Kentish Flats Offshore Wind Farm

FEPA Monitoring Summary Report

August 2007 (Final)

This monitoring summary report has been prepared by Kentish Flats Ltd as part of the FEPA monitoring program for the Kentish Flats Offshore Wind Farm. This report describes the environmental monitoring completed over the period 2004 to 2007 and covering the pre, during and post-construction periods (and the first 18 months of operation) and in line with the requirements of the Kentish Flats FEPA licence.

Individual technical surveys and studies form the basis for this monitoring summary report. Full copies of the technical reports may be obtained on request from:

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This report has been prepared on behalf of Kentish Flats Ltd & Vattenfall A/S by Offshore Environmental Solutions Ltd based on reports and technical studies produced by a team of technical experts and consultants.

More information on the Kentish Flats Offshore Wind Farm is available from the project website:
www.kentishflats.co.uk

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Executive Summary

The Kentish Flats Offshore Wind Farm is located in the Thames Estuary, some 8 to 10km off the North Kent Coast, north of Herne Bay & Whitstable. The main export cables come ashore at Hampton Pier, Herne Bay and run 2.5km inland to an existing substation where connection to the National Grid distribution network is made.

Construction of the Kentish Flats wind farm commenced in August 2004 and was completed at the end of August 2005. The wind farm became operational in September 2005 since when it has been generating electricity.

Environmental monitoring surveys have been carried out in and around the Kentish Flats Offshore Wind Farm site during the pre, during and post-construction phases as required by the licence issued under the Food and Environmental Protection Act (FEPA). This document describes the results of the monitoring completed to date. The monitoring activities, as defined in the FEPA licence, are due to come to a close at the end of 2007 (a three year program following installation of the main foundations).

The following paragraphs provide a brief overview of the key findings of each of the main monitoring studies completed to date at the Kentish Flats site.

Surveys of the wind farm site and export cable route for construction debris were completed using bathymetric and side scan sonar techniques before and after the main construction phase. Comparison of the two data sets identified 10 targets considered to be potential construction debris. Divers were deployed at each of these sites and confirmed that no debris was present within the area. The debris surveys have satisfactorily confirmed that there will no adverse effect on other sea-users arising from debris following completion of the construction phase.

Scour surveys have been conducted on a 6-monthly basis around four of the Kentish Flats turbines and inter-turbine cable routes since installation of the foundations. Scour has been consistent at a maximum depth of 2.3 metres and with a diameter around the foundations of 5 to 10 metres (with only slight seasonal variation). The surveys also identified depressions in the seabed resulting from the use of jack-up construction vessels. Subsequent surveys have confirmed that these depressions are infilling naturally. No gross changes in bathymetry across the wider area have been identified. The results of the scour surveys have confirmed that the observed scour is substantially less than that predicted by the Kentish Flats EIA.

Suspended Solids monitoring was conducted during the installation of the main export cables which crossed a shellfish production area (the Whitstable oyster beds). The levels of suspended solids were compared to data from a far-field reference site. Slight increases in suspended solids levels were recorded during cable installation but at all times these levels remained well within the agreed threshold levels and no further mitigation was therefore applied. The monitoring confirmed the predictions made by the Kentish Flats EIA that any increases in suspended sediment levels would be of low significance but acted as an important check on effects within the shellfish production area.

Ornithological monitoring has been conducted before, during and since the main construction phase with data collected from the wind farm and a reference area during monthly boat-based surveys, alongside aerial surveys of the wider Thames area. The results have been interpreted in relation to the five key objectives set out by the FEPA licence. In relation to bird distribution and behaviour, there has been an apparent decrease in the use of the wind farm area by divers during the initial operational phase. However, this observation must be treated with caution since the observation is based on only a single year of data, is not statistically significant, and is not apparent from analysis of the aerial monitoring data. It is also noted that diver numbers have fluctuated seasonally and inter-annually throughout the monitoring program and that the Kentish Flats is of relatively low importance for divers compared with other parts of the Thames estuary. There has been little other significant change in bird use or passage through the Kentish Flats area during the monitoring period too date. In relation to flight line disturbance, the passage of common terns to the south of wind farm has been subject to some deviation although this behaviour continues (as predicted by the Kentish Flats EIA). A general westerly migration of geese through the Thames estuary is also noted and where these occur close to the wind farm some displacement may occur although some geese have also been recorded flying through the wind farm. In relation to the flightlines or behaviour of SPA species, no significant effects have been recorded (noting the comments on divers above). Collision

risk for SPA species remains very low due to the low numbers of birds recorded and the generally low flight heights. Mitigation employed during construction (avoidance of piling during the main diver season) was successfully applied. The monitoring to date has generally confirmed the predictions made by the Kentish Flats EIA. The apparent avoidance of divers during the initial operational phase was not predicted and it is recommended that the final year of monitoring during the operational phase is reviewed in relation to this species.

The benthic invertebrate fauna within the wind farm and along the export cable route has been sampled before and after the main construction period and on an annual basis. The monitoring has recorded only natural variations in the seabed habitats and associated invertebrate communities. No evidence of change attributable to the construction of the Kentish Flats has been recorded (away from the very small area affected by scour). The findings of the monitoring program have confirmed the predictions made by the Kentish Flats EIA.

The intertidal habitats at the export cable landfall (at Hampton Pier, Herne Bay) were surveyed prior to construction as a baseline against which to measure post-construction effects in the event of the trenching of cables. However, cables were directionally-drilled underneath the beach area so that no significant disturbance of the intertidal area occurred. Post-cable installation surveys were not, therefore, considered necessary.

Measurement of the levels of a range of contaminants in the flesh of oysters was completed before and after the installation of the export cables to ensure that no adverse effects on the quality of shellfish within the designated production areas occurred. Oysters were collected from sites along the cable route and from a far-field reference site. Oyster flesh was removed and analysed by CEFAS laboratories. Only natural variations in contaminant levels were identified by the monitoring with no changes attributable to the construction works. The monitoring has, however, acted as an appropriate safeguard against any adverse effects on public health, as well as confirming the predictions made by the Kentish Flats EIA.

Seasonal trawl surveys for fish have been completed during the pre and post construction periods. The surveys, conducted using trawls used by the local commercial fishing industry, have been conducted within the wind farm area and at an appropriate reference site. Catch Per Unit Effort (CPUE) has been calculated for each survey and the results have been compared. CPUE tended to be higher in the wind farm area than at the reference site for most species. Some fluctuation in catch levels was apparent but this was attributable to natural variation. No effect arising from the construction of the wind farm was apparent. The monitoring has confirmed the predictions made by the Kentish Flats EIA.

Operational underwater noise measurements have been completed at the Kentish Flats wind farm as part of a COWRIE research project. The data was collected in May 2007 and is due to be reported later in 2007. Data for the Kentish Flats will be reported separately as part of the next monitoring summary report.

The faunal colonisation of the subsea structures has been recorded using underwater diver and video observations at a representative number of foundations during the summer of 2007. The data is currently being analysed and will be reported as part of the next monitoring summary report.

In summary, it can be concluded that the environmental monitoring completed to date at the Kentish Flats offshore wind farm has generally revealed only limited environmental impact arising from the construction phase in line with the predictions made in the Kentish Flats EIA. The apparent avoidance of the operational wind farm by divers will be reviewed in the next monitoring report and will consider the final year of monitoring data.

1. Introduction

The Kentish Flats Offshore Wind Farm is located some 8 to 10km off the North Kent coast, within the Thames Estuary (see Figure 1). The project is composed of 30 turbines within an area of seabed of 10km^2, mounted on monopile foundations. The turbines are connected together and to the shore by buried cables which transmit the electricity generated to an existing substation installation at Herne Bay where it joins the existing distribution grid.

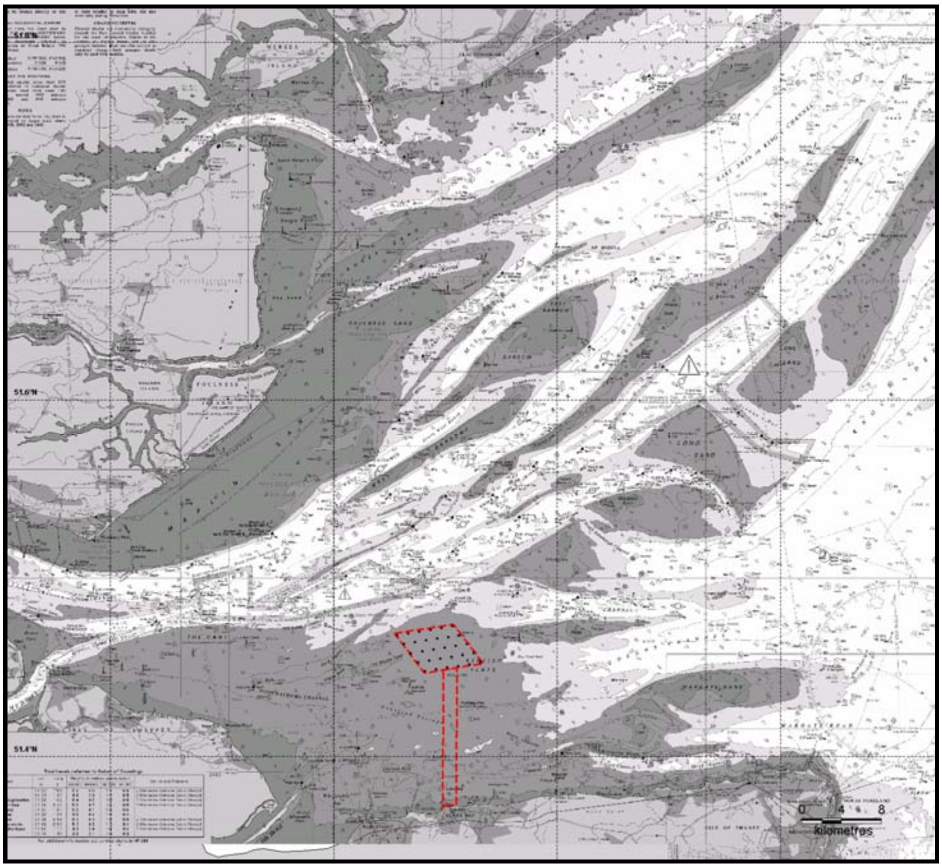


Figure 1 Location of the Kentish Flats Wind Farm within the Thames Estuary

Construction of the wind farm occurred during 2004 and 2005, with the wind farm entering the operational phase in September 2005 since when it has been generating electricity.

This report provides a summary of the environmental monitoring completed at the Kentish Flats Offshore Wind Farm before, during and after the construction phase and during the first 18 months of operation, in accordance with the requirements of the Food & Environmental Protection Act (FEPA) Licence No. 31780/05/1. The monitoring detailed in this report makes reference to the various conditions of the FEPA licence, based on the most recently amended version dated 22nd February 2005 (a copy of the most recent licence is available to download from www.mceu.gov.uk).

This report includes an overview of the construction of the Kentish Flats Offshore Wind Farm with a focus on those aspects of most relevance to the FEPA conditions (i.e. the offshore components). The report then goes on to provide a summary of the monitoring undertaken at the site to date and in relation to the following:

- Surveys for construction debris
- Scour surveys
- Suspended Solids monitoring
- Ornithological monitoring
- Benthic ecology monitoring
- Intertidal ecology survey
- Oyster surveys
- Fish surveys
- Operational underwater noise measurements
- Monitoring colonisation of the underwater structures

In each case, the results of the individual studies are integrated as appropriate in order to compare related environmental parameters (e.g. bird studies consider the results of the fish monitoring, benthic surveys include consideration of the results of the scour monitoring etc).

In addition, reference to the original predictions of the Environmental Impact Assessment (EIA) (GREP, 2002) is made, with reference to the main purpose of the monitoring studies and where appropriate recommendations are made in relation to the monitoring program at Kentish Flats.

2. Construction of the Kentish Flats Offshore Wind Farm

2.1. Introduction

The following sections describe the offshore and onshore construction of the Kentish Flats Offshore Wind Farm.

Construction of the project spanned the period summer 2004 to autumn 2005, including installation of the main offshore and onshore components, testing and commissioning (see Figure 2).

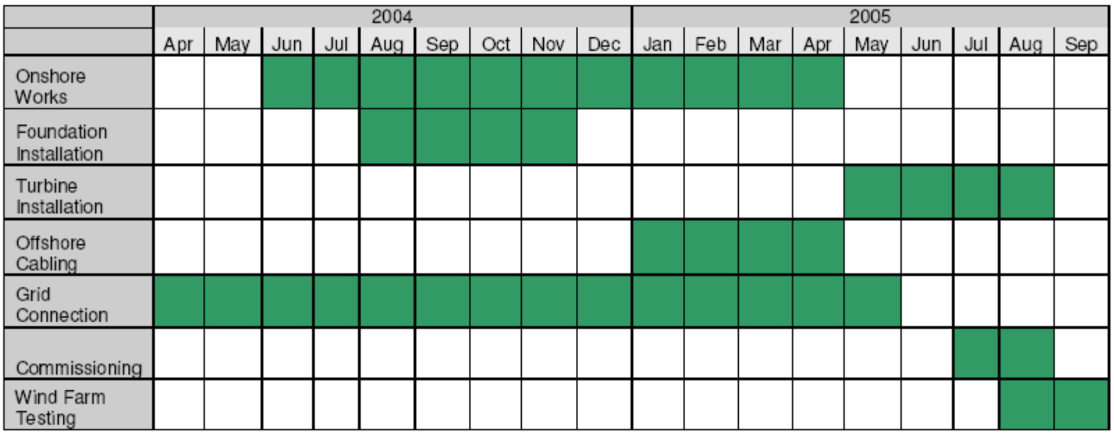


Figure 2 Kentish Flats Offshore Wind Farm Construction Program

The following sections provide an overview of the principle offshore and onshore construction activities together with an overview of the operation of the wind farm.

2.2. Main Construction Activities

The main offshore construction works included the following main components:

- Installation of 30 monopile foundations
- Installation of tower transition pieces
- Installation of 30 turbine towers and wind generators
- Installation and burial of connecting inter-turbine and export cables to landfall (with onshore cabling to an onshore substation connection)

2.2.1. <u>Monopile Foundation Installation</u>

The monopile foundations provide the support for each of the 30 turbines and consist of a welded steel tube of between 38 and 44 metres and 4.3m diameter. The steel tubes were piled into the seabed with penetration into the seabed of between 28 and 34 metres (depending on the nature of the geology at each turbine location).

Figure 3 Piling of a monopile using the jack up vessel MV Resolution

Piles were driven into the seabed by pile-driving using a hydraulic hammer (see Figure 3 and Figure 4). Piles are first upended to the vertical position and held by a pile ”gripper” before being driven into the seabed by the pile hammer.

Piling times for each of the foundations installed at Kentish Flats were between 1 and 2 hours. Piling operations were completed in November 2004.

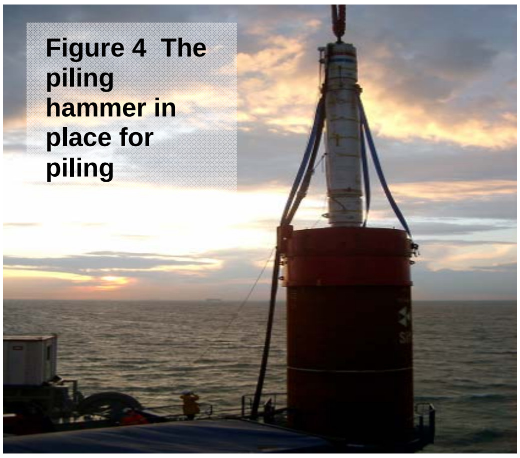


Figure 4 The piling hammer in place for piling

The vessel used for the foundation installation is the specialist offshore wind farm installation vessel the MV Resolution. The Resolution collected the foundations from the fabrication yard in Belgium, making 5 trips and carrying six sets of foundations on each trip. The Resolution then jacked itself up on its six jack-up legs at each of the turbine locations in order to complete the foundation installation process (see Figure 3).

2.2.2. The Transition Piece

Following the completion of the piling operations a transition piece was mounted onto the top of each of the monopiles (see Figure 5). This steel structure was grouted to the monopile using specialist cement adhesive and provided for levelling as well as having necessary equipment such as boarding ladders, cathodic protection, cable ducts for the submarine cables and appropriate navigational lighting. The transition piece thereby provided for safe access to the foundation for the turbine installation as well as during the operational phase.

Figure 5 Transition piece mounted on monopile

2.2.3. Turbine Tower & Generator Installation

Figure 6 Nacelles in bunny ears configuration

Pre-assembly of the wind turbine components was completed at the nearby Port of Felixstowe on the Suffolk coast. Components were transported to Felixstowe from the various fabrication plants around Europe and included tower sections, nacelles, hubs, blades, cables etc. Pre-assembly involved the preparation of the tower sections including fitting of cables, switchgear, ground controller and man-lift installation. The turbine nacelle was also prepared and two of the turbine blades attached (the "bunny-ears" configuration) ready for transport (see Figure 6). All of the components for two complete turbine installations were subsequently loaded onto the specialist installation vessel, the MV Sea Energy (see Figure 7).


Figure 7 MV Sea Energy Loaded with Turbine Components leaving Felixstowe

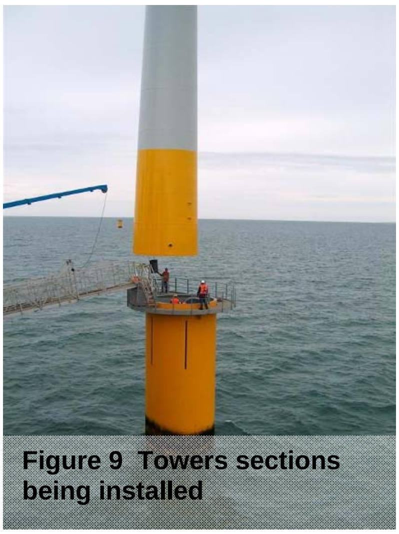


Figure 9 Towers sections being installed

For each turbine installation, three lifts were completed in order to install each of the Vestas V90 3MW turbines.


Figure 8 Nacelle being lifted into place

Firstly, the tower sections were lifted into place and bolted onto the transition piece. Secondly, the nacelle (with bunny ears) was lifted and bolted onto the top of the tower section. Finally, the third blade was lifted and bolted onto the nacelle rotor hub.

On average, the installation of each turbine required about 24 hours, including loading, transport from Felixstowe (6 to 8 hours), positioning and the three lifts. Installation continued around the clock with no limitation on tidal access to the site.

Following the installation of the main turbine components, engineers were then transported to each turbine by small vessel from the local port of Whitstable and began the commissioning process which lasted on average 2 days per turbine.

2.2.4. Offshore Cable Installation

The Kentish Flats turbines are inter-connected by buried inter-turbine cabling. The 30 turbines were connected in three blocks of ten, daisy-chain style; each block of ten is then connected to one of the three export cable. These cables were surface laid, and then buried using a subsea remotely operated vehicle (ROV) which used water jetting technology (see Figure 10).

Figure 10 ROV Used for Inter-turbine cable burial (courtesy Global Marine Systems)

Figure 11 Cable installed in foundation piece prior to turbine installation

In most cases target burial of >1 metres was achieved, except adjacent to each turbine where the cables approach the surface of the seabed before being fed through the J-tube on the foundation. Cables were then pulled through the J-tube and jointed to the cabling within the tower sections (once installed). Cables were tested following the installation process and in each case cable installation was completed prior to installation of the turbines.

From the turbine array, three main export cables were laid southwards to the cable landfall point at Hampton Pier, Herne Bay, a distance of 8 – 10km. Each of these three export cables were installed using a cable plough (see Figure 12). The cable plough used at Kentish Flats weighed 22 tons. Installation was achieved using a specialist cable installation barge. Burial of the export cables achieved the target burial depth of at least 1 metre.

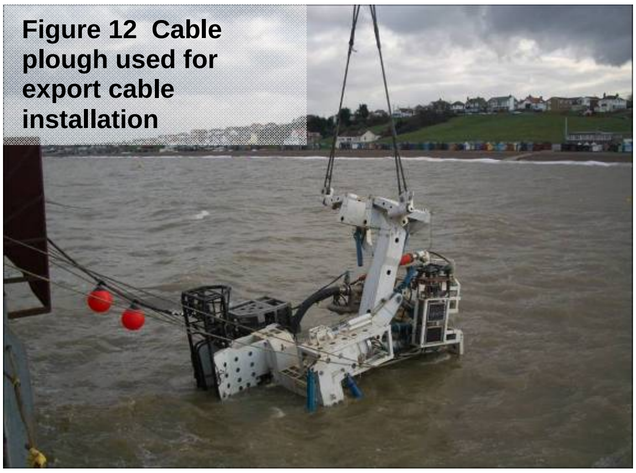


Figure 12 Cable plough used for export cable installation

The offshore cables at Kentish Flats are operated at 33kV and hold not only the three main phases for high-voltage transmission of power from the generators, but also vital optical fibre cables for remote communication with the turbines.

2.2.5. <u>Onshore Cable Installation</u>

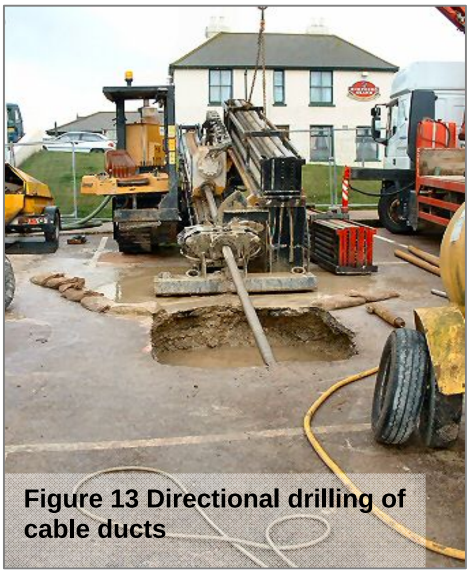


Figure 13 Directional drilling of cable ducts

Directional drilling was used to install cable ducts below the coastal defences at Hampton Pier, Herne Bay, the drilling emerging in the shallow subtidal area below the beach (see Figure 13). Each of the three cable ducts was 120m in length and each took approximately 24 hours to drill.

The three main export cables were then pulled through these ducts and into the jointing pit which was constructed behind the coastal defence.

Each of the three export cables were then connected to three separate cables which were laid in the ‘trefoil’ configuration (making a total of nine cables running from the jointing pit to the grid connection point).

The cables were installed from the jointing pit along roadways by trenching (see Figure 14) for 2.5km to the existing EDF Energy 132/33kV

Figure 14 Trenching of onshore cables along highways in Herne Bay

substation just south of Herne Bay.

At the existing EDF Energy Herne Bay substation, construction works were completed which extended the existing substation building in order to house the necessary switchgear to connect in the Kentish Flats cables.

2.2.6. Navigational Safety Measures

A number of navigational safety measures were installed on the Kentish Flats turbines in accordance with the requirements of the various consents issued for the project. These include:

- Navigational lighting to a specification agreed with Trinity House installed on eight of the turbines at the height of the boarding platform.

- Fog horns to a specification agreed with Trinity House installed on four of the turbines at the height of the barding platform.

- The turbines are painted a high-visibility yellow colour to just above the height of the boarding platform to improve visibility to surface shipping.

- Red fixed medium intensity aeronautical obstruction lights installed on eight of the turbines at nacelle height to CAA specifications.

Figure 15 Radar installation on Kentish Flats turbine

In addition, under the terms of the River Works Licence issued by the Port of London, a radar has been installed on one of the northern turbines in order to provide appropriate surveillance of shipping using the adjacent main shipping lanes into and out of the Thames (see Figure 15). The radar was installed on a purpose made bracket and radar signals are fed through the fibre optic cabling to the substation where they are transmitted by microwave link to the existing Port of London radar station. The radar data is then integrated into the existing Port of London surveillance system.

In addition, the River Works Licence provides for a direction to shipping which prevents navigation within 50 metres of each of the Kentish Flats turbines (except in emergency or for designated maintenance vessels).

2.2.7. <u>Operation & Maintenance</u>

The Kentish Flats turbines have been operational since September 2005. During the operational phase maintenance of the offshore turbines has been undertaken by Vestas personnel based at the purpose built maintenance facility at Whitstable Harbour. A total of 10 employees are employed full time on the routine maintenance of the turbines. A purpose built maintenance vessel also operates from Whitstable harbour alongside a smaller, fast RIB vessel which is used for crew transfers (see Figure 16).

Figure 16 The Kentish Flats maintenance vessels

Normal, planned maintenance during the operational phase includes:

- 3 months Turbine servicing
- Annual Full Turbine Servicing
- Mandatory HV Equipment Inspections
- Safety Inspections of climbing equipment.
- Lift inspections every 6 month.
- Annual Offshore Safety Rescue exercise in cooperation with Coast Guard
- Annual Inspections of Fire Fighting Equipment

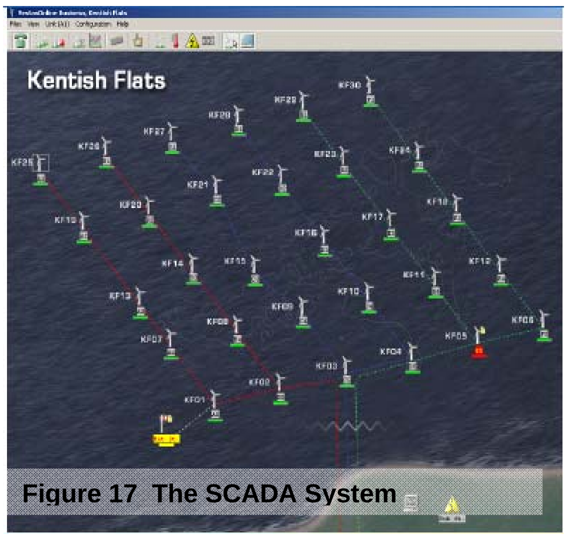


Figure 17 The SCADA System

Routine management and monitoring of the wind farm is achieved through a SCADA (Supervisory Control And Data Acquisition system) system (see Figure 17) which is able to monitor the performance and status of each of the turbines, sending and receiving data through the fibre optic cables. The SCADA system can be accessed remotely through the internet from any location.

In addition to the normal routine maintenance, the first 18 months of operation have also seen the need for some exceptional, unplanned maintenance. This has included, in addition to the normal minor teething troubles, some major works including problems with:

- Main Gearboxes
- Generator bearings
- Generator rotor cable connections from slipring unit
- Pitch system

In particular, the gearbox problem has resulted in the need to replace all 30 gearboxes since the end of 2006. This has resulted in the need to mobilize large plant to site such as jack-up vessels of the type used during the construction phase.

3. Kentish Flats Offshore Wind Farm FEPA Monitoring

3.1. Introduction

The following sections provide an overview of the key findings arising from the environmental monitoring completed at the Kentish Flats Offshore Wind Farm as required by the provision of the FEPA licence conditions. The results of the monitoring conducted to date and during the pre, during and post-construction periods of the development process are summarised, specifically in relation to the following monitoring studies:

- Debris surveys
- Scour surveys
- Suspended Solids monitoring
- Ornithological monitoring
- Benthic ecology monitoring
- Intertidal ecology survey
- Oyster surveys
- Fish surveys
- Operational underwater noise measurements
- Monitoring colonisation of the underwater structures

In addition, the relationship between the different variables subject to monitoring is also explored (e.g. scour effects and benthos; fish monitoring and birds etc) as required by the FEPA licence conditions.

Particular reference if also made to the findings of the original Kentish Flats Environmental Statement (ES) (GREP, 2002) in relation to the predicted environmental effects of the project. It is pertinent in interpreting the results of the FEPA monitoring that many of the monitoring requirements have been put in place specifically to confirm that the predictions made in the ES have accurately described the environmental effects arising from the development.

3.2. Environmental Monitoring Specifications & Timing

Table 1 summarises the environmental monitoring program set out by the FEPA licence for each of the main monitoring studies (greater detail on precise timing and scope of each survey is given under the summary of each of the studies in the following sections).

Monitoring requirement	Pre-construction	During Construction	Post-construction	Current Status
Debris surveys	✓	-	✓	Complete
Scour surveys	✓	-	✓	Continue until end 2007
Turbidity monitoring	✓	✓	-	Complete
Bird Surveys				
Boat surveys	✓	✓	✓	Continue until end 2007
Aerial surveys	✓	✓	✓	Continue until end 2007
Benthic faunal sampling	✓	-	✓	Continue until end 2007
Oyster monitoring surveys	✓	-	✓	Complete
Fish surveys	✓	-	✓	Complete
Subsea operational noise study	-	-	✓	Complete - COWRIE Study
Foundation biological video survey	-	-	✓	Complete - one-off only during 2007

Table 1 Summary of Key FEPA Monitoring Studies During Kentish Flats Offshore Wind Farm Development

All pre-construction monitoring was completed prior to the start of the main offshore construction works which was underway by August 2004. Post-construction monitoring started following the completion of the installation of the main foundation installation works which were completed by November 2004.

The post-construction monitoring schedule varied for each of the studies but for the longest running (birds, scour, benthos) was for a period of 3 years following the end of construction and are therefore due to finish at the end of 2007 (subject to review of the monitoring results by the regulatory authorities).

In all cases, the scope of each of the monitoring studies was agreed with the relevant regulatory bodies and their advisors (principally CEFAS and English Nature (now Natural England)) prior to any works being undertaken. Individual monitoring reports have been provided to the regulatory authorities and their advisors as they have been completed throughout the monitoring period.

3.3. *Construction Debris Surveys (FEPA Licence Item 9.28)*

3.3.1. Purpose of Monitoring Condition

To monitor the seabed before and after the construction phase to ensure that no new obstructions occur as a result of debris derived from the construction works within the main turbine array and along the export cable route. Where new obstructions are identified these must be investigated and where appropriate removed at the developers expense in order to protect other users of the sea and particularly fisheries interests.

The Kentish Flats ES identified the need to complete surveys of the seabed following construction in order to safeguard commercial fishing vessels against any major debris being left on the seabed which may damage fishing gear or endanger fishing vessels (ES Impact Statement 52; mitigation). Provided that suitable post-construction debris surveys and clearance was completed, a low significance was predicted in relation to effects on the fishing industry arising from construction debris.

3.3.2. Scope of Monitoring Studies

Bathymetric and side scan sonar surveying of the entire wind farm area and export cable route in appropriate grid lines both prior to and subsequent to the construction of the Kentish Flats wind farm. Comparison of the pre and post construction data should identify any new obstructions on the seabed which must be investigated and where appropriate removed by the developer. Representatives from the local fishing industry must be invited to attend these surveys in order to provide reassurance that the areas remain safe for fishing activities.

In addition, the main construction vessels to be fitted with black box recorders which log the precise route of their transits between the main construction port (Felixstowe) and the Kentish Flats site. This data should provide the ability to check any claims that debris on the seabed outside of the main construction site might have been derived from the construction ships during transit.

3.3.3. Monitoring Completed

A pre-construction survey was completed in early August 2004 using single beam bathymetry and side scan sonar which in combination were used to identify significant features on the seabed existing prior to the start of the Kentish Flats construction program. The area covered by the survey is shown in Figure 18, below.

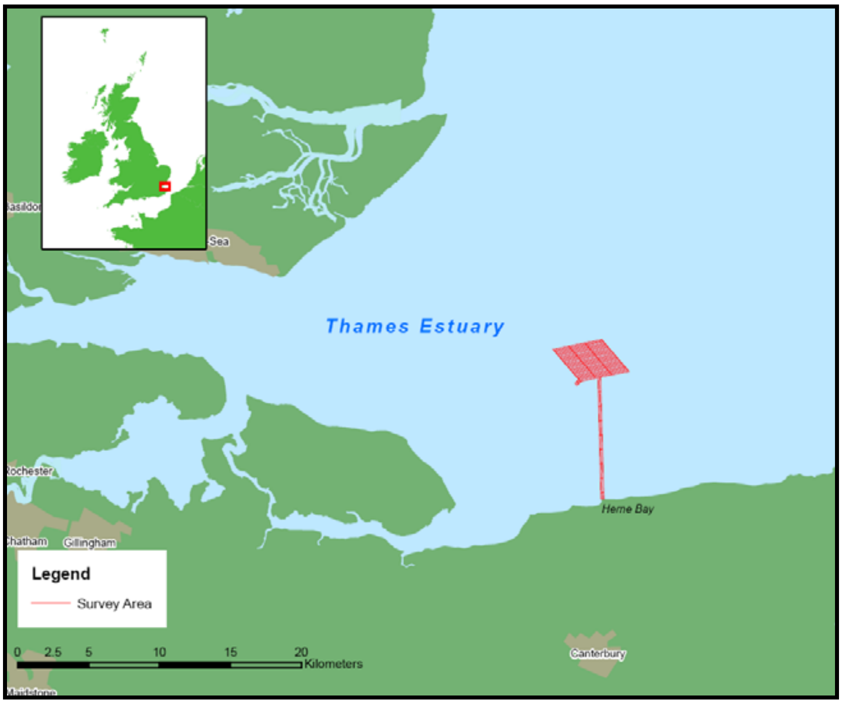


Figure 18 Area Covered by Debris Surveys

Single beam bathymetric surveying was used to determine variations in the seabed below the vessel which when combined provided a contoured chart of the seabed levels across the area. The side scan sonar detected differences in the reflectivity of the seabed and variations in seabed type as well as identifying seabed anomalies such as obstructions. Positioning was achieved using DGPS (Differential Global Positioning). Line spacing was at 100 metres with cross-lines at 1km spacing. Tidal variations were corrected by using tidal height data derived from the Port of London tide gauge at Herne Bay.

The survey was repeated using the same techniques and survey lines following the completion of the main construction works in September/October 2005.

For each survey, a Fisheries Liaison Officer (FLO) from Whitstable and another FLO from the Essex fleets were in attendance.

Each of the main construction vessels were also fitted with 'black-box' recorders and the records of their movements were retained following the completion of the construction works.

Full details of the pre and post construction debris surveys together with results of these surveys are provided in the relevant monitoring reports (Emu, 2005a; Emu 2005b)

3.3.4. Overview of Results

The pre-construction survey recorded depths of between 3.5m to 5.6m (below chart datum) across the main turbine area, shallowing along the export cable route to chart datum at the beach at Herne Bay. The pre-construction side scan sonar data identified a variety of seabed conditions across the wind farm area but with the majority of the area dominated by low profile sandy megaripples (generally <0.5m high). Areas of coarser sediments with no obvious bedforms were also identified, particularly along the export cable route.

The pre-construction side scan sonar data also identified several small targets, particularly towards the shoreward end of the cable route (thought to be derived from fishing activity). A total of 13 targets were identified during the pre-construction survey.

The post-construction survey recorded no significant changes in depths across the area, with the data comparing well with the pre-construction survey. This indicates that there have been no gross changes to the bathymetry of the wind farm or cable route as a result of the placement of the structures and associated construction activity.

With regard to the nature of the seabed, the post-construction side scan sonar also agrees closely with the pre-construction data although the precise location and boundaries of the mobile sediment features such as the megaripples have altered as a result of natural processes.

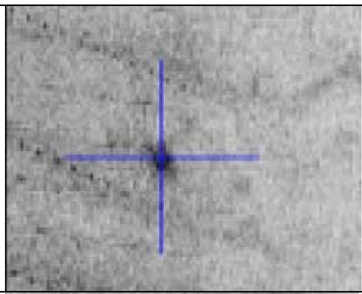
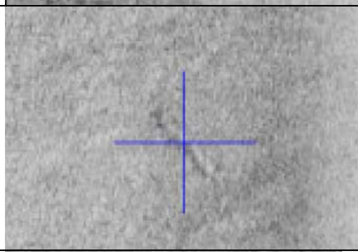
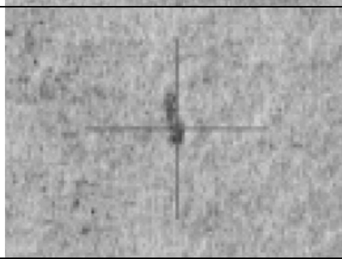
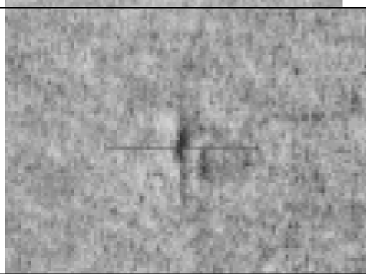
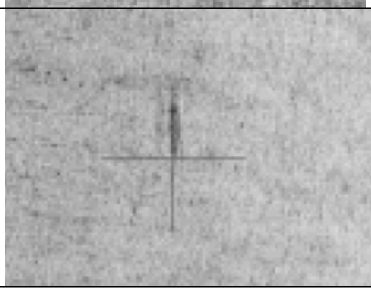
The side scan sonar data did record the depressions in the seabed derived from the feet of the jack-up vessels used for construction (see Section 3.4 below for more detail). These were evident as clusters of six regularly spaced depressions adjacent to each of the turbine locations. The linear cable trenches were also evident from the data, running between the turbines.

With regard to seabed features, a total of 52 anomalies were identified from the post-construction survey. Of these 34 were clearly the result of construction activity disturbing the seabed, for example relics of cable trenching activity or vessel anchoring. These were all recorded as having a very low relief and essentially show slight scars on the seabed. These scars are not considered to represent any hazard to others mariners or fishermen and were not, therefore considered further.

Only two targets were co-located with targets identified during the pre-construction surveys and were therefore discounted from further consideration. The remaining 11 targets identified pre-construction were not apparent from the post-construction data.

Of the remaining 16 anomalies, six were recorded within 50 metres of a turbine (within the area of restricted navigation as set out in the Port of London's River Works Licence) and were therefore discounted from further consideration following consultation with Defra and PLA.

The remaining 10 targets are summarised in Table 2. For a number of these the side scan sonar image is shown.

Target contact No.	Description of Anomaly	Side Scan Sonar Images	Details
02	Unknown feature		Target Height = 0.00m Target Length: 2.80m Target Shadow: 0.00m
07	Linear feature 13.5m long with low relief		Target Height = 0.00m Target Length: 13.56m Target Shadow: 0.00m
08	Elongated feature with rounded ends and low relief		Target Height = 0.00m Target Length: 5.00m Target Shadow: 0.00m
10	Appears to be a smooth mound, possibly spoil		Target Height = 0.00m Target Length: 2.5m Target Shadow: 0.00m
21	Subtle linear feature with low relief		Target Height = 0.00m Target Length: 4.96m Target Shadow: 0.00m
35	Long narrow linear feature		Target Height = 0.00m Target Length: 17.57m Target Shadow: 0.00
36	Single target, strong backscatter		Target Height = 0.00m Target Length: 3.10m Target Shadow: 0.00m

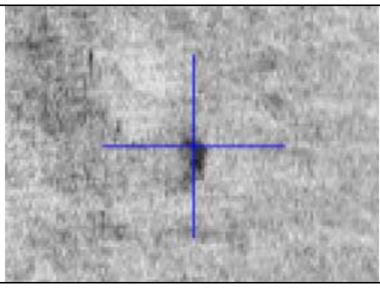
Target contact No.	Description of Anomaly	Side Scan Sonar Images	Details
38	Long narrow linear feature		Target Height = 0.00m Target Length: 10.61m Target Shadow: 0.00m
39	Poorly defined feature with moderate backscatter and low relief		Target Height = 0.00m Target Length: 3.81m Target Shadow: 0.00m
45	Long linear feature, possibly a rope or chain.		Target Height = 0.00m Target Length: 66.71m Target Shadow: 0.00m

Table 2 Summary of Post-construction Anomalies Identified from the side Scan Sonar Data

3.3.5. The Debris Clearance Procedure

The 10 targets identified from the post-construction debris survey as possible construction debris were targeted for further investigation as a pre-cursor to clearance.

In July 2006 a qualified marine diving contractor mobilised to site. The 10 targets were re-surveyed with side scan sonar and were subsequently inspected using divers. The diving surveys identified a number of seabed features which corresponded with the data from the side scan sonar but no construction debris was identified. The results of the diver inspections on the 10 targets are summarised in Table 3 below.

Target contact No.	Description of original Side Scan Sonar Anomaly	Diver Observation
02	Unknown feature	Sand and weed, no obvious feature
07	Linear feature 13.5m long with low relief	Sand and weed, no obvious feature
08	Elongated feature with rounded ends and low relief	Sand and weed, no obvious feature
10	Appears to be a smooth mound, possibly spoil	Shallow sand and shell mound
21	Subtle linear feature with low relief	Hard bottom, no obvious feature
35	Long narrow linear feature	Narrow feature, shells and weed
36	Single target, strong backscatter	Low sand mound
38	Long narrow linear feature	Sand bar
39	Poorly defined feature with moderate backscatter and low relief	Featureless seabed
45	Long linear feature, possibly a rope or chain.	Indentations on flat seabed

Table 3 Summary of Diver Observations at Side Scan Sonar targets

Finally, all of the 10 target areas were surveyed using a magnetometer which would detect ferrous objects (such as major pieces of construction debris). No objects were detected.

The contractor concluded that the side scan sonar features identified from the post-construction survey must have been natural features that, in some cases, have subsequently disappeared.

The clearance survey using divers and magnetometer confirmed that no construction debris had been left on the seabed within the Kentish Flats wind farm area (Quest Underwater Services, 2006).

3.3.6. Conclusions

In relation to the debris surveys, it has been confirmed that the technology deployed was capable of identifying small objects on the seabed that may have been related to construction debris. Targets identified have been subsequently investigated by divers and it has been confirmed that none of the targets correspond to construction debris. The surveys have been attended by representatives from the local fishing fleets.

The debris surveys have been completed in accordance with the requirements of the FEPA licence and have confirmed that no effects on other users of the sea (particularly the commercial fishing industry) will occur, as predicted in the Kentish Flats ES.

The findings of the debris surveys tend to be confirmed by the fish surveys conducted at the wind farm site following construction (see Section 3.10). Commercial bottom trawls have been towed through the wind farm with no problems related to seabed obstruction reported during these surveys within the areas covered by the fish sampling exercises.

3.4. Seabed Morphology & Scour Monitoring (FEPA Licence Item 9.21; Annex 1 - item 2)

3.4.1. Purpose of Monitoring Condition

To monitor changes in the bathymetry within the wind farm array and in particular around turbine foundations in relation to potential scour effects. To include monitoring of representative section of inter-turbine cables.

In relation to potential scour around the Kentish Flats turbine foundations, the ES predicted that scour could theoretically release up to 2000 – 2,500 m^3 of sediment but that the prevailing natural geological conditions would actually tend to limit the scale and extent of scour at the Kentish Flats. Scour along cable routes was predicted to be limited. Monitoring of scour around the turbines and cables was proposed in the ES to act as a check on these predictions.

3.4.2. Scope of Monitoring Studies

Monitoring around at least four turbines (locations to be representative of the various sedimentary environments present). Surveys to be undertaken immediately after foundation installation and thereafter at 6 monthly intervals for a period of three years, with a particular focus on the need for additional scour protection. Monitoring must also investigate cabling to ensure that hazards to mariners are minimised.

During the subsequent discussion on the precise nature of the monitoring at Kentish Flats, it was agreed that scour monitoring would focus on a set of four turbines and the inter-turbine cabling between them.

3.4.3. Monitoring Completed

Scour monitoring has been completed on a 6 monthly basis since the completion of the turbine foundation installation in November 2004 and compared to the pre-construction data collected in August 2004 (Table 4 below).

Report Title	Survey date	Comments
Kentish Flats Offshore Wind Farm Pre-construction Swath Survey	August 2004	Report on survey conducted prior to foundation installation
Kentish Flats Offshore Wind Farm Post-construction Swath Survey 1	January 2005	First post-construction survey slightly delayed due to weather
Kentish Flats Offshore Wind Farm Post-construction Swath Survey 2	November 2005	Survey slightly delayed due to bad weather
Kentish Flats Offshore Wind Farm Post-construction Swath Survey 3	April 2006	None
Kentish Flats Offshore Wind Farm Post-construction Swath Survey 4	October 2006	None
Kentish Flats Offshore Wind Farm Post-construction Swath Survey 5	March 2007	None

Table 4 Summary of Scour Surveys Completed to date.

In each case, monitoring has been completed using Swath bathymetry techniques - deploying a multibeam echosounding system to ascertain the depth of water in a wide swathe. This technique produces 100% data overlap which ensure that errors due to roll, pitch or heading can be eliminated. Line spacing for each survey was 20 metres due to the shallow nature of the Kentish Flats site. Vessel positioning was achieved using DGPS (Differential Global Positioning System). The bathymetry data was collected for tidal variations by use of tidal heights data collected from the Port of London tide gauge at Herne Bay.

Surveys in each case were conducted at four of the Kentish Flats turbines at the eastern edge of the wind farm – Turbines E2, F2, F3 and F4 and including the cable rote between the three "F" turbines, as shown in Figure 19.

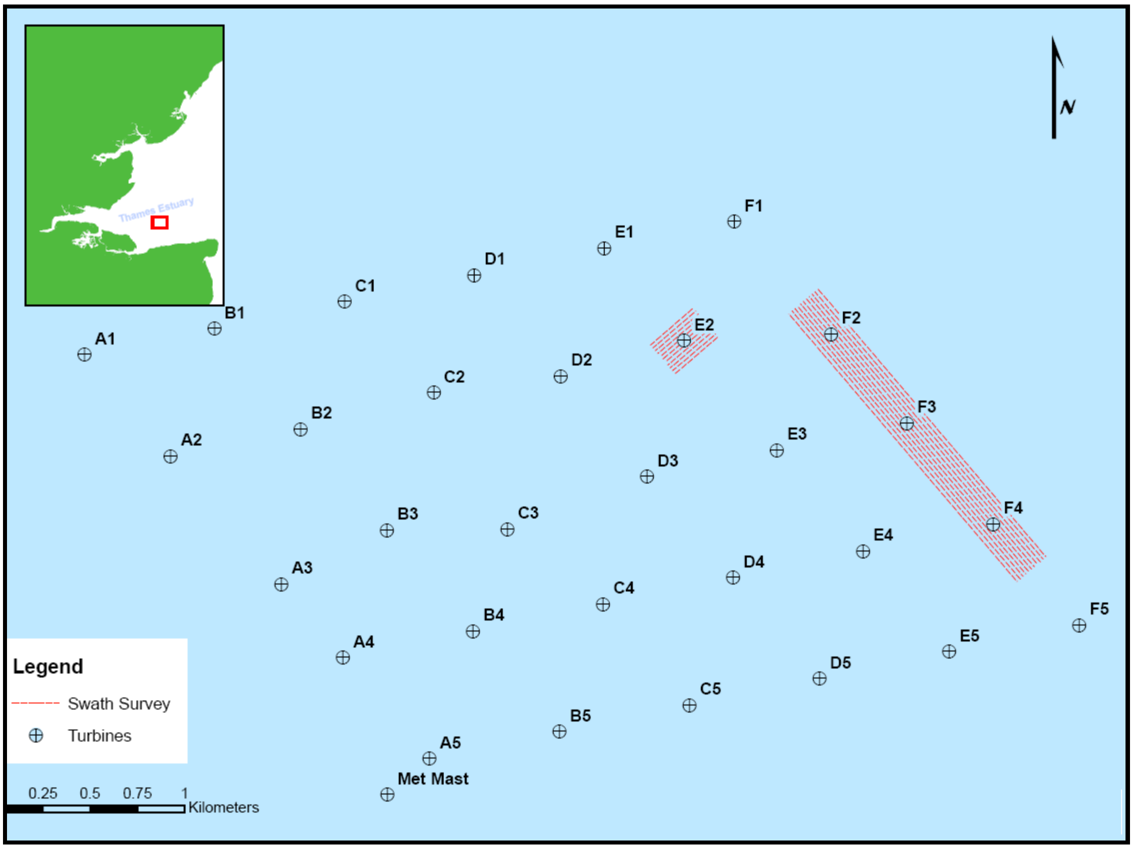


Figure 19 Location of Scour Survey within Kentish Flats Wind Farm

Full details of the pre and post construction scour surveys together with results of these surveys are provided in the relevant monitoring reports (Emu, 2005c; Emu 2005d; Emu 2005e; Emu, 2006a; Emu, 2006b; Emu 2007)

3.4.4. Overview of Results

The scour depth around each of the four turbine foundations surveyed are summarised in Table 5 for each of the surveys completed, relative to the pre-construction bathymetry recorded (negative values denote a deepening, positive values denote a shallowing).

Survey Date	E2	F2	F3	F4
January 2005	-0.8m	-1.1m	-1.4m	-1.1m
November 2005	-1.2m	-2.3m	-2.1m	-1.8m
April 2006	-1.4m	-1.6m	-1.7m	-1.7m
October 2006	-1.4m	-1.7m	-1.7m	-1.5m
March 2007	-1.5m	-1.9m	-1.7m	-1.7m

Table 5 Approximate Scour Depths Recorded During Each Scour Survey At Turbines E2, F2, F3 & F4

In each case the diameter of the scour around the turbine foundations has been consistent at between 5 and 10 metres (relative to a pile diameter of 4.3m). An example of the scour data showing an example of the limited scour depth and footprint derived from the swathe bathymetry data is shown in Figure 20, taken from the most recent survey completed in March 2007.

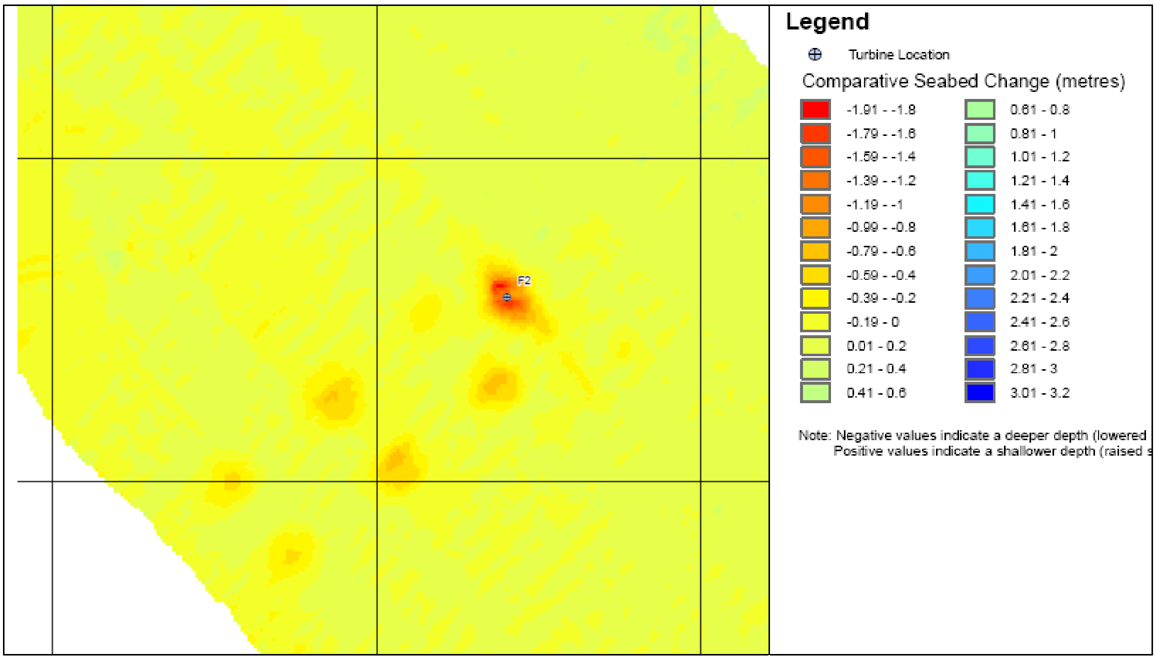


Figure 20 Bathymetric Comparison Plot for Turbine F2 from the March 2007 Survey

It is evident from the scour data summarised in Table 5 that scour around the Kentish Flats has quickly stabilised with only small variations between surveys, most likely the result of storm events, variations in tidal velocities and the prevailing bedload of shallow sandy sediments across the site. This is reflected in the intermittent build up and subsequent loss of sandy sediments around some of the turbines noted during some of the scour monitoring surveys.

Across the wider area surveyed and away from the turbines themselves, variations in bathymetry have been very small – between -0.2m and +0.2m when compared to the pre-construction data. Again such small variations may be explained by the natural variation in the mobile sandy sediments and megaripples that are recorded across the area. No trend in these variations is apparent.

It is noted during the monitoring surveys that no scour has been evident along the inter-turbine cable routes which have been monitored between turbines F2, F3 and F4.

A further feature that is evident from the swathe bathymetry data collected at each of the turbine locations are a set of six regular depressions in the seabed – apparent, for example in Figure 20. These depressions are the result of the jack-up vessel used for installation which, due to the relatively soft geology present sunk into the seabed as it extended its spud legs. Immediately post-construction, the survey undertaken in January 2005 recorded these depressions as having depths of between 0.5 and 2.0 metres. By the most recent survey (March 2007), these depths had reduced with a maximum depth (at F3) of 0.8m – a reduction of 1.2m. This clearly shows that these jack-up depressions are infilling naturally as a result of the mobile sandy sediments present across the area.

3.4.5. Conclusions

The scour monitoring conducted under the requirements of FEPA Licence condition 9.22 has clearly shown that at the Kentish Flats site scour around the turbine foundations is limited and has stabilised at a maximum of circa 1.9m with a diameter of up to 10 metres.

No additional scour protection methods will be required at Kentish Flats.

No scour has been recorded along the inter-turbine cable routes.

The depressions arising from the jack-up vessels used for installation are infilling as a result of natural sedimentary processes at circa 0.6 metres per annum.

Monitoring of the seabed pre and post-construction for debris has also confirmed that there have been no gross changes to the bathymetry of the wind farm area outside of the limited scour observed.

The scour monitoring has confirmed the predictions set out in the ES suggesting that scour would be limited at Kentish Flats due to the nature of the prevailing seabed geology and with limited scour along cable routes. The theoretical prediction for piles of the diameter used at Kentish Flats suggested that as much as 2,500m3 of sediment could be disturbed by scour. In fact the maximum observed scour (10m diameter to 1.9m depth) equates to the disturbance of circa 50m^3 per turbine (calculated as the volume of a cone around the turbine foundation).

3.4.6. Recommendations

The Kentish Flats monitoring has clearly demonstrated limited scour at the site both in relation to turbine foundations and inter-turbine cable routes, and well within the predicted effects described by the Kentish Flats ES. Scour has stabilised and the jack-up depressions are clearly infilling through natural processes.

It is, therefore, suggested that FEPA Condition 9.22 has been satisfied and it is recommended that scour monitoring at the Kentish Flats Offshore Wind Farm is no longer required.

3.5. Suspended Sediment Concentrations (SSC) Monitoring (FEPA Licence Item 9.4; Annex 1, Item 1)

3.5.1. Purpose of Monitoring Condition

To monitor the background suspended sediment concentrations and to act as a check on the generation of suspended sediment concentrations by the construction of the Kentish Flats Offshore Wind Farm, and in particular by the installation of the main export cables which cross the Whitstable oyster grounds. Suspended sediment concentrations to remain within agreed threshold limits during cable installation.

In the Kentish Flats ES (impact statements 7 & 16) the potential for an increase in suspended sediments during the installation of the export cables was identified, specifically related to the designated shellfish area (oyster beds) through which the cables passed and were considered to be of low significance. Monitoring of suspended solids in-situ was highlighted as a potential need to ensure the predicted low effects on water quality were confirmed.

3.5.2. Scope of Monitoring Studies

Monitor the prevailing, background levels of suspended sediments at an agreed reference area prior to the start of cable installation works. Subsequently, monitor the suspended sediment concentrations within 500 metres of the export cable installation vessel and at all time during cable installation works. Levels recorded during cable installation to be checked against agreed threshold levels and if thresholds were exceeded cable installation must be moderated or suspended.

3.5.3. Monitoring Completed

Suspended sediments were monitored at the Kentish Flats using Optical Backscatter Sensors (OBS).

In order to establish the prevailing background levels, twin OBSs were deployed at an agreed reference location (see Figure 21) 1 metre above the seabed and configured to take readings every 10 minutes. Water samples were collected over a tidal cycle during the initial deployment and at recovery of the instrument for determination of total solids (as mg/l^{-1}). This data was used to calibrate the data derived from the OBS instruments.

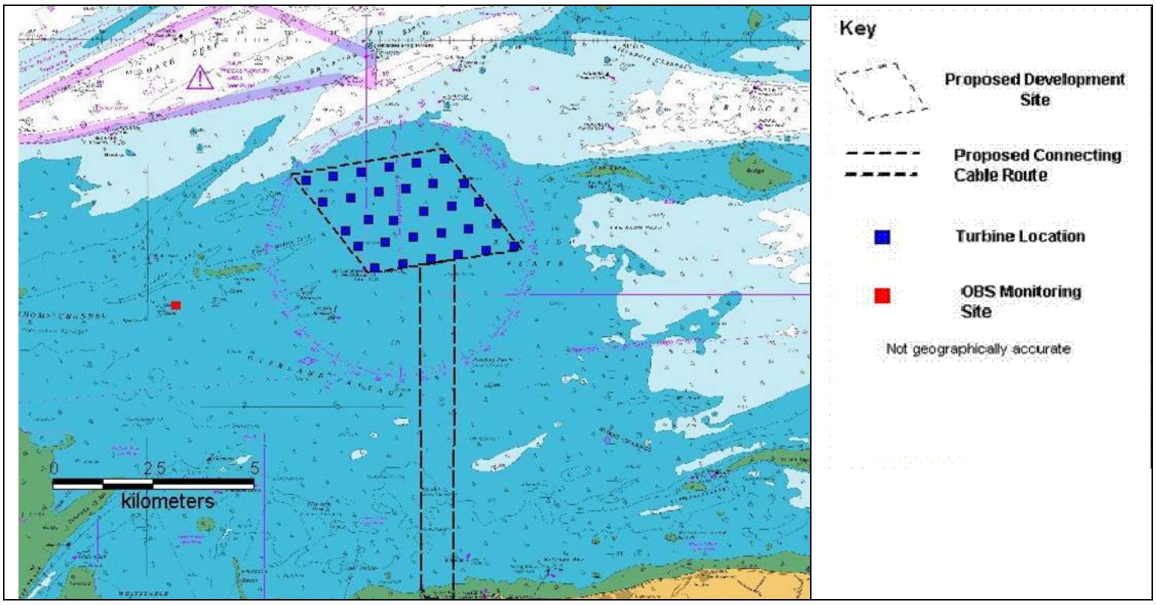


Figure 21 Location of Kentish Flats reference OBS Deployment

This reference data was subsequently used to derive agreed threshold limits that were applied during the monitoring of the export cable installation process. The following threshold and action levels were agreed with CEFAS:

- A peak value of >1000 mg l^{-1} (1026.3 NTU) should not be exceeded. If exceeded, confirmation of value through the deployment of a second device will be required as verification.

- Raised values of >300 mg l^{-1} (302.0 NTU) should not be exceeded for > 30 minutes. If they are exceeded, confirmation of values through the deployment of a second device will be required as verification, as well as measurement of existing background levels taken, at the end of the 30 minute period, from a site 2km north of the cable laying activity. If natural background levels are at, or in excess of, 250 mg l^{-1} (250.3 NTU), a further 30 minute period of monitoring will be required before any action is required.

If one or both values were to be exceeded at any time during the cable laying then the cable laying vessels would have been instructed to slow or cease activities until levels were reduced to below the thresholds specified.

Monitoring during cable laying was conducted from a mobile vessel using a handheld turbidity meter deployed every 10 minutes with readings taken at 1 metre above the seabed and at 1 metre intervals to the surface. The monitoring vessel was located at no less than 500 metres down-tide from the installation vessel. Water samples were taken every hour during cable installation and used to calibrate the sensor.

Full details of the suspended solids monitoring conducted during cable installation together with results of the survey are provided in the relevant monitoring report (Emu, 2005f)

3.5.4. Overview of Results

The reference data derived from the OBS moorings between October 2004 and January 2005 allowed a normal background level to be established. The modal figure derived from the data was between 50 and 55mg l^{-1}. The data indicate that the background suspended sediment values rarely exceeded 120mg l^{-1}. The frequency of occurrence of suspended sediment concentrations for the whole data set is shown graphically in Figure 22.

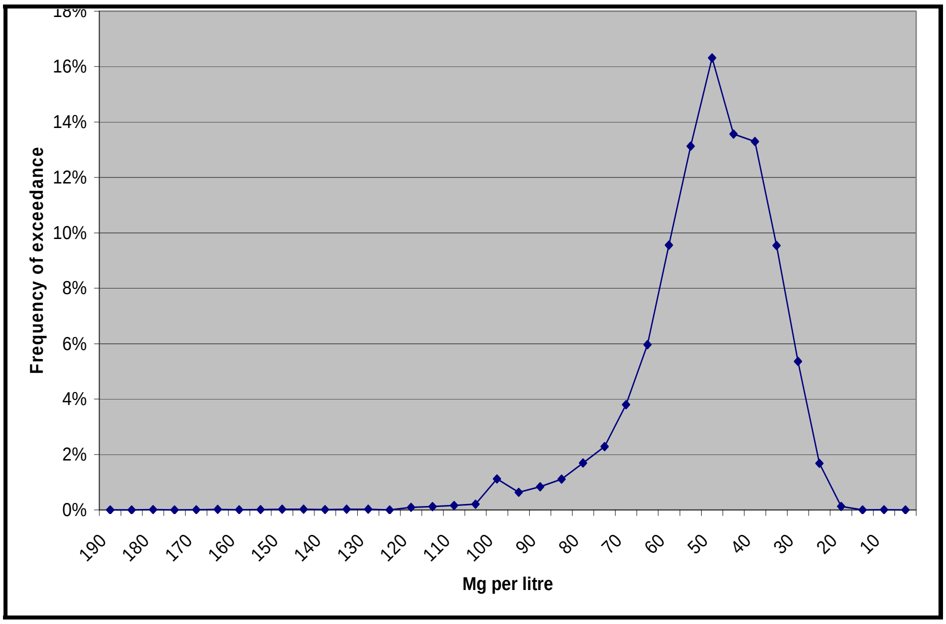


Figure 22 Baseline Suspended Sediment Concentrations frequency of Occurrence

During the installation of the export cables suspended sediment concentrations were somewhat elevated above the prevailing background levels. This is shown in Figure 23, which indicates that levels were most elevated during the installation of the second cable.

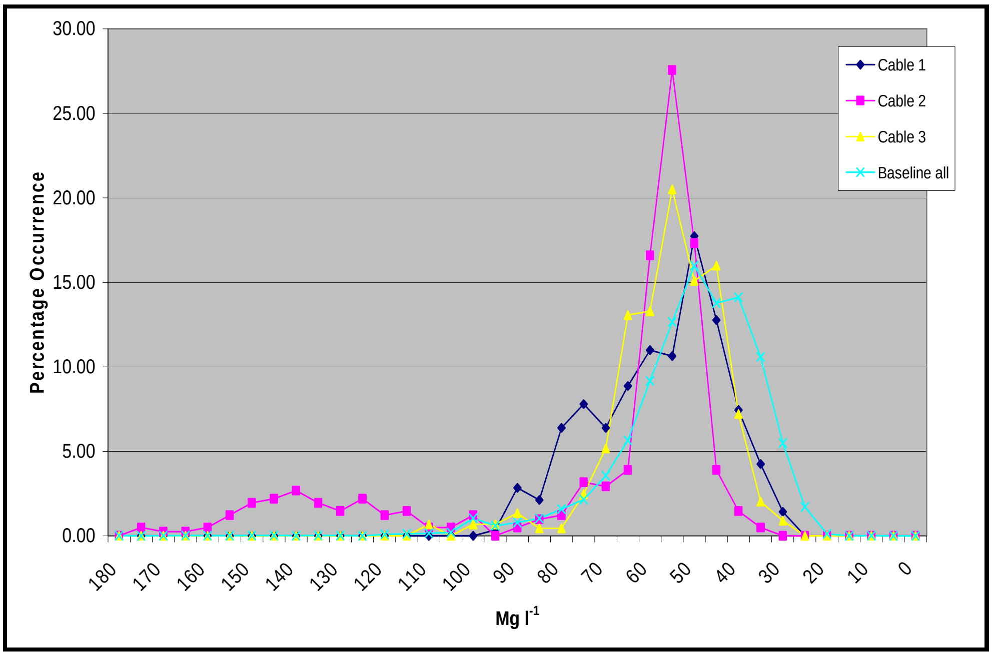


Figure 23 Frequency of Occurrence of Suspended Sediment concentrations During Cable Installation Compared to the Baseline Data

However, despite some increases in the levels of suspended sediment concentrations at locations down-tide of the cable installation operations, at no time were the agreed threshold levels exceeded.

3.5.5. Conclusions

The results show that the techniques employed during the monitoring were able to detect slight variations in the concentration of suspended sediments down-tide of the cable installation operations and were therefore appropriate for the control of the installation process relative to the agreed threshold levels developed for the Kentish Flats site.

At no time were threshold levels exceeded and as a result the cable installation program was completed as planned. The monitoring confirms the predicted low significance of the increase in suspended solids arising from export cable installation within the oyster areas.

Monitoring of the contaminant loading of the oysters surrounding the export cable installation route was also completed (see Section 3.9). The oyster monitoring confirms no adverse effects have arisen as a result of the export cable installation.

3.6. *Ornithological Monitoring (FEPA Licence Item 9.1 and Annex 2)*

3.6.1. Purpose of Monitoring Condition

To monitor the effects on bird species during the construction and operational phases of the Kentish Flats Offshore Wind Farm by reference to appropriate pre-construction monitoring data. Specifically, five objectives need to be fulfilled by the monitoring programme:

1. Determine whether there is any change in bird use and passage through the wind farm site, measured by species, abundance and behaviour.
2. Determine whether there is disruption to bird flight lines.
3. Determine the distribution of wildfowl and divers in the Thames Estuary, covering the Kentish Flats study area. This will include movements of wildfowl to and from the coastal SPA sites surrounding the Thames Estuary.
4. Determine the rate of bird collision at the Kentish Flats site.
5. Determine the effectiveness of mitigation measures implemented during wind farm construction.

The ES and accompanying Technical Addendum (GREP, 2002b) reviewed the potential effects of the construction and operation of the wind farm on bird species. The ornithological EIA concluded that there would be no significant impacts on most bird species. Low to Moderate significance was attributed to the potential temporary disturbance of divers during construction and the potential disturbance of flightlines used by common terns. Mitigation was set out in the ES with regard to effects on divers and a detailed monitoring program was proposed.

3.6.2. Scope of Monitoring Studies

Monitoring of the main Kentish Flats turbine area and an appropriate control area using a combination of aerial and boat based surveys to determine the distribution and behaviour of bird species in and around the wind farm site and in response to the construction and operation of the wind farm, by comparison to baseline data.

3.6.3. Monitoring Completed

Pre-construction monitoring of the Kentish Flats wind farm was conducted over the period October 2001 to November 2003, providing two years of uninterrupted boat surveys. Over this period a total of forty individual surveys were completed covering the wind farm site whilst two thirds of these surveys also covered the control area. The transects used during these boat surveys are shown in Figure 24.

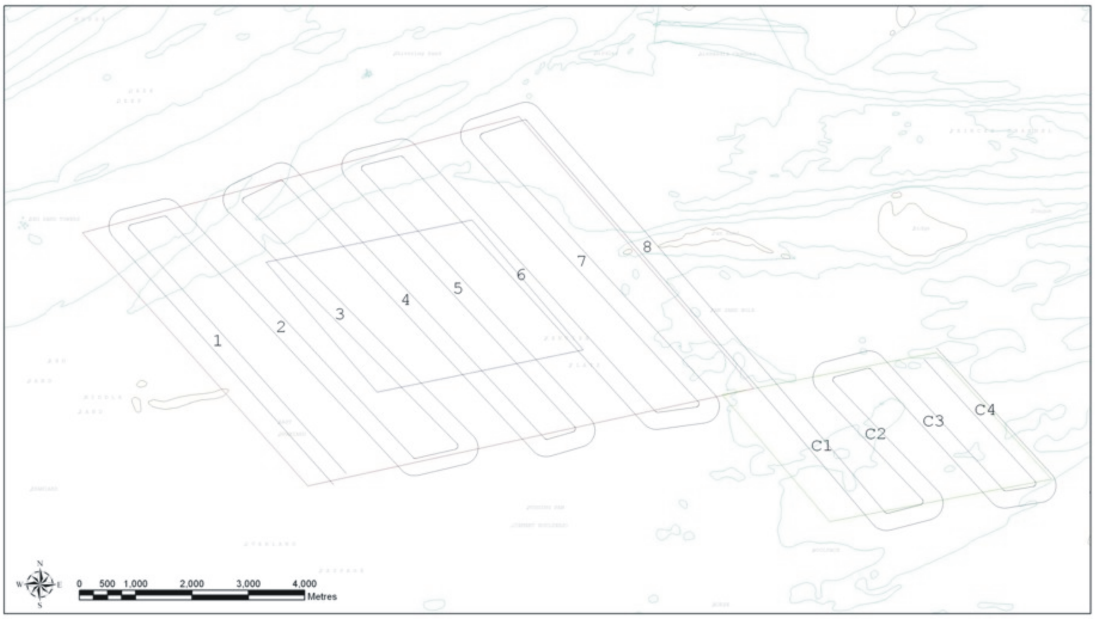


Figure 24 Location of Kentish Flats Boat Based Ornithological Survey Transects (Transects 1 to 8 cover the wind farm and buffer area; transects C1 to C4 cover the control area)

In addition, aerial survey data was collected over the period January 2002 to November 2003 in which time a total of five surveys were completed focusing on the winter period (but including two surveys during the summer months).

During the construction period and continuing into the operational phase of the wind farm, boat based surveys have continued with a total of between 16 & 17 surveys completed every year. The timing of each survey has varied slightly from year to year, but averages approximately one survey per month during January, February, March, June, July, August and December with two visits per month during April, May, September, October and November. The main wind farm area and buffer area are surveyed on each occasion with the control area surveyed at least every other month.

The aerial surveys have also been continued through the construction and operational period as part of the wider DTI sponsored aerial bird survey program (DTI, 2006). Five surveys have been completed each year, continuing the program established during the pre-construction monitoring period. The area covered by the DTI sponsored aerial survey program is shown in Figure 25.

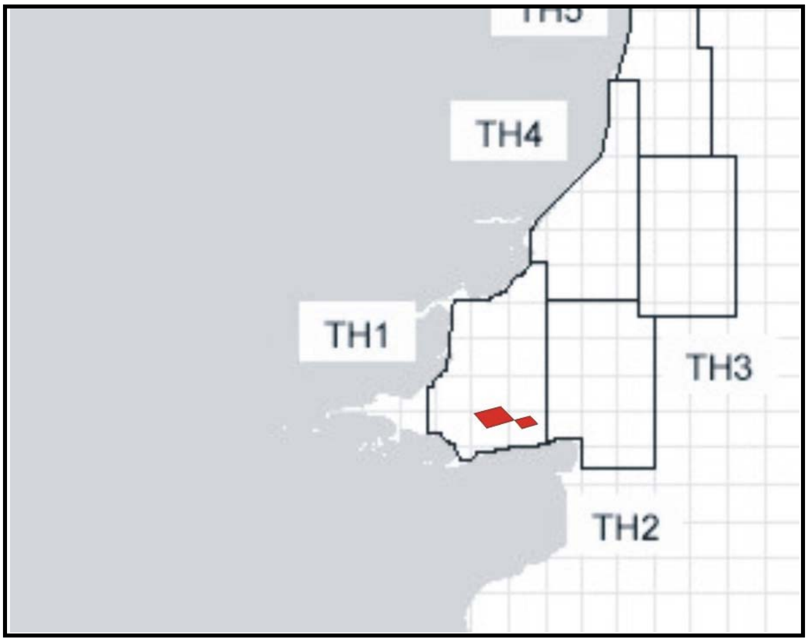


Figure 25 Area Covered by the DTI Sponsored Aerial Surveys in the Thames Strategic Area relative to the Location of the Kentish Flats Boat Survey Areas

Detailed methodologies and the results of each individual survey are presented in the various Kentish Flats Offshore Wind farm ornithological monitoring reports (ESS, 2004; ESS, 2005; ESS, 2006; ESS, 2007).

3.6.4. Overview of Results

Data derived from the boat based surveys have, in each case, been analysed to produce bird population estimates which have been continually updated over the monitoring period.

Evidence of change between the pre, during and post construction phases have been examined using two separate analyses for the boat data.

The first boat method looked at the estimates of densities for all 90 boat survey visits. The data for each month was analysed separately. Means and standard errors were calculated for each of the three phases of the development and for each species, tests were carried out comparing the construction phase with the pre-construction phase and the operational phase with the pre-construction.

The second (and more satisfactory) analysis was carried out by comparing the wind farm site with the control area. This should eliminate most of the natural variation in numbers between different years. There is less information available for this analysis because the control site was visited on only 31 of the 90 site surveys. The control site is also smaller, so estimates for it are less precise.

Data from the aerial surveys have been compared statistically by area by dividing the data from the TH1 area into three sections – the wind farm and buffer area, a reference area to the west and a further reference area to the east (including the boat survey control area).

The results of these analyses from the most recent ornithological monitoring report (data up to and including November 2006) (ESS, 2007), provide the most up to date analysis of the data with regard to the effects of construction and operation when compared to the pre-construction situation.

The results of the first analysis of the boat survey data – the quantitative density comparisons between the pre-construction, construction and operational phases suggest that:

- Red-throated diver numbers are lower during the operational phase than during pre-construction.
- Gannet numbers show no evidence of changes.
- Cormorant numbers were lower between December and April since the wind farm became operational, but not at other times of year.
- Lesser black-backed gull numbers in February were lower in the construction and operational phases. There were suggestions of differences in other months for this species and possible reductions for greater black-backed and herring gulls, but no consistent patterns were detected.
- Common tern numbers show no evidence of changes.
- Guillemot numbers appear to be low since the wind farm became operational

However, the monitoring report advises that these results must be treated cautiously for several reasons. The total number of birds in British waters can vary enormously between different years as can their distribution around the coasts. Further, the tests carried out for each month are not independent of each other.

The second analytical approach for the boat survey data, comparing the wind farm with the control area, used only those visits where both areas were surveyed and for the four species which were recorded at both sites on more than two visits (red-throated diver, lesser black-backed gull, herring gull and common gull). For these four species, the F tests comparing the three phases of the development were not statistically significant at the 5% level. This indicates that there is currently no statistically significant evidence of a direct effect on the numbers of birds using the wind farm site when comparing the pre and post construction data (although the relatively low power of the test is acknowledged).

This might suggest that the differences found in the first analyses were due to changes in the overall numbers visiting the general Thames area, rather than birds being displaced from the wind farm site.

Considering the aerial survey data, statistical comparisons between the wind farm and buffer area and the two reference areas (for diver, cormorant, seaduck, wader, gulls, terns, auks, and all birds) showed no statistically significant changes over the monitoring period thereby providing no suggestion of a significant displacement of birds as a result of the construction or operation of the Kentish Flats wind farm.

3.6.5. Conclusions

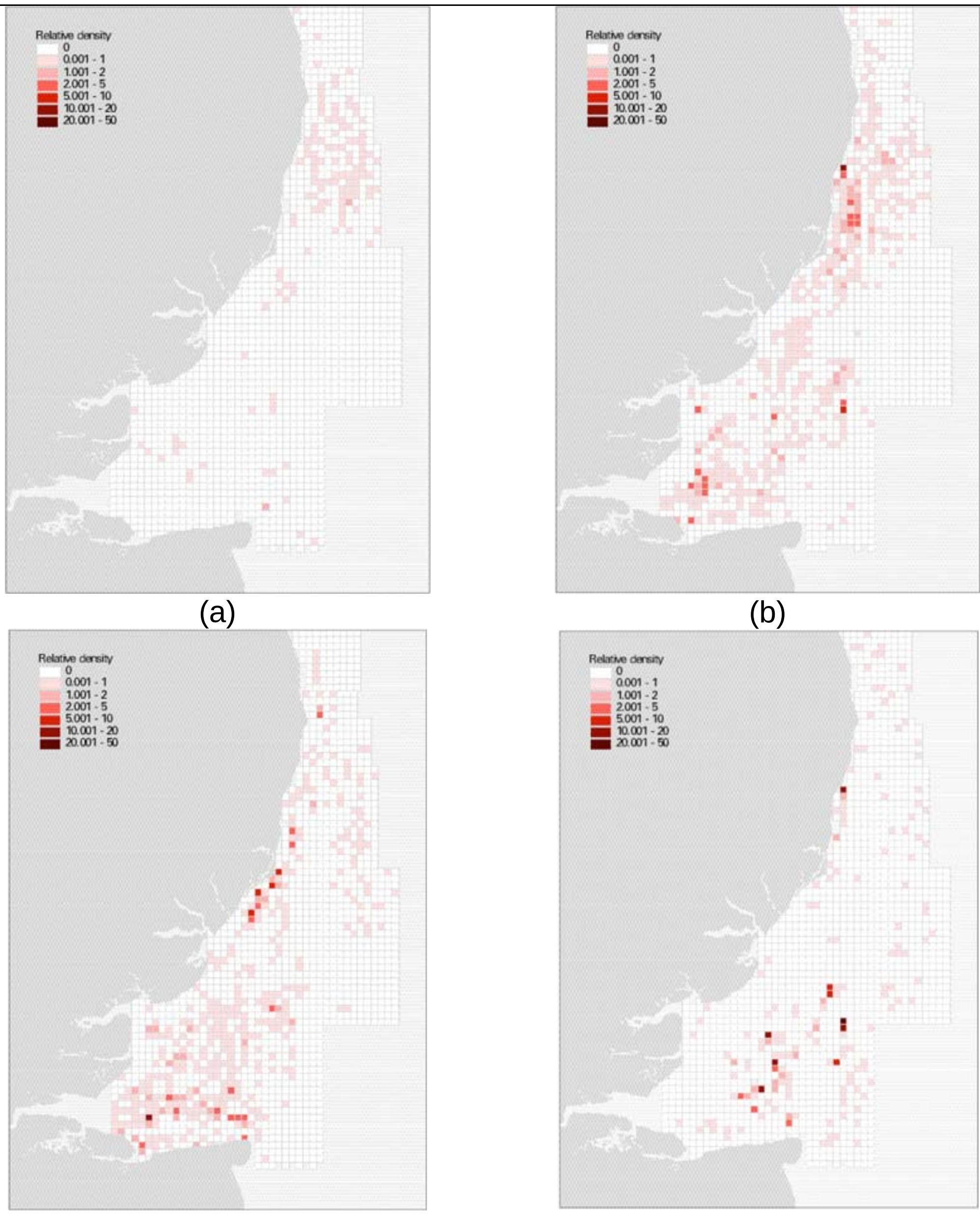
The most recent ornithological monitoring report (ESS, 2007) considers the results and analysis of all of the boat and aerial surveys conducted over the pre, during and post-construction/operational period in relation to the key FEPA licence monitoring objectives set out under Section 3.6.1 above. These conclusions in relation to the FEPA monitoring objectives are summarised as follows:

Objective 1 - Determine whether there is change in bird use and passage through the wind farm site, measured by species, abundance and behaviour.

The most apparent change, based on the more qualitative analysis summarised under Section 3.6.4 above is the apparent absence of divers from the Kentish Flats Wind Farm site during the first year of operation. Although no divers were seen within the wind farm area itself, divers were observed in the control area and the buffer zone (some sitting on the water within 100 metres of the edge of the site). The lack of divers within the wind farm during the first year of operation compares to the previous regular observations of divers within the wind farm area itself, even during the construction period.

Whilst this qualitative observation would seem to suggest an avoidance of the operational wind farm by divers, this observation must be treated with caution for a number of key reasons:

- The observation is based on only a single years data during the operational phase of the project
- The statistical analysis of the data from the wind farm and control areas showed no statistically significant change
- Analysis of the aerial survey data revealed no statistically significant changes in diver numbers
- Diver numbers recorded by the Kentish Flats surveys in Year 5 were generally low
- Diver numbers in the wind farm area have fluctuated seasonally and between years throughout the monitoring program
- The Kentish Flats wind farm area and surrounding area have always been of relatively low importance for red throated diver when compared to other parts of the Thames estuary (see Figure 26).



(a) (b) (c) (d)

Figure 26 Relative density of divers *Gavia spp*. recorded in Thames OWF Strategic Area during aerial surveys 2004/2005 (a) October/November 2004 (b) November/December 2004 (c) January/February 2005 (d) February/March 2005 (from DTI, 2006) (Refer to Figure 25 for relative location of Kentish Flats OWF)

In relation to other bird species, there appears to have been little other significant change in bird use and passage through the Kentish Flats Wind Farm, as measured by comparing species, abundance and behaviour between the pre-construction, construction and operational periods.

Objective 2 - Determine whether there is disruption to bird flight lines.

In relation to migratory species, several goose flights have been recorded during the boat surveys in the most recent surveys. While there is no evidence of a specific goose flight line though the wind farm, there is some evidence of a general flight line westwards up the estuary so there may be some minor displacement of goose flights around the turbines *en route* to and from the North Kent SPAs. There is also some evidence that some geese (greylag and Brent geese) do not alter their flight line and fly through the wind farm.

A curlew was also seen flying through the wind farm in March 2006 suggesting that the wind farm will not act as a barrier to passage by this species.

A feature noted from the pre and during construction data was the regular passage of common terns to the south of the wind farm, carrying fish and returning to breeding colonies in the Medway. This pattern has continued during the first operational year although it is noted that some deviation around the southern or northern boundaries of the wind farm en-route to and from feeding areas may be apparent. Common tern is the only species for which some slight deviation in flight lines is suggested, although this is based on only a single year of observations.

There is no evidence of a regular or specific flight line through the wind farm for passerine migrants any more than the rest of the Thames Estuary.

Objective 3 Determine the distribution of wildfowl and divers in the Thames Estuary, covering the Kentish Flats study area (to include movements of wildfowl to and from the coastal SPA sites surrounding the Thames Estuary).

Both the boat and aerial survey data sets suggest the minor importance of the Kentish Flats wind farm site and buffer zone for wintering divers, which will qualify the Thames SPA, and for Kent SPA wildfowl species. Figure 26 above indicates the relatively low numbers of divers recorded in and around the Kentish Flats site compared to other parts of the Thames estuary. That said, some avoidance of the wind farm by divers may be suggested by the first year of operational monitoring data (see Objective 1 above).

Movements of other SPA species such as geese have been noted during the operational phase, all of which could have been flying towards the coastal SPA sites around the Thames estuary.

Numbers of seaduck recorded have been generally low although greater numbers of common scoter have occasionally been recorded during the boat surveys. It is thought that number of scoter vary annually accounting for the occasional increased numbers seen in and around the wind farm area.

Data for waders suggests that they generally fly in an easterly direction towards the coastal SPA sites. Although numbers recorded during the boat surveys are generally low, there is no evidence to suggest that there has been any disruption to the flight lines of these species.

In conclusion, there is no evidence from the first year of operational monitoring that the Kentish Flats wind farm is affecting flight lines used by SPA species to and from the key coastal sites. Some suggestion of avoidance of the wind farm by divers is apparent although this observation should be treated with caution. It is also noted from the aerial survey data that the Kentish Flats is of little significance for divers when compared to other parts of the Thames Estuary (see Objective 1 above)..

Objective 4 Determine the rate of bird collision at the Kentish Flats site.

Formal collision risk assessment following the first year of operation has not been attempted following an examination of flight heights recorded. This suggests that for species of conservation interest, flight heights are normally below rotor height and collision risk is not a concern for these species. Most records of flight above rotor height (20 m above sea level) were gulls, and herring gull. Occasional deviation in flight heights for geese has been observed as they enter the wind farm where they have been seen to vary flight height from 20m to 60m as they pass through the turbine array.

In summary, the number of Kent SPA species, potential Thames SPA-qualifying species and other bird species of conservation concern which might be potential collision victims remains very low.

Objective 5 Determine the effectiveness of mitigation measures implemented during wind farm construction.

The only mitigation measure relating to birds related to the timing of the main turbine construction activities during the peak diver season in order to avoid disturbance to this species. This mitigation was successfully employed with foundation piling and turbine installation completed outside of the diver wintering period. It is noted that there is no evidence from the monitoring data that monopile-driving and increased boat traffic had any significant long term effects on bird populations.

Referring back to the predictions made in the Kentish Flats ES and subsequent Technical Addendum, the monitoring has confirmed that no effects have occurred for most bird species following the construction and initial operation of the wind farm. Mitigation employed avoided any disturbance of divers during the construction period as suggested in the ES. The predicted slight disruption to the common tern flight lines has been confirmed by the monitoring to date although it is not considered to be significant.

The apparent decrease in diver numbers within the wind farm during the initial operational period was not predicted by the ES (although impacts during the construction phase were expected). However, caution must be applied in considering this trend (see Objective 1 conclusions above). It is also the case that, even if divers are currently avoiding the operational site, the Kentish Flats wind farm has always been of marginal importance for this species in the context of the wider Thames estuary.

Considering the findings of the other FEPA monitoring, it is apparent that no significant changes to the occurrence of fish species or changes to the benthic communities resulting from the construction of the wind farm have been detected to date (beyond the very localised effects around the turbine foundations attributable to scour). That being the case, no indirect effects on the distribution or behaviour of bird species is indicated by these other monitoring studies.

3.6.6. Recommendations

The ornithological monitoring conducted to date has served to confirm the predictions made by the Kentish Flats ES. No significant effects on bird species have occurred during the construction or operational phase, with the exception of the predicted slight alteration to the flight lines of common terns. Currently further monitoring in relation to the Kentish Flats wind farm is not, therefore, considered necessary.

The monitoring conducted to date during the operational phase has provided a preliminary indication that divers may be currently avoiding the wind farm area. However, caution is needed in interpreting the currently available data. The final year of monitoring data, covering the second year of full wind farm operation will be analysed and reported during 2008. It is recommended that this data is reviewed in relation to effects on diver distribution and behaviour in relation to the further need for more targeted, diver related monitoring studies.

3.7. Benthic Communities (FEPA Licence Item 9.4 and Annex 1 – Item 4)

3.7.1. Purpose of Monitoring Condition

To monitor the potential effects on the seabed ecology within the wind farm array and in adjacent areas along the tidal axis that might arise directly or indirectly from the construction and operation of the wind farm when compared to an appropriate reference area. To include monitoring of the export cable route.

The Kentish Flats ES predicted no significant effects on the benthic communities arising from the placement of turbines, scour, cable installation or the use of jack-up vessels, with only small-scale, localised loss or disturbance of the seabed habitats. Mitigation and monitoring was set out in the ES in relation to the benthic communities.

3.7.2. Scope of Monitoring Studies

Monitoring annually (for a period of three years following construction of the foundations) at a subset of the sampling sites used during the pre-construction baseline survey (minimum 23 sites) and to include:

- 5 sites (minimum) within the wind farm area representing different habitat types and up/down drift conditions

- 3 sites (minimum) within the near field area of foundations to determine scour effects etc
- 8 sites (minimum) distributed around the wind farm within the area affected by sediment transport and deposition
- 3 sites along the export cable route
- 4 sites nearby but remote from the wind farm (controls). NB these should be outside of the tidal excursion and be spaced at reasonable distances around the development area.

Three replicate grab samples to be taken at each of the minimum number of sites.

3.7.3. Monitoring Completed

The seabed (benthic) ecology of the area has been monitored annually since the completion of the foundation installation and following collection of pre-construction data. The benthic ecology studies completed to date are summarised in Table 6. The benthic grab and beam trawl sampling sites used in the post-construction monitoring program (a sub-set of the baseline monitoring) are shown in Figure 27 & Figure 28.

Survey	Date	Summary of Survey
Pre-construction baseline survey	March 2002	46 sample stations (12 with replicates) covering the wind farm, export cable route, tidal excursions and reference area (total 70 samples). In addition 10 beam trawl samples collected.
Post-construction survey #1	June 2005 (following completion of foundation and cable installation)	23 samples sites covering the wind farm area, secondary impact areas and reference sites each with 3 replicates (total 69 samples). In addition 10 beam trawl samples collected.
Post-construction survey #2	May 2006	23 samples sites covering the wind farm area, secondary impact areas and reference sites each with 3 replicates (total 67 samples). In addition 10 beam trawl samples collected.
Post-construction survey #3	May 2007	Data being analysed

Table 6 Summary of Benthic Ecology Surveys Completed to date

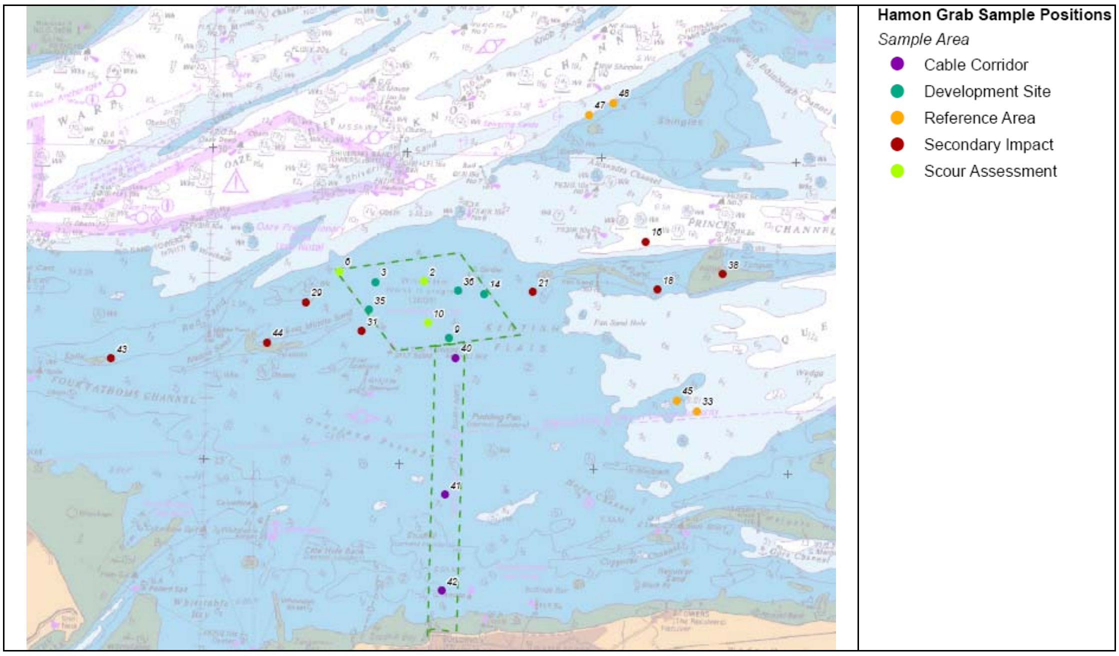


Figure 27 Kentish Flats Wind Farm Benthic Monitoring Grab Sample Sites

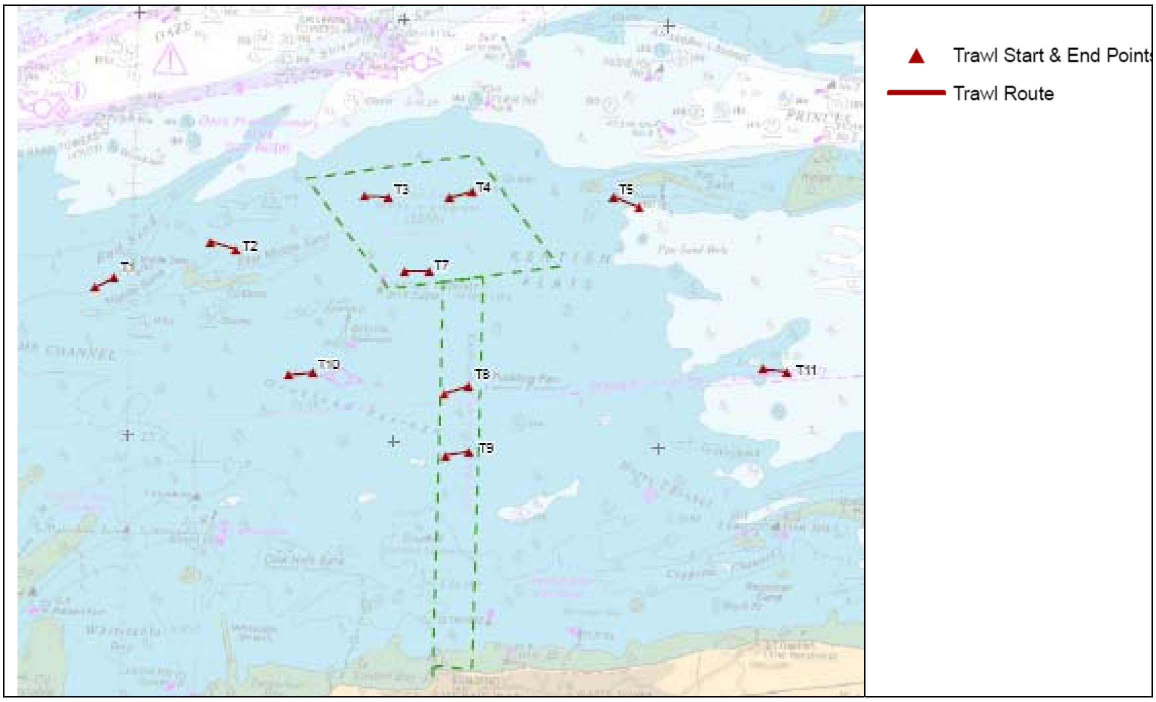


Figure 28 Kentish Flats Wind Farm Beam Trawl sampling Sites

In each case, benthic samples have been collected at each of the grab monitoring locations using a Hamon grab sampler which samples an area of seabed of $0.1m^2$. Samples for analysis for the benthic infauna and sediment characteristics have been collected in each case. Beam trawl samples have, in each case, been collected using a 2 metre scientific beam trawl with 5mm cod end towed over a distance of 500 to 1000 metres (data standardised for tow length). The data generated on infaunal and epifaunal macrobenthic species diversity, biomass and abundance together with seabed sediment characteristics have been analysed using a variety of univariate and multivariate techniques.

The monitoring reports have examined the nature of the benthos spatially and over time to investigate variations across the sampling area and also difference between surveys at the same sites that might be attributable to effects arising from the construction or operation of the Kentish Flats wind farm.

Full details of the pre and post construction benthic surveys together with results of these surveys are provided in the relevant monitoring reports (Emu, 2002; Emu, 2006c; Emu, 2007b).

3.7.4. Overview of Results

The most recently completed benthic ecology monitoring study (post-construction survey #2, samples collected May 2006) has compared the monitoring data with the baseline and reference data and provides the most up to date analysis of the trends in the benthic ecology of the Kentish Flats area. The following summary is drawn from this most recent analysis and focuses on the temporal changes in the seabed environment and associated benthic communities.

Temporal Variations in Seabed Sediments

The seabed sediment particle size characteristics were compared (using data from the baseline survey, monitoring survey #1 and monitoring survey #2) using multivariate statistical techniques. The results of the analysis are shown in Figure 29.

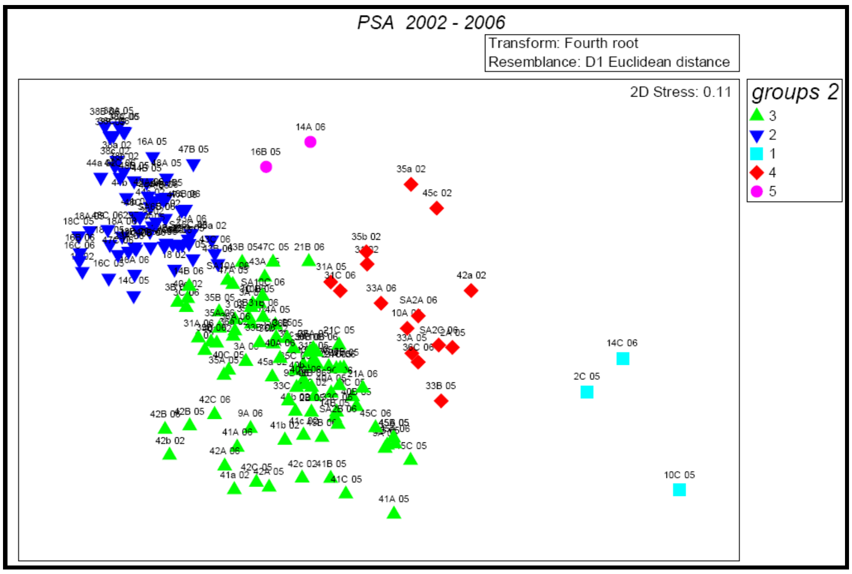


Figure 29 MDS Plot Comparing Particle Size Data from the 2002, 2005 & 2006 Kentish Flats Data sets

The analysis of the particle size data over the monitoring period shows a consistent pattern in the distribution of the various sedimentary environments between years. Inshore sites (particularly those along the export cable corridor) are characterized by heterogeneous sediments with a high silt content. Within the wind farm area and also at the inshore reference area, sediments are also heterogeneous but with a higher percentage of gravel. The sites to the east and west of the wind farm (the secondary impact sites) and at the offshore reference area are characterized by a more homogenous sedimentary environment composed mainly of sands.

Temporal Variations in Benthic Macroinvertebrate Communities

Multivariate analysis has also been used to investigate the temporal trends in the benthic invertebrate communities across the survey area and has considered both the infaunal and epifaunal components of these communities.

Analysis of the infaunal data derived from the grab samples over the monitoring period has allowed a description of the main faunal groups and their distribution across the survey area. The data analysis has also compared trends within each of the sampling areas shown in Figure 27 (i.e. development site, scour assessment, secondary impact, cable route, reference areas).

Multivariate analysis identified four main groups within the data when considering all of the data collected during the baseline and monitoring surveys (see Figure 30). These four groups are summarised in Table 7.

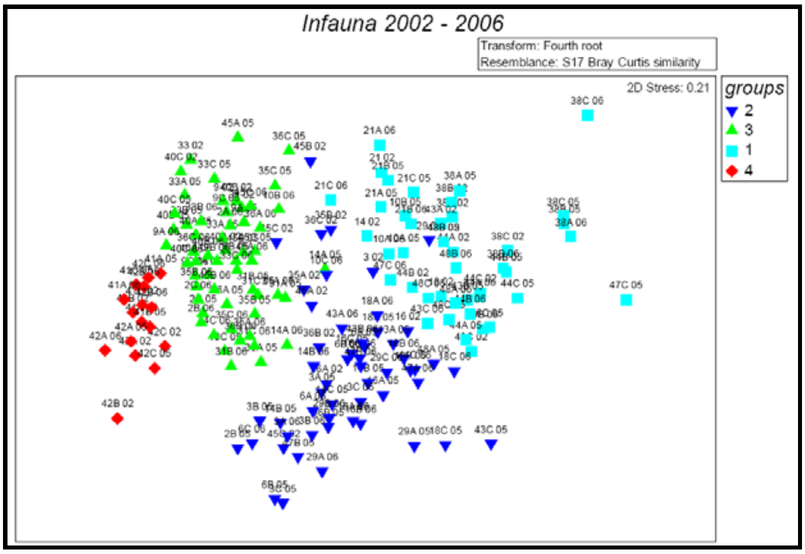
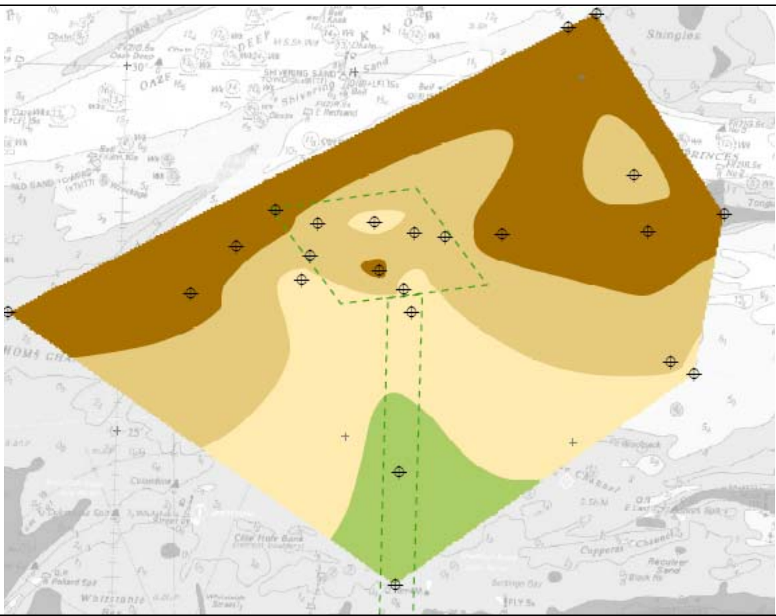


Figure 30 MDS Plot Showing Infaunal Groupings from the 2002, 2005 & 2006 Kentish Flats Grab Data sets

MDS Grouping	Summary of Grouping
1	Comprised the majority of replicate samples from the more offshore sites within the secondary impact and the reference area; characterized by sandy sediment and dominated by the polychaete worms *Nepthys cirrosa* and *Ophelia borealis* and the crustacean amphipod *Bathyporeia elegans*
2	Comprised the majority of the replicate samples from sites within the development area and the scour assessment sites. Some replicate samples from the more inshore sites within the secondary impact and the reference area to the south east of the development site also fell within this group. Characterized by sandy sediment with a high percentage of gravel and dominated by bivalves molluscs (*Abra alba* and *Fabulina fabula*) and the polychaete worm *Magelona johnstoni*
3	Some replicate samples from the development site, the scour assessment and the northern part of the export cable corridor. Characterized by sandy sediments with a high percentage of mud and gravel and dominated by the polychaete worm *Lanice conchilega* and *Spiophanes bombyx*
4	Comprised the replicate samples from the southern part of the export cable corridor. Characterized by mixed sediment with the highest percentage of mud and dominated by *Abra alba*, *Mediomastus fragilis* and the oligochaete *Tubificoides benedii.*

Table 7 Summary of Main Characteristics of the MDS Faunal Groupings

The distribution of the main faunal groupings is shown in Figure 31 allied to the main sedimentary environments across the survey area.



Legend

Kentish Flats Development Area & Cable Route (approx.)

Grab Sites

Habitat Regions

based on Natural Neighbour interpolation of PSA groups

- MOBILE SANDS (*Bathyporeia* and *Nephtys cirrosa*)
- STABLE SANDS (*Fabulina fabula* and *Magelona johnstoni*)
- GRAVELLY SAND (*Lanice conchilega*)
- MUDDY SAND (*Abra alba*)

Figure 31 Habitat Regions Based Upon Interpretation of the Multivariate Infaunal Data Analysis

Considering the trends in the infaunal communities over the monitoring period, temporal variations within the Kentish Flats development area were mainly associated with the abundance of the bivalve mollusc *A. alba* and the polychaete worms *L. conchilega*, *Scoloplos armiger*, *S. bombyx* and *M. johnstoni*. *A. alba* and *L. conchilega* showed a notable increase since the study began, both in terms of abundance and frequency of occurrence. Conversely, *S. armiger* and *M. johnstoni* showed a notable decrease over the monitoring period, whereas the abundance and frequency of occurrence of *S. bombyx* showed smaller fluctuation between years, and an overall decrease since the baseline survey. Increases of species abundances did not always reflect increases of the species frequency of occurrence, thus suggesting patchiness in the benthic communities. Sites 14 and 36 showed the largest variability within and between years, whereas sites 3 and 9 showed the highest similarity.

Within the secondary impact assessment area (situated along the tidal axis to the east and west of the wind farm area) temporal differences were primarily associated with an increase in the abundance of *A. alba* and the polychaete worm *O. borealis* over the monitoring period, whereas crustacean amphipods (e.g. *B. elegans*) and the polychaete *M. johnstoni* decreased. The white catworm *N. cirrosa* showed larger differences in terms of average distribution than average abundance between years. Sites 29 and 16 showed the highest variability, sites 21 and 31 the highest similarity.

Temporal variations within the export cable route corridor were associated with an increase of the average abundance and distribution of *A. alba*, *L. conchilega* and Euclymeninae species. The oligochaete *T. benedii* had declined since the study began.

Temporal variations within the reference area were associated with an increase of *A. alba and L. conchilega*, particularly with respect to the sites to the south east of the development area (33 and 45). The polychaete worms *N. cirrosa* and *S. bombyx* characteristic of the sites to the north east of the development site (47 and 48) also showed an increase over the monitoring period. It is noteworthy that stochastic recruitment events in the *N. cirrosa* population may affect the population size of other polychaetes present, creating a degree of variation in the community composition. The reference sites to the north east of the development site showed a higher degree of similarity within and between years.

The scour assessment sites showed an increase in average abundance and distribution of the mollusc bivalve *F. fabula*, and the polychaetes *L. conchilega* and *S. bombyx*, whereas *A. alba* and *N.cirrosa* decreased.

Epifaunal communities were investigated using the data derived from the beam trawl samples collected over the monitoring period. No temporal pattern of species distribution across the survey area was identified with respect to the epibenthic species from the trawl samples. Amongst the mobile epifauna, crustaceans and molluscs were evenly distributed across the survey area during all three survey occasions and species composition remained relatively constant between years, with crabs (*Pagurus bernhardus*) and shrimps (*Crangon crangon*) being the most widespread species on all survey occasions. Temporal differences were recorded with respect to occurrence of the crab *Macropodia rostrata* and *Hyas coarctatus*, which showed wider distribution across the survey area in 2006.

Amongst the molluscs the gastropods *Buccinum undatum* and *Crepidula fornicata* remained dominant in terms of frequency of occurrence during all survey occasions. Temporal differences were observed with respect to the little cattlefish *Sepiola atlantica* and the dog whelk *Hinia reticulata* whose distribution across the survey area increased in 2006. The bivalve *Mytilus edulis* also showed a higher frequency of occurrence in 2006. Echinoderms showed the least temporal variations, with *Asterias rubens*, *Ophiura ophiura* and *Psammechinus miliaris* being the most widespread species over time. Temporal fluctuations of both distribution across the survey area and abundance were inconspicuous.

Sessile epifauna from the trawl samples showed higher species diversity in 2006 and a larger distribution across the survey area. Newly recorded species in 2006 included *Clytia hemisphaerica* and *Sertularia argentea* which occurred in the majority of the trawl samples.

3.7.5. Conclusions

The results from the most recent monitoring study have been compared with the data collected during the baseline, pre-construction survey and the first post-construction study. The comparative analysis indicates that the pattern of sediment distribution across the survey area has been maintained over time. Temporal variations within each impact area were not significant, each area retaining a high degree of similarity between years.

Consideration of the trends in the infaunal communities recorded over the monitoring period indicated that the general distribution of the main macrofaunal assemblages has not changed over the monitoring period. No evidence of change attributable to the construction of the Kentish Flats wind farm is evident from the monitoring data.

However, temporal variations have occurred over the monitoring period in terms of the nature of the faunal assemblages. Comparing the post-construction data with that collected during the baseline study indicated variation in both species abundance and species type. In general, the faunal assemblages recorded in 2006 were indicative of a higher degree of stability than that previously recorded. The intra sample variability recorded in 2006, was much lower than that in 2002. In addition, the community comprised a notably higher abundance of *A. alba*, *L. conchilega* and *F.fabula*, all of which are indicative of relatively stable sediments. All of these species showed a consistent increase since the baseline study and are likely to have contributed to the establishment of new communities, particularly *L. conchilega*. The tube which this worm builds contributes to providing structure within the sediment, consolidating it and enabling the influx and establishment of other species. This was reflected in the overall increase of the species diversity and abundance recorded in 2006.

It should be noted that these changes to the benthic assemblages are not attributed to the effects of the Kentish Flats construction. These are considered to be broadscale, natural variations in the benthic communities attributable to natural fluxes in species composition, diversity and abundance.

The lack of significant changes to the seabed environment attributable to the construction of the wind farm, and indeed the natural variations within the area, have been confirmed by a number of the other monitoring studies completed to date. Monitoring of the seabed during both the debris and scour surveys has confirmed that only localised changes can be attributed to the effects of the wind farm (scour around the turbine structures) whilst the broader area between the turbines has not shown any significant change in either the nature of the seabed or the topography of the site. These surveys have confirmed that the cable installation has not resulted in significant change in the seabed and have also confirmed that depressions caused by the jack-up vessels are naturally infilling. These physical monitoring studies add weight to the conclusions drawn by the benthic monitoring studies that no gross changes to the seabed have occurred and where effects have been seen (for example cable routes, jack up depressions) the nature of the seabed means that benthic recovery would be expected.

The fish surveys have also not shown any change in the fish communities in and around the wind farm, beyond the natural variations which have also been observed at the control area. These surveys also tend to confirm that there has been no gross change in the ecosystem in and around the wind farm area.

Surveys of operational subsea noise and the faunal colonisation of the subsea structures have yet to be reported (see Sections 3.11 and 3.12). The results of these surveys will be considered in relation to the benthic monitoring data in the next monitoring summary report.

The benthic monitoring program (and associated seabed surveys) has confirmed the predictions set out in the Kentish Fats ES with no significant effects on the benthic communities away from the small areas occupied by the foundations or affected by the localised scour.

3.7.6. Recommendations

It is recommended that the final year of benthic data (collected in May 2007) should be analysed and compared to the previous monitoring and baseline data sets in order to complete the three year post-construction monitoring requirement.

The lack of any broadscale change in the benthic communities attributable to the wind farm and the small-scale effects on the seabed sediments (attributable to localised scour around the structures) demonstrated by the monitoring to date has confirmed the predictions in the Kentish Flats ES. Therefore no further monitoring of the benthic communities is currently considered necessary.

3.8. *Intertidal Habitats (FEPA Licence Annex 1 Item 4)*

3.8.1. Purpose of Monitoring Condition

To monitor potential effects on the intertidal habitats arising from the installation of the export cables at Hampton Pier, Herne Bay.

The Kentish Flats ES predicted that, where trenching of the cables were to be used to install the export cables, some temporary small scale disturbance of the intertidal habitats would occur. This was considered to be of low significance although mitigation was set out to reduce the area affected.

3.8.2. Scope of Monitoring Studies

Monitoring of the lower mid and upper shore along three transects running perpendicular to the shoreline in the area of the export cable installation. The precise details to be finalised depending on the methodologies used for the cable installation.

3.8.3. Monitoring Completed

Pre-construction, baseline monitoring of the intertidal habitats was completed at the end of September 2004. Triplicate core samples were taken at locations on the upper, mid and lower shore along each of three transects as shown in Figure 32 (two transects in the area of cable installation and one further east away from the anticipated area of disturbance). Samples were analysed for particle size characteristics and invertebrate fauna and the data described using a variety of univariate statistical techniques.

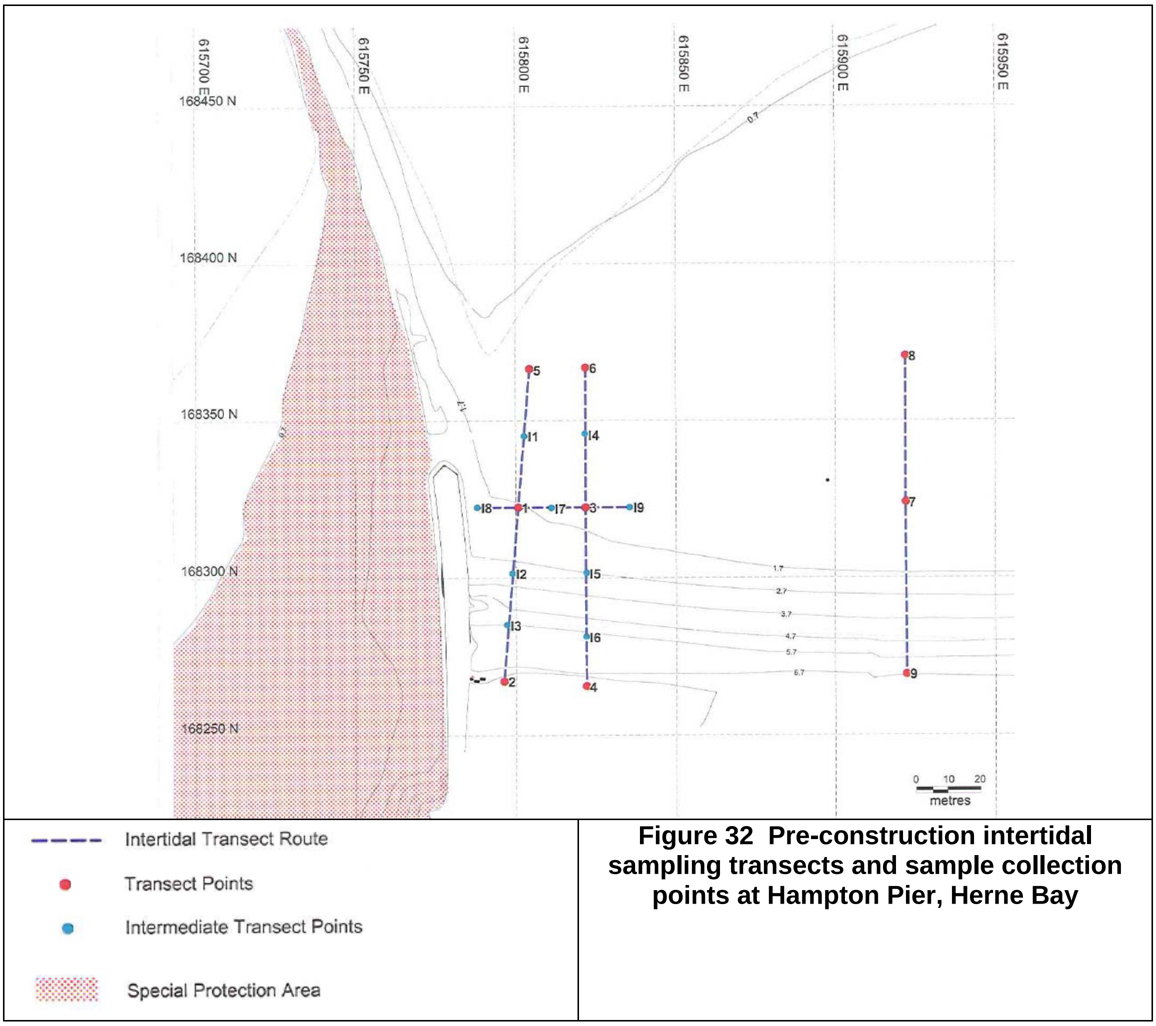


Figure 32 Pre-construction intertidal sampling transects and sample collection points at Hampton Pier, Herne Bay

Full details of the pre-construction intertidal monitoring are provided in Emu (2005g).

Post-construction monitoring was not undertaken due to the final choice of installation technique. Rather than using trenching across the intertidal area, directional drilling was used from behind the sea wall, emerging in the shallow subtidal. Therefore disturbance to the intertidal area was minimal and post-construction monitoring was not considered necessary. M&FA (formerly part of Defra) were informed of the intention not to complete post-construction monitoring by letter (dated 25/5/05).

3.8.4. Overview of Results

The pre-construction intertidal survey characterised the upper, mid and lower shore adjacent to Hampton Pier, Herne Bay. Sediments on the beach varied from gravelly upper shore to sand or mud in the mid-shore and sand in the lower shore (see Figure 33). Anoxic mud was noted beneath upper sands at both mid and lower shore sites.

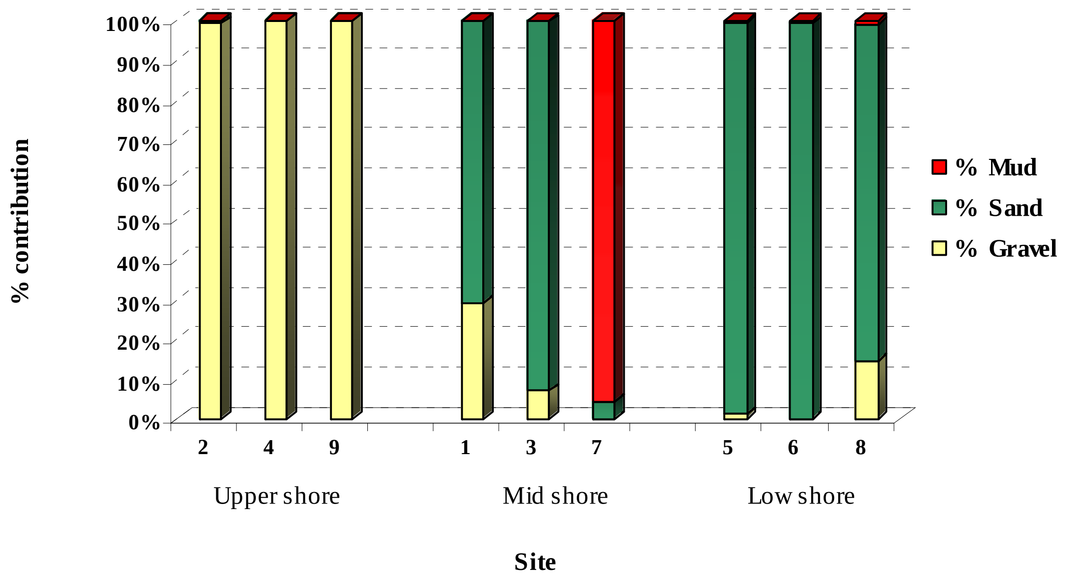


Figure 33 Sediment Composition at Sampling Transects (Upper, Mid and Lower Shore) - Baseline Intertidal Survey

Faunal diversity and abundance was low at all sites, with two of the three upper shore sites being abiotic (with no fauna recorded). Diversity was greater at mid shore sites, being dominated by polychaete worms such as *Hediste diversicolor* and *Arenicola marina* and bivalve molluscs such as *Hydrobia ulva* and *Macoma balthica*. Lower shore sites had the greatest diversity and abundances (total 9 species from all stations) with the polychaete worms dominating alongside bivalve mollusc species.

3.8.5. <u>Conclusions</u>

The intertidal sedimentary habitats adjacent to Hampton pier were characterised by impoverished infaunal communities with greatest diversity and abundance noted form the lower shores.

(a) Directional drilling works compound behind coastal defence wall

(b) emergence of directional drilled cable and offshore cable plough ready for offshore pull

(c) Directional drilling equipment

Figure 34 (a – c) Photographs showing Installation of the Intertidal Export Cables by Directional Drilling & Lack of Disturbance to the Intertidal Habitats

The final selection of directional drilling techniques for the installation of the export cables meant that no significant disturbance of the intertidal habitats occurred (as would have been the case had open trenching techniques been used – both from trenching and use of heavy plant on the beach). Lack of significant physical disturbance meant that post-construction intertidal monitoring was not considered necessary.

3.9. Monitoring of Contaminants in Oyster Flesh (FEPA Licence Annex 1, Item 3)

3.9.1. Purpose of Monitoring Condition

To monitor the nature and level of contaminants in the flesh of oysters collected around the export cable route (within the main oyster beds). To provide evidence, in co-operation with the local fishing industry and public health authorities that the construction process has no adverse affect on the Whitstable oyster beds.

The issue of impacts on oysters was addressed in the Kentish Flats ES (impact statement 35). The assessment process predicted that an increase in suspended solids during export cable installation could occur which had the potential to affect the water quality within the designated shellfish area. Monitoring of oysters for contaminant loading was proposed by the ES to act as a check on this potential impact (see also Section 3.5 – monitoring of suspended solids).

3.9.2. Scope of Monitoring Studies

To collect oysters from points within the export cable route corridor and at a reference point further afield. Flesh from oysters collected at each site to be analysed for a range of potential contaminants, comparing contaminant levels prior to and following cable installation.

3.9.3. Monitoring Completed

Pre-construction monitoring was completed in June 2004 (prior to cable installation) with post-construction monitoring completed in June 2005 (following completion of the cable installation). In each case oysters were collected at four sites (see Figure 35). Sampling was completed using a local oyster fishing vessel from Whitstable, using a standard oyster dredge. Between 5 and 10 oysters were collected at each site, sufficient to provide enough dried residue for analysis.

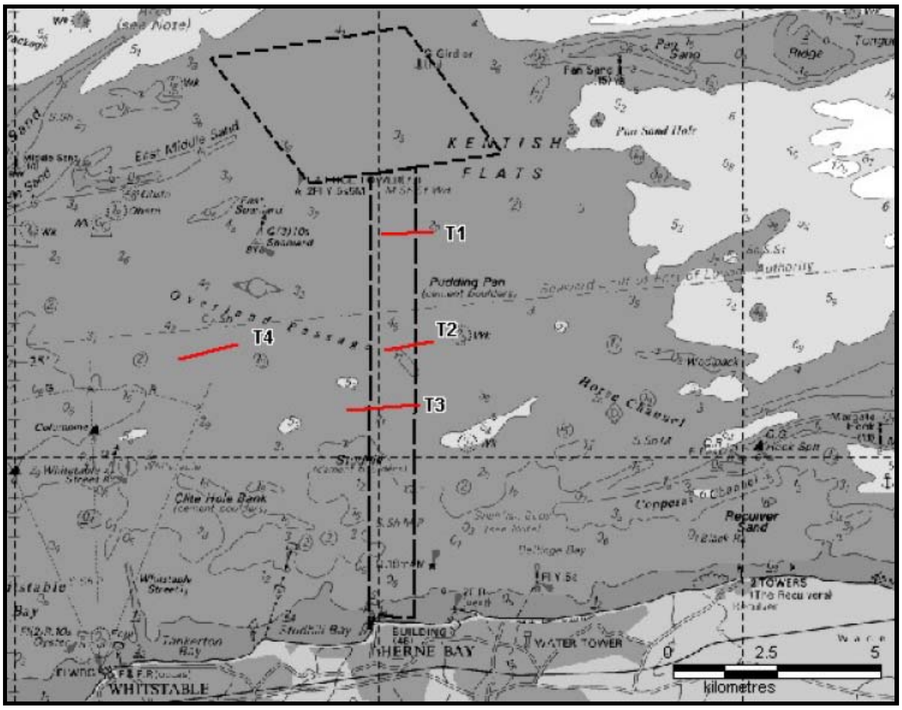


Figure 35 Oyster Monitoring Collection Sites

Oyster flesh was extracted and dried and was subsequently analysed for the following contaminants:

- Metals (Chromium, nickel, copper, zinc, arsenic, cadmium, lead, mercury and silver)
- Chlorinated biphenyls and pesticides including DDT, DDE & TDE, Organohalogens (alpha-HCH, beta-HCH, gamma-HCH, HCB), Dieldrin and polychlorinated bi-phenyls (PCBs).

Analysis of the oyster flesh was undertaken by the CEFAS laboratories at Burnham-on-Crouch.

3.9.4. Overview of Results

The results of the pre and post construction monitoring are set out in Table 8. Percentage change in the contaminants recorded from oysters collected from the cable route is compared with the percentage change at the reference area to the west as an indication of the natural variation in contaminant levels between the two sampling occasions.

	Mean Concentration mg/kg (adjusted wet weight) (Figures in parentheses = standard deviation)			
	Pre-construction cable route	Post Construction cable route	% Overall Change in cable route	% Change in Reference Area
As	1.26 (0.05)	1.22 (0.10)	-3.56	-13.63
Cr	0.17 (0.06)	0.50 (0.16)	193.33	523.33
Ni	0.15 (0.04)	0.31 (0.13)	104.00	178.18
Cu	78.48 (30.01)	61.09 (10.66)	-22.17	-59.93
Zn	482.06 (39.94)	357.91 (82.07)	-25.76	-26.82
Cd	0.56 (0.09)	0.56 (0.19)	0.78	-40.27
Pb	0.08 (0.01)	0.21 (0.07)	162.79	99.75
Hg	0.017 (0.012)	0.022 (0.003)	32.60	-15.00
Ag	0.06 (0.09)	0.09 (0.01)	47.63	223.00
ICES7 PCBs	0.01 (0.004)	0.005 (0.001)	-23.50	-24.27
SUM 25 PCB'S	0.02 (0.01)	0.01 (0.001)	-54.67	-50.76

Table 8 Summary of Mean Concentration of Contaminants in Oyster Flesh (Pre & Post Construction & % Change at Cable & Reference Sites.

Comparing the percentage change in the concentrations of these contaminants before and after cable installation, a number of changes are apparent. The data show an overall decrease in the levels of arsenic, copper, zinc, cadmium, and total PCBs in oyster tissues. Cadmium levels within the cable route area remained largely unchanged. Increases in the level of chromium, nickel and silver since the cable installation were mirrored by similar increases at the reference area site, indicating natural variation in the levels of these trace metals across the survey area. The mean lead and mercury concentrations increased over and above both the baseline level and in comparison to the values from the reference site (although in the case of lead a notable increase at the reference area following construction was also evident).

The overall levels of contaminants recorded during both studies were compared to historic oyster contaminant data from North Kent and from all commercial shellfish areas in England and Wales. It is noted from the historic data that the Thames estuary as a whole exhibits high concentrations of several metals when compared to national values (likely to be derived from riverine inputs, discharges and industrial sources), although the highest levels are associated with the upper estuary, further upstream from the Kentish Flats. However for the majority of the contaminants considered, levels during both the pre and post construction surveys fell within relevant guideline or standard concentrations (zinc was high but was also noted as being elevated during the historic sampling off North Kent - at levels well above those recorded during the Kentish Flats monitoring).

Statistical analysis of all of the data revealed a significant change between the pre and post construction surveys in concentrations of lead and chromium (in the case of chromium changes at the reference area were particularly high). Comparison to the historic data collected locally indicates that lead exceeded the maximum value previously recorded whilst chromium levels were within the range noted during the previous studies. However, levels of lead were below the current regulatory guidelines for shellfish.

Levels of PCBs and pesticides were either below the level of analytical detection or well within the relevant guideline levels.

3.9.5. Conclusions

The analysis of the contaminant data, comparing concentrations before and after the export cable installation, revealed a number of changes in the levels recorded. In all cases these were attributable to natural variation. In all cases the levels were within relevant guidelines and standards and in most cases well within the levels recorded from the North Kent area during previous surveys. It was concluded that the analysis of the oyster flesh revealed no evidence of any effect on contaminant loading attributable to the Kentish Flats construction program.

The results tend to confirm the findings of the suspended solids monitoring which identified only limited increases during the installation of the export cables suggesting that only a relatively small area was affected by the sediment disturbed by the cable laying.

The monitoring has, however, acted as an appropriate check on the prediction set out in the ES and has confirmed that effects arising from the export cable installation on the oyster habitats were of low significance. The contaminant sampling has also acted as a safeguard against any adverse public health effects that could have arisen should cable laying have led to a decrease in water quality or the quality of oysters landed from the Whitstable beds.

3.10. Monitoring of Fish (FEPA Licence Item 9.6 & 9.7)

3.10.1. Purpose of Monitoring Condition

To monitor the populations of fish within the wind farm area before and after construction in order to increase the understanding of the influence of wind farms in enhancing or aggregating fish.

Effects on fish species were predicted to be of low significance in the Kentish Flats ES (impact statements 34 to 40). Small-scale disturbance of fish habitat or avoidance of construction activity by fish was predicted but longer term effects were not expected to occur. The ES set out a number of proposals for mitigation.

3.10.2. Scope of Monitoring Studies

In conjunction with local commercial fishing interests, seasonal monitoring of fish populations within the wind farm before construction and in the first year following construction. The survey program should consider both pelagic and demersal species and should be conducted in liaison with the project Fisheries Liaison Officers (FLOs) in ensuring the safety of those engaged in other fishing operations on the wind farm site.

3.10.3. Monitoring Completed

Pre-construction monitoring of the fish populations within the wind farm area was completed during spring and summer 2004, prior to the installation of the turbine foundations. Subsequently, four post-construction surveys were completed following the installation of the foundations and offshore cables. The fish monitoring surveys completed and the sampling gear used during each survey are summarised in Table 9.

Study	Date of survey	Gear used	Reporting
Kentish Flats Baseline Fisheries Survey 1 – Field Survey Report	April 2004	Triple rigged otter trawl	Field survey report only
Kentish Flats Baseline Fisheries Survey 2 – Field Survey Report	June 2004	Bass Trawl	Field survey report only
Kentish Flats Baseline Fisheries Survey 3 – Field Survey Report	August 2004	Triple rigged otter trawl	Field survey report only
Kentish Flats Baseline Fisheries Surveys report	-	-	Summary report of data collected during pre-construction fisheries surveys as a baseline for post-construction monitoring
Kentish Flats Post-construction Fisheries Survey 1 – Field Survey Report	July 2005	Bass Trawl	Field survey report only
Kentish Flats Post-construction Fisheries Survey 2 – Field Survey Report	October 2005	Triple rigged otter trawl	Field survey report only
Kentish Flats Post-construction Fisheries Survey 3 – Field Survey Report	March 2006	Triple rigged otter trawl	Field survey report only
Kentish Flats Post-construction Fisheries Survey 4 – Field Survey Report	June 2006	Triple rigged otter trawl	Field survey report only
Kentish Flats Fisheries Comparative Study	-	-	A full data analysis report comparing pre and post construction data.

Table 9 Summary of Fish Monitoring Studies Completed at Kentish Flats

On each occasion trawls were completed at each of four trawl lines within the wind farm and at two separate reference areas (see Figure 36).

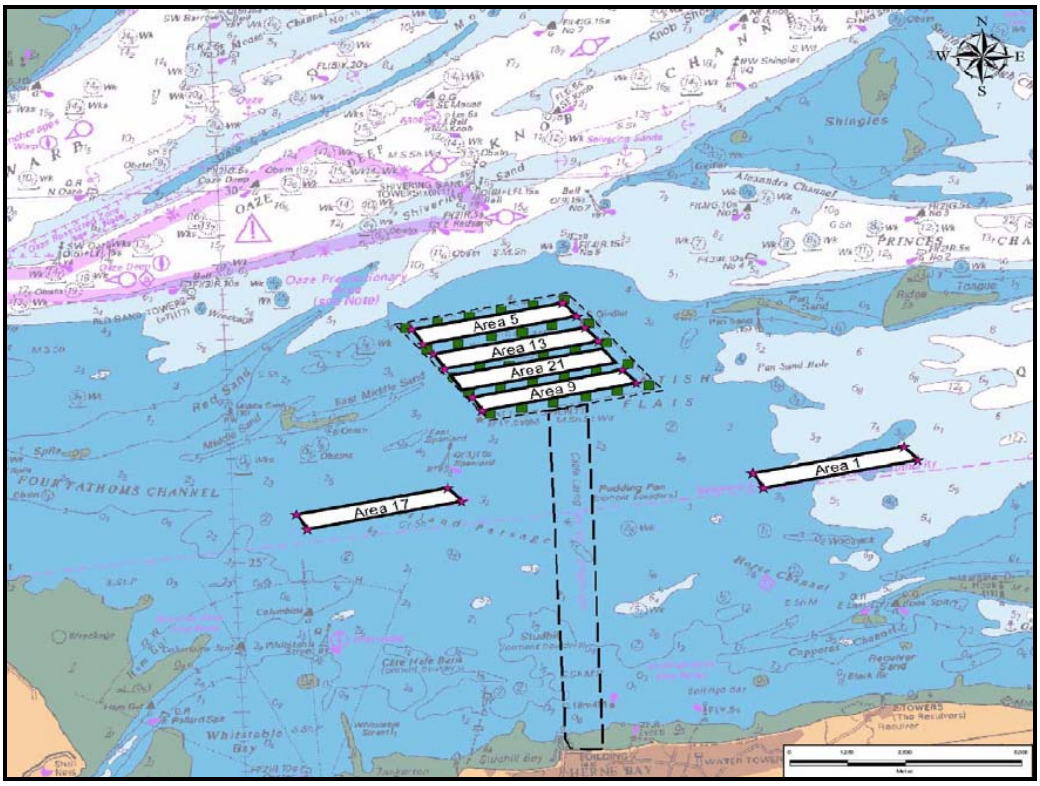


Figure 36 Location of Kentish Flats Fish Monitoring Trawl Sampling Locations

On each occasion either a triple rigged otter trawl or a single net bass trawl was used to sample demersal or pelagic species respectively (see Table 9). The trawls were deployed at the start of the pre-determined 2km trawl lines and towed at a steady rate until the end of the trawl line. Fish retained were identified, enumerated and measured. The sampling gear used was selected as it reflects that normally used during commercial fishing activity within the Thames Estuary.

Catch Per Unit Effort (CPUE) was calculated for each of the samples and represented as numbers of fish per 10,000m^2 of seabed trawled.

Full details of each of the surveys completed, the results of the findings and the data analysis and interpretation can be found in the relevant fish monitoring reports (Emu, 2004a; Emu, 2004b; Emu, 2004c; Emu, 2004d; Emu, 2005h; Emu, 2005i; Emu, 2006d; Emu, 2006e; Emu, 2006f).

3.10.4. <u>Overview of Results</u>

The CPUE data derived from each of the pre and post construction surveys has been compared in order to evaluate any apparent changes in the fish populations within the wind farm when compared to the reference areas. Consideration has been given to both the population of fish (by CPUE) and the diversity of the fish community (by number of species) in assessing the pre and post construction data.

Figure 37 compares the CPUE for each survey for the wind farm area, the reference area and for all samples combined.

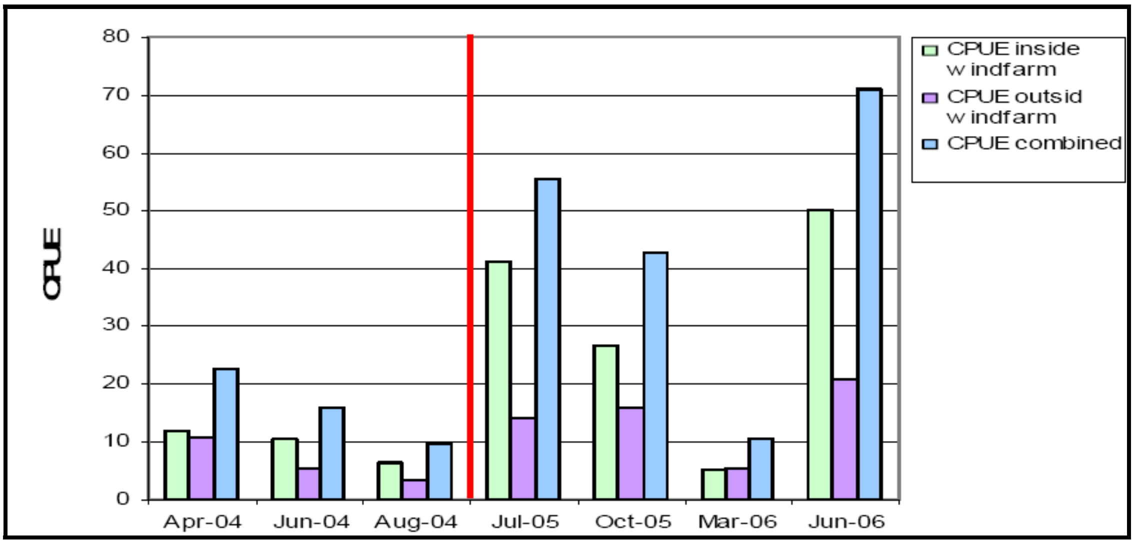


Figure 37 CPUE for all Species During Each Sampling and For Wind Farm & Reference Areas

Figure 37 shows the actual CPUE values for all surveys and Figure 38 and Figure 39 illustrate the numbers of species identified using the two types of survey gear, both pre and post construction.

In 2004 otter trawl surveys were conducted in April and August. The data indicate that the CPUE figures, in both the wind farm and reference areas, were higher in April when compared to August. Similarly Figure 38 indicates that the number of species retained was higher in April than August. The otter trawl surveys conducted post construction, during 2005, indicates a drop in the combined CPUE values between July and March, principally due to a drop in the CPUE inside the wind farm. However, the minimum in March 2006 was similar to minimum values in the pre-construction period. A less pronounced change was evident for the numbers of species, which reduced from 12 species identified in July to 10 species in March 2006.

Taking into account the Bass trawl data in the overall CPUE changes, it was evident that a considerable increase in catch occurred in both July 2005 and June 2006 compared to June 2004 and in relation to all other survey periods, both inside and outside the wind farm site. An increase in the number of species caught was also noted from the bass trawl data with 13 species in 2004 and 18 in 2006 (Figure 39).

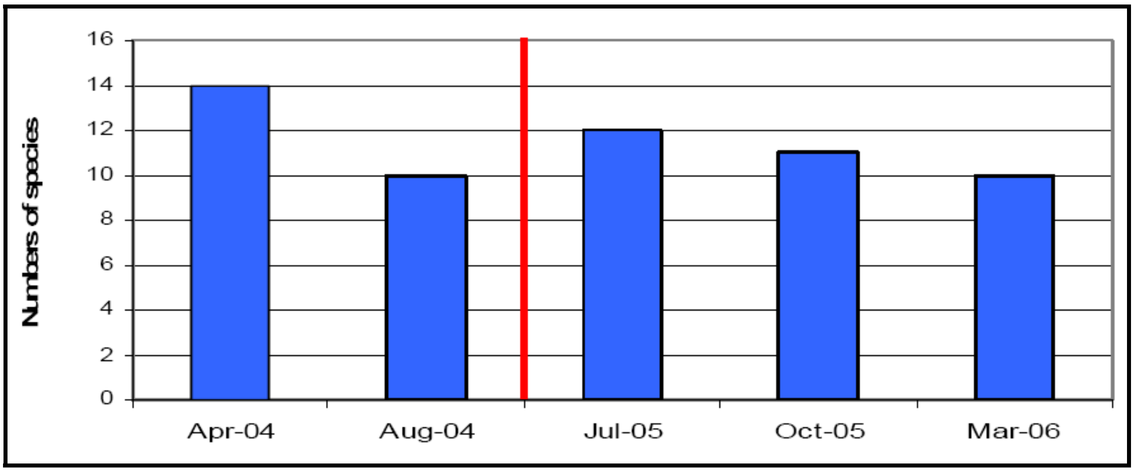


Figure 38 Numbers of Species Recorded On Each Survey Occasion Using an Otter Trawl

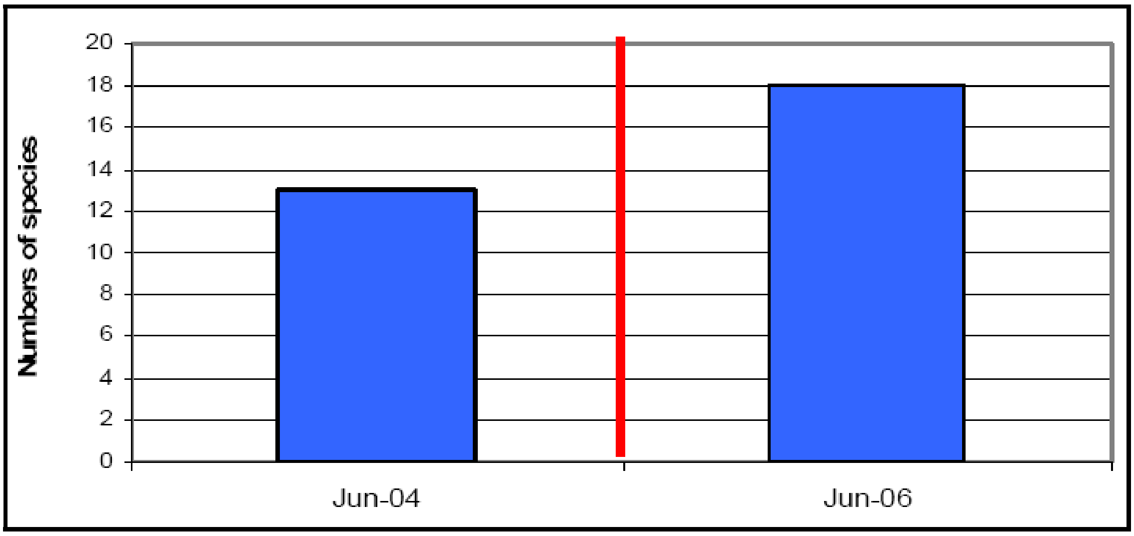


Figure 39 Numbers of Species Recorded On Each Survey Occasion Using a Bass Trawl

3.10.5. Conclusions

One clear trend that emerged from the data is that, in terms of catch per unit effort, values generally tended to be higher inside the wind farm area than in the reference area for most of the species studied, regardless of the fishing method used. This trend continued after construction was completed.

During the summer surveys, CPUE increased both inside the wind farm site and inside the reference areas. Numbers and CPUE values of bass, Dover sole, plaice and flounder were highest in the July 2005 otter trawl surveys, whilst dab, thornback ray (roker) and smooth hound were recorded in highest abundances during the June 2006 bass trawl survey.

Pre and post-construction bass trawl surveys were conducted during the month of June in 2004 and 2006 respectively. When all individuals caught were taken into account, the post-construction survey yielded greater numbers of individuals and higher CPUE values of bass, plaice, dab, thornback ray (roker), smooth hound and flounder. Dover sole, in contrast, was caught in greater numbers with higher CPUE values in 2004, although it should be noted that bass gear is not appropriate to survey for this species of fish.

The variation of the numbers of individuals and their corresponding CPUE at any specific location is reliant on a range of environmental factors, particularly in relation to migration. For example, variation in Dover sole numbers have been reported in other UK fisheries, with seasonal and annual fluctuations in sea water temperature cited as the most important contributory factor. The changes observed in the current study fall within those that could be anticipated for natural variation and no clear affect of the wind farm can be inferred from the data.

Similarly seasonal bass movement and feeding patterns seem to be strongly affected by water temperature, although tides, light intensity and wind strength also contribute. Bass are active predators, and while they are known to feed in preferred areas, they are a pelagic fish and highly mobile, with differing migratory patterns based on age of the individuals. The changes in the numbers of these fish and the fluctuation in population structure noted in the current study is likely to be due to the natural mobility of a population reaching maturity (> 3 years old), although with significant contribution, evident in 2005, of a new year class of less than 3 year old fish, which are likely to be largely resident in the Thames area. No differences were observed in terms of population structure between the wind farm and reference areas post-construction.

The monitoring data suggests that it is most likely that the changes in fish populations observed are driven by natural variation in physical conditions, rather than any effects of the Kentish Flats wind farm.

Several of the species caught in the area, including the thornback ray (roker), smooth hound and other elasmobranch populations can potentially be affected by electromagnetic forces (EMF) associated with wind farm sub-sea cables. The CPUE derived from the monitoring data for thornback rays indicates an increase in numbers year on year from 2004. This increase mainly occurred in the summer months, with CPUE increasing from 3.32 in

June 2004, to 13.06 in July 2005, up to 29.93 in June 2006. Of particular relevance to the impact of the EMF, there is no discernable difference between the data for the wind farm and the reference areas, including the population structure changes; therefore it is unlikely that the observed increase is due to the locality and operation of the Kentish Flats wind farm.

In summary the surveys carried out as part of the Kentish Flats fish monitoring study do not indicate that the construction or operation of the wind farm has had a deleterious effect on fish populations within the area. The relatively few changes identified, are likely to be due to the inherent natural variability of the populations investigated.

The results of the other monitoring studies tend to confirm the results of the fish monitoring studies. The bathymetric and side scan sonar surveys of the wind farm area (Sections 3.3 and 3.4) have demonstrated that there have been no gross changes to the seabed following construction. The benthic invertebrate monitoring studies have similarly demonstrated that any changes in the distribution or nature of the benthic communities are due to natural variability with no effects attributable to the wind farm construction or operation (apart from the small areas of scour around the structures). Operational subsea noise monitoring and the monitoring of the colonisation of the subsea structures will be reported during 2007 and will be considered in the next monitoring report, including comment on the implication of the findings on fish populations.

The findings of the fish monitoring have served to confirm the predictions made by the Kentish Flats EIA whereby only temporary and small scale effects were predicted but with no longer term effects on fish populations within the wind farm area.

3.11. Monitoring Operational Underwater Noise (FEPA Licence Item 9.5 and Annex 1 – item 6)

3.11.1. Purpose of Monitoring Condition

To collect data during the post-construction (operational) phase on the frequency and magnitude of underwater noise and vibration produced by the Kentish Flats wind farm.

3.11.2. Scope of Monitoring Studies

Deployment of monitoring equipment to monitor underwater noise and vibration derived from the operation of the Kentish Flats wind turbines and taking account of variations in water depth sediment type etc. The monitoring should take account of the effects of varying distance from the sound source and include appropriate measurements of background noise levels.

The data should be used, in conjunction with data derived from the biological monitoring program, to elucidate any interactions between noise generation and the provision of new habitat and fish aggregation effects of the turbine support structures.
It is noted in the FEPA licence condition that collaborative studies (such as COWRIE research projects) would be an acceptable means of fulfilling this condition.

3.11.3. Monitoring Completed

Underwater noise measurements were completed at the Kentish Flats offshore wind farm by Subacoustech in May 2007 as part of the COWRIE sponsored research program.

The survey methodology employed by subacoustech during noise measurements at offshore wind farms (as employed at Kentish Flats) is set out under Appendix A.

3.11.4. Overview of Results

It is expected that the results of the Subacoustech monitoring will be reported to COWRIE during 2007.

Subsequent to the publication of the COWRIE report, a synthesis of the results from the Kentish Flats monitoring will be prepared as part of the next Kentish Flats monitoring summary report. The data will be interpreted with regard to the findings of the benthic ecology, fish monitoring and epifaunal colonisation survey set out in Sections 3.7, 3.10 & 3.12 respectively.

3.12. Colonisation of the Subtidal Structures (FEPA Licence Annex 1 – Item 4)

3.12.1. Purpose of Monitoring Condition

To monitor the colonisation of the turbine foundations by invertebrate species and accompanying fish assemblages.

3.12.2. Scope of Monitoring Studies

Through appropriate video (remote or diver operated) observations and appropriate sample collection, describe the colonisation of the Kentish Flats subsea turbine structures.

3.12.3. Monitoring Completed

A one-off diver survey is scheduled for completion in July 2007. The survey will deploy divers and through the use of appropriate video techniques will record the invertebrate and fish diversity associated with the Kentish Flats subsea structures.

3.12.4. Overview of Results

The results of the colonisation study will be reported in the next monitoring summary report. The data will be interpreted with regard to the findings of the COWRIE underwater noise study summarised under Section 3.11 above.

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Appendix A Subacoustech Noise Monitoring Specification

Title	Specification for underwater noise and vibration measurement at Offshore Wind Farms
Project Number	544
Investigators	S J Parvin, J R Nedwell, A Brooker and R Workman
Company	Subacoustech Ltd
Report Number	544MeasurementSpecification.
Date	26 April 2007

Introduction

As part of the license granted for the development of an offshore wind farm the Food and Environmental Protection Act (FEPA) Licence 31272/02/0, as amended, places a requirement on the developer to carry out monitoring of underwater noise and vibration from the wind farm during the operational phase of its lifecycle.

This document details the specification that Subacoustech Ltd use for measuring and rating the effect of underwater noise from an offshore wind farm on marine wildlife. The monitoring strategy is described along with requirements for underwater noise measuring equipment that will be provided by Subacoustech.

Response to noise is subjective and affected by many factors (acoustic and non-acoustic). In general, the likelihood of a response from marine wildlife depends on factors including the margin by which it exceeds the background noise level, its level relative to the species' hearing ability and its frequency content.

The measurement of underwater noise at the Kentish Flats site is being conducted by Subacoustech on behalf of COWRIE, and is part of a programme of measurement and assessment of underwater noise and vibration from offshore wind farms. The measurement programme involves deploying calibrated hydrophone and geophone sensors over the side of a small survey vessel and recording the noise and vibration at locations inside and outside of the operational wind farm.

Measurement strategy

In order to provide a detailed characterisation of the noise produced by an offshore wind farm, measurements of underwater noise will be undertaken in the following manner. This strategy is based on an appreciation of the potential underwater sound generation mechanisms from wind turbines, and extensive experience in the measurement and assessment of underwater sound.

Measurement locations

The measurements will be taken along transect lines which extend radially from the centre of the turbine array. The measurements will extend to a distance outside the farm at which any wind farm noise contribution falls below the level of background noise or so that a reasonable assessment of this distance may be made using a suitable propagation model, subject to practical considerations such as boat safety. Condition 9.15 of the FEPA licence states that provision must be made during the construction phase of the windfarm to monitor subsea noise and vibration during the operation phase. However, given that underwater noise varies significantly with distance, regular measurement at a variety of locations will provide greater insight into the potential environmental impact of underwater noise. Fixed position measurements are therefore not to be undertaken as part of this survey.

Hydrophone depth

Measurements will be taken at two depths below the surface to elucidate any variations with depth in the water column. The water depth, within the constraints of the wind turbine array will be reviewed, and two hydrophone depths selected. As the site is comparatively shallow, the possible range of water column depths at the suggested measurement locations at any given time will be between 0 m and 10 m. To define strictly comparable measurement depths for all locations and tide states would be impossible. It is therefore suggested that, where possible, 3 m and 7 m depth measurements are taken, with half water column depth measurements where the water column is less than 5 m deep.

Ancillary measurements

At each measurement location the measurement conditions will be noted, these will include:

a) sea state;
b) wind speed;
c) exact location (to within 20m);
d) hydrophone depth;
e) water column depth;
f) any local shipping traffic;
g) turbine rotational velocity,
h) measuring equipment settings,
i) number of operating turbines and
j) other relevant information.

Vibration measurements

Measurements of the seabed vibration in the vicinity of the wind turbine are very difficult to obtain. This is because seabed vibration is subject to a large amount of error on seabed sediment as adequate geophone/accelerometer mounting is difficult to achieve. Of more relevance is that seabed vibrations will induce acoustic waves in the water. These can be measured far more accurately using a low noise hydrophone.

As part of this measurement programme, Subacoustech will, however deploy a geophone on a seabed suction plate and will measure seabed vibration in close proximity to operating turbines. Background measurements will be obtained by undertaking similar measurements away from the wind farm development.

Measuring equipment

To allow an assessment of the potential impact of underwater noise, the measuring equipment will meet the following specification.

Frequency range

To assess the response of local marine wildlife to underwater noise, the measuring equipment will measure underwater sound over the frequency range from 1 Hz and 150 kHz. This frequency range covers the hearing range of common fish and cetacea.

Sensitivity

The measuring equipment is able to measure underwater sound to levels well below ambient sea noise levels in typical shallow waters (sea state one) across the specified frequency range. This ensures that the contribution from wind farm noise to the measured noise will be known for frequencies where the wind farm noise is above background noise.

Dynamic range

The measuring equipment is able to measure underwater sound pressures up to 180 dB re 1 μPa over the specified frequency range. Subacoustech have undertaken many underwater noise surveys at offshore wind farm sites, and have developed the equipment to meet the dynamic range requirements for these measurements.

Data storage

The measuring equipment allows the underwater noise data to be reviewed as it is captured (both visually and audibly). It is then stored as broadband time histories (rather than processed data such as spectra). This data may be analysed in any format later required.

Traceability

All of the underwater noise and vibration measuring equipment used will be calibrated and traceable to international standards. The measurement chain will be calibrated with an acoustic calibrator or pistonphone, also with calibration certificates traceable to international standards.

Precautions against interference

Precautions must be taken to minimise the influence on the measurements from sources of interference such as the following:

a) self induced noise from hydrophone movement in the water column due to buoyancy effects and vessel movement;
b) electrical interference from ship board electrical systems, such as generators, gyrocompasses, and radio equipment (including mobile phones);
c) audio interference from ship board systems such as depth sounders, SONARS, engines and other machinery.

Where there exists a potential source of interference that cannot be avoided, the presence of the source will be noted. Measured levels will be considered valid only if they exceed readings on the measuring instrument owing to the above influences by at least 10 dB.

Assessment

The underwater noise data will be analysed and presented both in terms of un-weighted assessment metrics such as RMS Sound Pressure Level and peak level, and also by reference to the underwater hearing threshold of receptor species. For example, the dB_{ht}(*Species*) approach will be used to assess the sound level above a species threshold. From this perceived loudness data any behavioural effects will be inferred.

The sound level with range will be presented so that for example, in the far field a source level / transmission loss model, may be used to assess sound propagation.

An estimate of the range of behavioural effect of the underwater sound should be made using a suitable behavioural model.

Information to be reported

The following information will be presented along with the underwater noise measurement.

Measurement conditions

The measurement conditions will be reported, to include:

a) sea state;
b) wind speed;
c) exact location (to within 20m);
d) hydrophone depth;
e) water column depth;
f) local shipping traffic;
g) turbine rotational velocity;
h) number of operating turbines
i) other relevant information.

Measuring equipment

Details of the noise measuring equipment used, to include:

a) equipment settings;
b) details of data processing, to include signal conditioning and averaging parameters;
c) serial numbers;
d) details of the latest detailed calibration
e) details of calibration with an acoustic calibrator or pistonphone.

Assessment of measured underwater noise

An assessment of the potential effect of the measured underwater noise from the wind farm on local marine wildlife will be reported, to include:

a) the measured sound pressure levels and potential for effect on local marine wildlife;
b) the calculated propagation parameters;
c) the calculated or measured background noise level;

d) the calculated range where wind farm noise falls below background noise (furthest possible range of detection);
e) the likely range of audibility, if at all, of wind farm noise for local marine wildlife, if different from above;
f) the likely range of behavioural effect, if any, of wind farm noise on local marine wildlife
g) the likely range of physical effect, if any, of wind farm noise on local marine wildlife.