	35.8	58.3
	B+6				
	S-1	41.4	50.8	30.1	33.9

Transect C (Table 4) was 40m off from Bo-Do Installer, C1 to C5 represent an eastwardly progression in front of the barge: C2 was in line with the starboard thruster; C3 a central position in front of the Vertical Injector and C4 in line with the port thruster (Figure 4). The closest available control readings in terms of time have been used.

SSC at stations C1 and C5, beyond the ends of the Bo-Do Installer, were similar to background levels. There was a pronounced elevation off the starboard thruster (2.7 to 4.8 times background at C2) but no discernible influence due to the port thruster (C4) and, as was the case with Transect B, no marked change opposite the Vertical Injector.

Table 4. Suspended sediment measurements along transect C (perpendicular to the tide, 40m off Bo-Do Installer).

Position		control 3	C1	C2	C3	C4	C5
Time		16:17	15:50	15:55	16:00	16:04	16:08
Waypoint		22	17	18	19	20	21
Distance from cable laying (m)		100	40	40	40	40	40
Suspended sediments (mg/l) at bottom (B) plus Xm and surface (S) minus 1m	B+1	30.1	47.0	143.0	41.4	52.7	56.5
	B+2	30.1	45.2	94.1	35.8	30.1	32.0
	B+3	30.1	41.4	88.4	33.9	32.0	32.0
	B+4	30.1	39.5	80.9	33.9	30.1	32.0
	B+5	26.3	30.1	73.4	37.6	28.2	24.5
	B+6						
	S-1	26.3	28.2	67.7	37.6	26.3	20.7

Because Transect C was sampled around high water slack when there was no strong tidal flow to disperse sediments it was decided to take some additional readings immediately behind the Bo-Do Installer in case a sediment plume was being left in the track of the barge. These results are provided in Table 5. X1 was a station 20m behind the barge (approximately 40m from the Vertical Injector) above the buried cable; X2 was 20m off the north east corner of the barge in an area influenced by some wash from a thruster.

There does appear to be a marked peak in SSC at B+1 above the recently buried cable. SSC here was 4.5 times background. Further up the water column the elevation was less pronounced, 2 to 2.5 times background. There may be a slight effect due to prop wash as SSC at X2 was approximately 1.5 times background levels. Fifty metres behind the barge (70m from the operational Vertical Injector) at X3 there was no discernable elevation in SSC above background.

Table 5. Suspended sediment measurements at additional positions (see text and Figure 4 for explanation).

Position		control 3	X1	X2	X3
Time		16:17	16:36	16:41	16:45
Waypoint		22	23	24	25
Distance from cable laying (m)		100	40	50	70
Suspended sediments (mg/l) at bottom (B) plus Xm and surface (S) minus 1m	B+1	30.1	135.5	45.2	37.6
	B+2	30.1	67.7	43.3	33.9
	B+3	30.1	67.7	43.3	35.8
	B+4	30.1	64.0	41.4	31.2
	B+5	26.3	48.9	33.9	30.9
	B+6		60.2	56.5	
	S-1	26.3	65.9	43.3	24.1

4.2 Array Cable Monitoring

Cable laying works by jetting assisted ploughing had been in progress for approximately 1 hour when the survey vessel arrived on site. A control sample was obtained from approximately 150m uptide of Bo-Do Installer then a series of samples were taken immediately downtide of the Vertical Injector at distances of 50, 75 and 150m (Table 6). This is equivalent to Transect A in Figure 4.

Fifty metres from the vertical injector SSC at B+1 was increased by a factor of approximately 1.8. There was a relatively complex patter of turbidity higher up the water column with SSC apparently below background at B+2 and B+4 but elevated 2.2 times above background at S-1. Further away from the cable installation position SSC was close to or below baseline at most depths.

Cable installation works stopped at 11:50, concomitant with sampling at position A+150. Since survey of the first transect suggested that there was a very localised effect on SSC, not detectable beyond 50m, it was decided to focus efforts at the A+50m position in order to determine how quickly SSC dropped after works stopped. Additional readings made at 11:56 and 12:12; these are noted in Table 5 and should be compared with control readings taken at 12:20. There was residual elevation of SSC 1m above the seabed up to 22 min after cessation of works. Interestingly, higher up the water column there was evidence of SSC continuing to increase above background after works had stopped.

Table 6. Suspended sediment measurements at additional positions (see text for explanation).

Position		Control 1	A+50	A+75	A+150	A+50(2)	A+50(3)	Control 2	Control 3
Time		11:27	11:37	11:45	11:50	11:56	12:12	12:20	13:16
Waypoint		2	3	4	5	6	7	8	9
Distance from cable laying (m)		150	50	75	150	50	50	100	100
Suspended sediments (mg/l) at bottom (B) plus Xm and surface (S) minus 1m	B+1	338.7	602.2	225.8	225.8	526.9	489.3	252.2	240.9
	B+2	338.7	225.8	158.1	218.3	414.0	286.0	218.3	229.6
	B+4	289.8	150.5	101.6	150.5	150.5	267.2	180.6	203.2
	B+6	188.2	244.6	82.0	94.1	101.6	248.4	150.5	154.3
	B+8	75.3	203.2	82.8	94.1	97.9	207.0	124.2	
	S-1	67.7	150.5	82.8	90.3	90.3	135.5	82.8	124.2

From 12:37 the survey vessel was allowed to drift straight downtide from the Bo-Do Installer. There was no wind, the engines were turned off and the tide carried the vessel at 1.3 knots. During this drift the probe was left over the side and 2m below the surface. These data are plotted in Figure 5 and compared to control data for S-2m interpolated from Control 3 at 13:16. It was noted that SSC at S-2m increased after approximately 200m, remained elevated above background at 500m before dropping back down to control levels after 700m. At this stage the probe was lowered to B+1 where SSC was equivalent to Control 3.

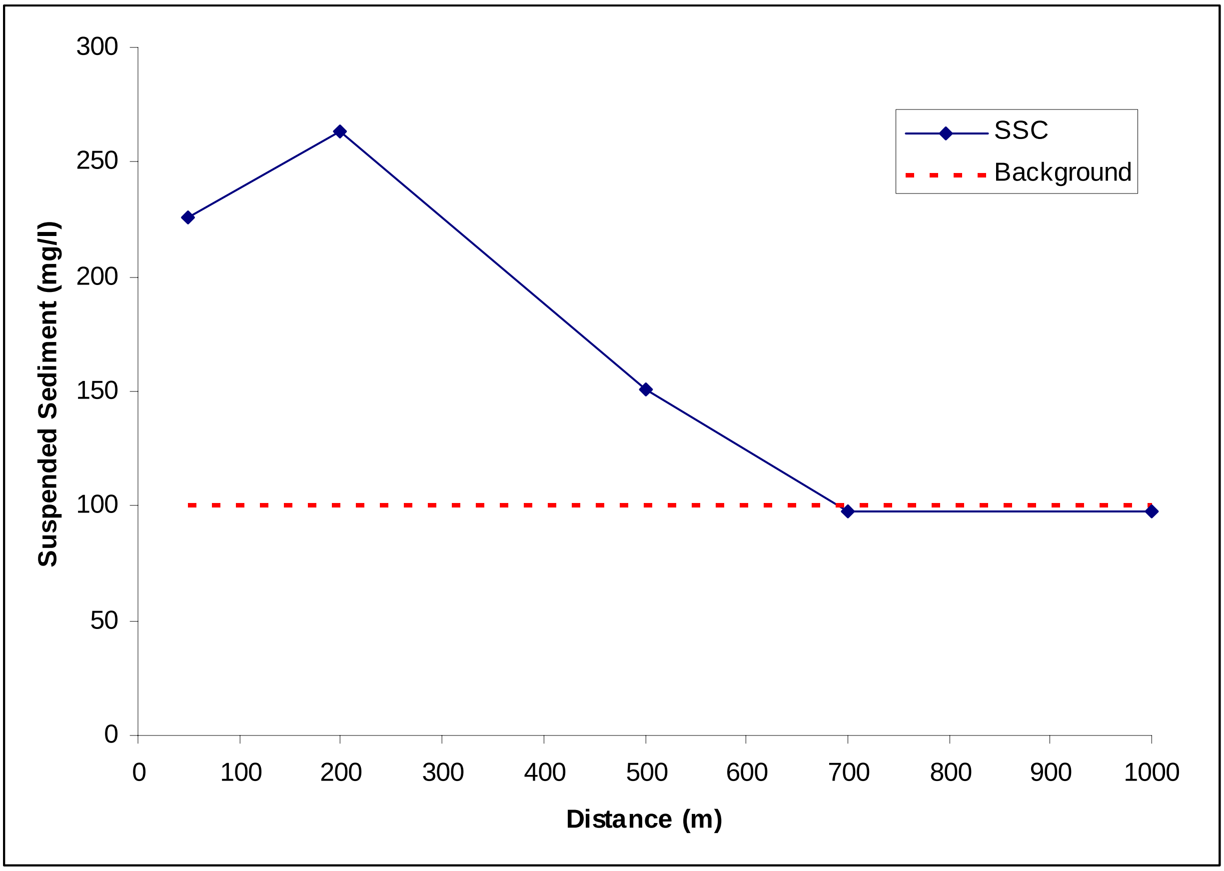


Figure 5. Suspended sediment concentration 2m below the surface along a transect downtide of the Bo-Do Installer after cable installation works had stopped

There was no visible sediment plume present at any stage during array cable installation monitoring. The seawater was noticeably more coloured than the previous survey of the export cable installation but this was widespread throughout control and 'impact' areas and appeared typical of the site to the survey team who have experience of this area from other survey activities.

5 Discussion and Conclusions

The surveys showed that neither the vertical injector ploughing (export cable) or jetting assisted ploughing (array cabling) elevated suspended sediment levels above the threshold level agreed prior to the commencement of cable installation works.

The maximum increase in SSC over background levels at any time during either survey was 4.8 times. Such increases were restricted to measurements within 50m of works and the impact cable laying was detectable above background only within around 500m of works. SSC levels never approached 3,000mg/l, the upper threshold applying to both sets of monitoring data given the relatively low background SSC levels and were also well below maximum natural levels expected in the Mersey estuary area (1,500mg/l).

Strong tidal flows had the effect of dispersing the sediment plume mobilised by works. The absolute increase over background at slack water was similar to other states of the tide but impacts were restricted to within 100m of works.

It was possible to differentiate the effects of cable burial from disturbance of seabed sediments due to other activities, notably, it is assumed, prop wash from the installation barge's thrusters. In broad terms the effect of prop wash was to increase SSC in bottom waters within 50m by a factor of 2.5. Active cable burial operations were therefore responsible for the remaining increase (i.e. typically less than doubling SSC). A similar pattern was seen during both vertical injector and jet-assisted ploughing.

SSC in areas affected by cable installation works was occasionally below control levels. It is clear, however, that turbidity is naturally variable. The array cable installations in particular took place over relatively fine bed sediments which are mobilised by natural processes such as tidal currents and wave action; the effects of such processes will vary both spatially, as seabed sediment conditions vary, and temporally as the influencing factors vary.

Both surveys were shorter than originally planned. The export cable installation monitoring was limited by tidal conditions as works approached the shore while array cable installation took place over relatively short periods, the latter part of one period being captured during monitoring. Measurements of SSC were obtained during slack water and when the tide was running strongly and it is considered that sufficient data were collected to be confident in the results.

In conclusion, the predictions of the Environmental Statement (SeaScape Energy 2002), that effects on SSC due to cable installation works would be short term and relatively small, are fully supported.

References

SeaScape Energy (2002) Burbo Offshore Wind Farm Environmental Statement.

National Wind Power (2003) North Hoyle Offshore Wind Farm. Pre-construction monitoring statement.

Npower Renewables (2005) North Hoyle Offshore Wind Farm. Post-construction monitoring statement.

Submarine Cable and Pipe (2006) Method Statement for the Installation of the Submarine Export Cables (provided as Appendix 1).

Appendix 1

METHOD STATEMENT FOR THE INSTALLATION OF THE SUBMARINE EXPORT CABLES

DOCUMENT: METHOD STATEMENT FOR THE INSTALLATION OF THE SUBMARINE EXPORT CABLES

CLIENT: SEASCAPE ENERGY LTD

EMPLOYER: ELSAM ENGINEERING A/S

PROJECT NAME: BURBO BANK OFFSHORE WIND FARM

PROJECT NO.: 1270

CONTRACT NO.:

Review and Approval Record of the Present Document

Action	Name	Function	Signature	Date
Client Approval				
Approved by		Project Manager		
Checked by		Deputy Project Manager		
Prepared by	A.Wiemken	Project Engineer		06.02.2006

Revision Status

Rev	Date	Description	Signatures			
			Prepared	Checked	Approved	
A01	30.01.06	First draft	AxW	EE	BM	
B01	06.02.06	For review	AxW	EE	BM	

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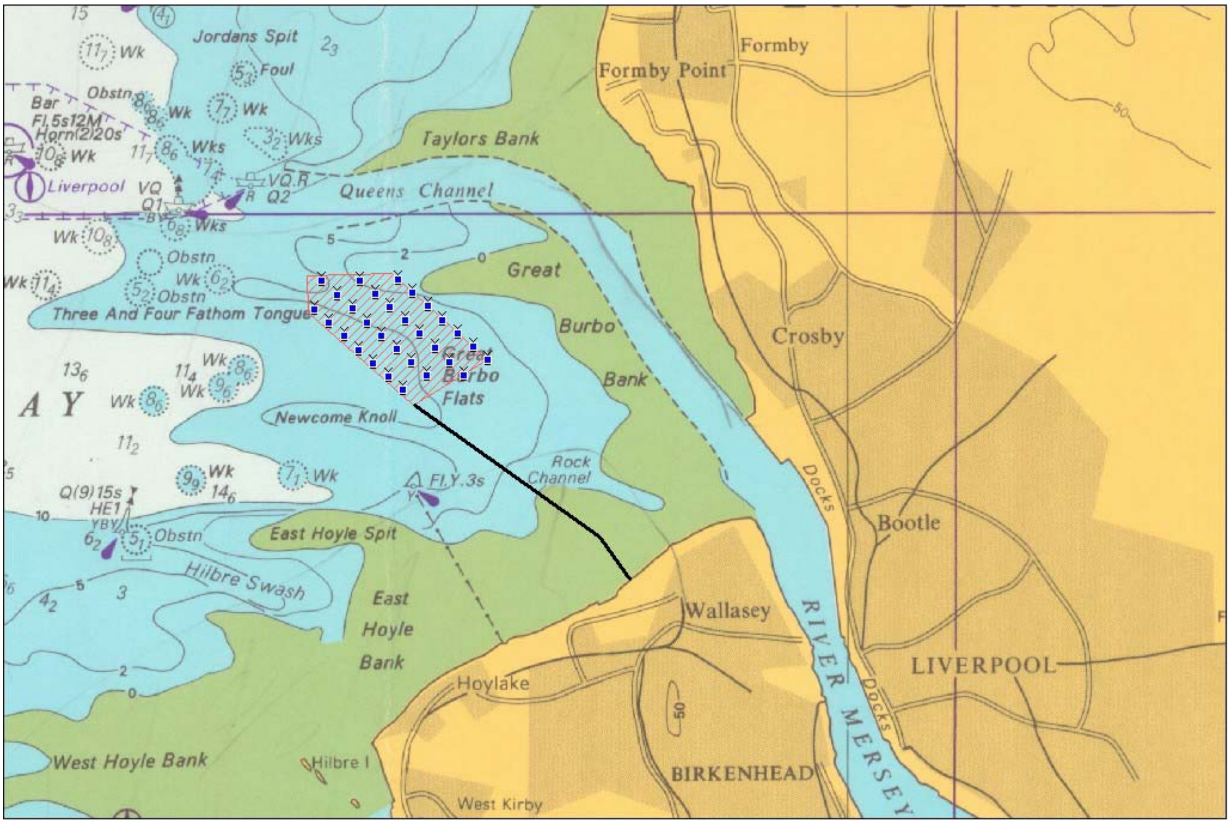


1 Introduction

The Burbo Offshore Wind Farm will consist of 25 Turbines installed on monopiles all connected via submarine cables which are an essential part of the installation, as they are the media for transporting the produced energy and the data to shore.

ELSAM ENGINEERING/SEASACPE ENERGY has chosen Submarine Cable and Pipe (SCP) as the Installation Contractor for the Submarine Cable Installation works for the Burbo Offshore Wind Farm Project.

The submarine cable installation works will be divided into two sections

1. **The installation of the Submarine Export Cables**
2. **The installation of the Submarine Infield Cables**

According to the ITT documents/contract the export cables have to be buried using ploughing techniques, and the infield cables are preferred installed by the use of jetting techniques.

The following method statement will describe the installation of the export cables by using the Vertical Injector (VI) as the ploughing tool for the export cable installation works.

2 Scope

1. This Method Statement shall clarify the methodologies of the Vertical Injector Ploughing Technique for installation of the Submarine Export Cables relevant for the Burbo Offshore Wind Farm Project

2. Explain why the Vertical Injector Ploughing Technique is of advantage to the environment.

3. This Method Statement shall propose and finally request permission to use the Vertical Injector Ploughing Technique for the simultaneous laying and burial of the three Submarine Export Cables.

3 Vertical Injector Ploughing Technique

The burial operation is divided into two operations:

1. **Using the Vertical Injector equipped with the Ripper and Vibrator in order to perform one PLGR run in each Shore Connecting Cable route to 3 m depth to loosen the sea bed and clear the cable route for any obstruction.**

2. **Using the Vertical Injector equipped with the Injector foot and Vibrator in order to perform the simultaneous laying and burial of the 3 Shore Connecting Cables in exactly the same trench as cleared with the Ripper.**

3.1 Using the Vertical Injector equipped with the Ripper and the Vibrator in order to perform the PLGR

In order to perform the PLGR, the Vertical Injector equipped with the Ripper and the Vibrator will be connected to the cable installation barge via two pennant wires in order to impinge the Vertical Injector with the requested horizontal pulling force. The vertical height and force of the Vertical Injector will be adjusted by means of the main crane.

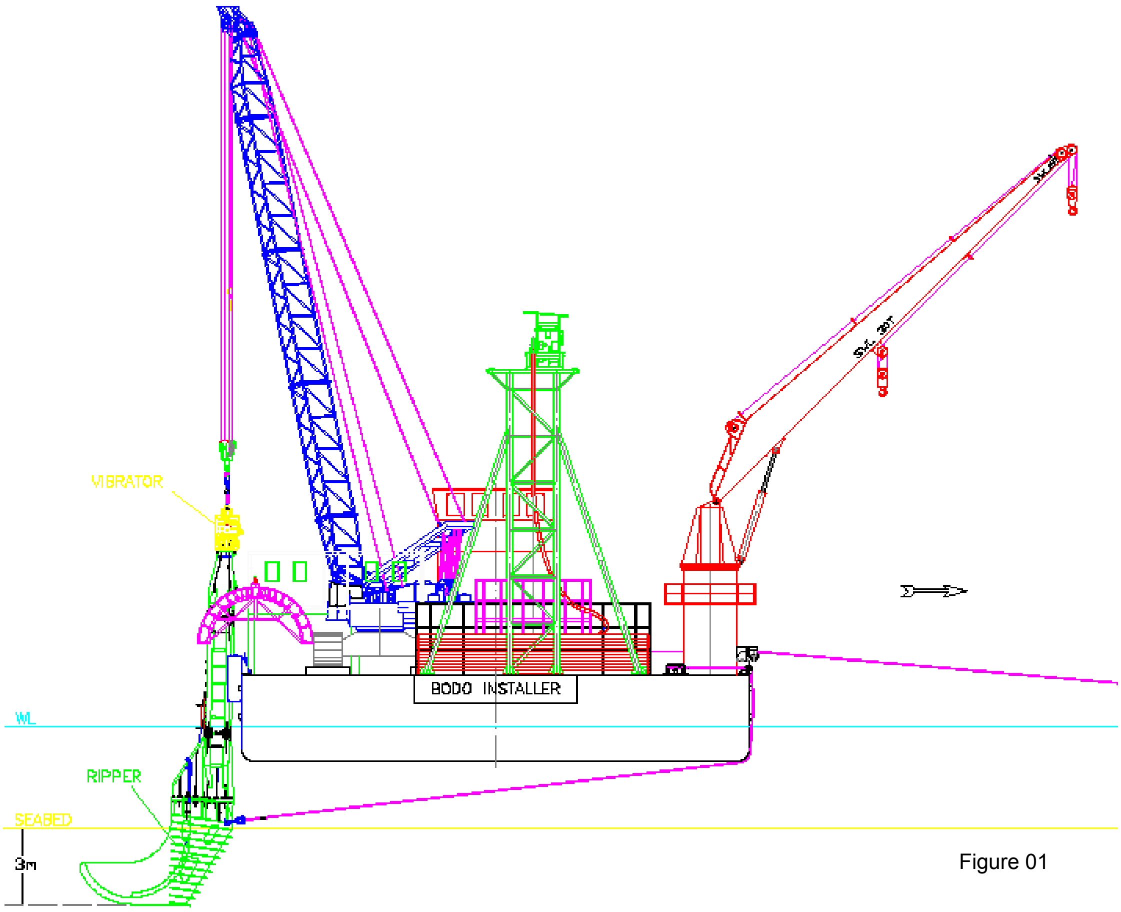


Figure 01

While the barge moves forward pulled by the main pulling winch and the constant tension four point mooring system in a controlled manner, the ripper will loosen the sediment and clear the proposed cable route undertaking the PLGR. In order to reduce the requested pulling force, a vibrator is rigidly coupled to the top side of the Vertical Injector, and the Ripper has an open face design (figure 02).
While performing the PLGR the position of the Vertical Injector and therefore the position of the pre-trenched cable route will be recorded. During simultaneous cable laying and burial operations, the Vertical Injector loaded with cable is able to follow the exact same route as recorded during PLGR.

3.2 Using the Vertical Injector equipped with the Injector Foot and the Vibrator in order to perform simultaneous cable laying and burial

The burial methodology of the VI will be the same as the burial methodology of the ploughs which have been used for the Kentish Flats and Barrow Wind Farm Projects. The VI can, by using the Vibrator and - like on the above mentioned installations – by using low pressure under heel lubrication, reduce the tow force by up to 50 % compared to a conventional plough.
This reduction of tow force will minimise the impact on the seabed during the deployment, pulling and recovery of the minimum 10-tonne pulling anchor needed to tow the installation barge.

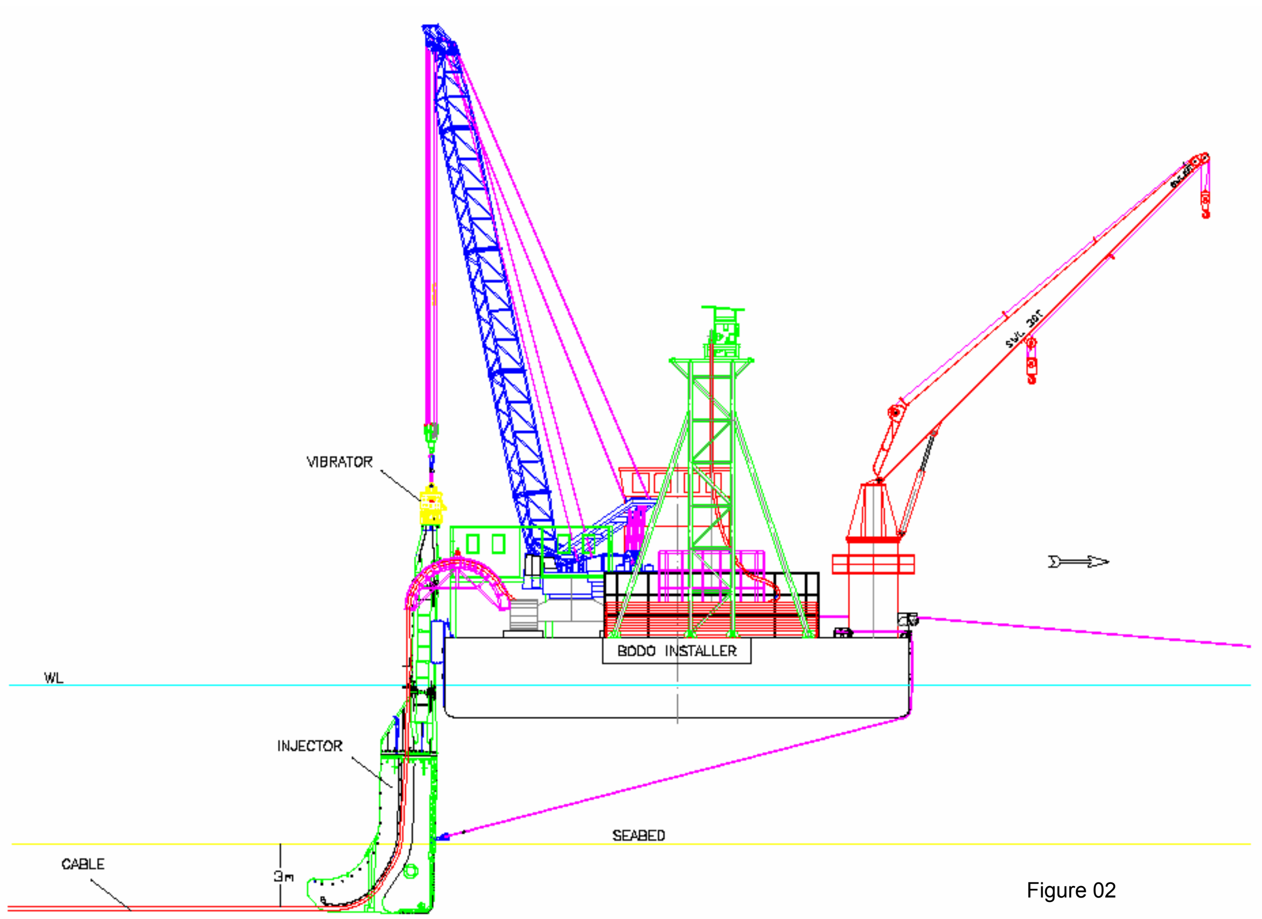


Figure 02

The forward facing nozzles of the VI will be blocked, so that no jetting can be done during the ploughing operation. On the bottom part of the VI some horizontal, downwards facing nozzles will be left open for the use of the underheel lubrication. The under heel lubrication will be done using low water pressure, lubricating the lower part of the injector foot in order to reduce the required pulling force.

Vertical Injector; simultaneous laying and burial sequences:

Start up at beach:
Once the barge is positioned as close as possible to the end of the pre-drilled ducts during high tide the cable will be pulled through the ducts and safely anchored in the beach man hole. VI will be lowered overboard and cable loaded into the injector. At the same time an onshore-based excavator will lower the final end of the duct into the required trenching depth during low tide. The VI loaded with cable will be placed in front of the duct. During high tide ploughing (simultaneous laying and burial) will be resumed by moving the barge in direction of the first alteration point.

Pull-in at monopole:
In close distance to the monopole, the VI will be slowly lifted up until the bottom end of the injector foot is exposed. Ploughing operation is stopped. The VI will be lifted to the surface, and the cable will be unloaded. The end of the cable with preinstalled pull-in devices will be safely lowered to the exposed end of the conduit and connected to the pre-installed messenger wire by divers. Once the messenger wire is connected, the pull-in operation will commence and continue until the cable is completely installed. Divers will airlift the end of conduit and cable in order to lower both to the appropriate depth.

4 Ripper

For the successful three-metre burial of the submarine export cables of the Burbo Offshore Wind Farm Project, a Pre Lay Grapnel Run (PLGR) with the open face designed ripper and the top-mounted vibrator will be performed.

The ripper is rigidly coupled to the boxed extension length or to the cone length depending on the required trenching depth.
Both the open face design of the ripper and the vibrator will reduce the required pulling force significantly.

The PLGR will be performed in order to loosen the sediment in the seabed.
The seabed sediment will basically remain in the same position, but it will be loose, so that friction and thereby tow tension for the cable laying is reduced.

The PLGR will of course also detect any debris and other obstructions to the cable deployment. This will be done to the full depth of 3 metres, further adding safety and reducing risk of damage to the submarine installation.

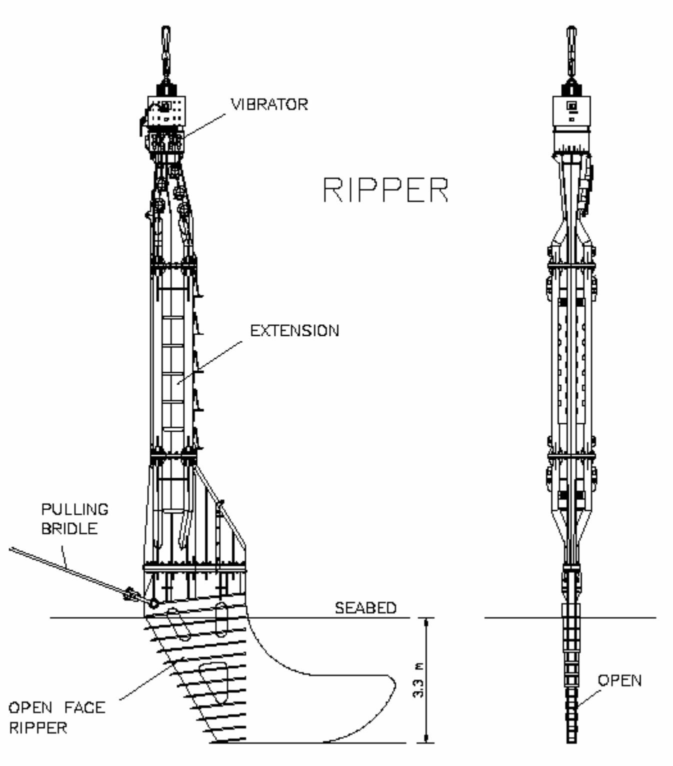
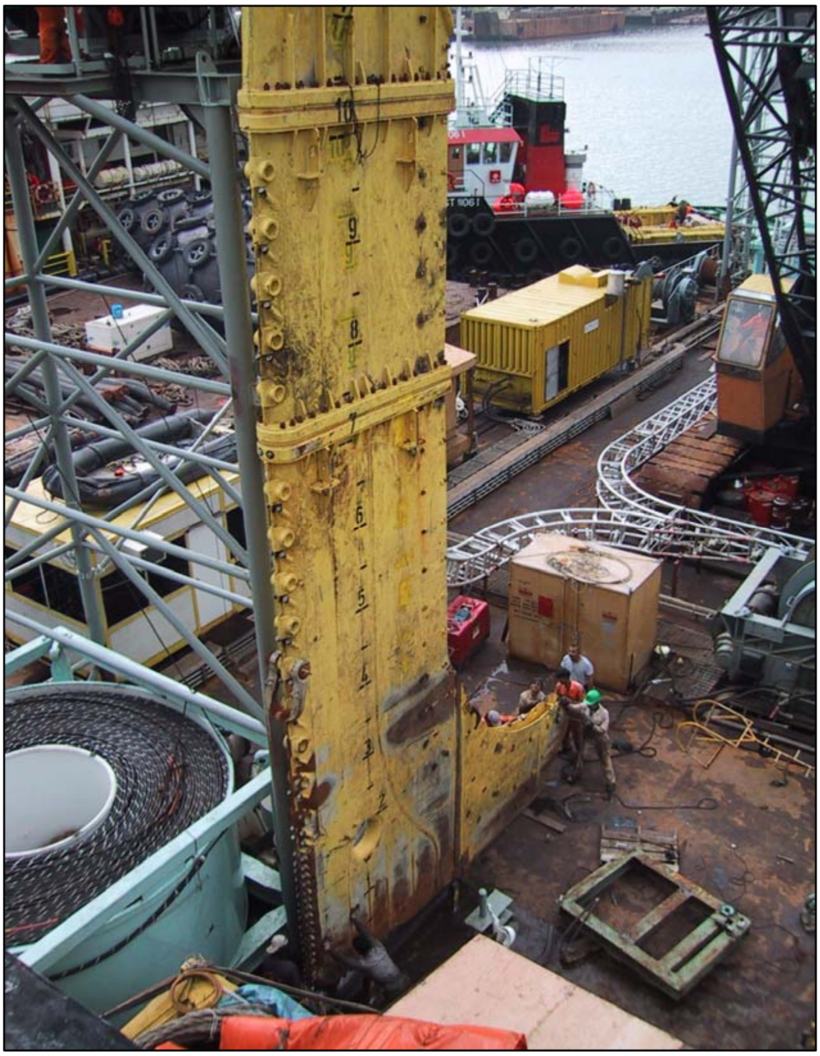


Figure 03

5 Vertical Injector



The Vertical Injector was developed in the early 20th Century and has since then installed hundreds of power cables and optic fibre cables. By the use of the Vertical Injector, burial depths of up to 18 metres have been achieved in various sediments.

The tool has successfully buried submarine cables in sandy/muddy sediments in the area around Hong Kong, in compacted sand sediments in the area around Thailand and in the Baltic Sea, in sediments with a high presence of boulders like river Rhine and Anadyr, Siberia and has successfully been used for submarine cable installations in pre-trenched/rock cut sections in e.g. Singapore.

In simultaneous cable laying and burial operations the Vertical Injector is directly connected to the barge in order to follow exactly the pre-set route which has been surveyed/pre-trenched by the Ripper.

Figure 04

The Vertical Injector Tool (see Attachment no. 1) consists of up to five sections, each rigidly coupled on top of the other. The sections are:

- The lower section is the injector foot which has a height of 7.5 metres. This is the section that will do the actual ploughing.
- The lower section will in this case also be used for the Pre Lay Grapnel Run (PLGR). The injector foot will be taken off, and the “Ripper” will be fitted to perform the PLGR.
- The middle section consists of boxed extension lengths, each having a height of three metres. These middle sections are used for deep burial operations (deeper than 6 metres). There can be two sections attached in the middle.
- The cone length with a height of three metres is the adapter piece for connecting the injector foot to the quadratic extension lengths. This has a length of 5 metres. Up to eight quadratic extension lengths can be mounted on the cone length in order to allow burial operations in water depths up to 50 metres.
- On top of the quadratic extension length, the water head with a height of three metres is fixed.

The injector foot is the part of the Vertical Injector that will be in the trench performing the actual burial.

The cable (illustrated by the red line) is loaded into the tool from the backside and is completely covered during the overall operation.

The injector can be used as a plough with or without vibrator or in a separate operation as a jetting device.

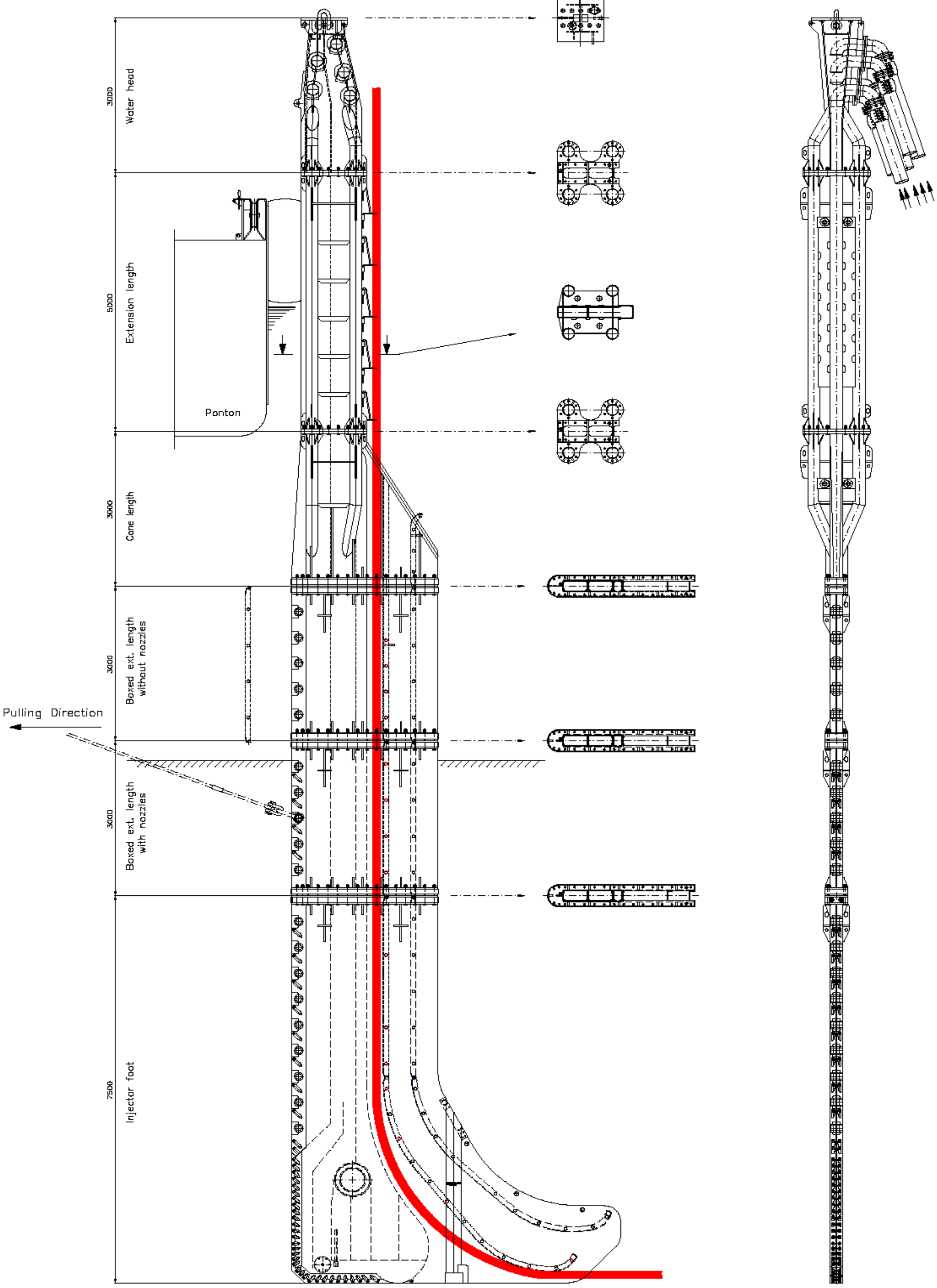
6 Environmental Aspects

By use of the Vertical Injector equipped with vibrator and ripper for the PLGR and the Vertical Injector equipped with vibrator and injector foot with under heel lubrication, the environmental impact will be reduced to a minimum because

- the same trench as was created and verified as a safe passage during the pre-lay ripper run will be used for the burial of the cable.
- the main parameter affecting the secondary sediments disturbance, the required tow tension of the anchors will be minimised.
- The PLGR to 3 metres will make it more likely that the burial target depth of 3 metres is achieved.
- The PLGR to 3 metres will lower the risk of cable damage and thereby the vast amount of extra marine operations, e.g. Post Lay Burial operations.

7 Attachments

Attachment no. 1: Vertical Injector



Appendix 2

Survey equipment- Suspended Sediments
Hydrolab Quanta probe

EFFICIENT RELIABLE EASY TO USE

PRESENTING

Quanta®

HYDROLAB'S SLEEK NEW WORKHORSE FOR WATER QUALITY MONITORING

HYDROLAB®
A HACH COMPANY BRAND

HELPING YOU PRESERVE THE WORLD'S WATER

INTRODUCING Quanta®

PORTABLE AND RUGGED, THE QUANTA SYSTEM IS BACKED BY A THREE-YEAR WARRANTY.

Hydrolab Corporation is proud to introduce the Quanta, the newest member in our family of robust water quality monitoring instruments. In designing the Quanta, our goal was to deliver a well-built, easy-to-use, multi-parameter instrument at a much lower price than has ever been seen on the market — without a single compromise in data quality.

The Hydrolab engineering team thoroughly analyzed our current and past instruments and incorporated the best designs from each into the Quanta. By combining state-of-the-art technology, designs proven by over 40 years of experience, and modern manufacturing principles, Hydrolab is able to offer the sleek, high-performance Quanta at a fraction of the cost of other professional-grade water quality instruments.

COMPACT AND COMPLETE

The Quanta is a complete system capable of monitoring multiple water quality parameters simultaneously. Each unit is custom configured to the parameters you want to monitor, and can operate at depths up to 100 meters. The Quanta display is durable, rugged and rated NEMA 6 (waterproof), capable of storing 200 frames of data, and shows five parameter values at once. The Quanta transmitter, display, and cable form a compact, light-weight system at an extraordinarily affordable price, with the best warranty in the industry.

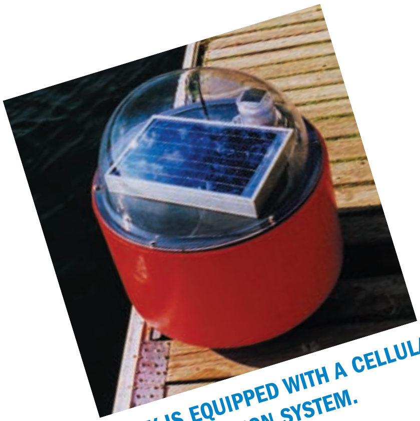
VERSATILE APPLICATIONS

The Quanta is designed for monitoring in rivers, lakes, streams, oceans and everything in between. It can be used in polluted or non-polluted water. When equipped with the optional flow cell, it can be used to monitor water quality parameters in ground water as well.

REMOTE OPERATION

Hydrolab offers land-based and buoy-based logging and communications systems for the Quanta. Utilizing advanced telecommunications technology, you can access your data from anywhere in the world.

STREAMSIDE MONITORING ALLOWS REMOTE ACCESS OF DATA.



BUOY IS EQUIPPED WITH A CELLULAR COMMUNICATION SYSTEM.

WHY QUANTA

The Quanta is multi-parameter, gathering readings from all sensors simultaneously. There is no need to change sensors or to use more than one instrument.

The Quanta can measure the following at depths up to 100 meters:

- ✔ Temperature
- ✔ Dissolved Oxygen
- ✔ Specific Conductance/Salinity
- ✔ pH
- ✔ ORP
- ✔ Depth
- ✔ Vented Level (submerged depth up to 10 meters)
- ✔ 4-Beam Turbidity

The Quanta comes with the popular SDI interface, allowing connection to a number of third-party dataloggers. Up to 10 Quanta transmitters can be daisy-chained together.

Except for the 4-Beam turbidity sensor, which uses GLI method 2, an approved methodology under the Safe Drinking Water Act, all of our sensors, as well as the sample circulator, conform to the specifications set forth in *Standard Methods for the Examination of Water and Wastewater*. This has long been recognized as the standard by the U.S. Environmental Protection Agency.

Optional accessories include a backpack, flow cell, and Secchi disk.

The Quanta display features an easy, intuitive menu system. It can log up to 200 frames of data, and allows quick calibration of the instrument.

The Quanta is backed by a three-year warranty.

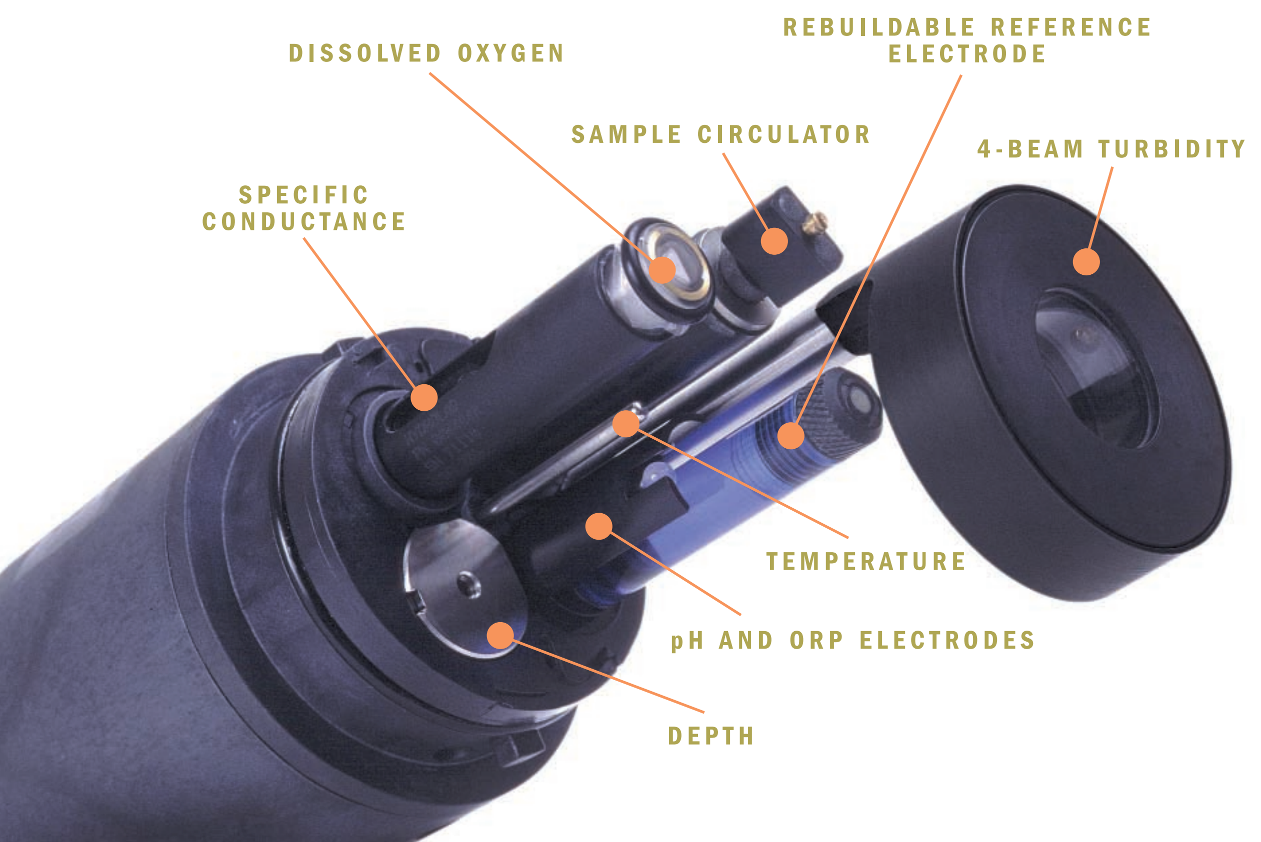
Quanta® COMPONENTS

A Quanta system is composed of three components — the Quanta transmitter, which houses the sensors, the Quanta display, which supplies power and shows the data, and a connecting cable. Each component is covered by a three-year warranty. At the heart of the Quanta is Hydrolab's superior sensor technology. These sensors have been rigorously field-tested and are proven to deliver reliable water quality data.

TEMPERATURE – Hydrolab uses a high stability thermistor in a 316 stainless steel tube. ▪ Never needs calibration.

DISSOLVED OXYGEN – Hydrolab uses the field-proven Clark Cell technology. ▪ Provides a continuous steady-state reading. ▪ Is low maintenance — easily and affordably cleaned and maintained. No need to recondition sensor.

SUPERIOR SENSOR TECHNOLOGY



pH – Hydrolab uses a standard pH glass sensor and unique rebuildable reference electrode. ▪ Our reference electrode is more reliable, lasts longer, is easier to maintain, and refills in seconds. ▪ No need to replace the sensor.

ORP – Hydrolab uses the standard platinum electrode.

SPECIFIC CONDUCTANCE – Hydrolab uses the standard four electrode cell methodology. ▪ Open cell design is easy to maintain and provides more reliable data — air bubbles and sediment do not affect sensor.

DEPTH – Hydrolab uses a custom-made high stability pressure sensor. ▪ Two ranges are available — 0 - 25 meters and 0 - 100 meters.

VENTED LEVEL – The Quanta is available with 0.003 meter (0.01 foot) accuracy over the range of 0 - 10 meters. This accuracy is valid for the full temperature range, not just at 25˚C. ▪ The vent provides automatic correction for changes in atmospheric pressure.

TURBIDITY – Only Hydrolab offers the 4-Beam turbidity sensor. ▪ The 4-Beam turbidity sensor is fouling resistant and accurate. ▪ Optional Quick-Cal Cube™ makes calibration verification a snap.

THE QUANTA DISPLAY

- ✔ **Shows readings of five parameters at once**
- ✔ **Simple, intuitive operation**
- ✔ **Low battery indicator**
- ✔ **Stores 200 frames of data**
- ✔ **Easy calibration**

ONLY HYDROLAB OFFERS A SAMPLE CIRCULATOR FOR MORE RELIABLE READINGS

The Quanta's integrated sample circulator creates a flow of water past the sensors. The miniature circulator facilitates fast, accurate, steady-state dissolved oxygen measurements, and provides other sensors these benefits:

- **Reduces response time — important when detecting moving contaminant plumes, or when the sensors are moved up or down in a water column.**
- **Reduces the harmful effects of sensor fouling by sweeping away debris and discouraging biologically active foulants (bacteria, algae, fungi) from attaching to the sensors.**
- **With a sample circulator, the instrument can be used in all environments, no matter the flow. The instrument can be deployed in poorly mixed areas of a water body or in perforated steel or PVC pipes where there is very little flow.**

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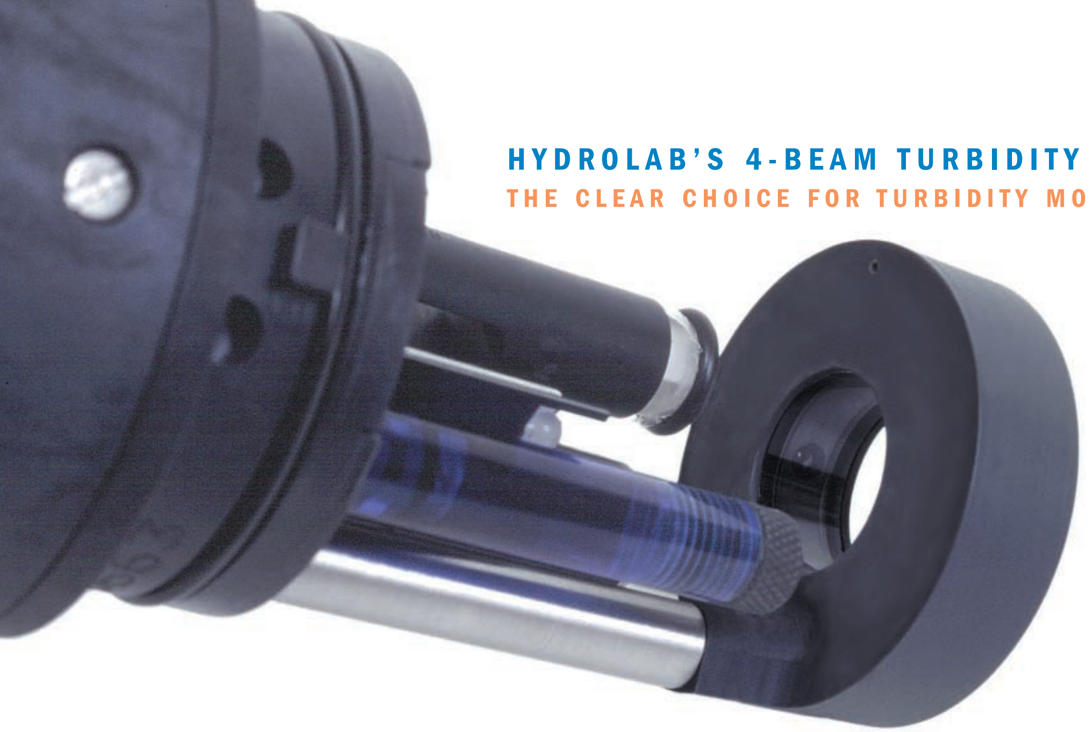

HYDROLAB'S 4-BEAM TURBIDITY SENSOR

THE CLEAR CHOICE FOR TURBIDITY MONITORING.

Hydrolab's patented 4-Beam turbidity sensor incorporates the same technology used in many drinking water facilities, where accurate, reliable data is critical. The sensor is ISO 7027 compliant, and offers these additional features:

FOULING COMPENSATION – The technology automatically calculates and compensates for fouling on the optical lenses. Stray air bubbles will not affect the turbidity readings.

AMBIENT LIGHT REJECTION – The patented technology is immune to ambient light influences. The turbidity sensor can therefore be used in shallow rivers and streams.

ROBUST LIGHT SOURCE – Provides stable, accurate measurements.

QUICK-CAL CUBE™ – Hydrolab offers a unique, patented cube for calibration verification. The Quick-Cal Cube™ can be used as a secondary standard to check the calibration of the 4-Beam turbidity sensor.

ACCURACY – The 4-Beam technology makes the sensor the most accurate available for in-situ monitoring.

LARGE RANGE – The sensor can be used in waters ranging from 0 – 1000 NTU.

THREE-YEAR WARRANTY – Like all Quanta sensors, the sensor is covered by a three-year warranty.

PERFORMANCE SPECIFICATIONS

	Range	Accuracy	Resolution
Temperature	-5 ˚C to 50˚C	± 0.15˚C	0.01˚C
Dissolved Oxygen	0 to 50 mg/L	± 0.2 mg/L ≤ 20 mg/L ± 0.6 mg/L > 20 mg/L	0.01 mg/L
Specific Conductance	0 – 100 mS/cm (autoranged)	± 1% of reading ± 0.01 PSS	4 digits
pH	0 to 14 units	± 0.2 units	0.01 units
ORP	-999 to 999 mV	± 20 mV	1 mV
4-Beam Turbidity	0 to 1000 NTU	± 5% of reading ± 1 NTU	0.1 NTU (<100) 1 NTU (≥100)
Depth 0-25 m	0 to 25 m	± 0.1m	0.1 m
Depth 0-100 m	0 to 100 m	± 0.3 m	0.1 m
Vented Level 0-10 m	0 to 10 m	± 0.003 m	0.001 m
Salinity	0 to 70 PSS	± 1% of reading ± 0.01 PSS	0.01 PSS

INSTRUMENT SPECIFICATIONS

Quanta Transmitter

Diameter: 7.6 cm (3 in)

Length: 22.9 cm (9 in)

Weight: 1.3 kg (3 lbs)

Quanta Display

Screen Size: 8.9 cm (3.5 in diagonal)

Weight (with batteries): 0.95 kg (2.1 lbs)

Memory: 200 data frames (1 frame can store all parameter values)

NEMA 6 rated (waterproof)

Low battery indicator

Operating temperature: -5˚C to 50˚C

Batteries: 3 “C” size batteries

Battery life: 15 Hours

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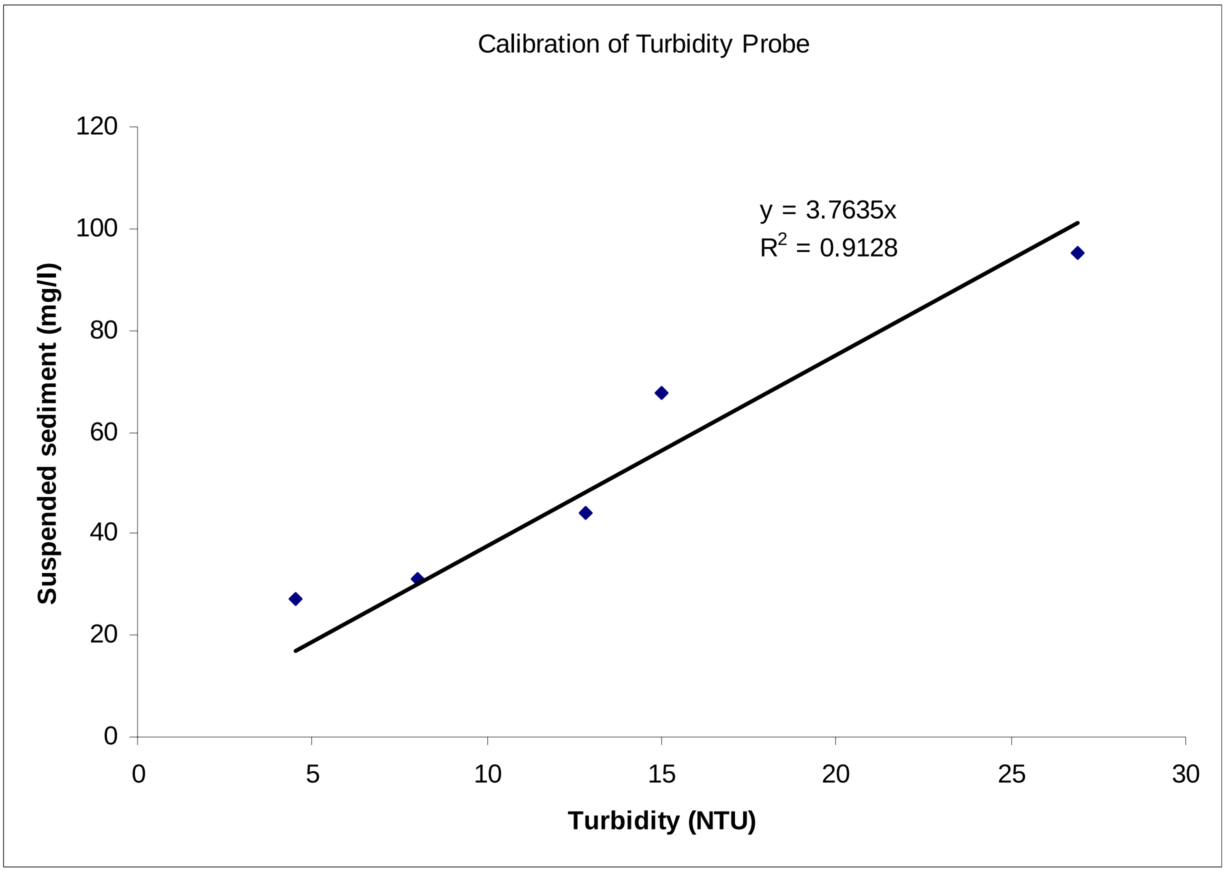
Appendix 3

Survey Data: suspended sediment calibration

Turbidity (NTU)	Suspended sediment (mg/l)
12.8	44.02
26.9	95.08
15.0	67.55
8.0	30.95
4.5	27.04



Annex 1(5) Benthic Organisms

Annex 1(5) a Sub-tidal Benthic Ecology

SeaScape Energy

Burbo Bank Offshore Wind Farm

Construction Phase
Benthic Grab Survey

Document: J3034 During Construction Grab Survey v4 (04-08)

Version	Date	Description	Prepared by	Checked by	Approved by
1	10-07	First Draft	TH		
2	11-07	Updated Draft	TH/LG	IGP	IGP
3	03-08	Draft Final	TH/IGP	LG	IGP
4	04-08	Revised Final	IGP	LG	IGP

This report has been prepared by Centre for Marine and Coastal Studies Ltd (CMACS) on behalf of SeaScape Energy.

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Cover photograph: construction work at Burbo in 2006.

Table of Contents

List of Figures

1 Executive Summary

Burbo Offshore Wind Farm is a twenty-five turbine, 90MW development located in Liverpool Bay approximately 6km from the coastlines of Wirral, Crosby and Liverpool.

A licence was issued to the wind farm developer, SeaScape Energy Ltd, which allows them to construct and operate the wind farm providing certain conditions are met. The licence (31864/07/0) was issued under the Food and Environment Protection Act (FEPA) and contains a specific requirement to monitor seabed sediments and associated invertebrate communities in and around the wind farm to allow the Licensing Authority (Marine and Fisheries Agency) to consider:

> *if any action may be required to mitigate or correct any adverse effects which may be identified.''*

The benthic (seabed) monitoring programme consists of annual surveys by grab sampling and beam trawling. It is being undertaken by Centre for Marine and Coastal Studies Ltd (CMACS) on behalf of SeaScape. The programme commenced with baseline (pre-construction) surveys in autumn 2005 which built upon surveys undertaken in 2002 in support of the project environmental impact assessment. This report presents the results of monitoring carried out in autumn 2006, during construction of the wind farm, and compares the results with baseline data.

Although overall invertebrate community types were relatively consistent the benthic fauna showed considerable changes between 2005 and 2006, with large reductions in numbers of many of the more abundant species. These changes were most marked in the central part of the wind farm and to the west where there were also increases in the proportion of mud in sediments.

These changes are believed most likely to reflect natural variability in what is a dynamic and heterogeneous area. It is important to note that it is unlikely that any changes in sediment conditions resulting from construction activities which commenced a few months earlier would have had time to cause significant effects on benthic organisms by autumn 2006.

Analysis of data collected in autumn 2007 will provide additional evidence to investigate the relationship between wind farm construction, seabed sediments and benthic invertebrates. These data will also be important since invertebrate communities will have had time to respond to significant effects of wind farm construction.

The distribution of one particular benthic invertebrate, the thumbnail crab *Thia scutellata* has been investigated in some detail since this is rare species of conservation interest. This species was recorded in grabs, in very low numbers, in both 2005 and 2006. The occurrence of this species is sporadic and changes in the distribution are not believed to be associated with wind farm construction.

2 Introduction

2.1 Overview

Burbo offshore wind farm is a twenty-five turbine development located in Liverpool Bay approximately 6km from the coastline of Wirral, Crosby and Liverpool. Under the conditions of Food and Environment Protection Act (FEPA) Licence 31864/07/0, dated 23 July 2007, issued to SeaScape Energy Ltd to construct and operate the wind farm, there is a requirement to undertake monitoring of benthic organisms and seabed sediments as part of a comprehensive programme of environmental monitoring including also wider sedimentary and hydrological processes, fish and ornithology. The purpose of this monitoring, as identified in paragraph 9 of the FEPA licence, is:

> *''to allow the Licensing Authority to consider if any action may be required to mitigate or correct any adverse effects which may be identified.''*

Centre for Marine and Coastal Studies Ltd (CMACS) was commissioned by SeaScape Energy Ltd to develop and then undertake the programme of monitoring to discharge SeaScape's responsibilities under the FEPA licence.

2.2 Rationale and Objectives

The FEPA licence calls for annual benthic surveys, comprising: pre-construction baseline in late summer/autumn 2005; construction, late summer/autumn 2006 and three years post-construction/operation during late summer/autumn 2007-2009 to provide information on subtidal benthic ecological communities and seabed sediments. As required under the terms of the FEPA licence, CMACS devised the approach to monitoring of benthic organisms and sediments in line with guidance provided in Boyd (2002).

Boyd (2002) provides a rationale for benthic surveys at aggregate extraction sites[1] which has been adapted by CMACS in relation to monitoring of the construction and operation of Burbo Offshore Wind Farm. Benthic communities are a logical target for investigation of the effects of construction and operation of wind farms since:

[1] Advice for aggregate extraction surveys is used in the absence of specific advice in relation to offshore wind farms.

A. They may be valued because of their links with other resources (e.g. as food to commercially important fisheries) and they have representatives that are commercially harvested (e.g. certain crabs, shrimps and bivalves). They may also have intrinsic value due to rarity or other feature(s) of conservation importance. Because of the open nature of the marine environment, evaluations of benthic biodiversity, productivity and trophic interactions may all bear upon ecosystem integrity.
B. They are constant features of the seabed, and can vary predictably in association with the physical habitat and in response to man-made changes. Furthermore, unlike shifting populations of planktonic organisms or many pelagic fish species, adults of most benthic invertebrate species are either sessile or mobile within narrow spatial ranges. Thus they are good indicators of locally induced environmental changes.

Change to benthic communities can not be understood without knowledge of associated seabed sediments, and sediment sampling is therefore an integral part of the benthic monitoring programme. Equally importantly, the FEPA licence calls for monitoring of seabed sediments to provide information in relation to coastal process modelling outputs. The EIA considered the consequences of wind farm construction and operation for sediment transport and deposition; post-consent monitoring is required to validate the predictions made.

The benthic monitoring programme has been informed by characterisation surveys undertaken by CMACS in support of the environmental impact assessment for Burbo Offshore Wind Farm in April 2002. The ES noted that the two main biotopes identifying during characterisation surveys in 2001 (IGS.FabMag and CMS.AbrNucCor) were important as a source of prey organisms for flatfish, and therefore of significance at least to Liverpool Bay.

The EIA also identified that the nationally scarce thumbnail crab (*Thia scutellata*) was present as a relatively small population at Burbo compared with populations further offshore into Liverpool Bay. This was considered to be important at the level of UK Waters (i.e. nationally).

The benthic monitoring has the following specific objectives:

1. To identify changes in benthic communities over time attributable to the effects of wind farm construction or operation. If such change is evident, to determine the significance in terms of:
    a. benthic communities *per se;*
    b. other trophic groups, notably fish.
2. To monitor the distribution of species of interest (i.e. *Thia scutellata*).
3. To identify changes in sediment characteristics over time attributable to the effects of wind farm construction or operation to help understand any changes to benthic communities and in support of coastal process monitoring work.

Investigation of the above will allow CMACS to comment on two of the main conclusions of the ES: 1, that there would be no significant adverse effects upon benthic ecological receptors; and, 2, that there would be no change to sediment pathways and minimal deposition of material from scour or as a result of construction activities.

The benthic monitoring is therefore aimed at identifying change in benthic communities and seabed sediments. In order to determine whether such change is related to construction and/or operation of the wind farm it is important to understand natural variability. In this respect the Burbo site represents a challenging environment as it is particularly dynamic; indeed, the ES noted that a number of workers had shown that community composition in the muddy sand fauna of the Burbo Bight area varied greatly between years:

> *Factors such as the level of recruitment (especially of bivalves, which varies enormously from year to year), the degree of storminess and the level of bioturbation (reworking and loosening of the sediments by the infauna), especially by high densities of Lagis koreni and Abra alba, are all probably very important factors affecting these changes.*

2.3 Survey Context

This report details results of the September 2006 benthic survey which was undertaken while construction of the wind farm was ongoing.

The offshore elements of the construction of the wind farm commenced with placement of a scour filter layer in May 2006 prior to installation of turbine foundations (monopiles) between June and August 2006. Three electricity export cables were installed between July and August 2006; intra-array cabling commenced in August 2006 and continued into 2007. Rock armour was placed around all turbines between September and November 2006.

The 2006 benthic survey was therefore undertaken immediately after the period of monopile and export cable installation works ended. The survey coincided with ongoing array cable installations but took place before significant scour protection had been placed, and in advance of any inter-array cabling works. If benthic communities were affected by construction works the 3-4 months since commencement of such works is probably insufficient for effects on community structure to become evident, and it is only in future (post-construction) surveys that wind-farm induced change may become apparent. However, effects on seabed sediments, if present, should be seen more quickly.

The 2006 survey is a repeat of the baseline survey in 2005 and, the above notwithstanding, the focus of this report is to compare results between the two surveys.

The intention is to repeat the survey annually; the need for continued survey beyond one year of post-construction data (2007 survey) will be reviewed in the first post-construction monitoring report.

3 Methods

3.1 Overview

The 2006 construction survey was a repeat of the pre-construction baseline survey carried out in September/October 2005 and comprised collection of triplicate grab samples from each of twenty stations (Figure 1). The survey and analysis methods are consistent with those in the Monitoring Method Statement (doc ref: J3034 Burbo FEPA Methods v1.5), as agreed with statutory consultees in advance of the baseline benthic survey.

The survey was designed to provide detailed information about benthic populations and sub-tidal sediment types in and around the development area. As explicitly required by the FEPA licence, benthic sample stations take into account such factors as precise monopile locations and locations of cables, whilst ensuring adequate coverage of the extent and direction of the full tidal excursion.

Initial site selection prior to the pre-construction baseline survey in 2005 was based on information acquired by CMACS during the project EIA (SeaScape Energy 2002), including a benthic characterisation survey which deployed grab samples across the area.

Three sample stations (6, 7 and 8) were positioned in the near-field area of the monopile foundations for Turbine BB27 to investigate potential scour effects, including any localised changes to seabed sediments (see Figure 1 for detail on positions). A further six stations (sites 5, 9, 10, 11, 13 and 14) were positioned within the wind farm array. These sites were positioned so as to give good coverage of the three communities found during the characterisation surveys - the IGS.Fabmag biotope (sites 5, 6, 7, 8 and 9); the IGSNepcirBat biotope (sites 13 and 14) and an unclassified area (sites 10 and 11) that had some similiarity to IGS.NcirBat but was slightly muddier and much richer faunally.

Three stations were located along the export cable route to investigate possible effects of cable installation. Two (16 and 17) were within 2 km of the wind farm; the other (19) was approximately at the mid-point of the export cable route. Sites 16 and 17 were also in the area from which the thumbnail crab *Thia scutellata* had been recorded in 2002. Station 20 was selected as a reference station to the east of the export cable route, where impacts to sediments/benthic invertebrates would only be expected if export cable installation works caused significant disturbance, which was not the case. Sites 16 and 17 were located on the IGS.FabMag biotope while sites 19 and 20 were in the relatively low diversity biotope IGS.NepcirBat.

Two stations (sites 12 and 15) were positioned immediately outside of the wind farm area (approximately 600 m distant) to investigate for near-field effects. Site 12 was the muddiest site found during the characterisation survey, and was the only area inside or outside of the windfarm that matched the rich, bivalve dominated biotope CMS.AbrNucCor. Site 15 was in the biotope NepcirBat.

Further sites were located at locations comparatively remote to the wind farm development area, both within and outside the tidal excursion. The former, positioned both offshore (sites 2, 3 and 4) and inshore (Site 18) of the wind farm, were selected to assess for possible far field effects but are also considered of use as reference sites if used with caution. Sites 2, 3 and 4 were on the IGS.FabMag biotope while Site 18 was in the IGS.Nepcir biotope.

Site 1, outside the tidal excursion, was selected as an overall control. It is recognised that the greater depth, relatively coarse substrate and distance from the Mersey Estuary do compromise the value of Site 1 as a control for the sediments and communities in the wind farm. The faunal community of this site was unknown at the time the surveys were planned. However, it was a requirement of the FEPA licence that the full extent of one tidal excursion from the wind farm be covered by the survey, and this site lies at a distance approximately equal to one full tidal excursion of a typical spring tide. At this distance there were no areas with conditions that appeared likely to be comparable with the wind farm sites.

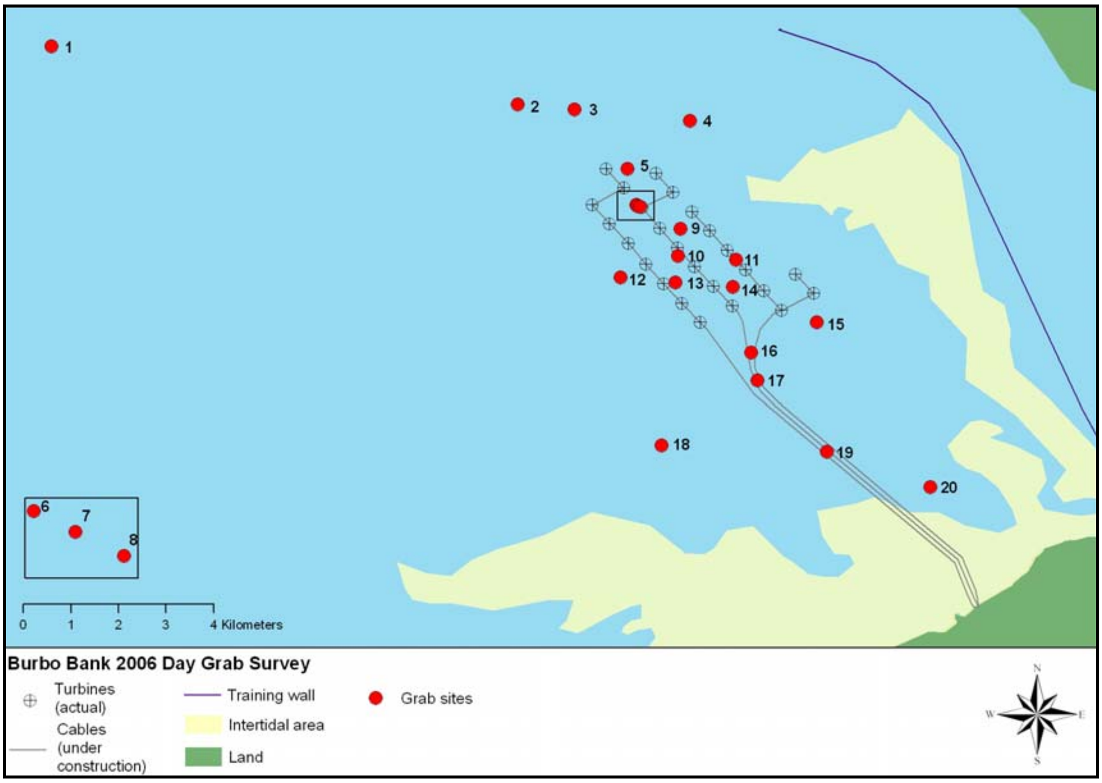


Figure 1 Benthic monitoring stations (2006 survey fixes). Inset shows site numbers 6-8, which were located circa 150, 100 and 50 metres from turbine BB27, in line with ebb tidal flows. Note that export cables and turbine monopile foundations were installed at the time of survey but array cable positions are pre-installation.

3.2 Sample collection

Grab sampling was carried out from the survey vessel 'Aquadynamic' on the 14th and 16th September 2006 and all samples were obtained using a 0.1 m^2 Day Grab. At each station the survey vessel was positioned to within at least 10 m of the target point using DGPS and actual sample position recorded to ± 2 m. Positional fixes are provided in Appendix 1.

Upon collection of each complete sample of at least 5 litres volume, with no stones in the grab jaws, the following procedures were followed at sea:

1. each sample was photographed;
2. sediment volume was recorded and a description of sediment character made (Appendix 2);
3. a small sub-sample (c. 400 g) was taken for particle size and total organic carbon (toc) analysis and stored in a foil tray in a cool place;
4. the remaining sediment, constituting the faunal sample, was gently sieved on-board the vessel over a 1mm mesh using a low pressure seawater hose;
5. the retained faunal sample was placed in a labelled airtight bucket with an additional internal label.

Samples were stowed onboard until they could be further processed ashore. No preservatives were used at sea for health and safety reasons.

Back ashore faunal samples were preserved using buffered formal saline solution to a final formalin concentration of around 4-5%.

The particle size/toc analysis subsample was frozen until required for analysis.

3.3 Laboratory analysis

3.3.1 Sediments

Particle size analysis (PSA) of most samples was carried out using dry sieving, after drying to constant weight at 70 ˚C, on the following series of sieves:

5 mm, 2 mm, 1 mm, 600 µm, 425 µm, 300 µm, 212 µm, 150 µm, 63 µm, pan (= <63 µm).

A number of samples where the sediment was particularly muddy were analysed using laser size diffraction as dry sieving would have under-represented the fine fraction. Laser sizing was applied to 12 of the 60 samples (Samples 3.1, 3.3, 9.2, 10.1, 11.1, 12.1, 12.2, 13.1, 13.2, 13.3, 14.1 and 14.2).

For data analysis purposes the size classes determined by laser diffraction were converted to those outlined for dry sieving.

Quality control measures for sediment particle size analyses comprised:

- use of a laboratory that participates in the NMBAQC scheme.

Organic content of the sediments was determined by loss on ignition as a surrogate for toc. Samples were combusted in a furnace at 450˚C. Analysis was carried out on the < 1 mm fraction to avoid undue influence from large stones.

A number of descriptors of the sediments were calculated, including median particle size, mean particle size (calculated from the mean Phi size, where Phi is log 2 of size in mm), and a sorting index (the standard deviation of Phi). These indices were then used to determine the sediment type, including degree of sorting, after the system of Buchanan *et al*. (1984, Table 1 and Table 2). However, the main classification system used to describe sediment type was based on the "Folk triangle" as used by the British Geological Survey (Figure 2).

Table 1 Classification used for defining sediment type (based on Wentworth, 1922; from Buchanan, 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 (based on Wentworth, 1922; 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

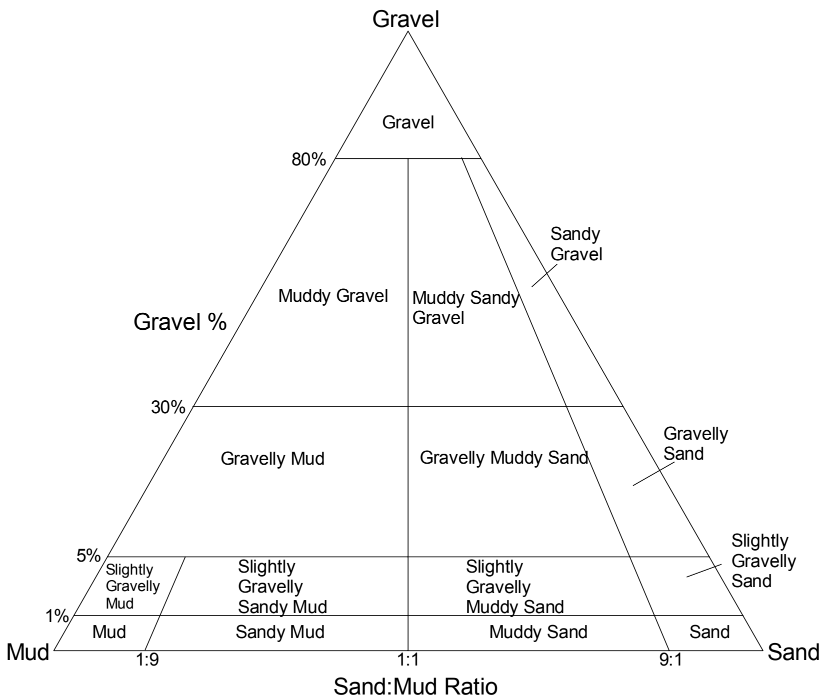


Figure 2 Sediment classifications after Folk (1954), where “gravel” refers to particles greater than 2mm and “mud” to particles less than 63μm; as used by the British Geological Society.

3.3.2 Fauna

In the laboratory each faunal sample was carefully washed over a 1mm sieve using fresh water under a fume hood until all formalin was removed. The samples were then carefully sorted, with the aid of low power microscopes where necessary, and all fauna removed into pots containing the major groups (molluscs, worms, Crustacea, echinoderms and "others") and stored in 70% industrial denatured alcohol (IDA). All specimens were then identified to species as far as possible. The majority of taxa were counted but colonial organisms were recorded on a presence or absence basis.

Quality control procedures comprised:

- preparation of a reference collection of all taxa stored in IDA;
- re-sorting by an experienced technician of a random selection of the samples (typically 10%). If specimens amounting to more than 5% of the total specimens originally found (or more than 10% of any one group) were found then the entire batch of samples is re-sorted; and,
- use of a laboratory that participates in the NMBAQC scheme.

3.4 Statistical analysis of benthic faunal data

Benthic faunal data were organized into a MS Access database. Different life history stages of the same species, which were recorded separately, were generally combined and treated as one for the purposes of statistical analysis.

Indices of species richness and universal features of community structure were calculated. A variety of univariate, multivariate and graphical techniques were used to investigate the data. Colonial fauna recorded on a presence or absence basis were normally assigned a value of 1 or 0 respectively for analytical purposes.

Multivariate analysis was undertaken using PRIMER Version 5 (Clarke and Warwick, 1994). Dendrograms and Multi Dimensional Scaling (MDS) plots were produced based on square-root transformed abundance data to provide a balance between rare and common taxa. The Bray-Curtis similarity coefficient (Bray and Curtis, 1957) was used. Dendrograms were plotted using hierarchical clustering with group average linking.

Stress values are provided for each MDS plot; a stress value of <0.05 indicates that there is an excellent representation of the relationship between the various samples, 0.1 indicates good ordination and 0.2 indicates a potentially useful 2-dimensional picture (Clarke and Warwick, 1994). In order to investigate the effect of the environmental data on the stations, MDS plots were repeated with sediment information superimposed.

The geographic information system ArcView was also used to represent data spatially. This provides a visual means to assess changes in the spatial distribution of benthic macrofaunal communities.

4 Results & Discussion

4.1 Sediments

Field descriptions and raw data following particle size analysis are presented in Appendices 2 and 3 respectively. Sediment classifications and a selection of other parameters are plotted in Figure 3A-3E where baseline (2005) data are provided for comparison.

Where a single description of the sediment at a sample location is given this has been based on the predominant sediment type from the three replicates, or, where this was not appropriate, by looking at the overall characteristics of the pooled replicates. For example, sediment type at the westerly reference site (Site 1) in 2005 varied between sand and gravelly sand but is described as slightly gravelly sand in Figure 3A.

Sediment character at most offshore sites, including the reference station (Site 1) and several sites in the northern part of the array was consistent between 2005 and 2006. This was the situation at Sites 7 & 8 close to Turbine BB27 which were consistently sandy; however, at Site 6 (approx. 140m from the turbine) one of the 2006 replicate samples contained muddy sand demonstrating that finer (silty) sediments were deposited in at least one isolated patch.

The shallow inshore sites towards the south east of the study area tended to have higher gravel contents in 2006 than the previous year. In all cases the change was very small (average gravel content for all 18 samples from Sites 15 - 20 increased from 0.9 to 1.8%) but this was frequently just sufficient to result in a change of classification since the threshold between “sand” and “slightly gravelly sand” lies at 1% gravel content. Similarly, there was a small but consistent increase in the grain size of the fine and medium sands that make up the bulk of the sediments. Given the small differences involved, it is unlikely that this is ecologically significant.

Rather larger changes were apparent in the central section of the survey area (Sites 9 to 14). Here, the reported mud content (fraction not retained on a 63μm sieve; Figure 3B) of most samples rose by an average of almost 50% such that sediments at these stations were dominated by muds. A number of possible explanations have been considered for these significant changes:

- Nature of the sediment has not changed in reality but has apparently changed due to differences in analytical technique between the two years (laser sizing was not carried out on finer sediment samples from the 2005 survey and dry sieving can under-represent fine sediments if they adhere together). Considerable care was taken to ensure that sediments did not adhere and sediment descriptions and photographs support the results.

- Nature of the sediment has not changed in reality but by chance the grabs have landed on areas of higher mud content in a heterogeneous environment. This seems extremely unlikely since the change is consistent across one specific region of the site and there is consistency between replicates.

- Nature of the sediment has changed but this is part of the natural fluctuations seen in this sort of inshore environment.

- Nature of the sediment has changed and this is due at least in part to the activities on the site.

These are believed to be real changes and field notes and photographs of each sample taken after collection support this position (Appendix 2). This leaves the question of whether or not the increase in fine surface sediments in 2006 is due at least in part to wind farm construction activities, namely placement of filter layers in May and monopile and export cable installation works preceding the benthic survey. It is understood from coastal process studies in support of the Project EIA (ABPmer 2002) that finer (silt) sediments are mobile under normal tidal and wave conditions at Burbo Bank and modelling work suggested very rapid dispersal across Liverpool Bay of fine material disturbed during construction. It would also be surprising if the very limited quantities of sediment mobilised during export cable installation works resulted in detectable deposition on the bank to the north. Export and array cable installation works were construction activities with the highest capacity to mobilise sediments into suspension but monitoring demonstrated that impacts were very small (cf. During Construction Suspended Sediment Concentration Monitoring study, CMACS 2006).

It is worth noting that studies by Eagle (1973 and 1975), in support of the development of a long sea outfall for sewage effluent off Spencer's spit in the 1970s which partly cover the present study area, mentioned that some of the sediments had "ephemeral silts deposits". This was noted in the Burbo Environmental Statement (SeaScape Energy 2002), "*fine sediments deposited on the surface of grab samples*" in the muddier areas sampled during the characterisation survey.

The evidence, albeit at an early stage in the monitoring, suggests that the observed changes are most likely to represent fluctuations related to natural events in the dynamic coastal/estuary mouth environment.

Variation in percentage total organic carbon (TOC, as loss on ignition; Figure 3E) reflected the trend in sediment particle size (Figure 3C) in that there was a high degree of consistency between years other than at several sites towards the centre of the wind farm area. Here there was an increase in TOC, especially at Sites 11 and 13 near the eastern and western boundary of the array respectively. These sites, which became muddier between 2005 and 2006, were richer in organic content in 2006. This is in line with expectations as muddy sediments tend to hold more organic matter.

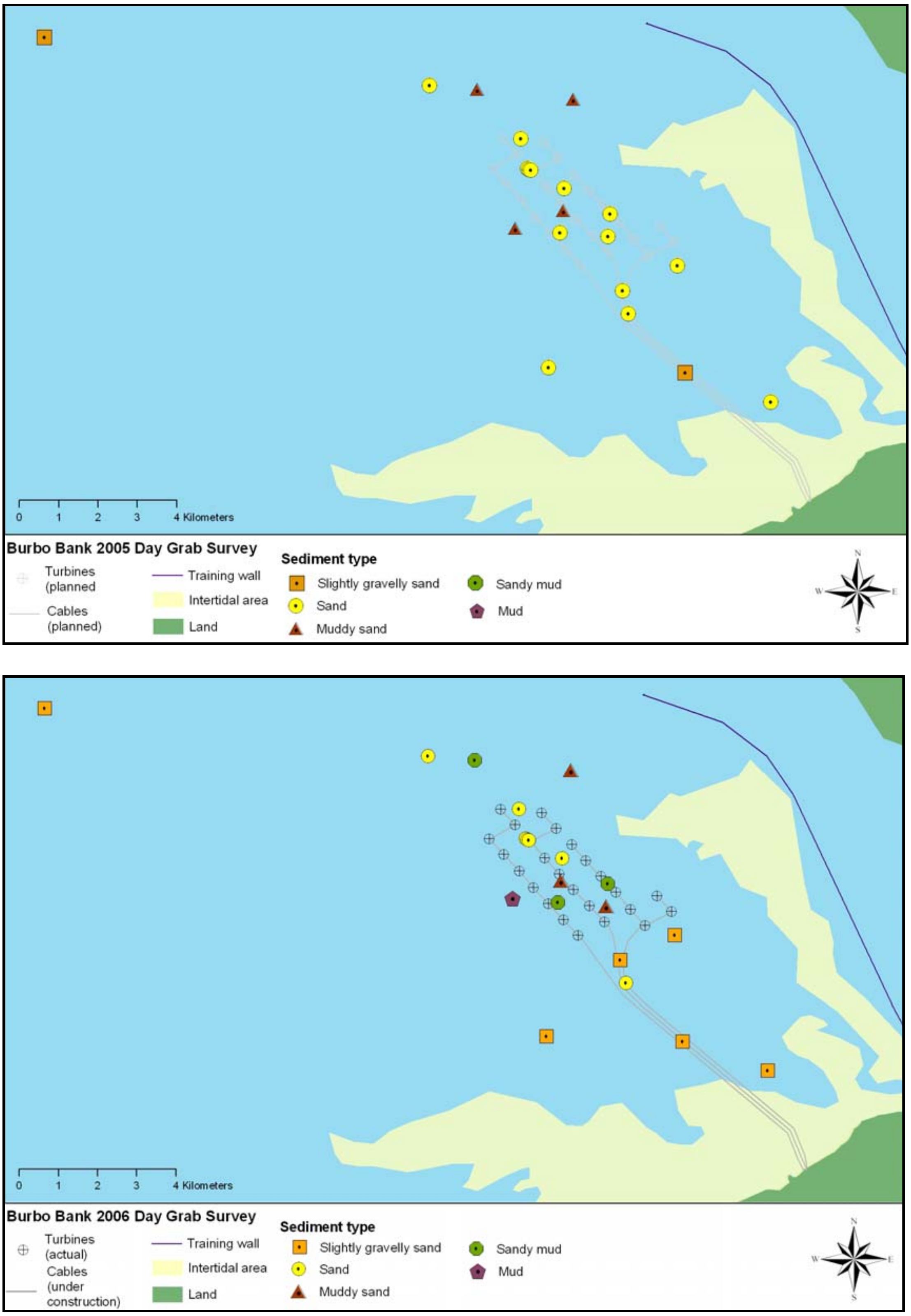
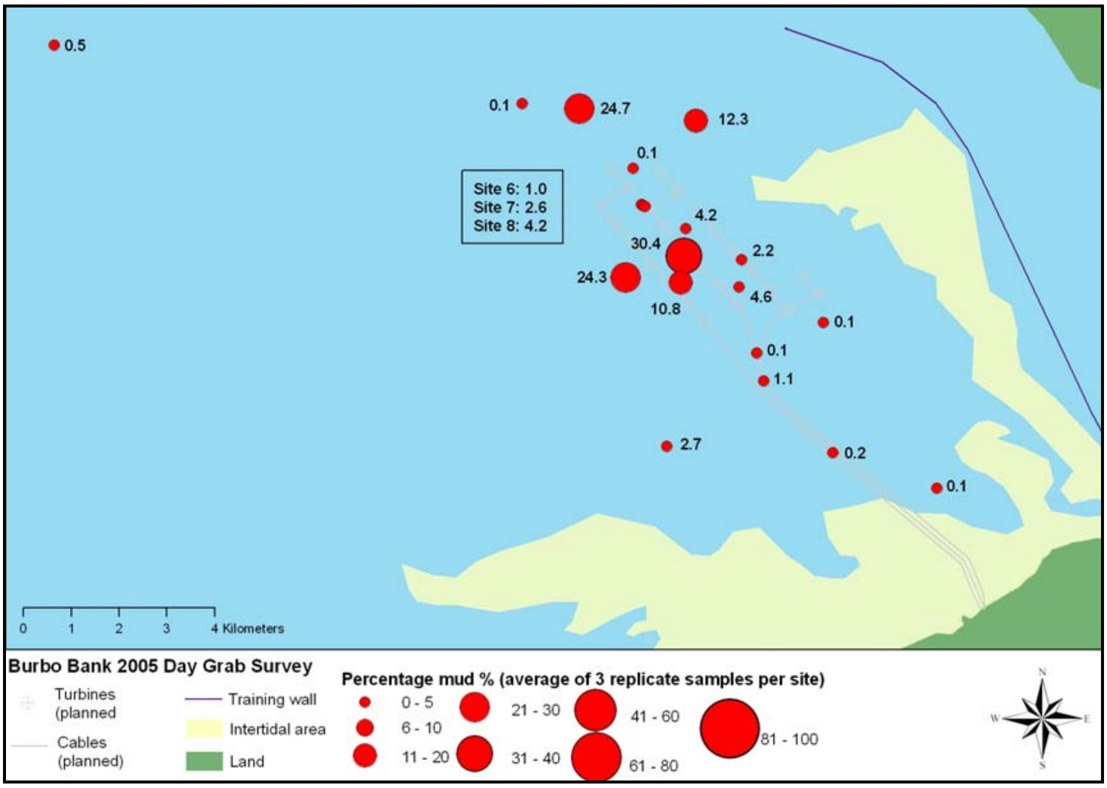


Figure 3A Sediment descriptions for grab sample sites in 2006 compared to 2005 data.



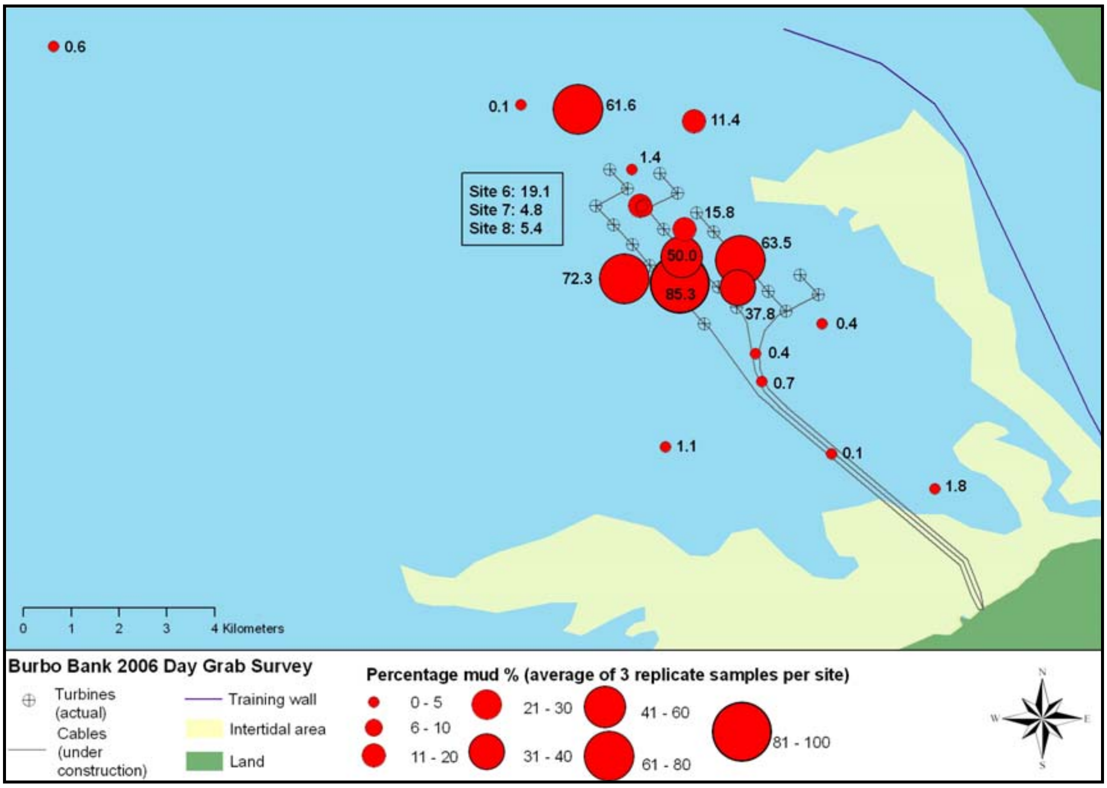


Figure 3B Percentage mud of sediments from grab sample sites in 2006 compared to 2005 data.

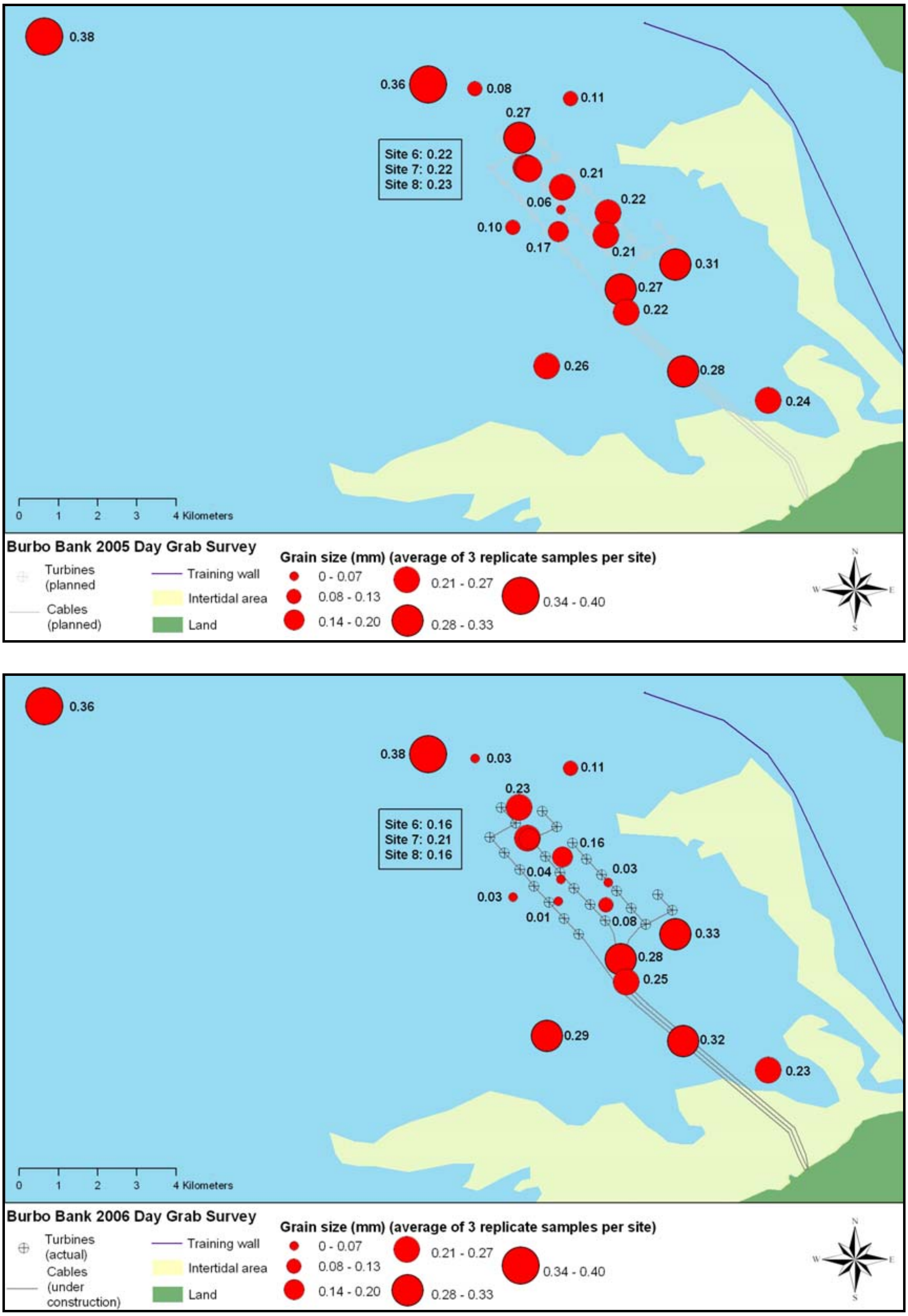
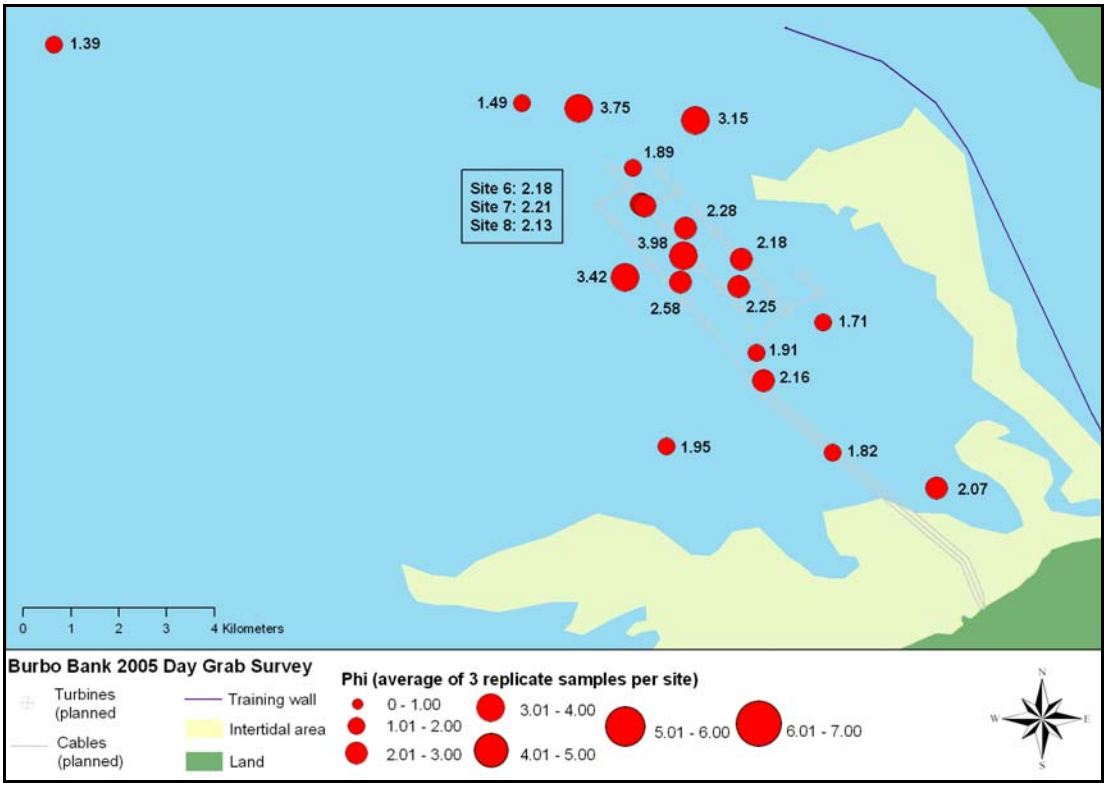


Figure 3C Grain size of sediments from grab sample sites in 2006 compared to 2005 data.



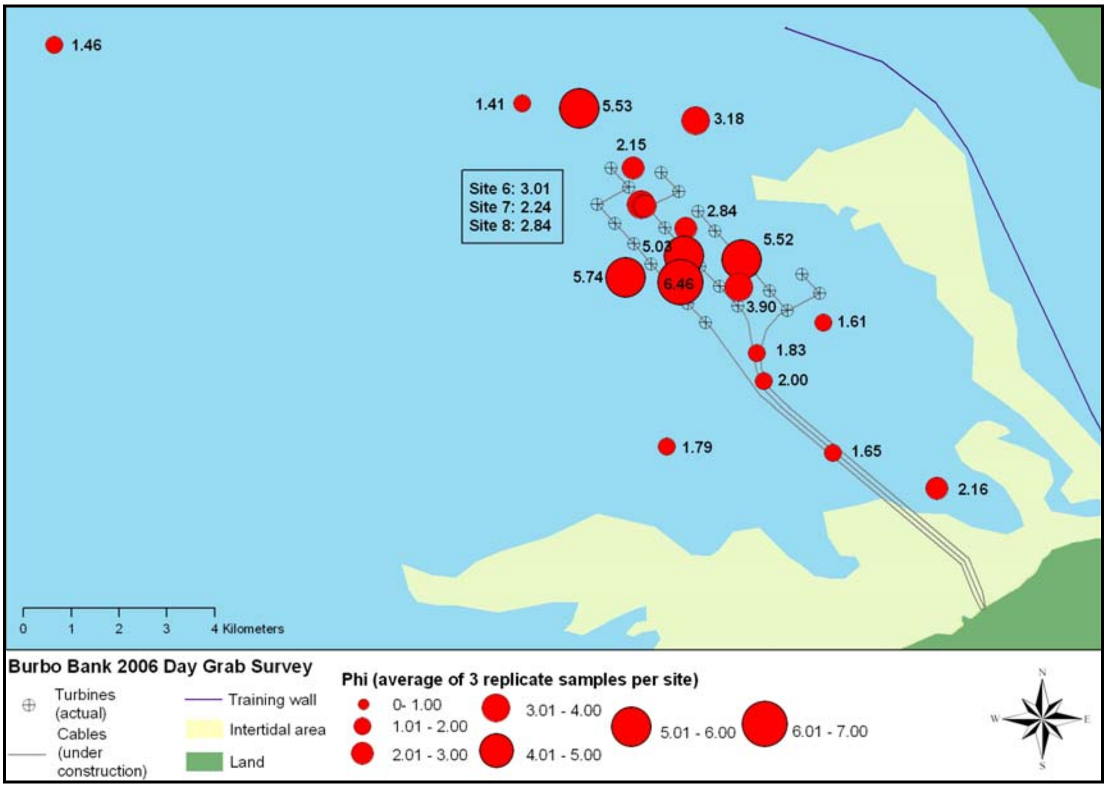
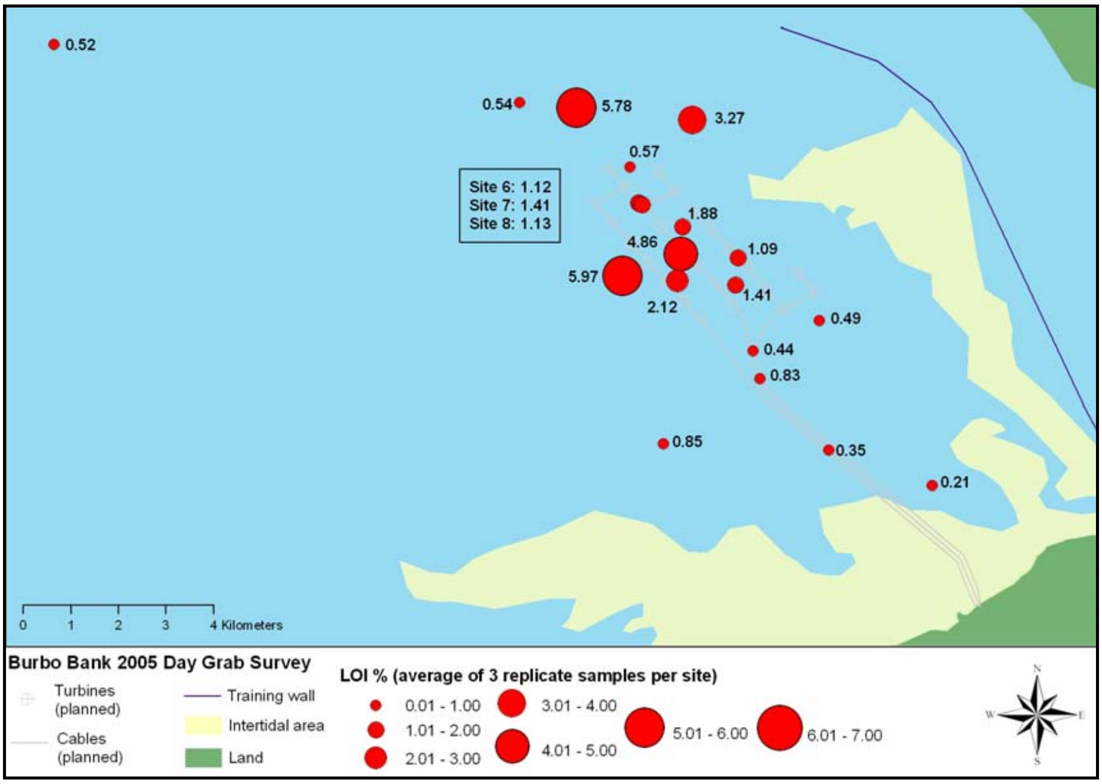


Figure 3D Sediment phi from grab sample sites in 2006 compared to 2005 data.



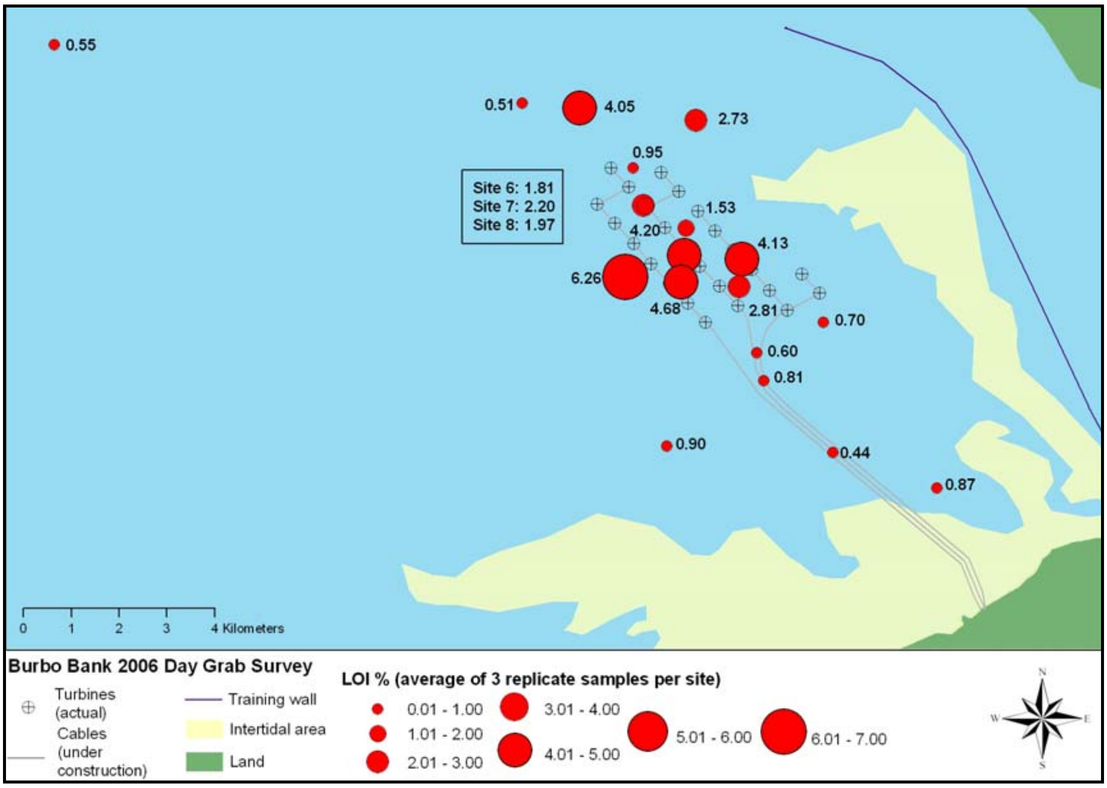


Figure 3E Organic matter content (loss on ignition) of sediments from grab sample sites in 2006 compared to 2005 data.

4.2 Fauna

Raw faunal data are provided as Appendix 4 and a full species list as Appendix 5.

4.2.1 Abundance and species richness

The number of taxa where more than ten individuals were recorded (Table 3) was 35 in 2006 as opposed to 42 in 2005. There was also a marked drop in the total number of organisms recorded in 2006. A large part of this is due to the extremely high numbers of small *Donax vittatus* found at Site 19 in 2005. However, even ignoring this species, which is discussed further below (Section 4.2.2), there was a considerable decline in the overall number of organisms recorded and in the abundance of most of the more common species.

The average number of countable individuals per site and average number of taxa recorded are presented in Figure 4 and Figure 5, along with the equivalent values from the 2005 baseline survey. These figures reveal a clear and widespread trend for reduced abundance and taxon richness.

The trend for reduced abundance (Figure 4) is apparent at most of the sites within the wind farm and a number outside, but not at the more distant sites (offshore Sites 1 and 2, and inshore Site 20) or at Sites 5 and 10 within the wind farm area. Benthic diversity, as measured by taxon richness (Figure 5) and the Shannon diversity index (Figure 6 and Table 4), also remained at comparable levels to 2005, or increased, at these sites.

The largest drop in average number of taxa per sample was well outside the wind farm area, at Site 18 (several kilometres south of the wind farm and west of the export cable route) where the average number of taxa recorded fell from 31 in 2005 to 21. Conversely, diversity as measured by the Shannon index remained high at this location and this was due to the relatively even distribution of abundance between species.

The wind farm area was generally less diverse in 2006 than in 2005 (Figure 6 and Table 5). In the majority of cases the main reductions in diversity have occurred across the central area of the wind farm (Sites 9 – 13) and at several inshore sites south of the turbine array (Figure 6). A decrease in diversity is also apparent at Site 2 (several km north of the wind farm) and Site 5 in the northern part of the wind farm area.

Although there were reductions in numbers of taxa and numbers of individuals at sites 6, 7 and 8, within the near field of turbine BB27, these were relatively modest and diversity indices were similar to 2005. Site 8 (closest to the turbine at approximately 50 m distance) remains one of the most species rich of all of the sites.

The site with the most taxa in 2006 was Site 9 (26 taxa), within the wind farm area. Shannon diversity was relatively low here, however, due to the dominance of a small number of species, *Mysella bidentata*, *Lagis koreni* and *Pharus legumen*.

Although there have clearly been marked changes in benthic invertebrate abundance and richness between the Baseline and Construction surveys it is worth noting that both the numbers of individuals and taxa per grab recorded in 2006 were broadly similar to those from the 2002 EIA characterisation survey (SeaScape 2002). The 2002 surveys were carried out with relatively little replication (but at a larger array of sites) and site-specific data must therefore be treated cautiously; however, this is consistent with the dynamic nature of benthic communities in the area, under the influence of natural events as previously noted in Section (3.1).

Table 3 Total numbers of the most numerous taxa (all those where ten or more were found) from the 2006 grab surveys, together with the numbers of the same taxa in 2005. Symbols in the “change” column indicate those taxa found in larger (▲) or smaller (▼) numbers than in 2005.

Name	Total 2005	Total 2006	Change
Mysella bidentata	2908	**2044**	▼
Magelona johnstoni	1031	**1976**	▲
Lagis koreni	5274	**1297**	▼
Donax vittatus	16239	**300**	▼
Pharus legumen	706	**267**	▼
Nephtys hombergii	276	**256**	▼
Abra alba	401	**218**	▼
Spiophanes bombyx	289	**202**	▼
Phoronis spp.	93	**180**	▲
Nephtys cirrosa	130	**132**	▲
Glycera tridactyla	142	**131**	▼
Nemertea spp.	197	**120**	▼
Spisula subtruncata	380	**118**	▼
Diastylis bradyi	208	**111**	▼
Fabulina fabula	105	**78**	▼
Pholoe baltica	157	**70**	▼
Ophiura sp. Juv.	73	**68**	▼
Ophiura ophiura	35	**59**	▲
Nucula sp. (Juv.)	20	**45**	▲
Diastylis rathkei	6	**38**	▲
Gastrosaccus spinifer	33	**36**	▲
Scalibregma inflatum	219	**33**	▼
Polinices pulchellus	81	**29**	▼
Eteone longa/flava (agg.)	86	**24**	▼
Acronida brachiata	22	**20**	▼
Edwardsia claparedii	37	**19**	▼
Mactra stultorum	23	**14**	▼
Phialella quadrata	23	**13**	▼
Owenia fusiformis	181	**13**	▼
Nephtys sp. (Juv.)	78	**12**	▼
Schistomysis kervillei	2	**12**	▲
Lanice conchilega	37	**10**	▼
Nucula nitidosa	13	**10**	▼
Dosinia sp.	4	**10**	▲
Echinocyamus pusillus	4	**10**	▲

Table 4 Diversity indices 2006 by sample

Sample	S	N	d	J'	H'(loge)
1.1	25	45	6.30	0.92	2.96
1.2	21	41	5.39	0.95	2.90
1.3	18	36	4.74	0.87	2.52
2.1	9	14	3.03	0.89	1.97
2.2	11	18	3.46	0.86	2.06
2.3	8	12	2.82	0.92	1.91
3.1	12	74	2.56	0.51	1.26
3.2	6	36	1.40	0.66	1.19
3.3	13	70	2.82	0.60	1.54
4.1	13	273	2.14	0.53	1.35
4.2	10	321	1.56	0.59	1.36
4.3	14	308	2.27	0.53	1.41
5.1	17	525	2.55	0.22	0.63
5.2	19	261	3.23	0.39	1.16
5.3	15	262	2.51	0.34	0.92
6.1	19	73	4.20	0.82	2.41
6.2	18	131	3.49	0.68	1.98
6.3	21	107	4.28	0.85	2.60
7.1	17	64	3.85	0.88	2.49
7.2	18	56	4.22	0.88	2.55
7.3	18	108	3.63	0.74	2.13
8.1	21	92	4.42	0.77	2.35
8.2	18	73	3.96	0.84	2.43
8.3	23	140	4.45	0.59	1.85
9.1	25	331	4.14	0.49	1.56
9.2	29	567	4.42	0.39	1.31
9.3	23	273	3.92	0.49	1.54
10.1	6	34	1.42	0.57	1.02
10.2	9	65	1.92	0.58	1.27
10.3	10	162	1.77	0.38	0.87
11.1	7	40	1.63	0.76	1.49
11.2	9	23	2.55	0.76	1.67
11.3	11	47	2.60	0.71	1.71
12.1	12	36	3.07	0.88	2.19
12.2	7	20	2.00	0.74	1.44
12.3	5	24	1.26	0.83	1.34
13.1	5	7	2.06	0.96	1.55
13.2	4	8	1.44	0.88	1.21
13.3	5	12	1.61	0.92	1.47
14.1	12	132	2.25	0.69	1.71
14.2	18	601	2.66	0.44	1.27
14.3	15	538	2.23	0.50	1.35
15.1	11	29	2.97	0.86	2.06
15.2	14	40	3.52	0.86	2.28
15.3	9	28	2.40	0.81	1.78
16.1	21	104	4.31	0.72	2.20
16.2	21	127	4.13	0.72	2.18
16.3	15	105	3.01	0.82	2.23
17.1	21	269	3.57	0.63	1.92
17.2	24	441	3.78	0.58	1.84
17.3	24	687	3.52	0.33	1.06
18.1	20	69	4.49	0.84	2.51
18.2	20	53	4.79	0.88	2.65
18.3	23	44	5.81	0.94	2.94
19.1	13	41	3.23	0.74	1.91
19.2	11	22	3.24	0.90	2.16
19.3	10	36	2.51	0.80	1.83
20.1	5	9	1.82	0.95	1.52
20.2	10	27	2.73	0.87	2.01
20.3	19	63	4.34	0.68	2.00

S = No of taxa
N = Number of countable individuals
d = Margaleff's species richness index
J' = Pielou's eveness index
H' = Shannon Wiener diversity index

Table 5 Comparing diversity indices for grab stations between 2005 and 2006 (based on pooled data for three replicates in each case).

Site	S		N		d		J'		H'(loge)	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
1	39	41	103	122	8.20	8.33	0.87	0.87	3.17	3.24
2	15	18	39	44	3.82	4.49	0.77	0.82	2.08	2.36
3	17	19	105	180	3.44	3.47	0.61	0.50	1.72	1.47
4	24	20	1671	902	3.10	2.79	0.43	0.47	1.38	1.41
5	33	28	466	1048	5.21	3.88	0.66	0.26	2.30	0.87
6	34	30	465	311	5.37	5.05	0.69	0.75	2.42	2.57
7	44	27	472	228	6.98	4.79	0.74	0.80	2.78	2.63
8	41	36	410	305	6.65	6.12	0.78	0.67	2.88	2.42
9	39	36	1875	1171	5.04	4.95	0.42	0.41	1.54	1.48
10	19	16	175	261	3.49	2.70	0.73	0.42	2.15	1.16
11	36	16	607	110	5.46	3.19	0.65	0.64	2.32	1.76
12	20	15	139	80	3.85	3.19	0.70	0.75	2.09	2.04
13	25	8	1125	27	3.42	2.12	0.45	0.82	1.46	1.71
14	29	21	3095	1271	3.48	2.80	0.36	0.46	1.22	1.40
15	23	22	381	97	3.70	4.59	0.38	0.78	1.20	2.42
16	33	30	618	336	4.98	4.99	0.49	0.68	1.71	2.32
17	39	32	2114	1397	4.96	4.28	0.55	0.46	2.02	1.60
18	55	38	617	166	8.40	7.24	0.64	0.85	2.57	3.10
19	28	21	15511	99	2.80	4.35	0.03	0.73	0.12	2.24
20	9	23	59	99	1.96	4.79	0.77	0.70	1.70	2.19

S = No of taxa
N = Number of countable individuals
d = Margaleff's species richness index
J' = Pielou's eveness index
H' = Shannon Wiener diversity index

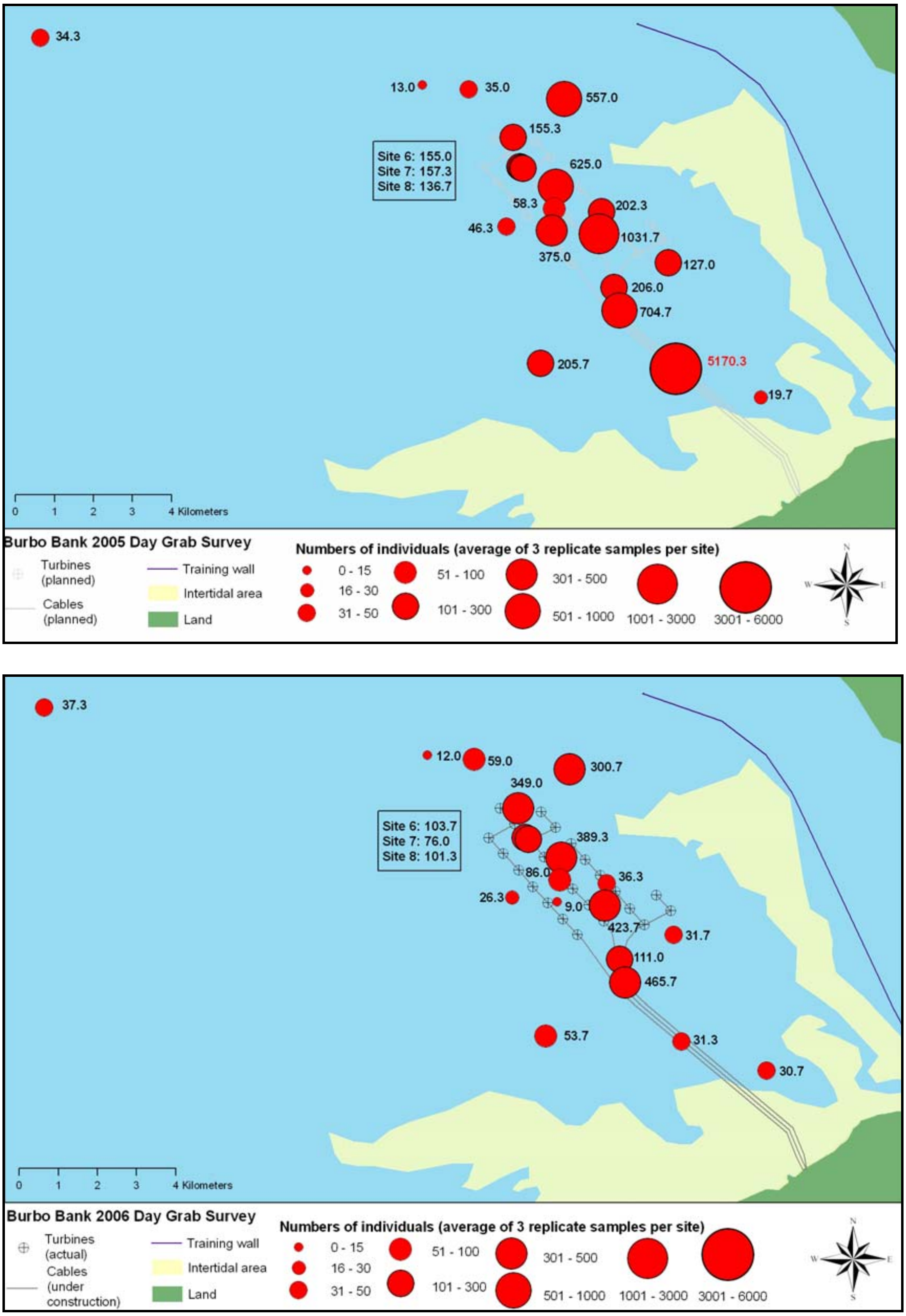
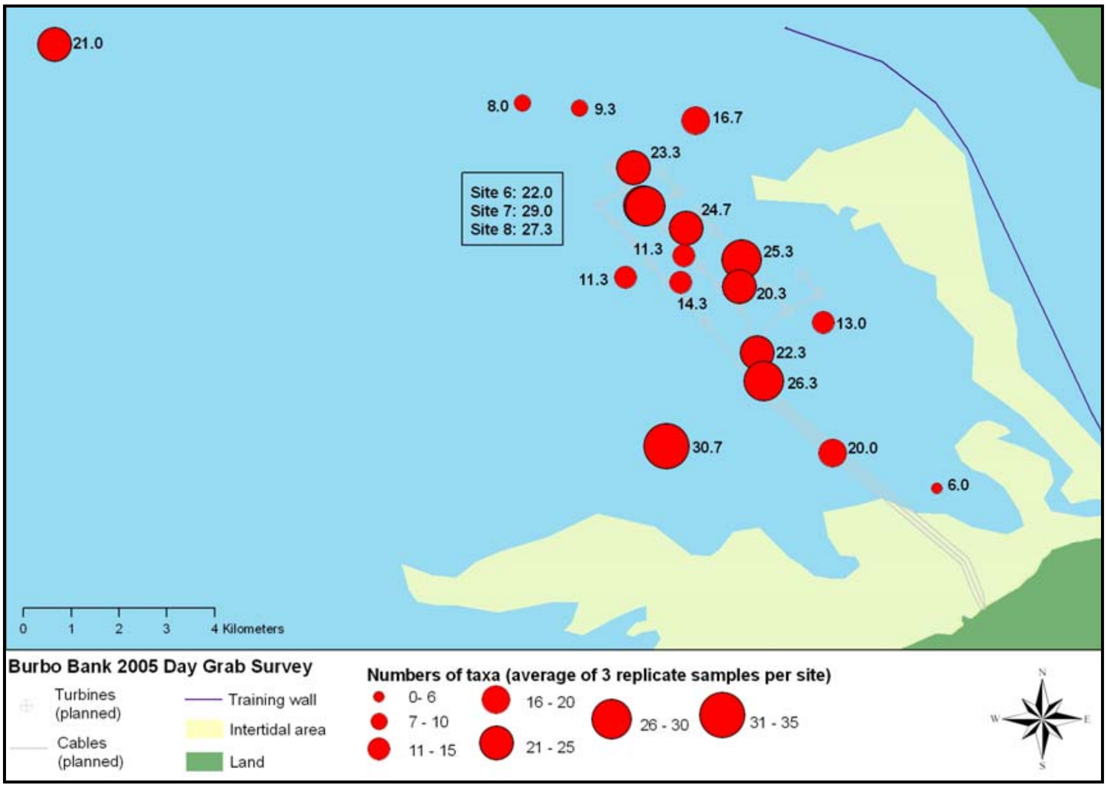


Figure 4 Numbers of individuals recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.



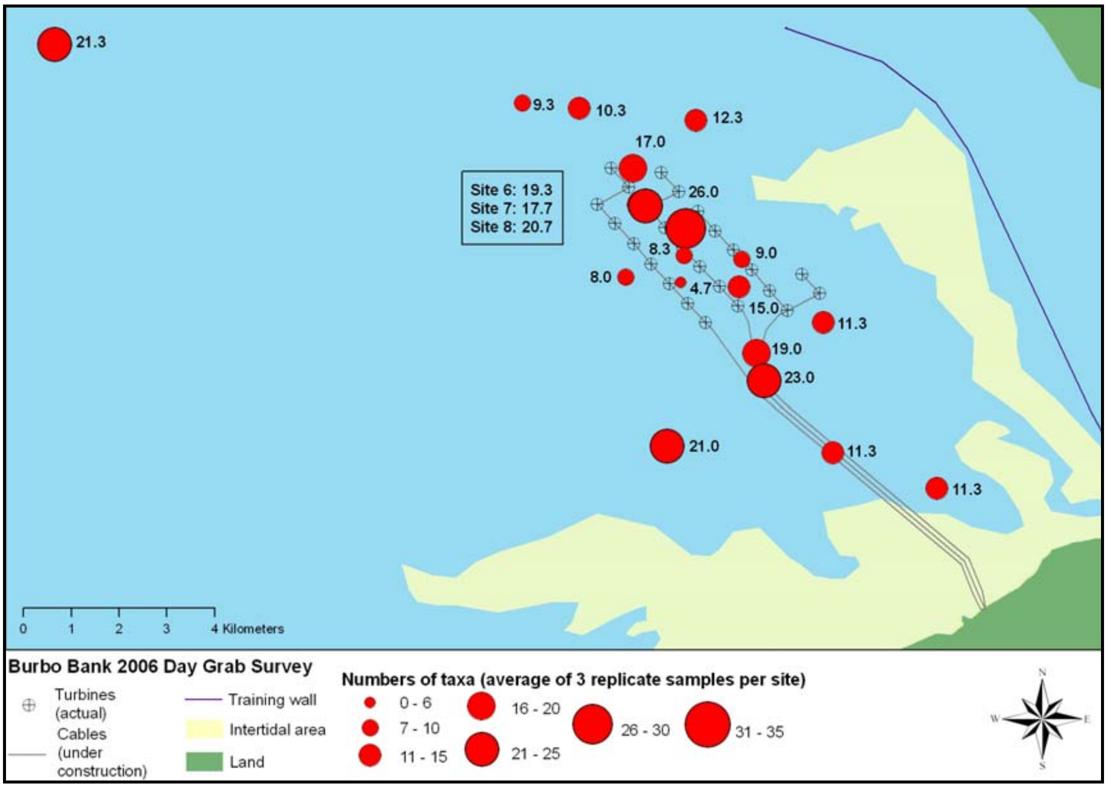


Figure 5 Numbers of different taxa recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.

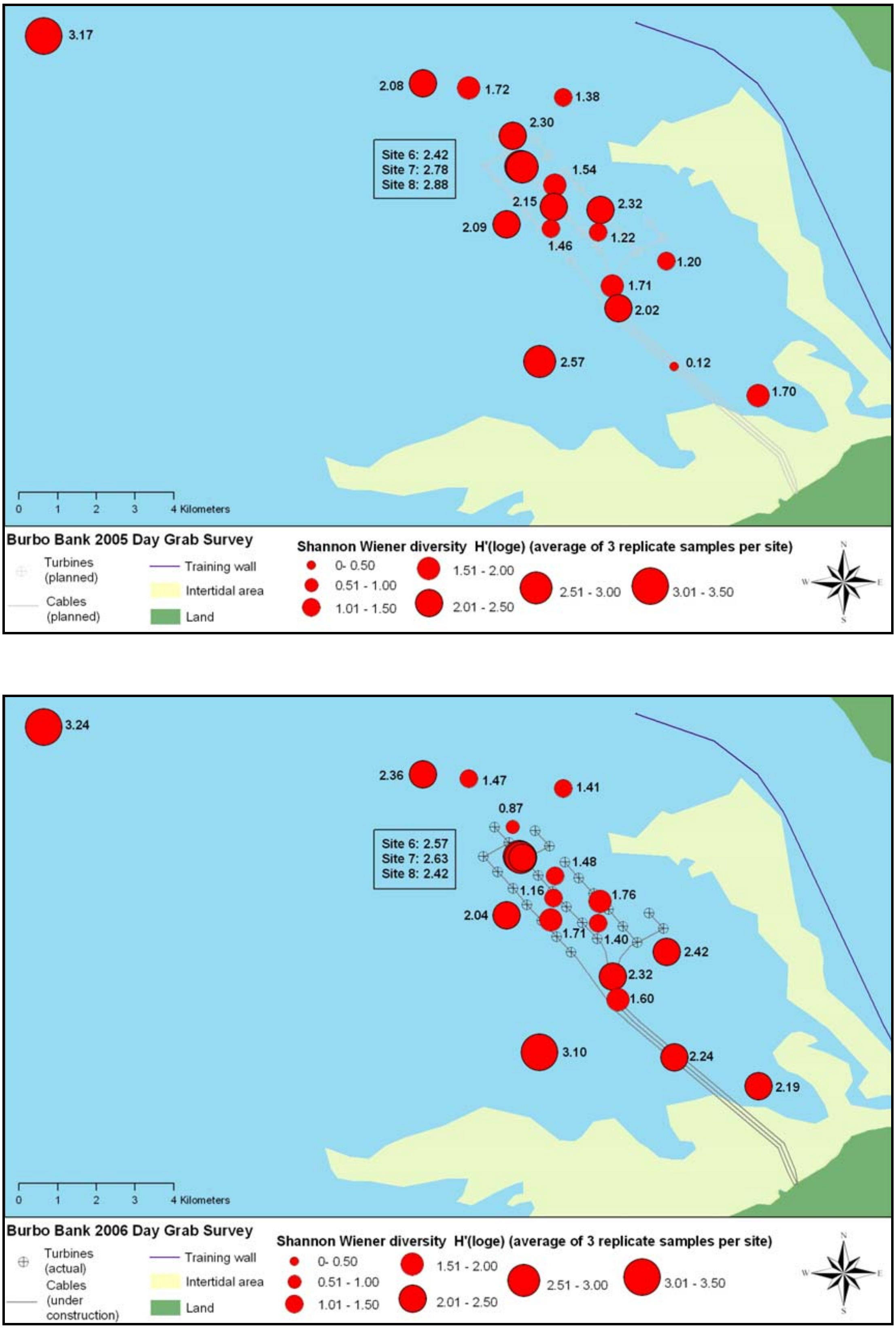


Figure 6 Shannon Wiener diversity index recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.

4.2.2 Individual taxa

In general taxa that were dominant in 2005 were also dominant in 2006, although clearly there were large fluctuations in actual numbers.

As noted in Section 4.2.1, the general trend was for reduced abundance of individuals; for example the worm *Owenia fusiformis* was quite abundant in 2005 (181 individuals recorded) but relatively scarce in 2006 (13). The most dramatic reduction was seen with the bivalve *Donax vittatus* (16,239 down to 300 total individuals). The polychaete worm *Lagis koreni* was still common but at markedly lower densities (5,274 down to 1,297).

Relatively few species were present at increased abundance in 2006 but the total number of *Magelona johnstoni* approximately doubled (1,031 up to 1,976). Several other less common taxa also increased, including *Nemertea* spp. *Phoronis* spp. and *Glycera tridactyla*.

Distribution maps of many of the more abundant species have been prepared in order to investigate possible changes in distribution and/or abundance in relation to the distribution of sediment type and to the wind farm development (Figure 7 - Figure 15). Again, the most marked changes in abundance, predominantly reductions, have occurred in the central part of the Survey Area, particularly around Sites 9 - 14, both in and around the wind farm, although there is considerable variation. The large reductions in abundance of the polychaete *Lagis koreni* and bivalve *Donax vittatus* referred to above are seen in Figure 9 and Figure 10 and are most apparent for *Lagis koreni* at Site 14 (southern part of the array) and *Donax vittatus* at Sites 15 and 19 (south of the array and on the export cable route).

Even the polychaete worm *Magelona johnstoni,* which increased in total abundance between 2005 and 2006, was less abundant in the central part of the wind farm array. This species did occur in greater numbers in the northern part of the array in 2006, at Site 5, however.

Additional information on the distribution of benthic macrofauna is available from the 2m scientific beam trawl surveys that are undertaken immediately after the benthic grab survey (CMACS 2007). The primary purpose of these trawls is to sample smaller demersal fish species but some beam trawl sites are distributed so that they cover ground close to grab stations but sample much more extensively (up to 1 km tows). Infauna is collected where the beam digs into soft sediments and smaller invertebrates may be retained by the 4mm cod end mesh if this becomes clogged with sediment or larger organisms. Beam trawls are therefore only a semi-quantitative method for sampling invertebrates, particularly smaller infaunal species such as those discussed above, but there was roughly a 26% decline in total invertebrate abundance between 2005 and 2006 and the general trend mirrors the reductions observed in the grab surveys.

The focus of the reduction in invertebrate abundance as recorded by trawl surveys was the wind farm area and northern offshore sites. At a species level, however, the trend was not simple and there were some notable differences to the patterns recorded by the grab surveys. For example, the bivalve *Abra alba* was only recorded at a single trawl site in 2005 (west of the array, close to Grab Station 12) but was more abundant in 2006 trawls, including sites within the wind farm array from where marked reductions in abundance were noted in the 2006 grab survey.

Several of the most abundant species in these surveys, including *Abra alba* and *Lagis koreni*, have long been known to vary hugely in abundance from year to year. Eagle (1975) noted that the abundance of *Lagis* and *Abra* varies greatly within any one area, such that one or other is often dominant but with very large changes in densities from year to year. Loss of the animals to storms was considered important, and it was also suggested that bioturbation of the sediment by these animals may have contributed to this by loosening the sediments. Rees and Walker (1983) made similar observations in various parts of Liverpool Bay and the North Wales coast, and also noted that in the Burbo Bight area over a time span of approximately a decade the two most abundant species were always drawn from only four species (*L. koreni*; *A. alba*; *Nephtys hombergi* and *Mysella bidentata*). *Donax vittatus*, often very abundant in inshore clean sands, including historically adjacent to the Wirral foreshore (Bassindale, 1938), is also known to fluctuate greatly in abundance from year to year, as was found in these surveys.

Overall, it can be stated that there were declines in both invertebrate abundance and number of taxa between 2005 and 2006 and that change was most apparent within the wind farm area, particularly in areas where muddier sediments occur. It should be remembered that relatively little time was available between commencement of wind farm construction works and benthic surveys for invertebrate communities to respond to environmental change, other than by absence as a result of gross effects such as smothering which clearly has not occurred. The changes recorded will be considered further in relation to invertebrate community distributions in Section 4.2.4; however, results from monitoring in 2007, a full year or more after commencement of construction and after the completion of array cabling works that had only recently started in September 2006, will help to clarify the nature and significance of changes.

One species, the thumbnail crab, *Thia scutellata*, is of specific interest as a nationally scarce species. This small crab inhabits a specific habitat of loose, well-sorted medium sands into which it can easily burrow, occurs widely off the North Wales coast, but has a relatively limited distribution in Wales and the U.K. (Rees, 2001), possibly because even within fields of sand waves the precise conditions it prefers are limited. It is considered by the Countryside Council for Wales to be a “species of concern” (Moore, 2002). Its main Irish Sea populations are 6-12 miles offshore from the North Wales coast, with some off the east coast of Anglesey. These appear to represent the major known populations in British waters, although it has also been recorded in limited areas in central Cardigan Bay and Carmarthern Bay, Constable Bank and Menai Straits (Rees, 2001) as well as sporadically in Southern England (NBN Gateway unpublished data).

In the surveys carried out in 2002 in support of the EIA for Burbo OWF, small numbers of this species were found in very shallow sands roughly parallel to the Wirral shoreline in the vicinity of Site 16 and 17 (south of the wind farm). As seen in Figure 15, in both 2005 and 2006 small numbers were found again but distributions were rather different. The species was present at Sites 16 and 17 in 2005 but absent from both these stations in 2006. The recorded slight increase in the proportion of gravels at these stations is not thought to be significant and the sediment here remains predominantly well sorted medium sand. In 2006 the species was re-found at Site 2 offshore of the wind farm and for the first time at the western reference station (Site 1).

This species has been found in much higher densities in the area of the Hamilton East development some 30 km North of Prestatyn, where a survey using 39 grab samples found an average of 2.3 crabs per grab, equivalent to an average of 23 crabs per m^2 over an area of several km^2 (Holt and Shalla, 2001). It can be inferred from this that the preferred habitat for this species around Burbo is patchily distributed and the absence in 2006 of *T. scutellata* south of the wind farm, and indeed its occurrence at Site 1, may simply reflect the fact that because numbers are small occurrence in grab samples is sporadic.

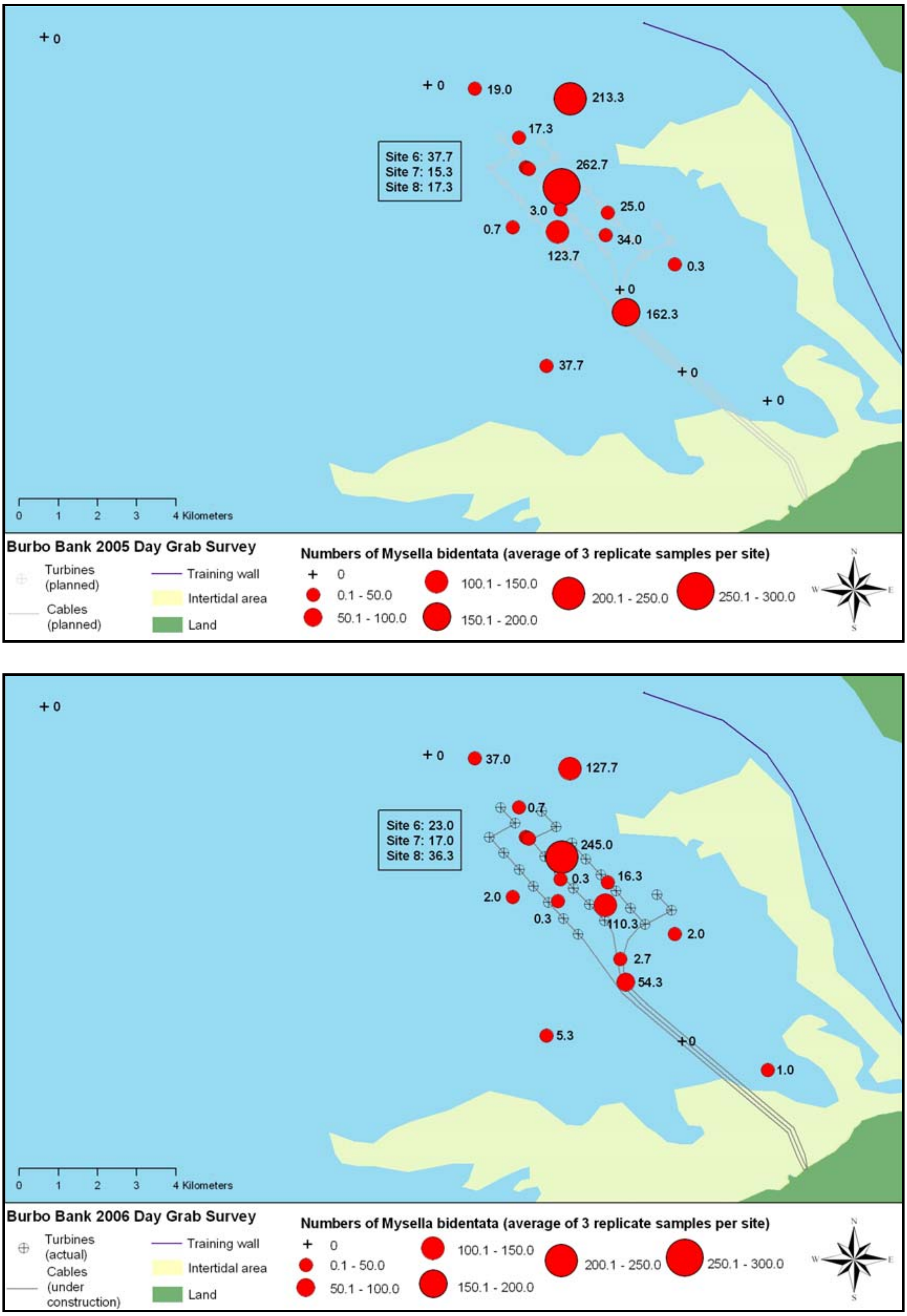


Figure 7 Numbers of *Mysella bidentata* recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.

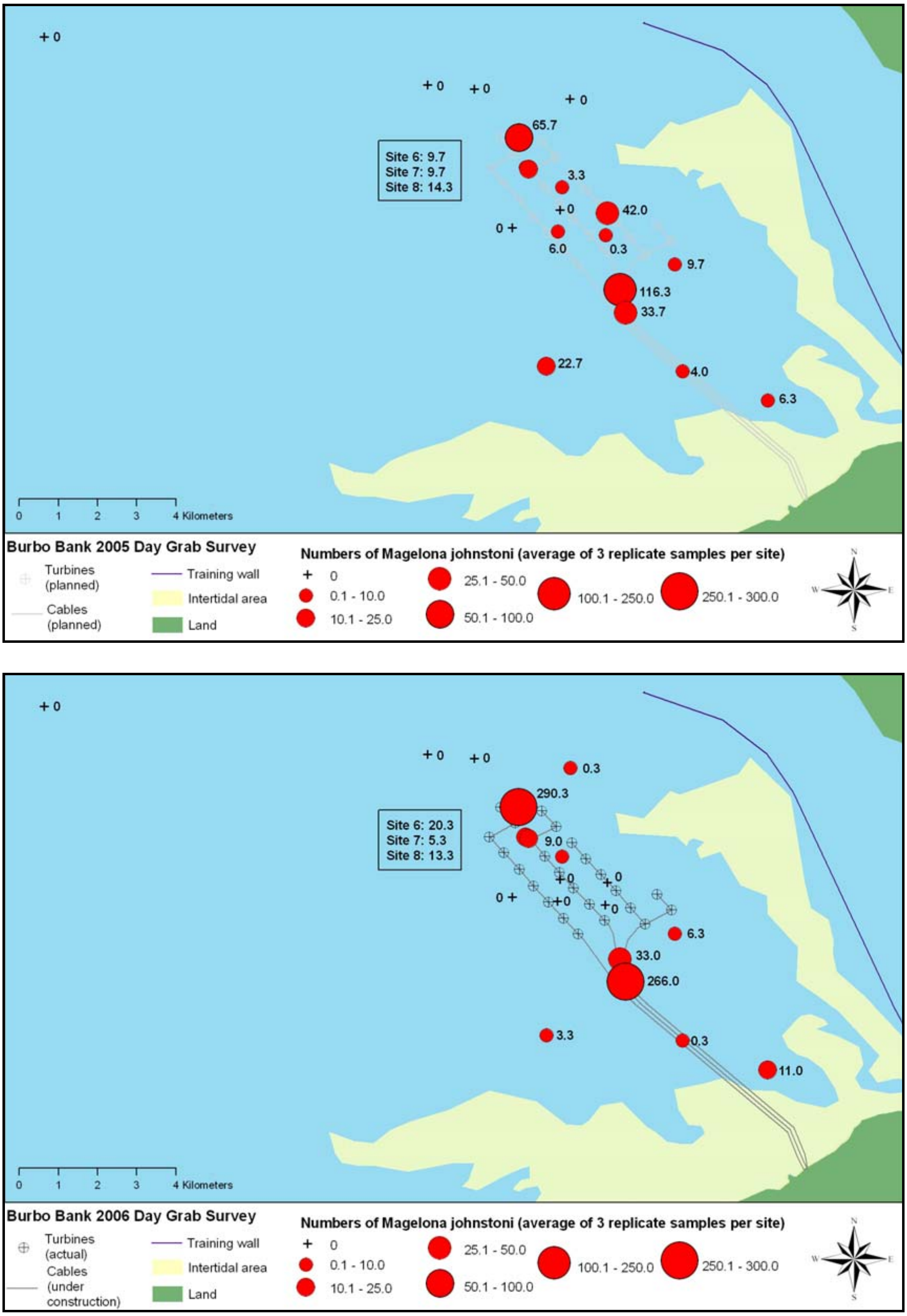


Figure 8 Numbers of *Magelona johnstoni* recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.

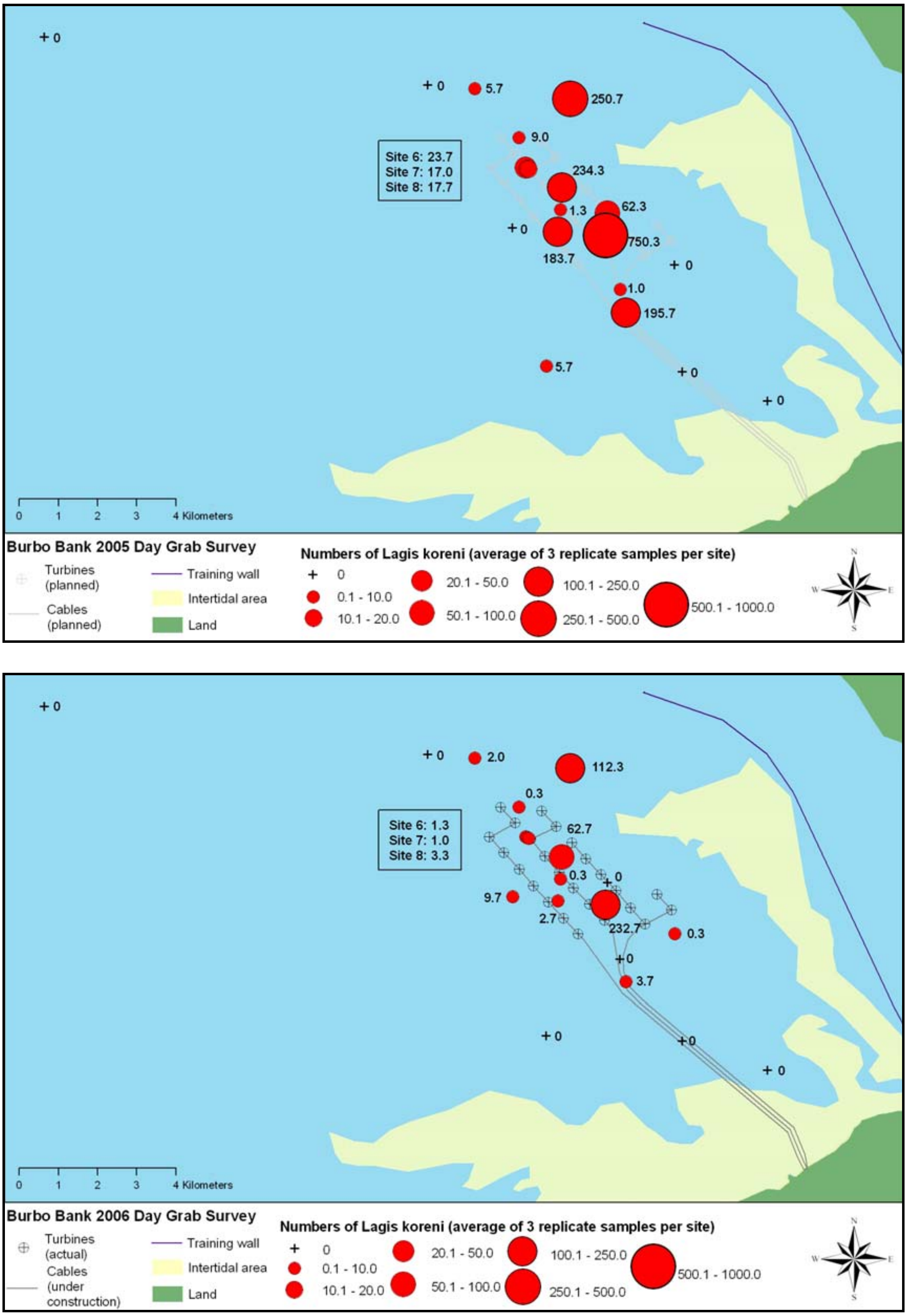


Figure 9 Numbers of *Lagis koreni* recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.

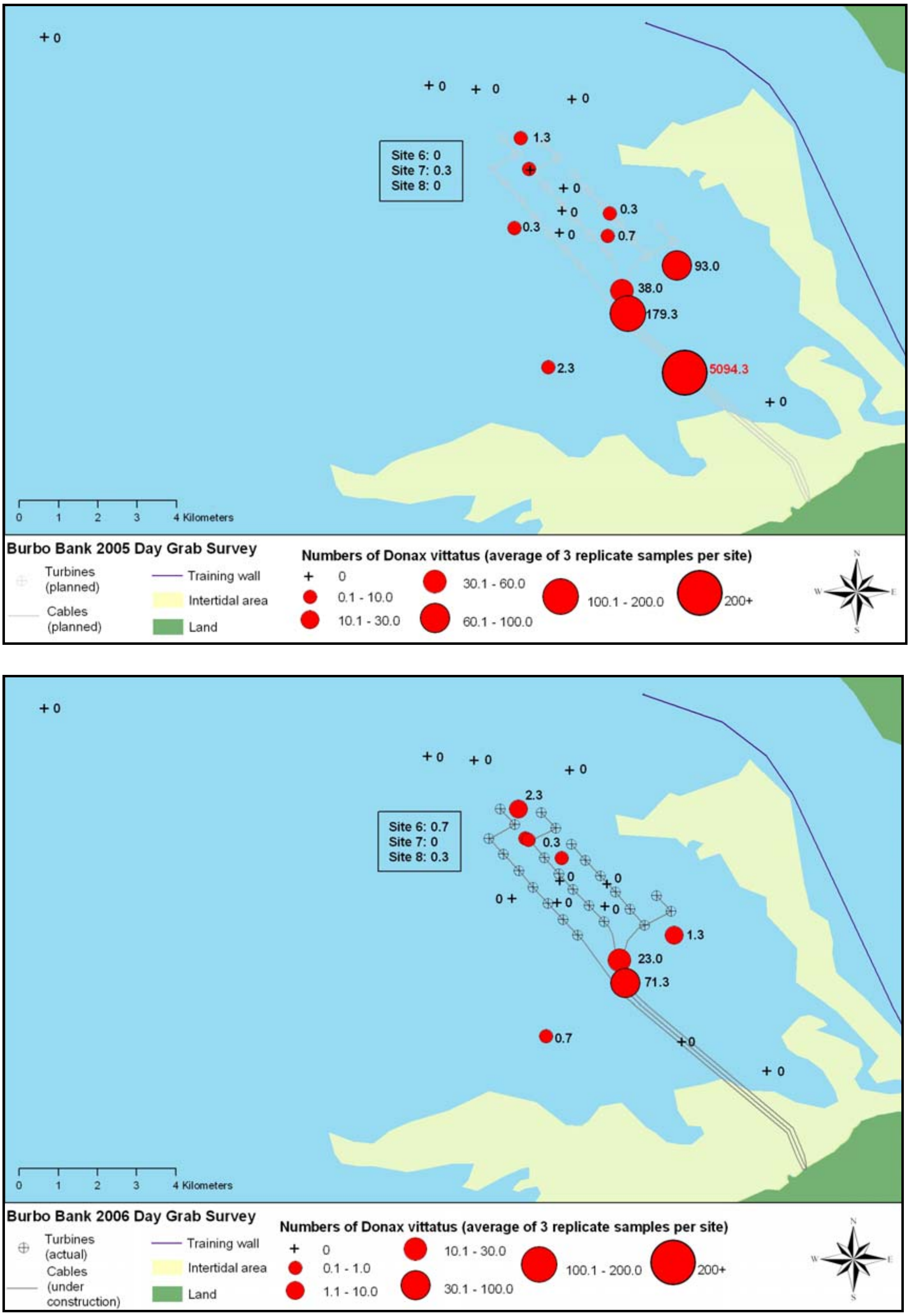


Figure 10 Numbers of *Donax vittatus* recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.

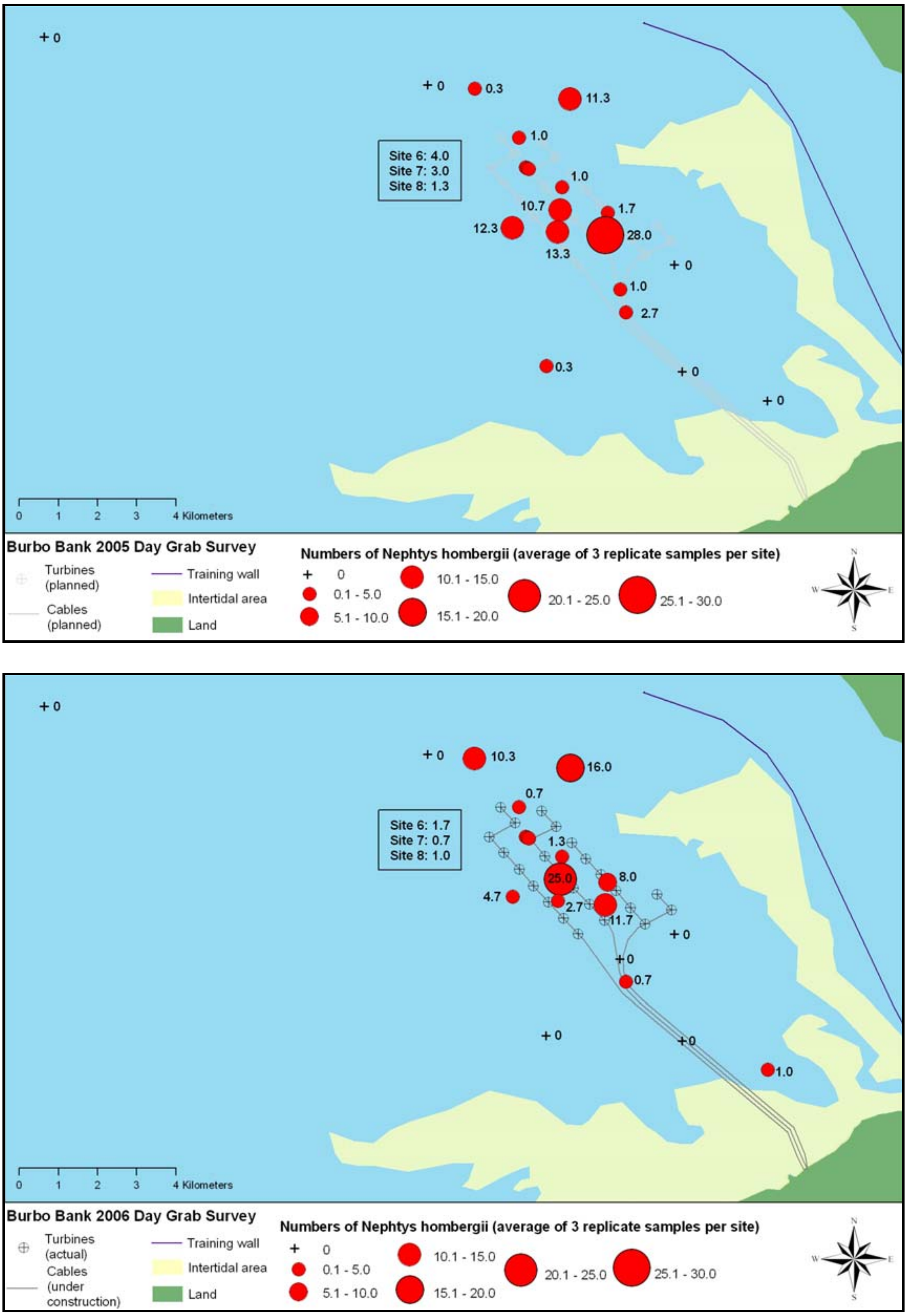
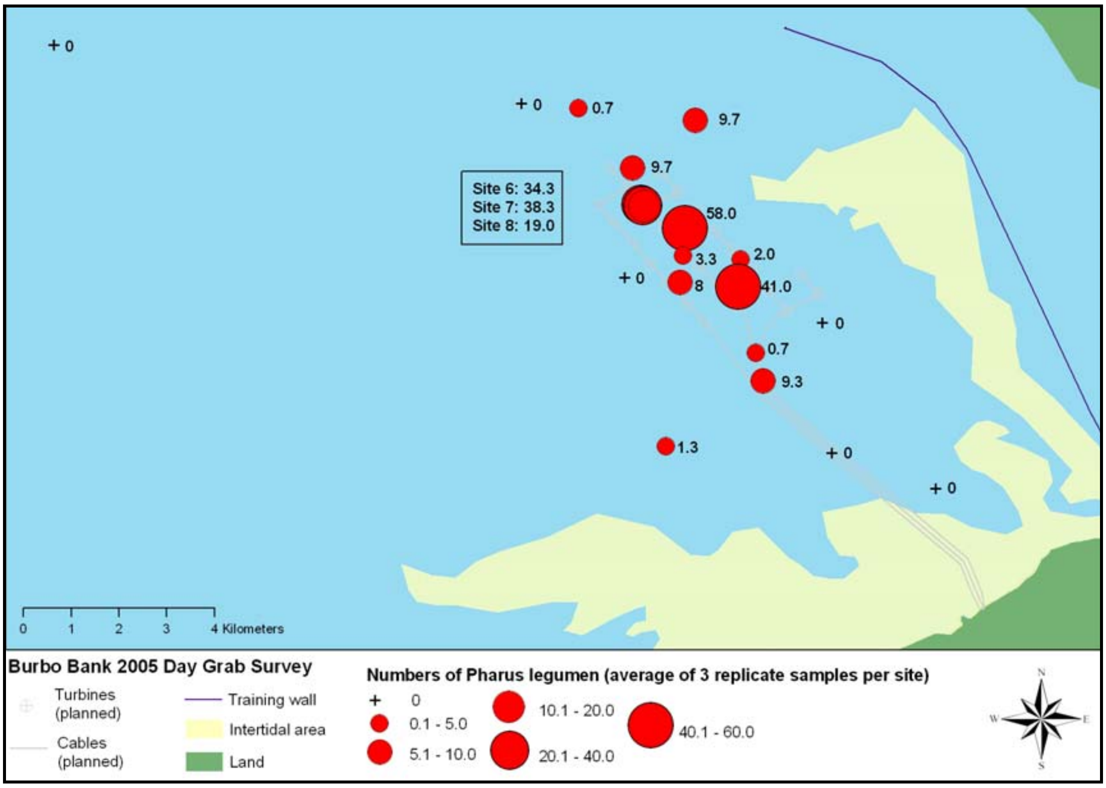


Figure 11 Numbers of *Nephtys hombergii* recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.



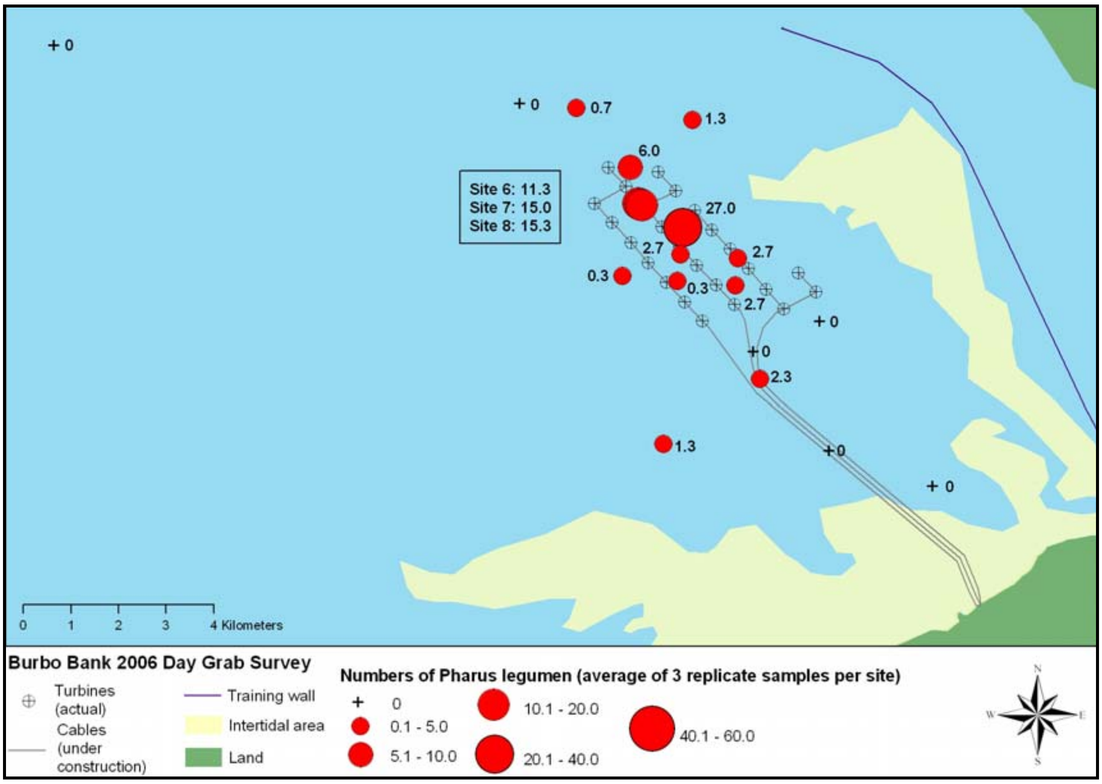
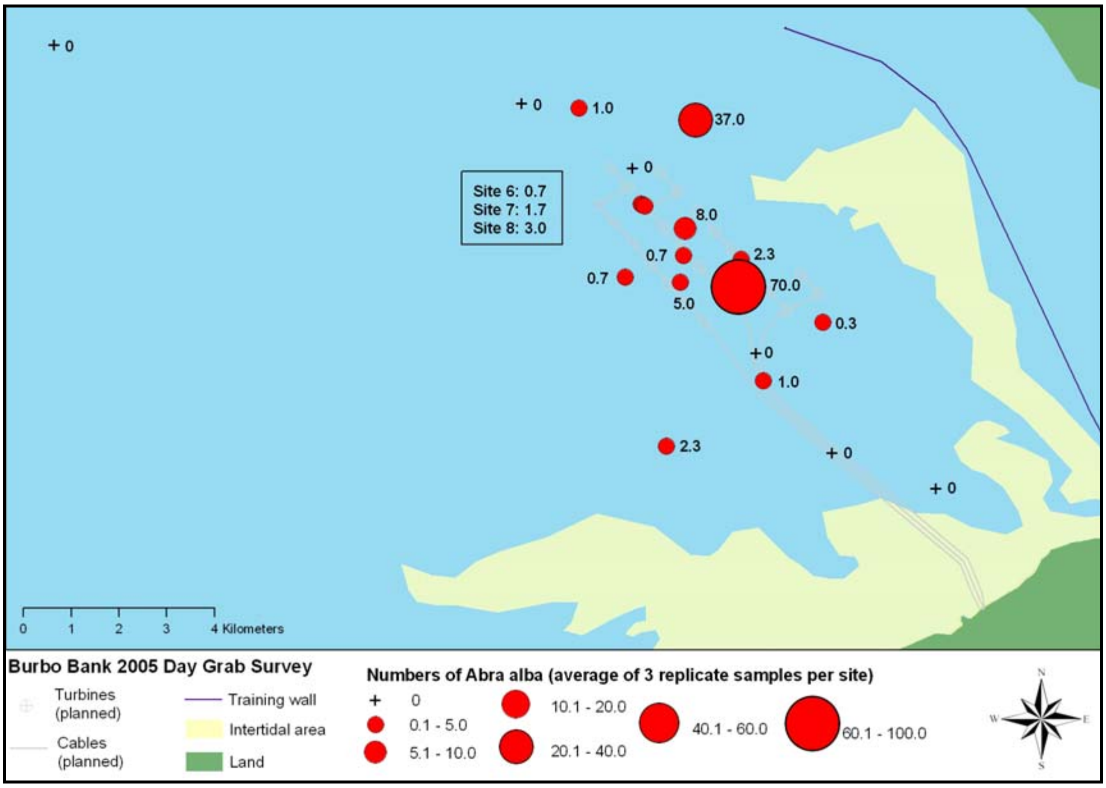


Figure 12 Numbers of *Pharus legumen* recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.



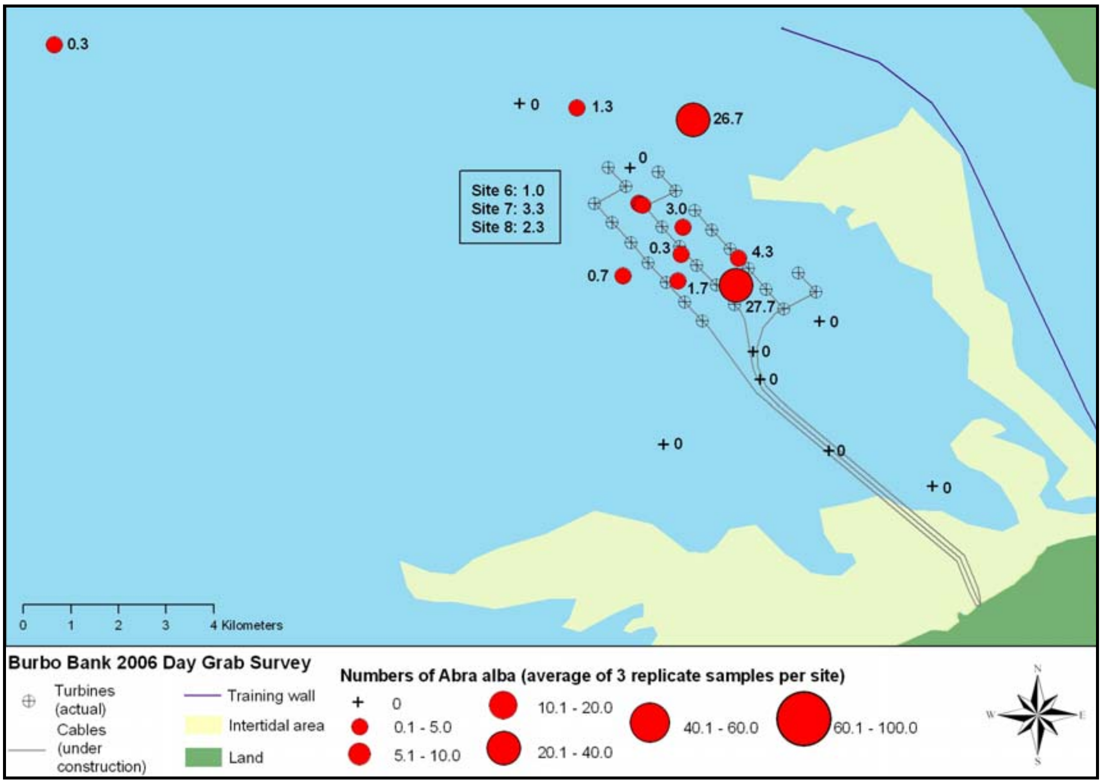
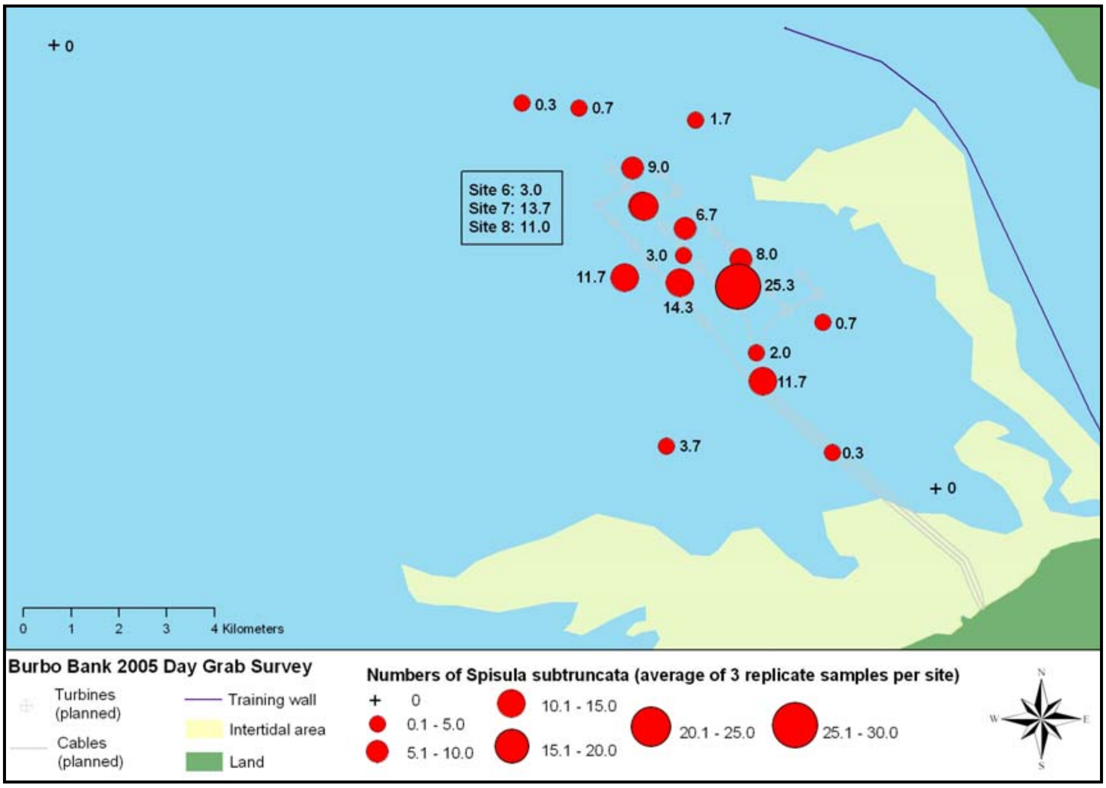


Figure 13 Numbers of *Abra alba* recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.



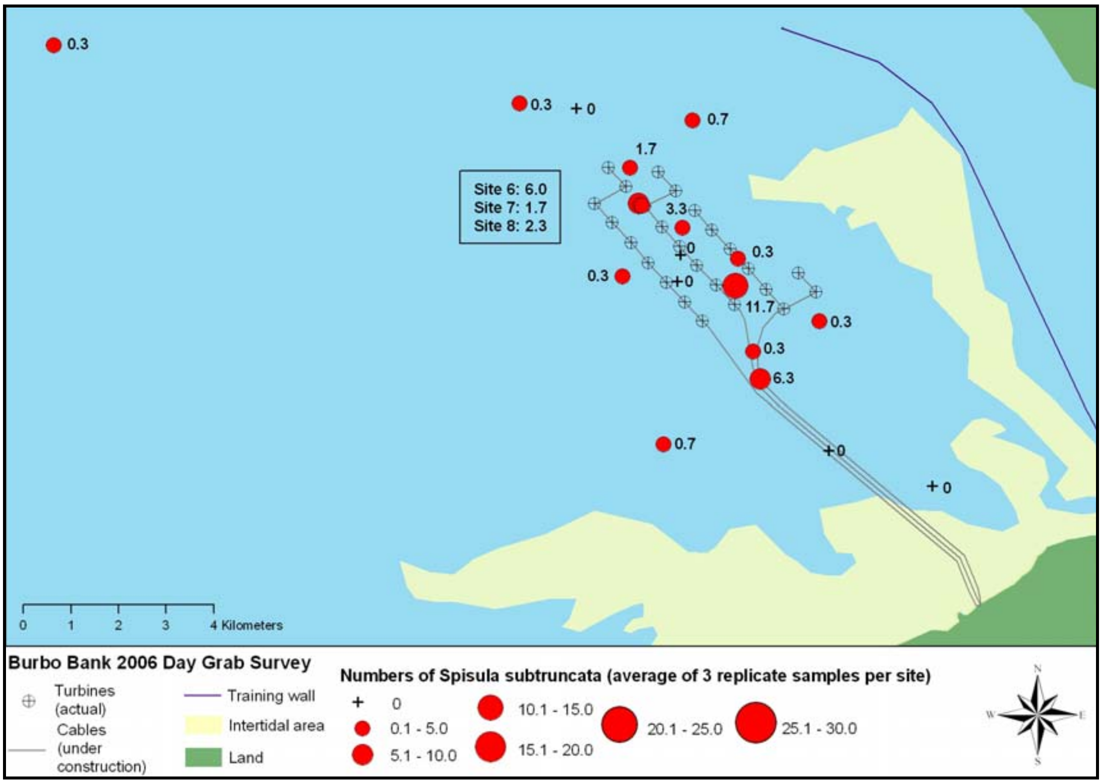
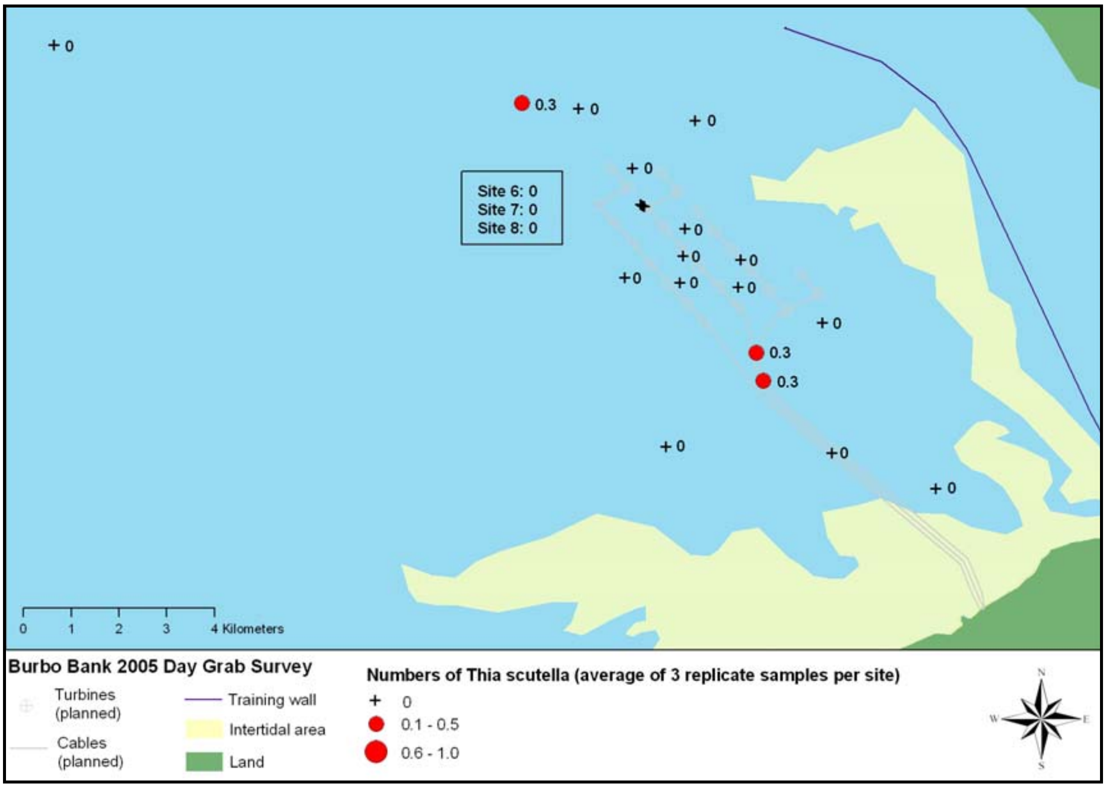


Figure 14 Numbers of *Spisula subtruncata* recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.



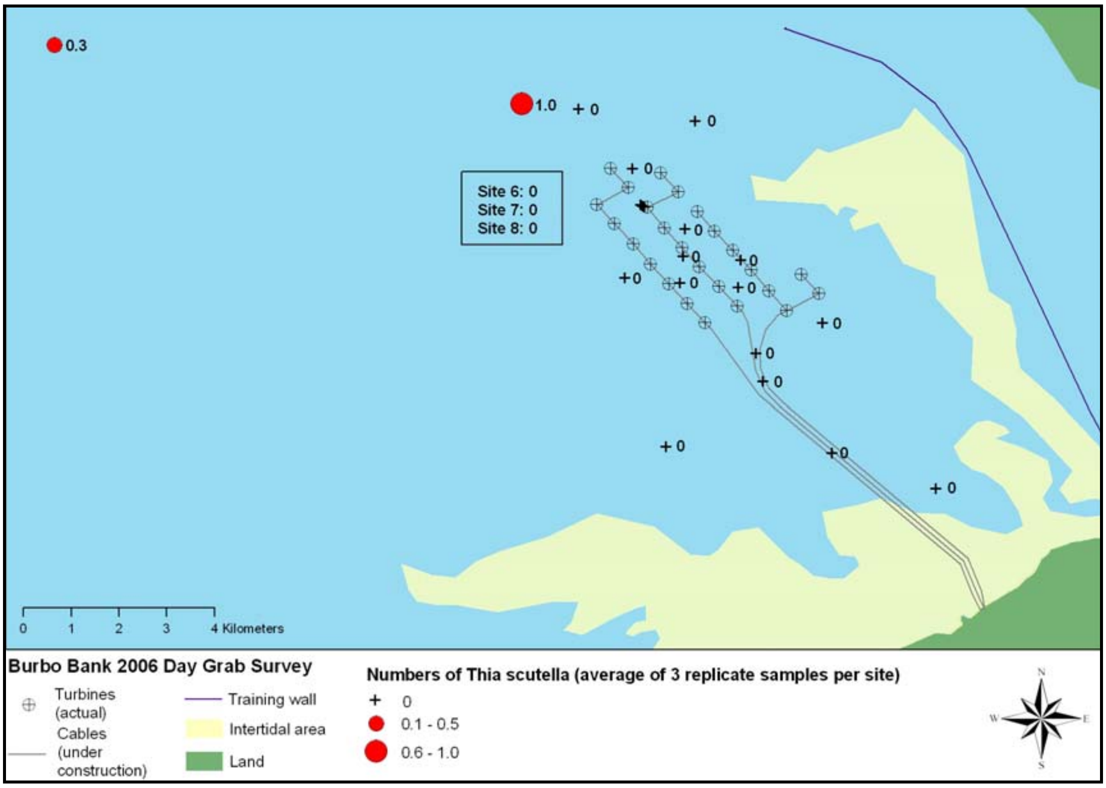


Figure 15 Numbers of *Thia scutella* recorded (average of 3 replicate samples per site) for grab sample sites in 2005 and 2006.

4.2.3 Multivariate analysis

Figure 16 presents two multi-dimensional scaling (MDS) plots and associated dendrograms summarising the relationships between all replicate samples from the 2006 survey. It is clear from this figure that in all cases the three replicate samples from each site cluster well, and in the main are much more similar to each other than to samples from other sites, even when they occur on similar sediment types.

One site where replicates cluster slightly less well is the inshore station (Site 20). This is a shallow water site with generally low species richness and low abundance of organisms but replicate three was relatively rich and contained more organisms than the first two samples which had a Bray Curtis similarity of around 60%.

It can also be seen that broad sediment type is quite closely linked to the benthic invertebrate distributions. Clear groupings are difficult to identify, but using a similarity coefficient of around 25% as a cut-off gives four groups of samples that link reasonably well to the sediment data while retaining the majority of replicates within the same groups as each other (Figure 16b). These groups are discussed further in relation to community and biotope descriptions in Section 4.2.4, below.

Figure 17 shows the relationship between sites using pooled data from all three replicates at each location for 2006 and 2005. This provides a means to compare community structure between years. In the great majority of cases the same sites cluster very closely together, indicating that, despite the changes in abundance of certain taxa, and the reduction in richness of taxa recorded generally in 2006, communities recorded at each station tend to be similar. Moreover, using a similarity index of 30% (similar to that used in Figure 16) with the data from both years (Figure 17) gives similar groupings to those of the 2006 data alone. This suggests that these groups are ecologically significant. There are several exceptions: Sites 11, 13 (within the central area of the wind farm) and 19 (on the export cable route) cluster differently in the two years.

The most obvious difference is with Site 19 but, as discussed above, this is almost entirely due to the huge numbers of *Donax vittatus* found at that site in 2005 which were more or less absent in 2006. *D. vittatus* is well known for being patchily distributed and, like many bivalves, may vary enormously in abundance from year to year. With the exception of this single species the fauna at Site 19 was relatively consistent between the two years and typical of the biotope Nepcir.Bat (see below). The other two sites on the cable route (16 and 17) showed very strong similarities between the two years.

At Site 11 three characteristic taxa were present in all three replicates in both years; these were *Nephtys hombergii*, *Mysella bidentata* and *Abra alba*. The shift in community composition was associated with considerable reductions in abundance or absence of numerous other worm and bivalve species, notably the polychaetes *Lagis koreni, Magelona johnstoni* and *Spiophanes* *bombyx*, and the bivalves *Fabulina fabula*, *Donax vittatus* and *Spisula subtruncata*.

The changes at Site 13 were even more pronounced. In 2005 this site had a very similar suite of species to Site 11, and similarly high abundances of *Lagis koreni* and *Mysella bidentata*. By 2006 there was a relatively impoverished fauna with a total of only 27 specimens in the three replicates, composed almost entirely of 8 *Nephtys hombergi*, 8 *Lagis koreni* and 5 *Abra alba*, all of which were also present in 2005.

The reasons for these changes at Sites 11 and 13 in the central part of the wind farm may be related to the increased 'muddiness' of samples in this area; however, other sites (e.g. Site 14 in the same area) also became muddier but no significant shift in invertebrate community composition has been seen. The mechanisms behind these changes are therefore unclear at present.

At sites 6,7 and 8, situated within the near field of Turbine BB27, samples from the two years cluster particularly closely together (Figures 16 and 17), indicating a high degree of community similarity between the two years. This is consistent with the observation that sediments showed minimal changes between the two years.

Site 1, the westerly reference station, is seen in Figure 17 to have a distinct invertebrate community, despite having similar seabed sediment conditions (slightly gravelly sand) to a number of other stations. This is not surprising given the greater depth and distance of this station from the other sites, a necessity of positioning a site beyond a tidal excursion.

4.2.4 Community descriptions

The 2005 monitoring report pointed out that the EIA characterisation survey of 2002 was more suited to describing community types because it involved sampling relatively large numbers of stations at the expense of replication. The monitoring surveys involve fewer sites but more replication in order to detect changes at specific sites. Moreover, the surveys were carried out at different times of year (spring in 2002; late summer/autumn in 2005 and 2006). Nevertheless, some useful comparisons can be made between the general communities found in the baseline and during construction surveys and the 2002 survey. As there was insufficient time leading up to the 2006 survey for benthic invertebrate communities to adjust to any effects of wind farm construction community descriptions are presented here to provide a basis for further discussion when post-construction survey data are available.

The clusters identified in Figure 16, with the exception of cluster A (Site 1 only) match reasonably well with the three biotopes identified during the 2002 surveys. Cluster B, mainly shallow inshore sites (15, 19 and 20, but also Site

2), has a reasonable similarity to SS.Ssa.IFiSa.NcirBat[2] (*Nephtys cirrosa* and *Bathyporeia* spp in infralittoral sand), a relatively depaupurate biotope, although the numbers of *Bathyporeia* are lower than is usual in this biotope.

Cluster C is the richest community, with relatively high numbers of species and individuals. The fauna associated with this cluster matches well with the biotope SS.SSA.IMuSa.FabMag[3] (*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves in infralittoral compacted fine muddy sand).

Cluster D shares a considerable number of species with cluster C, but is generally less rich in species and is associated with the muddier sediments. In 2005 this area was associated with the biotope SS.SSaIMuSa.SsubNhom (*Spisula subtruncata* and *Nephtys hombergii* in shallow muddy sand). In the 2006 survey the numbers of *S. subtruncata* were very low, but nevertheless this biotope probably remains the best match for this community.

Many of the sites described here as SsubNhom and, indeed, FabMag biotopes, display elements of an *Abra* dominated biotope community since there are many *Lagis koreni*, *Mysella bidentata*, *Pholoe* spp., *Amphiura brachiata* and *Abra alba*. This was also the case in the previous surveys in 2002.

Site 1, the deeper water offshore site, has some similarity to the NepCir bat communities of the shallowest areas discussed above, mainly due to the relatively high numbers of *Nephtys cirrosis*, but is a comparatively higher diversity community with quite high numbers of venerid and other robust bivalves such as *Goodallia triangularis*, *Dosinia* sp, and *Chamelia gallina*, as well as the small bivalve *Moerella pygmaea*. Overall, this community forms a very good match with the biotope SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand). Connor *et al.* (2004) point out that this biotope also has strong affinities with the FabMag biotope. Interestingly, Site 18 displays characteristics of both the NcirBat (replicate 2) and the FabMag (reps 1 and 3) biotopes.

Whilst the communities do display strong affinities with a relatively small set of biotopes as discussed, it is clear that there is great degree of overlap between them, probably as a result of very major fluctuations in the dominant community members (particularly bivalve and polychaete species) that appear to be a long standing feature of this area. Despite this clear variability, largely the same biotopes, with broadly similar distributions, occurred in 2006 as in 2005. There are strong similarities also with some of the communities identified in 2002 and this is important since some of the communities at Burbo were considered of value to commercially exploited fish resources.

[2] Formerly "IGS.NcirBat" in Connor *et al.* 1997; classifications now used are the 2004 versions from Connor *et al*., 2004.
[3] Formerly "IGS.FabMag" in Connor *et al.* 1997.

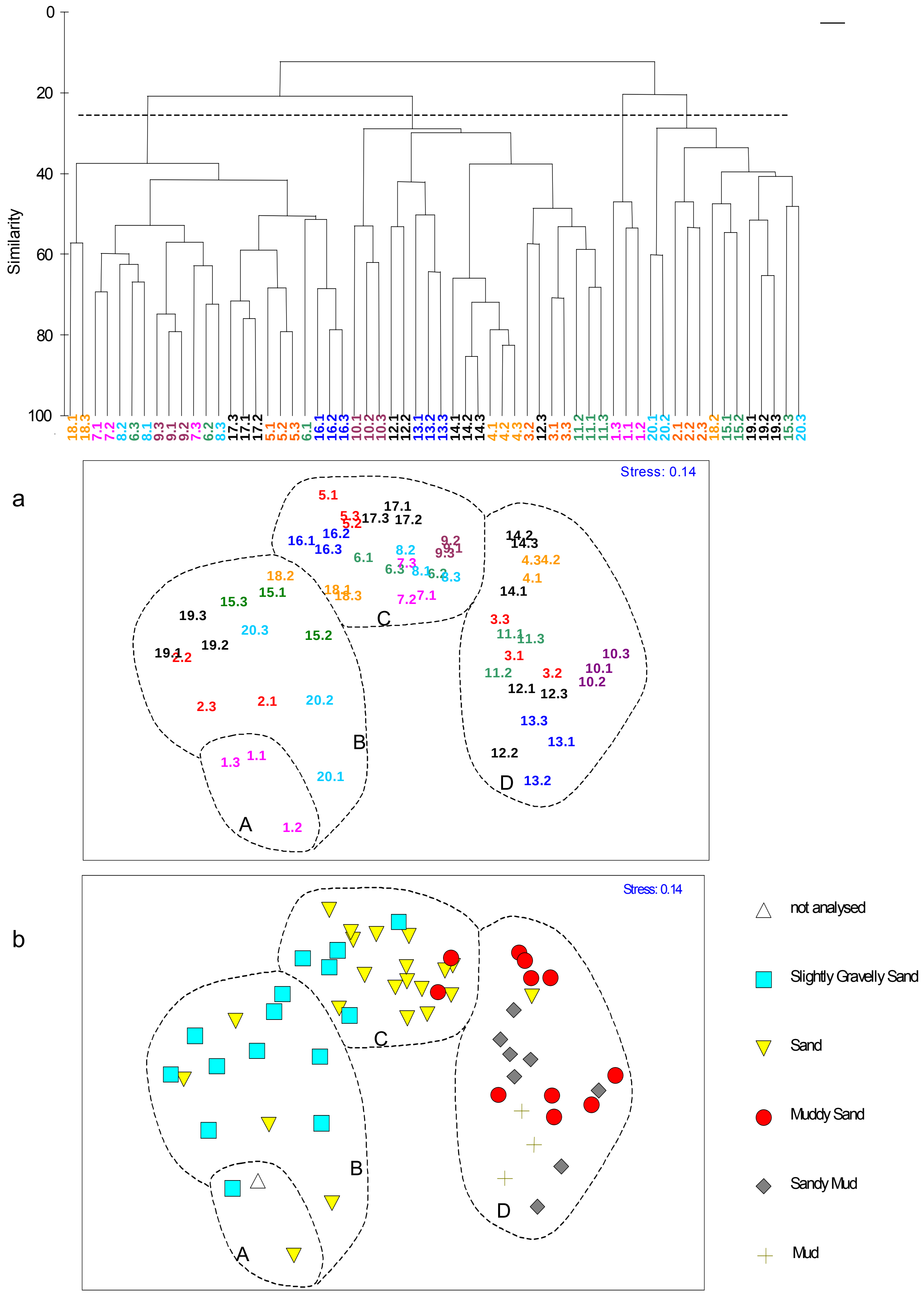


Figure 16 Multi-dimensional scaling (mds) plots and associated dendrogram showing the relationships between the communities in individual Day Grab samples from 2006. In MDS plot (a) replicates from the same site are given the same colour, while in the bottom plot (b) sediment description (Folk triangles) has been superimposed. Groupings (A,B,C & D) outlined on the mds plots relate to the 25% similarity cutoff shown on the dendrogram.

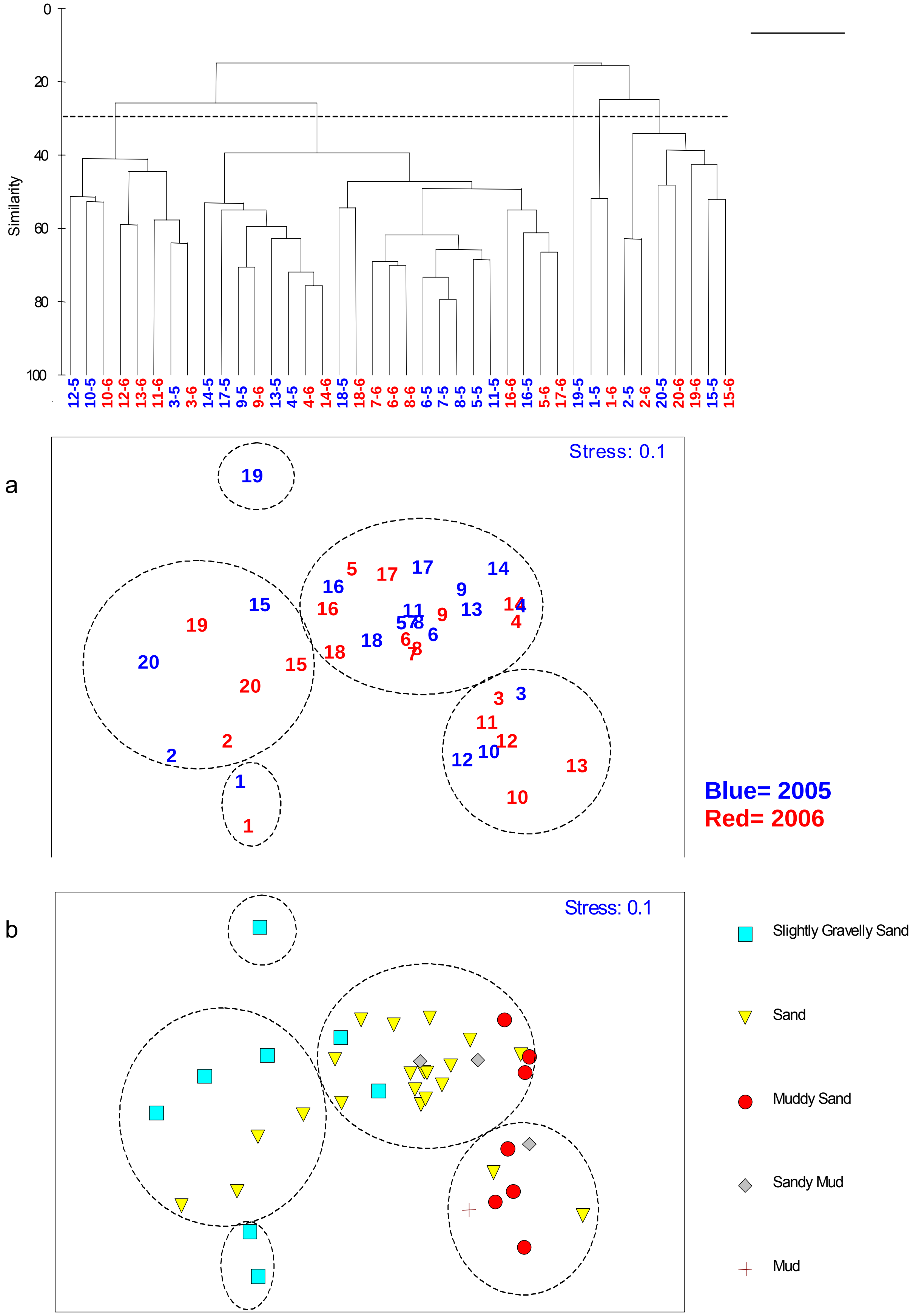


Figure 17 Multi-dimensional scaling (mds) plots and associated dendrogram showing the relationships between the communities in Day Grabs from 20 sites (pooled data from 3 replicates in each case) in 2005 and 2006. In the top MDS plot (a) sites are coloured according to year, while in the bottom plot (b) sediment description (Folk triangles) has been superimposed. Groupings outlined on the mds plots relate to the 30% similarity cutoff shown on the dendrogram.

5 Conclusions

The stated objectives of the benthic monitoring were as follows:

1. To identify changes in benthic communities over time attributable to the effects of wind farm construction or operation. If such change is evident, to determine the significance in terms of:

a. benthic communities *per se;*

b. other trophic groups, notably fish.

2. To monitor the distribution of species of interest (i.e. *Thia scutellata*).

3. To identify changes in sediment characteristics over time attributable to the effects of wind farm construction or operation to help understand any changes to benthic communities and in support of coastal process monitoring work.

Objectives 1 and 3

The benthic fauna have shown considerable changes between 2005 and 2006, with marked reductions in numbers of many of the more abundant species. These changes have been most noticeable in the muddier central section of the windfarm site, where there appear also to be increases in the proportion of mud in the sediments. Overall community types at each station are relatively unchanged, however.

The possibility that the observed changes are a result of wind farm construction activities cannot be ruled out at this early stage in the monitoring programme; however, there are a number of factors that suggest this is unlikely:

1) Construction activities would be expected to cause, if anything, a loss of finer sediments and a resultant coarsening of the remaining seabed in the vicinity of turbine foundations if scour was extensive. In contrast, a relatively wide scale increase in the proportion of fine sediments with patchy areas of fine sediment approximately 150 m from Turbine BB27 was recorded. This observation will be related to ongoing scour monitoring in the next benthic monitoring report.

2) The timescales involved are so short (a few months) that it would be unlikely that any changes in sediment conditions resulting from construction activities would have had time to cause significant effects on benthic organisms.

3) There is strong evidence from the literature that large fluctuations in the most abundant species in this area are very much the norm, and that, at high densities, burrowing activities of the animals themselves can cause sufficient loosening of the sediments to make the animals prone to subsequent removal by storms.

4) There were strong similarities between the results of the EIA characterisation survey in 2002 and the 2006 during construction survey which further supports the hypothesis that the observed change is related to natural variability.

5) At the three sites in the near-field area of turbine BB27 there were, with the exception of one replicate sample, negligible changes to sediment type. The reductions in richness and diversity of the faunal community between 2005 and 2006 here are believed to be consistent with natural variation.

It should be noted that the survey took place before rock dumping in September 2006 to provide scour protection at Turbine BB27. The first post-construction survey in 2007 will provide evidence of the effects of this work on sediment characteristics and benthic invertebrates.

Objective 2

Thumbnail crab *Thia scutellata* was recorded in similar (low) numbers in 2006 as in 2005. The preferred habitat for this species, well-sorted medium sands, is patchily distributed across the survey area and due to the low number of individuals encountered occurrence in grabs is sporadic.

The absence of this species south of the wind farm in 2006 is not believed to be associated with wind farm construction.

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Appendix 1

Positions of each benthic grab as recorded from vessel DGPS (WGS84 Decimal degrees).

Site/Sample No	Latitude	Longitude	Site/Sample No	Latitude	Longitude
1.1	53.51582	-3.39712	11.1	53.48705	-3.17535
1.2	53.51580	-3.39713	11.2	53.48708	-3.17540
1.3	53.51581	-3.39711	11.3	53.48705	-3.17546
2.1	53.51260	-3.24856	12.1	53.48176	-3.21146
2.2	53.51258	-3.24860	12.2	53.48170	-3.21144
2.3	53.51259	-3.24862	12.3	53.48178	-3.21145
3.1	53.51264	-3.23030	13.1	53.48169	-3.19377
3.2	53.51262	-3.23034	13.2	N.R	N.R
3.3	53.51260	-3.23038	13.3	53.48178	-3.19368
4.1	53.51234	-3.19363	14.1	53.48199	-3.17546
4.2	53.51239	-3.19368	14.2	53.48191	-3.17547
4.3	53.51237	-3.19364	14.3	53.48191	-3.17547
5.1	53.50240	-3.21211	15.1	53.47654	-3.14800
5.2	53.50237	-3.21199	15.2	53.47649	-3.14805
5.3	53.50234	-3.21203	15.3	53.47655	-3.14800
6.1	53.49572	-3.20855	16.1	53.46989	-3.16807
6.2	53.49570	-3.20846	16.2	53.46993	-3.16807
6.3	53.49566	-3.20839	16.3	53.46990	-3.16807
7.1	53.49556	-3.20770	17.1	53.46476	-3.16523
7.2	53.49557	-3.20784	17.2	53.46474	-3.16520
7.3	53.49559	-3.20778	17.3	53.46469	-3.16524
8.1	53.49545	-3.20715	18.1	53.45113	-3.19365
8.2	53.49547	-3.20721	18.2	53.45111	-3.19369
8.3	53.49542	-3.20711	18.3	53.45106	-3.19386
9.1	53.49192	-3.19368	19.1	53.45253	-3.14144
9.2	53.49197	-3.19372	19.2	53.45246	-3.14151
9.3	53.49196	-3.19375	19.3	53.45248	-3.14152
10.1	53.48682	-3.19370	20.1	53.44760	-3.09126
10.2	53.48686	-3.19373	20.2	53.44758	-3.09125
10.3	53.48686	-3.19361	20.3	53.44757	-3.09125

N.R: not recorded.

Appendix 2

Field notes made during grabbing over the 14th and 16th September 2006.

Site	Replicate	Estimated Vol (L)	Notes
1	1.1	10	Coarse/med sand with shell fragments, some clay and pieces of sea glass
	1.2	9	Coarse/med sand with shell fragments, with more clay pieces than previous. Large piece of steel wire encrusted with hydroids
	1.3	8	Coarse/med sand with shell fragments and large lumps of clay
2	2.1	10	Coarse sand and shell fragments
	2.2	9	Coarse sand and shell fragments
	2.3	9	Coarse sand and shell fragments
3	3.1	10	Soft mud with anoxic layer
	3.2	10	Soft mud with anoxic layer
	3.3	10	Soft mud with anoxic layer
4	4.1	10	Soft mud with many Pectinaria sp
	4.2	10	Soft mud with many Pectinaria sp
	4.3	10	Soft mud with many Pectinaria sp
5	5.1	9	Med sand with shell fragments and some mud
	5.2	8	Med sand with shell fragments and some mud
	5.3	8	Med sand with shell fragments and some mud
6	6.1	7	Soft mud with anoxic layer and Ensis sp
	6.2	8	Soft mud with anoxic layer and Ensis sp
	6.3	7	Soft mud with anoxic layer and Ensis sp
7	7.1	8	Soft mud with some medium sand and shell fragments and Ensis sp.
	7.2	7	Soft mud with some medium sand and shell fragments and Ensis sp.
	7.3	7	Soft mud with some medium sand and shell fragments and Ensis sp.
8	8.1	10	Soft mud with anoxic layer and Ensis sp
	8.2	9	Soft mud with anoxic layer and Ensis sp
	8.3	9	Soft mud with anoxic layer and Ensis sp
9	9.1	8	Soft mud and coarse sand with anoxic layer and Ensis sp
	9.2	7	Soft mud and coarse sand with anoxic layer and Ensis sp 1x Solea solea thrown back
	9.3	8	Soft mud and coarse sand with anoxic layer and Ensis sp
10	10.1	10	Soft mud with anoxic layer, coarse sand and shell fragments
	10.2	9	Soft mud with anoxic layer, coarse sand and shell fragments
	10.3	8	Soft mud with anoxic layer, coarse sand and shell fragments
11	11.1	10	Soft mud with many Pectinaria sp
	11.2	10	Soft mud with many Pectinaria sp
	11.3	10	Soft mud with many Pectinaria sp and small Ensis sp
12	12.1	10	Soft mud
	12.2	10	Soft mud
	12.3	10	Soft mud
13	13.1	10	Soft mud with little in terms of shell frags or biota
	13.2	10	Soft mud with little in terms of shell frags or biota
	13.3	10	Soft mud with little in terms of shell frags or biota
14	14.1	10	Sandy mud/ some anoxia
	14.2	10	Sandy mud/ some anoxia
	14.3	10	Sandy mud/ some anoxia
15	15.1	9	Medium sand/ few shell fragments

Site	Replicate	Estimated Vol (L)	Notes
	15.2	10	Medium sand plus an anoxic layer
	15.3	9	Medium sand/ a little anoxia and a few shell fragments
16	16.1	9	Fine sand
	16.2	8	Medium/ fine sand
	16.3	5	Fine sand
17	17.1	7	Fine, silt-muddy sand
	17.2	9	Fine, silt-muddy sand
	17.3	8	Fine, silt-muddy sand
18	18.1	10	Fine sand/ muddy with shell fragments and shells
	18.2	7	Fine sand/ silt and mud/ shell fragments and shells
	18.3	8	Muddy sand and shell fragments
19	19.1	9	Medium sand and shells
	19.2	9	Medium sand with a little mud/ shells
	19.3	9	Medium sand and more shells
20	20.1	9	Muddy sand/ anoxic below surface layer/ a little clay
	20.2	7	Medium/ fine sand and small amount of clay
	20.3	9	Slightly muddy sand

Appendix 3

Sediment data from grabs collected over the 14th and 16th September 2006.

Code	LOI %	% 5.00 mm	% 2.0 mm	% 1.0 mm	% 600 um	% 425 um	% 300 um	% 212 um	% 150 um	% 63 um	% <63 um	site id	Mean phi	Mean mm	1 std	skew-ness	kurt-osis	Classification after Buchanan	Folk Triangles after BGS
1.1	replicate sample not analysed																		
1.2	0.486	0.56	0.39	0.77	6.14	22.78	51.62	11.78	3.61	2.13	0.22	1.2	1.38	0.38	0.52	-0.09	1.46	Moderately well sorted medium sand	Sand
1.3	0.519	1.44	0.46	0.38	2.09	18.05	51.63	15.37	4.56	5.10	0.92	1.3	1.54	0.34	0.59	0.22	1.80	Moderately well sorted medium sand	Slightly Gravelly Sand
2.1	0.540	0.05	0.03	0.18	4.32	20.44	59.02	14.64	0.87	0.34	0.10	2.1	1.40	0.38	0.39	-0.11	1.31	Well sorted medium sand	Sand
2.2	0.493	0.14	0.02	0.17	1.56	21.93	55.00	19.12	1.56	0.41	0.08	2.2	1.47	0.36	0.41	0.00	1.21	Well sorted medium sand	Sand
2.3	0.508	0.04	1.46	1.97	3.51	22.80	56.65	11.87	1.16	0.42	0.10	2.3	1.35	0.39	0.46	-0.23	1.44	Well sorted medium sand	Slightly Gravelly Sand
3.1	3.318	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	14.80	84.90	3.1	6.45	0.01	2.18	-0.01	0.75	Very poorly sorted silt	Sandy Mud
3.2	3.550	0.00	0.00	0.03	0.16	0.11	2.31	2.85	5.96	66.01	22.56	3.2	4.01	0.06	1.71	0.58	2.80	Poorly sorted silt	Muddy Sand
3.3	5.268	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.47	21.02	77.46	3.3	6.15	0.01	2.29	0.03	0.70	Very poorly sorted silt	Sandy Mud
4.1	2.680	0.00	0.07	0.03	0.24	1.13	0.82	2.95	22.06	62.79	9.90	4.1	3.18	0.11	1.07	0.28	1.94	Poorly sorted very fine sand	Sand
4.2	3.102	0.00	0.00	0.00	0.13	0.15	0.63	10.30	16.95	58.89	12.96	4.2	3.17	0.11	1.25	0.25	2.16	Poorly sorted very fine sand	Muddy Sand
4.3	2.412	0.00	0.00	0.07	0.15	0.16	0.94	2.28	23.49	61.56	11.35	4.3	3.20	0.11	1.12	0.31	2.04	Poorly sorted very fine sand	Muddy Sand
5.1	0.615	0.00	0.01	0.06	0.25	0.61	6.42	61.61	25.71	4.97	0.37	5.1	2.14	0.23	0.37	0.20	1.10	Well sorted fine sand	Sand
5.2	0.597	0.00	0.00	0.05	0.19	0.49	4.85	58.37	31.12	4.57	0.37	5.2	2.17	0.22	0.34	0.19	0.85	Very well sorted fine sand	Sand
5.3	1.630	0.00	0.03	0.09	0.57	1.43	10.21	58.25	20.08	5.81	3.54	5.3	2.13	0.23	0.55	0.34	1.88	Moderately well sorted fine sand	Sand
6.1	1.354	0.00	0.07	0.08	0.29	0.49	3.18	50.76	34.02	7.12	3.98	6.1	2.24	0.21	0.52	0.37	1.43	Moderately well sorted fine sand	Sand
6.2	2.044	0.00	0.00	0.00	0.00	0.10	5.14	24.64	15.07	5.98	49.05	6.2	4.59	0.04	2.67	0.43	0.66	Very poorly sorted silt	Muddy Sand
6.3	2.033	0.00	0.04	0.06	1.00	2.79	4.35	51.94	28.91	6.53	4.36	6.3	2.20	0.22	0.59	0.30	1.73	Moderately well sorted fine sand	Sand
7.1	1.824	0.00	0.11	0.31	0.75	1.22	3.95	48.00	33.95	7.43	4.29	7.1	2.23	0.21	0.56	0.30	1.55	Moderately well sorted fine sand	Sand
7.2	3.159	0.00	0.11	0.45	0.57	1.96	6.02	43.82	30.03	10.05	7.01	7.2	2.30	0.20	0.92	0.44	2.57	Moderately sorted fine sand	Sand
7.3	1.627	0.00	0.00	0.07	0.34	1.62	6.60	50.94	31.22	5.99	3.21	7.3	2.19	0.22	0.53	0.27	1.50	Moderately well sorted fine sand	Sand
8.1	2.116	0.00	0.00	0.01	0.20	0.51	3.60	44.96	30.12	12.46	8.15	8.1	2.44	0.18	1.02	0.60	2.68	Poorly sorted fine sand	Sand
8.2	2.259	0.07	0.11	0.24	0.44	2.41	7.32	50.14	28.92	6.69	3.67	8.2	2.19	0.22	0.57	0.27	1.62	Moderately well sorted fine sand	Sand

Code	LOI %	% 5.00 mm	% 2.0 mm	% 1.0 mm	% 600 um	% 425 um	% 300 um	% 212 um	% 150 um	% 63 um	% <63 um	site id	Mean phi	Mean mm	1 std	skew-ness	kurt-osis	Classification after Buchanan	Folk Triangles after BGS
8.3	1.523	0.00	0.00	0.04	0.24	0.63	3.89	54.56	28.88	7.44	4.32	8.3	2.22	0.21	0.53	0.43	1.49	Moderately well sorted fine sand	Sand
9.1	1.905	0.10	0.05	0.06	0.77	1.37	6.11	47.05	33.73	7.40	3.37	9.1	2.22	0.21	0.55	0.25	1.51	Moderately well sorted fine sand	Sand
9.2	1.339	0.00	0.00	0.00	0.00	0.17	5.53	26.39	19.55	7.15	41.25	9.2	4.09	0.06	2.57	0.73	0.73	Very poorly sorted silt	Muddy Sand
9.3	1.343	0.00	0.23	0.32	0.34	0.68	5.39	48.01	34.99	7.39	2.65	9.3	2.22	0.21	0.51	0.26	1.39	Moderately well sorted fine sand	Sand
10.1	4.155	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	16.71	82.78	10	6.36	0.01	2.22	0.00	0.74	Very poorly sorted silt	Sandy Mud
10.2	4.316	0.00	0.00	0.08	0.34	0.82	0.35	2.86	11.02	46.54	37.99	10	4.62	0.04	2.22	0.60	0.93	Very poorly sorted silt	Muddy Sand
10.3	4.117	0.00	0.00	0.02	0.39	0.66	4.48	8.92	13.67	42.81	29.06	10	4.11	0.06	2.20	0.52	1.35	Very poorly sorted silt	Muddy Sand
11.1	3.156	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	11.43	88.51	11	6.59	0.01	2.11	-0.02	0.77	Very poorly sorted silt	Sandy Mud
11.2	4.791	0.00	0.00	0.05	0.41	1.97	5.26	10.05	22.60	28.77	30.88	11	4.06	0.06	2.32	0.56	1.13	Very poorly sorted silt	Muddy Sand
11.3	4.448	0.00	0.00	0.00	0.00	0.00	0.00	0.14	3.39	25.32	71.17	11	5.91	0.02	2.34	0.10	0.68	Very poorly sorted silt	Sandy Mud
12.1	6.586	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.16	90.86	12	6.68	0.01	2.06	-0.02	0.77	Very poorly sorted silt	Mud
12.2	5.705	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.59	96.44	12	6.87	0.01	1.90	0.00	0.74	Poorly sorted silt	Mud
12.3	6.500	0.00	0.00	0.05	0.27	11.63	16.13	7.69	9.22	25.46	29.55	12	3.69	0.08	2.56	0.44	1.01	Very poorly sorted very fine sand	Muddy Sand
13.1	3.323	0.00	0.00	0.00	0.00	0.00	0.00	0.12	2.53	22.33	75.01	13	6.05	0.02	2.32	0.06	0.69	Very poorly sorted silt	Sandy Mud
13.2	5.336	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	11.08	88.92	13	6.60	0.01	2.10	-0.02	0.77	Very poorly sorted silt	Sandy Mud
13.3	5.383	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.94	92.10	13	6.72	0.01	2.03	-0.02	0.77	Very poorly sorted silt	Mud
14.1	3.668	0.00	0.00	0.00	0.00	1.69	7.98	14.91	6.15	10.69	58.59	14	5.05	0.03	2.81	0.12	0.64	Very poorly sorted silt	Sandy Mud
14.2	2.138	0.00	0.00	0.00	0.00	3.03	13.26	24.73	10.12	7.94	40.93	14	4.01	0.06	2.68	0.67	0.74	Very poorly sorted silt	Muddy Sand
14.3	2.613	0.00	0.25	0.13	0.91	1.58	12.91	31.05	18.59	20.58	14.00	14	2.64	0.16	1.52	0.57	1.86	Poorly sorted fine sand	Muddy Sand
15.1	0.580	0.00	1.16	1.66	1.31	1.92	73.21	17.87	1.99	0.73	0.17	15	1.57	0.34	0.33	0.12	1.45	Very well sorted medium sand	Slightly Gravelly Sand
15.2	0.861	0.93	1.47	0.92	0.55	3.18	64.44	23.61	3.16	1.20	0.54	15	1.63	0.32	0.37	0.12	1.24	Well sorted medium sand	Slightly Gravelly Sand
15.3	0.665	0.18	0.14	0.08	0.10	2.59	65.96	26.02	3.25	1.24	0.45	15	1.65	0.32	0.32	0.28	0.90	Very well sorted medium sand	Sand
16.1	0.672	0.18	1.15	0.79	0.69	2.32	28.68	50.69	13.54	1.32	0.65	16	1.85	0.28	0.42	-0.07	1.03	Well sorted medium sand	Slightly Gravelly Sand
16.2	0.572	0.31	1.17	1.37	1.30	3.29	32.08	45.39	13.61	1.12	0.36	16	1.82	0.28	0.48	-0.13	1.15	Well sorted medium sand	Slightly Gravelly Sand
16.3	0.543	0.24	0.84	1.18	1.29	3.28	28.77	47.92	15.14	1.12	0.22	16	1.85	0.28	0.47	-0.13	1.14	Well sorted medium sand	Slightly Gravelly Sand
17.1	1.063	1.41	2.14	0.44	0.88	1.05	14.93	47.79	25.73	4.15	1.47	17	2.05	0.24	0.56	-0.07	1.50	Moderately well sorted fine sand	Slightly Gravelly Sand
17.2	0.624	0.00	0.23	0.18	0.18	2.72	25.42	49.25	19.15	2.60	0.27	17	1.94	0.26	0.44	0.00	1.06	Well sorted medium sand	Sand

Code	LOI %	% 5.00 mm	% 2.0 mm	% 1.0 mm	% 600 um	% 425 um	% 300 um	% 212 um	% 150 um	% 63 um	% <63 um	site id	Mean phi	Mean mm	1 std	skew-ness	kurt-osis	Classification after Buchanan	Folk Triangles after BGS
17.3	0.751	0.05	0.33	0.60	0.51	2.02	19.09	52.75	21.47	2.72	0.46	17	2.00	0.25	0.43	0.00	1.23	Well sorted medium sand	Sand
18.1	1.006	0.00	0.34	0.60	0.89	4.02	36.36	39.06	14.10	3.03	1.61	18	1.85	0.28	0.48	0.07	0.99	Well sorted medium sand	Sand
18.2	0.649	2.65	2.35	2.27	2.68	6.38	35.01	37.77	9.41	1.28	0.20	18	1.70	0.31	0.78	-0.29	2.10	Moderately sorted medium sand	Slightly Gravelly Sand
18.3	1.029	1.40	0.75	1.47	1.43	4.34	37.88	32.82	15.54	2.83	1.53	18	1.82	0.28	0.56	0.03	1.15	Moderately well sorted medium sand	Slightly Gravelly Sand
19.1	0.448	0.82	2.26	2.12	2.00	5.58	57.30	23.61	5.66	0.58	0.06	19	1.62	0.33	0.56	-0.06	2.01	Moderately well sorted medium sand	Slightly Gravelly Sand
19.2	0.456	1.01	2.67	1.70	1.32	3.17	47.54	29.56	11.80	1.10	0.12	19	1.72	0.30	0.65	-0.08	1.79	Moderately well sorted medium sand	Slightly Gravelly Sand
19.3	0.414	0.61	2.59	3.19	1.77	4.47	57.64	23.00	5.98	0.68	0.07	19	1.62	0.33	0.62	-0.09	2.32	Moderately well sorted medium sand	Slightly Gravelly Sand
20.1	1.084	0.00	0.05	0.11	1.01	1.02	2.24	28.90	49.79	12.90	3.98	20	2.39	0.19	0.55	0.16	1.56	Moderately well sorted fine sand	Sand
20.2	0.505	0.96	0.89	0.30	0.65	1.42	21.77	45.57	25.31	2.82	0.30	20	2.00	0.25	0.46	-0.02	1.00	Well sorted medium sand	Slightly Gravelly Sand
20.3	1.012	0.00	1.53	0.52	1.20	2.23	16.82	36.55	35.00	5.02	1.12	20	2.09	0.24	0.55	-0.06	1.12	Moderately well sorted fine sand	Slightly Gravelly Sand

Appendix 4

Raw faunal data from grabs collected over the 14th and 16th September 2006.

Name	BB 1.1	BB 1.2	BB 1.3	BB 2.1	BB 2.2	BB 2.3	BB 3.1	BB 3.2	BB 3.3	BB 4.1	BB 4.2	BB 4.3	BB 5.1	BB 5.2	BB 5.3	BB 6.1	BB 6.2	BB 6.3	BB 7.1	BB 7.2	BB 7.3
Protozoa																					
Lagotia viridis	P	P	P	P	P	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cnidaria																					
Athecata sp.	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tubularia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bougainvillia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phialella quadrata	P	P	P	P	-	P	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calycella syringa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrallmania falcata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Campanulariidae	-	-	P	-	P	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-
Clytia hemisphaerica	-	-	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Actinaria	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cerianthus lloydii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sagartiidae sp.	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Edwardsia claparedii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nemertea																					
Nemertea spp.	2	1	3	2	1	1	1	-	1	-	-	-	7	6	8	6	-	5	6	2	4
Entoprocta																					
Pedicellina sp.	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pedicellina cernua	P	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polychaeta																					
Aphrodita aculeata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gattyana cirrosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Malmgreniella arenicolae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pholoe baltica	-	-	-	-	-	-	-	-	1	5	9	5	-	1	-	-	1	-	-	-	-
Sthenelais limicola	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	BB 1.1	BB 1.2	BB 1.3	BB 2.1	BB 2.2	BB 2.3	BB 3.1	BB 3.2	BB 3.3	BB 4.1	BB 4.2	BB 4.3	BB 5.1	BB 5.2	BB 5.3	BB 6.1	BB 6.2	BB 6.3	BB 7.1	BB 7.2	BB 7.3
Eteone longa/flava (agg.)	-	-	-	-	-	-	-	-	-	1	-	1	2	-	1	-	-	-	-	-	-
Anaitides groenlandica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anaitides mucosa	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anaitides rosea	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	1
Glycera sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycera oxycephala	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycera tridactyla	-	-	-	-	-	-	-	-	-	-	-	1	19	13	11	2	3	4	2	-	5
Podarkeopsis capEnsis	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Exogone hebes	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nereis longissima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephtys sp. (Juv.)	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-
Nephtys assimilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephtys caeca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephtys cirrosa	7	3	8	5	7	4	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Nephtys hombergii	-	-	-	-	-	-	8	10	13	21	15	12	-	1	1	1	3	1	2	-	-
Marphysa bellii	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scoloplos armiger	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aricidea cerrutii	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poecilochaetus serpens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Aonides paucibranchiata	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scolelepis (Scolelepis) bonnieri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spio decorata	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Spiophanes bombyx	1	-	-	-	1	2	-	-	-	-	-	-	6	7	3	6	13	12	-	2	12
Magelona filiformis	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	-	-	-	-	-
Magelona mirabilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magelona johnstoni	-	-	-	-	-	-	-	-	-	1	-	-	462	197	212	24	17	20	3	6	7
Chaetozone christie	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Chaetozone setosa	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	1
Capitella capitata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Mediomastus fragilis	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-

Name	BB 1.1	BB 1.2	BB 1.3	BB 2.1	BB 2.2	BB 2.3	BB 3.1	BB 3.2	BB 3.3	BB 4.1	BB 4.2	BB 4.3	BB 5.1	BB 5.2	BB 5.3	BB 6.1	BB 6.2	BB 6.3	BB 7.1	BB 7.2	BB 7.3
Clymenura johnstoni	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophelia borealis	-	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scalibregma inflatum	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	4
Owenia fusiformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagis koreni	-	-	-	-	-	-	1	3	2	85	121	131	1	-	-	1	3	-	-	1	2
Lanice conchilega	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycirrus sp.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaeta																					
Oligochaeta spp.	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	4	-	-	-
Crustacea																					
Parastic Copepoda sp.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gastrosaccus spinifer	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Schistomysis kervillei	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Perioculodes longimanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pontocrates arenarius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Synchelidium maculatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orchomene nanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atylus falcatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ampelisca brevicornis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-
Bathyporeia sp. Juv	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathyporeia elegans	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathyporeia guilliamsoniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Megaluropus agilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Idotea linearis	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Iphinoe trispinosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-
Diastylis bradyi	-	-	-	1	1	-	-	-	1	-	-	-	12	3	7	3	2	4	2	4	3
Diastylis laevis	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3	2	1
Diastylis rathkei	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	6	8	-
Crangon allmanni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crangon crangon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Crangon trispinosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	BB 1.1	BB 1.2	BB 1.3	BB 2.1	BB 2.2	BB 2.3	BB 3.1	BB 3.2	BB 3.3	BB 4.1	BB 4.2	BB 4.3	BB 5.1	BB 5.2	BB 5.3	BB 6.1	BB 6.2	BB 6.3	BB 7.1	BB 7.2	BB 7.3
Pagurus bernhardus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corystes cassivelaunus	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Thia scutellata	1	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liocarcinus sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liocarcinus holsatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Portumnus latipes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mollusca																					
Polinices pulchellus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	6	-	4	1
Acteon tornatilis	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	1	-
Nucula sp. (Juv.)	-	-	-	1	-	-	1	-	-	1	-	4	-	-	-	2	-	1	1	1	-
Nucula hanleyi	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nucula nitidosa	-	-	-	-	-	-	1	1	3	-	-	-	-	-	-	-	-	-	-	-	-
Nucula nucleus	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mytilidae sp. Juv.	-	-	-	-	-	-	4	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Tellimya ferruginosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mysella bidentata	-	-	-	-	-	-	51	20	40	132	136	115	-	1	1	-	59	10	5	4	42
Goodallia triangularis	4	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mactra stultorum	-	-	-	-	-	-	-	-	-	-	1	3	1	1	-	-	-	-	1	-	-
Spisula solida	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spisula subtruncata	1	-	-	1	-	-	-	-	-	1	1	-	1	2	2	6	3	9	2	1	2
Pharus legumen	-	-	-	-	-	-	-	-	2	1	-	3	6	4	8	5	13	16	17	12	16
Fabulina fabula	-	-	1	-	-	-	-	-	-	-	-	-	2	12	4	6	4	3	1	2	-
Moerella pygmaea	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Donax vittatus	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	2	-	-	-	-	-
Gari fervEnsis	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Abra alba	-	1	-	-	-	-	2	-	2	22	29	29	-	-	-	-	2	1	6	3	1
Chamelea gallina	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dosinia sp.	1	2	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dosinia exoleta	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thracia sp. Juv.	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cochlodesma praetenue	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	BB 1.1	BB 1.2	BB 1.3	BB 2.1	BB 2.2	BB 2.3	BB 3.1	BB 3.2	BB 3.3	BB 4.1	BB 4.2	BB 4.3	BB 5.1	BB 5.2	BB 5.3	BB 6.1	BB 6.2	BB 6.3	BB 7.1	BB 7.2	BB 7.3
Bryozoa																					
Alcyonidium sp.	-	-	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triticella flava	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conopeum reticulum	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electra pilosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phoronida																					
Phoronis spp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	3	-	-	-
Echinodermata																					
Ophiurida sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphiura sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Acronida brachiata	-	-	-	-	-	-	-	-	1	-	4	-	-	-	-	-	-	2	-	-	-
Amphiura filiformis	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Ophiura sp. Juv.	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	1	3	1	-
Ophiura ophiura	1	-	-	-	-	-	-	-	-	-	3	1	-	2	-	-	2	1	2	1	4
Echinocyamus pusillus	5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Echinocardium cordatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pisces																					
Solea solea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	BB 8.1	BB 8.2	BB 8.3	BB 9.1	BB 9.2	BB 9.3	BB 10.1	BB 10.2	BB 10.3	BB 11.1	BB 11.2	BB 11.3	BB 12.1	BB 12.2	BB 12.3	BB 13.1	BB 13.2	BB 13.3	BB 14.1	BB 14.2	BB 14.3
Protozoa																					
Lagotia viridis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cnidaria																					
Athecata sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tubularia sp.	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bougainvillia sp.	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phialella quadrata	-	-	-	P	-	-	-	-	P	-	-	P	P	-	-	-	-	-	-	-	-
Calycella syringa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	BB 8.1	BB 8.2	BB 8.3	BB 9.1	BB 9.2	BB 9.3	BB 10.1	BB 10.2	BB 10.3	BB 11.1	BB 11.2	BB 11.3	BB 12.1	BB 12.2	BB 12.3	BB 13.1	BB 13.2	BB 13.3	BB 14.1	BB 14.2	BB 14.3
Hydrallmania falcata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Campanulariidae	-	-	P	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clytia hemisphaerica	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-
Actinaria	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cerianthus lloydii	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Sagartiidae sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Edwardsia claparedii	-	-	-	-	-	-	1	1	3	-	1	1	3	5	2	-	-	-	-	-	-
Nemertea																					
Nemertea spp.	2	6	-	5	4	3	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Entoprocta																					
Pedicellina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pedicellina cernua	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polychaeta																					
Aphrodita aculeata	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Gattyana cirrosa	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Malmgreniella arenicolae	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pholoe baltica	-	-	1	4	15	5	-	-	-	-	-	-	-	-	-	-	-	-	-	6	7
Sthenelais limicola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eteone longa/flava (agg.)	-	1	-	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anaitides groenlandica	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Anaitides mucosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anaitides rosea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycera sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Glycera oxycephala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycera tridactyla	3	4	1	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1	2	1
Podarkeopsis capEnsis	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exogone hebes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nereis longissima	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephtys sp. (Juv.)	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3
Nephtys assimilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephtys caeca	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	BB 8.1	BB 8.2	BB 8.3	BB 9.1	BB 9.2	BB 9.3	BB 10.1	BB 10.2	BB 10.3	BB 11.1	BB 11.2	BB 11.3	BB 12.1	BB 12.2	BB 12.3	BB 13.1	BB 13.2	BB 13.3	BB 14.1	BB 14.2	BB 14.3
Nephtys cirrosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephtys hombergii	1	-	2	1	3	-	24	21	30	8	6	10	4	1	9	2	2	4	11	10	14
Marphysa bellii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scoloplos armiger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aricidea cerrutii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poecilochaetus serpens	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aonides paucibranchiata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scolelepis (Scolelepis) bonnieri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spio decorata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spiophanes bombyx	4	6	2	2	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magelona filiformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magelona mirabilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magelona johnstoni	16	5	19	6	16	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetozone christie	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetozone setosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capitella capitata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mediomastus fragilis	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clymenura johnstoni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophelia borealis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scalibregma inflatum	-	-	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Owenia fusiformis	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lagis koreni	-	-	10	63	88	37	-	1	-	-	-	-	10	10	9	1	4	3	32	382	284
Lanice conchilega	-	-	-	4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycirrus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaeta																					
Oligochaeta spp.	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Crustacea																					
Parastic Copepoda sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gastrosaccus spinifer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Schistomysis kervillei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	BB 8.1	BB 8.2	BB 8.3	BB 9.1	BB 9.2	BB 9.3	BB 10.1	BB 10.2	BB 10.3	BB 11.1	BB 11.2	BB 11.3	BB 12.1	BB 12.2	BB 12.3	BB 13.1	BB 13.2	BB 13.3	BB 14.1	BB 14.2	BB 14.3
Perioculodes longimanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pontocrates arenarius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Synchelidium maculatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orchomene nanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atylus falcatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ampelisca brevicornis	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathyporeia sp. Juv	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Bathyporeia elegans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathyporeia guilliamsoniana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Megaluropus agilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Idotea linearis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iphinoe trispinosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diastylis bradyi	-	-	2	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Diastylis laevis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diastylis rathkei	2	1	3	-	-	1	-	-	2	2	-	1	-	-	-	-	-	-	5	1	3
Crangon allmanni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crangon crangon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crangon trispinosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pagurus bernhardus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corystes cassivelaunus	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thia scutellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liocarcinus sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Liocarcinus holsatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Portumnus latipes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mollusca																					
Polinices pulchellus	1	-	-	2	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Acteon tornatilis	-	-	-	-	-	1	-	-	-	-	-	1	1	-	-	-	1	-	-	-	-
Nucula sp. (Juv.)	-	-	1	1	1	1	-	3	-	-	-	1	1	1	-	-	1	1	1	8	3
Nucula hanleyi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nucula nitidosa	-	1	-	-	-	-	-	-	1	-	-	-	2	-	-	1	-	-	-	-	-
Nucula nucleus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	BB 8.1	BB 8.2	BB 8.3	BB 9.1	BB 9.2	BB 9.3	BB 10.1	BB 10.2	BB 10.3	BB 11.1	BB 11.2	BB 11.3	BB 12.1	BB 12.2	BB 12.3	BB 13.1	BB 13.2	BB 13.3	BB 14.1	BB 14.2	BB 14.3
Mytilidae sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
Tellimya ferruginosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mysella bidentata	25	9	75	188	382	165	1	-	-	18	10	21	3	-	3	-	-	1	54	120	157
Goodallia triangularis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mactra stultorum	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spisula solida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spisula subtruncata	3	2	2	2	3	5	-	-	-	1	-	-	-	1	-	-	-	-	2	22	11
Pharus legumen	17	21	8	32	22	27	4	2	2	2	1	5	-	-	1	1	-	-	3	3	2
Fabulina fabula	1	5	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Moerella pygmaea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Donax vittatus	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gari fervEnsis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Abra alba	4	2	1	2	3	4	-	-	1	8	1	4	2	-	-	2	-	3	17	25	41
Chamelea gallina	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Dosinia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dosinia exoleta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thracia sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cochlodesma praetenue	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bryozoa																					
Alcyonidium sp.	-	-	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Triticella flava	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conopeum reticulum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electra pilosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phoronida																					
Phoronis spp.	2	-	2	-	3	1	3	34	120	-	1	-	6	1	-	-	-	-	-	-	-
Echinodermata																					
Ophiurida sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Amphiura sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acronida brachiata	-	-	1	2	1	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Amphiura filiformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophiura sp. Juv.	3	2	-	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-	2	10	7

Name	BB 8.1	BB 8.2	BB 8.3	BB 9.1	BB 9.2	BB 9.3	BB 10.1	BB 10.2	BB 10.3	BB 11.1	BB 11.2	BB 11.3	BB 12.1	BB 12.2	BB 12.3	BB 13.1	BB 13.2	BB 13.3	BB 14.1	BB 14.2	BB 14.3
Ophiura ophiura	1	3	-	1	1	2	-	1	1	-	1	-	2	-	-	-	-	-	3	4	3
Echinocyamus pusillus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Echinocardium cordatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pisces																					
Solea solea	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	BB 15.1	BB 15.2	BB 15.3	BB 16.1	BB 16.2	BB 16.3	BB 17.1	BB 17.2	BB 17.3	BB 18.1	BB 18.2	BB 18.3	BB 19.1	BB 19.2	BB 19.3	BB 20.1	BB 20.2	BB 20.3
Protozoa																		
Lagotia viridis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-
Cnidaria																		
Athecata sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tubularia sp.	-	-	-	P	-	-	-	-	-	P	P	-	-	-	-	-	-	-
Bougainvillia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P
Phialella quadrata	-	P	-	-	-	P	-	-	-	-	-	P	-	-	-	-	-	-
Calycella syringa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P
Hydrallmania falcata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P
Campanulariidae	P	-	-	P	-	-	-	-	-	-	-	-	P	-	-	-	-	-
Clytia hemisphaerica	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-
Actinaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cerianthus lloydii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sagartiidae sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Edwardsia claparedii	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Nemertea																		
Nemertea spp.	-	2	2	1	1	-	1	1	3	7	3	2	3	4	10	-	-	2
Entoprocta																		
Pedicellina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P
Pedicellina cernua	-	-	-	-	-	-	-	-	-	-	P	-	P	P	P	-	-	-
Polychaeta																		

Name	BB 15.1	BB 15.2	BB 15.3	BB 16.1	BB 16.2	BB 16.3	BB 17.1	BB 17.2	BB 17.3	BB 18.1	BB 18.2	BB 18.3	BB 19.1	BB 19.2	BB 19.3	BB 20.1	BB 20.2	BB 20.3
Aphrodita aculeata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gattyana cirrosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Malmgreniella arenicolae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pholoe baltica	-	-	-	1	-	-	4	4	-	-	-	1	-	-	-	-	-	-
Sthenelais limicola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eteone longa/flava (agg.)	1	-	-	-	1	1	1	3	2	-	3	-	-	-	2	-	-	-
Anaitides groenlandica	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
Anaitides mucosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anaitides rosea	-	-	-	1	-	-	-	1	-	1	-	1	-	-	-	-	-	-
Glycera sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycera oxycephala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycera tridactyla	-	-	-	4	4	7	12	9	14	3	-	1	-	-	-	-	1	-
Podarkeopsis capEnsis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exogone hebes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nereis longissima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephtys sp. (Juv.)	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Nephtys assimilis	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephtys caeca	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Nephtys cirrosa	5	6	5	7	1	5	-	1	2	2	9	-	10	6	12	2	7	16
Nephtys hombergii	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	1	1
Marphysa bellii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scoloplos armiger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aricidea cerrutii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poecilochaetus serpens	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-
Aonides paucibranchiata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scolelepis (Scolelepis) bonnieri	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	2
Spio decorata	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Spiophanes bombyx	7	11	1	9	27	11	4	13	10	10	6	5	-	-	-	-	-	1
Magelona filiformis	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Magelona mirabilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1

Name	BB 15.1	BB 15.2	BB 15.3	BB 16.1	BB 16.2	BB 16.3	BB 17.1	BB 17.2	BB 17.3	BB 18.1	BB 18.2	BB 18.3	BB 19.1	BB 19.2	BB 19.3	BB 20.1	BB 20.2	BB 20.3
Magelona johnstoni	4	3	12	40	33	26	117	151	530	2	6	2	-	1	-	3	4	26
Chaetozone christie	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetozone setosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capitella capitata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mediomastus fragilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clymenura johnstoni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophelia borealis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scalibregma inflatum	-	-	-	-	-	-	-	-	-	12	-	6	-	-	-	-	-	-
Owenia fusiformis	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	6	3
Lagis koreni	-	1	-	-	-	-	2	8	1	-	-	-	-	-	-	-	-	-
Lanice conchilega	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Polycirrus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaeta																		
Oligochaeta spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crustacea																		
Parastic Copepoda sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gastrosaccus spinifer	6	3	2	-	-	-	-	-	1	-	-	-	16	2	3	-	1	1
Schistomysis kervillei	-	-	2	1	1	5	-	-	-	-	-	-	1	-	-	-	-	-
Perioculodes longimanus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Pontocrates arenarius	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Synchelidium maculatum	-	-	-	1	1	-	-	-	-	1	-	-	-	-	-	-	-	-
Orchomene nanus	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Atylus falcatus	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Ampelisca brevicornis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathyporeia sp. Juv	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathyporeia elegans	-	1	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1
Bathyporeia guilliamsoniana	-	-	-	-	-	-	-	-	-	-	2	1	-	1	-	-	2	-
Megaluropus agilis	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-
Idotea linearis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iphinoe trispinosa	-	-	1	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-
Diastylis bradyi	1	-	2	3	5	6	7	4	12	3	8	3	1	2	4	-	-	1

Name	BB 15.1	BB 15.2	BB 15.3	BB 16.1	BB 16.2	BB 16.3	BB 17.1	BB 17.2	BB 17.3	BB 18.1	BB 18.2	BB 18.3	BB 19.1	BB 19.2	BB 19.3	BB 20.1	BB 20.2	BB 20.3
Diastylis laevis	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Diastylis rathkei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crangon allmanni	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Crangon crangon	-	-	-	-	3	-	1	-	-	-	-	-	-	-	-	-	-	1
Crangon trispinosus	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Pagurus bernhardus	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Corystes cassivelaunus	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-
Thia scutellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liocarcinus sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liocarcinus holsatus	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-
Portumnus latipes	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Mollusca																		
Polinices pulchellus	-	1	-	1	-	-	-	2	1	-	1	2	-	2	1	-	-	-
Acteon tornatilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nucula sp. (Juv.)	-	-	-	-	1	1	2	-	4	1	-	-	-	-	-	-	-	-
Nucula hanleyi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nucula nitidosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nucula nucleus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mytilidae sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Tellimya ferruginosa	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-
Mysella bidentata	1	5	-	-	5	3	35	104	24	14	-	2	-	-	-	-	3	-
Goodallia triangularis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mactra stultorum	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Spisula solida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spisula subtruncata	-	1	-	2	3	5	5	9	5	-	1	1	-	-	-	-	-	-
Pharus legumen	-	-	-	-	-	-	3	2	2	-	-	4	-	-	-	-	-	-
Fabulina fabula	-	-	-	4	1	1	12	8	6	-	-	-	-	-	-	-	-	-
Moerella pygmaea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Donax vittatus	1	3	-	17	28	24	50	107	57	-	2	-	-	-	-	-	-	-
Gari fervEnsis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Abra alba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Name	BB 15.1	BB 15.2	BB 15.3	BB 16.1	BB 16.2	BB 16.3	BB 17.1	BB 17.2	BB 17.3	BB 18.1	BB 18.2	BB 18.3	BB 19.1	BB 19.2	BB 19.3	BB 20.1	BB 20.2	BB 20.3
Chamelea gallina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dosinia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dosinia exoleta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thracia sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cochlodesma praetenue	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-
Bryozoa																		
Alcyonidium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P
Triticella flava	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-
Conopeum reticulum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electra pilosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P
Phoronida																		
Phoronis spp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Echinodermata																		
Ophiurida sp. Juv.	-	-	-	-	-	-	3	1	1	-	-	-	-	-	-	-	-	-
Amphiura sp. Juv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acronida brachiata	-	1	-	-	1	-	-	-	-	3	-	1	-	-	-	-	-	-
Amphiura filiformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophiura sp. Juv.	1	-	-	5	6	7	4	4	3	-	1	-	-	-	-	-	-	-
Ophiura ophiura	1	-	-	2	2	2	-	3	3	2	2	2	-	-	-	-	-	-
Echinocyamus pusillus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Echinocardium cordatum	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
Pisces																		
Solea solea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 5

Species list from grabs collected over the 14th and 16th September 2006.

Class	Family	Name	Authority
Crustacea			
Maxillopoda		Parasitic copepoda sp	
Eumalacostraca	Ampeliscidae	Ampelisca brevicornis	Costa (1853)
	Bodotriidae	Iphinoe trispinosa	Goodsir (1943)
	Corystidae	Corystes cassivelaunus	Bosc (1802)
	Crangonidae	Crangon allmanni	Kinahan (1857)
	Crangonidae	Crangon crangon	Linnaeus (1758)
	Crangonidae	Crangon trispinosus	Halistone (1835)
	Dexaminidae	Atylus falcatus	Metzger (1871)
	Diastylidae	Diastylis bradyi	Norman, 1879
	Diastylidae	Diastylis laevis	Norman, 1869
	Diastylidae	Diastylis rathkei	Kroyer (1841)
	Idoteidae	Idotea linearis	Pennant (1777)
	Lysianassidae	Orchomene nanus	Kroyer (1846)
	Melphidippidae	Megaluropus agilis	Hoek (1889)
	Mysidae	Gastrosaccus spinifer	Goes (1864)
	Mysidae	Schistomysis kervillei	G O Sars (1885)
	Oedicerotidae	Perioculodes longimanus	Bate & Westwood (1868)
	Oedicerotidae	Pontocrates arenarius	Bate (1858)
	Oedicerotidae	Synchelidium maculatum	Stebbing (1906)
	Paguridae	Pagurus bernhardus	Linnaeus (1758)
	Pontoporeiidae	Bathyporeia elegans	Watkin (1938)
	Pontoporeiidae	Bathyporeia sp. Juv	Lindstrom (1885)
	Pontoporeiidae	Bathyporeia guilliamsoniana	Bate (1956)
	Portunidae	Liocarcinus sp. Juv.	
	Portunidae	Liocarcinus holsatus	Fabricius (1798)
	Portunidae	Portumnus latipes	Pennant (1777)
	Thiidae	Thia scutellata	(Fabricius, 1793)
Annelida			
Polychaeta	Aphroditidae	Aphrodita aculeata	Linnaeus (1758)
	Capitellidae	Capitella capitata	Fabricius (1780)
	Capitellidae	Mediomastus fragilis	Rasmussen (1973)
	Cirratulidae	Chaetozone christie	
	Cirratulidae	Chaetozone setosa	Malmgren (1867)
	Eunicidae	Marphysa bellii	Audouin and Milne-Edwards (1833)
	Glyceridae	Glycera sp. juv.	
	Glyceridae	Glycera oxycephala	Ehlers (1887)
	Glyceridae	Glycera tridactyla	Schmarda (1861)
	Hesionidae	Podarkeopsis capensis	Day (1963)
	Magelonidae	Magelona filiformis	Wilson (1959)
	Magelonidae	Magelona mirabilis	Johnston (1865)
	Magelonidae	Magelona johnstoni	Johnston (1865)
	Maldanidae	Clymenura johnstoni	McIntosh (1915)
	Nephtyidae	Nephtys sp. Juv.	

Class	Family	Name	Authority
	Nephtyidae	Nephtys assimilis	Oersted (1843)
	Nephtyidae	Nephtys caeca	Fabricius (1780)
	Nephtyidae	Nephtys cirrosa	Ehlers (1868)
	Nephtyidae	Nephtys hombergii	Savigni (1818)
	Nereididae	Nereis longissima	Johnston (1840)
	Opheliidae	Ophelia borealis	Quatrefages (1866)
	Orbiniidae	Scoloplos armiger	O F Muller (1776)
	Oweniidae	Owenia fusiformis	Chiaje (1842)
	Paraonidae	Aricidea cerrutii	Laubier (1966)
	Pectinariidae	Lagis koreni	Malmgren (1866)
	Pholoidae	Pholoe baltica	
	Phyllodocidae	Eteone longa/flava (agg.)	Fabricius (1780)
	Phyllodocidae	Anaitides groenlandica	Oersted (1842)
	Phyllodocidae	Anaitides mucosa	Oersted (1842)
	Phyllodocidae	Anaitides rosea	McIntosh (1877)
	Poecilochaetidae	Poecilochaetus serpens	Allen (1904)
	Polynoidae	Gattyana cirrosa	Pallas (1766)
	Polynoidae	Malmgrenia arenicolae	
	Scalibregmatidae	Scalibregma inflatum	Rathke (1843)
	Sigalionidae	Sthenelais limicola	Ehlers (1864)
	Spionidae	Aonides paucibranchiata	Southern (1914)
	Spionidae	Scolelepis (Scolelepis) bonnieri	Mesnil (1896)
	Spionidae	Spio decorata	Bobretzky (1870)
	Spionidae	Spiophanes bombyx	Claparede (1870)
	Syllidae	Exogone hebes	Webster and Benedict (1884)
	Terebellidae	Lanice conchilega	Pallas (1766)
	Terebellidae	Polycirrus sp.	Grube (1850)
Oligochaeta		Oligochaeta spp.	
Platyhelminthes			
Platyhelminthes		Turbellaria sp.	
Nematoda			
Nematoda		Nemertea spp.	
Mollusca			
Gastropoda	Acteonidae	Acteon tornatilis	Linnaeus (1758)
	Astartidae	Goodallia triangularis	Montagu (1803)
	Naticidae	Polinices pulchellus	Risso (1826)
Pelecypoda	Donacidae	Donax vittatus	da Costa (1778)
	Mactridae	Mactra stultorum	Linnaeus (1758)
	Mactridae	Spisula solida	Linnaeus (1758)
	Mactridae	Spisula subtruncata	da Costa (1778)
	Montacutidae	Tellimya ferruginosa	Montagu (1808)
	Montacutidae	Mysella bidentata	Montagu (1803)
	Mytilidae	Mytilidae sp. Juv.	
	Nuculidae	Nucula sp. (Juv.)	
	Nuculidae	Nucula hanleyi	Winckworth (1931)
	Nuculidae	Nucula nitidosa	Winckworth (1930)
	Nuculidae	Nucula nucleus	Linnaeus (1758)
	Periplomatidae	Cochlodesma praetenue	Pulteney (1799)
	Pharidae	Pharus legumen	Linnaeus (1758)

Class	Family	Name	Authority
	Psammobiidae	Gari fervensis	Gmelin (1791)
	Semelidae	Abra alba	W Wood (1802)
	Tellinidae	Fabulina fabula	Gmelin (1791)
	Tellinidae	Moerella pygmaea	Loven (1846)
	Thraciidae	Thracia sp. Juv.	
	Veneridae	Chamelea gallina	Linnaeus (1758)
	Veneridae	Dosinia exoleta	Linnaeus (1758)
	Veneridae	Dosinia sp. juv.	
Echinodermata			
Ophiuroidea	Amphiuridae	Acronida brachiata	Montagu (1804)
	Amphiuridae	Amphiura sp. Juv.	
	Amphiuridae	Amphiura filiformis	O F Muller (1776)
	Ophiuridae	Ophiurida sp. Juv.	
	Ophiuridae	Ophiura sp. Juv.	
	Ophiuridae	Ophiura ophiura	Linnaeus (1758)
Echinoidea	Fibulariidae	Echinocyamus pusillus	O F Muller (1776)
	Loveniidae	Echinocardium cordatum	Pennant (1777)
Protozoa			
Protozoa	Folliculinidae	Lagotia viridis	
Cnidaria			
Leptolida	Bougainvilliidae	Bougainvillia sp.	Lesson (1830)
	Campanulariidae	Campanulariidae sp	
	Clytiinae	Clytia hemisphaerica	Linnaeus (1767)
	Phialellidae	Phialella quadrata	Forbes (1848_
	Sertulariidae	Hydrallmania falcata	Linnaeus (1758)
		Athecata sp. indet.	
Hexacorallia	Cerianthidae	Cerianthus lloydii	Gosse (1859)
	Edwardsiidae	Edwardsia claparedii	Panceri (1869)
	Sagartiidae	Sagartiidae sp.	
		Actiniaria sp	
Hydrozoa	Calycellidae	Calycella syringa	Linnaeus (1767)
Bryozoa			
Gymnolaemata	Alcyonidiidae	Alcyonidium sp.	Lamouroux (1813)
	Electridae	Electra pilosa	Linnaeus (1767)
	Membraniporidae	Conopeum reticulum	Linnaeus (1767)
	Triticellidae	Triticella flava	Dalyell (1848)
Phoronida			
Phoronida	Phoronidae	Phoronis sp.	
Entoprocta			
Entoprocta	Pedicellinidae	Pedicellina sp.	
	Pedicellinidae	Pedicellina cernua	Pallas (1774)

Annex 1(5) c.1 Intertidal Baseline Biotope Survey

SeaScape
Energy

Burbo Bank Offshore Wind Farm

Baseline and Rapid Assessment Intertidal Ecology Monitoring

Document: J3034 Intertidal baseline and post installation v3 (04-08)

Version	Date	Description	Prepared by	Checked by	Approved by
0	01-07	Internal Draft	KJN		
1	03-07	Issued draft	KJN	IGP	IGP
2	11-07	Minor edits	IGP	LG	IGP
3	04-08	Added exec summary	KJN		

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Cover photograph: Export cable laying works at Wallasey foreshore.

Contents

EXECUTIVE SUMMARY

Burbo Offshore Wind Farm is a twenty-five turbine, 90MW development located in Liverpool Bay approximately 6km from the coastlines of Wirral, Crosby and Liverpool.

A licence was issued to the wind farm developer, SeaScape Energy Ltd, which allows them to construct and operate the wind farm providing certain conditions are met. The licence (31864/07/0) was issued under the Food and Environment Protection Act (FEPA) and contains a specific requirement to undertake invertebrate sampling across the foreshore in the cable landfall area.

To provide a baseline for monitoring, a walkover biotope survey and sediment core sampling were carried out in July 2006 with a further round of core sampling in November 2006 to investigate immediate impacts of cable burial. Invertebrates in the July cores were identified to species where possible, counted and total biomass for each sample was estimated by blotted wet-weight analysis. The invertebrates from the November cores were split into higher taxonomic groups (phylum or class) only, counted and weighed for biomass to provide a rapid assessment.

Three biotopes were identified, but a mobile sand and sparse fauna biotope dominated the surveyed area. Thirty-six species were identified from the samples with polychaete worms most frequently represented followed by amphipod shrimps. Numbers of individuals and biomass were generally low but varied greatly between sample, station and month.

The biotopes and invertebrate fauna were as expected for this kind of shore; mobile sand dominated by errant groups such as amphipods and burrowing polychaetes, with large numbers of tube building polychaetes fixed in the sand.

Although there were some appreciable differences in faunal composition, numbers and biomass between the July and November samples, it was not possible to separate seasonal effects from effects of cable burial and a further round of sampling is recommended for July 2007.

1 INTRODUCTION

Intertidal invertebrate sampling was included as a condition of the Food and Environment Protection Act (FEPA) licence (Ref 31864/03/0) issued to SeaScape Energy Ltd for Burbo Bank offshore wind farm.

The following is an extract of relevant text from the FEPA licence:

> *''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.''*

Centre for Marine and Coastal Studies Ltd (CMACS) has been appointed by SeaScape Energy Ltd to devise and undertake pre and during-construction surveys to fulfil requirements for environmental sampling and monitoring under the FEPA licence. Accordingly, CMACS discussed the requirements for intertidal invertebrate sampling with consultees and devised agreed survey methods and programme (CMACS 2006a).

The survey strategy was specifically adapted to meet a request from Michael Young of English Nature (now Natural England) for additional intertidal work in relation to information provided for an appropriate assessment of cable landfall works (CMACS 2005). The methods have been designed to assess the effect of cable trenching on the intertidal invertebrates as a food resource for birds.

The survey programme was scheduled around installation of three submarine power export cables installed from the offshore wind farm through to a shore connection behind sea defences on north Wirral foreshore. Cables were buried approximately 3m below the sediment surface using a cable plough device.

The cable installation process included a 'pre-lay grapnel run' (PLGR) along each export cable route using the cable plough device but without actually installing cable. This was done to check for obstructions that might damage the cable and is considered equivalent to cable installation in terms of environmental effects.

The PLGR took place in July 2006, cable installation works commenced the following month on 25th August 2006 and trenching operation took place during suitable weather windows over the next week or so, and was completed on September 2nd. The total route length was just over 8km; during suitable weather conditions the trenching proceeded at a rate of approximately 250m per hour with pauses of 30 minutes or so to re-position anchors when required.

The final intertidal invertebrate survey strategy comprises:

1. baseline biotope survey shortly before PLGR works in July 2006, supported by sediment core samples;
2. a photographic survey in July 2006 immediately after PLGR works to record physical recovery of the route;
3. repeat sediment core sampling in November 2006 after final cable landfall works ('rapid assessment sampling');
4. repeat biotope survey planned for July 2007 if a detectable impact is revealed by step 3.

The photographic survey (2, above) was reported in CMACS (2006b). Detail on cable installation methodology was summarised in CMACS (2006c). The results of the baseline (pre-construction) intertidal biotope mapping (1) and rapid assessment post-construction intertidal invertebrate sampling (3) are reported here.

2 METHODS

Access to the site was from a car park at the top of the shore near to the cable landfall where it was possible to descend the sloping concrete sea defence to the beach level. The shore at New Brighton is gently sloping and more than 3 km of intertidal is exposed on large tides. As a result, the flood tide advances up the shore at a rapid rate and field personnel completed the surveys at least 30 minutes before low water to give sufficient time to return to the top of the shore safely. In addition, all personnel wore inflatable lifejackets.

The monitoring approach was as follows:

1. Biotope Survey
    a. Walk over biotope survey of the cable route corridor supported by sediment core samples.
    b. Additional $1m^2$ quadrats to check for presence of larger burrowing animals that might be missed by core sampling.
2. Rapid Bioassessment
    a. Re-sampling of selected sediment cores from 1, a.

The distribution of sample sites in relation to the cable routes is described in Figure 1.

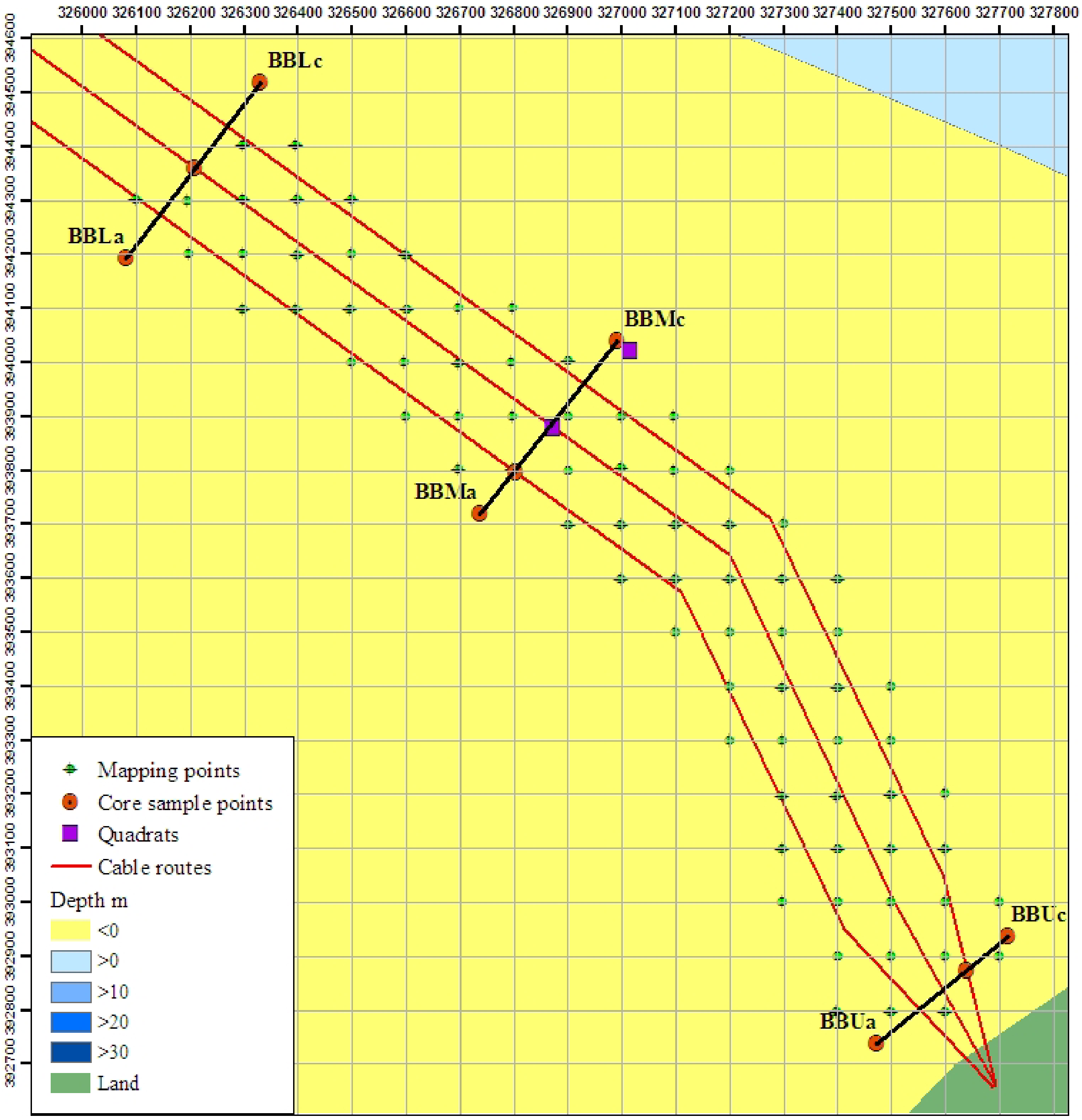


Figure 1. Survey points and sample points for biotope mapping over the intertidal portion of the cable route. BB = Burbo Bank; L = lower shore; M = mid shore; U = upper shore for each cable route (a-c).

2.1 Biotope survey

The survey was designed in line with the most recent MNCR methodologies (Wyn *et al*. 2000). The proposed cable route was overlaid by a grid of 100m squares and a mapping point established at each cross point along the cable route corridor (see Figure 1). The survey was carried out by following a pre-programmed route on a hand-held GPS. At each of the mapping points the biotope was identified using the latest (v. 04.05) biotope manual and noted as a target note for that point. Hand searching with a trowel and sieve aided biotope classification in the field.

Intertidal biotope survey was carried out on 13th July and sampling was carried out on 13th July, two weeks before PLGR works, and 23rd November 2006, one week after confirmation was received that cable installation works had been completed. The July survey was carried out on the largest amplitude spring tide for that month. Low water on spring tides tends to occur early in the morning in Liverpool Bay and therefore the November survey was carried out on the largest amplitude tide that occurred in daylight.

2.2 Sediment core samples

Sediment core samples were taken on three shore-perpendicular transects across the cable routes on the lower, mid and upper shore (see Figure 1). Each transect had three sampling stations:

1. within the cable route corridor directly on top of the planned position of one of the cables;
2. either side of the cable route corridor; and,
3. 100m distant from the cable route corridor.

At each site three cores were taken to a depth of 15cm for to provide quantitative data on intertidal invertebrate communities. One additional core sample was obtained at each site for sediment particle size analysis (July samples only). The cores were taken to provide information on the abundance of infaunal species and the available prey for shore birds. In addition, invertebrate and particle size data from the cable route cores was used to confirm biotope identification.

Cores were transported to the laboratory in coolboxes with coldblocks, washed through a 500μm sieve and preserved in 4% buffered formalin. All organisms from the July samples were identified to species level, whereas those from the November samples were split into higher taxonomic groups (Phylum or Class). This coarser treatment of the November samples was to enable a rapid assessment of any immediate effects on faunal abundance from the cable burial works. All the organisms from each sample were weighed (as blotted wet-weight) on analytical scales to provide information on the biomass available at each station.

2.3 Quadrats

During an initial walk-over of the cable route site, tests (dead remains) of the sea potato *Echinocardium caudatum*, and shells of the sand gaper *Mya arenaria*, razor shell *Ensis siliqua* and the razor shell-like bivalve *Pharus legumen* were present protruding from and on the surface of the sand. These large species are unlikely to be sampled satisfactorily by core samples as they are generally present at low density and buried deep in the sand. However, they are potentially more vulnerable to disturbance caused by cable burial since individuals are long-lived and reproduce relatively slowly compared to other intertidal invertebrate groups such as certain amphipods and polychaetes. The bivalves have been noted to be important as a food source for shorebirds, especially oystercatchers and curlews, but are probably less important than smaller and more abundant bivalves, polychaetes and crustaceans on the shore.

It was decided to perform a limited and specific survey for these species at two stations on the midshore transect (see Figure 1). One station was placed over the central cable and the other 100m to the northeast of the cable route corridor.

A $1m^2$ quadrat was laid on the sediment surface at the site and dug out with a spade to a depth of 30-40cm and washed through a garden sieve (6mm mesh). All organisms retained in the sieve were identified, counted in the field and returned live to the sediment as quickly as possible.

3 RESULTS AND DISCUSSION

3.1 Biotope mapping

A biotope map of the intertidal cable route corridor is presented in Figure 2.

Three biotopes were identified from field notes taken on the walkover survey and from the invertebrate cores and particle size analysis. The site was dominated by LS.LSa.FiSa.Po.Ncir - *Nephtys cirrosa* dominated littoral fine sand. This was characterised on the walkover survey by large areas of standing water and obvious ripples in the sand with occasional casts of the lugworm *Arenicola marina*. From the mid to upper shore may have been classified as LS.LSa.MoSa.AmSco – Amphipods and *Scolelepis* spp. in littoral medium-fine sand. However, the presence of small numbers of nemerteans, *Spiophanes bombyx*, *Angulus tenuis* and particularly *Nephtys* spp. suggested that is was probably LS.LSa.FiSa.Po.Ncir with a reduced fauna and had the ‘part’ suffix added to the label on the map.

At the very top of the shore there was a small patch of LS.LSa.MuSa.CerPo - *Cerastoderma edule* and polychaetes in littoral muddy sand. This was based around the Ua sampling station which was revealed to have a distinctly different particle size distribution, with a greater proportion of fine sediment than any of the other sites. The fauna was somewhat different to the other upper shores sites, lacking *Scolelepis* in any numbers but with much higher abundances of bivalves and the spionid polychaete *Pygospio elegans*.

At the bottom of the shore, there was much less standing water and the sand was not as obviously drawn up into sand waves. Here there was abundant evidence of razor shells *Ensis* sp. and there were sea potatoes *Echinocardium cordatum* of various sizes and condition in at least one of each core sample from the lower shore stations. On the basis of these two species and supported by other species present the biotope of the lower shore was classified as SS.SSA.ImuSa.EcorEns - *Echinocardium cordatum* and *Ensis* spp. in lower shore and shallow sublittoral slightly muddy fine sand.

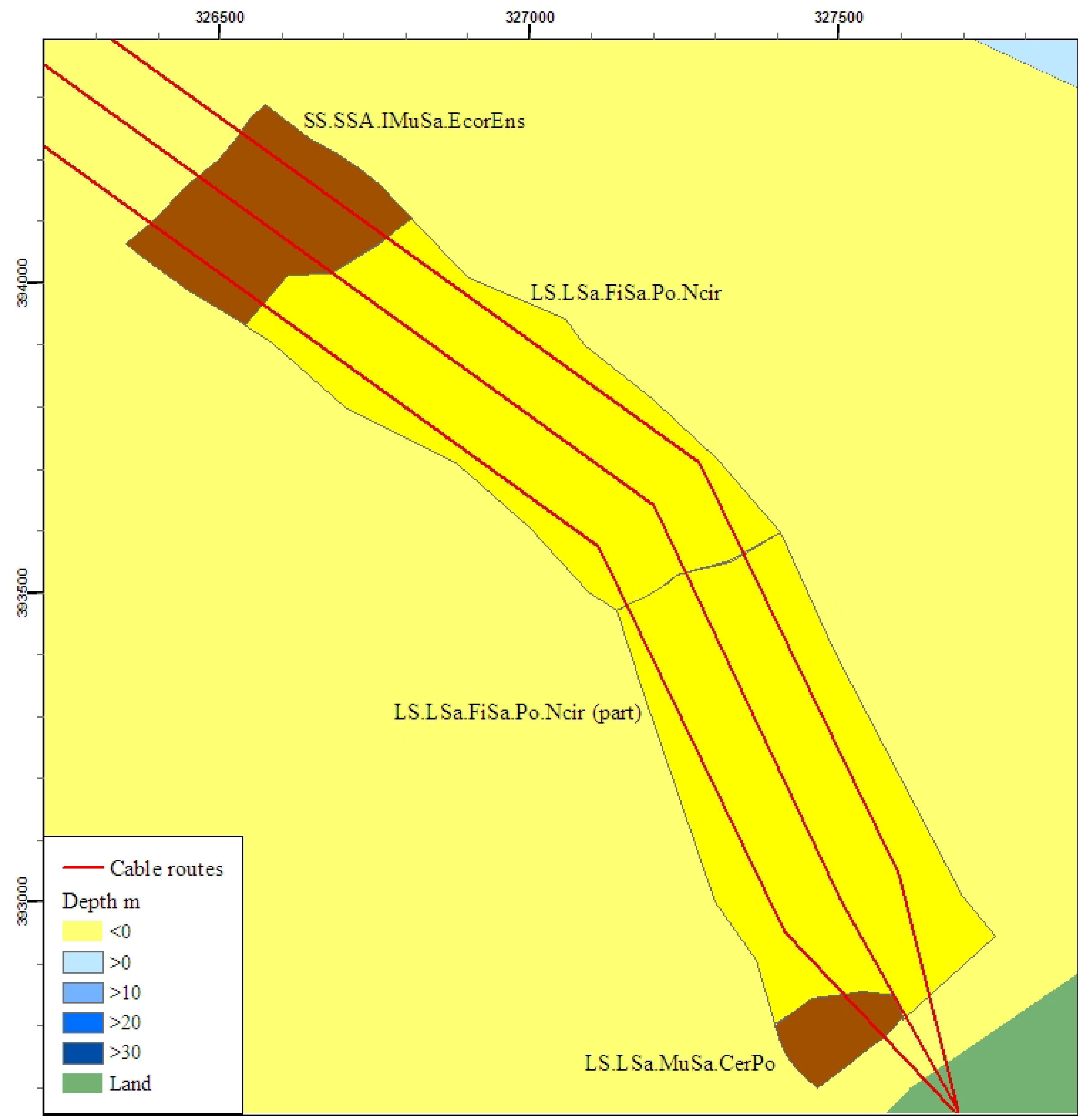


Figure 2. Biotope map of the intertidal portion of the cable route corridor (July 2006 baseline survey).

3.2 Sediment core samples (rapid assessment sampling)

3.2.1 Intertidal invertebrates

Raw data are provided in Appendix 2.

Samples were obtained from all nine stations in July and five stations in November. The lower shore samples in July were taken higher up the beach than originally planned as the tide did not retreat far enough to reach the plotted points. The actual sampling points are shown in Figure 3.

Direct comparisons between July and November surveys can only be made for the upper shore and middle shore stations as the tide did not have sufficient amplitude to expose the lower shore stations sampled in July (even though these were slightly higher up the beach than planned, as noted above). Samples were taken at the low water mark in November but these were only 100m downshore from the middle shore stations and are not included in the comparison.

Thirty six invertebrate taxa were identified to species level with a further nine taxa identified to genus or higher taxonomic level. Polychaetes dominated in terms of diversity with 14 species identified, followed by amphipods with nine species. Bivalves, gastropods, echinoderms, nematodes, oligochaetes, nemerteans, decapods and cumaceans were also represented. The lower shore samples tended to be the most speciose and the upper shore samples the least.

Polychaetes also dominated in terms of numbers with *Pygospio elegans* and *Magelona johnstoni* reaching a maximum mean density (MMD) of 567/m^2 at station Ua and 500/m^2 at station Ma respectively. Species of the amphipod genus *Bathyporeia* were almost as abundant reaching MMDs of 467/m^2 at station Ua (*B. sarsi*) and 400/m^2 at station Lb (*B. elegans*). Also abundant were the polychaetes *Eteone longa* agg. (MMD 467/m^2 at station Lb), small *Nephtys* sp. (MMD 433/m^2 at station La) and *Spiophanes bombyx* (MMD 333/m^2 at stations Ua and Mb).

A comparison between the numbers of organisms of all taxonomic groups found in July and November samples from two of the upper shore and middle shore stations is displayed in figure 4(i). In addition, comparisons between the numbers of the principle groups (polychaetes, amphipods and bivalves) are shown in Figures 4(ii)-(iv). Numbers of organisms were highly variable both between sample stations and between replicates from the same station. There were much higher numbers of organisms in July on the mid shore than in November, which was mainly due to large numbers of polychaetes on this part of the shore in July. Upper shore communities were more variable with lower numbers of invertebrates in July than in November at the station Ub, which was entirely due to very high numbers of amphipods which exceeded numbers for this group for all other stations in both months.

Higher numbers of invertebrates were found in July at station Ua than in November due to higher numbers of amphipods and bivalves in July (polychaete numbers were similar between months at this sampling station). With the exception of a single replicate (Ua2), polychaete numbers were higher in July than in November. Amphipod abundances were higher in July than in November at Ua and Mb, and higher in July at two out of three replicates at Ma but higher in November than in July at Ub.

Bivalve numbers were generally low with the exception of station Ua in July. In November only a single individual was found at Ua but two individuals were found at Ub where none had been recorded in July.

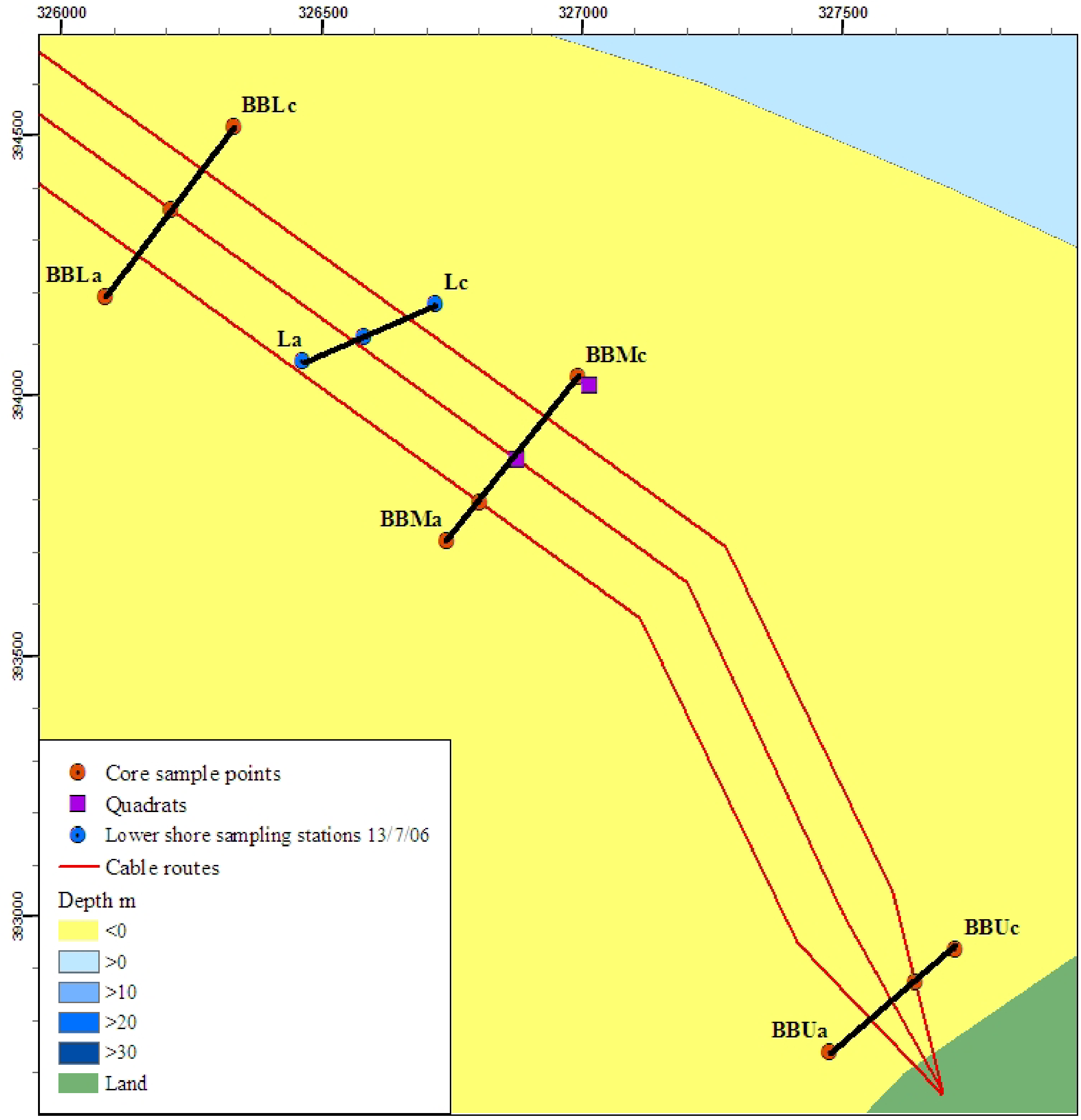


Figure 3. Sampling points for intertidal cores 13th July 2006. The upper and mid-shore samples were taken as planned, but the tide did not retreat far enough to expose the orange lower shore sample points and these samples were taken at the lowest limit of the tide on that date and are represented by the blue points.

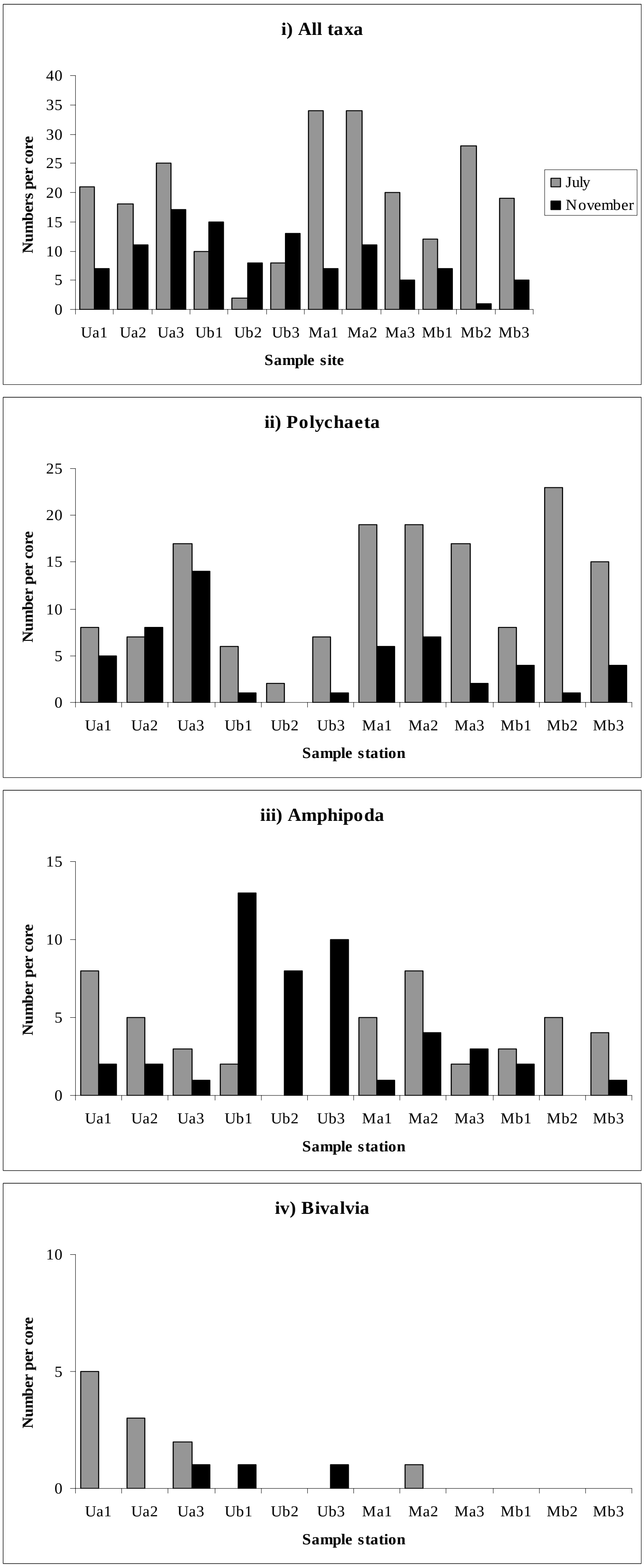


Figure 4. Numbers of all taxa and principle taxonomic groups found in the July and November sediment core samples.

3.2.2 Biomass

The data on biomass as wet weight provides information on the quantity of biological material 'available' to consumers such as flatfish and wading birds.

Both biomass and numbers of individuals were generally very variable between replicates at each station and average values were calculated. Averages were then multiplied by 100 to provide biomass and numbers per square metre. Average number of individuals at each sampling station are displayed in Figure 5. Biomass data for the July samples is presented in Figure 6 and a comparison between the upper and middle shore stations between July and November is presented in Figure 7.

The distribution of individual organisms down and across the shore was not reflected in the distribution of biomass. The highest average number of individuals were found at stations Ma and at Lc; however these sites also had some of the lowest biomass. Site Ua had a mid range number of individuals but by far the highest biomass, due to the presence of large individuals of the thin tellin *Angulus tenuis* and Baltic tellin *Macoma balthica*. Sites Ma and Lc, however, had large numbers of small organisms, particularly amphipods and spionid polychaetes. The highest combined biomass for any one replicate was just over 2g per m^2 for Ua1. There was a large individual of *Echinocardium cordatum* in Lc1 which weighed 54g; however, it was decided to omit this measurement from the data displayed in the figures since adults of this species generally burrow deep into the sediment and are not considered prey for fish or wading birds. Including this data would have skewed the results unrealistically to the lower shore and confused meaningful comparison of available biomass between sampling stations.

Of the four sites where comparisons are made between July and November, biomass was higher at three of the sites in July. Biomass was higher in November at site Mb; there were no bivalves at this station in either July or November that could influence the biomass with a single individual. It is interesting to note that numbers of individuals at site Mb were much higher in July than November, suggesting that there were some very large organisms, probably polychaetes (e.g. adult *Nephtys* sp.), present. In addition, a mysid shrimp was found at station Mb1 in November which may have contributed considerably to the total biomass. At the other sites there had been marked decreases in biomass and because this decline occurred at both the cable burial sites and the control sites it is probable that this is a seasonal effect rather than a result of the cable burial works.

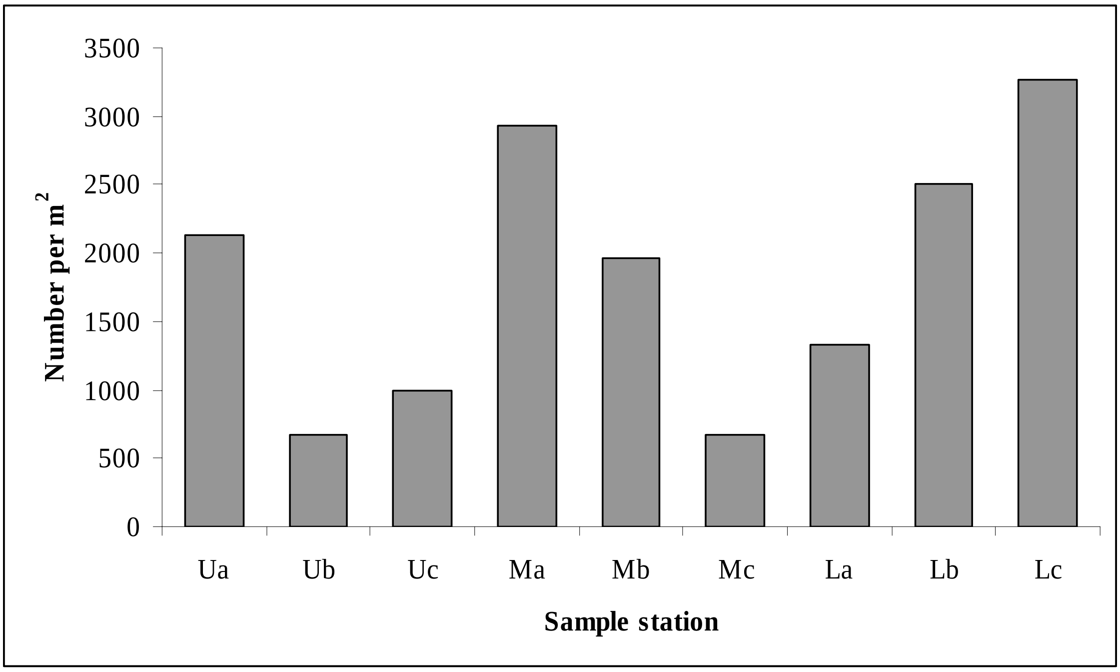


Figure 5. Average number of individuals of all taxa found at each sample station in July 2006.

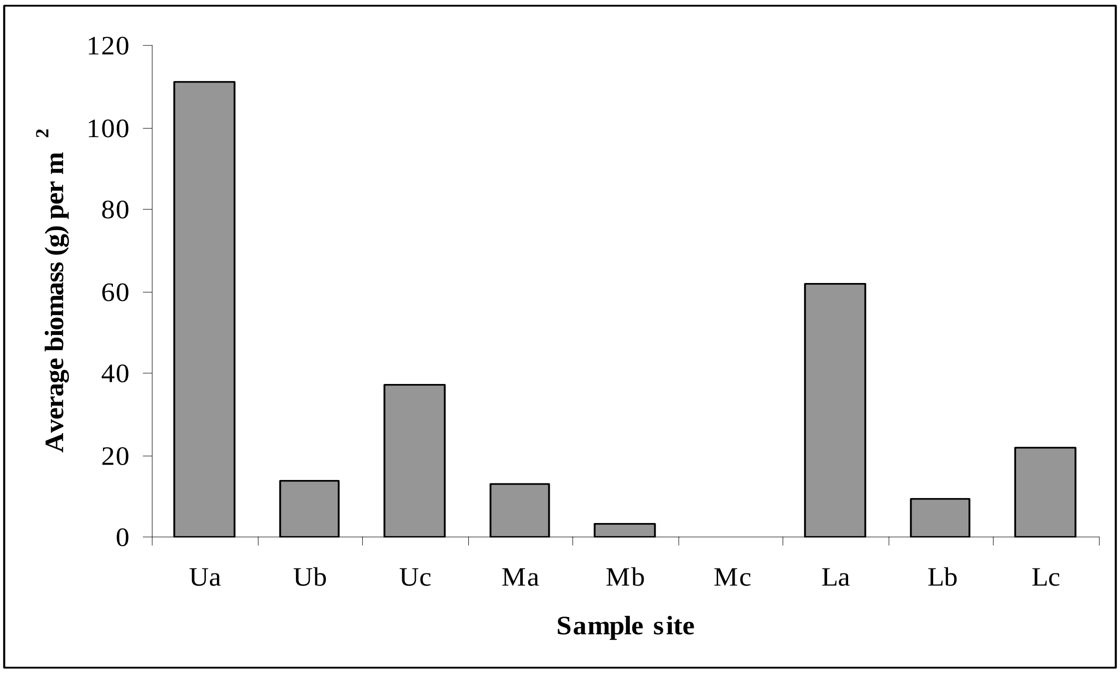


Figure 6. Average biomass per metre squared for each of the sampling stations in July 2006.

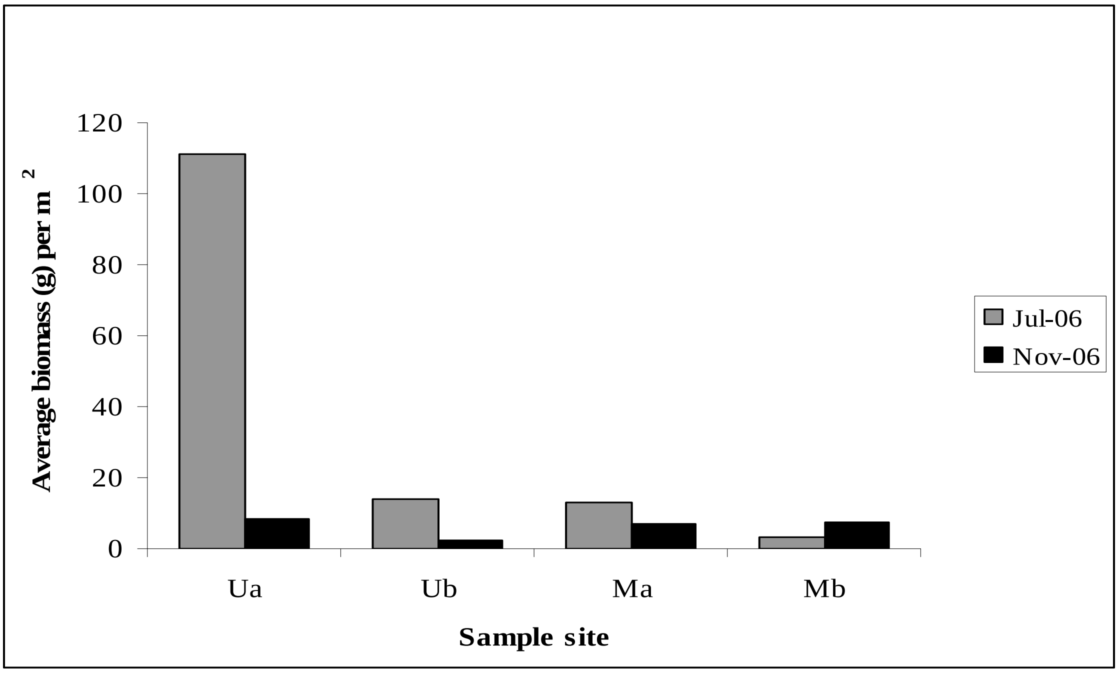


Figure 7. Comparison of average biomass per metre squared between July and November samples.

3.2.3 Particle size analysis (July samples)

Particle size analysis indicated that the shore was made up of mainly coarse and medium sands with the finer sands at the top of the shore. On the lower and middle shore, the majority of the sediment was medium sand making up between 40 and 65% of each sample with a further 15-25% fine sand and 25-35% coarse sand. The upper shore samples had a much higher proportion of fine sand, reaching nearly 70% at station Ua and with lower proportion of coarse sand.

Table 1. Fractional data as percentage of total start dry weight.

Sample site	La	Lb	Lc	Ma	Mb	Mc	Ua	Ub	Uc
Sieve (mm)	% Weight of Fraction								
5	0.42	0.36	0.22	0.98	0.20	0.31	0.38	0.07	0.19
2	0.09	0.19	0.44	1.07	0.03	0.03	0.01	0.23	0.49
1	0.22	0.28	0.56	0.99	0.15	0.08	0.03	0.30	0.61
0.600	0.21	0.20	0.70	0.90	0.13	0.10	0.03	0.23	0.56
0.425	0.82	0.49	1.31	1.89	0.82	0.44	0.11	2.67	0.95
0.300	25.56	30.29	3.69	35.22	35.87	28.73	4.60	17.11	23.01
0.212	51.34	46.21	66.10	39.72	40.84	51.88	11.84	26.02	32.86
0.150	18.96	20.10	25.69	17.15	20.13	16.97	67.95	46.91	35.26
0.063	2.32	1.86	1.23	2.05	1.80	1.43	14.92	6.41	6.04
<0.063	0.05	0.03	0.05	0.04	0.02	0.02	0.13	0.05	0.04

Table 2. Descriptions of sediment types based on the Wentworth Scale

Site	Wentworth description
La	Well sorted coarse sand
Lb	Well sorted coarse sand
Lc	Well sorted coarse sand
Ma	Moderately well sorted coarse sand
Mb	Moderately well sorted coarse sand
Mc	Well sorted coarse sand
Ua	Very well sorted medium sand
Ub	Moderately well sorted medium sand
Uc	Moderately well sorted medium sand

3.3 Quadrats

Two $1m^2$ quadrats were dug as planned on the mid-shore to a minimum depth of 30cm. However, thorough sieving of the excavated sediment revealed no large organisms and it became apparent that the shells noted scattered on the shore had probably been washed up from deeper water. Similarly, it was not necessary to dig quadrats on the lower shore as the cores sampled sea potatoes *Echinocardium cordatum* satisfactorily and an appreciation of razor shell *Ensis* sp. numbers could gained by noting signs of their burrowing whilst surveying the shore. Therefore quadrats were not repeated during the post cable-burial survey in November 2006.

4 CONCLUSIONS

The biotopes present within the cable route on the North Wirral foreshore were as expected for this area. A previous intertidal biotope map was produced by CMACS for the environmental statement (SeaScape Energy, 2002, see Appendix 1) which showed that the majority of the shore was dominated by sand with amphipods and polychaetes with muddy areas at the very top and bottom of the shore. The 2006 pre-construction survey revealed that little has changed in the intervening years.

The invertebrate fauna was also as expected for this kind of shore; dominated by highly mobile groups such as amphipods and burrowing polychaetes, with large numbers of tube building polychaetes fixed in the sand.

Due to weather-related delays, the cable-laying barge was unable to complete the burial works until the autumn. This placed constraints on the post-construction re-survey of the shore in terms of daylight access to the shore at low water and also the comparability of data. However, some comparison was possible between the data for the upper and middle shores between July and November. These comparisons revealed substantial variation in numbers of invertebrates both between sites and between months. It was apparent, however, that there was no link between the cable burial works and variation in invertebrate numbers or biomass. This was mainly due to a recorded increase in biomass of bivalves on the cable burial route that could not have been due to colonisation within four months.

Overall it was expected that any effect of the cable burial works would have the greatest impact on slow growing and non-mobile organisms such as bivalve molluscs whereas mobile species, such as amphipods, would not be particularly affected. The data do not bear this out, however, seasonal effects are probably masking any effect of the cable burial works.

The data from the survey described in this report and from previous surveys has shown the intertidal area within the cable route of the Burbo Bank offshore wind farm to comprise of mobile sands with a fauna of opportunistic species, many of which are highly mobile and it is likely that the area affected by cable burial works recovered quickly. However, due to the temporal separation of the pre- and post works sampling, it is apparent that seasonal effects have made it difficult to reach conclusions on the effect of the cable works. Therefore, it is proposed that a repeat walk-over survey with limited core sampling in support is carried out in July 2007 to allow direct comparison with the data collected during July 2006.

References

CMACS (2005) Burbo Bank Offshore Wind Farm. Provision of data for use in an Appropriate Assessment of the lkely effects of the intertidal cable route on the Mersey Narrows and North Wirral Foreshore proposed Special Protection Area (pSPA). Version 1.0, December 2005.

CMACS (2006a) Burbo Bank Offshore Wind Farm FEPA Monitoring Methods. Version 1.5, 15th August 2006.

CMACS (2006b) Burbo Offshore Wind Farm Pre-construction Photographic Cable Route Survey. Version 2.0, 11th August 2006.

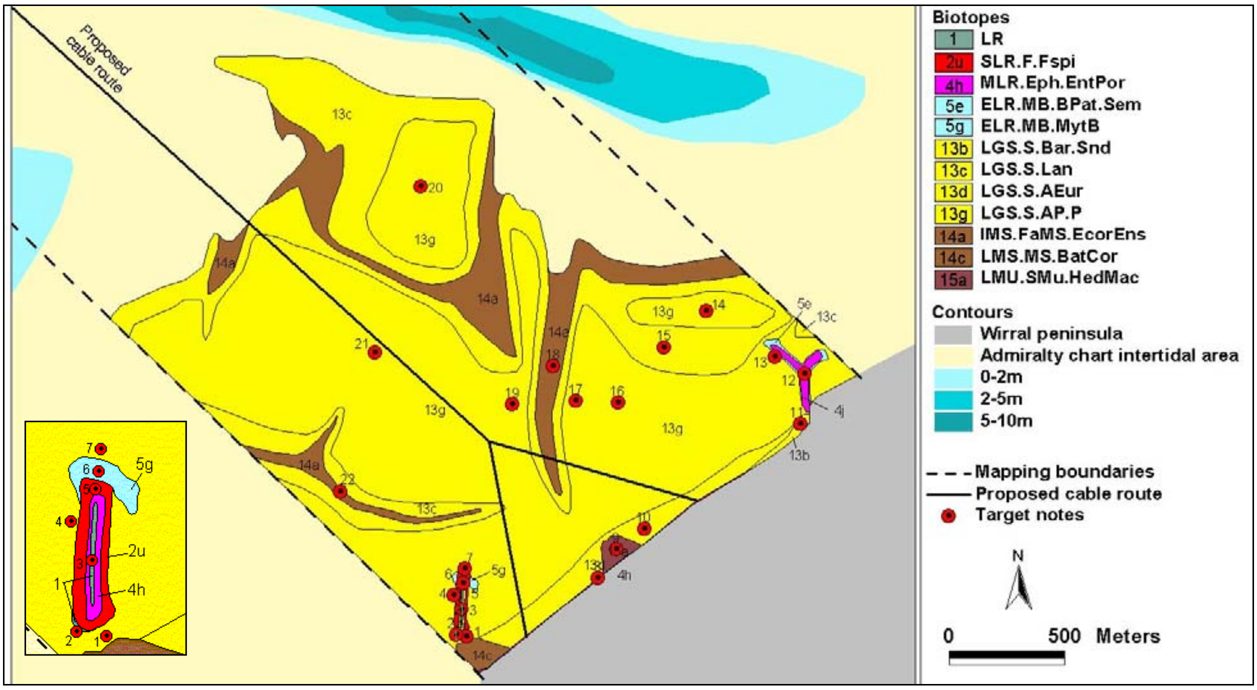
CMACS (2006c) Burbo Offshore Wind Farm Suspended Sediment Concentration Monitoring. Version 1.0, December 2006.

SeaScape Energy (2002) Burbo Offshore Wind Farm Environmental Statement.

Wyn, G, Brazier, P and McMath, M (2000) *CCW's Handbook for Marine Intertidal Phase 1 Survey and Mapping.* Countryside Council for Wales Marine Science Report: 00/06/91. Countryside Council for Wales, Bangor.

Appendix 1

Original biotope mapping (CMACS for SeaScape Energy 2002).



Appendix 2. Intertidal invertebrate raw data.

	BBI Ua			BBI Ub			BBI Uc		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Angulus tenuis	1	1	0				1	0	0
mean (per square metre)			66.667						33.333
SD			0.5774						0.5774
Atylus swammerdami									
mean (per square metre)									
SD									
Bathyporeia elegans									
mean (per square metre)									
SD									
Bathyporeia pilosa							1	0	0
mean (per square metre)									33.333
SD									0.5774
Bathyporeia sarsi	6	5	3	2	0	0	3	2	7
mean (per square metre)			466.67			66.667			400
SD			1.5275			1.1547			2.6458
Bathyporeia guilliamsoniana									
mean (per square metre)									
SD									
Bathyporeia pelagica							0	1	0
mean (per square metre)									33.333
SD									0.5774
Bathyporeia sp.	2	0	0				0	0	3
mean (per square metre)			66.667						100
SD			1.1547						1.7321
Carcinus maenas	0	0	1						
mean (per square metre)			33.333						
SD			0.5774						
Cerastoderma edule	0	1	0						
mean (per square metre)			33.333						
SD			0.5774						
Cerastoderma edule (juv.)	2	0	1						
mean (per square metre)			100						
SD			1						
Corophium sp.									
mean (per square metre)									
SD									
Crangon crangon	0	1	1						
mean (per square metre)			66.667						
SD			0.5774						
Cumopsis goodsiri									
mean (per square metre)									
SD									
Diastylis rugosa									
mean (per square metre)									
SD									
Echinocardium cordatum									
mean (per square metre)									
SD									
Echinocardium sp. (damaged)									
mean (per square metre)									
SD									

	BBI Ua			BBI Ub			BBI Uc		
Echinocardium sp. Juv									
mean (per square metre)									
SD									
Eteone flava/longa									
mean (per square metre)									
SD									
Eumida sp.									
mean (per square metre)									
SD									
Glycera tridactyla									
mean (per square metre)									
SD									
Hydrobia ulvae	0	1	1	2	0	1			
mean (per square metre)			66.667			100			
SD			0.5774			1			
Lagis koreni									
mean (per square metre)									
SD									
Lanice conchilega									
mean (per square metre)									
SD									
Macoma balthica	1	1	1				0	1	0
mean (per square metre)			100						33.333
SD			0						0.5774
Mactridae sp. Juv									
mean (per square metre)									
SD									
Magelona johnstoni									
mean (per square metre)									
SD									
Magelona mirabilis									
mean (per square metre)									
SD									
Magelona sp. juv.									
mean (per square metre)									
SD									
Magelona sp. (damaged)									
mean (per square metre)									
SD									
Micropotopus maculatus									
mean (per square metre)									
SD									
Mysella bidentata									
mean (per square metre)									
SD									
Mytilidae sp. juv.									
mean (per square metre)									
SD									
Nematoda	0	1	0						
mean (per square metre)			33.333						
SD			0.5774						
Nemertea							0	0	1
mean (per square metre)									33.333
SD									0.5774

	BBI Ua			**BBI Ub**			**BBI Uc**		
Nephtys cirrosa				0	1	0			
mean (per square metre)						33.333			
SD						0.5774			
Nepthys hombergi	1	1	1	0	0	1			
mean (per square metre)			100			33.333			
SD			0			0.5774			
Nephtys sp. Juv.									
mean (per square metre)									
SD									
Nephtys sp (damaged)	0	0	1						
mean (per square metre)			33.333						
SD			0.5774						
Oligochaeta									
mean (per square metre)									
SD									
Ophelia borealis									
mean (per square metre)									
SD									
Ophiuroidea sp. Juv.									
mean (per square metre)									
SD									
Owenia fusiformis				0	0	1	0	0	1
mean (per square metre)						33.333			33.333
SD						0.5774			0.5774
Paradoneis lyra									
mean (per square metre)									
SD									
Perioculodes longimanus									
mean (per square metre)									
SD									
Polinices pulchellus									
mean (per square metre)									
SD									
Pontocrates altamarinus									
mean (per square metre)									
SD									
Portumnus latipes									
mean (per square metre)									
SD									
Pygospio elegans	3	5	9	1	1	4	0	1	1
mean (per square metre)			566.67			200			66.667
SD			3.0551			1.7321			0.5774
Scolelepis squamata				3	0	0	1	3	0
mean (per square metre)						100			133.33
SD						1.7321			1.5275
Scolelepis sp.	1	0	0	0	0	1	0	0	1
mean (per square metre)			33.333			33.333			33.333
SD			0.5774			0.5774			0.5774
Spiophanes bombyx	3	1	6	2	0	0	1	1	0
mean (per square metre)			333.33			66.667			66.667
SD			2.5166			1.1547			0.5774
Spionidae sp. (damaged)									
mean (per square metre)									
SD									

	BBI Ua	BBI Ub	BBI Uc
Tellimya ferruginosa			
mean (per square metre)			
SD			
Terebellidae sp (damaged)			
mean (per square metre)			
SD			

	BBI Ma			BBI Mb			BBI Mc		
	1	2	3	1	2	3	1	2	3
Angulus tenuis									
mean (per square metre)									
SD									
Atylus swammerdami									
mean (per square metre)									
SD									
Bathyporeia elegans	0	1	0	0	2	0	0	1	0
mean (per square metre)			33.3			66.667			33.333
SD			0.58			1.1547			0.5774
Bathyporeia pilosa							1	0	0
mean (per square metre)									33.333
SD									0.5774
Bathyporeia sarsi	0	1	0						
mean (per square metre)			33.3						
SD			0.58						
Bathyporeia guilliamsoniana	0	4	0				0	1	0
mean (per square metre)			133						33.333
SD			2.31						0.5774
Bathyporeia pelagica									
mean (per square metre)									
SD									
Bathyporeia sp.	1	1	0	3	3	3	0	1	0
mean (per square metre)			66.7			300			33.333
SD			0.58			0			0.5774
Carcinus maenas									
mean (per square metre)									
SD									
Cerastoderma edule									
mean (per square metre)									
SD									
Cerastoderma edule (juv.)									
mean (per square metre)									
SD									
Corophium sp.	4	1	2	0	0	1			
mean (per square metre)			233			33.333			
SD			1.53			0.5774			
Crangon crangon	2	1	0						
mean (per square metre)			100						
SD			1						
Cumopsis goodsiri	2	3	0	1	0	0			
mean (per square metre)			167			33.333			
SD			1.53			0.5774			
Diastylis rugosa									
mean (per square metre)									
SD									
Echinocardium cordatum									
mean (per square metre)									
SD									
Echinocardium sp. (damaged)									
mean (per square metre)									
SD									

	BBI Ma			BBI Mb			BBI Mc		
Echinocardium sp. Juv									
mean (per square metre)									
SD									
Eteone flava/longa	5	3	2	1	4	0	0	0	1
mean (per square metre)			333			166.67			33.333
SD			1.53			2.0817			0.5774
Eumida sp.									
mean (per square metre)									
SD									
Glycera tridactyla									
mean (per square metre)									
SD									
Hydrobia ulvae	3	0	1						
mean (per square metre)			133						
SD			1.53						
Lagis koreni	1	0	1						
mean (per square metre)			66.7						
SD			0.58						
Lanice conchilega									
mean (per square metre)									
SD									
Macoma balthica									
mean (per square metre)									
SD									
Mactridae sp. Juv									
mean (per square metre)									
SD									
Magelona johnstoni	6	6	3	2	4	3	1	0	0
mean (per square metre)			500			300			33.333
SD			1.73			1			0.5774
Magelona mirabilis	0	0	1	0	0	1			
mean (per square metre)			33.3			33.333			
SD			0.58			0.5774			
Magelona sp. juv.									
mean (per square metre)									
SD									
Magelona sp. (damaged)	0	0	1	1	0	2			
mean (per square metre)			33.3			100			
SD			0.58			1			
Micropotopus maculatus									
mean (per square metre)									
SD									
Mysella bidentata									
mean (per square metre)									
SD									
Mytilidae sp. juv.	0	1	0						
mean (per square metre)			33.3						
SD			0.58						
Nematoda	2	0	0						
mean (per square metre)			66.7						
SD			1.15						
Nemertea									
mean (per square metre)									
SD									

	BBI Ma			BBI Mb			BBI Mc		
Nephtys cirrosa	0	3	2						
mean (per square metre)			167						
SD			1.53						
Nepthys hombergi				1	2	3			
mean (per square metre)						200			
SD						1			
Nephtys sp. Juv.	2	3	4	1	6	3	1	2	0
mean (per square metre)			300			333.33			100
SD			1			2.5166			1
Nephtys sp (damaged)									
mean (per square metre)									
SD									
Oligochaeta	0	1	0						
mean (per square metre)			33.3						
SD			0.58						
Ophelia borealis									
mean (per square metre)									
SD									
Ophiuroidea sp. Juv.	1	0	0						
mean (per square metre)			33.3						
SD			0.58						
Owenia fusiformis	0	0	1	0	1	0			
mean (per square metre)			33.3			33.333			
SD			0.58			0.5774			
Paradoneis lyra							0	0	1
mean (per square metre)									33.333
SD									0.5774
Perioculodes longimanus									
mean (per square metre)									
SD									
Polinices pulchellus									
mean (per square metre)									
SD									
Pontocrates altamarinus									
mean (per square metre)									
SD									
Portumnus latipes	0	1	0						
mean (per square metre)			33.3						
SD			0.58						
Pygospio elegans									
mean (per square metre)									
SD									
Scolelepis squamata							3	0	0
mean (per square metre)									100
SD									1.7321
Scolelepis sp.							0	3	3
mean (per square metre)									200
SD									1.7321
Spiophanes bombyx	4	4	1	1	6	3			
mean (per square metre)			300			333.33			
SD			1.73			2.5166			
Spionidae sp. (damaged)	1	0	0				1	0	0
mean (per square metre)			33.3						33.333
SD			0.58						0.5774

	BBI Ma			BBI Mb			BBI Mc
Tellimya ferruginosa							
mean (per square metre)							
SD							
Terebellidae sp (damaged)	0	0	1	1	0	0	
mean (per square metre)			33.3			33.333	
SD			0.58			0.5774	

	BBI La			BBI Lb			BBI Lc		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Angulus tenuis							1	1	0
mean (per square metre)									66.67
SD									0.577
Atylus swammerdami							0	3	0
mean (per square metre)									100
SD									1.732
Bathyporeia elegans	0	2	1	4	5	3	1	6	0
mean (per square metre)			100			400			233.3
SD			1			1			3.215
Bathyporeia pilosa									
mean (per square metre)									
SD									
Bathyporeia sarsi							0	0	1
mean (per square metre)									33.33
SD									0.577
Bathyporeia guilliamsoniana	2	0	0	2	1	1	5	5	10
mean (per square metre)			66.667			133.33			666.7
SD			1.1547			0.5774			2.887
Bathyporeia pelagica									
mean (per square metre)									
SD									
Bathyporeia sp.	1	2	10	3	6	3	3	3	1
mean (per square metre)			433.33			400			233.3
SD			4.9329			1.7321			1.155
Carcinus maenas									
mean (per square metre)									
SD									
Cerastoderma edule									
mean (per square metre)									
SD									
Cerastoderma edule (juv.)									
mean (per square metre)									
SD									
Corophium sp.									
mean (per square metre)									
SD									
Crangon crangon	0	3	2						
mean (per square metre)			166.67						
SD			1.5275						
Cumopsis goodsiri									
mean (per square metre)									
SD									
Diastylis rugosa	0	0	1						
mean (per square metre)			33.333						
SD			0.5774						
Echinocardium cordatum							2	0	0
mean (per square metre)									66.67
SD									1.155
Echinocardium sp. (damaged)	1	0	0						
mean (per square metre)			33.333						
SD			0.5774						

	BBI La			BBI Lb			BBI Lc		
Echinocardium sp. Juv	0	1	0	0	1	1			
mean (per square metre)			33.333			66.667			
SD			0.5774			0.5774			
Eteone flava/longa	1	3	1	6	4	4	7	4	0
mean (per square metre)			166.67			466.67			366.7
SD			1.1547			1.1547			3.512
Eumida sp.							0	2	0
mean (per square metre)									66.67
SD									1.155
Glycera tridactyla							0	0	1
mean (per square metre)									33.33
SD									0.577
Hydrobia ulvae									
mean (per square metre)									
SD									
Lagis koreni									
mean (per square metre)									
SD									
Lanice conchilega				0	1	0			
mean (per square metre)						33.333			
SD						0.5774			
Macoma balthica									
mean (per square metre)									
SD									
Mactridae sp. Juv				0	1	0	2	0	0
mean (per square metre)						33.333			66.67
SD						0.5774			1.155
Magelona johnstoni	0	0	1	1	1	1	4	8	3
mean (per square metre)			33.333			100			500
SD			0.5774			0			2.646
Magelona mirabilis	0	1	0	0	1	0			
mean (per square metre)			33.333			33.333			
SD			0.5774			0.5774			
Magelona sp. juv.	1	0	0	1	0	0			
mean (per square metre)			33.333			33.333			
SD			0.5774			0.5774			
Magelona sp. (damaged)									
mean (per square metre)									
SD									
Micropotopus maculatus	0	1	0						
mean (per square metre)			33.333						
SD			0.5774						
Mysella bidentata							4	1	0
mean (per square metre)									166.7
SD									2.082
Mytilidae sp. juv.	0	1	0				0	1	0
mean (per square metre)			33.333						33.33
SD			0.5774						0.577
Nematoda									
mean (per square metre)									
SD									
Nemertea									
mean (per square metre)									
SD									

	BBI La			BBI Lb			BBI Lc		
Nephtys cirrosa	1	1	2	2	0	4			
mean (per square metre)			133.33			200			
SD			0.5774			2			
Nepthys hombergi	1	0	1	0	1	2	0	2	3
mean (per square metre)			66.667			100			166.7
SD			0.5774			1			1.528
Nephtys sp. Juv.	4	3	6	2	4	1	1	3	0
mean (per square metre)			433.33			233.33			133.3
SD			1.5275			1.5275			1.528
Nephtys sp (damaged)									
mean (per square metre)									
SD									
Oligochaeta									
mean (per square metre)									
SD									
Ophelia borealis				0	1	1	0	0	1
mean (per square metre)						66.667			33.33
SD						0.5774			0.577
Ophiuroidea sp. Juv.	0	0	1	0	1	0			
mean (per square metre)			33.333			33.333			
SD			0.5774			0.5774			
Owenia fusiformis	0	1	0	0	2	2			
mean (per square metre)			33.333			133.33			
SD			0.5774			1.1547			
Paradoneis lyra									
mean (per square metre)									
SD									
Perioculodes longimanus				0	0	1			
mean (per square metre)						33.333			
SD						0.5774			
Polinices pulchellus	1	0	0	0	1	0	0	0	1
mean (per square metre)			33.333			33.333			33.33
SD			0.5774			0.5774			0.577
Pontocrates altamarinus	1	0	0	1	0	0	1	0	0
mean (per square metre)			33.333			33.333			33.33
SD			0.5774			0.5774			0.577
Portumnus latipes									
mean (per square metre)									
SD									
Pygospio elegans									
mean (per square metre)									
SD									
Scolelepis squamata				1	0	0			
mean (per square metre)						33.333			
SD						0.5774			
Scolelepis sp.									
mean (per square metre)									
SD									
Spiophanes bombyx	1	1	0	3	1	1			
mean (per square metre)			66.667			166.67			
SD			0.5774			1.1547			
Spionidae sp. (damaged)									
mean (per square metre)									
SD									

	BBI La			BBI Lb	BBI Lc		
Tellimya ferruginosa	1	0	0		7	0	0
mean (per square metre)			33.333				233.3
SD			0.5774				4.041
Terebellidae sp (damaged)	0	0	2				
mean (per square metre)			66.667				
SD			1.1547				

Annex 1(5) c.2 Intertidal Photographic Survey

SeaScape Energy

Burbo Bank Offshore Wind Farm

Pre-construction
Photographic Cable Route Survey

Document: J3034 Cable Route Recovery v2.0 (04-08)

Version	Date	Description	Prepared by	Checked by	Approved by
1	08-06	Draft	LG	IGP	IGP
2	04-08	Final	LG	IGP	IGP

This report has been prepared by Centre for Marine and Coastal Studies Ltd (CMACS) on behalf of SeaScape Energy.

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Cover photograph: Pre-construction export cable trenching works at Wallasey foreshore.

Table of Contents

1. Executive Summary

A photographic survey was undertaken on the North Wirral foreshore at Wallasey as part of ongoing environmental monitoring to comply with the conditions of the Food and Environmental Protection Act (FEPA) 1985: Part II (as amended) issued to 'Seascape Energy Ltd' for the Burbo Banks Offshore Wind Farm. This survey was undertaken specifically to meet the requirements of English Nature (now Natural England) to monitor areas within the Mersey Estuary and North Wirral Foreshore pSPA following submission of an Appropriate Assessment covering foreshore crossing works.

The photographic survey was undertaken during trial ploughing of the western export cable route. Photographs were taken of intertidal sediments on the next available low tide after works.

The majority of the foreshore appeared unaffected by the trial ploughing works that had taken place earlier. The majority of the intertidal sediments appeared undisturbed and no obvious signs of ploughing, i.e. a deep trench, were present.

The survey was undertaken because of concerns that cable ploughing might leave visible scars on the beach, including trenches that would take a substantial time to infill and recover.

This survey clearly demonstrated that physical disturbance to sediments was relatively subtle and that physical recovery was rapid.

It was not considered necessary to repeat the survey after a further tidal cycle had passed given the small scale initial disturbance.

2. Introduction

A photographic survey was recently undertaken on the North Wirral foreshore at Wallasey as part of ongoing environmental monitoring to comply with the conditions of the Food and Environmental Protection Act (FEPA) 1985: Part II (as amended) issued to 'Seascape Energy Ltd' for the Burbo Banks Offshore Wind Farm. This survey was undertaken specifically to meet the requirements of English Nature to monitor areas within the Mersey Estuary and North Wirral Foreshore pSPA following submission of an Appropriate Assessment covering foreshore crossing works (CMACS ref: J3034 Intertidal Appropriate Assessment v1.1, Jan 2006).

English Nature requested a photographic survey to show recovery of intertidal sediments following cable ploughing works. The first ploughing works to take place on the foreshore were trial ploughs involving deployment of the cable installation plough under sub-maximal tension and with sediment penetration depths of up to 2m (the cables will be installed to up to 3m depth) but *without* any cable installation. This work is undertaken to assess effects upon sediment composition, mobility and coherence so that these can be qualitatively assessed before cabling works proceed and installation pulling forces adjusted appropriately.

Three power export cables will be installed on the foreshore. The photographic recovery survey was undertaken during the trial ploughing of the western most route (Figure 1). A second (and equivalent) trial was completed several days later on the eastern route. The central cable route was subject to a grapnel drag to check for debris but no ploughing has yet been undertaken here.

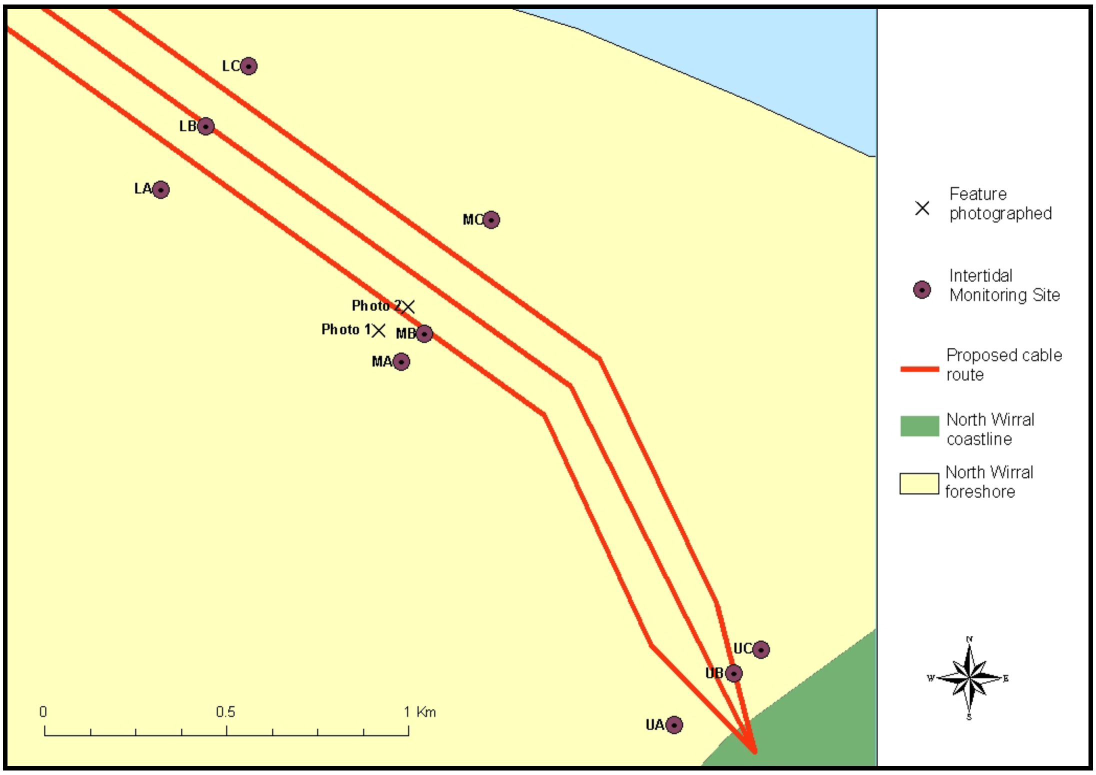

Figure 1 Intertidal monitoring sites and the proposed cable route for Burbo Banks Offshore Wind Farm.

NB photographs were taken at and around intertidal monitoring sites and at the 'feature' sites as indicated.

3. Methods

The survey was undertaken at low water (11:55am) on the North Wirral foreshore at Wallasey on Tuesday 18th July. Cabling works were temporarily suspended during this time, awaiting the turn of the tide and suitable tidal conditions for ploughing (see Figure 2). Ploughing had commenced during the previous tidal cycle on the lower and mid-shore sections of the Wallasey foreshore.

Figure 2 Photograph of the LM Construction barge aground at low water, after undertaking cabling works.

A series of photographs were taken at sites along the planned cable trench at points on the lower, middle and upper shore to identify any areas disturbed by the works (see Figure 1). Any interesting features and/or indicative signs of disturbance were photographed and documented using a hand-held GPS.

4. Results

Unfortunately, the lowest sites (LA-LC) were inaccessible owing to tidal conditions. Consequently, photographs were taken of any interesting features at the lowest points possible on the shore and in both a downshore and upshore direction at all mid (MA, MB and MC) and upper shore intertidal monitoring sites (UA, UB and UC).

Overall, vast expanses of the foreshore appeared unaffected by the trial ploughing works that had taken place earlier. The majority of the intertidal sediments appeared undisturbed and no obvious signs of ploughing, i.e. a deep trench, were present.

Small striation marks were observed on the lowest accessible points on the shore and were photographed (see Photo 1 and Figure 1 for site locations). These marks are indicative of the barge's anchor line bouncing along the seabed during leaving impressions on the sediment surface.

Photo 1 Striation marks from the barge anchor line.

Obvious signs of ploughing were not observed. However, a shallow depression was apparent on the mid-shore where preliminary cabling works had occurred and the practise cable trench was ploughed. This feature was photographed but is not overly apparent (see Photo 2).

The ploughing operation effectively cuts a slit into sediments which then fold back over after the plough moves on. Sediments are also assumed to be highly mobile here and would therefore be expected to fill in any depression relatively quickly. It is therefore perhaps unsurprising that little evidence of the works was visible shortly afterwards.

Photo 2 Shallow impression of the cabling trench at low water (approximate position is between the dashed lines).

Sediments immediately over the plough route were slightly softer than surrounding sediments but not markedly so.

Photographs of the surface sediments at site MC, furthest east of the proposed cable corridor show no effects of the cabling works (see Photo 3 AB).

Photo 3 Photograph of the downshore (A) and upshore (B) area at intertidal monitoring site MC.

Photographs of the surface sediments at sites MB and MA, within and west of the cable route trench showed minimal signs of disturbance (See Photo 4 AB and Photo 5 AB). Shallow impressions of a trench were apparent in this area, but this was very subtle. Small striation marks indicative of the barge's anchor line were apparent on the sediment surface downshore of site MA.

Photo 4 Photograph of the downshore (A) and upshore (B) area at intertidal monitoring site MB.

Photo 5 Photograph of the downshore (A) and upshore (B) area at intertidal monitoring site MA.

No sign of any broad scale effects from the cabling works was observed on the upper shore. Sediments were undisturbed at all upper shore intertidal monitoring sites (see Photo 6, Photo 7and Photo 8 AB).

Photo 6 Photograph of the downshore (A) and upshore (B) area at intertidal monitoring site UA.

Photo 7 Photograph of the downshore (A) and upshore (B) area at intertidal monitoring site UB.

Photo 8 Photograph of the downshore (A) and upshore (B) area at intertidal monitoring site UC.

5. Conclusions

The survey was undertaken because of concerns that cable ploughing might leave visible scars on the beach, including trenches that would take a substantial time to infill and recover.

This survey has clearly demonstrated that physical disturbance to sediments is relatively subtle and that physical recovery is rapid.

It was not considered necessary to repeat the survey after a further tidal cycle had passed given the small scale initial disturbance. Similarly, it is not anticipated that actual cable installation works will result in grossly different impacts.

CMACS will however visit the site shortly after completion of export cable installation works for the purpose of invertebrate sample collection and will take additional photographs at this stage.

Annex 1(5) c.3 Intertidal Post-construction Biotope and Photographic Surveys

Burbo Bank Offshore Wind Farm

Post-construction intertidal biotope surveys

Document: J3034 Post-construction intertidal biotope survey 2007 v3 (04-08)

Version	Date	Description	Prepared by	Checked by	Approved by
1	10-07	Draft	KJN	IGP	
2	11-07	Final	KJN	IGP	IGP
3	04-08	Added exec summary	KJN	LGP	IGP

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Cover photograph: area of export cable works at Wallasey foreshore.

1 EXECUTIVE SUMMARY

Burbo Offshore Wind Farm is a twenty-five turbine, 90MW development located in Liverpool Bay approximately 6km from the coastlines of Wirral, Crosby and Liverpool.

A licence was issued to the wind farm developer, SeaScape Energy Ltd, which allows them to construct and operate the wind farm providing certain conditions are met. The licence (31864/07/0) was issued under the Food and Environment Protection Act (FEPA) and contains a specific requirement to undertake invertebrate sampling across the foreshore in the cable landfall area.

This report presents results of a walkover biotope survey and sediment core sampling undertaken in August 2007. This survey follows baseline sampling at the same time of year in 2006.

Biotopes had changed very little between 2006 and 2007 with the majority of the survey area dominated by a mobile sand with sparse fauna biotope in both years.

Thirty species were identified from the invertebrate samples in 2007, six fewer than in the previous year. However, in common with 2006, invertebrate samples in 2007 showed great variation in numbers, diversity and biomass between sample and station with some exceptional abundances of certain amphipod species.

Also reported here are the results of a photographic survey to examine any lasting effects of cable burial on the nature of the shore. This showed that two weeks after cable burial small areas of disturbed sediment were still apparent on the shore but that these were no longer visible and shore appeared back to normal a further two weeks later.

The nature of the shore was very similar in 2007 to the baseline of 2006 and those changes that had occurred could not be attributed to the cable burial works as many of the differences were recorded from the control stations as well as those over the cables. Overall, the shore at New Brighton has recovered as predicted in the Environmental Statement and no further monitoring is recommended.

2 INTRODUCTION

Intertidal invertebrate sampling was included as a condition of the Food and Environment Protection Act (FEPA) licence (Ref 31864/07/0) issued to Seascape Energy Ltd for Burbo Offshore Wind Farm.

The following is an extract of relevant text from the FEPA licence:

''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.''

Centre for Marine and Coastal Studies Ltd (CMACS) has been appointed by SeaScape Energy Ltd to develop and undertake pre, during and post-construction surveys to fulfil requirements for environmental sampling and monitoring under the FEPA licence. Accordingly, CMACS discussed the requirements for intertidal invertebrate sampling with consultees and devised agreed survey methods and programme (CMACS 2006a).

The survey strategy was adapted to meet a request from Michael Young of English Nature (now Natural England) for additional intertidal work in relation to information provided for an appropriate assessment of cable landfall works (CMACS 2005). The methods have been designed to assess the effect of cable trenching on the intertidal invertebrates as a food resource for birds.

The survey programme was scheduled around installation of three submarine power export cables installed from the offshore wind farm through to a shore connection behind sea defences on the north Wirral foreshore. Cables were buried approximately 3m below the sediment surface using a cable plough device.

The cable installation process included a 'pre-lay grapnel run' (PLGR) along each export cable route using the cable plough device but without actually installing cable. This was done to check for obstructions that might damage the cable and is considered equivalent to cable installation in terms of environmental effects.

The PLGR took place in July 2006, cable installation works commenced the following month on 25th August 2006 and took place during suitable weather windows until completion on September 2nd.

The intertidal survey strategy comprises:

1. baseline biotope survey shortly before PLGR works in summer (July) 2006, supported by sediment core samples (CMACS 2006b);
2. a photographic survey in July 2006 immediately after PLGR works to record physical recovery of beach sediments along the route (CMACS 2006c);
3. repeat sediment core sampling after final cable landfall works in November 2006 ('rapid assessment sampling') (CMACS 2006b);
4. repeat biotope survey planned for summer 2007 if a detectable impact is revealed by step 3 (this report).

The repeat biotope survey (step 4) has been undertaken not because a detectable impact was identified following step 3 but because the temporal separation of the pre- and post works sampling made it difficult to reach conclusions on the effect of the cable installation works. For this reason the focus of this report is on a comparison between pre and post-construction data from summers 2006 and 2007 respectively.

In October 2007 additional works were undertaken on the foreshore. The works involved re-exposure of each of the three export cables towards the top of the shore (but below mean high water). In consultation with Natural England it was agreed that CMACS would visit the sites within 2 weeks of the works and undertake a photographic survey to check that the beach had recovered. This survey is also reported here.

3 METHODS

Access to the site was from a car park at the top of the shore near to the cable landfall where it was possible to descend the sloping concrete sea defence to the beach level. The shore at Wallasey/New Brighton is gently sloping and more than 3 km of intertidal is exposed on large tides. As a result, the flood tide advances up the shore at a rapid rate and field personnel completed the surveys at least 30 minutes before low water to give sufficient time to return to the top of the shore safely. In addition, personnel worked in pairs, wore inflatable lifejackets and carried mobile phones.

The survey consisted of a walk over biotope survey of the cable route corridor supported by sediment core samples from selected positions. This approach is described below.

3.1 Biotope survey

The design of the biotope survey was identical to that of the July 2006 baseline (CMACS 2006b) to allow comparison between years. The survey area was overlain with a 100m grid and a mapping point established at each point where eastings and northings crossed (Figure 1). A hand-held GPS was used to navigate a route down the shore visiting each of the mapping points. Notes were taken of the habitat and any obvious fauna (e.g. worm casts or tubes) at each of the mapping points and the biotope subsequently identified with the latest (version 04.04) biotope manual. Hand searching for infauna with a trowel and sieve was employed to aid biotope classification.

Intertidal biotope survey was carried out on 2nd August 2007. This date was chosen as it provided a good low tide during daylight hours.

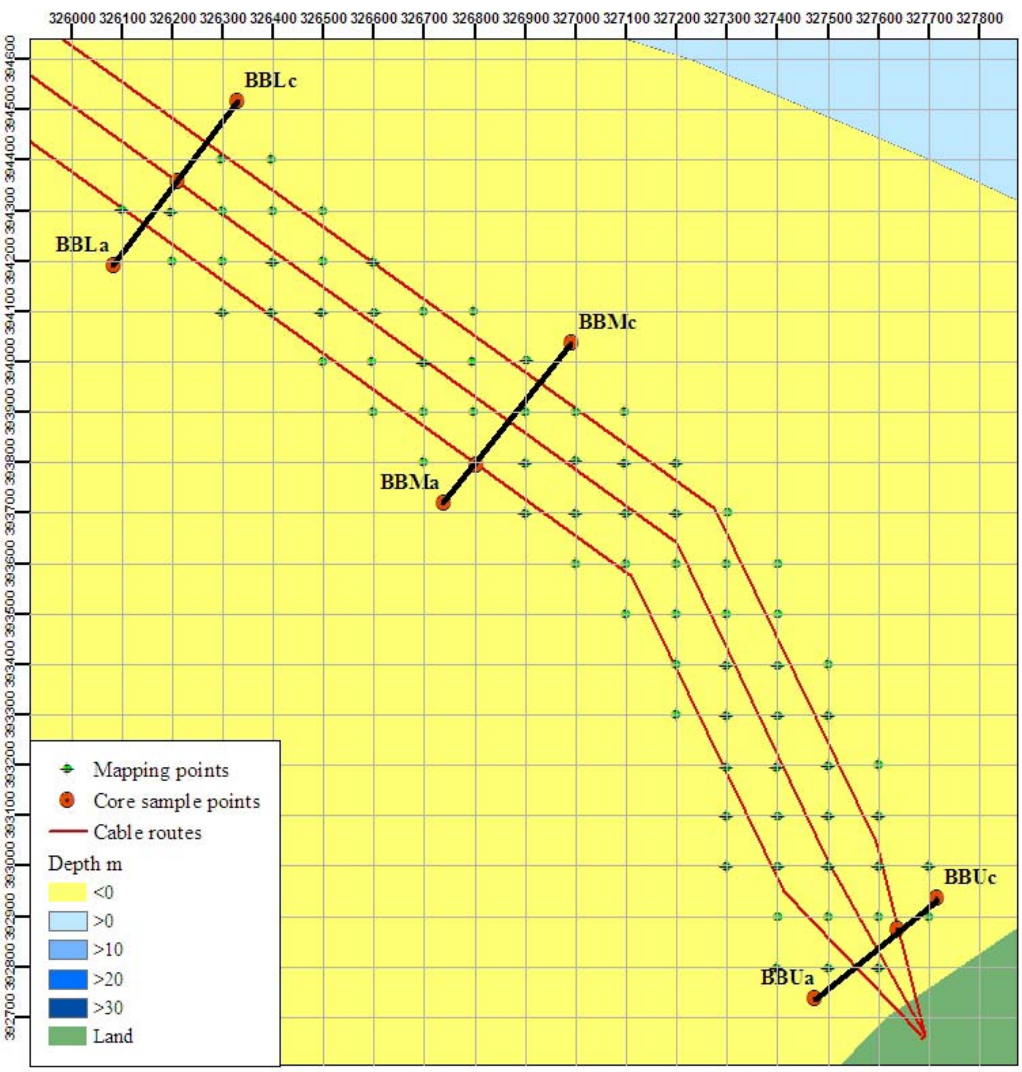


Figure 1. Survey points and sample points for biotope mapping over the intertidal portion of the cable route. BB = Burbo Bank; L = lower shore; M = mid shore; U = upper shore for each cable route (a-c).

3.2 Sediment core samples

Sediment core samples were taken on three shore-perpendicular transects across the cable routes on the lower, mid and upper shore (black lines in Figure 1). Each transect had three sampling stations:

1. within the cable route corridor directly above one of the cables;

2 & 3. either side and 100m distant from the cable route corridor.

At each site three cores were taken to a depth of 15cm to provide quantitative data on intertidal invertebrate communities. One additional core sample was obtained at each site for sediment particle size analysis. The cores were taken to provide information on the abundance of infaunal species and the available prey for shore birds. In addition, invertebrate and particle size data from the cable route cores was used to confirm biotope identification.

Cores were transported to the laboratory in cool boxes with cold blocks, washed through a 500μm sieve and preserved in 4% buffered formalin. All organisms from the samples were identified to species level where possible. All the organisms from each sample were weighed (as blotted wet-weight) on analytical scales to provide information on the biomass available at each station.

3.3 Photographic survey following additional works

Cables were exposed at the following positions:

- 12HDD SJ 27576 92775
- 22HDD SJ 27612 92807
- 31HDD SJ 27651 92841

The timetable of works was as follows:

- 12HDD: Excavation and backfilling Friday 5 October 2007.
- 22HDD: Excavation and backfilling Friday 5 October 2007.
- 31HDD: Excavation and backfilling Saturday 6 October 2007.
- 31HDD: Re-excavated and backfilling Tuesday 16 October 2007.

CMACS visited the beach at Wallasey on Wednesday 24th October (within the planned 2 week period).

4 RESULTS AND DISCUSSION

4.1 Biotope mapping

A biotope map of the intertidal cable route corridor is presented in Figure 2a; this is set alongside the map from the summer 2006 baseline survey (Figure 2b).

The majority of the survey area consisted of LS.LSa.FiSa.Po.Ncir - *Nephtys cirrosa* dominated littoral fine sand, which suggests that there has been little change in the habitat and its fauna since July 2006. Indeed, the general appearance of the shore was much the same: large areas of standing water and obvious ripples in the sand with occasional casts of the lugworm *Arenicola marina*. The lower shore has also shown little or no change since 2006, consisting of the razorfish and sea potato biotope SS.SSA.ImuSa.EcorEns - *Echinocardium cordatum* and *Ensis* spp. in lower shore and shallow sublittoral slightly muddy fine sand.

In 2006 the upper shore around sampling station Ua was classified as a different biotope to the area around site Ub and Uc. This distinction was made on the sediment characteristics of the site, with generally finer sediment at site Ua than at the other two sites. In addition there were some key differences in the fauna present – particularly the common cockle *Cerastoderma edule* and the spionid polychaete *Pygospio elegans*. In 2007, there were not such obvious differences in sediment characteristics and fauna as there was in 2006. However, in 2007 the fauna from Ua, Ub and Uc had much in common with LS.LSa.MuSa.CerPo and LS.LSa.FiSa.Po.Ncir (the two upper shore biotope descriptions of 2006) and it was decided that the upper shore was a composite of the two biotopes and has been mapped and labelled as such (see figure 2).

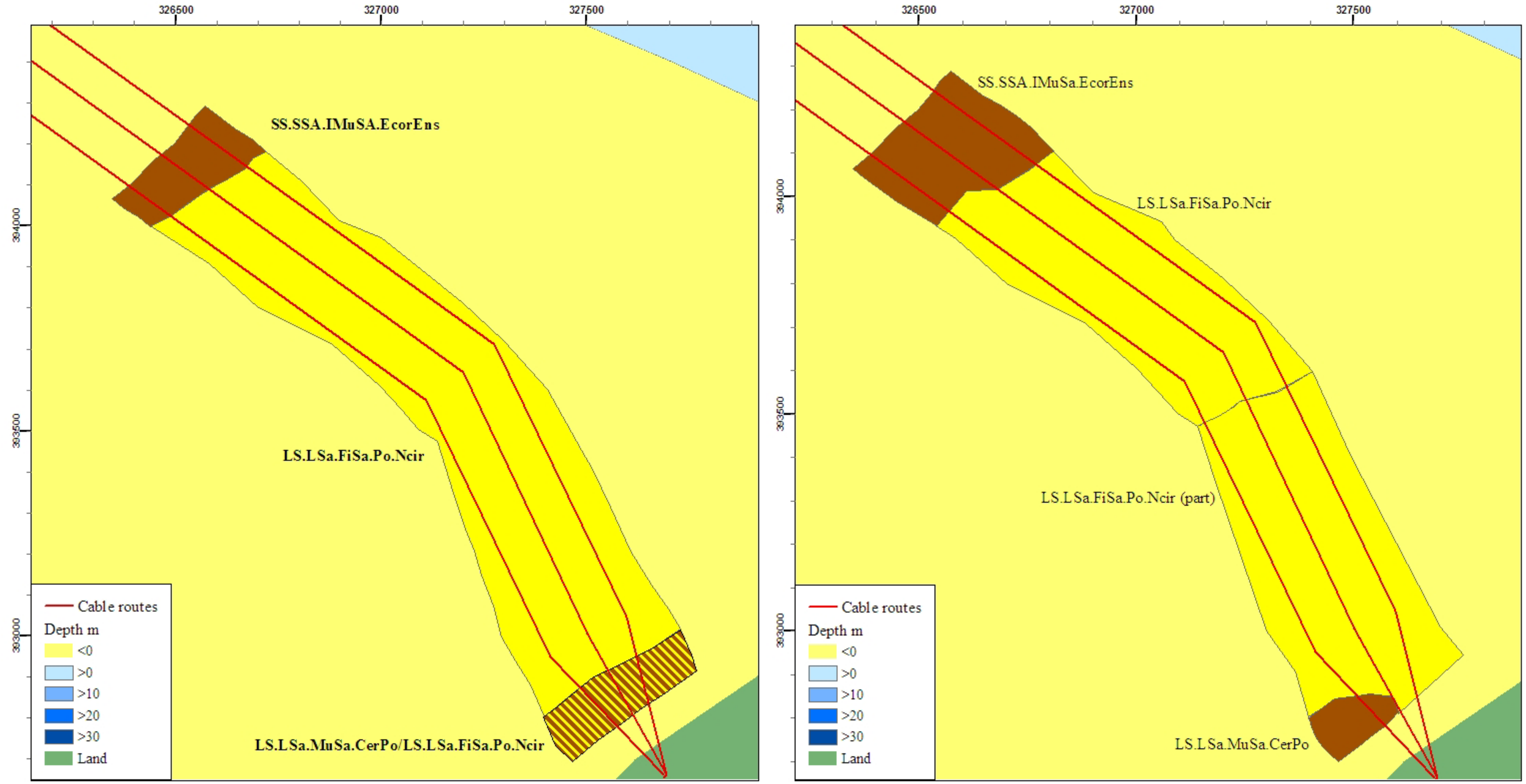


Figure 2a (left). Biotope map of the intertidal portion of the cable route corridor (post-construction, summer 2007); **2b (right)** baseline, summer 2006.

4.2 Sediment core samples

4.2.1 Intertidal invertebrates

Raw data are presented in Appendix 2.

Positions of invertebrate cores relative to the cable are shown in Figure 3.

Thirty taxa were identified to species level with a further four identified to genus or higher taxonomic level. Diversity was highest amongst the polychaetes with 16 species followed by amphipods with five species. Other taxonomic groups represented included bivalves, copepods, cumaceans, decapods, echinoderms, gastropods, nematodes and ostracods. Species diversity amongst the polychaetes has increased since 2006 but not all of the same species were present; *Glycera tridactyla* and *Lanice conchilega* were all recorded in 2006 but not in 2007 and the new species recorded in 2007 were *Magelona filiformis*, *Malacoceros fuliginosus*, *Spio filicornis* and *Spio martinensis*. Amphipod diversity was down with *Atylus swammerdami*, *Bathyporeia guilliamsoniana*, *Microprotopus maculatus* and *Periculodes longimanus* all missing from the 2007 samples. All of these amphipod species and also the polychaete species were all found in very low numbers in 2006 and therefore their absence from the samples may not necessarily represent an absence from the shore.

The remaining species of *Bathyporeia* found in the samples were very abundant compared to 2006 and were also the most abundant organisms in the 2007 samples reaching a maximum mean density (MMD) of 1833/m^2 in the case of *Bathyporeia sarsi* at site Ub, almost four times higher in abundance than the maximum for 2006. Other species were also much more abundant than in 2006: adult catworms *Nephtys* sp. were more abundant in 2007 than in 2006 but only reached a MMD of 167/m^2 at site Ma. The juveniles, however, were very abundant reaching 1533/m^2 at site La. Most other organisms were at low abundance but ostracods, a new taxa for 2007, were higher than the rest at 367/m^2 at site Lc.

Figure 4 compares the abundance of all organisms at each of the sampling stations between 2006 and 2007. In 2006, there were large differences in the extremes of abundance, which was not repeated in 2007 where abundances of fauna were more uniform across the shore (with the exception of Ub where there was a very high abundance of *Bathyporeia sarsi* as previously described). The number of taxa at each sampling station (figure 5) showed a similar trend with less variability in 2007 than in 2006, although there were more species present at six of the nine stations in 2006 than in 2007.

There are slight differences in the faunal composition of the samples and the abundance of certain species suggests that there has been a disturbance on the shore. In 2007 certain sessile or tube building organisms were at a much reduced abundance (e.g. *Magelona johnstoni*) or were absent entirely (e.g. *Angulus tenuis*) whereas mobile fauna such as *Bathyporeia* spp. and *Nephtys* spp. were much more abundant than in 2006. On the upper shore, *Pygospio elegans* and *Spiophanes bombyx* were at much reduced abundance in 2007 compared to 2006 and had been replaced to a certain extent by species of *Spio*. However, these changes occurred at all sampling stations rather that just those that were directly over the cable and therefore it is probable that they are due to natural variations in what are sparse populations anyway rather than as a result of disturbance from cable burial in 2006.

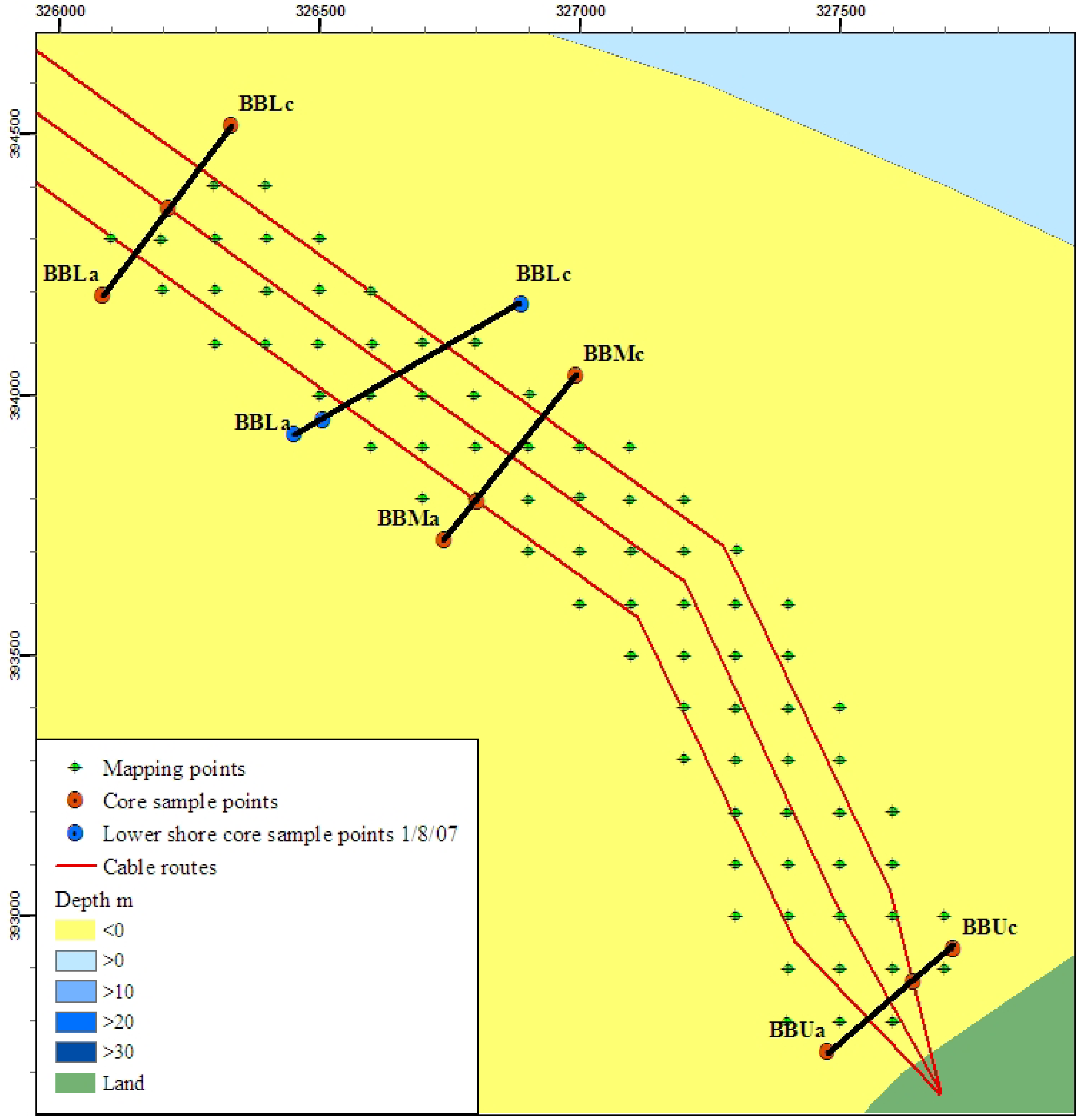


Figure 3. Sampling points for intertidal cores 1st August 2007. The upper and mid-shore samples were taken as planned, but the tide did not retreat far enough to expose the orange lower shore sample points and these samples were therefore taken at the lowest limit of the tide on that date and are represented by the blue points.

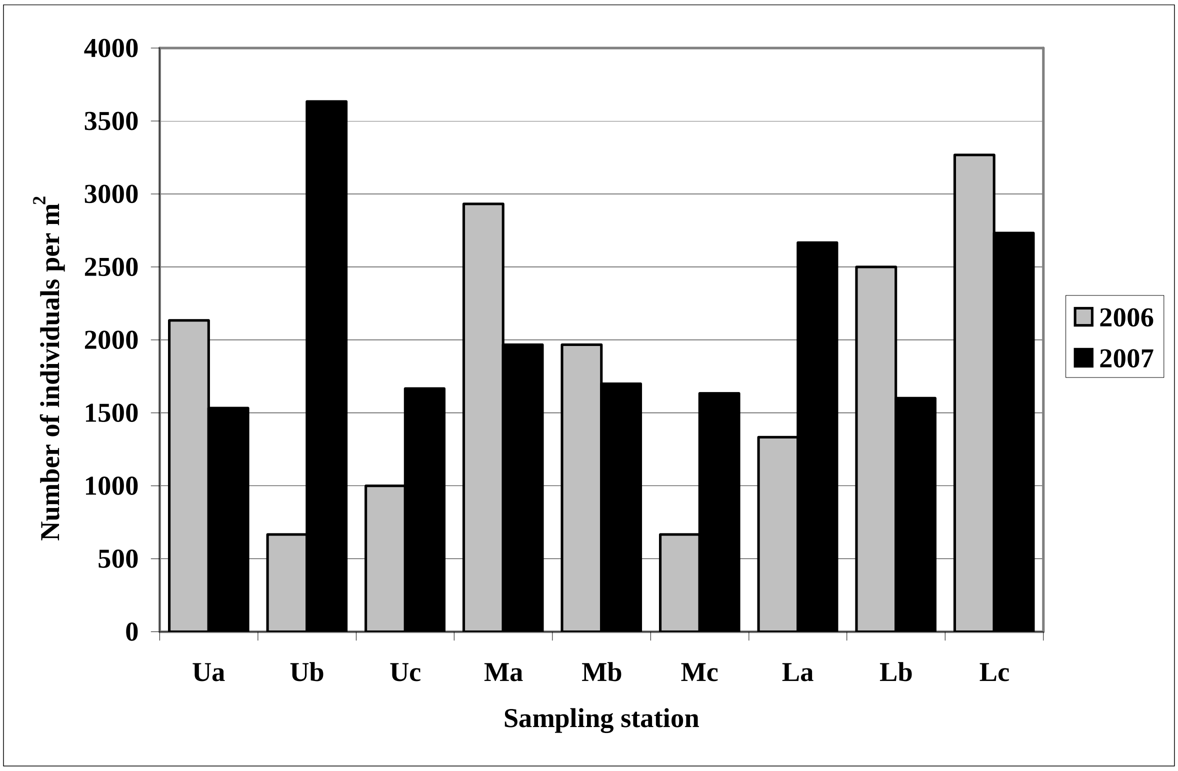


Figure 4. Numbers of all taxa found in the July 2006 and August 2007 sediment core samples (averaged from 3 replicates).

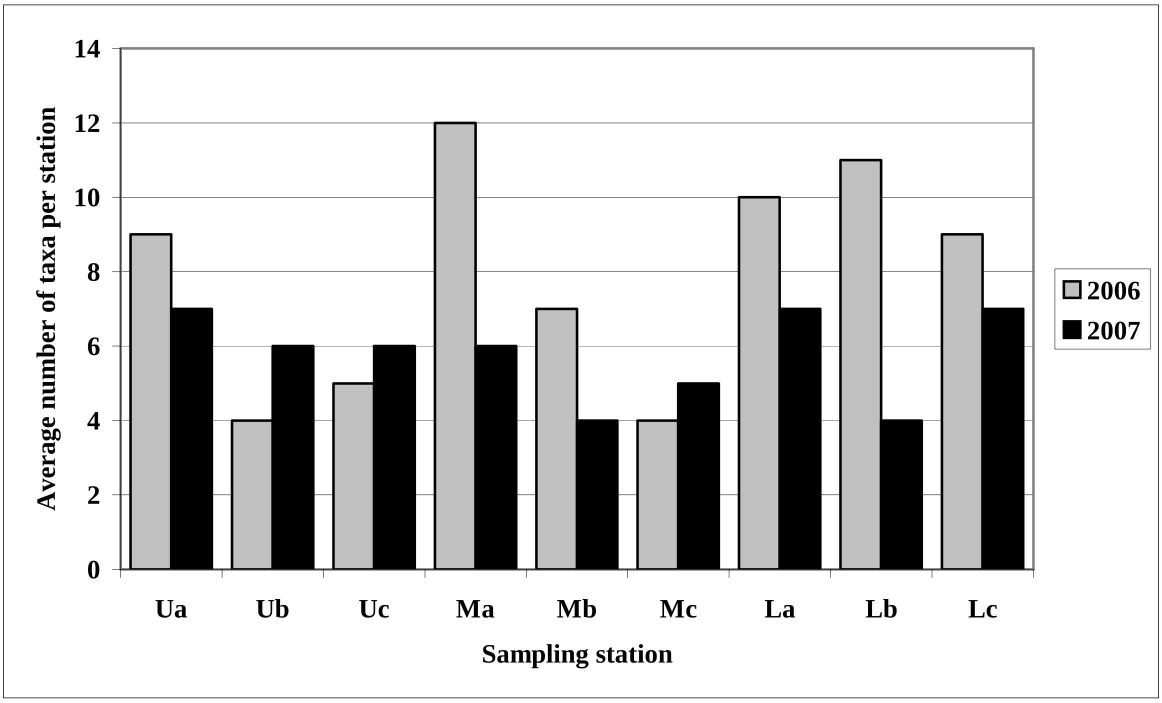


Figure 5. Sample site species richness (as numbers of taxa) found in the July 2006 and August 2007 sediment core samples (averaged from 3 replicates).

4.2.2 Biomass

Figure 6 compares the biomass of organisms (as blotted wet weight) found at each sampling station, presented as grams per square metre, calculated by averaging the three replicate 0.1 m^2 core samples and multiplying the result by 100.

In 2006, biomass varied greatly between sampling stations, largely due to relatively high biomass at two sites, Ua and La. This was due to the presence of a few large individual organisms

There was less variability in 2007. Biomass was highest at site Ua in both years (111 g/m^2 in 2006 and 44 g/m^2 in 2007). Biomass was lowest at site Mc in 2006 and site Lb in 2007. Biomass was higher at three stations in 2007 than in 2006; Ub, Mb and Mc but was lower than in 2006 at all other sites and markedly so at Ua, Uc, La and Lb, which was probably due to the absence of larger organisms such as the sea potato *Echinocardium cordatum* and the thin tellin *Angulus tenuis*. It is important to note that the large drops in biomass were not uniformly present at all stations positioned over cables and therefore are not likely to have been caused by the cable burial works.

As highlighted in figure 4, the numbers of individuals at each site were often markedly higher in 2007 than in 2006 but this is not reflected in the biomass measurements. This suggests that there were large numbers of small organisms present in 2007. There are a number of potential explanations, including the possibility that there has been a disturbance which has removed larger, slow growing organisms. If this is the case then the fact that this appears to have affected the whole site and not just the cabled areas suggests again that it is not due to the cable burial works but some other factor such as a natural event (e.g. storm) or natural population fluctuation.

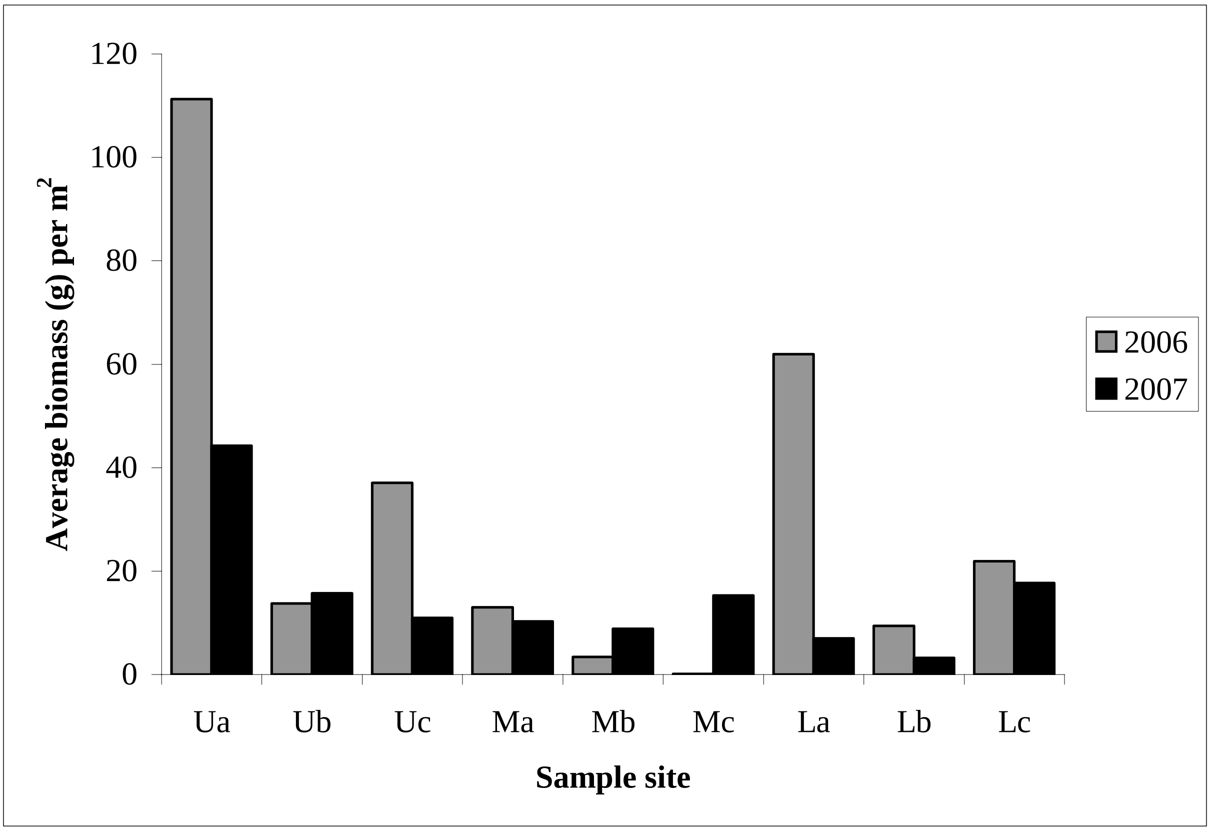


Figure 6. Average biomass per metre squared for each of the sampling stations in July 2006 and August 2007.

4.2.3 Particle size analysis

The particle size data for 2006 were reanalysed along with the 2007 data. This produced different results for the baseline particle size data due to a fault in the software used previously. Data are presented in Tables 1a and 1b.

Using the new analysis method all sites in both years were identified as fine sand and most were well sorted (Table 2). Only the sediment classification at site Uc had changed at all between years and then the change was minor from ‘moderately well sorted fine sand’ to ‘well sorted fine sand’. The sediment profiles of the lower and middle shore were similar to each other and similar between years with 60-80% medium sand, 20-35% fine sand and very small quantities of silt and coarse sand. The upper shore had a lower proportion of medium sand than lower and middle at 15-55%, up to 70% fine sand and 6-15% silt. The proportion of coarse sand was also low on the upper shore.

Table 1a. Fractional data as percentage of total start dry weight (2006).

Sample site	La	Lb	Lc	Ma	Mb	Mc	Ua	Ub	Uc
Sieve (mm)	% Weight of Fraction								
5	0.42	0.36	0.22	0.98	0.20	0.31	0.38	0.07	0.19
2	0.09	0.19	0.44	1.07	0.03	0.03	0.01	0.23	0.49
1	0.22	0.28	0.56	0.99	0.15	0.08	0.03	0.30	0.61
0.600	0.21	0.20	0.70	0.90	0.13	0.10	0.03	0.23	0.56
0.425	0.82	0.49	1.31	1.89	0.82	0.44	0.11	2.67	0.95
0.300	25.56	30.29	3.69	35.22	35.87	28.73	4.60	17.11	23.01
0.212	51.34	46.21	66.10	39.72	40.84	51.88	11.84	26.02	32.86
0.150	18.96	20.10	25.69	17.15	20.13	16.97	67.95	46.91	35.26
0.063	2.32	1.86	1.23	2.05	1.80	1.43	14.92	6.41	6.04
<0.063	0.05	0.03	0.05	0.04	0.02	0.02	0.13	0.05	0.04

Table 1b. Fractional data as percentage of total start dry weight (2007).

Sample site	La	Lb	Lc	Ma	Mb	Mc	Ua	Ub	Uc
Sieve (mm)	% Weight of Fraction								
5	0.69	0.48	0.42	0.81	0.21	0.31	0.12	0.04	0.00
2	0.77	0.61	0.84	0.60	0.43	0.63	0.47	0.30	0.16
1	0.66	0.67	0.59	0.63	0.16	0.62	0.42	0.51	0.05
0.600	0.67	0.72	0.59	0.62	0.13	0.65	0.46	0.74	0.04
0.425	1.00	1.32	0.73	0.89	1.35	1.30	0.71	1.02	1.15
0.300	36.62	39.35	10.91	17.71	26.02	26.00	4.27	8.31	3.32
0.212	32.29	35.71	50.90	44.36	43.70	41.71	17.12	30.63	25.27
0.150	23.56	19.14	32.34	30.77	24.98	26.11	68.93	47.71	62.50
0.063	3.71	1.96	2.62	3.58	2.90	2.62	7.40	10.67	7.46
<0.063	0.05	0.03	0.05	0.03	0.10	0.07	0.10	0.07	0.05

Table 2. Descriptions of sediment types based on the Wentworth Scale

Site	2006	2007
La	Well sorted fine sand	Well sorted fine sand
Lb	Well sorted fine sand	Well sorted fine sand
Lc	Very well sorted fine sand	Very well sorted fine sand
Ma	Well sorted fine sand	Well sorted fine sand
Mb	Well sorted fine sand	Well sorted fine sand
Mc	Well sorted fine sand	Well sorted fine sand
Ua	Well sorted fine sand	Well sorted fine sand
Ub	Moderately well sorted fine sand	Moderately well sorted fine sand
Uc	Moderately well sorted fine sand	Well sorted fine sand

4.3 Photographic survey following additional works

The survey was undertaken on 24th October, 8 days after completion of the works. The last works were at site 31HDD, which had to be re-excavated and back-filled on 16th October, having originally been excavated and back-filled on 6th October.

There was an area of spoil at 12HDD (in Figure 7a the bands on the ranging pole are both 50cm tall so this is a relatively small and low profile mound but the site has clearly not recovered). In close up the stones and clays from the excavations can be seen (Figure 7b). The tide had not yet been able to disperse these accumulations and coarser material. This site was visited 19 days after works were completed.

Figure 7a. Site 12HDD 19 days after cable exposure and re-burial.

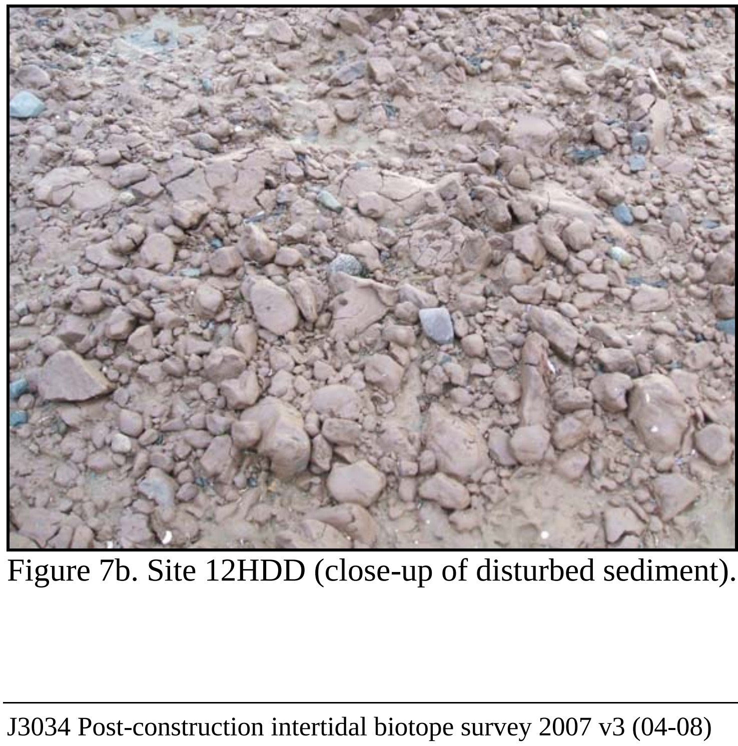


Figure 7b. Site 12HDD (close-up of disturbed sediment).

By contrast, at 22HDD (Figure 8) there was very little evidence of the works (in fact the remains of bait digging elsewhere by anglers were more obvious).

Figure 8. Site 22HDD 19 days after cable exposure and re-burial.

There was a little disturbance at 31HDD (Figure 9) but, again, this was limited compared to Site 12HDD, even though the recovery time at this site, which had been re-excavated, was the shortest at only 8 days.

Figure 9. Site 31HDD 8 days after cable exposure and re-burial.

It was somewhat surprising that the remains of the works were more apparent at 12HDD than 22HDD or 31HDD, which were respectively excavated around the same time or later, and the contractors were asked to investigate. The following response was received:

> '12HDD was the first duct to be excavated, the crew had some difficulties to locate the exact location of the cable duct end. They had to dig down 3 – 5 times before the end was located. This first excavation was more time consuming than expected and the holes had to be "poorly" backfilled because the incoming tide did not allow the crew to make a proper backfilling.''

This explains the clay still visible on 24th October. Whilst this is clearly a small-scale issue (i.e. limited to the immediate area of works) it was considered appropriate to visit the site again after a further 2 weeks (i.e. approximately 1 month after works). Accordingly, a further series of photographs were taken on 9th November.

On this final visit there was no visible evidence of disturbance at any of the locations. The condition of site 12HDD is shown in Figure 10.

Figure 10. Site 12HDD 35 days after cable exposure and re-burial.

5 CONCLUSIONS

The intertidal survey of 2007 has revealed very few differences from the findings of the 2006 survey in the biotic and abiotic components of the North Wirral foreshore in the vicinity of the Burbo Bank offshore wind farm export cable.

The biotopes present had not changed although the extent of one biotope at the top of the shore had increased since 2006. All of the biotope designations for the cable were very similar to those reported for the area in the Burbo Environmental Statement (Seascape Energy, 2002). Likewise, the particle size analysis showed that the sediments on the shore had not changed between 2006, 2007 and the Environmental Statement of 2002.

There were differences in the fauna and the biomass found at each of the sampling stations between years, but that is to be expected on a sandy shore with small, fast growing individuals that occur at low densities. In addition the changes in fauna and biomass did not point to an effect that could be attributed to disturbance from the cable burial.

When they were undertaken, it was expected that the shore would recover quickly after the cable burial works were completed and the results of the surveys have confirmed this expectation. The Burbo Environmental Statement (Seascape Energy, 2002) predicted that the shore would recover quickly after cable burial works, but that molluscs may take longer to recolonise disturbed areas than amphipods and polychaetes. The intertidal surveys of 2006 and 2007 support the expectations of the assessment to an extent: there were fewer molluscs in 2007 than in 2006 but polychaetes and amphipods appeared unaffected, though there was some variation in species present between years. The intertidal surveys of 2006 and 2007 discovered a much higher diversity of infauna than was reported in the Environmental Statement; eleven taxa were reported in the ES whereas up to forty taxa were reported in the latest surveys.

In summary, the biotopes and sediments on the North Wirral foreshore were very similar before and after cable burial works and were comparable to those reported in the Environmental Statement. The slight changes in the beach infauna were not specific to the cable burial area and were indistinguishable from natural variations.

References

CMACS (2005) Burbo Bank Offshore Wind Farm. Provision of data for use in an Appropriate Assessment of the likely effects of the intertidal cable route on the Mersey Narrows and North Wirral Foreshore proposed Special Protection Area (pSPA). Version 1.0, December 2005.

CMACS (2006a) Burbo Bank Offshore Wind Farm FEPA Monitoring Methods. Version 1.5, 15th August 2006.

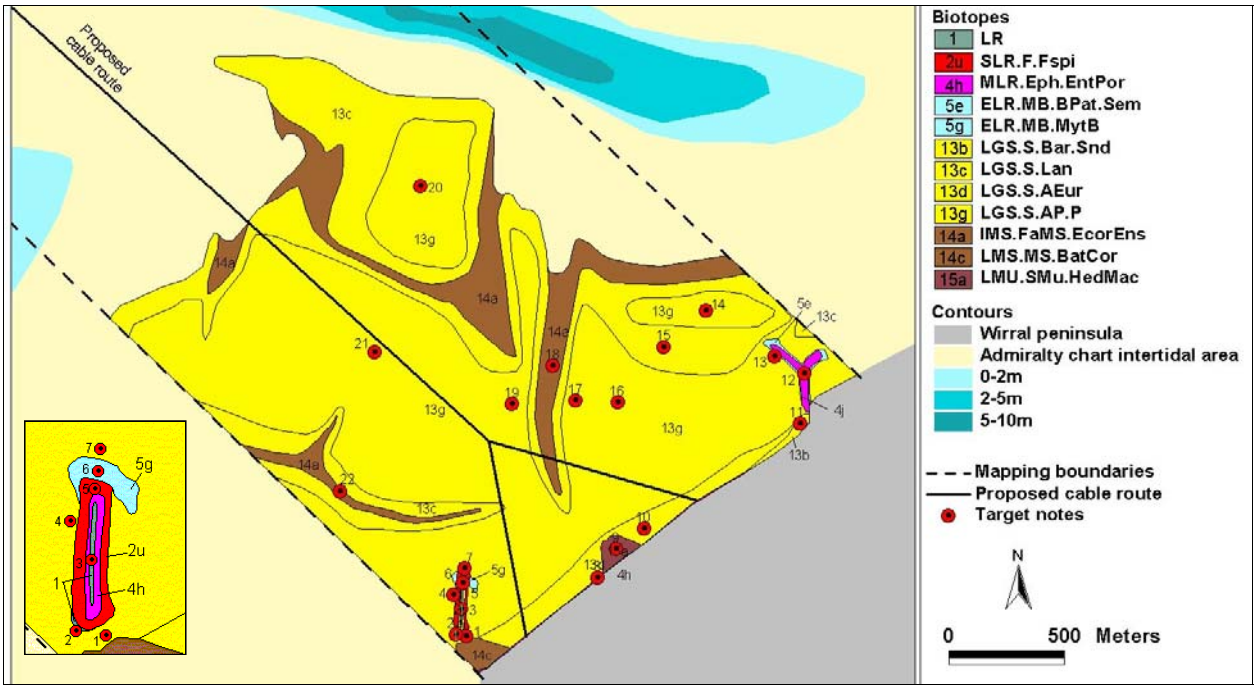
CMACS (2006b) Burbo Bank Offshore Wind Farm. Baseline and Rapid Assessment Intertidal Ecology Monitoring. Version 1.2, 13th November 2007.

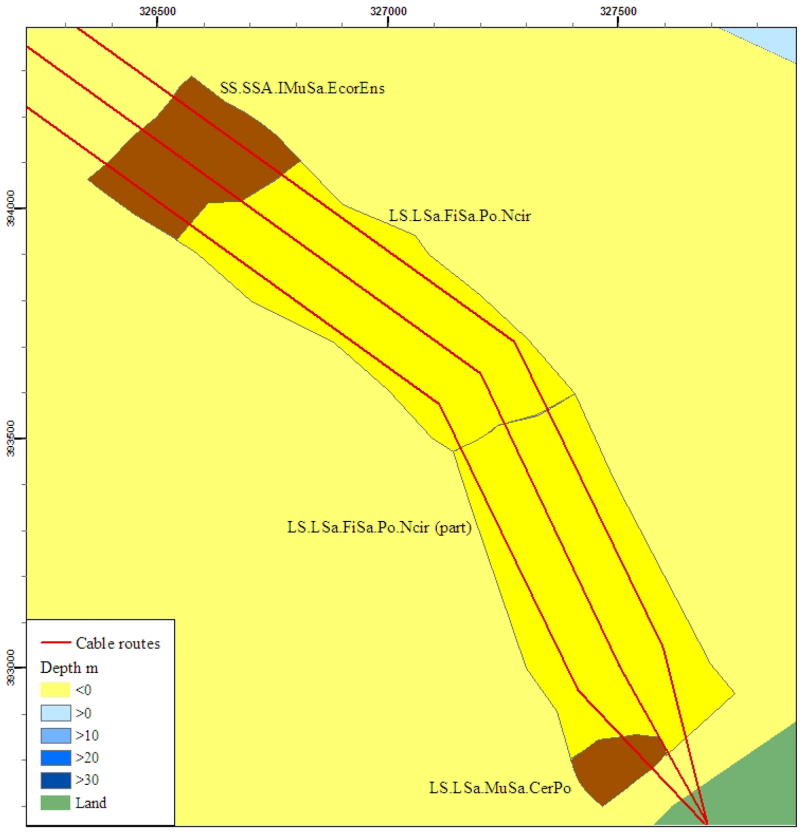
CMACS (2006c) Burbo Offshore Wind Farm Pre-construction Photographic Cable Route Survey. Version 2.0, 11th August 2006.

SeaScape Energy (2002) Burbo Offshore Wind Farm Environmental Statement.

Wyn, G, Brazier, P and McMath, M (2000) *CCW's Handbook for Marine Intertidal Phase 1 Survey and Mapping.* Countryside Council for Wales Marine Science Report: 00/06/91. Countryside Council for Wales, Bangor.

Appendix 1. Original biotope mapping (CMACS for SeaScape Energy 2002, 2006).





Appendix 2. Intertidal invertebrate raw data.

	BBI Ua			BBI Ub			BBI Uc		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Ammodytes tobianus									
mean (per square metre)									
SD									
Bathyporeia elegans				0	0	1			
mean (per square metre)						33.333			
SD						0.5774			
Bathyporeia pilosa				1	2	0			
mean (per square metre)						100			
SD						1			
Bathyporeia sarsi	1	3	0	21	24	10	3	10	12
mean (per square metre)			133.33			1833.3			833.33
SD			1.5275			7.3711			4.7258
Bathyporeia pelagica									
mean (per square metre)									
SD									
Bathyporeia sp.	0	5	0	11	17	10	2	0	3
mean (per square metre)			166.67			1266.7			166.67
SD			2.8868			3.7859			1.5275
Cerastoderma edule				0	0	1			
mean (per square metre)						33.333			
SD						0.5774			
Cerastoderma edule (juv.)	0	1	0						
mean (per square metre)			33.333						
SD			0.5774						
Copepoda									
mean (per square metre)									
SD									
Crangon crangon	1	0	0	1	0	0			
mean (per square metre)			33.333			33.333			
SD			0.5774			0.5774			
Cumopsis goodsiri									
mean (per square metre)									
SD									
Echinocardium sp. (damaged)									
mean (per square metre)									
SD									
Echinocardium sp. Juv									
mean (per square metre)									
SD									
Eteone flava/longa							1	1	0
mean (per square metre)									66.667
SD									0.5774
Eurydice sp. (juv.)							0	1	0
mean (per square metre)									33.333
SD									0.5774
Eurydice pulchra	1	0	0	0	1	0			
mean (per square metre)			33.333			33.333			
SD			0.5774			0.5774			
Hydrobia ulvae	0	0	2				1	0	0
mean (per square metre)			66.667						33.333
SD			1.1547						0.5774

	BBI Ua			BBI Ub			BBI Uc		
Lagis koreni									
mean (per square metre)									
SD									
Macoma balthica	0	1	0				1	0	0
mean (per square metre)			33.333						33.333
SD			0.5774						0.5774
Magelona johnstoni									
mean (per square metre)									
SD									
Magelona mirabilis									
mean (per square metre)									
SD									
Magelona sp. juv.							0	1	0
mean (per square metre)									33.333
SD									0.5774
Malacoceros fuliginosus									
mean (per square metre)									
SD									
Nematoda									
mean (per square metre)									
SD									
Nephtys cirrosa	1	1	1	1	1	1	0	1	1
mean (per square metre)			100			100			66.667
SD			0			0			0.5774
Nepthys hombergi	0	2	0						
mean (per square metre)			66.667						
SD			1.1547						
Nephtys sp. Juv.							0	1	0
mean (per square metre)									33.333
SD									0.5774
Nephtys sp (damaged)									
mean (per square metre)									
SD									
Ophelia borealis									
mean (per square metre)									
SD									
Ostracoda	0	0	4	0	1	0			
mean (per square metre)			133.33			33.333			
SD			2.3094			0.5774			
Owenia fusiformis									
mean (per square metre)									
SD									
Paradoneis lyra									
mean (per square metre)									
SD									
Pontocrates altamarinus									
mean (per square metre)									
SD									
Portumnus latipes									
mean (per square metre)									
SD									
Pygospio elegans	2	1	1				0	0	1
mean (per square metre)			133.33						33.333
SD			0.5774						0.5774

	BBI Ua			BBI Ub			BBI Uc		
Scolelepis squamata				1	0	0	1	0	1
mean (per square metre)						33.333			66.667
SD						0.5774			0.5774
Scolelepis sp.									
mean (per square metre)									
SD									
Spiophanes bombyx	0	0	1	1	0	0	1	0	0
mean (per square metre)			33.333			33.333			33.333
SD			0.5774			0.5774			0.5774
Spio filicornis	4	0	0						
mean (per square metre)			133.33						
SD			2.3094						
Spio martinensis	0	0	1				3	0	2
mean (per square metre)			33.333						166.67
SD			0.5774						1.5275
Spio sp.	1	2	8	0	1	1	0	2	0
mean (per square metre)			366.67			66.667			66.667
SD			3.7859			0.5774			1.1547
Spionidae sp. (damaged)	0	1	0	0	0	1			
mean (per square metre)			33.333			33.333			
SD			0.5774			0.5774			

	BBI Ma			BBI Mb			BBI Mc		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Ammodytes tobianus							1	0	0
mean (per square metre)									33.333
SD									0.5774
Bathyporeia elegans	0	0	2				1	0	0
mean (per square metre)			66.7						33.333
SD			1.15						0.5774
Bathyporeia pilosa									
mean (per square metre)									
SD									
Bathyporeia sarsi	0	1	0						
mean (per square metre)			33.3						
SD			0.58						
Bathyporeia pelagica				0	1	0			
mean (per square metre)						33.333			
SD						0.5774			
Bathyporeia sp.	1	1	2				2	1	1
mean (per square metre)			133						133.33
SD			0.58						0.5774
Cerastoderma edule									
mean (per square metre)									
SD									
Cerastoderma edule (juv.)									
mean (per square metre)									
SD									
Copepoda									
mean (per square metre)									
SD									
Crangon crangon							0	2	0
mean (per square metre)									66.667
SD									1.1547
Cumopsis goodsiri	1	0	0						
mean (per square metre)			33.3						
SD			0.58						
Echinocardium sp. (damaged)	0	1	0						
mean (per square metre)			33.3						
SD			0.58						
Echinocardium sp. Juv	1	0	2	0	1	0			
mean (per square metre)			100			33.333			
SD			1			0.5774			
Eteone flava/longa									
mean (per square metre)									
SD									
Eurydice affinis									
mean (per square metre)									
SD									
Eurydice pulchra				0	0	1	0	0	1
mean (per square metre)						33.333			33.333
SD						0.5774			0.5774
Hydrobia ulvae									
mean (per square metre)									
SD									

	BBI Ma			BBI Mb			BBI Mc		
Lagis koreni									
mean (per square metre)									
SD									
Macoma balthica									
mean (per square metre)									
SD									
Magelona johnstoni	1	1	0	1	1	0			
mean (per square metre)			66.7			66.667			
SD			0.58			0.5774			
Magelona mirabilis	1	0	1				1	0	0
mean (per square metre)			66.7						33.333
SD			0.58						0.5774
Magelona sp. juv.	1	0	0	1	0	1			
mean (per square metre)			33.3			66.667			
SD			0.58			0.5774			
Malacoceros fuliginosus	1	0	0						
mean (per square metre)			33.3						
SD			0.58						
Nematoda									
mean (per square metre)									
SD									
Nephtys cirrosa	0	2	3	0	0	2	1	1	2
mean (per square metre)			167			66.667			133.33
SD			1.53			1.1547			0.5774
Nepthys hombergi	1	0	0						
mean (per square metre)			33.3						
SD			0.58						
Nephtys sp. Juv.	18	11	4	7	13	17	10	10	11
mean (per square metre)			1100			1233.3			1033.3
SD			7			5.0332			0.5774
Nephtys sp (damaged)				0	1	0			
mean (per square metre)						33.333			
SD						0.5774			
Ophelia borealis				0	1	0			
mean (per square metre)						33.333			
SD						0.5774			
Ostracoda				0	1	0	1	0	1
mean (per square metre)						33.333			66.667
SD						0.5774			0.5774
Owenia fusiformis									
mean (per square metre)									
SD									
Paradoneis lyra									
mean (per square metre)									
SD									
Pontocrates altamarinus									
mean (per square metre)									
SD									
Portumnus latipes				0	1	0			
mean (per square metre)						33.333			
SD						0.5774			
Pygospio elegans									
mean (per square metre)									
SD									

	BBI Ma			BBI Mb			BBI Mc		
Scolelepis squamata									
mean (per square metre)									
SD									
Scolelepis sp.							0	1	0
mean (per square metre)									33.333
SD									0.5774
Spiophanes bombyx	1	0	1	0	0	1			
mean (per square metre)			66.7			33.333			
SD			0.58			0.5774			
Spio filicornis							0	0	1
mean (per square metre)									33.333
SD									0.5774
Spio martinensis									
mean (per square metre)									
SD									
Spio sp.									
mean (per square metre)									
SD									
Spionidae sp. (damaged)									
mean (per square metre)									
SD									

	BBI La			BBI Lb			BBI Lc		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Ammodytes tobianus							1	0	0
mean (per square metre)									33.33
SD									0.577
Bathyporeia elegans	0	0	1	0	0	2	0	2	0
mean (per square metre)			33.333			66.667			66.67
SD			0.5774			1.1547			1.155
Bathyporeia pilosa									
mean (per square metre)									
SD									
Bathyporeia sarsi	0	0	2						
mean (per square metre)			66.667						
SD			1.1547						
Bathyporeia pelagica	0	2	0				0	0	2
mean (per square metre)			66.667						66.67
SD			1.1547						1.155
Bathyporeia sp.	2	1	3	1	0	5	3	1	0
mean (per square metre)			200			200			133.3
SD			1			2.6458			1.528
Cerastoderma edule									
mean (per square metre)									
SD									
Cerastoderma edule (juv.)									
mean (per square metre)									
SD									
Copepoda				0	0	1			
mean (per square metre)						33.333			
SD						0.5774			
Crangon crangon									
mean (per square metre)									
SD									
Cumopsis goodsiri									
mean (per square metre)									
SD									
Echinocardium sp. (damaged)									
mean (per square metre)									
SD									
Echinocardium sp. Juv	0	3	0				0	1	0
mean (per square metre)			100						33.33
SD			1.7321						0.577
Eteone flava/longa	1	0	0						
mean (per square metre)			33.333						
SD			0.5774						
Eurydice affinis									
mean (per square metre)									
SD									
Eurydice pulchra				1	0	0			
mean (per square metre)						33.333			
SD						0.5774			
Hydrobia ulvae									
mean (per square metre)									
SD									

	BBI La			BBI Lb			BBI Lc		
Lagis koreni							0	0	1
mean (per square metre)									33.33
SD									0.577
Macoma balthica									
mean (per square metre)									
SD									
Magelona johnstoni	3	2	0	0	1	0	1	2	3
mean (per square metre)			166.67			33.333			200
SD			1.5275			0.5774			1
Magelona mirabilis	0	1	1				1	0	0
mean (per square metre)			66.667						33.33
SD			0.5774						0.577
Magelona sp. juv.	0	0	1				1	1	2
mean (per square metre)			33.333						133.3
SD			0.5774						0.577
Malacoceros fuliginosus									
mean (per square metre)									
SD									
Nematoda							0	1	0
mean (per square metre)									33.33
SD									0.577
Nephtys cirrosa	0	1	1	1	0	1	1	1	2
mean (per square metre)			66.667			66.667			133.3
SD			0.5774			0.5774			0.577
Nepthys hombergi									
mean (per square metre)									
SD									
Nephtys sp. Juv.	18	7	21	12	0	17	10	23	8
mean (per square metre)			1533.3			966.67			1367
SD			7.3711			8.7369			8.145
Nephtys sp (damaged)									
mean (per square metre)									
SD									
Ophelia borealis	0	0	1						
mean (per square metre)			33.333						
SD			0.5774						
Ostracoda							2	1	8
mean (per square metre)									366.7
SD									3.786
Owenia fusiformis							0	1	0
mean (per square metre)									33.33
SD									0.577
Paradoneis lyra	0	0	1						
mean (per square metre)			33.333						
SD			0.5774						
Pontocrates altamarinus	0	2	0	3	0	1			
mean (per square metre)			66.667			133.33			
SD			1.1547			1.5275			
Portumnus latipes	0	1	1	0	0	1			
mean (per square metre)			66.667			33.333			
SD			0.5774			0.5774			
Pygospio elegans	0	1	0						
mean (per square metre)			33.333						
SD			0.5774						

	BBI La			BBI Lb			BBI Lc		
Scolelepis squamata									
mean (per square metre)									
SD									
Scolelepis sp.									
mean (per square metre)									
SD									
Spiophanes bombyx	2	0	0	0	0	1	1	0	0
mean (per square metre)			66.667			33.333			33.33
SD			1.1547			0.5774			0.577
Spio filicornis							1	0	0
mean (per square metre)									33.33
SD									0.577
Spio martinensis									
mean (per square metre)									
SD									
Spio sp.									
mean (per square metre)									
SD									
Spionidae sp. (damaged)									
mean (per square metre)									
SD									

Annex 1(6) Electromagnetic fields

SeaScape Energy

Burbo Offshore Wind Farm

Electromagnetic Fields and Marine Ecology

Document: J3034 EMF v2 (09-07)

Version	Date	Description	Prepared by	Checked by	Approved by
1	04-06	First Draft	Ian Gloyne-Phillips	KJN	IGP
2	09-07	Final Report	IGP	SD	IGP

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Contents

Executive Summary

Burbo Offshore Wind Farm is a twenty-five turbine, 90MW development located in Liverpool Bay approximately 6km from the coastlines of Wirral, Crosby and Liverpool.

A licence was issued to the wind farm developer, SeaScape Energy Ltd, which allows them to construct and operate the wind farm providing certain conditions are met. The licence (31864/07/0) was issued under the Food and Environment Protection Act (FEPA) and contains a specific requirement to provide information on electromagnetic fields (EMF) associated with power cables used to export electricity from the wind farm to shore, including cabling within the array. This condition was included because of concerns that EMF could have adverse consequences for certain electromagnetically sensitive marine species such as the elasmobranchs (sharks, skates and rays).

The significance of EMF for electrosensitive fish species is a subject of ongoing research. The present report addresses the requirements of the FEPA licence by providing information on the magnitude and attenuation of fields around submarine power cables used in the wind farm and provides an assessment of the likely significance for marine species using best available information.

Based on information provided by the cable manufacturers which calculated a maximum magnetic field of approximately 0.54µT, and with reference to modelling of comparable cables at other wind farms, it is predicted that the maximum induced electrical field at Burbo will be lower than 100µV/m. This level is important since above this magnitude it is considered theoretically possible that there might be a repulsive effect for elasmobranchs.

The environmental impact assessment for Burbo Offshore Wind Farm predicted no more than a low magnitude impact to elasmobranchs from electric fields and a negligible impact due to magnetic field effects on magnetically sensitive species such as migratory teleosts and eels. These conclusions are supported by the current work but because of the uncertainty about EMF other aspects of the monitoring programme have been developed to include monitoring of species that could be affected. The results of such monitoring will become available after surveys take place while the wind farm is generating power.

1 Introduction

Centre for Marine and Coastal Studies Ltd (CMACS) was appointed by SeaScape Energy Ltd to devise and undertake pre and during-construction surveys to fulfill requirements for environmental monitoring under the Food and Environment Protection Act (FEPA) licence (Ref 31864/03/0) for Burbo Offshore Wind Farm (BOWF) in Liverpool Bay. The licence has since been amended a number of times and the current version is 31864/07/0.

A specific requirement of the FEPA licence relates to electromagnetic fields:

FEPA Licence, Annex 1(6)

> *The Licence Holder must provide the Licensing Authority with information on attenuation of field strengths associated with the cables, shielding and burial described in the Method Statement (to be submitted to the Licensing Authority as a matter of urgency) and related to data from the Rødsand windfarm studies in Denmark and any outputs from the COWRIE tendered studies in the UK (where appropriate). This is to provide reassurance that the cable shielding and burial depth(s), both between the turbines and along the cable route to shore, given the sediment type(s) at the Burbo site are sufficient to ensure that the electromagnetic field generated is negligible. Should this study show that the field strengths associated with the cables are sufficient to have potential detrimental effect on electrosensitive species, further biological monitoring to that described in Section 7 of this Annex may be required to further investigate the effect.*

A method statement (CMACS 2006) has been submitted to Defra outlining the approach proposed to address this condition:

> CMACS and Cranfield University have recently completed a COWRIE study into electromagnetic fields and their significance for marine organisms. We will provide information on the magnetic and induced electrical field strengths likely to be produced by BOWF to the Licensing Authority along with our best interpretation of the significance of such fields.
>
> It must be stressed that further research work is planned, by CMACS and others, to investigate the environmental significance of, in particular, anthropogenic induced electrical fields in the marine environment. This is likely to be collaborative work undertaken by the offshore wind farm industry as a whole. The results of such work will feed into the reporting on electromagnetic fields at BOWF.

The collaborative work referred to above is currently underway. CMACS is part of a consortium of researchers running an experimental mesocosm study looking specifically at the ability of elasmobranch fishes to detect electric fields equivalent to those produced by offshore wind farms. The results of this research will assist investigators in determining whether or not an ecological impact will occur. At present, the level of scientific understanding is sufficient only to say that there is potential for an impact to occur.

Further discussion of the possible nature of ecological impacts associated with EMF is provided in Section 3. Before considering this we have reviewed technical information on the cabling arrangements at BOWF to predict the magnitude of EMF (Section 2).

2 Anticipated Electromagnetic Fields

2.1 Cable specifications

Three types of high voltage submarine power cable are installed at BOWF: FXCTV 3x500mm^2; FXCTV 3x240mm^2 and FXCTV 3x95mm^2. All are 50Hz AC, tri-core (copper), XLPE insulated, copper screened and steel armoured which are common characteristics of cables used across the offshore wind farm industry. The cables are rated at up to 36kV.

The cables differ in the cross sectional area of copper conductors. Larger cables are used to carry higher power loads, for example the export cables to shore are FXCTV 3x500mm^2 design. Detailed design information is provided as Appendix 1.

The cables are buried to a depth of approximately 3m throughout the vast majority of the wind farm and all the power export route. This may confer a benefit in reducing the maximum magnitude of EMF at the sediment-seawater interface; however, Gill *et al*. (2005) suggested that burial to such depths does not necessarily act to reduce EMF significantly since the magnetic field produced by the cable (see Section 2.2) is likely to be propagated through seabed sediments largely undiminished.

2.2 Magnetic field

ABB have provided a calculation of the anticipated magnetic (B) field strength immediately above the ground (i.e. seabed) over a FXCTV 3x500mm^2 cable buried 3m deep (Appendix 2). This cable will carry the highest power load and is therefore anticipated to produce the highest electromagnetic field.

The maximum predicted B field is approximately 0.54µT (Appendix 2, page 1). ABB also calculated that a magnetic field of up to 0.05 µT would be present approximately 10m from the seabed/water interface above the buried cable (Appendix 2, page 2).

2.3 Induced electrical field

Submarine power cables of the type used at BOWF do not generate an electric field directly; instead, an electromagnetic field (EMF) with two components is generated: an electric field (E) which is contained within the cable by armouring and a magnetic field (B, referred to in Section 2.2, above) which can be detected outside of the cable.

The magnetic field is dynamic as a result of the fact that AC currents flowing in each conductor of the cable generate changing B fields around the conductor. These changing B fields in turn generate an induced electric (iE) field in the surrounding environment (CMACS 2003).

Gill *et al.* (2005) provide comparative information on B and iE fields produced by industry standard offshore wind farm cables. Higher rated cables than those installed at BOWF (132kV) have been predicted to generate B fields of up to 1.6µT during maximum load which in turn would induce electric fields up to 91µV/m.

Similar (33kV) cables were installed at Kentish Flats offshore wind farm and CMACS (2004) cited in Gill *et al*. (2005) reported that B fields of up to 0.015 µT and iE fields of up to 2.5 µV/m would be anticipated under full power generation conditions.

It is not possible to accurately predict the iE fields which will be produced at BOWF once the wind farm is operational by simple comparison to the figures provided above for a similar (33kV) cable. Neither can the iE field be calculated readily from the known B field, to which the iE field is complexly related; however, an indication of the likely maximum field strength can be estimated and this is considered to offer sufficient accuracy and confidence for current purposes. For a given power load the resultant EMF will be (directly) proportionally higher for a higher voltage cable (CMACS 2003) and a smaller resultant EMF can be expected from lower voltage cables. It is predicted that the iE field produced by the main power export cables will be below the 91µV/m level calculated for a fully loaded 132kV cable and is likely to be closer to the 2.5µV/m figure calculated for Kentish Flats offshore wind farm. In the following section it will be seen that based on current understanding of the potential biological significance of iE fields for elasmobranch fish a key point is that the maximum iE field produced by BOWF, although likely to be above 0.5µV/m, is not anticipated to exceed 100µV/m.

The highest fields would be expected for the export to shore cables. Smaller fields, but still within the range 0.5 to 100µV/m, would be anticipated for inter-array cables. Induced electrical fields within this range would be expected to be propagated for distances of metres to tens of metres from the seabed/seawater interface immediately above the buried cable.

The BOWF environmental statement (SeaScape Energy 2002) made reference to iE field calculations undertaken by Liverpool University for the 150kV export cable from Horns Rev offshore wind farm in Denmark. An emission of around 100µV/m was predicted by Gill and Taylor (2001) and the BOWF environmental statement commented that significantly lower iE fields would be produced by BOWF which would attenuate rapidly within tens of metres of the cable. In light of information available since the BOWF environmental statement was written it can be stated that this was a reasonable assertion supported by recent modelling work and no evidence to contradict the statement has been found.

3 Likely Significance of Electromagnetic Fields

The prediction, in Section 2.3, that the maximum iE field produced by BOWF will be below 100µV/m is important. In the environmental statement the work of Gill and Taylor (2001) was referenced; the authors suggested that 100µV/m may represent a threshold between attraction (0.5µV/m to 100µV/m) and repulsion (above 100µV/m) of elasmobranch fish species (sharks, skates and rays).

The BOWF Environmental Statement predicted no more than a low magnitude impact to elasmobranchs due to possible attraction to iE fields (which might be mistaken for bioelectric fields emitted by prey) since this was anticipated to be a temporary and relatively trivial effect. A negligible impact due to magnetic field effects on magnetically sensitive species such as migratory teleosts and eels was predicted because of the localised and low level magnetic field (very much smaller than the geomagnetic field) and over-riding importance of olfaction (smell) for salmonids navigating coastal waters.

It is very important to note that such effects as attraction or repulsion of elasmobranchs or disruption to migration are theoretical. There is no evidence that either magnetic or induced electrical fields associated with offshore wind farms have produced such effects or resulted in environmental impacts. Recent information was reviewed by Gill *et al*. (2005) who made reference to all available studies, including those at Rødsand (Hvidt *et al*. 2003) which are alluded to in the FEPA licence (interestingly, Hvidt communicated to Gill *et al*. that there were no electrosensitive species in the vicinity of Rødsand).

Despite a number of ongoing offshore wind farm monitoring programmes in England and Wales as well as Scandinavia there has essentially been no advance in understanding of the significance of EMF for marine organisms, especially for elasmobranchs which are considered to be potentially the most sensitive group because of their sensitivity to very small electric fields (0.5µV/m), dependence on electrosense for both foraging and intraspecific behaviour and the vulnerability of stocks of a number of species, including the rays. For this reason there is now a major ongoing COWRIE funded study which is being undertaken by a consortium comprising Cranfield and Liverpool Universities, CEFAS and CMACS. This study, a control experiment investigating the response of individual fish to EMF in large scale experimental enclosures, is expected to report in spring 2008.

In summary, the predictions of the BOWF environmental statement, both in terms of the likely magnitude of EMF and possible environmental impacts, are still considered to be reasonable. Because the maximum iE field is predicted to be below 100µV/m more serious impacts associated with repulsion effects are not anticipated. However, because of the current lack of certainty with regard to the significance of EMF, in particular for elasmobranchs, the environmental monitoring programme at BOWF has been expanded to include additional elements targeted at detecting effects on electrosensitive fish species if indeed they do occur. This is described further in the following section.

4 Ongoing Activities

4.1 Site specific biological monitoring

The full programme of environmental monitoring is described in CMACS (2006).

The programme includes two elements that will provide information on the distribution of fish in relation to submarine cables and allow for interpretation of the effects, if any, of electromagnetic fields on fish distributions in and around the wind farm area. These elements are as follows:

- Annual commercial fish survey (4m beam trawl).
    - Two kilometre long trawls were carried out at thirteen sites in and around the wind farm in April/May 2006, immediately before the first offshore construction work took place. Annual repeat surveys in May will continue until the end of the monitoring programme. These surveys will provide information on the distribution of elasmobranchs and certain magnetically sensitive fish species within and outside the wind farm area before construction, after construction and during the wind farm operation phase.
    - Because of concerns in relation to EMF an investigation of elasmobranch feeding activity in and around the wind farm is being undertaken using fish caught during the commercial trawl survey. A subsample of dogfish caught in the 2006 commercial trawl survey had their digestive tract removed, gut contents were analysed and, where possible, prey items identified to species level. It is anticipated that some inferences can be made into dogfish foraging behaviour inside the wind farm by comparing measures of gut 'fullness' with regard to time and location of dogfish caught. During the operational phase of the wind farm these results will be compared to wind farm generating status leading up to the survey.
- Annual scientific benthic trawl survey (two metre beam trawl).
    - These are standardised 300m monitoring tows undertaken annually in autumn. Whereas the 4m beam trawls focused solely on fish, these trawls are used to monitor the abundance of all benthic and demersal organisms. While not as efficient at catching fish as the 4m beam trawl, rays and numerous plaice (potentially both a magnetically and electrically sensitive species) have been caught in these tows. The data obtained will also be used to examine the distribution of electrically and magnetically sensitive fish within and around the wind farm area.

The above surveys have been designed with the need to monitor *potential* effects of electromagnetic fields on fish species. Sampling sites have therefore been distributed to include tows immediately over buried cables, within the wind farm array itself while other sites are away from cables. Data from these surveys should be sufficient to allow detection of major effects of electromagnetic fields on fish distribution, if such effects occur. The gut content analysis adds the further potential to detect more subtle effects on feeding activity.

4.2 Other studies

As noted in Section 3, there is an ongoing COWRIE funded study which is expected to report in spring 2008. The outcome of this study will be followed and the monitoring programme adjusted if required; however, it is hoped that this study and the information provided in this report will be sufficient to discharge the monitoring condition.

5 References

CMACS (2003) A baseline assessment of electromagnetic fields generated by offshore wind farm cables. Rep No COWRIE-01-2002 66. Centre for Marine and Coastal Studies.

CMACS (2006) Burbo Bank Offshore Wind Farm FEPA Monitoring Methods. Version 1.5, 15th August 2006.

Gill AB and Taylor H (2001) The potential effects of electromagnetic fields generated by cabling between offshore wind turbines on elasmobranch fishes, Countryside Council for Wales, Contract Science Report 488.

Gill AB, Gloyne-Phillips IT, Kimber J and Neal K (2005) The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms – a review. Rep No COWRIE-EM-FIELD 2-06-2004.

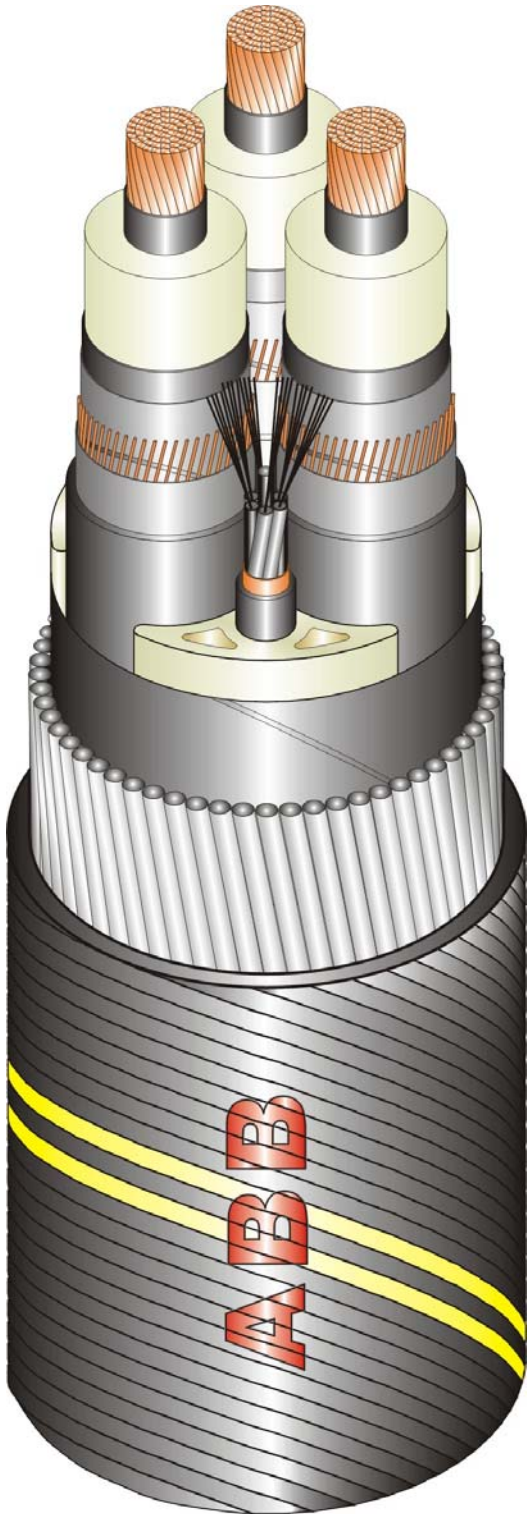
Hvidt CB, Bech M & Klaustrup M (2003) Monitoring Programme- status Report 2003. Fish at the cable trace. Nysetd offshore wind farm at Rødsand.

SeaScape Energy (2002) Burbo Offshore Wind Farm Environmental Statement.

Appendix 1

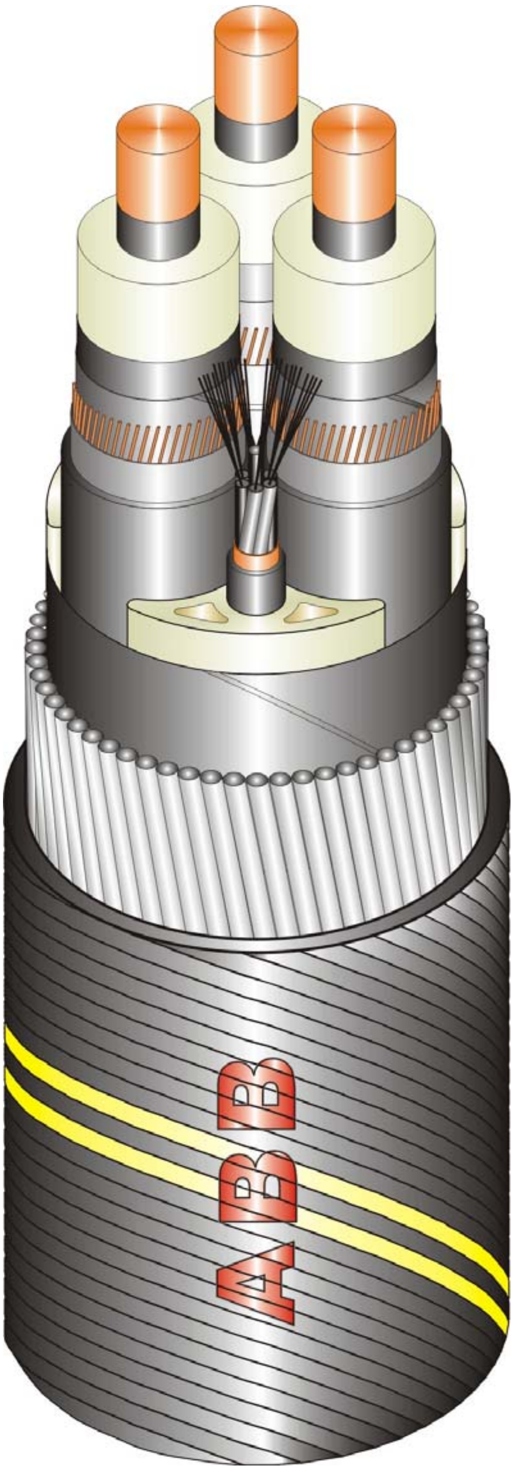
Technical Specification of Cables

12. CABLE DESIGN FXCTV 3X500MM^2



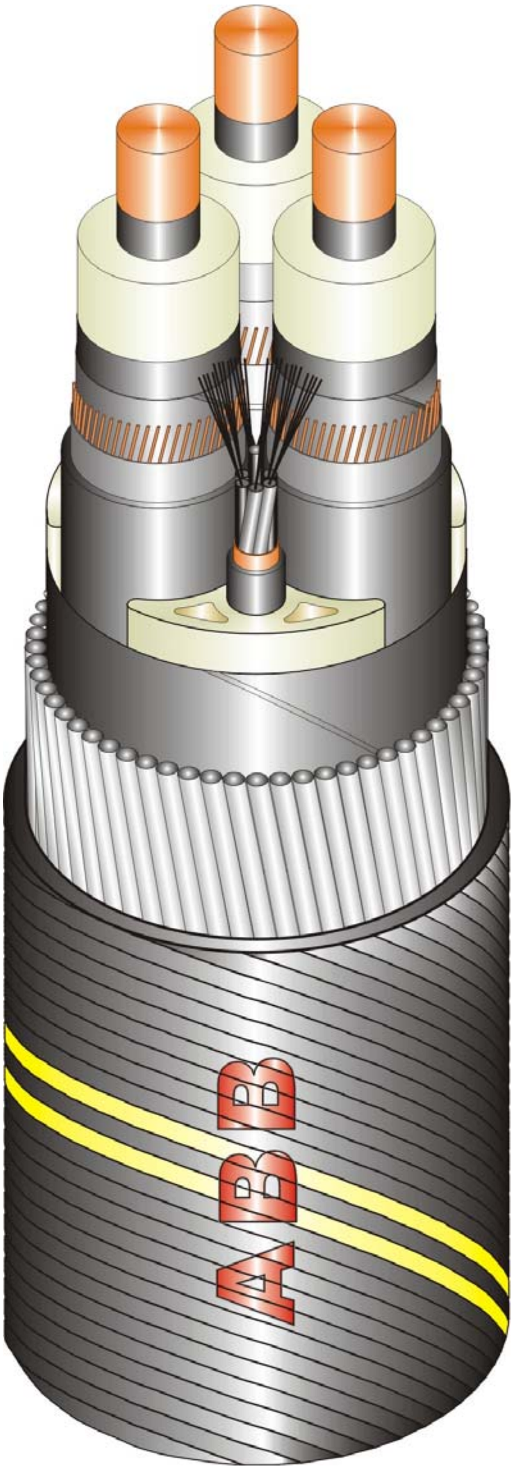
Designation	FXCTV 3 x 500 mm^2	
Rated voltage	18/30 kV U_{max} 36kV	
Impulse level	170 kV	
Conductor		
type	round, compact	
material	copper	
longitudinal water seal	compound + swelling tape	
cross-section	3 x 500	mm^2
diameter	26,2	mm
Conductor screen		
material	conductive PE	
thickness	1,0	mm
Insulation		
type	dry cured, triple extruded	
material	XLPE	
thickness	8	mm
Insulation screen		
material	conductive PE	
thickness	1,0	mm
Longitudinal water seal		
material	swelling tape	
thickness	0,6	mm
Metallic screen		
material	copper wires	
cross-section	3 x 17	mm^2
Longitudinal water seal		
material	swelling tape	
thickness	0,6	mm
Inner sheath		
material	conductive PE	
thickness	2,0	mm
Assembling		
material 1	polymeric profiles	
material 2	fibre optical cable	
material 3	grease	
Cable core binder		
material	polymeric tape	
thickness	0,2	mm
Bedding		
material	Bitumen impregnated tape	
thickness	0,5	mm
Armour		
material 1	Galvanized steel wires	
material 2	Bitumen	
wire diameter	4,0	mm
Armour		
material 1	Polypropylene yarns	
material 2	Bitumen	
thickness	4,0	mm
Complete cable		
diameter	≈ 140	mm
weight	≈ 35	kg / m

13. CABLE DESIGN FXCTV 3X240MM^2



Designation	FXCTV 3 x 240 mm^2	
Rated voltage	18/30 kV U_{max} 36kV	
Impulse level	170 kV	
Conductor		
type	round, solid (or compacted)	
material	copper	
cross-section	3 x 240	mm^2
Conductor screen		
material	conductive PE	
thickness	1,0	mm
Insulation		
type	dry cured, triple extruded	
material	XLPE	
thickness	8	mm
Insulation screen		
material	conductive PE	
thickness	1,0	mm
Longitudinal water seal		
material	swelling tape	
thickness	0,6	mm
Metallic screen		
material	copper wires	
cross-section	3 x 14	mm^2
Longitudinal water seal		
material	swelling tape	
thickness	0,6	mm
Inner sheath		
material	PE	
thickness	3,0	mm
Assembling		
material 1	polymeric profiles	
material 2	fibre optical cable	
material 3	grease	
Cable core binder		
material	polymeric tape	
thickness	0,2	mm
Bedding		
material	Bitumen impregnated tape	
thickness	0,5	mm
Armour		
material 1	Galvanized steel wires	
material 2	Bitumen	
wire diameter	4,0	mm
Armour		
material 1	Polypropylene yarns	
material 2	Bitumen	
thickness	4,0	mm
Complete cable		
diameter	≈ 120	mm
weight	≈ 22	kg / m

14. CABLE DESIGN FXCTV 3X95MM²



Designation	FXCTV 3 x 95 mm²	
Rated voltage	20/34 kV U_{max} 36kV	
Impulse level	170 kV	
Conductor		
type	round, solid	
material	copper	
cross-section	3 x 95	mm²
Conductor screen		
thickness	0,8	mm
Insulation		
type	dry cured, triple extruded	
material	XLPE	
thickness	8,0	mm
diameter	31	mm
Insulation screen		
thickness	1,0	mm
Longitudinal water seal 1		
material	conductive swelling tape	
thickness	0,6	mm
Metallic screen		
material	copper wires	mm
cross-section	3 x 12	mm²
Longitudinal water seal 2		
material	conductive swelling tape	
thickness	0,6	mm
Inner sheath		
material	PE	
thickness	3,0	mm
Fillers		
material	polymeric profiles	
material	grease	
material	fiber optic cable	
Cable core binder		
material	nylon	
thickness	0,15	mm
Bedding		
material	bitumen impregnated tape	
Armour		
type	wires, single layer	
material	galv. steel wires	
thickness	4	mm
Outer cover		
material	polypropylene yarn	
thickness	4 mm	
Complete cable		
diameter	≈ 106	mm
weight	≈ 16	kg / m

Appendix 2

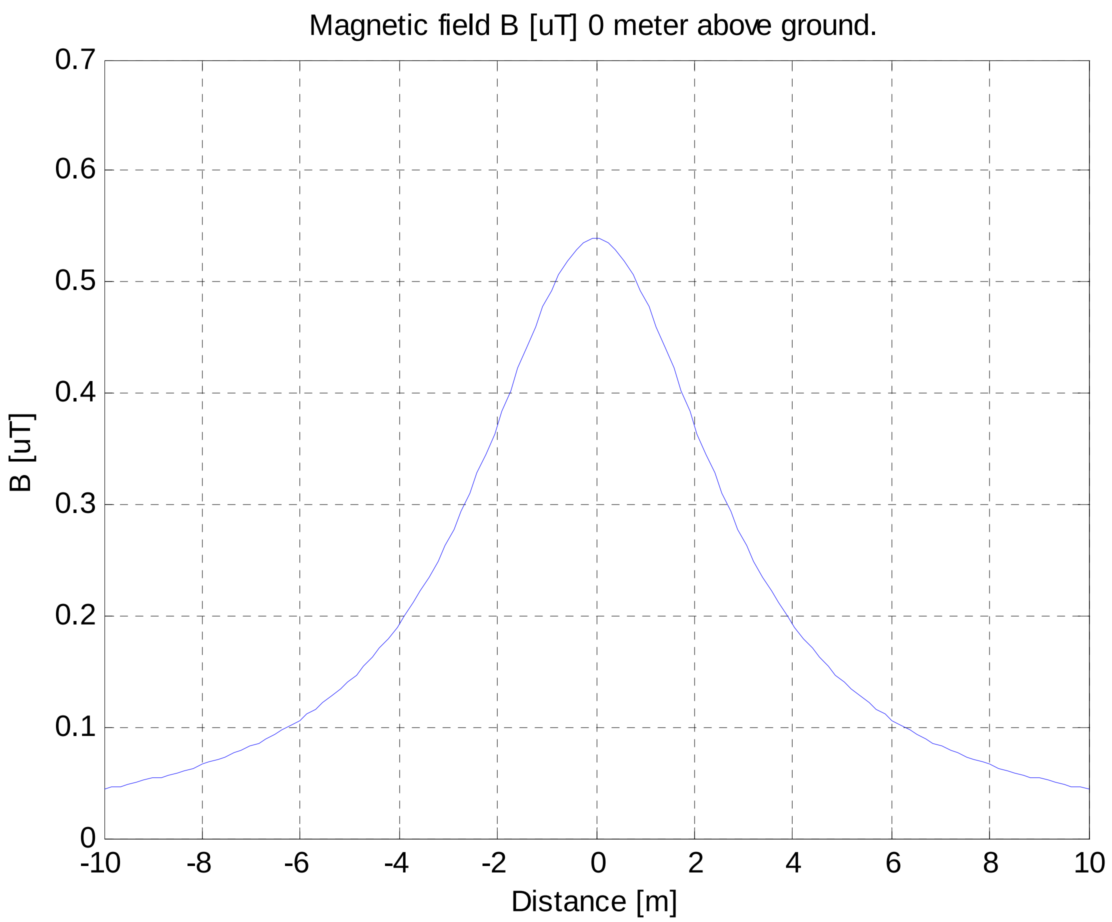
Magnetic Field Predictions

Burbo Offshore Windfarm
ABB Power Technologies AB High Voltage Cables

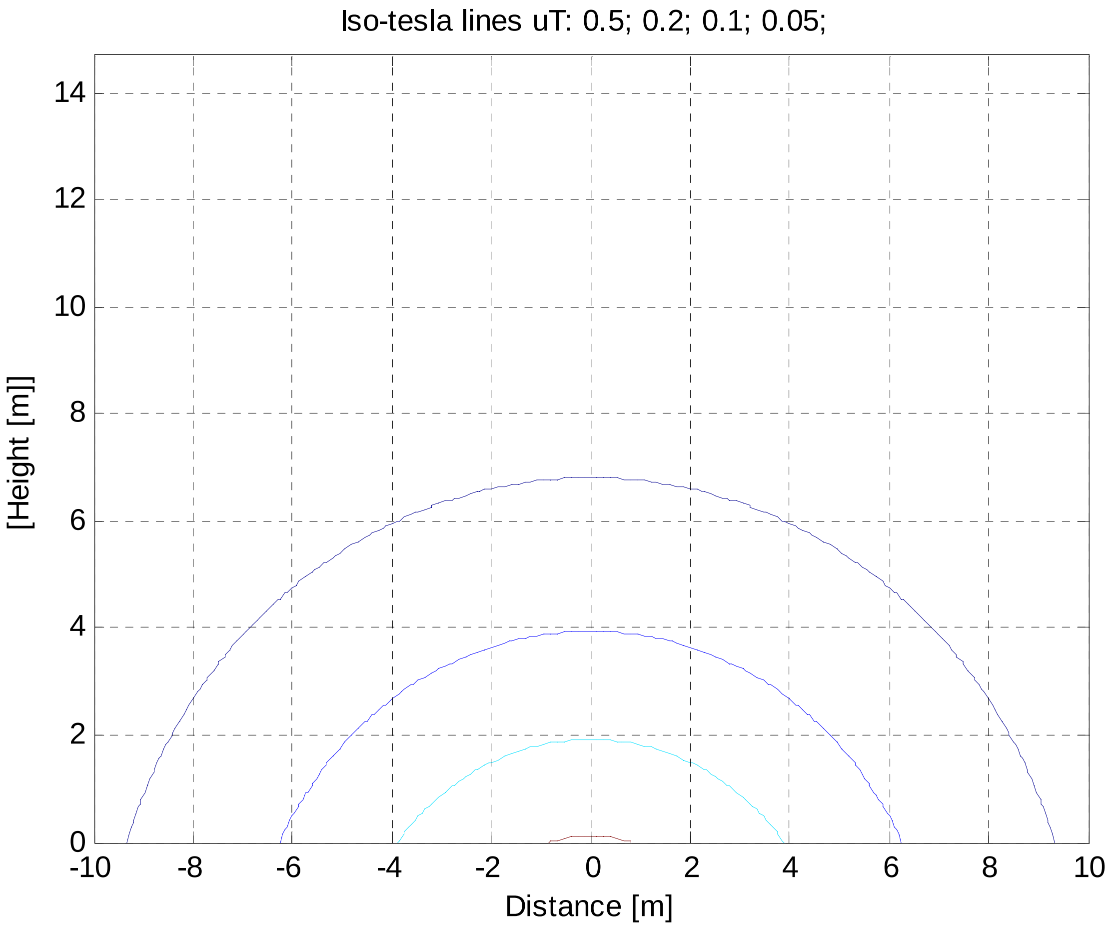
1. Basic input data for calculation of EMF

- Burial depth: 3 m
- Current per WTG: 40 A
- Number of WTG's: 9 pcs.
- Cable: Please see § 3

2. Diagrams:



Burbo Offshore Windfarm
ABB Power Technologies AB High Voltage Cables



Annex 1(7) Marine Fish

4m Beam Trawls

SeaScape Energy

Burbo Bank Offshore Wind Farm

Construction Phase Commercial Fish Survey

Document: J3034 Commercial Fish Survey Construction Phase
V4 (April 2008)

Version	Date	Description	Prepared by	Checked by	Approved by
1	06/07	First Draft	KJN/LG	SWD	
2	07/07	Submitted Report	KJN/LG	SWD	IGP
3	09/07	Revised Report	KJN/LG	IGP	IGP
4	04-08	Exec Summary Added	IGP	LG	IGP

This report has been prepared by Centre for Marine and Coastal Studies Ltd (CMACS) on behalf of SeaScape Energy.

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Cover photograph: Commercial 4m benthic beam trawl onboard commercial fishing vessel 'Admiral Grenville'.

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Appendices

List of Tables and Figures

1. Executive Summary

Burbo Offshore Wind Farm is a twenty-five turbine, 90MW development located in Liverpool Bay approximately 6km from the coastlines of Wirral, Crosby and Liverpool.

A licence was issued to the wind farm developer, SeaScape Energy Ltd, which allows them to construct and operate the wind farm providing certain conditions are met. The licence (31864/07/0) was issued under the Food and Environment Protection Act (FEPA) and contains a requirement to monitor fish in and around the wind farm. The requirement for fish monitoring is partly met through annual 4m beam trawls.

The spring 2007 survey was the second annual commercial fish survey. As with the baseline survey in 2006 it was undertaken in May. This was after the majority of wind farm infrastructure had been installed but before power generation commenced.

Relatively high numbers of fish were caught in 2007, including at sites in close proximity to the wind farm. The composition of catches was similar, for example dab was a dominant species in both 2006 and 2007, but significant numbers of a range of other species including rays and flatfish were captured in 2007 that were not recorded in 2006. No specific conclusions are yet drawn as this will be a focus of the 2008 survey report.

In spring 2008 the first commercial fish survey during wind farm operation will be undertaken. This will be of particular interest in relation to the investigation of elasmobranch foraging activity within the wind farm. Stomach contents have been retained and analysed from dogfish caught during the surveys and these data will be used to review foraging behaviour of individuals caught within and around the wind farm with those outside it.

2. Introduction

Burbo Bank offshore wind farm is located approximately 7km off the Wirral and Sefton coastline on Burbo Flats within Liverpool Bay. The construction of the wind farm commenced with installation of turbine foundations (monopiles) and three electricity export cables in July 2006; intra-array cabling has continued into 2007 and final works to bury sections of cable were ongoing during this years commercial fish survey.

Centre for Marine and Coastal Studies (CMACS) Ltd carried out the first commercial fish survey at Burbo Flats during May 2006 and collated baseline data describing the presence and abundance of demersal fish species within and around the development area as part of the pre-construction phase of the project. The May 2007 commercial fish survey is a repetition of this baseline survey and was undertaken during the construction phase of the project in compliance with the conditions of the Food and Environment Protection Act (FEPA) 1985. To this end the beam trawl survey carried out during May 2007 covered the same sites, both inside the turbine array and control sites north and west of the wind farm area, surveyed in 2006 and collated comparative data on the presence and abundance of demersal fish species within and around the development area.

This report describes the results of the commercial fish survey of May 2007 and identifies the main demersal species and their size class distributions on and around the Burbo Bank. Some basic comparisons between the results of the construction phase 2007 and pre-construction phase 2006 surveys are included. However, such comparisons of the data are tentative at this stage and the main findings represent preliminary interpretations of the data available. Conclusions will be drawn out after review of data collected in a post-construction survey planned for May 2008.

3. Methods

The survey was carried out over 3 days from 16th to 18th May 2007 aboard the fishing vessel ‘Admiral Grenville’ (Figure 1) operating out of the East Canada Dock in Liverpool. The vessel remained at sea for the duration of the survey so that the vessel could carry out normal commercial fishing during the hours of darkness when onboard scientific staff were at rest. The survey was carried out using twin 4m commercial beam trawls (Figure 2) with 80mm mesh cod-end and a chain matrix between the beam and footrope.

Figure 1. Fishing vessel 'Admiral Grenville'

Figure 2. 4m commercial beam trawl on ‘Admiral Grenville’

Trawling was carried out over the ground at a speed of 3.5-4 knots, in keeping with the previous methodology used during the baseline survey in May 2006, and deemed to be the most efficient speed for the capture of fish. Trawling was carried out for 30 minutes over a distance of 2km. Trawl location, duration and other details are presented in Appendix 1. Trawling at sites 7 and 8 was limited owed to the close proximity of construction activities and laid cables. Consequently, the trawls at sites 7 and 8 were combined to create a single trawl covering the length of the proposed turbine array. Trawl 9 and Trawl 6 were shortened from 30 minutes at 3.5-4 knots to 15 minutes, to restrict its full length to within the proposed wind farm area and to minimise any potential damage to gear and the vessel from trawling in very shallow water respectively. Equivalent steps were taken during the preliminary baseline survey in May 2006.

Once the gear had been retrieved to deck, the contents of the cod-ends of each trawl were emptied into port and starboard bins, where any sediment could be washed off. One at a time, these bins were tilted so that the contents poured gradually onto a conveyor belt, which ran into the whale-back on the bow of the vessel where the contents of the trawl could be sorted on a second conveyor belt. Discards of the trawls dropped into a chute at the end of the second conveyor belt that emptied at sea-level. The port trawl was used in all of the trawls except trawl 4 as the port catch was lost in this case. Each trawl and any species of interest were photographed (see Appendix 3 and Appendix 4).

As the catch passed along the conveyor in the whale-back (Figure 3), all fish were picked out of the trawl contents by the CMACS representatives on board. Benthic epifauna were not considered in this survey and were returned to sea via the chute previously described. The fish from each trawl were photographed in boxes and then counted, all commercial fish species with the addition of dab *Limanda limanda* were measured, elasmobranchs were sexed and measured.

Figure 3. Conveyor and chute in the whale-back of 'Admiral Grenville'

As in the baseline study in May 2006, it was necessary to take the stomachs of dogfish *Scyliorhinus canicula* that were caught in the trawls. This was undertaken to provide information on whether these small sharks forage within the turbine array, especially once the farm is operational, and allow comparisons to be made with the findings of the previous year's survey.

Laboratory analysis of dogfish stomachs was in keeping with the methodology described previously in the May 2006 Burbo Banks Offshore Wind Farm Commercial Fish Survey Report (CMACS ref: J3034 4m Beam Trawl Survey v2.0 (April 2006)).

4. Results

4.1. Numbers and taxa

Distribution maps displaying the location of each trawl site and detailing the numbers of species and individuals are presented below within Figure 4 and Figure 5 respectively, all raw data are summarised in Appendix 2.

A total of twenty-three species of fish were caught during the survey with the highest abundance of individuals (881 individuals) at site 10 to the north of the proposed turbine array (see Figure 5). Numbers of fish taxa were highest at several sites (13 taxa) including sites 1-4 and site 11, located some distance west of the proposed development area and inshore the wind farm area respectively (see Figure 4).

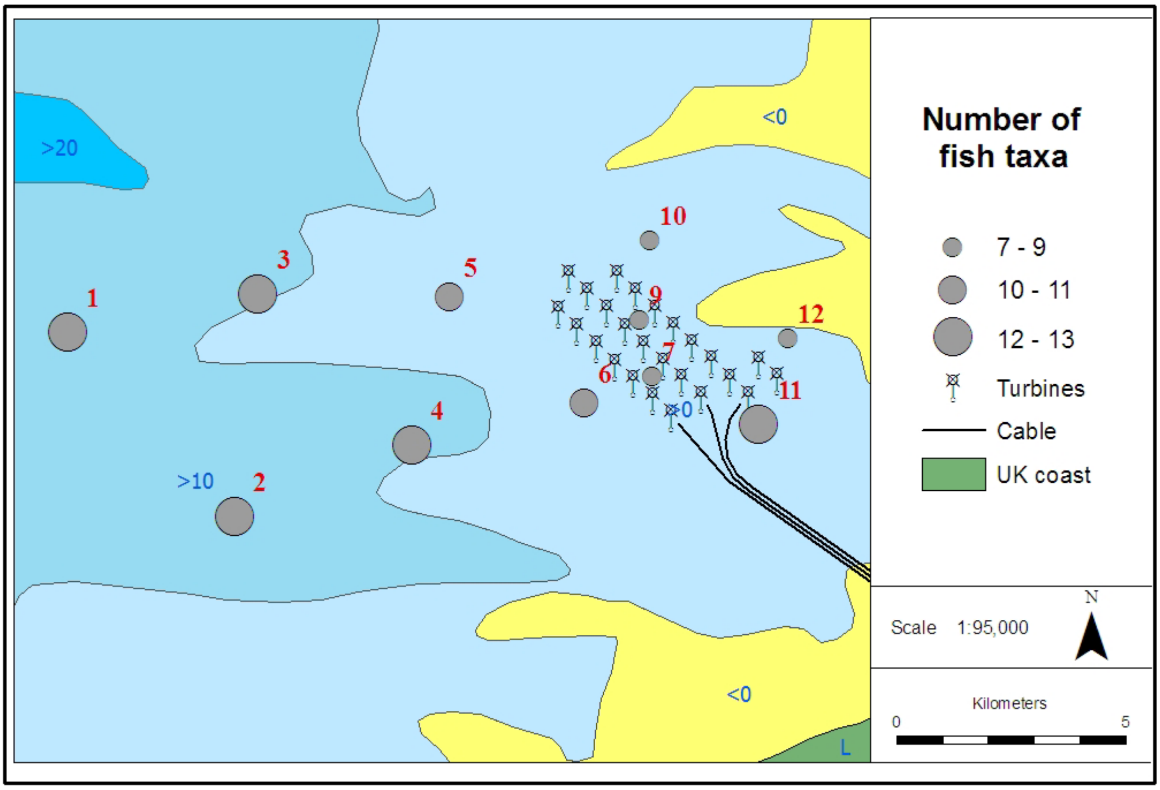


Figure 4. Numbers of species of fish at each of the trawl sites. Red numbers denote site, blue numbers denote water depth in metres.

No obvious patterns in diversity were recorded across the development area, although larger numbers of fish taxa tended to be observed in trawls from the deeper water sites located west of the turbine array, over the 10m contour line. Comparatively, lower numbers of fish taxa were observed in trawls within and close to the wind farm area, with the exception of site 11 where thirteen different fish taxa were recorded. Sites 5 and 6, in the near-field area to the west, were somewhat less diverse, with 10 different taxa being recorded from each trawl. Sites within and in close proximity to the east of the proposed turbine array were least diverse, with the lowest number of fish taxa being observed at site 10 (7 taxa) just north of the wind farm area. The remaining trawls contained either 8 or 9 different species of fish (sites 7, 9 and 12).

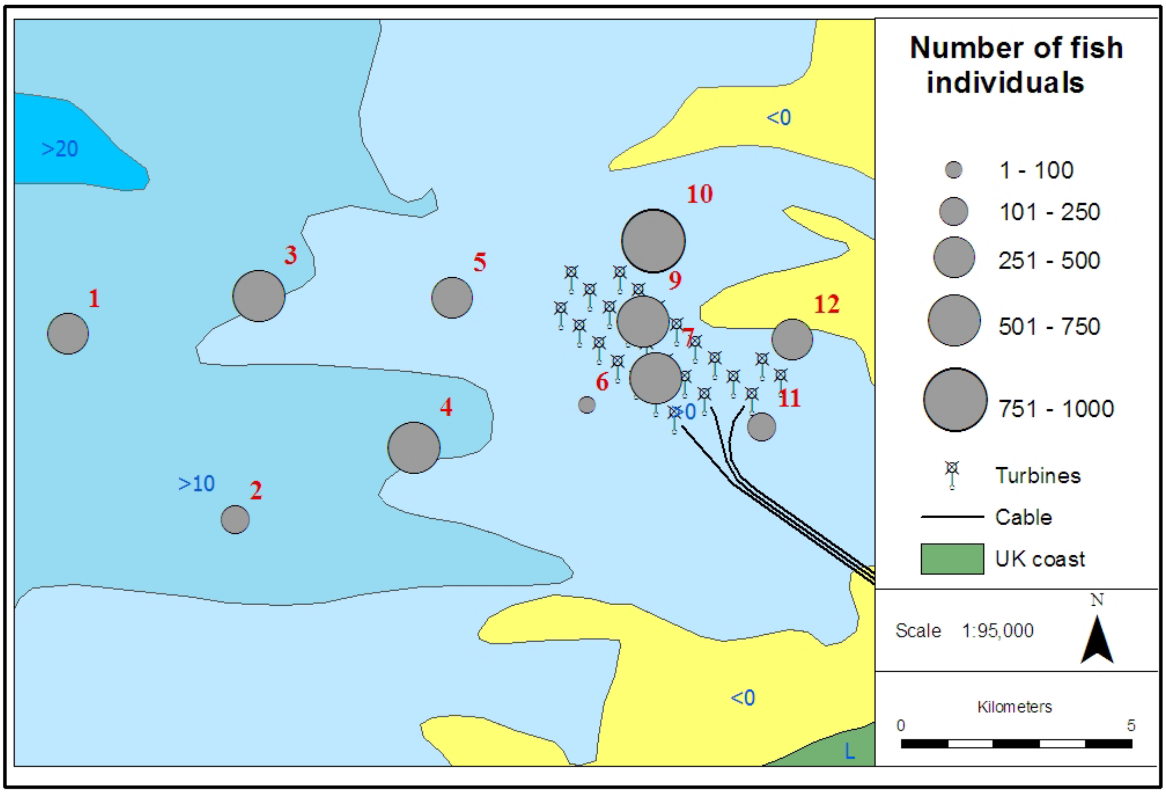


Figure 5. Numbers of fish individuals at each trawl site. Numbers in red denote site, numbers in blue denote water depth in metres.

The largest number of fish was recorded at site 10 (881 individuals) just north of the wind farm area. Comparatively large numbers were also recorded at site 4 just inside the 10m isobath west of the wind farm (667 individuals) and at two sites within the turbine array at sites 7 and 9 (611 and 662 individuals respectively). However, some caution should be used when interpreting count data from trawls 7 and 9, as the total numbers recorded from site 7 are a combination of two trawls (7+8), longer in length and duration than the other standard 30 minute tows. Efforts to restrict trawling within the wind farm area also reduced the length of the tow possible at site 9 to half the length of the standard trawls observed elsewhere across the site.

The remaining trawls from the deep-water sites (>10m) contained variable numbers of fish, although relatively high numbers were observed at site 3 just inside the 10m isobath (503 individuals). Fewer fish were counted at the western most sites (390 individuals site 1 and 213 individuals site 2). There was no obvious pattern in fish abundance across sites in the turbine array itself or in the areas close to the wind farm area. The lowest numbers were observed at site 6 (89 individuals) and 11 (190 individuals) just west and south of the proposed turbine boundaries, adjacent to areas of comparatively high abundance at sites 5 (491 individuals) and 12 (345 individuals) located further west and east of the wind farm area respectively.

Of the twenty-three taxa recorded in the survey, 3 were recorded just once. These included pogge *Agonus cataphractus,* turbot *Psetta maxima* and cuckoo ray *Raja naevus.* Previous beam trawl surveys have not shown any of these three taxa to be common in the Burbo Bank area. Pogge are also relatively small in size and were not recorded with any great frequency probably owed to the large commercial mesh size of the gear used allowing small species to pass through and escape the nets.

4.2. Common species

The most common species recorded from the survey was dab *Limanda limanda* with a total of 3417 individuals being recorded from all 12 trawls. Dab generally made up over 40% of the numbers of fish recorded from any one trawl, with the exception of trawls 2 (31%) and 11 (29%), up to a maximum of 88% in trawl 9 (figure 6). The proportion of fish recorded for each species per trawl are provided in Figure 6. The majority of the dab recorded were between 150-250 mm in length (figure 8). This suggests the population of dab surveyed over the Burbo Bank area are mainly composed of mature individuals between 2-5 years of age (www.fishbase.org). Dab are known to reach a maximum size of 400 mm with a life expectancy up to 12 years. Trawling at Sites 11 and 12 both recorded individual dab 283 mm in length, the largest observed during the survey.

The next most common fish recorded was plaice *Pleuronectes platessa* with a total of 708 individuals recorded from all 12 trawls. Although present at every site, plaice were more abundant at some deeper water sites (sites 1 and 2) and close to the proposed turbine array (Site 11) comprising 31-35% of total fish numbers caught. Plaice had a broad size range between 100-450 mm length, although most individuals recorded were < 250 mm. Most plaice ranged between 150-250 mm (figure 9), although the largest individual was 420 mm and was recorded during trawling at Site 3.

Flounder *Platichthys flesus*, thornback ray *Raja clavata* and dover sole *Solea solea* were also caught in relatively large numbers. Flounder were most abundant at site 10 (122 individuals), where they comprised 14% of the total trawl. Flounder were present in all trawls, albeit in lower numbers compared to dab and plaice, with the exception of site 2 where none were recorded. Individual flounder were generally of a large size, the majority of individuals being measured between 250-400 mm, with peaks in the 250-300 mm and 300-350mm size classes (figure 10). The largest individual was recorded from trawl 9 (425 mm). Dover sole were present in similar numbers at most sites across the survey area. Slightly higher numbers were apparent at site 12 (26 individuals) representing 8% of the total catch. The majority of the population were between 200-350 mm, with most individuals measuring over 240mm total length (figure 12). This suggests the majority of the population is above the minimum landing size of 240 mm for this species.

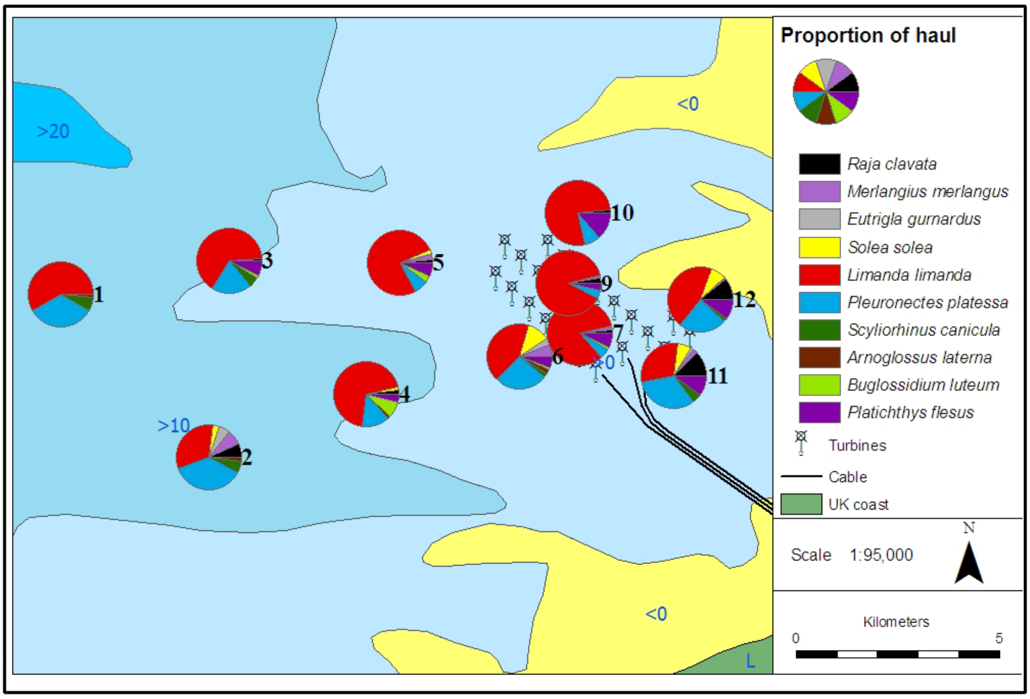


Figure 6. Proportion by numbers of catch in each trawl of the eleven most common species in the survey. Numbers in black denote site, numbers in blue denote depth in metres.

4.3. Elasmobranchs

Five species of elasmobranch were recorded during the survey: thornback ray *Raja clavata*, lesser spotted dogfish *Scyliorhinus canicula,* starry smooth hound *Mustelus asterias,* tope *Galeorhinus galeus* and cuckoo ray *Raja naevus* (figure 7). Thornback rays were the fourth most abundant fish species observed. This species was recorded from every trawl in relatively smaller numbers, with the exception of site 6 where none were observed. Generally larger numbers were present during trawling at the shallower sites, east of and within the wind farm area compared to the deeper water sites to the west. Most individuals were observed at sites 11 and 12 comprising 12% and 11% of the total catch respectively. The site is clearly important for juvenile rays, with most recorded being between 100-200 mm in length (figure 11), although some large adults were also recorded (largest: 808 mm female from site 10). Of the 138 individuals 77 were male and 61 were female suggesting an uneven sex ratio in the sampled population slightly biased towards males. Only a single cuckoo ray was observed at site 12 east of the proposed development area. Small numbers of tope and starry smooth hound were also recorded, usually in isolated incidents. Two tope were observed from relatively deeper water (>10m) at site 4, west of the proposed wind farm area. These individuals consisted of a single male 960 mm and a single female 796 mm. Three starry smooth hounds were recorded individually at sites 5, 7 and 11, two of which were male and one of which was female. These individuals were between 650-700 mm total length indicative of juvenile size (www.fishbase.org). Larger numbers of the lesser-spotted dogfish were observed (82 individuals) from 9 of the 12 trawls although none were present at sites 7 (7+8) and 10. Of the 82 lesser-spotted dogfish recorded 25 were male and 57 were female suggesting the population has an uneven sex ratio heavily biased toward females.

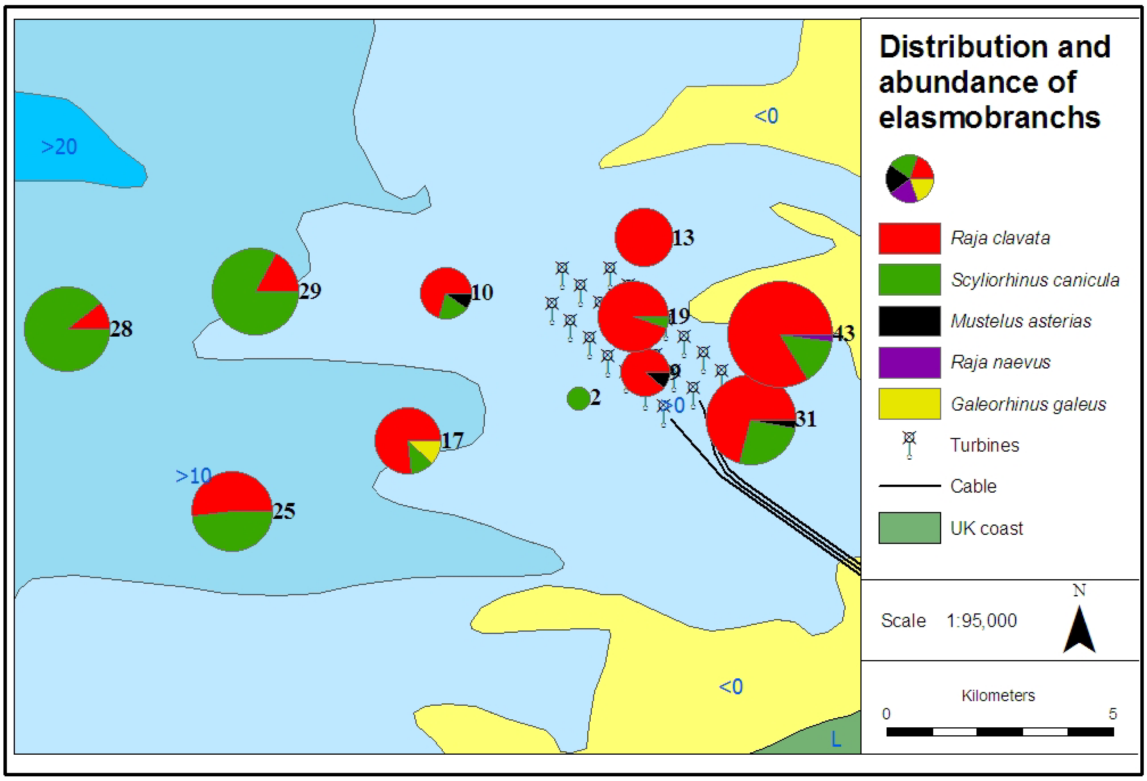
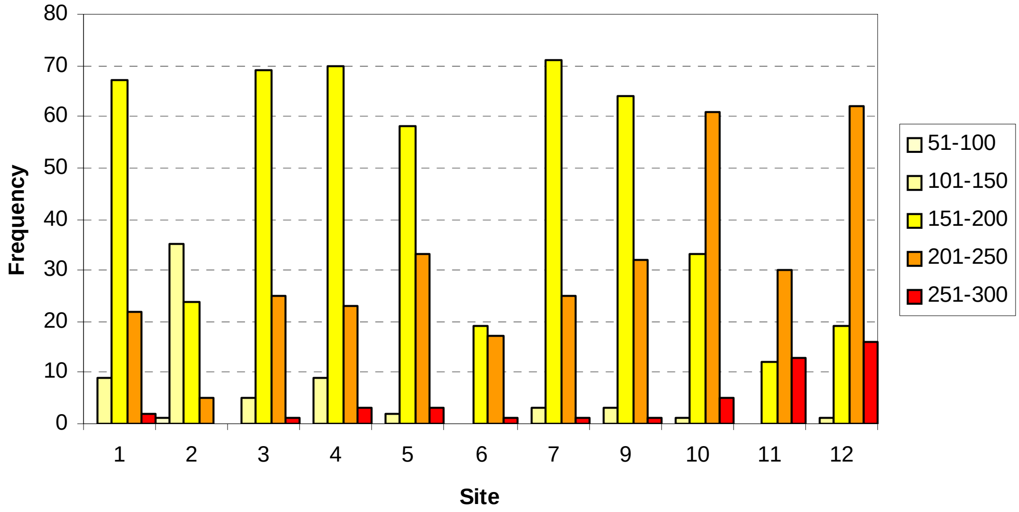


Figure 7. Proportion by numbers of elasmobranchs in each trawl. Numbers in black denote site, numbers in blue denote depth in metres.

4.4. Other/Protected species

None of the fish species recorded during the May 2007 survey are protected individually under any national or international legislation. However, commercial marine fish are listed under a grouped species biodiversity action plan (www.ukbap.org.uk). The priority species listed under this action plan are those for which the International Council for the Exploration of the Seas (ICES) scientists' assessment is that they are below Safe Biological Limits (SBL). These include species like cod, plaice and sole. These fish taxa are protected under the Regulations underpinning the Common Fisheries Policy. One of the more unusual fish observed was the anglerfish *Lophius piscatorius* from sites 2 and 3 in the deeper water to the west of the proposed wind farm area.



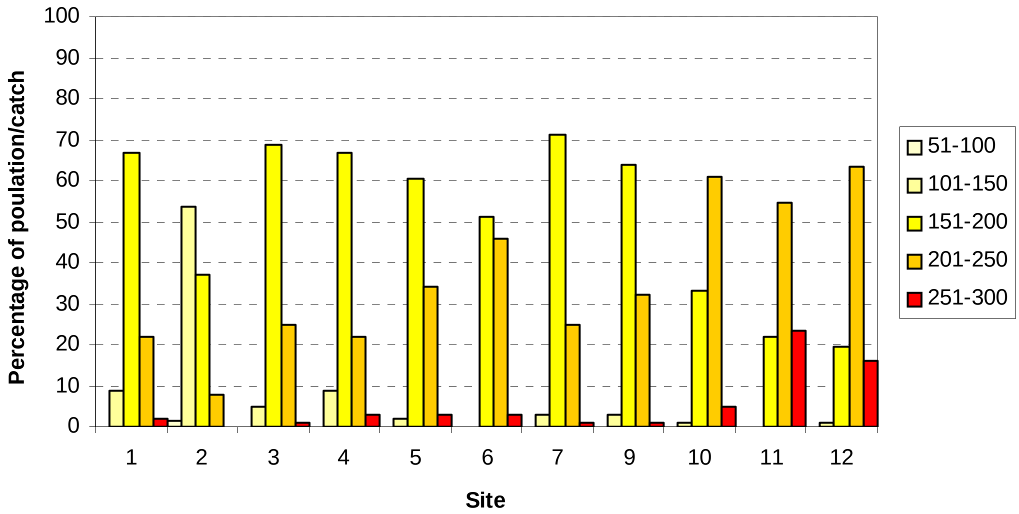
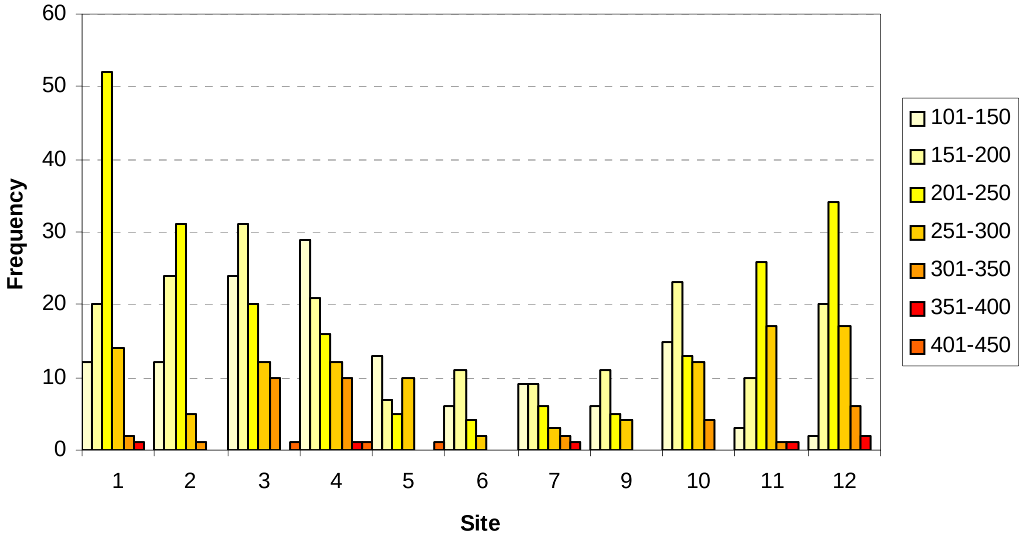


Figure 8. Size distribution plots for dab *Limanda limanda* at each trawl site. Size classes are in millimetres and are shown in the legend to the right of each plot. The upper graph plots actual numbers of dab from each trawl and the lower graph plots proportion



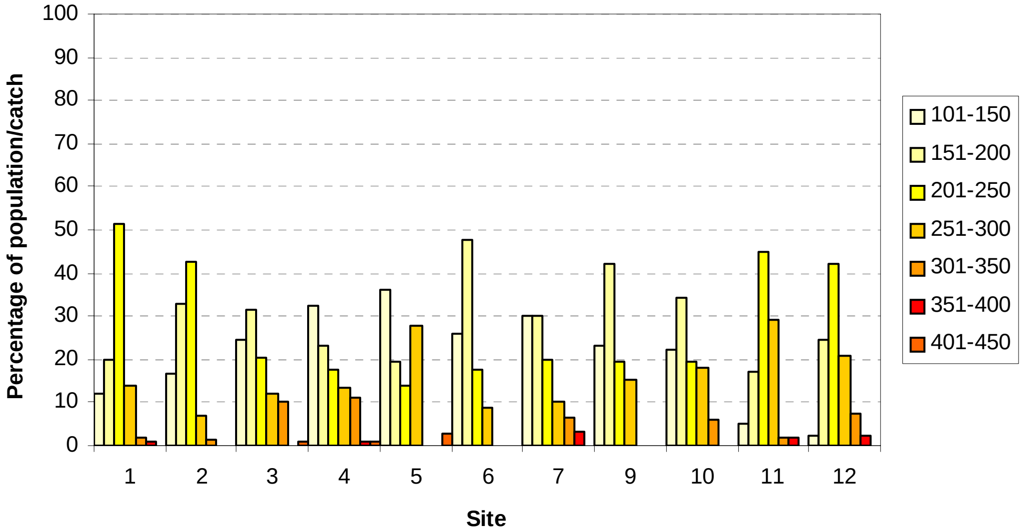
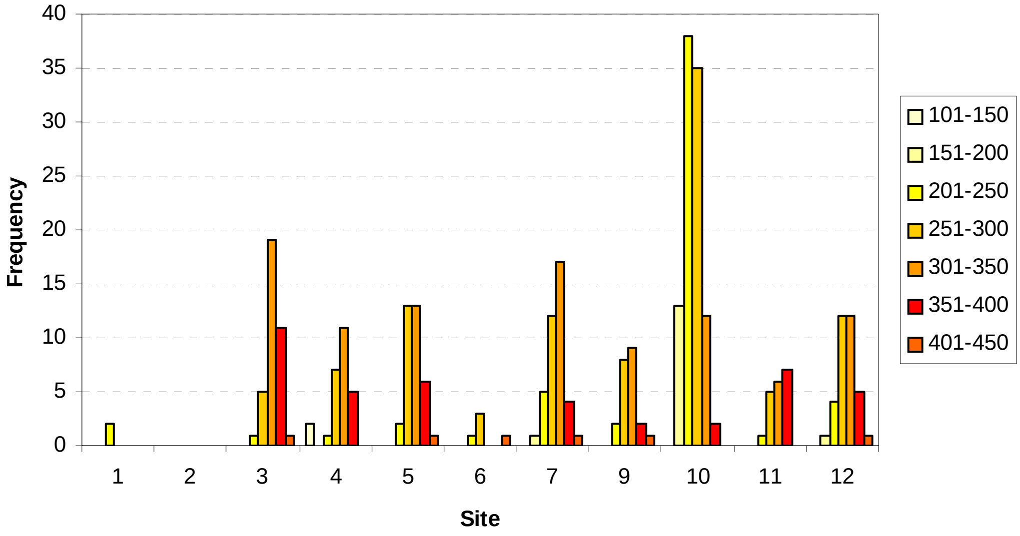


Figure 9. Size distribution plots for plaice *Pleuronectes platessa* at each trawl site. Size classes are in millimetres and are shown in the legend to the right of each plot. The upper graph plots actual numbers of plaice from each trawl and the lower graph plots proportion of the catch in each size class as a percentage of the number of plaice in each trawl.



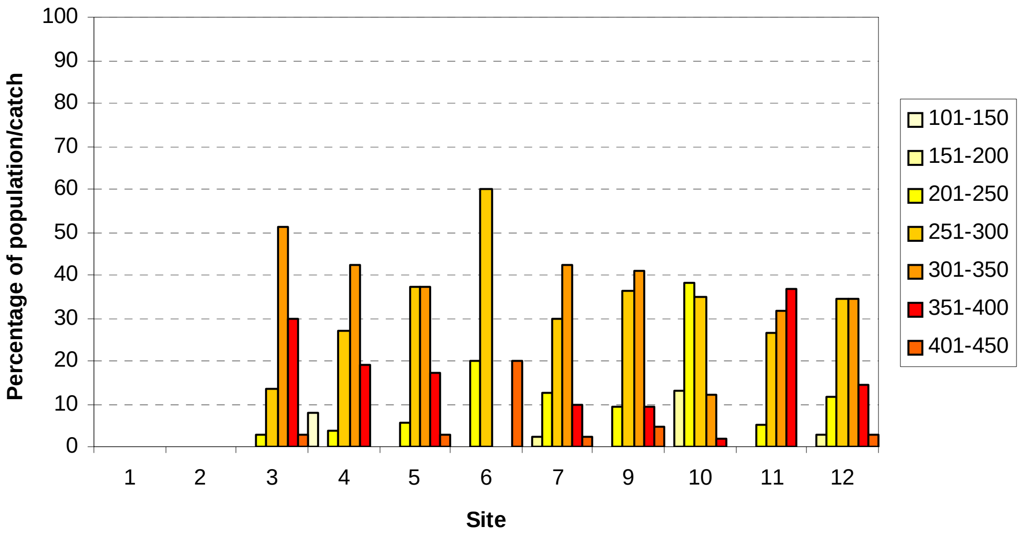
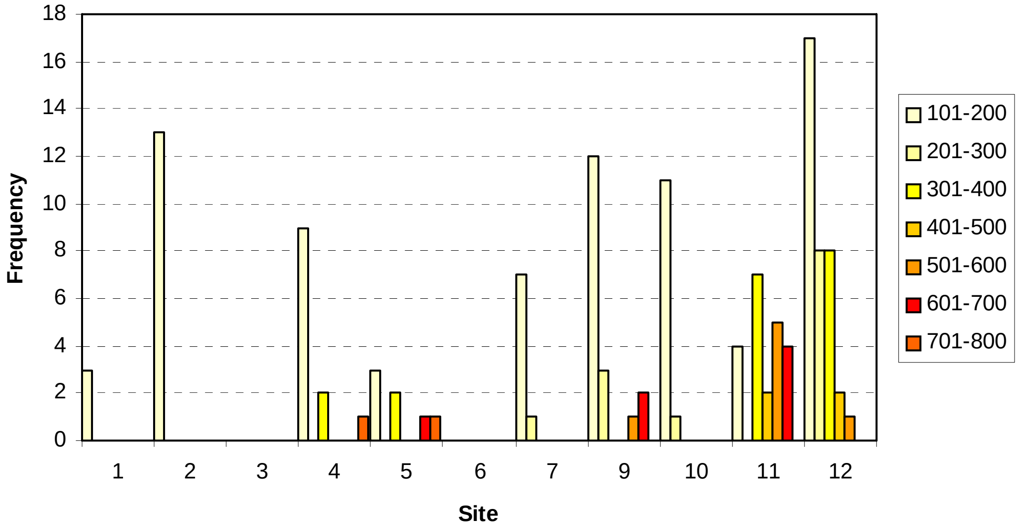


Figure 10. Size distribution plots for flounder *Platichthys flesus* at each trawl site. Size classes are in millimetres and are shown in the legend to the right of each plot. The upper graph plots actual numbers of flounder from each trawl and the lower graph plots proportion of the catch in each size class as a percentage of the number of flounder in each trawl.



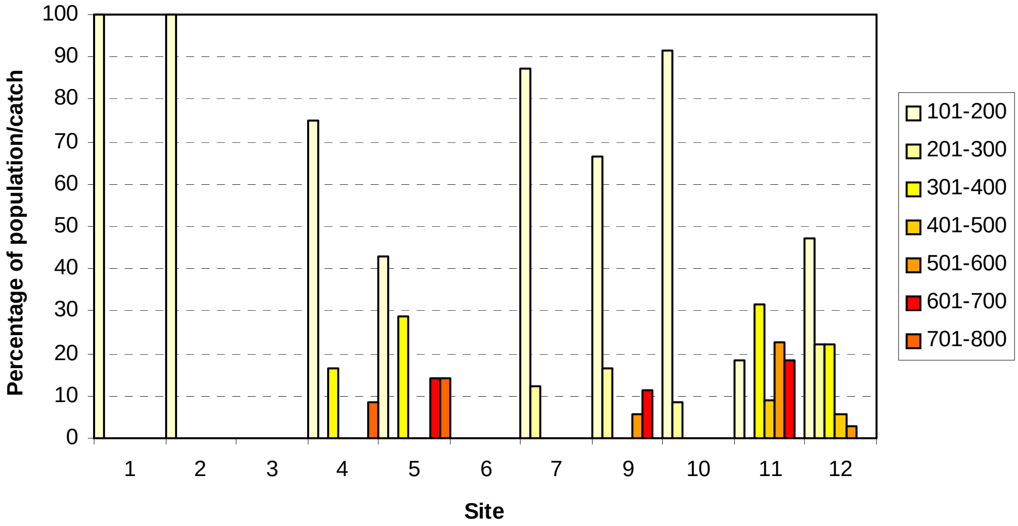
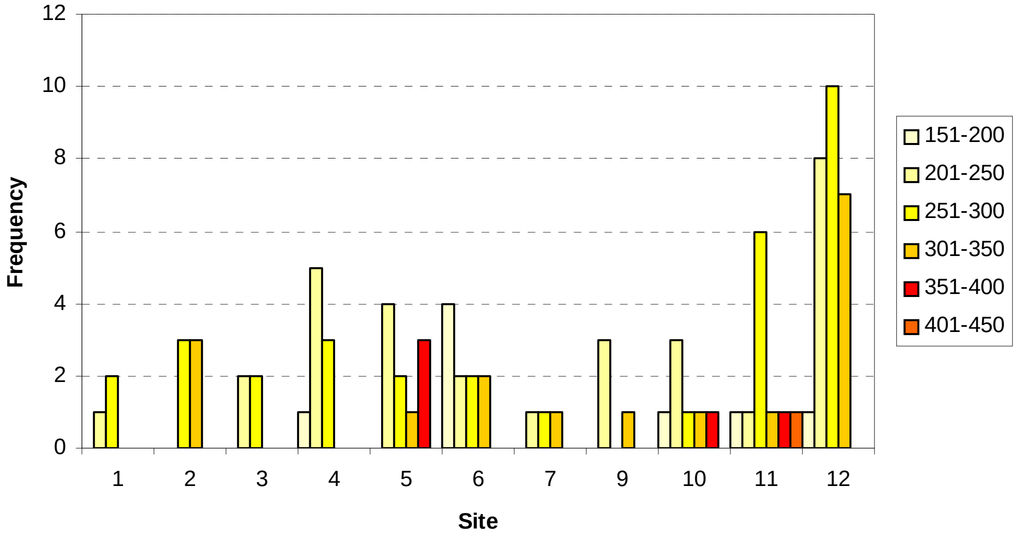


Figure 11. Size distribution plots for thornback ray *Raja clavata* at each trawl site. Size classes are in millimetres and are shown in the legend to the right of each plot. The upper graph plots actual numbers of thornback ray from each trawl and the lower graph plots proportion of the catch in each size class as a percentage of the number of thornback ray in each trawl.



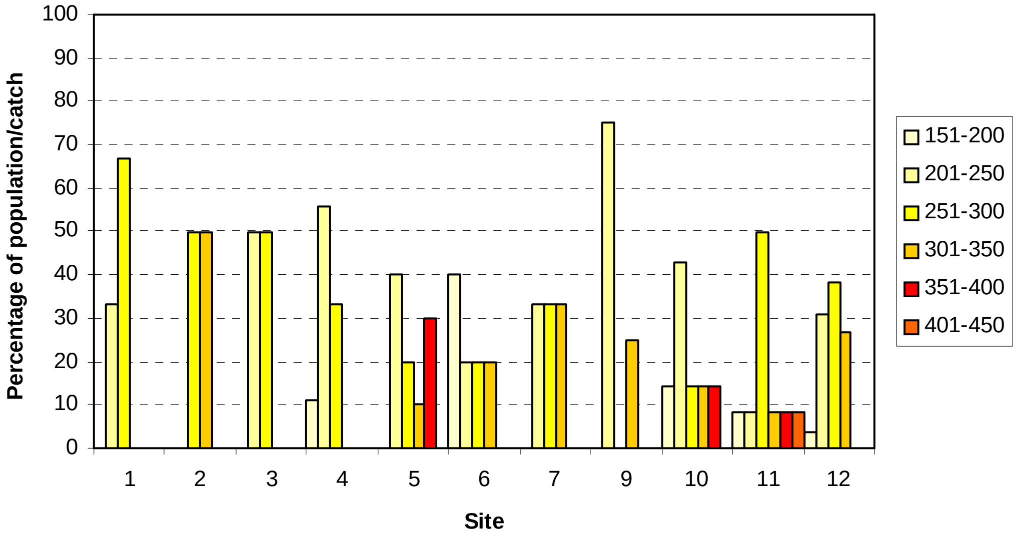


Figure 12. Size distribution plots for dover sole *Solea solea* at each trawl site. Size classes are in millimetres and are shown in the legend to the right of each plot. The upper graph plots actual numbers of sole from each trawl and the lower graph plots proportion of the catch in each size class as a percentage of the number of sole in each trawl.

4.5. Dogfish stomach contents

A table describing the fullness and contents of the dogfish guts is presented in Appendix 5.

4.6. Comparisons between the 2006 and 2007 commercial trawl surveys

In general, higher numbers of fish were recorded per site during the 2007 commercial trawl survey, with the exception of sites 3 and 4. Overall numbers of total fish were greater in 2007, when 5042 individuals were recorded compared to 3081 in 2006. Some similarities between years were observed, especially at sites 2, 6 and 11, where very similar numbers of total fish were recorded. Considerably more fish were observed during 2007 at several of the shallower water sites within the proposed turbine array, specifically at sites 7+8, 9 and 10. Comparatively more individuals were also reported at sites 5 and 12 in close proximity to the wind farm area in 2007 compared to 2006. The largest numbers of fish were observed at site 4 during the 2006 survey; consistently high numbers of individuals were common in the deeper water sites west of the turbine array compared to sites further east. Although considerable numbers of fish were also observed at these sites during the 2007 survey, the largest number of total fish was reported for site 10 just north of the array and numbers of fish at several of the shallower eastern sites were also observed. These patterns suggest an increase in total fish abundance between 2006 and 2007 across the survey area, especially at the shallower sites east of and within the proposed development area.

No obvious differences in numbers of fish taxa were apparent between surveys. Twenty-three different fish species were described during 2007 compared to 22 in 2006. Total numbers of taxa recorded at each site were similar between survey years, where sites located in deeper water to the west of the proposed turbine area were generally most diverse. This was the case for site 4 during 2006 and sites 1-4 in 2007. A large number of fish taxa were also recorded at site 11 during 2007 just south of the proposed turbine array. The least diverse site was site 10 during both survey years.

The order of species importance, in terms of total numbers of individuals, was very similar between 2006 and 2007 (Table 1). Dab was the most common fish species recorded during both survey years, albeit in higher numbers during 2007 (3417 individuals compared to 1995 individuals in 2006). Plaice was the next abundant. Flounder, thornback ray, dover sole and solenette were also some of the commonest fish taxa observed from trawls in both survey years. Overall larger numbers of these fish were recorded in 2007. In addition to thornback ray, lesser-spotted dogfish and starry smooth hound were recorded during both surveys. A further two species of elasmobranch were present in 2007, including tope and cuckoo ray, although only present in very small numbers.

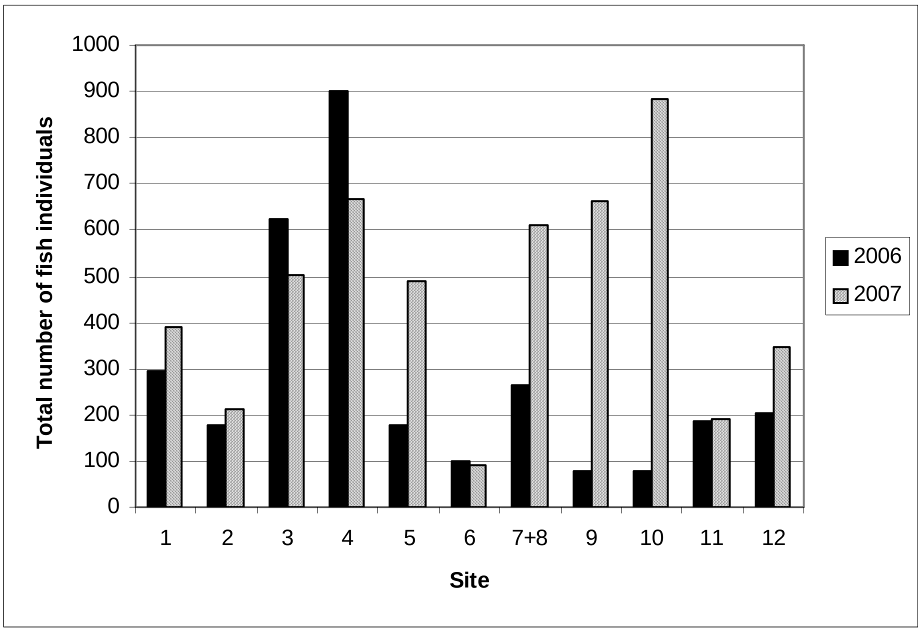
Table 1. Total numbers of the commonest fish taxa recorded in 2006 and 2007.

2006	Total nos	2007	Total nos
Dab	1995	Dab	3417
Plaice	282	Plaice	708
Solenette	203	Flounder	346
Flounder	143	Thornback ray	138
Dover sole	134	Dover sole	95
Thornback ray	101	Solenette	88

Similarities in the size distributions of fish are common in several of the most abundant fish taxa observed in both survey years (Table 2). These data suggest that the majority of the fish being recorded are mature, and in the case of dover sole are above the minimum landing size of 240 mm for this species. According to these data, Burbo Bank also appears to be an important area for juvenile thornback ray.

Table 2. Size distribution data for the commonest fish taxa recorded in 2006 and 2007.

Fish Taxa	2006	2007
Dab	150-250 mm	150-250 mm
Plaice	200-250 mm	< 250 mm (150-250 mm)
Flounder	250-300 mm, 300-350 mm	250-300 mm, 300-350 mm
Dover sole	200-350mm, > 240 mm	200-350mm, > 240 mm
Thornback ray	100-200 mm, 200-400 mm	100-200 mm



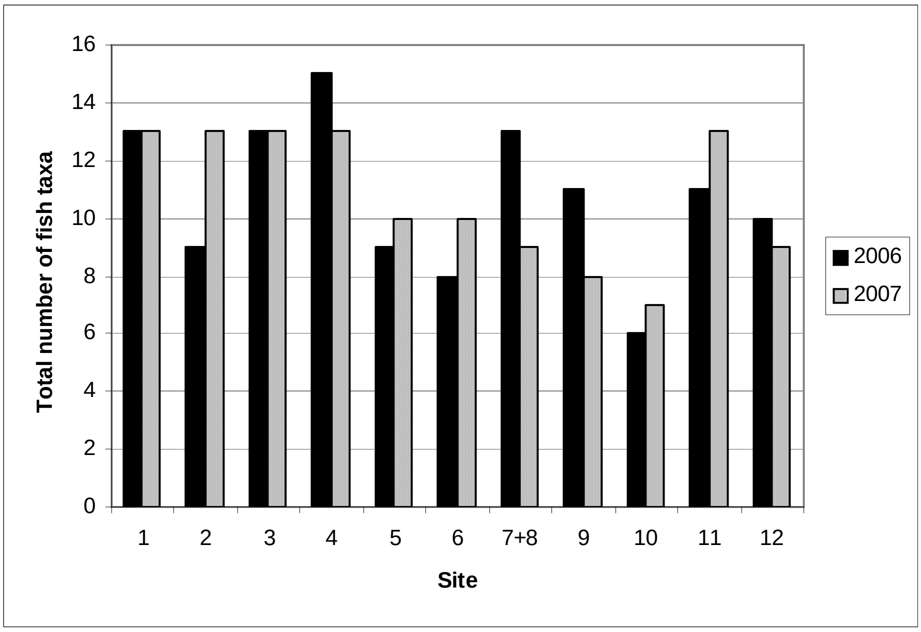


Figure 13. Comparisons of total fish numbers and total fish taxa recorded during the 2006 and 2007 commercial fish trawl surveys at Burbo Banks Offshore Wind Farm. The upper graph plots actual numbers of total individuals and the lower graph plots actual numbers of fish taxa recorded for each trawl during both the 2006 and 2007 beam trawl surveys.

Appendices

Appendix 1. Trawl survey field notes

	1	2	3	4	5	6	7+8	9	10	11	12
Date	17/05/07	17/05/07	16/05/07	16/05/07	16/05/07	16/05/07	17/05/07	17/05/07	16/05/07	17/05/07	17/05/07
Time: Start	08:51	10:06	18:58	18:11	16:36	17:20	14:25	13:15	20:37	12:33	11:39
Time: Finish	09:21	10:36	19:28	18:41	17:06	17:45	14:40	13:30	21:07	13:03	12:09
Start Position	53°28.3N 3°20.2W	53°26.5N 3°18.4W	53°28.8N 3°16.94W	53°27.2N 3°14.3W	53°29.97N 3°15.46W	53°29.0N 3°13.4W	53°28.65N 3°12.72W	53°29.65N 3°11.78W	53°30.6N 3°10.49W	53°28.38N 3°09.29W	53°29.5N 3°09.5W
End Position	53°30.6N 3°22.0W	53°27.9N 3°21.1W	53°30.1N 3°19.6W	-	53°28.7N 3°14.0W	53°27.98N 3°11.6W	53°28.9N 3°11.38W	53°28.89N 3°10.38W	53°30.5N 3°13.0W	53°27.0N 3°06.58W	53°28.39N 3°06.47W
Speed (knots)	3.5-4	3.5-4	3.5-4	3.5-4	3.5-4	3.5-4	3.5-4	3.5-4	3.5-4	3.5-4	3.5-4
Direction	Against tide	Against tide	Against tide	Against tide	Against tide	Slack water	-	Against tide	Against tide	Against tide	Slack water
Tide height (m)	6.0	6.0	5.9	5.9	-	-	-	-	-	-	-
Weather conditions	NW 3-4	NW 3-4	W 2-3	SW 3-4	W 2	W 1	-	W/SW 4	-	W/SW 3	W 3
Notes	Clean trawl	Clean trawl	Mud and starfish	Mud and starfish	-	Water too shallow to complete 30min tow	Combined with tow 8, as unsure of cable proximity	Muddy	Clean trawl	Clean trawl	Clean trawl

Appendix 2. Numbers of fish caught in each trawl

Species	Vernacular	1	2	3	4	5	6	7+8	9	10	11	12	Total
Lophius piscatorius	Anglerfish		1	1									**2**
Raja clavata	Thornback ray	3	13	5	13	7		8	18	13	22	36	**138**
Merlangius merlangus	Whiting	2	15	3	6	14	5	13	9	2	5	4	**78**
Eutrigla gurnardus	Grey gurnard	3	12	3	4	1	3				3		**29**
Galeorhinus galeus	Tope				2								**2**
Solea solea	Dover sole	3	6	4	9	11	10	3	4	7	12	26	**95**
Aspitrigla cuculus	Red gurnard	1			1								**2**
Limanda limanda	Dab	216	65	315	453	370	37	505	579	667	55	155	**3417**
Pleuronectes platessa	Plaice	126	73	98	90	36	23	30	26	67	58	81	**708**
Scyliorhinus canicula	Lesser-spotted dogfish	25	12	24	2	2	2		1		8	6	**82**
Arnoglossus laterna	Scaldfish	5	4	4	8		2	1					**24**
Buglossidium luteum	Solenette	1		6	51	14	1	8	2	3	1	1	**88**
Callionymus lyra	dragonet	2	2	1	2								**7**
Platichthys flesus	Flounder	2		37	26	35	5	42	23	122	19	35	**346**
Agonus cataphractus	Pogge						1						**1**
Scophthalmus rhombus	Brill										4		**4**
Psetta maxima	Turbot										1		**1**
Mustelus asterias	Starry Smooth hound					1		1			1		**3**
Trisopterus minutus	Poor cod	1									1		**2**
Echiichthys vipera	Lesser Weever		5										**5**
Ammodytes sp.	Sandeel		3										**3**
Hyperoplus sp.	Sandeel		2	2									**4**
Raja naevus	Cuckoo ray											1	**1**
Total number of individuals		**390**	**213**	**503**	**667**	**491**	**89**	**611**	**662**	**881**	**190**	**345**	**5042**

Appendix 3. Trawl survey photographs

Photo1. Trawl 1.

Photo 2. Trawl 2.

Photo 3. Trawl 3.

Photo 4. Trawl 4.

Photo 5. Trawl 5.

Photo 6. Trawl 6.

Photo 7. Trawls 7.

Photo 8. Trawl 9.

Photo 9. Trawl 10.

Photo 10. Trawl 11.

Photo 11. Trawl 12.

Appendix 4. Photographs of special interest

Photo 12. Male tope *Galeorhinus galeus* from trawl 4.

Photo 13. Anglerfish (or monkfish) *Lophius piscatorius* from trawl 3.

Appendix 5. Dogfish stomach contents

The fullness index is a qualitative and relative comparison and therefore the stomachs of several dogfish are needed to gain an appreciation of the size and shape of an empty, half-full or full stomach.

Fullness index:

0 – All three divisions of the gut appear empty with no distension.
1 – All three divisions of the gut contain digested remains or at least one food item OR only one division of the gut contains any appreciable amount of matter and is clearly distended far beyond its usual size.
2 – All three divisions of the gut are approximately half-full OR two divisions of the gut are full and clearly distended beyond their usual size whilst the third contains little matter
3 – All three divisions of the gut are more than half-full.

Sample	Fullness index	Contents of gut division		
		Stomach	Duodenum	Spiral valve intestine
Trawl 1	1	Five pieces of white tissue One well digested fish (no skin or head)	Skin and chetae of a polychaete Numerous intestinal nematodes	Empty
Trawl 2	2	Pereopods and chelae of a hermit crab One large piece of white tissue Chetae of a large polychaete	Some brown digested material	Full of completely digested material
Trawl 2	3	Hermit crab parts Large piece of flesh may be *Pharus* or *Ensis* Fish vertebrae Chetae of a large polychaete	Full of digested remains with some chetae	Full of milky fluid of digested material
Trawl 2	2	Four pieces of white tissue Nematodes	Partially filled with well digested material	Full of digested remains
Trawl 4	2	Digested remains of a swimming crab Numerous nematodes	Brown, grainy material Numerous intestinal nematodes	Full of pink, grainy material
Trawl 5	1	Some well digested remains One decapod leg One polychaete Two pieces of white tissue	Empty apart from intestinal nematodes	Empty
Trawl 5	1	One digested crab One digested fish One digested polychaete Pereopods and chelae of hermit crab Well digested remains	Numerous intestinal nematodes	Some digested material
Trawl 9	2	Full of well digested material but nothing identifiable One piece of white tissue	Partially filled with digested material	Full of digested remains
Trawl 11	1	Two pieces of white flesh, possibly *Pharus* or *Ensis* Digested prawn parts	Some digested remains and nematodes	Some digested remains
Trawl 12	2	Very full of digested material but nothing identifiable Numerous pieces of white tissue	Full of brown, grainy digested remains	Some pink grainy material

2m Beam Trawls

Burbo Bank Offshore Wind Farm

Construction Phase

2m beam trawl survey

Document: J3034 Benthic Beam Trawl Report 2006 v3 (04-08)

Version	Date	Description	Prepared by	Checked by	Approved by
1	11/07	First Draft	LG	TH	IGP
2	03/08	Minor Edits	IGP	LG	IGP
3	04/08	Final version	IGP	LG	IGP

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Cover photograph: 2m benthic beam trawl frame and net onboard survey vessel 'Aquadynamic'.

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Figures Overleaf

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1 Executive Summary

Burbo Offshore Wind Farm is a twenty-five turbine, 90MW development located in Liverpool Bay approximately 6km from the coastlines of Wirral, Crosby and Liverpool.

A licence was issued to the wind farm developer, SeaScape Energy Ltd, which allows them to construct and operate the wind farm providing certain conditions are met. The licence (31864/07/0) was issued under the Food and Environment Protection Act (FEPA) and contains specific requirements for surveys of subtidal benthic (seabed) invertebrate ecology and fish. These are in part addressed by an annual 2m scientific beam trawl survey which complements other work, notably grab sampling and 4m (commercial) beam trawl surveys.

The 2m beam trawl survey is undertaken by Centre for Marine and Coastal Studies Ltd (CMACS) on behalf of SeaScape. The programme commenced with baseline (pre-construction) surveys in autumn 2005 which built upon surveys undertaken in 2002 in support of the project environmental impact assessment. This report presents the results of monitoring carried out in autumn 2006, during construction of the wind farm, and compares the results with baseline data.

Some clear differences in benthic fauna sampled by beam trawls were apparent between the baseline survey in 2005 and the during construction survey in 2006. The most notable trend was a marked decrease in abundance of epibenthic invertebrates and infauna sampled by trawls across many sites.

Such trends are considered very likely to reflect natural variability in what is a dynamic environment. Moderate-high similarity between the majority of trawl catches also suggests that there is relatively little difference between the fish, epibenthic communities and elements of the infauna sampled by trawls within and outside the wind farm. This suggests that the presence of the wind farm was not a strong influence on these organisms; however, it has to be pointed out that the survey was undertaken only a few months after wind farm construction commenced. Some organisms, especially invertebrates, may not respond to subtle environmental change for some time and the next survey, in 2007 after completion of remaining construction works, will provide valuable new data.

2 Introduction

Burbo Bank offshore wind farm is approximately 6 km off the Wirral and Sefton coastline on Burbo Flats within Liverpool Bay.

The Centre for Marine and Coastal Studies (CMACS) Ltd has been contracted by Seascape Energy Ltd to develop and undertake a programme of environmental monitoring to ensure compliance with a Food and Environmental Protection Act (FEPA) 1985: Part II (as amended) licence (No 31864/07/0) issued to Seascape. The monitoring programme includes requirements for surveys of subtidal benthic ecology and fish. These are in part addressed by an annual 2m scientific beam trawl survey which complements other work, notably grab sampling and 4m (commercial) beam trawl surveys. This report presents results from the September 2006 (during construction) 2m beam trawl survey and compares these with data from the pre-construction (baseline) survey of September 2005.

The construction of the wind farm commenced in May 2006 when a filter layer of stones was placed on the seabed at positions of wind turbine foundations in advance of hammer piling of the monopile bases the following month. Electricity export cables were installed between July and August 2006, intra-array cabling continued into 2007 and was ongoing during the September 2006 2m beam trawl survey. Rock armour dumping to provide scour protection around wind turbine bases took place between September and November 2006.

The primary aim of the surveys is to provide information on epifaunal benthic invertebrates and populations of smaller demersal fish species in and around the wind farm area to investigate whether construction and operation of the wind farm has any adverse impacts upon these environmental receptors.

These surveys will be repeated annually as part of the proposed monitoring required to comply with the conditions of the FEPA license issued to Seascape for the Burbo Bank Offshore Wind Farm. Future monitoring will commence in September/October to coincide with previous surveys. The need for continued survey will be reviewed annually following the first post-construction (wind farm operation) surveys.

3 Methodology

This following section details the methodologies used to collect biological samples from the field, as well as the sample processing and subsequent data analysis.

3.1 Field Survey

The survey was conducted over two days on the 16th and 17th of September 2006 using the survey vessel 'Aquadynamic' operating out of Liverpool Marina returning to berth on a daily basis. A standard CEFAS design 2m beam trawl with a 4mm square mesh cod end equipped with a chain matrix was used, being towed at each site for a distance of 300m at a speed of 2 knots to allow sufficient warp for the trawl to "fish" the bottom properly. All tows were undertaken into the prevailing current and 11 sites were surveyed in total (see Figure 1 and Appendix 1 for site locations). Site 11 could not be sampled because of ongoing wind farm construction activities nearby.

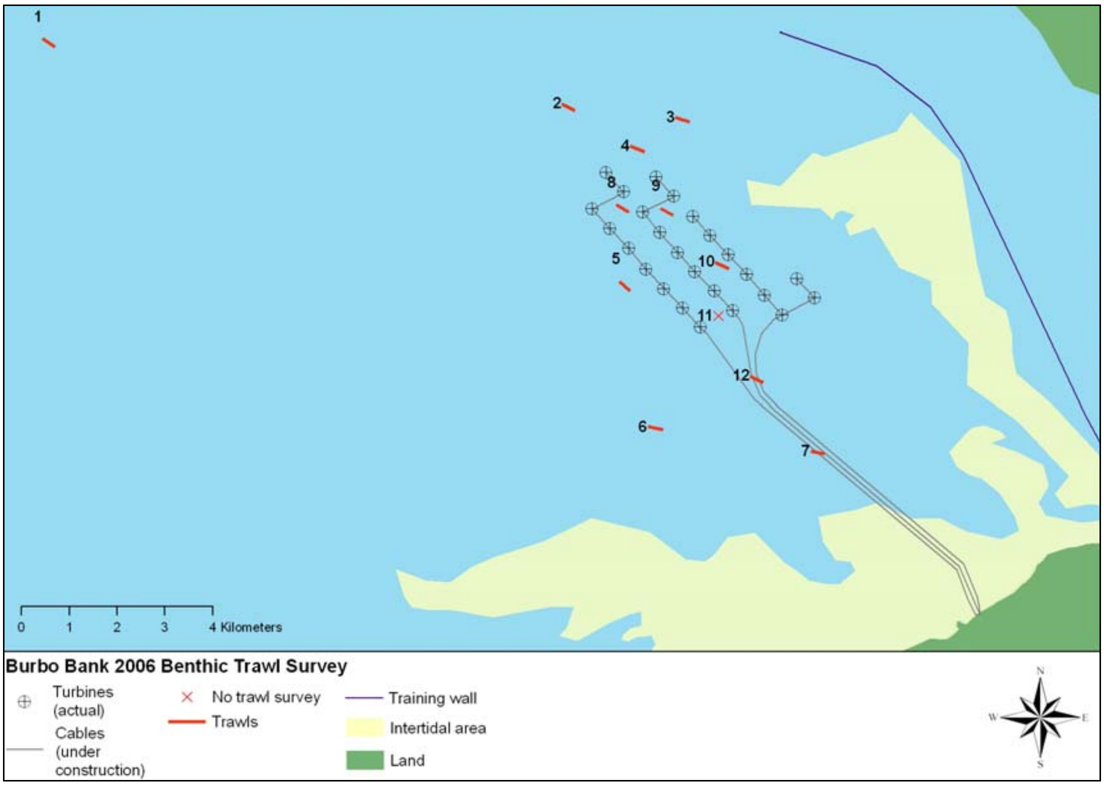


Figure 1 Benthic trawl locations sampled during September 2006 (N.B. Sampling at site 11 was not possible because of ongoing construction activities within the wind farm development area).

At each site, once the trawl was retrieved, the catch was photographed before being sorted and all organisms identified and counted where practical. Colonies of hydroids, bryozoans and soft corals were either assessed using an abundance scale (presence/absence) or recorded by weight (g). Where identification of certain species was not possible in the field these were retained, preserved and taken back to the laboratory for identification. Sub-sampling was undertaken at sites where very large hauls or large numbers of individual species were captured. On such occasions the catch was searched methodically for all large epifauna and any fish species before being divided into an appropriate fraction with the remaining organisms identified, counted then scaled up according to the fractional divide. Any commercial fish species captured, including elasmobranchs, were measured. The sex of elasmobranchs was also recorded where possible.

3.2 Statistical analysis

Raw data were organized into a database (Microsoft Access). Analysis was then undertaken, mainly using PRIMER Version 5 (see Clarke and Warwick, 1994, for an introduction to PRIMER). A variety of univariate, multivariate and graphical techniques were also used to provide information concerning species richness and universal features of community structure.

Multivariate analysis, (dendrograms and Multi Dimensional Scaling (MDS) plots) was based on the mean root-transformed abundance of species found, which provides a sensible balance between rare and common species, and uses the Bray-Curtis similarity coefficient (Bray and Curtis, 1957). The dendrograms were plotted using hierarchical clustering with group average linking. Site 11 was removed from all statistical analysis since it was not surveyed in 2006.

MDS ordination was also based on the Bray-Curtis similarity coefficient. Stress values are provided for each MDS plot; a stress value of <0.05 indicates that there is an excellent representation of the relationship between the various samples, 0.1 indicates good ordination and 0.2 indicates a potentially useful 2-dimensional picture (Clarke and Warwick, 1994). The above analysis was repeated with water depth superimposed in order to investigate the importance of this environmental variable.

The geographic information system ArcView has also been used for the analyses to allow the data to be represented spatially. This is an important tool, as it provides a visual template against which future changes can be compared.

4 Results

4.1 Fish

4.1.1 Abundance and distribution data

Fish abundance data and a full species list from the 2006 beam trawl survey at the Burbo Bank Offshore Wind Farm are provided in Appendices 2 and 3 respectively. Length data from commercial fish species are provided in Appendix 4. Photographs of each haul (before sorting) are presented in Appendix 5.

In total 876 fish from 17 species were recorded, with the largest number of individuals recorded at Site 3 to the north of the Burbo Bank wind farm (see Figure 2 and Figure 3), and at Site 5 in the near-field area west of the turbine array.

Fish numbers within the Burbo Bank wind farm area were variable, but generally lower than at sites outside of the wind farm and near-field areas. Good numbers of fish were caught at Site 12 on the export cable route, however.

Only 10 fish were counted from Site 1, the westerly reference site.

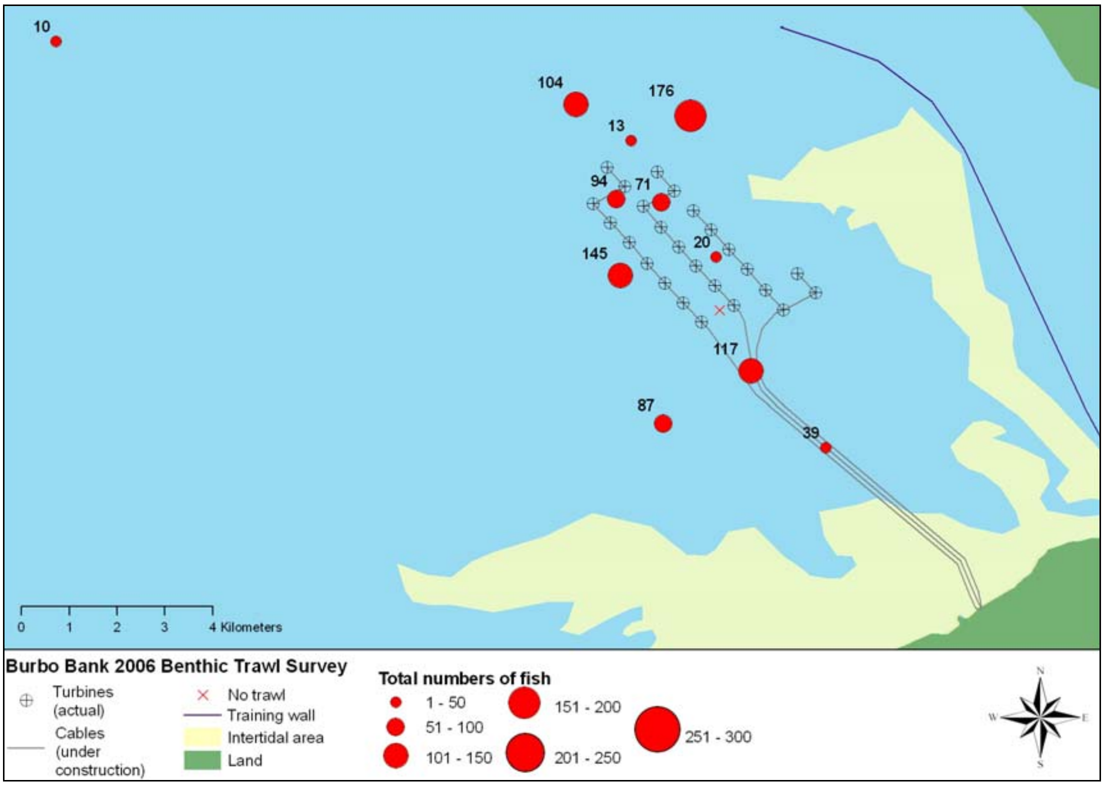


Figure 2 Total numbers of fish recorded during the 2006 beam trawl survey at Burbo Banks Offshore Wind Farm (see Figure 1 for site locations).

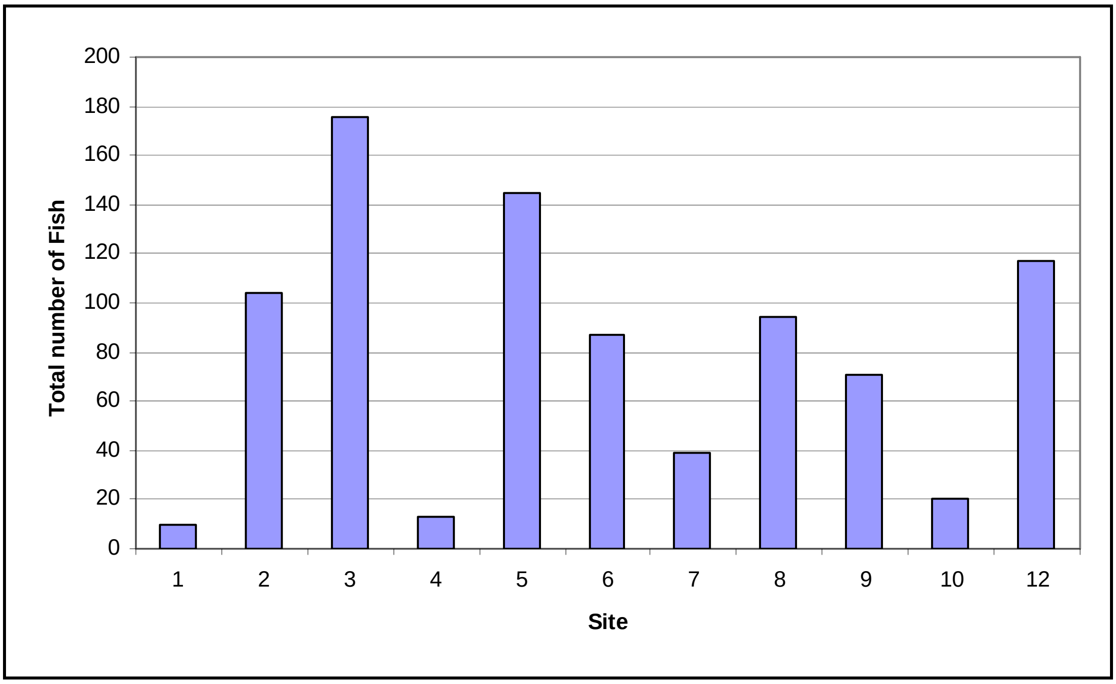


Figure 3 Total numbers of fish by site recorded during the 2006 beam trawl survey at Burbo Banks Offshore Wind Farm.

4.1.2 Main taxa and distribution data

The most common fish species recorded was the Solenette (*Buglossidium luteum*) with a total of 337 individuals recorded from 9 of the 11 trawl sites. The highest incidence of this species (90 individuals) was recorded at Site 3 to the north of the wind farm. Large numbers of Dab (*Limanda limanda*) were also recorded (188 individuals) and this was the most common commercial fish species; this species was documented at 8 of the 11 sites and was most abundant at Site 5, immediately west of the wind farm. Comparatively lower numbers of other commercial species were recorded.

Of the 11 sites surveyed, Site 7 on the export cable route, and Site 2 north of the wind farm were the most species rich (see Figure 4 and Figure 5) with 11 and 9 species respectively. Sites within the wind farm area had moderately high numbers of fish species present (5-9 species), with the exception of Site 4 where only 3 fish species were recorded.

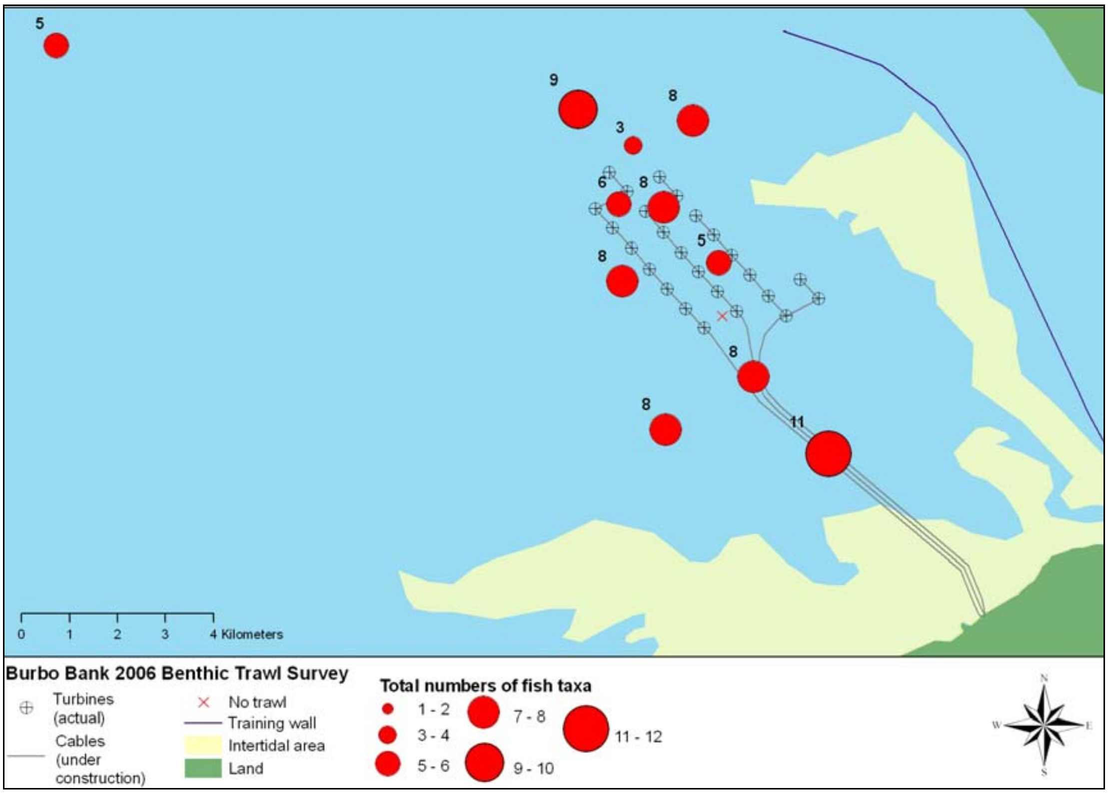


Figure 4 Total numbers of fish taxa recorded during the 2006 beam trawl survey at Burbo Banks Offshore Wind Farm (see Figure 1 for site locations).

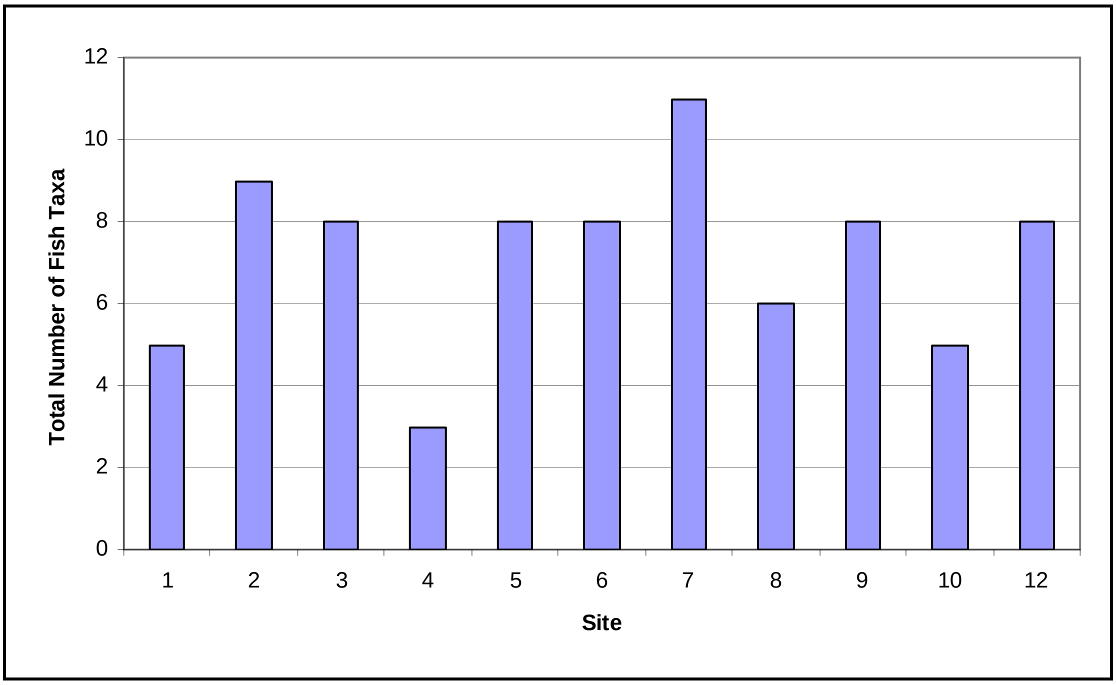


Figure 5 Total numbers of fish taxa by site recorded during the 2006 beam trawl survey at Burbo Banks Offshore Wind Farm.

Two species of elasmobranch were recorded during the 2006 beam trawl survey (Figure 6 and Figure 7). Two adult male Thornback ray (*Raja clavata*) were recorded at sites 1 and 7. These individuals measured 258 and 420 mm in length respectively.

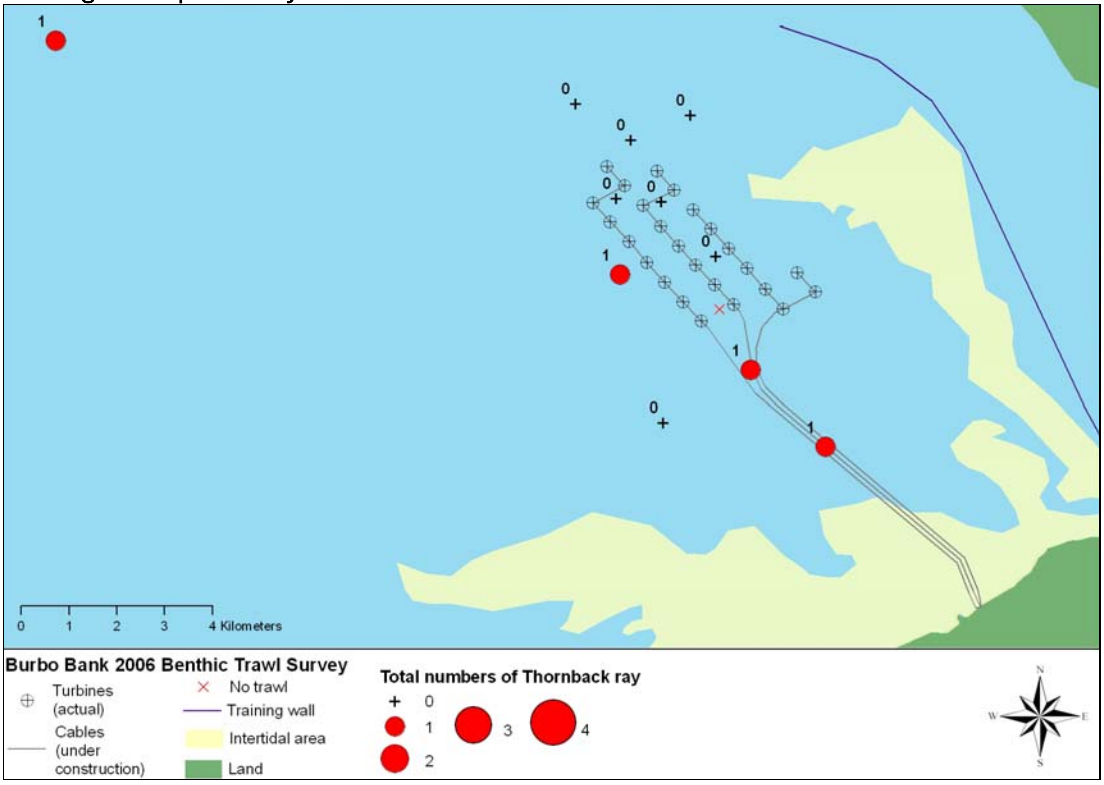


Figure 6 Total numbers of Thornback ray recorded during the 2006 beam trawl survey at Burbo Banks Offshore Wind Farm (see Figure 1 for site locations).

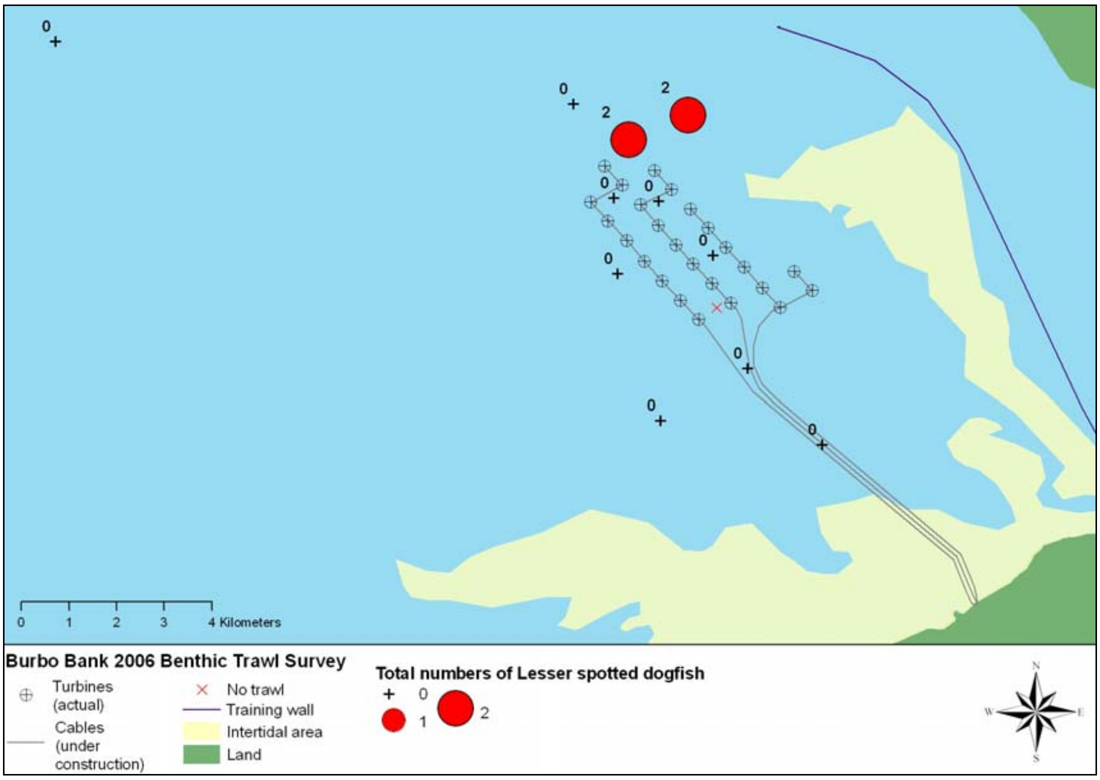


Figure 7 Total numbers of Lesser spotted dogfish recorded during the 2006 beam trawl survey at Burbo Banks Offshore Wind Farm (see Figure 1 for site locations).

Two female Thornback ray were recorded at sites 5 and 12 measuring 258mm and 309mm in length respectively. A total of four female Lesser spotted dogfish (*Scyliorhinus caniculus*) were recorded from Site 3 (595 and 590mm) and 4 (630 and 620mm).

No rare or unusual species were recorded during the 2006 beam trawl survey. However, it should be noted that the Sand Goby is protected and legislated for under Appendix III (Protected Fauna Species) of the Bern Convention owed to its trophic position and importance. In addition, a grouped UK British Diversity Action Plan has also been described for commercial marine fish, which although found over broad geographical areas are at risk locally from excessive exploitation and stock collapse and are protected under the legislation and regulations underpinning the Common Fisheries Policy.

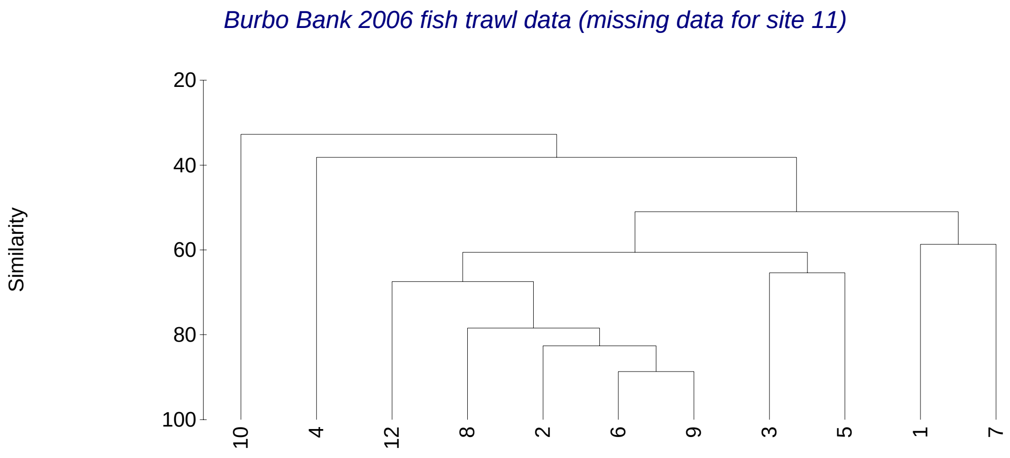
The distributions of some of the commonest and most important commercial fish species are displayed in Figure 16 – Figure 25 and compared to 2005 survey data in Section 4.3.1.

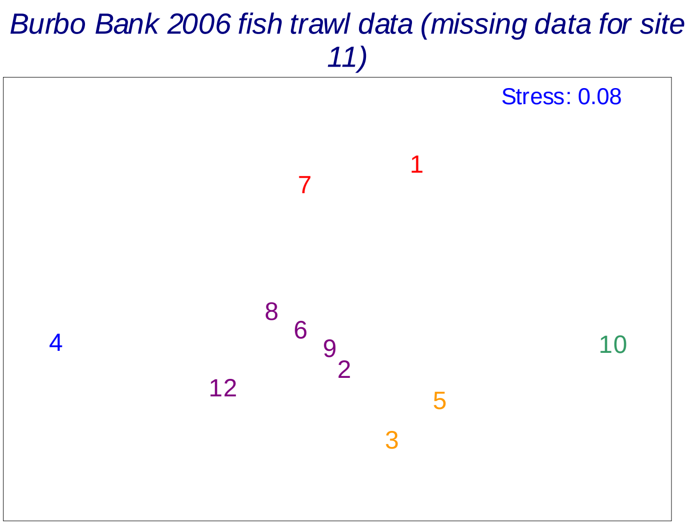
4.1.3 Statistical analysis

Site similarity from the beam trawl survey in 2005 is displayed in Figure 8 as a dendrogram and an associated MDS plot. A third figure takes account of depth.

There is relatively poor clustering and groupings tend to contain sites from quite different parts of the survey area. For example, one of the larger groupings (Sites 2, 6, 8, 9 and 12) contains sites both within and outside of the wind farm and from relatively onshore and offshore areas. This is probably related to homogeneity of the substrate in these areas.

Depth appears to have little influence on the composition of trawls.





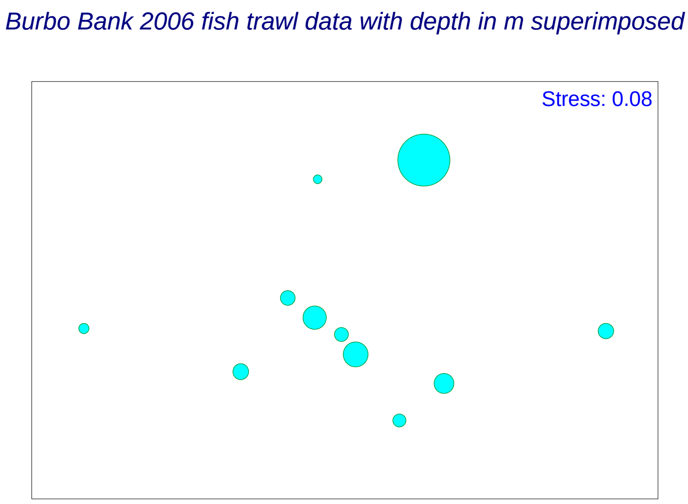


Figure 8 Multidimensional scaling (MDS) plot and associated dendrogram (both based on a Bray Curtis similarity matrix based on fourth-root transformation of data from the entire dataset), including a MDS plot accounting for depth (Larger cirles = deeper depths) for fish from each beam trawl sample undertaken at Burbo Bank during the 2006 survey.

4.2 Invertebrates

4.2.1 Abundance and distribution data

Raw data for benthic species recorded during the beam trawl survey and a full species list are provided in Appendices 2 and 3 respectively. In total, 56,625 invertebrates were recorded representing 27 species from the phyla Crustacea, Polychaeta, Mollusca and Echinodermata (Figure 9 and Figure 10). One colonial species, *Alcyonium digitatum,* was also recorded.

The highest numbers of invertebrates were recorded in trawls from near-field sites north of the wind farm. Moderate numbers of individuals were caught in trawls within and adjacent to the central area of the wind farm but sites on the export cable route and the cable route reference site to the west yielded far fewer total invertebrates. Only low numbers of invertebrates were caught also at the westerly control station (Site 1).

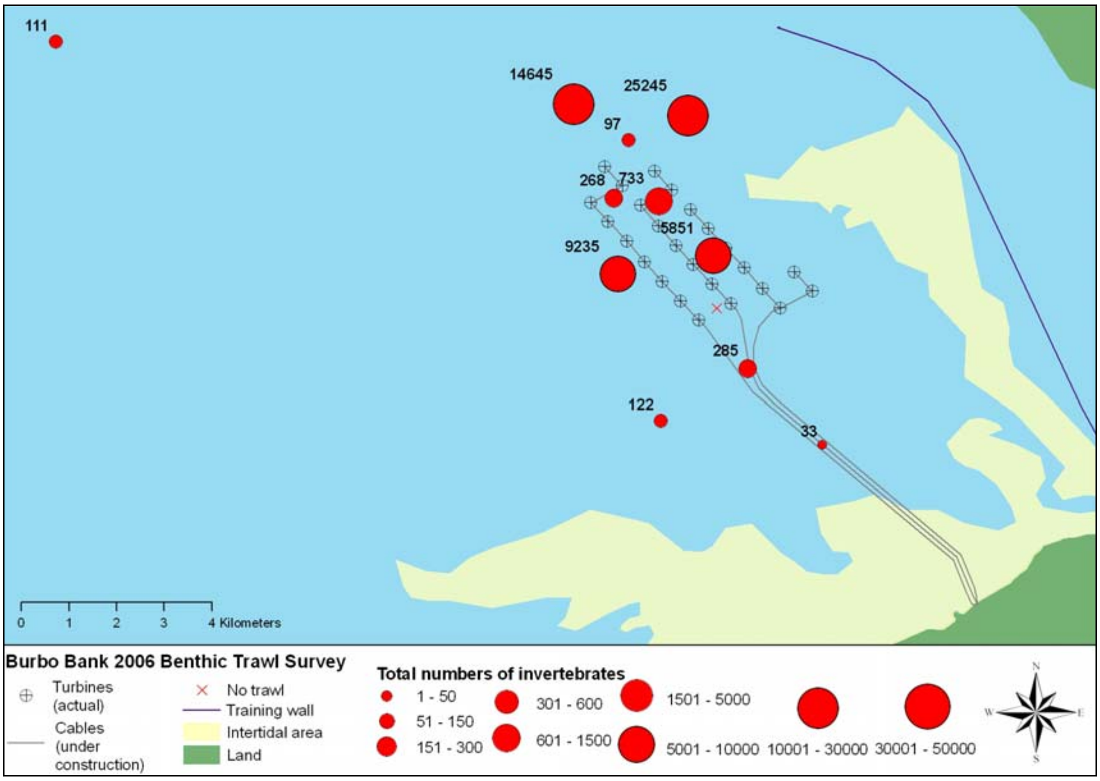


Figure 9 Total numbers of invertebrates recorded during the 2006 beam trawl survey at Burbo Banks Offshore Wind Farm (see Figure 1 for site locations).

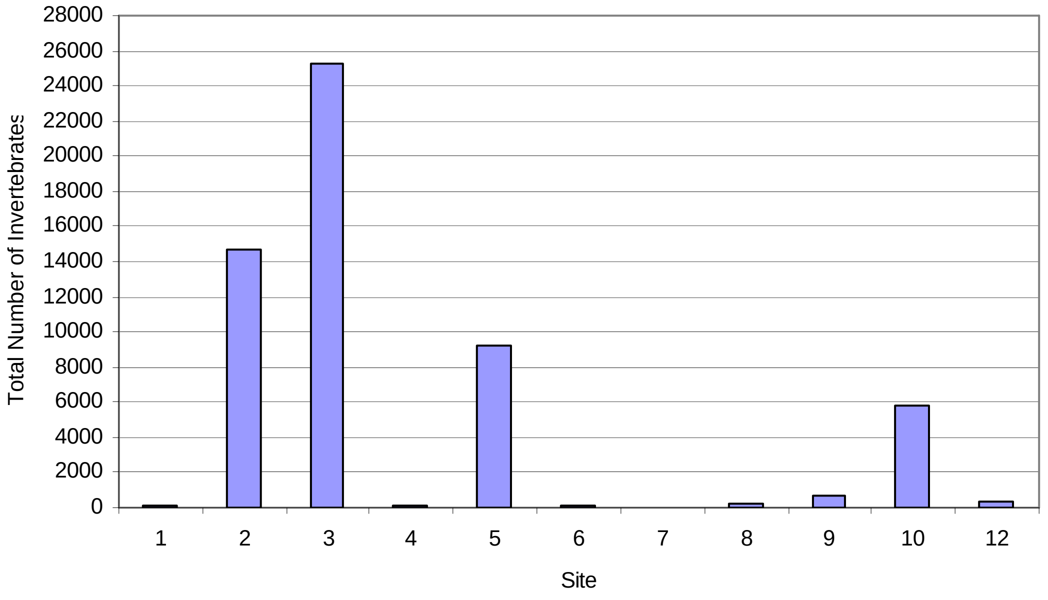


Figure 10 Total numbers of invertebrates by site recorded during the 2006 beam trawl survey at Burbo Banks Offshore Wind Farm.

4.2.2 Dominant taxa and distribution data

The most abundant invertebrate species was the brittle star *Ophiura ophiura* with a total of 27,258 individuals recorded from all stations. The highest density of brittle stars was recorded at Site 3 (11,312 individuals) in the near-field area north/northeast of Burbo Bank wind farm.

The bivalves *Spisula subtruncata* and *Abra alba* were a prominent component of several stations, notably sites 3 and 5, in the near-field area to the north/northeast and west of the Burbo Bank development area respectively.

The seastar *Asterias rubens* and the necklace shell *Euspira pulchella* were also recorded, predominantly at sites 5 and 3 respectively.

Of the 11 stations surveyed, Site 2 in the near-field area directly north/northwest of the wind farm was most species rich, with a total of 17 different invertebrate taxa recorded (and Figure 12). *Ophiura ophiura* was the most abundant species at this site.

The majority of trawls in the near-field areas to the north (sites 2 and 3) and west (Site 5) were relatively species rich. Sites 9 and 10 within the wind farm area were less rich but generally more diverse than stations south of the wind farm, including the two on the export cable route.

The distributions of some of the more common invertebrate taxa are presented in Figure 29 – Figure 35 and compared to 2005 survey data.

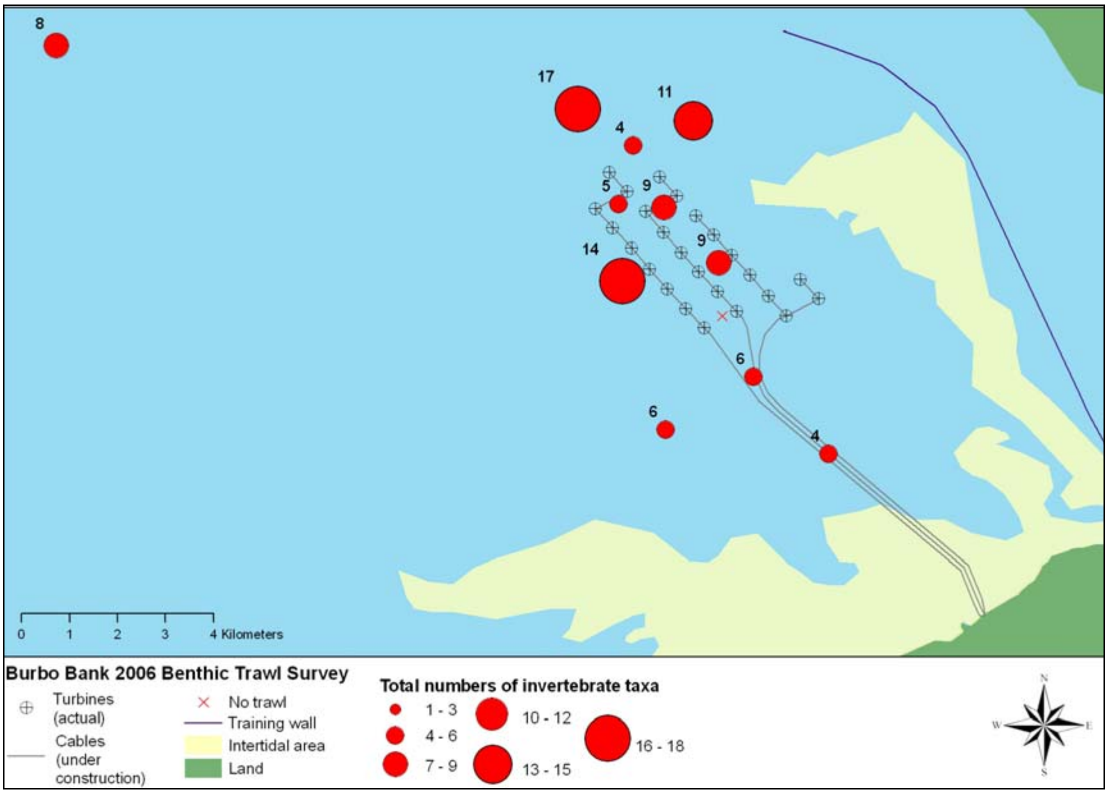


Figure 11 Total numbers of invertebrate taxa recorded during the 2006 beam trawl survey at Burbo Banks Offshore Wind Farm (see Figure 1 for site locations).

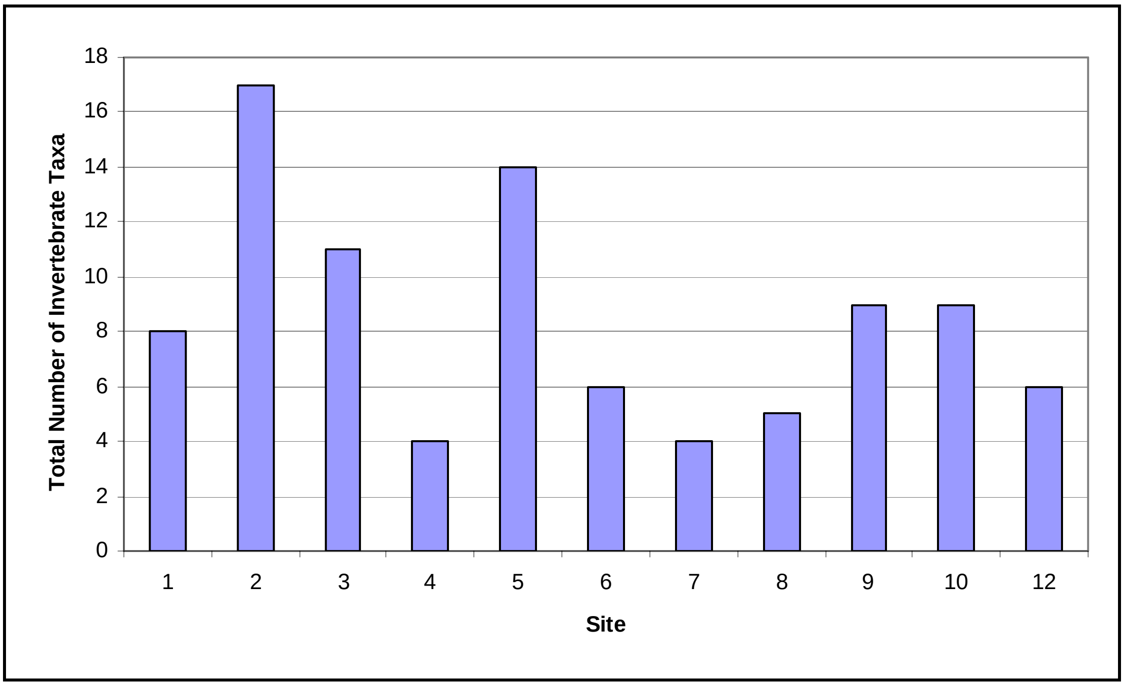


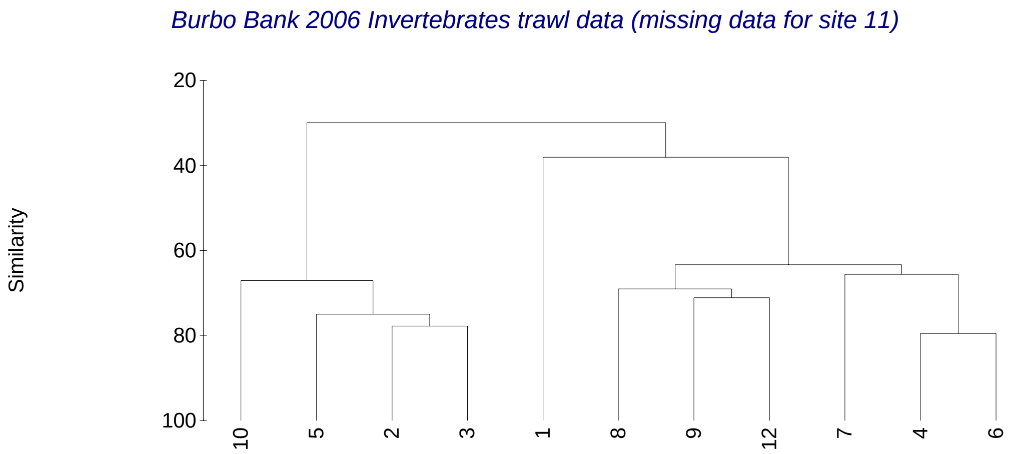
Figure 12 Total numbers of invertebrate taxa by site recorded during the 2006 beam trawl survey at Burbo Banks Offshore Wind Farm.

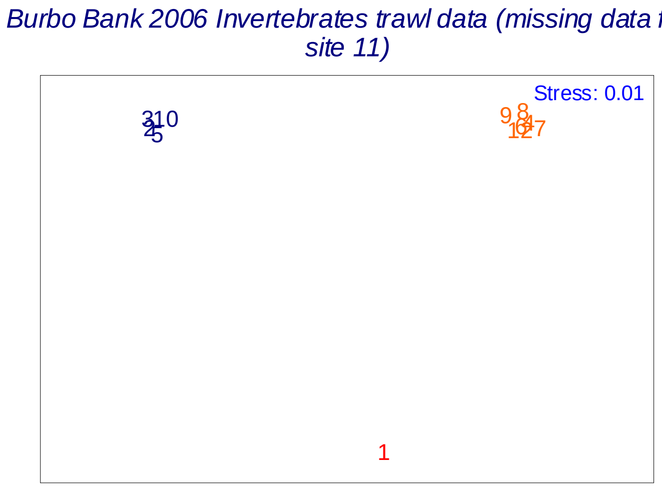
4.2.3 Statistical analysis

Site similarity from the beam trawl survey in 2006 is displayed in Figure 13 as a dendrogram and associated MDS plot. The third figure also accounts for depth.

Two distinct groups cluster very well together. Each grouping contains sites from both offshore and inshore locations and within and outside of the wind farm. The main characteristic separating these sites into such distinct groups is the abundance of certain molluscs, notably *Spisula subtruncata* and *Abra alba*, and the brittle star, *Ophiura ophiura* at sites 2, 3, 5 and 10

The haul at Site 1, the westerly control and deepest site, was markedly different from all other sites.





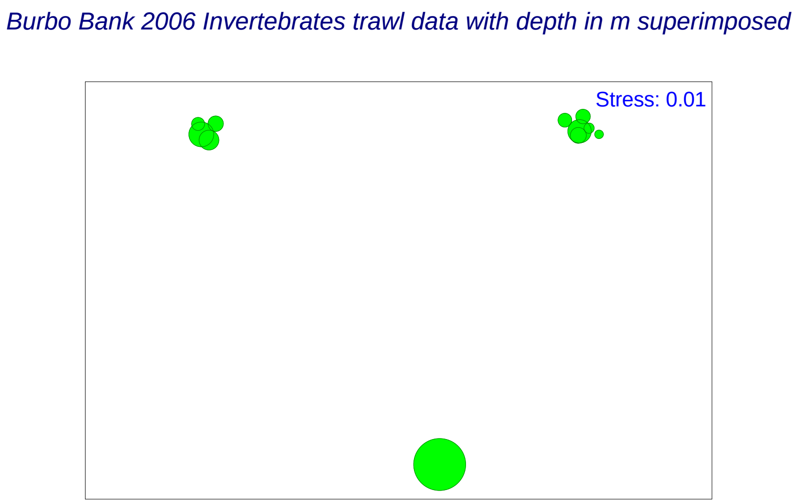


Figure 13 Multidimensional scaling (MDS) plot and associated dendrogram (both based on a Bray Curtis similarity matrix based on fourth-root transformation of data from the entire dataset), including a MDS plot accounting for depth (Larger cirles = deeper depths) for invertebrate faunafrom each beam trawl sample undertaken at Burbo Bank during the 2006 survey.

4.3 Comparisons between the 2005 and 2006 beam trawl surveys.

4.3.1 Fish

The total number of fish caught in each haul in 2005 and 2006 are compared in Figure 14.

In total, very similar numbers of fish were caught in 2006 as in 2005. Excluding the 78 individuals caught at Site 11 in 2005 (not surveyed in 2006), 932 individuals were captured in 2005 compared to 876 in 2006. There was variation in the abundance of fish between sites over the two years, however.

Most fish were recorded at Site 9 during the pre-construction survey of 2005 when 267 fish, mainly solenette (*B. luteum*), were caught at this site towards the northeast of the wind farm array. Far fewer individuals (71) were recorded at this site a year later.

In contrast, sites to the north of the wind farm tended to produce more fish in 2006 than the previous year.

Consistently low numbers of fish were captured at Site 1 in both years.

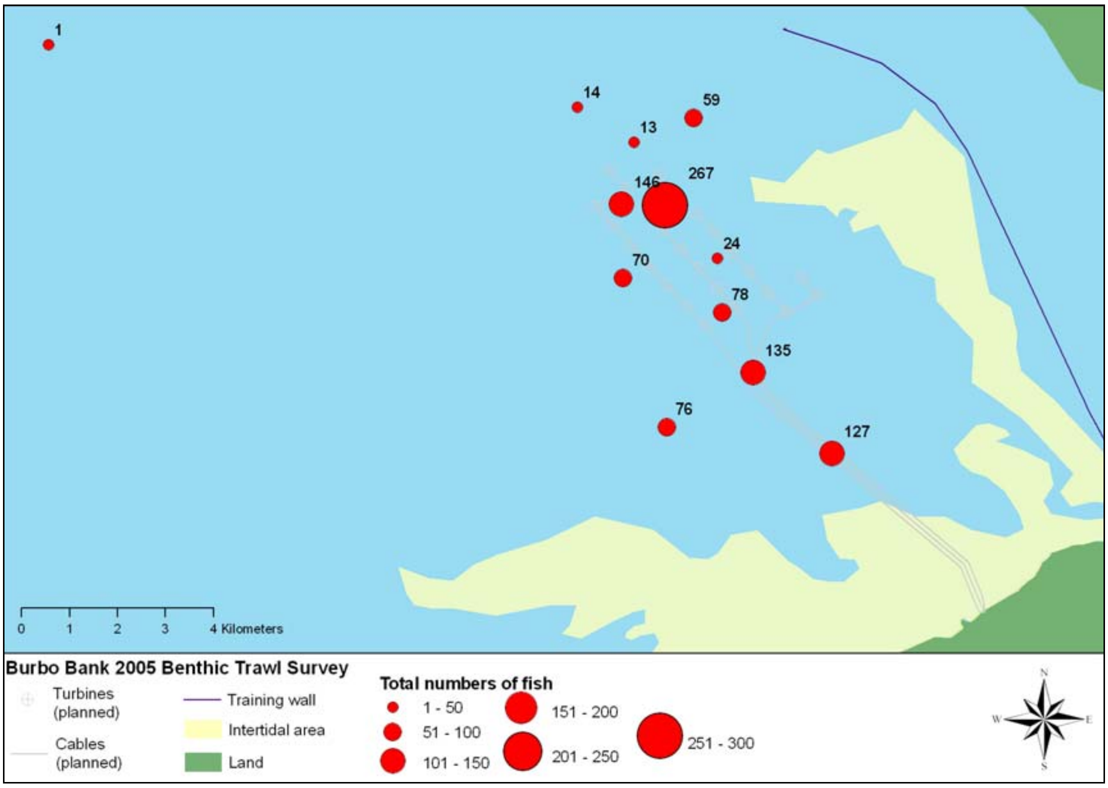
Comparisons between the 2005 and 2006 beam trawl surveys also show variable numbers of fish taxa over the two survey years (Figure 15). Overall, the Burbo Bank development area was more speciose in 2005, when 23 species of fish were recorded compared to 17 in 2006.

Maps of many of the more abundant species have been prepared in order to investigate possible changes in distribution and/or abundance in relation to the wind farm development (Figure 16 - Figure 25). In the majority of cases the main changes in abundance have occurred at sites within and north of the wind farm.

Several species were more numerous and widespread across the survey area, including wind farm array, in 2006. This was especially the case for lesser weever fish (Figure 19), scald fish (Figure 21) and plaice (Figure 22). These fish taxa were absent from several sites within the wind farm and north of the development area in 2005.

Distributions of other fish species were more consistent between the two trawl surveys, although numbers of individuals were generally higher in 2005. This trend is observed in numbers of sand goby, whiting, solenette and dab (Figure 16, Figure 17, Figure 18 and Figure 20). In the majority of cases the main changes in abundance of these fish taxa were apparent at several sites within the wind farm, specifically sites 5, 8 and 9 in the cases of solenette, dab and whiting. Numbers of sole were also lower in 2006 (Figure 23).

Small numbers of elasmobranchs were recorded during both trawl surveys (Figure 24 and Figure 25). The only elasmobranchs recorded within the wind farm were two lesser spotted dogfish and thornback rays in 2005, although two thornback rays were recorded on the export cable route in 2006.



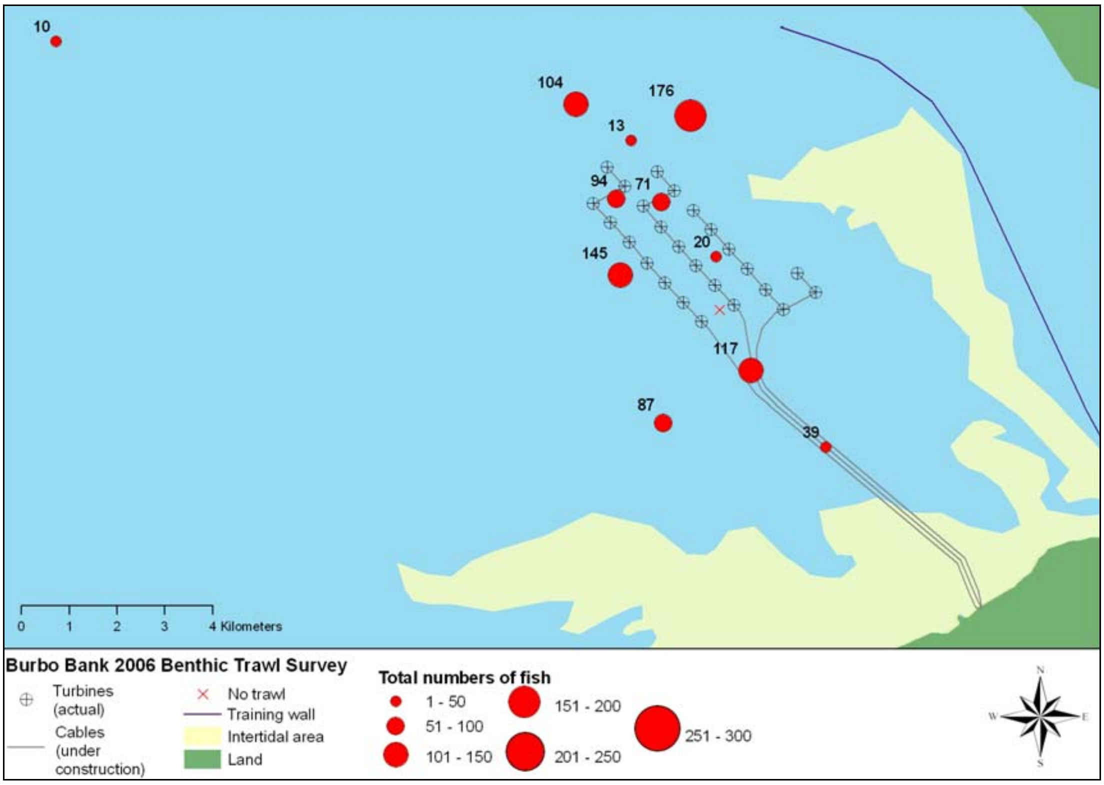
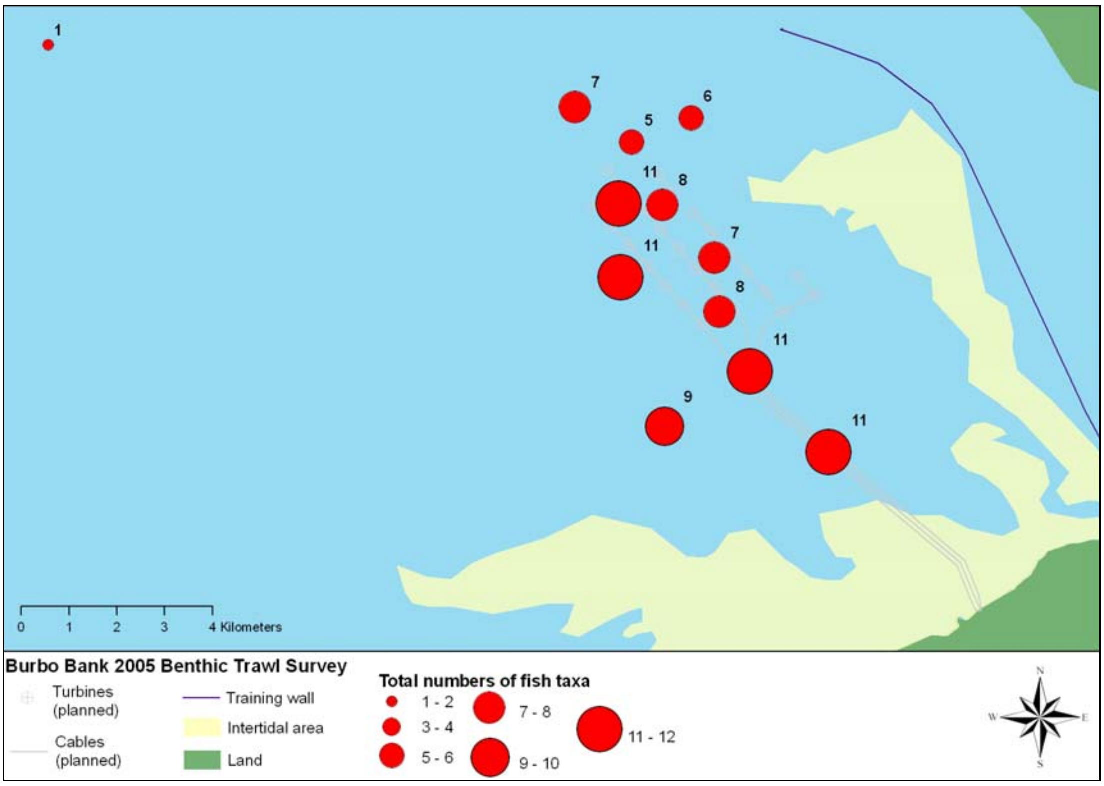


Figure 14 Total numbers of fish recorded during the 2005 and 2006 beam trawl surveys.



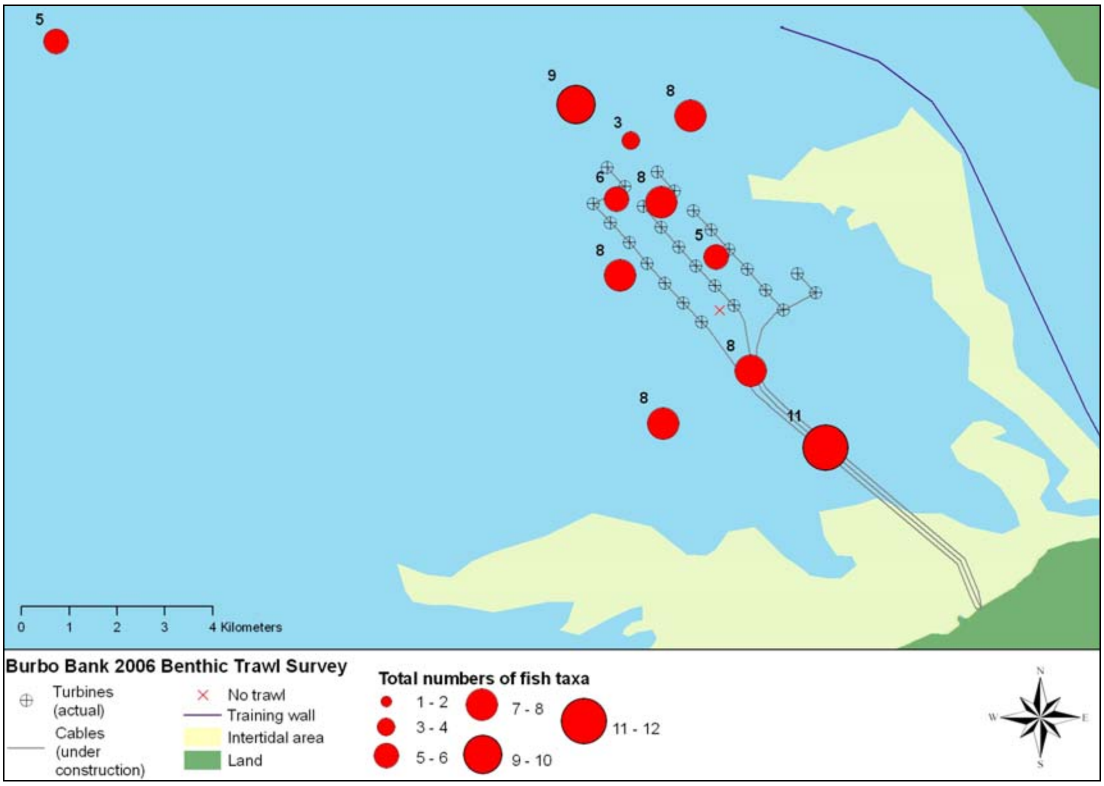
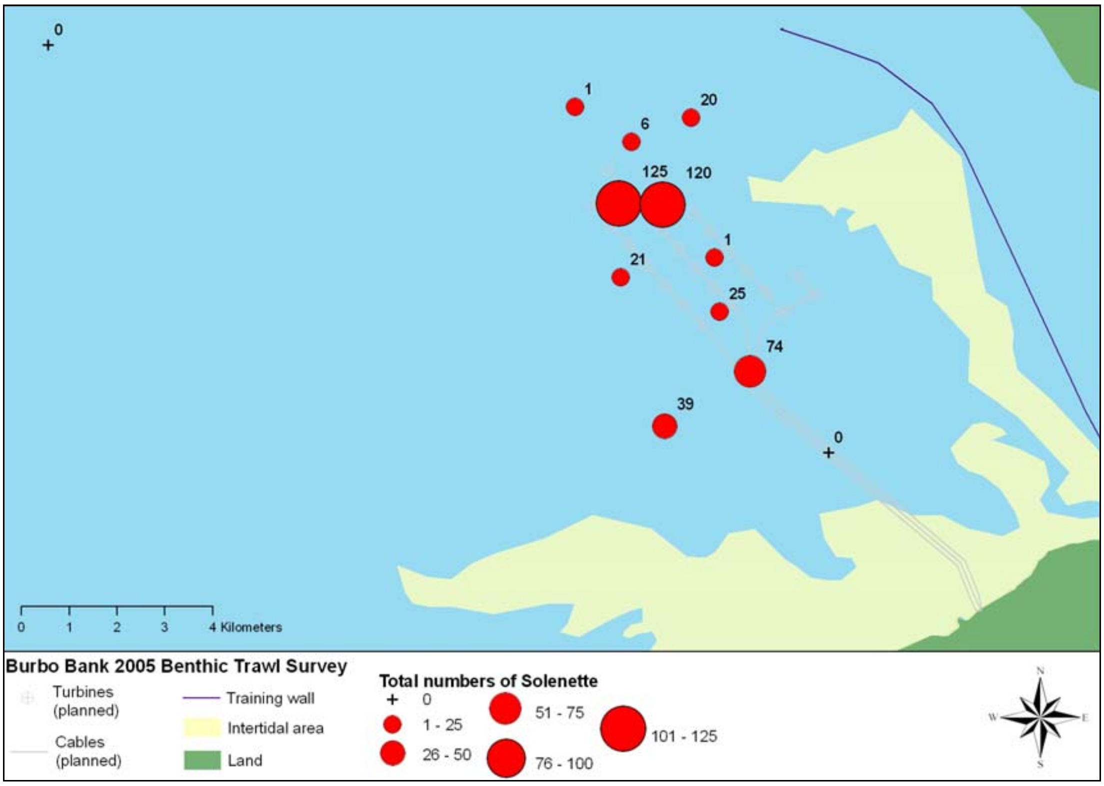


Figure 15 Total numbers of fish taxa recorded during the 2005 and 2006 beam trawl surveys.



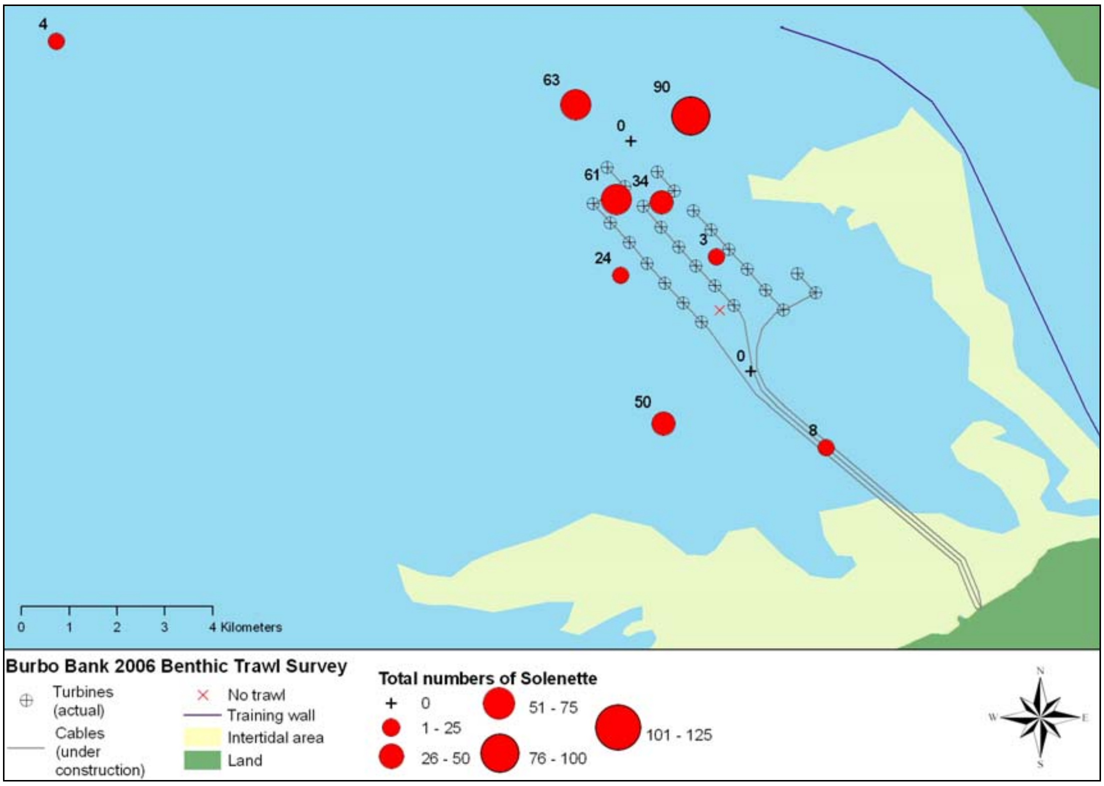
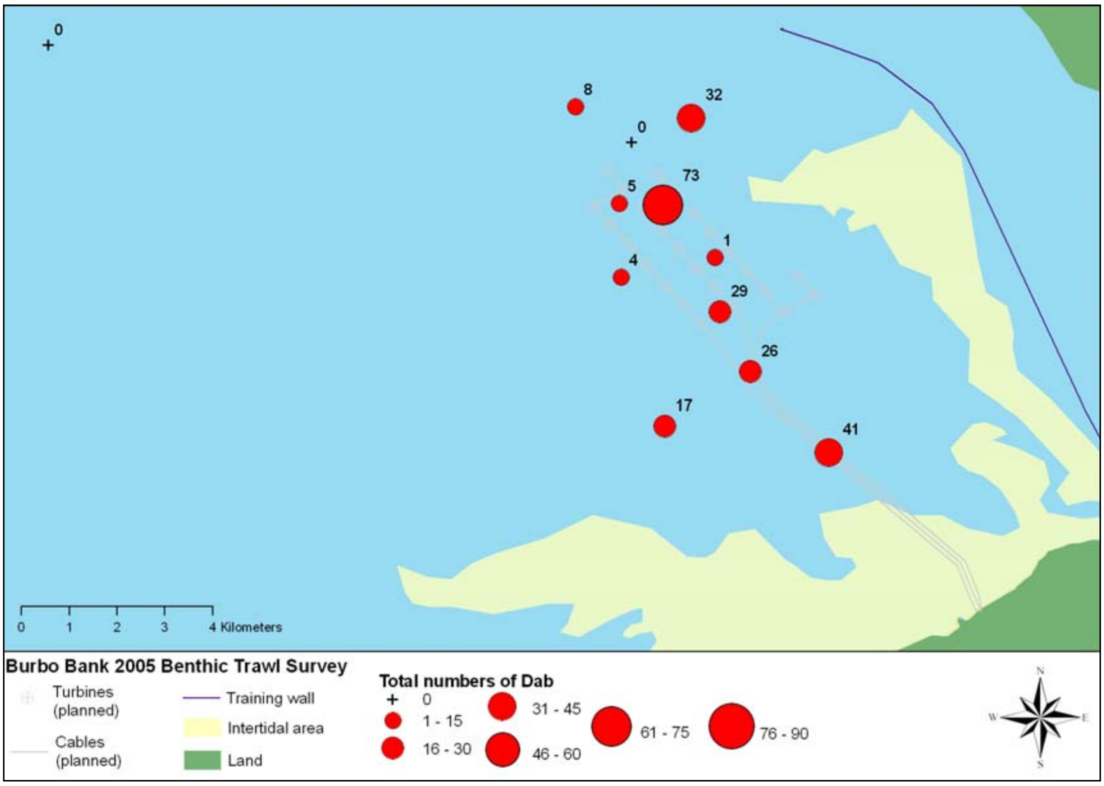


Figure 16 Total numbers of solenette recorded during the 2005 and 2006 beam trawl surveys.



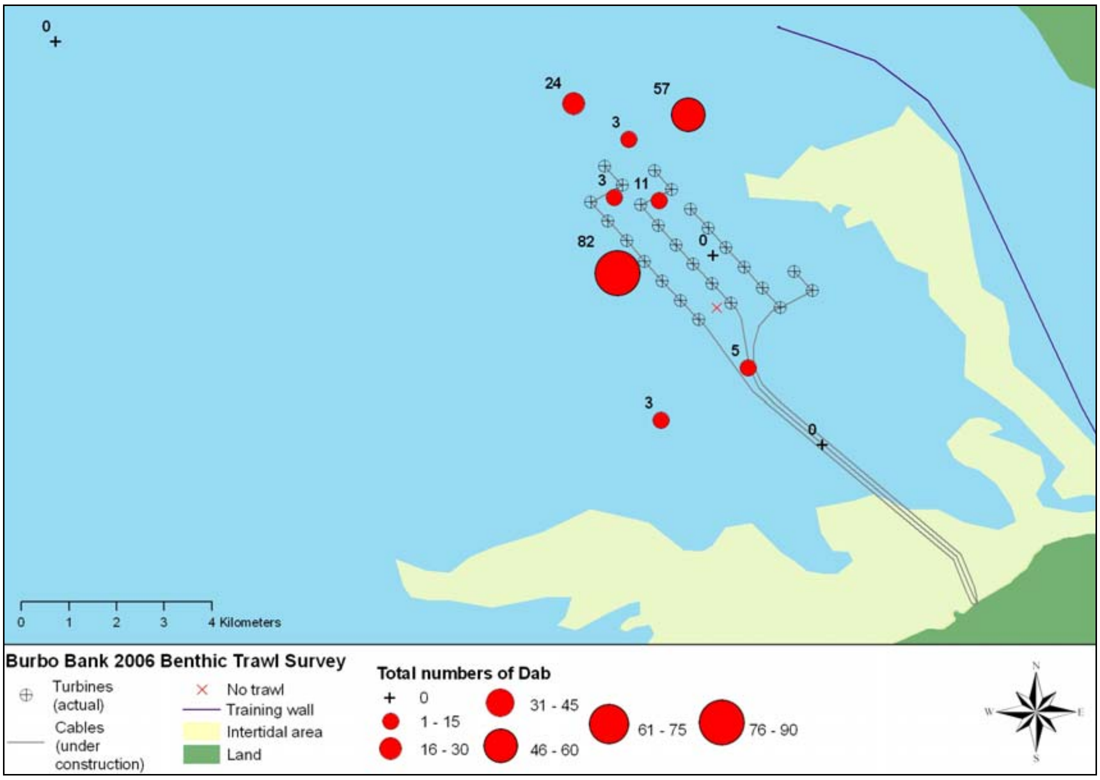


Figure 17 Total numbers of dab recorded during the 2005 and 2006 beam trawl surveys.

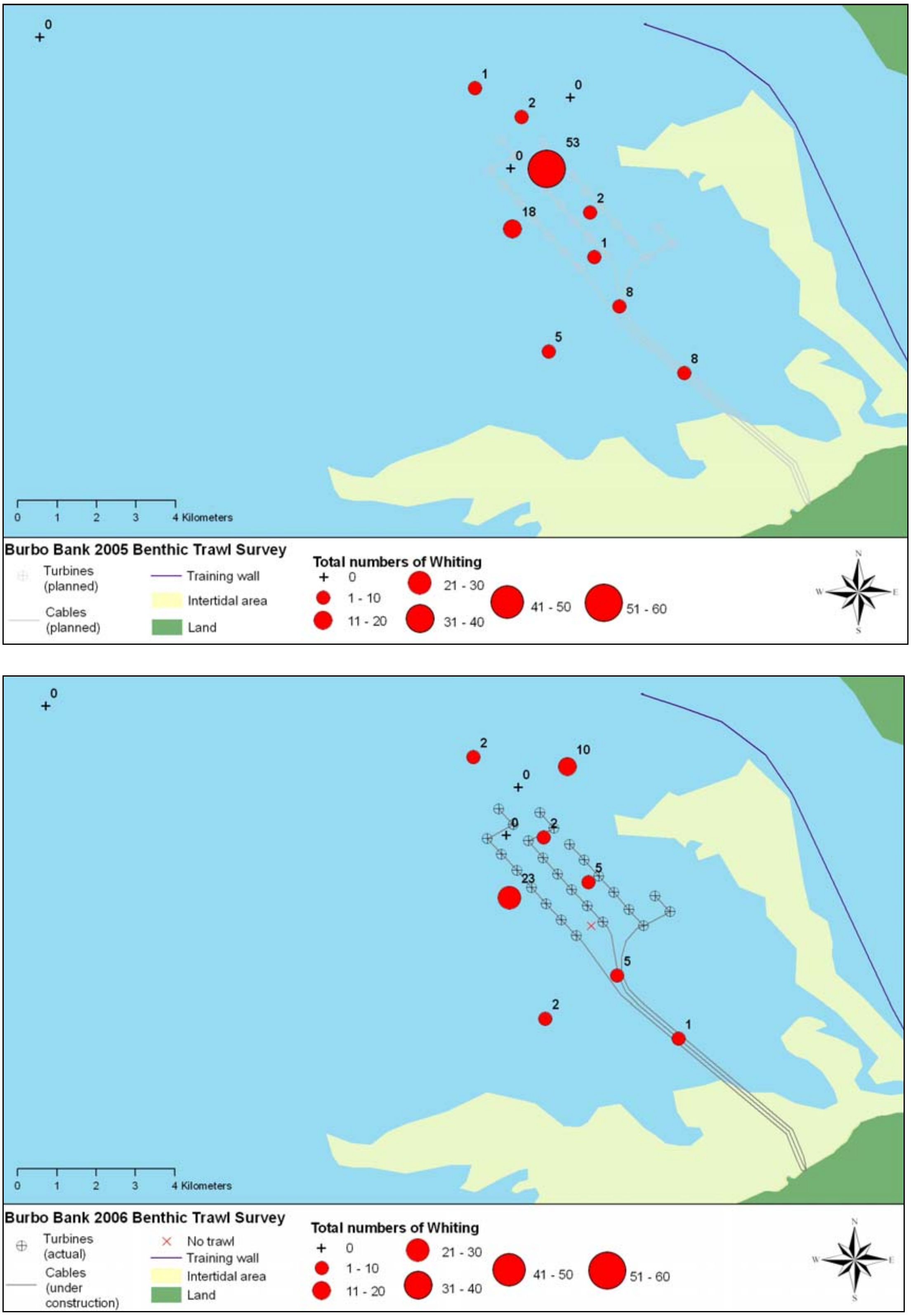


Figure 18 Total numbers of whiting recorded during the 2005 and 2006 beam trawl surveys.

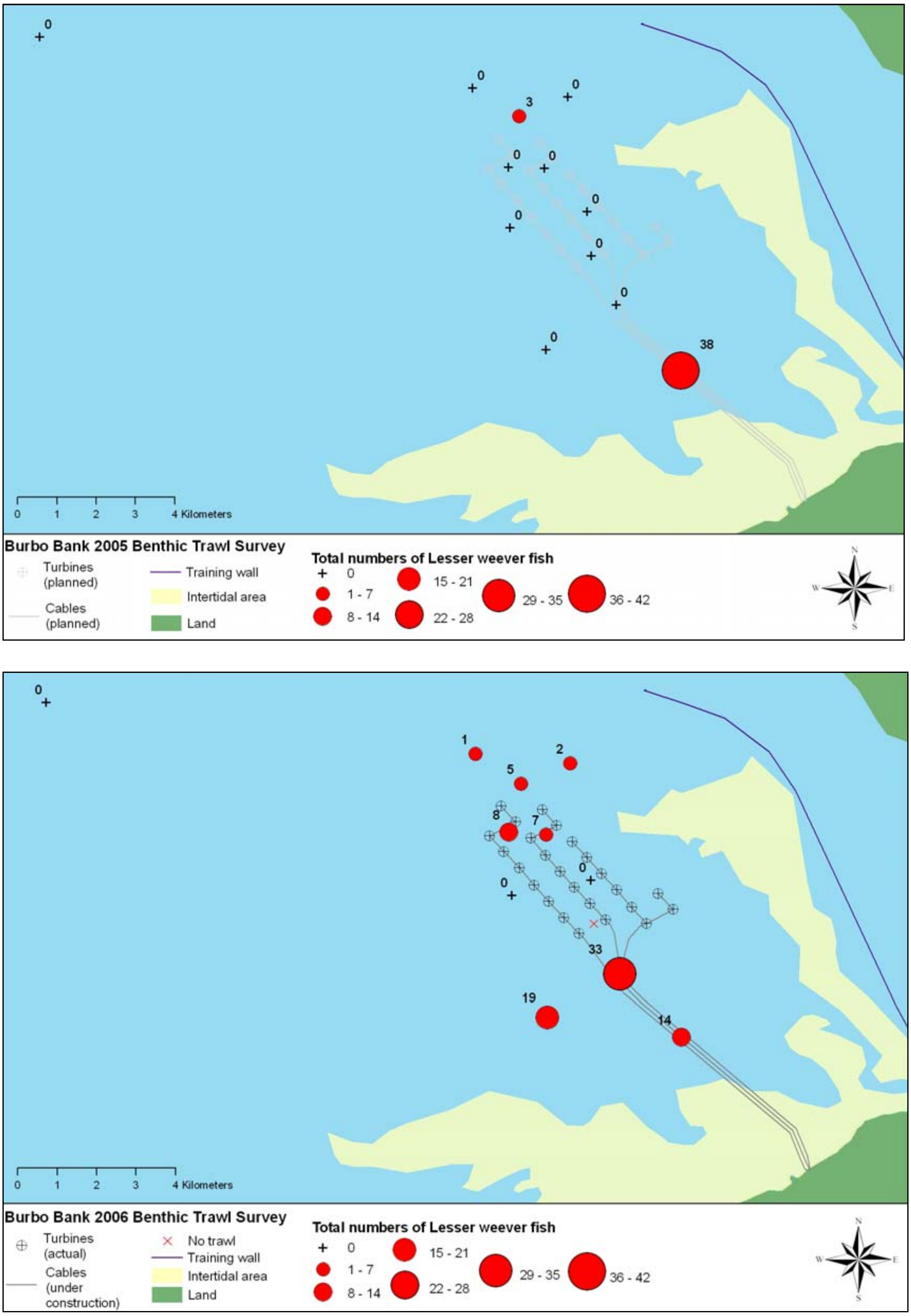


Figure 19 Total numbers of lesser weever fish recorded during the 2005 and 2006 beam trawl surveys.

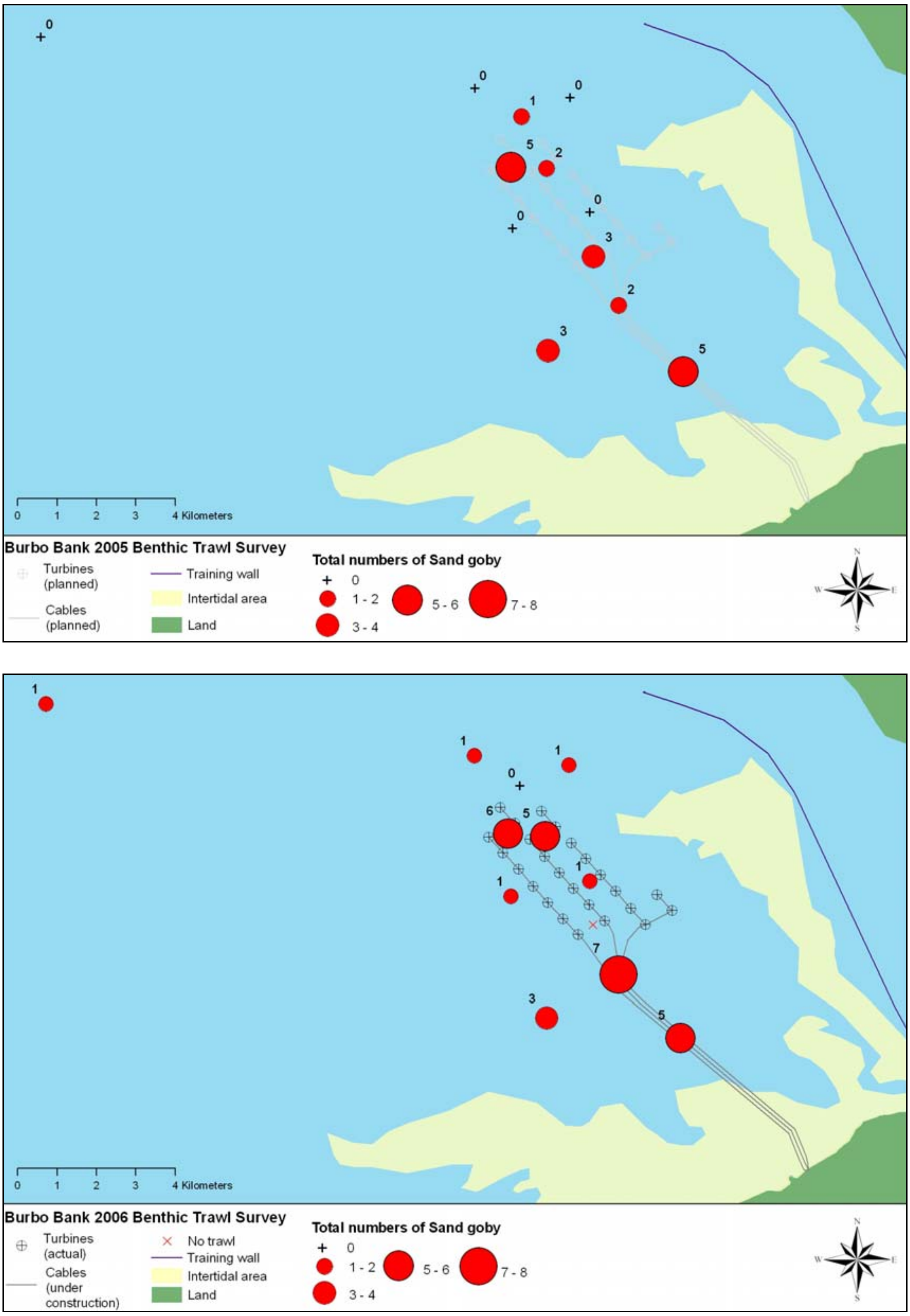


Figure 20 Total numbers of sand goby recorded during the 2005 and 2006 beam trawl surveys.

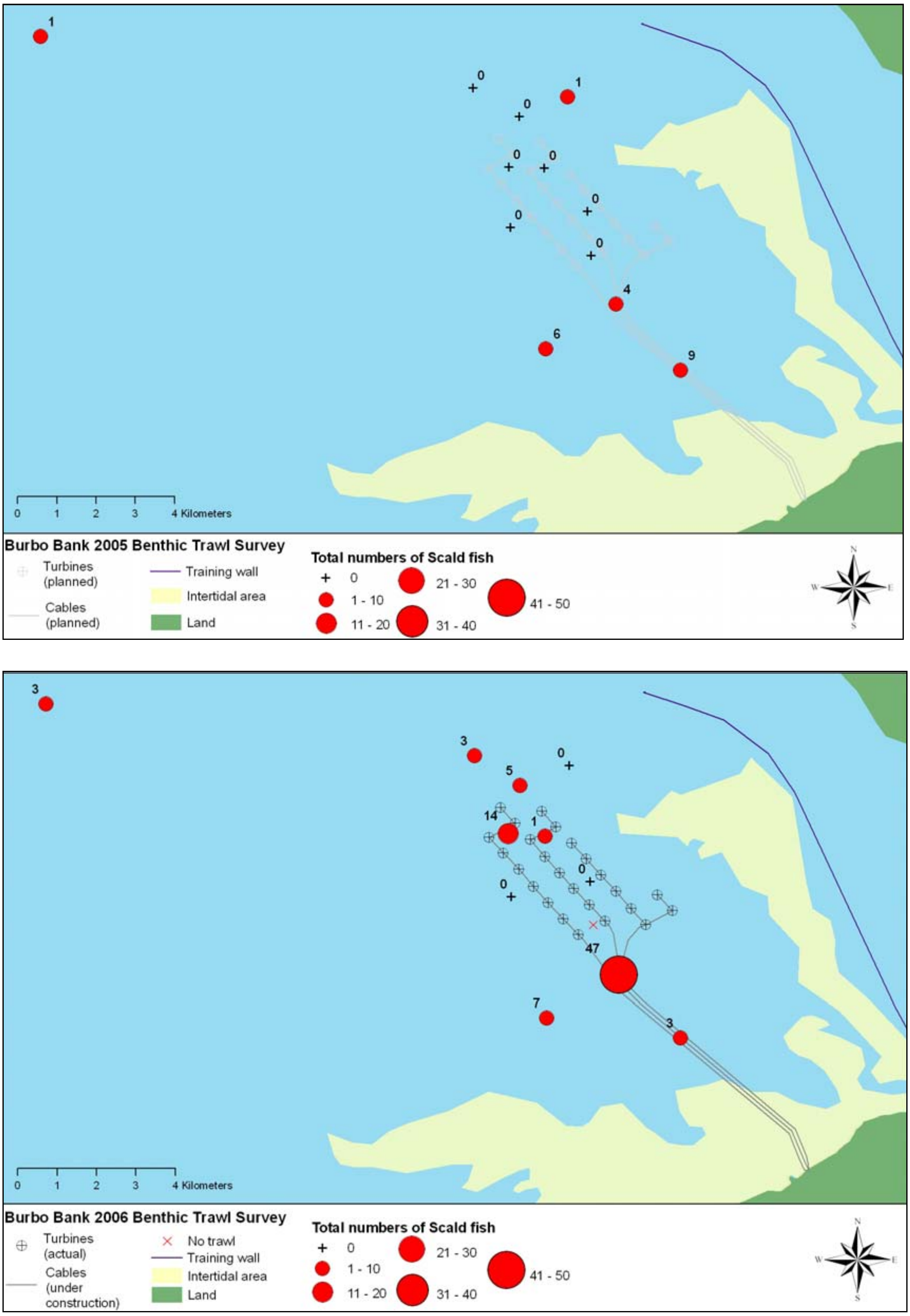


Figure 21 Total numbers of scald fish recorded during the 2005 and 2006 beam trawl surveys.

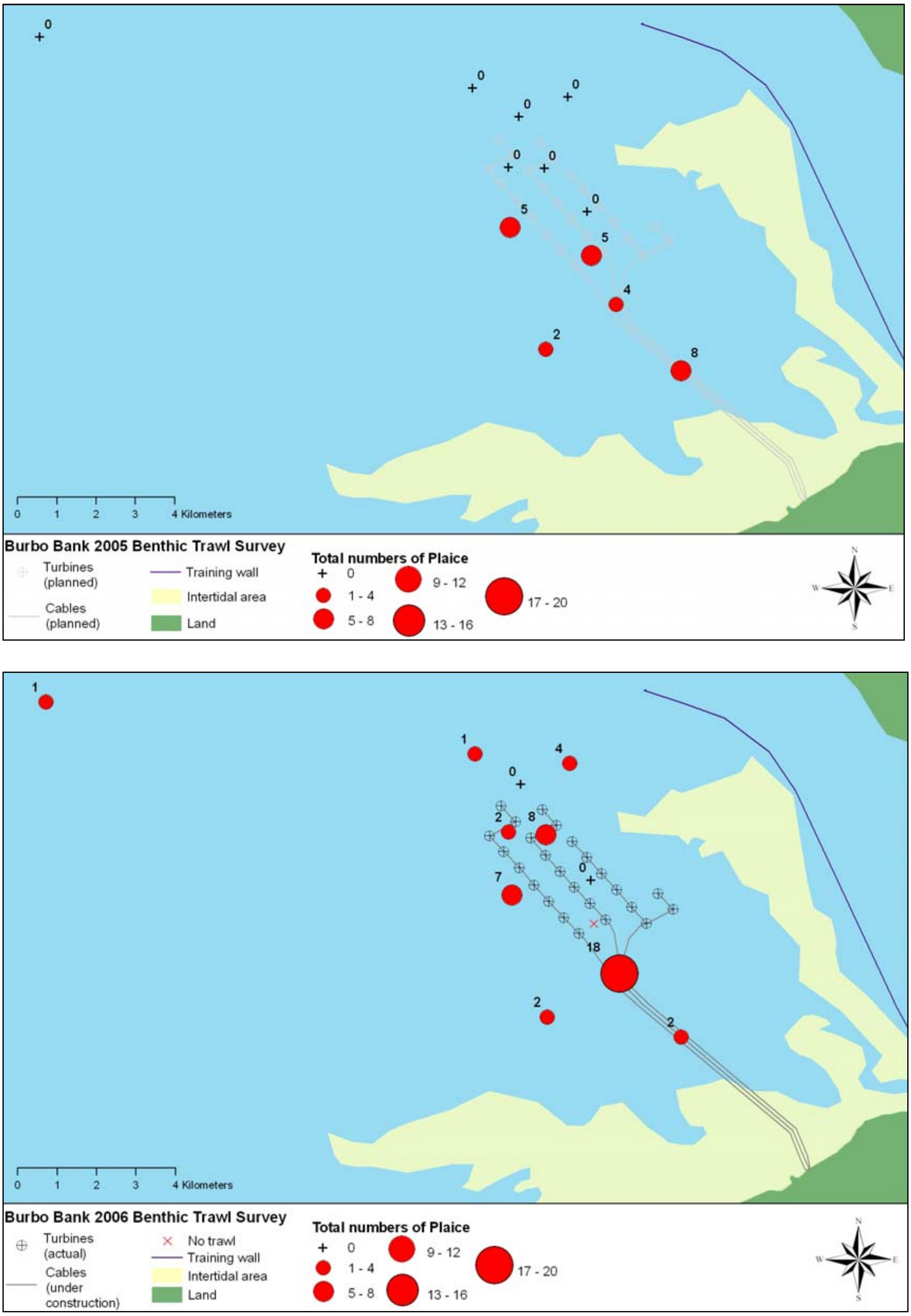


Figure 22 Total numbers of plaice recorded during the 2005 and 2006 beam trawl surveys.

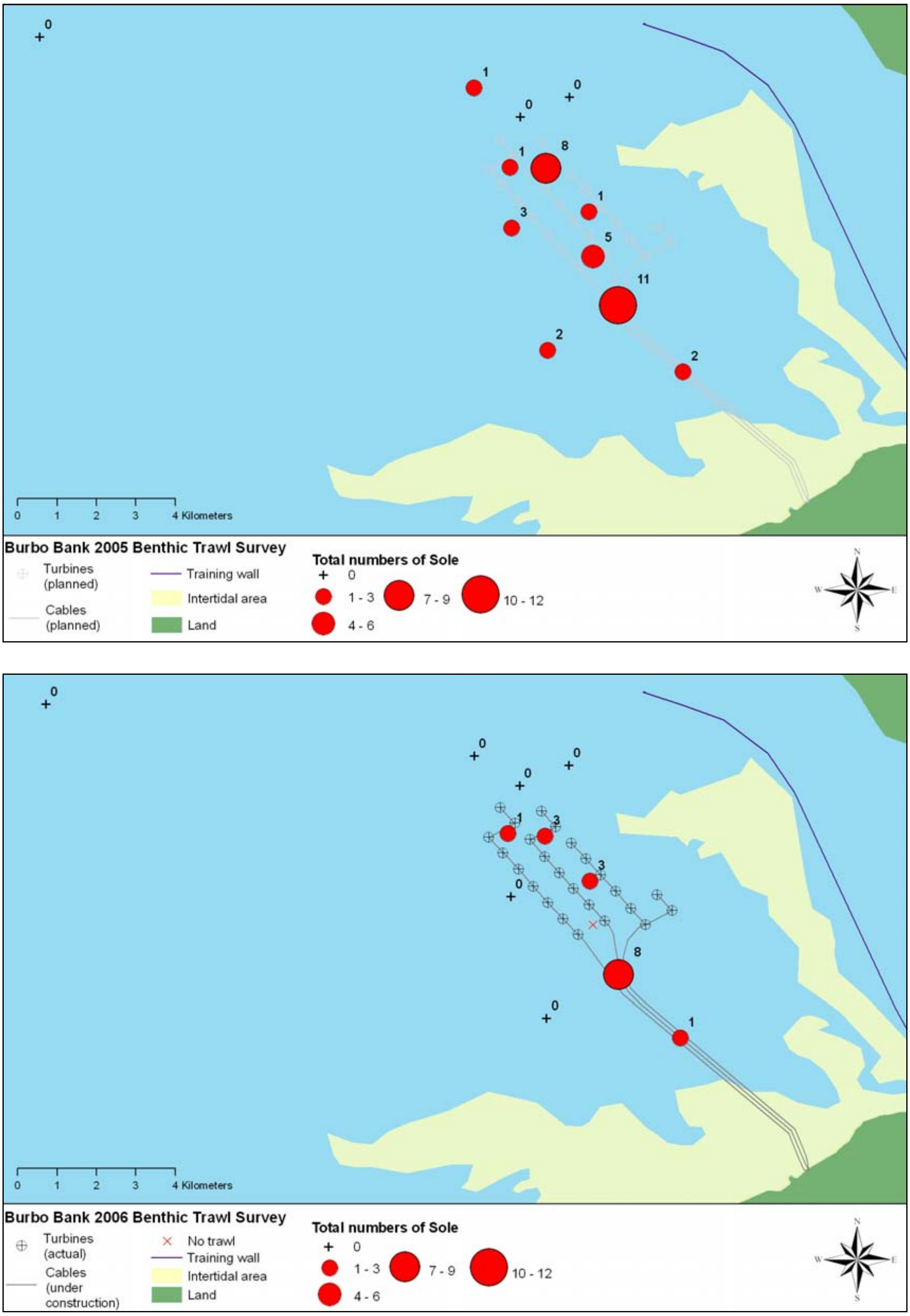


Figure 23 Total numbers of sole recorded during the 2005 and 2006 beam trawl surveys.

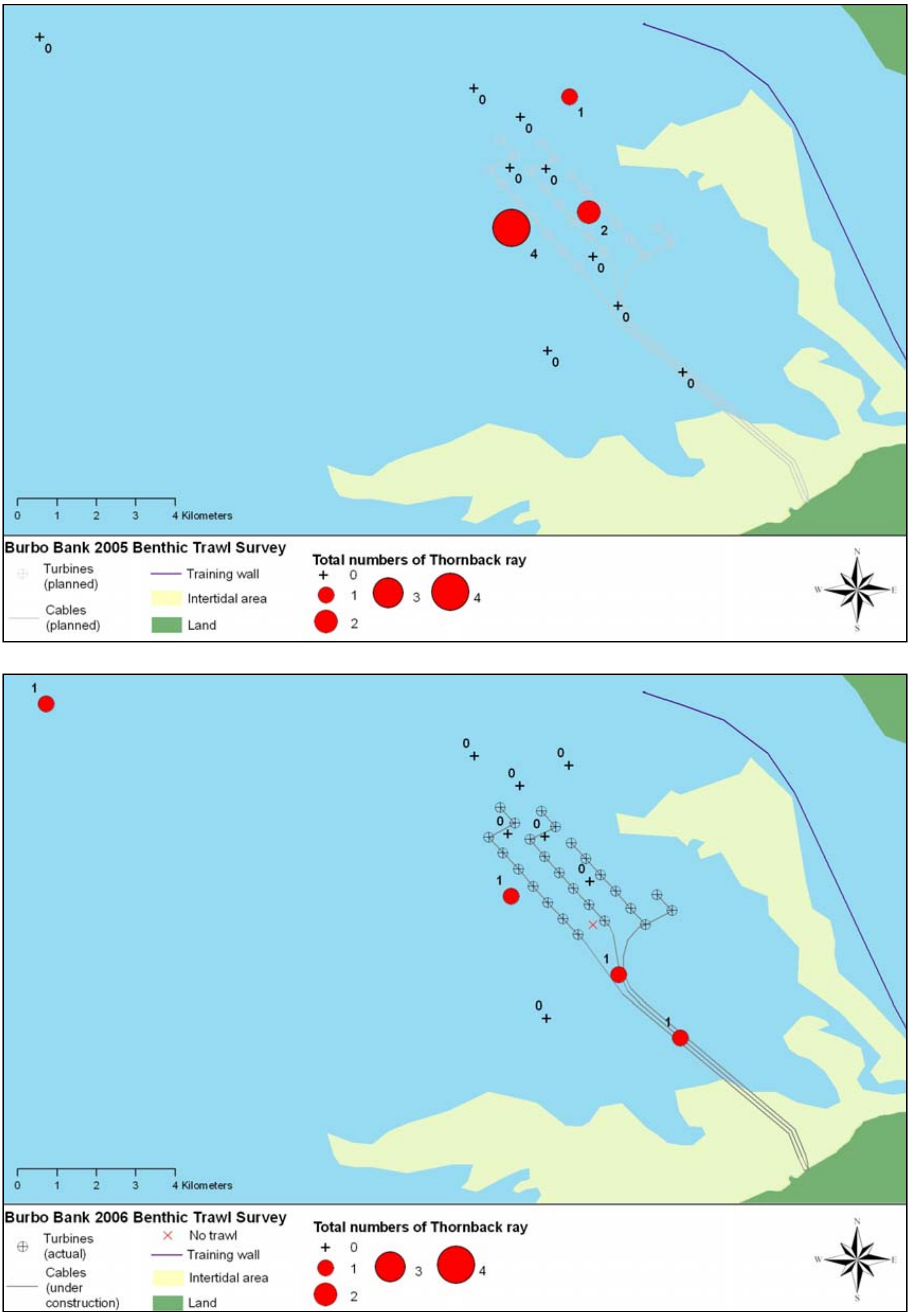
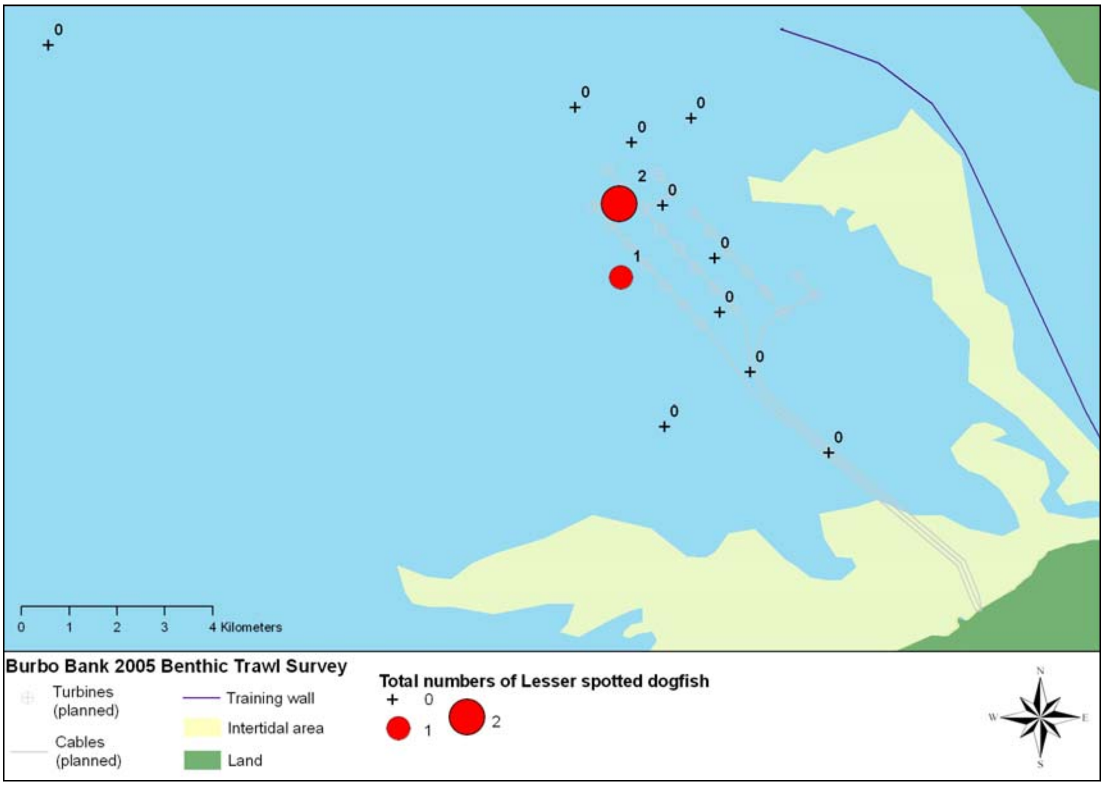


Figure 24 Total numbers of thornback ray recorded during the 2005 and 2006 beam trawl surveys.



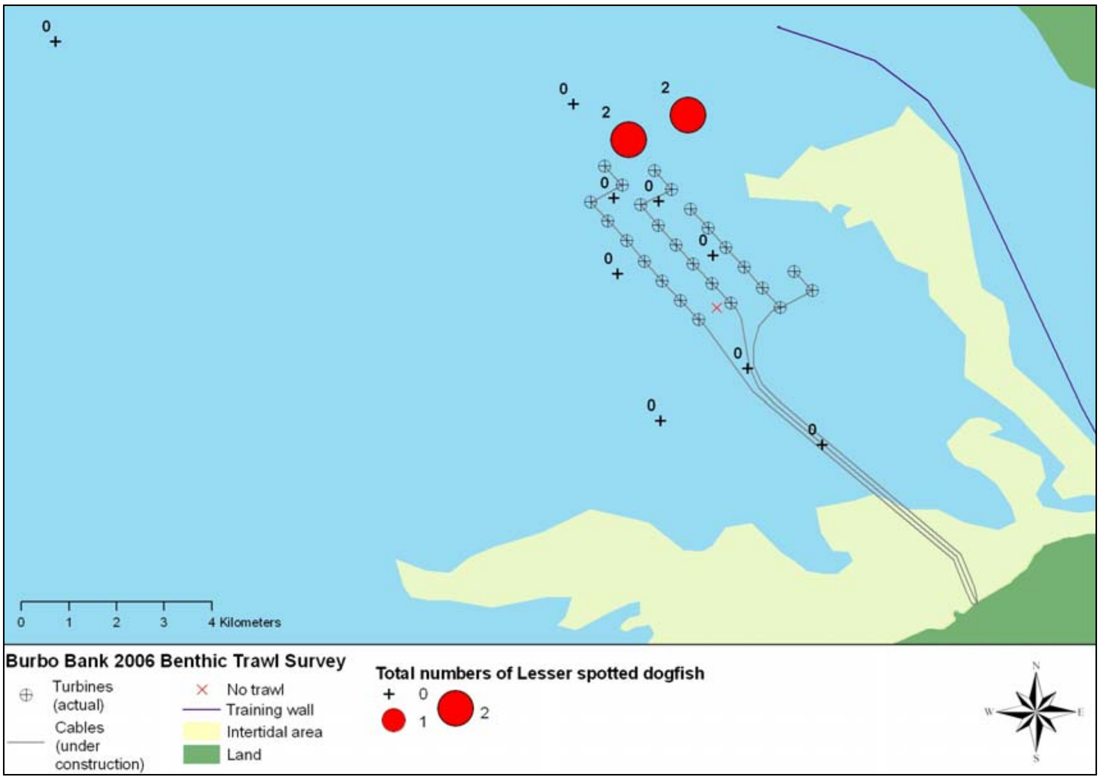


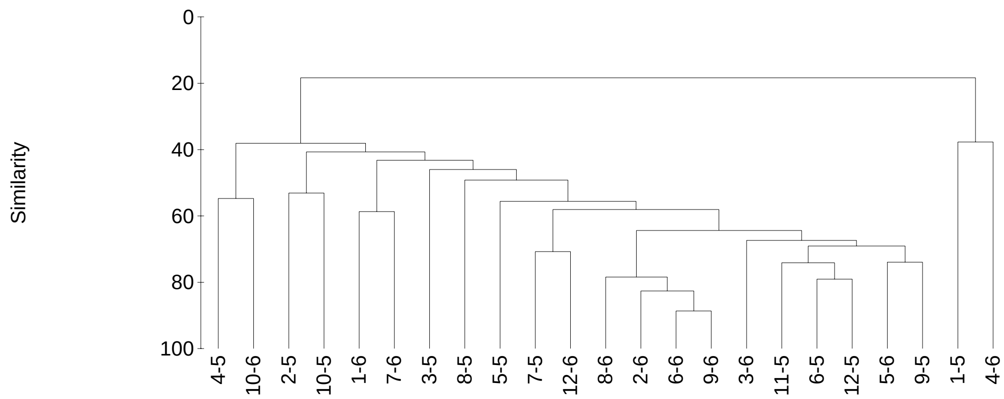
Figure 25 Total numbers of lesser spotted dogfish recorded during the 2005 and 2006 beam trawl surveys.

4.3.2 Statistical analysis (fish)

Site similarity from the beam trawl surveys in 2005 and 2006 is displayed in Figure 26 as a dendrogram and associated MDS plot.

Most sites show moderate (approximately 50%) similarity between years, reflecting consistency in trawl composition between years. Sites 1 and 4 are the exceptions, and are quite different to the other trawls. This is due to the very low abundance and diversity of fish caught at sites 1 and 4 in 2005 and 2006 respectively.

Burbo Bank 2005&2006 fish trawl data (missing data for site 11 2006)



Burbo Bank 2005&2006 fish trawl data (missing data for site 11 2006)

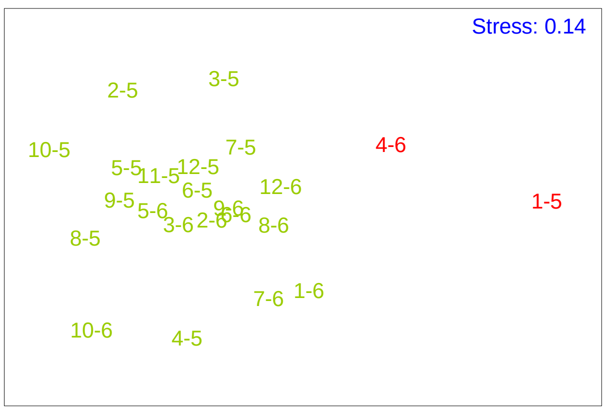


Figure 26 Multidimensional scaling (MDS) plot and associated dendrogram (both based on a Bray Curtis similarity matrix based on fourth-root transformation of data from the entire dataset) for fish from each beam trawl sample undertaken at Burbo Bank during the 2005 and 2006 survey.

4.3.3 Invertebrates

Total numbers of invertebrates recorded at Burbo Bank offshore wind farm were greater in 2005 than in 2006. This was a consistent trend across most, though not all, sites (Figure 27). Excluding the 14,992 individuals recorded at Site 11 in 2005 (not surveyed in 2006), 76,923 individuals were caught in 2005 compared to 56,625 individuals in 2006. This represents a 26% decrease in invertebrate numbers over one year.

The brittle star *O. ophiura* accounted for the majority of invertebrates recorded in both 2005 and 2006 (Figure 29). Large numbers of several bivalve species were also recorded in both years.

Invertebrates were consistently abundant north/northeast of the turbine array at Sites 2 and 3 (though less so in 2006 as in 2005), largely because of the brittle star beds in this area. Sites within and close to the wind farm also had moderately high, invertebrate abundances in both years. Fewer invertebrates were recorded elsewhere across the development area; lowest numbers were at Site 1 (westerly control) in 2005 and Site 7 (export cable route) in 2006. Both the latter sites had low numbers of invertebrates in each year.

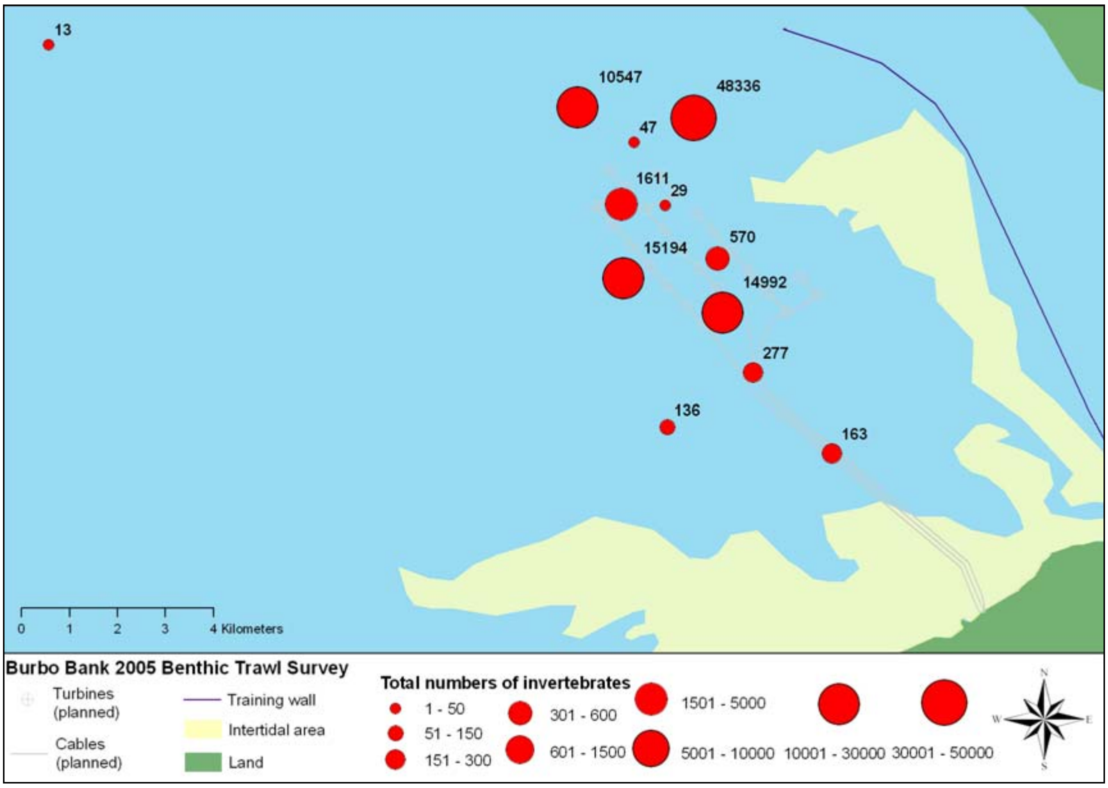
Sites 2 and 3 also had consistently high numbers of invertebrate taxa (Figure 28). Invertebrate richness was slightly higher in 2005 than in 2006 (31 taxa compared to 27). Consistently low numbers of taxa were recorded at Site 7 on the export cable route in both years and there was similarly low taxon richness at sites 1, and 4.

Maps of many of the more abundant species have been prepared in order to investigate possible changes in distribution and/or abundance in relation to the wind farm development (Figure 29 to Figure 35). In the majority of cases the main changes in abundance have occurred at northern offshore sites and sites within the wind farm.

Bivalve species were widespread across the survey area, including the wind farm in 2006. This was the case for *Spisula subtruncata* (Figure 30) and *Abra alba* (Figure 35), which were absent from all sites within the wind farm and outside in 2005, with the exception of Site 5 west of the turbine array.

Numbers of other invertebrate species were more consistent between the two trawl surveys and generally widespread at sites within the wind farm and outside. There was variation in the abundance of individuals between sites however, with a more even distribution of individuals in 2006, although total abundance was higher in 2005 for most invertebrate taxa. This was the case for *Asterias rubens* (Figure 32). This trend was also observed in numbers of *Ophiura ophiura* (Figure 29), *Crangon crangon* (Figure 33) and *Liocarcinus holsatus* (Figure 34). However, in the majority of these cases the main differences in abundance and distribution of these invertebrate taxa were caused by large catches of individuals in 2005 at sites both north and within the wind farm, specifically at sites 3 and 8. A more even distribution of individuals is observed in 2006, with a higher proportion of individuals being distributed amongst sites within the wind farm compared to survey in 2005.

The number and distribution of *Philine aperta* (Figure 31) was comparable between the two trawl surveys, being limited to the near-field areas west and north-west of the wind farm.



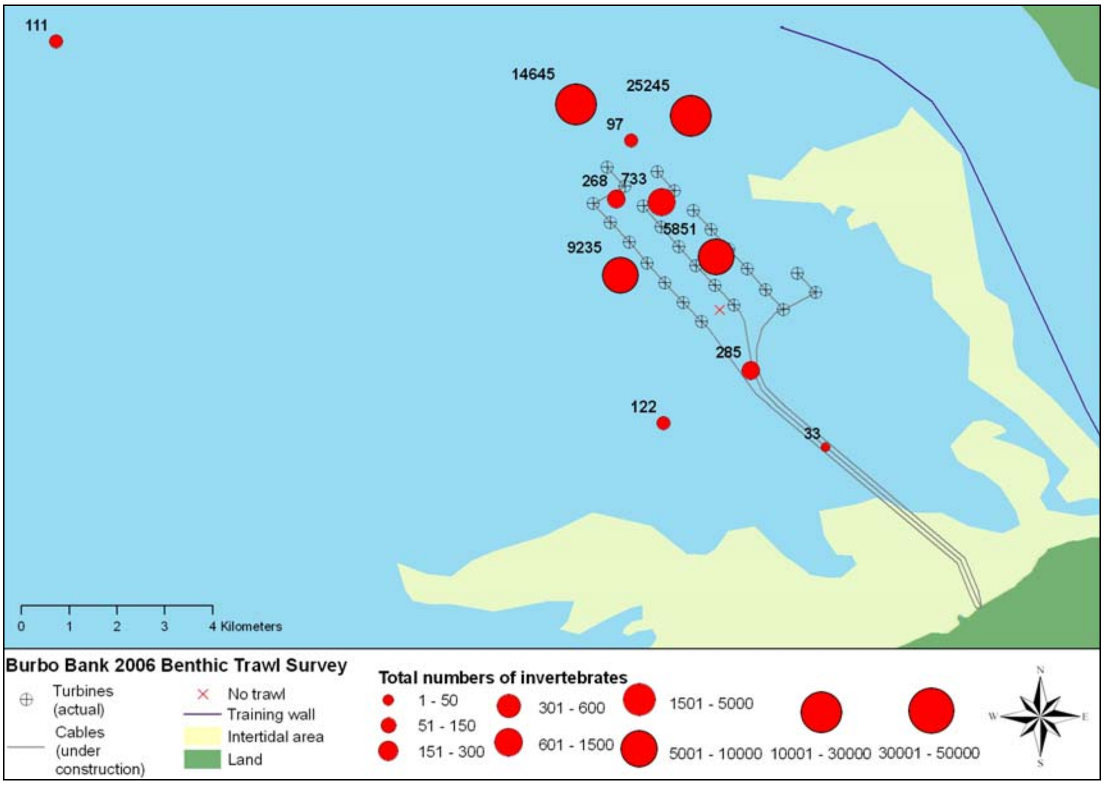


Figure 27 Total numbers of invertebrates recorded during the 2005 and 2006 beam trawl surveys.

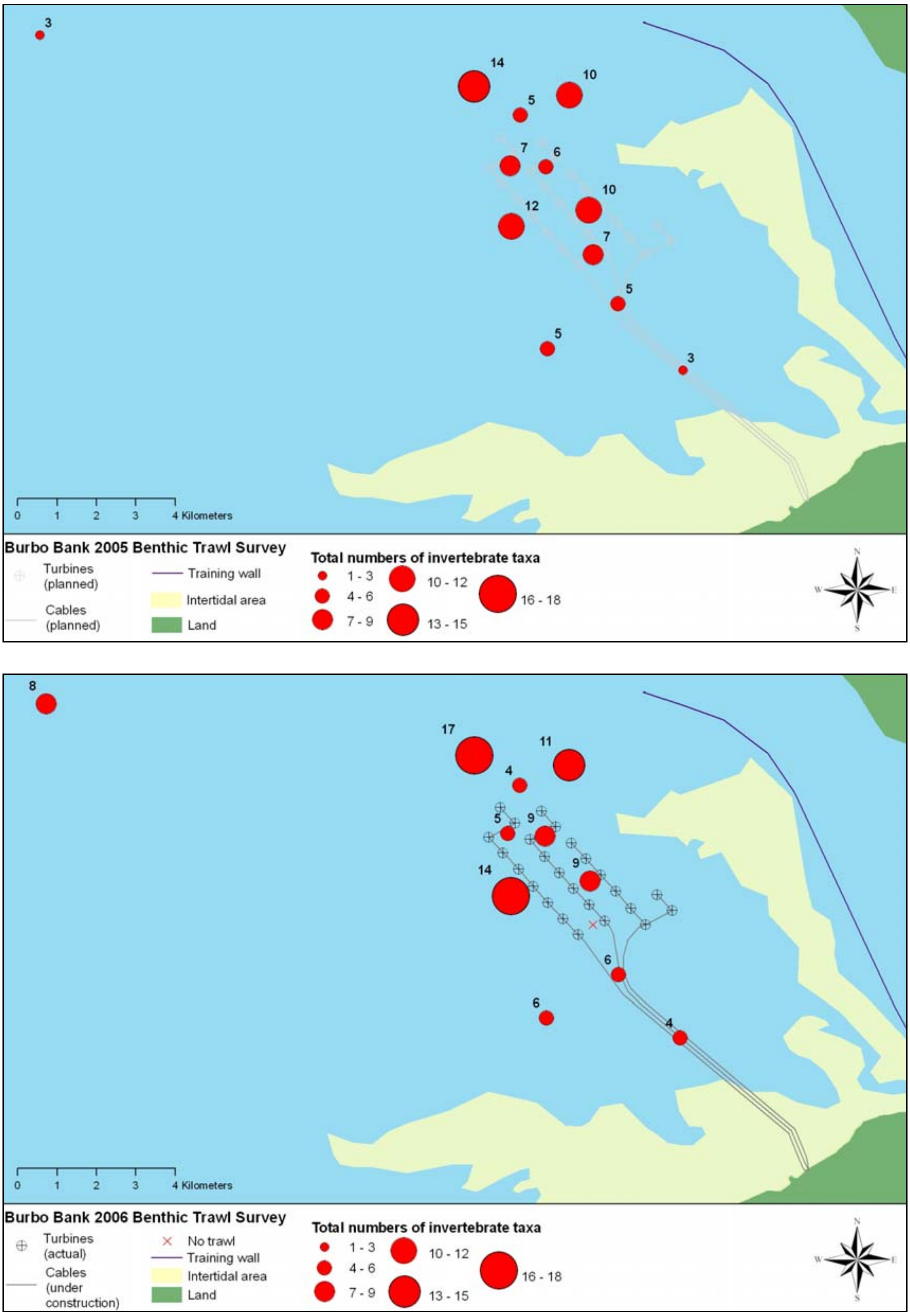
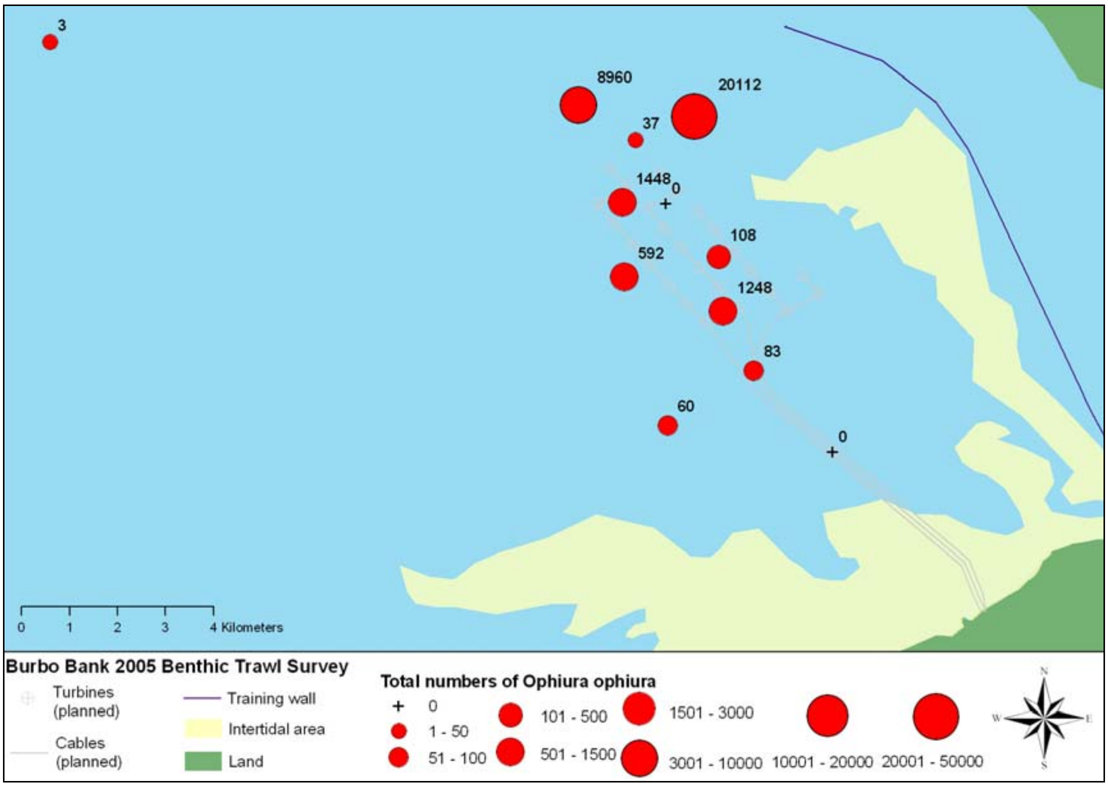


Figure 28 Total numbers of invertebrate taxa recorded during the 2005 and 2006 beam trawl surveys.



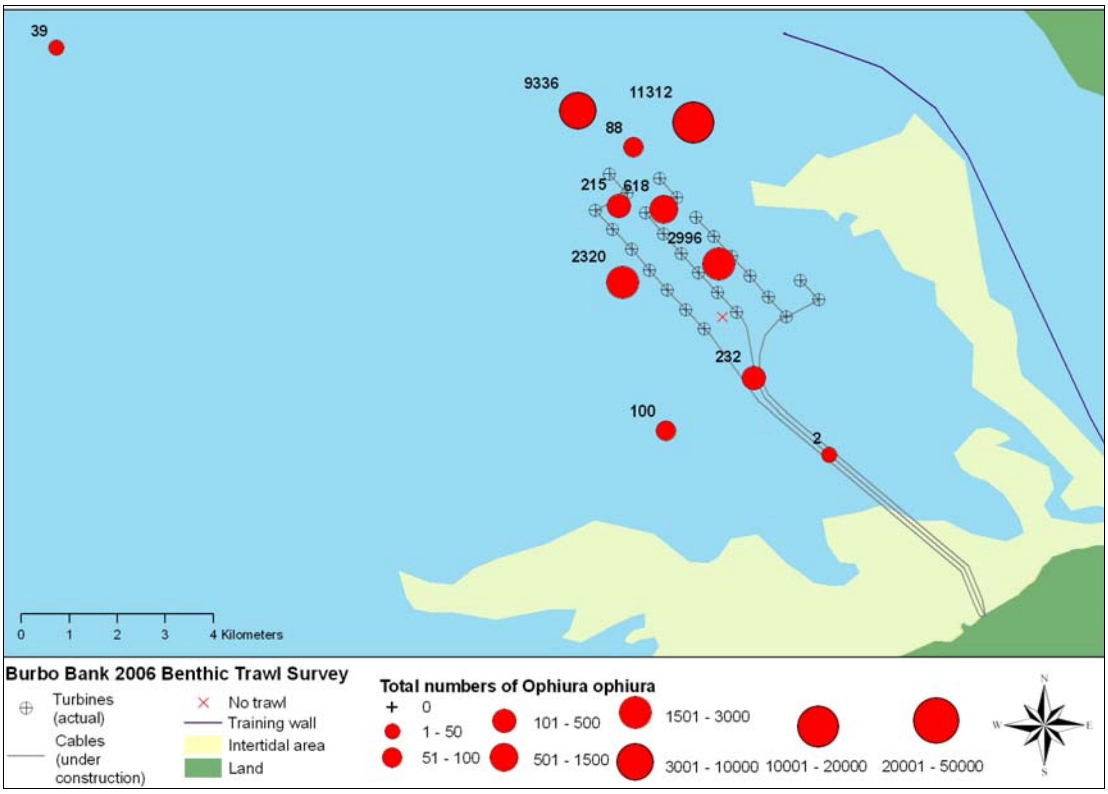
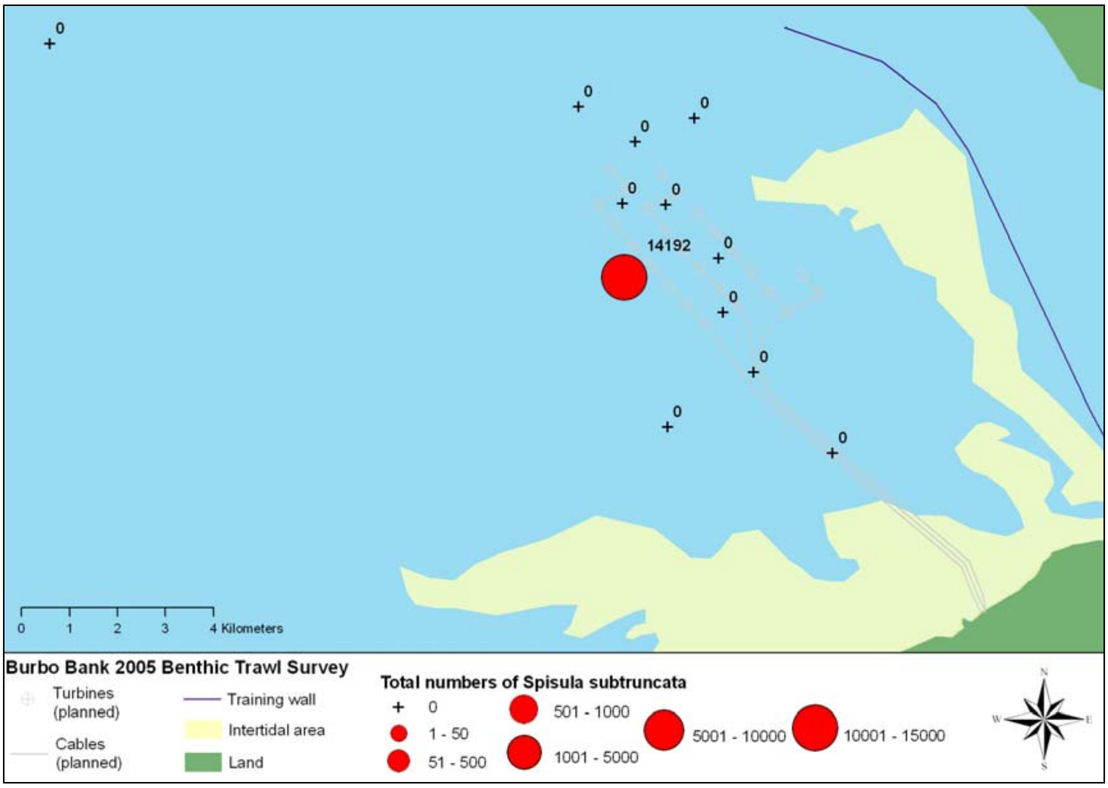


Figure 29 Total numbers of *Ophiura ophiura* recorded during the 2005 and 2006 beam trawl surveys.



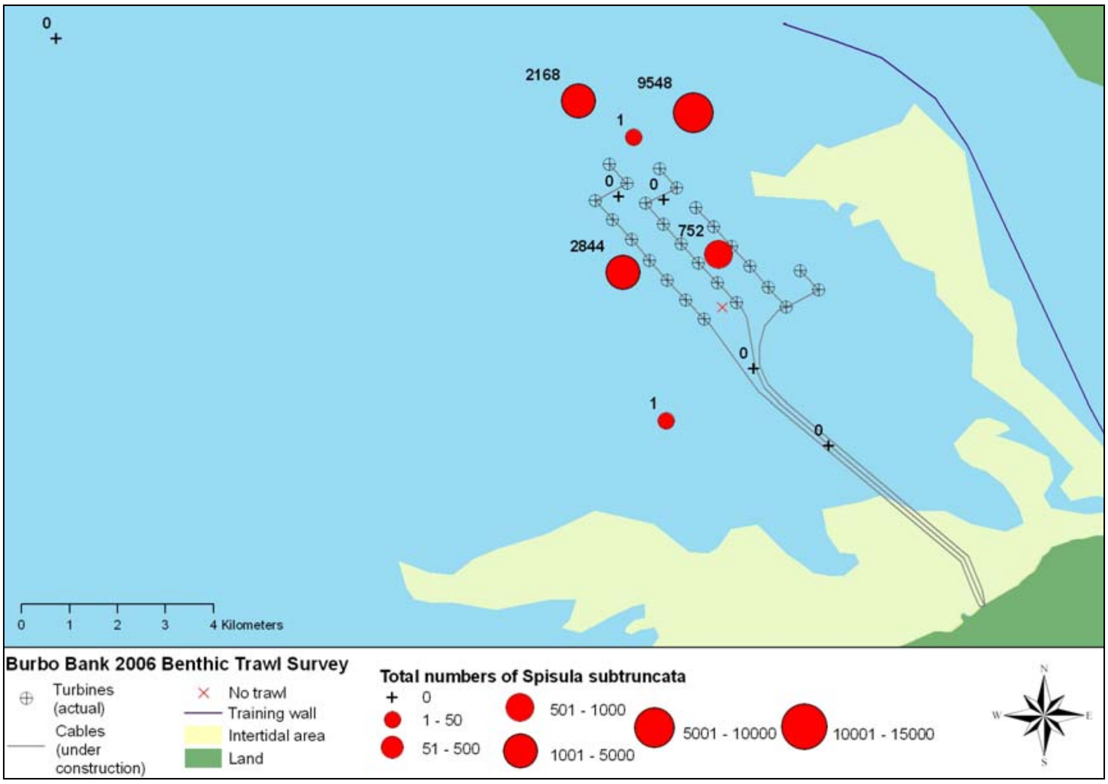
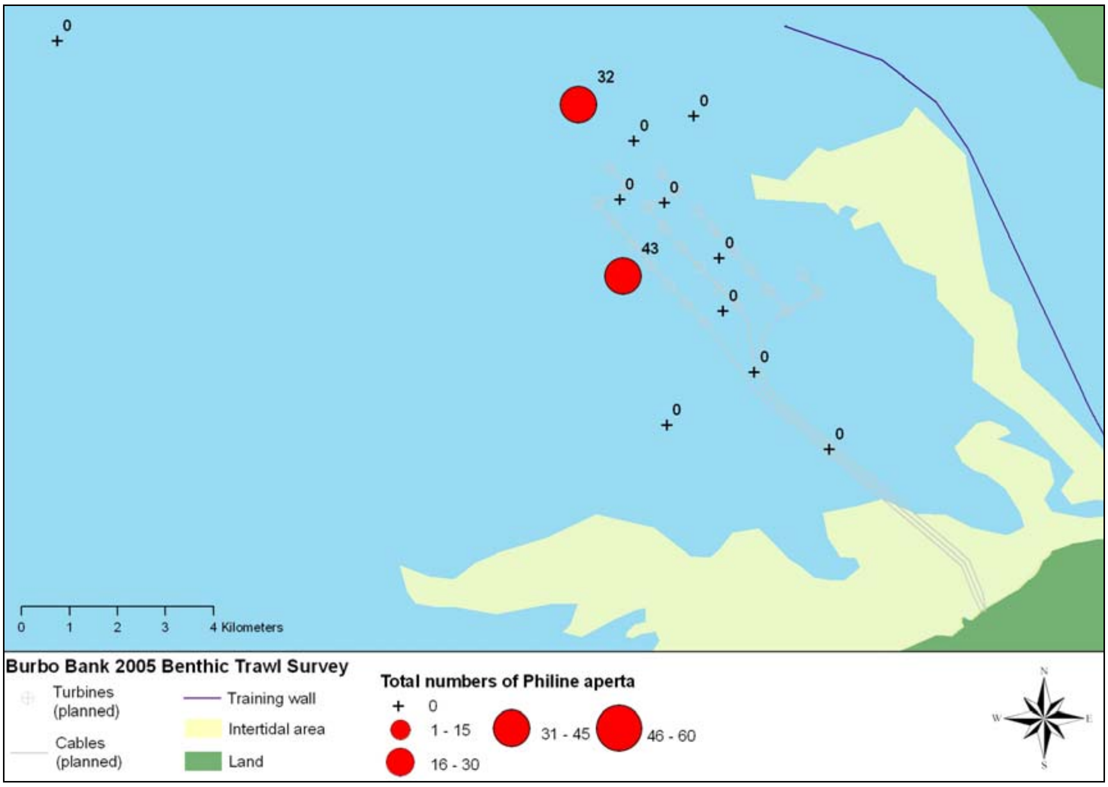


Figure 30 Total numbers of *Spisula suntruncata* recorded during the 2005 and 2006 beam trawl surveys.



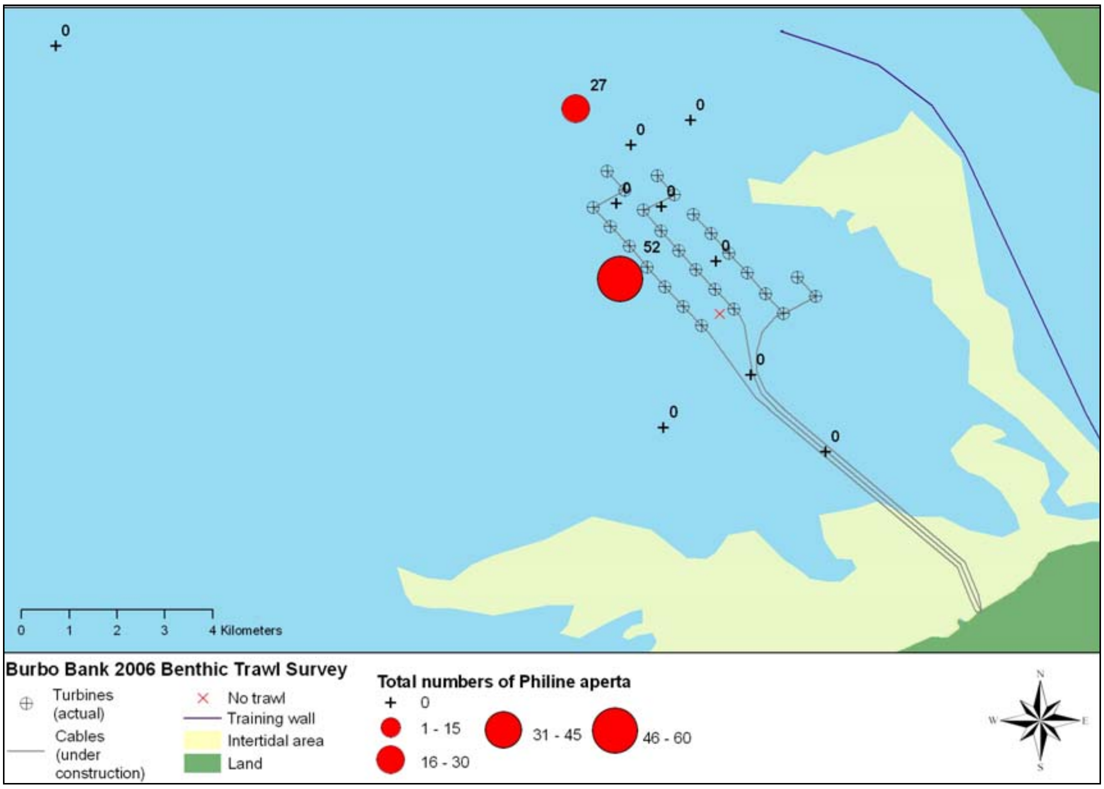
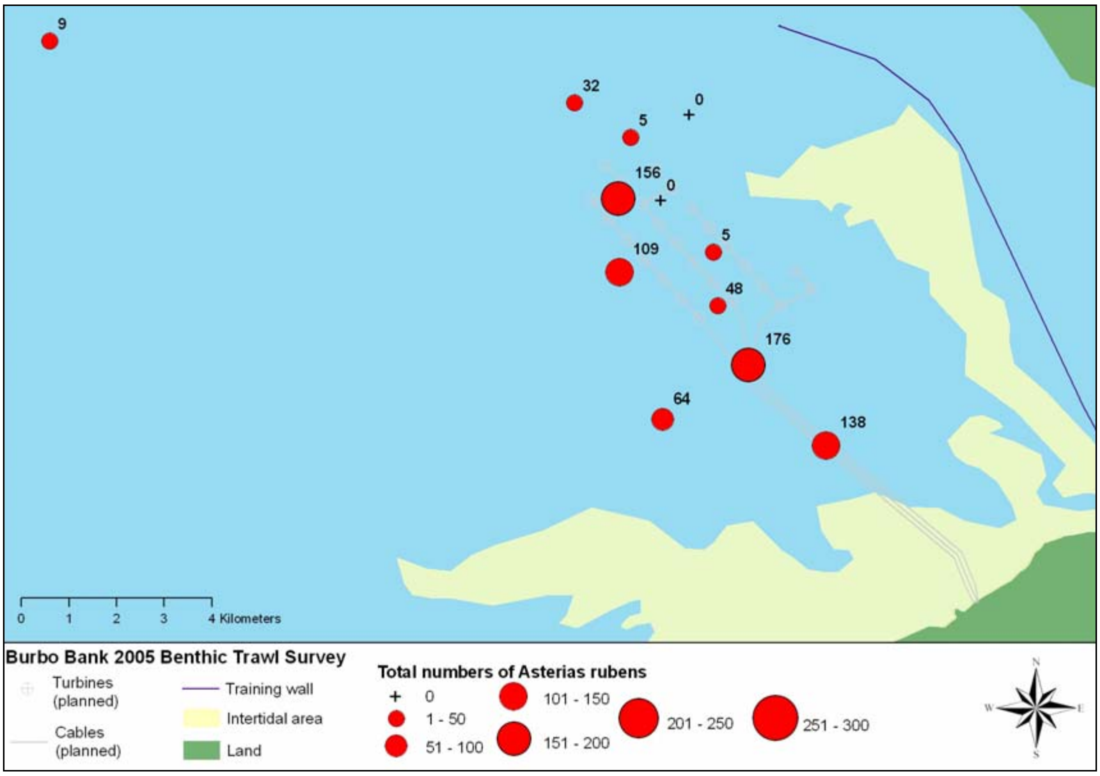


Figure 31 Total numbers of *Philine aperta* recorded during the 2005 and 2006 beam trawl surveys.



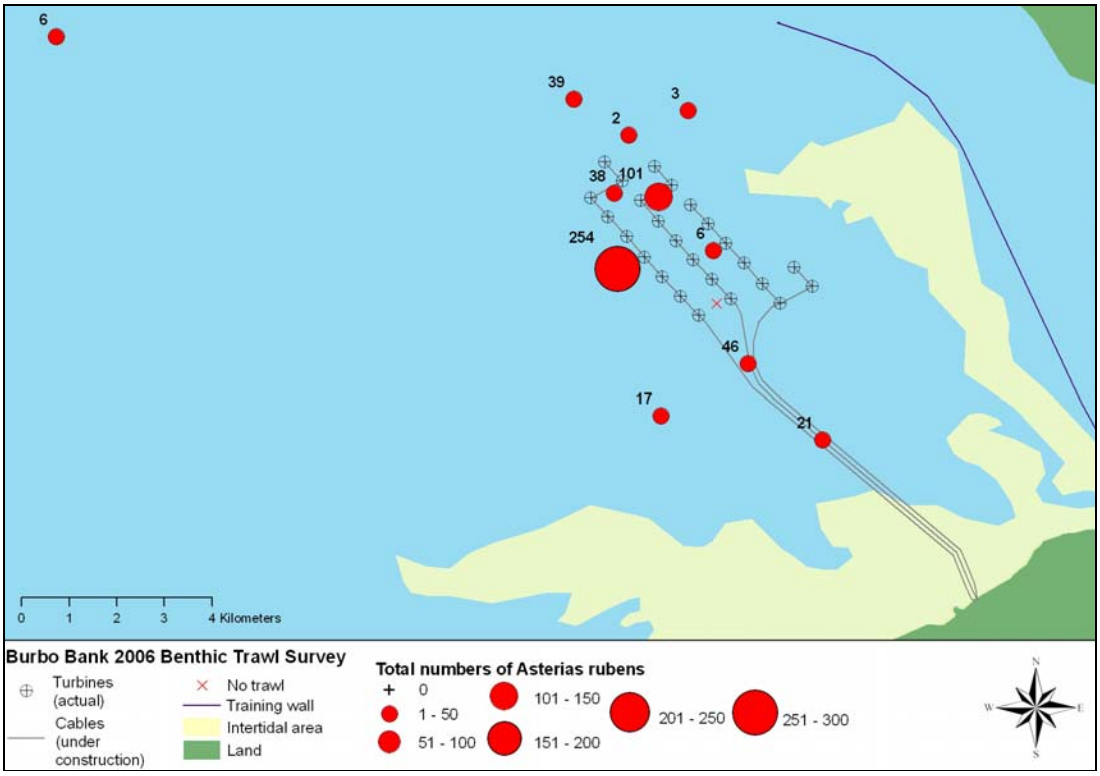
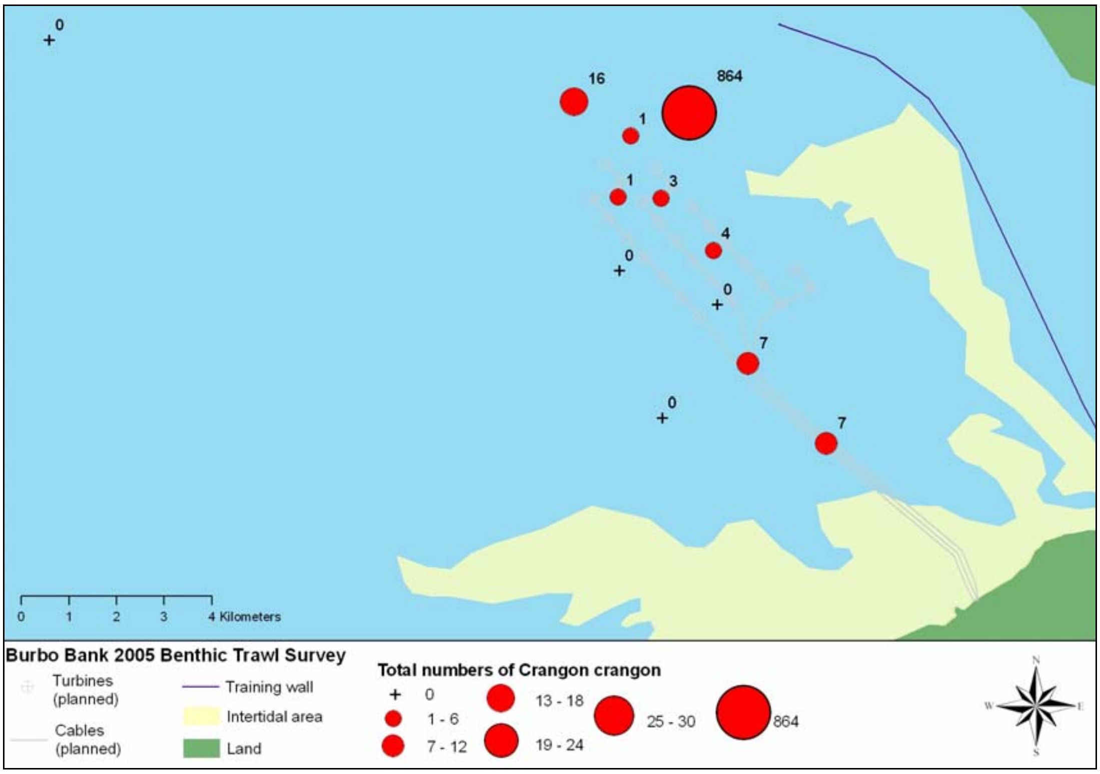


Figure 32 Total numbers of *Asterias rubens* recorded during the 2005 and 2006 beam trawl surveys.



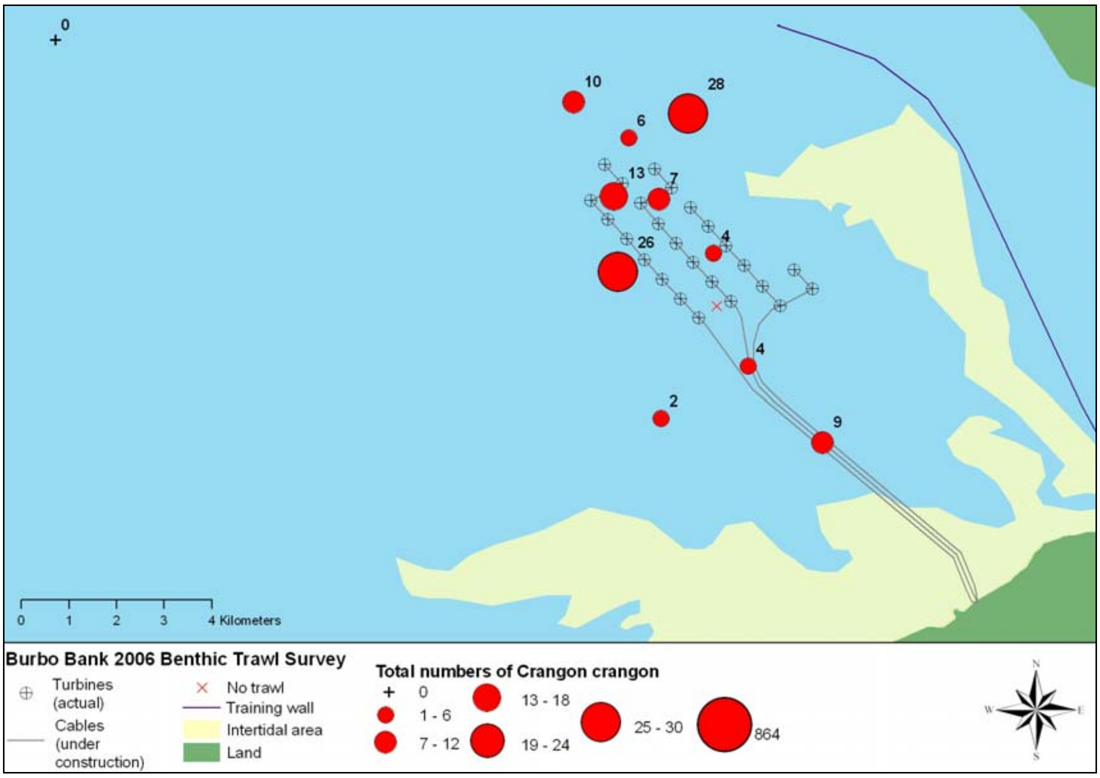
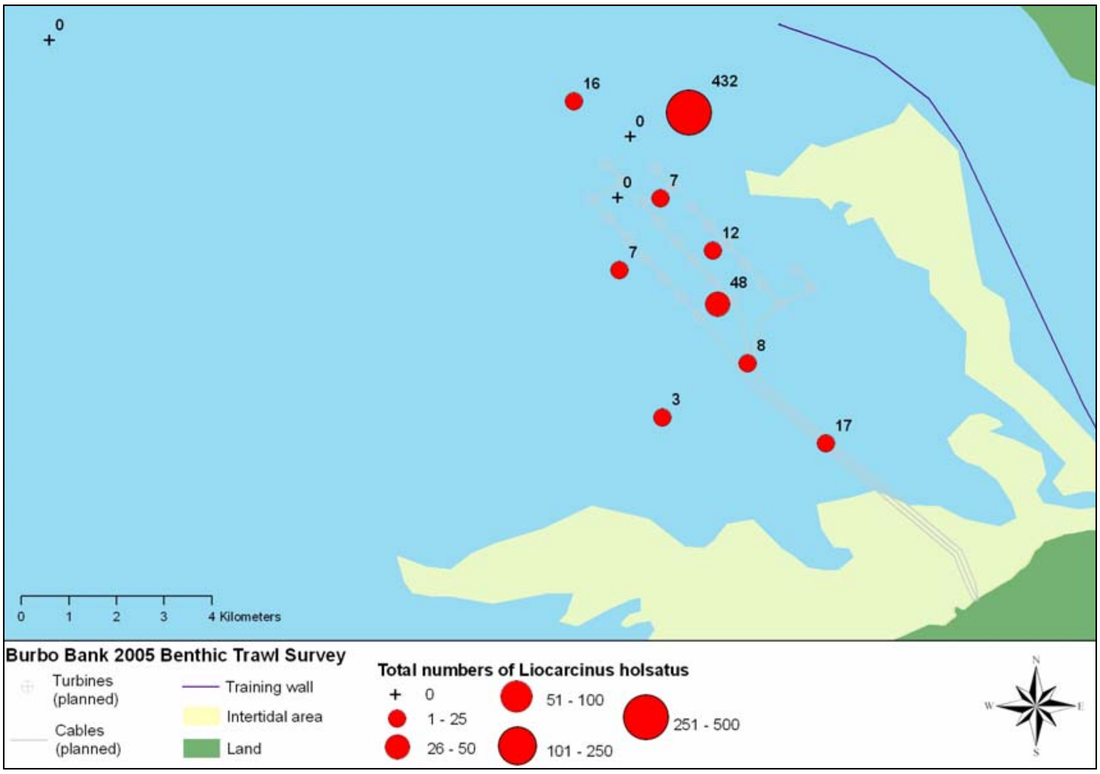


Figure 33 Total numbers of *Crangon crangon* recorded during the 2005 and 2006 beam trawl surveys.



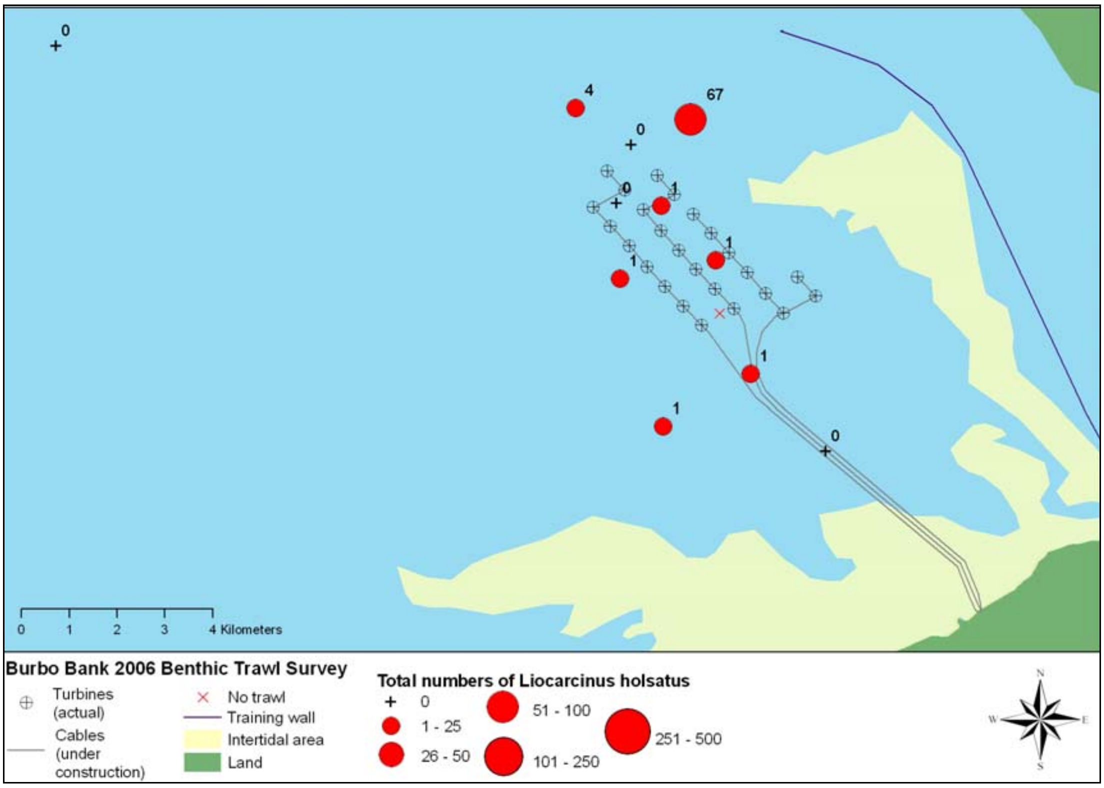


Figure 34 Total numbers of *Liocarcinus holsatus* recorded during the 2005 and 2006 beam trawl surveys.

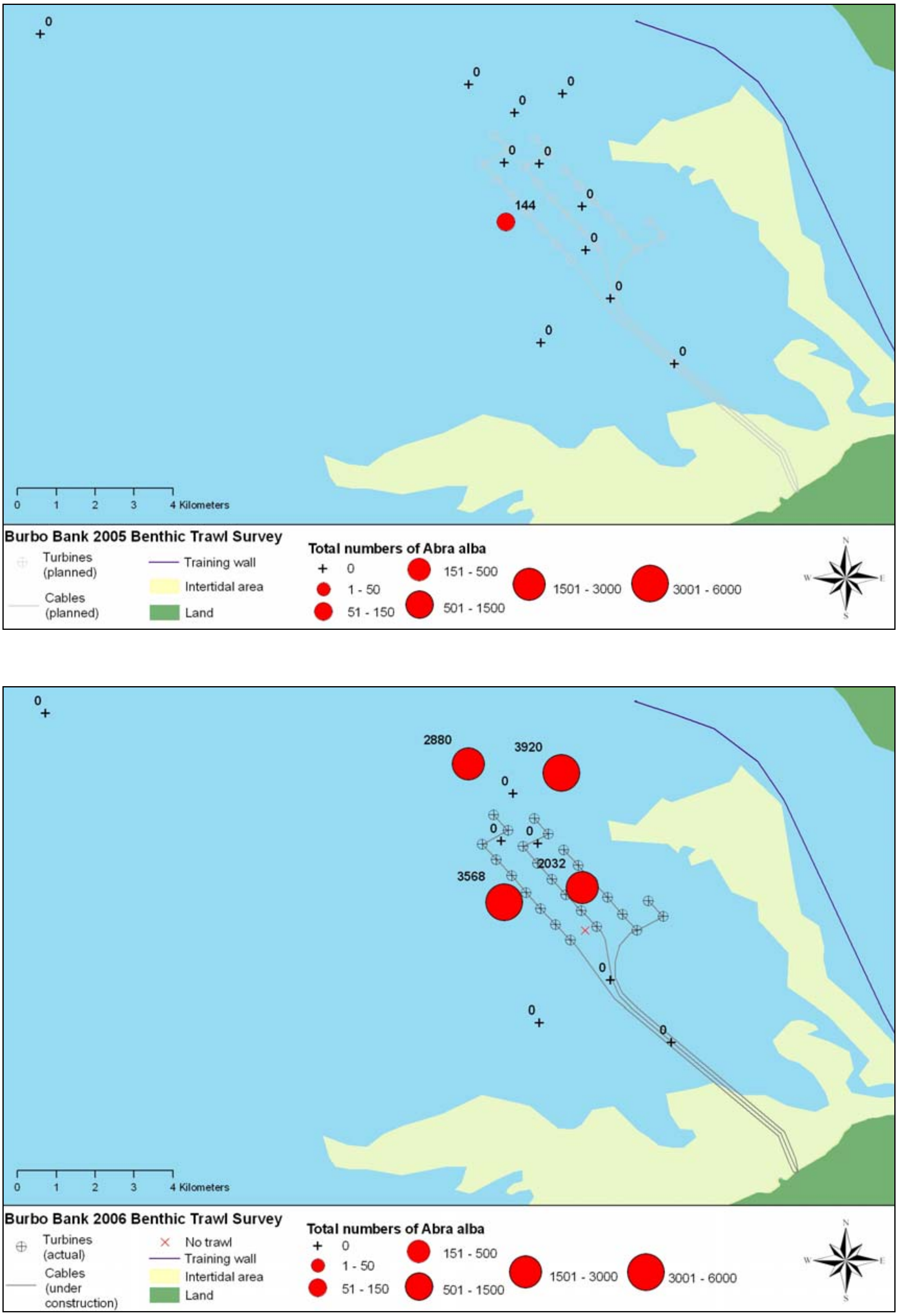
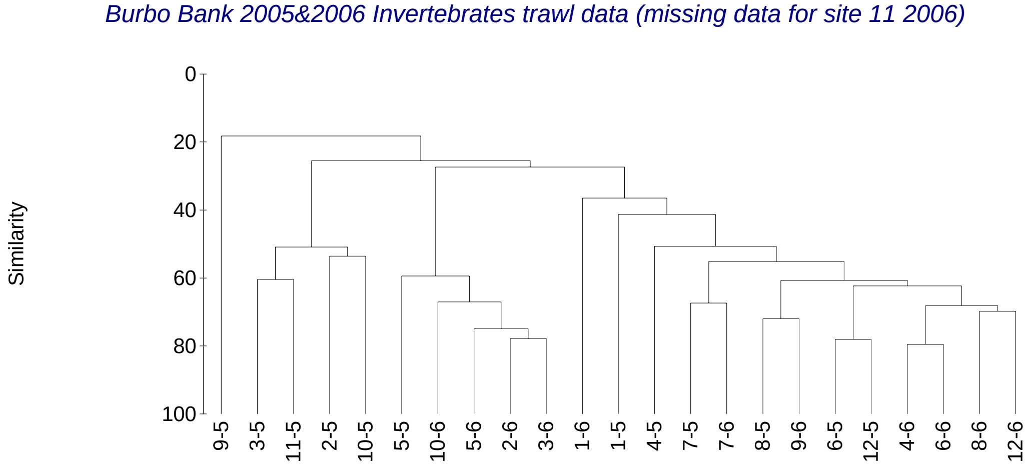


Figure 35 Total numbers of *Abra alba* recorded during the 2005 and 2006 beam trawl surveys.

4.3.4 Statistical analysis (invertebrates)

Site similarity from the beam trawl surveys in 2005 and 2006 is displayed in Figure 36 as a dendrogram and associated MDS plot.



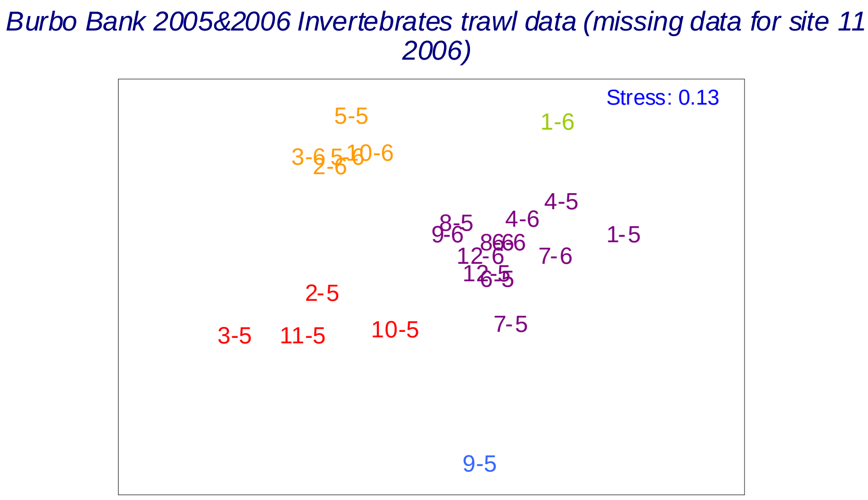


Figure 36 Multidimensional scaling (MDS) plot and associated dendrogram (both based on a Bray Curtis similarity matrix based on fourth-root transformation of data from the entire dataset for invertebrate fauna from each beam trawl sample undertaken at Burbo Bank during the 2005 and 2006 survey.

Sites 2, 3 and 10 cluster well together in both survey years. High numbers of molluscs and *Ophiura ophiura* were recorded in both years at these sites. However, there is considerable inter-annual variation which suggests that communities at these sites have changed but in similar ways. The high similarity between the other trawl sites suggests that there is relatively little difference between the epibenthic communities and elements of the infauna sampled by trawls within and outside the wind farm. Site 9 is the exception in

2005. This is due to the dominance of *Ophiura opiura* at the site in 2005, which was otherwise populated by low numbers of few invertebrate taxa.

5 Conclusions

Some clear differences in benthic fauna sampled by beam trawls were apparent between the baseline survey in 2005 and the during construction survey in 2006. A marked decrease in abundance of epibenthic invertebrates and infauna sampled by trawls was apparent across many sites, but this was by no means a simple trend and there were exceptions with some species. The mollusc, *Abra alba*, for example, was recorded at only one site in 2005 but was abundant at four sites within and north of the wind farm in 2006.

These trends are considered very likely to reflect natural variability in what is a dynamic environment. This observation is supported by the results of the benthic grab survey (CMACS 2007) which references scientific literature highlighting large fluctuations in key benthic species under natural influences such as storms.

The moderate-high similarity between the majority of trawl catches suggests that there is relatively little difference between the fish, epibenthic communities and elements of the infauna sampled by trawls within and outside the wind farm. This suggests that the presence of the wind farm was not a strong influence on these organisms; however, it has to be pointed out that the survey was undertaken only a few months after wind farm construction commenced. Some organisms, especially invertebrates, may not respond to subtle environmental change for some time and the next survey, in 2007 after completion of remaining construction works, will provide valuable new data.

6 References

CMACS (2007) Burbo Bank Offshore Wind Farm. During-construction Benthic Grab Report (November 2007).

Appendix 1

Position fixes for trawls undertaken during the 2006 beam trawl survey at Burbo Bank offshore wind farm.

		Trawl Position Start		Trawl Position End		
Trawl Site	Date	Latitude	Longitude	Latitude	Longitude	Depth (m)
1	16/09/2006	53.51632	-3.39514	53.51764	-3.39935	20.5
2	16/09/2006	53.51316	-3.23028	53.51408	-3.23469	NR
3	16/09/2006	53.51293	-3.19398	53.51349	-3.19865	10.0
4	17/09/2006	53.50736	-3.21200	53.50654	-3.20725	9.0
5	17/09/2006	53.48201	-3.21165	53.48037	-3.20810	11.2
6	16/09/2006	53.45522	-3.19402	53.45550	-3.19887	13.8
7	16/09/2006	53.45332	-3.14261	53.45357	-3.14716	9.7
8	17/09/2006	53.49620	-3.21484	53.49500	-3.21064	9.7
9	17/09/2006	53.49630	-3.20081	53.49515	-3.19662	10.2
10	17/09/2006	53.48707	-3.18216	53.48614	-3.17777	10.5
11	no trawl- site in construction area of wind farm array					
12	17/09/2006	53.46641	-3.16817	-3.16377	53.46548	11.1

N.B. NR: not recorded

Appendix 2

Raw data for the 2006 beam trawl survey at Burbo Bank offshore wind farm.

		Burbo Banks Trawls											
Common Name	Species Name	1	2	3	4	5	6	7	8	9	10	11	12
Fish													
Pogge	Agonus cataphractus	0	0	0	0	4	0	0	0	0	9	no trawl- site in construction area	0
Lesser sand eel	Ammodytes tobianus	0	0	0	0	0	0	1	0	0	0		0
Scald Fish	Arnoglossus laterna	3	3	0	5	0	7	3	14	1	0		47
Solenette	Buglossidium luteum	4	63	90	0	24	50	8	61	34	3		0
Dragonet	Callionymus lyra	0	0	0	0	0	0	2	0	0	0		0
Weever	Echiichthys vipera	0	1	2	5	0	19	14	8	7	0		33
Greater sand eel	Hyperoplus lanceolatus	0	0	0	0	0	0	1	0	0	0		0
Dab	Limanda limanda	0	24	57	3	82	3	0	3	11	0		5
Whiting	Merlangus merlangus	0	2	10	0	23	2	1	0	2	5		5
Flounder	Pleuronectes flesus	0	1	0	0	0	0	0	0	0	0		0
Plaice	Pleuronectes platessa	1	1	4	0	7	2	2	2	8	0		18
Sand Goby	Pomatoschistus minutus	1	1	1	0	1	3	5	6	5	1		7
Thornback Ray	Raja clavata	1	0	0	0	1	0	1	0	0	0		1
Lesser Spotted Dogfish	Scyliorhinus caniculus	0	0	2	0	0	0	0	0	0	2		0
Sole	Solea solea	0	8	0	0	3	1	0	0	3	0		1
Tub gurnard	Trigla lucerna	0	0	0	0	0	0	1	0	0	0		0
Poor cod	Trisopterus minutus	0	0	11	0	0	0	0	0	0	0		0
Cnidarians													
Plumose Anemone	Metridium senile	40	0	0	0	4	0	0	0	0	0		0
Polychaetes													
Sea mouse	Aphrodita aculeata	0	14	0	0	3	0	0	0	0	0		0
Tubeworm	Lagis koreni	0	0	0	0	0	0	0	0	0	0		1
Crustaceans													
Masked crab	Corystes cassivelaunus	0	0	0	0	4	0	0	0	0	0		0
Shrimp	Crangon allmanni	1	0	0	0	0	0	0	0	0	0		0
Brown Shrimp	Crangon crangon	0	10	28	6	26	2	9	13	7	4		4
Isopod	Idotea sp	0	0	0	0	0	0	0	0	1	4		0
Crab	Liocarcinus holsatus	0	4	67	0	1	1	0	0	1	1		1
Longed-legged spider crab	Macropodia sp	2	0	0	0	0	0	0	0	0	0		0
Hermit crab	Pagurus bernhardus	0	23	3	0	6	0	0	1	2	0		0
Pink Shrimp	Pandalus montagui	17	0	0	0	0	0	0	0	0	0		0
Molluscs													
Bivalve	Abra alba	0	2880	3920	0	3568	0	0	0	0	2032		0
Prickly cockle	Acanthocardia echinata	0	8	0	0	0	0	0	0	0	0		0
Gastropod	Acteon tornatilis	0	0	0	0	0	0	0	0	0	8		0
Common whelk	Buccinum undatum	0	10	56	0	0	0	0	0	1	0		0
Striped Venus	Chamelea gallina	0	16	0	0	0	0	0	0	0	0		0
Necklace shell	Euspira catena	0	0	0	0	0	0	0	1	0	0		0
Necklace shell	Euspira pulchella	0	48	252	0	140	0	0	0	1	48		0
Rayed Trough Shell	Mactra stultorum	0	19	28	0	9	0	0	0	0	0		0

		Burbo Banks Trawls											
Common Name	Species Name	1	2	3	4	5	6	7	8	9	10	11	12
Gastropod	Philine aperta	0	27	0	0	52	0	0	0	0	0		0
Little Cuttlefish	Sepiola atlantica	2	16	0	0	4	1	1	0	1	0		1
Bivalve	Spisula subtruncata	0	2168	9548	1	2844	1	0	0	0	752		0
Echinoderms													
Brittle star	Amphiura brachiata	0	24	28	0	0	0	0	0	0	0		0
Common starfish	Asterias rubens	6	39	3	2	254	17	21	38	101	6		46
Sand star	Astropecten irregularis	4	3	0	0	0	0	0	0	0	0		0
Brittle star	Ophiura ophiura	39	9336	11312	88	2320	100	2	215	618	2996		232
Colonials													
Dead Mans Fingers	Alcyonium digitatum	A	A	A	A	A	A	A	A	A	A		P

N.B. P = present, A = absent

Appendix 3

Species list for the 2006 beam trawl survey at Burbo Bank offshore wind farm.

Class	Family	Name	Authority
Pisces			
Osteichthyes	Agonidae	Agonus cataphractus	Linnaeus (1758)
	Ammodytidae	Ammodytes tobianus	Linnaeus (1758)
	Ammodytidae	Hyperoplus lanceolatus	Le Sauvage (1824)
	Bothidae	Arnoglossus laterna	Walbaum (1792)
	Callionymidae	Callionymus lyra	Linnaeus (1758)
	Gadidae	Merlangius merlangus	Linnaeus (1758)
	Gadidae	Trisopterus minutus	Linnaeus (1758)
	Gobiidae	Pomatoschistus minutus	Pallus (1770)
	Pleuronectidae	Limanda limanda	Linnaeus (1758)
	Pleuronectidae	Platichthys flesus	Linnaeus (1758)
	Pleuronectidae	Pleuronectes platessa	Linnaeus (1758)
	Soleidae	Buglossidium luteum	Risso (1810)
	Soleidae	Solea solea	Linnaeus (1758)
	Trachinidae	Echiichthys vipera	Cuvier (1829)
	Triglidae	Trigla lucerna	Linnaeus (1758)
Chondrichthyes	Rajidae	Raja clavata	Linnaeus (1758)
	Scyliorhinidae	Scyliorhinus caniculus	Linnaeus (1758)
Crustacea			
Eumalacostraca	Corystidae	Corystes cassivelaunus	Pennant (1777)
	Crangonidae	Crangon allmanni	Kinahan (1857)
	Crangonidae	Crangon crangon	Linnaeus (1758)
	Majidae	Macropodia sp	Leach (1814)
	Iodoteidae	Idotea sp	Fabricius (1798)
	Paguridae	Pagurus bernhardus	Linnaeus (1758)
	Pandalidae	Pandalus montagui	Leach (1814)
	Portunidae	Liocarcinus holsatus	Fabricius (1798)
Annelida			
Polychaeta	Aphroditidae	Aphrodita aculeata	Linnaeus (1758)
	Pectinariidae	Lagis koreni	Malmgren (1866)
Mollusca			
Pelecypoda	Cardiidae	Acanthocardia echinata	Linnaeus (1758)
	Mactridae	Mactra stultorum	Linnaeus (1758)
	Mactridae	Spisula subtruncata	da Costa (1778)
	Semelidae	Abra alba	W Wood (1802)
Gastropoda	Acteonidae	Acteon tornatilis	Linnaeus (1758)
	Buccinidae	Buccinum undatum	Linnaeus (1758)
	Naticidae	Euspira catena	da Costa (1778)
	Naticidae	Euspira pulchella	Risso (1826)
	Philinidae	Philine aperta	Linnaeus (1767)

Class	Family	Name	Authority
	Veneridae	Chamelea gallina	Linnaeus (1758)
Cephalopoda	Sepiolidae	Sepiola atlantica	Orbigny in Ferussac and Orbigny (1840)
Echinodermata			
Asteroidea	Asteriidae	Asterias rubens	Linnaeus (1758)
	Astropectinidae	Astropecten irregularis	Pennant (1777)
Ophiuroidea	Amphiuridae	Amphiura brachiata	Montagu (1804)
	Ophiuridae	Ophiura ophiura	Linnaeus (1758)
Cnidaria			
Hexacorallia	Metridiidae	Metridium senile	Linnaeus (1761)
Octocorallia	Alcyoniidae	Alcyonium digitatum	Linnaeus (1758)

Appendix 4

Fish Lengths recorded during the 2006 beam trawl survey at Burbo Bank offshore wind farm.

		Length (mm)						
Site	Individual	Dab	Flounder	Lesser Spotted Dogfish	Plaice	Sole	Thornback Ray	Whiting
1	1				248		Male 258L	
2	1	221	322		140	187		105
	2	196				339		105
	3	211				205		
	4	236				115		
	5	215				111		
	6	196				78		
	7	181				105		
	8	211				110		
	9	224						
	10	215						
	11	251						
	12	153						
	13	187						
	14	339						
	15	205						
	16	230						
	17	258						
	18	233						
	19	176						
	20	201						
	21	166						
	22	203						
	23	175						
	24	137						
3	1	195		Female 595L	231			145
	2	186		Female 590L	302			120
	3	221			185			128
	4	206			134			131
	5	199						117
	6	205						161
	7	227						142
	8	212						150
	9	141						100
	10	222						109
	11	235						
	12	205						

		Length (mm)						
Site	Individual	Dab	Flounder	Lesser Spotted Dogfish	Plaice	Sole	Thornback Ray	Whiting
	13	202						
	14	224						
	15	220						
	16	220						
	17	260						
	18	205						
	19	192						
	20	166						
	21	183						
	22	227						
	23	174						
	24	221						
	25	247						
	26	216						
	27	189						
	28	159						
	29	234						
	30	226						
	31	228						
	32	220						
	33	221						
	34	202						
	35	191						
	36	213						
	37	170						
	38	269						
	39	246						
	40	190						
	41	191						
	42	214						
	43	201						
	44	135						
	45	158						
	46	219						
	47	254						
	48	178						
	49	250						
	50	231						
	51	199						
	52	183						
	53	189						
	54	185						
	55	204						

		Length (mm)						
Site	Individual	Dab	Flounder	Lesser Spotted Dogfish	Plaice	Sole	Thornback Ray	Whiting
	56	192						
	57	135						
4	1	214						
	2	198						
	3	155						
5	1	241			345	215	Female 258L	144
	2	220			268	302		149
	3	239			211	230		133
	4	221			318			186
	5	245			226			122
	6	188			310			130
	7	220			200			105
	8	241						100
	9	246						144
	10	244						103
	11	220						142
	12	229						149
	13	195						170
	14	187						149
	15	232						105
	16	219						120
	17	228						100
	18	198						122
	19	223						117
	20	264						90
	21	250						91
	22	199						93
	23	207						126
	24	217						
	25	168						
	26	214						
	27	251						
	28	242						
	29	264						
	30	223						
	31	200						
	32	261						
	33	266						
	34	255						
	35	238						
	36	205						
	37	225						
	38	204						

		Length (mm)						
Site	Individual	Dab	Flounder	Lesser Spotted Dogfish	Plaice	Sole	Thornback Ray	Whiting
	39	188						
	40	188						
	41	215						
	42	266						
	43	194						
	44	208						
	45	225						
	46	186						
	47	202						
	48	240						
	49	229						
	50	194						
	51	240						
	52	253						
	53	218						
	54	211						
	55	160						
	56	178						
	57	197						
	58	200						
	59	239						
	60	206						
	61	206						
	62	210						
	63	199						
	64	212						
	65	180						
	66	215						
	67	217						
	68	130						
	69	196						
	70	173						
	71	187						
	72	232						
	73	238						
	74	215						
	75	173						
	76	144						
	77	130						
	78	165						
	79	203						
	80	202						
	81	186						

		Length (mm)						
Site	Individual	Dab	Flounder	Lesser Spotted Dogfish	Plaice	Sole	Thornback Ray	Whiting
	82	200						
6	1	156			121	205		84
	2	201			192			120
	3	121						
7	1				218		Male 420L	60
	2				129			
8	1	180			324			
	2	228			131			
	3	147						
9	1	221			142	303		92
	2	240			140	225		83
	3	192			148	178		
	4	142			167			
	5	129			140			
	6	170			134			
	7	196			108			
	8	182			120			
	9	182						
	10	145						
	11	150						
10	1			Female 630L				102
	2			Female 620L				88
	3							104
	4							115
	5							70
11: no trawl- site in construction area								
12	1	239			210		Female 309L	98
	2	230			215			82
	3	170			275			90
	4	271			137			79
	5	173			149			91
	6				164			
	7				159			
	8				240			
	9				191			
	10				136			
	11				134			
	12				126			
	13				125			
	14				140			
	15				106			
	16				82			
	17				87			

		Length (mm)						
Site	Individual	Dab	Flounder	Lesser Spotted Dogfish	Plaice	Sole	Thornback Ray	Whiting
	18				87			

Appendix 5

Survey photographs

Site 1

Site 2

Site 3

Site 4

Site 5

Site 6

Site 7

Site 8

Site 9

Site 10

Site 12

Annex 2 Ornithology

SeaScape Energy

Burbo Bank Offshore Wind Farm

Ornithological Survey - Construction Period

March 2008

Report no: 0002-NH50931-NHR-03

CMACS Centre for Marine and Coastal Studies Ltd

SeaScape Energy

Burbo Bank Offshore Wind Farm

Ornithological Survey - Construction Period

Author:	Roy Leigh	
Checker:	David Hoare	
Approver:	John Moorcroft	

Report no: 0002-NH50931-NHR-03 Date: March 2008

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Hyder Consulting

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Appendix A

1 Summary

In order to comply with a FEPA licence granted for the construction of the Burbo Bank offshore wind farm, a series of boat based ornithology surveys were undertaken at approximately monthly intervals between May 2006 and the end of July 2007. The aim of the surveys was to monitor the effects of the construction phase of the Scheme, and to follow-on from a pre-construction monitoring program (September 2005 to April 2006[1]).

The survey methodology followed that utilised in the pre-construction studies, where ornithologists recorded bird observations along seven transect routes. These transects passed through the wind farm construction area (hereinafter referred to as the ‘wind farm area’) with an adjacent buffer area and reference area. The survey targeted specific species for their nature conservation status, as identified in the Environmental Impact Assessment for the Scheme.

In general, the survey area holds few bird species, and those that do occur are present in low numbers. Construction period survey results were similar to those from pre-construction surveys. Given these low numbers, it was not possible to determine any difference in abundance and distribution between construction and pre-construction periods for the wind farm area, the buffer area and the reference area; the notable exception being cormorant *Phalacrocorax carbo,* which regularly used the recently built wind turbines as roosting sites and therefore records increased within the wind farm area.

Records of two target species, common scoter *Melanitta nigra* and red-throated diver *Gavia stellata*, did show some bias towards the buffer area and reference area, but given the low numbers of birds involved were predominantly recorded in flight, it is considered unsafe to relate this distribution to construction activity. The final target species, common tern *Sterna Hirundo*, appeared unaffected by the construction activity and distribution remained relatively constant for the small numbers recorded.

Of the other noteworthy species recorded, auks *Alcid spp*. also showed a bias towards the buffer area and reference area, but this may relate to existing disturbance from the Queen’s Channel shipping lane, which lies adjacent to the wind farm area.

The overall effects of construction activity on birds are considered likely to have been limited as only small numbers of birds were recorded, which is consistent with pre-construction surveys. Given these low numbers and the existing levels of disturbance in the area, it is considered likely that construction of the wind farm has had no significant effect on the favourable conservation status of the bird population in its natural range.

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[1] Hyder Consulting (UK) Ltd Report No. NH50931/D1/1

2 Introduction

Centre for Marine and Coastal Studies Ltd (CMACS), on behalf of SeaScape, commissioned Hyder Consulting (UK) Ltd to undertake a series of offshore bird surveys on the site of the consented Burbo Bank offshore wind farm, located on the Burbo Bank in Liverpool Bay. These surveys were required to comply with a FEPA licence (Ref 31864/07/0). The aim of the surveys was to monitor the effects of the construction phase of the Scheme (May 2006 to July 2007), and to follow-on from a pre-construction monitoring program (September 2005 to April 2006). Construction technically continued to November 2007, but all activities which may have the potential to effect birds occurred within the period covered by this report; namely piling, cabling and physical construction. This report details surveys through the various construction phases of the Scheme (see Table 4-1).

The Scheme comprises twenty-five 3.6 MW wind turbines, with each turbine at approximately 130m high from sea level to blade tip. The wind farm site also lies adjacent to the Queen's Channel shipping lane.

Pre-construction surveys found that numbers of birds using the survey area were small, and that distribution tended to be biased to the south and west of the survey area (and away from the Queen's Channel shipping lane which lies adjacent to the wind farm area).

2.1 Existing Environment

The survey area lies within Liverpool Bay, which constitutes part of the English tidal zone of the Irish Sea. The bay area stretches from the southern point of Morecambe Bay south to Red Wharf Bay in Anglesey. Burbo Bank is situated approximately 6.4km from the Sefton coastline, off the north Wirral foreshore. Liverpool Bay is under consideration for designation as a Special Protection Area (SPA) in accordance with Article 4 of the EC Directive on the Conservation of Wild Birds 79/409/EEC (hereinafter referred to as the Birds Directive).

The two nearby estuaries, the Mersey and the Dee, are both designated SPAs for internationally important numbers of wintering waterfowl and for breeding tern populations (Dee only). The Mersey Narrows and North Wirral Foreshore Site of Special Scientific Interest (SSSI) is a candidate SPA, also for wetland bird species.

3 Survey Methodology

3.1 Boat-Based Surveys

The surveys were undertaken monthly between May 2006 and July 2007 wherever practically possible. Each survey followed the methodology agreed through consultation with English Nature (now Natural England), the Royal Society for the Protection of Birds (RSPB), the Lancashire Wildlife Trust and the Countryside Council for Wales (CCW) prior to the pre-construction surveys, and encompassed the whole of the wind farm area, a buffer area and adjacent reference area (which combine to form the survey area). The extent of the survey area is shown on Figure 1.

The methodology was designed to survey seabirds using the survey area and to provide data to assess:

- Species abundance
- Species distribution
- Migratory pathways
- Foraging areas.

This data can then be used to assess the potential level of disturbance to birds resulting from construction activity and the subsequent operation of the wind farm when compared with data collected from the adjacent reference area.

The primary method employed was strip band line transect surveys (based upon Camphuysen *et al,* 2004), with an overall 300m band. The wind farm area, buffer area and adjacent reference area were crossed by seven evenly distributed transect routes approximately 1 nautical mile apart. The reference area has comparable oceanographic features (depth / tidal / position / seabed composition and profile) to the wind farm area, but is subject to much reduced shipping-related disturbance. It is acknowledged that the reference area should offer identical conditions to the wind farm area, but no such area was available. The chosen reference area therefore represents the best available option. The NGR co-ordinates of the transects are provided in Table 3-1, and the position of the survey transects is shown on Figure 1.

Transect No.	British National Grid Co-ordinates	
1	SD 19996 03334	SJ 24610 98953
2	SD 19361 02531	SJ 23975 98173
3	SD 18519 01876	SJ 23362 97388
4	SD 17937 01127	SJ 22584 96697
5	SD 17164 00462	SJ 21863 96056

Transect No.	British National Grid Co-ordinates	
6	SJ 16456 99772	SJ 21240 95240
7	SJ 15814 98995	SJ 20458 94626

Table 3-1 Transect Co-ordinates

Each transect had an overall observational 300m band width, which was further sub-divided into 5 bands (A-E) as follows;

A 0-50m, **B** 50m-100m, **C** 100m-200m, **D** 200m-300m and **E** >300m.

Positioning and chronological data were logged at commencement, during and on completion of each transect.

The ship traversed the series of pre-determined transects at a preferred speed of 10 knots (range 5-15 knots).

Two ornithologists were positioned in the vessel on a purpose built observation platform approximately 5m above sea level. The observers viewed from both sides of the vessel and scanned the area perpendicular to the boat using binoculars. This also included sweeps ahead of the boat, so as to ensure that no under-counting of divers *Gaviidae* occurred, as these are known to be susceptible to disturbance from on-coming vessels.

All observations were logged using dictaphones, noting the time, position and band location and, wherever possible, age, sex and activity. For birds recorded only in flight, approximate height and direction were also recorded.

Vessel based monitoring also provided supplementary data i.e. water temperature, depth, visibility, wind speed and sea state were recorded on each survey.

3.2 Target Species

Target bird species followed those identified prior to pre-construction surveys; common scoter, red-throated diver (both of which represent candidate species for the proposed Liverpool Bay SPA), cormorant (which occurs in nationally important numbers and is a feature of the Mersey Narrows and North Wirral Foreshore SSSI / candidate SPA) and common tern (a qualifying interest for the Dee Estuary SPA and also for the Mersey Narrows and North Wirral Foreshore SSSI / candidate SPA).

With the exception of the commoner gull species (records of kittiwake *Rissa triadactyla*, little gull *Larus minutus* and Mediterranean gull *Larus melanocephalus* are included), all other observed bird species were recorded due to the previously identified historical commuting route for some species between the North Wirral foreshore and the Ribble estuary to the north, meaning that birds could potentially pass through the wind farm area (Casella Stanger, 2002).

Any other noteworthy observations, such as cetacean species, were also recorded.

3.3 Evaluation

This report focuses on numerical data derived from the field surveys and compares counts from the wind farm area, buffer area and the reference area to provide an indication of the potential effect of the construction and commissioning activities on bird presence and numbers. Comparison is also made with counts and distribution data gathered in pre-construction surveys. The construction period data is presented in tabular format (Appendix A), giving a total number of individuals recorded for each species along each sailed transect.

Data provided via the Joint Nature Conservation Committee (JNCC) Aerial Bird Survey Program provides a higher level of information which could be correlated with the boat survey data and fed into the overall avian population assessment. However, no such correlation has been undertaken for this report given the relatively small number of total records for target species (cormorant aside).

4 Survey Results

Summary survey data are contained in Appendix A.

4.1 Overview

Table 4-1 provides an overview of the construction activity time-line and a summary of the total number of recorded bird species from the combined wind farm area and the adjacent reference area (the survey area).

4.2 Target Species Accounts

Target species data are summarised below. Individual species counts are presented in graph form for both the construction period and the pre-construction survey period in order for comparisons to be made. It should, however, be noted that numbers of birds recorded during each survey will have been influenced by a range of other factors such as sea state, tidal cycles and non-wind farm related disturbance.

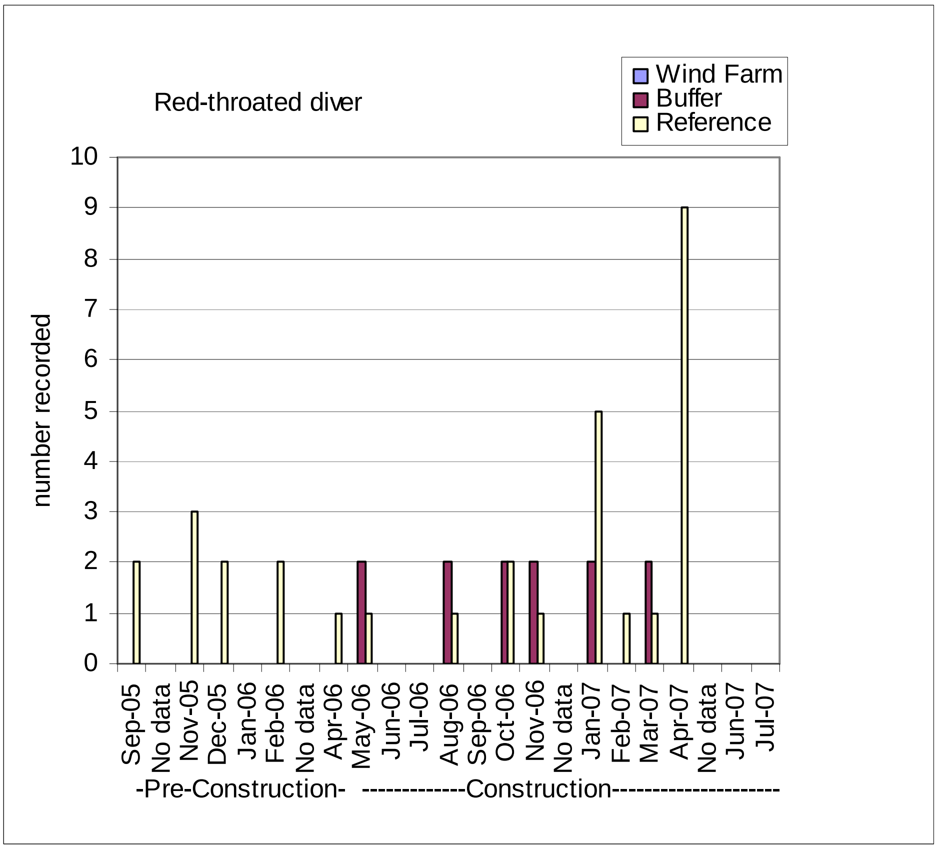
Red-throated Diver *Gavia stellata. Conservation Status: listed on Annex 1 of the EC Birds Directive, listed on Schedule 1 of the Wildlife and Countryside Act 1981 (as amended) and Amber listed on Birds of Conservation Concern*.

Red-throated divers occurred in low numbers through the construction period (typically 1-3 birds, but with a higher count of 9 birds in April 2007, presumably coinciding with the spring passage period). The majority of records were of birds in flight, so the possibility that some records have been duplicated cannot be eliminated.

Numbers recorded were broadly consistent with those noted during the pre-construction surveys.

No birds were recorded within the wind farm area. Birds were recorded within the buffer area and reference area towards the seaward end of the transects. Birds were disturbed from the water on two occasions only, with the remainder being birds noted in direct flight through the survey area and beyond. Flight was typically recorded at a height of 2-5m above the surface and no birds were seen to land, perhaps suggesting that many of the birds recorded were commuting through the survey area rather than using it as a foraging site.

The numbers of red-throated divers recorded are shown in Graph 4-1 and distribution is mapped in Figure 2.



Graph 4-1 Red-throated Diver Distribution & Abundance

	2006								2007						
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Construction Activity															
Scour Protection															
filter layer															
rock armour															
Monopile Installation															
Hammer piling															
Turbine Installation															
Cabling															
export route															
array cables															
Target Species															
Red-throated diver	3	0	0	3	0	4	3	NS	7	1	3	9	NS	0	0
Common scoter	0	0	0	7	12	0	0	NS	9	8	10	0	NS	0	0
Cormorant	9	16	29	13	33	11	11	NS	16	79	17	2	NS	18	11
Common tern	4	0	0	18	2	0	0	NS	0	0	0	0	NS	6	19
Other Noteworthy Species															
Auk *sp.*	9	12	50	6	15	11	13	NS	13	1	12	24	NS	3	13
Wader *sp.*	0	0	0	0	0	2	0	NS	0	1	0	0	NS	0	4
Kittiwake	4	1	10	1	3	0	1	NS	1	0	1	0	NS	2	0
Little gull	0	0	0	0	1	0	0	NS	0	0	0	0	NS	0	7
Mediterranean gull	0	1	1	0	0	0	1	NS	0	0	1	0	NS	0	0
Gannet	0	0	13	0	0	0	0	NS	0	0	0	0	NS	0	0
Great-northern diver	0	0	0	0	0	0	0	NS	0	0	0	1	NS	0	0
Manx shearwater	0	0	0	0	0	0	0	NS	0	0	0	0	NS	6	0
Great-crested grebe	0	0	0	0	0	0	2	NS	1	0	0	2	NS	0	0

Table 4-1 Overview of Construction Time-Line and Species Data for the Survey Area (Combined Transects)

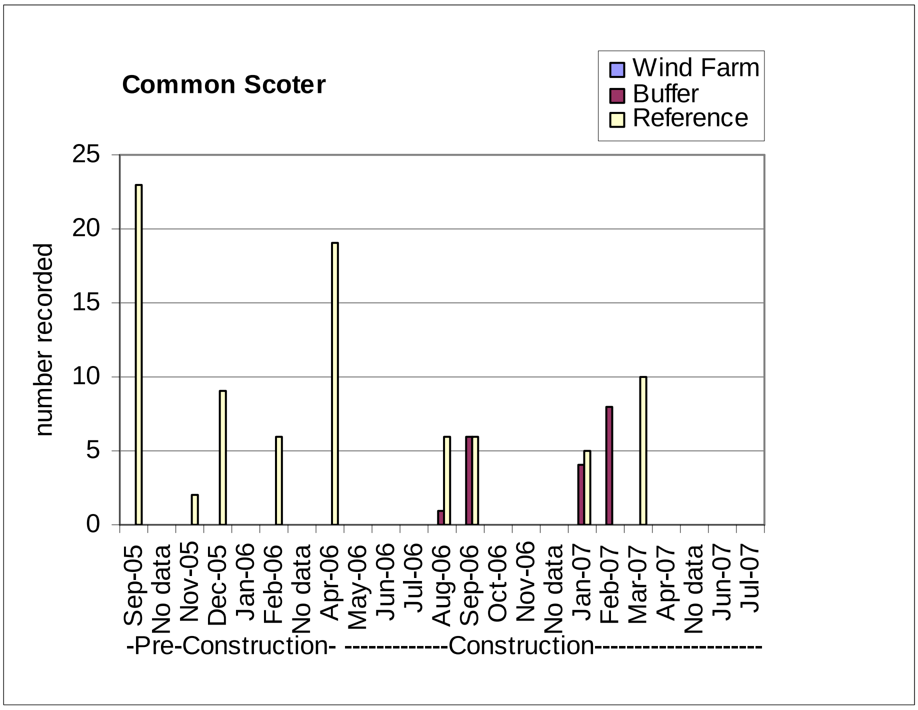
Common Scoter *Melanitta nigra. Conservation Status: listed on Schedule 1 of the Wildlife and Countryside Act 1981 (as amended) and Section 74 of the Countryside Rights of Way Act 2000. The species is a UK Biodiversity Action Plan priority species and is red listed on Birds of Conservation Concern.*

Common scoters were recorded infrequently within the survey area, with a total of eight records, all of which related to small parties (the largest being 10 birds). All records were of birds in flight at heights from 1-5m.

Whilst there was a small reduction in numbers for comparable months in the pre-construction surveys, numbers in both studies were very low and this is not considered to be significant.

This pattern of small parties being recorded in flight only is also consistent with pre-construction surveys, as is their distribution within the survey area (the majority of records being on the seaward end of the transects, see Figure 3). During the construction period no birds were recorded within the wind farm area, four of the recorded eight groups were within the buffer area and four groups were within the reference area. Seven groups of scoter were recorded during the pre-construction surveys, three of which were within the wind farm area.

Given the small numbers and the behaviour of the birds recorded, it again suggests that birds were commuting through the survey area rather than using it as a foraging area.



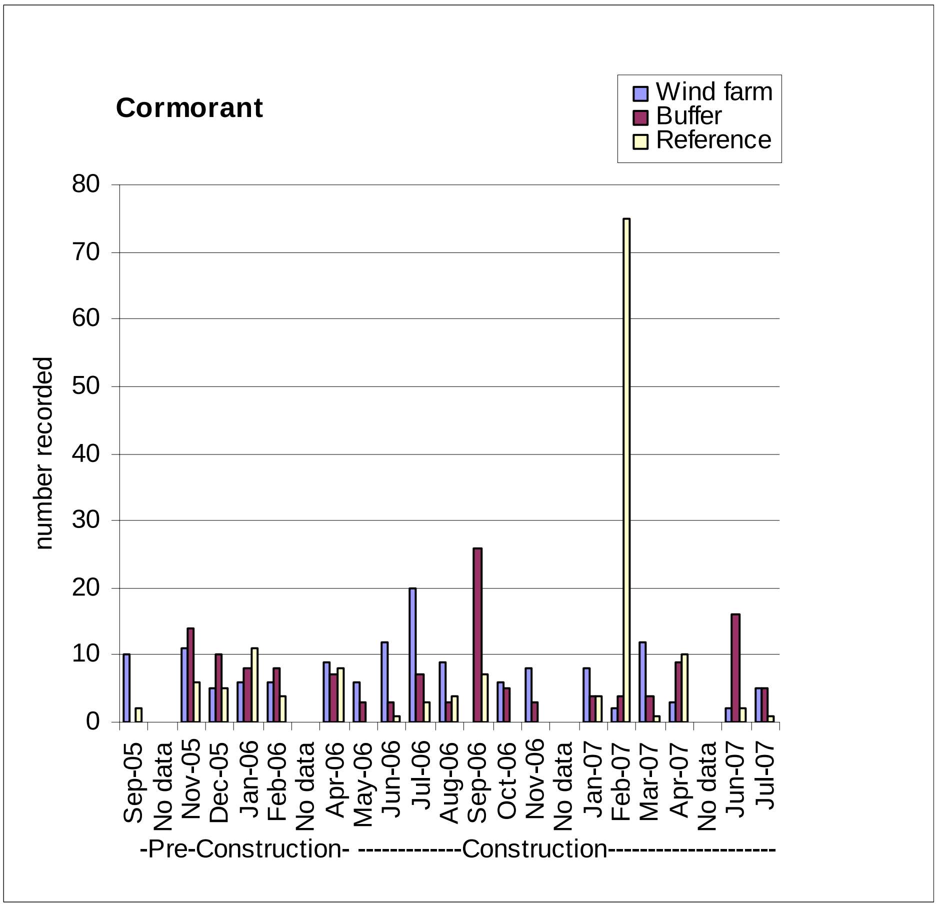
Graph 4-2 Common Scoter Distribution & Abundance

Cormorant *Phalacrocorax carbo. Conservation Status: Amber listed on Birds of Conservation Concern.*

Cormorants were recorded during all survey visits, with the majority of records relating to birds perched on the partially completed turbine towers, on buoys and on exposed sandbars adjacent to the reference area when the tidal state permitted. Many records were of birds in flight with relatively few records of birds on the water (c.7% of records). Birds were often noted commuting into and out of the River Mersey.

Numbers overall were broadly consistent with those recorded during pre-construction surveys, but there was a notable change in distribution. During construction, numbers were generally greatest within the wind farm area as a direct result of the increased roosting opportunities provided by the turbines. A peak count of 76 birds within the reference area in February 2007 relates to birds using an exposed sand bar over the low tide.

The numbers of cormorants recorded during the survey effort are shown in Graph 4-3 and distribution is detailed on Figures 4a and 4b.



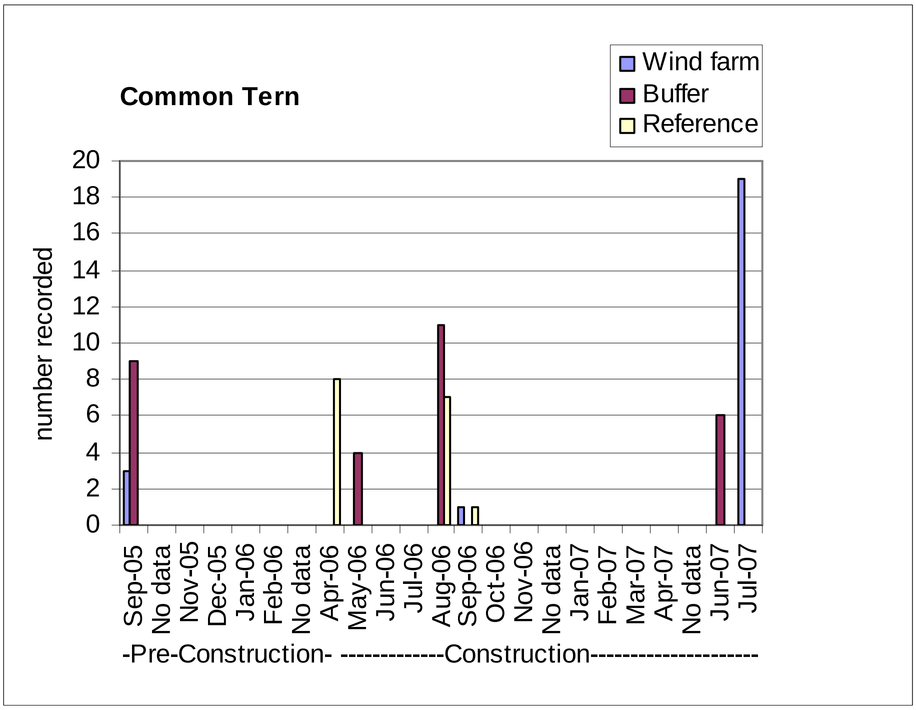
Graph 4-3 Cormorant Distribution & Abundance

Common Tern *Sterna Hirundo. Conservation Status: listed on Annex 1 of the EC Birds Directive.*

Common terns were noted in low numbers across the survey area. A few individuals (highest count of 6 birds together) were recorded in the spring and early summer, but numbers increased in the late summer period (highest count of 19 birds together), presumably as birds dispersed from breeding locations as both adult and juvenile birds were recorded.

Birds were recorded within the wind farm area, buffer area and the reference area in broadly similar numbers, and were also noted feeding around vessels both in and adjacent to the turbines. The numbers of common terns recorded are shown in Graph 4-4. Numbers were again comparable to those of pre-construction surveys, but it should be noted that most of the pre-construction surveys fell outside the period when the species is present (April-September).

The distribution of records is illustrated in Figure 5; there was a clear bias towards the landward end of the transects but no obvious difference between the wind farm area, the buffer area and the reference area.



Graph 4-4 Common Tern Distribution & Abundance

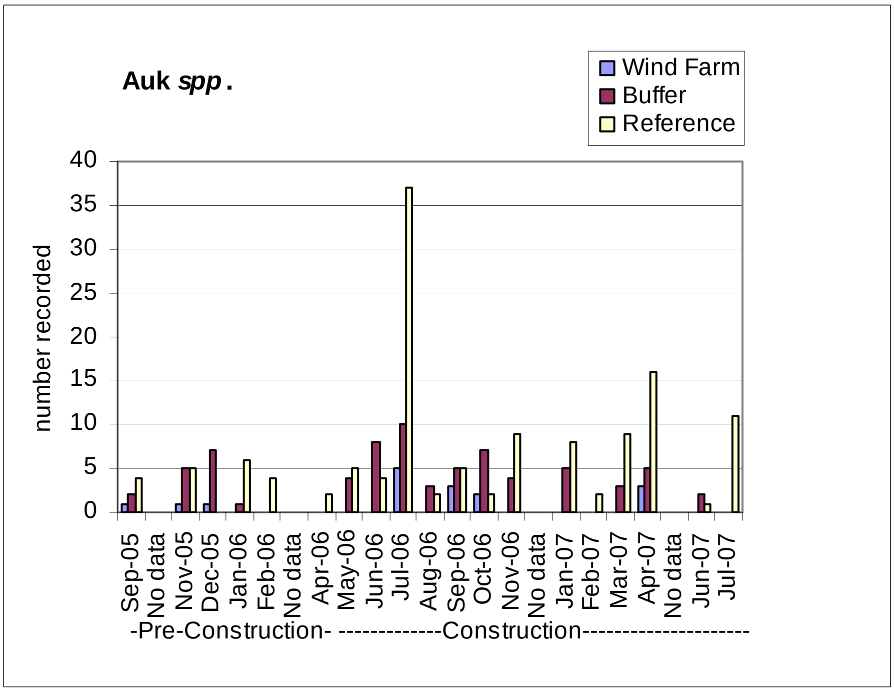
4.3 Other Noteworthy Species

A brief summary of other species which are considered noteworthy either in the context of the Scheme or the importance of the Liverpool Bay area is included as follows;

Auk Species *Alcid spp*.

All identified auk species were guillemots *Uria aalge*. Birds were recorded throughout the year, but with the largest numbers occurring through the late summer (presumably as birds dispersed from breeding locations) and through the winter months. Numbers were higher within the buffer area and reference area and towards the seaward end of the transects, but birds were also regularly recorded within the wind farm area. Overall, numbers recorded were marginally higher during the construction period, but the increase was small and is not considered to be relevant.

The numbers of auk species recorded are shown in Graph 4-5 and distribution is detailed in Figure 6.



Graph 4-5 Auk Species Distribution & Abundance

Wader Species

Wader species recorded during the construction surveys were as follows;

- Turnstone *Arenaria interpres*; 2 birds together in May 2006
- Dunlin *Calidris alpina*; 1 bird in October 2006

- Oystercatcher *Haematopus ostralegus*; 1 bird in October 2006 and 1 bird in February 2007
- Curlew *Numenius arquata*; 4 birds together in June 2007.

Wader species recorded during the pre-construction surveys were as follows;

- Dunlin; four groups (4, 5, 11 and 6 birds) in November 2005
- Knot *Calidris canutus*; one party of 25 birds in November 2005
- Grey Phalarope *Phalaropus fulicaria*; 2 birds together in December 2005.

The numbers of waders recorded both pre and during construction are therefore considered to be so low as to be insignificant in the context of the Scheme and the populations of the nearby SPAs.

4.4 Incidental Observations

Marine mammal records during the construction period are summarised as follows;

- Harbour porpoise *Phocoena phocoena;* single animals recorded on five dates, one of which was recorded within the wind farm area.
- Atlantic grey seal *Halichoerus grypus;* one animal recorded (May 2006) within the reference area.

Figure 7 presents the locations of the above records.

5 Conclusions

It is considered that the observations provide a representative picture of the species and numbers of birds that typically use the survey area, their behaviour and distribution. The low numbers of most bird species recorded within the wind farm area during the construction period is consistent with the pre-construction surveys and may relate to high levels of disturbance created by shipping activity in the area, particularly towards the Liverpool end (eastern side) of the Scheme. In all species, the numbers recorded during the construction period were broadly consistent with those recorded during the pre-construction surveys.

Distribution of records varied between species; cormorants showed a clear preference for areas where perches were available and therefore numbers increased from pre-construction surveys within the wind farm area as the turbine towers were gradually built. It is considered reasonable to assume that the species is not particularly sensitive to disturbance resulting from construction activity. Post-construction monitoring will confirm whether the birds continue to utilise the turbines.

Numbers of common scoter and red-throated divers recorded were low, which suggests that the survey area is likely to be of lower value for these species than other parts of the proposed Liverpool Bay SPA. As both species were recorded almost exclusively in flight, it is considered likely that the majority of records relate to birds commuting across the proposed SPA area to other, preferred foraging grounds to the north or west of the survey area. Records of these species, along with those of auks, did show some distribution bias towards the buffer area and reference area, and particularly the seaward (western) end of the transects, but as results were broadly similar to those of pre-construction surveys, it is not considered possible to attribute this to wind farm related activity, especially given existing disturbance from the adjacent Queen's Channel shipping lane.

Numbers of common terns recorded were also low, with all records in relatively close proximity to the North Wirral foreshore and some birds foraging within the wind farm area during construction. Given that no other terns were recorded (both Sandwich *Sterna sandvicensis* and little terns *S. albifrons* also breed at Gronant, on the Welsh side of the Dee mouth), this would suggest that numbers of terns feeding within the survey area are relatively low, and also that common terns do not appear susceptible to the effects of construction disturbance.

Numbers of waders recorded were also very low. Given the numbers of birds wintering on the nearby estuarine SPAs, it is considered reasonable to assume that wader flights across the wind farm area are infrequent and in relatively low numbers. No evidence of regular commuting across the wind farm area was discovered.

The effects of construction activity on birds are likely to have been limited as only small numbers of birds were recorded, which is consistent with pre-construction surveys. Given these low numbers and the existing levels of disturbance in the area, there is little to suggest that wind farm related displacement has occurred. Overall, it is considered likely that construction of the wind farm has had no significant effect on the favourable conservation status of the bird population in its natural range.

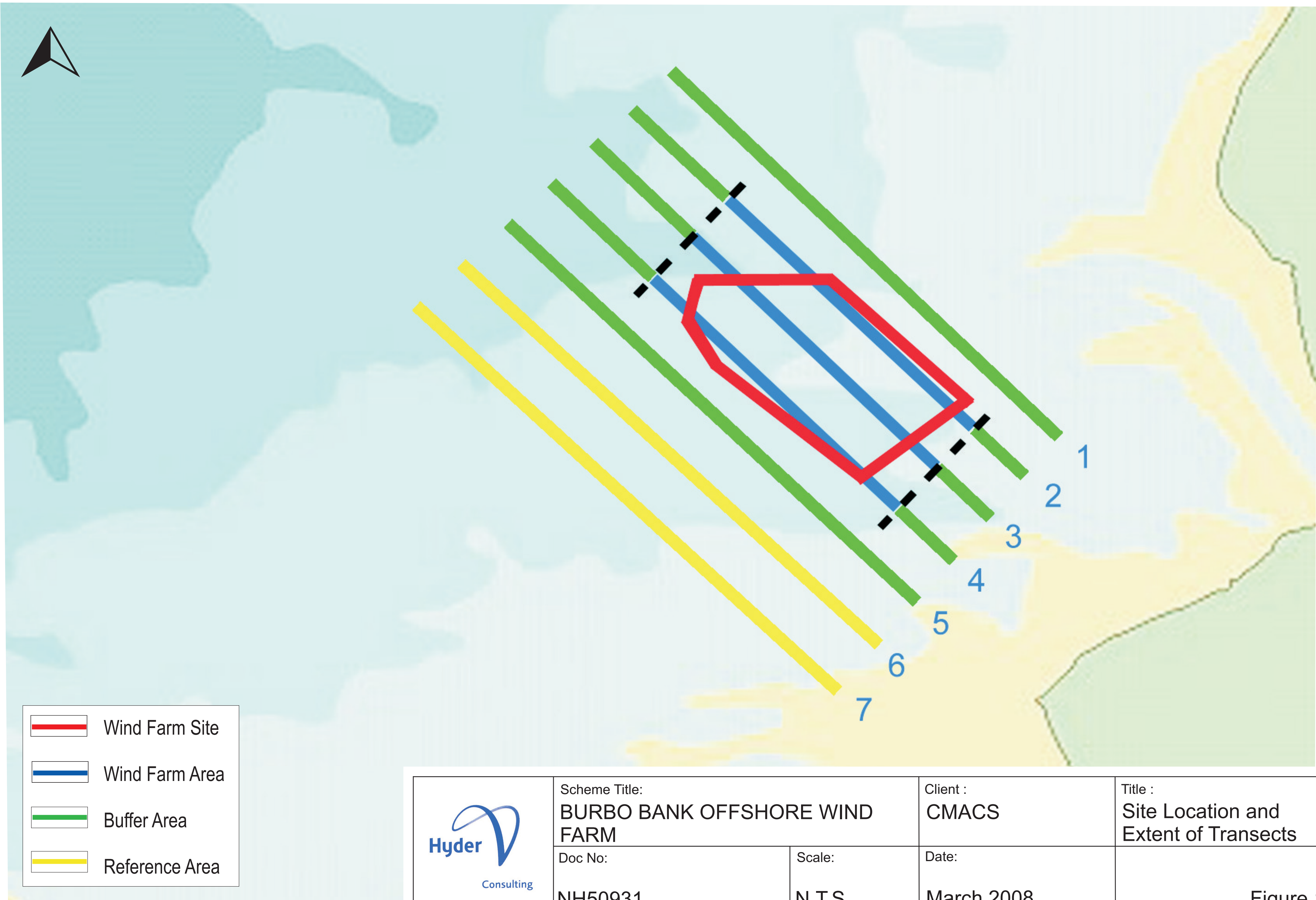
6 References

Camphuysen, Fox, Leopold & Petersen (2004) *Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore windfarms in the UK*. COWRIE Report

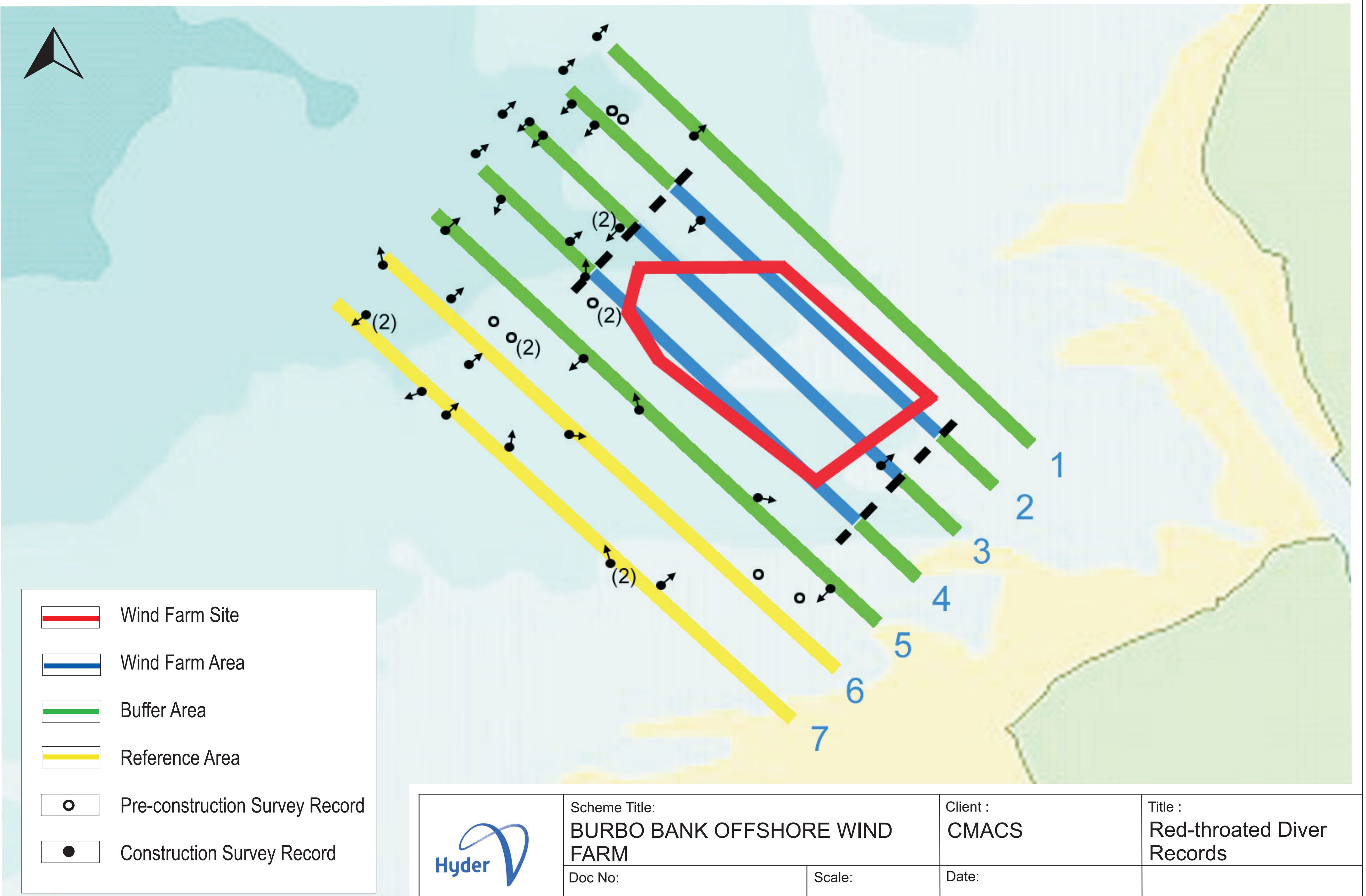
Casella Stanger Ltd (2002) *Burbo Offshore Wind Farm – Ornithology Final Report.* Report 137020102/FO/R1/Rev2. Casella Stanger Ltd

Webb A., McSorley C.A., Dean B.J. and Reid J.B. (2006). *Recommendations for the selection of, and boundary options for, an SPA in Liverpool Bay* Joint Nature Conservation Committee Report, No. 388

Figures

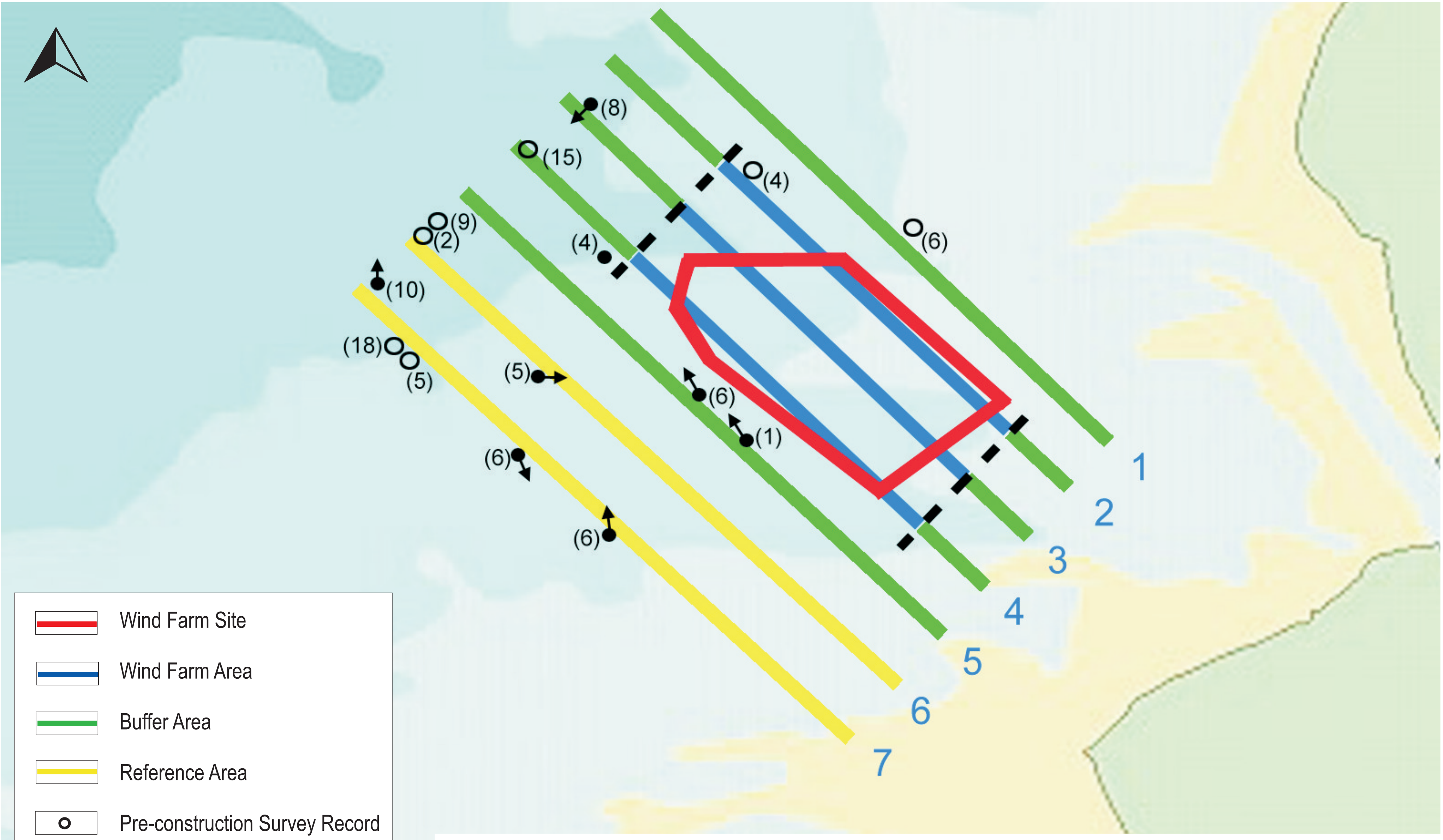


Hyder Consulting	Scheme Title: BURBO BANK OFFSHORE WIND FARM		Client : CMACS	Title : Site Location and Extent of Transects
	Doc No: NH50931	Scale: N.T.S.	Date: March 2008	Figure 1



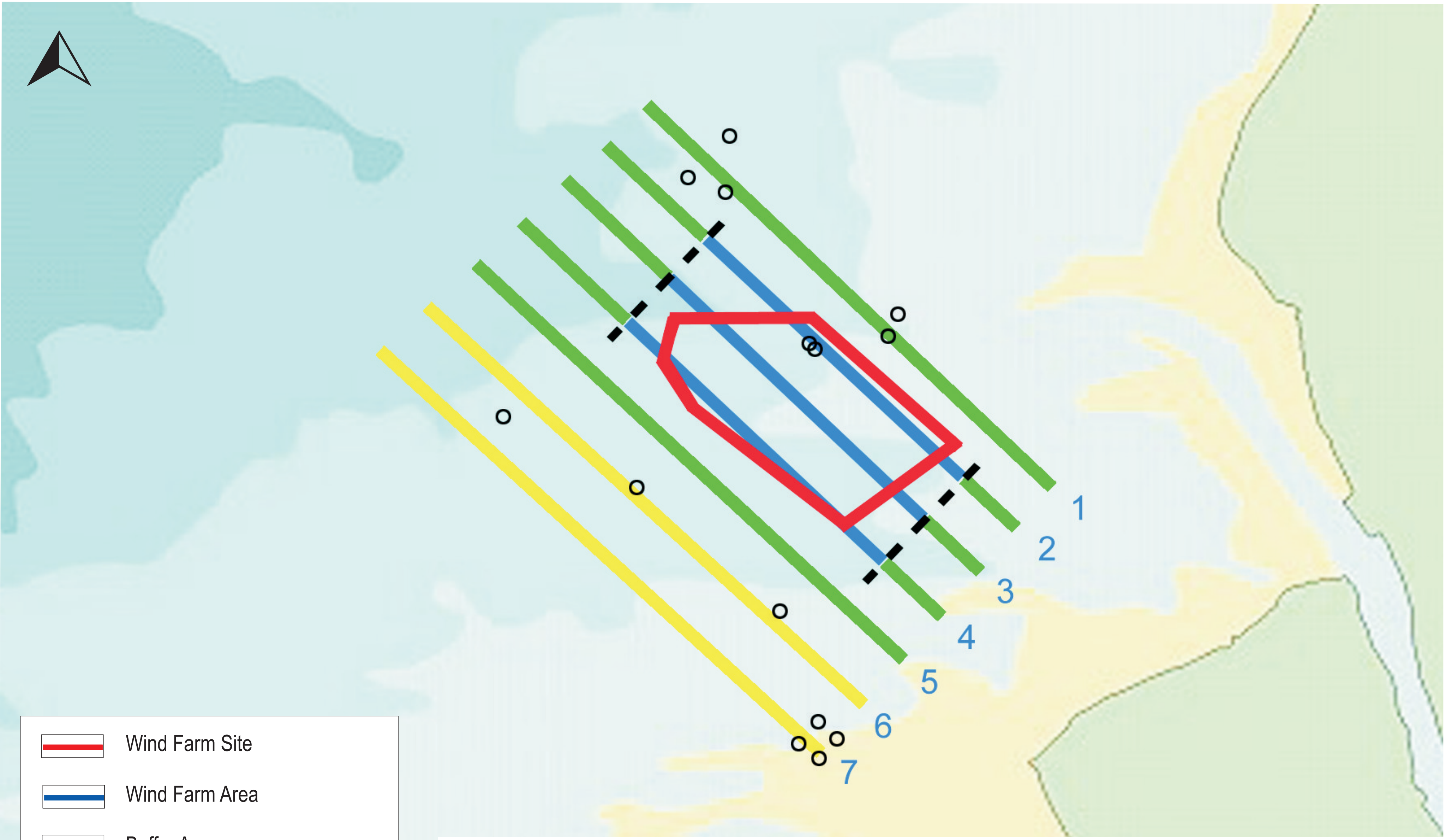
All records are of individual birds unless (n) given

Hyder Consulting	Scheme Title: BURBO BANK OFFSHORE WIND FARM		Client : CMACS	Title : Red-throated Diver Records
	Doc No: NH50931	Scale: N.T.S.	Date: March 2008	Figure 2



All records are of small flocks; number of individuals is given in brackets (n)

Hyder Consulting	Scheme Title: BURBO BANK OFFSHORE WIND FARM		Client : CMACS	Title : Common Scoter Records
	Doc No: NH50931	Scale: N.T.S.	Date: March 2008	Figure 3



Hyder Consulting

Scheme Title: BURBO BANK OFFSHORE WIND FARM

Client : CMACS

Title : Cormorant: Pre-construction Survey Records

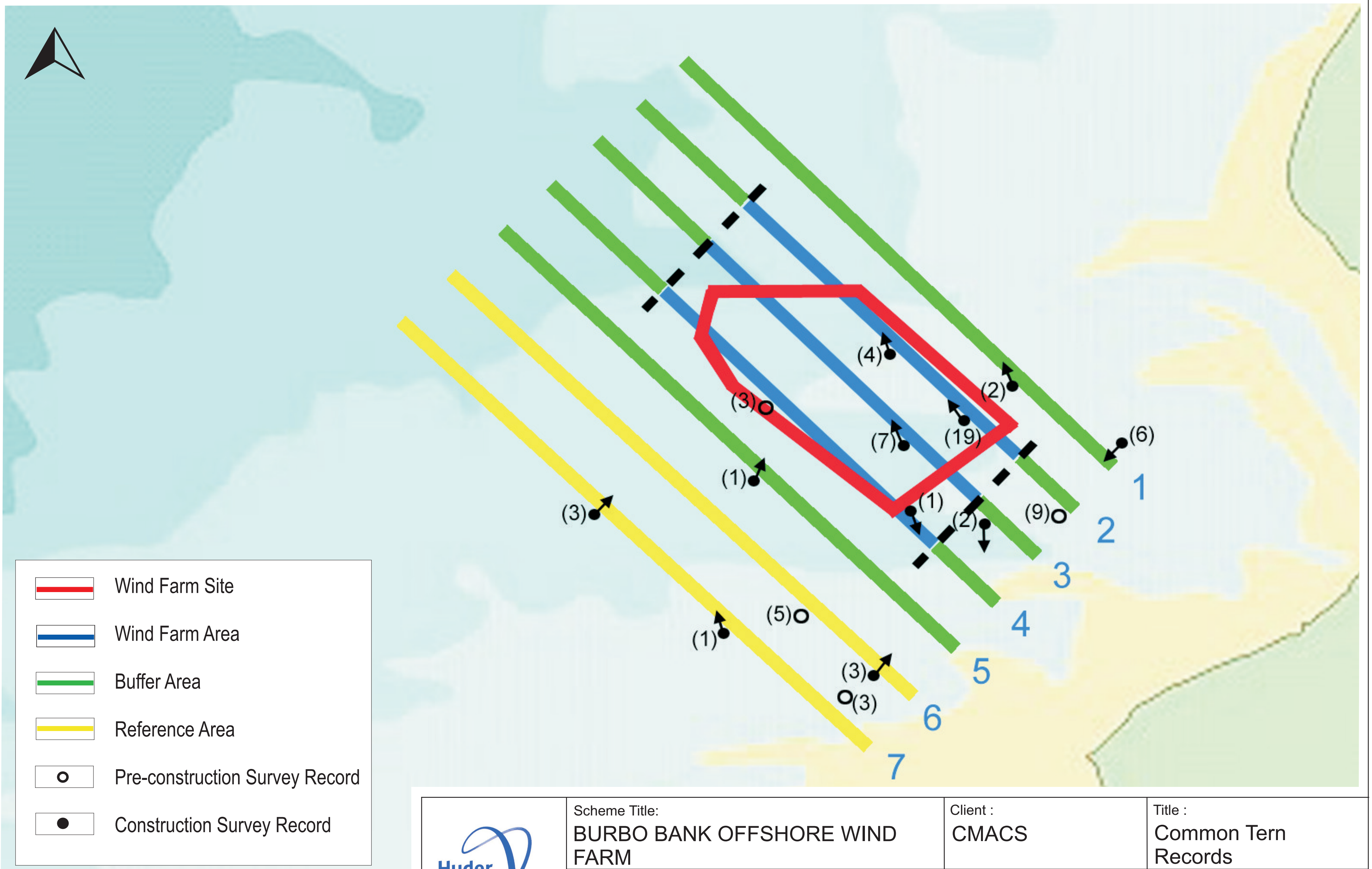
Doc No: NH50931

Scale: N.T.S.

Date: March 2008

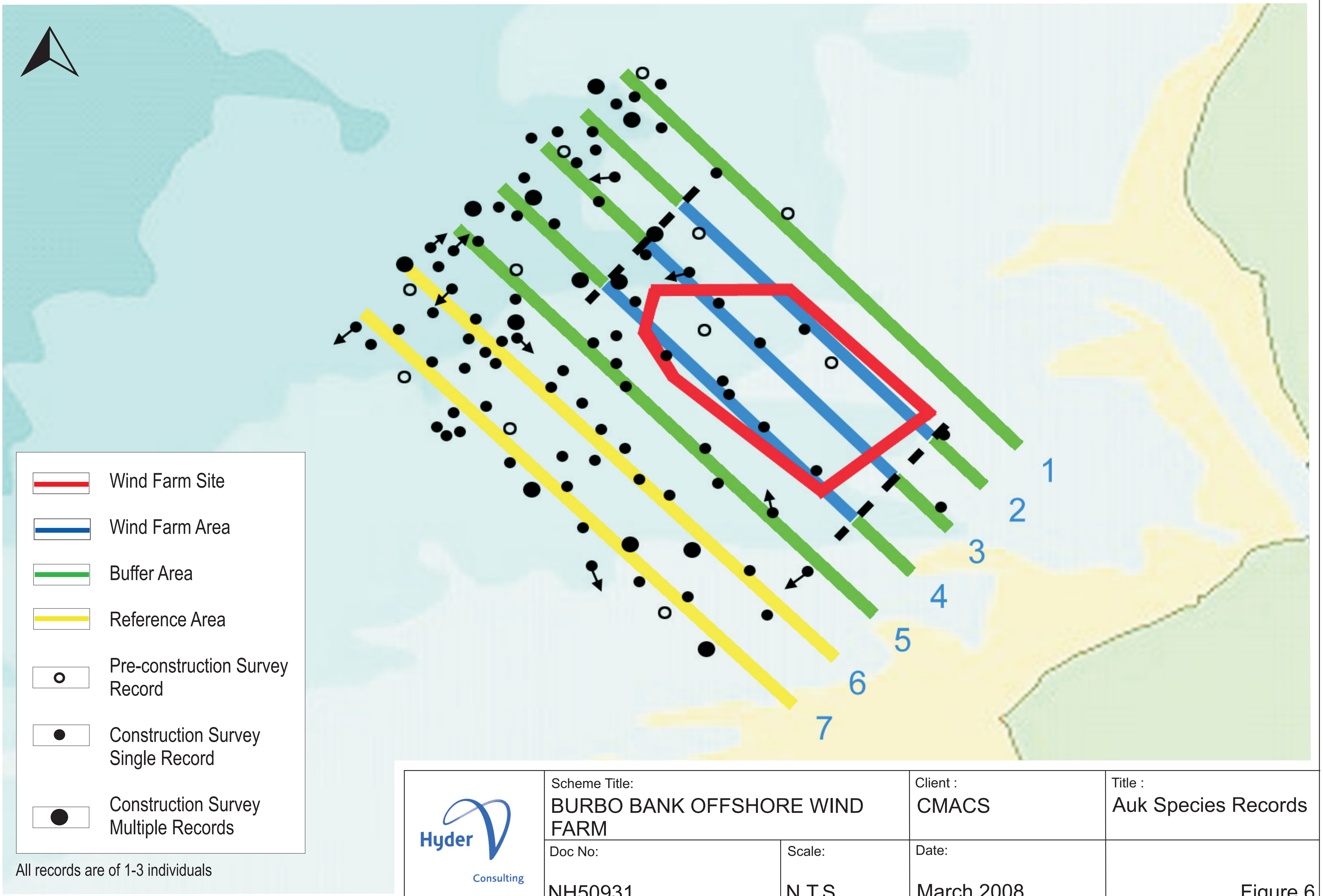
Figure 4a

Hyder Consulting	Scheme Title: BURBO BANK OFFSHORE WIND FARM		Client : CMACS	Title : Cormorant: Construction Survey Records
	Doc No: NH50931	Scale: N.T.S.	Date: March 2008	Figure 4b

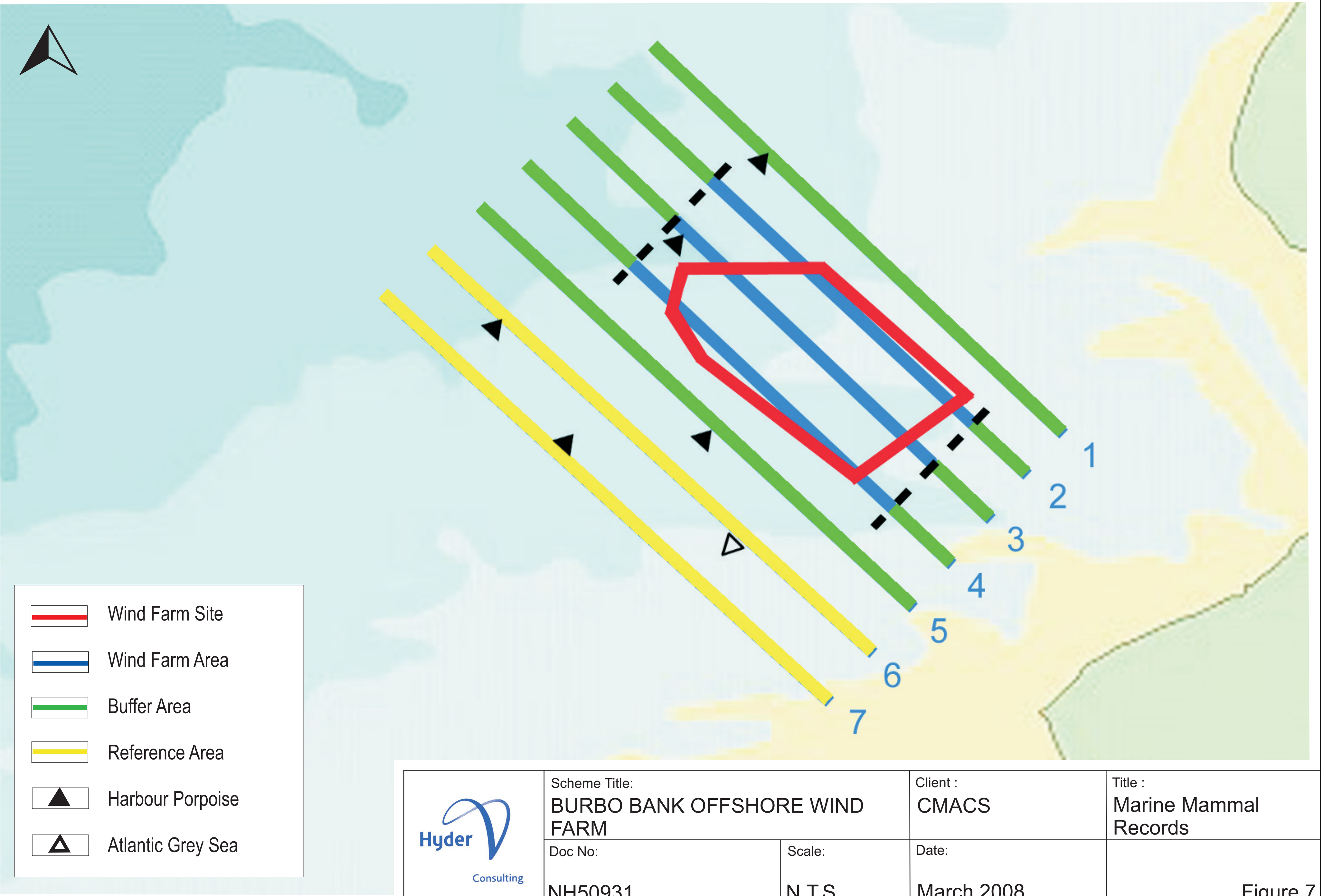


All records are of small flocks; the number of individuals is given in brackets (n)

Hyder Consulting	Scheme Title: BURBO BANK OFFSHORE WIND FARM		Client : CMACS	Title : Common Tern Records
	Doc No: NH50931	Scale: N.T.S.	Date: March 2008	Figure 5



Hyder Consulting	Scheme Title: BURBO BANK OFFSHORE WIND FARM		Client : CMACS	Title : Auk Species Records
	Doc No: NH50931	Scale: N.T.S.	Date: March 2008	Figure 6



Hyder Consulting	Scheme Title: BURBO BANK OFFSHORE WIND FARM		Client : CMACS	Title : Marine Mammal Records
	Doc No: NH50931	Scale: N.T.S.	Date: March 2008	Figure 7

Appendix A

Ornithological Survey Data by Transect

BTO Species Identification Codes

CA	Cormorant	*Phalacrocorax carbo*
RH	Red-Throated Diver	*Gavia stellata*
CX	Common Scoter	*Melanitta nigra*
CN	Common Tern	*Sterna hirundo*
Auk	Auk species	*Alcid spp.*
Wader	Wader species	*Charadriiform spp.*
KI	Kittiwake	*Larus tridactyla*
MU	Mediterranean Gull	*Larus melanocephalus*
LU	Little Gull	*Larus marinus*
ND	Great northern diver	*Gavia immer*
GG	Great-crested grebe	*Podiceps cristatus*
GX	Gannet	*Morus bassanus*
MX	Max Shearwater	*Puffinus puffinus*

16.05.06. Survey time 06.05hrs – 08.13hrs Conditions: Incoming tide (high water 11.21hrs/9.5m), sea state 2-3.							
Species	T1	T2	T3	T4	T5	T6	T7
CA		3	3			1	2
RH	1	2					
CN		2			1		1
Auk		3		3		3	
KI		1			1	1	1
Grey Seal			1				

09.06.06. Survey time 11.35 – 13.36hrs Conditions: Decreasing tide (high water 10.16hrs/7.9m), sea state 2-3.							
Species	T1	T2	T3	T4	T5	T6	T7
CA	3	1	9	2	1		
Auk	1				6	2	3
KI						1	
MU		1					

13.07.06. Survey time 08.27 – 10.34hrs Conditions: Incoming tide (low water 08.27hrs/0.9m), sea state data not available.							
Species	T1	T2	T3	T4	T5	T6	T7
CA		2			1	2	24
Auk	12	4		1	3	6	24
KI				10			
MU		1					
GX	1	3	4	2	3		
Harbour Porpoise					1		

15.08.06. Survey time 11.35 – 13.36hrs Conditions: Incoming tide (low water 10.37/1.5m), sea state 4.							
Species	T1	T2	T3	T4	T5	T6	T7
CA	3	1	3	6			
RH			2	1			
CN		9		2	5	2	
CX	6					1	
Auk				2	2	2	
KI						1	

26.09.06. survey time 14.26 – 16.26hrs Conditions: Decreasing tide (high water 13.56hrs/8.6m), sea state 4-5.							
Species	T1	T2	T3	T4	T5	T6	T7
CA	2	23	1	2	2		3
CN		1					1
CX						6	6
Auk	1	5		8	1		
KI			2	1			
LU		1					

13.10.06. Survey time 14.16-16.48hrs Conditions: decreasing tide (high water 15.10hrs/7.7m), sea state 4-5.							
Species	T1	T2	T3	T4	T5	T6	T7
CA		7	3	1			
RH		2			1		1
Auk						8	3
Wader		1			1		
Harbour Porpoise					1		

07.11.06. Survey time 11.35 – 13.36hrs Conditions: Around high water (11.49hrs/9.5m), sea state 5.							
Species	T1	T2	T3	T4	T5	T6	T7
CA		7	3	1			
RH			2				1
Auk		1			6	3	3
KI						1	
MU				1			
GG	2						

16.01.07. Survey time 11.35 – 13.36hrs Conditions: Increasing tide (Low water 10.39hrs/2.3m). Sea state data not available.							
Species	T1	T2	T3	T4	T5	T6	T7
CA	5	1	7	2		1	
RH	1		2	1	3		
Auk		1			6	3	3
CX	5	4					
KI						1	
GG			1				

23.02.07. Survey time 07.30-09.29

Conditions: Decreasing tide (low water 09.24hrs/1.5m), sea state 3-4.

Species	T1	T2	T3	T4	T5	T6	T7
CA		1	3				c.75
RH							1
Auk						1	
Wader					1		
CX		8					

28.03.07. Survey time 10.41 – 12.42hrs

Conditions: High water 08.09hrs/7.0m – low water 15.25hrs/2.8m, sea state 2-3.

Species	T1	T2	T3	T4	T5	T6	T7
CA		1	12	3		1	
RH		2				1	
Auk					6	4	2
KI						1	
CX							10
MU				1			
Harbour Porpoise			1				

25.04.07. Survey time 11.00 – 12.55hrs

Conditions: Incoming tide (high water 12.36hrs/9.1m), sea state 3-4.

Species	T1	T2	T3	T4	T5	T6	T7
CA	2		7	5		2	6
RH						4	5
Auk	2	5		7		8	2
ND					1		
GG	2						

12.06.07. Survey time 07.34 – 09.32hrs Conditions: Incoming tide (high water 09.08hrs/8.5m), sea state 3.							
Species	T1	T2	T3	T4	T5	T6	T7
CA		8	1	5		3	1
CN	6						
Auk sp	1			2			
KI		1					2
MX			4	2			

18.07.07. Survey time 07.34 – 09.32hrs Conditions: Decreasing tide (low water 10.17hrs/2.5m), sea state 2-3.							
Species	T1	T2	T3	T4	T5	T6	T7
CA	1	3	6			1	
CN		19					
Auk	8	1			2	2	
Wader				4			
LU		1				7	
Harbour Porpoise		1					

All tide time and height data from Gladstone Dock, Liverpool, and times have been adjusted for daylight saving where appropriate.