Preface

Scira Offshore Energy Ltd is proud to present to you the Environmental Statement of the Sheringham Shoal wind farm. This statement is a reflection of two years of work on all possible impacts by a multidisciplinary team of SLP Energy, Econcern, Hydro and Royal Haskoning together with many other external consultants, and in close cooperation with the Statutory Consultees and other stakeholders. Scira wishes to thank all of them for their work, cooperation and inputs.

We believe the Sheringham Shoal wind farm could be a great project, creating a lot of green energy and we think that all impacts have been properly assessed, however, if you have any question or remark, please do not hesitate to contact us.

Regards,

Albert van der Hem

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1 Introduction

1.1 Background

Scira Offshore Energy Ltd. is proposing to construct and operate an offshore wind farm, known as Sheringham Shoal at a site located 17km offshore from the coastal town of Sheringham on the north Norfolk Coast.

This Environmental Statement (ES) describes the proposed project which includes the offshore structures related to the wind farm, the export cables, the landfall and the onshore works and documents the findings of the Environmental Impact Assessment (EIA) process.

This ES accompanies the applications being made by Scira Offshore Energy Ltd for the environmental and other consents for the operation and decommissioning of the Sheringham Shoal project which are discussed in Section 2.

1.2 Background to the developers

1.2.1 Scira Offshore Energy

Scira Offshore Energy (hereafter referred to as Scira) is a project specific company formed by Hydro from Norway, Econcern from the Netherlands and SLP Energy from the UK.

Scira considers offshore wind energy as an opportunity, both for society and from a business perspective. Its strategy combines the following elements:

- Active involvement of society to create and maintain the necessary support for wind energy projects and to find optimal solutions for any problems and damages that may occur.
- Pro-active risk management.
- Balance between innovation and proven technology.

The origins of the name Scira

The town of Sheringham is on the north Norfolk coast, with houses and shops down to the edge of the sea. But the ancient town of Sheringham, today known as Upper Sheringham, is the settlement listed in the Domesday book of 1086. The town was then known variously as Silingham, Siringham or Schyringham. As with many of Norfolk's town and villages, the name is of Scandinavian origin, meaning the 'home of Scira's people.' Source: www.sheringham-network.co.uk/tourist info/local history

1.2.2 Hydro

Hydro is a Fortune 500 energy and aluminium supplier founded in 1905. Over the past 40 years, the company has become a leading offshore producer of oil and gas, based on a strong position in the development of the Norwegian petroleum industry. The company has a long track record in deep waters and rough seas, developing projects not only in the North Sea but all over the world. Recently, the company has also invested in wind and hydrogen energy production. Apart from its activities in the field of energy, Hydro is also the third-largest integrated aluminium supplier in the world, with a presence on every continent.

In 2005, Hydro realised a turnover of £13 billion. It currently employs some 35,000 employees in nearly 40 countries.

1.2.3 Econcern

E-concern, was founded in 1984 and soon became a strong niche player in the renewable energy sector, firstly in the Netherlands and now throughout Europe. As such, Econcern has vast experience in the energy sector and specifically the wind energy sector. The company is involved in offshore wind projects in Denmark, the Netherlands, Belgium and the UK.

Econcern is a holding of which various daughter companies are involved in the Sheringham Shoal Project: Evelop manages the project development, while the consultant Ecofys is responsible for the EIA.

In 2005, Econcern realised a turnover of £38 million. It currently employs over 300 employees in the Netherlands, Germany, Belgium, UK, Spain, Italy and Poland.

1.2.4 SLP Energy

SLP Engineering, the parent company for SLP Energy, was established in 1970 as an oil and gas industry service contractor. Since then, SLP has evolved into a fully integrated turnkey solutions provider.

In the late 1990's SLP was one of the first companies in this sector to recognise the opportunities emerging from the offshore renewable sector. As such in 2000 SLP Energy was established to provide dedicated services and innovative solutions to this market through its expertise in offshore design, engineering, fabrication, construction, installation and project management.

SLP has actively moved into the specifics of offshore wind energy through the construction of several meteorological masts and through innovating foundations for wind turbines. In parallel, SLP is developing an increasing portfolio of on-shore windfarms.

SLP Engineering and its subsidiaries have an annual turnover of £60 million and employ around 300 personnel at its sites in Lowestoft and London.

1.3 Background to the Sheringham Shoal Offshore Wind Farm

1.3.1 Historical background

The Crown Estate, as landowner of the seabed out to the 12 nautical mile territorial limit plays an important role in the development of the offshore wind industry by leasing areas of seabed for the placing of turbines. A number of Government departments are also involved, as potential developers require a number of statutory consents in addition to permission from the landowner, to build and operate offshore wind farms.

The Crown Estate's announcement of the first major round of UK offshore wind farm development in December 2000 resulted in 18 companies pre qualifying for the right to develop an offshore wind farm project at various locations around the UK. To date, 13 of these sites have gained consent and three sites are now generating electricity. In July 2003, following the success of the Round One competition, The Crown Estate, in discussion with the Department of Trade and Industry (DTI), invited developers to bid for site option agreements in the second round of offshore wind farm development. Arrangements for Round Two were designed to facilitate offshore wind farm development in three strategic areas namely the:

North West;

Greater Wash; and

Thames Estuary.

These areas had already been the subject of a Strategic Environmental Assessment (SEA), which reported on the potential impact of various scenarios of offshore wind farm development and identified a maximum build scenario that could reasonably be accommodated within each strategic area (BMT Cordah, 2003).

In December 2003, The Crown Estate offered 12 companies/consortia, options for 15 site lease agreements spread across each of the three strategic areas. Scira obtained the option to develop the Sheringham Shoal site. This agreement grants Scira a development option, during which time Scira must obtain the relevant statutory consents. Once these are in place, the option agreement could then be converted into a full lease of the seabed for a period of 40 years.

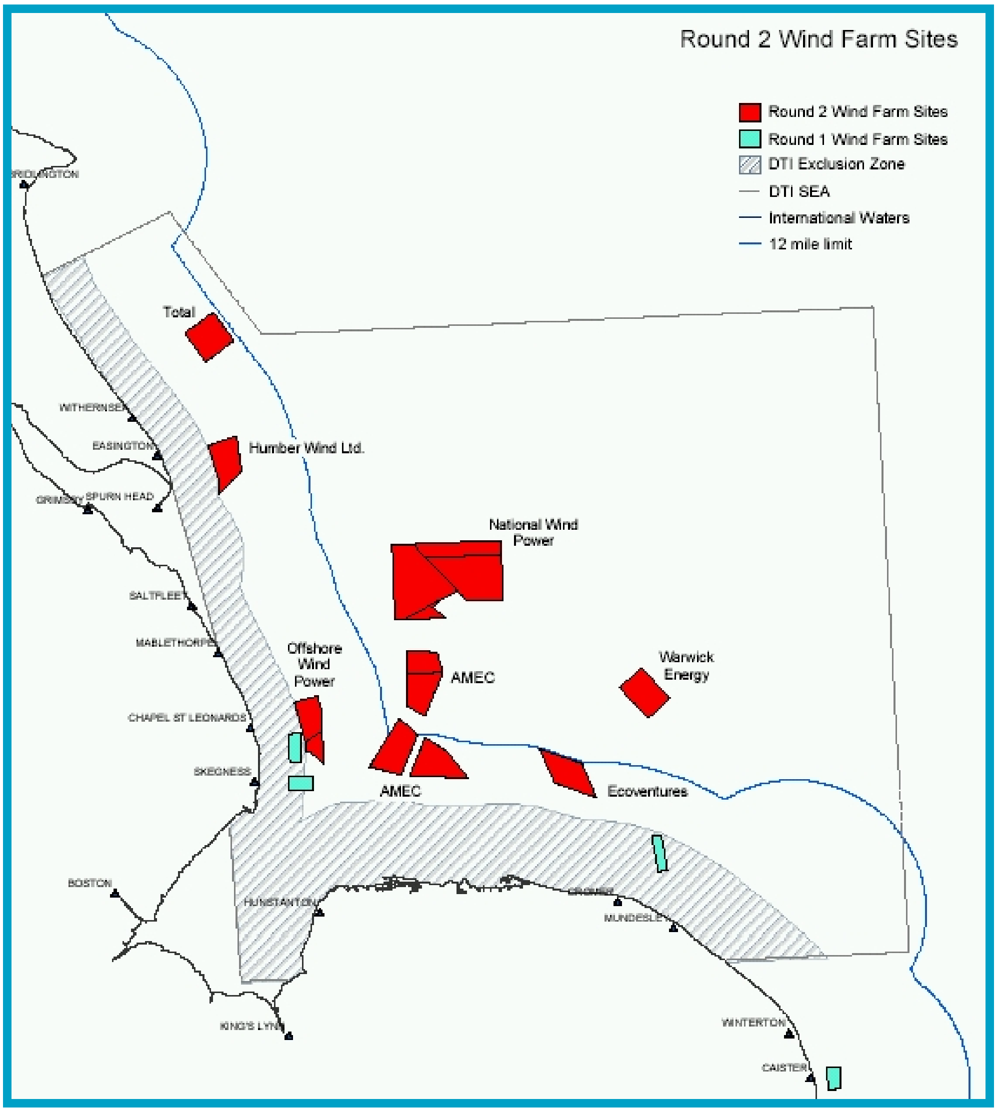

Figure 1.1 Round 1 and round 2 sites in the Greater Wash strategic area. Source: Crown Estate, 2004.

Since the award, the consortium partners have actively joined forces to take the project forward. This has involved producing environmental information (in the form of this ES) for the purposes of EIA, developing outline designs for the wind farm and associated infrastructure and consulting with potential consultees in the consents processes and other interest groups, including the wider public.

1.3.2 Site choice

The proposed wind farm would be located approximately 17 to 20km offshore from the north Norfolk coastal town of Sheringham and approximately 5km north of the offshore sand bank known as Sheringham Shoal (see Figure 1.2). It would consist of between 45 - 108 turbines located in water depths from 16m to 22m at lowest astronomical tide (LAT).

The proposed site was chosen based on the following rationale:

- The area lies within the 12 nautical mile (nm) boundary of territorial water, but as far off the coast as possible, maximising the wind regime, whilst minimising visual effects and possible effects on birds.
- The shipping intensity, including beam trawling, is low.
- The area does not coincide with aggregate or disposal sites, oil and gas platforms, MoD Practice and Exercise Areas, or existing cables or pipelines.
- The offshore site is not part of any designated nature conservation sites, nor on current and foreseeable information is it likely to become part of a designated area.

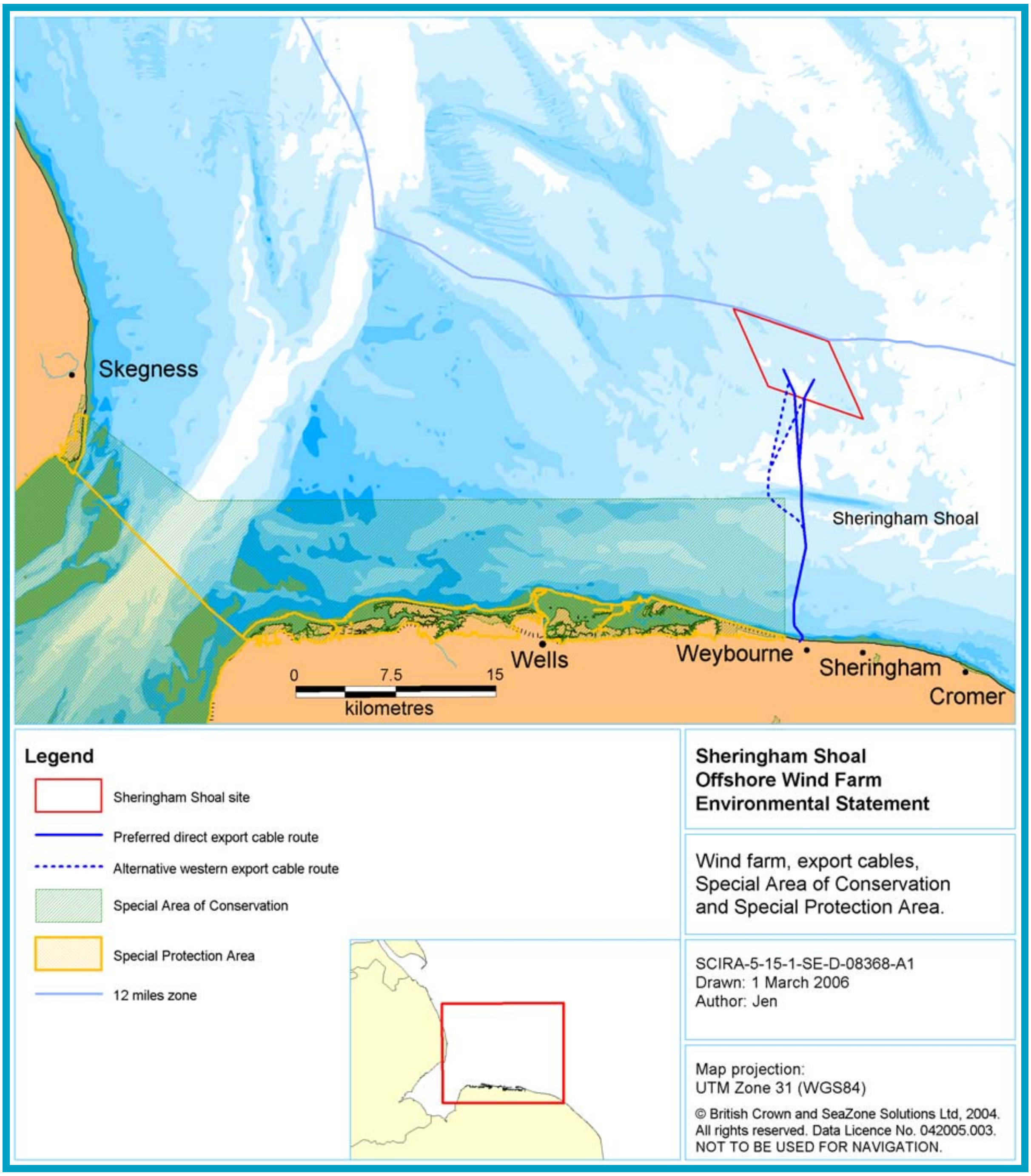

Figure 1.2 Surroundings of the proposed Sheringham Shoal Offshore Wind farm. Source: Scira 2005.

1.4 Renewable Energy Policy

1.4.1 International and European policy

In 1997, more than 160 nations met in Kyoto, Japan, to negotiate binding limitations on greenhouse gases for the developed nations, pursuant to the objectives of the United Nation's Framework Convention on Climate Change of 1992. The outcome of the meeting was the Kyoto Protocol, in which the developed nations agreed to limit their greenhouse gas emissions, relative to the levels emitted in 1990. The Kyoto Protocol became binding on signatory states (which include the UK) following Russian ratification in February 2005. Different countries have individual targets for their energy generation from renewable sources. The European Union's overall emission target under the Protocol is a reduction of greenhouse gas emissions to 8% below 1990 levels by the commitment period of 2008 to 2012 (www.dti.gov.uk).

1.4.2 National energy policy

The UK's Climate Change Programme, published in November 2000 (DETR, 2000) includes the development of renewables in its plans to reach the UK's Kyoto target[1]. The Government proposed an initial ten year strategy, which included a target to generate 10% of the UK's electricity from renewable sources by 2010. Other targets included reducing greenhouse gas emissions to 12.5% below 1990 levels by 2012 and cutting carbon dioxide (CO_2) emissions to 20% below 1990 levels by 2010.

These initial targets were revised in February 2003 with the Energy White Paper '*Our Energy Future - Creating a Low Carbon Economy'* (DTI, 2003). The central aim of the UK Government's energy policy is to establish a supply of energy that is diverse, sustainable and secure and is offered at competitive prices. Key to this goal is a 60% reduction of CO_2 emissions by 2050. The development of renewable energy plays a key role in the Government's strategy for carbon reduction. In particular, it has set a revised target that 15% of the UK electricity supply should come from renewable sources by 2015, and has an aspiration of 20% of renewable energy supply by 2020. The Government's targets for renewable energy will help the UK to meet its international obligations, but also obtain greater security of energy supply through the promotion of indigenous electricity generation. The construction of wind farms, (both on- and offshore) is expected to be the largest contributor to the development of the renewable energy sector and wind energy will provide the greatest contribution to the 2010 target of all of the renewable energy technologies.

The Government aims to work with industry to meet these targets and, as part of its Climate Change Programme, has introduced a number of incentive measures including the Renewables Obligation (RO). The RO came into force in April 2002[2] and places an obligation on all licensed electricity suppliers in England and Wales to source a growing percentage of their energy from renewable sources. The original RO started at 3% in 2003, rising gradually to 10.4% by 2010/2011. The RO currently stands at 5.5% in 2005/2006, increasing gradually to a requirement of 15.4% by 2015/16 (www.dti.gov.uk, 2005).

In January 2006, the Government launched an Energy Review consultation document called 'Our Energy Challenge: securing clean, affordable energy for the long term' (DTI, January 2006). The consultation has a broad scope and considers all aspects of the energy system including both energy supply and demand. The Government is expected to report later in 2006. However, the terms of the consultation document clearly indicate that there are no changes in the Government's commitment to the exploitation of the UK's energy resources.

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[1] The UK and European Economic Community are signatories to the Kyoto Protocol (http://unfccc.int/)
[2] Renewable Obligation Order 2002 made under the terms of the Utility Act 2000 and amended by the Renewables Obligation (Amendment) Order 2004.

The Sheringham Shoal project also contributes to realizing regional energy policies, which are discussed in detail in Section 4, Policy Framework and Guidance.

1.5 Contributions from the proposed wind farm to the national policy targets

The 10% renewable energy target by 2010 is expected to require the generation of 33.6TWh per annum (Ecofys, 2003), and the proposed offshore wind farm, once operational, will contribute 0.8 TWh to this target (Calculations based on BWEA 2005, applied load factor: 30%).

In addition, the proposed wind farm will help the UK move towards its goals by reducing emissions of carbon dioxide by approximately 28,000ktonnes over its 40 year lifetime (based on avoided emissions from coal powered plants. BWEA, 2005). Furthermore, the proposed installation will reduce the emissions of other air quality pollutants by 74ktonnes of SO_2 and 27ktonnes of NO_x (Ecofys, 2003).

1.6 The EIA project team

Scira commissioned Ecofys together with Royal Haskoning and SLP to undertake the Environmental Impact Assessment (EIA). All three companies worked hand in hand on this assignment.

Table 1.1 provides an overview of the subcontractors involved in the various EIA surveys and studies.

Table 1.1 Overview of EIA sub contractors.

Subject area	Sub-consultant
Geophysical surveys	Envision and Royal Haskoning
Geotechnical surveys	Fugro Environmental Services
Metocean data collection	Gardline
Hydrodynamics and Geomorphology	HR Wallingford
Aerial Bird surveys	WWT (Wildfowl and Wetlands Trust)
Boat based bird surveys	ESS (Environmentally Sustainable Systems) and Econ
Radar based bird surveys	CSL (Central Science Laboratory)
Ornithology	Econ and Ecofys
Marine biological surveys	Institute of Estuarine and Coastal Studies (IECS, (University of Hull)
Benthic ecology	IECS (University of Hull) and Royal Haskoning
Natural fisheries resources	Brown and May Marine (BMM) and Royal Haskoning
Commercial fisheries	BMM and Royal Haskoning
Marine Mammals	Royal Haskoning
Seascape and Visual Character	ERM (Environmental Resources Management) and Ecofys
Shipping radar surveys	Anatec
Navigational risk assessment	Anatec
Archaeology	Wessex Archaeology
Radar interference	QinetiQ
Socio-economic impact and tourism	Royal Haskoning
Ecological surveys	Norfolk Wildlife Services
Landfall and onshore cable route studies	Royal Haskoning
Second opinion and review	RPS
Legal advice	Bond Pearce

1.7 Report structure

This Environmental Statement is structured in five parts:

- Part one introduces Scira Offshore Energy Ltd. and the Sheringham Shoal Offshore Wind farm, describes the EIA process and the policy framework.
- Part two focuses on the wind farm and site to shore (export) cable and is topic based, whereby each section describes a separate environmental parameter. Details on the existing environment, impacts during construction, operation and decommissioning are presented as well as any necessary mitigation and monitoring proposals.
- Part three is set out in a similar format to Part two, and describes the cable landfall and onshore cable route and associated infrastructure.
- Part four sets out the information for appropriate assessment.
- Part five summarises the main findings of the EIA.
- Part six contains supporting technical or site specific survey information in the form of appendices.

1.8 References

- BMT Cordah, 2003: Environmental Report: Offshore Wind Strategic Environmental Assessment
- DTI 2002: Our energy future - creating a low carbon economy
- Scira 2004: Sheringham Shoal Offshore Wind farm – Scoping Report
- www.crownestate.co.uk/
- www.dti.gov.uk/energy (14th February 2006)
- http://www.bwea.com/edu/calcs.html (BWEA 2005:

2 Project Details

2.1 Introduction

This section provides a detailed description of the offshore and onshore elements of the Sheringham Shoal Offshore Wind Farm project, including the construction methodology, operation, maintenance and decommissioning stages. In a number of cases finalized and definitive details are not yet available, for example the foundation type, turbine size and manufacturer, installation methodology, electrical design or final choice of cable route (two alternative routes have been proposed). Many of these areas would be dependent on the chosen Contractor following a competitive tendering exercise as well as further geotechnical studies. However, all the likely development scenarios and construction options are described in this section and the EIA has assessed each of these possibilities based on the worst realistic case approach described in Section 1. Finalised project details would be provided to the Department of Trade and Industry (DTI) and Marine Consents Environment Unit (MCEU) following consent determination and in line with any associated conditions.

The operational lifetime of the project is anticipated to be 40 years (in line with the Crown Estate lease) with an option to re-power if necessary during this time.

2.2 Description of the Project

2.2.1 Overview of the project characteristics

The proposed wind farm would be located approximately 17 to 23km offshore from the north Norfolk coastal town of Sheringham and approximately 5km north of the offshore sand bank known as Sheringham Shoal. The wind farm would comprise between 45 and 108 turbines located in water depths of approximately 15m to 22m at lowest astronomical tide (LAT).

The wind farm turbines would be connected via an inter array network of cables which would link at one or two offshore transformer substations located within the wind farm. From these stations power would be exported via two marine cables which would make landfall in the vicinity of Weybourne Hope on the north Norfolk coast. Two routes for the site to shore export cables are being considered; a preferred direct route which passes directly across Sheringham Shoal and an alternative western route which passes to the west of the shoal.

Onshore, the cables would be connected to a new switch station situated in the grounds of the Muckleburgh Collection, approximately 800m inland. From the switch room a new electrical connection would be required in order to pass electricity into the existing 132kV distribution network and/or 400kV transmission network. These networks are operated by EdF and National Grid Transco respectively. This new grid connection (from the switch station to distribution and/or transmission network/s) would be the subject of a separate consent.

Figure 2.1 provides an overview of the project as described above, with the site coordinates listed in Table 2.1. The key project characteristics are summarised in Table 2.2.

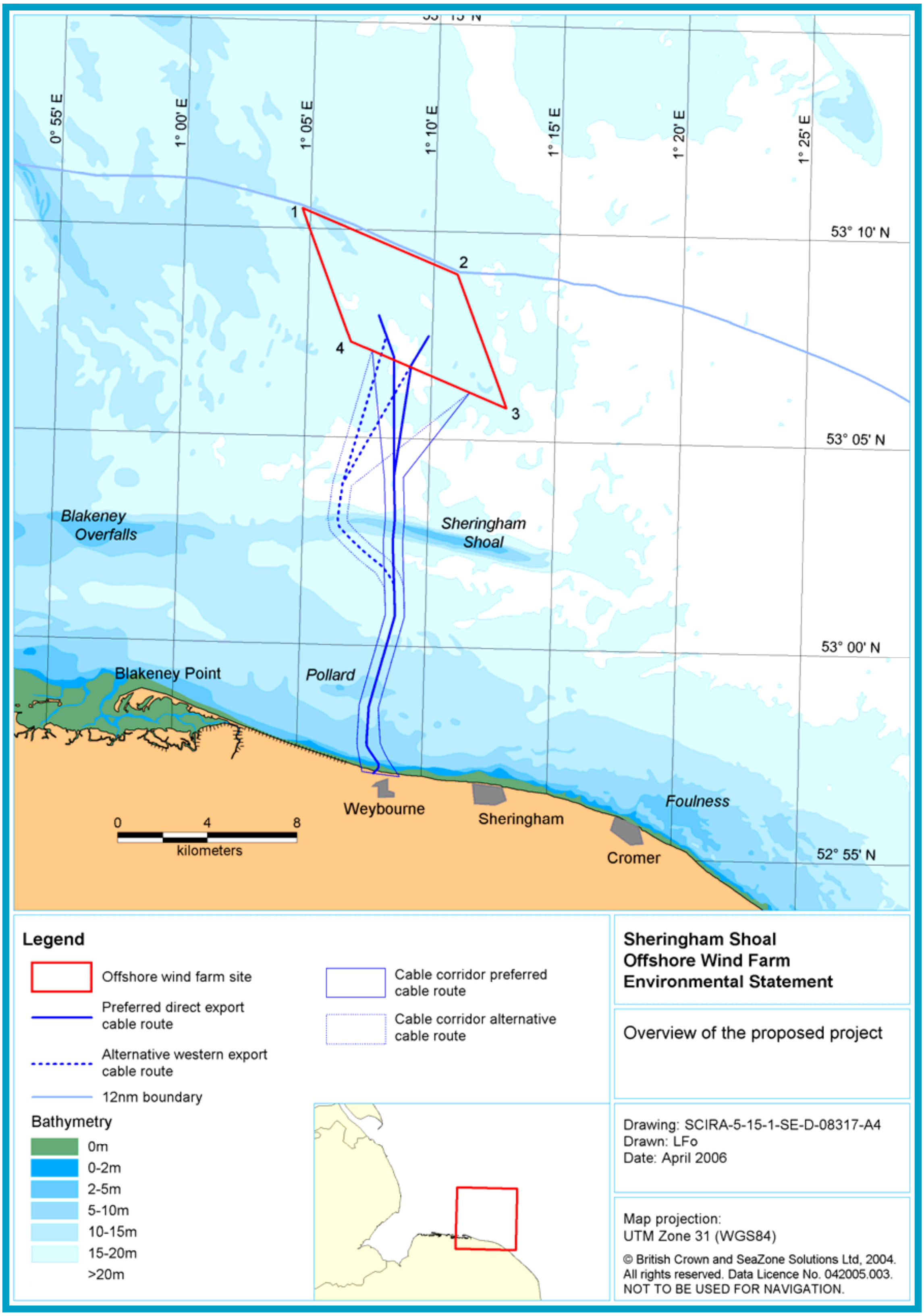


Figure 2.1 Overview of the proposed project

Table 2.1 Coordinates of the selected site in WGS84 format

Point	Latitude (N)		Longitude (E)	
	[deg]	[min]	[deg]	[min]
1	53	10.4788	01	4.6665
2	53	8.9810	01	10.9461
3	53	5.7867	01	13.0286
4	53	7.2916	01	6.7490

Table 2.2 Key project characteristics

Nominal output	240 - 315MW
Min/max number of turbines	45 – 108
Min/max nominal turbine capacity	3 – 7MW
Total area	35sq.km (10sq. n.miles)
Total perimeter	Approx. 24km (13n.miles)
Minimum distance to shore	Approx. 17 km (9n.miles)
Approximate net yield of the wind farm	0.83TWh/yr - Equivalent to about 176,130 households
CO_2 Offset	An estimated 28M tonnes over the 40 years lifetime
Offshore cable length (dependent on final route chosen)	Approx. 21km (direct route) 22km (western route)
Landfall location	Vicinity of Weybourne Hope
Onshore cable route	Approx. 800m to new switch room

2.2.1.1 Foundation types

A number of foundations types are being considered in order to anchor the turbines securely to the seabed. These include monopiles, multi-piled structures utilising three or four piles per structure, gravity base structures and suction caisson structures. These are described in detail in Section 2.4.

2.2.1.2 Turbine units

The turbine model would not be selected until after consent is granted, but it is expected one model, with an installed capacity in the nominal output range of 3 – 7MW, would be adopted for the whole wind farm. All turbines units are anticipated to comprise a tubular steel tower, nacelle, containing a variable speed gearbox, a brake, generator and three blades. It is anticipated that a transformer stepping up to approximately 20-50kV would be located within the tower or the nacelle. Figure 2.2 shows the general layout of a typical wind generator (nacelle).

The turbines would typically begin generating electricity at hub height wind speeds of approximately 3m per second (m/s) rising to the maximum rated output at speeds of around 14m/s and above. The turbines are normally designed to shut down automatically at wind speeds above 25m/s for safety reasons.

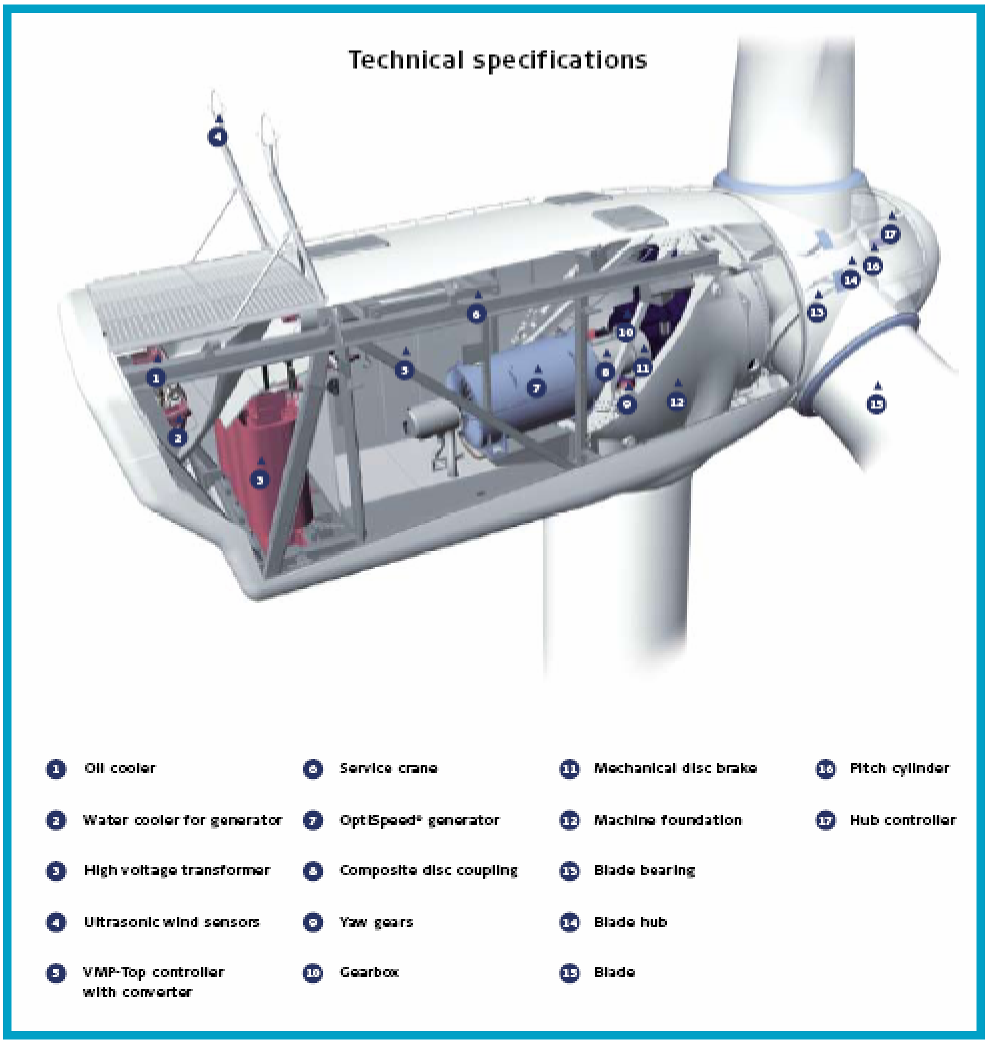


Figure 2.2 A Typical Nacelle Layout (Courtesy of Vestas Wind Systems A/S 3MW))

2.2.1.3 Inter turbine and site to shore (export) cables

Cabling is anticipated to comprise of 20-50kV inter turbine cables linking each of the turbines to one or two offshore sub-station(s) (see Section 2.3). The cables are expected to consist of armoured 3 phase AC marine XLPE (Cross-Linked Polyethylene) cables which are the dominant technology of today (see Figure 2.3). Cables may contain an integral fibre optic for control and data signals. At the offshore substation(s) the voltage would be stepped up to a likely level of up to 150kV via the onboard transformers.

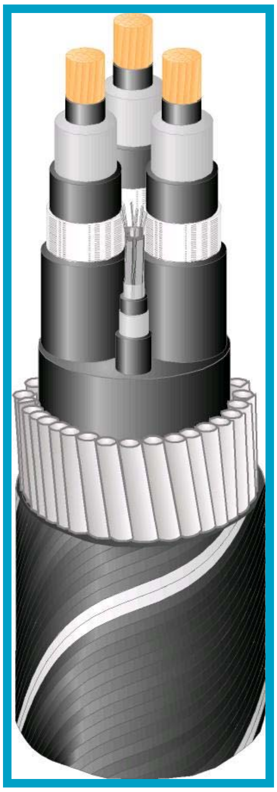


Figure 2.3 Typical 3 Core Copper XLPE Armoured 132 kV Subsea Cable with fibre optic cable (Courtesy of ABB)

From the substation(s) the export cables would be routed to shore. Burial depths would vary according to factors including ground conditions, but are expected to range from approximately 0.5m to 3m. The export cables are anticipated to be up to approximately 100m apart for the majority of the offshore route.

As stated above, it is anticipated that export cables would operate at voltages of up to 150kV. However voltage levels up to 450kV would also be considered as technologies and relative costs develop.

2.2.1.4 Landfall and Onshore Grid Connection

The export cables would be landed in the vicinity of Weybourne Hope, crossing under the shingle beach, and ducted onto land which makes up the Muckleburgh Collection. Onshore the marine cables would be anchored firmly in one or more concrete based cable connection pit(s), where they would be connected to land based cables which would also be buried. The onshore cable route would link to a new switch room built in the vicinity of the museum. The switch room may house reactive compensation, metering and any other equipment that may be required in addition to switch equipment. All cables would be buried to a target minimum depth of 1m and the land returned to its previous condition. The general arrangement is shown in Figure 2.4.

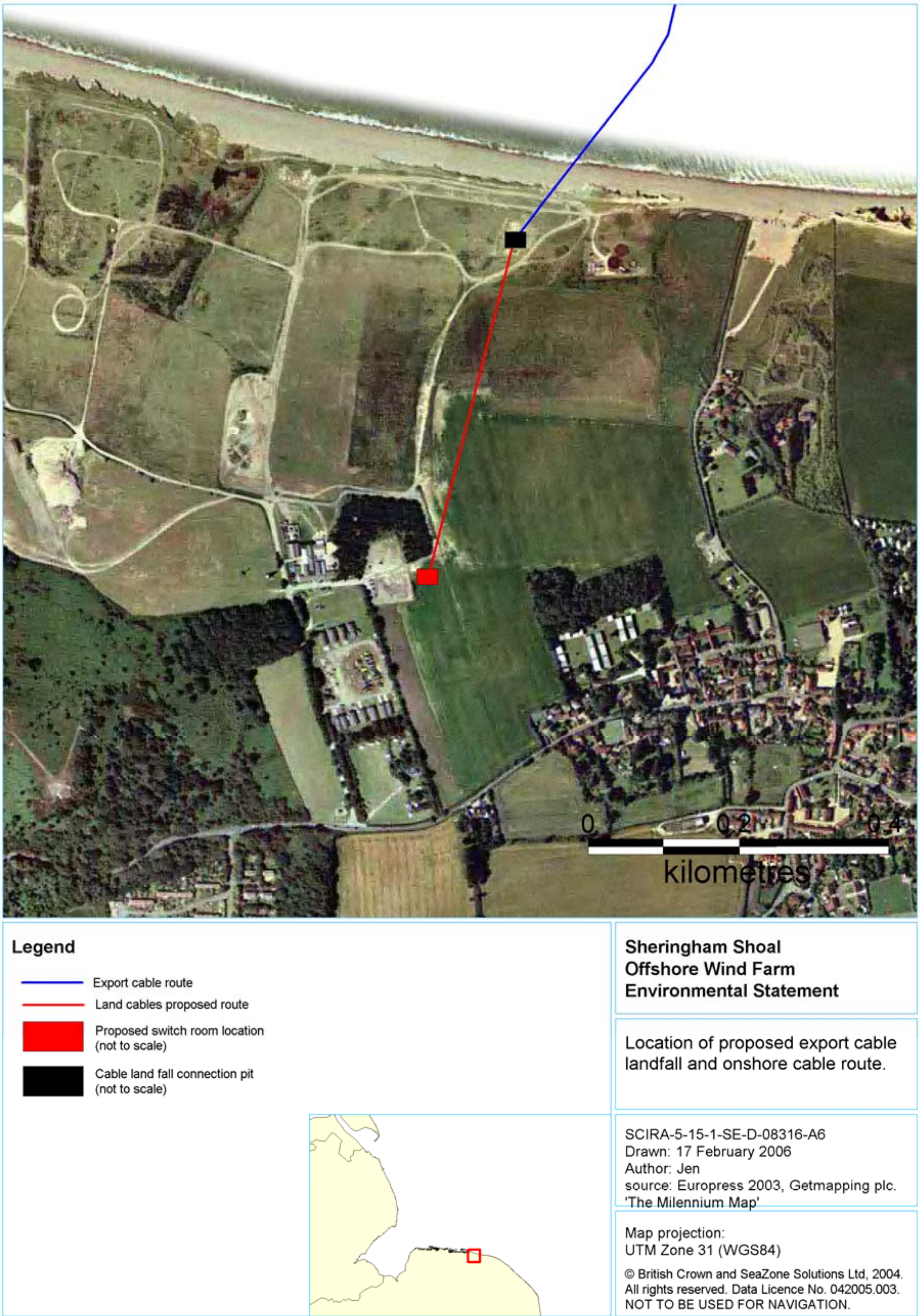


Figure 2.4 Location of proposed export cable landfall and onshore cable route

2.3 Wind Farm layouts

2.3.1 Overview of layouts

A number of layout options for the wind farm are being considered which would depend on the type of turbine that is chosen. The nominal capacity of the turbine (7 – 3MW) would determine the number required (45 – 108 respectively) in order to reach the proposed nominal total output of 315MW. The indicative layout options, using a range of turbine sizes, are shown in Figure 2.5 and Figure 2.6. Table 2.3 sets out the various wind farm parameters for the proposed layout options.

Table 2.3 Indicative Layout Options

Layout Options	45 x 7MW	63 x5MW	70x4.5MW	88X 3.6MW	108x3MW
Indicative number of turbines	45	63	70	88	108
Turbine rated capacity (MW)	7	5	4.5	3.6	3
Rotor diameter of turbine (m)	150	126	120	107	90
Hub height (m)[3]	97	85	82	75.5	67
Anticipated number of columns	9	9	10	11	12
Anticipated number of rows	5	7	7	8	9
Wind farm capacity (MW)	315	315	315	315[4]	315[5]
Distances between rows and columns					
Perpendicular distance between rows[6] (by number of rotor diameters)	7.4	5.9	6.2	6.1	6.2
Perpendicular distance between rows (m)	1108	738	738	633	554
Distance between rows (m)[7] (turbine to turbine)	1120	780	750	650	570
Perpendicular distance between columns (by number of rotor diameters)[8]	4.4	5.3	4.9	5.1	5.3
Perpendicular distance between columns (m)	661	661	588	529	481
Distance between columns (m) (turbine to turbine)[9]	900	900	800	720	660

[3] Reference MHWS
[4] As maximum installed capacity is limited to 315 MW, either there would be 87 turbines or the individual output of some turbines would be capped to keep within 315 MW total.
[5] As maximum installed capacity is limited to 315MW, either there would only be 105 turbines of their individual output would be capped to keep within 315MW total.
[6] The perpendicular distance between rows; the distance between adjacent turbines is larger.
[7] This is the minimum distance between two turbines in different rows
[8] The perpendicular distance between columns; the distance between adjacent turbines is larger.
[9] This is the closest distance possible between two turbines in different columns.

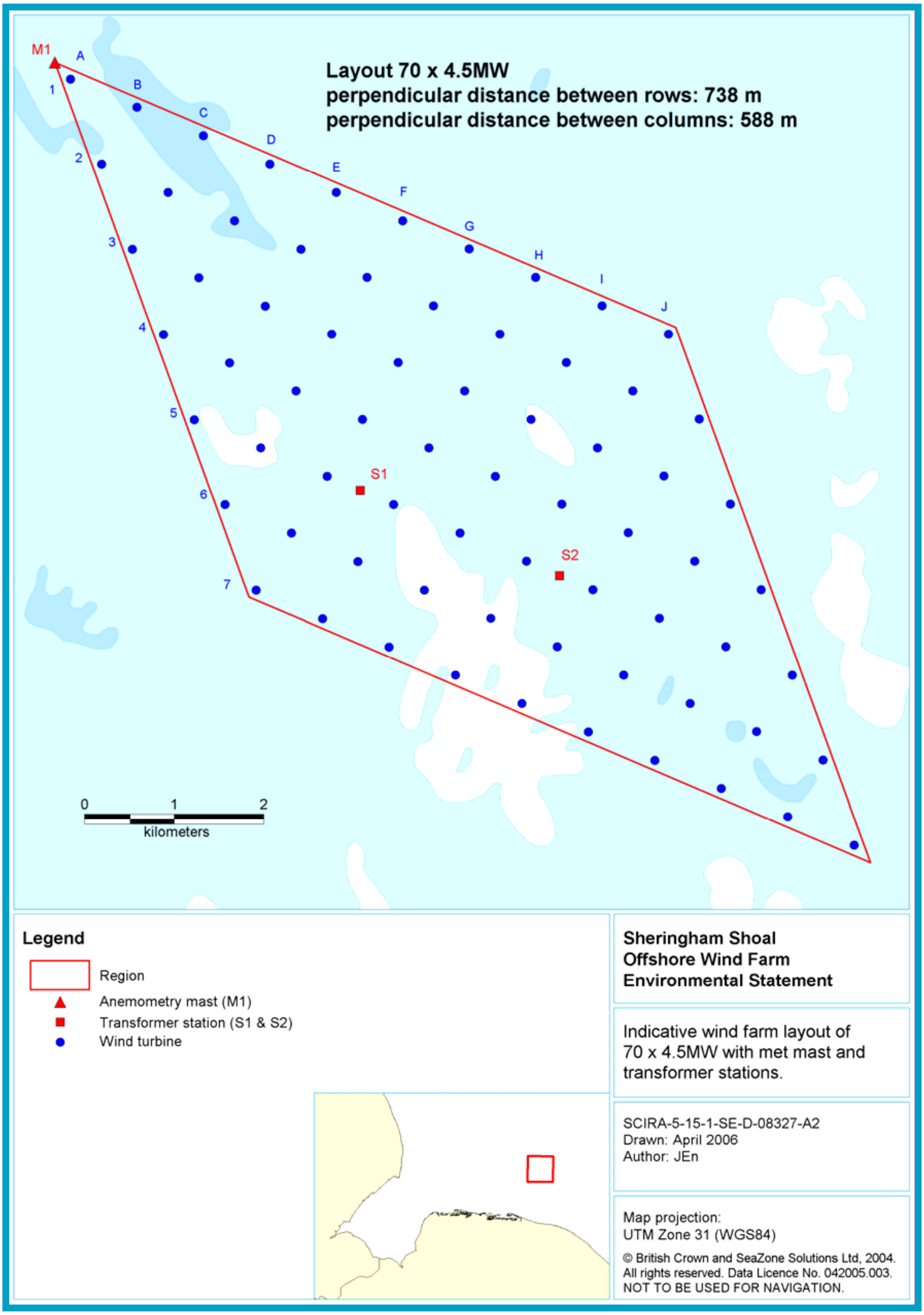


Figure 2.5 Indicative 70 x 4.5 MW Wind Farm Layout, met mast and transformer stations

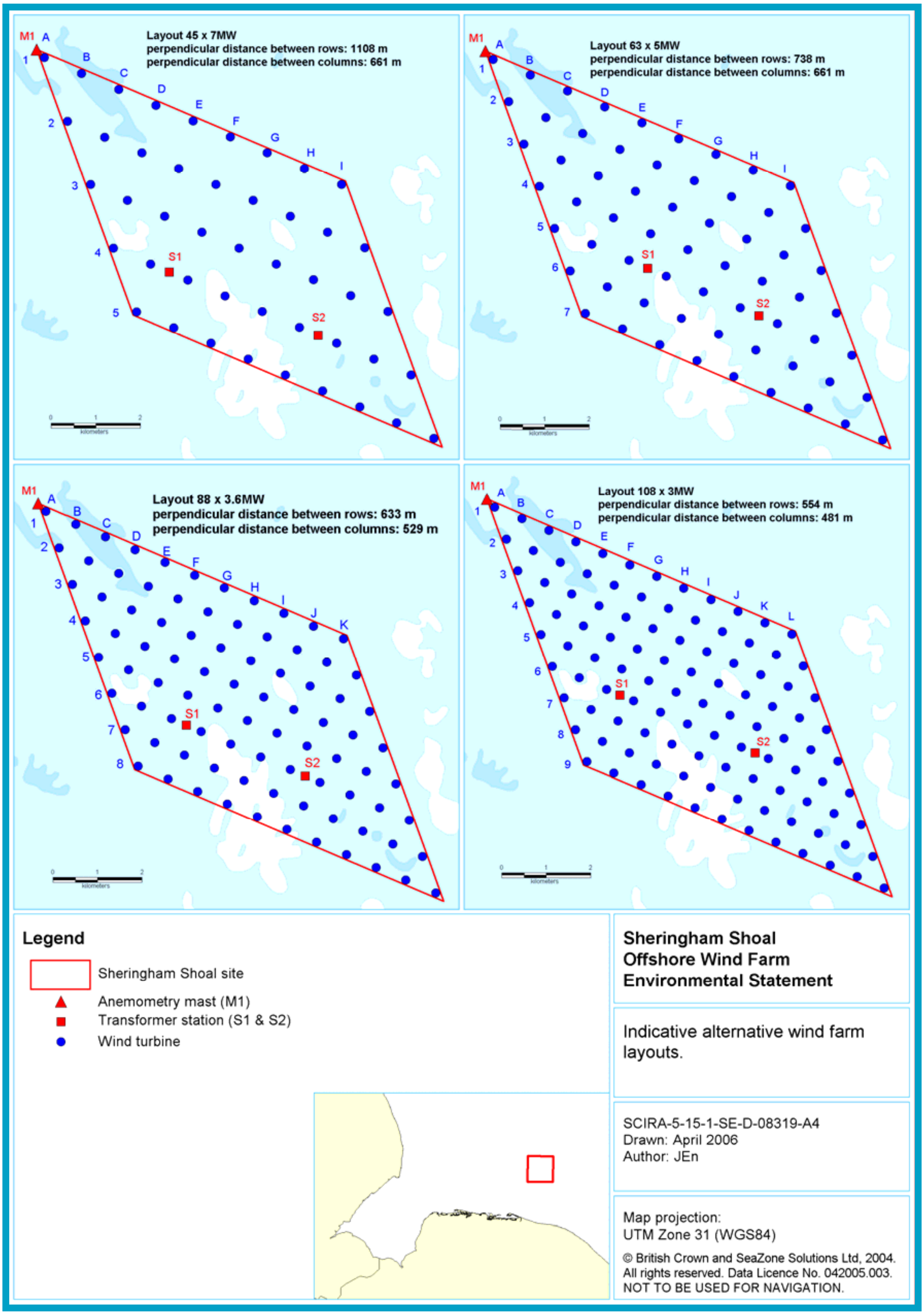


Figure 2.6 Indicative alternative Wind Farm Layouts

2.3.2 Lighting and navigation aids

2.3.2.1 General

The wind farm installation would be designed and constructed with all requisite lighting and marking requirements as specified by the Civil Aviation Authority (CAA), Trinity House Lighthouse Service (THLS) and the Maritime and Coastguard Agency (MCA). General requirements are summarised below. Initial navigation risk assessments have been undertaken in close consultation with the CAA, THLS and MCA (see Section 14, Shipping and Navigation).

2.3.2.2 Aviation marking and warning lighting

The guidance utilised is that issued by the CAA "Lighting of Wind Turbine Generators in United Kingdom Territorial Waters", annex A – 8AP-51-06-19 (September 2003). In accordance with the guidance key elements of the proposed aviation lighting would be as follows:

- Aviation lights to only be fitted to the outer perimeter of the turbine formation, including each corner.
- The maximum distance between turbines fitted with aviation lights shall be no more than 3.5km.
- During construction, the aviation lighting would be placed along the completed external boundaries of the development and would be moved as each boundary turbine is completed.
- The nature of each aviation light, when fitted to a turbine, would be a medium intensive steady red light and would be fitted as close as possible to the top of the nacelle.
- Lights would be fitted in such a way as to be displayed in all directions, save for the blades the aviation light is not to be obstructed.

2.3.2.3 Navigational marking and warning lighting specifications

The navigational markings and fog horn specifications are yet to be agreed and finalised with THLS but they are anticipated to be as follows:

- All Significant Peripheral Structures (SPS), corner or significant point in the wind farm periphery, are to be marked with yellow flashing navigation lights clearly visible from all directions in the horizontal plane. These lights would display the IALA "special mark" characteristic, flashing yellow (F1 Y 5s) with a not less than 5 nautical miles nominal range.
- As a minimum, lights on individual SPS's would exhibit synchronised flashing characteristics, and synchronisation of all the SPS's would be considered.
- In the case of a large or extended wind farm, the distance between SPS's should not normally exceed 3 nautical miles.
- Selected intermediate structures, on the periphery of the wind farm, other than the SPS's, should be marked with yellow flashing lights (F1 y 2.5s), which are also visible to the mariner from all directions in the horizontal plane. The flash character of these lights should be distinctly different from those displayed on the SPS's, with a range of not less than two nautical miles. The lateral distance between such lit structures or the nearest SPS should not exceed 2 nautical miles.
- All navigation lights are to be placed at least 12m above the level of the Highest Astronomical Tide (HAT), but below the height of the turbine blades.
- The SPS should also be equipped with omnidirectional fog signals, with a character of one blast of 2 seconds duration every 30 seconds, to be sounded when the visibility is 2 nautical miles or less. The fog signals should have an IALA usual range of 2 nautical miles.

- All of the offshore structures within the wind farm (including substation(s)) should be coloured yellow (BS No. 381 C 356) from at least HAT to the height of the lights (or the equivalent height on the unlighted structures.
- In the event that the meteorological mast is constructed before the other structures in the wind farm, then it should be marked as a standalone structure by means of a Morse "U" every 15 seconds white light, with a 10 nautical mile nominal range. The light to be exhibited about 12m above HAT and exhibited at least at night and when the visibility is 2 nautical miles or less.
- Temporary marking of the wind farm would be required during construction, but this is to be assessed nearer to the construction period.

2.3.2.4 Other Turbine Markings

Each turbine would be individually marked and numbered in accordance with the MCA marine guidance notice MGN 275(M) (MCA 2004).

It is proposed that the turbines would be externally painted in such a manner as to minimise visual intrusion from more distant views. The proposed colour scheme is a light grey (RAL 7035) currently used on the North Hoyle and Scroby Sands offshore wind farms (see Plate 2.1). The bases of the towers would be yellow in accordance with MGN 275.

Plate 2.1 Indicative colour scheme of turbines

2.4 Foundations

2.4.1 Introduction

The wind turbines and offshore substation(s) would require the foundations to satisfy a number of installation, operational and environmental conditions as well as cost considerations. The design of the site specific foundation support structures would normally be influenced by a range of site requirements including:

- The dimensions of the turbines to be installed.
- Mean sea levels and water depth variations.
- Loading characteristics of the site wind resource and wave characteristics.
- Seabed stability factors.
- Soil conditions.
- Access and maintenance requirements of the structures.
- Logistic and transport costs.
- Material costs, manufacturing cost and structural limitations.
- Type of, and cost of, associated installation equipment.
- Export and Import cable access facilities.
- Environmental considerations of foundation type and placement methodology.

A key consideration of the turbine type relates to the geological and geotechnical characteristics of the site, as described below.

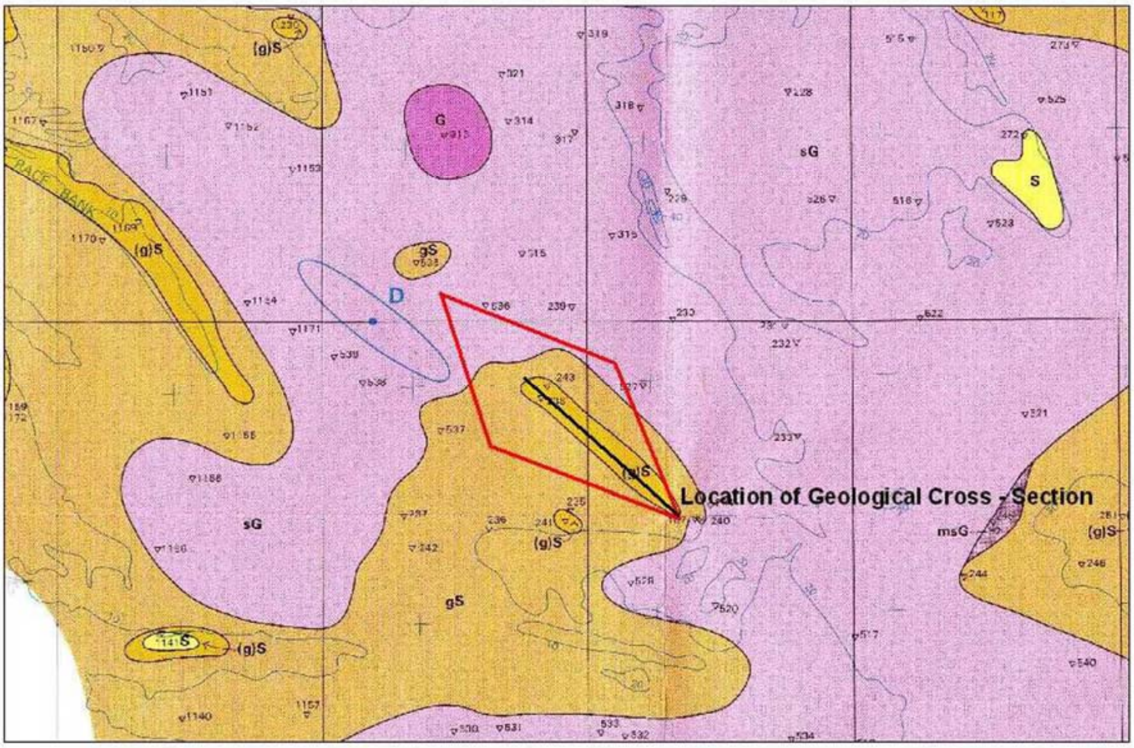
2.4.2 General geological characteristics of the site, cable route and landfall

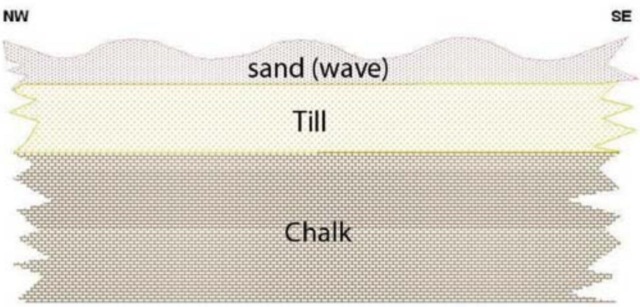
The following description of the geological characteristics of the site are based on interpretation of shallow geophysical and geotechnical surveys combined with bore hole data collected in the Greater Wash area (Royal Haskoning 2005). The characteristics of the area are therefore subject to confirmation when further more detailed geotechnical investigations take place.

The mobile surface sediment of the site and cable route, comprises mainly gravely fine to medium sand, derived from reworking of the late Pleistocene glacial till bed known as the Bolders Bank Formation. This glacial till overlies Cretaceous chalk bedrock. The upper surface of the chalk slopes down to the north, from surface exposure near the shore to about 20m below the bed to the north of the wind farm site. Both the glacial till and the chalk surface are cut by channels and depressions, in filled by sand/gravel/clay/peat beds and covered by mobile surface sediments. The most notable channel is the 10m – 20m deep Weybourne Channel, identified by BGS running normal to the shoreline off Pollard Shoal. Figure 2.7 indicates the general distribution presented by British Geological Survey (BGS), whilst Figure 2.8 and Figure 2.9 indicate the geology of the site at surface and depth. The thickness of the non-cohesive surface layer varies widely. Close to shore it is generally less than 0.5m thick, while the bank at Sheringham Shoal is up to 10m thick. The smaller Pollard Shoal has an approximate thickness of 3m to 5m. Both are surrounded by mega-rippled sand. Within the wind farm site there are sand waves up to 3.5m in amplitude over the southern portion, while to the north there are areas with only sand streaks and thin patches across the glacial till surface.

The location of the banks and the general bathymetry is apparently relatively stable although analysis of historic data suggests that Sheringham Shoal has experienced some change to depth and extent (see Section 6, Hydrodynamics and Geomorphology).

Plate 2.2 shows 6x1m core lengths, starting with the sand, then bolder clay and final chalk units, taken from a vibrocore on the edge of Pollard Shoal.

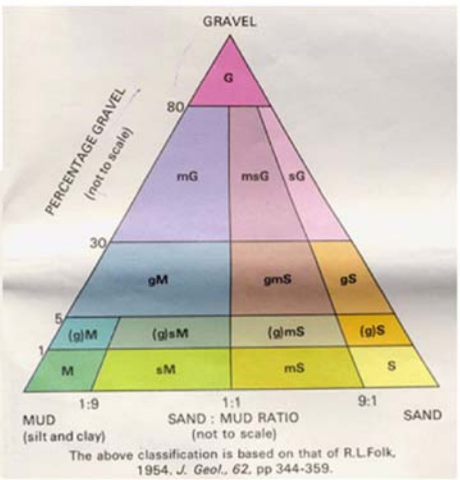




Simplified Geological cross - section across the South - East of the site. location is black line in picture (not to scale)

Legend

M . . . . Mud
sM . . . Sandy mud
(g)M . . Slightly gravelly mud
(g)sM . Slightly gravelly sandy mud
gM . . . Gravelly mud
S . . . . . Sand
mS . . Muddy sand
(g)S . . Slightly gravelly sand
(g)mS Slightly gravelly muddy sand
gmS . Gravelly muddy sand
gS . . . Gravelly sand
G . . . . Gravel
mG . . Muddy gravel
msG . Muddy sandy gravel
sG . . . Sandy gravel



Sheringham Shoal Offshore Windfarm Environmental Statement

General geological distribution by BGS.

Drawing: SCIRA-5-15-1-SE-D-08395-A2
Drawn: March 2006
Author: JEn
source: Royal Haskoning

Map projection:
Mercator (WGS84)

NOT TO BE USED FOR NAVIGATION.

Figure 2.7 General geological distribution by BGS

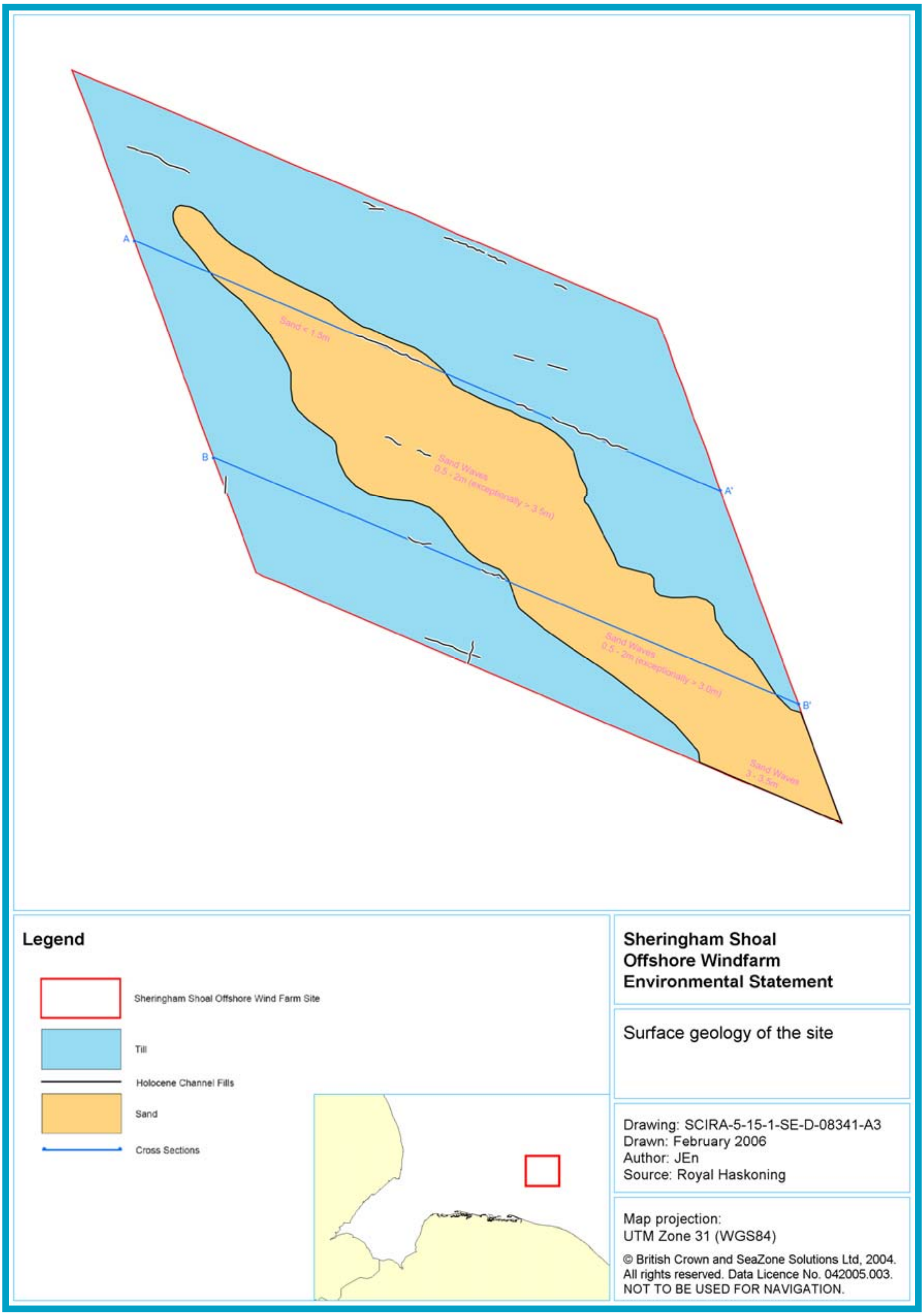
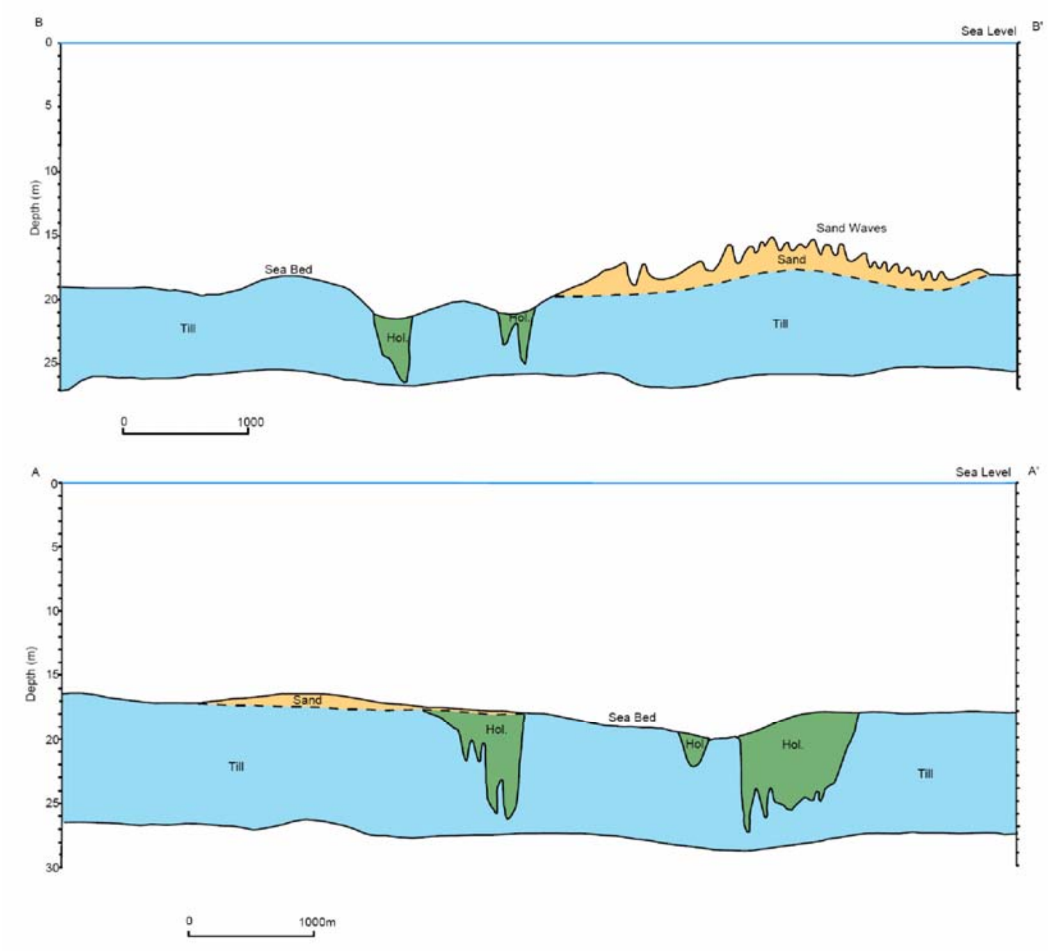
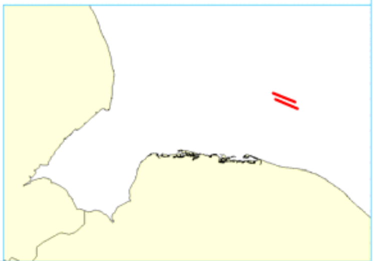


Figure 2.8 Surface geology of the site



Legend

Hol. - Holocene Channel Fill



Sheringham Shoal
Offshore Windfarm
Environmental Statement

Subsurface sediments at two locations across the site

Drawing: SCIRA-5-15-1-SE-D-08340-A3
Drawn: February 2006
author: JEn
source: Royal Haskoning

Figure 2.9 Subsurface sediments at two locations across the site

Plate 2.2 6x1m vibrocore lengths, showing sand, bolder clay then final chalk units (VC5 edge of Pollard Shoal)

Close to the proposed landfall area near Weybourne there is a change in coastal orientation due to offshore banks, bathymetry, wave exposure and geology. To the west is a shingle barrier spit extending over 15km westwards from Kelling to Blakeney Point, fronting low lying reclaimed land and marshes. The shingle beach at Weybourne Hope slopes steeply to low tide level, where it gives way to a flatter sand platform.

East from Weybourne the shingle beach is backed by eroding cliffs of glacial till above a chalk base. The lower foreshore is formed by surficial gravely sand over a chalk platform. Plate 2.3 and Plate 2.4 provide views from the landfall point towards the west and east respectively.

Plate 2.3 Landfall looking east

Plate 2.4 Landfall looking west

2.4.3 Foundation Options

Currently, it is anticipated that the following foundation types could be used in the construction of the wind farm.

- Monopile;
- Multi – Pile (tripod structure with 3 piles);
- Multi – Pile (quadruped structure with 4 piles);
- Gravity Base;
- Suction Caisson; or
- a combination of the above.

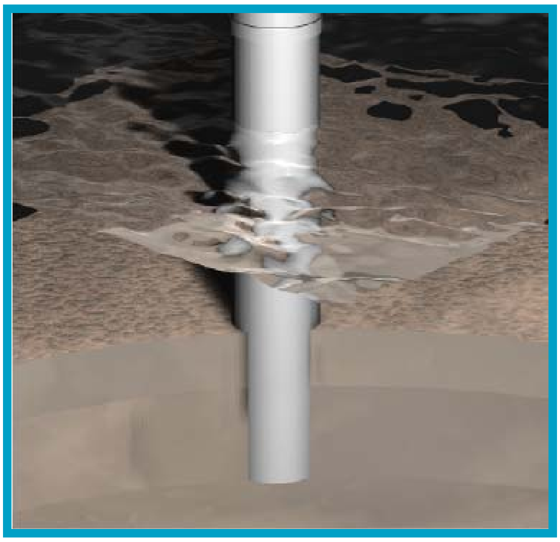
The site geotechnical investigations are currently limited to the upper 6m in the proposed wind farm site. The descriptions given below are therefore based upon general knowledge of the area and are not specific enough for detailed engineering design. A variety of foundation types may be suitable for the development, and the particular foundation type that is actually used would be dependant upon environmental and functional requirements that would be assessed in more detail.

However at the Sheringham Shoal site, with a large number of proposed wind turbines, it is expected that standardisation would be a large element in the selection of the foundation and the basis for the choice would, in most likelihood, be a solution combining the total lowest cost with due consideration for environmental and technical requirements.

2.4.4 Monopile

2.4.4.1 General Description

With the exception of sites in the Baltic Sea which are generally in shallow water, a monopile has become the standard foundation type for supporting wind turbines offshore. The monopile is a large diameter steel tube that is either driven or driven and bored (see Plate 2.5 and Plate 2.6) to an adequate depth to resist the design loading conditions. A steel tubular transition piece (with boat access facilities attached) is then normally fitted over the top of the monopile and grouted to it to provide a secure support for the tower. This is the most probable type of foundation that would be adopted for turbines at the smaller end of the range. For the bigger and heavier turbines being considered for this project, the required dynamic response of the structure and turbine, and the required fatigue durability given the water depth, could be such as to drive up the size and weight of a monopile so that other foundation schemes could be more attractive from a cost viewpoint.



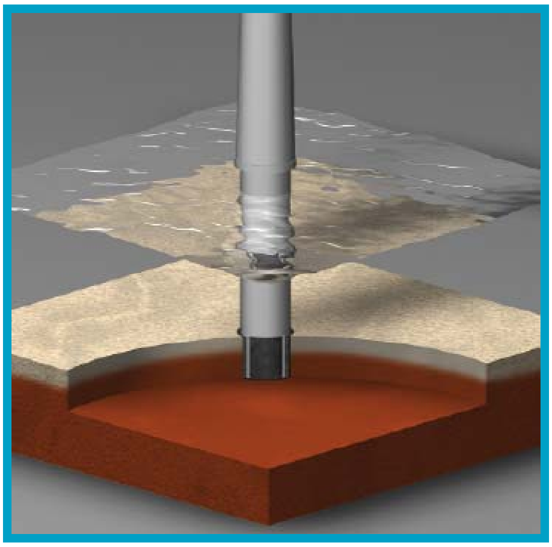


Plate 2.5 Driven Pile *Plate 2.6 Driven & Bored Pile*

Pile dimensions are indicative only and are expected to be within the following ranges:

- Monopile diameter 5– 7.5 m
- Pile wall thickness 50 – 100 mm
- Pile length 35 – 85 m
- Pile penetration 25 – 70 m
- Approx weight 200 – 1500 tonnes
- Transition piece diameter 5.2 – 7.8 m
- Transition piece thickness 35 – 55 mm
- Transition piece length 35 – 40 m
- Approx weight 150 – 450 tonnes

Current hammer availability dictates a maximum pile diameter of around 6m, although it is anticipated that such hammer sizes could increase in the future. Therefore, pile sizes up to 7.5m diameter have been considered.

2.4.4.2 Construction

The monopile foundations are constructed onshore and are prefabricated prior to site delivery. Steel plates are delivered from steel mills to fabricators where the steel plates are rolled and welded together into a monopile structure. Various parts of the monopile could be constructed to various plate thicknesses depending on the soil structure specific to the installation location (see Plate 2.7, Plate 2.8 and Plate 2.9 depicting 4m diameter monopiles).

Plate 2.7 Pile prior to installation

Plate 2.8 Internal Pile view

The monopile is typically jointed with the turbine by one of two methods. In the case of North Hoyle, a 10m transition piece with flange and grouted connection to the monopile was utilised, to which the turbine tower could be attached. The grout used would a high strength cementitious grout or equivalent that is already commonly used in the UK offshore sector. In the case of Scroby Sands the 4m diameter monopile was driven with a flange already fitted (see Plate 2.9), negating the need for a transition piece, grouting equipment and grouting crew. It is envisaged that the following quantities may be required:

- Grouting concrete requirement 20 – 100 tonnes per turbine

Plate 2.9 Pile, complete with tower flange, ready for loading

2.4.4.3 Transportation

It is anticipated that monopiles would be transported to the development site offshore by one or more of the following methods.

- Loading from the quayside on to a jack up barge, which is towed to the site by tug, or by self powered installation vessel, to be transported to the site (see Plate 2.10);

Plate 2.10 Loading components onto jack-up barge from quayside

- A towed dumb barge/vessel shuttle service between quayside facility and site location (with jack up permanently on site location).
- Sealing each end of the pile and towing the pile out to the location.

As an example, at the North Hoyle wind farm the monopiles were floated to the installation location. At the Scroby Sands wind farm the monopiles were loaded onto a jack up which proceeded to site and installed its cargo of five monopiles, before returning to the quayside facility for a further five monopiles for installation. The number of vessels required for the delivery would depend on the mode of transport.

2.4.4.4 Installation

Typically no seabed preparation is required prior to monopile installation but in seabed areas prone to heavy scour it may be efficient to place a layer of crushed stone on the seabed prior to installation. Once on the installation site, the monopiles would typically be lifted, secured and driven into the seabed. In order to lift the monopile a safe and secure working platform is required; this could be in the form of a jack up barge, complete with crane, or jack up vessel complete with crane. Jack up barges are normally used for this operation (see Plate 2.11 and Plate 2.12) providing a stable base for the large crane required and working platform for the pile drive hammer and operating equipment.

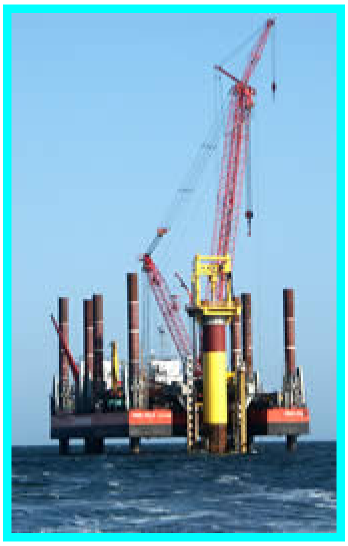


Plate 2.11 Monopile Hammer installation *Plate 2.12 Monopile Internal Bore*

Once the pile is on site it is lifted into a vertical position and secured in to the platform pile gate. The monopile is then lowered to the seabed in preparation for the drive hammer. The crane is detached from the pile and then attached to the pile hammer. The pile is allowed to initially sink into the seabed under its own weight with constant surveillance of the vertical alignment on the pile. If the pile is within vertical alignment parameters the first initial blows are initiated with the pile hammer. Again constant checks would be maintained on the vertical alignment of the monopile and close monitoring of the drive force would be maintained to ensure no failure in the monopile structure.

Once the pile drive has been completed, the sleeve or the transition piece, if relevant, is placed over the pile. The sleeve/transition piece contains the access ladders to the access platform, the ships fenders (to protect access up the ladders) and the 'J' tubes for the export/import cables.

Depending on the soil characteristics it could be necessary to drill into the underlying strata in order to reduce the driving force required to drive the pile. This would involve lowering a large diameter drill into the pile and drilling out the internal soils, drilling would then be continued beyond the end of the pile to provide a slightly smaller diameter socket into which the pile would then be driven. This drill-drive-drill process would be repeated until the pile reaches its final elevation.

The drilling would at maximum remove 3,100m^3 of material from a single pile and would be undertaken using a closed loop drilling procedure. All material (including chalk fines) drilled from inside the pile would be circulated within the pile and be pumped to the rig utilising a non–toxic biodegradable lubricant. On the rig this material would be settled and separated from the seawater. The seawater would then be returned to the pile/sea and the solids would be re-deposited within the placed pile, disposed of in a pre-determined location offshore (e.g. licenced disposal site), or returned to shore for disposal. Such a methodology would be aimed to ensure that at no time would the drill cuttings come into contact with the water column around the pile.

Figure 2.10 shows an indicative design of a monopile foundation.

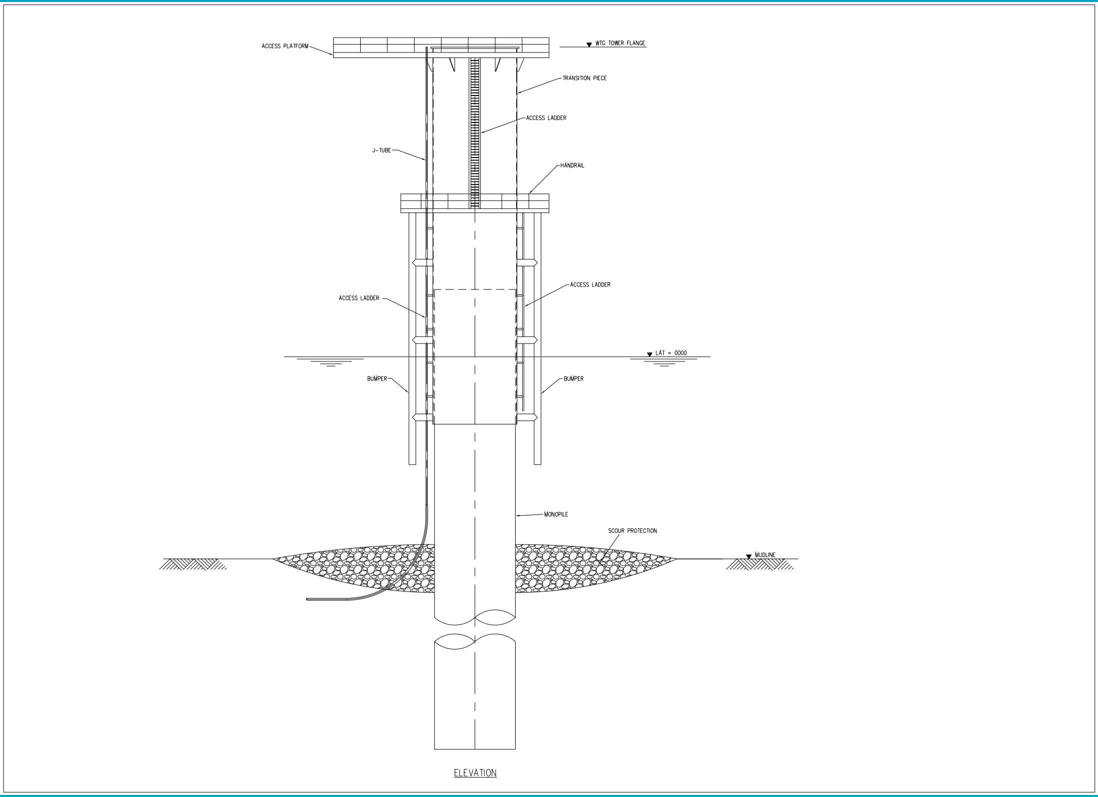


Figure 2.10 Indicative design of a mono pile foundation.

2.4.5 Multi – Pile

2.4.5.1 General Description

The multi piled tripod or quadruped foundation option is a concept that has been widely used in the offshore oil and gas industry and is constructed in steel (see Plate 2.13a, b and c). At the time of writing, the multi-pile option has not however been installed for offshore wind farms, since this foundation type is generally considered as being more suitable for larger scale turbines, soil conditions not suitable for monopiles, and areas where difficulties arise in terms of seabed preparation or scour protection.

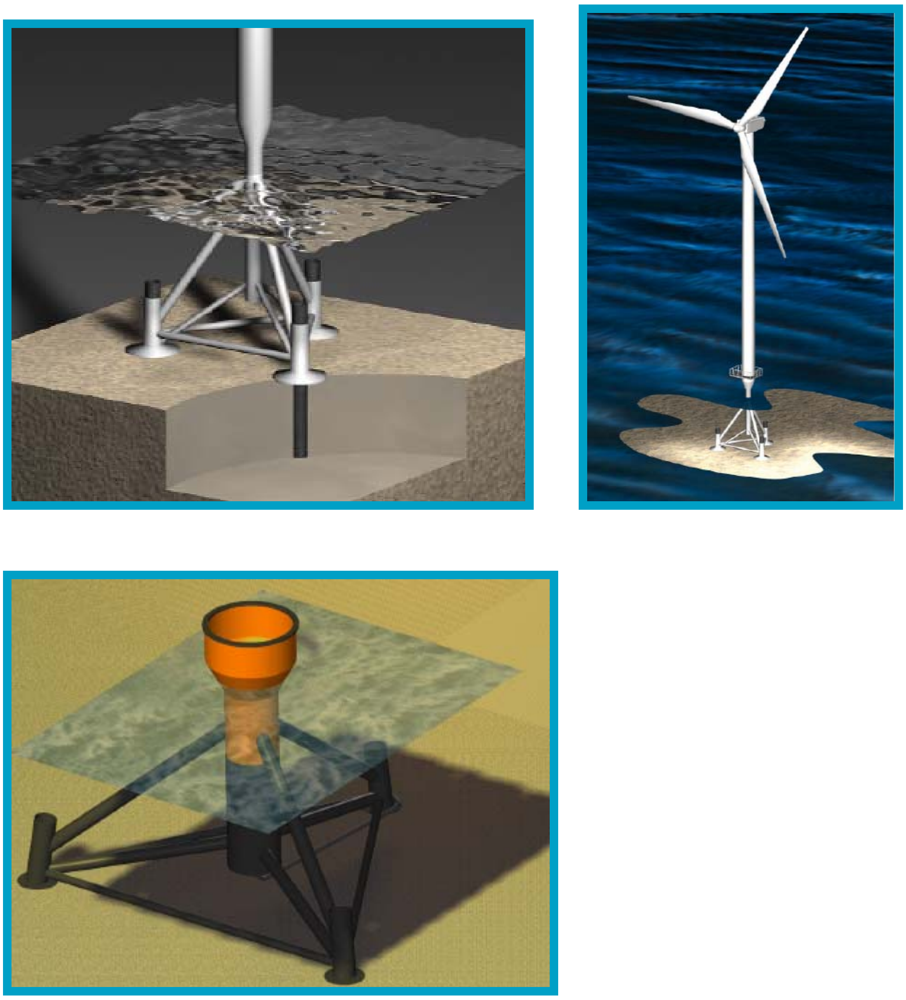


Plate 2.13a, b and c Illustrative multi pile foundations

2.4.5.2 Construction

For the tripod foundation a central core tube is typically supported by three raking and three horizontal braces attached at their opposite ends to pile sleeves through which the piles are driven and grouted. Alternatively, a mechanically swaged pile connection could be used. The central column (which could be tapered) would extend from just above the seabed to the base of the tower, most probably avoiding the need for a transition piece.

Typically the following dimensions would be expected:

- Structure base dimension 25 – 35 m
- Number of supporting piles 3
- Securing pile diameter 1.4 – 3.0 m
- Securing pile seabed penetration 20 - 65 m
- Main column diameter 5 – 6 m
- Weight (including piles) 500 – 1500 tonnes

The quadruped structure is similar to the tripod structure except that four supporting braces and four pile arms are utilised instead of three. Typically the following dimensions would be expected for the quadruped foundation:

- Structure base dimension 20 – 30m
- Number of supporting piles 4
- Securing pile diameter 1.0 – 3.0m
- Securing pile seabed penetration 20 - 40m
- Main support tube diameter 5 – 6 m
- Weight (including piles) 500 – 1500 tonnes

2.4.5.3 Transportation

The transport methodology of the multi-pile foundation unit could be either in the self-floating mode, or as a unit positioned on a transportation vessel (e.g. barge) in a similar way to that of the monopile.

2.4.5.4 Installation

The installation procedure described below is that for a tripod foundation structure. Installation of a quadruped foundation unit would, however, be of a similar nature.

Prior to the installation of the tripod foundation it is anticipated that the seabed may require levelling. Once on site, the tripod steel structure is lifted and placed on the prepared seabed, where the structure would be temporarily supported by mudmats to prevent sinking into the seabed prior to installation. The mudmats could be made from aluminium or steel. It is anticipated that following final installation any loose sediments on the seabed would scour from beneath the mud mats with the result that they would not be in permanent contact with the seabed. The tripod would be secured to the seabed by driving piles through the tripod feet. The piles would be typically driven by conventional surface/underwater hammer however, where there is a particularly hard stratum to penetrate, drilling could be required. As for monopile installation drilling would be achieved by utilising a drill-drive-drill approach.

The structure could be connected to the piles with conventional grouted tubular pile sleeve connections. This would use up to a maximum of 25 tonnes of grout per pile, making a total maximum of about 75 tonnes of grout per tripod or about 100t per quadruped. It is anticipated that a maximum of 5 tonnes (5%) of grout may be released into the water column around each structure as part of the installation process.

Upon completion of the foundation piling, should a flange not be utilised on the top of the tubular structure, a transition piece may be fitted, this would also require approximately 20 to 100 tonnes of grouting concrete[10].

As with the monopile foundation, scour protection may be considered for the tripod foundation.

[10] Range appropriate also for the quadruped

Figure 2.11 and Figure 2.12 show indicative illustration and design of a tripod foundation.

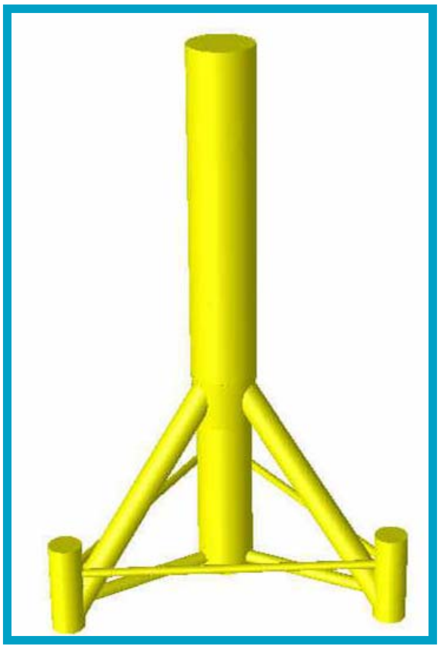


Figure 2.11 Illustration of a Tripod Foundation

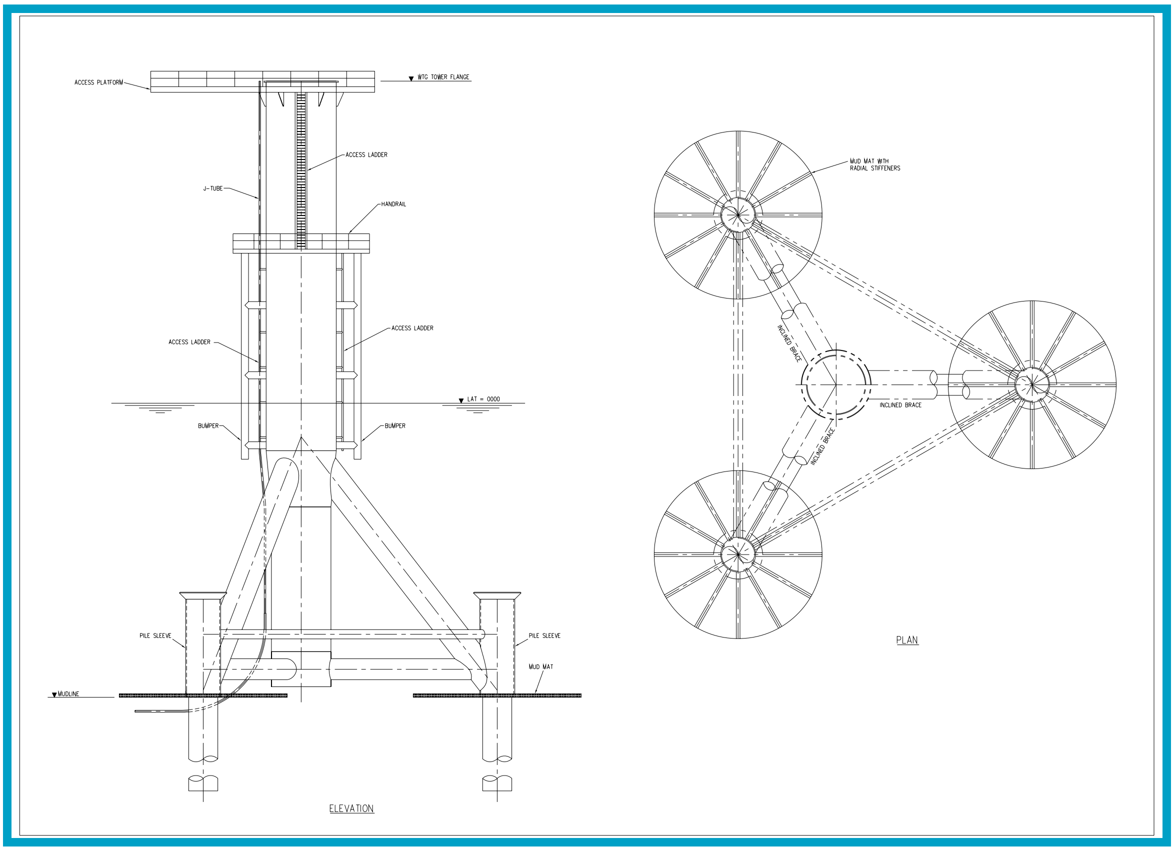


Figure 2.12 Indicative design of a tripod foundation

2.4.6 Gravity Base

2.4.6.1 General Description

The gravity base foundation is normally constructed from reinforced concrete with a steel tubular, or alternatively concrete, column embedded/formed into it. This concept follows standard practice onshore and has been used most frequently offshore in the Baltic Sea where the water depth has generally been less than 10m. The principle is that the gravity base foundation relies primarily on its own weight to provide the necessary resistance to overturning and sliding forces, even in extreme weather conditions (see Figure 2.13). Some form of seabed preparation such as placement of a layer of crushed rock may be necessary, however, a minimum requirement would be to level the seabed, possibly, by up to 2.5m in depth, Any significant quantities of excess material that needed to be disposed of, over and above surface leveling, would be taken off site, although onsite disposal may also be an option.. The addition of a steel skirt designed to penetrate the seabed could be included to assist stabilisation, with the effect that the size of the base can be reduced.

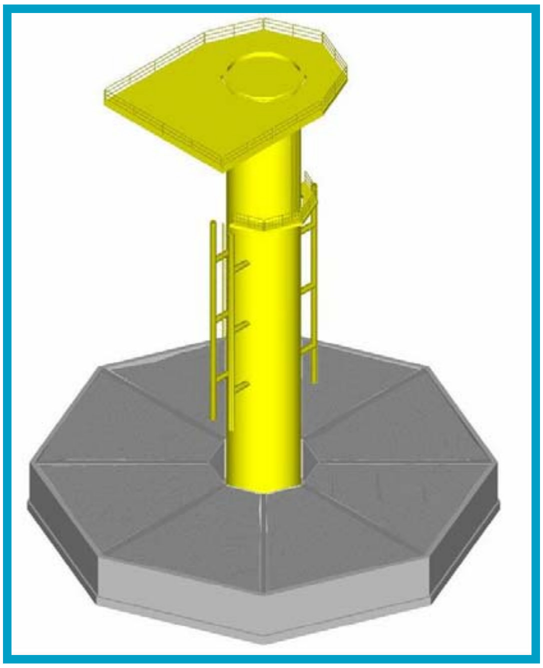


Figure 2.13 Illustrative gravity base foundation

The size of the gravity base would be dictated by a number of criteria, including:

- Weight required for stability, made up of self weight plus any ballast weight;
- Bearing area required on the seabed; and
- Depth of placement in sea bed

Gravity bases are typically circular but may be square or multi sided (see Plate 2.14 a and b). Dimensions of the gravity base foundations are likely to vary across the site to take account of local seabed conditions and actual water depth. The required design would be completed following more detailed site investigations. Typically, the design comprises a number of ballast compartments surrounding the central column which together sit on a concrete slab as depicted.

The following dimensions would be typically expected:

- Base dimension (across flats) 30 – 50m
- Base height (excluding steel skirt) 5 – 7 m
- Column diameter 5 – 6 m
- Column length 40 – 50 m

Plate 2.14 a and b Examples of gravity based structures

Construction

Concrete construction is an established technology in the UK, therefore consideration would be given to the concrete caisson foundations being manufactured locally. The foundation sections might be cast at a local port (e.g. Lowestoft, Great Yarmouth) or further afield either on shore and floated out to sea, or by casting on a dumb barge for onward transport to the installation location. The quantities, for the concrete gravity base foundation are expected to be in the following range:

- Concrete 3,000 – 7,000tonnes
- Ballast (On Site) 5,000 – 25,000tonnes
- Scour Protection 1,250 – 2,000m^3
- Steel reinforcement 150 – 500tonnes

2.4.6.2 Transportation

The concrete gravity base foundation may be prefabricated in such a way as to allow the structure to be floated from the construction yard to the installation site. Tugs would tow the structure in a controlled manner, but weather conditions and a clement sea state would be critical for such a tow. Ideally, construction would be undertaken locally to allow for transport in a timely manner with a lower risk of weather downtime.

Alternatively, the concrete gravity base foundations could be prefabricated on the deck of flat top barges, allowing easy transport to site with less dependence on suitable weather conditions. Use of barges allows the fabrication of the foundations to be undertaken at a greater distance from the wind farm location.

2.4.6.3 Installation

Once on site the ballast compartments of the floating gravity foundation would be progressively flooded to allow a controlled descent to the seabed which is first prepared by levelling and placement of crushed stones. Once in position on the seabed, the ballast compartments would be filled with heavy stones, rock or hematite (iron ore). The source of this material would be determined by the Contractor.

Should the gravity foundations arrive on flat top barges they would be offloaded from the barges by a floating crane vessel (see Plate 2.15), and gently lowered on to the seabed.

Plate 2.15 Transportation of Gravity Based structures

Figure 2.14 shows an indicative design of a gravity base foundation.

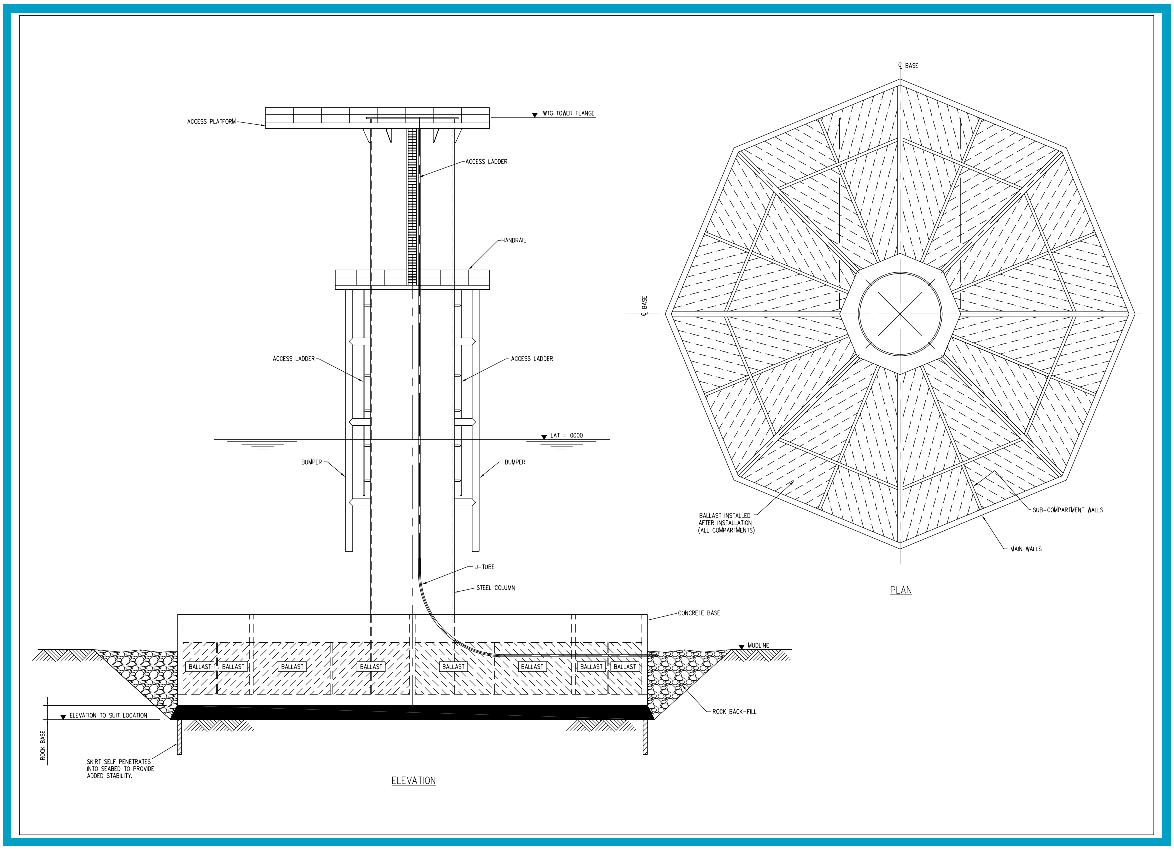


Figure 2.14 Indicative design of a gravity base foundation.

2.4.7 Suction Caisson

2.4.7.1 General Description

Suction caissons are an alternative to driven or bored piles, especially in sandy soils, and can be used with monopile, tripod or quadruped foundations (see Plate 2.16a and b). They are similar to upturned buckets that penetrate the seabed typically to a depth of about 8 - 15m to anchor the structure in place. When used with a monopile there would be a single suction caisson, of typically 20 - 30m in diameter, in place of the pile. When used with the tripod and quadruped structures, multiple caissons would be used with each one typically being 5m - 10m in diameter.

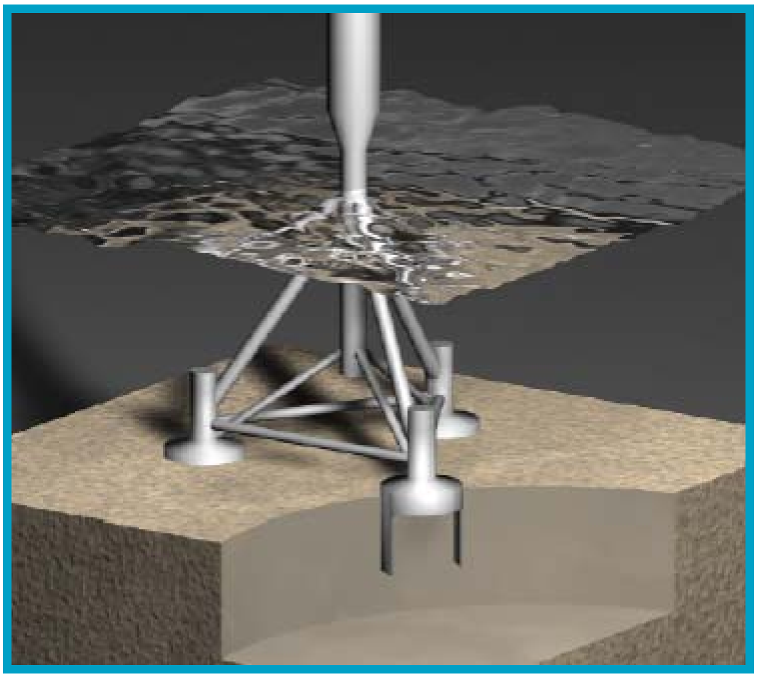


Plate 2.16a Illustrative multi leg suction caisson

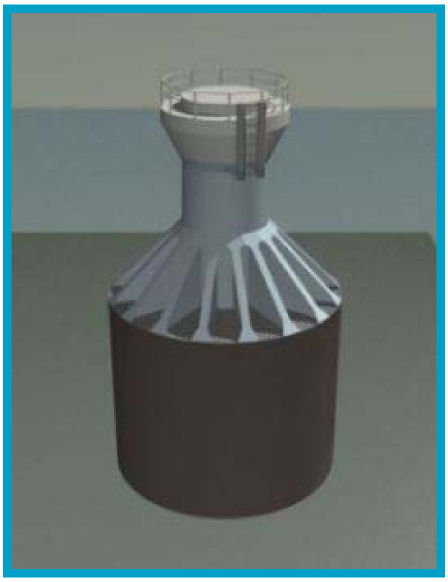


Plate 2.16b Suction Bucket Foundation

2.4.7.2 Construction

The suction caisson is normally constructed from steel and can be prefabricated onshore prior to site delivery.

Transportation

The suction caisson may be transported to site as an integral part of the foundation unit. This type of foundation design is ideally suited to “floating” transport.

2.4.7.3 Installation

Installation would be expected to comprise lowering the structure (onto a previously levelled seabed) by either crane or release of air from ballast tanks. Once on the seabed the suction caissons would be installed by sucking the water from inside the caisson, so that the reduced pressure within the caisson allows the caisson to be forced down into the seabed due to self weight and hydrostatic head of water surrounding it.

2.4.8 Foundation Types related to Size of Turbine

The range of turbine characteristics is such that not all the foundation types discussed above would be appropriate solutions for all turbines types. Table 2.4 presents a matrix showing the anticipated foundation types for each turbine. It should be noted that there are likely to be specific geotechnical issues, as yet unknown, that would influence the final selection of foundation types. This summary, however, is based on what is currently known about the site.

Table 2.4 Indicative Foundation Types applicable to Different Wind Turbines

	Foundation Type					
Turbine Capacity	Monopile	Tripod	Quadruped	Gravity Base	Single Suction Caisson	Multiple Suction Caisson
3MW	X	X		X	X	
3.6MW	X	X	X	X	X	X
4.5MW	X	X	X	X	X	X
5MW	X	X	X	X		X
7MW		X	X	X		X

2.5 Scour and scour protection

Scour can occur around any structure placed on the seabed. It occurs when the soil particles around the structure are displaced by the action of eddy currents generated in the near vicinity of a structure that causes obstruction to the flow. This effect leads to seabed disturbance.

The severity of the scour depends on the wave and current velocities at the site, the type of soil (sand is more likely to scour than clay due to its granular structure) and the size and shape of the obstruction. Scour manifests itself by the formation of scour holes that are formed immediately around the obstruction and extend outwards from it.

If scour protection is found to be necessary, protection would primarily be used to ensure structural integrity of the foundation during its design lifetime. This is especially important for the integrity of gravity and suction caisson foundations. For piled foundations, both monopile and multi-pile systems, it is feasible to design for the effects of scour occurring. This usually means taking account in the design for loss of lateral support to the pile at the seabed and results in marginally longer piles.

To provide for scour in the design of the piles could be more cost effective than to provide protection against scour. However, for all foundation designs, including a monopile and multi-pile systems it is also necessary to consider the effect that scour would have on the cables leading from and to the foundation. Scour protection could be the only viable method to ensure the long term integrity of the cables.

Scour protection would be provided by the placement of rock, concrete mattresses or frond mats around the foundations, these methods may be used alone or in combination as described below;

- Rock dumping – This method involves placing graded rock onto the seabed around the foundation to stabilise the soil. Typically for a monopile, a 5-15m wide ring is used.
- Concrete mattresses – Concrete mattresses are made of concrete blocks of which there are a range of sizes and shapes; woven together with high-strength non-biodegradable rope to form a mattress. The mattresses would be placed around the foundation to prevent scour.

An example of a concrete mattress is shown in Plate 2.17.

Plate 2.17 Concrete Mattress (Source: Submat/SLP Engineering)

- Frond mats – These are made from a series of non-biodegradable fronds tied to a net or mat, the fronds are anchored to the seabed or attached to the top of mattresses to capture floating sediment. This results in the formation of a protective barrier.

An example of Fronds is shown in Plate 2.18.

Plate 2.18 Fronds (Source: Pro-dive marine services)

The actual size of scour protection measures would depend on the seabed soils, local current and tide effects and the configuration of the structure. Each of the foundation types considered has a different susceptibility to scour. Plate 2.19 below shows scour around a test model of a single suction caisson foundation on sand.

Plate 2.19 Illustrative Scour Effects (source: HR Wallingford)

Table 2.5 indicates which foundation types would require scour protection and the likely extent of the scour protection required.

Table 2.5 Indicative scour and potential scour protection per foundation option

Foundation Type	Overall Foundation Diameter (m)	Area of Seabed Covered with Foundation Structure (m^2)	Need for Scour Protection	Area Affected by Scour if no Scour Protection (m^2)	Volume of Scoured Material if no Scour Protection (m^3)	Area Covered by Scour Protection (m^2)	Approximate Volume of Scour Protection per Turbine Foundation (m^3)	Total Area of Seabed (Foundation +Scour Protection) (m^2)
Monopile	5.0 – 7.5	20 – 45	As required (5)	N/A(5)	N/A(5)	0 – 550 (1)	0 – 550 (3)	20 – 595
Piled Tripod	1.4 – 3 (4) (3 piles)	4.5 – 22	Unlikely	40 – 45	15 – 20	0 – 375 (2)	0 – 375 (3)	4.5 - 397
Piled Quadruped	1.0 – 3 (4) (4 piles)	3 -30	Unlikely	50 – 55	20 – 25	0 - 500 (2)	0 – 500 (3)	3 – 530
Gravity Base	30 – 55	700 – 2400	Yes	N/A	N/A	1250 - 2000 (1)	1250 – 2000 (3)	1950 – 4400
Single Suction Caisson	25 – 35	500 – 1000	Yes	N/A	N/A	1100 – 1400 (1)	1100 – 1400 (3)	1500 – 2400
Multiple Suction Caisson	5 – 10 (4) (3 suction buckets)	55 – 235	Yes	N/A	N/A	250-1020 (2)	250 – 1020 (3)	355 - 1255

Notes:
1) *Based on 10m scour protection around structure.*
2) *Based on 5m scour protection around each pile.*
3) *Scour protection assumed to be 1m deep.*
4) *Diameter of single pile/bucket given.*
5) *For most soil types scour is expected to be minimal. For soil types in which scour will occur, scour protection will be provided.*

2.6 Seabed disturbance

The magnitude of seabed disturbance produced by each foundation option is important to quantify, as it is seabed disturbance that leads to potential effects that must be considered as part of the EIA process. Direct disturbance and loss of the seabed would result from the footprint of the foundation, including any seabed sediment removal and scour protection. Indirect disturbance to the seabed would result from the effects of scour, in the cases where no scour protection is proposed (see Table 2.5). Table 2.6 provides the area of direct seabed disturbance by foundation as well as the approximate volume of soil to be removed. Any excess material that needed to be disposed of would be taken offsite (although onsite disposal may also be an option). Table 2.7 provides an indication of the percentage of the wind farm site which would be disturbed directly by the foundation and scour protection.

Table 2.6 Direct Seabed Disturbance and Volume of soil removed

Foundation Type	Overall Foundation Diameter (m)	Approximate Volume of Soil Removed per Turbine (m^3)
Monopile (1)	5.0 – 7.5	0- 3100(1)
Piled Tripod (2)	1.4 – 3 (4) (3 piles)	0 – 900
Piled Quadruped (2)	1.4 – 2 (4) (4 piles)	0 – 550
Gravity Base (3)	30 – 55	2000 – 5000
Single Suction Caisson	25 – 35	0
Multiple Suction Caisson	5 – 10 (4) (3 suction buckets)	0

Notes

1 It is anticipated that there would be no sediment removal if piles are driven rather than drilled. The calculations are based on a 7m monopile that has been drilled. This is the worst case.

2 Soil removal would only be required if piles require drilling which is unlikely

3 Differing levels of seabed preparation and levelling would be required up to 2.5m depth.

4 Diameter of single pile/bucket given.

Table 2.7 Indicative seabed Disturbance Effects for Different Foundation Options for the maximum and minimum number of turbines

Foundation Type	% Wind Farm Site Covered with Structures and Scour/Scour Protection	
	108 x 3MW Turbines	45 x 7MW Turbines
Monopile	0.18	0.03
Piled Tripod	0.12	0.05
Piled Quadruped	0.17	0.07
Gravity Base	1.35	0.56
Single Suction Caisson	0.75	0.31
Multiple Suction Caisson	0.38	0.16

Note: All percentages are based on combined maximum structure and scour protection size multiplied by the no. of turbines as a percentage of the total wind farm area.

2.7 Turbines

2.7.1 General turbine description

A decision on the particular turbine size, manufacturer and model has not as yet been made and would be part of the Contract Tendering process at a later stage of the project. For the purposes of the EIA, therefore, a selection of turbines have been considered ranging from 3MW to 7MW.

The proposed turbine towers would be fabricated from rolled steel, welded into sections, with access ladder and cabling housed internally. The number of turbine tower sections would depend on the agreed final height/name plate capacity of the turbines to be utilised. The 3MW machine, with an expected tower height of about 56m, would be expected to have two tower sections whereas the 7MW machine, with a anticipated tower height of around 86m, would be expected to have a minimum of three tower sections. A summary of typical turbine characteristics is provided in Table 2.8.

Table 2.8 Summary of Typical Turbine Characteristics (dimensions indicative)

Component	Turbine				
	3MW	3.6MW	4.5MW	5MW	7MW
Turbine Power (MW)	3	3.6	4.5	5	7
Hub Height (m) [1]	67	75.5	82	85	97
Rotor Diameter (m)	90	107	120	126	150
Max Tip Height From Tower Base (m)	103	120	133	140	164
Tower Base Diameter (m)	4.5	5	5.5	6	6

Notes: 1) Hub height given relative to MHWS level.

2.7.2 Turbine Installation

In general it is anticipated that the turbine components would be loaded onto a jack up/dumb barge or side leg stabilised vessel at the operations support base port (eg Lowestoft, Great Yarmouth or one of the Humber ports such as Grimsby or Hull), and either be towed to site, as with a jack up/dumb barge, or travel under its own power. Once on location the jack up barge/transport vessel would secure itself to the seabed to provide a stable base for crane operations and turbine installation procedures.

A typical installation could have the following format: The first lift would be to load the base tower section onto the foundation base (see Plate 2.18), a possible second and third tower section may follow (depending on the type of turbine model) until all the tower sections have been loaded and secured to the foundation (see Plate 2.19a-i). The nacelle would then be hoisted and located at the top of the tower and securely bolted down. The rotor hub, complete with two/three blades, would then be lifted onto the front of the nacelle and secured, if required the third blade would then be fitted. It is anticipated that each turbine would take approximately 48 hours to install.

Plate 2.20 Making Ready For Turbine Tower

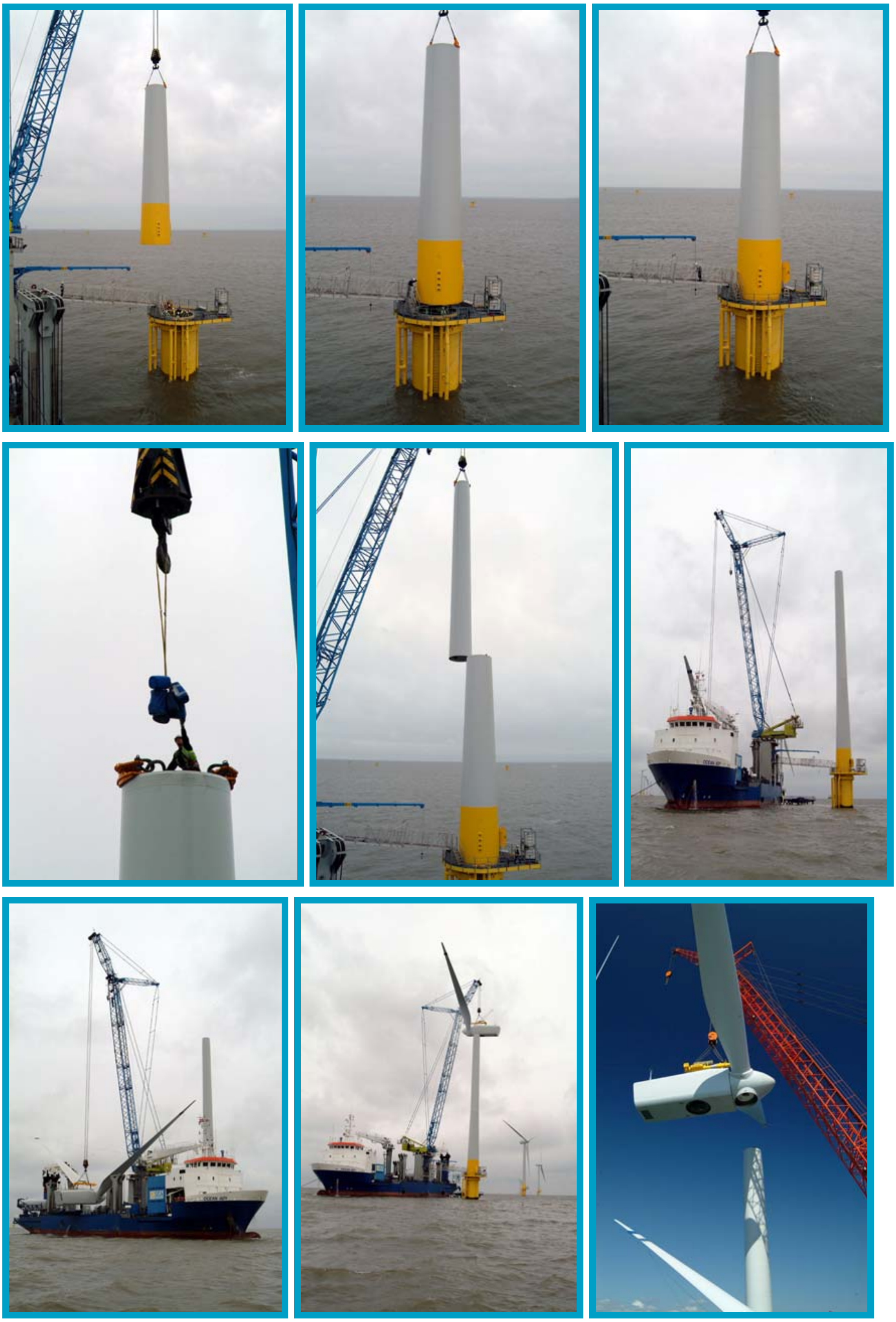


Plate 2.21 a - i Turbine assembly

Access into the tower would be via a secure door entry in the base, with lift/access ladder to intermediate levels contained within the tower. Control cabinets and breakers would be placed within the tower.

The nacelle would contain the drive shaft, gear box, generator, transformer and maintenance crane, the crane being able to remove the components from within the nacelle and lower them to the base of the turbine, without the need for external craneage.

Emergency lighting and basic survival amenities would be provided in case required by stranded crews (e.g. due to bad weather).

All functions of the turbine would be monitored and controlled by micro-processor based control units mounted within the nacelle and tower. Blade pitching would be activated by either hydraulic or electrical motor system, depending on the turbine model chosen. Yawing of the nacelle would be carried out by a number of electrical yaw gears, which mesh with the large toothed yaw ring mounted on the top of the tower.

A counter device may be attached to the base of the nacelle to ensure the nacelle does not undertake too many complete rotations in any one direction. Too many rotations would damage the power cable from the nacelle to the tower. The nacelle cover protects all the components contained within the nacelle, and access to the nacelle is gained through an opening from the tower.

Typically, turbine blades are manufactured from glass fibre reinforced epoxy with each blade consists of two blade shells which are bonded to a supporting beam. Each blade would be fitted with a lightning conductor, embedded in to the tip of the blade and running the length of the blade internally. Special steel root inserts connect the blade to the blade bearing which in turn would be fitted to the blade rotor hub. The blade rotor hub is in turn attached to the drive shaft placed within the turbine

2.7.3 Operational Turbine Noise levels

Noise emissions from wind turbines can be divided in to two main sources: those emitted from the blades and those associated with mechanical noise. The noise levels associated with the blades are known as aerodynamic noise, and are created by the wind passing over the blades. The mechanical noise is mainly attributed to that emitting from the gear box and the generator.

Currently available noise data for the following turbines indicate noise source levels at 10m/s wind speed 10m height above ground (IEC 61400-11 edition 2, 2002) as:

- Vestas V90 (3MW) 108.0 dB (A)
- REpower 5M (5MW) 108.7 dB (A)

Figure 2.15 shows the 35dB(A) contour of the wind farm. 35dB(A) corresponds to a negligible noise level. For example, the maximum noise level for built environment during night time is 41 dB(A).

The most sensitive receptors to noise are considered to be residents along the north Norfolk coast, however, the distance separation between the noise source and the receptors completely mitigates any potential noise impact. It is not considered that other users of the sea, for example those on commercial or recreational vessels, would experience any adverse impact from the noise levels, even allowing for slightly higher noise levels from 7MW machines (assumed to be the worst case even though there would be fewer of them).

Given these results, airborne noise from the turbines has not been considered further within the EIA.

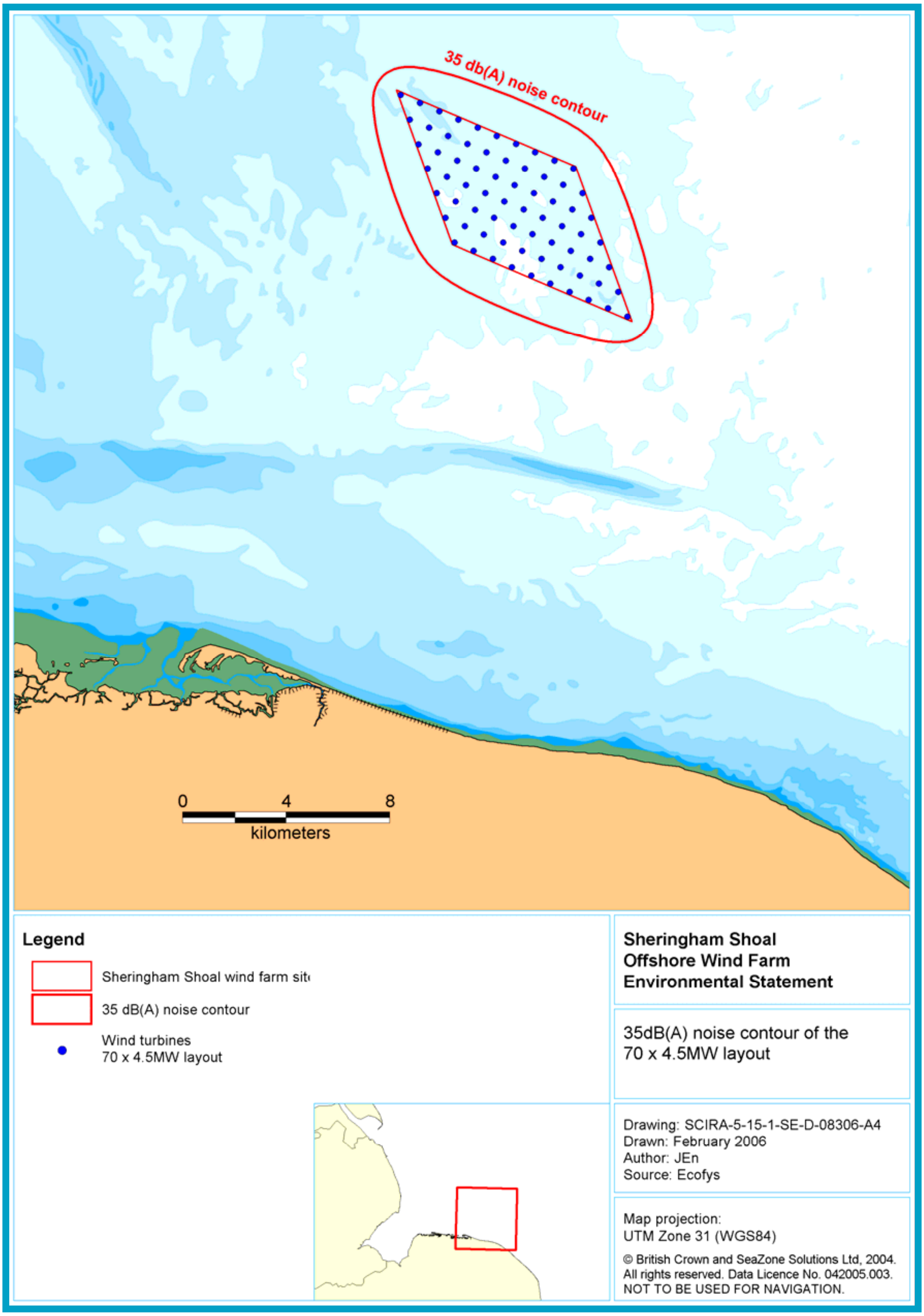


Figure 2.15 35db(A) noise contour of the 70 x 4.5 MW layout.

2.8 Other Offshore Components

2.8.1 Offshore Transformer Station

2.8.1.1 General description

One or two offshore transformer substations would be required to increase the generated voltage and to contain the necessary switchgear and plant. The inter turbine cabling is anticipated to be at a voltage of 20-50kV, which would collect at the offshore substation(s) (see Plate 2.22). The substation(s) would contain the necessary switch gear and transformer(s) to increase the voltage from 20-50kV to voltages of up to 150 kV. The power generated offshore would then be exported to shore at voltages up to 150 kV.

The exact number and location of transformer stations within the wind farm would be finalised at a later stage and may be influenced by factors including turbine selection and equipment/cable costs.

Plate 2.22 Illustrative offshore transformer substation

The engineering of the substation(s) has not progressed to a sufficient level of detail to provide detailed qualitative data parameters. However as a general indication the substation(s) would be expected to be around 20m x 20m x 15m in height and an approximate weight of between 600 – 2000 tonnes.

The main elements of the substation would be as follows:

- 20-50kV to up to 150kV transformer(s) and associated switch gear;
- Reactive compensation equipment;
- Back up communications power by small generator or battery backup;
- Possible diesel generator and tank;
- Possible emergency accommodation with associated facilities; and
- Possible emergency helipad facility.

Any liquids stored or utilised on the substation would be safely stored and adequately bunded to minimise any possible risk of spillages.

2.8.1.2 Construction

The majority of the construction of the offshore substation(s) would be undertaken onshore. Works might be undertaken at any yard with steel fabrication modular offshore construction experience. Consideration would be given to using the fabrication facilities available at either Lowestoft and Great Yarmouth or at one of the Humber ports such as Grimsby or Hull. All electrical switch gear, transformers and necessary panels are envisaged to be fitted onshore prior to transportation to site.

2.8.1.3 Transportation

The substation would be transported to site by either a barge, or a transport vessel with large flat load deck. The advantage of the transport vessel being that it would be able to power itself to the location whereas the barge would require tugs.

2.8.1.4 Installation

The completed substation, once transported to the site, may be lifted by a shear leg crane or a jack up barge and would be placed on the chosen foundation type most suitable for the ground conditions. The foundation type could be the monopile, tripod, quadruped or the gravity base structure or a purpose designed steel framed foundation. It is anticipated that the substation would be painted the same marine grey as the wind turbines with the requisite navigation lights. Boat access would also be provided for operation and maintenance and emergency requirements.

2.8.2 Meteorological Mast

It is currently anticipated that a meteorological mast would be installed as part of the development in order to measure ambient wind speed. The mast would be located in the north west corner of the wind farm site (53° 10.4687N 01° 4.6625E) in water depths of around 15-17m (LAT).

2.8.3 In-field cabling

2.8.3.1 General description

It is anticipated that the turbines generating voltage would be stepped up to 20-50kV by onboard transformers situated in either the turbine nacelle or turbine tower. The inter connecting turbine cables would be laid between the turbines and terminate at the offshore substation(s). Each interconnecting cable may contain a fibre optic cable via which communications between the turbine, substation and shore would be passed.

2.8.3.2 Cable layout, burial and connection

Figure 2.17 provides an indication of how the wind farm inter turbine cabling might be laid out for a 45 x 7MW layout. However it should be noted that the final electrical design and cable routing has not yet been determined and may vary.

The inter turbine cable is anticipated to be approximately 100-200mm in diameter and to be buried to a target depth of approximately 1-3m within the site depending on ground conditions. The cable would most probably be winched up to the turbine through a foundation mounted ‘J’ tube and ducted from the ‘J’ tube, into the turbine tower.

The cable could be buried by one of two methods generally used for shallow water cable installations namely, the ploughed method or the trenched/jetted method. Outline methodologies of these two methods are described below.

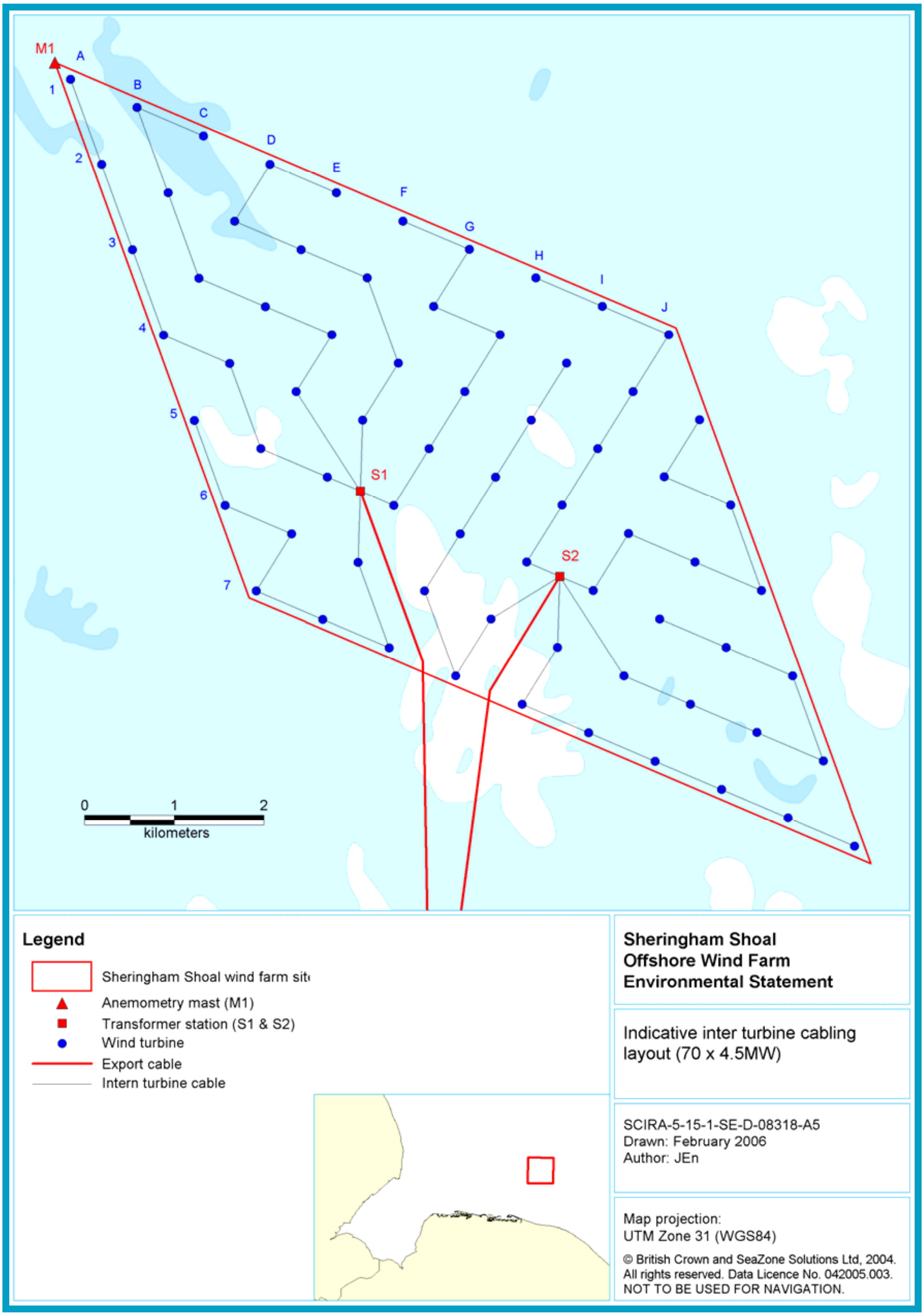


Figure 2.16 Indicative inter turbine cabling layout (45 x7 MW)

2.8.3.3 Towed Plough Method

The plough would be attached to a barge and placed on the seabed. As the barge moves forward, the plough is dragged along the seabed. The marine cable is paid out from the barge into the front of the bell mouth of the plough. The cable passes from the bell mouth to the cable trough and on through the plough share (see Plate 2.23 a-d). As the plough is dragged the share cuts a deep narrow trench for the cable and the cable is dropped into the trench, and held there by a depressor.

Plate 2.23 a-d Ploughed cable installation (across a beach with some pre-excavation in places)

As the plough is dragged along, and the share cuts into the seabed, the trench behind the plough collapses onto the cable leaving only a small indent on the seabed. The depth of the cable burial can be adjusted by the variation of the height of the plough skids at the front of the plough. Sensors mounted on the plough would indicate critical parameters which include, but would not be limited to, depth of burial, and cable tension during ploughing.

2.8.3.4 Self Propelled Ploughs

Self propelled ploughs vary from towed ploughs in that they do not rely on a barge for towing, but use a caterpillar track system (see Plate 2.24). The self propelled plough could also have the cable drum mounted on it, reducing the need for vessel mounted cables but requiring pre cut cable lengths, which can be wasteful.

Plate 2.24 Self propelled plough

2.8.3.5 Trench Method

For short runs, for example in proximity to the foundation bases, the trenching method could be utilised. For this method a trench is excavated by either a digger from above sea level or a jet equipped remotely operated vehicle (ROV) from below (see Plate 2.25), the cuttings from the trench being placed to one side. The cable is then laid in the excavated trench and the cuttings back filled over the laid cable. This system tends to be slow, costly and highly susceptible to strong sea currents which can quickly backfill the excavated trench before the cable has been successfully laid.

Plate 2.25 Jet equipped remotely operated vehicle

2.8.3.6 Jetting Method

There are two methods of jetting, namely, fluidising the seabed and forward jetting. The fluidising method operates by a sledge being placed over the cable to be buried, jets fluidise the seabed under the cable and the cable sinks in to the seabed under its own weight (see Plate 2.26 a and b). The forward jetting method is usually undertaken on a towed base or could also be self propelled. High pressure water lances form a trench in advance of the cable, which is subsequently dropped into the trench which is allowed to collapse around the cable.

Plate 2.26a Jetting Sledge

Plate 2.26b Remote Jetting Sledge

The preferred cable burial method would be determined in discussion with the installation contractor following a more detailed engineering assessment.

2.9 Site to Shore (Export) Cables

2.9.1 General description

As described above from the offshore substation(s) the wind farm output would be transmitted via two export cables to landfall in the vicinity of Weybourne Hope. Each of the two marine export cables is anticipated to be a three core armoured XPLE cable with an anticipated diameter of around 150-250mm. It is anticipated that total burial distance from the wind farm to shore would be between approximately 21 and 22km, depending on the route taken. Again, a fibre optic communications cable may be incorporated into the marine cables.

Cable burial depths would vary according to factors such as ground conditions experienced, but are expected to range from approximately 0.5m to 3m. The export cables are anticipated to be up to approximately 100m apart for the majority of the offshore route.

Two cable route options are currently being considered, namely:

- A preferred direct route from the wind farm to landfall crossing Sheringham Shoal (approximately 21km); and
- An alternative western route avoiding Sheringham Shoal (approximately 22km).

These routes are shown in Figure 2.17 and described below.

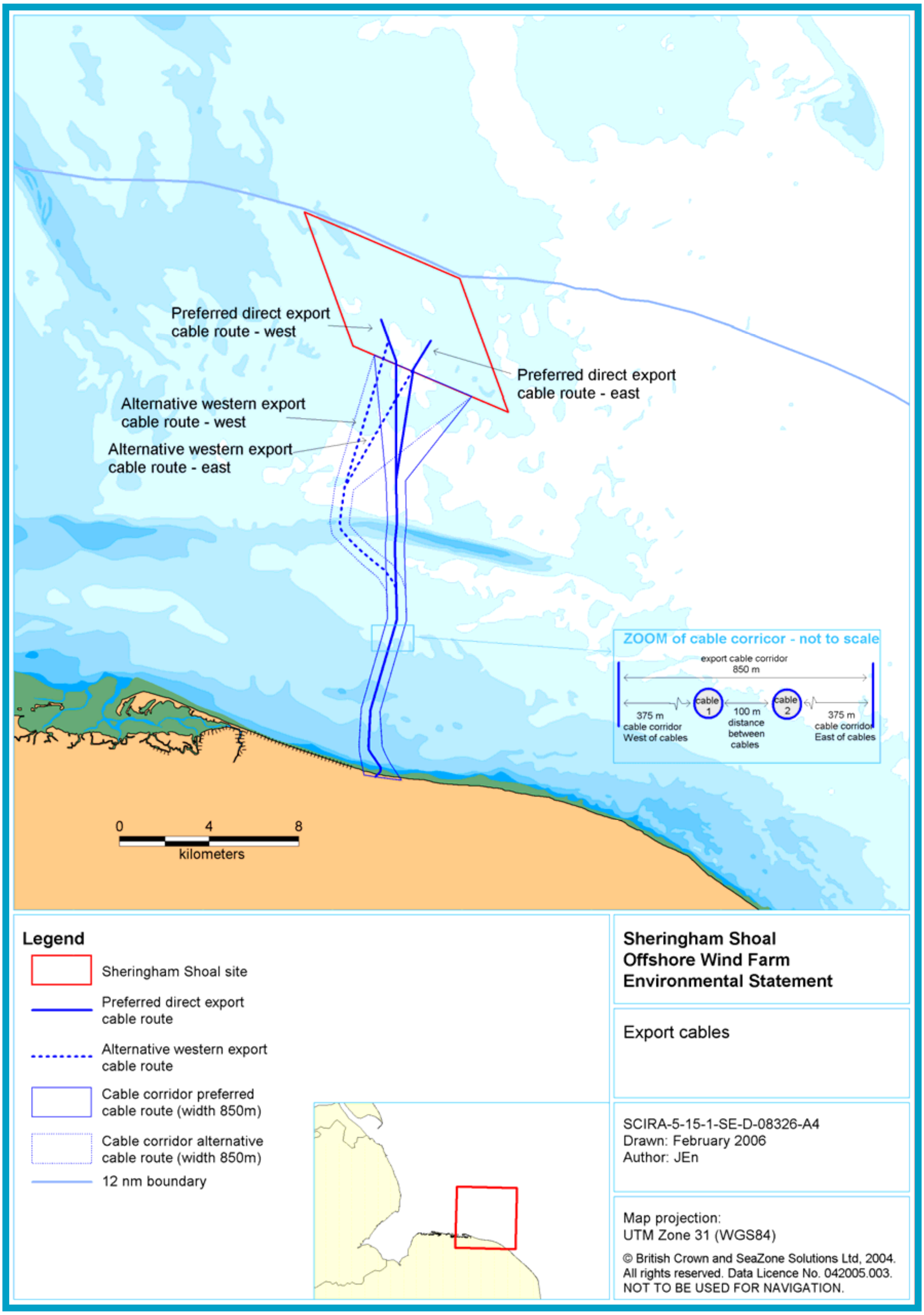


Figure 2.17 Wind Farm site and export cables.

2.9.1.1 Direct route crossing Sheringham Shoal

The preferred export cable route is positioned to traverse the shortest length of sea bed whilst avoiding (as much as possible) hard materials (Chalk) at surface. The route is therefore related to the outcrop at the sea bed of 'softer' geological formations to allow easier burial and avoid disturbance of chalk.

The cable is positioned to cross two mobile sand banks; Sheringham Shoal (medium to coarse sand with migrating sand waves along its flanks) and Pollard Shoal (sand and gravelly sand). Across the flanks of Sheringham Shoal the cable could be positioned in a trough of a sand wave. The troughs of the sand waves are approximately 1-2m in depth with a wave length of 120-200m. It would therefore take over 40 years for the crest of the sand wave (assuming a migration rate of several meters per year) to pass over the cable location before the cable is located beneath the trough of the adjacent sand wave.

The flanks of the Shoal have a gradient of 1:80 with a minimum LAT water depth of around 5 - 6m. The gradual movement of the Sheringham Shoal in a south easterly direction is also responsible for the gradual depletion of sediment on the northern side of the Shoal, in the order of 1m in 10 years (see Section 6).

Between the Sheringham Shoal and the wind farm site, the cable is positioned to cross predominantly Bolders Bank Formation (till) at surface whereas south of the Shoal it crosses Swarte Bank and Egmond Ground Formations (heterogeneous tills, sands and clays). Closer to shore the cable follows the outcrop of the Weybourne Channel deposits (sand/gravel overlain by silt/sand) which are likely to extend to where the cable corridor meets the coast in the vicinity of Weybourne Hope. However, Chalk is crossed along three shorter sections of the route south of the Shoal, totalling approximately 1.6km. This was unavoidable and was dictated by the extent and orientation of the Chalk outcrop in a direct line between the wind farm site and the land fall sites (Royal Haskoning, 2005). The Chalk may be covered by recent sediments (various lithologies) or a sand/gravel lag up to 2m thick (see Figure 2.18).

The direct route is preferred because of its shorter length, and because there would be no need to cross the North Norfolk SAC. Latest information from English Nature indicates that the Sheringham Shoal is not on the shortlist to be designated as an SAC (see Section 5, Nature Conservation Designations).

2.9.1.2 Alternative western cable route

An alternative export cable route passes around the western end of Sheringham Shoal joining the preferred route at a point south of the Shoal. The sea bed geology of the alternative route has not been mapped in detail. This route was originally identified to avoid any potential problems with exposure of the cable due to migrating sand waves identified along the north (and possibly south) flank of Sheringham Shoal and any potential larger scale movement of the bank as a whole. As the alternative cable route is positioned to pass around the western end of Sheringham Shoal it should avoid any interaction with large (bank) or small (sand waves) mobile bedforms. However, if the route does interact with the sand waves, they are large enough for the troughs to accommodate burial of the export cables.

The proposed alternative route is approximately 1km longer than the direct route and would cross the periphery of the offshore SAC area (see Section 5).

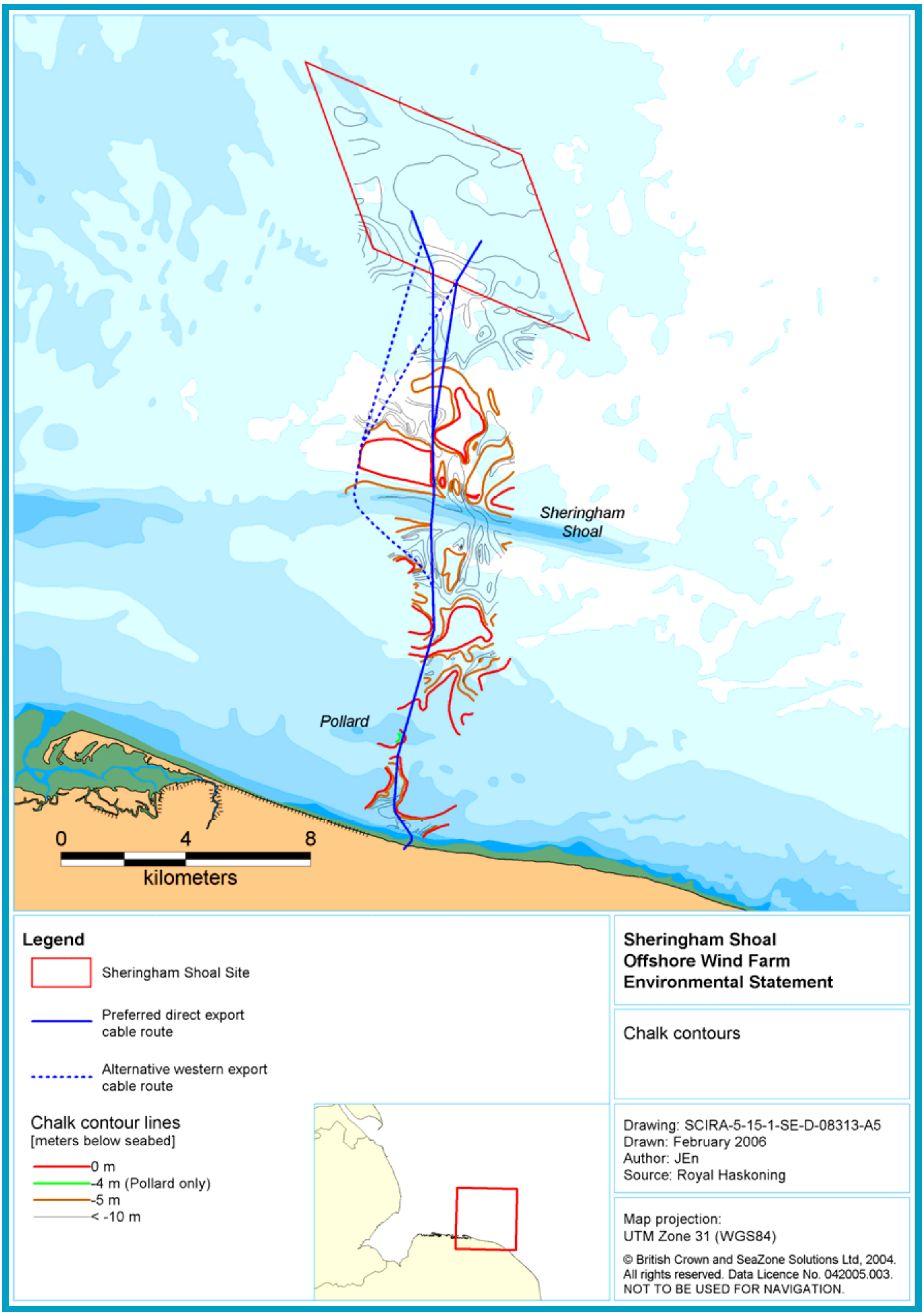


Figure 2.18 Wind farm export cable routes and Chalk outcrops

2.9.1.3 Export Cable laying

It is proposed that the cables be laid to a minimum depth of 1m below the seabed except for the crossing of the Pollard and Sheringham Shoals where a depth of approximately 1-3m would be expected for these areas. It is anticipated that the cables would be buried within a minimum 850m corridor and have a separation of up to 100m.

A temporary construction corridor of approximately 1200m would be required. The construction corridor is used for placement of the anchor arrays which the cable laying barge vessel uses to pull itself along with the cable burying plough in tow (see Plate 2.27). An accompanying tug would reposition the anchors as and when required by the cable laying barge. In order to minimise sediment seabed disturbance the cable plough method of installation is likely to be used, although a final decision has not yet been made.

Plate 2.27 Cable plough behind tow vessel

Once the first cable has been buried the second cable burial would commence which would run parallel to the first with a minimum separation of about 50m, but contained within the 850m corridor. A cable burial rate of 1–1.5km a day should be achievable (speeds of 1.5m/s could be achieved dependant on soil conditions). The actual rate at which the cables would be buried depends on seabed formations, geology, tidal currents and weather; however it is anticipated that each cable would take a minimum of 13 days to lay. No cable crossings are required.

2.10 Construction Safety Zones

As described in 2, under the provisions of the Energy Act 2004 it is proposed that a 500m safety zone would apply around each offshore structure, to ensure the personnel carrying out these activities and those navigating in this sea area are not exposed to unnecessary risk (see Section 14, Shipping and Navigation).

2.11 Construction Noise during installation

During construction, a number of operations would be taking place which are likely to be the source of elevated noise levels. Over and above general construction activities, piling using a driven technique would lead to the greatest increase in noise levels. BS 5228: Part 1: 1997 *Noise and vibration control on construction and open sites* is the standard normally used to assess the impacts of construction noise upon nearby residential properties; however, the distance over which the noise is expected to propagate means that any prediction of site-based noise at residential receivers would be extremely unreliable; the standard states that “*At distances over 300m noise predictions should be treated with caution…because of the increasing importance of meteorological effects*”. It is probable that more local sources of noise would tend to dominate and influence the ambient noise climate near the receivers.

The following simple, standard calculation can be used to show that with source noise levels of 120 dB(A) L_{eq} (pers. Comm.. MENCK GmbH) from the piling operations, at landfall some 17km away, receiver noise levels would be in the region of 27dB(A), assuming hemispherical propagation of the noise over a hard reflecting surface:

Sound pressure level @ receiver dB (A) = sound power level - 20 Log_{10} (Distance) – 8

Sound pressure level @ receiver dB (A) = 120 – 20 Log_{10} (17000 m) - 8 = 27 dB(A) L_{eq}

These noise levels are not only short term but would be well below typical rural background (L_{A90}) noise levels in the UK, which are normally in a range from the mid 30's to mid 40's dB(A).

In addition, the UK is predominantly subject to southerly or south-westerly winds, which would tend to significantly reduce noise levels upwind of the source (i.e. on the north Norfolk coast).

It could be possible, under extremely calm conditions and with a temperature inversion or with a gentle prevailing easterly wind, that the low frequency impulsive 'thump' associated with the noisier piling activity, would be audible at these distances. However, the energy level and hence perceived loudness of any received noise would be very low indeed and should certainly not be expected to be the cause of nuisance.

Other construction activities would tend to be between 5 and 30 dB quieter than the piling noise. and would possess less intrusive characteristics than pile-driving. These other construction noises are unlikely to be audible or the cause of nuisance on land, at 17km distance, under normal meteorological conditions.

Underwater noise is addressed in Section 9, Marine Ecology, 10, Natural Fisheries and 11, Marine Mammals.

2.12 Onshore Project Components

2.12.1 Introduction

The marine cables would be landed in the vicinity of Weybourne Hope, crossing the shingle beach to be anchored firmly and jointed to the land based cables at one or more cable connection pit(s) (see Plate 2.26 a, b and c). As discussed with officers of North Norfolk District Council (NNDC) and the landowner, the land based cable route would cross the museum grounds in a southerly direction for approximately 750m until terminating at a switch room, located adjacent to the museum. It is anticipated that from here suitable connection(s) to either EDF's 132kV network and / or National Grid Transco's 400 kV network would be made. (Consent for this new connection will be applied for separately).

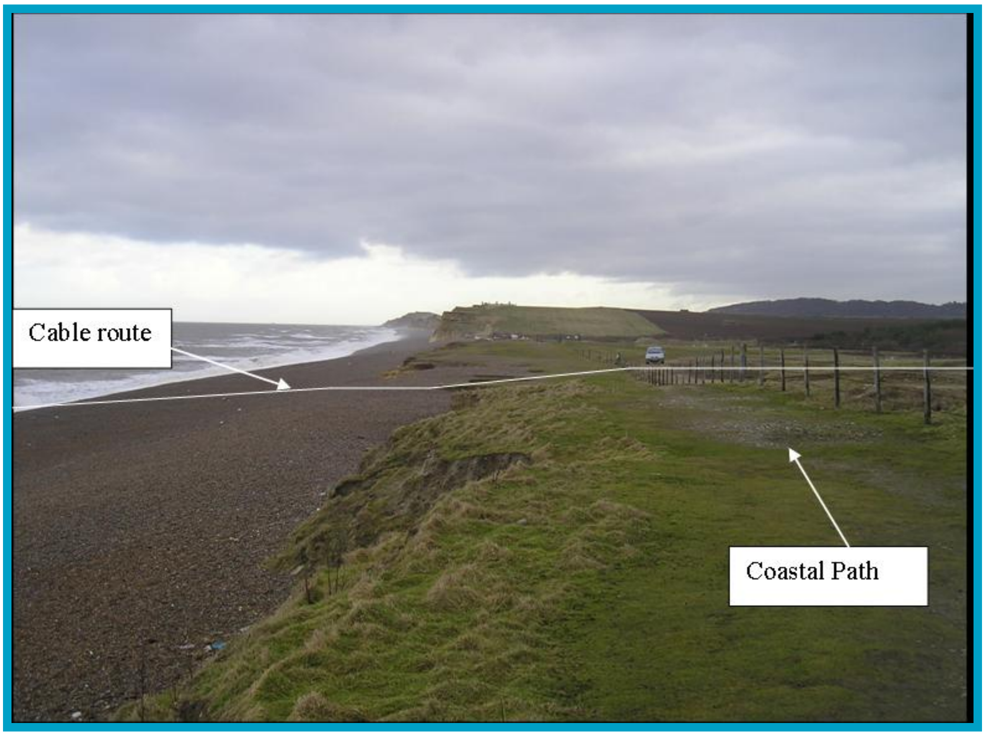


Plate 2.28a View looking east from the landfall point

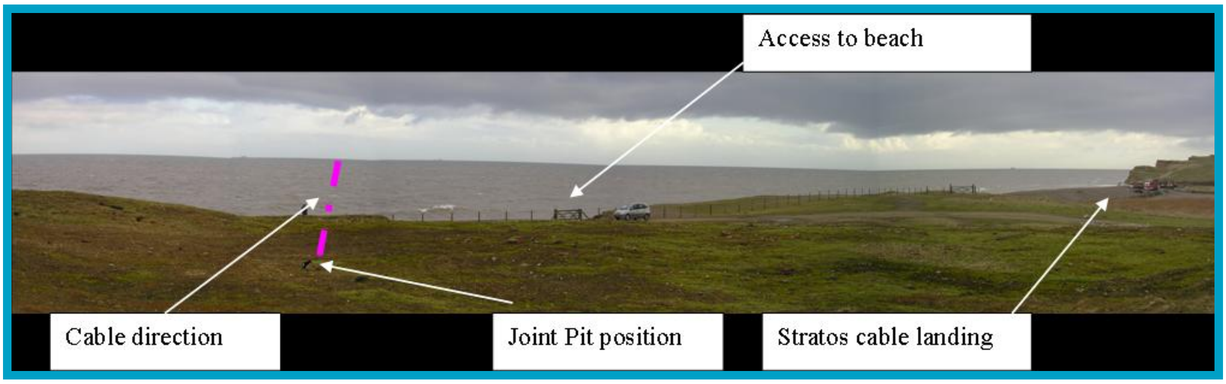


Plate 2.28b Panoramic view from behind the Joint Pit position, looking North.

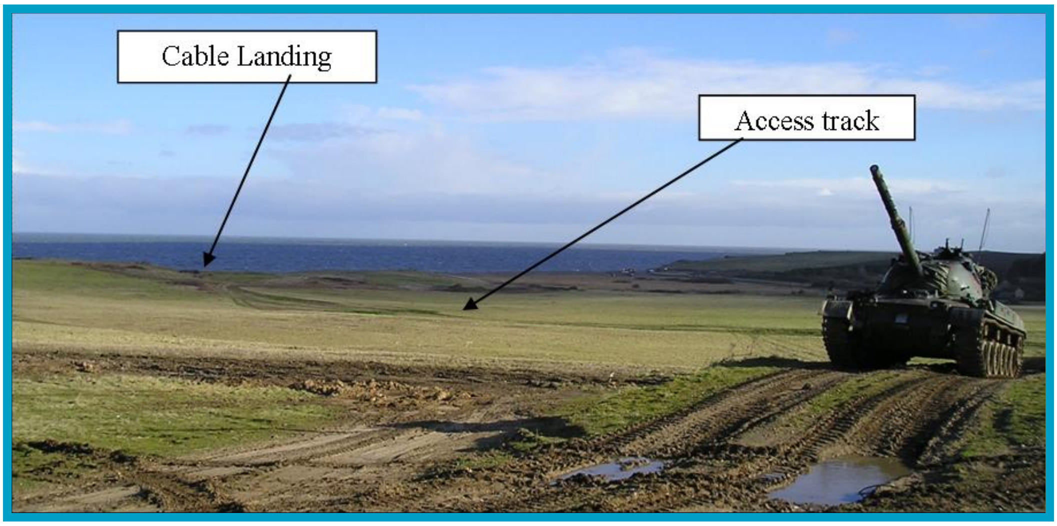


Plate 2.28c View from Museum looking North North West toward landing area

2.12.2 Onshore Cable Construction Methodology

2.12.2.1 Landfall

The construction methodology at the point of landfall has not yet been finalised and is pending detailed technical investigations. The description below is based on preliminary engineering studies.

It is currently proposed that in order to bring the marine cables ashore the "beaching " of the cable would be undertaken in three key stages;

- Stage One - Directional borehole preparation and completion;
- Stage Two - Beach preparation; and
- Stage Three - Cable drawing process.

These stages are described in outline below. A detailed methodology would be agreed with NNDC prior to construction, including details such as working hours.

Stage One - Directional borehole preparation and completion

The cliff at the proposed landfall is made up of various grades of clay and sand with flint and chalk boulders, with the predominant bedrock being chalk. The beach itself is made up of a stone/ shingle bank which is highly mobile. The mobility of the shingle bank is dependant on the state of the tides and the sea state. The low water area of the beach is made up of sand, shingle and finer stones.

In order to protect the cliff edge and ensure the natural sea defences are not weakened as well as minimise any impact on the top soil, coastal path, flora and fauna, it is proposed that the cable be ducted under the cliff line as illustrated in Figure 2.19.

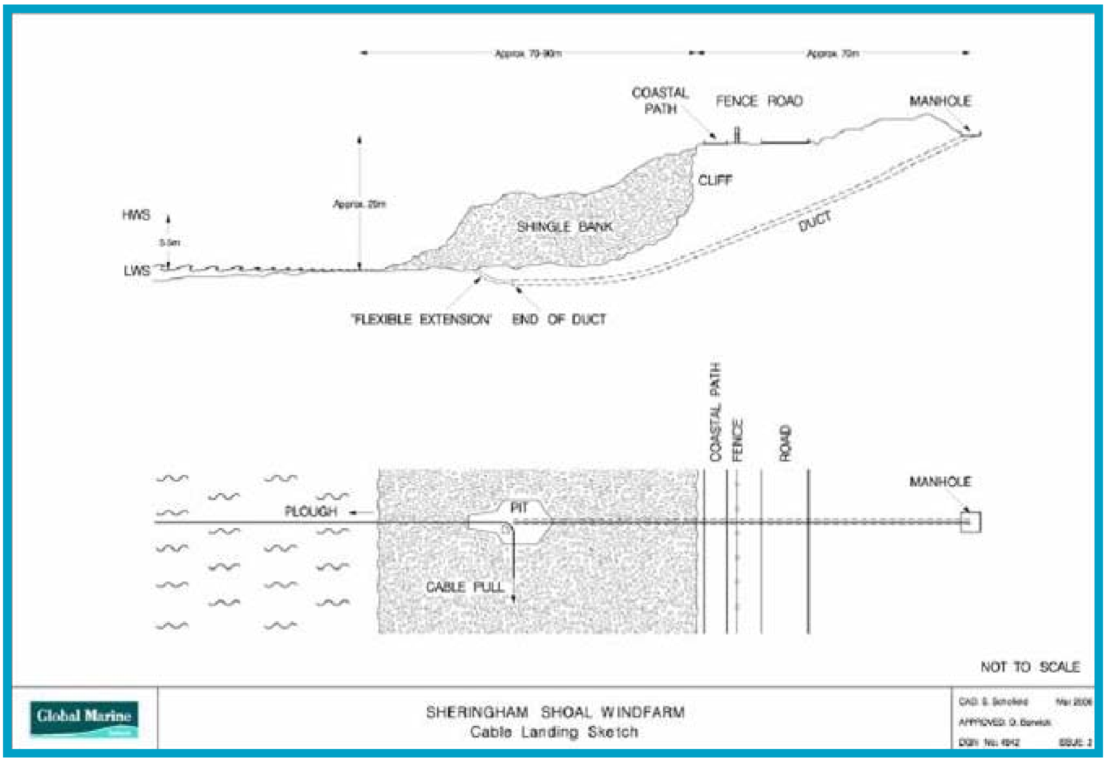


Figure 2.19 Cable Landing Illustration

Directional bore equipment would be erected at the cable connection point and the bore hole drilled. A duct liner would then be installed, through which the cable would be later drawn. It is anticipated that a liner in the region of 300 – 350mm would be required in the drilled duct, to provide adequate clearance for a 150 - 250mm diameter cable, the bullnose (pulling head), stoppers and strap wires at the head of the cable. It is anticipated that installation of the duct liner would take less than one tidal cycle.

Two separate ducts would be required for the two cables. The separation of the ducts at the connection pit would typically be 2m as this enables the duct entrances to be stable enough not to impact on each other and also acts as adequate separation for the cables to protect against heat transfer.

Stage Two - Beach Preparation

The duct exit can be positioned anywhere to the seaward side of the shingle bank subject to the technical parameters of the drilling operation. An exit close to low water mark would minimize removal of shingle, however, enough beach space is required to allow for the duct liners to be pulled back through the directional drilled hole. The duct exit would be approximately 1m below the natural seabed/beach.

Prior to cable installation, the beach site is prepared. This involves:

- Setting up a pulling winch at the connection pit;
- Excavation to locate the pre-installed duct using diggers;
- Clearing or 'Pigging' of the duct to ensure it is clear, reeving of the pulling line and temporarily sealing the end to ensure no further debris enters the duct; and
- Attachment of a marker line to easily locate the duct end.

On the day of installation the beach requires final preparation involving the following tasks:

- Opening up of the beach to locate duct end;
- Move away excess pebbles between the duct end and the water line; and
- Undertake diver inspection of the cable route out to installation vessel.

Stage Three - Cable Drawing Process

A hauling line from the vessel is brought ashore and taken around a quadrant placed on the beach to the landward side of the duct entrance. The line is attached to a digger which then proceeds along the beach, hauling in the cable which is paid out from the vessel with flotation buoys attached. This continues until the cable end is in line with the duct entrance. The cable hauling line is then attached to the cable end. The winch at the connection pit then takes over the cable pull. Once sufficient cable is ashore, the cable is temporarily anchored. The floats are removed by divers and the cable left laying on the seabed. Cable testing would take place to ensure that the cable is intact.

At the next high water the installation vessel would approach the beach, launch the plough and commence laying and burying of the cable. On any exposed beach area the diggers would dig a trench alongside the cable and then lower the cable into the trench. This trench is below the natural 'seabed' level. At low water springs this operation would continue offshore to meet up with the plough burial start position.

The operation is anticipated to typically take one to two days for preparation, one day for the installation and two days for beach burial out to the spring low water mark. During non working periods, the cable would be buried at a shallow depth to ensure safety. Public access would be restricted to the area during the installation period.

2.12.2.2 Cable Connection Pit

Once drawn through the cable ducting it is anticipated that each marine cable would terminate in a concrete based connection pit. It has not yet been decided whether connection pits for each marine cable would be situated adjacent to each other, separated in order to enhance connection security, or combined in a single larger pit.

The cable connection pit(s) would be constructed on the southern side of the beach and located above the 50 year flood level and behind the 50 year beach retreat level. It is anticipated that the cable connection pit(s) would be approximately 1m below the land surface and would each have the following approximate dimensions:

- Length 10m
- Width 3m

Following connection of the marine cables with the onshore cables, the cable connection pit may be back filled with sand. Concrete high voltage tiles would be placed on top followed by the replacement of soil and reinstatement of the surface.

Once installed, the connection pit(s) themselves are not expected to require access unless a fault requires excavation. However, routine access would be required to the cable's sheath and earthing system and it is anticipated that this would be provided by the use of 'link boxes'. These are small pits located in the vicinity of the connection pit(s) containing links and sheath voltage limiters. Link boxes are anticipated to be approximately 500mm deep, with access and protection provided via a manhole cover.

2.12.2.3 Land Cables

From the cable connection pit(s) land cables would be routed to the switch room. These cables would operate at voltages up to 150kV. The cables would consist of either two 3 core cables or three single core cables for each of the two marine export cables. One or more fibre optic communications cables may also be included.

A trench would be excavated from the cable connection pit to the proposed switch room. The trench would be constructed so as to have dimensions of approximately 2m – 3m wide at its deepest and, where practical approximately 6m wide at surface level, minimising the need for costly and slow shuttering to stabilise the trench. The trench would be excavated to sufficient depth to ensure that the cables are buried to a target minimum depth of approximately 1m below the land surface. An excavator would be used to form the trench, although hand digging may be required around obstacles. Topsoil and subsoil would be stored separately. Cables would be bedded on a layer of sand with protective warning concrete tiles placed above the cables as well as a warning tape. Following this the subsoil and topsoil would be replaced and the route reinstated.

It is envisaged that a 20m working corridor would be required in which to bury the cables.

2.12.2.4 Switch Room

The proposed switch room building would be brick built with a flat or pitch roof with dimensions of up to 20m x 10m and a height of up to 5m. The equipment specification for the switch room has not been finalised however equipment could include, reactive compensation facilities, switchgear and metering. The wind farm's communications and computer links connected to any fibre optic communications cable may also be housed in the switch room.

Following discussions with NNDC, screening of the building would be provided, for example via extension to the existing tree belt and / or use of raised banks. The building would be designed to blend in as far as practical with the World War II theme of the existing buildings and the woodland backdrop (see Plate 2.29a-d) when viewed from the south. Once operational, permanent access would be required and would be via the main access to the Muckleburgh Collection.

Traffic movements associated with the construction of the onshore works are estimated to include around 100 to 120. heavy goods vehicle (HGV) movements for the delivery of the cable, warning tiles and tape, cement, sand bags and shuttering etc. The schedule for the works is anticipated to be over a period in the order of 16 weeks. Some abnormal loads would be required to deliver the excavators and other construction plant.

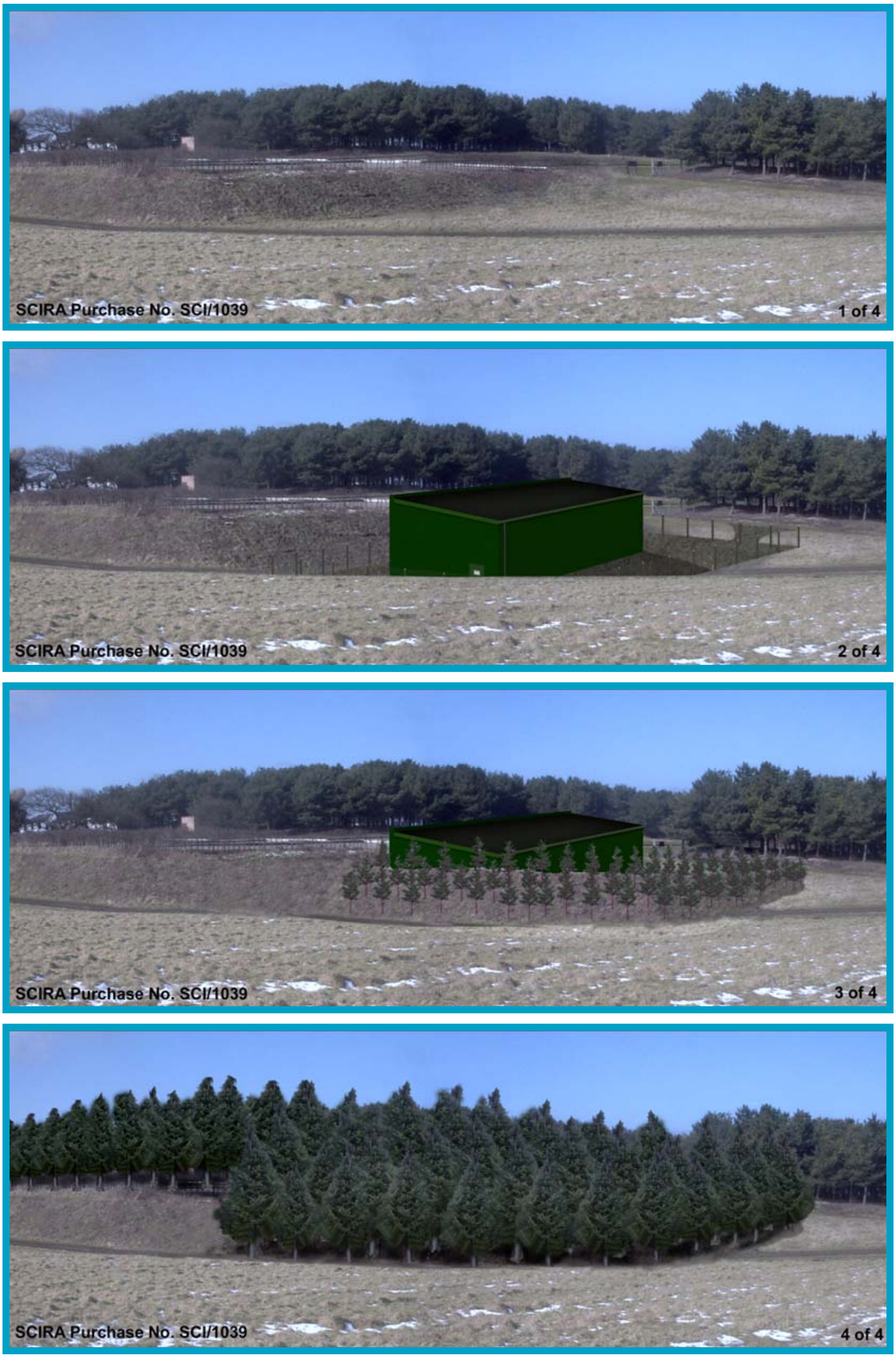


Plate 2.29a-d Photomontage of proposed new Switch Room Building at "The Muckleburgh Collection" Weybourne, Norfolk (viewed from south).

2.13 Construction and Installation Programme

The most suitable period for offshore construction activities, cable laying and landfall is during the spring and summer months when the weather is most favourable. However, it has not yet been determined whether construction would take place over one season or spread over a longer period. This would be influenced by factors including the chosen size and therefore number of turbines. It is anticipated, however, that the majority of the onshore cable works would be undertaken over the winter period when the museum is closed to minimise interference to the museum operations and facilities as well as recreational users and tourists in the area.

An indicative schedule is provided in Figure 2.20, although this is subject to change.

	First installation period				Second installation period				
	Yr 1	Year 2				Year 3			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Delivery and construction									
• Delivery foundations at harbour	■	■			■	■			
• Delivery transition pieces at harbour		■	■			■	■		
• Delivery turbines at harbour		■	■	■		■	■	■	
• Delivery transformer station at harbour		■				■			
• Assemblage turbines at harbour		■	■	■		■	■	■	
• Delivery of jointing pit, switch room and land cables	■	■							
Installation									
• Foundation and transition pieces		■	■	■	■	■	■		
• Turbines			■	■			■	■	
• Transformer station		■	■			■	■		
• Infield cables (25-35 km)			■	■			■	■	
• Application scour protection			■	■			■	■	
• Export sea cable (21-22 km)		■	■			■	■		
• Landfall works	■	■							
Commissioning			■	■	■		■	■	■

Figure 2.20 Indicative Construction Plan

2.14 Health and Safety Plan

2.14.1 Principles

Box 2.1 provides an extract from the BWEA's "Guidelines for Health & Safety in the Wind Energy Industry" booklet ISBN Number 1 870064 30 5. The content of the report is anticipated to form the basis for the Health and Safety plan for the proposed Sheringham Shoal wind farm project.

Box 2.1 Guidelines for Health & Safety in the Wind Energy Industry

Introduction

The design, construction, operation, maintenance and removal of offshore wind farms requires consideration of a number of matters over and above those for onshore ones. Offshore wind farms are at the mercy of wind, wave and weather, and present difficulties in terms of access, work and emergency response. The safety and survival of personnel working offshore is of paramount importance. When work is being carried out on unmanned structures a vessel must always be in attendance with good communication links between weather stations, vessel and personnel to enable speedy evacuation should there be an adverse change in the sea state.

Site Development and Planning

When identifying potential offshore sites for wind farms, particular attention could need to be paid to oceanographic and meteorological factors. Areas with large tidal ranges or severe currents would present problems in terms of access for normal operations and also when dealing with an emergency. Such conditions could well severely restrict the size of 'working windows' and should be taken into account when selecting a site and/or the design of equipment to be used. Any vessels used for access and transport of material would need to be assessed for their ability to hold position and the size of such vessels could be restricted by available water depth. Strong currents could also make the seabed prone to scour problems. The proximity of shipping lanes would also have to be taken into account, together with the possibility of vessel collision, whether from passing vessels or in-field craft servicing the wind farm.

Design, Assembly, Manufacture and Specification

Due to the nature of the environment, the design of the wind turbines and ancillary equipment needs to take into account not only wind and weather but also the potential corrosion problems not usually found at inland sites.

Fire offshore is potentially much more serious than onshore. It is not possible to run away from a fire offshore. Therefore, a fire risk assessment should be performed for every installation, including the identification of appropriate prevention, detection, control and mitigation measures. A fixed fire fighting system could be necessary in order to provide an appropriate level of protection for personnel when working offshore.

The design phase is particularly important for offshore wind farms since the cost of retrofitting equipment is much greater than for onshore sites.

Designers should aim to maximise the work, such as fabrication, commissioning and testing, which can be done onshore in order to minimise the work to be undertaken offshore.

During design, the means of access and egress from the turbines needs to be addressed. Specialised commercial access systems and craft are available for this type of operation and fitting such a system should be considered at the design stage.

Offshore wind farms should be designed to minimise the need to work at height in exposed positions. As far as possible, the use of vertical ladders should be eliminated not only to reduce the risk of falls but also fatigue and making the rescue of casualties easier.

Consideration should be given to the potential need to interrupt the offshore operations because of weather or sea state. The design should include an erection sequence which allows the partially erected structure to be left in a safe condition whilst waiting on weather. It is best to avoid the need for a prolonged weather window, which could be difficult to obtain during much of the year at many sites around the UK.

Construction, Commissioning, Dismantling and Demolition

During these phases, it is assumed that personnel would be accommodated either onshore or on a suitable vessel. Where on site accommodation is not provided, a vessel must be in attendance throughout the period work is taking place to ensure that personnel can be promptly recovered from the work place should the sea state change.

One of the key issues which needs to be addressed during this and the operation and maintenance phase is that of emergency response. Any offshore emergency would have to be dealt with using the resources available offshore or on an attendant vessel.

It is recommended that a site specific evacuation, escape and rescue risk assessment be performed for individual sites and individual construction operations. Such a risk assessment would provide the basis for the development of an appropriate emergency response plan.

The emergency response plan should address all foreseeable emergency situations, *e.g. persons falling into the water*, and should be the subject of regular desk top exercises and drills. The emergency response plan would need to clearly set out the roles and responsibilities of everyone together with the actions to be taken to deal with all reasonably foreseeable scenarios requiring an emergency response. The plan should also address the need for the taking of persons to a place of safety, which means somewhere where medical treatment and other facilities are available. Everyone working offshore would need to receive appropriate basic training supplemented by more specialised training for those given specific roles in an emergency. Refresher training would be required at appropriate intervals.

Careful consideration would need to be given to the provision of appropriate means of evacuation and rescue, taking into account the need to handle casualties. The most appropriate arrangement could well be an attendant vessel which can deploy groups of men on a number of turbines within the site but be within easy reach in order to take personnel off in the event of deterioration in the weather or as a result of illness or injury. Such a vessel needs to be of such a design that it can reach all the turbines in a particular site and be capable of taking people off safely, including any casualties. It would also need to be manned by a competent crew who have received appropriate training and are exercised regularly in the emergency scenarios with which they could be involved. Appropriate means of communication between the vessel and the turbines and the shore would need to be available.

When planning work, it would be necessary to take into account accurate weather forecasts, preferably from at least two sources, and organise the work on the basis of the attendant vessel's performance in terms of its ability to take off personnel, especially casualties, in relation to the weather and sea state.

Any pollution risks would need to be identified and appropriate procedures established to deal with any pollution incident.

Operation and Maintenance

Appropriate policies and procedures need to be devised and implemented with respect to site visits, distinguishing between planned maintenance visits and unplanned intervention visits in the event of a breakdown. The former can be carefully planned to ensure that such activities are undertaken during the summer when weather and sea conditions are likely to be at their most benign and more daylight is available. However, intervention visits could be necessary during the winter months and the policies and procedures should clearly reflect the adverse weather policy for the particular site to ensure that such visits are properly planned and only undertaken when conditions are considered to be safe and personnel, including casualties, can be recovered by the attendant vessel.

If there is the possibility of personnel being marooned on a turbine overnight due to weather or sea conditions, suitable sleeping accommodation could have to be provided. Such accommodation would need to include shelter, heating, emergency power and supplies of food and drinking water.

2.14.2 Applicable Health & Safety Legislation

The construction and operation of the wind farm would be undertaken in accordance with relevant and appropriate guidance. The following list is no more than indicative:

- The Health And Safety At Work, Etc. Act 1974
- Management Of Health And Safety At Work Regulations 1999
- Health And Safety (First Aid) Regulations 1981
- The Reporting Of Injuries, Diseases And Dangerous Occurrences Regulations 1995
- The Workplace (Health, Safety And Welfare) Regulations 1992
- Personal Protective Equipment At Work (PPE) Regulations 1992
- The Manual Handling Operations Regulations 1992
- The Provision And Use Of Work Equipment Regulations 1998
- Lifting Operations & Lifting Equipment Regulations 1998
- Health And Safety (Display Screen Equipment) Regulations 1992
- Control Of Substances Hazardous To Health Regulations 1999
- The Noise At Work Regulations 1988
- Electricity At Work Regulations 1989
- Construction (Design And Management) Regulations 1994
- Construction (Health, Safety And Welfare) Regulations 1996
- Confined Spaces Regulations 1997
- Fire Precautions (Workplace) Regulations 1997
- Diving At Work Regulations 1997
- Other Relevant Legislation
- The Pressure Systems and Transportable Gas Containers Regulations 1989
- The Safety Signs Regulations 1980
- The Safety Representatives and Safety Committee's Regulations 1977
- Fire Precautions Act 1971
- The Safety, Quality and Continuity Regulations 2001
- The Electricity (Overhead Line) Regulations 1970
- The Construction (Head Protection) Regulations 1989
- The Factories Act 1961
- Offices, Shops and Railway Premises Act 1963
- Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997.

2.15 Operation and Maintenance (O & M)

A detailed O&M strategy has not yet been established and would be determined at a later stage, taking account of issues including turbines selected and procurement strategy. Such a strategy would also determine whether a requirement exists for offshore manning on a regular or permanent basis.

2.15.1 Operational Wind Farm Safety Zones

As described in Section 2, under the provisions of the Energy Act 2004 it is proposed that an operational safety zone would apply around each turbine and structure located offshore. The purpose of the exclusion zone would be to minimise any possible interaction between sea users and access to the installations by unauthorised vessels.

It is proposed that during operation a 100m safety zone would apply around each individual turbine for all vessels not associated with the wind farm. It is envisaged that recreational vessels and potters would be permitted up to this zone. A 500m safety zone would be applied for merchant shipping and other specific activities which by their nature represent a risk to the structures and cables, e.g. towed gears such as otter trawls and beam trawls, dredging activities and anchoring of certain vessels (see Section 14, Shipping and Navigation).

2.15.2 Operation and Maintenance Strategy

2.15.2.1 Minor Maintenance

The design of the wind farm would ideally be such that human intervention is minimised, involving a supervisory role only with occasional call outs for breakdowns, service requirements and repairs.

It is anticipated that a minimum of three to four 2 man crew teams (preferably locally sourced labour) may be required to undertake the service and maintenance requirements of the wind turbines. These would include but not be limited to, regular service and maintenance, resetting of breakers, minor fault repairs and small maintenance issues associated with the operation of wind turbines.

2.15.2.2 Scheduled Maintenance Periods

The scheduled maintenance periods associated with wind turbines are anticipated to include the following requirements:

- 3 monthly: Checking of lubricants and oil levels, ladder access integrity, navigation lights, aviation lights, etc.
- 6 monthly: Checking of lubricants and oil levels, hydraulic pump levels, controller cabinets, gear box oil levels, emergency stop sensor testing, fire alarm system test, etc.
- 12 monthly: Checking of lubricants and oil levels, pump levels, gear box oil quality tests, overall visual check, tower mounting bolt torque check, yaw ring torque check, blade integrity.

The above actions are indicative of the actions undertaken during the 3, 6 and 12 monthly checks and are not intended as an exhaustive list.

2.15.2.3 Unscheduled Maintenance Requirements

As with all operational equipment, repairs and maintenance may be required that are not normally incorporated in the scheduled maintenance check periods, including failure or damage of components. Nacelle mounted cranes would normally be able to load and offload nacelle items requiring repair or replacement, but specialised vessel support could be required to load and offload the replacement parts onto the wind turbines. In the extreme instance an external crane could be required to load/offload critical parts.

In addition, occasional surveys would be required to check the burial depth of the inter turbine cable and export cables and scour protection would need to be monitored, depending on foundation type. This inspection could involve the use of 3 dimensional scans of the foundation base to obtain a clear picture of the protection status.

2.15.2.4 Maintenance Vessel Requirements

It is anticipated that approximately two maintenance vessels could be required for the offshore wind farm. The type of vessel might be based on a catamaran hull design, providing a stable basis and adequate deck space for service items. A crew cabin to accommodate at least 12 crew members may be provided, which would provide a warm and dry accommodation.

The size and power of the vessel would be determined by the location of the home port for operations. The nearest all tidal ports would be Great Yarmouth and Lowestoft, and the nearest tidal port is Wells next the Sea.

2.16 Decommissioning Plan

A detailed Decommissioning Plan would be agreed with the DTI and Crown Estate, prior to commencement of construction taking into account the provisions of the Energy Act 2004, and the regulations and guidelines expected to be implemented under these provisions. It is currently expected that the Decommissioning Plan would include for the complete removal of all offshore structures deployed in the wind farm above the seabed including the complete removal of gravity base structures and the cutting of monopile foundations to an agreed depth beneath the seabed. It is expected that buried cables would be left in place and notified, in line with current practice.

Decommissioning would involve the dismantling of structures, probably in reverse order to the construction sequence, involving similar plant to that used during their installation and undertaken in accordance with the relevant guidelines, legislation and good practice at the time in order to minimise environmental impacts and ensure pollution prevention. Where possible, consideration would be given to decommissioned structures and materials being reused or recycled. In some instances, it may be considered that leaving certain equipment or materials in-situ on the seabed (such as electrical cables and scour protection material) would be the best practical environmental option in order to minimise disturbance to the marine habitats and species that may have substantially colonised the areas.

It is proposed that the land cable would be isolated, left in-situ and notified as such. The switch room would be decommissioned and all switch gear and cables isolated. The switch room itself might be incorporated into the general facilities of the Muckleburgh Collection, depending on discussions with the landowner.

The Decommissioning Plan would be regularly updated in light of any changes to legislation or best practice and in particular would be thoroughly reviewed as the wind farm approaches the end of its operational life.

2.17 References

- Garrad Hassan, Construction Plant for Offshore Wind Farms, May 2003.
- SLP Engineering, Monopile Foundation Feasibility Study, February 2005.
- SLP Engineering, Gravity Base Foundation Feasibility Study, February 2005.
- SLP Engineering, Tripod Foundation Feasibility Study, February 2005.
- Global Marine Systems Ltd., Cable Landing Study, February 2006.

3 Regulatory and Legislative Context

3.1 Introduction

This section outlines the consent and regulatory requirements relating to the construction, operation and decommissioning of the Sheringham Shoal Offshore Wind Farm, export cable route and onshore ancillary infrastructure. The approach to the Environmental Impact Assessment (EIA) process is also described including the assessment methodology, consultation and communication exercise.

3.2 Consents Requirements

An Agreement for Lease under the Crown Estate Act (1961) is already in place between The Crown Estate and Scira Offshore Energy Ltd. (Scira). This Agreement grants Scira a seven year option to develop an offshore wind farm at the Sheringham Shoal site, within which time Scira is required to obtain all necessary consents. Once all consents are obtained, the Agreement would be converted into a full Lease of the seabed for the wind farm and ancillary elements such as cables.

There are a number of consents that will be required for all phases of development i.e. construction, operation and decommissioning. Guidance has been provided on this issue by the Department of Trade and Industry's (DTI) Offshore Renewables Consents Unit (ORCU) (DTI, 2004). The guidance provides a summary of the statutory consents required for an "offshore wind generating station" under the various Acts of Parliament. A summary of the consents that Scira intends to apply for are set out in Table 3.1, with further details on additional aspects provided below.

Table 3.1 Statutory consents applied for by Scira

Act of Parliament	Consent type	Competent Authority
Section 36 - Electricity Act 1989	For construction and operation of an offshore wind power generating station within territorial waters adjacent to Great Britain, including all ancillary infrastructure.	Department of Trade and Industry (DTI)
Section 5 - Food and Environment Protection Act (FEPA) 1985	For depositing articles or materials in the sea/tidal waters below MHWS (mean high water springs) around Great Britain, including the placement of construction material or disposal of waste dredgings.	Department of Environment, Food and Rural Affairs (DEFRA) through the Marine Consents Environment Unit (MCEU)
Section 34 - Coast Protection Act (CPA) 1949	To make provision for the safety of navigation in relation to the inter array cabling and the export cable route.	DEFRA through MCEU.
Section 90 Town & Country Planning Act 1990	Deemed planning permission sought as part of the section 36 application for the onshore elements of the works.	DTI

In gaining consent under the Electricity Act or the Food and Environment Protection Act, conditions may be imposed to control and mitigate the impact of the development.

Onshore, the cables would be connected to a new switch room situated in the grounds of the Muckleburgh Collection, approximately 800m inland. From the switch room a new electrical connection would be required in order to pass electricity into the existing 132kV distribution network and/or 400kV transmission network. These networks are operated by EdF and National Grid Transco respectively. This new grid connection (from the switch station to distribution and/or transmission network/s) would be the subject of a separate application for consent under the Town and Country Planning Act 1990.

3.2.1 Deemed planning permission

As listed in Table 3.1, under section 36, deemed planning permission will be sought for the onshore elements of the project, including the landfall, onshore cable route and jointing chamber. No separate consent for the onshore works will be submitted, however, the Local Planning Authority i.e. North Norfolk District Council will be a statutory consultee as part of the section 36 consent determination.

3.2.2 Extinguishment of public rights of navigation

The Energy Act 2004 introduces a new sub section into section 36 of the Electricity Act, relating in particular to navigation, namely section 36A. Section 36A gives power to the Secretary of State to make a declaration, on application by a developer, which extinguishes public rights of navigation through the place where the generating station would be established, meaning the area of seabed covered by each individual offshore structure. This application will be made by Scira as part of their section 36 application.

3.2.3 Safety Zones

The Energy Act 2004 also enables a Safety Zone to be established around offshore renewable energy installations and in the case of wind farms this may be established around each offshore structure by up to a maximum of 500m from its outer edge.

The purpose of the Safety Zone is to minimise the risk of collisions between vessels and offshore installations by establishing a zone within which navigation will be regulated. Permission will be provided for specified vessel types to enter the Safety Zone, such as those required for maintenance or involved in an emergency or distress situation.

Different Safety Zones can be established to cover the main phases of the wind farm including construction, operation and decommissioning.

The applicant must make a case, based on safety grounds for the establishment of Safety Zones, which is likely to be tailor made to the particular generating station. An application does not need to be made at the same time as the section 36 consent, although the guidance does state that an intention to do so would be useful, as the Secretary of State must take the request for any Safety Zones into account when deciding to grant consent. The Secretary of State is also able to establish a Safety Zone on his own initiative if the view is that one is required.

Scira intend to apply for a 500m Safety Zone around each offshore structure for the period of construction and eventual decommissioning of the project. This is to ensure the safety of construction vessels and other vessels navigating in the area (see Section 14, Shipping and Navigation). During operation a 100m safety zone would apply around each individual turbine for all vessels not associated with the wind farm. It is envisaged that recreational vessels and fishing vessels employing potting or long lining gear would be permitted up to this zone. A 500m safety zone would be applied for merchant shipping and other specific activities which by their nature represent a risk to the structures and cables, e.g. towed gears such as otter trawls and beam trawls, dredging activities and anchoring of certain vessels (see Section 14, Shipping and Navigation).

3.3 Requirement for Environmental Impact Assessment

The proposed development will be subject to an EIA, as required under EC Directives 85/337/EEC and 97/11/EC (The Assessment of Certain Public and Private Projects on the Environment). These Directives have been transposed into UK legislation via the Electricity Works (Environmental Impact Assessment) Regulations 2000 (SI 2000/1927) for the purposes of a Section 36 Electricity Act 1989 application.

Under these regulations, offshore wind farm developments are listed as a Schedule 2 project, described as “installations for the harnessing of wind power for energy production (wind farms)”. This means that an Environmental Statement (ES) should be prepared for developments likely to have significant environmental effects. This ES has been prepared for the Sheringham Shoal Offshore Wind Farm for the purposes of gaining all consents.

The EIA has been prepared in accordance with the Schedules related to the 2000 Regulations. In addition, the requirements and advice of the DTI in their Guidance Note ‘Offshore Wind Farm Consents Process’ (DTI, 2004) have been followed, as well as guidance issued by CEFAS, MCEU and others. Relevant guidance that has been used in the assessment is cited within each topic section.

EIA Regulations have not been made under the Food and Environment Protection Act 1985, but Section 8 of that Act enables the Secretary of State to require environmental information to be provided in connection with applications under Section 5 of the Act. Outside the area of port authorities there are no EIA Regulations which specifically attach to applications under Section 34 of the Coast Protection Act 1949. However, the environmental information provided in the context of the Section 36 Electricity Act and Section 5 Food and Environment Protection Act applications will provide sufficient information to enable EIA of the Coast Protection Act application.

3.4 Requirement for Appropriate Assessment

Under the Conservation (Natural Habitats, & c.) Regulations 1994 (SI 1994/2716 as amended), the relevant Competent Authority must consider the effect of a development on the integrity of a European site (including candidate and proposed sites), if the development is considered likely to have a significant effect on that site. A European site constitutes a Special Area of Conservation (SAC) or Special Protection Area (SPA) for birds. Of relevance to this project is the Wash and North Norfolk European marine site, which includes the Wash and North Norfolk Coast cSAC, and the North Norfolk Coast SPA.

Section 27, Information for Appropriate Assessment provides information for use by the Competent Authority, in this case the DTI, to assist in carrying out an Appropriate Assessment. In particular, it reports on the potential effect of the Sheringham Shoal Offshore Wind Farm on the European site’s conservation objectives and favourable condition criteria.

3.5 Requirement for Decommissioning

There is a need to consider the plans required for the decommissioning of the Sheringham Shoal project under the Lease with The Crown Estate and the Energy Act 2004. There are a number of key issues that need to be addressed as part of any plan to ensure the requisite reinstatement of the seabed, in addition to a need to ensure availability of adequate funds to undertake decommissioning. The provisions for decommissioning under the Energy Act have not yet been enabled, but are expected.

Following consent, a Decommissioning Plan would be agreed with the DTI and The Crown Estate prior to the commencement of construction. This would take into account the statutory provisions under the Energy Act. Further details of the decommissioning phase are provided in Section 2.

3.6 The Environmental Impact Assessment Process

EIA is a tool for systematically examining and assessing the impacts and effects of a development on the environment. The resultant ES reports on the EIA and contains:

- Description of the development proposal, including any alternatives considered;
- Description of the existing environment at the site and its environs;
- Prediction of potential impacts on the existing human, physical and natural environment at the site and assessment of subsequent effects;
- Description of mitigation measures to avoid or reduce such effects;
- Description of monitoring requirements; and
- Non-Technical Summary.

The following stages are typically included in an EIA:

- Screening determination of whether a development proposal needs an EIA;
- Scoping determination of the issues to be addressed by the EIA;
- Consultation and public participation;
- Original data collection and surveys where necessary to fill data gaps;
- Impact identification and evaluation;
- Identification of mitigation and residual impacts;
- Identification of monitoring requirements;
- Submission of the ES to the relevant authorities as part of the consents process;
- Liaison and consultation to resolve matters or representations/objections; and
- Decision on whether the development proposal should proceed.

3.6.1 Statutory Screening and Scoping Opinions

Government has provided advice that all offshore wind farm developments would be subject to an EIA (DTI, 2004). Scira accepts this advice.

Following the provision of two separate Scoping Reports (Ecofys 2004, Royal Haskoning 2005). one relating to the offshore development and the other relating to the landfall and onshore cable route, two Scoping Opinions have been received from DTI as recorded in minutes of meetings.

The Scoping Opinions stipulated the need to utilise the advice within the relevant guidance and highlighted the following issues for consideration within the ES:

- The area is likely to be a herring spawning area, this should be assessed carefully.
- The approach to benthic ecology as described in the scoping report (Ecofys 2004) is supported, but the assessment should have a broader focus to all benthic ecology and not just sabellaria reefs.
- DTI would be prepared to consider a submission of the ES with less than two years of bird data, provided the Crown Estate and English Nature support this approach.

3.6.2 Original data collection and surveys

Further to the findings of the Scoping Reports and consultation with *inter alia* DEFRA Sea Fisheries Inspectorate (SFI), MCEU, the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), English Nature, Eastern Sea Fisheries Joint Committee (ESFJC), Maritime Coastguard Agency, Trinity House, local fishing organisations and the local planning authority, the following surveys were undertaken as part of the EIA.

- Oceanographic survey,
- Geophysical survey;
- Shallow geotechnical surveys
- Natural fisheries and epifaunal survey;
- Marine water and sediment quality;
- Benthic survey;
- Marine archaeological survey;
- Shipping survey (radar & AIS);
- Commercial fishing survey and observation trips;
- Bird surveys (aerial and boat based, radar);
- Terrestrial survey (extended Phase 1 habitat survey); and
- Seascape and visual character assessment.

Details of each of the surveys are provided in the relevant section of the ES.

3.6.3 Impact identification and evaluation

Impact identification and evaluation was carried out via a number of methods and techniques including data collation and literature review, consultation, reference to relevant guidance and standards, original data collection and analysis including multivariate analysis and computer modelling, as well as experience of similar schemes. Details of the assessment methodology and data sources are provided for each parameter in the relevant section.

All the proposed options (e.g. number of turbines, foundation types and methods of cable installation) of the Sheringham Shoal project have been assessed under each environmental parameter as described in Section 2, Project Details, such that the full range of impacts are evaluated and described as well as the worst case (i.e. an options based assessment approach). This approach has been taken on the basis that definitive project details are not yet known and a number of options and final decision making is dependent on various factors such as further geotechnical investigations, economic evaluation and procurement processes (see Section 2).

Scira is aware that all development which may take place under any consents granted for this project, to the extent that it may give rise to significant environmental effects, must be adequately addressed in the EIA. This awareness is based on a number of court judgements, including R v Rochdale MBC ex parte Tew [1999 3PLR74] and R v Rochdale MBC ex parte Milne [2001 81PCR27].

The case law gives rise to a potential difficulty for many infrastructure proposals, including the proposed Sheringham Shoal project, in that at the time consents are granted there will necessarily remain a number of features of the project which are not yet fully determined.

However, it is considered that the full range of possible options that may wish to be built are described and assessed in this ES (i.e. they are within the so called Rochdale Envelope) including consideration of the worse realistic case for each environmental parameter assessed. This provides a degree of flexibility in the implementation of the project thus ensuring compliance with the awarded consents and EIA law, in addition to preserving the commercial need to implement the development in a variety of ways.

3.6.4 Significance levels

In order to provide a consistent framework for considering and evaluating impacts, significance levels have been assigned to each impact. Table 3.2 sets out the assigned definitions.

Table 3.2 Terminology for classifying environmental impacts

Impact Significance	Definition
Major adverse	The impact gives rise to serious concern and it should be considered as unacceptable.
Moderate adverse	The impact gives rise to some concern but is likely to be tolerable depending on scale and duration.
Minor adverse	The impact is undesirable but of limited concern.
Negligible	The impact is not of concern.
No Impact	There is an absence of one or more of the following: impact source, pathway or receptor.
Minor beneficial	The impact is of minor significance but has some environmental benefit.
Moderate beneficial	The impact provides some gain to the environment.
Major beneficial	The impact provides a significant positive gain.

A number of criteria have been utilised to determine the significance of the environmental impacts. These are:

- Magnitude of the impact i.e. local, regional or national;
- Spatial extent of the impact i.e. small scale or large scale;
- Duration of the impact i.e. short term or long term;
- Reversibility of the impact including species or habitat recoverability, sensitivity and tolerance;
- Conservation or protected status;
- Probability of occurrence of the impact;
- Confidence in the impact prediction; and
- The margins by which set values are exceeded e.g. water quality standards.

3.6.5 Mitigation and residual impacts

Mitigation measures have been described where potentially significant adverse impacts have been identified, either as part of the design or as a measure implemented during construction, operation or decommissioning. Each impact assessment section assigns a significance level to the impact described which takes into account any stated mitigation measures. Scira has agreed to these measures and they are therefore expressed as commitments.

3.6.6 Monitoring

Monitoring can be important to verify the predicted impacts of the proposed development on the site and surrounding area and habitats, particularly where levels of uncertainty remain following the EIA. Monitoring programmes are sometimes required to take place during construction, and for a period after construction is complete such as during operation. Monitoring requirements have been described where necessary. In most cases further liaison with the relevant regulator is expected in order to agree detailed requirements.

3.6.7 Cumulative effects

The EIA Directives recorded in Section 3.3 require consideration of the cumulative effects of wind farms with other projects progressed (or to be progressed) in the past, present or foreseeable future. In addition, the Habitats Directive (92/43/EEC) requires 'appropriate assessment' of plans or projects that are likely to have a significant effect on a European site, when assessed in combination with other plans or projects.

In the context of offshore wind farms, cumulative effects might occur as a result of the development of an offshore wind farm at a single site, from multiple sites in close proximity, or in combination with effects from other human activities, such as aggregate extraction, marine disposal, dredging operations, fishing, pipeline construction, oil installations, natural processes and other uses of the sea. The term cumulative effect has been used throughout this document, where this also encompasses in combination effects as a sub set of cumulative effects.

The cumulative effects scoping report undertaken for the Greater Wash Round 2 projects (Posford Haskoning, 2004) identified areas of interactions based on the spatial and temporal components of the various environmental parameters reviewed. It was agreed at a Stakeholders Workshop in June 2004 that the Wash Developers would proceed with the assessment of cumulative effects based on an incremental or 'building block' approach. This stems from the fact that Round 2 developers are proceeding with their data collection requirements at varying paces. It is clear that most of those Round 2 developers with sites within the 12nm territorial limit are advancing at a faster rate than those outside the limit and therefore information on all sites would not be available at the time of a project specific EIA. All reasonable information that is available has been used in this assessment.

It was agreed that the reporting of cumulative effects would form part of each development's EIA based on information that was reasonably available either in the public domain or shared between the developers in terms of each of their site specific studies or other project information. It will be incumbent on later applicants to take into account any additional information available within their cumulative assessments. The cumulative assessment also relies on project specific information being available in terms of other Round 2 locations, output and layouts and construction programmes.

Within this ES cumulative effects are addressed under each environmental parameter with a discussion as to those Round 1 and 2 projects which are considered (under that particular parameter) as well as other projects or activities in the area.

3.6.8 Consideration of alternatives

As part of the EIA and in the course of the project development process, a number of alternative options were considered but discarded at various stages. In line with the relevant EIA Regulations, those alternatives that were considered and subsequently discarded are described below.

3.6.8.1 Various lay-outs aimed to minimize radar interference

Due to the concerns on radar issues raised by the MoD, a number of slightly varying locations and orientations of the site were briefly considered in a study undertaken by Qinetiq. As described in Section 16, Military and Aviation, these options were not progressed since an alternative solution to the radar interference issues has been taken forward with the MoD.

3.6.8.2 Offshore cable route East of Sheringham Shoal to Weybourne

As part of the cable route scoping document, three routes were identified from the offshore wind farm array to the proposed Weybourne landfall point. These three routes were as follows: east of Sheringham Shoal, over Sheringham Shoal and west of Sheringham Shoal.

The easterly route, around the Sheringham Shoal is not only the longest alternative; but it also would involve crossing of several telecommunication cables, extensive sandwave areas and installation through a greater length of chalk substrate. For these reasons, this option has been disregarded being the least favourable of the three (Royal Haskoning, 2004).

3.6.8.3 Wind farm layout 75 x 4.2 MW

A layout comprising 75 turbines each with a capacity of 4.2MW was the base case for the wind farm site scoping document. However, the manufacturer (Vestas) has ceased the development of this machine and replaced it with the 4.5 MW machine. The base case alternative has now become the 70 x 4.5 MW layout which is described in Section 2, Project Details.

3.6.8.4 Onshore cable – western route

An onshore cable route to the west of the proposed route was proposed and taken forward as part of the EIA. However, the route was not preferred due to the existing infrastructure in the area, including existing foul water drains (used and disused), a water supply main, existing 11kV site cables and BT cables. The majority of these facilities are routed through the Muckleburgh Collection and along the access road to the museum.

The location of these and the woodlands surrounding the museum make the western route option through the Muckleburgh Collection technically challenging and it was considered very unlikely that the required clearance could be achieved between the required two 132kV cables and the existing facilities.

The eastern route option would avoid the majority of these facilities with the exception of the foul water main, which would need to be crossed.

Discussions were held with representatives of North Norfolk District Council (NNDC) who had originally commented that the western route would be their preferred option, due to compliance with Local Plan policies (i.e. switch room fitting in with existing setting of museum buildings) and initial issues raised by the Environmental Protection Team relating to noise and dust impact.

NNDC agreed, however, that the constraints made the western route option technically unfeasible and that although the western route would be preferred, there were no serious issues with the eastern route. They would however want to ensure certain mitigation measures were in place to limit the impact of the eastern route, relating to visual and landscape impact, noise and air quality. These aspects are discussed further in Section 0, Landscape and Visual Character and Section 26, Noise, Dust and Air Quality.

3.7 Consultation and Community Involvement

Consultation was carried out with in excess of 20 statutory and non-statutory bodies representing key interests and user groups in the north Norfolk area and the wider area during the Scoping Study. Initial consultation included a description of the project proposals and invited comments and requested relevant data or information. Detailed formal and informal consultation has continued throughout the EIA via correspondence and meetings. All comments received have been taken into consideration during the EIA.

Groups consulted included *inter alia*:

- Associated British Ports – Lowestoft;
- Bristow Helicopters;
- British Chamber of Shipping;
- British Marine Aggregate Producers Association (BMAPA);
- Centre for Environment, Fisheries and Aquaculture Science (CEFAS);
- Civil Aviation Authority (CAA);
- Countryside Agency;
- Cromer Crab Company;
- Defence Estates;
- Department for Environment, Food and Rural Affairs (DEFRA);
- Department for Transport (DfT);
- Department of Trade and Industry (DTI);
- East Anglian Fishermen's Society;
- East of England Tourist Board;
- Eastern Sea Fisheries Joint Committee (ESFC);
- English Heritage;
- English Nature;
- Environment Agency;
- Ofcom;
- International Cable Protection Committee;
- King's Lynn Conservancy Board;
- King's Lynn Fishermen's Association:
- Maritime and Coastguard Agency (MCA);
- Maritime Conservation Society;
- Ministry of Defence – Defence Estates;

- National Air Traffic Services (NATS);
- National Angling Association;
- National Coast Watch Institution;
- National Federation of Fishermen's Organisation (NFFO);
- Nautical Archaeology Society;
- Norfolk Coast Partnership;
- Norfolk County Council (NCC);
- Norfolk Landscape Archaeology;
- Norfolk Ornithological Association;
- Norfolk Wildlife Trust;
- North Norfolk and Wells District Fishermen;
- North Norfolk Shellfishermen;
- North Norfolk District Council (NNDC);
- Royal Commission on the Historical Monuments of England;
- Royal National Lifeboat Institution (RNLI);
- Royal Society for the Protection of Birds (RSPB);
- Royal Yachting Association (RYA);
- Sea Fisheries Inspectorate (SFI);
- The National Trust; and
- Trinity House Lighthouse Service (THLS);

Summary tables containing the consultation responses can be found in Appendix 3.1.

3.7.1 Public consultation and exhibitions

To ensure that local people were aware of and involved in the EIA process, an all day public exhibition was held on 28th and 29th of April 2005 in Sheringham (see Plate 3.1). Some 300 visitors attended the exhibition, of which 120 returned a questionnaire.

Nearly three quarters of the exhibition visitors were in favour, in principle, of building an offshore wind farm off the coast of Sheringham. However, approximately half of the visitors expressed concerns over particular aspects of the wind farm. The top five concerns were:

- Bird Life;
- Fishing;
- Visual Impact;
- Peripheral Construction; and
- Sea Life.

Plate 3.1 View of the information panels at the public launch of Scira in April 2005.

In addition to the public meeting, Scira presented its plans at various forums in north Norfolk, such as the District Council, various Town Councils, and through the regional media.

Scira maintains a dedicated website containing up-to-date information on the project plans and its progress: www.scira.com.

A tailor-made communication campaign dedicated to the fishing community is also ongoing.

3.8 References

- CCW, EN, JNCC 2004: Nature Conservation Agency Guidance on Offshore Windfarm Development, September 2004.
- CEFAS, 2004: Offshore Wind Farms: Guidance Note for Environmental Impact Assessment in Respect of FEPA and CPA Requirements, June 2004
- DTI, 2004. Department for Trade and Industry, Marine Consents and Environment Unit, August 2004, Guidance Notes, Offshore Wind Farm Consents Process.
- Ecofys, 2004. Sheringham Shoal Offshore Wind Farm Scoping Report, produced for Scira Offshore Energy, October 2004.
- MCA, 2004. Maritime and Coastguard Agency, Marine Guidance Note MGN 275 (M), Proposed UK Offshore Renewable Energy Installations (OREI) - Guidance on Navigational Safety Issues, August 2004.
- Posford Haskoning, September 2004, Greater Wash Round 2 Offshore Wind Farms: Cumulative Effects for the Wash Developers

4 Policy Framework and Guidance

4.1 Introduction

The wind farm development will be assessed and taken forward in the context of relevant national, regional and local planning and policy guidance, as well as a number of Acts of Parliament. This section sets out the plans, policies and Acts identified as being of relevance to various components of the project which include the:

- Town and Country Planning Act (1990);
- Planning and Compulsory Purchase Act (2004);
- Wildlife and Countryside Act (1981);
- Countryside and Rights of Way Act (2000);
- PPS9 Nature Conservation (2005);
- PPG15 Planning and the Historic Environment (1994);
- PPG16 Archaeology and Planning (1990);
- PPG20 Coastal Planning (1992);
- PPS22 Renewable Energy (2004);
- Regional Spatial Strategy for East Anglia (2000);
- East of England Plan (2004);
- Norfolk Structure Plan (1999);
- North Norfolk District Council Local Plan (1998); and
- Norfolk Biodiversity Action Plan (1999).

The Acts of Parliament under which the various consents for the Sheringham Shoal project are being sought are detailed in Section 1, Regulatory and Legislative Context.

It must be stressed that onshore planning control only applies as far as mean low water springs. Below that level none of the law or advice applying only to onshore development has any application.

4.2 National Policy

4.2.1 Town and Country Planning Act 1990

The key statutory instrument controlling the development of land in England and Wales is the Town and Country Planning Act (T&CPA) 1990, as amended by the Planning and Compulsory Purchase Act 2004.

Sections 38.6 of the 2004 act and 54A of the 1990 Act require planning applications to be determined in accordance with the development plan (Structure Plan, Local Plan etc) unless other material considerations indicate otherwise. The onshore elements of the project would be covered by deemed planning permission, as part of the section 36 consent under the Electricity Act (1989), however, the Local Planning Authority, in this case North Norfolk District Council, will be a statutory consultee and therefore local planning policy remains relevant. Further information on the Development Plans relevant to the Sheringham Shoal project is provided in this section.

4.2.2 Wildlife and Countryside Act 1981, as amended by the Countryside and Rights of Way Act 2000

The Wildlife and Countryside Act (WCA) 1981 is divided into three sections:

- Part I, which deals with wildlife protection;
- Part II, which covers nature conservation, countryside and National Parks; and
- Part III, which deals with public rights of way.

The revised Section 28, contained in Schedule 9 of the Countryside and Rights of Way Act 2000 (CRoW Act), provides significantly enhanced duties on English Nature, Site of Special Scientific Interest (SSSI) owner/occupiers and statutory authorities to conserve and enhance the special features for which SSSIs are designated. In particular, English Nature's consent must be sought before certain works can be carried out which could result in direct physical damage to the special interest of a SSSI.

The Weybourne Cliffs SSSI and the North Norfolk Coast SSSI are located at a distance of approximately 350m and 1.150m respectively from the export cable landfall. Section 19, Nature Conservation Designations (Onshore) provides further details.

Section 26 of the CRoW Act has been advised on in the recent Planning Policy Statement (PPS) 9 (see below).

4.2.3 Planning Policy Statement (PPS) 9 Biodiversity and Geological Conservation

PPS9 is the amended Planning Policy Guidance 9, which incorporates the wildlife legislation, cited above and was published in August 2005. It is important as it provides guidance on how planning applications affecting sites of nature conservation importance should be dealt with. The protection of SSSIs and the implementation of the Habitats Directive are key areas covered by the guidance. Of relevance to this project is the potential existence of protected species in the area of the onshore cable route, such as great crested newts and reptiles. Further details are provided in Section 19, Onshore Nature Conservation Designations and Section 21, Terrestrial Ecology.

4.2.4 Planning Policy Guidance (PPG) 15: Planning and the Historic Environment

PPG15 states that:

"It is fundamental to the Government's policies for environmental stewardship that there should be effective protection for all aspects of the historic environment."

In respect of Development Control, PPG15 says of all Local Planning Authorities that:

"They should expect developers to assess the likely impact of their proposals on the site or structure in question, and to provide such written information or drawings as may be required to understand the significance of a site or structure before an application is determined."

A number of features of historic interest are in proximity to the onshore cable route; see Section 0, Landscape and Visual Character and Section 0, Terrestrial Archaeology and Cultural Heritage.

4.2.5 Planning Policy Guidance (PPG) 16: Archaeology and Planning

PPG16 sets out the Secretary of State's policy on archaeological remains. It acknowledges the fragile and finite nature of such remains, and states that the desirability of preservation of archaeological remains and their setting is a material consideration within the planning process. PPG16 provides that there is a presumption in favour of the physical preservation of nationally important archaeological remains. Where preservation in situ is not justified, it is reasonable for Planning Authorities to require the developer to make appropriate and satisfactory provision for excavation and recording of remains.

PPG16 suggests that it is in the developer's own interests to include an initial assessment of whether the site is known or likely to contain archaeological remains, as part of their research into the development potential of a site. It also adds that Local Planning Authorities can expect developers to provide the results of such assessments as part of their application for sites, where there is good reason to believe there are remains of archaeological importance. PPG16 identifies, however, that in spite of the best pre-planning application research, there may be occasions when the presence of archaeological remains only become apparent once development has commenced.

A number of features of known or potential archaeological interest are in proximity to the onshore cable route; see Section 0, Terrestrial Archaeology and Cultural Heritage.

4.2.6 Planning and Policy Guidance (PPG) 20: Coastal Planning

PPG20 sets down general guidance with respect to coastal planning and also makes specific reference to Heritage Coasts.

Paragraph 1.17 defines the main objectives of Heritage Coast, one objective being:

"To take account of the needs of agriculture, forestry and fishing, and of the economic and social needs of the small communities on these coasts, through promoting sustainable forms of social and economic development, which in themselves conserve and enhance natural beauty and heritage features".

PPG20 also defines the Conservation Policy aims, the purpose of these being to protect and enhance the natural character and landscape of the undeveloped coastline. Importantly, the guidance document also acknowledges that certain activities require a coastal location, one of these being renewable energy generation.

The contents of PPG20 are relevant to the Sheringham Shoal project given that the majority of the north Norfolk coast is protected by a range of conservation and landscape designations including the Wash and North Norfolk European marine site and the North Norfolk Area of Outstanding Natural Beauty and Heritage Coast.

4.2.7 Planning Policy Statement (PPS) 22: Renewable Energy

The current government policy guidance on renewable energy is PPS22. This policy is intended to "stimulate positive planning which facilitates renewable energy developments" in line with the Government objectives for renewable energy (see Section 1, Introduction). It sets out the principles that regional planning bodies and Local Planning Authorities should take into account in the preparation of Regional Spatial Strategies and Local Development Documents respectively.

Key principles include the following:

- "*Regional spatial strategies and local development documents should contain policies designed to promote and encourage, rather than restrict, the development of renewable energy resources*";
- *"The wider environmental and economic benefits of all proposals for renewable energy projects, whatever their scale, are material considerations that should be given significant weight in determining whether proposals should be granted planning permission";*
- *"Community involvement in renewable energy projects and … knowledge of and greater acceptance by the public of prospective renewable energy developments that are appropriately located should be promoted by authorities and developers";* and
- *"Development proposals should demonstrate any environmental, economic and social benefits as well as how any environmental and social impacts have been minimised through careful consideration of location, scale, design and other measures".*

Important considerations are included in PPS22 with respect to locational considerations.

With respect to internationally designated sites, PPS22 states that where developments are likely to have an adverse effect on a site of international importance for nature and heritage conservation, planning permission should only be granted once an assessment has shown that the integrity of the site would not be adversely affected. Areas of potential relevance to the Sheringham Shoal project include:

- Special Protection Areas;
- Special Areas of Conservation; and
- RAMSAR sites.

For sites with nationally recognised designations, planning permission for renewable energy projects should only be granted where it can be demonstrated that the objectives of designation of the area will not be compromised by the development and any significant adverse effects on the qualities for which the area has been designated are clearly outweighed by the environmental, social and economic benefits. Sites that are relevant to the Sheringham Shoal project include:

- Sites of Special Scientific Interest;
- Areas of Outstanding Natural Beauty;
- Heritage Coasts; and
- Scheduled Monuments.

The companion guide to PPS22 specifies that the appropriate treatment of the above areas will vary according to the reasons for designation, and may be related to specific landscape, visual or nature conservation characteristics. Local Planning Authorities could also identify 'special circumstances' cases, where appropriate.

The above principles do not apply to 'buffer zones' around international or nationally designated areas, although the potential impact on designated areas of renewable energy projects close to their boundaries will be a material consideration to be taken into account in determining planning applications.

4.3 Regional Policy

The Regional Spatial Strategy (RSS) is the existing policy covering the period up to 2016. In the East of England the existing RSS is formed by Regional Planning Guidance (RPG) 6 for East Anglia (2000). RPG 6 for East Anglia was approved by the Secretary of State on 23 November 2000 and guides planning and transport policy in Cambridgeshire, Norfolk and Suffolk up to 2016.

In respect of renewable energy, RPG 6 states in Policy 60 that:

"Development plans should include proposals for renewable energy generators and set out the criteria by which applications for such generators will be considered. Account should be taken of their land use and environmental implications and the desirability of such developments in sustainability terms."

Other relevant policies include Policy 38 on the protection of designated areas as follows:

"Development plans should give priority to protecting and enhancing areas designated at international or national level for their intrinsic importance in terms of nature conservation or landscape quality. They should also ensure that policies and proposals for areas covered by these designations are integrated with other strategies. Development likely to significantly affect sites of international importance for nature conservation should be allowed only if there are no alternative solutions and only if there are imperative reasons of overriding public interest. If such development is allowed then compensatory measures, necessary to ensure that the overall coherence of Natura 2000 is protected, must be provided. Development likely to significantly affect Sites of Special Scientific Interest should only be allowed if the benefits clearly outweigh the nature conservation value of the site."

The RSS will be superseded by the East of England Plan (see below).

While the RSS only applies to the onshore elements of the proposed development the onshore grid is an integral part of the offshore wind farm, and an essential feature of a proposal for renewable energy generation. It therefore attracts the positive advice in policy 60 of RPG6.

4.3.1 Regional Planning Guidance for the Regional Spatial Strategy to the East of England

The East of England Plan is the new Regional Spatial Strategy (RSS) for the East of England prepared by the East of England Assembly. It will update existing RSSs where they cover the East of England to guide planning and transport policy up to 2021.

The draft East of England Plan was published in December 2004 and it is undergoing consultation until March 2006. It is anticipated that the final East of England plan will be approved by 2007. The relevant policies of the Plan are as follows.

Policy ENV8: Renewable Energy and Energy Efficiency.

"To help the region move towards energy self-sufficiency, and meet and improve on its renewable energy targets…, local development documents will contain policies for promoting and encouraging energy efficiency and renewable energy. These policies will presume in favour of, and emphasise the wider sustainable development benefits associated with, energy efficiency and renewable energy …"

Specific targets are included as detailed in Table 4.1.

Table 4.1 Reviewed renewable energy targets for 2010 and 2020 expressed as the percentage contribution of renewables to total electricity consumption in the East of England

2010 Excluding offshore wind	2010 Including offshore wind	2020 Excluding offshore wind	2020 Including offshore wind
10%	14%	17%	44%

Source: Draft East of England plan, 2004

Policy ENV2: Landscape Character

"Planning authorities and other agencies in their plans, policies and programmes will provide the strongest levels of landscape character protection for the East of England's finest landscapes and areas of national importance – … Norfolk Coast … Areas of Outstanding Natural Beauty; and the North Norfolk … Heritage Coasts. …"

Policy ENV3: Biodiversity and Earth Heritage

"Planning authorities and other agencies in their plans, policies and proposals will ensure that the internationally and nationally designated sites in the region … are given the strongest level of protection. The region's biodiversity, earth heritage and natural resources will be protected and enriched through conservation, restoration and re-establishment of key resources …

• ensuring that all new development minimises any damage to the biodiversity and earth heritage resource and, where possible, enhances it. …"

4.3.2 Norfolk Structure Plan

The Norfolk Structure Plan (Norfolk County Council, 1999) sets key policies for Norfolk and provides the framework for more detailed policies in Local Plans. The plan gives particular emphasis to the need to protect the county's rural landscape, historic sites and wildlife habitats in a number of general policies.

Policies that are relevant to the Sheringham Shoal project are:

Policy RC.9

"Renewable energy developments will be encouraged to locate where their scale, siting or cumulative effect would not have a significant adverse environmental impact. Where there is harm, the need to protect the County's environmental assets will be weighed against the advantages judged to accrue from the proposed level of renewable energy generation.

Careful scrutiny will be given to the scale, type and impact of proposals for renewable energy development in or adjacent to the Broads, the Area of Outstanding Natural Beauty, the Heritage Coast, SSSIs, Special Protection Areas (birds), Special Areas of Conservation, National Nature Reserves, Ramsar sites and Local Nature Reserves. Particular regard will be paid to the potential to impinge on the aims of designation.

Outside these designated areas, proposals for renewable energy projects will be supported, subject to environmental and transport considerations."

Policy ENV.1

“High priority will be given to protecting the environmental assets of the County and conserving and enhancing biodiversity. In particular there will be special emphasis given to the protection, conservation and enhancement of areas of local landscape character, wildlife value, historic urban or rural environments, the setting of urban areas, towns and villages and the quality and character of the environment generally. “

Policy ENV.2

“Development which would be detrimental to the character of Areas of Outstanding Natural Beauty, the Heritage Coast and the Broads will not be permitted unless there is an overriding proven national need for the development and there are no suitable alternative sites.”

Policy ENV.4

“The distinctive character of the Norfolk countryside and coast will be protected for its own sake and proposals for development in these areas but outside the areas of special protection will only be acceptable where they do not significantly harm the character of these areas.”

Policy ENV.6

“Development which would adversely affect, whether directly or indirectly, the integrity of designated and proposed Ramsar sites, Special Protection Areas (birds), or Special Areas of Conservation, will not be permitted unless:

(i) there is no alternative solution;

(ii) there are imperative reasons of overriding public interest; and

(iii) appropriate compensatory measures can be agreed.”

Policy ENV.7

“Development which would adversely affect, whether directly or indirectly, the integrity of other designated and proposed National Nature Reserves and Sites of Special Scientific Interest will not be permitted unless planning conditions or obligations will prevent any damaging impact on the site or there are other imperative factors which override the nature conservation importance of the site.”

Policy ENV.8

“Development which would be detrimental to designated and proposed sites of regional and local importance for nature conservation and geological interest, including Local Nature Reserves and County Wildlife Sites, will only be acceptable where it can be demonstrated that there are reasons for the proposals which outweigh the need to safeguard the nature conservation interest of the site

Policy ENV.9

“All areas of important wildlife quality, whether designated or not, will be protected and the sympathetic management of features of the landscape which are of importance for wild fauna and flora, including protected species, will be encouraged.

In considering proposals for new development, where areas of important wildlife quality could be adversely affected and conflict of interest is unavoidable, appropriate mitigation measures will be required and consideration will be given to opportunities for management and for creating new wildlife habitats.”

Policy ENV.10

"The County Council will conserve and enhance the wildlife value of roadside verges consistent with the need for highway safety."

Policy ENV.13

"The quality and local distinctiveness of the historic urban and rural built environment will be maintained and improved by:

(i) protecting all listed buildings, historic landscapes, sites of archaeological importance, whether scheduled or not, and their settings against demolition, and inappropriate alteration or development …"

4.3.3 North Norfolk Local Plan

The North Norfolk Local Plan was formally adopted by the North Norfolk District Council in April 1998. The Plan provides a detailed framework for the control of development and use of land that will guide planning decisions at least until 2007.

The plan contains a policy specific for wind turbine developments (Policy 99), which is fully included below. However, this policy mainly refers to onshore wind farms. Those of relevance to the onshore cable route and ancillary development are listed.

Policy 99: Wind Turbines

"Development proposals for wind turbines, including ancillary development, will only be permitted where:

(a) there would be no significant detrimental impact on the appearance, amenity or character of an area;

…

(c) there would be no significant detrimental impact on the transport network;

…

In assessing the impact that proposals will have in terms of the above criteria, the Council will take account of the benefit of clean renewable energy that will be generated and will balance this with the need to protect certain areas.

In the Norfolk Coast Area of Outstanding Natural Beauty, Historic Parks or Gardens, Conservation Areas, Sites of Special Scientific Interest and the Broads, and on sites adjoining these from which such areas would be affected, proposals will only be permitted when proven national interest and a lack of suitable alternative sites would justify an exception."

Other policies that will be relevant to the onshore elements of the proposed wind farm project are the following:

Policy 5: The Countryside

"In the Countryside high priority will be given to the protection and enhancement of the appearance and character of the area, and development proposals will not be permitted unless they are for the purposes listed below and are in accordance with the other policies of the Local Plan... (l) renewable energy projects…"

Policy 20: Norfolk Coast Area of Outstanding Natural Beauty

"In the Norfolk Coast Area of Outstanding Natural Beauty the prime planning consideration will be the conservation and enhancement of the beauty of the area, and development proposals that would be significantly detrimental to it will not be permitted."

Policy 26: Undeveloped Coast

"In the Undeveloped Coast development proposals that do not require a coastal location or would be significantly detrimental to the appearance or character of the area will not be permitted."

Policy 30: Important Landscape Features

"Development proposals that would be significantly detrimental to the appearance or character of important landscape features will not be permitted."

Policy 32: Statutorily Designated Sites of Nature Conservation Importance

"Development proposals that could be significantly detrimental to the nature conservation interests of designated Ramsar Sites, Special Protection Areas, Special Areas of Conservation, Sites of Special Scientific Interest, the Broads, or National or Local Nature Reserves, either directly or indirectly, will not be permitted."

Policy 33: Nature Conservation Outside Statutorily Designated sites

"Development proposals that could be significantly detrimental to a County Wildlife Site, either directly or indirectly, will not be permitted unless the proposed development is in the public interest and cannot be accommodated elsewhere."

Policy 45: Archaeology

"In the case of development proposals affecting sites where important archaeological remains may exist, the Council will require the results of an archaeological field evaluation to be submitted prior to determining any planning application. Where the physical preservation of remains in situ is not justified, the Council will consider imposing a planning condition on any planning permission granted requiring an agreed programme of archaeological work to be carried out.

Development proposals that would have a significantly adverse effect on Scheduled Ancient Monuments or other nationally important sites and monuments, or their settings, will not be permitted. In the case of development proposals affecting other sites of archaeological interest, the Council will seek preservation of remains in situ as first preference. Where preservation in situ is not feasible, or merited, planning permission may be granted subject to satisfactory provision being made for excavation and recording."

Policy 48: Coastal Erosion Risk Areas

"Notwithstanding the fact that a development proposal may be in accordance with the other relevant policies of the Local Plan, in areas at risk from coastal erosion, new development, or the intensification of existing development, will not be permitted unless:

(a) there would be no increase in risk to life nor significant increase in risk to property; or

(b) following the implementation of a coast protection scheme the residual risk to life or property is considered to be insignificant."

Policy 95: Groundwater Protection

"In areas around potable groundwater sources or over vulnerable areas of aquifers, development proposals will not be permitted where the Council, in consultation with the Environment Agency, considers that there would be a significant risk to the quality of the underlying groundwater."

4.3.4 Norfolk Biodiversity Action Plan

Biodiversity: the UK Action Plan was launched in 1994 and identifies 59 broad activities for conservation work over the next 20 years (the '59' steps). It establishes fundamental principles for future biodiversity conservation in the UK and highlights the important species and habitats in an area. The important species and habitats for Norfolk include skylarks, song thrush, otter, water voles, great crested newts, and coastal and floodplain grazing marshes. Further details are included in Section 9 (Marine Ecology) and Section 24 (Terrestrial Ecology).

4.3.5 Compliance with Planning Policy

Some of the policies quoted in this section are relevant to the assessment of application for deemed planning permission for the onshore cable. Compliance with these policies is discussed within the relevant topic sections of this Environmental Statement. Relevant sections include Section 8, Ornithology; Section 13 and 22, Seascape/Landscape and Visual Character; Section 21, Terrestrial Ecology; Section 23, Terrestrial Archaeology and Cultural Heritage; and Section 27, Appropriate Assessment.

In general, it is considered that the onshore elements of the Sheringham Shoal project (while noting that the onshore elements are an essential feature of the overall renewable energy development) comply with the relevant national, regional and local policies.

5 Nature conservation designations

5.1 Introduction

This section outlines the existing marine nature conservation designations of relevance to the Sheringham Shoal project. This section does not address the potential impacts of the Sheringham Shoal project on these designations, as these are covered under the relevant section within Part Two of the ES, namely, Section 8, Ornithology and Section 9 Benthic Ecology.

Terrestrial sites such as Sites of Specific Scientific Interest (SSSIs) are discussed in Section 0, Nature Conservation Designations, Terrestrial.

5.2 Statutory international designations

5.2.1 Introduction

Relevant international nature conservation designations include: Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar sites.

SPAs are statutory designated sites, which are classified under EU law in accordance with Article 4 of the EC Directive on the conservation of wild birds (79/409/EEC), also known as the “Birds Directive”. SPAs are designated for supporting significant populations of rare and vulnerable birds, listed in Annex I to the Birds Directive, and for regularly occurring migratory species. These designations do not extend below the mean low water mark. Those sites of relevance to the project include the Wash SPA, the North Norfolk Coast SPA and the Gibraltar Point SPA.

SACs are sites designated under the EU Directive 92/43/EEC on the conservation of habitats and of wild fauna and flora (the “Habitats Directive”) because they make a significant contribution to conserving priority habitat types and species, excluding birds, listed in the Annexes to the Directive. SACs together with SPAs form the Natura 2000 network, which is designed to protect Europe’s most important areas for wildlife. The relevant site for this project is the Wash and North Norfolk Coast SAC.

Ramsar sites are designated under the Convention on Wetlands of International Importance, especially as Waterfowl Habitat (the “Ramsar Convention”). The Convention’s remit goes beyond birds, however, to provide a framework for national action and international co-operation for the conservation and wise use of wetlands and their natural resources. The North Norfolk Coast Ramsar is discussed in this section.

5.2.2 Wash and North Norfolk Coast European marine site

The Wash and North Norfolk European marine site includes:

- the Wash and North Norfolk Coast SAC;
- the Wash SPA;
- the North Norfolk Coast SPA; and
- the Gibraltar Point SPA.

The Wash and North Norfolk Coast SAC and the North Norfolk Coast SPA are the sites of most relevance to the offshore components of the wind farm and are considered further below (where the habitats and species are of relevance to the project). However, when referring to the European marine site, all the designations that form it are considered as integral. The boundary of each of the sites is shown on Figure 5.1, Figure 5.2, Figure 5.3, Figure 5.4 and Figure 5.5.

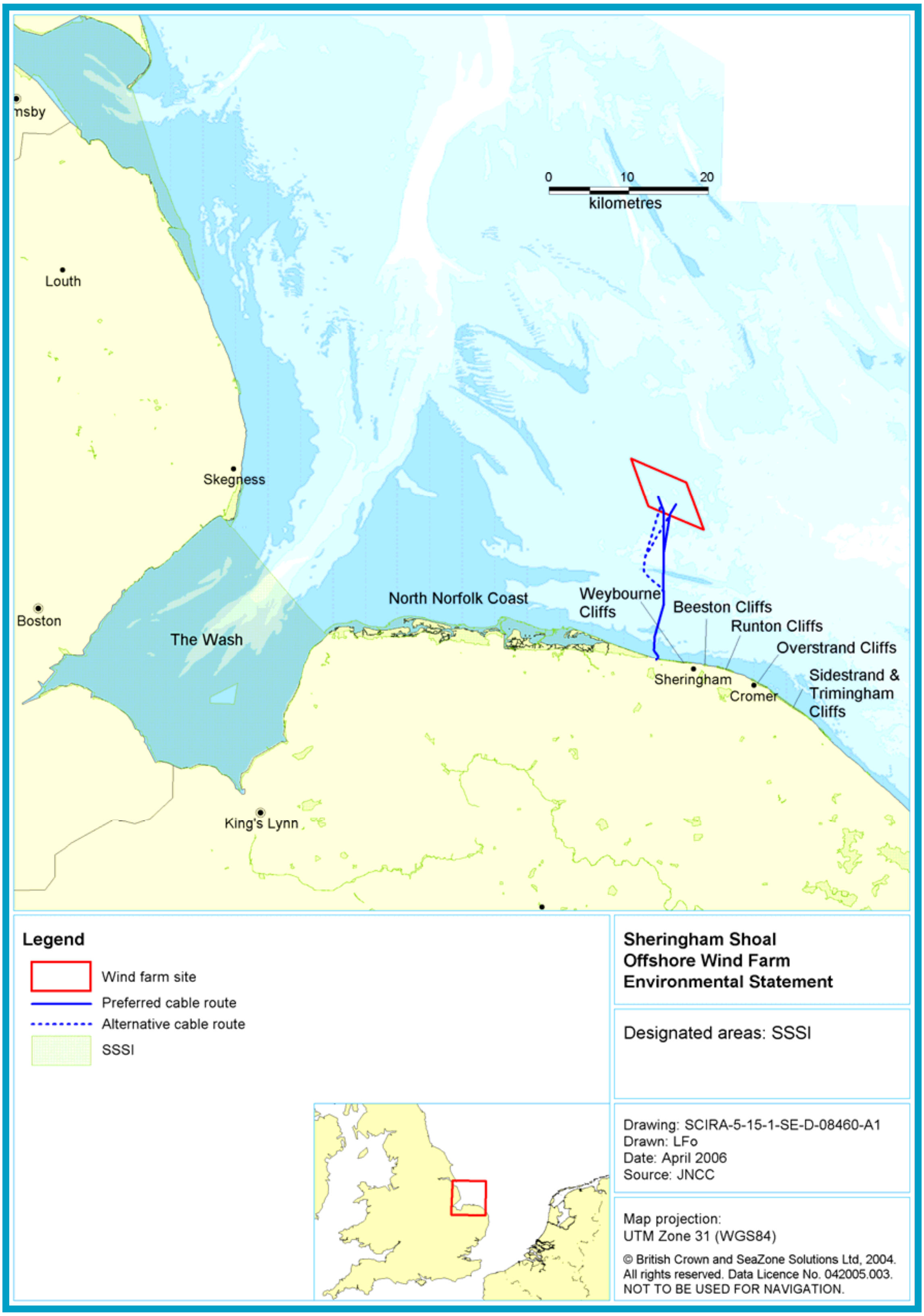


Figure 5.1 Designated Areas: SSSI. Source: Own Compilation of JNCC

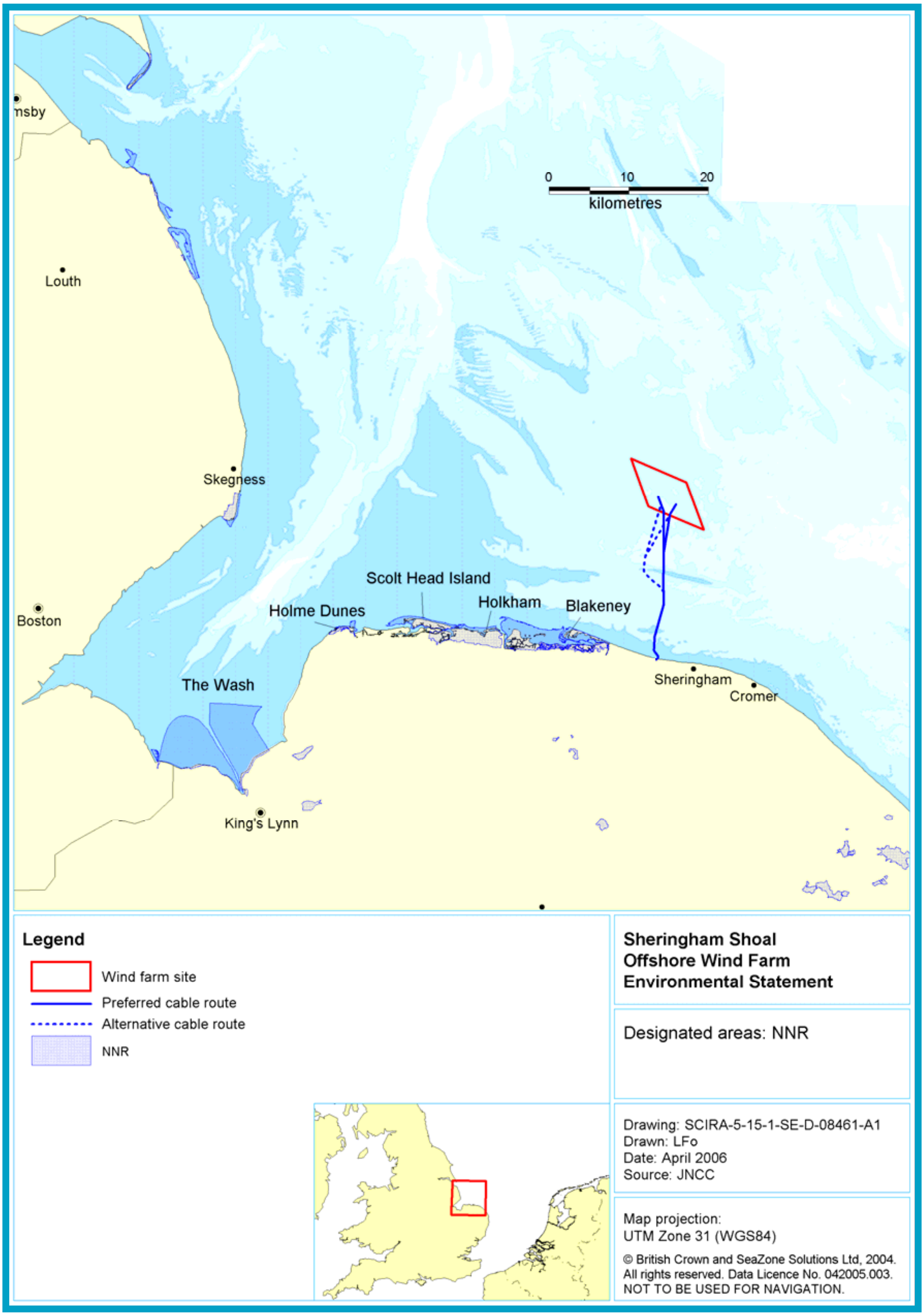


Figure 5.2 Designated Areas: NNR. Source: Own Compilation of JNCC

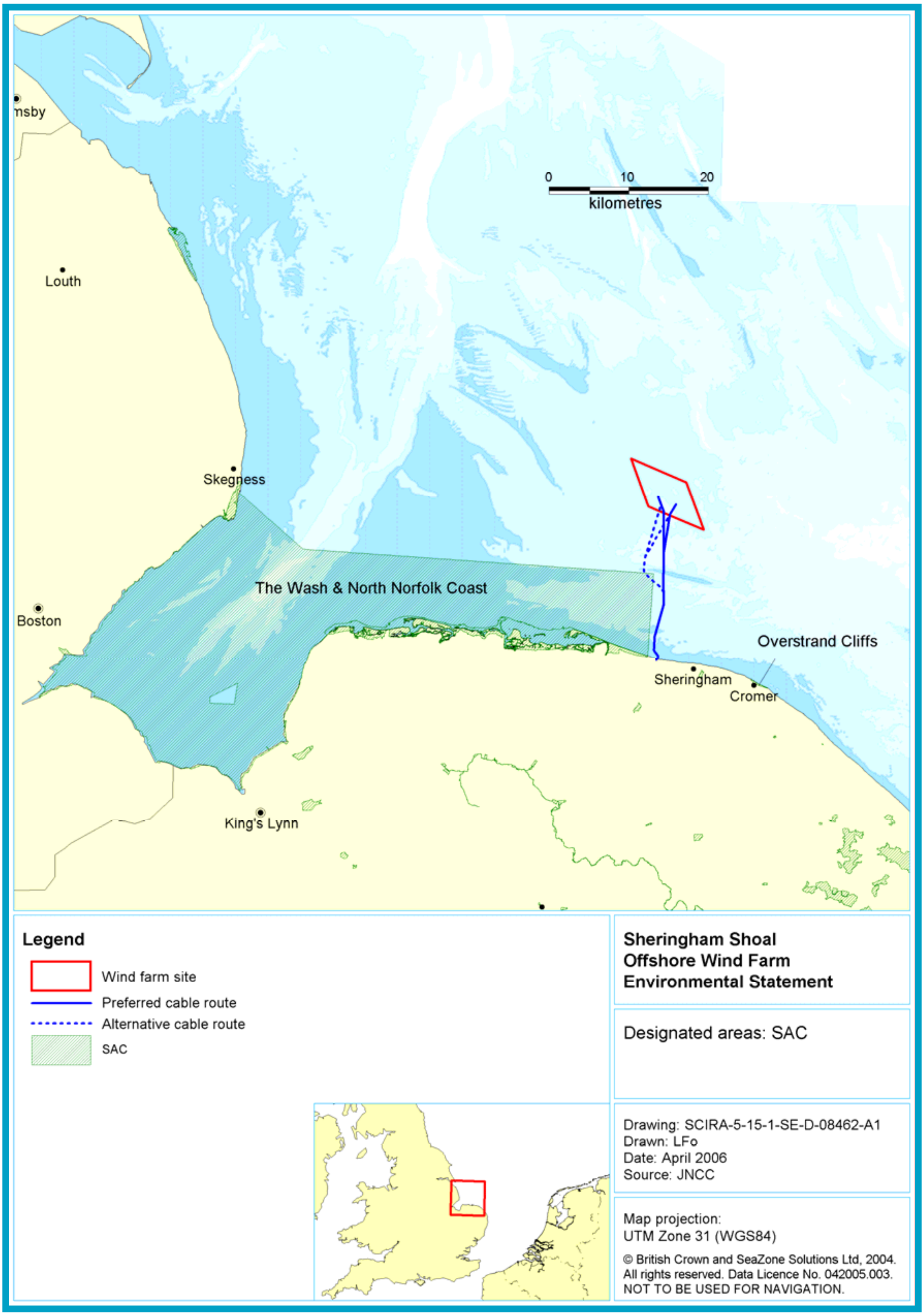


Figure 5.3 Designated Areas: SAC. Source: Own Compilation of JNCC

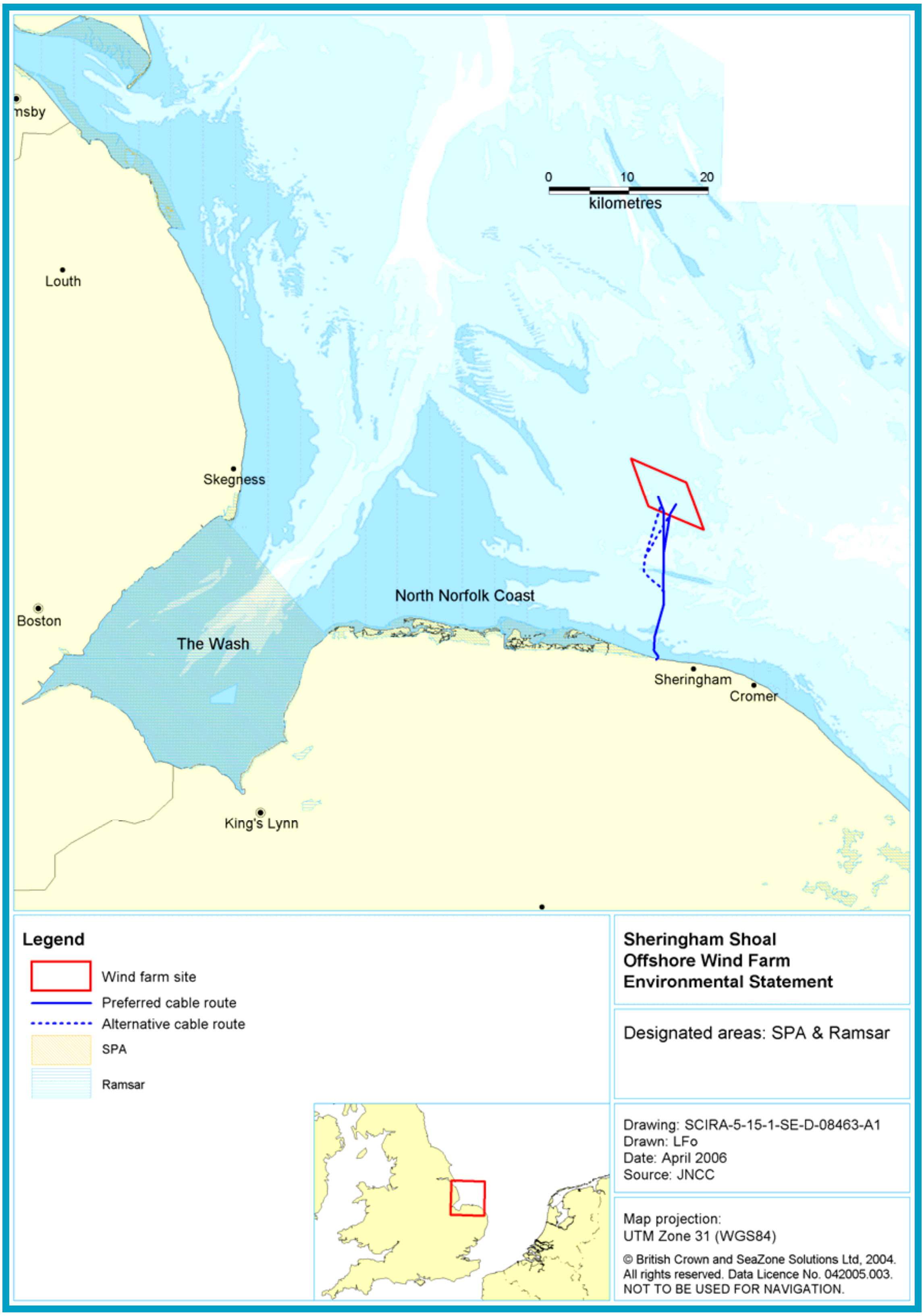


Figure 5.4 Designated Areas: SPA & Ramsar. Source: Own Compilation of JNCC

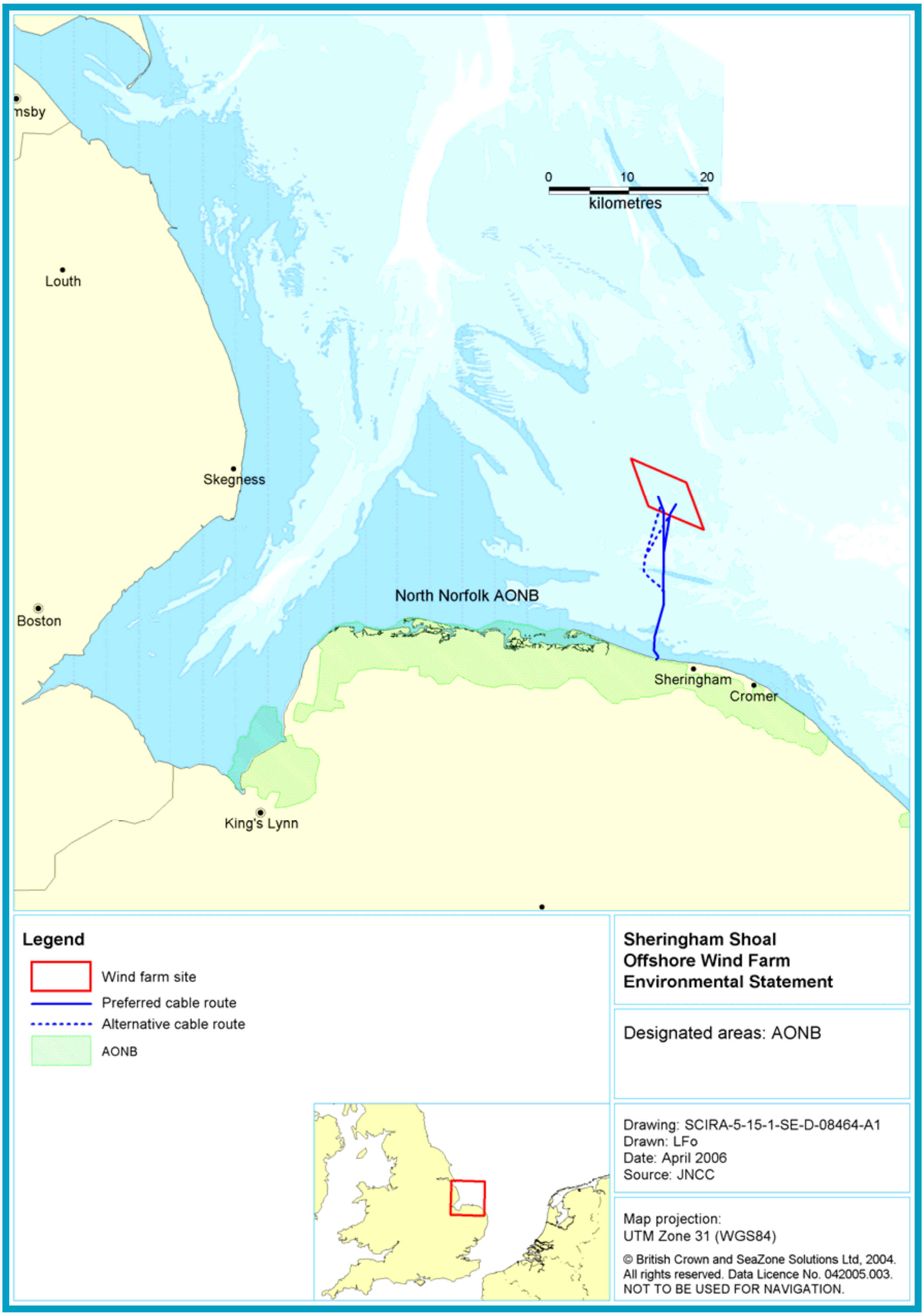


Figure 5.5 Designated Areas: Area of Outstanding Natural Beauty. Source: Own Compilation of JNCC

The Wash and North Norfolk Coast SAC qualifies as a SAC for the following Annex I habitats, as listed in the EU Habitats Directive:

- Large shallow inlets and bays.
- Sandbanks which are slightly covered by seawater all the time (referred to in this document as subtidal sandbanks).
- Mudflats and sandflats not covered by seawater at low tide (referred to in this document as intertidal mudflats and sandflats).
- Reefs (eg: *Sabellaria spinulosa*).
- Samphire (glasswort) *Salicornia* spp. and other annuals colonising mud and sand.
- Atlantic salt meadows (*Glauco-Puccinellietalia*).
- Mediterranean and thermo-Atlantic halophilous scrubs (*Arthrocnemetalia fructicosae*) (Referred to in this document as Mediterranean saltmarsh scrubs).

The Wash and North Norfolk Coast also qualifies as a SAC for the following Annex II species, as listed in the EU Habitats Directive:

- Common seal (*Phoca vitulina*).

The Wash is the largest embayment in the UK, and is connected via sediment transfer systems to the north Norfolk Coast.

Sandy sediments occupy most of the subtidal area and subtidal communities present include large areas of dense brittle star *Ophiothrix fragilis* beds. Species include polychaetes such as the sand mason *Lanice conchilega* and the bivalve tellin *Angulus tenuis*. The sublittoral sandbanks also provide important nursery grounds for young commercial fish species, including plaice *Pleuronectes platessa*, cod *Gadus morhua* and sole *Solea solea* (Brown et al, 1997).

Intertidal sandflats predominate in the Wash and along the north Norfolk coast. Some intertidal soft mudflats are found in the areas sheltered by barrier beaches and islands along the north Norfolk coast. The biota includes large numbers of polychaetes, bivalves and crustaceans.

Well developed stable reefs of the common tube-dwelling polychaete worm *Sabellaria spinulosa* are known to be present in the Wash, especially in the inner Wash. These reefs are particularly important as they are diverse and productive habitats which support many associated species.

In north Norfolk, saltmarshes form an almost continuous belt over 35km long covering about 2200 ha, of which at least 1600ha can be considered as Atlantic salt meadow (Burd 1989). The saltmarshes of north Norfolk are some of the most botanically rich in Britain. A typical zonation is from the pioneer salt marsh with glasswort, common cord-grass *Spartina anglica* through a low-mid saltmarsh dominated by sea aster *Aster tripolium* and sea purslane *Atriplex portulacoides*. The mid upper saltmarsh frequently has a high cover of common sea lavender *Limonium vulgare* and thrift *Armeria maritime*. There are transitions to Mediterranean scrubs.

The Wash and North Norfolk Coast European marine site holds some 9% of the total UK common seal population and is the largest colony of common seals in the UK (see also Section 11 Marine Mammals). The extensive intertidal sand flats of the Wash and the north Norfolk Coast provide ideal conditions for breeding and haul-out sites of the common seal (Brown et al 1997).

The size of the seal populations is provided in Table 5.1.

Table 5.1 Numbers of common seals counted in the Wash and North Norfolk Coast European marine site in August 1998 (Sea Mammal Research Unit (NERC), 1999).		
Count site	Count 1	Count 2
Blakeney Point	535	738
The Wash	2367*	2381

Note: Data taken from fixed-wing aerial surveys carried out during the August moult.

* one area used by common seals was missed on this flight (100-150 seals)

5.2.2.1 Future Designations

Of the current SACs along the coast of England, most sites are inshore and attached to the coast where the seaward boundary of does not extend far out into the marine environment.

The new methods necessary for the identification of offshore SACs developed by JNCC and others, and the availability of seabed geological information for English waters, has provided new evidence for the widespread existence of possible Annex I habitat located offshore. This has highlighted the potential gap in the SAC site series between the coast and the 12 nautical mile limit.

In view of this, and with the support of Defra, English Nature is working towards identifying possible additional SACs for certain marine habitats (subtidal sandbanks and reefs) within English territorial waters. In 2003, English Nature contracted BMT Cordah to identify datasets that are relevant to subtidal sandbank and reef features around England (English Nature Research Report 659). As a result of this work and further data collation carried out by English Nature, a scoping list of 21 sites has been drafted (Brown 1997, EN Workshop Oct. 2005). A number of these marine sites have been identified off the eastern Norfolk coast including Haisborough Sand, Sunk Sand and Scoby Sands. The subtidal sandbank of Sheringham Shoal has not however been considered to be a marine site and a further round of studies or investigations are not envisaged (pers. Comm. English Nature).

5.2.2.2 North Norfolk Coast SPA / Ramsar Site

The North Norfolk Coast SPA qualifies under the EU Birds Directive for the following features:

- Internationally important populations of regularly occurring Annex I bird species;
- Internationally important populations of regularly occurring migratory bird species; and
- Internationally important assemblage of waterfowl, including the internationally important populations of regularly occurring migratory bird species.

Ramsar criteria 1,2,5,6 have been applied for the justification of the North Norfolk Coast Ramsar site.

- Relating to Ramsar Criterion 1: The site is one of the largest expanses of undeveloped coastal habitat of its type in Europe. It is a particularly good example of a marshland coast with intertidal sand and mud, saltmarshes, shingle banks and sand dunes. There are a series of brackish water lagoons and extensive areas of freshwater grazing marsh and reed beds.
- Relating to Ramsar criterion 2: Supports at least three British Red Data Book and nine nationally scarce vascular plants, one British Red Data Book Lichen and 38 British Red Data Book invertebrates.
- Relating to Ramsar criterion 5: Assemblages of wildfowl of international importance. Over winter the area regularly supports 91,536 waterfowl (5 year peak mean 1991/92-1995/96).

- Relating to Ramsar criterion 6: Breeding and over wintering bird species of international importance, as identified at designation (see Table 5.2).

Table 5.2 North Norfolk Coast SPA/ Ramsar site: species and population data

Species	Population	Importance	Status
Avocet *Recurvirostra avosetta*	177 pairs representing at least 30.0% of breeding GB pop. (Count as at 1998). 153 individuals representing at least 12.0% of wintering GB population. (Count as at 1997/98)	European	Annex 1
Bittern *Botaurus stellaris*	3 individuals representing at least 15.0% of the breeding GB pop. (Count as at 1998). 5 individuals representing at least 5.0% of wintering GB population. (5 year peak mean 1991/94 – 1998/99)	European	Annex 1
Common Tern *Sterna hirundo*	460 pairs representing an average of 0.4% of the Northern European/ Eastern European breeding populations, representing at least 3.7% of the breeding GB population. (Count as at 1996)	International	Annex 1
LittleTern *Sterna albifrons*	330 pairs representing an average of 0.5% of the Eastern Atlantic breeding population (5 year mean 1992/96); 377 pairs representing at least 15.7% of the breeding GB population. (5 year mean1994/98)	International	Annex 1
Sandwich Tern *Sterna sandvicensis*	3,700 pairs representing an average of 2.8% of the Western Europe/Western Africa breeding populations. (Source period not collated); 3,457 pairs representing at least 24.7% of the breeding GB population. (5 year mean1994/98)	International	Annex 1
Roseate Tern *Sterna dougallii*	2 pairs representing at least 3.3% of breeding GB population. (5 year mean 1994/98)	European	Annex 1
Marsh Harrier *Circus aeruginosus*	14 pairs representing at least 8.8% of breeding GB population. (Count as at 1995)	European	Annex 1
Hen Harrier *Circus cyaneus*	16 individuals representing at least 2.1% of wintering GB population. (5 year peak mean 1993/94 – 1997/98)	European	Annex 1
Mediterranean Gull *Larus melanocephalus*	2 pairs representing at least 20.0% of breeding GB population. (Count as at 1996)	European	Annex 1
Bar-tailed Godwit* *Limosa lapponica*	1,236 individuals representing at least 2.3% of wintering GB population. (5 year peak mean 1991/92 – 1995/96)	International	Annex 1
Golden Plover *Pluvialis apricaria*	2,667 individuals representing an average of 1.1% of the Western wintering Palearctic population.; representing at least 1.1% of wintering GB populations. (5 year peak mean 1991/92 – 1995/96)	European	Annex 1
Ruff *Philomachus pugnax*	54 individuals representing at least 7.7% of wintering GB population. (5 year peak mean 1993/94 – 1998/99)	European	Annex 1

Redshank *Tringa totanus*	700 pairs representing at least 1.2% of breeding Eastern Atlantic wintering population. (Count as at 1998). 2,998 individuals representing at least 2.0% of wintering Eastern Atlantic population. (5 year peak mean 1993/94 – 1997/98)	European	Breeding / Migratory
Ringed Plover	220 pairs representing at least 1.4% of breeding Europe/North Africa wintering populations. (Count as at 1998). 1,256 individuals representing at least 2.5% of the Europe/North Africa wintering populations. (5 year peak mean 1994/95 – 1998/99)	European	Breeding / Migratory
Knot *Caladris canutus*	10,801 individuals representing an average of 3.1% of the North-Eastern Canada/Greenland/Iceland/North-western Europe populations. (5 year peak mean 1991/92 – 1995/96); 3,457 pairs representing at least 24.7% of the breeding GB populations. (5 year mean1994/98)	International	Migratory
Dark-Bellied Brent Goose *Branta bernicla bernicla*	11,512 individuals representing at least 3.8% of wintering Western Siberia/Western Europe populations. (5 year peak mean 1991/92 – 1995/96)	International	Migratory
Pink-footed Goose *Anser brachyrhynchus*	23,802 individuals representing at least 10.6% of wintering Eastern Greenland/Iceland/UK populations. (5 year peak mean 1991/92 – 1995/96)	International	Migratory
Pintail *Anas acuta*	1,139 individuals representing at least 1.9% of wintering Northwestern Europe population. (5 year peak mean 1991/92 – 1995/96)	International	Migratory
Wigeon *Anas penelope*	14,039 individuals representing at least 1.1% of wintering Western Siberia/Northwestern/Northeastern Europe populations. (5 year peak mean 1991/92 – 1995/96)	International	Migratory

(Source: JNCC website)

*Species occurring at levels of international importance as identified post-designation

5.3 References

- Brown, Burn, Hopkins & Way. 1997. The Habitats Directive: Selection of Special Areas of Conservation in the UK. JNCC Report, No. 270.
- English Nature Report 659 (2005) Identification of Marine Habitats relevant to SACs
- HMSO (1994). Regulation 33(2) of the Conservation (Natural Habitats & c.) Regulations 1994. Statutory Instrument 1994 No. 2716
- JNCC (2006) Designated & Proposed Ramsar sites in the UK & Overseas Territories & Crown Dependencies www.jncc.gov.uk
- Multi Agency Geographical Information for the Countryside (MAGIC) 2006. www.magic.gov.

6 Hydrodynamics and geomorphology

6.1 Introduction

This section describes the existing hydrodynamic and geomorphological conditions in the vicinity of the Sheringham Shoal Offshore Wind Farm site and export cables route. The potential impacts that could arise during the construction, operation and decommissioning of the Sheringham Shoal project are discussed for each of the foundation types being considered as well as the various installation methods.

6.2 Assessment methodology

A hydrodynamic and geomorphological study was undertaken by HR Wallingford (HR Wallingford, 2006), providing the basis for this chapter. The assessment included:

- A desk study to determine the existing wave, tidal and sedimentary processes within the wind farm site and surrounding sea area, along the export cables route and at the adjacent coastline;
- An assessment of the magnitude and significance of impacts on the physical environment resulting from the construction, operation and decommissioning of the Sheringham Shoal project in line with the requirements listed in Section 3.3 of the *Offshore Wind Farms: Guidance Note for Environmental Impact Assessment in Respect of FEPA and CPA Requirements* (CEFAS, 2004), which include:
- Scour around turbine structures and cables;
- Effect of cable laying on suspended sediment concentrations;
- Effect of the wind farm on wave and tidal patterns, seabed forms and sediment pathways;
- Effect of the wind farm on the coastline;
- Cumulative effects with other wind farms and in-combination effects with other activities; and
- The influence of climate change.

The study also included follow up work on: modelling of sediment dispersion during cable installation; assessment of foundation scour potential for different areas of the wind farm: and an assessment of the impact of large gravity bases (see Appendices 6.1, 6.2 and 6.3 also based on HR Wallingford, 2006).

HR Wallingford holds much of the existing information required for the desk-based assessment following work carried out in the wider study area and as part of the Southern North Sea Sediment Transport Study (HR Wallingford *et al*, 2002). Other information has been collected from sources such as the Future Coast study (Defra, 2002), related Shoreline Management Plans and coastal strategy studies (HRW, 1994-2004 and Halcrow 1996). This information is further supplemented by site specific data collected as part of the EIA process, including bathymetric, geophysical and surface sediment information as listed below.

- Envision (2005). Accoustic, video and grab sample survey of Sheringham Shoal Offshore Wind Farm. Envision Mapping Ltd report prepared for Scira;
- Royal Haskoning (2005). Sheringham Shoal Offshore Wind Farm Seismic Survey: Interpretive report; and
- Geological Assessment (2004), Brian D'Olier, SCIRA-7-1-2-EX-ST-07080-Z1
- Gardline (2005), Hydrodynamics and Sediment Study
- GRAS (2005) ESA – Rapid Test Action, Case study : Sheringham Shoal Offshore Windfarm

Impacts have been assigned a level of likely significance (from major to negligible), according to the definitions as described in Section 1. The assignment of significance includes consideration of the natural variability of the coastal and nearshore system, the inherent uncertainty within a dynamic environment and the ability to measure or otherwise quantify any changes resulting from the wind farm. The impacts are described quantitatively where possible. Potential mitigation measures are noted.

Gaps in existing knowledge are highlighted, with further studies recommended only where such studies will provide a significant improvement in the understanding of potential impacts or mitigation measures. Consideration is given to recently completed work for the Department of Trade and Industry (DTI) and the Department for Environment, Food and Rural Affairs (Defra), relating to the generic impacts of wind turbines on waves, currents and sediment transport (ABPMer, 2005).

This study has not considered the proposed sub-stations in detail as their number and final location have not been defined yet.

6.3 Description of the existing environment

6.3.1 Introduction

The main site lies in water depths of 15m to 22m below Chart Datum (CD) to the north of the elongate sand bank known as Sheringham Shoal, which rises up to a shallowest point of about -3mCD. The area is exposed to wave conditions generated within the North Sea, with the most severe conditions arriving from the north and northeast due to fetch lengths of over 500km, while the most frequent waves are driven by winds blowing over the much shorter fetches from the south and west. The tidal range near Weybourne is about 4.5m (Mean Spring Tide) and the currents run in a generally shore parallel direction with an easterly flood and westerly ebb; peak currents occur close to high and low water. Currents at the main site exceed 1m/s on Spring tides, giving rise to significant bed transport and the formation of mobile bed features such as sand waves and mega-ripples. Closer to shore the currents are slightly weaker, but still sufficient to mobilise sands and fine gravels and influence littoral drift.

The sea bed comprises mainly superficial gravely sands or sandy gravels derived from the reworking of the underlying glacial till. Close to shore the glacial till thins out, leaving the chalk bedrock with a generally thin cover of sandy gravel, except at the small sand bank feature known as the Pollard.

Much of the shoreline in the area of the proposed landfall is formed of a steep shingle beach, fronting eroding cliffs of glacial till over a chalk base. In the immediate area of the proposed landfall the shoreline is more varied. The high cliffs give way to areas of lower ground at Weybourne Gap and Kelling Hard, separated by an area of low and eroding chalk cliff that is understood to be the preferred landfall site. Where the backshore is low, the shingle beach forms a barrier ridge and is the main defence against backshore flooding.

To the west of the landfall area, the low cliffs give way to the shingle ridge of Blakeney Point and further sand / shingle barrier island features fronting the low-lying coastal fringe with tidal inlets and salt marshes. To the east, the chalk formation dips down, leaving only the softer and more easily eroded glacial till cliffs, protected by a shingle beach that gives way to a more sandy beach beyond Cromer. Plate 6.1 and Plate 6.2 show the coastal area close to the proposed landfall area (Weybourne Hope) and a section of the eroding cliffs to the east, with glacial till above the chalk base.

There are no coast defence works or management operations near the proposed landfalls. Further east, starting from Sheringham, there are groynes and sections of seawall. To the west the shingle ridge fronting the Cley marshes is maintained by regular re-grading.

Plate 6.1 Weybourne Gap shingle ridge

Plate 6.2 Eroding cliffs and steep shingle beach to the east of the proposed landfall

6.3.2 Tidal range and extreme water levels

6.3.2.1 Astronomical tidal range

The tidal level at any instant in time will be the summation of an ‘astronomical’ tidal level and a ‘residual’ level caused by meteorological effects. Astronomical tidal levels can be forecasted accurately, but the residual components due to atmospheric pressure, winds, and temperature are not easily predicted. Deep atmospheric depressions and strong winds can form storm surges, radically altering the predicted tides. If a large storm surge coincides with a high astronomical tidal level, then the resulting ‘total’ water level can cause great problems to coastal defences, occasionally leading to disastrous flooding of low-lying areas, as seen in 1953 and 1978.

The tide off the East Anglian coastline travels as an anti-clockwise gyre centred close to Great Yarmouth. The rise and fall of the tide is small close to the centre of this gyre, increasing further from the centre as illustrated by Figure 6.1. Near Weybourne, the mean spring tide range is estimated at 4.85m. Due to the form of the tidal gyre, the tide levels offshore are assumed to be similar to the adjacent coastal location along the Norfolk shore. Based on interpretation of Admiralty tidal data, the predicted tidal range data for various shoreline locations are set out in Table 6.1.

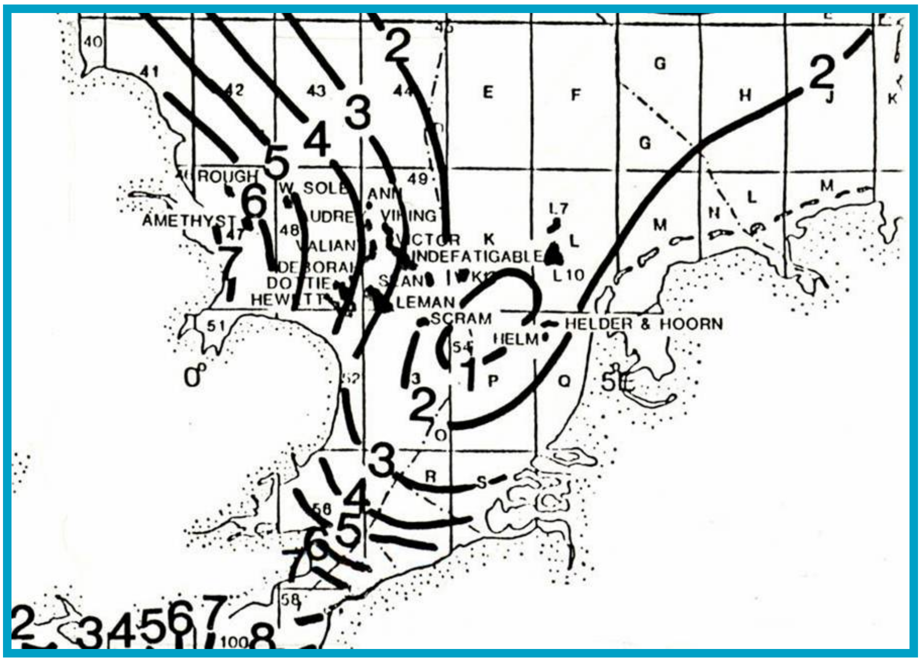


Figure 6.1 Southern North Sea tidal ranges (metres)

Table 6.1 Predicted tidal levels

	Hunstanton mODN	Blakeney Bar mODN	Kelling mODN	Cromer mODN
MHWS	3.65	2.95	2.70	2.45
MHWN	1.85	1.75	1.45	1.35
MSL	0.1	---	0.05	0.05
MLWN	-1.25	---	-0.80	-0.65
MLWS	-2.85	---	-2.15	-1.95

Note: Levels are given relative to Ordnance Datum, 2.75m above Admiralty Chart Datum at Cromer, Kelling and Blakeney Bar, and 3.75m above Chart Datum at Hunstanton

6.3.2.2 Storm surges

North Sea surges tend to originate off the north-west coast of Scotland, and propagate into the North Sea in the form of a progressive long wave. Coriolis force guides the surges southwards down the eastern coast of the UK and around the North Sea in an anticlockwise direction. The speed of propagation of the surge is similar to that of the astronomical tidal wave.

The meteorological conditions that produce surges in the North Sea are varied. The most severe surges are generally of the type described below.

Large low-pressure systems tracking north-eastwards from the Atlantic Ocean, between Iceland and the British Isles, generate strong south westerly winds. These winds cause a small positive surge on the north-west coast of Scotland, as water 'piles up', and a small negative surge on the east coast of the UK, as water is pushed towards Norway. As the depressions move further north-eastwards, the wind veers and starts to blow from the north. These northerly winds further enhance the surge, which by now will have propagated around the north coast of Scotland and into the north-west North Sea. This surge travels down the eastern coast of Britain being constantly reinforced by strong northerly winds, and reaches a maximum in the south western corner of the North Sea (Figure 6.2). In the study area, the maximum surge elevation expected once in 50 years is between 2.50m and 2.75m, with values at the wind farm site being slightly lower than along the coast.

As surges propagate into the shallower water in the southern North Sea, surge/ tide interaction can become a prominent feature. That is to say the extent of the surge can be amplified or restricted depending on the astronomical tidal level at the time.

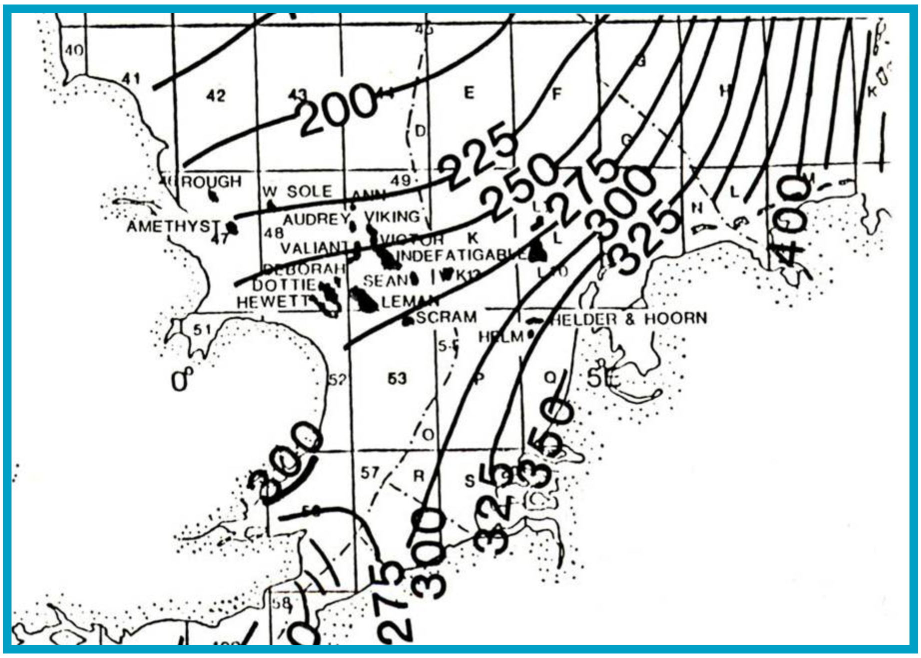


Figure 6.2 Southern North Sea 1:50 year surge elevations (cm)

6.3.2.3 Total water levels

Extreme water levels (tide + surge) around the UK have been studied by a variety of authors over a number of years (e.g. Graff, 1981; Flather, 1987 and Dixon & Tawn 1994, 1995, 1997) Dixon and Tawn (1997) use the most advanced methods and their work is generally regarded as containing the most accurate information. The results have been adopted for use in this study, in combination with the long term tidal record from the A-Class tide gauge at Cromer.

Dixon and Tawn (1997) provide estimates of 1-year water levels, together with tabulated values that are added to the 1-year level to obtain higher return period estimates. They recommend that, where the 1-year water level at the location of interest is known with greater confidence (for example, from local gauge measurements) than the estimate provided, then the local estimate should be used. The A-Class tide gauge at Cromer has been analysed to provide this 1-year total water level. Extreme levels at Kelling are taken to be 0.25m higher than at Cromer, based on differences between MHWS at the two locations. Results of this analysis are given in Table 6.2, giving present day extreme water levels for Kelling and Cromer, in mODN.

Table 6.2 Extreme (present day) water levels for Kelling and Cromer (mODN)

Location	Extreme water levels (mOD) at a range of return periods (years)			
	1	10	50	100
Kelling	3.42m	3.95m	4.29m	4.50m
Cromer	3.17m	3.70m	4.04m	4.25m

Note: Levels are given relative to Ordnance Datum, 2.75m above Admiralty Chart Datum at Cromer and Kelling

6.3.3 Tidal currents

Strong tidal currents accompany the rapid spatial changes in tidal range along the coastline of North Norfolk. An initial appraisal of currents can be gained from the information published on the Admiralty Charts for this coastline. Details on measured current speeds and directions are provided at two locations in and around the study area. These details are reproduced in Table 6.3. Position A is located near the southeast corner of the wind farm. While Position B is about 4km directly north of Blakeney Point, and about 10km west of the cable route.

The time-base for Table 6.3 is relative to high water at Immingham. High water at Kelling occurs approximately 30 minutes later than at Immingham. This adjustment means that peak easterly (flood) currents occur about 0.5 – 1.5 hours after high water and peak westerly (ebb) currents occur about 0.5 – 1.5 hours after low water. This distribution of currents relative to water levels has an impact on sediment transport, with enhanced eastward transport (or reduced westward) along the upper shingle beach and enhanced westward transport along the lower sandy beach.

These Admiralty data points are useful, but more detailed and extensive appraisals of tidal currents can be derived from numerical models. HR Wallingford has developed a regional tidal flow model of the southern North Sea using the finite element based model TELEMAC (HR Wallingford *et al*, 2002).

Table 6.3 Tidal streams (from Admiralty Charts)

Time relative to HW Immingham	Position A 053°05.4'N, 001°13.2'E			Position A 053°01.2'N, 000°58.5'E		
	Dir (°N)	Speed (m/s)		Dir (°N)	Speed (m/s)	
		Sp	Np		Sp	Np
-6hr	300	1.0	0.5	283	1.0	0.5
-5hr	296	1.2	0.6	282	0.9	0.5
-4hr	289	1.2	0.6	281	0.9	0.5
-3hr	281	0.8	0.4	270	0.7	0.4
-2hr	248	0.2	0.1	227	0.1	0.1
-1hr	131	0.4	0.2	122	0.4	0.2
HW	120	0.8	0.4	108	0.8	0.4
+1hr	115	1.1	0.6	102	1.1	0.6
+2hr	111	1.1	0.6	098	1.1	0.6
+3hr	109	0.8	0.4	094	0.8	0.4
+4hr	087	0.3	0.2	087	0.4	0.2
+5hr	326	0.3	0.2	303	0.3	0.2
+6hr	301	0.8	0.4	290	0.7	0.4

Figure 6.3 and Figure 6.4 are snapshots of tidal current vectors and residuals from the regional model. The spring tide flow is generally coastline parallel near shore and west north west – east south east across the main wind farm site. Current speeds are slightly lower closer inshore because of the increased frictional resistance of the seabed. They are predicted to be about 0.7m/s close to high and low tide. The residual flows are complex in the area of the wind farm, and are important to the nett sediment transport. Further information on tidal flows is provided in Appendix 6.2, which sets out the results of additional studies on suspended sediment dispersion.

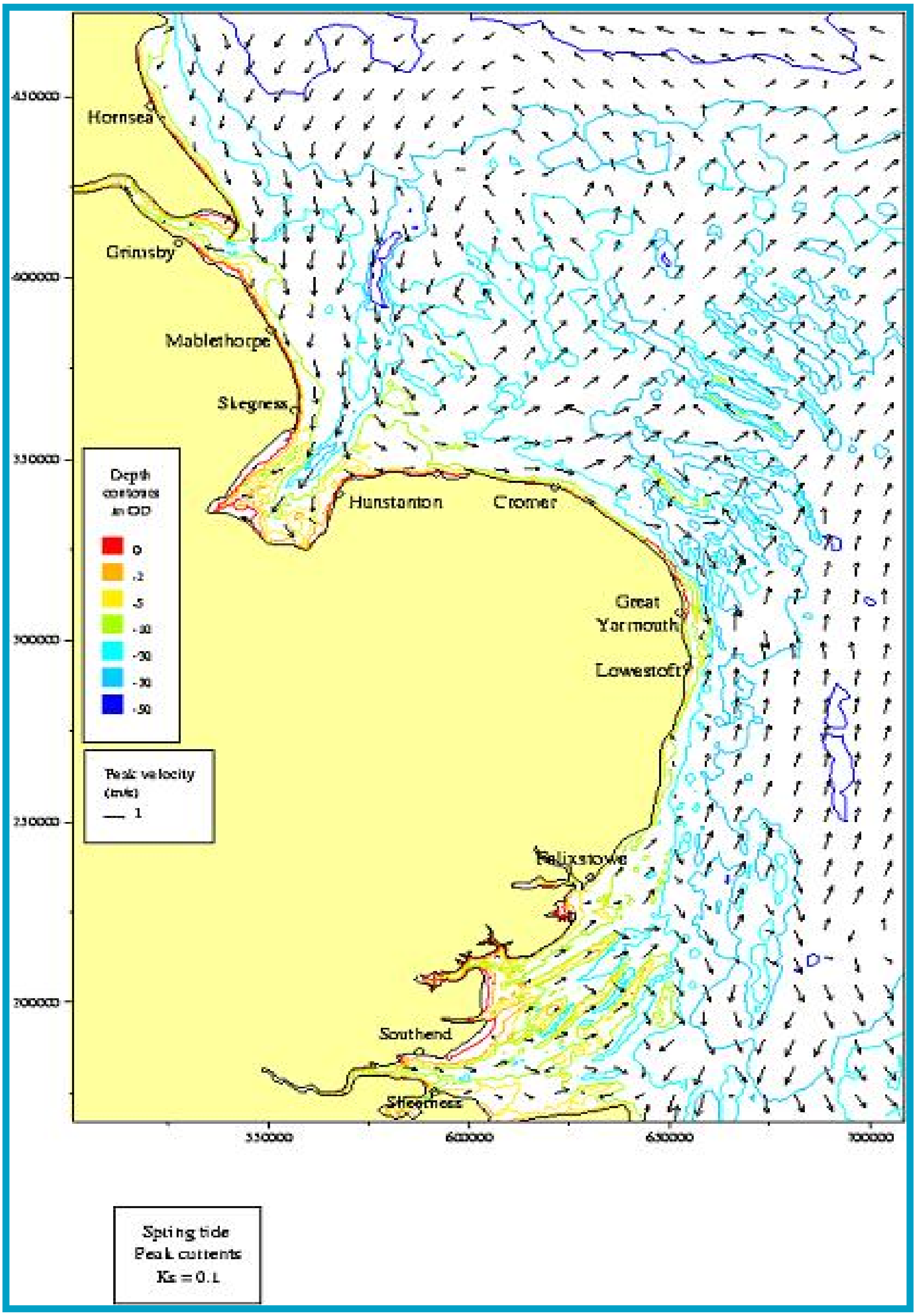


Figure 6.3 Peak spring tide currents, Southern North Sea Source: HR Wallingford et al (2002)

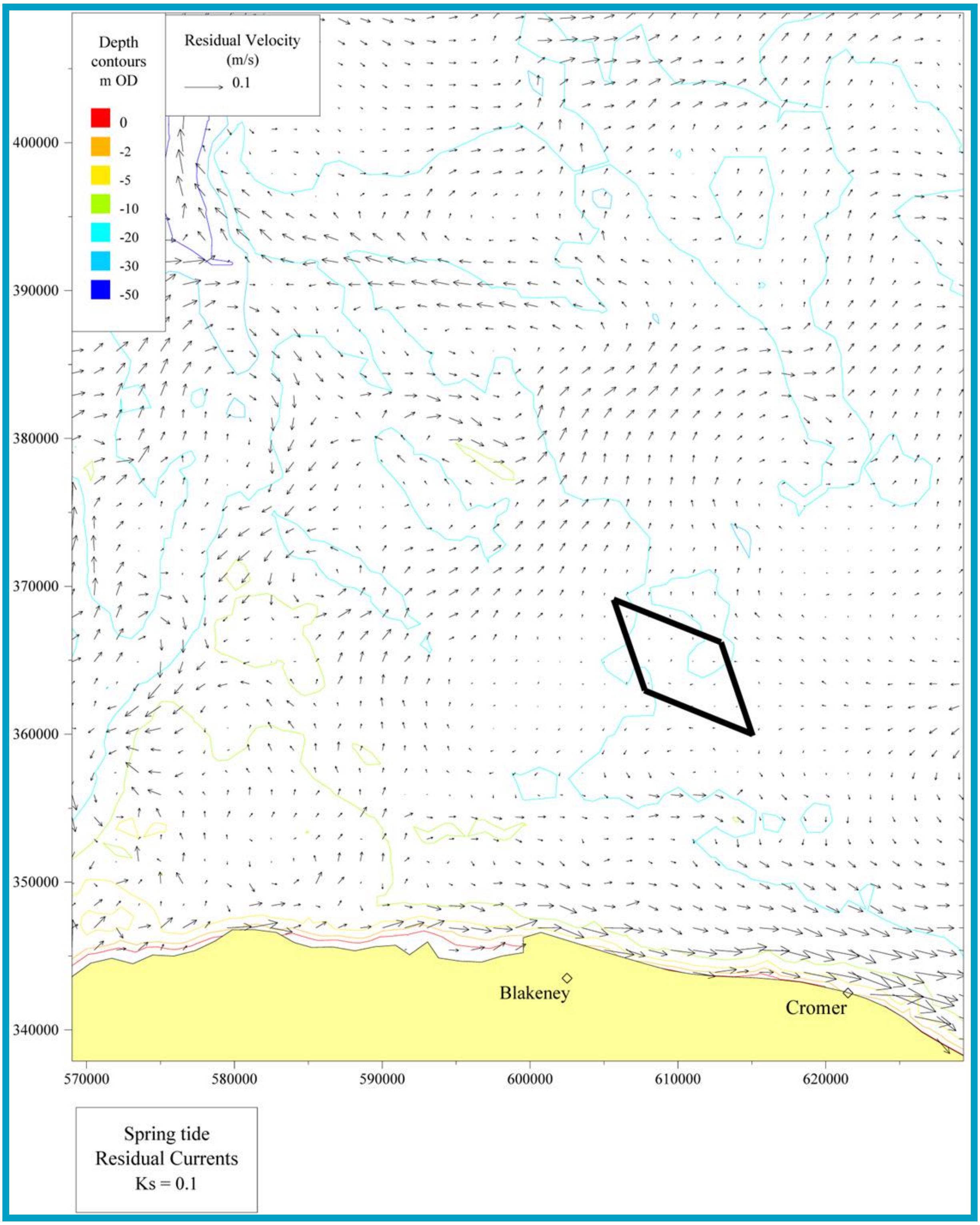


Figure 6.4 Spring tide residual velocity Source: HR Wallingford et al (2002)

6.3.4 Wave Climate and Extremes

The wind farm site and cable route are exposed to waves generated across the North Sea, but modified by the numerous banks across the Greater Wash area. Due to the complexity of the bathymetry and the varying fetch lengths for different directional sectors, it would be necessary to undertake site specific modelling to obtain reliable wave data to support engineering design. However, for the purposes of the EIA, there are several acceptable data sources arising from previous HR Wallingford studies (HR Wallingford, 1990 and HR Wallingford, 1998). These include offshore conditions at several locations, and near shore conditions local to the pipeline landfall.

Winds and waves from the southwest through northwest are most frequent, but the fetch lengths are relatively short and waves are small (significant wave height (Hs) generally less than 1m, rarely above 2m). North-westerly through north-easterly winds are less frequent, but are not fetch limited and, therefore, generate the largest waves. Offshore waves above 4m are relatively common during winter storms, and extreme Hs can be in excess of 10m, as seen for Outer Dowsing data based on hindcasting over 10 years using modified wind data from Spurn Head, validated against 3 years of measurements and 15 years of vessel observed data (HR Wallingford, 1990). See Table 6.4.

Table 6.4 Offshore extreme waves (MHWS, all directions)

Return Period (years)	Significant wave height (H_s) (m)	
	NE Sheringham Ref 10 (3hr)	Outer Dowsing Ref 9 (1hr)
1	5.4	9.0
10	6.8	11.2
50	7.7	12.8
100	8.1	13.5

Near shore conditions are less severe due to the influence of the banks, such as Sheringham Shoal. This influence is most apparent at low tide when the shallow water depths over the Shoal cause significant wave breaking, and hence a reduction in wave heights from the seawards to the landwards side of the bank. The other banks and the generally shallower water west from the wind farm site also influence wave directions due to refraction. These effects will vary in intensity with wave direction and near shore location. They are in part responsible for the changing character and orientation of the coast westwards from Kelling. Table 6.5 sets out the extreme wave conditions close to the proposed cable landfalls (HR Wallingford, 1998).

Table 6.5 Extreme near shore wave conditions for Kelling (3hr duration, MHWS)

Return period (years)	Significant wave height height (m)
1	4.2
10	5.2
50	5.9
100	6.2

6.3.5 Joint probability events

There is a strong correlation between tidal surges and large wind waves within the Southern North Sea as they are generated by similar conditions. The coincident occurrence of a surge, causing water levels to be higher than the predicted tidal condition, and severe wave conditions can give rise to conditions that influence structural design and sediment transport. For a given probability of joint occurrence, expressed in terms of return periods, the conditions may range from very high water levels with a modest wave condition to very severe waves with a modest water level.

In relation to the environmental impacts, events with severe wave conditions and high water levels can cause short term disturbance and may be important during construction or cable laying. They may also give rise to coastal erosion and flooding, possibly affecting the landfall site. Severe events can also significantly alter the form of offshore banks, giving rise to longer term changes to the coastal and near shore morphology.

6.3.6 Future conditions

The proposed wind farm is assumed to have a design life of 40 years, during which time it is anticipated that the site conditions may vary due to the effects of global climate change. The important parameters will be increasing sea level and changes to the frequency and direction of strong winds.

Global sea levels have been rising over the past century, and rates are predicted to increase. Dixon and Tawn (Reference 8) indicate a rate of sea level rise in the recent past of 1.7mm/yr for this area, approximately equal to the global average value. Because of continuing climate changes, particularly the increase in temperature of the world's oceans, mean sea level will continue to increase. Predictions from various numerical simulations of the world's atmosphere in the coming few decades, and other sources, seem to be agreed that the present rate of increase in mean sea level will accelerate. Since this will occur over the expected lifetime of the wind farm, it is necessary to anticipate higher tidal levels. Global sea levels must be considered with local isostatic changes of ground levels to give relative water level change. At present there is an assumption by DEFRA and the Environment Agency that relative sea level change along the Anglian coast will be 6mm/year over the next 50 years, giving 240mm over the design life of the wind farm. Ongoing work by several institutions will provide refinements to this accepted standard in the future.

The impacts of climate change on winds and waves have not reached a similar state of agreement. It is generally accepted that the design of coastal structures should consider the potential for increased storminess and changes to the dominant directions. Due to the configuration of the North Sea, the proposed wind farm site is predominantly exposed to severe waves from the northwest to northeast and there is no reason to suppose that future extreme waves will arrive from a changed direction. Wave predictions done in previous HR Wallingford studies off Norfolk and Lincolnshire show significant variability in wave height from year to year, but no significant overall trend of direction or energy. However, the frequency of strong winds may increase, affecting both extreme wave heights and surge levels. In the absence of any certainty it would be prudent to take a conservative approach and allow for design conditions at a higher level of predicted return period than would be the case if present conditions were assumed to continue.

6.3.7 Geology and geomorphology

The seabed and coastline around the proposed development have been strongly influenced by the last Ice Age and the post-glacial period. Large quantities of sediment were laid down over the underlying chalk formations by retreating glaciers and associated rivers. The material has been reworked by fluvial processes while sea level was below present levels, and then by waves and currents during the post-glacial transgression and up to the present day. There has been general onshore movement of fine sediment into the coastal fringes around the Wash, formation of sand and gravel barrier ridges and islands, and the formation of numerous offshore banks.

In support of the EIA, the bed sediments at and around the offshore site have been sampled, and geophysical / geotechnical surveys have been completed (D'Olier, 2004; Envision 2005, Fugro 2005 and Royal Haskoning, 2005). Information for the main site, cable route and coast has also been derived from Admiralty Charts, British Geological Survey publications, Sothern North Sea Sediment Transport Study and previous studies (HR Wallingford *et al*, 2002; JNCC, 1996; BGS, 1987 and Halcrow, 2002). The available information indicates variability of surface sediment distribution and underlying strata across the site and along the cable route. For getting more information about the amount of scourable material in the wind farm area, a geology report was made by Royal Haskoning (2005). Figure 2.8 (Section 2) shows the geology in the wind farm area. In this report the information of the Seismic Survey Interpretive Report of Royal Haskoning (2005) was used.

6.3.7.1 Wind farm site and cable route

The mobile surface sediment of the study area comprises mainly gravely fine to medium sand, believed to be derived from reworking of the late Pleistocene glacial till bed known as the Bolder Bank Formation. The glacial till overlies Pleistocene heterogeneous sediment of the Swarte bank and Egmond Formation, which is near-surface inshore of Sheringham Shoal. The underlying bedrock is Cretaceous Chalk, which is exposed or near-surface within about 5km of the shore. The chalk is also exposed at the low eroding coastal cliffs at the proposed landfall. Figure 6.5 indicates the general facies distribution presented by BGS. This information is presented, in detail in Royal Haskoning (2005).

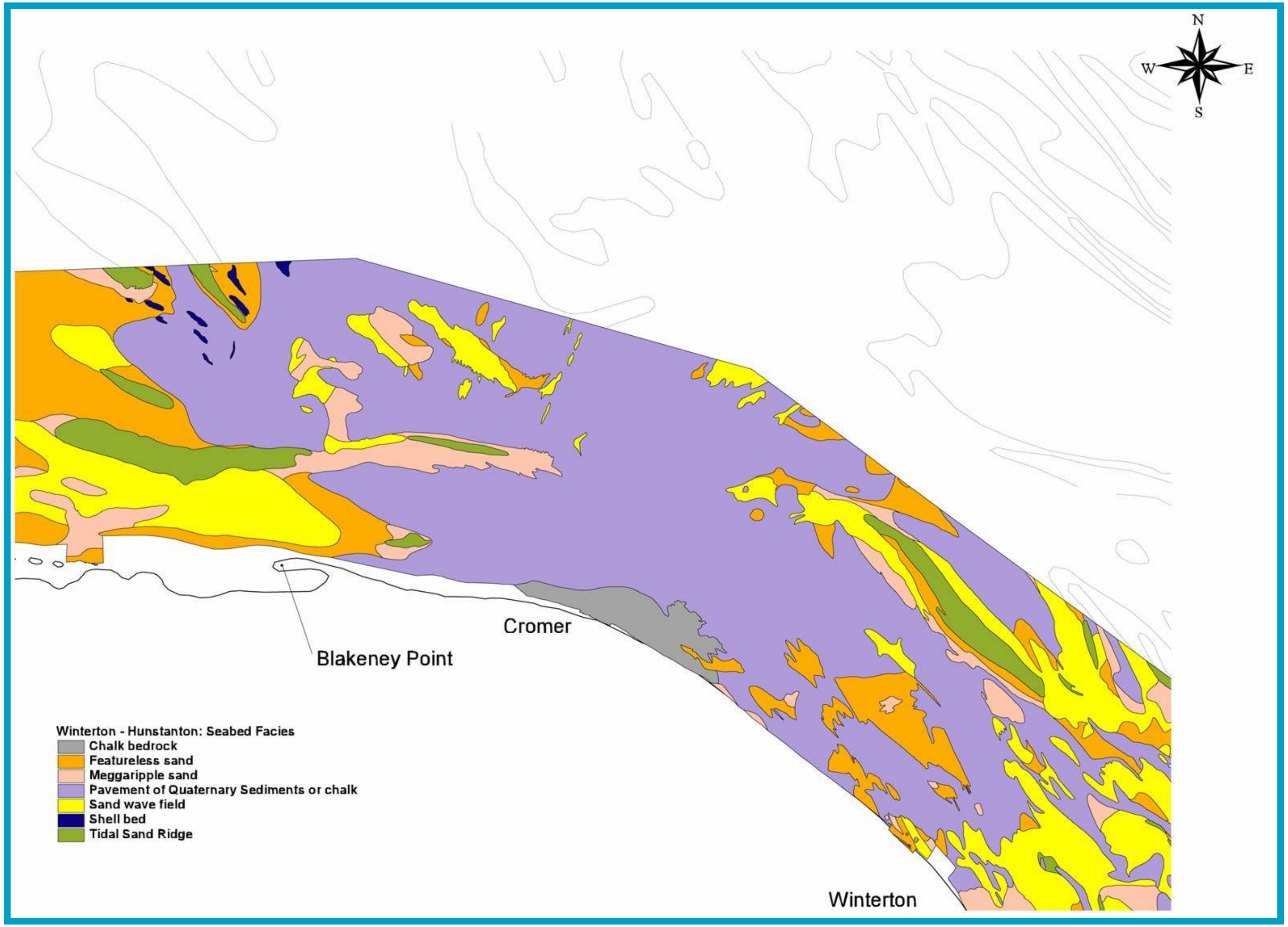


Figure 6.5 British Geological Survey seabed facies Source: HR Wallingford (2002)

The upper surface of the chalk slopes down to the north, from surface exposure near the shore to about 20m below the surface across much of the wind farm site and a maximum of 45m below the bed to the west of the wind farm site (Envision, 2005). Both the glacial till and the chalk surface are cut by channels and depressions, infilled by Holocene sand/gravel/clay/peat beds and covered by mobile surface sediments. The most notable is the 10m – 20m deep Weybourne Channel area, identified by Royal Haskoning (2005) in the near shore area near Weybourne. Infill channels are also found across the central and north-western areas of the main wind farm site, but are not sufficiently defined to support mapping.

The thickness of the non-cohesive surface layer varies widely. Close to shore it is believed to be generally up to only 0.5m, while the bank at Sheringham Shoal is up to 10m thick. The smaller Pollard Bank has an approximate thickness up to 5m. Both are surrounded by mega-ripples and sand waves. Within the wind farm site there are mega-ripples and sand waves up to 5m in amplitude, forming a linear strip from southeast to northwest of around 10km length and 1km width. In other parts of the site the surface sediment is less than 1m depth with areas of sand streaks and thin patches across the glacial till surface. As with the infill channels, there is insufficient definition to support mapping of surface sediment thickness.

6.3.7.2 Sand bank mobility

The location of the banks and the general bathymetry is apparently relatively stable. A comparison of Admiralty surveys from 1961 - 63 and 1992 - 93 shows very little significant difference over 30 years. Figure 6.6, Figure 6.7 and Figure 6.8 show the major contours from the two surveys, and an overlay to illustrate changes. Allowing for the different densities of soundings and the quality of position fixing, it appears that there is little change (note that the close nearshore area including Pollard Bank was not resurveyed in 1992-93).

A more detailed digital analysis of the bathymetry over Sheringham Shoal was undertaken using the Admiralty Collector Charts of 1950 and 1992, plus the Envision 2005 swathe bathymetric survey (Envision, 2005). All charts were corrected to the same projection and vertical datum. The resolution of the surveys increased over time, with the 2005 survey showing a high level of seabed detail. The digitised surveys were prepared as ground models, and analysed for change over time. The results are set out in Figure 6.9. The Pollard Shoal was not analysed as the 1950 survey was the only data set available.

This detailed work shows that Sheringham Shoal has shifted south, and possibly east, with a trend of surface elevation change of about 1m per decade. The north, and possibly west, side of the bank is dropping and the south, and possibly east, side of the bank is growing. In addition, the 2005 swathe survey clearly shows the presence of sand waves up to 1m amplitude along the north face of the bank, indicating potential elevation changes of between 2m and 6m along the eastern cable route over the assumed 40 year design life of the project.

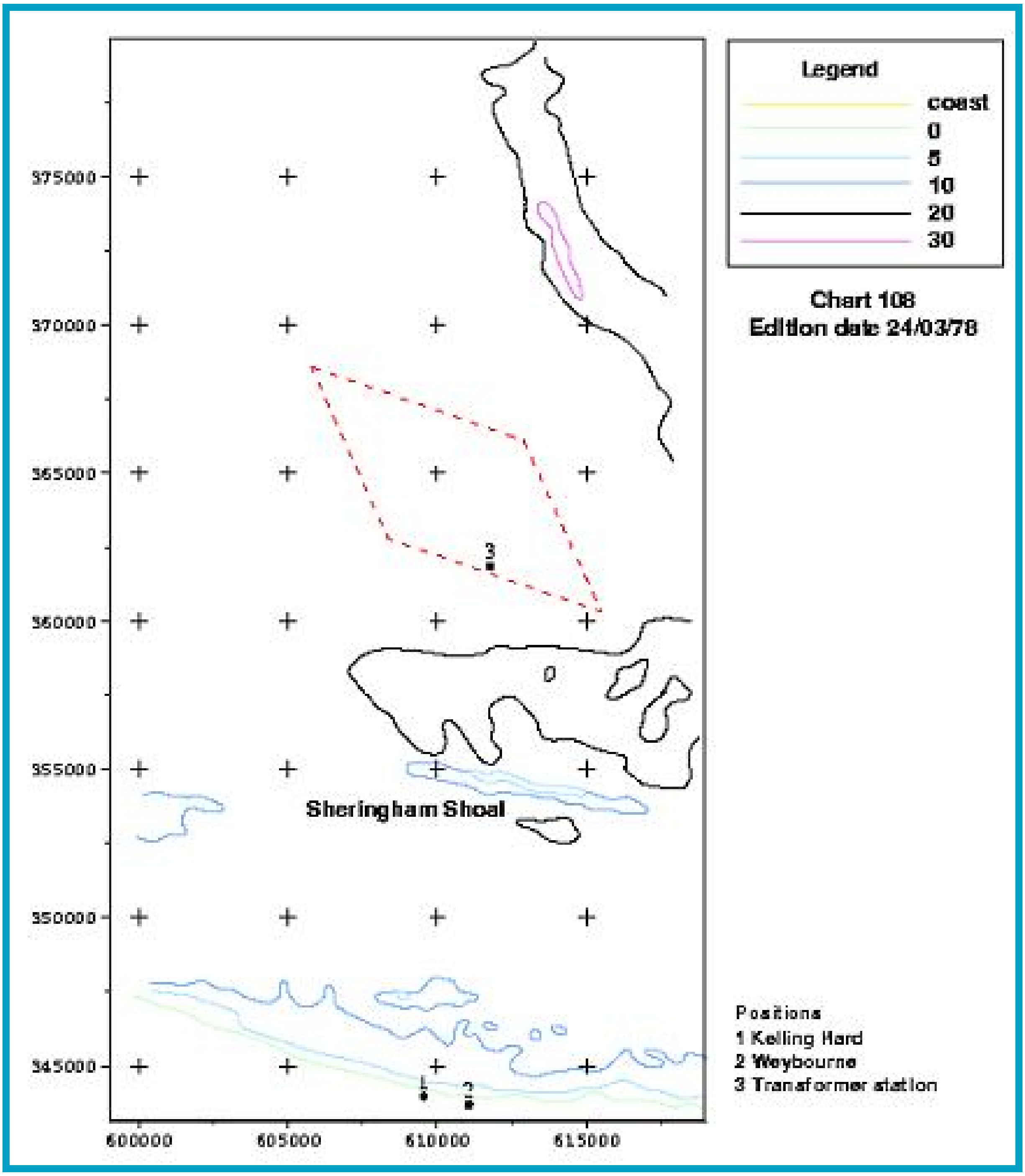


Figure 6.6 Landfall seabed contours – 1961 to 1963 survey

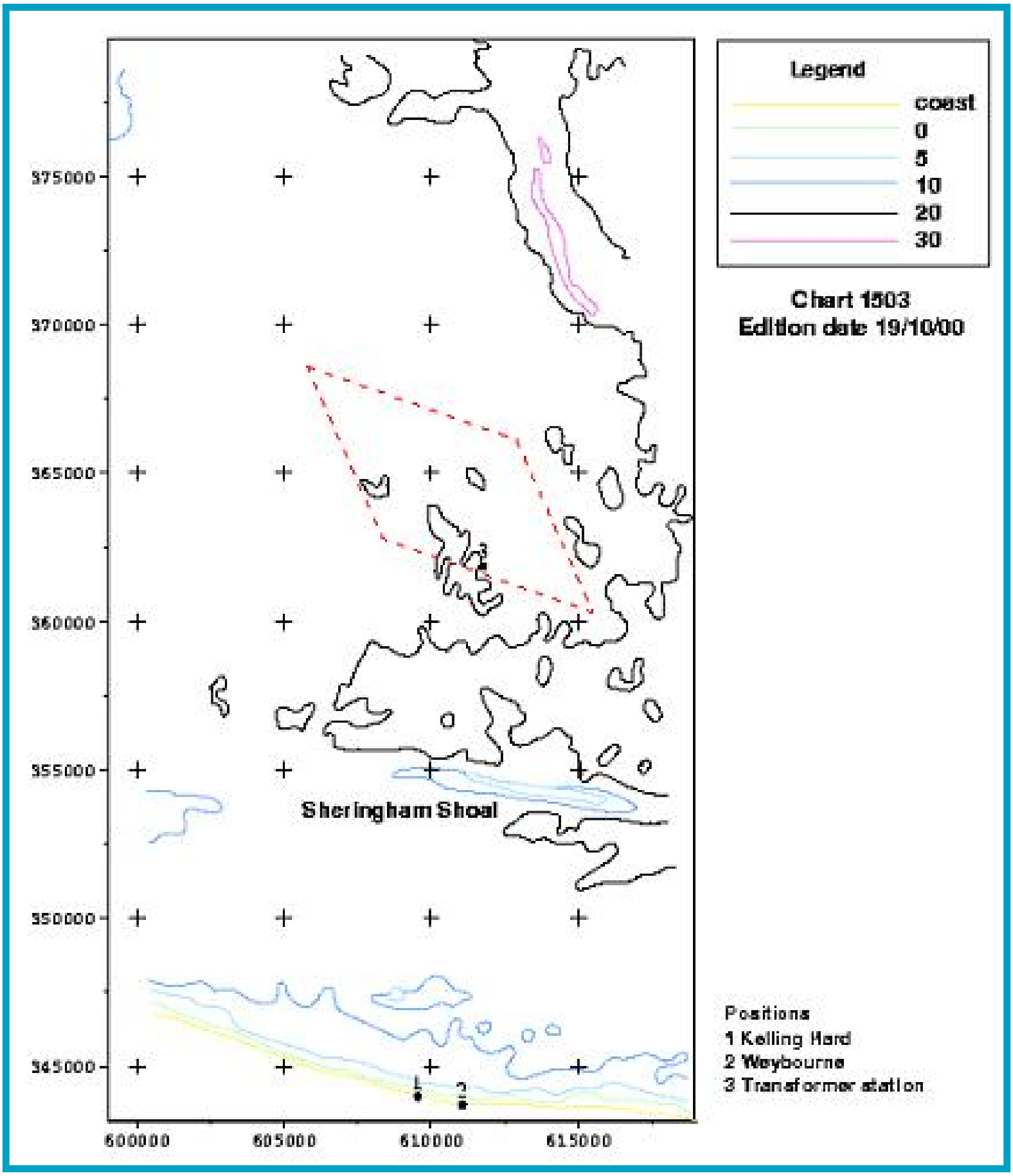


Figure 6.7 Landfall seabed contours – 1992 to 1993 survey

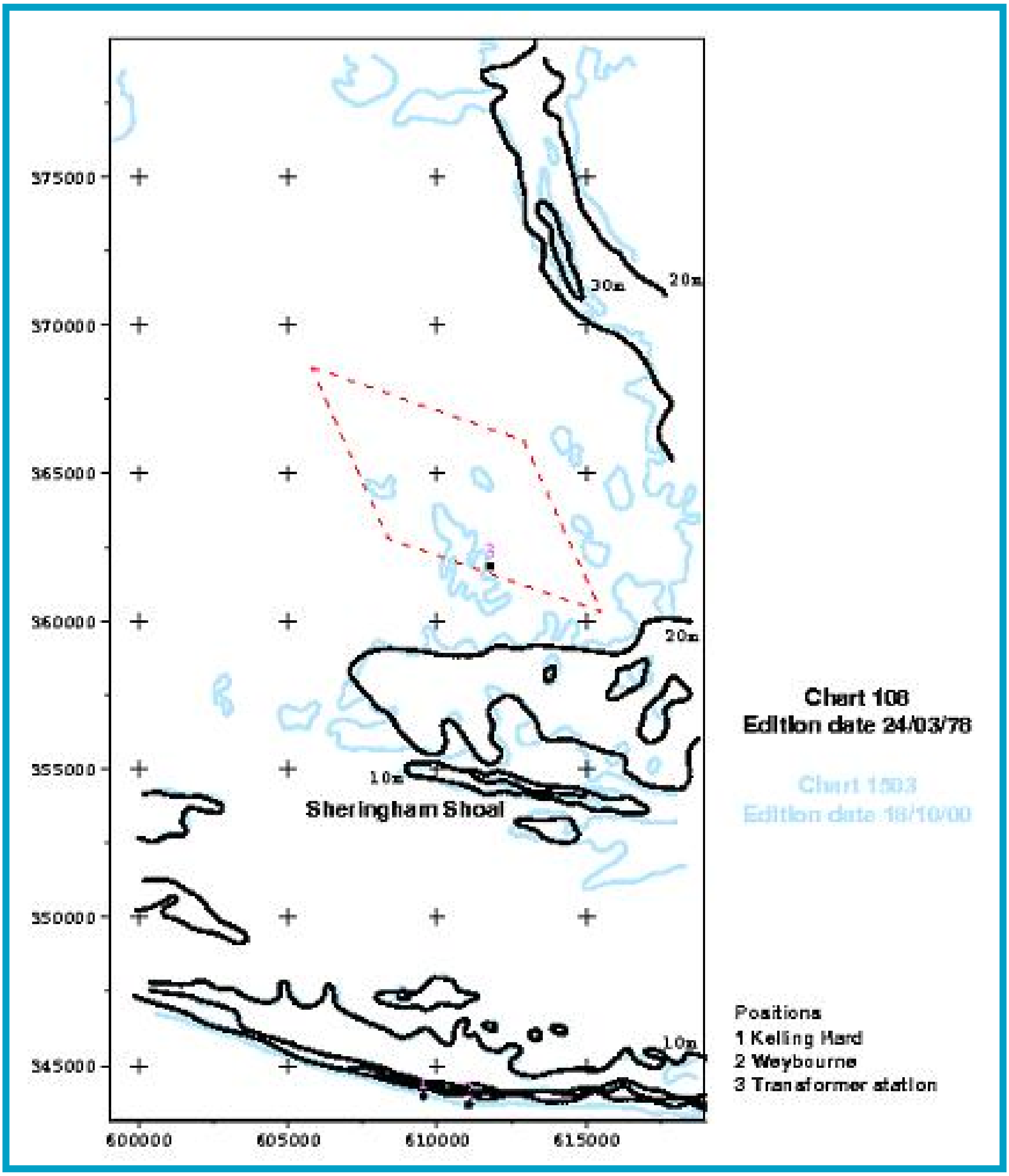


Figure 6.8 Comparison of landfall seabed contours

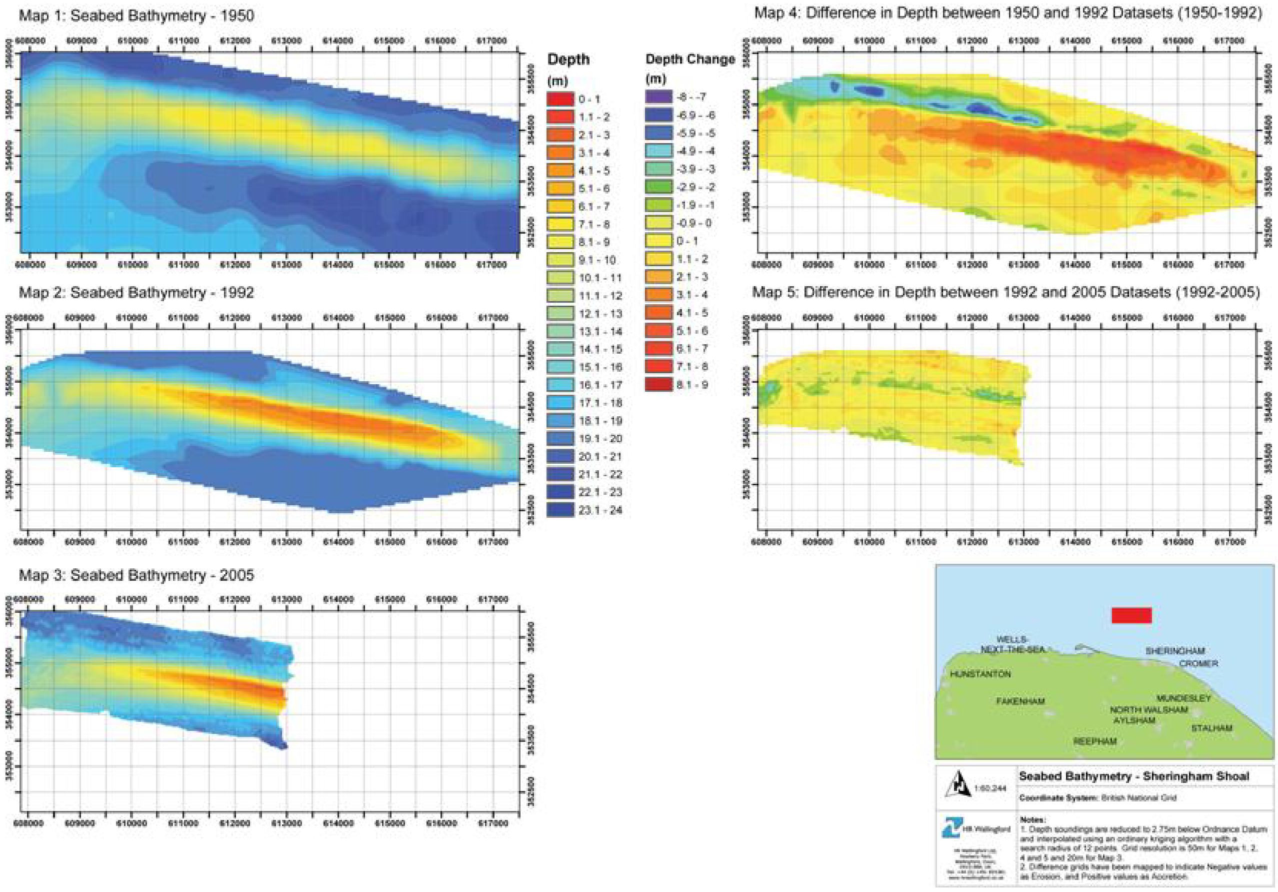


Figure 6.9 Comparison of bathymetric surveys from 1950, 1992 and 2005

The bathymetric analysis provides less substantive evidence of change along the western route over Sheringham Shoal. The route passes through an area of sand waves up to 4m elevation. There is no evidence to support a rate or direction of sand wave migration, or a rate of general bed level change, but it is reasonable to assume that wave migration could result in bed elevation change by 4m over the project design life.

Despite the lack of evidence, it is assumed that the Pollard Shoal is also subject to short and long term mobility.

6.3.7.3 Landfall

The landfall area is subject to ongoing retreat as a result of cliff and near shore seabed erosion along the coast and the landward migration of the shingle beach, as discussed further in Section 6.3.9.

The coastal cliffs are most resistant where there is a base layer of chalk, but the chalk surface dips down to the east leaving only the soft glacial cliffs. Historic map analysis indicates that cliff erosion rates along the North Norfolk coast vary from 0.3m/year up to as much as 2.0m/year, with an average of about 0.5m/year along the frontage from Kelling to Sheringham. The eroded material feeds littoral drift to the west and east depending on sea conditions and location.

In the absence of further beach management interventions or the impacts of offshore developments, the shoreline will gradually retreat, possibly with occasional periods of rapid change in response to severe events. Breaching of the barrier ridge off Cley and opening of new tidal channels further west are possible developments. Cliff erosion will be influenced by the frequency of storms and surges, and there is uncertainty regarding future rates of change.

6.3.8 Seabed processes

Seabed transport is driven by tidal currents combined with waves, and is a function of the type and availability of bed sediment. The relative importance of waves and tidal currents varies depending on local conditions, with the effects of waves dependent on the wave height and period relative to the depth of water. Seabed transport pathways for the development area have been investigated by various studies, and are considered at a regional level by the SNSSTS (HR Wallingford *et al*., 2002). This important work made use of all available field information combined with numerical modelling to derive a coherent image of regional sea bed pathways.

The existing sediment transport regime for the Southern North Sea was simulated using the HR Wallingford TELEMAC, SANDFLOW and COSMOS models. The results of that work provide an indication of the transport regimes at the wind farm site, the cable route and landfall. The tidal currents can mobilise material up to coarse sand under normal spring tide conditions (see Figure 6.10), while suspended loads vary from typical mean summer values of less than10 mg/l to typical mean winter values of 30 mg/l (see Figure 6.11 and Figure 6.12). During storm events the natural levels of suspended sediments may increase well above these mean values. Tidal current residuals, and therefore nett transport vectors, vary from the shore to the outer limits of the main site giving significant differences in rate and direction.

Model results vary considerably depending on assumptions about bed roughness, wave stirring, wind stresses and tidal state. This variability reflects the natural variability of sea conditions. A summary of the results indicates a moderate and persistent easterly pathway between the surf zone and Sheringham Shoal, with a moderate but directionally variable transport across the main wind farm site. By combining the model results and seabed indicators (sand wave asymmetry, mega-ripple patterns, sand ribbons, sand banks, etc) the SNSSTS built up a relatively comprehensive and authoritative picture of bed transport. Figure 6.13 to Figure 6.15 present some of the model results under various model scenarios, and an indication of the interpreted overall situation is set out in Figure 6.16.

Over most of the development area the dominant driver for sediment transport is tidal current. The effects of unbroken waves in the relatively deep water of the site are limited mainly to a stirring effect whereby the entrainment process is enhanced, particularly during periods of higher wave activity. By this process, wave action can increase the magnitude of the suspended sediment concentration, but the transport pathways are unaltered.

Large waves in relatively shallow water cause wave breaking that generates an additional driving force, and this process does alter the direction of sediment transport. However, for the proposed wind farm location, the seabed levels are generally greater than 15mCD. The onset of wave breaking due to depth limitation occurs when the wave height exceeds a factor of the water depth of between 0.55 and 0.8. This range criterion indicates that only the most extreme individual waves of over 8m would break over the shallowest parts of the wind farm at lowest tide levels, while at high tide levels only waves above about 10m would be likely to break. These are conditions that would only occur during severe wind conditions with an occurrence probability of about 1:1 year. Consequently it is appropriate to focus attention on the potential impact of the turbine foundations on the sand transport patterns due to tidal currents alone.

At the wind farm site and along the cable route, tidal currents are sufficient to transport sand and fine gravel, and significant transport will occur during strong onshore winds when waves are sufficiently large to enhance transport by disturbing the seabed. Sand ribbons, mega-ripples and sand waves are all found, together with the large bank features of Sheringham Shoal and the Pollard.

Current speeds are lower closer inshore because of the increased frictional resistance of the seabed, but are still predicted to be up to 0.7m/s at high and low tide. These current speeds, on their own, are capable of mobilising and transporting sand and fine gravel. The added effects of breaking waves that disturb and agitate the larger gravel and shingle particles, means that tidal currents along this coast can affect beach sediment transport. During storm surges the currents are potentially much stronger and may make a significant contribution to short term beach responses, particularly in combination with storm waves.

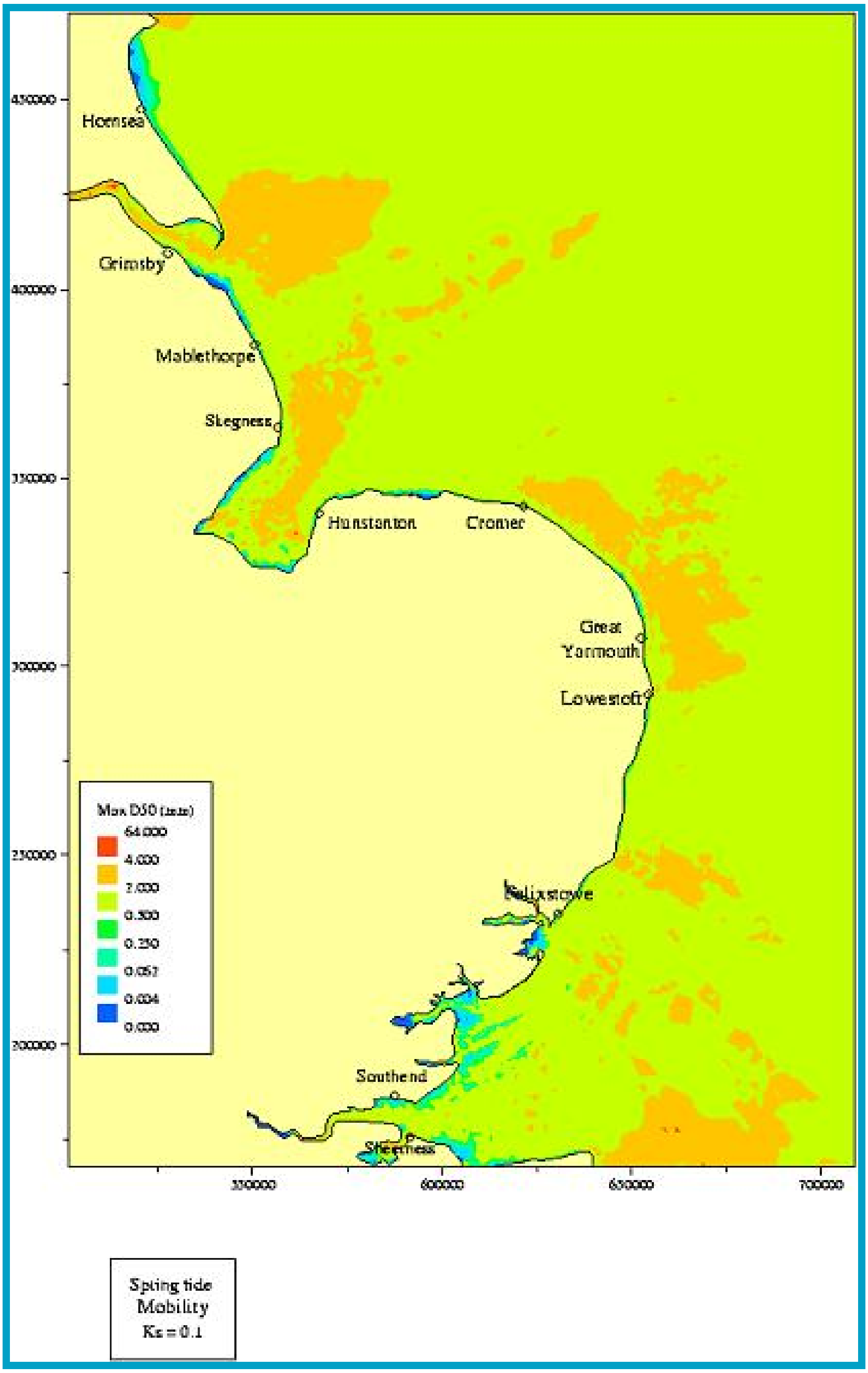


Figure 6.10 Seabed mobility – maximum mobile grain size under spring tides Source: HR Wallingford et al (2002)

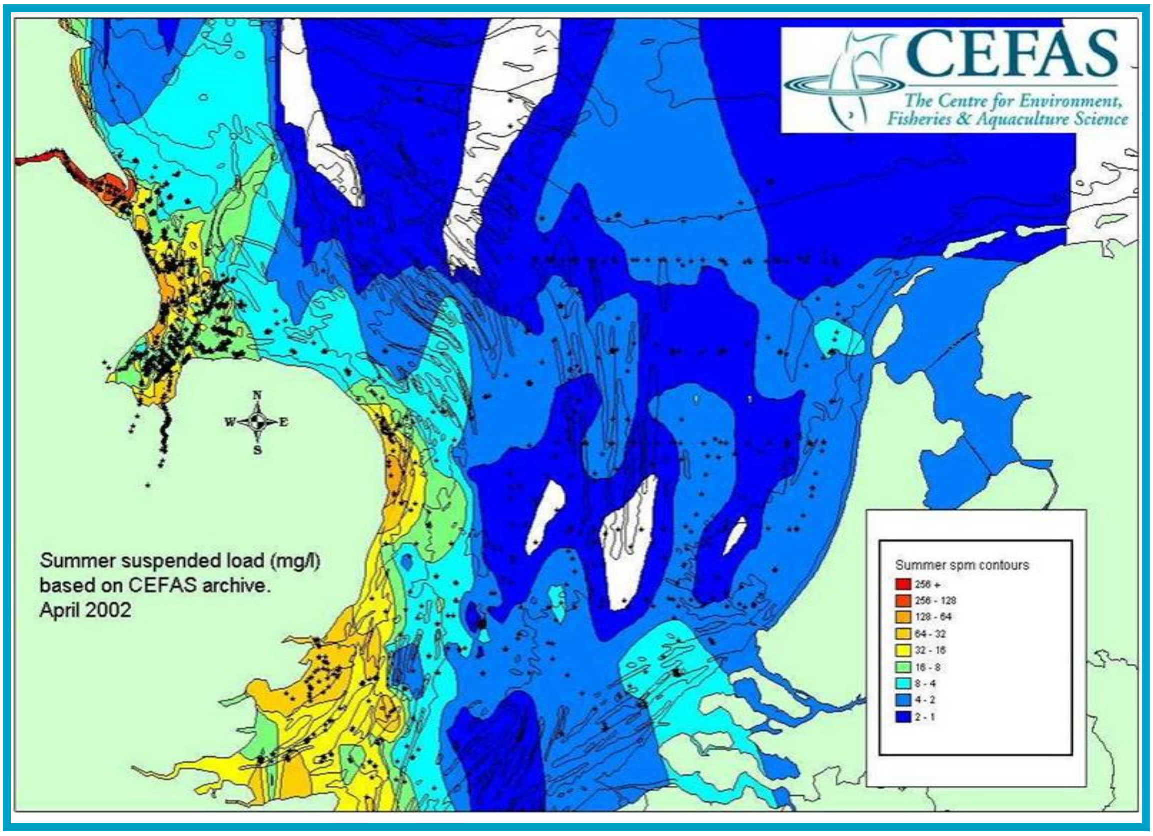


Figure 6.11 Mean summer suspended sediment concentrations (units: mg/l) Source: HR Wallingford et al, (2002)

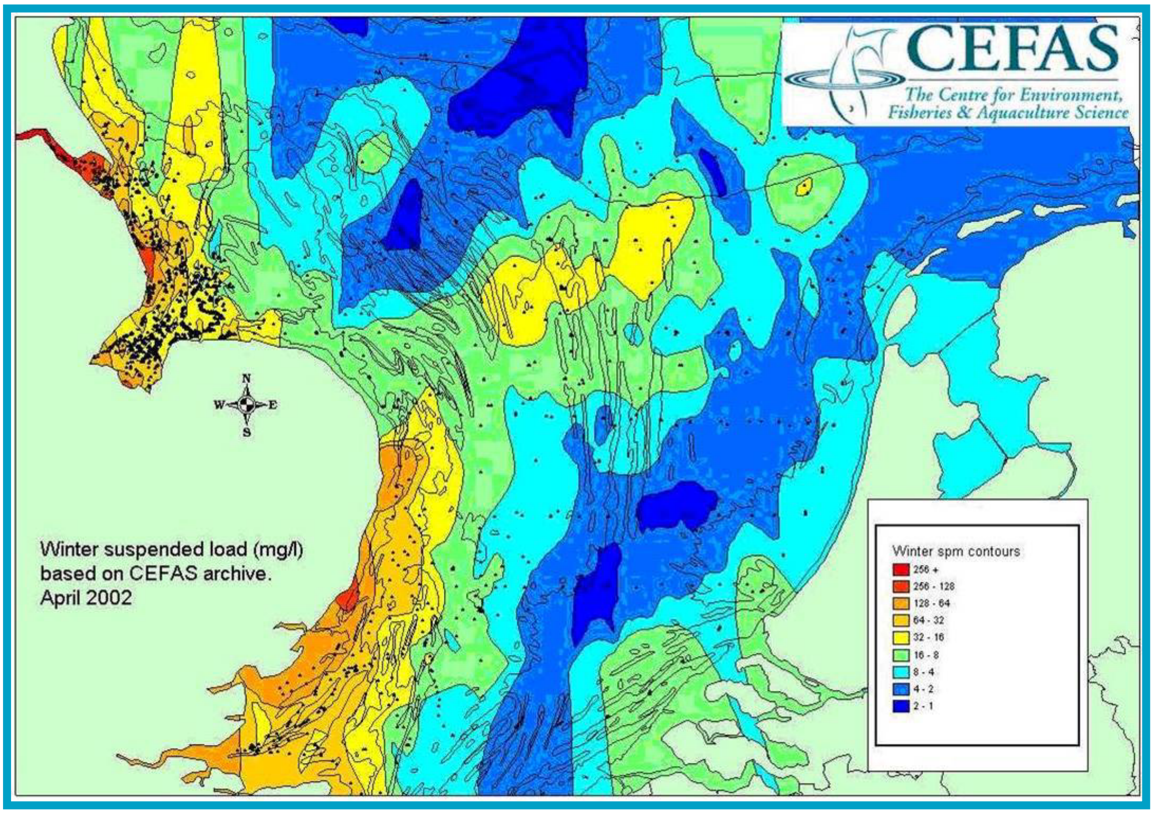


Figure 6.12 Mean winter suspended sediment concentrations (units: mg/l) Source: HR Wallingford et al, (2002)

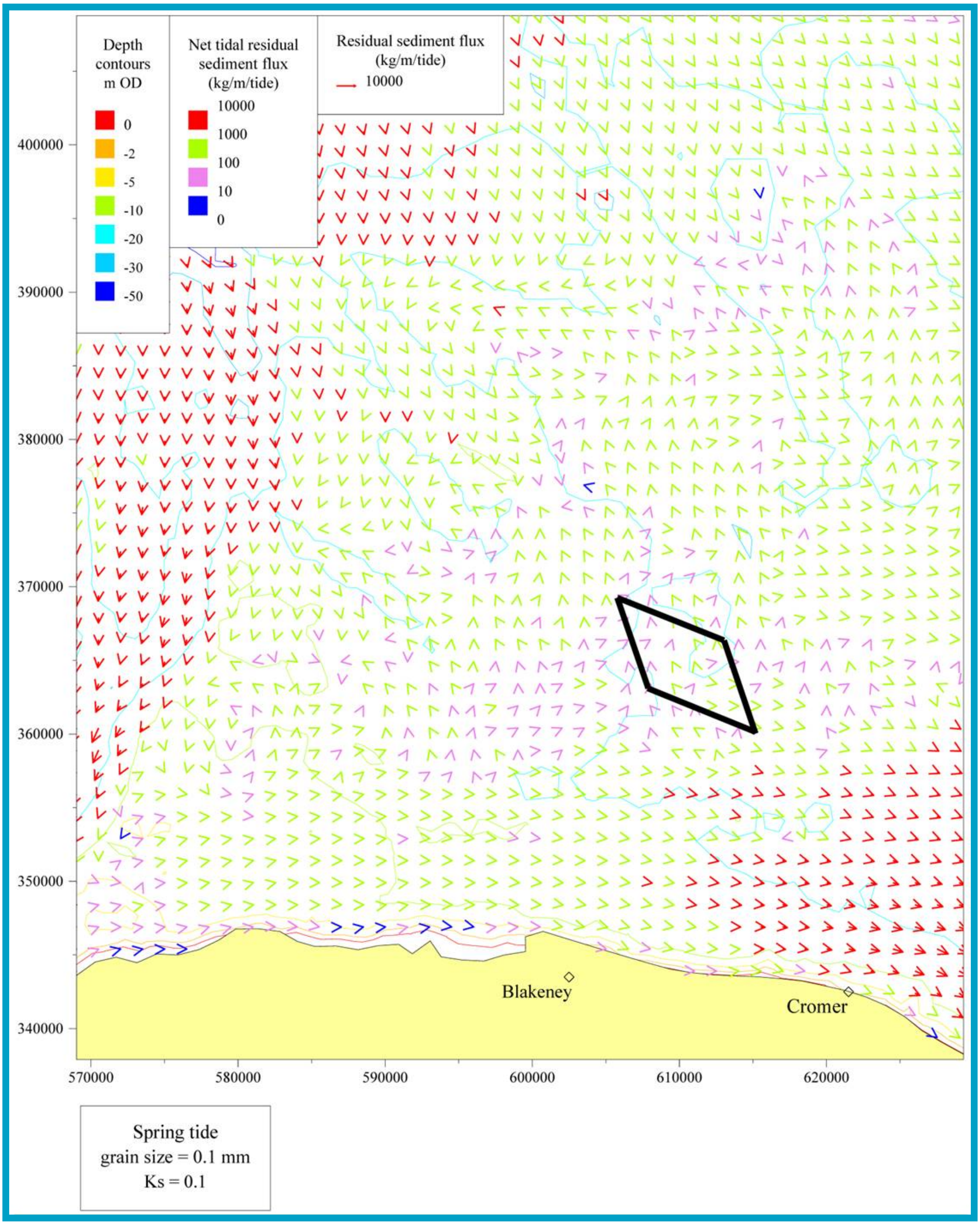


Figure 6.13 Nett sediment flux patterns; spring tide (0.1mm sand) Source: HR Wallingford et al (2002)

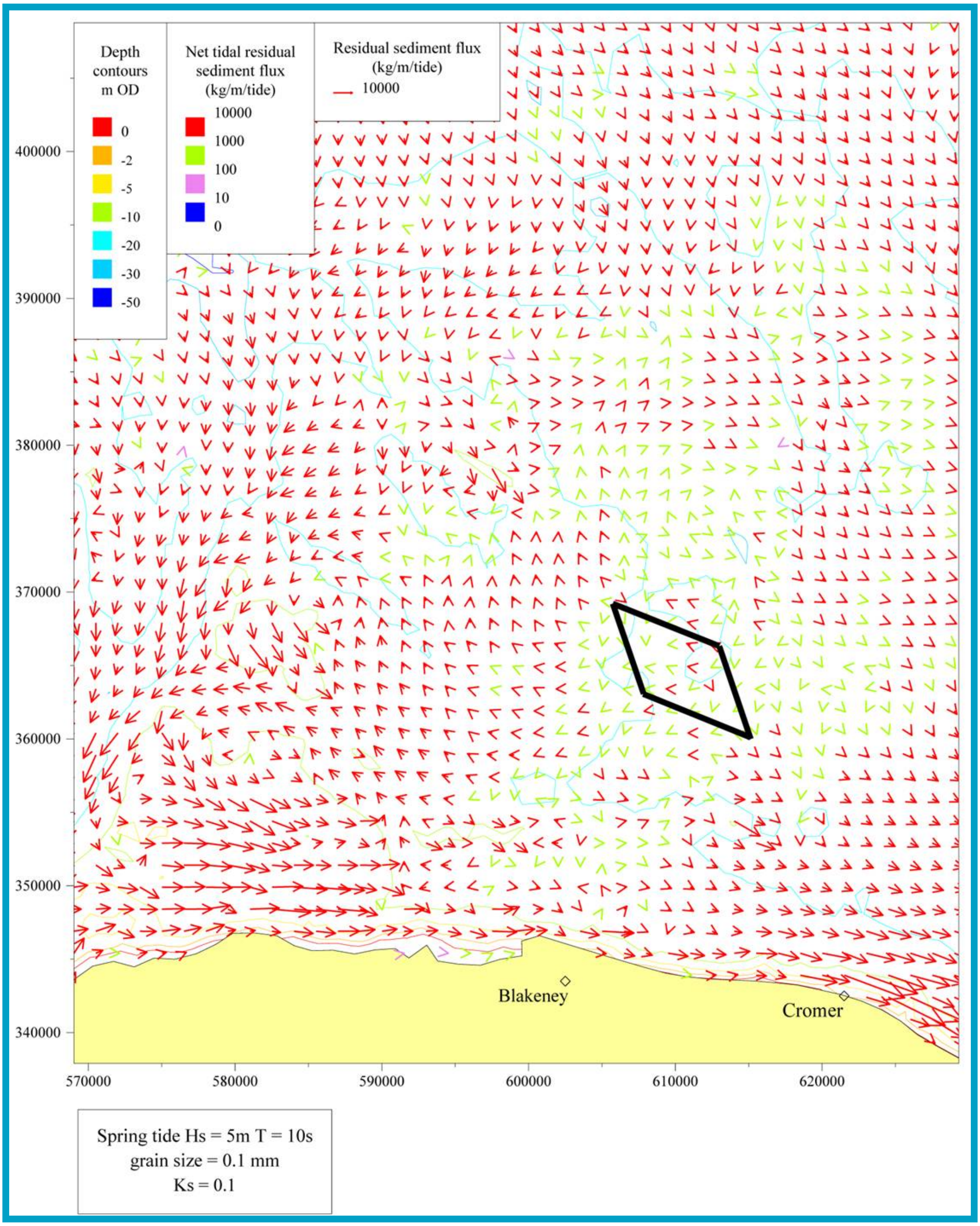


Figure 6.14: Nett sediment flux patterns; spring tide with 5m/10s storm waves (0.1mm sand) Source: HR Wallingford et al (2002)

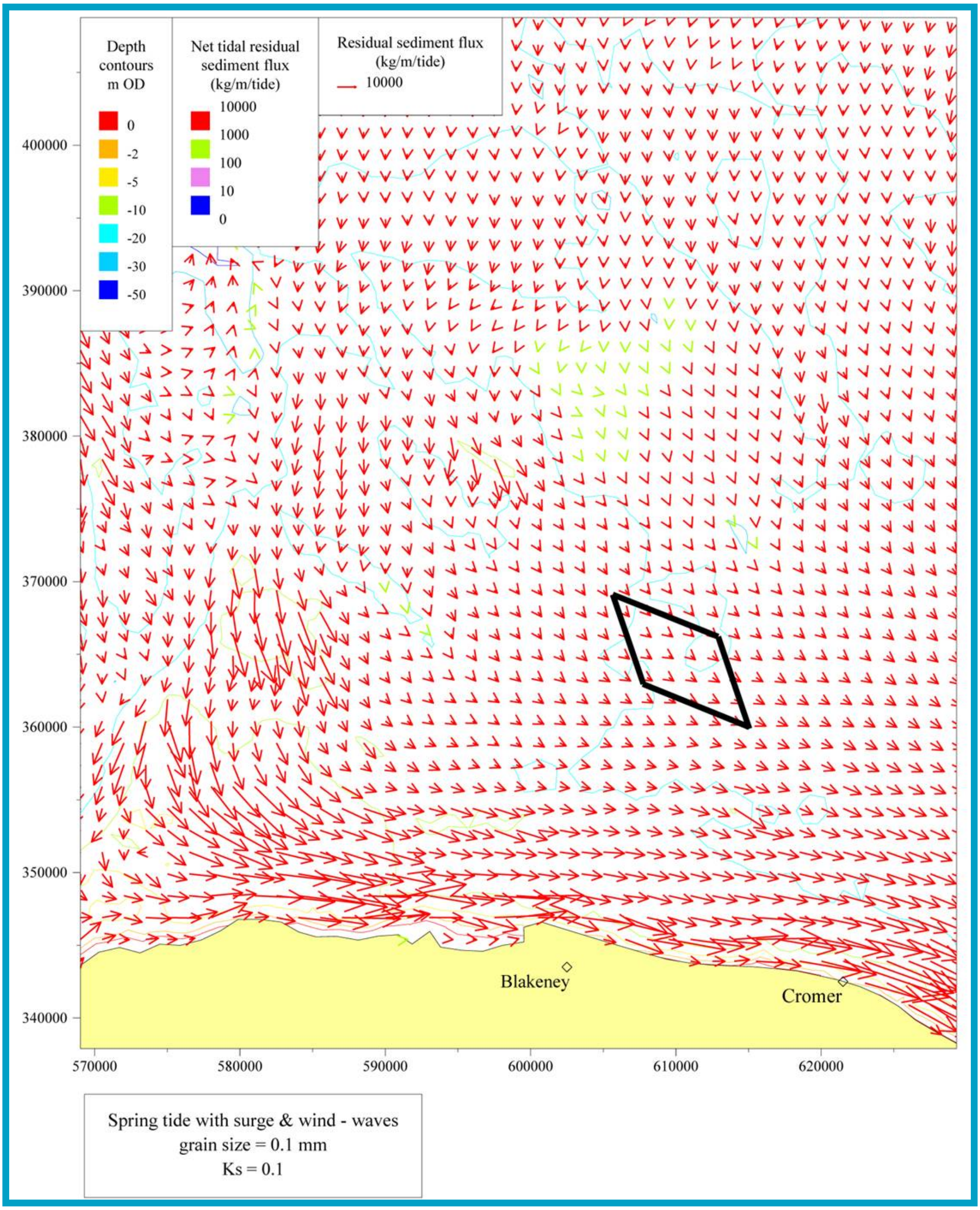


Figure 6.15: Nett sediment flux patterns; spring tide with surge (0.4mm sand) Source: HR Wallingford et al (2002)

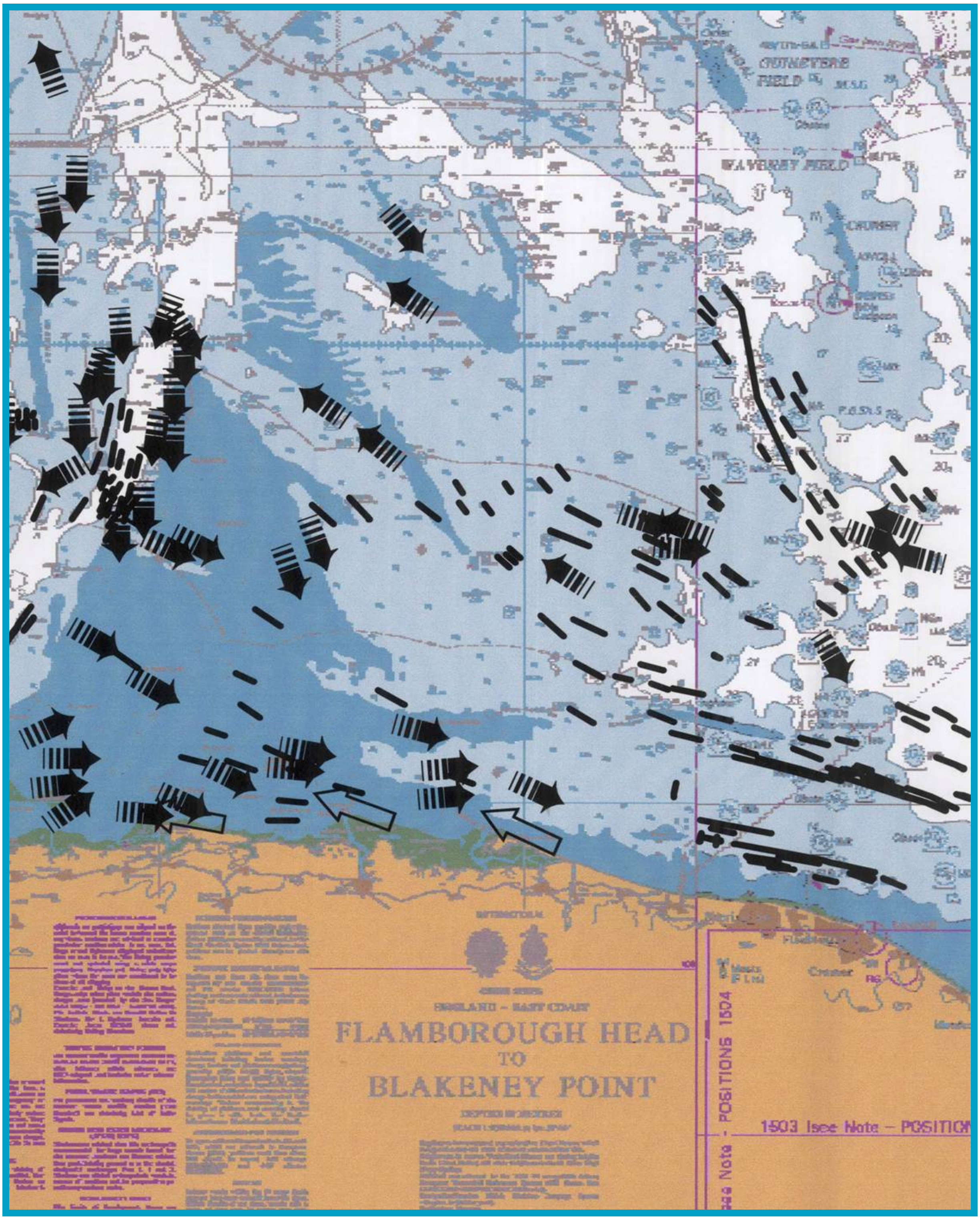


Figure 6.16: Combined seabed sediment transport indicator map Source: HR Wallingford et al (2002)

6.3.9 Coastal morphology and processes

This section describes the existing coastal situation and the predicted future evolution assuming no further onshore or offshore development. The area considered extends over the maximum area over which the proposed development, including the cable route, could potentially influence the coastal processes, taking in the North Norfolk shore from Scolt Head Island in the west to Cromer in the east. Given the dominant wave directions, tidal currents and known sediment transport routes, there are no potential impacts beyond these frontages.

The area has been intensively studied over the past fifty years due to concerns about coast erosion and flooding, the licensing of dredging areas and the construction of pipelines connecting offshore gas fields with onshore processing facilities. With regard to the coast and near shore zone studies have been completed for the Anglian Coastal Atlas in the late 1980s, Shoreline Management Plans in the 1990s, the Future Coast 2002 project and localised Coastal Strategy Studies in the last few years (Halcrow, 2002; HR Wallingford, 1994; HR Wallingford, 2002; HR Wallingford, 2004 and Halcrow, 1996); of these references, the recent and ongoing Strategy Studies are assumed to take precedence as they take account of the earlier work. Further offshore the principal reference for the whole Greater Wash area is the Southern North Sea Transport Study (HR Wallingford *et al*, 2002), which brings together an extensive modelling study with all of the previous information on sea bed processes.

Close to the proposed landfall area near Weybourne there is a change in coastal orientation due to offshore banks, bathymetry, wave exposure and geology. To the west is a shingle barrier spit extending over 15km westwards from Kelling to Blakeney Point, fronting lowlying reclaimed land and marshes. Studies have estimated that it is retreating landward at up to 1m/year, and in the past has extended by more than 80m/year towards the west, with the formation of secondary recurved spits off the Point. The spit is fed by nett westward transport of gravel eroded from the cliffs near Weybourne, but this supply is apparently reducing. The shingle beach slopes steeply to low tide level, where it gives way to a flatter sand platform. Regular regrading is carried out along the ridge opposite the village of Cley in an attempt to reduce the risk of breaching during storms.

Beyond Blakeney Point there are saltmarshes fronted by broad sand beaches up to the Wells channel. Further east, the sand beach is backed by dunes, sometimes forming barrier islands of sand over shingle. The largest island is Scolt Head extending over 7km and apparently growing westwards into Brancaster Bay.

East from Weybourne the shingle beach is backed by eroding cliffs of glacial till above a chalk base. The lower foreshore is formed by surficial gravely sand over a chalk platform. Further east the chalk surface dips and disappears, leaving the softer glacial till subject to more rapid erosion (Plate 6.2). Drift direction along this frontage is variable from year to year, and it is recognised as a drift divide zone.

At Sheringham, the seafront is protected by a seawall and groynes, forming an artificial headland in advance of the adjacent eroding cliffs. There is only limited transport of shingle eastwards past Sheringham, but sand is free to pass in either direction along the lower beach.

Beyond Sheringham there is a wide sub-tidal chalk platform fronting a beach that is mainly sand with a sparse covering of shingle along the upper swash zone. The cliffs are formed of weak glacial till, that is subject to both wave erosion and slipping. There is a seawall at Cromer and groynes to both west and east. Beyond Cromer there are timber defences along the backshore that reduce cliff erosion.

There have been numerous studies of long shore drift rates, for the Norfolk coast. The SNSSTS provides a summary of past studies and attempts to provide an overview. The methods used to estimate rates vary widely, and so do the results. Key factors are assumptions about material type and availability, offshore wave conditions used and length of record applied, method of nearshore wave modelling, consideration of tidal currents and surges, impact of defence structures and specific location along the shore. Figure 6.17 summarises the best estimates of mean drift rates.

Further estimates of drift along the coastline between Kelling and Cromer have been made recently to illustrate annual variability. Offshore wave data from 1978 to 2001 were used to predict wave conditions for near shore wave prediction points located on the -3.25mCD contour (HR Wallingford, 2004). Drift estimates were made using the standard CERC formula with a simple set of assumptions. Annual mean nett drift results for four locations along the coastline, Kelling, Weybourne, West Sheringham and West Cromer are summarised in Figure 6.18. The graph includes the net longshore transport rates for point K (West Cromer) which is a sandy beach and the values are an order of magnitude higher than the shingle beaches and have therefore been plotted against a secondary y-axis. It is noticeable that during the 23 years, the annual drift direction reverses several times. Figure 6.18 also illustrates the difficulty in comparing results from different periods as averaging the results over different periods yields different mean nett potential transport rates. This high level of variability and uncertainty is important with respect to assessing the potential impacts of the proposed wind farm.

Beach profile changes occur over a variety of timescales, which vary from a single tide or storm through to seasonal variations and long term trends lasting thousands of years. Most beaches exhibit a seasonal variation in profile variability and volume in response to changing wave energies. During the summer months most beaches build up to produce a high beach with a berm above the high tide mark, and in the winter, higher waves comb down the beach moving sand down to, and below the low water mark. These changes are important to the design of the cable landfall, where sufficient allowance must be made for the expected envelope of change, including potentially severe beach cut back during storm surge events.

Environment Agency has surveyed the beach surface along 13 shore normal profiles, from Weybourne to Cromer. The surveys were carried out in the summer and winter months from January 1992 to January 2003 so that the seasonal variations in beach morphology can be examined. Profiles at the western end of their survey frontage are most relevant to this study, and show level changes of +/-1.5m and an erosional trend of about 0.4m/year. The envelope may need to be larger to account for extreme events not represented in the data set. The data set also does not include the shallow sloping sub-tidal beach, where erosion of the underlying chalk platform is non-reversible and leads to ever increasing exposure of the upper beach and cliffs to the action of waves.

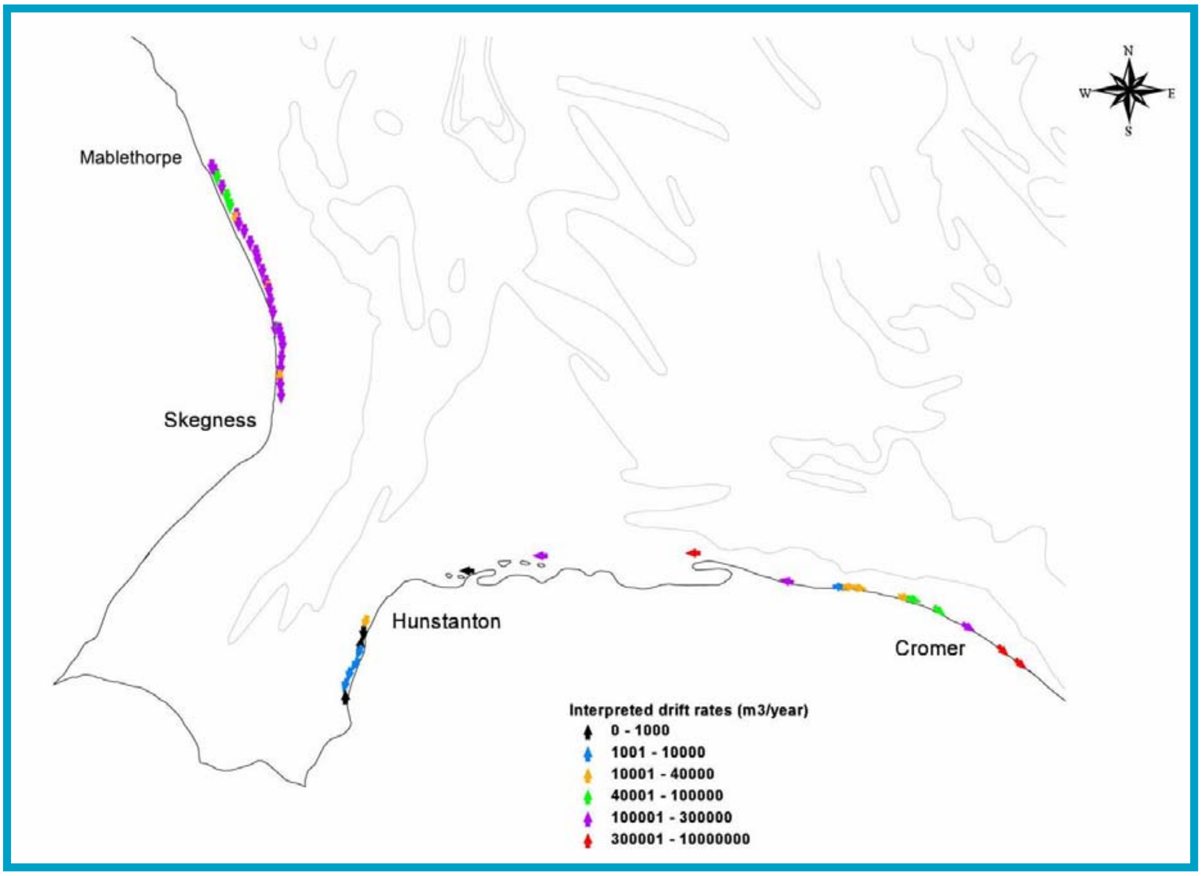


Figure 6.17: Longshore transport predictions Source: HR Wallingford et al (2002)

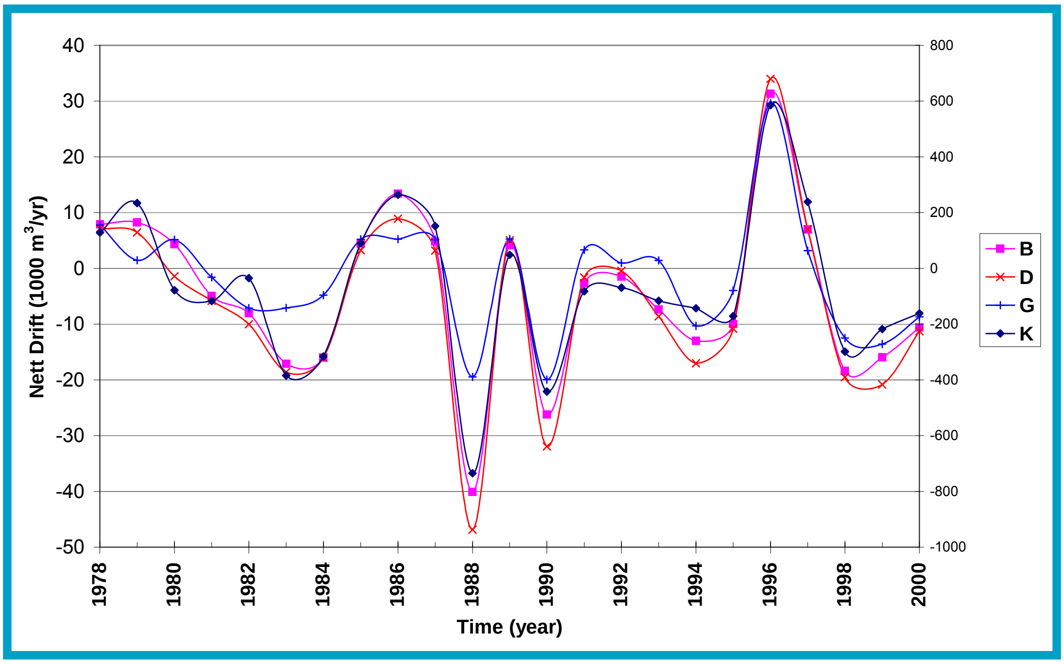


Figure 6.18: Estimated annual net potential longshore drift rates for four points along the North Norfolk coast; 1978 to 2001 Source: HR Wallingford (2004)

Also of relevance to the landfall design are the North Norfolk Shoreline Management Plans. The preferred SMP options are:

- Sheringham to Cromer: 'managed retreat', setting the present coastal defences further landwards and accepting some cliff recession;
- Sheringham town frontage: 'hold the line' of the existing defences;
- Kelling and Sheringham: 'do nothing', allowing continued erosion
- West from Kelling: 'managed retreat', accepting some cliff recession and managing the roll-back of the shingle ridge to Blakeney Point.

These strategies indicate that erosion of the beach at the proposed landfall location is likely to be ongoing.

6.4 Impacts during construction and operation

In this paragraph the description of the impacts during construction and impacts during operation have been combined. The impacts are very much related to both activities and therefore could not be separated in all cases.

6.4.1 Impacts on waves

6.4.1.1 Localised impacts

Waves would be modified in the immediate vicinity of the turbine foundations. Monopiles or the central cylinders of small gravity base foundations (diameter of about 30-40m, elevation above seabed of about 3m, central column diameter of about 6m) are considerably narrower than the typical wavelength of most waves affecting the study area and, therefore, it is considered that the direct impact on waves would be small, other than immediately around each structure, and there would be no discernible interaction between the foundations. The reasons for these conclusions are set out below.

Waves are disturbed by the presence of cylinders when the diameter, D, becomes large relative to the wavelength, L. A value of $D/L \geq 0.2$ is generally taken as the regime in which wave scattering becomes important. A reflected wave is generated when it hits a large cylinder and moves outwards from it. On the sheltered side of the cylinder there would be a shadow zone where wave fronts are bent around the cylinder. These waves are the diffracted waves and, combined with the reflected waves, they are referred to as the scattered waves.

The wave climate for the area around the proposed wind farm site includes short period waves likely to be influenced by these simple foundations for a significant percentage of time. However, these short period waves have low heights and therefore the resulting scattered and diffracted waves would be small. Foundations may be considered to act independently if the scattered waves have decayed to an insignificant wave height when they reach the nearest adjacent foundation.

Several approaches to simulating wave diffraction and scattering are available. Recent published research from Oxford University (Ohl *et al*, 2001) clearly supports the view that the scattered waves created by interactions with any one cylindrical foundation would be **negligible** before reaching the nearest adjacent foundation, assuming the range of configurations likely for an offshore wind farm. Sample results of previous research are set out in Figure 6.19 and Figure 6.20 using 5m and 20m diameter cylinders at only 200m spacings. The contour values of increased wave energy indicate that there are no areas with a 10% change using 5m diameter piles but there are areas of 40% increase/decrease with the 20m cylinders. Even with the larger cylinders the effects are negligible in the down-wave direction outside the area of the piles. These results are only a simple example with one wave condition, but indicate that there is **no**

potential for significant accumulating impacts with monopiles or small gravity bases spaced as described in Section 2.

Even under likely worst case conditions as simulated using a simplified numerical model for a shallow sand bank under CEFAS/Defra research project (Halcrow, 2003) the cumulative impact of closely spaced monopiles has been shown to reduce incident wave heights by no more than 5%, with no influence on wave period. More realistic non-linear, random wave modelling, using the range of turbine spacings proposed for this project, shows that the cumulative impact of a wind farm on wave conditions would be **negligible**. This conclusion has been independently reached by HR Wallingford during Round 1 studies, by recent DTI research for wind farm impacts (ABPMer, **2005**) and by field studies undertaken by CEFAS at Scroby Sands (CEFAS, 2005).

In the situation that large gravity base structures will be applied for 3 MW turbines (worst case), the spacings in the dominant wave direction is 570m.. The impacts are discussed in Appendix 6.3. It is considered that there would be local scattering and some down-wave sheltering but the effects would not be significant beyond the boundaries of the wind farm. Further definition of the extent of any impacts would require numerical modelling, including detailed definition of the proposed foundations.

Multi-leg foundations may also be proposed for the wind turbines. There are no standard methods for assessing the impact of complex, braced structures on wave conditions, but it is assumed that they would have only slightly more impact on wave energy scattering or dissipation than the monopiles, and that the overall effect would still be **negligible**. Detailed testing of this assumption would require a physical model, as numerical models are not able to allow for detailed interactions between waves and intricate structure.

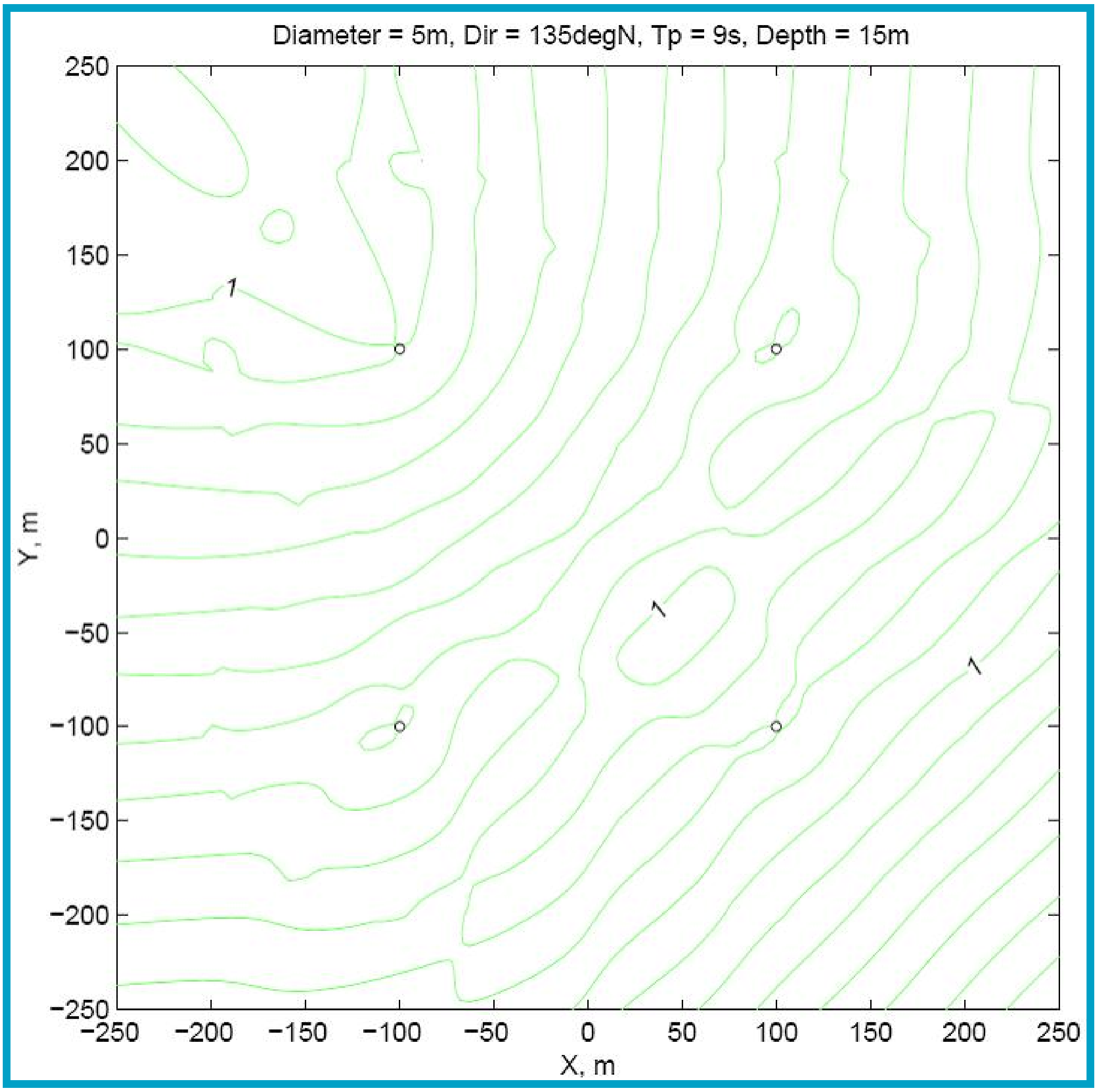


Figure 6.19: Wave scattering from 5m diameter cylinders at 200m spacing Source: derived from Ohl et al (2001)

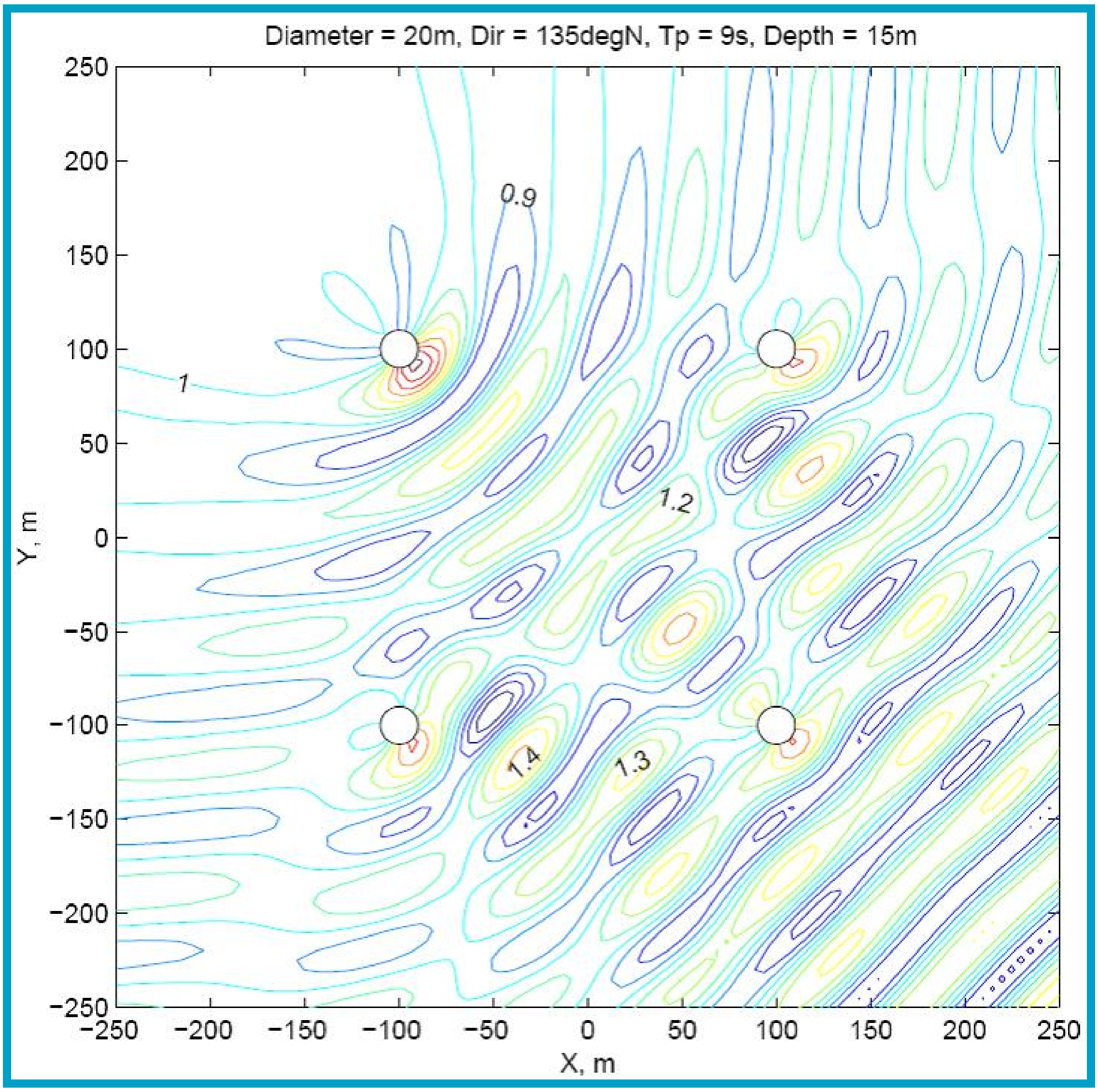


Figure 6.20: Wave scattering from 20m diameter cylinders at 200m spacing Souce: derived from Ohl et al (2001)

6.4.1.2 Far-field and coastal impacts

Significant wave effects are considered to be limited to the vicinity of the monopile and small gravity base foundations, with no significant interactions between structures, and therefore **no significant accumulating effect**. Given the nature and depth of the seabed at the proposed wind farm site it is considered that the structures would not significantly modify the seabed in a more general sense, either by large scale erosion or accretion, although there may be some minor deposition in the lee of the large gravity bases. This conclusion is in line with industry research (ABPMer, **2005** and CEFAS, 2005) that concludes far-field impacts due to monopile influences on the wave climate would be **negligible** for a situation with similar characteristics to the development site.

The conclusion is **less certain for gravity bases with a large profile above the seabed**, due to the lack of research and modelling. Impacts could be further quantified with greater confidence using an appropriate numerical model capable of resolving the structures and including the effects of diffraction, reflection, refraction, shoaling and the effects of breaking. However, given the dimensions of the proposed gravity bases it is considered likely (Appendix 6.3) that only large waves during storm conditions would be affected, and there would be **no significant** impact on the general wave regime either within the site or along the adjacent coast.

It should be noted that the natural variations over time in the level and extent of Sheringham Shoal (Figure 6.7) would have a much greater impact on nearshore wave conditions than any effects caused by the turbine foundations, regardless of type.

6.4.2 Impacts on currents

6.4.2.1 Localised impacts

Currents would be modified in the immediate vicinity of the turbine foundations. Tidal currents in the area are essentially rectilinear with normal velocities up to more than 1m/s. In the immediate lee of the proposed foundations there would be a flow separation zone and downstream turbulence. Standard design guidance (CEFAS, 2005) suggests that this zone typically extends 6-10 cylinder diameters downstream (36m to 60m for a 6m diameter monopile), and within this zone there is likely to be generation of turbulence that is greater than normal, especially during peak flood and ebb conditions. There may also be some shedding of turbulent vortices that extend beyond this main zone of influence. As the structures are separated by at least 570m in the dominant flow direction, it can be assumed that there is **no significant** interaction between monopiles with respect to flows.

This conclusion **does not apply to large gravity base structures** set at the minimum distances proposed for the wind farm. The impacts are discussed in Appendix 6.3 based on a desk study assessment following completion of the main assessment. It is concluded that there are no significant changes to the broad scale flow regime, with an overall flow reduction within the wind farm of only 2%, but with local increases around each structure. Local effects can not be quantified with confidence using desk based methods. A finite element flow model capable of resolving the detail of each structure would be required to simulate the situation if the potential changes were considered sufficiently significant to the local sediment processes and the associated benthic community. This is addressed further in the scour section below. (For this foundation type scour protection will be applied in all cases, see Section 2) .

The use of multi-leg foundations would give rise to more complex interactions than monopiles, and potentially a greater area of local disturbance. However, there is **no reason to believe that there would be any significant interaction between structures, nor any significant cumulative impacts**

6.4.2.2 Far-field impacts

Currents are dominated by tidal processes at the wind farm site and along the cable route, with enhanced currents due to storm surges and wave breaking near the landfall. Other than in the immediate vicinity of the monopiles, currents are considered unlikely to be modified to a discernible extent by the scheme, and therefore there would be **no significant impact** on adjacent areas. This conclusion is also supported by industry research (ABPMer **2005** and CEFAS, 2005).

Section 6.4.2.1 and Appendix 6.3 discuss the situation for large gravity bases. It is shown that there are **no significant impacts** on the overall flow regime.

6.4.3 Impact on scour

6.4.3.1 Localised impacts

The potential impact of the foundations and any exposed cable on the sediment transport would depend on the local modifications to the waves and currents, as described above, and the availability of potentially mobile sediment. The acceleration of the tidal current and generation of turbulence, together with wave stirring, would tend to scour sediment from around the foundation base or from beneath exposed cables on both the flood and ebb tide, and deposit it downstream.

A best estimate for the depth of scouring for EIA purposes can be based on existing literature (e.g. Whitehouse, 1998; Whitehouse *et al*, 2004; Den Boon *et al*, 2004; Zaaijer, 2003 and DNV, 2004), the recent monitoring experience from the Scroby Sands wind farm (CEFAS, 2005) and engineering judgement. Further work would be required for engineering design.

For the purposes of considering the worst case situation for the environmental impact assessment, it is assumed that there is sufficient current to cause scour at all turbine locations and that the surface sediment is non-cohesive, homogeneous and unlimited. In reality it is known that the sediment distribution across the site is variable, with areas of sand waves giving a mobile depth up to 5m, areas of potentially poorly consolidated sub-strata and other areas with only a thin and patchy mobile layer over stiff glacial till where scour would be limited. (See Section 2, Figure 2.8 Surface geology of the site). For the purposes of this impact assessment it is assumed that the monopile situation would be representative of the worst case in terms of the maximum depth of scour in the case that there is no scour protection.

Scour is not assessed in detail for gravity based structures within this Section as it is considered that any level of scour may lead to instability and would be unacceptable. Therefore scour protection would be required as part of standard engineering design (Appendix 6.1 provides supplementary details on the need for scour protection within different areas of the wind farm site and with both monopiles and gravity bases).

At present there is no accepted method of assessing scour around multi-leg structures, apart from physical modelling, so the situation is not addressed in detail. If multi-leg structures are taken forward then further studies would be needed to consider wave and current interactions, and resultant potential scour. These studies will learn what the impact will be on scour and thus if scour protection is needed or not. Existing limited research (e.g. Whitehouse *et al*, 2004 and zaaijer, 2003) suggests that scour and accretion would be influenced by the dimensions of the legs at the seabed, the distance of separation, the presence of cross-bracing close to the seabed and the orientation of the legs in relation to the currents. The upstream leg(s) would suffer similar scour to a single monopile of similar dimensions, while the downstream ones would be exposed to lower flow velocities and therefore would have less scour. However, as currents are approximately rectilinear at the site, the upstream and downstream legs are interchangeable, and the nett effect would be approximately equal scour at each leg, with the potential for cumulative scour if the legs are closer together than the diameters of each individual scour hole. Detailed engineering design should not rely on this assessment, and physical modelling may be required to optimise scour protection.

The foundation of the sub station(s) will be similar to the type that will be chosen for the windturbines. No additional significant effects are anticipated, because the number of substations will be very low compared to the number of turbines and scour protection will be applied if necessary.

The results of the scour assessment under approximate worst case conditions for the wind farm site and cable corridor are as follows:

Case 1: Wind farm monopiles

Input parameters assumed:

Monopile diameter *:	6m
Water depth:	16m or 28m at times of peak current
Peak tidal current:	1.0m/s.
Sediment size range 1:	d10 = 0.010mm d50 = 0.220mm d90 = 0.450mm
Sediment size range 2:	d10 = 0.004mm d50 = 0.08mm d90 = 0.30mm
Current speed threshold of motion:	0.3 - 0.5m/s
Assumed depth of potentially erodable sediment:	Unlimited

d10 = size of smallest 10 percentile of sediment range

* Monopile diameter: 6m is the most likely option. (7.5m Is the maximum monopile diameter).

Conclusions:

The steady velocity required to initiate sediment transport is approximately 0.5m/s, while the minimum wave height needed to mobilise the sediment is approximately 0.9m (d50 = 0.22mm) and 0.6m (d50 = 0.08mm). This indicates that under peak flow conditions the tide alone is capable of moving sediment and causing scour around the structure, even in the absence of any waves. In homogenous fine sand conditions, the scour hole due to tidal currents alone has the potential to extend about 5D horizontally from the pile and up to about 1.8D vertically under worst case conditions, where D is the monopile diameter. Assumed D = 6m, then scour may extend approximately 30m from the outside of the structure (37.5m if D = 7.5m) and over 10m in depth (13.5m if D = 7.5m). The presence of waves will tend to speed up the rate at which the scour occurs, although the presence of storm waves with Hs greater than about 3m may inhibit the scour depth and extent.

Experience from other wind farms has shown that scour can occur rapidly after foundation construction. Although scour may not constitute a significant structural or ecological risk, it may cause a problem for the cable connections. Monitoring of the seabed immediately after foundation construction would guide the need for rock placement.

A more detailed review of scour potential at the wind farm site has been undertaken as additional work and is presented in Appendix 6.1. This work indicates likely scour potential for different areas of the wind farm site and the requirement for scour protection assuming that foundations may be either up to 7.5m diameter monopiles or gravity bases with a large profile above the seabed.

Case 2: Wind farm and export cables (assumed not buried and normal to maximum flow direction))

Input parameters assumed:

Cable:	Diameter = 0.25m
Water depth:	as Case 1
Current:	as Case 1
Sediment:	as Case 1
Threshold of motion:	as Case 1

Conclusions:

The tide alone is capable of moving surface sediment and causing scour under any unburied cables, even in the absence of any waves. After cable laying, a scour hole may quickly develop to a depth of approximately 0.15m underneath the cable and this may grow to around 0.70m after 10 to 15 tidal cycles, assuming that flows are approximately perpendicular to the cable (parallel flows will cause less scour). The scour may extend up to 10m either side of the cable. If the cable sags, the depth of the hole may be as large as 1m underneath the initial cable position. To prevent this all offshore cables will be buried (See Section 2).

Scour due to the combined influence of the turbine foundations and the cables may cause a particular (engineering) problem in areas of mobile sand.

6.4.4 Impacts on sediment transport

6.4.4.1 Localised impacts

Assuming a final spacing between turbines of at least 570m in the dominant tidal flow direction, it is considered unlikely that there would be any overall sheltering effect due to 7.5m diameter monopiles that could give rise to broad scale accretion or erosion over the area of the wind farm. A generic industry modelling review undertaken for the DTI (ABPMer **2005**) supports the view that broad scale effects are **unlikely** for a situation with similar characteristics to the study site. More recent work (CEFAS, 2005) has been undertaken by CEFAS at Scroby Sands in which repeated high quality swathe sounding surveys showed **no evidence** of broad scale sea bed change as a result of the OWF foundations (although there was clear evidence of localised scour at each turbine and one possible area of downstream turbulent disturbance extending several hundred metres across the crest of the shallow bank).

This assertion of no overall effect **can not be applied to the large gravity base structures** of the type and dimensions proposed for the wind farm. Appendix 6.3 considers the impacts and concludes that there would be **no significant impact** on overall sediment transport across the site, but there will be an impact on sediment processes in the immediate area of each turbine. These effects can not be defined by a desk assessment and numerical modelling would be required to provide greater confidence.

6.4.4.2 Far-field impacts

It is anticipated that the impact on sediment transport is likely to be restricted to localised areas around the monopiles and along the cable route during burial and the immediate post-burial recovery period. It is considered that the proposed development would have **no significant or measurable impact** on the general sediment transport regime or morphology of the area.

As discussed, this assertion of **no overall effect** can be applied to large gravity base structures of the type and dimensions proposed for the wind farm, although there may be local impacts due to scour (in the event that protection is not placed) and leeside deposition.

Increased suspended sediment loads due to potential seabed levelling for gravity bases is likely to extend over an area of several kilometres for several days due to the tidal excursion and the high concentrations of fine materials released at each foundation location. The suspended load would not include chalk fines, as the chalk beds are below the maximum extent of excavation within the wind farm site and for this reason sediment dispersion and deposition due to gravity base levelling was **not modelled** for this study.

6.4.5 Impact on suspended sediment

Sediment brought into suspension due to construction activities and later scour around the foundations will be transported downstream a short distance. The increase would depend on the type of foundation and construction method, while the significance of the impact would depend on the sensitivity of the receiving environment. Assessment of ecological impacts should take account of the moderate background levels of suspended sediment throughout the area, as well as the active bedload transport regime that gives rise to the widespread mobile bed features (sand ribbons, ripples and waves).

Driving monopiles would cause considerably less suspended sediment than drilling, as any spoil lost during drilling operations may remain on the seabed for a sufficient time to allow tidal currents to transport fine particles away from the site. Gravity bases would also cause short term disturbance as some ground works, possibly including seabed levelling to 2.5m, are likely to be required prior to placement, potentially releasing large quantities of disturbed sediment into the water column. The potential extent of distribution is discussed below in relation to cable installation.

Cables would be buried within the site and along the export cable route. It is intended that the cable would be installed by ploughing where possible, although trenching may be required for stiff glacial till or chalk. Regardless of burial method, bed sediment would be disturbed causing increased suspended loads during laying operations. The impacts would depend on the installation method employed, composition of the bed and the sensitivity of the benthos during the construction period. Sand and coarser sediment would only be dispersed over a short distance, while finer sediment, and particularly chalk fines, would be dispersed over a wider area in the form of a plume.

Additional work has been undertaken to define the extent of plume dispersion due to cable installation and the extent of the depositional footprint using a numerical model. This work is presented in Appendix 6.2. The results are based on a number of assumptions, but are considered to provide a reasonable simulation of the impact of cable laying. The modelling did not consider the much larger volumes of sediment that may be released due to seabed preparation and levelling for gravity bases.

Suspended load for disturbed silt and clay (at a level above 1mg/l) during ploughing is predicted to extend as a plume over a distance of less than 2km in either direction before either settling out of suspension or dispersing to a level of less than 1mg/l. The settled material can be re-suspended as the tidal flows flood and ebb. Ploughed chalk is predicted to give a much larger plume of around 9km as the chalk fines are assumed to remain in suspension. The worst case situation occurs with a slow ploughing rate (causing a plume for a longer time) and a neap tide as this situation maximises the time taken for chalk concentrations to drop below 1mg/l. The results in Appendix 6.2 show the maximum concentration levels (contours of up to 20mg/l – however this will be higher in the immediate area of disturbance).

The predicted plume for trenched chalk extends more than 10km in either direction at a level of up to 20mg/l, but levels above 1mg/l last for less than the six tides used in the model. This is a result of the much higher initial volume of disturbed sediment.

The footprint of silt deposition was found to extend over a wide area, but at an unmeasurable rate. Even under slack water conditions, the maximum rate of deposition over the six tide simulation was less than 0.5mm in the areas of greatest deposition, and in most of the footprint area the rate was far less. This result is anticipated as the deposited fines would be re-suspended on each tide, with no measurable material left in place.

6.4.5.1 Far-field impact of suspended sediment transport

The analyses described in Section 6.4.5, including suspended sediment dispersion, anticipate that the impact on sediment transport is likely to be restricted to localised areas around the monopiles and along the cable route during burial and the immediate post-burial recovery period. As stated above the rate of sediment deposition due to construction for the general area of the wind farm and adjacent areas will be less than 0.5mm (see above). It is therefore considered that the impact of the proposed development on the general sediment transport regime or morphology of the area would be **negligible**.

As discussed in Appendix 6.3, this assertion of no overall effect can be applied to large gravity base structures of the type and dimensions proposed for the wind farm (worst case foundation type), although there may be local impacts due to scour (in the event that protection is not placed) and leeside deposition.

Increased suspended sediment loads due to excavation for gravity bases are likely to extend over an area of several kilometres for several days due to the tidal excursion and the high concentrations of fine materials released at each foundation location. The suspended load would not include chalk fines, as the chalk beds are below the maximum extent of excavation within the wind farm site. The suspended sediment is expected to settle down within a short period. The area is already affected by high bed load transport and seasonally enhanced suspended sediment concentrations, so the work will only affect the area for a short time period. And so sediment dispersion and deposition due to potential seabed levelling for gravity base foundations was not modelled for this study. Impacts during operation.

6.4.6 Impact on coastal processes

There is the potential for littoral drift to be affected at the cable landfall at Weybourne Hope, depending on the design and construction approach. At present, it is assumed that the landfall would be achieved by ploughing or trenching across the foreshore and trenching or drilling under the shingle beach and through the low cliffs to the backshore. If this is the case then there would be **negligible impact** on the shoreline, apart from short term impacts during construction, provided that the depth of installation is sufficient to minimise any future risk of exposure due to short term beach draw-down or long term erosion. Impacts would be **negligible** provided that the foreshore levels are reinstated using the trenched material immediately following cable laying.

A geotechnical survey of the shingle beach is advisable prior to final landfall design, to determine the form of the core beneath the mobile surface layer. There is likely to be a relatively impermeable core that would need to be reinstated after disturbance to ensure that the beach is not weakened and more likely to breach.

Further work is also required to determine the natural envelope of beach profile change at the landfall. The cable would need to be installed below the lowest level expected, making an allowance for ongoing erosion and regression over the life of the wind farm.

The open coast from Cromer to Blakeney Point is in the lee of the wind farm depending on the near shore wave direction. During the dominant north-westerly through north-easterly conditions, waves passing through the wind farm will also pass over Sheringham Shoal. It is considered that the impact of the proposed wind farm on wave and current regimes, and therefore near shore transport, would be **negligible** in relation to the impact of Sheringham Shoal.

The short period waves incident on the foundations would mainly be scattered, rather than dissipated, although some energy would be lost when waves break against the foundations. At longer wavelengths, and particularly with large gravity base structures, the waves would exert a force on the foundations, thus absorbing a small amount of energy from the waves and reducing the energy of the transmitted wave. The amount of loss would be insignificant in relation to the total wave energy passing through the wind farm for monopiles and low-profile gravity bases, but may be locally observed for gravity bases with a large profile above the sea bed during severe wave events.

In all cases, the natural changes due to Sheringham Shoal will cause a far greater impact on wave conditions than could be attributed to the turbine foundations. It is clear that within the context of natural variability in the wave climate at the coast and the great variability of the existing coastal processes, the potential magnitude of any change is insignificant.

As previously noted, little research work has been done on multi-leg structures in relation to impacts on waves, currents or bed stability. The amount of disturbance to the wave field would depend on the configuration and the volume of the structures. It assumed that the influence would be only slightly greater than for monopiles, and for either case the impact on coastal processes would be **negligible**.

6.5 Impacts during decommissioning

No specific proposals have been set out for the decommissioning of the turbine foundations or cables at the end of their design life of 40 years. It is assumed that permanently buried cables would be left in place, and that foundations would be removed at or below the seabed surface. Any exposed, or potentially exposed cable lengths would also need to be removed. Under this situation there would be **no broad scale or long term** impacts on seabed or coastal processes. Locally, scour pits may fill approximately back to the surrounding seabed level, and there would be short term increases in suspended loads due to any required seabed disturbance. Any exposed or potentially exposed cables in areas of seabed mobility may need to be cut and removed. Again, this would not be expected to cause anything but temporary and local disturbance.

6.6 Cumulative and in-combination impacts

The development is one of eleven potential wind farm projects in the Greater Wash area, and is close to several cables, licensed dredging areas and pipelines serving the Southern North Sea gas fields.

The existing pipelines come onshore to the east of Cromer and are therefore out of the area of potential influence of the wind farm. There is a cable route close to the proposed landfall at Weybourne Hope, but there is no evidence to suggest that it has any impact on seabed or coastal processes. Regional dredging areas are all remote from the site and outside any possible area of influence.

The assessment described in this section has asserted that monopile, multi-pile, suction caisson and small gravity base foundations spaced at distances of between 570m and 1120m have **a negligible cumulative impact** on waves, currents or sediment transport, either within the wind farm site or over a wider area. If individual turbine foundations do not have an influence on adjacent foundations, then there is no potential for one wind farm having a cumulative impact with a neighbouring wind farm at several kilometres distance. This conclusion is in line with the findings of CEFAS with regard to tidal excursions, as submitted to the developers in October 2004 (CEFAS, 2004).

This conclusion can also be applied with reasonable certainty to closely spaced gravity bases with a large profile above the sea bed. Although there may be some local impact on currents, waves and sediment processes in the area of each structure, there is no suggestion that this effect would extend over a sufficient area to influence processes at other wind farms or in relation to any other sea bed infrastructure or dredging activity.

6.7 Summary

A study of hydrodynamic and geomorphological processes was undertaken to set out existing knowledge and to assess the potential impacts of the Sheringham Shoal project in accordance with CEFAS guidance notes (CEFAS, 2004). The study has also included modelling of sediment dispersion during cable installation, an assessment of foundation scour potential for different areas of the wind farm and an assessment of the impact of large gravity bases. This latter work is set out in Appendices 6.1, 6.2 and 6.3.

The impacts of the development are assessed in relation to the waves, currents, sediment distribution, sediment transport regime (bedload and suspended load) and bedforms. The assessment considers impacts at the structures and along the cables, within the boundaries of the wind farm and further afield (specifically including the North Norfolk coastline), and takes account of the full life of the development from construction to decommissioning. Consideration is given to the natural variability of the coastal and near shore system and inherent uncertainty within a dynamic environment.

Impacts have been assigned a level of likely significance (from major to negligible). The impacts are described quantitatively where possible. Potential mitigation measures are noted.

It is considered that the proposed schemes using up to 7.5m diameter monopiles, multi-leg, suction caisson or gravity bases are likely to have some localised impact on the waves, currents and corresponding sediment transport regime in the immediate vicinity of the turbines and cabling, but are unlikely to have any significant or measurable far field impacts. The proximity to the other wind farm sites, cables, pipelines and dredging areas would not result in any cumulative impacts with regard to coastal or seabed processes. This general conclusion concurs with the findings for the already consented Round 1 wind farms set within similar nearshore situations and recent industry research.

Localised issues of concern for all foundation options are:

- Increased suspended sediments, including chalk fines, during foundation installation, cable laying and decommissioning, possibly impacting on any shell fishery activities and benthic ecology within the plume dispersion area;
- Increased suspended sediments, not including chalk fines, during bed excavation for gravity base foundation installation and removal;
- Ongoing scour potential around turbine foundations throughout operational life, possibly requiring protection in some areas;
- High potential for future exposure of cables throughout operational life due to sand wave activity within the main site and large scale bed mobility across Sheringham Shoal; and
- High potential for future exposure of the export cables at the landfall due to shoreline erosion requiring protection measures.

The potential for broad scale changes to the seabed as a result of the combined effect of all the turbines depends on the dimensions and spacing of the foundations, plus the seabed stability and the wave/current conditions. The proposed wind farm is anticipated to have between 45 and 108 turbines founded on monopiles, multi-piles, suction caissons or gravity base foundations as described in Section 2 with spacing of 570m to 1120m (depending on direction and size of turbine).

A rough rule of thumb for the extent of disturbance to the current field of up to 10 length-scales suggests that the current would be affected for a distance of only 75m leeward of each monopile, although turbulent vortices may be apparent over a greater distance. This indicates that these foundations can be considered as independent of each other in respect of the impact on the currents. Wave effects are considered to be similarly restricted in the spatial extent of their impact with monopiles.

Understanding of the impacts of large gravity bases or more complex, multi-leg foundations is less well defined. Overall flow reductions of around 2% for the wind farm site are estimated from desk assessment of large gravity bases. This level of change is considered to be insignificant in terms of general sediment transport process, but may have impacts on local processes and may need further assessment if it is considered that the local ecology is sensitive to low levels of deposition.

The potential sediment transport patterns along the assumed routes of the cables have been assessed. The cables pass through areas of large scale bed mobility (sand waves and banks) requiring that the cables should be deeply buried to reduce the potential for future uncovering. As the maximum practicable depth of burial is about 3m, it is likely that future exposure will occur across the Pollard Bank, Sheringham Shoal and within the SE sand wave area of the wind farm site, Monitoring and a management plan for reburial are required.

From an environmental impact perspective the existing natural mobility of the sediment indicates that the turbines are unlikely to have a significant impact beyond their immediate area following construction, over the design life or during decommissioning. Changes due to the structures are likely to be less than those experienced due to natural variation and are therefore insignificant. This is likely to be true for both the seabed and the shoreline.

The background levels of suspended sediment concentration at the wind farm, and along the cable route are believed to be moderate (10mg/l to 30mg/l seasonal range of mean values), so the transient impact of plumes arising from the installation process may be significant under specific circumstances. Any potential environmental impacts would depend on the season and the likely sensitivity of the benthic ecosystem. The proposed cable route is directed through the "Weybourne Channel" and over the Pollard Bank in order to minimise laying through chalk, and this should reduce the potential impact of dispersed chalk fines within the immediate near shore zone. It has been shown by numerical modelling that increases in suspended sediment levels due to cable laying are small, localised and short lived. Increases are considered very low and probably insignificant for ploughing, but potentially significant for trenching if there are sensitive habitats close to the cable route during installation.

The beach at Weybourne Hope is subject to strong drift and cross-shore profile change in response to the high energy wave and tidal environment. It is also subject to ongoing erosion, with a historic retreat rate of about 0.4m/year, including the low cliffs at the rear of the beach. The design and installation of the cable landfall must take account of the envelope of beach profile change and the future erosion. Although trenching is possible, it may be prudent to use horizontal directional drilling to install the cable to avoid any disturbance to the low cliffs. If trenching is preferred then it is recommended that coring of the beach is undertaken prior to design and a study is completed to define the likely profile envelope and safe burial depth.

6.8 References

- ABPMer (2005) Assessment of potential impact of Round 2 offshore wind farm developments on sediment transport. DTI, London.
- British Geological Survey (1987) Seabed Sediments around the United Kingdom (South Sheet): 1:1,000,000
- CEFAS (2004) Offshore wind farms: Guidance notes for Environmental Impact Assessment in respect of FEPA and CPA requirements.
- CEFAS (2004). Greater Wash Cumulative Impacts – Coastal Processes. 1pg. CEFAS document circulated to developers, 14 October 2004.
- CEFAS (2005) Scroby Sands Offshore Wind Farm coastal process monitoring: Final Report. Report AE0262 (Oct 2005 draft).
- CEFAS (2005) Assessment of the significance of changes to the inshore wave regime from an offshore wind array. CEFAS Report AE1227.
- Den Boon, JH *et al.* (2004). Scour behaviour and scour protection for monopile foundations of offshore wind turbines. Poster paper for EWEA Conf, London (in press).
- Dixon, MJ. and Tawn, JA (1994). Estimates of extreme sea conditions: extreme sea levels at the UK A-class sites: site by site analyses. Internal Document 65, Proudman Oceanographic Laboratory, Bidston.
- Dixon, MJ and Tawn, JA (1995). Estimates of extreme sea conditions: extreme sea levels at the UK A-class sites: optimal site by site analyses and spatial analyses of the East Coast. Internal Document 72, Proudman Oceanographic Laboratory, Bidston.
- Dixon, MJ and Tawn, JA (1997). Estimates of extreme sea conditions: spatial analyses of the UK coast. Internal Document 112, Proudman Oceanographic Laboratory, Bidston.
- DNV (2004). Design of offshore wind turbine structures (draft).
- Envision (2005). Accoustic, video and grab sample survey of Sheringham Shoal Offshore Wind Farm. Envision Mapping Ltd report prepared for Scira.
- Flather, RA (1987). Estimates of extreme conditions of surge and tide using a numerical model of the north-west European continental shelf. Estuarine Coastal Shelf Science, 24, 69-93.
- Graff, J (1981). An investigation of the frequency distributions of annual sea level maxima at ports around Great Britain. Estuary, Coast and Shelf Science (12), 389-449.
- GRAS (2005) ESA – Rapid Test Action, Case study : Sheringham Shoal Offshore Windfarm

- Halcrow (2002) Future Coast. Defra.
- Halcrow (1996) Sheringham to Lowestoft Shoreline Management Plan, Sediment Sub-cell 3B. Phase 2 – Shoreline Management Plan Strategy Document.
- HR Wallingford (1988). Coastal Defence Management Study for the Anglian Region: Offshore Wave Climate. HRW Report EX 1665.
- HR Wallingford (1990). Mablethorpe to Skegness Sea Defence Study: Joint probability of high waves and high water levels. HRW Report EX2161
- HR Wallingford (1994). Sheringham Coast Protection Scheme 902. Stage 2 – Beach recharge and control structures. HRW Report EX 2888,
- HR Wallingford (2002). Cromer Coastal Defence strategy Study: Final Report. HRW Report EX4363
- HR Wallingford (2004). Kelling to Cromer Strategy Study. HRW Report EX4985 (Draft).
- HR Wallingford (2006). Sheringham Shoal Wind farm: Coastal and seabed processes. HRW Report EX5117, Rel 6.0.
- HR Wallingford; CEFAS/UEA; Posford Duvivier and Dr B D'Olier, (2002) Southern North Sea Sediment Transport Study Phase 2 Inception Report. HR Report TR 117.
- Joint Nature Conservation Committee (1996) Coasts and seas of the United Kingdom, Region 6: Eastern England – Flamborough Head to Great Yarmouth.
- Ohl, COG, Taylor, PH, Eatock Taylor, R, Borthwick, AGL (2001). Water wave diffraction by a cylinder array part II: irregular waves. Journal of Fluid Mechanics, 442, 33 - 66.
- Royal Haskoning (2005). Sheringham Shoal Offshore Wind Farm Seismic Survey: Interpretive report. Report 9P5074/R/DBRE/PBor.
- Royal Haskoning (2005). Sheringham Shoal Offshore Wind farm – Site Geology Report 9P5074/R/DBRE/PBor.
- Whitehouse, RJS (1998). Scour at Marine Structures. Thomas Telford. 216 pp. ISBN 07277 26552.
- Whitehouse, RJS *et al*. (2004).Testing of the interaction of coastal wind farm foundations with the seabed: scour and liquefaction. 29th ICCE, Lisbon (in press).
- Whitehouse RJS, Damgaard JS and Langhorne DN (2000). Sandwaves and seabed engineering: Applications to submarine cables. Proc Marine Sandwave Dynamics Workshop, Lille.
- Zaaijer, MB (2003). Comparison of monopile, tripod, suction bucket and gravity base design for a 6MW turbine. QWEMES European Seminar, 2003 (www.owemes.it/articli/zaaijer.htm)
- Geological Assessment (2004), Brian D'Olier, SCIRA-7-1-2-EX-ST-07080-Z1

7 Marine and Coastal Water Quality

7.1 Introduction

This section identifies the marine and coastal water quality characteristics of the study area and assesses the magnitude and significance of changes associated with the proposed Sheringham Shoal project. The impacts on water quality during construction, operation and decommissioning are identified and evaluated with reference to a number of EC Directives concerning water quality. Where available, information collected as a result of various monitoring programmes is used to support the findings.

7.2 Assessment Methodology

7.2.1 Study Area

The study area is that defined by the area over which direct and indirect effects could occur as a consequence of the proposed development. This is determined by the modelling work undertaken by HR Wallingford which assesses plume dispersion from the proposed construction activities (see Section 6 Hydrodynamics and Geomorphology).

7.2.2 Data Availability

The offshore location of the Sheringham Shoal Wind Farm means that information available on water quality for the area where the turbines would be installed is limited. Monitoring programmes carried out by the various responsible authorities as a consequence of EC Directive requirements generally only cover areas where designations or outfalls discharging particular substances are located. These are predominantly located inshore. There are several sites monitored annually for parameters, such as metals for example, by CEFAS located offshore however these sites are located several kilometres from the study area. Additionally, data is only collected once a year and information is only available up until 2002 (CEFAS *pers. comm.*)

Currently classification systems for waters in estuaries exist, however similar systems for coastal waters do not. The situation will be revised with the introduction of the Water Framework Directive, where both coastal and estuarine environments will be assessed and classified based on a wide range of environmental parameters. Monitoring for the Water Framework Directive classifications will start in 2006 and classifications of areas will be implemented by 2015. Although representing a significant change in the area classified by Directives, the Water Framework Directive seaward limit is currently set by DEFRA at 1 nautical mile.

There are currently two types of water quality designations in the proposed study namely:

- Bathing waters; and
- Shellfish waters.

The Environment Agency is responsible for monitoring water quality at these locations and reports the data against guideline standards and environmental quality standards (EQS) which are designed to protect the environment and human health.

The approach to assessing the potential effects on water quality arising from the Sheringham Shoal project is based on a comparison of the predicted changes to the relevant water quality parameters against the criteria established as environmental quality standards (EQS) within these Directives. Where EQSs do not exist (for example suspended solids concentrations), the impact is assessed with reference to the background conditions. Site specific data supporting the assessment of the predicted changes to water quality has also been derived from the results of the sediment plume modelling studies undertaken for the project (see Section 6 Hydrodynamics and Geomorphology) and seabed sediment quality analysis (see Section 9 Benthic Ecology).

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 7.4 – 7.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section 1 for the definition of significance levels.

7.3 Existing Environment

7.3.1 Designated bathing waters

Bathing water quality is assessed by standards listed in the EC Bathing Waters Directive. The Directive was adopted by the Council of the European Communities in 1975 and transposed into law for England and Wales to form the Bathing Waters (Classification) Regulations 1991. The Directive is concerned with the quality of bathing waters for the purpose of protecting public health and requires monitoring of microbiological parameters and a small number of physical parameters (visible oil etc).

There are two types of microbiological standards set out in the Directive, namely the mandatory standards and the more stringent guideline standards. The mandatory standards are:

- 10,000 total coliforms per 100ml of water; and
- 2,000 faecal coliforms per 100ml of water.

For bathing water to comply with the Directive, 95% of samples collected within a bathing season (15th May to 30th September) must meet these and other physical criteria.

The guideline standards should be achieved where possible and are:

- 500 total coliforms per 100ml of water (in 80% samples);
- 100 faecal coliforms per 100ml of water (in 80% samples); and
- 100 faecal streptococci per 100ml of water (in 90% samples).

Water quality is classified as ‘excellent’, ‘good’ or ‘poor’. ‘Excellent’ relates to the achievement of the more stringent guideline standards and ‘good’ relates to the achievement of the mandatory standards. Bathing waters classified as ‘poor’, fail to meet the Directive’s minimum mandatory standard.

In December 2000, the European Commission put forward a proposal to revise the EC Bathing Waters Directive. Following several years of discussions and revisions, the directive is now due to be enacted in April 2006. Member states will then have two years in which to transpose the legislation into UK law. The main differences to the current Directive resulting from the proposed revisions would include:

- A change in the standards and parameters to be applied;
- A new bathing water classification system;
- Proactive beach management;
- A significant increase in the information available to the public;
- The classification of the bathing water based on three seasons of data rather than the current one season; and
- The opportunity for member states to make changes to the list of designated bathing waters, the length of the bathing season and the location of the monitoring point.

There are five designated bathing water sites in the vicinity of the export cable works. These are shown in Figure 7.1

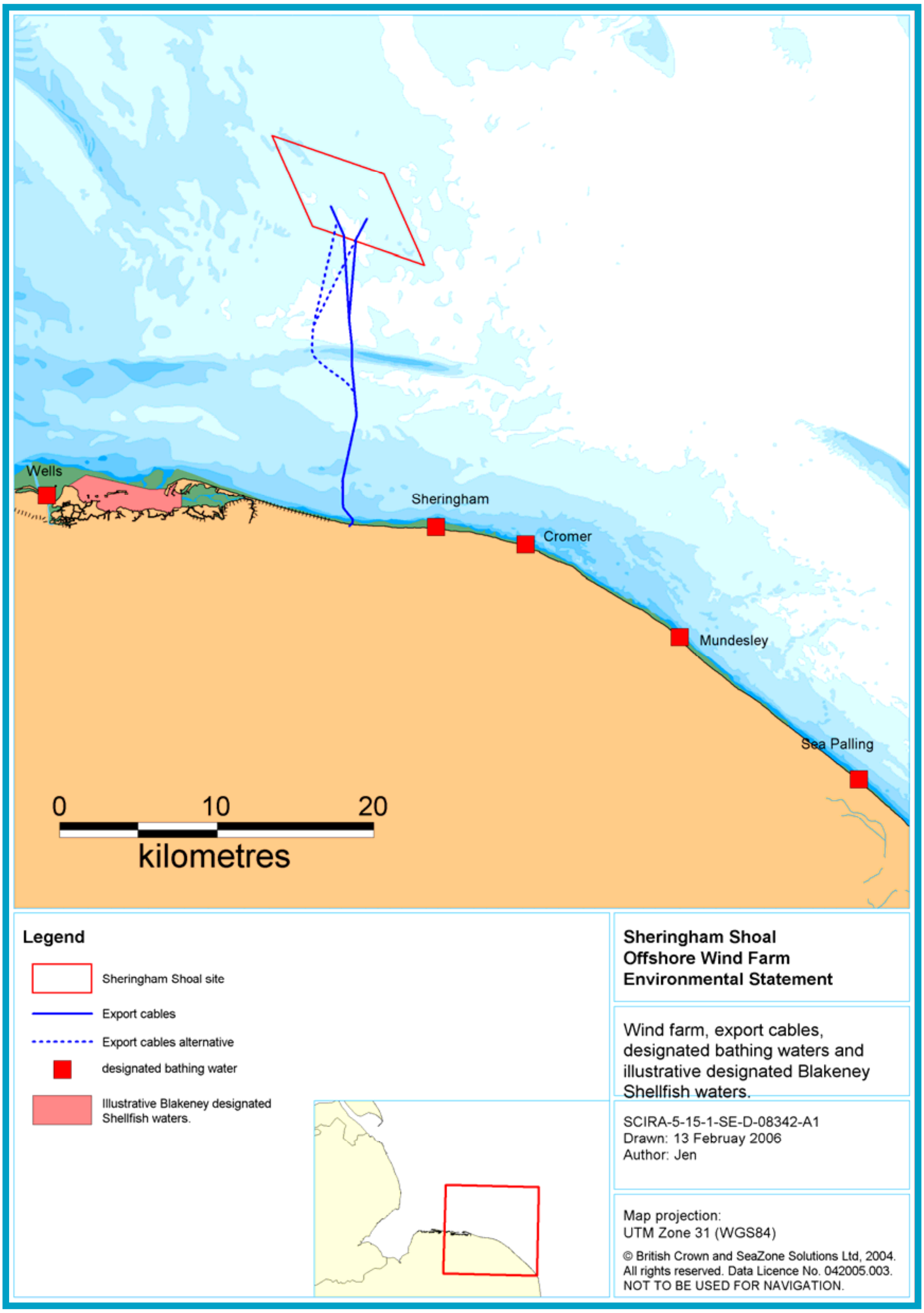


Figure 7.1 Location of designated bathing and shellfish waters

Bathing water quality at these designated bathing waters for the period 1995 to 2005 is illustrated in Table 7.1.

Table 7.1 Bathing Water quality at each of the designated bathing waters

Bathing Water	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wells	G	G	G	E	G	E	G	E	E	G	E
Sheringham	E	E	E	E	E	E	E	E	E	E	E
Cromer	G	E	G	E	E	E	E	E	E	E	E
Mundesley	G	G	E	E	E	E	G	E	E	E	E
Sea Palling*	-	-	-	-	-	-	-	E	E	E	E

Note: P = poor; G = good; E = excellent

*Sea Palling was newly designated in 2001/02.

All five bathing waters passed the mandatory standards in the last four years and in 2005, all five passed the more stringent guideline standards.

Designated bathing waters may also apply for Blue Flag and/or a Seaside Award, both of which are administered by ENCAMS (Environmental Campaigns). In addition to water quality which meets the requirements of the EC Bathing Waters Directive, these awards require the beach to be clean, safe and well managed. The Blue Flag requires compliance with the guideline standards of the EC Bathing Waters Directive and the Seaside Award requires compliance with the mandatory standards of the Bathing Waters Directive. In 2005, Mundesley, Sea Palling and Sheringham were awarded Blue Flags and Seaside Awards and Cromer was awarded with a Blue Flag. Applications for awards in 2006 are currently in progress. The stretch of beach at Weybourne Hope is advertised as dangerous for bathing due to strong undertow.

7.3.2 Designated shellfish waters

The Shellfish Waters Directive (79/923/EEC) is designed to protect the aquatic habitat of the bivalve and gastropod molluscan species of shellfish. Species covered include oysters, mussels, cockles, scallops and clams (but not crustacean shellfish such as crabs, crayfish and lobsters). The Shellfish Waters Directive is implemented in the UK under the Shellfish Waters (Shellfish) (Classifications) Regulations 1997. Shellfish waters are monitored for various parameters based on water quality standards established by the Directive. These parameters include:

- suspended solids;
- salinity;
- dissolved oxygen (DO);
- organo-halogenated substances (e.g. PCBs, organochlorine pesticides);
- trace metals;
- faecal coliforms in shellfish flesh; and
- others parameters such as colour of the water, hydrocarbons, pH, temperature.

For each substance, the Directive specifies the minimum number of samples to be taken, the water quality standards to be met and the percentage of samples that must meet these standards. The standards are either a numeric limit or a descriptive standard (see Table 7.2).

The water quality standards have been met if the following percentage of the samples analysed do not exceed the limit values:

- 100% for metals and organo-halogen compounds;
- 95% for salinity and dissolved oxygen (DO);
- 75% for other substances; and
- No evidence of harm to the shellfish from organo-halogenated compounds.

Table 7.2 Selected imperative Environmental Quality Standards (EQS) for shellfish waters

Parameter	Units	Standard
Suspended solids	mg/l	A discharge affecting shellfish waters must not cause the suspended solid content of the waters to exceed by more than 30% the content of waters not so affected
Salinity	Parts per thousand (i.e. g/l)	≤ 40 parts per thousand A discharge affecting shellfish waters must not cause their salinity to exceed by more than 10% the salinity of the waters no so affected
Dissolved oxygen	% saturation	Average of individual values >70% and an individual measurement may not indicate a value lower than 60% unless there are no harmful consequences for the development of shellfish colonies
Organo-halogenated substances	-	The concentration of each substance in the shellfish waters or in the shellfish flesh must not reach or exceed a level which has harmful effects on the shellfish and their larvae
Metals (Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn)	mg/l	The concentration of each substance in the shellfish waters or in the shellfish flesh must not reach or exceed a level which has harmful effects on the shellfish and their larvae. The synergic effects of these metals must be taken into consideration

The closest designated shellfish water is located at Blakeney, 17km south of the offshore wind farm and 8km west of the export cable landfall (See Figure 7.1). Since its designation, the shellfish water at Blakeney has complied with the mandatory standards.

The Shellfish Hygiene Directive, although not a Directive directly protecting water quality, stipulates the level of treatment required depending on numbers of bacteria in the shellfish flesh. This Directive is designed to protect human health. Since shellfish are grown in the natural environment, it is a commonly held view that the concentration of bacteria in the flesh directly relates to the quality of the surrounding water in which they grow. The monitoring undertaken as a consequence of this Directive can therefore be used as a rough indicator of water quality.

Under the Shellfish Hygiene Directive, standards are set in terms of concentrations of coliform bacteria and salmonella. Shellfish are classed in categories ‘A’, ‘B’, ‘C’ and ‘P’ where ‘A’ is the highest quality and can be collected direct for human consumption. ‘P’ is the poorest quality and shellfish are prohibited from collection. Monitoring for the Shellfish Hygiene Directive is carried out by the local authorities and the data is collated by the Food Standards Agency. Table 7.3 lists the species commercially collected within the shellfish water and their classifications.

Table 7.3 Designated bivalve mollusc production areas in the Blakeney Shellfish Water (Source: Food Standards Agency website 2006)

Bed Name	Species	Classification
Simpool	Common Mussel	B
Stiffkey	Common edible cockle	B/C
Morston Strand	Pacific Oyster	B
Freshes Creek	Pacific Oyster	B

7.3.3 Offshore water quality

As described above, information describing offshore water quality is limited. This predominantly relates to the lack of drivers in the various monitoring programmes for water quality measurements (CEFAS *pers. comm.*). Additionally, the sites monitored under the National Marine Monitoring Programme are located some distance from the study area and are only collected on an annual basis. For these reasons, the information has not been included as part of this assessment.

There is however information available with respect to typical mean summer and winter values for suspended solids. Figure 7.2 and Figure 7.3 illustrate typical suspended sediments for both summer and winter.

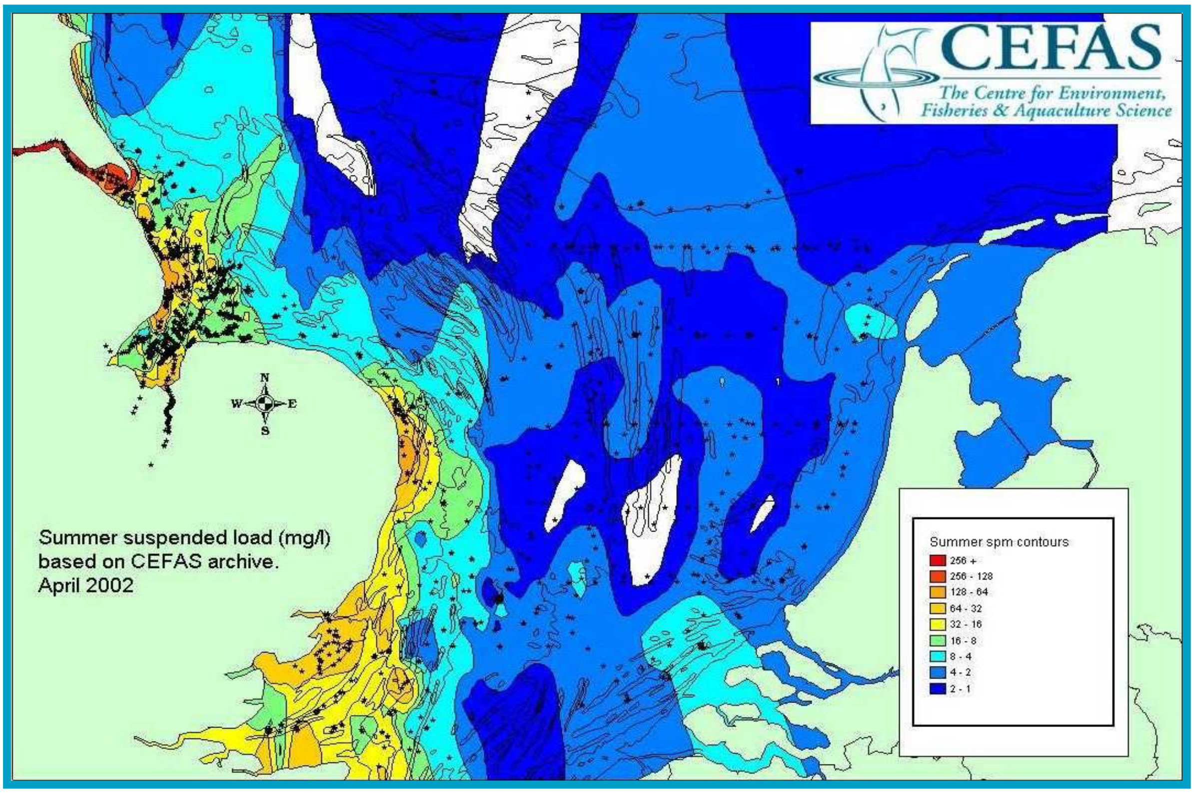


Figure 7.2 Mean summer suspended sediment concentrations (units: mg/l) (spm in key refers to suspended particulate matter)

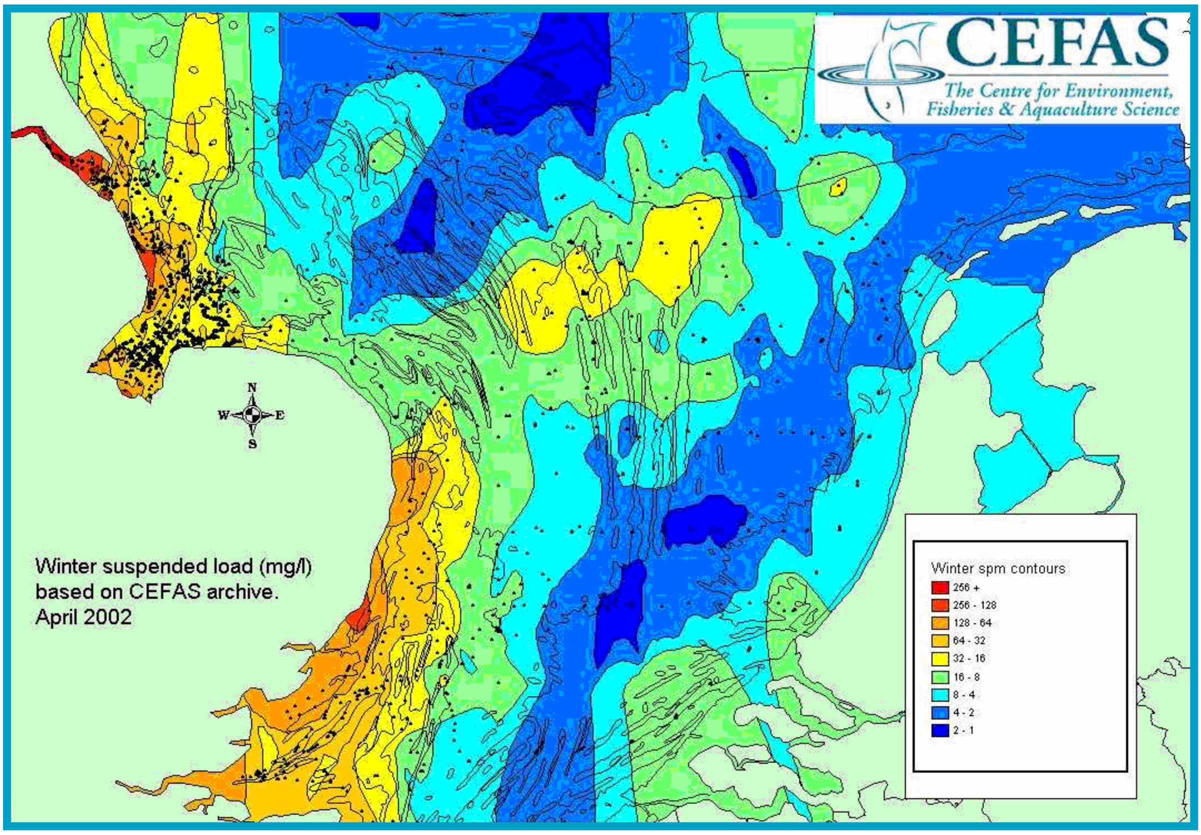


Figure 7.3 *Mean winter suspended sediment concentrations (units: mg/l) (spm in key refers to suspended particulate matter)*

From Figure 7.2 and Figure 7.3 it can be seen that suspended solids loads vary from typical mean summer values of less than 10mg/l to typical mean winter values of 30mg/l. During storm events, the natural levels of suspended solids may increase well above these values (See Section 6).

7.4 Impacts during construction

7.4.1 Impacts due to re-suspension of sediments

Seabed sediment could potentially be disturbed as a result of construction activities on the seabed, including:

- installation of turbine and offshore substation foundations (including seabed preparation and spoil disposal);
- installation of inter-array and export cables; and
- the placement of scour material and activity of construction vessels, such as placement of spud legs.

Any sediment that is disturbed and enters into suspension would subsequently be transported and dispersed by the prevailing tidal currents and would ultimately be re-deposited onto the seabed. Such disturbance to seabed sediments (both surface sediments and the underlying bedrock) has the potential to impact on the water quality both in offshore waters adjacent to the construction activity and at coastal and far-field sites.

There are no water quality standards relating to suspended solids in marine waters. However the Shellfish Water Directive requires that a discharge affecting designated shellfish waters must not cause the suspended solids content of the waters to be exceeded by more than 30% in 75% or more of samples compared with waters not so affected. Therefore the standards of the Directive have been met if 75% of samples do not exceed the limit value.

The Bathing Waters Directive does not have standards relating to suspended solids, although aesthetic appearance of the bathing water during the bathing season is an important component of the recreational value of beach areas.

To assess the impact on the marine environment, predicted suspended solids concentrations have been compared to typical background concentrations experienced in the areas impacted.

7.4.1.1 Installation of turbine and offshore substation foundations

The various turbine and substation foundation options that are being considered for the Sheringham Shoal project (see Section 2) all have the potential to resuspend varying amounts of sediment.

Driven monopiles would have the least impact in relation to resuspension of sediments since little sediment would come into contact with the water column. It is anticipated that if piles need to be drilled, then sediment arisings would be removed direct to the surface via a closed system of drilling (see Section 2). At the surface the arisings (sediment and a biodegradable lubricant) would be settled out and the arisings disposed of either on or offsite (with an option to dispose of within the monopile structure). A lubricant is used to aid the drilling process and can safely be returned to the water with no deleterious effects, other than localised aesthetics.

Gravity bases may require the seabed to be prepared for installation by levelling. Such large scale disturbance of surface material (2000-5000m^3 per foundation) would lead to significant dispersion plumes of disturbed material. As demonstrated by the dispersion studies undertaken for cable burial (see Section 6 and Appendix 6.2) background concentrations would be temporarily increased above the suspended solids concentration range typically experienced in the area, but would decrease rapidly beyond the immediate vicinity (10s of metres) of the preparation area due to the rapid settlement of the coarse material at the site (see Section 6). It is considered that there would be a **moderate** impact on the suspended solids concentrations in the water column in the immediate foot print of the development during preparation activities, decreasing to a **negligible** impact within a short time (one tidal cycle). Overall, due to the coarse nature of the surface and sub surface sediments and therefore the very rapid settlement of the sediments and the low sensitivity of the receiving waters a **negligible** impact on water quality is anticipated. Due to the depth of the chalk bedrock in the wind farm site (below 9m below the surface) no impacts from disturbance of chalk would occur.

For installation of foundations using multi-legs or by suction piles, there are no additional anticipated significant impacts other than those applicable to monopiles and gravity bases (see Section 6).

The distance to the designated waters (approx. 17km to the nearest bathing and shellfish waters) and the exposed location of the area would ensure good dispersion and dilution. Significant increases in suspended solid concentrations above background concentrations within the designated areas are not predicted therefore **no impact** on the water quality of designated waters is expected.

7.4.1.2 Installation of inter turbine array and export cables

Re-suspension of seabed sediment could potentially occur as a consequence of the installation of both the inter-array and site to shore (export) cables.

It is anticipated that the plough or trench method of cable laying would be used to install the main export cables whilst a number of options could be used for installation of the inter turbine array, including jetting and trenching (see Section 2).

Since the installation of the main export cables requires disturbance of the seabed in areas closer to the designated waters, this impact is considered to be the likely worst case scenario. As such, modelling has been undertaken to assess the likely impacts of resuspension of sediments (See section 6) associated with the installation of export cables.

Sediments to be disturbed along the proposed cable route are based on the findings of grab samples and borehole logs (See section 6) and indicate that the mobile surface layers mainly consist of sandy gravel with less than 4% fines. The sub layer varies from heterogeneous Holocene layers to the bolder clay of the Bolders Bank formation and typically has a silt/clay content of approximately 60%. For the purposes of modelling, a worst case scenario has been assumed which requires that all of this fine material would be available for dispersion. In reality however, much of it is likely to remain in large lumps and therefore will not disperse (See Section 6). Additionally, silt/clay areas are modelled as if there is no surface sediment (i.e. installation directly into the silt/clay material).

Full details of the modelling assessment are found in section 6. The following paragraphs summarise the main findings.

In areas where the export cables are proposed to be buried up to 3m, the cable is installed in sands only with no disturbance of the underlying chalk. Since the percentage of fine sediment recorded from the sediment samples is less than 4%, dispersion from these areas is assumed to be very low (See Section 6). The modelling therefore focuses on the areas where high percentage of fine material is likely to be disturbed (based on the above assumptions).

Figure 7.4 and Figure 7.5 present predicted sediment dispersion as a result of installation of export cables through chalk using plough installation. This is considered to be the worst case scenario as disturbance of chalk produces the most fines. Results are presented as maximum concentration plots i.e. peak increases of suspended solids experienced at each point over a period of six tides.

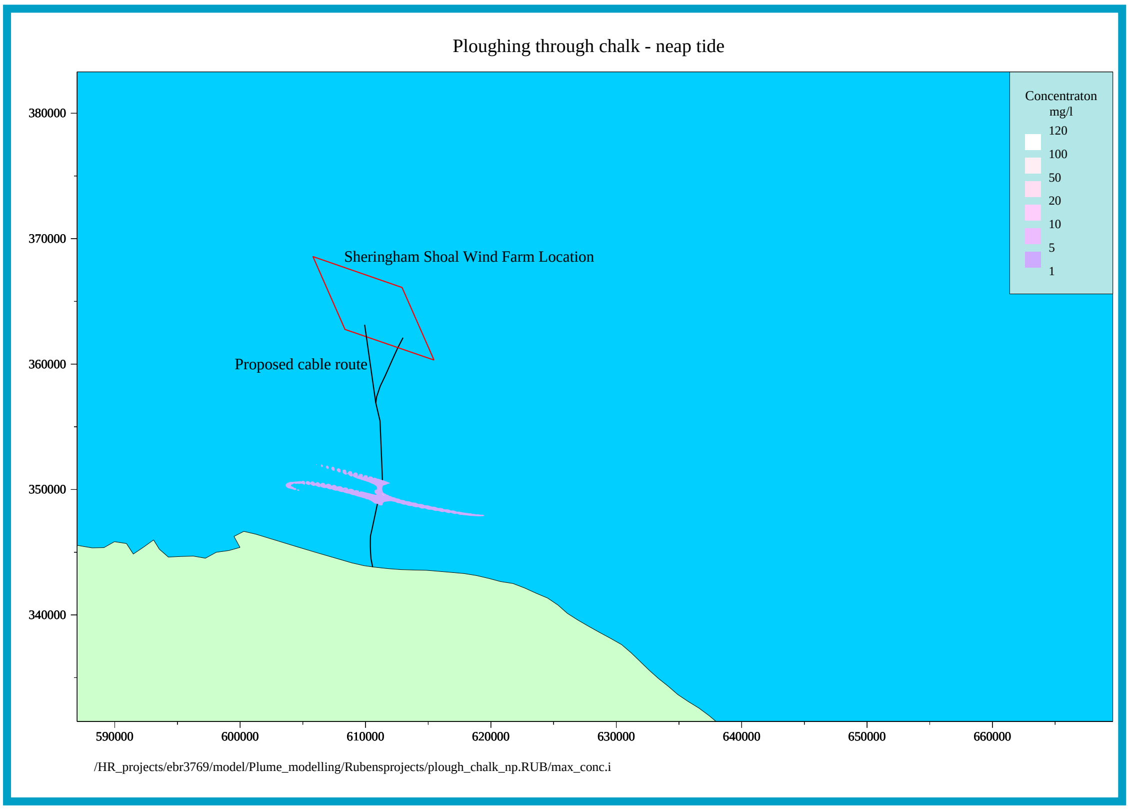


Figure 7.4 *Peak concentrations of suspended solids during neap tides for installation of export cables using the plough method*

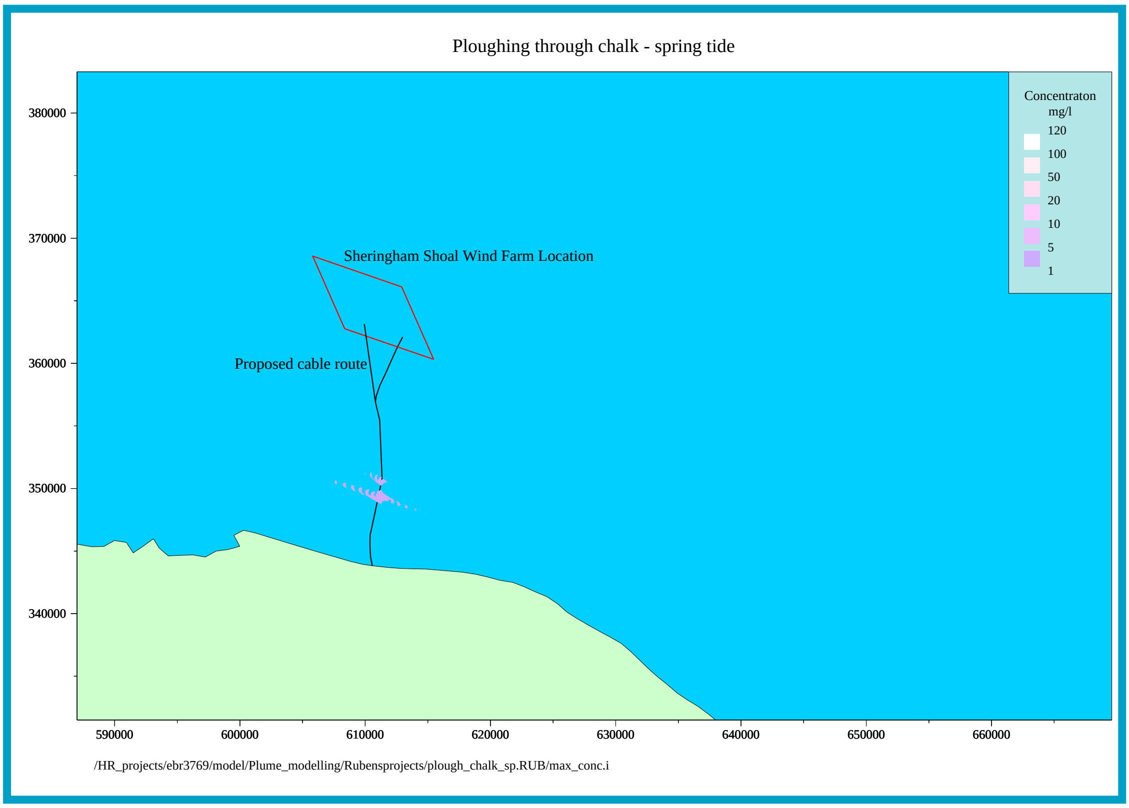


Figure 7.5 *Peak suspended solids predicted to occur over spring tides for installation of export cables using the plough method*

During cable installation there would be increases in sediment concentrations which would rapidly disperse through the water column depending on the state of the tide. As can be seen in Figure 7.4 and Figure 7.5, the dispersion footprint for both tides (spring and neap) indicates that worst case conditions are experienced during neap tides where the plume footprint extends for 9km in each direction (compared to 4km for springs). Concentration levels however reduce to less than 1mg/l above background within a single flood or ebb excursion.

Figure 7.6 presents predicted sediment dispersion as a result of installation of export cables through chalk using the trenching methodology. Since the worst case scenario for cabling using the plough technique was shown to be during neap tides, results for the neap tidal model run only, are presented.

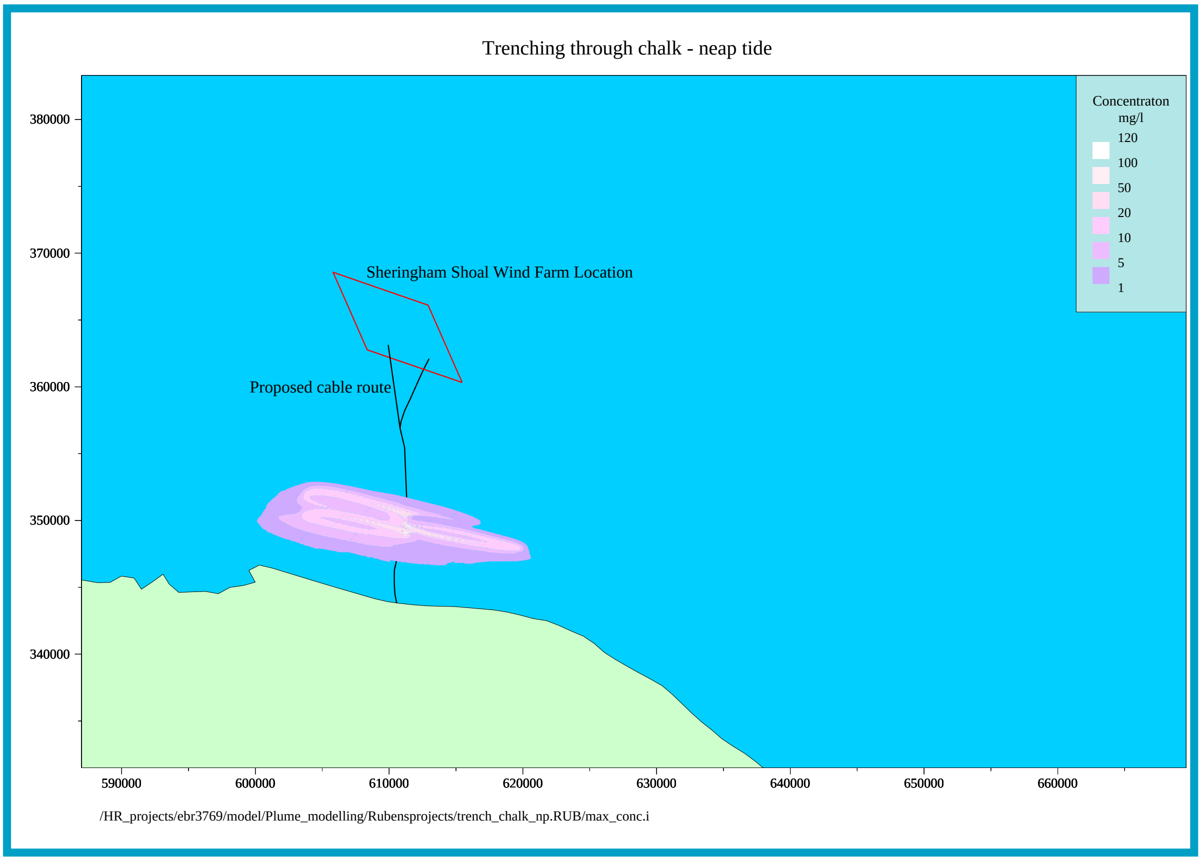


Figure 7.6 Peak suspended solids predicted to occur over neap tides for installation of export cables via trenching

The volume of material released by trenching is much higher and the predicted plume extends more than 10km in either direction at a suspended solids level of 20mg/l above background concentrations. The model predicts a gradual drift of the plume towards the shore however, over six tides, the plume is predicted to disperse to suspended solids concentrations of less than 1mg/l above background.

The total length of chalk at surface or near surface is approximately 1.6km (for the preferred direct cable route) as detailed in Section 2. The disturbance of chalk in these areas could lead to a visible milky plume at the surface, however this would be of an aesthetic nature only. Additionally, the plume is not predicted to impact on any of the coastal designations and the offshore area which is impacted, is considered to be of low sensitivity in terms of water quality.

The impact on water quality of the offshore area and on the designated waters situated along the coastline, is therefore considered to be of **negligible significance**.

The proposed cable route would be directed through the Weybourne Channel and over the Pollard Bank in order to minimise laying through chalk. This would reduce the potential impact of dispersed chalk fines within the immediate near shore area and therefore reduce the impact on the non-designated bathing water at Weybourne Hope. Additionally, the installation will only occur over a very short period of time. An impact of **negligible significance** is therefore predicted.

Impacts from elevated suspended sediments on habitats and species in the area are discussed in Section 9, Benthic Ecology and Section 10, Natural Fisheries.

7.4.1.3 Other construction activity

There may also potentially be impacts associated with vessels and equipment required for installation of the turbines and cables. These are however, considered to be very small since activity would be localised to the development and would only be impacting on the seabed for very short periods of time. The impact to the surrounding water quality is therefore deemed to be of **negligible** significance.

Overall, due to the temporary nature of the plumes generated, the high mixing and dispersion of the area, the relatively small spatial area affected and the distance to any designated sites, impacts on water quality are considered to be of **negligible** significance.

7.4.2 Impacts due to re-suspension of contaminants

The potential for the re-suspension of seabed sediments or disturbance of the underlying chalk bedrock during the installation of the cables and turbines, has the potential to release associated sediment-bound contaminants into the water column. The release of chemical contaminants could potentially increase the concentration of contaminants in the water column and affect compliance with EQSs at sites monitored by the Environment Agency (see above).

The mean concentrations of Polycyclic aromatic hydrocarbons (PAH), Polychlorinated biphenyls (PCB) and metals recorded from the seabed sediments sampled for sediment contaminant concentrations as part of the benthic survey undertaken by IECS (see Section 9), are below the limit of detection at all sites. The risk of breaching the EQS is therefore considered to be nil. Consequently there would be **no impact** on the quality of designated waters due to re-mobilisation of contaminated sediments.

Impacts from re-mobilisation of contaminated sediments on habitats and species in the area are discussed in Section 9, Benthic Ecology and Section 10, Natural Fisheries.

7.4.3 Impacts due to re-suspension of pathogens

During the construction phase, there is the potential for bacteria present within the sediment to be re-suspended into the water column. This could potentially cause exceedances of the statutory standards in relation to the designated bathing waters. Uptake of bacteria by shellfish in the designated shellfish water could also impact on compliance with the guideline values for faecal coliforms in shellfish flesh (as described in the Shellfish Waters Directive) but could also cause the shellfish bed classifications to be downgraded (as described in the Shellfish Hygiene Directive).

Sediment samples taken from within the disturbed areas show a relatively low percentage of fine organic material. This significantly reduces the risk of high levels of bacterial contamination in the sediments, since fine mud sediments, with high organic content, retain more contaminants than relatively coarse sandy sediments. Since the area to be disturbed is predominantly sandy, it is unlikely that high concentrations of pathogens would be associated with the sediments.

Given the above, **no impact** on the Bathing Water and Shellfish Waters is predicted.

7.4.4 Impacts due to accidental spillage of construction materials

During the construction period, there is the potential for pollution from spills or leaks of fuel, oil and construction materials such as grout. Other materials that would enter the water column include drilling lubricants.

The risk of this arising would be minimised by following standard good practice with regard to the pollution prevention guidance issued by the Environment Agency. In addition, any chemicals used would be approved in line with the *Offshore Chemicals Regulations 2002* and approved by MCEU/Defra. Drilling lubricants would be non toxic and biodegradable and capable of dispersal in seawater.

In addition, the Contractor would have in place appropriate Site Environmental Management Plans (SEMP) and Pollution Control Plans (PCPs), agreed with the relevant statutory bodies which will ensure the adoption of best practice on site. These will act to reduce the potential for accidental pollution to occur and in the unlikely event that such pollution does occur, will ensure a rapid and appropriate response. The appropriate storage of oils and lubricants on construction vessels would be undertaken as best practice and all waste disposed of in accordance with the relevant guidance and duty of care legislation.

Overall, given good construction practice, a **negligible** impact on water quality is anticipated.

7.5 Impacts during operation

Work during the operational phase would not require any significant disturbance of sediments. The only potential risk of impact on water quality is from accidental spillage of materials from maintenance vessels, the turbines or the offshore substations during routine maintenance.

By ensuring pollution prevention guidelines and best practice guidelines are adhered to, the risk of accidental spillage would be minimised. As described above, operational and maintenance plans will ensure appropriate storage, use, pollution prevention and rapid clear up in case of incident. **No impacts** are anticipated.

7.6 Impacts during decommissioning

Impacts on water quality during decommissioning would largely be associated with the removal of the offshore structures. Re-suspension of sediment is therefore a potential risk and impacts are likely to be similar to those described for the construction phase above, should disturbance of the sea bed be required for removal. Any arisings disposed of in the monopile would remain in situ, since it is likely that monopiles would be cut off below the surface. Removal of gravity based foundations and scour protection would cause some suspension of sediments due to partial adhesion of sediments to the underside of structures when lifted. Impacts of a similar nature (but smaller magnitude) to construction would be anticipated. Any need to deal with the arisings would be dealt with in the Decommissioning Plan (see Section 2).

As it is likely that cables would remain in situ once disconnected, impacts associated with the removal of the cables would not occur. Impacts are anticipated to be either of **negligible** or **no impact.**

7.7 Cumulative effects

The impacts on water quality predicted for the Sheringham Shoal project are highly localised and short term. Other activities which may have a potentially cumulative effect could be the construction of other wind farms during the same period. However, given that the impacts associated with these developments are likely to produce similar localised, short term impacts, the distance separation means that no interactions are likely, nor are any increased scale of impact envisaged.

No other activities, such as marine aggregate dredging or disposal are in proximity of the Sheringham Shoal project (see Section 1, Other Human Activities).

7.8 Summary

There are five designated bathing water areas and one designated shellfish water area located within the vicinity of the Sheringham Shoal project, the nearest being located at Sheringham and Blakeney respectively. Both the bathing waters and shellfish waters meet mandatory standards.

Impacts on water quality due to re-suspension of sediments during the construction phase are considered to be potentially most significant. However, the exposed location of the site, the localised extent and nature of the sediment disturbance and the distance of construction activities in relation to the designations (between 8 and 17km) is such that no impacts on the designated sites are anticipated. The low sensitivity of the water quality outside these designations also ensures that impacts are of **negligible significance**. The disturbance of short lengths of areas of surface and near surface chalk on the export cable route could lead to a visible milky plume, however this would be of an aesthetic nature only.

The impact of re-suspension of sediment contaminants and bacteria has also been assessed as **no impact,** predominantly due to the low risk of bacterial contamination and the general low level of contamination found within the sediments within the areas to be disturbed.

Adherence to standard pollution prevention guidance, site environmental plans and best practice will reduce risks to water quality from accidental spillage.

Impacts on water quality during the operational phase are considered to be negligible, given adherence to standard pollution prevention guidance and good practice during maintenance.

During decommissioning, impacts on water quality would largely be associated with the removal of the offshore structures. Re-suspension of sediment is therefore a potential risk and impacts are likely to be similar to those described for the construction phase above. It is anticipated that the export cables would remain in situ once disconnected.

7.9 References

- www.environment-agency.gov.uk
- www.encams.org
- www.food.gov.uk

8 Ornithology

8.1 Introduction

This section describes the baseline conditions of the ornithological interest of the Sheringham Shoal offshore wind farm site and surrounding area. It identities and assesses the potential environmental impacts during the construction, operation and decommissioning of the project. Mitigation and monitoring measures are discussed where necessary. The ornithological interests associated with the onshore cable route are discussed in Section 0, Terrestrial Ecology.

8.2 Assessment Methodology

8.2.1 Introduction

Wind farms may impact on birds in three main ways:

- Mortality as a result of collision with turbine blades, towers and ancillary structures;
- Displacement from preferred areas used for feeding, roosting, resting, moulting or passage; and,
- Indirect effects through changes in habitat or prey supply.

Mortality is obviously relevant on an individual level but would only be significant at population level once a specific number of individuals are lost. Disturbance and displacement are considered together as it is difficult to separate these two effects. Displacement may only be a problem if alternative areas are not available and significant if measurable impacts on individual fitness are ultimately manifested at a population level (i.e. reduced breeding productivity). A barrier effect of a wind farm would be especially relevant for birds purposefully passing through on migration or cummuting through on a more frequent basis, e.g. for foraging trips. Indirect effects may be particularly difficult to measure requiring integrated simultaneous monitoring of important habitat variables and for example, prey supply such as fish stocks. However, impacts may be both positive or negative and mediated through both distribution and abundance for example by fish associating with structures thereby enhancing prey supply, although construction activity may have initially negatively affected fish reproduction patterns and behaviour through noise and vibration (Nedwell & Howell, 2004).

Assessment of the ornithological interest on the impacts of offshore wind farms is generally focussed on true seabirds (e.g. petrels, shearwaters, Gannet *Morus bassanus*, skuas, gulls, terns and auks) and those typically spending a part of their annual life cycle at sea (e.g. divers and sea-duck). However other groups may be incorporated including those passing through the prospective site such as a range of waterfowl and waders associated with coastal or wetland habitats, migrating land birds such as passerines and aerial species such as hirundines and Swift *Apus apus* that may also forage over the open sea as well as the land.

The underlying aims of the field surveys were to establish:

- Bird activity and densities within the development area, buffer zone and control area;
- Movement and activity of internationally and nationally important bird species;
- Bird activity during periods of migration (autumn and spring);
- The importance of the site in terms of feeding, roosting and resting birds for birds of particular interest.

From this baseline, the potential impacts of construction, operation and de-commissioning of the proposed wind farm site are predicted using significance level assessment. Where necessary, mitigation measures to reduce any impacts upon birds are proposed.

A number of species/groups were identified in the Scoping Report as being of particular relevance to the Sheringham Shoal wind farm, mostly but not exclusively linked to the proximity of the North Norfolk Coast and Wash Special Protection Areas (SPA's)[11] and their qualifying species and assemblages (see Table 8.1 and Section 5, Nature Conservation Designations). These species/groups were:

- Divers – Red throated Diver *Gavia stellata* and Black-throated Diver *Gavia arctica*;
- Geese – Pink-footed Goose *Anser brachyrhynchus* and Dark-bellied Brent Goose *Branta bernicla*;
- Waders;
- Sea-duck – Eider *Somateria mollissima*, Common Scoter *Melanitta nigra* and Velvet Scoter *M. fusca*;
- Terns – Sandwich Tern *Sterna sandvicensis*, Common Tern *S. hirundo*, Roseate Tern *S. dougalli* and Little Tern *S. albifrons*;
- Auks – Guillemot *Uria aalge* and Razorbill *Alca torda.*

Linked to this, and after consultation with English Nature and the Royal Society for the Protection of Birds (RSPB) seven key issues were identified:

- Possible reduced productivity of internationally important tern colonies due to disturbance of feeding areas;
- Potential disturbance to nationally important populations of divers and sea-duck over-wintering off the North Norfolk Coast;
- Potential disturbance of sea-duck that may use the proposed site as a moulting area;
- Possible disturbance of post breeding auks;
- Potential disruption of migration routes used by large numbers of waterfowl wintering in North Norfolk and the Wash;
- Potential disruption of similar migration routes of land birds such as pipits, wagtails, thrushes and warblers;
- Potential strikes of sea-birds during bird movements in stormy weather.

[11] A specific designation for sites of international importance for birds

Table 8.1 Internationally important sites for nature conservation near the proposed Sheringham Shoal wind farm, their designations and qualifying bird species and assemblages.

Site	Designation	Qualifying bird species/assemblages: Breeding season	Over winter	On passage
The Wash	Ramsar site, cSAC, SPA, NNR, SSSI	Common Tern, Little Tern, Marsh Harrier	Avocet, Bar-tailed Godwit, Black-tailed Godwit, Curlew, Grey Plover, Golden Plover, Knot, Oystercatcher, Turnstone, Dunlin, Redshank, Pintail, Shelduck, Dark-bellied Brent Goose, Pink-footed Goose, Whooper Swan. Assemblages of >20,000 waterfowl.	Ringed Plover, Sanderling
North Norfolk Coast	Ramsar site, cSAC, SPA, NNR, SSSI	Avocet, Bittern, Common Tern, Little Tern, Roseate Tern, Sandwich Tern, Marsh Harrier, Mediterranean Gull, Redshank, Ringed Plover	Avocet, Bar-tailed Godwit, Bittern, Golden Plover, Knot, Redshank, Hen Harrier, Ruff, Pintail, Wigeon, Dark-bellied Brent Goose, Pink-footed Goose. Assemblages of >20,000 waterfowl.	Ringed Plover

8.2.2 Survey Objectives and Justification

A detailed and extensive programme of surveys over a two-year period (the baseline) in 2004, 2005 and early 2006 was developed following consultation with English Nature. Twenty-nine boat-based surveys specifically conducted over the immediate study area (the wind farm site and a control area) were used as the principal survey platform throughout the study period, between March 2004 and February 2006.

This was supplemented by seven aircraft-based (aerial) surveys over the larger Greater Wash Area to provide additional information on the study area and to define its local and regional context. The aerial surveys encompassed peak periods of abundance for a range of seabirds of conservation importance, during winter 2004/05 and summer 2005. The aerial survey programme was undertaken in collaboration with other developers of proposed wind farm sites in the Wash arranged by the Department of Trade and Industry (DTI).

In addition, supplementary information on bird use of the airspace inshore of the site was provided by continuous intensive (day/night) radar studies conducted over two selected periods during peak bird migration in autumn 2004 and 2005.

Different survey effort was applied in summer, autumn and winter to meet specific survey objectives in line with the key issues (see section 8.2.1 above). Thus:

- An intensive programme of boat-based and aerial surveys from May to August was employed to investigate the distribution of Sandwich and Common Terns foraging offshore from the breeding colonies at Scolt Head and Blakeney Point (the latter being closer and thus of particular relevance to the proposed site), as well as identifying usage by post-breeding auks and/or moulting sea-ducks;

- Boat-based effort during autumn (August-November) was reinforced by specific use of radar focussed on the peak passage period of September/October, in order to investigate migration routes and flight heights of seabirds, wildfowl, waders and passerines;
- The winter period was divided into early, middle and late periods with boat-based and aerial surveys conducted in each to ensure that any concentrations of over-wintering sea-duck and divers were detected, in order to establish the potential for disturbance of these groups in the vicinity of the site.

Full details of the agreed survey programme are provided in Appendix 8.1.

8.2.3 Survey and Sampling Methodology

8.2.3.1 Introduction

The use of different survey methods with known specific biases allowed assessment of all the different groups of birds likely to be encountered and especially those of particular importance (see section 8.2.1 above). Boat-based and aerial surveys are general tools with a focus on seabirds, with some groups such as divers and sea-duck readily disturbed by boats being best assessed by aerial surveys. However, identification to species level of groups such as gulls, terns and auks is most readily undertaken during boat surveys. Distinguishing between different species and even different groups in radar studies relies on simultaneous visual observation of birds detected. Radar does however, have the advantage of being able to record nocturnal movements.

8.2.3.2 Boat-based surveys

A total of 29 surveys were conducted between March 2004 and February 2006, using the transect route shown in Figure 8.1 [12]. Dates of these surveys are provided in Appendix 8.1.

The boat survey area (124km^2) was defined by the site proposed to contain the proposed development (35km^2), a buffer strip of (54km^2) of up to 1.5km width around the site in which indirect effects may arise (e.g. through displacement of birds), and an adjacent area of similar size to the site (35km^2), as a control area (Figure 8.1). Total transect length was 89km. The site and buffer and control areas were determined after consultation with English Nature and the RSPB. In addition, at the request of the RSPB, in the summer of 2005 a further survey transect of 5km in length for a maximum survey area of 5km^2 was established along Sheringham Shoal, some 5.6km to the south of the proposed site. This was primarily to assess the importance of the shoal for feeding terns.

[12] A somewhat different survey route was used in the first two surveys (March and April 2004). See Appendix 8.2 for details.

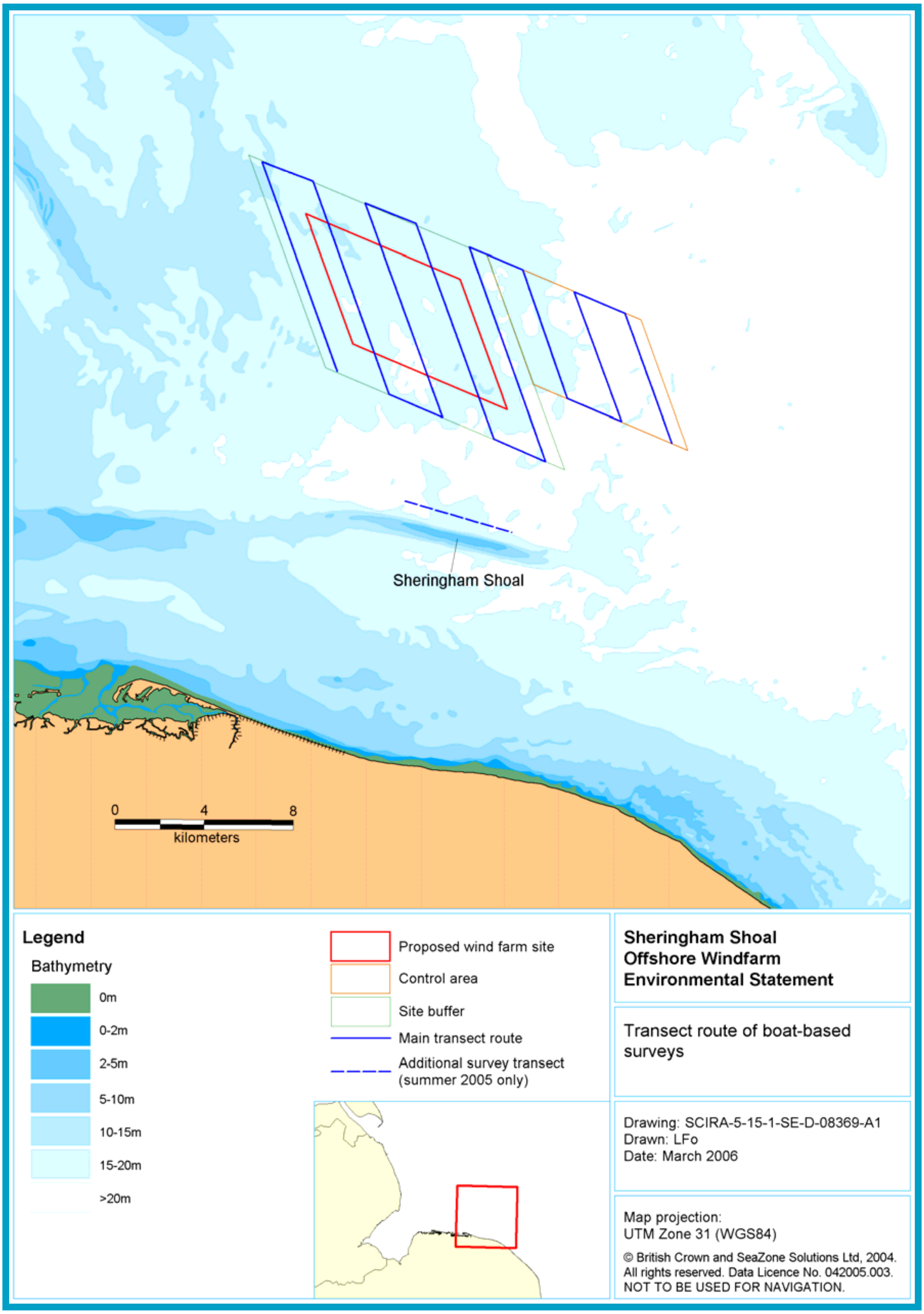


Figure 8.1 The study area, showing the proposed development, the site buffer, the control area, and the ornithological transect route.

In general, the survey methodology followed that recommended by COWRIE (Collaborative Offshore Wind Research into the Environment established by the Crown Estate) building on those published by Komdeur *et al.* 1992). Poor conditions (in excess of a sea state 5) in which surveys should not be undertaken according to the recommendations of both COWRIE and Camphuysen *et al*. 2004 may occur in any season in the Wash, particularly in the east of the area where the site is located. Despite this, only three surveys were missed, with the most serious shortfall in May/June 2004 offset by a full programme of surveys in the equivalent period in 2005.

Six vessels have been used during the survey period, all of which met the COWRIE recommendation of 5m or more eye height for observers (see Appendix 8.1). To ensure good survey coverage, most surveys after September 2004 were conducted from the Mfv Jubilee Intrepid, which is a larger (21.3m), more stable vessel able to operate effectively in more challenging conditions.

All surveys employed a team of at least two observers, who, on all but the first nine surveys, were supported by a liaison officer with specific responsibility for safety issues, ensuring compliance with the agreed survey route as well as recording environmental data. The vessel itself was operated by a dedicated skipper and his crew. Details of the observation teams are provided in Appendix 8.1.

Plate 8.1: Surveyors on board the Mfv Jubilee Intrepid. © Dan Brown.

Whilst the standard techniques of line-transect for birds on the water supplemented by snapshot counts for flying birds as recommended by COWRIE (Camphuysen *et al*. 2004) were used, some modifications were made to improve detection of birds, estimation of population size in the survey area and data interpretation, thereby maximising the value of the data gathered. Thus, while birds were generally detected by eye, forward scanning using high quality binoculars was undertaken to improve detection of divers and sea-duck in particular, that are known to flush from the sea surface at considerable distance from the vessel. Moreover, two 90^0 line transects were operated simultaneously wherever possible, to improve the probability of detection of rare species and those occurring at low density. Snapshot counts were operated over 180^0 ahead of the vessel at specified distance intervals of 500m rather than time intervals to account for any deviations in boat speed according to strong tidal flow. This also meant that a consistently high number (approx. 200) of snapshots were taken in the same locations over time. Finally, all recording of birds was undertaken in real time rather than time blocks allowing more accurate positioning of birds.

For all birds encountered (both singly and in groups or flocks) during the survey, their distance from the boat, flight height and direction (from eight compass directions) and general behaviour (e.g. foraging, carrying prey etc.) were recorded. Following recommended methodology, on both line transects and during snapshots, birds were assigned to five distance bands (A: 0-50m, B: 50-100m, C: 100-200m, D: 200-300m and E: >300m). Distances were continuously verified using objects of known distance (by GPS) and range finders. Birds in A-D were defined as 'in transect' (or snapshot) and used in density calculation. As a result of the difficulty in estimating flight height (despite the use of reference structures) a precautionary approach was adopted and birds were assigned to four heights according to the prospective area swept by turbine blades (0m-water surface, 0-20m-below turbine blade height, 20-120m-within the sweep of turbine blades and >120m above turbine blade height). Two letter species identification codes recommended by the British Trust for Ornithology (BTO) were used throughout, with other behaviours coded as defined by COWRIE. All bird data and a number of environmental variables affecting visibility and thus survey efficiency (e.g. rain, cloud cover, glare, wind speed and sea state) were recorded on modified Seabirds at Sea survey forms using a standard protocol (see Appendix 8.1).

8.2.3.3 Aerial surveys

Aerial surveys of the Greater Wash (GW) strategic area, including the Sheringham Shoal wind farm study area, were undertaken from November 2004 to August 2005 by the Wetland Advisory Service (WAS) of the Wildfowl & Wetlands Trust (WWT) for the DTI. Surveys were undertaken in each of seven key periods: early winter, mid winter (1 & 2), late winter, breeding-incubation, breeding-chick rearing and post fledging/moult.

The whole survey area of $7001km^2$ was divided into survey blocks, as shown in Figure 8.2. The Sheringham Shoal wind farm site lies within the GW5 survey block. Each survey of GW5 was conducted over one day (typically four hours flight time centred on midday GMT) in selected good weather conditions generally with wind speeds of <15 knots, using the recommended COWRIE methodology (Camphuysen *et al.* 2004).

Surveys were conducted from Partenavia PN68 aircraft flying at an altitude of 76m (250ft) and a speed of approximately $200kmh^{-1}$ along transects of c. 20-65km at 2km intervals oriented along a north-south axis to the shore, which helps reduce glare and improves detectability of birds. The location of the aircraft was recorded every five seconds using GPS, allowing the subsequent accurate positioning of any bird(s) to within a few hundred metres (WWT 2005).

For each observation of a bird(s), their identity, number, general behaviour (e.g. swimming, flying etc.), distance from the transect line, and time of observation were recorded using a dictaphone. Using a clinometer, birds were assigned to one of four distance bands (A:44-163m, B:163-282m, C:282-426m, D:426-1000m) when perpendicular to the flight path of the aircraft. At <44m birds cannot be seen beneath the body of the aircraft. The survey method assumes all birds in Band A are detected and greatest effort is concentrated in this band.

Despite the use of only experienced observers, species identification is cautionary and only those individuals seen clearly were assigned to species level. Otherwise, birds were assigned to taxa such as diver spp., pale-backed gull (Common *Larus canus* or Herring *L. argentatus* gulls), dark-backed gull (Lesser *L. fuscus* and Great *L. marinus* Black-backed gulls), large gull (Herring, Lesser and Great Black-backed gulls), small gull (*Larus* spp. smaller than *L. canus*), gull (*Larus* spp. and Kittiwake *Rissa tridactyla*), tern (*Sterna* spp.) and auk spp. In the latter category the numerically dominant Guillemot and Razorbill were rarely separated.

Additional aerial survey results are available from a less intensive survey campaign in the winter 2002/03 (Cranswick *et al.* 2003). Using a series of transects at 4km intervals, surveys of a more limited area, but including the Sheringham Shoal wind farm site, were undertaken in February and March 2003. The data from these surveys have been kindly provided by WWT and are included in the current analysis.

8.2.3.4 Radar surveys

The Central Science Laboratory (CSL) Bird Detection Radar system was deployed continuously under optimal conditions (apart from short periods of rain in both years) day and night for six days (116 hours) from 18th-23rd October in 2004 and for four days/nights (96 hours) from 19th-23rd September 2005. See Appendices 8.5 and 8.6 for the radar survey reports.

The equipment was located close to sea level onshore at Weybourne, providing an unobstructed view of the offshore area to a maximum range of 11.1km (S-band system) including in the direction of Sheringham Shoal. Therefore, whilst radar could not cover the actual site (located from 17km offshore) it provided an indication of bird movements through the site, particularly for birds travelling in a generally southerly direction to land.

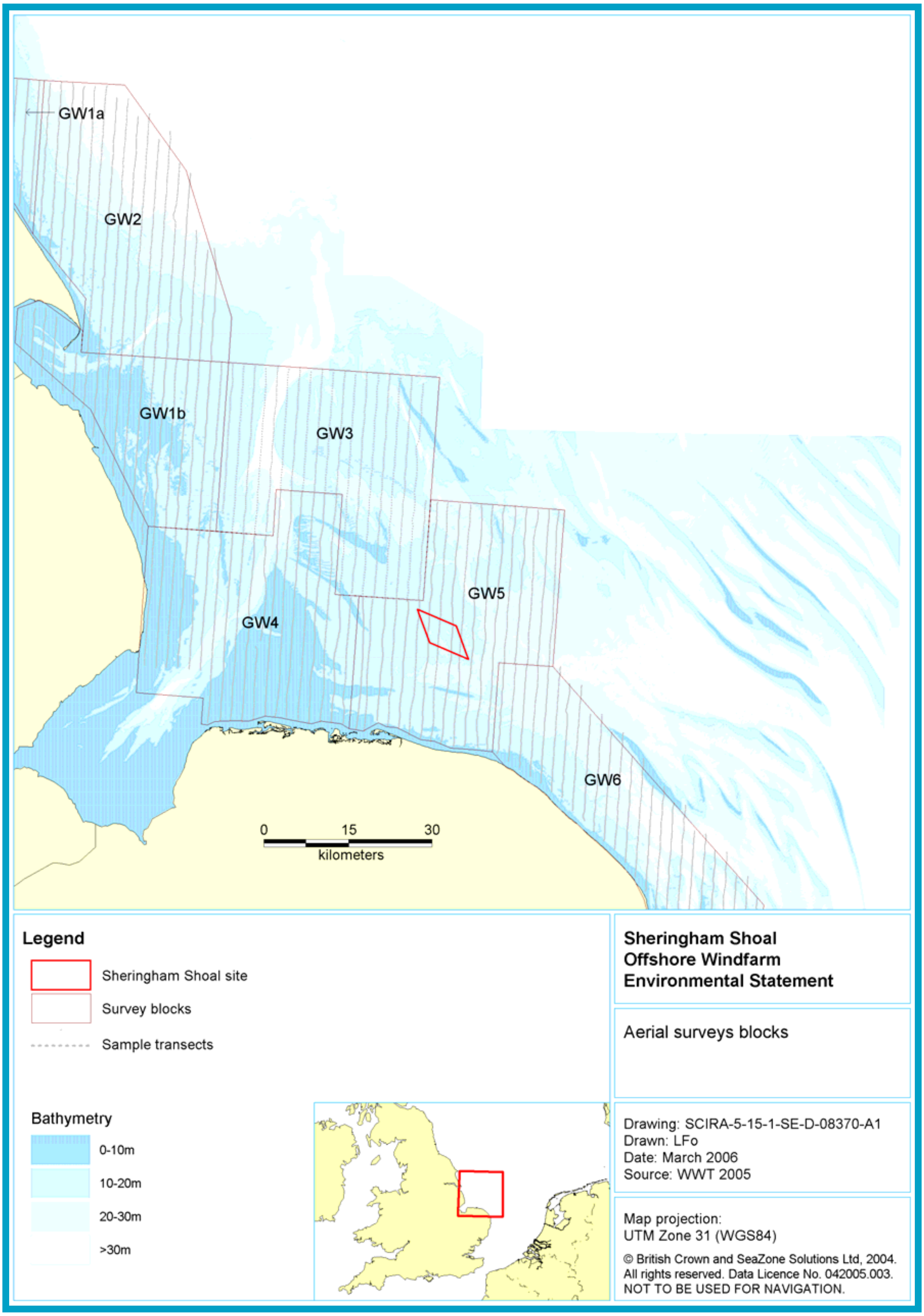


Figure 8.2 Aerial survey blocks and transect route.

Both the S-band horizontal system (Furuno surveillance antenna FR-2135S-B) and the X-band vertical system was used in 2005 after the restriction of the X-band system by the licensing requirements of the Civil Aviation Authority (CAA) in 2004. The S-band system has a 10cm wavelength, peak pulse power of 30kW, pulse width of 0.3μs, beam width of 25° in the vertical plane and 2.5° in the horizontal plane, covering 360° when rotated. The antenna head was positioned at a height of approximately 4m. The X-band system has a 3cm wavelength, peak pulse power of 25kW, pulse width of 0.07μs, beam width of 20° in the vertical plane and 0. 9° in the horizontal plane. The system scans through a narrow arc to 1.4km but to a height of 3km, allowing birds to be assigned to different height categories relative to turbine height. In 2004, without the use of X-band a worst-case scenario of assuming all birds were at potential strike height of turbines was adopted.

The use of radar to observe bird movements is generally limited to detecting presence or absence of individuals or flocks, with only occasional identification of groups/species inferred by range (correlated with size) and speed. By carrying out simultaneous visual observations however, inferences can be made regarding the nature of the bird assemblages present, during daylight hours. Whilst visual observation cannot 'see' the same number of targets detected by radar, it does provide information on species composition.

Although radar tracks were detected at up to 11km during the study, only the highest quality targets (large individual birds such as large gulls, Gannet and geese and flocks of >50 individuals of thrush-sized passerines) could be detected at >7km. Individual passerines were detected at <4km, corresponding to the distance of the bulk of movements recorded offshore.

8.2.4 Data Analysis

8.2.4.1 Population size and density estimation from boat surveys

In boat-based surveys, estimates of population size for each species were derived by multiplying the density of individuals (ind. km^{-2}) by the area of the boat survey area or site and buffer alone. The density of any species was determined by adding together the calculated density of the two different components of the population – individuals in flight and those on the water – using only birds 'in transect' (birds in bands A-D). The transect area was $52.79km^2$ (i.e. 43% of the survey area).

Snapshots were used to calculate the density of birds in flight i.e. number of birds in c.200 snapshots divided by area ($300m^2$ x 2 for a 180° scan x c.200 snapshots). The standard protocol assumes all individuals of even the smallest species are seen at a distance of up to 300m (bands A-D). For birds on the water, the reducing detectability of birds at increasing distance from the observer was taken into account by assuming that the numbers in each 100 m band should be equal, assuming a non-aggregated distribution of birds. To reduce variance and allow correction factors to be calculated for different sea state (detectability of birds reducing with greater wave height) a large data set involving >3,000 observations from a large number of pooled surveys at different sites in the Wash was used. Assuming all birds were seen in band A+B, meaningful correction factors for bands C and D could be calculated for the principal auk species – Guillemot and Razorbill – which dominated the pool of birds on the water surface. At sea states ≥ 2, the proportion of birds that could be seen at >200m was low (2-5%), and to reduce error in population estimation, effective transect width was reduced to 200m (bands A-C) for a total transect area of $35.29km^{-2}$ (i.e. 29% of boat survey area), and correction factors only applied to band C.

For rare species, which either did not occur in transect and/or for which a density could not be derived the number observed was taken as a minimum population estimate.

See Appendix 8.2 for further details.

8.2.4.2 Population size and density estimation from aerial surveys

In aerial surveys estimates of population size for each species were derived according to three different methods of calculating density, namely extrapolation, estimation and distance sampling, which were then multiplied by the area of the survey block to give estimated populations. The survey transect width, measuring 956 m, was divided into 4 bands (Table 8.2).

Table 8.2 Distance bands used for aerial surveys (Source: WWT 2005)

Band	Distance from plane (m)	Width (m)
A	44-163	119
B	163-282	119
C	282-426	144
D	426-1000	574

Population estimation involved calculating density by taking the total number of birds recorded in bands A and B and dividing by the survey area of these two bands, based on the assumption that all birds in bands A and B were seen but a proportion of birds were missed in bands C and D. A distance sampling correction was applied to a limited number of species where sufficient records had been obtained. This used birds in bands A and B, applying a correction factor to the birds in band B derived from the total number of birds recorded in band B (all surveys) divided by the total number of birds recorded in band A (all surveys).

For rare species, which either did not occur in transect and/or for which a density could not be derived, the number observed was taken as a minimum population estimate.

The survey effort of the Port side surveyor and the Starboard side surveyor were handled separately in order to calculate real survey effort and exclude surveyor breaks. A total population of each species was calculated by adding the total for each survey block, although not all blocks were surveyed on each occasion.

See Appendix 8.3 for further details.

8.2.4.3 Population size and density estimation from radar

Radar returns were automatically filtered to remove ‘clutter’ (permanent landscape features) and ‘noise’ (randomly generated returns) by specially developed mathematical algorithms. Therefore, only potential bird targets were recorded onto Microsoft Access databases (one for each 24 hr period). Only bird targets tracked for a minimum of 5 consecutive antenna rotations (i.e. at least 10 seconds) were used to ensure high quality outputs with a clear directional component.

Each track was displayed as a straight-line vector showing length of track and bearing (16 colour-coded divisions in ArcGIS software, allowing interpretation of large-scale migration patterns and flight lines. Tracks were divided according to day/night and time blocks where required.

8.2.5 Significance Level Assessment

8.2.5.1 Conservation importance of the populations

The first step in assessing the significance of any impact is to determine the importance of the subject. For birds, the conservation importance of the population is the currency of evaluation, with the standard use of the 1% criterion as recommended by the Joint Nature Conservation Committee (JNCC). For example, the population of the study area would be *internationally important* if it exceeded 1% of the European flyway population, *nationally important* if it exceeded 1% of the GB population, *regionally important* if it exceeded 1% of the population in the Greater Wash and *locally important* if it exceeded 1% of the population in Norfolk. Every effort was made to use appropriate numbers for either breeding and wintering populations. Typically, the passage population is some derivative of the breeding or wintering population, although some estimates of post-breeding birds (e.g. for auks - Tasker *et al*. 1987) are available and others may be derived by the known population in particular months of the year when birds are on passage (see *Important Bird Areas for Seabirds in the North Sea* - Skov *et al*. 1995; *An atlas of seabird distribution in north-west European waters* - Stone *et al*. 1995).

Threshold values for international and national populations were derived from figures presented in BirdLife International (2004), which represents the most up-to-date amalgam of international and national population data. Where necessary, data were also compared with information presented in the extensive data sets of Skov *et al.* (1995) and Stone *et al*. (1995).

Given that no systematic attempt had previously been made to survey seabirds in the Wash, regional population sizes of non-breeding species were derived from the current programme of aerial surveys (see section 8.2.4.2 above) as well as from the western North Sea area of Stone *et al*. (1995), which incorporates the Wash. In the case of the latter, for any species this involved using the density value at the time of year (usually month but occasionally using the highest value within a season) corresponding to the peak use of the Wash by that species as observed in boat-based surveys, multiplying by the Greater Wash survey area of 7000km^2 defined by aerial surveys.

Local population estimates were derived from the *Birds of Norfolk* (Taylor *et al*. 1999) and the systematic recording of birds presented in annual Norfolk Bird & Mammal Reports published by the Norfolk & Norwich Naturalists' Society.

8.2.5.2 Significance categories

Assessment of the ecological significance of the various effects upon a species population relies on defining the sensitivity of the species and the magnitude of any negative effect. These are combined within matrix analyses to derive the level of significance of any impact. This process is based on the Environmental Assessment Regulations (1999) and on the Institute of Environmental Assessment Guidelines (1995). The definitions of sensitivity and magnitude used here (Table 8.3 and Table 8.4) follow those developed by Scottish National Heritage (SNH) and the British Wind Energy Association, BWEA (Percival *et al.* 1999), and which have been used in recent offshore wind developments (e.g. the London Array).

Significance is interpreted as defined in Table 8.6 with the major significance levels implying unacceptable effects possibly requiring changes to the nature of the proposed development. In contrast, moderate significance would imply potentially significant impacts, but which may be alleviated through mitigation. Minor and negligible significance require no action other than best practice in design and implementation. The methodology assesses the nature of negative impacts, although neutral or positive impacts may be included within the minor and negligible categories.

The sensitivity of the species was as defined in Table 8.3. The magnitude of an effect was defined using an adaptation of Table 8.4, e.g. using the percentage of birds seen feeding in the wind farm as a measure of the number of birds that would be displaced from important habitat. The magnitude and sensitivity were combined using the matrix in Table 8.5 to define the significance level and interpreted as in Table 8.6.

Table 8.3 Definition of terms relating to the sensitivity of the ornithological components (species) of the proposed site.

Sensitivity	Definition
Very High	Cited interest of SPAs, SACs and SSSIs. Cited means mentioned in the citation text for the site as a species for which the site is designated (SPAs/SACs) or notified (SSSIs).
High	Other species that contribute to the integrity of an SPA or SSSI. An impact on a local population of more than 1% of the national population of a species. An impact on ecologically sensitive species (e.g. large birds of prey or rare birds - <300 breeding pairs in the UK).
Medium	Regionally important population of a species, either because of population size or distributional context. EU Birds Directive Annex 1, EU Habitats Directive priority habitat/species and/or W&C Act Schedule 1 species (if not covered above). UK BAP priority species (if not covered above).
Low	Any other species of conservation interest (e.g. species listed on the Birds of Conservation Concern not covered above).

Table 8.4 Definition of terms relating to the magnitude of an effect upon the ornithological components (species) of the proposed site.

Magnitude	Definition
Very High	Total loss or very major alteration to key elements/ features of the baseline conditions such that post development character/composition/ attributes will be fundamentally changed and may be lost from the site altogether. Guide: >80% of population/habitat lost
High	Major alteration to key elements/ features of the baseline (pre-development) conditions such that post development character/composition/attributes will be fundamentally changed. Guide: 20-80% of population/habitat lost
Medium	Loss or alteration to one or more key elements/features of the baseline conditions such that post development character/composition/attributes of baseline will be partially changed. Guide: 5-20% of population/habitat lost
Low	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible but underlying character/composition/ attributes of baseline condition will be similar to pre-development circumstances/patterns. Guide: 1-5% of population/habitat lost
Negligible	Very slight change from baseline condition. Change barely distinguishable, approximating to the 'no change' situation. Guide: <1% of population/habitat lost

Table 8.5 Matrix of magnitude of effect and sensitivity used to assess the level of significance of each contribution. Shaded cells indicate impacts of some or serious concern (as defined in Table 8.6).

		Sensitivity			
		Very High	High	Medium	Low
Magnitude	Very High	Major	Major	Major	Moderate
	High	Major	Major	Moderate	Minor
	Medium	Major	Moderate	Minor	Minor
	Low	Moderate	Minor	Minor	Negligible
	Negligible	Minor	Negligible	Negligible	Negligible

Table 8.6 Interpretation of significance categories.	
Impact	Definition
Major	The impact on birds gives rise to serious concern and should be considered unacceptable.
Moderate	The impact on birds gives rise to some concern but it is likely to be tolerable (depending upon its scale and duration).
Minor	The impact on birds is undesirable but of limited concern.
Negligible	The impact on birds is not of concern.

8.3 Description of the existing environment

8.3.1 Avian assemblage & important species

8.3.1.1 Boat-based surveys

A total of 6,125 individuals of 61 identified species were recorded from boat-based surveys over the study period (Table 8.7). In addition, ten non-specific taxa of varying levels of identification were recorded. For example, ‘Large gull sp.’ and ‘Small gull sp.’ were recorded where birds were at great distance or seen only fleetingly.

True seabirds were strongly represented, with, for example, all four possible Northern hemisphere skuas, all four auks likely to be encountered in the North Sea and all seven UK breeding gull species amongst the species recorded. A range of groups apart from true seabirds and those typically spending a part of their annual life cycle at sea were also represented. These included a range of waterfowl and waders at least associated with wetland or coastal habitats, and a range of land birds such as passerines and a raptor (Kestrel *Falco tinnunculus*), as well as aerial species such as Swallow *Hirundo rustica* and Swifts.

Over 500 individuals of four species were seen: Guillemot (1191 ind.), Sandwich Tern (746 ind.), Razorbill (743 ind.) and Gannet (583 ind.). Between 100-500 individuals of Kittiwake, Fulmar *Fulmarus glacialis*, Lesser Black-backed Gull, Common Tern, Great Black-backed Gull, Little Gull *Larus minutus*, Common Gull, Starling *Sturnus vulgaris* and unidentified auk were recorded.

Overall, the density of birds in the study area fluctuated greatly, from just 0.30 ind. km^{-2} in late June 2004 to a peak of 22.15 ind. km^{-2} in October 2004. Seasonal peaks were seen in mid-October in both years, driven by the presence of auks (Guillemot and Razorbill), with lesser peaks in early July 2004 and mid-August 2005, both caused by Guillemot. The peak densities seen in October are in line with that expected in the Western North Sea (22.45 ind. km^{-2}) for the same month, but are generally lower than would be expected for the rest of the year (Stone *et al.* 1995).

Table 8.7 Total number observed (sum of all 29 surveys), maximum density (individuals km^{-2}), and estimated maximum population size (number of individuals) of all bird species in both the wind farm (with 1.5km buffer) and overall boat survey area. The conservation importance (defined in section 8.2.5.1) of populations in the wind farm and the boat survey area in a national (N), regional (R), and Local (L) context are shown.

Species	Total number	Maximum density		Maximum population size		Conservation importance	
		Wind farm + buffer	Boat survey area	Wind farm + buffer	Boat survey area	Wind farm + buffer	Boat survey area
Red-throated Diver	20	0.07	0.05	6	6	L	L
Diver spp.	5	0	0	3*	3*	-	-
Fulmar	404	0.32	0.21	28	26	L	L
Manx Shearwater	5	0.03	0.02	3	2	-	-
Sooty Shearwater	3	0.04	0.03	4	4	L	L
Storm Petrel	3	0	0	2*	2*	L	L
Leach's Petrel	1	0	0	1*	1*	L	L
Gannet	583	1.21	1.09	107	134	R	R
Cormorant	2	0	0	2*	2*	-	-
Grey Heron	4	0.17	0.12	15	14	-	-
Brent Goose	5	0	0	5*	5*	-	-
Pintail	1	0	0	1*	1*	-	-
Eider	5	0.08	0.06	7	7	-	-
Common Scoter	77	0.03	0.23	3	28	-	-
Duck spp.	55	0.33	0.23	29	28	-	-
Kestrel	1	0	0.02	0	1*	-	-
Grey Plover	1	0	0	1*	1*	-	-
Lapwing	11	0.41	0.29	37	36	-	-
Dunlin	3	0	0	2*	2*	-	-
Bar-tailed Godwit	2	0	0	2*	2*	-	-
Whimbrel	1	0	0	1*	1*	-	-
Curlew	1	0.04	0.03	4	4	-	-
Redshank	2	0	0	2*	2*	-	-
Green Sandpiper	2	0	0	2*	2*	-	-
Turnstone	1	0	0	1*	1*	-	-

Table 8.7 Total number observed (sum of all 29 surveys), maximum density (individuals km^{-2}), and estimated maximum population size (number of individuals) of all bird species in both the wind farm (with 1.5km buffer) and overall boat survey area. The conservation importance (defined in section 8.2.5.1) of populations in the wind farm and the boat survey area in a national (N), regional (R), and Local (L) context are shown.

Species	Total number	Maximum density		Maximum population size		Conservation importance	
		Wind farm + buffer	Boat survey area	Wind farm + buffer	Boat survey area	Wind farm + buffer	Boat survey area
Wader spp.	2	0	0	2*	2*	-	-
Pomarine Skua	1	0	0	1*	1*	L	L
Arctic Skua	37	0.12	0.15	11	18	L	L
Long-tailed Skua	1	0	0	1*	1*	L	L
Great Skua	19	0.14	0.1	12	12	-	-
Skua spp.	2	0.03	0.02	2	2	-	-
Mediterranean Gull	1	0	0	1*	1*	L	L
Little Gull	170	1.16	1.3	103	160	R/N	N
Black-headed Gull	96	0.15	0.27	14	33	-	-
Common Gull	148	0.33	0.27	30	33	-	-
Lesser Black-backed Gull	286	0.73	0.58	64	72	R	R
Herring Gull	78	0.21	0.18	19	22	-	-
Great Black-backed Gull	178	0.18	0.19	16	24	L	L
Kittiwake	412	0.77	1.02	69	127	L	L
Small Gull sp.	2	0	0	1*	1*	-	-
Large Gull sp.	82	0.14	0.1	13	12	-	-
Sandwich Tern	746	0.3	0.72	27	89		R
Common Tern	244	0.57	0.77	51	95	R	R
Arctic Tern	1	0	0	1*	1*	L	L
Tern sp.	24	0.12	0.09	11	11	-	-
Guillemot	1191	10.7**	8.9**	1105**	949**	R	R
Razorbill	743	12.5**	13.7**	1690**	1113**	R/N	R/N
Little Auk	1	0	0.02	0	1*	-	-
Puffin	30	0.27	0.25	24	30	L	L
Auk spp.	135	0.3	0.27	27	33	-	-

Table 8.7 Total number observed (sum of all 29 surveys), maximum density (individuals km^{-2}), and estimated maximum population size (number of individuals) of all bird species in both the wind farm (with 1.5km buffer) and overall boat survey area. The conservation importance (defined in section 8.2.5.1) of populations in the wind farm and the boat survey area in a national (N), regional (R), and Local (L) context are shown.

Species	Total number	Maximum density		Maximum population size		Conservation importance	
		Wind farm + buffer	Boat survey area	Wind farm + buffer	Boat survey area	Wind farm + buffer	Boat survey area
Feral Pigeon	5	0	0	2*	2*	-	-
Collared Dove	1	0	0.02	0	1*	-	-
Short-eared Owl	1	0	0	1*	1*	-	-
Swift	77	0.18	0.12	16	15	-	-
Skylark	2	0	0	1*	1*	-	-
Swallow	3	0.03	0.02	3	2	-	-
House Martin	6	0	0	5*	5*	-	-
Meadow Pipit	28	0.16	0.16	14	20	-	-
Pied Wagtail	1	0	0	1*	1*	-	-
Robin	1	0	0	1*	1*	-	-
Wheatear	1	0	0	1*	1*	-	-
Blackbird	14	0.08	0.06	7	7	-	-
Fieldfare	2	0	0	2*	2*	-	-
Song Thrush	16	0	0.06	0	14*	-	-
Mistle Thrush	1	0	0	1*	1*	-	-
Thrush spp.	13	0	0	13*	13*		
Goldcrest	1	0	0	1*	1*	-	-
Starling	117	1.05	0.72	94	89	-	-
Chaffinch	1	0	0	1*	1*	-	-
Crossbill	2	0	0	2*	2*	L	L
Passerine spp.	4	0	0	3*	3*	-	-
Total	6125						

* Denotes maximum number of birds observed where the population estimate derived from density values would otherwise be zero.

** Derived using distance sampling correction factors.

8.3.1.2 Radar

In total, 29,023 bird movements were recorded in October 2004 (Parnell *et al.* 2004) with 104,920 movements in September 2005 (Parnell *et al.* 2005). The inter-annual difference appeared to be caused by a greater number of passage birds in September compared to October. Migration in 2005 was most obvious on a broad westerly front (SW to NW) whereas in 2004 it occurred in two distinct directions, southerly (1.3% of all movements) and westerly (25%).

In 2005, clear peaks in bird movement were seen at dawn (flying east) and dusk (flying west). Visual observations recorded these movements as comprising over 80% of mixed gull species, the majority of which were seen within 1km offshore. In both years, nocturnal migration was evident, peaking between 22:00 and 04:00. The short range of detection achieved at night indicates these birds were passerines (being smaller they are harder to detect). In 2005, more bird movements were observed during the day than at night, whereas in 2004, 50.9% of movements were recorded at night, and 49.1% during the day. Annual variation has been observed elsewhere; for example, at Horns Rev, nocturnal migration was greater than diurnal in 2003, but in 2004 the tracks were recorded almost equally day and night (Christensen *et al.* 2004, Christensen & Hounisen 2005).

In 2005, flight heights of birds were categorised into bands from 0 to 3000 m. Whilst not directly comparable to the height bands used for boat-based surveys, the results could be grouped into 0-20 m (approx. 8.5% of all observations); 20-100m (approx. 7%); 100-250 m (approx. 17%); and > 250 m (approx. 67.5%) (Parnell *et al.* 2004 & 2005). There were no subdivisions of height in the band 100-250 m, so it is not known what proportion of birds detected at this height would be flying within the potential strike zone of the turbines (20–120 m), although it is likely that he bulk of bird movements were well above potential turbine height.

The radar surveys were supported by visual observations carried out from the same location, during daylight hours when the radar was in operation. In 2004, 7,223 birds of 35 species were recorded, dominated by Pink-footed Goose (4,900 ind. – 67.8%) and Black-headed Gull *Larus ridibundus* (1,224 ind. – 17%). In 2005, 19,827 ind. of 52 species were observed, dominated by seabirds (83.6% of observations). Gulls contributed 80.5%, driven by a large number of Black-headed Gulls (12,213 ind. – 61.5%). The next most abundant group was waterfowl, accounting for only 13.8% of observations, of which Pink-footed geese dominated (2,473 ind. – 12.5% of all individuals). Notably, only 96 (1.8% of all birds) Black-headed Gulls were recorded in boat-based surveys within the study area.

8.3.2 Species/Groups of potential concern

8.3.2.1 Key species recorded in boat-based surveys

Boat-based surveys recorded a number of notable species within the study area, which fall into certain categories of conservation importance, based on calculated threshold population level (see 8.2.5.1 above). These included two species with nationally important populations on at least one occasion, and five species of regional importance. The former group comprised Little Gull and Razorbill and the latter group comprised Common and Sandwich Tern, Gannet, Guillemot and Lesser Black-backed Gull.

When sensitivity matrix analysis (see Table 8.3 above) is applied to assess the significance level of impacts of the proposed development, Common and Sandwich Tern are classified as *very high* sensitivity whereas Little Gull and Razorbill are defined as *high* sensitivity and Guillemot, Gannet and Lesser Black-backed Gull are defined as *medium* sensitivity. Further detailed analysis of these species, population size, activity on the site and significance of impacts is carried out in sections 8.3, 8.3.6.1 and 8.5 below. The key species are summarized in Table 8.8.

Table 8.8 Key species recorded in boat-based surveys.

Species	Apparent conservation importance (see text)	Sensitivity
Sandwich Tern	Regional	Very high
Common Tern	Regional	Very high
Razorbill	Regional/National	High
Guillemot	Regional	Medium
Gannet	Regional	Medium
Little Gull	Regional/National	High
Lesser Black-backed Gull	Regional	Medium

The fact that tern and auk species were classified as being of *very high* and *high* sensitivity complies with the key concerns raised in the Scoping report, with the possibility of reduced productivity of internationally important tern colonies due to disturbance of feeding areas, and the possible disturbance of post breeding auks.

8.3.2.2 Other species recorded in boat-based surveys

Breeding seabirds

Fulmars reached a peak estimated population of 85 ind. within the boat survey area in late May 2004. The local breeding population comprises 74 pairs with additional non-breeding birds present in the area throughout the year (NNNS, 2004). Whilst the proportion of birds seen within the study area clearly exceeds the 1% threshold for local or even regional importance (2 ind. and 3 ind. respectively), this pales into insignificance on a national basis where the 1% threshold lies at 10,120 ind. The breeding birds around the Wash are not a significant constituent of the UK breeding population.

Post-breeding seabirds

Common Scoter were identified in the Scoping Report as being of particular relevance to the proposed Sheringham Shoal site. However, there were only four records of this species during the survey period, and never in numbers that reached even local importance levels (1% threshold = 95 ind. based on maximum local counts, NNNS 2004). Two records on consecutive surveys in July 2005, of 41 ind. in total, are most probably of immature birds that are known to spend the summer off the Norfolk coast (Taylor *et al.* 1999). They generally favour areas to the western side of the Wash, and all 41 ind. were flying either S (4 ind.), SW (4ind.) or W (33 ind.), and hence none of these birds were using the boat survey area as a moulting site. The two separate records of 15 ind. in each of August and September 2004 are likely to be post-breeding birds returning to the Wash area from Scandinavian breeding grounds. Of these, all were recorded flying, 16 ind. west and 14 ind. south, and again not using the study area for post-breeding moult. A small group of six ind. (two males and four females) was seen flying west in November 2005, presumably towards the areas known to support over-wintering flocks (e.g. Holkham Bay, Scolt Head, and Titchwell). Overall, there is no evidence that the over-wintering population of Common Scoter in the Wash (NNNS 2004) regularly use or even cross the proposed site.

A total of five Eider were recorded within the boat survey area, and as all were observed in flight, there was no evidence of this species using the study area for post-breeding moult.

Migrant seabirds

A number of migrant seabirds were recorded in the boat-based surveys in small numbers, occasionally in locally notable numbers. One Arctic Tern was recorded in September 2004, three Sooty Shearwaters in August and September 2005, three Storm Petrels in September 2004 and November 2005 and a single Leach's Petrel in August 2005. A total of 30 Puffins were seen, most over-wintering in the area, and a single Little Auk was observed in late January 2005.

All four Skua species regularly seen in the UK were recorded in the study area. Arctic Skua was the most numerous with 37 individuals recorded in total, with a peak of 10 ind. in July 2004, in line with observations for July from the north Norfolk coast (e.g. 10 at Sheringham 8th July 2004, NNNS 2004). Nineteen Great Skuas were seen in total, generally between July and November, and single records of Pomarine and Long-tailed Skua were made.

A single observation of one unaged Mediterranean Gull on the additional Sheringham Shoal control transect on 28th July 2005 could constitute an immature and scarce migrant bird, or one of the few breeding adult birds (6 pairs in 2004, NNNS 2004) from the breeding sites on the Norfolk coast.

Migrant passerines and land birds

During the 29 boat-based surveys a total of 285 individuals of 21 species of land birds were identified with an additional four unidentified passerines and 13 Thrush spp. Of these, the only species with maximum counts >20 ind. were Swift and Starling. The Swift peak, in late June 2004 (49 ind.) is likely to consist of individuals that are breeding on the coast, and foraging over the boat survey area, on a broad NW–W–SW flight line.

The majority of Starlings recorded (96%) were flying in a southerly direction (35% flying southwest) in November 2004 and October 2005. This is consistent with protracted autumn passage, when large numbers are seen west along the north Norfolk coast (e.g. 2,200 at Sheringham October 2004) and south at Hunstanton (e.g. 6,133 in October 2004, NNNS 2004). The maximum estimated population in the boat survey area for this species was 89 ind. which is insignificant in the context of these large scale protracted passage movements, or even when taken into context with the number of movements observed by radar tracking (see 8.3.2.2 below).

One unusual observation of a land bird was made when two Crossbills (*Loxia curvirostra*) landed on board the survey vessel on July 4th 2005, both in intermediate plumage. Whilst scarce, it is not unusual for small numbers of Crossbill to be seen coming in off the sea at Sheringham (e.g. 5 on both 1st and 8th July 2004, NNNS 2004). It is likely that the two individuals were immigrating immature birds from breeding grounds to the north, as there were no confirmed breeding birds in Norfolk in that year (NNNS 2004).

Migrant waterbirds and waders

Small numbers of migrant waders and other waterbirds were observed through the survey period. Pink-footed Geese were notable by their complete absence within the study and it would appear that the large over-wintering population in north Norfolk do not routinely cross the proposed wind farm site. This is corroborated by the radar surveys, which show far greater numbers of Pink-footed geese in inshore waters, the majority flying parallel to the coastline. Only very small numbers of migrant ducks were recorded, including unidentified ducks (total 55 ind. all in flight) and one adult male Pintail *Anas acuta* in March 2005, flying north.

A total of 26 individual waders were recorded over all surveys, the only notable count of 11 Lapwing on July 4th 2005, 10 of which were flying SW within the potential strike zone of the turbines (20–120 m above sea surface). Lapwing are considered to be highly manoeuvrable and not at risk from collision with structures such as turbines.

The lack of numbers of waders and waterbirds crossing the boat survey area suggest that the proposed site is not part of an important migration route for these species. This must be taken into context with radar observations, which show far more movements than visual observations will record. For example, in 2004, 7,223 visual records of birds made were in daylight from Weybourne, when 14,250 radar tracks were recorded in the same period (Parnell *et al.* 2004). However, even if the observations of migrating waders and waterbirds are subject to this scaling, the study area does still not appear an important flyway for these migrating species.

Wintering seabirds

The only diver species recorded within the study area on boat-based surveys was Red-throated Diver, and this only in low numbers with a maximum peak population estimate of only 6 ind. This is very low compared with the maximum estimated population of divers in aerial surveys (the majority of which will be Red-throated) of almost 1,400 wintering in the Greater Wash (resulting in a regionally important population of 14 ind. at peak). A maximum of 114 in the GW5 area were recorded in aerial surveys. Indeed, although only around 80–100 birds are thought to over-winter in the Wash (Brown & Grice 2005), monthly day counts in excess of 120 are regularly made from the north Norfolk coast between November and March (NNNS 2004), suggesting some movement throughout the winter period. Whilst the peak population estimate for the proposed site may confer local importance, it does not reach the threshold of regional importance in the context of the wider Wash, based on the numbers observed during the aerial surveys. Additionally, the aerial surveys showed concentrations of divers in two main areas to the west of the Wind farm study area: 1) a zone north of the consented Lynn & Inner Dowsing site and 2) the coastal waters offshore from Scolt Head and Blakeney. The aerial surveys actually recorded no divers within the wind farm site itself.

8.3.2.3 Species/groups recorded in radar studies

Pink-footed Geese

During both radar surveys, large numbers of Pink-footed Geese were seen. In 2004, 4900 ind. were recorded, of which 2,500 (51%) were flying east, 1,550 (32%) west, 700 (14%) north and 150 (3%) south, all at a height of 120m, and within 5.6km of the shore. Following a similar trend, in 2005, of the 2473 ind. seen, 44% (1,093 ind.) were flying east, 30% (640 ind.) west and 26% (640 ind.) south. In 2005, the mean flight height was 72 m (max = 200 m, min = 50m).

Over-wintering Pink-footed Geese are a qualifying species of the both the Wash SPA (with 33,265 individuals representing at least 14.8% of the wintering Eastern Greenland/Iceland/UK population) and the North Norfolk SPA (where 23,802 individuals represent at least 10.6% of the same population www.jncc.gov.uk). The counts on which these designations are based (5 year mean peak from 1991/2 to 1995/6) are now rather outdated as recent coordinated counts in 2004 for three major North Norfolk roosts totalled >137,000 individuals in December (Norfolk Bird & Mammal Report 2004).

It would appear that there has been a massive increase in the Pink-footed Goose population in Norfolk in the last few decades. This may account for the discrepancy in the numbers of birds seen in radar studies and the status of Pink-footed Geese in *The Birds of Sheringham* (Taylor 1987). The author comments that *"[Pink-footed goose] is an irregular passage migrant recorded in small numbers. The majority of records have involved small parties flying along the coast between December and March)*" and gives the maximum count (from Sheringham) in 1965 as 200 ind. flying west. However, the numbers observed visually through the radar surveys are comparable with recent observations of movements along the North Norfolk coast, as birds move from roosting areas to feeding sites. For example, almost daily movements of birds between the populations in the northwest and east of Norfolk are seen, peaking at 5,200 birds flying east at Sheringham in October 2004.

Although the migration routes taken by Pink-footed Geese are not completely understood, birds from Iceland and Greenland arrive in the UK in early or mid-September, with numbers increasing up to mid-October. Some birds head straight to North Norfolk, whereas ringing recoveries indicate others land further north in Lancashire, dispersing to eastern England in mid-winter

(Wernham *et al.* 2002). Both direct routes from Iceland or staging posts within Britain would not be expected to cross the Sheringham Shoal proposed wind farm.

The general direction of Pink-footed geese observed would suggest that birds seen are undertaking movements between roosts, or to and from feeding areas, and the vast majority of birds are flying along the coast, presumably using it as a reference. Again, there is no suggestion that the birds would have cause to cross the proposed wind farm area. Even the birds on southward flight paths are likely to be flying inland to feeding sites away from the north Norfolk coast, such as the Heigham Holmes area of the Upper Thurne where 6,000 were recorded in November 2004 (NNNS 2004). Alternatively they may have been heading towards the roost at Horsey Mere, where large numbers are present, and 9,256 were recorded in November 2004 (NNNS 2004). With such large numbers of birds present in the Norfolk area throughout the winter period, and the highly mobile nature of this species, (e.g. regularly switching roost sites – Wernham *et al.* 2002 foraging up to 10 km from the roost site – Vickery & Gill 1999) it is not surprising that large flocks were seen from shore based observations at Sheringham. Such numbers were not recorded during the boat-based or aerial surveys, suggesting that this species is very unlikely to occur offshore, but far more likely to be restricted to the inshore waters and across land.

Brent Geese

Brent Geese were only observed during the programme of radar observations in small numbers – 16 ind. in 2004, all flying east at a mean altitude of 48.2 m (max 150 m, min 1 m), with 53 ind. in 2005, all flying west. As only 5 ind. were seen in the study area on boat-based surveys, there is no evidence that their migration route crosses the proposed wind farm, and it is likely that Brent Geese, in a similar pattern to Pink-footed Geese move in more inshore waters, using the coast for guidance, and do not pass through the proposed site.

Seaduck

Very low numbers of seaduck were seen from shore based observations, in close agreement with the small number seen in boat-based surveys (8.3.3.1 above). Two Eider were seen in 2004, flying west at 750 m from the shore and at a height of 20 m, with none recorded in 2005. Twenty-two Common Scoter were recorded in 2004 (7 flying east and 15 west) with this pattern repeated in 2005 with 49 in total (9 east and 40 west). Only one Velvet Scoter was recorded during the radar surveys in 2005, flying west at 1m.

Divers

The only diver species to be recorded from shore was Red-throated Diver, with a total of seven observations in 2004 (six flying east and one flying west), all below 20 m above the sea surface, and 22 birds over 18 separate occasions in 2005 (12 flying east, nine west and one south), again all below 20 m above sea surface.

Terns

As to be expected, more terns were recorded in the 2005 surveys as they were conducted one month earlier than those of 2004. A total of 162 Sandwich Terns were recorded in 2005, in a period when the boat-based surveys recorded no terns the study area. The terns observed were predominantly flying east (75%), indicative of autumn passage birds following the shore. Only 4 Sandwich Terns were seen in 2004. Common Terns were not recorded in 2004, and only 3 ind. seen in 2005, suggesting that the passage of Common Tern had already occurred by the time these surveys were undertaken as on boat-based surveys (8.3.2.1 above). No Roseate or Little Tern were recorded.

Auks

A total of 52 unidentified auks were seen in 2004, all flying east (60%) or west (40%) and more than 1 km from the shore. Guillemot were the only auk species recorded in 2005, with 4 flying west very close to the sea surface.

Waders

Very few waders were recorded in either period of surveying, with a total count of 29 ind. in 2004 and 111 in 2005, and again the majority were flying east (2004–55%, 2005–4.5%) or west (2004–34%, 2005–63%). In 2005, a total of 30 (27%) unidentified waders were recorded flying north. Low numbers of birds tends to confirm the pattern recorded in boat-based surveys and there is no evidence that the Sheringham Shoal site lies on a major migration route.

Passerines

The majority of night time movements in both series of surveys were attributed to passerines, although the visual observations during the day did not detect such a high level of passage. This is perhaps due to difficulties in observing small birds at altitude, and the impossibility of visual observation in darkness. As detected by the radar, passerine migration occurs along the north Norfolk coast in a broad front (5-6km), generally in pulses, moving both westwards along the coast and southwards over land. In 2005, the additional information gained from the X-band radar showed that peak bird movements were consistently at altitudes of approximately 100-1000m, highly suggestive of migratory movement as opposed to commuting flights. This in turn would suggest that the majority of the bird movements are at an altitude that will not be affected by the proposed site, even if the migratory flight paths cross it from Europe. However, the effect of poor weather on migratory passerines may mean that they are forced to fly at lower altitude. This phenomenon was not seen during these radar surveys.

8.3.3 Species of very high sensitivity

8.3.3.1 Sandwich Tern

Status

The global population of Sandwich Tern is estimated to be 160,000–170,000 pairs with a European population of some 69,000–79,000 pairs (Mitchell *et al*. 2004), contributing >50% of the total. With a recent moderate decline in the European population, Sandwich Tern has been evaluated as Depleted and afforded SPEC 2 status[13] (BirdLife International 2004). It is thus of conservation concern in a European context.

The 12,000 pairs in the UK form an important part (15–17%) of the European population. These birds are divided between a few large colonies, the most important of which is Scolt Head (4,200

13 In Birdlife International (2004), each of the 524 species assessed is assigned to one of five categories, indicating the conservation status of populations at European level.
SPEC 2: species not of global conservation concern but whose status is unfavourable in Europe in which their population or range is concentrated.

pairs in 2000–Mitchell *et al*. 2004) in Norfolk, which interchanges with the nearby Blakeney Point colony, which has supported from 75 to 4,000 pairs in recent years (Brown & Grice 2005). The Scolt Head/Blakeney colonies support at least 24.7% (5 year mean for 1994–1998) of the British breeding population and 5–6% of the European breeding population. Sandwich Tern is thus one of a number of qualifying species for the North Norfolk Coast SPA (www.jncc.gov.uk). See Figure 8.4 for the location of the breeding colonies.

As a result of small biogeographical population size and high European threat and conservation status Sandwich Tern is perceived to be relatively vulnerable to the impacts of offshore wind farms, scoring highly (ranked 4th of 26 species assessed) (i.e. more vulnerable) in a recent sensitivity assessment (Garthe & Hüppop 2004).

Temporal and spatial use of the study area

In the study area, Sandwich Terns were ubiquitous in surveys between April-September 2004 and April-August 2005 coincident with their presence at the North Norfolk breeding colonies. In 2004, a noticeable peak in numbers was recorded in late May. In 2005, although the highest numbers and densities were achieved in May, a larger number of birds were more consistently recorded, especially in late June and into early July (Appendix 8.2). This inter-annual difference in the use of the study area was conceivably linked to the breeding success of the birds. At the closer Blakeney colony in 2004, few chicks (c.300) were ultimately raised, meaning many adults had no requirement to feed chicks. In contrast, in 2005, three times as many more (c.900) chicks fledged (D. Wood, National Trust, *pers. comm.*) and thus many more adults were actively foraging in the chick-rearing period throughout June and into July. The use of the wind farm and surrounds may therefore be expected to vary between years.

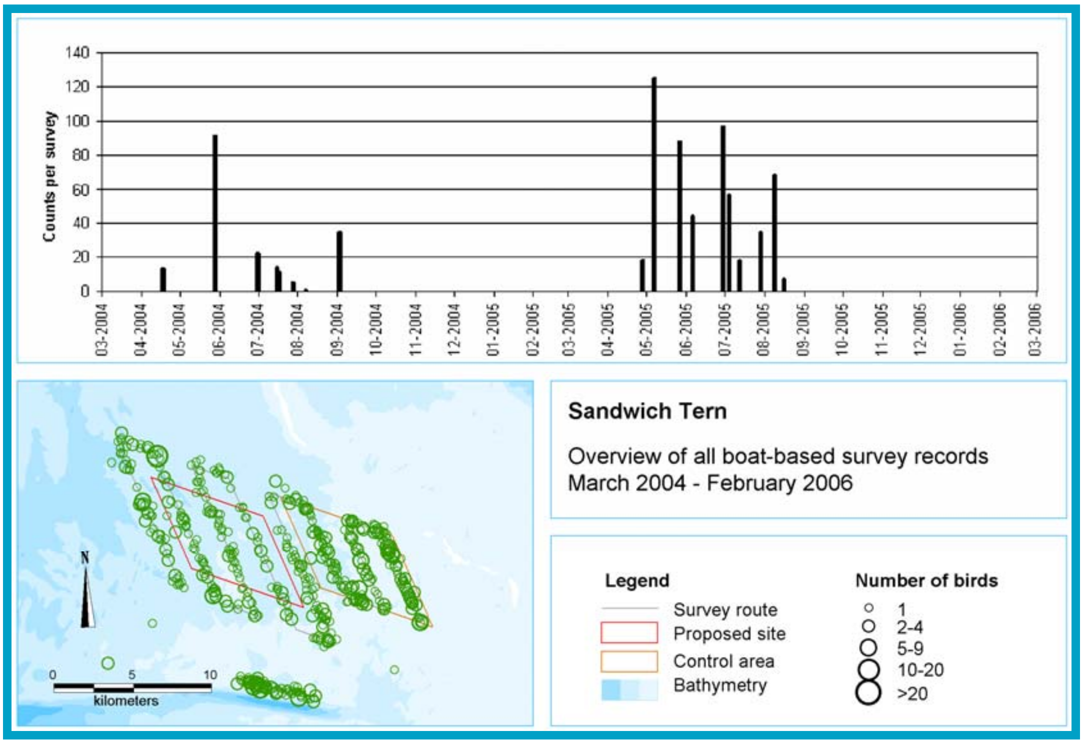


Figure 8.3 Temporal and spatial overview of all boat-based survey records of Sandwich Terns.

Fewer birds were encountered in the proposed site and buffer area than in the control area to the east (Figure 8.3) which is reflected in the lower density estimates in the site and buffer (0.3 ind. km^2, 27 ind.) compared to the boat survey area as a whole (0.72 ind. km^2, 89 ind.), ultimately meaning the numbers of birds present surpassed the 1% regional population criterion in the boat survey area, but not in the site and buffer itself.

Of the 616 birds in the boat survey area for which the flight direction was recorded, the majority were travelling along a NE (27%)/E (16%) and SW (16%) axis, strongly suggesting movement through the site away from, and back to, the colonies. The fact that a relatively small proportion of birds were recorded as feeding (by diving) (3.5%-records from 2005 only) suggests the study area is not a particularly productive fishing ground. Indeed, there is only one record of a tern catching a fish on the site. The fact that half (50%) of feeding observations were recorded on just two occasions in late June and early July 2005 at the end of the chick rearing period, coupled with <1% of birds carrying prey to waiting chicks, reinforces the suggestion that the boat survey does not routinely support an exploitable prey supply in the breeding period.

It appears from the limited data available that the Sheringham Shoal itself, some 5km to the south of the study area offers more suitable foraging habitat for Sandwich Terns than the study area itself. First, a relatively high number of birds were recorded, resulting in a much higher encounter rate (maximum of 42 birds = 8.4 ind. km^{-1}) than the boat survey area (maximum of 125 birds = 1.4 ind. km^{-1}). The magnitude of this difference was not entirely reflected in density estimates, as by chance, relatively few birds appeared in snapshots, although density estimates were still higher (maximum of 2.0 ind. km^{-2}). Second, a greater proportion of birds were recorded as fishing (13%), with a higher, but still low proportion (2%) of birds carrying prey. In contrast to the main study area, the majority of birds were flying SW (37%) and potentially returning to the colonies, although the main axis of flight was very similar with the bulk of the rest of the birds flying E (23%) and N (20%).

Plate 8.2: Sandwich Tern with sandeel, rarely seen at the study area. © Martin Perrow, ECON.

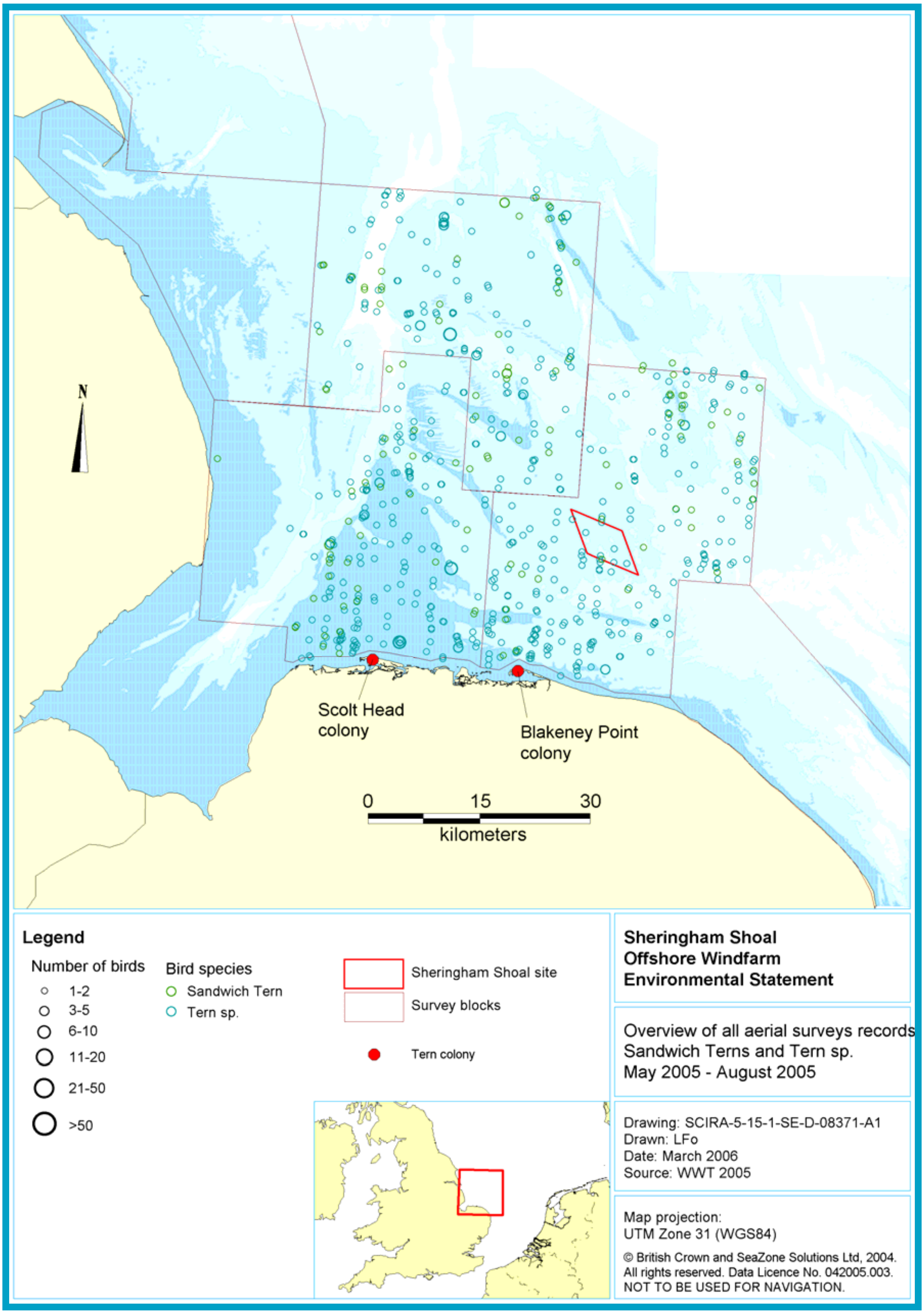


Figure 8.4 The distribution of all the Sandwich Terns and unidentified terns observed during the 3 summer aerial surveys between May 2005 and August 2005.

Whereas aerial surveys provide a reasonable indication of the likely range of foraging birds, any assessment of the relative use and importance of one area compared to another is fraught with difficulty as a result of the low frequency of observations. Some areas may also only be utilised as certain times (e.g. season, state of breeding attempt, time of day and state of tide) according to the availability of their fish prey. Sandwich Terns are likely to use rapid flight (40 km hour^{-1} - Christensen & Hounisen 2005) and wide-ranging behaviour to exploit resources limited in space and time. Thus, it may be difficult to detect even important sites for birds where use may be restricted to very short periods of time, even where this occurs with reasonable frequency.

Nonetheless, aerial surveys do appear to detect a reasonable proportion of the Sandwich Terns likely to be foraging at sea, assuming that 90% of unidentified terns are Sandwich Terns as corresponding to the proportion of Sandwich Terns at the breeding colonies (3,650 pairs of Sandwich Terns cf. 390 pairs of Common Terns). To illustrate, in May 2005, assuming one bird of a pair is tied to the nest, the estimated total of 1,553 Sandwich Terns represents 42% of the birds expected. In June, 1,452 birds represented 40% of the expected population (assuming both parents are not foraging simultaneously). The proportion of birds encountered is thus relatively high given that neither inshore waters (recording was stopped and the plane turned round 1–2 km from the coast) nor the inner Wash to the east (as a result of MOD restrictions) containing potentially more important foraging areas such as Sunk Sands were surveyed. Both the previous work of Allcorn *et al*. (2003) and anecdotal information in Taylor *et al.* (1999) suggests these areas may contain a high proportion of Sandwich terns from the colonies.

Detection of a moderate proportion of birds improves confidence in the patterns of distribution revealed by aerial surveys, which suggest that the Sheringham Shoal area is relatively unimportant (Figure 8.4) within the GW5 survey block, which is also not favoured over the other similar-sized survey blocks (Table 8.9). In general, it appears that Sandwich Terns may be encountered virtually anywhere to the east of the main channel of the Wash (Lynn Deeps) to the limit of the aerial surveys (around 60km from the colonies), with possible centres of activity near the colonies, a SW-NE line along Lynn Deeps from Hunstanton to Triton Knoll and in the NE corner of GW5 at Dudgeon Shoal.

In support of the relative lack of use of the proposed wind farm site, the density and consequent population estimates of birds recorded in the study area during boat surveys were relatively low (maximum of 0.72 ind km^{-2} and 88 individuals) compared to previous estimates of >11.7 ind. km^{-2} for the North Norfolk coast, 9.7 ind. km^{-2} for the Farne Islands and >5 ind. km^{-2} for Voordelta (Netherlands), Scharhörn and Norderoog (Germany/Denmark) and Hirsholmene, all outlined as important areas for Sandwich Tern in the breeding season (April/May) (Skov *et al*. 1995). At peak, the maximum density recorded in the study area was more similar to that for the South and East North Sea in June (0.25 ind. km^{-2}) reported by Stone *et al*. (1995), which may be seen as a general 'background' value.

Table 8.9 Extrapolated population sizes of terns in the aerial survey blocks covering the tern breeding colonies on the North Norfolk Coast in the breeding season. During May and June it was assumed that 90% of unidentified terns were Sandwich terns (see text).

Species	Survey Block								
	GW3			GW4			GW5		
	T5	T6	T7	T5	T6	T7	T5	T6	T7
	May	June	Jul/Aug	May	June	Jul/Aug	May	June	Jul/Aug
Sandwich tern	42	125	113	42	165	9	8	190	0
Common tern	16	12	167	76	35	295	46	45	158
Tern spp.	433	217	227	477	469	185	691	394	65
Total	491	354	507	595	669	489	745	819	223

8.3.3.2 Common Tern

Status

The global breeding population of Common Tern is thought to be 460,000-620,000 pairs, although this is likely to be an underestimate as many Asian birds have not been censussed (Mitchell et al. 2004). Some 270,000-570,000 pairs breed in Europe, accounting for >50% of the global population in <50% of the global breeding range. The Non-SPEC population is regarded as Secure (BirdLife International 2004). With around 10,000 pairs, Britain supports 3-4.5% of the European population and 1.6-2.2% of the World population (Mitchell et al. 2004).

Despite supporting a considerable proportion of the European population, with colonies vulnerable to events such as predation, disturbance and food shortage, Common Tern is not of conservation concern in the UK. Contrary to this, it is included as a qualifying species in the North Norfolk Coast SPA, supporting at least 3.7% (460 pairs - 1996 count) of the British breeding population (www.jncc.gov.uk).

Temporal and spatial use of the study area

Common Terns were consistently recorded from May-September in the study area in both years. The numbers of birds were generally so small (1-15 ind.) to mean density estimates could often (79% of occasions) not be calculated and if so, were very low (<0.03 ind. km^{-2}). This suggests very limited use of the site during the breeding season of the small (390 pairs in 2005 – D. Wood, M. Rooney *pers comm.*) breeding population at Blakeney Point and Scolt Head.

An estimated peak population of 95 birds (191 birds were actually seen[14] contributing 78% of all records – see Figure 8.5) in the boat survey area (0.77 ind. km^{-2}) in mid-August 2005 was clearly exceptional and is indicative of post breeding dispersal. It seems unlikely that the birds seen at this time originate entirely from the Scolt Head and Blakeney breeding population as this would represent some 25% of adult population and 27% of the juveniles fledged (3 juveniles seen cf. 11 fledged from Scolt and Blakeney in 2005 (D. Wood, M. Rooney *pers comm.*). It seems more likely that many of the Common Terns seen at this time were birds on passage from coastal colonies further North such as the large colony on Coquet Island in Northumberland, or even perhaps inland breeding birds. Further indication that there were birds on passage was the occurrence of the majority (64%) of birds in groups/flocks (3-23 ind.). Moreover, 14% of birds

[14] The discrepancy between the estimated population and the numbers of birds observed may be explained by the chance lack of flocks in snapshots as well as circling birds being recorded on several occasions during the survey but not in snapshots.

were recorded on the water, 93% of which were within two flocks of 10 and 15 ind. Of the 86% of flying birds, the majority had no clear direction (48%), indicating a lack of dedicated passage, but a more casual dispersal, with some birds resting on the surface.

Birds were not recorded on the surface at any other time and thus overall, 88% of birds were recorded in flight. The great majority of these, 84%, were recorded at <20m above sea surface and below the height of the prospective turbines, with 16% between 20-120m, within the potential strike zone.

Overall, the large numbers of birds in the mid-August 2005 survey, influence the patterns of flight direction with 39% of birds recorded circling. This apart, the prevailing flight directions were NE (28%) in the direction of Dudgeon Shoal, and E (11%), and thus consistent with the pattern displayed by Sandwich Terns (see 8.3.3.1 above). Also, similar to Sandwich Terns, was the small proportion (6%) of birds seen actively feeding (13 ind.) or carrying fish (1 ind.). The final shared feature with Sandwich Terns was the tendency of Common Terns to occur in the control rather than the proposed site (Figure 8.6). This was not the case in mid-August 2005 however, with a relatively high density (0.57 ind. km^{-2}) of Common terns within the site and buffer.

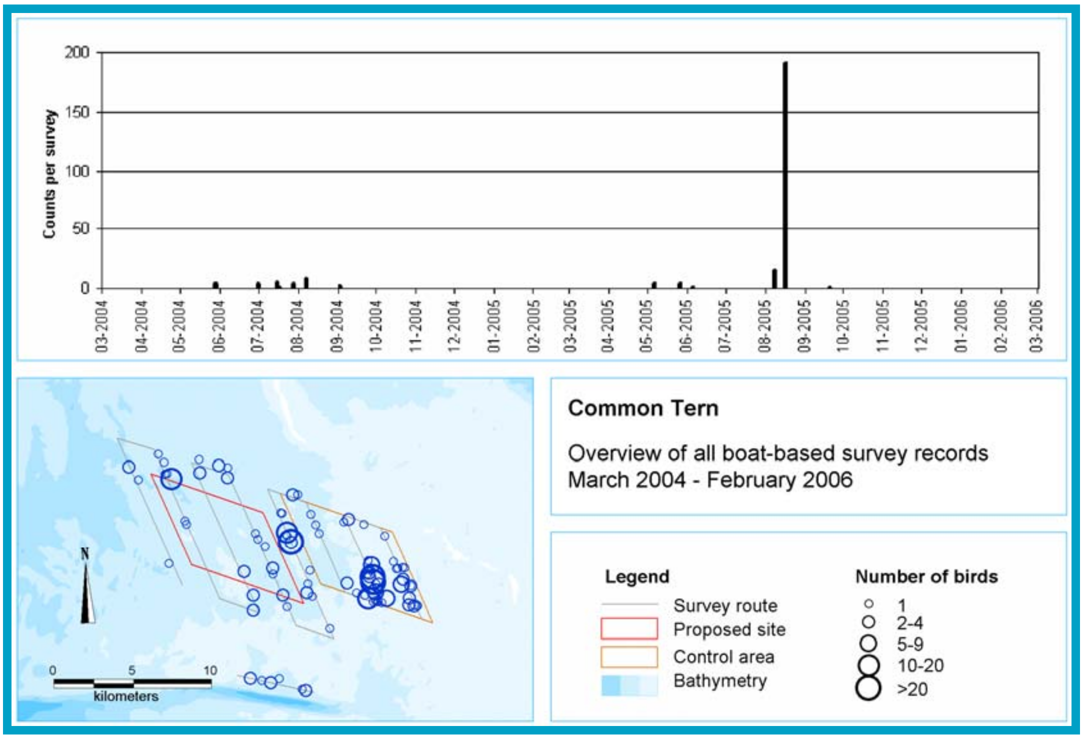


Figure 8.5 Temporal and spatial overview of all boat-based survey records of Common Terns.

Relative importance of the study area and site

As to be expected from a small breeding population, the aerial surveys in May and June 2005 detected relatively few birds at sea (138 and 92 birds respectively in GW3, GW4 and GW5 combined[15] – Table 8.9). However, as with Sandwich Terns (see 8.3.3.1 above) it appears that a relatively large proportion of the expected population (not accounting for non-breeders or inland breeders foraging at sea) were recorded (35% in May and 24% in June), thereby increasing confidence in the interpretation of the patterns of relative use. In May/June most birds were recorded within 15 km of the colonies at Scolt Head and Blakeney although odd birds were recorded to around 50 km towards Triton Knoll to the N and Dudgeon Shoal to the NE (Figure 8.6). The greater predilection for more inshore waters than Sandwich terns is shown by the preference for GW4 and GW5 compared to GW3 (Table 8.9) and is in agreement with the typical foraging range (Allcorn *et al* 2003). In the July/August survey there is a dichotomy between birds near the colonies and birds far out to sea (Figure 8.7) although it is perhaps too simple to divide between breeding and passage birds respectively.

Plate 8.3: Common Tern. © Martin Perrow, ECON.

[15] not incorporating the small proportion of Common terns likely to be contained within the 'Tern spp.' category

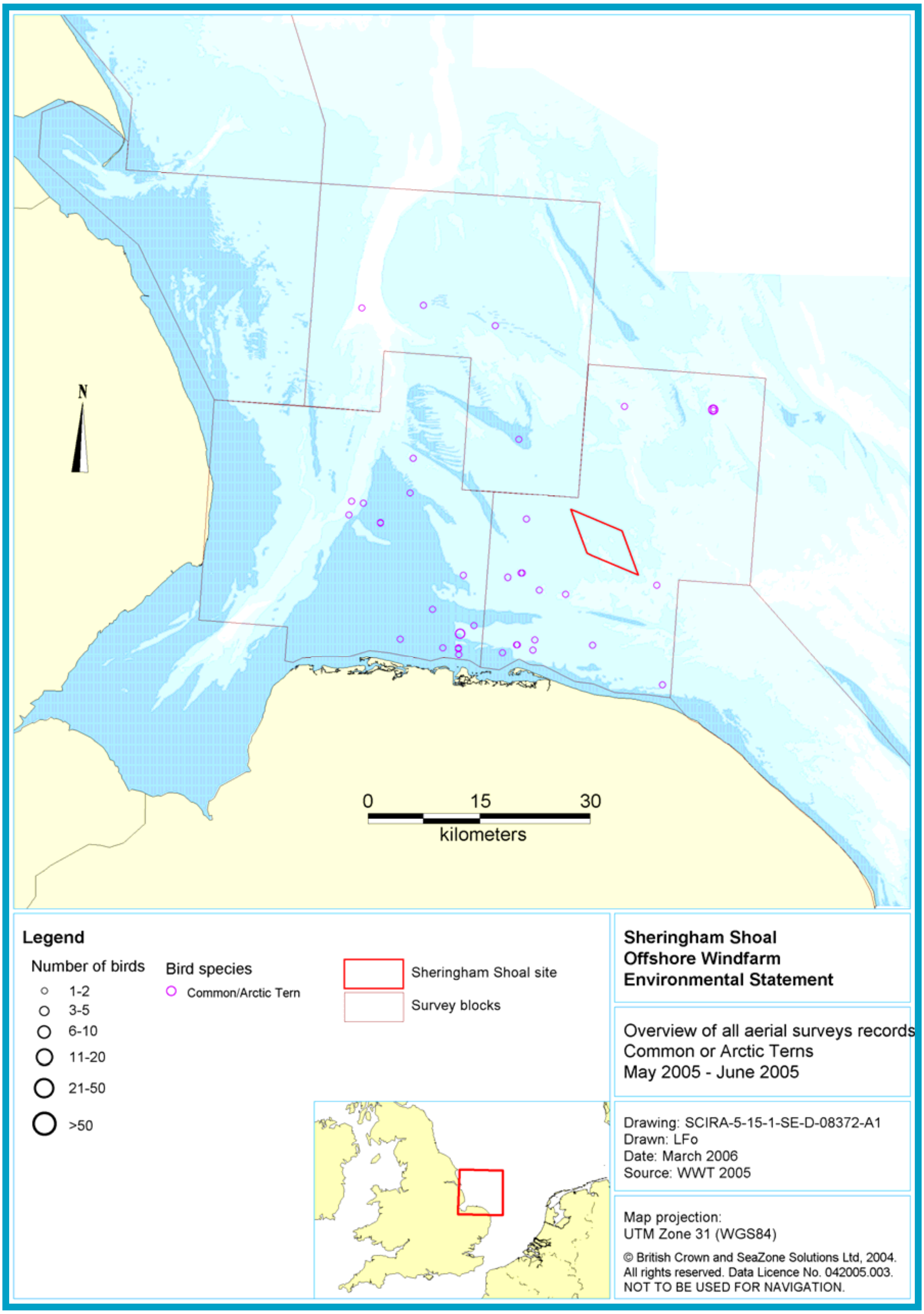


Figure 8.6 The breeding season (May and June surveys) observations of Common Terns from aerial surveys.

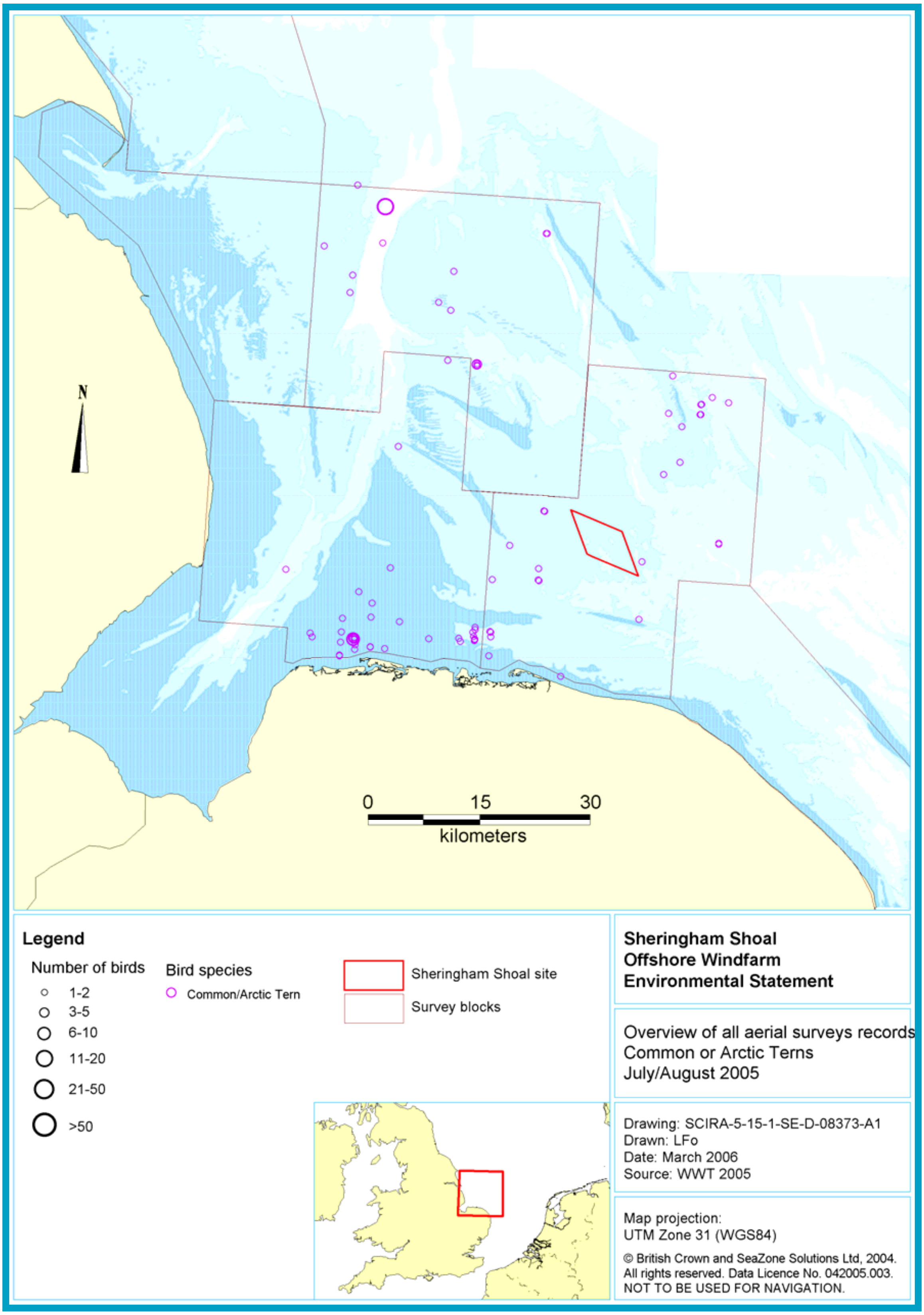


Figure 8.7 The post-fledging season (July/August survey) observations of Common Terns from aerial surveys.

Late summer assemblies of birds on passage near the colonies are not unknown and indeed up to 5,000 birds were recorded annually at Scolt Head in the 1950's (Taylor *et al*. 1999). Whilst these events appear to be a thing of the past, in excess of 500 birds to a maximum of 1,150 were recorded from coastal watch points in the 1990's, and more recently 350 individuals were recorded flying east at Sheringham on 12th August 2004 with a further 340 individuals the following evening (NNNS 2004).

Movements of Common Terns through Norfolk waters of this scale are not unexpected given the presence of >2,500 pairs in large coastal colonies to the north in the UK, which may follow the east coast through the Wash on southward autumn passage to wintering grounds in West and South Africa. There is clearly a mismatch between the numbers potentially present and regional population estimates. For example, the aerial survey in July/August 2005 estimated only 620 ind. in GW3, 4 and 5 combined. In this, there were fewer birds in GW5 than the other areas and an almost complete absence of birds in the wind farm study area itself (Figure 8.7), and yet a population of 95 ind. was recorded in the boat-based survey in the same period. As in the case of Little Gull (see 8.3.4.1 below), Common Terns on southward autumn passage through the Wash may do so on a broad front, with some evidence of a preference for the inshore waters of GW4 as well as far out to sea (Table 8.9, Figure 8.7). Movement is also likely to be relatively rapid with mobile flocks travelling through the area. Whilst movement through the Wash implies that many birds will cross GW5, there is no suggestion that the study area or the wind farm will be preferred compared to any other.

The passage of Common Terns is also likely to vary in intensity between years with peak August daily counts from the north Norfolk coast of 1,950 west at Scolt Head (2001), 385 west at Scolt Head (2002), none of note in August 2003 and 350 east at Sheringham (2004) (from NNNS 2001 – 2004).This is mirrored by the large difference in numbers of Common Terns in the survey area in August with just 8 ind. recorded in 2004 cf. 191 in 2005. Without further information it is difficult to judge whether the number of birds present on the study area on passage in 2005 was exceptional. However, even assuming the worst-case scenario that it was, the density and numbers of birds involved are not particularly high. For example, despite suffering from an underestimate of just 7,500 ind. in the entire North Sea in July-September, Skov *et al*. (1995) recorded densities to 2.75 ind. km^{-2} involving 2,500 birds in the Voordelta and 0.74 ind. km^{-2} involving 2,300 birds in the German Bight.

8.3.4 Species of High Sensitivity

8.3.4.1 Little Gull

The global population of Little Gull is thought to be 101,000–212,000 individuals (Wetlands International 2002), with 24,000–58,000 breeding pairs in Europe, which constitutes less than half of its global breeding range (BirdLife International 2004). The European breeding range of Little Gull has recently shifted westwards and the bulk of the breeding population (to 20,000 pairs) now resides in Finland. It is thought that recovery from the previous moderate decline has not been achieved and Little Gull is classed as Depleted (SPEC 3) and of conservation concern in a European context (BirdLife International 2004).

European Little Gulls winter as far south as the western Mediterranean and West Africa, with 11,000 remaining in European waters, including the North Sea where they are concentrated around Dutch, Belgian, German and Danish coasts (Skov *et al*. 1995). A few (150-350 ind.) remain in British waters (Brown & Grice 2005). Concomitant with the shift in breeding range Little Gulls now appear to take a more westerly route on passage to wintering grounds. Thus, a large, but unknown, number of birds cross the North Sea to follow the English East coast southwards. Numbers recorded on passage have increased radically from the 1970's onwards and especially in recent years (Brown & Grice 2005). Whilst peak passage occurs in September/October, it is protracted with birds undertaking feeding and roosting movements whilst undergoing complete moult (Hartley 2004). Following moult, most birds continue migration. The cause of the shift in migration pattern is unknown, although an increasing frequency of easterly winds in the passage period and changes in the distribution of available food (small fish and invertebrates) in the North Sea may be involved.

Temporal and spatial use of the study area

In boat-based surveys, Little Gulls were recorded between the end of July (2004 only) and early December, with a distinct peak in both years in mid-October, coincident with passage. The few birds lingering into early winter in boat surveys and late winter in aerial surveys (see Appendix 8.3) suggests some over-wintering in the Wash. Peak estimated population size in the study area was remarkably consistent between years (160 ind. in 2004 and 112 ind. in 2005). Density values reached 1.3 ind. km^{-2} and 1.16 ind. km^{-2} in the boat survey area and wind farm (+buffer) respectively.

Closer inspection of the behaviour of the birds in the study area reveals that only 46% of birds were recorded flying, the rest sitting on the water surface as single birds or in small groups. Flight direction was predominately eastwards (34%) followed by circling (32%). No feeding activity was ever observed. There were no obvious features of the boat survey area to suggest that it is especially suitable for resting and this behaviour is most likely to have been caused by local conditions. To illustrate on the successive October surveys accounting for 94% of Little Gulls, conditions were calm with light southerly/south-easterly winds. It may simply have been energetically favourable for birds to break passage under such conditions.

As to be expected from birds on passage there is no obvious selection of any part of the study area (Figure 8.8). Of the birds in flight, 89% were below turbine height (<20m above sea surface), with just 11% at potential strike height (20-120m).

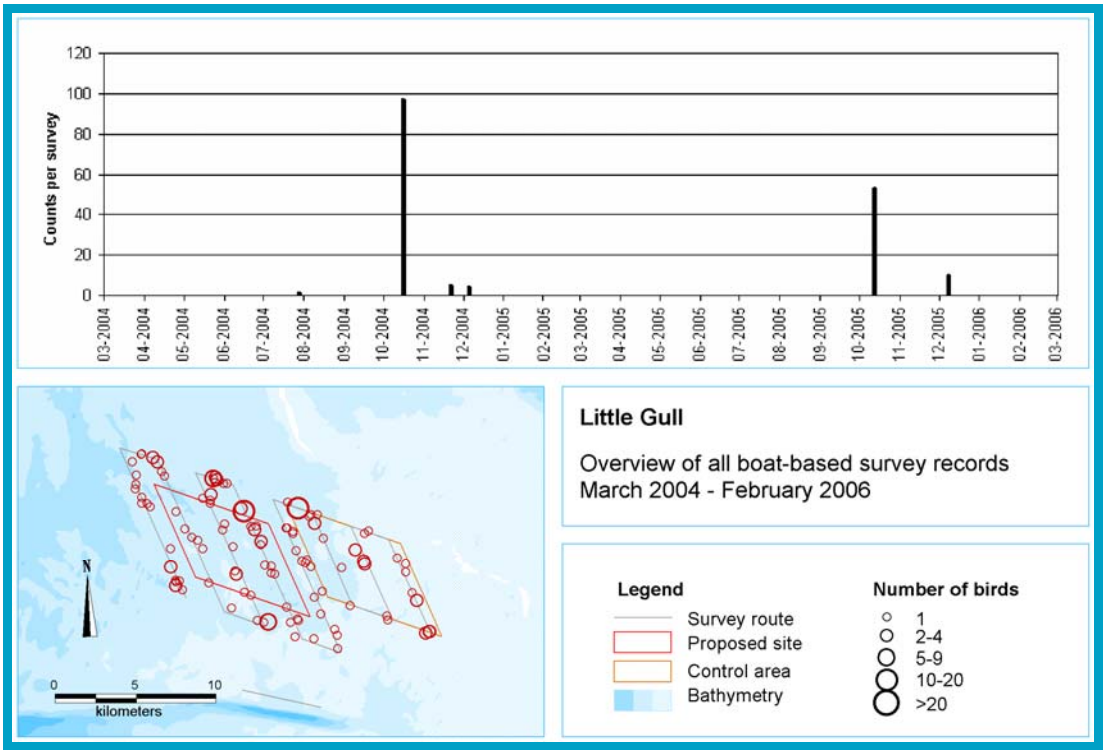


Figure 8.8 Temporal and spatial overview of all boat-based survey records of Little Gulls.

Relative importance of the study area & site

At face value, the maximum density of birds present would seem to confer national importance. For example, Skov *et al*. (1995) list the Tyne to North Yorkshire (1700 ind.–0.8 ind. km^{-2}) in the UK and Blåvandshuk (1000 ind. – 2.45 ind. km^{-2}), the Voordelta (2600 ind.–1.5 ind. km^{-2}) and the Dutch coast (1700 ind.–0.41 ind. km^{-2}) on the Continent as being of international importance to Little Gulls in the passage period. Applying the 1% criterion to the total population estimate of 9,000 birds by Skov *et al*. (1995) would confer international importance to the study area.

However, the apparent importance of any population depends on the availability of recent survey data at the right time and it is clear that published estimates of the Little Gull population in the North Sea and potentially British waters are just far too low, particularly as the status of the species in UK waters has recently radically changed (see above). For example, Wetlands International (2002) suggest 84,000 ind. are present in the European population. Even if just 50% of these cross the North Sea to UK waters on passage, the 1% criterion would require >400 ind. to be present. The UK day count record of 9,500 ind. made as recently as 11th September 2003 offshore of Spurn Point (Hartley 2004)[16], suggests many tens of thousands of Little Gulls may be present in British waters. Unfortunately, no density estimate was available from this study, although an encounter rate of 38.3 ind. km^{-1} was obtained (i.e. much higher than the maximum 1.09 ind. km^{-1} recorded in the boat survey area at Sheringham Shoal).

[16] This count was made in relation to a further offshore development illustrating the importance of such work

The total estimated maximum population in the Greater Wash area from the aerial surveys was 2,032 ind. This is an underestimate as no attempt is made to tease the Little Gulls from the large number of unidentified 'Small Gull sp.' Moreover, the surveys were conducted outside the peak passage period, with the closest in early November. Boat-based surveys within a few days of the aerial survey and at the peak passage periods a few weeks earlier allow a calibration factor to be calculated to estimate peak population in the Wash. Applying the 16-fold difference suggests the Wash supports >32,000 Little Gulls during the peak passage period. This seems much more realistic considering numbers seen at Spurn Head (see above) and in Norfolk Waters in recent years such as the 2,687 past Mundesley on 7th November in 2000 (Brown & Grice 2005). Further, in the Norfolk Bird & Mammal Reports in recent years (from 2001-2004) maxima at any one site were 1,141 on Oct 21st 2001, 1,267 at Sheringham on Oct 16th 2002, 600 on Nov 1st 2003 (all at Sheringham) and 2,550 at Scratby on Oct 10th 2004. A large movement between Oct 7th-11th 2004 produced 10,236 records from several sites.

These figures suggest that far from being nationally important, the maximum number of Little Gulls seen in the study area is not even of regional importance (1% being 320 ind.) or even local significance, as many coastal areas watched from shore produce >100 Little Gulls in the peak passage period. These records also require birds to be pushed closer to shore perhaps by onshore winds. In fact, a much larger proportion of the population may be present far out to sea. For example, the 330 Little Gulls (single birds and small groups to 4 ind.) in the first aerial surveys early November 2004 occurred in a broad swathe across the Wash, with the majority of birds around 30 km offshore (Figure 8.9). The next (mid-winter) survey in late November/early December recorded fewer birds (95 ind.) further inshore in the Wash with a concentration around the deep-water channel of Lynn Deeps (Figure 8.10).

On no aerial survey was GW5 important for Little Gulls (range 0-2% of records) compared to GW3 (64% of records at T1, 78% at T3) and GW4 (60% at T2 and 100% at T4). Whilst Little Gulls almost certainly have to cross GW5 to continue passage to the east or south, they may do so close to shore (accounting for the records in the Norfolk Bird & Mammal Reports-see above) especially in the presence of onshore winds. Indeed, Little Gulls were recorded in small numbers in the visual component of the radar surveys, with 20 ind. in 2004 (75% flying west) between 25 and 7500 m offshore, and 32 ind. in 2005, all flying east close to shore.

Otherwise, birds may continue passage far out to sea and there is thus no evidence to suggest that the study area is especially important for Little Gulls within the context of the wider Wash.

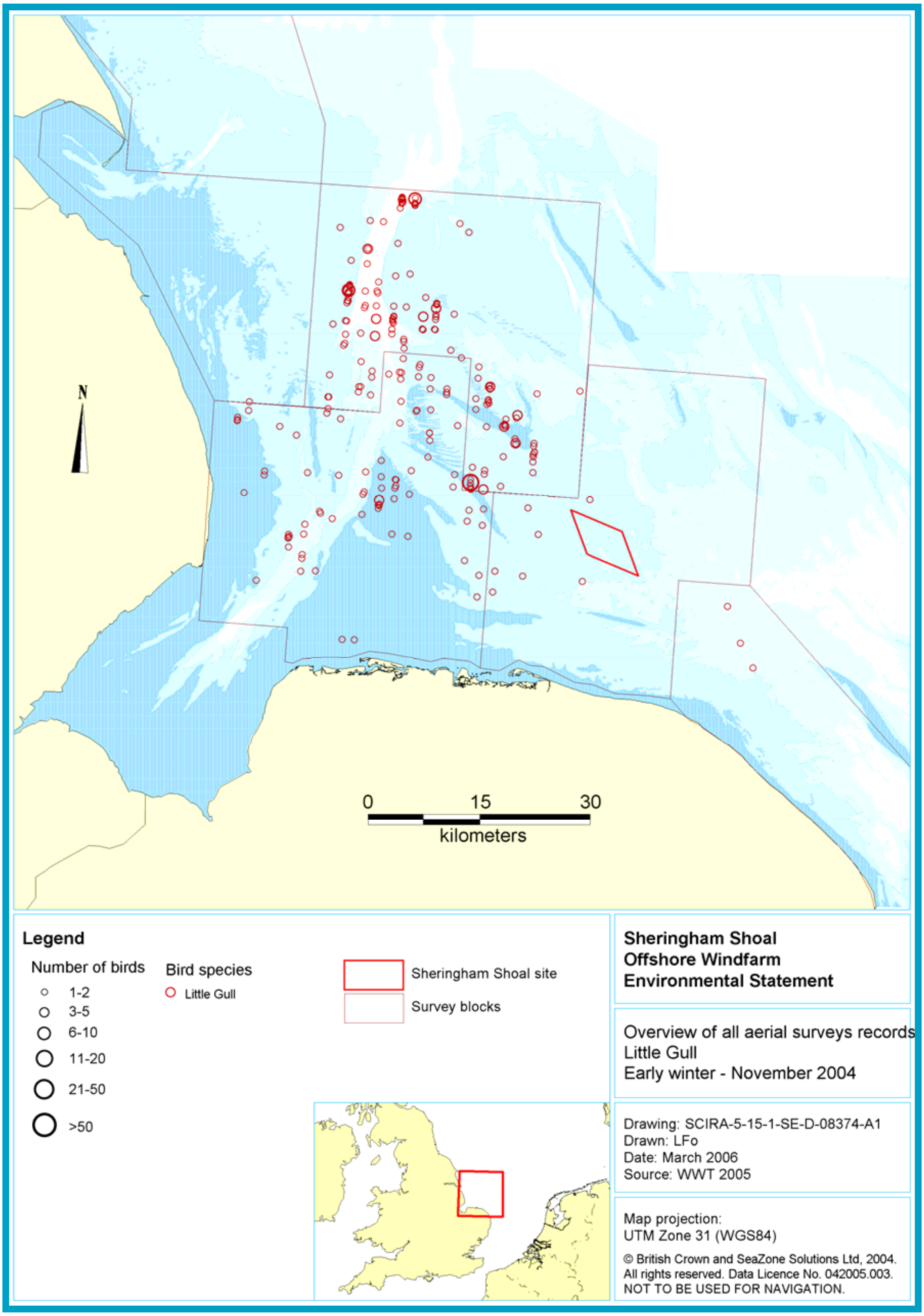


Figure 8.9 The distribution of all the Little Gulls observed during the early winter aerial survey in November 2004.

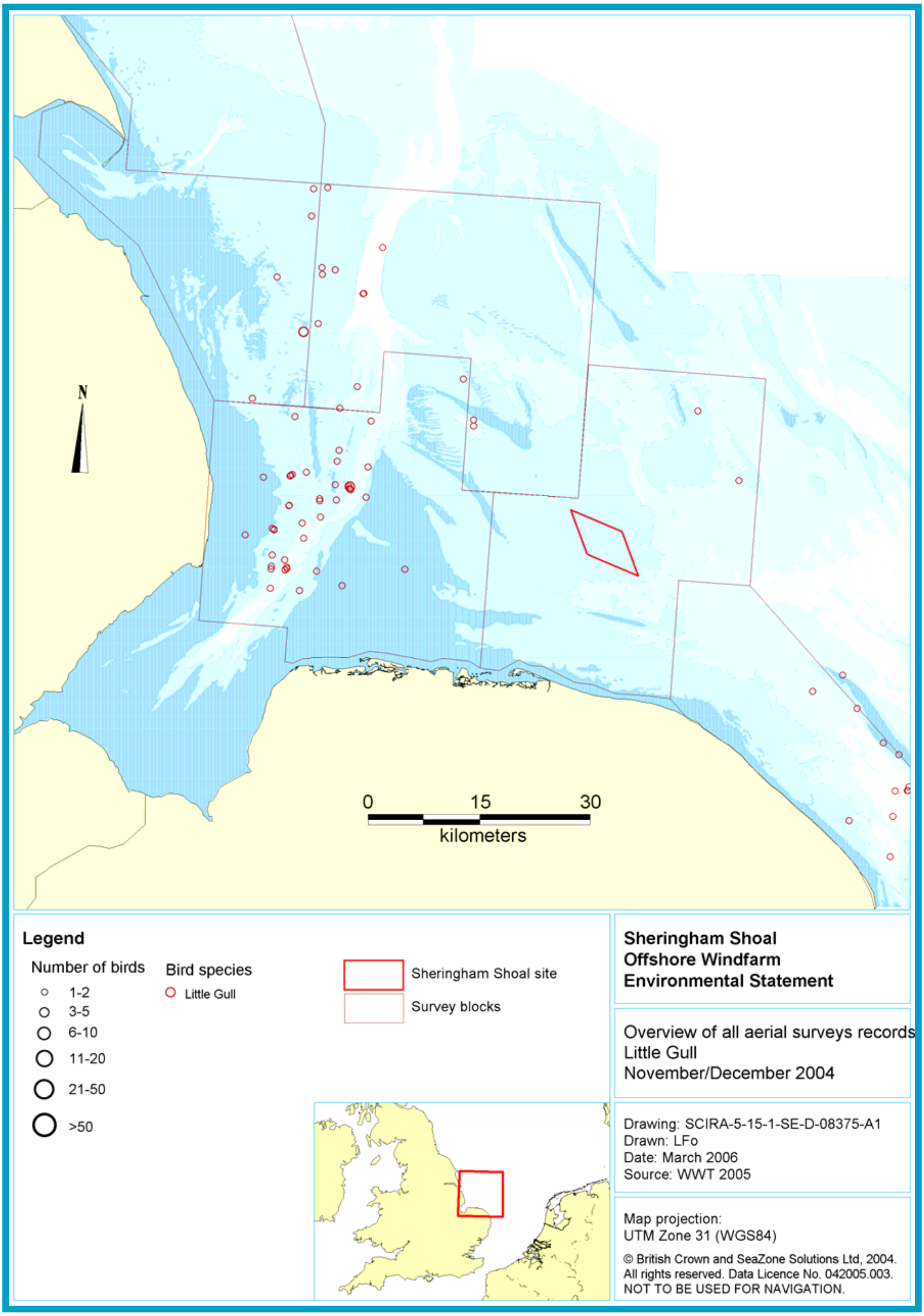


Figure 8.10 The distribution of all the Little Gulls observed during the mid-winter aerial survey late November - early December 2004.

8.3.4.2 Razorbill

Status

The global population of Razorbill is estimated to be 610,000–630,000 pairs, all of which breed in the Northern Atlantic (Mitchell *et al*. 2004). Thus Europe contributes 75% of the species' global range. The Secure population of >430,000 pairs constitutes a favourable, Non-SPEC conservation status in a European context (BirdLife International 2004). Britain supports 110,000 pairs of Razorbills; 18% of the global population and including 73% of the race *islandica*. Most nest in Scotland, although significant colonies are also present in England; the largest of which is Bempton Cliffs (between Speeton and Flamborough Head) with 8,539 pairs, around 8% of the British total. After breeding, many *islandica* appear to stay in British waters, which Tasker *et al*. (1987) estimated to be around 220,000 individuals. This may be much higher depending on breeding success and the number of fledged juveniles present.

Temporal and spatial use of the study area

Razorbills were recorded in every month apart from August in the boat-based surveys. Small numbers were present in spring and summer with a dramatic peak in autumn (mid October), consistent with autumn passage (Figure 8.11). Thereafter, numbers reduced dramatically over the winter period. There was a considerable inter-annual difference in the (distance sampling corrected) estimated peak number of birds (1690 ind. in 2004 and 187 ind. in 2005). There is some evidence that numbers in Norfolk's waters were exceptionally high in 2004, with the highest total of >3,000 seen in a day from shore at Sheringham amongst the highest recorded in Norfolk (Taylor *et al*. 1999).

In autumn 2004, during the peak passage period, Razorbills appeared to favour the westernmost edge of the study area, although in 2005 the birds were distributed evenly throughout. However, since numbers were much lower in 2005 (300 auks in total compared to 564 in 2004), it is impossible to know whether this is simply due to high levels of natural variability in distribution within the population. At peak in 2004, the vast majority (93%) of birds were on the water surface, apparently mostly resting. The very calm conditions may have caused the birds to break passage. Of those in flight, 45% were flying in no particular direction and 39% were purposely heading NE. In 2005, a much higher proportion of birds were in flight (51%) and heading almost exclusively in an E (33%), SE (31%) or S (32%) direction. In flight, Razorbills were exclusively recorded below potential turbine blade height. With a total lack of foraging observations, dedicated use of the study area appears limited and movements across it appear unpredictable and may be dependent on the prevailing wind.

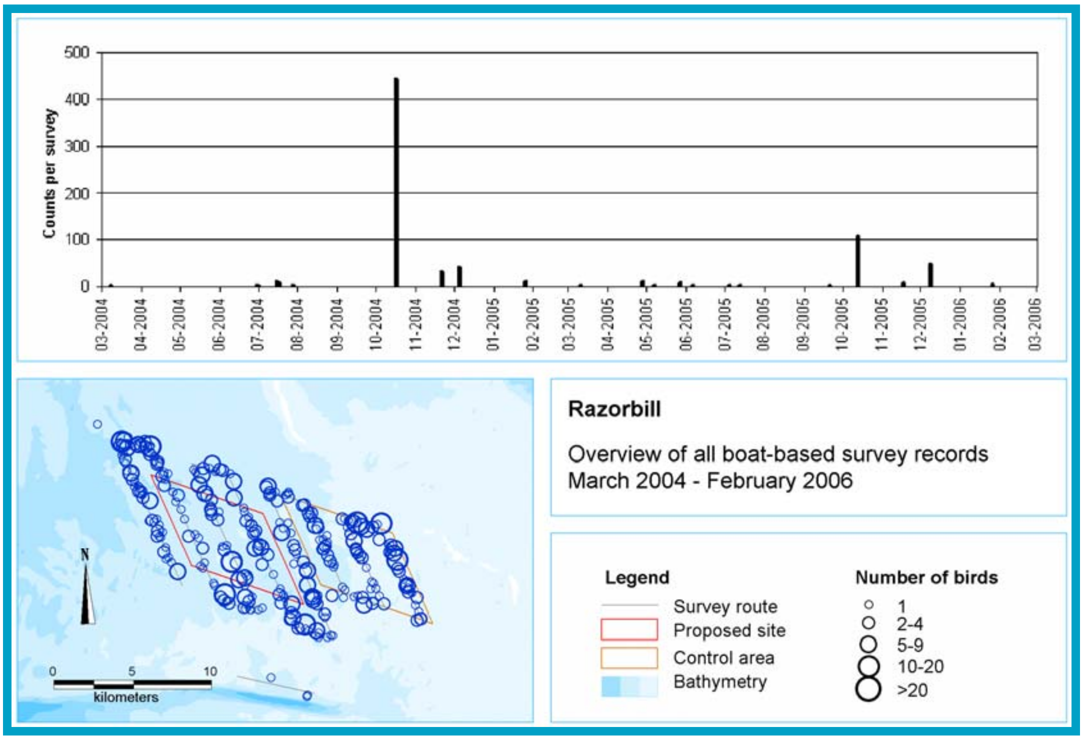


Figure 8.11 Temporal and spatial overview of all boat-based survey records of Razorbills.

Relative importance of the site

Immediately after breeding, c. 75% of the Razorbill population of the North Sea is thought to aggregate in just three internationally important sites: Moray Firth, Aberdeen Bank and Flamborough Head (Skov *et al*. 1995). After the adults moult, large numbers cross the North Sea to spend the winter in the internationally important Skagerak and Kattegat, where they may achieve enormous density (to 100 ind. km^{-2}) in favoured areas. Birds from other parts of the North Atlantic, probably especially Iceland swell the numbers of wintering birds in the North Sea, which may reach 440,000 ind.

In this study regional population estimates relied on calibration from:

- Known density of Razorbills in the wider western North Sea from Stone *et al*. (1995) applied to the area of the Greater Wash (sampled in aerial surveys). The calculation also required an estimate of the proportion of Razorbills (73%) amongst unidentified auks present, as derived from current boat-based surveys in the Wash in October.
- Numbers of unidentified auks from aerial surveys conducted in November after peak autumn passage. This used the proportion of Razorbills (47.8%) to other auks present in boat surveys conducted at the same time.

The estimates were broadly similar, ranging from 11,406 ind. to 21,186 ind. In 2004 at least, this suggests the Greater Wash contained up to 10% of the North Sea post-breeding population and was thus of international importance. In fact, it may be that in exceptional years the Wash may contain far more Razorbills and be even more important than this. The scope for this may be illustrated by using the calculation of a scale factor from boat surveys conducted at peak population in October and November at a number of sites in the Wash and applied to the available aerial survey in November. The 11-fold decline in Razorbills from October to November in boat surveys at a number of sites in the Wash, this suggests an incredible 121,000 ind. were present at peak passage in October 2004. This is around 48% of the post-breeding British population of 220,000 ind. estimated by Tasker *et al*. (1987). Markedly lower productivity [than the long-term mean] of Razorbills in 2004 (and 2003) (Mavor *et al*. 2005) would suggest relatively few juveniles were present to inflate Tasker *et al*.'s population estimate.

Whilst 121,000 ind. in the Greater Wash may seem to be a considerable overestimate, it is actually more in keeping with the large autumn passage movements seen from shore in some years and the perception that the Wash contains large numbers of post-breeding auks despite the previous lack of surveys. The peak day count of Razorbills in Norfolk waters is around 13,000 from Scolt Head on 2nd Oct 1997 (Taylor *et al.* 1999) and in 2004 on the 11th October 2004, 1,000 ind./hr passed Salthouse in North Norfolk heading east with some of these perhaps accounting with 250 ind./hr passing Eccles to the south. Intuitively, such birds are likely to represent a fraction of the total in Norfolk waters occurring as they do within a small part of the sea area within a couple of kms of the coast (although they may become concentrated by strong onshore winds at times). The prevalence of auks offshore was shown by their selection for those aerial survey blocks further offshore such as GW3 and GW5 throughout the winter (Table 8.10 below).

In GW3, there was some evidence of concentration of birds along the edge of the deep/shallow interface around Triton Knoll to the north, whilst in GW5 auks aggregated around Dudgeon Shoal in the north-east (Figure 8.12). At this time, both the aerial and the boat-based surveys showed the study area contained few auks. Thus, although Razorbills amongst other auks on autumn passage appear to show some selection for GW3 and GW5 containing the study area there is little evidence to suggest that the study area itself is particularly attractive. Indeed, the use of the latter appears to be extremely limited in space and time with large numbers occurring briefly perhaps as birds head to Dudgeon Shoal, which appears to be particularly favoured

In October 2004, unusually large numbers on the site may have been linked to exceptionally calm conditions, causing birds to break passage and rest on the surface. This conferred an exceptionally high maximum density estimate in the boat survey area of 13.7 ind. km^{-2} (12.5 ind. km^{-2} in the site), which is much higher than the 2.7 ind. km^{-2} recorded by Stone *et al*. (1995) in October in the western North Sea incorporating the Wash. Whilst the maximum density value from the boat surveys is higher than all but one of the North Sea sites documented in Skov *et al.* (1995) at the same time of year, it pales into insignificance with the 98.2 ind. km^{-2} recorded for Fornæs in the Northern Kattegat in Denmark, illustrating the potential for Razorbills to form dense aggregations.

In conclusion, whilst the boat survey area supported numbers of Razorbills of regional, approaching national, importance on one occasion, this is a reflection of the importance of the wider Wash for post-breeding Razorbills and it seems the study area has no more potential than any other area of similar size in the Greater Wash and particularly GW3 or other parts of GW5 to accumulate such an aggregation. This is reinforced by the lack of specific use (no feeding records) within the study area (see Appendix 8.2).

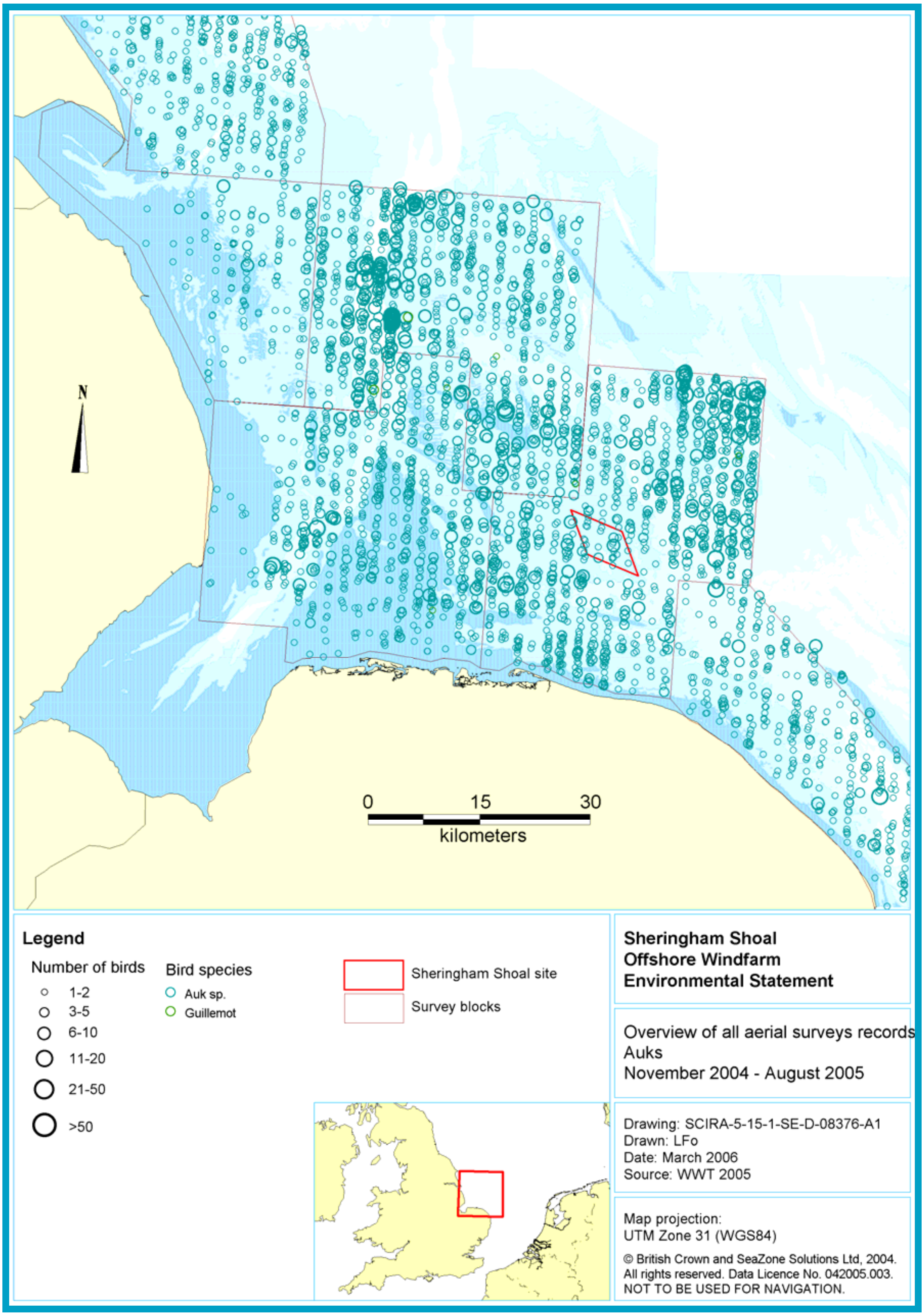


Figure 8.12 The distribution of all auks observed during the 7 aerial surveys carried out between November 2004 and August 2005.

Table 8.10 Estimated population sizes (derived using distance sampling correction factors) of auks in the aerial survey blocks over the winter of 2004/5 and late summer 2005 (GW3, 4 & 5 only). Numbers of Guillemots and Razorbills are estimated from the proportions of the two species present in boat-based surveys from three different sites conducted in the Wash in equivalent time periods, and incorporating the small number (35) of positively identified Guillemots in survey T7.

Survey block	Survey	Month	Taxa/species		
			Auks*	Razorbill	Guillemot
GW1+2	T1	Oct/Nov	3365	1609	1504
	T2	Nov/Dec	1248	363	767
	T3	Jan/Feb	2002	227	1653
	T4	Feb/Mar	4960	596	3839
GW3	T1	Oct/Nov	5704	2727	2550
	T2	Nov/Dec	4176	1214	2567
	T3	Jan/Feb	1113	126	919
	T4	Feb/Mar	996	120	771
	T7	Jul/Aug	2148	3	2145
GW4	T1	Oct/Nov	4166	1991	1862
	T2	Nov/Dec	2526	734	1553
	T3	Jan/Feb	793	90	655
	T4	Feb/Mar	353	42	273
	T7	Jul/Aug	414	1	413
GW5	T1	Oct/Nov	10091	4824	4511
	T2	Nov/Dec	1314	382	808
	T3	Jan/Feb	772	87	637
	T4	Feb/Mar	608	73	471
	T7	Jul/Aug	816	1	815
GW6	T1	Oct/Nov	557	266	249
	T2	Nov/Dec	1996	580	1227
	T3	Jan/Feb	1411	160	1165
	T4	Feb/Mar	778	93	602

* Auks includes Razorbill, Guillemot, Puffin and Little Auk.

8.3.5 Species of Medium Sensitivity

8.3.5.1 Gannet

Status

The global breeding population of Gannet is thought to be 390,000 pairs (Mitchell *et al.* 2004), with more than 75% of this population in Europe (Birdlife International 2004). This Non-SPEC^{E} [17] population has been increasing since the 1970s and is currently classified as Secure (Birdlife International 2004). Gannets breed in a small number of sites in north-western Europe, and Britain supports an exceptionally large proportion (259,311 pairs comprising 59%) of the world population, concentrated at a small number (21) of breeding sites (Mitchell *et al.* 2004). The largest of these and indeed the largest gannetry in the world, is St Kilda. The closest colony to the Wind farm study area is Bempton Cliffs in North Yorkshire (2,552 pairs in 1998-2000), which is also one of the fastest growing.

Temporal and spatial use of the study area

In boat-based surveys, Gannets were recorded in all months apart from March in both 2004 and 2005. Small numbers (<10 ind.) were present over the winter to spring (December to April/May) period in keeping with the low numbers over-wintering in the Wash, illustrated by the total estimated population of the Greater Wash of just 32 in the mid-winter aerial survey carried out in late November and early December 2004. On this occasion, no Gannets were seen either on the study site or in the greater GW5 survey block.

The low numbers of birds (total GW5 population estimate of 46 ind. in an aerial survey of May 2005) in the egg laying and early chick rearing season (March to July) suggests few adults reach the Sheringham Shoal area from breeding colonies, despite their propensity for huge foraging movements (up to 540 km–Hamer *et al*. 2000). Overall, adult birds comprised a low proportion (30%) of the birds aged during this period (data from boat surveys from March to July from both years) confirming that the bulk of the Gannets occurring in the study area were non-breeding birds, typical of the pattern for the wider North Sea in summer (Skov *et al*. 1995).

The great majority of records were from the autumn passage period (July-October), with an exceptional peak population estimate of 134 ind. in mid-July 2004 at a density of 1.09 ind. km^{-2} in the boat survey area (1.21 ind. km^{-2} in the site and buffer). This was >2 fold higher than any other estimate in this period, the next being 59 ind. in mid-August 2005. The exceptional movement included the largest number (13 ind.) of 1st-year birds from any survey suggesting (early) dispersal from breeding colonies. The low number and thus proportion of 1st years in August 2005 (2 ind.) suggests inter-annual variation in the numbers of juveniles passing through the study area.

Typical of the complex dispersal patterns of Gannets (Wernham *et al*. 2002), the flight direction of birds was variable with birds recorded heading in all directions (as well as no particular direction). However, during the autumn passage period in both years there was some evidence of a south/south east trend with 26% heading south east and 14% heading south (data from boat surveys carried out September-November in both years), although birds were also observed flying in other directions. It is possible that some birds were spending time in the region, their more localized movements obscuring the southward movements of birds taking a direct migrational route.

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[17] Species whose global populations are concentrated in Europe, but which have a Favourable conservation status in Europe.

The great majority (c.87%) of Gannets were recorded in flight, and of these just 10% were recorded within the potential strike zone of the turbines (between 20-120m above sea surface) with the majority (89.6%) below the height of the prospective turbine rotors. As to be expected from birds at low height (as foraging is typically undertaken by birds climbing up to c. 40m - Cramp *et al.* 1974) very little foraging activity was recorded, with only three individuals (0.6%) engaged in feeding. With birds generally passing through the study area with little obvious purpose, there was no apparent selection of the particular parts of the study area including Sheringham Shoal by Gannets (see Figure 8.13).

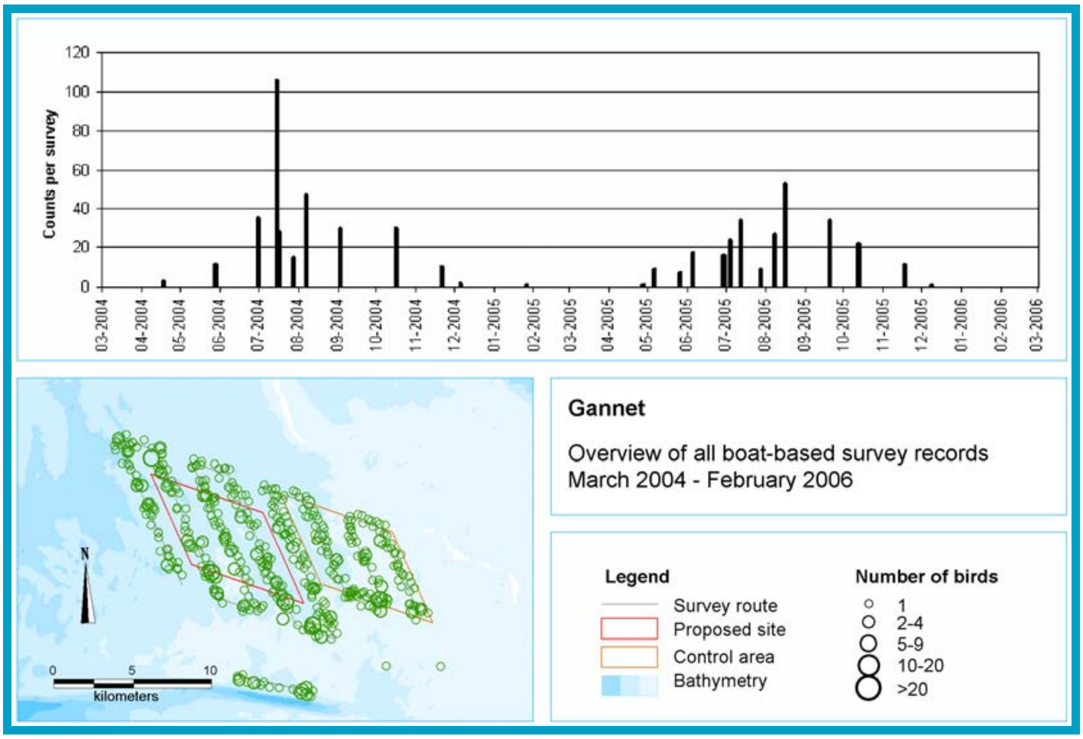

Figure 8.13 Temporal and spatial overview of all boat-based survey records of Gannets.

Relative importance of the study area

The apparent regional importance of the study area for Gannet (Table 8.8) hinges on the available estimates of the regional population. As with the other species, these are derived from a limited number of aerial surveys over the winter period 2004 and summer 2005 and the density of birds in the wider western North Sea reported by Stone *et al*. (1995) multiplied by the area of the Greater Wash. The former produced a total population of just 479 ind. in late summer 2005 compared to 5,740 ind. estimated from the extrapolation derived from Stone *et al*. (1995). The former may simply suffer from a chance lack of movement on the day of survey and there is little doubt that the latter figure is likely to be closer to reality.

This is part evidenced by the numbers of Gannets that may be seen from shore-based observations in Norfolk waters. For example, in 2004, 738 ind. were recorded from Scolt Head on September 23rd 2004 with 975 past Sheringham on 11th October. Regular daily counts of >100 birds were made from a number of sites between April and November (Norfolk Bird & Mammal Report 2004). Indeed, day counts of between 1,000-2,000 ind. of this '*common passage migrant*' are recorded annually from the Norfolk Coast in autumn (Taylor *et al*. 1999). This is despite the suggestion from the aerial surveys that much of the passage of Gannets is likely to occur far out to sea (>40 km) with the northern parts of GW3 (Triton Knoll) and GW5 (Dudgeon Shoal) preferred, linking with coastal areas north of the Humber (Figure 8.14). Numbers of birds close to shore may depend on the occurrence of strong onshore winds.

The presence of several and even many thousand Gannets in the Wash at times is perhaps not unexpected given the annual dispersal of over half a million breeding adults from British breeding colonies (Mitchell *et al*. 2004), let alone large numbers of mobile non-breeding birds. Further, a minimum (and now outdated) estimate of 150,340 ind. was calculated to be present in the North Sea in the autumn passage period by Skov *et al*. (1995). A range of sites along the English east coast supported densities >1 ind. km^{-2}, such as North East Bank (2.08 ind. km^{-2}) and Barmade Bank-Spurn (1.11 ind. km^{-2}) containing large numbers of birds (10,600 and 12,200 ind. respectively). The estimated peak densities of 1.09 ind km^{-2} and 0.61 ind. km^{-2} on the Sheringham Shoal study site during autumn passage in 2004 and 2005 respectively are within the typical range of what may be seen as ‘background’ values for the wider Western North Sea in August (0.81 ind. km^{-2}) and September (0.82 ind. km^{-2}) (Stone *et al*. 1995). Overall, the peak numbers recorded on the Sheringham Shoal study site do not appear exceptional or even unusual compared to many other similar areas in the Wash.

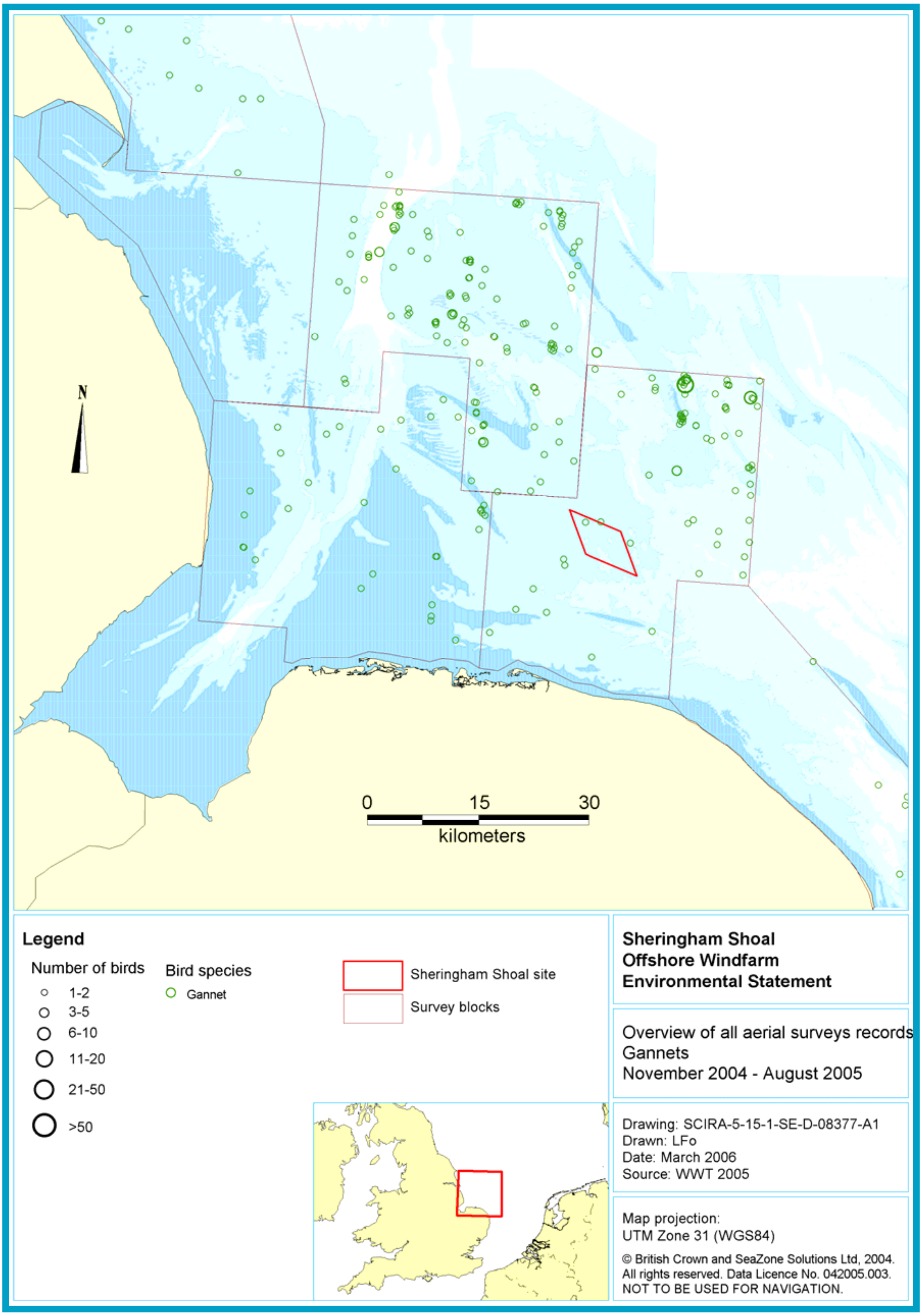

Figure 8.14 The distribution of all the Gannets observed during the 7 aerial surveys carried out between November 2004 and August 2005.

8.3.5.2 *Lesser Black-backed Gull*

Status

The global breeding population of Lesser Black-backed Gull is thought to be in excess of 750,000 individuals (Wetlands International 2002), with 300,000-350,000 breeding pairs in Europe, which accounts for >75% of its breeding range (Birdlife International 2004). The overall Non-SPEC[E] population is classified as Secure (Birdlife International 2004).

Temporal and spatial use of the study area

In boat-based surveys, Lesser Black-backed Gulls were present on the site from May-November 2004 and April-October 2005. The absence over winter is entirely consistent with the abandonment of the wider North Sea in this period, with movement to the waters of the English Channel (Skov *et al*.1995) as well as inland, including within Norfolk (Taylor *et al*. 1999).

An exceptional peak population estimate of 72 ind. was recorded in late May 2005 at a density of 0.58 ind. km^{-2} in the boat survey area (0.73 ind. km^{-2} in the site and buffer). This was >2 fold higher than any other estimate, the next being 31 ind. in early July 2005 (see Figure 8.15). A single flock of 14 ind. in the May survey was partly responsible for the relatively high total. The presence of a high proportion of adults (51% of aged birds) in this survey in the breeding season is suggestive of breeding birds associated with the large colonies on the Outer Wash Trial Bank or the smaller Gorleston/Yarmouth colony (160 pairs in 2003-Norfolk Bird & Mammal Report 2003). However, both of these colonies are 65km or more from the study area, which is likely to be beyond typical foraging range, especially since birds were not recorded foraging in the study area and many other suitable areas are likely to be present closer to the colonies. Moreover, birds were not flying in the appropriate direction (at least for the Trial Bank) with most (17%) flying in a south easterly direction. Whilst some of the birds may originate from the small numbers of birds that may still breed in the Wells/Warham area and on Blakeney Point (Taylor *et al*. 1999), most birds on the study area seems likely to have been passage migrants.

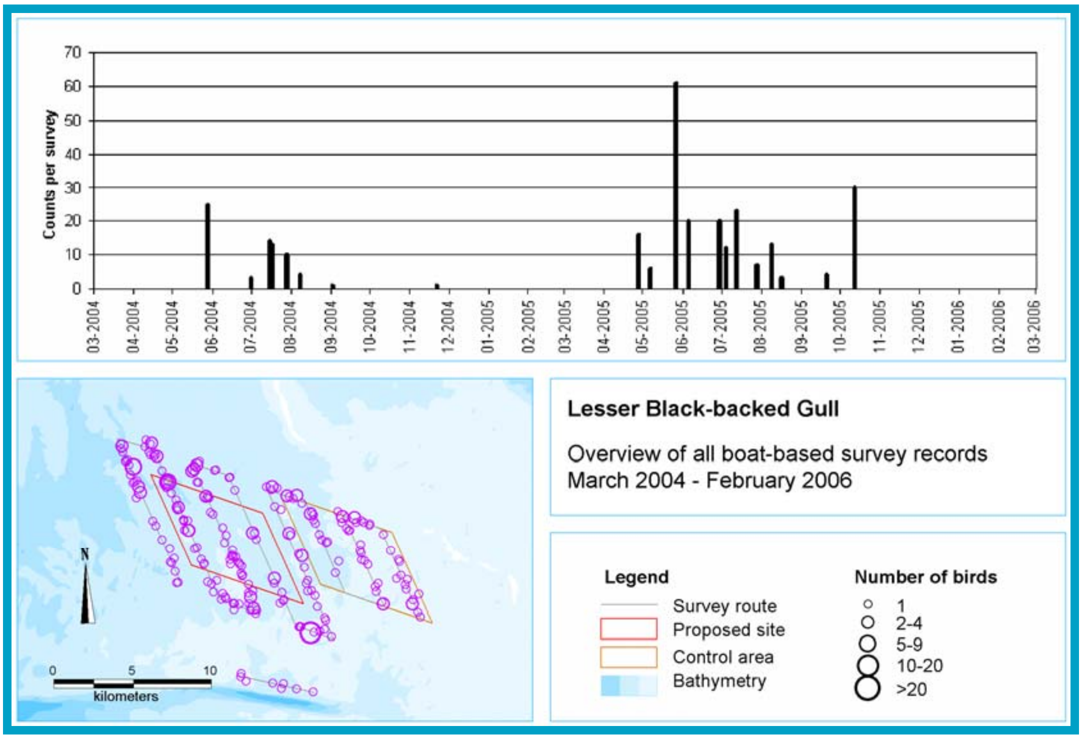

Figure 8.15 Temporal and spatial overview of all boat-based survey records of Lesser Black-backed Gulls.

Passage is known to peak in April or even May (Taylor *et al*. 1999) with most of the largest counts in this period from Sheringham including 65 west on May 17th 2003 (Norfolk Bird & Mammal Report 2003) and 75 west on April 12th 2004 (Norfolk Bird & Mammal Report 2004). It is not clear where such birds come from or where they are heading to and may be part of a non-breeding population complementing breeders at the known sites. Summer aggregations of birds are known from coastal sites with for example, 1,800 at Lynn Point in August 2003 (NNNS 2003), 1,500 at Saddlebow in August 2004 (NNNS 2004), 1,573 in July 2003 (NNNS 2003) and 1,338 at Eau Brink in July 1998 (Taylor *et al*. 1999).

In accordance with a mixture of passage and non-breeding summering birds, the flight directions were variable, but with a general tendency for movement along a SE (24% of all records) or S (17% records) and NW axis (17% records) i.e. to and from land. As to be anticipated from such movement, there was no apparent selection of particular parts of the study area (Figure 8.16), nor was there any evidence of specific use of the site (i.e. no feeding records). Birds were generally recorded flying (88% of records) with a moderate proportion of these (26.5%) within the potential strike zone of the turbines (20-120m above sea surface) although most (73.5%) were recorded at height bands at <20 m above sea surface.

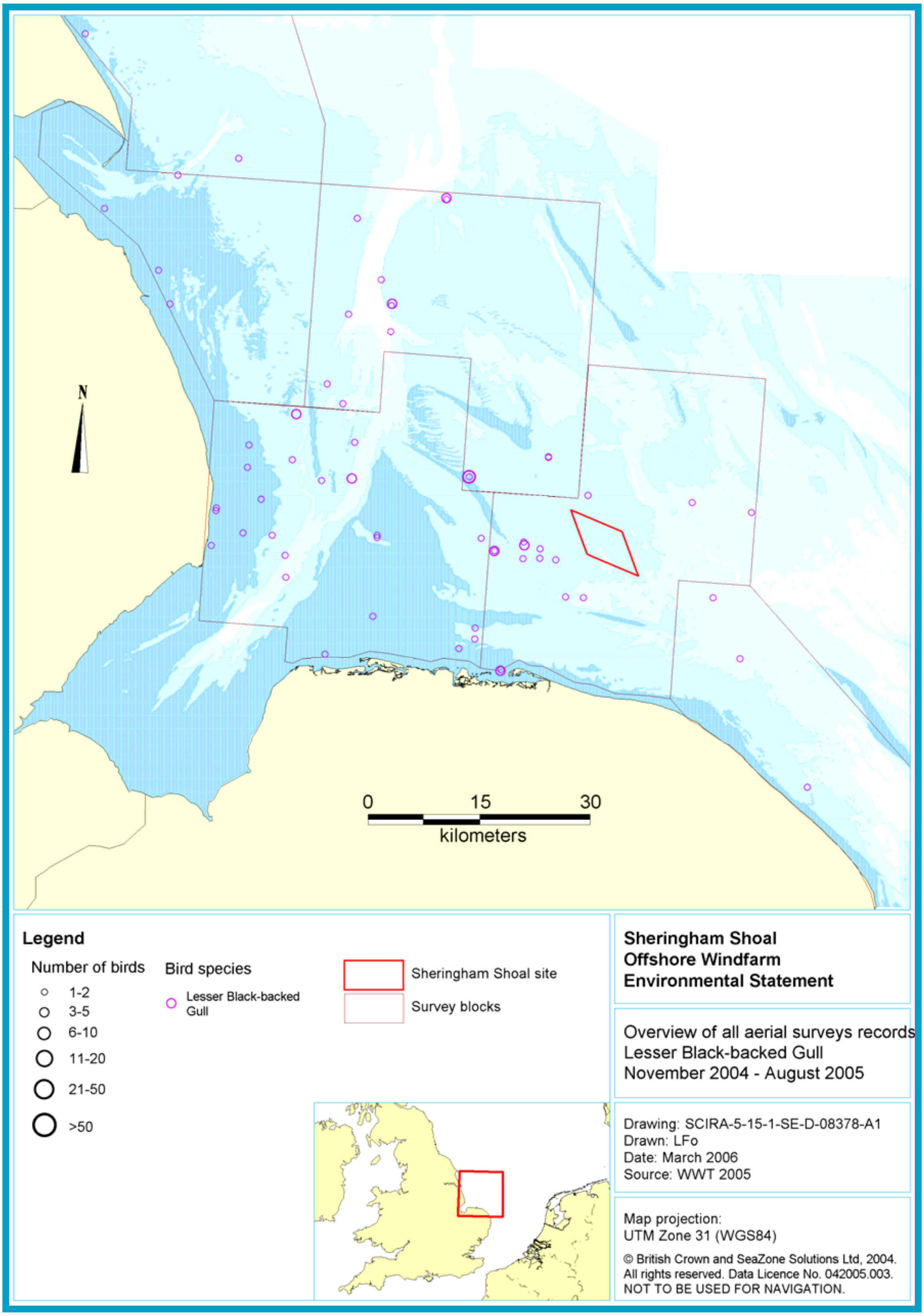

Figure 8.16 The distribution of all the Lesser Black-backed Gulls observed during the 7 aerial surveys carried out between November 2004 and August 2005.

Relative importance of the study area

As with Gannet (see 8.3.5.1) amongst other species, the apparent regional importance of the study area for Lesser Black-backed Gull is dependent on the available estimates of the regional population. The density estimate in late spring from Stone *et al*. (1995) for the western North Sea applied to the Wash suggests 560 ind., whilst summer aerial surveys produced a maximum of just 22 ind. (partly as a result of the lack of separation of dark-backed gulls into relevant species). Both are far lower than known to be present from the breeding population at the Outer Trial Bank (i.e. 2,774 ind.). Although the latter value was used to represent the regional population, this does not take non-breeding birds into account and is still likely to be a considerable underestimate of the birds present in the Wash.

As a consequence, only a relatively small number of birds (28 ind.) is required to exceed the 1% regional population threshold. Numbers exceeding this total are regularly recorded in Norfolk coastal waters in the passage and summer period (see above). Indeed, any site close to breeding grounds such as the Outer Trial Bank or Great Yarmouth/Gorleston (e.g. Scroby Sands wind farm -Perrow *et al*. 2004) is also likely to support seemingly important numbers of birds.

The maximum density estimate of 0.58 ind.km^{-2} recorded in the boat survey area is between the 'background' densities of 1.65 ind. km^{-2} and 0.08 ind. km^{-2} in May for the south and east and western parts of the North Sea respectively (Stone *et al*. 1995). Moreover, Skov *et al*. (1995) report a density of 0.11 ind. km^{-2} involving 22,825 ind. (perhaps including the race *intermedius*) for the extensive area of the eastern North Sea bordering the coast or East Anglia through the Channel including May and June.

In general, there seems to be nothing particularly unusual or exceptional about the numbers of Lesser Black-backed Gulls in the study area compared to any other similar-sized area in the wider Wash and especially other parts of GW5. For example similar counts were obtained from boat-based bird surveys of Scroby Sands wind farm site in 2004, with up to 42 birds observed (Perrow *et al.* 2004). This exceeds all counts made on at the Sheringham Shoal wind farm site, with the exception of the unusual peak of 61 birds seen in late May in 2005.

8.3.5.3 Guillemot

Status

The global population of Guillemot is over 7 million pairs (Mitchell *et al.* 2004). The European North Atlantic accounts for <50% of its global range (Non-SPEC) but the population is still very large (>2 million pairs) and Secure (BirdLife International 2004). Britain holds 1.32 million birds, constituting around 12% of the World population and 30% of the North Atlantic population (Brown & Grice 2005). As a result of the presence of internationally important numbers of birds in a few breeding colonies, Guillemot is of conservation concern in the UK.

The majority of British Guillemots nest in Scotland, although some 92,000 birds breed in England, the area between Speeton and Flamborough Head (Bempton Cliffs) in Yorkshire being the most important. Here, 46,625 birds were counted in 1998-2002, representing a trebling of numbers since 1969/70 (Mitchell *et al.* 2004). This is despite a number of 'wrecks' in the North Sea, comprising 20,000-50,000 birds in 1994 with further losses in 2004, when widespread breeding failure of birds also occurred.

Temporal and spatial use of the study area

In boat-based surveys, Guillemots were recorded in all months in all parts of the study area, and were only absent in one survey in May 2005 (see Figure 8.17). Guillemots shared two seasonal peaks in abundance. The earliest of these was in July, corresponding to the southward dispersal of adults and their chicks (in adult male and chick combinations) from breeding colonies ultimately to winter offshore (Taylor *et al.* 1999). During this time adult birds moult and chicks are yet to fledge. This was represented by the small proportion of flight records of birds at this time (3%). This in turn suggests the majority of these birds are likely to be from the breeding colony at Flamborough Head, which is the nearest colony to the site (Taylor *et al.* 1999).

There was some suggestion of inter-annual variation in the numbers of immediately post-breeding birds, as no peak occurred in July 2005. However, in 2004 the population in the boat survey area declined from 867 ind. to 362 ind. to 10 ind. within a 13 day period, illustrating that birds pass through the area rapidly and may not always be detected in fortnightly surveys. Movement through the study area also appears to have been more protracted in 2005 with the observation of juveniles throughout July and into August, compared to the exclusive peak in mid July in 2004. The higher proportion of flying birds in 2005 (35%) also indicates variation in moult patterns between years, which may also influence the number of birds on the site. In both 2004 and 2005 an obvious winter peak occurred in October, when the greatest numbers of Guillemots are usually observed from the Norfolk coasts (Taylor *et al.* 1999).

Overall Guillemots were generally observed on the water (81% of records), and of the 19% flying all were <20m (below the strike zone). Birds apparently passed through the site in all directions in a similar manner to Razorbills (section 8.3.4.2).Only one individual was actually observed using the site for foraging.

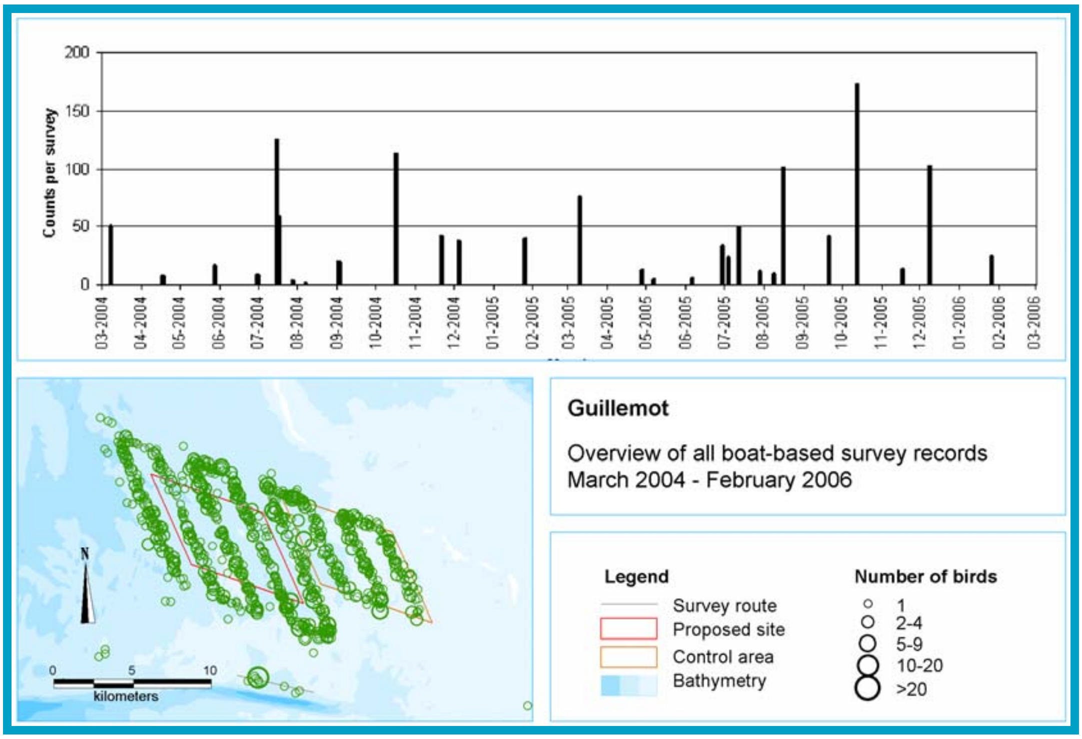

Figure 8.17 Temporal and spatial overview of all boat-based survey records of Guillemots.

Relative importance of the study area & site

The maximum population estimate of Guillemots in the site and buffer using distance sampling from the boat survey data correlation was 1,105 ind. This appears to be of regional importance. In comparison with the highly variable regional population estimates: 10,675 ind. based on aerial survey data, 100,674 ind. based on the Western North Sea density from Stone *et al.*, and 112,069 ind. based on the Western North Sea density *and* incorporating a proportion of unidentified birds likely to be Guillemots based on a proportion calculated from boat-based surveys.

However, data from the aerial surveys of the Greater Wash shows that numbers of Guillemots within GW5, the area in which the wind farm is located, were not particularly high in comparison with the rest of the Wash. The mean estimated population size for GW5 (Table 8.10) is 1,448 ind., which is smaller than that of GW3 (1,730 ind.) and GW7 (1,940 ind.), similar to that of GW4 (1,151 ind.), and greater than that of GW6 (811 ind.). The importance of the study area within GW5 also appears to be low, with auks only observed there on one occasion in summer (10th August 2005), and with no obvious winter aggregations. This is in keeping with only one bird observed foraging in the study area during the boat surveys, suggesting that the area is not particularly attractive and unlikely to accumulate aggregations of foraging birds.

Comparison of the maximum density of Guillemots calculated from the boat surveys (10.67 ind. km^{-2} in mid October 2005) with the density of Guillemots in the wider Western North Sea in October (10.32 ind. km^{-2} – Stone *et al.*1995) reveals the site to be of only average importance even when peak numbers of birds are present, and indeed these densities are much lower than those observed over a large expanse of the northern coasts from Moray Firth (15.91 ind. km^{-2}), to the Aberdeen Bank (28.17 ind. km^{-2}), to the Tees (34.71 ind. km^{-2} – Skov *et al* 1995).

Plate 8.4: Guillemot with chick. © Martin Perrow, ECON.

8.3.6 Summary of the use of the site by the seven key species

8.3.6.1 Sandwich Tern

Despite the relative proximity of the study area to the Blakeney Point colony in particular, relatively few Sandwich Terns at low density were encountered in boat-based surveys. Detection of a reasonable proportion of the Sandwich Tern population in aerial surveys in the breeding season reinforced the suggestion that the study area was relatively unimportant. Some centres of activity were noted in the aerial surveys including areas close to the colonies, along a SW-NE line to the east of the main Wash channel to Triton Knoll, and to the NE at Dudgeon Shoal up to the limit covered by the aerial surveys (c. 60 km).

The latter site may be the target of birds observed leaving the colony to the NE, presumably on foraging trips. A proportion of these appear to reach and forage over Sheringham Shoal located over 5km to the south of the study area, which tends to support a higher density and proportion of foraging birds (albeit still low) suggesting this is more suitable habitat than the study area itself. Indeed very little foraging activity has been recorded in the study area, with most birds simply flying through and even then mostly through the control site to the east.

8.3.6.2 Common Tern

Very low numbers in the study area during the breeding season suggests very limited use of the study area by the small (390 pairs in 2005) breeding population at Blakeney Point and Scolt Head.

A single exceptional number of birds in flocks in mid-August 2005 was indicative of post breeding southerly passage most probably involving birds from coastal colonies further North and/or inland. Common Terns on southward autumn passage through the Wash may do so on a broad front, and there is no evidence that the study site was selected other over similar-sized areas. In fact, aerial surveys suggest a preference for other parts of the Wash as well as far out to sea.

8.3.6.3 Little Gull

There is evidence of a very recent westerly shift in the autumn migration pattern of Little Gulls with many birds crossing the North Sea to follow the East Coast southwards on what may be a protracted passage. Recent records suggest tens of thousands of Little Gulls are likely to be present in British waters at some time in autumn (September/October) with a potentially large population passing through the Greater Wash area.

Aerial surveys suggest Little Gulls may pass through at considerable distance from shore (c. 30 km) with some driven closer by onshore winds. Although birds are likely to cross the general area in which the proposed site is located to continue passage to the east, there is no evidence to suggest that the study area is especially important for Little Gulls within the context of the wider Wash. In fact, the initial assessment of the presence of important densities and numbersin the study area may largely be an artefact of a lack of reliable population estimates.

8.3.6.4 Razorbill

Boat-based surveys recorded a concentrated passage of Razorbills through the study area in October, which varied considerably in magnitude between years. Inter-annual variation in the numbers of Razorbills on passage in Norfolk waters is well documented, and 2004 appears to have been exceptional.

Stemming from a high density, the population of Razorbills in the study area appears to confer regional verging on national importance. However, the importance of the Wash is thought to have been considerably underestimated, and the maximum numbers of Razorbills estimated to be present in the study area are not thought to be exceptional or indeed unusual compared to other areas. Aerial surveys suggest auks favour some parts of the Wash and the occurrence of birds briefly in the study area may be linked to dispersal to Dudgeon Shoal, one such area. Indeed, the presence of large numbers in 2004 may have been linked to exceptionally calm conditions, causing birds to break passage and rest on the surface. Otherwise, Razorbills showed no active use of the site, for example for feeding, and passed through rapidly.

8.3.6.5 Gannet

Gannets are extremely wide-ranging when foraging from breeding colonies. This, combined with complex migration patterns and the occurrence of a large pool of non-breeding birds in the North

Sea, means that a low density of Gannets may be present around all UK coasts at any time of year.

Relatively large numbers of Gannets may occur in the Wash especially in the autumn passage period. Birds are very mobile and although they may occur close to the coast, perhaps especially in onshore winds, aerial surveys show they may otherwise pass through far out to sea. The peak population at the Sheringham Shoal wind farm site in mid July 2004 was exceptional for the study area but does not appear exceptional or even unusual compared to any other similar area in the wider Wash. Numbers in the study area and attained regional importance partly as a result of the lack of reliable population estimates.

8.3.6.6 Lesser Black-backed Gull

Lesser Black-backed Gulls breed in the Wash at the Outer Trial Bank (1,387 pairs) as well as further afield on rooftops at Great Yarmouth/Gorleston and Lowestoft, and in very small numbers on the North Norfolk Coast. However, the sites or larger populations all appear to be too distant to routinely account for the birds occurring in the study area. The exceptional peak in numbers in May 2005 was coincident with passage in Norfolk waters (Taylor *et al*. 1999), although the presence of birds during the summer suggests that a pool of non-breeding, including adult birds are present in the Wash. In general, there seems to be nothing particularly unusual or exceptional about the numbers of Lesser Black-backed Gulls in the study area compared to any other similar-sized area in the wider Wash.

8.3.6.7 Guillemot

Although Guillemots were recorded in all months of the year in the study area, distinct population peaks were consistently recorded in late summer (July/August) and then again in early autumn (October). The first of these corresponds to the dispersal of adults and chicks from breeding colonies. As the birds are flightless at this time it is most likely that birds in the Wash originate from the closest colony in North Yorkshire (Bempton Cliffs). The second, larger peak corresponds to the dispersal of birds from further afield into the wider North Sea, some of which over-winter in the Wash.

Although the data gained from boat-based surveys suggests that the estimated site population of Guillemot could reach regionally important numbers at times, the aerial survey data indicates that auks are relatively evenly distributed throughout the Wash, with neither the site itself nor the surrounding area being particularly favoured. However, winter aggregations of auks were noted at Dudgeon Shoal, and is it possible that birds observed in the study area in October may be *en-route* to this area.

8.4 Impacts during construction

8.4.1 Introduction

The potential impacts during construction on birds could include a combination of both direct and indirect effects. The most obvious direct effect of construction is disturbance, which could be due to either the general increases in boat traffic and human presence on the site, or to the specific effects of construction activities (e.g. noise, vibration), or both. Indirect effects through changes in prey supply are also considered. The impacts during construction of the proposed wind farm on the seven key species are discussed below.

At present, data from existing offshore wind farm sites is scant, and the work that has been carried out is often inconclusive due to a variety of factors, such as insufficient surveys during peak periods and insufficient or inconclusive pre-construction data, and generally reflects the difficulties associated with assessing changes in habitat usage of a number of highly mobile, seasonally occurring species. However, construction monitoring at two operational sites – North

Hoyle in the UK (RWE Group 2005) and Horns Rev in Denmark (Christensen & Hounisen 2005) - has involved the analysis of the impacts of construction on some of the key species found at the Sheringham Shoal wind farm site.

Data from both North Hoyle and Horns Rev relating to these species were largely inconclusive. At North Hoyle, pre-construction data was gathered when the Sandwich Terns were not present in winter, and the paucity of records for Razorbills also meant that no conclusions could be drawn. However, it appeared that Common Terns showed no change in distribution patterns pre- and during construction (RWE Group 2005).

At Horn's Rev the number of records was also a limiting factor, since usage of the wind farm site was low compared to the surrounding locality. No statistically significant construction related avoidance impacts could be detected although auks were consistently higher during the baseline years than during the period of construction, and all observations were from over 2.5 km away from actual construction activities. However, the work did highlight a positive impact on Herring Gull, ecologically similar to Lesser Black-backed Gull, numbers of which significantly increased in the wind farm period during construction, and which were probably attracted to the area by the increased boat activity (Christensen *et al.* 2002).

8.4.2 Direct effect: disturbance on the site due to increased boat traffic

The theoretical basis of disturbance may be constructed from the work of Garthe & Hüppop 2004) which defines the sensitivity of the key species of concern at Sheringham Shoal. This work derived vulnerability scores for disturbance by ship and helicopter traffic based on the combined opinions of 13 seabird experts. Five categories of vulnerability are defined which correspond to the terminology introduced in section 8.2.5.2, i.e. 5 = very high (or vulnerable), 4 = high, 3 = medium, 2 = low, 1 = negligible. This enabled the likely significance of increased boat traffic to be assessed by combining the sensitivity of the population (based on conservation concern) with species specific tolerances to disturbance from boat and helicopter traffic using Table 8.5. The ranks assigned to the key species are given in Table 8.11.

Table 8.11 Vulnerability of each species as derived by Garthe & Hüppop (2004). Shaded cells indicate the combinations of sensitivity and vulnerability that give rise to potential significant impacts.

Species	Sensitivity	Vulnerability to boat traffic
Sandwich Tern	Very high	2 – low
Common Tern	Very high	2 – low
Little Gull	High	1 – negligible
Razorbill	High	3 – medium
Gannet	Medium	2 – low
Lesser Black-backed Gull	Medium	2 – low
Guillemot	Medium	3 - medium

The results of this analysis suggest that there would be a relatively small, but potentially significant reduction in the numbers of Sandwich Terns, Common Terns, Razorbills and Guillemot using the site during construction due to the impacts of increased boat traffic. However, actual use of the site by these species also requires consideration, as discussed below.

8.4.2.1 Terns

Construction is planned to take place throughout the year (Section 2), encompassing the breeding and peak passage periods for both tern species in any one year. It is likely that the site will constitute some part of the foraging range of Sandwich Terns from the colonies on the north Norfolk coast, but the data (sections 8.3.3.1 and 8.3.3.2) suggests that the site is relatively unimportant for these species as a feeding area. For birds passing through the site on route to other feeding areas (e.g. Dudgeon Shoal) the temporary disturbance during construction may result in deviation from the straight line route with the potential for metabolic disbenefits. Given the localized nature of the construction activities at any specific time, the temporary effect would be considered of **minor adverse significance** for Sandwich Terns.

In contrast, the majority of Common terns appear to be migrants, and therefore disturbance does not constitute the equivalent loss of habitat as in the case of Sandwich Terns. The temporary impact of construction is therefore predicted to be **negligible** for Common Terns.

8.4.2.2 Auks

Peak period of occurrence of Razorbills is in October. Although construction may take place throughout the year, disturbance of Razorbills for a temporary period during construction would not necessarily result in any significant impacts on the birds, since the site appears to be of limited importance for them (no birds observed feeding, and no particularly obvious aggregations, section 8.3.4.2). As a consequence, the impact of temporarily disturbance of Razorbill and Guillemot is considered of **negligible significance**.

8.4.3 Direct effect: disturbance due to noise & vibration from construction related activities

It is anticipated that the noise and vibration associated with any pile driving activity could result in the avoidance of the area by all bird species for the time during which this is undertaken, although data from other studies on this aspect of construction is scant. Compared to disturbance due to increased boat traffic, piling is a much noisier activity but of shorter duration. In absence of specific data on this effect, the impact assessment broadly follows the impact assessment due to increased boat traffic (determined in the previous section). Consequently any effect is considered to be of **minor adverse significance** for the impact on Sandwich Terns. For the other key species any impacts are anticipated to be **negligible**.

8.4.4 Direct effect: disturbance due to cable laying activities

Most potential effects during construction relate to activities at the wind farm *site*. However, cable laying activities between the wind farm and the landfall site could in principle also impact upon birds. Consultation with English Nature and the RSPB has indicated that the cable crossing of Sheringham Shoal, some 5.6 km to the south of the proposed site, is of some concern, as this may be an important area for feeding terns.

The data available from the additional survey transect along the shoal confirms that the shoal offers more suitable foraging habitat for Sandwich Terns than the wind farm site itself with both the encounter rate and the proportion of birds recorded as fishing being notably higher (section 8.3.3.1).

Nonetheless, the magnitude of the disturbance caused by the cable laying is limited, since the activity in the immediate vicinity of the shoal will last a few days at most, with total laying of the 21km stretch taking 13 days for each of the two export cables (see Section 2, Project Details). The impact from this short change from baseline condition is considered to be of negligible magnitude and consequently the effect on terns is considered of **minor adverse significance** at most.

8.4.5 Indirect effect: changes in prey supply

Indirect effects of construction activities have the potential to seriously affect birds and may be difficult to predict. For example at Scroby Sands the effects of pile driving on spawning fish has been raised as a potential cause of poor numbers of young-of-the-year herring, the main food source of Little Terns. Low fish numbers then contributed to the complete breeding failure of the birds in that season (Perrow *et al.* 2006).

Changes in prey supply could result from changes in the nature of the seabed, suspended sediment, or construction noise. At the Sheringham Shoal wind farm site any effects on the seabed would be unlikely to affect the birds of concern, which all feed on pelagic fish and invertebrates. Due to the highly temporary increases in suspended sediment would also be unlikely to have serious impacts.

In Section 10 (Natural Fisheries) it is concluded that neither the site nor the cable route constitute an active herring spawning ground. For other pelagic fish species it is concluded that the effects of construcion noise on the early life stages of spawning fish are considered negligible.

A combination of negligible effects on pelagic spawning fish and furthermore based on the relative unimportance of the site for feeding birds suggests the indirect effect of change in prey supply to be of **negligible** significance.

8.4.6 Mitigation & Residual impacts

Potential impacts on Sandwich Terns from increased boat traffic are considered likely to be of minor adverse significance at most, with minimal residual impacts.

Since construction will take place during the breeding season for Sandwich Tern a monitoring methodology will be put into place to confirm the nature of any residual impact (see section 8.8).

8.5 Impacts during operation

8.5.1 Introduction

The impacts on birds during operation are all likely to be of a direct nature. Visual impacts and the effects of moving structures could potentially result in disturbance and displacement and also act as a barrier to bird flight routes. The proposed wind farm could also impact on bird populations by causing additional mortality through collisions with the turbines. These impacts are discussed below.

8.5.2 Direct effect: disturbance and displacement

Disturbance and displacement could occur both as a result of disturbance due to visual impacts and the effects of moving structures, and as a result of increases in boat traffic, which are expected to occur as a result of maintenance activity. The magnitude of potential disturbance and displacement impacts will depend on:

1. The sensitivity of the species to disturbance;
2. The importance of the local habitat for the species; and
3. The availability of alternative sites nearby.

In order to make an assessment using the methodology set out in 8.2.5.2 the following parameters were used:

1. The vulnerability score based on the combined opinions of 13 seabird experts as reported by Garthe & Hüppop (section 8.4.2) as a measure for sensitivity to disturbance;
2. The percentage of birds that have been recorded feeding in the wind farm area as a measure of the importance of the local habitat;
3. The proportion of birds recorded in the wind farm site during the combined aerial surveys as a % of the total in survey blocks GW3, GW4 and GW5 as a measure for the availability of nearby alternative sites.

Using each of the above an overall magnitude of the displacement effect on each species was derived (Table 8.12).

Table 8.12 The magnitude of the disturbance and displacement effect determined from three different scores (see text).

Species	1. Vulnerability score	2. % of birds seen feeding	3. % of birds recorded in site	Overall magnitude of effect **
Razorbill	3 (Medium)	0	0.6% *	Low
Guillemot	3 (Medium)	0.1	0.6% *	Low
Sandwich Tern	2 (Low)	3.5	0.8%	Negligible
Common Tern	2 (Low)	6.1	<<1%	Negligible
Gannet	2 (Low)	0.87	<<1%	Negligible
Lesser Black-backed Gull	2 (Low)	0	<<1%	Negligible
Little Gull	1 (Negligible)	0	<<1%	Negligible

* Value for Auk sp.

** The justification of the overall magnitude of effect is explored in the text.

8.5.2.1 Auks

Of the seven key species, Razorbill and Guillemot are the most sensitive to disturbance and displacements with a medium vulnerability score. However, the lack of specific use (no observed foraging) and the conclusion that the wind farm site has no more potential than any other area of similar size in the Greater Wash (sections 8.3.4.2 and 8.3.5.3) substantiate that the magnitude of the disturbance and displacement effect is low. The impact of disturbance and displacement is therefore predicted to be of **minor adverse significance**.

8.5.2.2 Terns

The magnitude of the disturbance and displacement effect for Sandwich Tern and Common Tern is estimated to be negligible, as the response of the species to disturbance is low and the site is not of particular importance for these species as a feeding area, and that alternative areas are available. This assessment is in line with observations from existing offshore wind farm that Sandwich Tern and Common Tern pass through wind farms, flying between the turbines (see section 8.5.3 and references therein).

Based on the very high sensitivity of the species (Table 8.3), the overall significance of the impact is considered of **minor adverse significance**.

8.5.2.3 Other key species

In line with the assessment for terns, the disturbance and displacement effect for Gannet, Lesser Black-backed Gull, and Little Gull is estimated to be of negligible magnitude. Based on the medium (Gannet and Lesser Black-backed Gull) or high (Little Gull) sensitivity of the species and Table 8.5 the impact of the disturbance and displacement effect is considered to be **negligible**. In fact, at Horns Rev offshore wind farm, Little Gulls positively associated with the wind farm after construction are perhaps attracted by potential prey associated with turbine bases area (Christensen *et al*. 2003).

8.5.3 Direct effect: barrier effect

Birds may percieve lines of turbines as barriers to passage, be daily, seasonal or annual. In accordance with this results of Horns Rev radar analysis indicated that birds deviated at distances of 1-2 km to avoid the site. It is specifically mentioned that observers saw terns and Gannets taking evasive action in this way (Christensen & Hounisen 2004), although Sandwich Terns have also been observed passing through (Christensen *et al.* 2003). Observations from the wind farm at Yttre Strengtund in Sweden recorded both Common and Arctic Terns passing through the site on migration, flying between the turbines without making any deviation (Petterson 2005). Thus, it may be anticipated that the preferred flight lines of certain bird species, especially terns, across the site would not be disrupted by the presence of turbines, especially if suitable corridors between the turbines are available.

The proposed turbines at the Sheringham Shoal wind farm will be positioned 570-1120 m apart, depending on turbine size and orientation to bird flight direction. With the 108 x 3 MW layout as the assumed worst case situation for the barrier effect, the minimum distance between turbines is 570 m. With a rotor diameter of 90 m, this gives a minimum gap of 480 m between rotors.

8.5.3.1 Terns

The data shows a prevailing NE-SW flight direction for both Sandwich Terns and Common Terns (see 8.3.3.1 and 8.3.3.2), strongly suggesting movement through the site on route between the nearest colony at Blakeney Point and foraging grounds further offshore, possibly around Dudgeon Shoal. Barrier effect and residual displacement for both tern species could conceivably be reduced even further if corridors between the turbines were to align with these general directions.

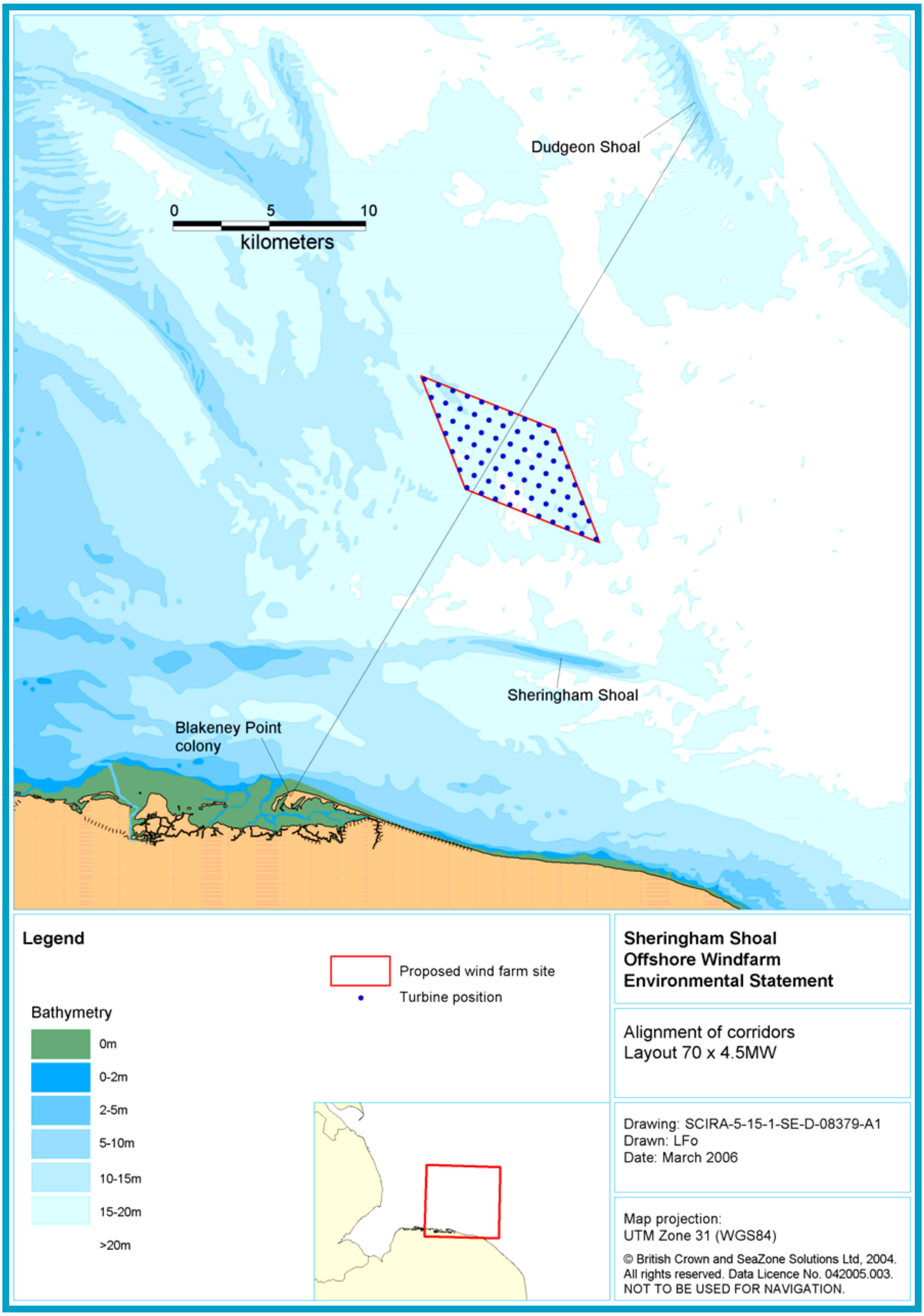

Figure 8.18 Corridors between the wind turbines are aligned with the prevailing NE-SW flight direction of terns through the proposed wind farm site. The layout shown is 70 x 4.5 MW.

Five different sizes of wind turbine are being considered for the proposed wind farm at Sheringham Shoal, each with a specific layout (see Section 2). Corridors between the turbines oriented in the approximate NE-SW direction have been incorporated in all five layouts. The preferred 70 x 4.5 MW layout is illustrated in Figure 8.18, the solid line indicating the direct route between the tern colony at Blakeney Point and Dudgeon Shoal. Table 8.13 summarises the relevant parameters for all five wind farm layouts, including an estimate for the length of detour for a bird flying from Blakeney Point to Dudgeon Shoal following a corridor through the wind farm.

With flight corridors within the wind farm the estimated average detour length is reduced to below 0.1km for all but one layout (see Figure 8.18). The residual impact of the barrier effect with these corridors in place is therefore predicted to be of negligible magnitude.

Table 8.13 Wind farm layout parameters relevant to the flight corridors for terns and migrant big birds.

Wind farm layout	Orientation of the corridors * [degrees]	Distance between turbines [m]	Minimum width of the corridors (tip to tip) [m]	Estimated detour length ** [km]
108 x 3 MW	36	660	570	< 0.1
88 x 3.6 MW	34	720	616	< 0.1
70 x 4.5 MW	30	800	680	< 0.1
63 x 5 MW	39	900	775	< 0.1
45 x 7 MW	15	900	750	~ 0.25

* The direct flight line (as in Figure 8.18) corresponds to 31 degrees.

** Estimated detour for birds flying from Blakeney Point to Dudgeon Shoal following a central corridor through the wind farm. The total distance being approx. 40 km.

Moreover, even if the preferred flight lines of the terns were to be disrupted by the presence of the turbines, relatively small deviations in course by flying birds at some distance from the site would be required to take them past the wind farm. For example, the estimated *maximum* detour length for a bird flying from Blakeney Point to Dudgeon Shoal to avoid the wind farm would be between 2km and 5km depending on the distance from the site where the deviation commences. This is a 5 to10% increase over the total flight distance of approx. 40km. Given that Sandwich terns are capable of routinely flying large distances to foraging grounds, such deviations are thought unlikely to bear any significant costs to individual fitness and ultimately breeding productivity. The impact of the barrier effect is therefore predicted to be of **minor adverse significance** at most.

Migration

Although the extensive boat-based survey programme has shown little evidence of migrant waterfowl, waders or passerines passing through the proposed site of the wind farm within visible height range, it is expected that the general flight direction of such passage would correspond to the approximate NE-SW direction. Alternatively. it is also likely that migrant waterfowl would to some extent be diverted around the wind farm, as has been recorded at several other offshore wind farms (Desholm & Kahlert 2005). It is also possible that the potential barrier effect would be minimized by the corridors between turbines that are provided in the layout. It is thus anticipated that any impact on migrant birds would be of negligible significance.

8.5.4 Direct effect: risk of collision

8.5.4.1 Introduction

The proposed wind farm could impact on bird populations by causing additional mortality through bird collisions with the wind turbines. Mortality as a result of collision with turbine blades can be assessed using collision risk modelling. The collision risk model used in this assessment is the model developed by SNH and BWEA (Percival *et al.* 1999, Band 2000), taking into account the recent appraisal of the model by the BTO and NERI (Chamberlain *et al.* 2005).

The model is essentially a mechanistic calculation assuming that flight patterns are unaffected by the presence of the wind turbines. The outcome of the collision risk model is a theoretical number of individuals at risk of collision, assuming that the birds do not actively avoid the turbines. The probability that the birds will take avoiding action is then incorporated by multiplying the predicted collision rate by 1 minus the probability of avoidance.

The probability of avoidance, or avoidance rate, is typically estimated to be very high (well above 99%) in most case studies (e.g. Percival 2000). For impact assessment SNH has recently recommended a highly precautionary approach, using a value of (only) 95% as an avoidance rate. Such a low avoidance rate certainly overestimates the rate of mortality caused by a wind farm.

The approach used here is to use a more realistic but still precautionary avoidance rate of 98% in the impact assessment. Calculated mortality rates are also given for the avoidance rates of 99% and 99.5% (see Table 8.14).

The primary results from the collision model calculations are presented in Appendix 8.4. Only those key species in which a proportion of the population was observed flying at rotor height were included. Therefore, collision risk was calculated for Sandwich Tern (13% of the recorded birds were flying at risk height, see Appendix 8.2), Common Tern (16%), Little Gull (10%), Gannet (10%), and Lesser Black-backed Gull (27%). Guillemot and Razorbill were excluded since these species were never recorded flying at heights of greater than 20m above sea surface.

In accordance with the specifications of the Rochdale Envelope the impact assessment assumes the worst case scenario for birds. For collision risk assessment, this is specified as the site layout with a large number of small turbines, i.e. the 108 x 3 MW layout.

Table 8.14 Summary of the results from the collision model calculations (see Appendix 8.4).

Species	Sandwich Tern	Common Tern	Gannet	Little Gull	Lesser Black-backed Gull
Bird parameters used in collision risk model:					
Bird length (m) **	0.38	0.33	0.93	0.26	0.58
Wingspan (m) **	1.00	0.87	1.72	0.77	1.42
Flight speed (m/s) *	10.5	10.5	13.0	11.5	11.5
% active at night †	0%	0%	25%	25%	50%
% at rotor height ‡	13.3%	15.7%	9.9%	9.9%	26.5%
Collision modelling results: (number of individuals)					
Annual mortality at 98% avoidance	23	3	31	8	33
Annual mortality at 99% avoidance	12	1	16	4	16
Annual mortality at 99.5% avoidance	6	1	8	2	8

*From Christensen & Hounisen 2005

**Taken from http://www.rspb.org.uk

†Derived from nocturnal activity codes by Garthe & Hüppop 2004.

‡From boat-based survey records.

The calculated mortality from the collision risk modelling were assessed on three levels:

1. Local - the significance of the impact of collision mortality on the site population of any species is calculated from annual passage rates of birds passing through the site.
2. Regional - the significance of the impact of collision mortality on the estimated regional population of any species for the greater Wash area, using best available data.
3. Super regional - the significance of the impacts of collision mortality on the estimated annual mortality rate of the part of the UK population of any species likely to pass through the Wash.

8.5.4.2 Impact on local site populations

The significance of the impact of calculated collision mortality on the annual site population is based on an assessment of mortality in relation to the annual rate of passage of birds through the site. Passage rates can be estimated from the average densities of flying birds of any species at the wind farm site (per species and per month from snapshots taken during the boat-based surveys). The average number of flying birds was multiplied by the time spent in the site (assuming that birds flew through the site in a straight line at a mean species-specific flight speed) to give an hourly passage rate, which was then scaled up to give the number of birds passing through the site per month. Additional scale factors were used to account for the difference between diurnal and nocturnal activity patterns. Monthly values were then summed to give an annual passage rate, i.e. the site population (Table 8.15). Whilst this appears to provide realistic figures for most species, the passage rate of Little Gull is a considerable overestimate, since their movement through the site is highly seasonal focussed on early October.

Table 8.15 Assessment of the impacts of calculated collision on site population assuming 98% avoidance rate.

Species	Sandwich Tern	Common Tern	Gannet	Little Gull	Lesser Black-backed Gull
Sensitivity	Very high	Very high	Medium	High	Medium
Passages through site per year *	98,000	11,000	130,000	52,000	60,000
% passages resulting in collision	0.024%	0.024%	0.024%	0.015%	0.055%
Magnitude of effect	Negligible	Negligible	Negligible	Negligible	Negligible
Significance of impact	Minor	Minor	Negligible	Negligible	Negligible

*Calculated based on densities of flying birds as derived from snapshots during boat-based surveys.

Assuming a precautionary 98% avoidance rate, the calculated collision rates are expressed as a percentage of the passage rates. The magnitude of the impact on the site population was then assessed using the matrices presented in section 8.2.5.2. The overall significance of the predicted impacts on all species is either minor or negligible, indicating that turbine strike would not be expected to have any significant impacts on the local site populations.

8.5.4.3 Impact on regional populations

The methodology described above was also used to assess the magnitude and significance of the likely impacts on regional populations in the Greater Wash area (Table 8.16).

Table 8.16 Assessment of the impact of calculated collision on regional population assuming 98% avoidance rate.

Species	Sandwich Tern	Common Tern	Gannet	Little Gull	Lesser Black-backed Gull
Sensitivity	Very high	Very high	Medium	High	Medium
Estimated regional population	7,300 ‡	780 ‡	5,700 *	32,000 †	2,800 **
% regional population affected	0.3%	0.4%	0.5%	0.03%	0.8 %
Magnitude of effect	Negligible	Negligible	Negligible	Negligible	Negligible
Significance of impact	Minor	Minor	Negligible	Negligible	Negligible

*Best estimate calculated from Western North Sea density from Stone *et al.* (1995) during peak month multiplied by the area of the Greater Wash surveyed during the aerial surveys.

**Number of birds recorded breeding on Outer Trial Bank in 2005 (Brown & Grice 2005). This assumes that the birds in the wind farm site are from this colony, which is actually unlikely – see text.

†Based on maximum count of 2032 from the aerial survey data, scaled up to accommodate for the timing of the survey, since no aerial surveys were carried out during the peak passage period.

‡2005 Scolt Head and Blakeney Point breeding colony figures from site wardens.

Again, assuming a precautionary 98% avoidance rate, the calculated collision rates are expressed as a percentage of the estimated regional population. The magnitude of the impact on the site population was then assessed using the matrices presented in section 8.2.5.2. The overall significance of the predicted impacts on all species was either minor or negligible, indicating that turbine strike would not be expected to have any significant impacts in a regional context.

8.5.4.4 Impacts on part of the UK population likely to pass through the Wash

The capacity of each species to accommodate additional mortality due to the wind farm over background levels was investigated on the part of the UK population likely to pass through the Wash. The background annual mortality was calculated using estimated population sizes for this wider region and a species-specific annual mortality rate available from the literature. The increase in mortality due to the wind farm (assuming a precautionary 98% avoidance rate) was then expressed as an percentage increase over this background mortality (Table 8.17).

Table 8.17 Assessment of the impact of calculated collision on the part of the UK population likely to pass through the Wash assuming 98% avoidance.

Species	Sandwich Tern	Common Tern	Gannet	Little Gull	Lesser Black-backed Gull
Sensitivity	**Very high**	**Very high**	**Medium**	**High**	**Medium**
Estimated east coast population	24,000 [1]	13,000 [2]	623,000 [3]	32,000 [4]	97,000 [5]
Background annual mortality rate *	12%	12%	6%	20%	7%
Background annual mortality	2880	1560	37380	6400	6790
% increase over background mortality	0.8%	0.2%	0.08%	0.14%	0.5%
Magnitude of effect	Negligible	Negligible	Negligible	Negligible	Negligible
Significance of impact	Minor	Minor	Negligible	Negligible	Negligible

*Taken from Garthe & Hüppop 2004

[1] UK birds likely to pass the Wash calculated from breeding numbers from East Coast of the UK only (Norfolk to Orkney), based on Seabird 2000 breeding numbers. Birds from the UK West coast have not been recovered around the North Sea coasts (Wenham *et al.* 2002).

[2] UK birds likely to pass the Wash calculated from breeding numbers from SE Scotland (Perth and Kinross south), NE, E and SE England (to East Sussex, including inland counties Leics, Cambs, Northants, Beds, Bucks Greater London), based on Seabird 2000 breeding numbers.

[3] Global population estimate from Birdlife Int (2004). Birds likely to be encountered in the Wash may also include non-breeding sub-adults, during the breeding period, numbers of which are unknown. The entire UK population is deemed likely to pass through the Wash in the course of a year as birds highly mobile and long-ranging.

[4] No UK breeding birds. Based on maximum count of 2032 from the aerial survey data, scaled up to accommodate for the timing of the survey, since no aerial surveys were carried out during the peak passage period. As in Table 8.16.

[5] UK breeding population from Seabird 2000 data in Mitchell et al. 2004. Birds breeding in the southern half of the UK are likely to pass through the Greater Wash as are birds from Norway and possibly Iceland (Skov et al 1995). Winter UK numbers from Migration Atlas, but a large proportion of these will over-winter inland in the UK.

The magnitude of the impact of collision on the annual mortality rates of the population likely to pass through the Wash was then assessed using the matrices presented in section 8.2.5.2. The overall significance of the predicted impacts on was either minor or negligible for all species, indicating that turbine strike would not be expected to have any significant impacts on the mortality rate in a super regional context.

8.5.5 Conclusions in relation to collision mortality

Mortality due to collision with wind turbines is obviously significant on an individual level but may only be so on a population level once a specific number of individuals are lost. In the sections above, collision risks for the key species Sandwich Terns, Common Terns,

Gannets, Little Gull and Lesser Black-backed Gull at the proposed wind farm Sheringham Shoal have been assessed on three population levels.
Two important precautionary assumptions are used in the impact assessment. First, the annual mortality was calculated with the worst case 108 x 3 MW layout (Rochdale Envelope). Second, a precautionary avoidance rate of 98% was used. Notwithstanding this precautionary approach, the significance of the impact is predicted to be **negligible or minor adverse** for all species and on all three assessment levels. It is concluded therefore that mortality due to collision with the wind turbines is unlikely to be of significance on a population level for any of these species during normal weather conditions.

Whilst if there have been concerns that under exceptional storm conditions both seabirds as well as migrant passerines, waders and waterfowl, which would otherwise pass through the area above turbine height, could be at risk, it should be stated that at wind speeds above about 25m/s (wind force 10Bft and above) the wind turbines are shut down for safety reasons. This is deemed to eliminate the risk of birds being hit by a rotor blade.

8.5.6 Mitigation and Residual Impacts

The main issues identified in the sections above are disturbance/displacement impacts, the barrier effect (limited to high sensitivity species) and collision. Since both Sandwich Terns and Common Terns have been observed passing through wind farms, flying between the turbines without making any deviation, the impact of the barrier effect is likely be reduced further since flight corridors for the birds are incorporated in the wind farm design.

8.6 Impacts during decommissioning

The impacts during decommissioning are expected to be similar to the impact during the construction phase (see section 8.4).

Thus, any effect is considered to be of **minor adverse significance** for the impact on Sandwich Tern. For the other key species any impacts are expected to be **negligible**.

8.7 Cumulative effects

8.7.1 Cumulative Assessment Methodology

A methodology was devised for the assessment of cumulative impacts based on the matrices described in section 8.2.5.2 Due to the differing methodologies employed on other sites, the effects could only be assessed in terms of general categories (e.g. very low, low etc.). Since the exact percentage of the population likely to be affected was not known for the other sites, the value for each defined magnitude was estimated by comparing peak densities recorded at the other site with the peak densities recorded at Sheringham Shoal. The cumulative effect was then assessed in an additive capacity, which was classified according to the magnitudes defined in Table 8.6. The matrix of magnitude of effects and sensitivity was then used to assess the level of significance as before (Table 8.5). This was considered the most appropriate way to assess impacts on birds since the impacts considered most likely, namely distirbance/displacement and turbine strike, would be expected to result in potentially additive effects, for example in relation to mortality and habitat loss.

8.7.2 Cumulative effects from Round 1 consented sites

The data used to assess cumulative impacts was taken from the ornithological reports from the three Round 1 consented sites in the Wash. These are Lynn & Inner Dowsing (LID), which are treated as one site due to their proximity, and Norfolk (also known as Cromer). It was assumed that unless species had been specifically identified as being at risk from some level of impact at both Sheringham Shoal and any of the other sites, that any cumulative effects (i.e. over and above those discussed in this document) would not occur as a result of the proposed Sheringham Shoal development. The only species identified as potentially at risk at LID that were also present at the Sheringham Shoal site were Gannet and terns. The majority of the latter, when identified, were Sandwich Terns (Gill *et al.* 2004). There were no species identified as being at risk at both the Sheringham Shoal and Norfolk sites (Norfolk Offshore Wind 2002).

Sandwich Terns

Calculation of the cumulative additive effects of impacts from developments at LID and Sheringham Shoal, required the assessment of the overall effect of each development. In the case of the Sheringham Shoal site, the magnitude of the disturbance and displacement effect on Sandwich Tern was classified as *low*, based on a small percentage (<1%) of birds recorded in the site itself (see Table 8.12). Since densities of Sandwich Terns at both Sheringham Shoal and LID were similar (LID peak density= 0.27 ind. km^{-2}, Sheringham Shoal peak density=0.30 ind. km^{-2}), the overall effect were taken to be comparable, with the result that for the purposes of this analysis the effect on Sandwich Tern at LID was also classified as *low.* This is in keeping with the statement in Gill *et al.* (2004) that no detectable effects on the regional population would occur.

Even given the very high sensitivity of Sandwich Terns, the cumulative impact is predicted to be still of **minor adverse significance**. The monitoring proposal for Sandwich Terns discussed in section 8.8 would provide the information required to further assess the likelihood of this potential cumulative impact occurring.

Gannets

Gannet densities at LID (peak=0.42 ind. km^{-2}–Gill *et al.* 2004) were far lower than at Sheringham Shoal (1.09 ind. km^{-2}). Therefore, since the overall effect on Gannet at Sheringham Shoal had been classified as being of negligible magnitude the overall effect on Gannet at LID were also classified as the same. Given the medium sensitivity of Gannets, the cumulative impact is predicted to be of **negligible** significance.

8.7.3 Cumulative effects from Round 2 sites

Whilst a number of other Round 2 sites are planned in the Wash, it was not possible to assess potential cumulative impacts with the Sheringham Shoal project since the other sites are yet to submit their definitive intentions and site specific bird data is not yet available.

8.7.4 Cumulative effects from other activities

Other activities near the wind farm site that potentially give rise to cumulative effects are limited to the nearby shipping lanes (see Section 14). The nearest marine aggregates sites, oil and gas activities and military zones are far enough away not to be of concern in this context.

In combination disturbance or displacement effects from shipping would be expected most likely for the key species most vulnerable to boat traffic such as: Razorbill and Guillemot (see Table 8.11). However. the distribution of all auks observed during the 7 aerial surveys carried out between November 2004 and August 2005 (Figure 8.12) shows no indication that the density of auks is lower in or near shipping lanes compared to elsewhere in the survey area.

Therefore, since the overall impact of disturbance or displacement of auks during operation of the wind farm has been classified as being of low magnitude the overall effect is classified as the same. Given the high sensitivity of Razorbill and the medium sensitivity of Guillemot, the cumulative impact is predicted to be of **minor adverse significance** at most for both species.

8.8 Monitoring proposals

A combination of boat-based surveys, aerial surveys and radar studies were used to establish the ornithological baseline. A suitable programme will be developed in cooperation with English Nature to monitor impact of the development upon the species identified as of potential concern. Given the internationally important tern colonies at the Norfolk coast, monitoring efforts will be focussed on Sandwich and Common terns.

Boat-based surveys during the summer and autumn are deemed suitable to establish density and population sizes of birds of concern in the study area and control during construction and operation. In particular, a summer survey programme comparable to that undertaken in the baseline is thought adequate to determine populations and use Sandwich and Common terns and Lesser Black-backed Gulls and the late summer passage of Gannet and Guillemot. A number of surveys from late September to the end of October would allow assessment of the passage of Little Gull and Razorbill as well as other migrant species. With little use of the study area by birds during winter no boat surveys are required.

With the lack of importance of divers and sea-ducks and with the low relative use of the study area compared to the wider area, there is no further requirement for aerial surveys. The relative unimportance of the study area for migrant waterfowl, waders and passerines also eliminates the need for further radar studies.

Given the importance of Sandwich Tern, species specific monitoring effort, over and above determination of density and population size may be worthwhile to determine the nature and magnitude of any residual impact. The monitoring undertaken on a similar species, Little Terns, at the Scroby Sands Offshore Wind Farm, where impacts were also predicted as “moderate at most”, provides a suitable model. This will be further discussed with English Nature.

8.9 Summary

8.9.1 Introduction

An intensive programme of boat-based surveys over two years supplemented by aerial surveys at key times in summer and winter and radar studies during successive autumn migration periods, was used to describe the bird use and activity within the Sheringham Shoal study area containing the proposed wind farm.

A number of species/groups raised as being of potential importance in the scoping studies including divers, sea-duck and migrant waterfowl (including Pink-footed and Brent Geese), waders and passerines did not occur on the site in sufficient numbers to be of concern. In the case of divers and sea-duck, aerial surveys illustrated that other areas were of far greater importance within the Greater Wash. Whereas Pink-footed geese, amongst other waterfowl were observed during radar studies there was no evidence that these crossed the proposed wind farm site, and were more typically undertaking local movements in inshore coastal waters. Passerine and possibly wader migration tended to occur at night on a broad front, but generally at sufficient height to mean that even if birds crossed the site, they were at little risk from potential turbine strike. This does not account for poor weather, although the risk to birds, including seabirds, would be reduced in extremely windy conditions by the automatic shutdown of the turbines.

The maximum estimated population size in the study area of a small number of species (seven) was high enough (i.e. at least of regional importance-1% or more of regional population), on at least one occasion to warrant further investigation. These included Sandwich and Common Terns, Little and Lesser Black-backed Gulls, Gannets, and the auks, Razorbill and Guillemot. Both tern species were assessed as being of very high sensitivity on account of their inclusion within either the Wash or North Norfolk Coast SPA’s. Little Gull and Razorbill were classed as of high sensitivity on account of their potential to occur in numbers of national importance (1% of national population). Gannet, Lesser Black-backed Gull and Guillemot were classed as of medium sensitivity.

A precautionary worst-case assessment of any potential impacts of the proposed development upon the species of concern was undertaken. This used both significance level assessment involving matrix analysis of sensitivity and magnitude of any effects, as well as a thorough ecological appraisal of seasonal variation and patterns of each species of the study area and proposed site.

8.9.2 Impacts on key species of very high sensitivity

8.9.2.1 Sandwich Tern

With little specific use of the wind farm and buffer area by foraging birds, and the availability of alternative areas, the significance of disturbance during construction and displacement during operation is considered *minor* adverse. Although evidence from other offshore sites is scant, at Horns Rev offshore wind farm, Sandwich Terns were regularly seen to enter the wind farm area (Christensen *et al*. 2003). Thus, it may be anticipated that preferred flight lines of sandwich tern across the site would not be disrupted by the presence of turbines, especially since preferred flight lines have been considered and incorporated in the design layouts.

Only a low proportion (13%) of birds were recorded in the zone potentially occupied by the turbines and the risk of collision was deemed to be of *minor* adverse significance irrespective of whether the site population (number of passage movements), the regional population, or the background mortality levels of the UK population likely to pass through the site was used in calculations.

In conclusion, the presence of the Sheringham Shoal wind farm may conceivably have a *minor* adverse impact upon Sandwich Terns. Rigorous monitoring will help determine the nature of any residual effects should they occur.

8.9.2.2 Common Tern

With limited use of the wind farm and buffer area by foraging birds, and the availability of alternative areas there was a *negligible* significance of disturbance during construction and a *minor* adverse significance of displacement during operation.

A highly precautionary approach to assess collision risk was conducted as though the birds were part of the breeding population in the SPA. The relatively low proportion (16%) of birds recorded in the zone potentially occupied by the turbines provided the same *minor* adverse significance as for Sandwich Tern.

Monitoring within any programme devised for Sandwich Terns may determine the nature of any residual effects should they occur.

8.9.3 Impacts on key species of high sensitivity

8.9.3.1 Little Gull

The high proportion (54%) of birds on the surface was thought to result from birds breaking passage under unfavourably calm conditions. With no feeding activity ever observed there was little specific use of the wind farm and buffer area by foraging birds. The significance of disturbance and displacement during construction and operation was considered to be *negligible*.

Only a low proportion (10%) of birds were recorded in the zone potentially occupied by the turbines and the risk of collision was deemed to be of *negligible* significance.

In conclusion, the presence of a wind farm at the proposed Sheringham Shoal site is unlikely to have a detectable negative impact on Little Gulls.

8.9.3.2 Razorbill

With the peak period of occurrence in October, when construction activity is likely to reduce due to adverse weather, disturbance during construction was deemed to be *negligible.* With evidence of disturbance from boats (Garthe & Hüppop 2004), the effect of displacement in the longer term during operation was assessed as of *minor* adverse significance.

With the complete lack of birds within the range of turbine blades, it was concluded there is a *negligible* risk of individual mortality through collision.

8.9.4 Impacts on key species of medium sensitivity

8.9.4.1 Gannet

With little specific use of the wind farm and buffer area by foraging birds (<1% feeding), there was a *negligible* significance of disturbance during construction and a negligible significance of displacement during operation.

Only a low proportion (10%) of birds were recorded in the zone potentially occupied by the turbines and the risk of collision was considered to be *negligible*.

In conclusion, the presence of a wind farm at the proposed Sheringham Shoal site is unlikely to have a detectable negative impact on Gannet.

8.9.4.2 Lesser Black-backed Gull

With no specific use of the wind farm and buffer area by foraging birds, there was a *negligible* significance of disturbance during construction and *negligible* significance of displacement during operation.

A highly precautionary approach to assessment was conducted as though the birds were part of the local breeding population. The moderate proportion (27%) of birds recorded in the zone potentially occupied by the turbines did not greatly influence the risk of collision, which was concluded to be *negligible*.

In conclusion, the presence of a wind farm at the proposed Sheringham Shoal site is unlikely to have a detectable negative impact on Lesser Black-backed Gull.

8.9.4.3 Guillemot

Guillemots showed negligible active use of the study area (1 feeding record) and passed through rapidly. Without specific use the impact of temporarily disturbance during construction was deemed to be *negligible.* Given the availability of alternative areas the impact of displacement in the longer term during operation was assessed as *minor* adverse.

With the complete lack of birds within the range of turbine blades, it was concluded there is a *negligible* risk of individual mortality through collision.

8.9.5 Cumulative impacts

As a result of a lack of shared species of concern or a low significance level attached to the impacts of the consented Round 1 sites at Lynn & Inner Dowsing and Norfolk (Cromer), no cumulative impact over and above that determined for the proposed development at the proposed Sheringham Shoal site itself were anticipated.

8.9.6 Overall conclusion

Seven key species were subject to detailed impact assessment. This concluded that no single species would be likely to incur impacts that would require revision of the worst-case scenario of the proposed development.

However, the potential for a significant impact upon Sandwich and Common Terns was noted. Although the significance of the impact has been integrated in the layouts of the wind farm by incorporating corridors between turbines in the main flight direction of the terns, even without such mitigation the significance of the impact displacement and barrier effect upon Sandwich and Common Terns is predicted to be of *minor adverse* significance at most, and therefore of limited concern.

The nature and magnitude of any residual impact upon any species of concern, is best assessed through a rigorous monitoring programme. This will inform any necessary changes in operational procedure to further mitigate any impact and to allow the impact of other Round 2 developments in the Greater Wash to be better assessed. In general terms, monitoring may readily include a tailored programme of boat-based surveys to cover all species of concern. Any impacts upon Sandwich terns, which are the primary species of concern, is likely to also require a more specific programme of monitoring.

8.10 References

- Allcorn, R., Eaton, M.A., Cranswick, P.A., Perrow, M., Hall, C., Smith, L., Reid, J., Webb, A., Smith, K.W.S., Langston, R.H.W. & Ratcliffe, N. (2003). A pilot study of breeding tern foraging ranges in NW England and East Anglia in relation to potential development areas for offshore windfarms. RSPB / WWT / JNCC, Sandy, UK: 27pp.
- BirdLife International (2004). Birds in Europe; population trends and conservation status. BirdLife Conservation Series No.12. BirdLife International, Cambridge, UK: 374pp.
- Brown, P. & Grice, P. (2005). Birds in England. T & AD Poyser, London, UK: 694pp.
- Chamberlain, D., Freeman, S., Rehfisch, M., Fax, T., Desholm, M. (2005). Appraisal of Scottish Natural Heritage's Wind Farm Collision Risk Model and its Application. Report by BTO, April 2005.
- Camphuysen, C.J., Fox, A.D., Leopold, M.F. & Petersen, I.B. (2004). Towards standardized seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the U.K. Report to COWRIE, 38pp.
- Christensen, T.K., Clausayer, I. & Petersen, I.K. (2002). Base-line investigations of birds in relation to an offshore wind farm at Horn's Reef, and results from the year of construction. NERI report to Tech-wise A/S.
- Christensen, T.K., Hounisen, J.P., Clausayer, I. & Petersen, I. K. (2003). Visual and radar observations of birds in relation to collision risk at the Horns Rev offshore wind farm. Annual Status Report 2003. NERI report commissioned by Elsam Engineering A/S 2003/2004.
- Christensen, T.K., Hounisen, P.J. Clausager, I., & Petersen, I. (2004). Visual and Radar Observations of Birds in Relation to Collision Risk at the Horns Rev Wind Farm.
- Christensen, T.K. & Hounisen, J.P. (2005). Investigations of migratory birds during operation of Horns Rev offshore wind farm. Annual Status Report 2004. NERI report commissioned by Elsam Engineering A/S 2005.
- Cramp, S., Bourne, W.R.P & Saunders, D. (1974). The seabirds of Britain and Ireland. William Collins & Sons & Co. Ltd. London, UK: 287pp.
- Cranswick, P.A., Hall, L. & Smith, L. (2003). Aerial Surveys of Birds in Prposed Strategic Areas for Offshore Windfarm Developments, Round 2: Preliminary Report, Winter 2002/03, WWT Research Report to DTI, June 2003.

- Desholm, M., & Kahlert, J. (2005). Avian collision risk at an offshore wind farm. *Biology Letters* 1(3): 296-298.
- Garthe, S. & Hüppop, O. (2004). Scaling possible adverse effects of marine wind farms upon seabirds: developing and applying a vulnerability index. Journal of Applied Ecology, 41, 724-734.
- Gill, P., Sales, D., Beasley, F., Pullinger, M. & Pinder, S. (2004) Ornithological monitoring report for Lynn and Inner Dowsing offshore windfarms. Report to Centrica Ltd. 142pp
- Hartley, C. (2004). Little Gulls at sea off Yorkshire in autumn 2003. British Birds, 97(9), 448-455.
- JNCC (1995). Guidelines for the selection of biological SSSi's. JNCC, Peterborough, UK
- Komdeur, J., Bertelsen, J. & Gracknell, G. (1992). Manual for aeroplane and ship surveys of waterfowl and seabirds. IWRB Special Publication No. 19. International Wetland Research Bureau, Slimbridge UK, 37pp.
- Nedwell, J., & Howell, D. (2004). A review of offshore wind farm related underwater noise sources. Technical Report S44 R0308, prepared by Subacoustech Ltd., Hampshire, UK, for COWRIE.
- Mavor, R.A., Parsons, M. Heubeck, M. & Schmitt, S. (2005). Seabird numbers and breeding success in Britain and Ireland, 2004. UK Nature Conservation, No. 29, Joint Nature Conservation Committee, Peterborough, UK: 104pp.
- Mitchell, P.I., Newton, S., Ratcliffe, N. & Dunn, T.E. (2004). Seabird populations of Britain and Ireland (Results of the Seabird 2000 Census 1998-2002). T & AD Poyser, London, UK: 511pp.
- Norfolk Offshore Wind (2002) Cromer Offshore Wind Farm Environmental Statement, Chapter 8. 37pp.
- Parnell, M., Walls, R.J., Brown, M.B., Budgey, R. & Allan, J. (2004) The remote monitoring of offshore avian movement using bird detection radar at Weybourne, North Norfolk. Central Science Laboratory (Bird Management Unit) report commissioned by Scira Offshore Energy for the offshore Sheringham Shoals Wind Farm part of the Greater Wash Strategic Area.
- Parnell, M., Walls, R.J., Brown, M.B. & Brown, S. (2005) The remote monitoring of offshore avian movement using bird detection radar at Weybourne, North Norfolk. Central Science Laboratory (Bird Management Unit) Report commissioned by Scira Offshore Energy.
- Percival, S.M. (2000). Birds and wind turbines in Britain. British Wildlife, 12, 8-15.
- Percival, S.M., Band, B. & Leeming, T. (1999). Assessing the ornithological effects of wind farms: developing a standard methodology. Proceedings of the 21st British Wind Energy Association Conference 161-166.
- Perrow, M.R., Skeate, E.R., & Tomlinson, M.L. (2005). Scroby Sands Ornithological Monitoring: Assessing the potential impact of the proposed wind farm upon Little tern *Sterna albifrons*: the construction phase 2004. Report to E.ON Renewables Offshore Wind Limited.
- Perrow, M.R., Skeate, E.R., Lines, P.L., Brown, D., & Tomlinson, M.L. (2006). Radio telemetry as a tool for impact assessment of offshore wind farms: the case of Little Terns *Sterna albifrons* at Scroby Sands, Norfolk, UK. Ibis, 148, 57-75.
- Pettersson, J. (2005). The impact of offshore wind farms on bird life in Southern Kalmar Sound, Sweden. Report to Swedish Energy Agency.
- RWE Group (2005). Ornithology. In: Annual FEPA Monitoring Report 2005. North Hoyle Offshore Wind Farm. Report to npower renewables.

- SCIRA (2005). Sheringham Shoal Offshore Windfarm – Scoping report, Birds.
- Skov, H. Durinck, J. Leopold, M.F. & Tasker, M.L. (1995). Important Bird Areas for seabirds in the North Sea. BirdLife International, Cambridge, UK; 156pp.
- Stone, C.J., Webb, A. Barton, C., Ratcliffe, N. Reed, T.C., Tasker. M.L., Camphuysen, C.J. & Pienkowski, M.W. (1995). An atlas of seabird distribution in north-west European waters. Joint Nature Conservation Committee, Peterborough, UK: 326pp.
- Tasker, M.L., Webb, A., Hall, A.J., Pienkowski, M.W. & Langslow, D.R. (1987). Seabirds in the North Sea, Nature Conservancy Council, Peterborough, UK: 336pp.
- Taylor, M. (1987). Birds of Sheringham. Poppyland Press, North Walsham, UK: 88pp. ISBN 0946142860.
- Taylor, M, Seago, M., Allard, P. & Dorling, D. (1999). The Birds of Norfolk. Pica Press, East Sussex, 552pp.
- Wetlands International (2002). Waterbird Population Estimates, Third edition. Wetlands International Global Series No. 12, Wageningen, The Netherlands.
- WWT (2005). Aerial Surveys of Waterbirds in Strategic Windfarm Areas: 2004/05 Final Report, WWT Wetlands Advisory Service Report to Department of Trade and Industry, October 2005.

9 Marine Ecology

9.1 Introduction

This section describes the benthic biological resource of the Sheringham Shoal offshore wind farm (Sheringham Shoal project) and wider study area. Baseline conditions with respect to benthic infaunal and epifaunal assemblages are presented and discussed. Against this baseline, an assessment of the potential impacts associated with the construction, operation and decommissioning of the Sheringham Shoal project and export cables routes is made, along with an assessment of the cumulative impacts in combination with other activities and proposed projects occurring in the wider study area.

Impacts associated with the Natural Fish Resource and Commercial Fisheries are described in Sections 10 and 12 respectively.

9.2 Assessment methodology

Info on the marine biological resource of the near shore environment of The Wash and north Norfolk coast and the southern North Sea is readily available. General descriptions of the habitats and species assemblages present are available from a number of sources including, *inter alia*, Allen (2000) and Ellis and Rogers (1999) as well as a range of Environmental Statements produced for other offshore wind farm projects (e.g. Lewis *et al*., 2002 and Royal Haskoning, 2002) and aggregate dredging licences (e.g. Entec, 1999 and 2003). Such information sources have been drawn upon in this section to support the establishment of baseline conditions. However, in isolation, this information does not provide a detailed enough foundation upon which to undertake an assessment of the potential impacts of the Sheringham Shoal project. Detailed site specific studies have also, therefore been commissioned and the results fed into the Environmental Impact Assessment (EIA) process. These are described below.

9.2.1 Acoustic, video and grab survey

Prior to carrying out the intrusive surveys for infauna and epifauna, commissioned specifically to describe the benthic communities within the study area, Envision Mapping Limited (Envision) was commissioned to provide a determination of major bedform and sediment categories and conspicuous faunal communities (Sotheran *et al.*, 2005), in order to ensure that suspected sensitive areas could be avoiding during infaunal and epifaunal sampling. Specifically, the purpose of the initial survey was to:

- Identify the occurrence of *S. spinulosa* and, if present, describe the extent of development of reef communities likely to be of conservation importance;
- Identify other benthic habitats that might be sensitive to the construction and operation of an offshore wind farm;
- Survey the seabed bathymetry of the study area;
- Collect geophysical data using a sub-bottom profiler for seabed geological mapping; and
- Collect sidescan sonar data for seabed mapping and geological interpretation.

To achieve these objectives, a range of acoustic techniques were used including:

- Acoustic Ground Discrimination System (AGDS) to measure sediment characteristics and water depth at a coarse resolution;
- Swath bathymetry for detailed 100% coverage of the depths of the seabed; and

- Sidescan-quality images of the seabed for the description of seabed features.

Following completion of the acoustic, video and grab survey, the site specific infaunal and epifaunal surveys were carried out with the following objectives in mind:

- characterisation of the subtidal macrofauna;
- characterisation of the epibenthic communities;
- post survey assessment of the status of any *Sabellaria spinulosa* found and identification of any reef structures and areas of notably high density;
- identification of potential herring spawning grounds; and
- identification of areas of dense *M. modiolus*.

The assessment and methods utilised were in compliance with the DEFRA Guidance note for Environmental Impact Assessment in respect of FEPA and CPA requirements (Version 2 – June 2004). In addition, all methodologies were agreed with CEFAS prior to initiation.

Following the completion of the analysis of the infaunal samples, a second video survey was carried out at certain locations that could support dense aggregations of *S. spinulosa.* The purpose of this survey was to ascertain the presence/absence of potentially sensitive reef structures. The drop down video system comprised a digital video camera with lighting fitted within a water filled box and frame. This arrangement permitted seabed footage to be collected in the very turbid waters within the area as it provided a column of clear water between the camera lens and the seabed (Emu 2006).

9.2.2 Intertidal walkover

A site visit was undertaken involving a visual observation of the intertidal zone within the potential impact area for cabling. The intertidal zone near Weybourne Hope comprises a shingle beach backed by a steep shingle bank. The shingle beach is highly mobile and, as such, does not provide a suitable habitat for species colonisation and can be described as barren or highly impoverished. Due to the limited potential for significant adverse impacts to occur in this area, a more detailed survey was not considered necessary.

9.2.3 Subtidal benthic grab survey

The survey was designed to characterise the subtidal infauna and sediments present within the proposed turbine site, cable route and adjacent waters to the east and west of the development area, in order to account for tidal excursion. In addition, sampling stations were included to act as control sites to enable future monitoring of un-impacted areas and to enable assessment of the level of impact within the development site. Stratified sampling was carried out with sampling stations being chosen based on a grid system. Guidance documents (Boyd, 2002; CEFAS, 2004) were used to determine the sampling strategy which was then agreed by CEFAS.

Macrofaunal sampling was carried out at 54 subtidal stations, using a standard $0.1m^2$ Day grab (Figure 9.1) with three replicate samples being taken at 25 of these stations and one replicate sample being taken from the remaining 29 stations. This was to enable adequate spatial coverage (ensuring that representative sampling of the different habitats was carried out) whilst allowing statistical comparison with future data sets (e.g. post construction monitoring) to determine the level of any impact. Replicate sampling at these stations also allowed an assessment of the degree of variability within the benthic communities to be made (between and within sites). Further information on the survey methodology is provided in Appendix 9.2.

9.2.4 Subtidal epibenthic survey

A series of trawl routes were identified (see Figure 9.2), following consultation with CEFAS. A total of 24 trawl routes were chosen (including four controls) to ensure spatial coverage of the proposed development area, the cable route and the predicted tidal excursion. Sampling was carried out in April 2005, with dispensation to use trawl gears within the site from both the Eastern Sea Fisheries Joint Committee (ESFJC) and the Department of Environment Food and Rural Affairs (Defra). Epifaunal sampling was carried out for 5 minutes at each location, using a 2m beam trawl with a 10mm mesh and a 6mm cod end liner. Further details of the sampling methodology are provided in Appendix 9.1.

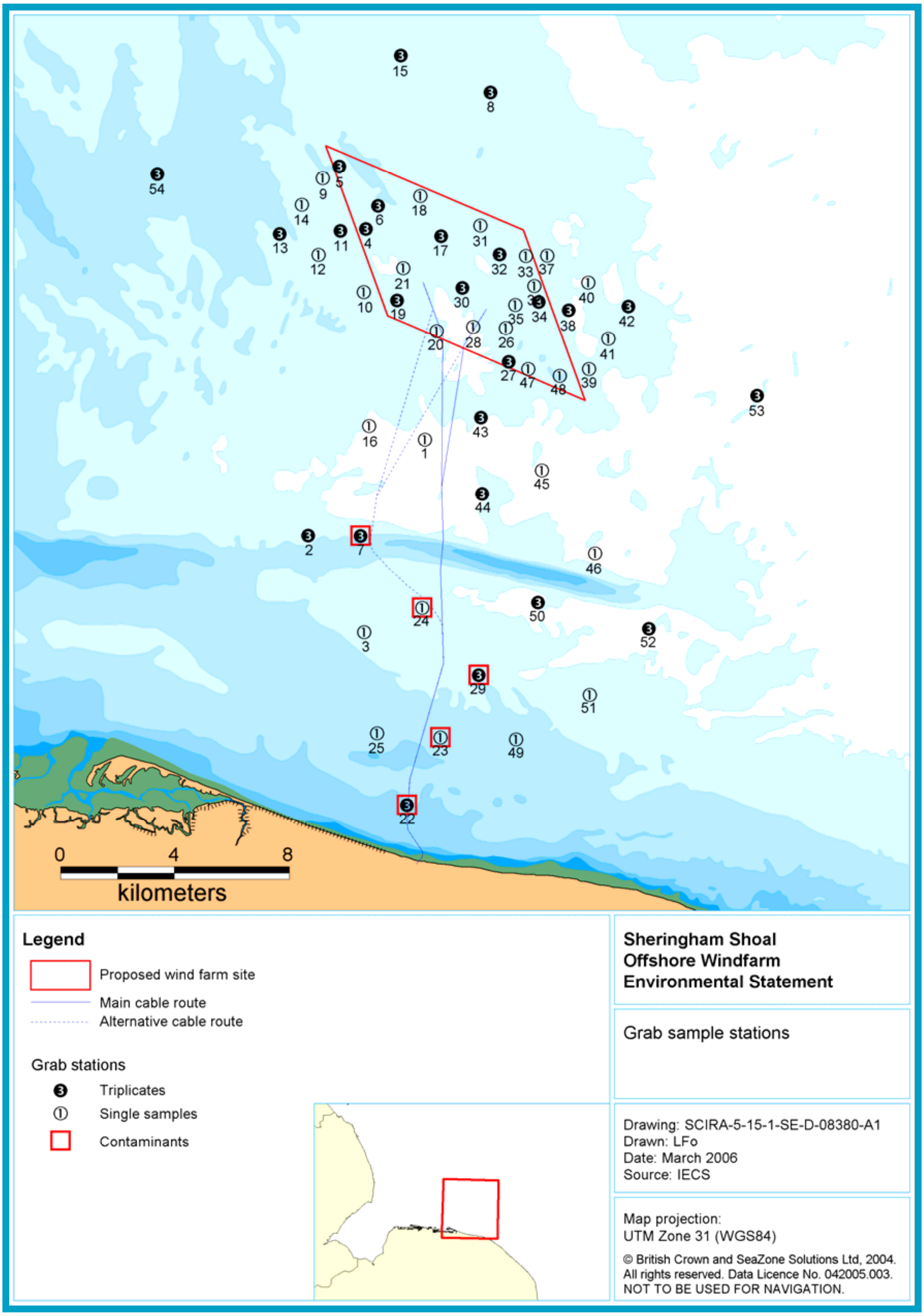

Figure 9.1 Grab sampling locations

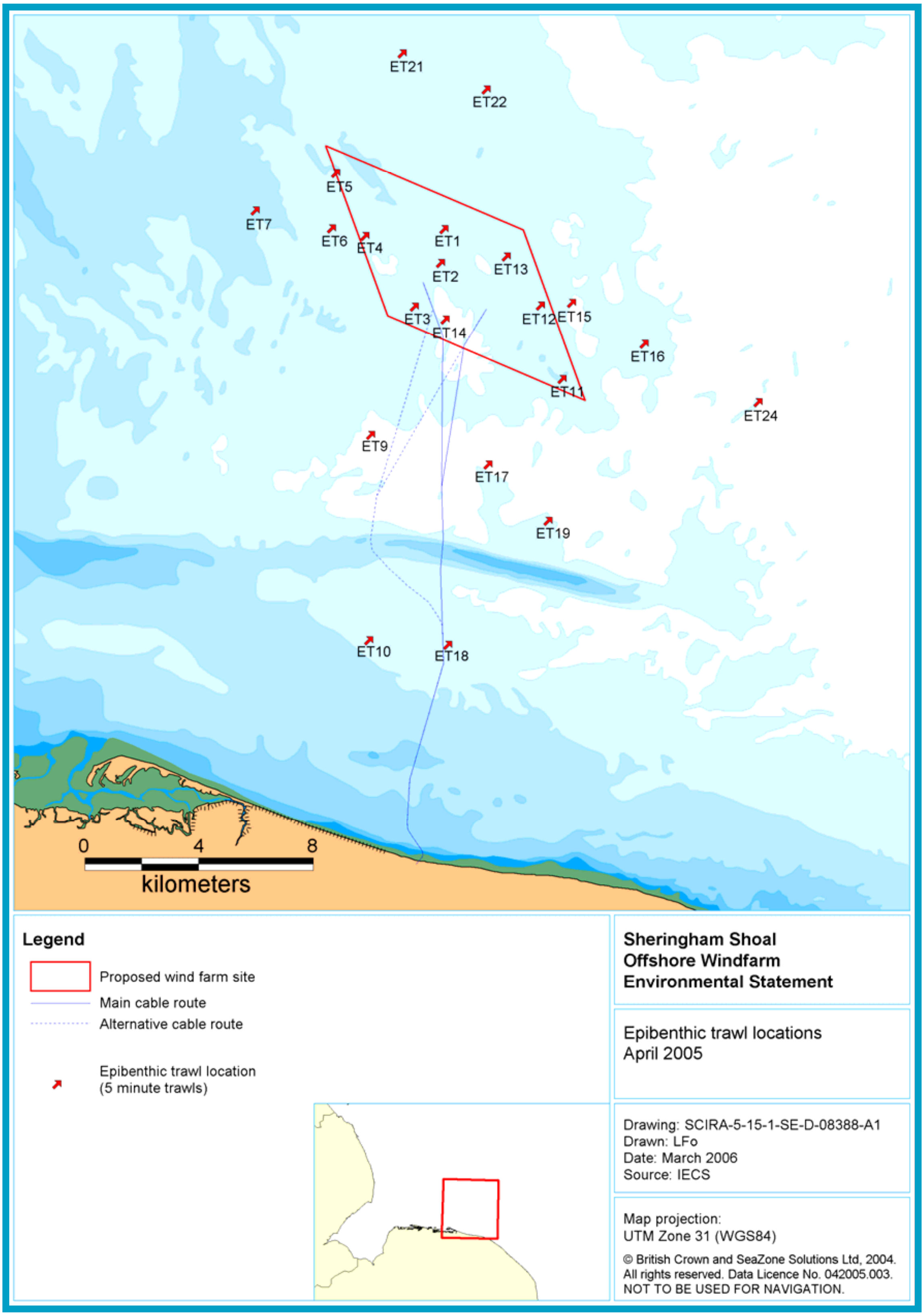

Figure 9.2 Epifaunal trawl sampling locations

9.2.5 Data analysis

Univariate and multivariate analysis of collected data was carried out using the software packages PRIMER v.5 and SPSS v.12, in order to provide information on species abundance, diversity and evenness and to determine any similarities between samples and groupings of communities/species.

A more detailed discussion of the statistical tests employed in the analysis is given in Appendix 9.3.

9.2.6 Sediment chemistry

Sampling stations for the collection of sediments for chemical analysis were identified through discussion with CEFAS. Five locations were identified within and around the proposed cable corridor. Samples were only taken in the nearshore environment, as it was agreed that the potential for historical contamination in the wind farm area was limited, given the prevailing sedimentary and hydrodynamic regime and the lack of fine material to which contaminants could bind. The sample locations chosen were 7, 22, 23, 24 and 29 (see Figure 9.1).

The five sediment samples were analysed by ALcontrol Laboratories in Rotherham UK. To extract the metals from the sediment samples, air-dried and milled sediment samples were digested with a 3:1 mixture of hydrochloric and nitric acid. The samples were then filtered to remove remaining particles prior to analysis. The measurement of metal concentrations was determined by Inductively Coupled Plasma - Mass Spectrometry (ICPMS), using a Varian Ultramass. See Table 9.3 for a list of determinands tested.

9.2.7 Impact Assessment

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 9.4 - 9.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines.

Assessment of the ecological significance of the various effects upon benthic communities relies on defining the sensitivity of the communities and the magnitude of any negative effect. These are combined within matrix analyses to derive the level of significance of any impact. This process is based on the Environmental Assessment Regulations (1999) and on the Institute of Environmental Assessment Guidelines (1995).

Significance is interpreted as defined in Table 8.5 with the major adverse significance levels implying unacceptable effects possibly requiring changes to the nature of the proposed development. In contrast, moderate adverse significance would imply potentially significant impacts, but which may be alleviated through mitigation. Minor adverse and negligible significance require no action other than best practice in design and implementation. The methodology assesses the nature of negative impacts, although neutral or positive impacts may be included within the minor and negligible categories.

Table 9.1 Matrix of magnitude of effect and sensitivity used to assess the level of significance of each contribution. Shaded cells indicate impacts of some or serious concern (as defined in table 8.6).

		Sensitivity			
		Very High	High	Medium	Low
Magnitude	Very High	Major	Major	Major	Moderate
	High	Major	Major	Moderate	Minor
	Medium	Major	Moderate	Minor	Minor
	Low	Moderate	Minor	Minor	Negligible
	Negligible	Minor	Negligible	Negligible	Negligible

Table 9.2 Interpretation of significance categories.

Impact	Definition
Negligible	The impact is not of concern.
Minor adverse	The impact is undesirable but of limited concern.
Moderate adverse	The impact gives rise to some concern but it is likely to be tolerable (depending upon its scale and duration).
Major adverse	The impact gives rise to serious concern; it should be considered unacceptable.

9.3 Description of the existing environment

9.3.1 General Characterisation of wider survey area.

The southern North Sea is characterised by shallow water, large seasonal temperature fluctuations, relatively low salinity, strong tidal currents and highly mobile substrata (Jennings *et al.*, 1999). The substratum is largely composed of coarse sediments (Covey, 1998; Allen, 2000) with a large anticlockwise gyre being the main mechanism of sediment re-distribution (Ducrotoy *et al.*, 2000). Due to these strong tidal currents, wave action and during storms, sediment re-suspension is frequent and, consequently, turbidity is high (Allen, 2000). The nature of the benthic communities reflects these dynamic environmental conditions with community structure being a function of depth, physical processes and anthropogenic influences (Glémarec, 1973). Between Sheringham and West Runton, isolated stretches of chalk bedrock extend into the subtidal, representing the only significant area of hard substrata along the coast (Covey, 1998). The distribution of exposed chalk in coastal areas is extremely limited in Europe and, within the British Isles, is largely confined to the south and east coasts of England (George *et al.*, 1995).

Broadscale ecological studies showed the dominant infaunal species in this region to be the polychaete *Nepthys cirrosa*, the echinoderm *Echinocardium cordatum* and the amphipod *Urothoe poseidonis* (Künitzer *et al.*, 1992). Jennings *et al.* (1999) found the free-living epibenthos to be characterised by the echinoderms *Ophiura ophiura* and *Asterias rubens* and the decapods *Pagurus bernhardus,* and *Liocarcinus holastus*. Dominant sessile species included the hydroids *Hydractinia echinata, Hydrallmania falcata* and *Sertularia argentea,* the bryozoans *Electra pilosa* and *Flustra foliacea* and the soft coral (Alcyonaria) *Alcyonium digitatum.* Other species which appear to be widespread throughout the area include the polychates *Sabellaria spinulosa, Caulleriella zetlandica* and *Lanice conchilega,* the decapod *Pisidia longicornis* and *Ampelisca* spp. (amphipoda) (Duineveld *et al.*, 1991; Covey, 1998; Kenny & Rees, 1994; Kenny & Rees, 1996; Kenny *et al*, 1998; Allen, 2000; Lewis *et al.*, 2002; Sotheran *et al.,* 2005; Proctor *et al.*, 2006).

Duineveld *et al.* (1991) found a shallow coarse sand community characterised by the polychaetes *Ophelia borealis*, *Scoloplos armiger* and *Pisione remota* and the echinoderm *Echinocyamus pusillus* to be present offshore of Lincolnshire and East Anglia. Further north, off the Yorkshire coast, the sediments were finer with the communities being characterised by the polychaetes *Magelona papillicornis* and *Spiophanes bombyx,* the horseshoe worm *Phoronis* spp., the amphipod *Bathyporeia elegans,* and the bivalve *Tellina fabula.* Dominant epifaunal species in the southern North Sea included *Crangon crangon* (decapoda) and the bryozoan *Alcyonidium gelatinosum.*

Smaller scale ecological studies within the area have largely been concentrated around the intertidal areas of estuaries and marine inlets, areas where human pressures are greatest with relatively little work being carried out in inshore subtidal areas (Covey, 1998). In offshore areas, extensive aggregate extraction areas exist between the Humber estuary and north Norfolk and as a result, data from a considerable number of monitoring surveys are available. Characteristic species found in the area include *Balanus crenatus* (barnacle), *Dendrodoa grossularia* (Ascidiacea) and *F. foliacea* (horn wrack). Other widespread species included *Pisidia longicornis* and *S. spinulosa* (Covey, 1998; Kenny & Rees, 1994; Kenny & Rees, 1996; Kenny *et al*, 1998). Diver observations have also revealed clumps of the horse mussel *Modiolus modiolus* (Covey, 1998).

Ellis & Rogers (1999) recorded over 75 subtidal epifaunal species from sandy gravels in the East Anglia area, the most commonly occurring including *Liocarcinus holastus, Asteria rubens* and *Pandalus montagui*. Other common species included *Alcyonidium diaphanum* and *Sabellaria* spp. Allen (2000) found the benthic communities within the coarse to medium sands of the Race Bank area (to the north east of the north Norfolk coast) to be dominated by *S. spinulosa*, which represented 22% of the community, with the amphipods *Ampelisca diadema* and *A. spinipes*, the polychaetes *L. conchilega* and *Spiophanes bombyx* and the decapod *P. longicornis* also being commonly recorded.

Specifically within the Sheringham Shoal area, acoustic and video surveys carried out by Sotheran *et al.* (2005) showed the sediments within the proposed turbine site to be mixed and largely composed of cobbly, shelly sand and gravelly sand with a limited number of sites being sandy. Along the proposed cable route, the sediments were finer, mainly being composed of gravelly sand and sand. Dominant infaunal species included *S. spinulosa, P. longicornis,* Molgulidae, *D. grossularia* and *C. zetlandica* with two major biotopes being present – SS.SBR.PoR.SspiMx (sparse or moderately dense crusts of *S. spinulosa* on circalittoral mixed sediment) and SS.SCS.ICS (infralittoral coarse sand). The sedimentary environment around the proposed wind farm site was described as a level area of cobbly shelly sand, partly overlain by a series of large sand waves running from the north west to the south east. The area was classed as being hydrodynamically active with characteristically species poor communities.

To the east, offshore of Cromer, Royal Haskoning (2002) found a community dominated by *S. spinulosa* with *L. conchilega* and *P. longicornis* also being widespread. The epifauna was largely dominated by the crustaceans *P. montagui* and *Crangon crangon*. In the inshore area, approximately 2km off the coast of West Runton (approximately 2km to the east of Sheringham), George *et al.* (1995) reported an area of flint cobbles and pebbles, with occasional large flint boulders, colonised by several species of hydroid, *Pomatoceros triqueter,* several suspension feeding polychaete species, including *L. conchilega, Polydora* spp. and *Sabellaria* spp. The barnacle *Verruca stroemia*, the mollusc *Crepidula fornicata* and the brittlestar *Amphipholis squamata* were all commonly recorded. Additionally, 47 species of bryozoan were recorded.

9.3.1.1 Biogenic reefs

S. spinulosa is a suspension feeding polychaete which constructs and inhabits tubes made of sand attached to cobbles and stones. Whilst it is generally a solitary species, it can form raised 'biogenic' reefs on the seabed of up to several meters across and up to 60cm in depth (Northern Ireland Habitat Action Plan, 2005). Such reefs lead to stabilisation of mobile cobble, pebble and gravel substrata, providing a consolidated habitat and increasing habitat heterogeneity, thus allowing a range of epibenthic species together with specialised 'crevice infauna' to become established. Such species would otherwise be absent and *S. spinulosa* is therefore classed as a key structuring species which can considerably increase species the diversity of an area (Holt *et al.*, 1998; English Nature, 1999a). *S. spinulosa* reefs are classed as a priority habitat under the UK Biodiversity Action Plan (UK Biodiversity Group, 1999) and are included as a sub-feature of other Annex 1 habitats under the Habitats Directive (92/43/EEC) (UK Biodiversity Group, 1999; Allen *et al.*, 2002).

The main environmental requirement of this species is a good supply of suspended sand, a firm substratum to which it can attach itself and it is generally most successful in areas of mixed sediment. Well developed reefs are typically found in areas of high turbidity, usually in subtidal regions to depths of approximately 40m (Northern Ireland Habitat Action Plan, 2005). Despite its wide geographical distribution, *S. spinulosa* rarely forms large reefs and more commonly occurs as solitary individuals or small groups encrusting pebbles, shell and rock (English Nature, 1999a). However, *S. spinulosa* is particularly widespread in the North Sea and the reefs in certain areas of the Wash and north Norfolk coast area are considered to be particularly well developed (Wilson, 1970; UK Marine SAC Project, undated). Although numbers of S*. spinulosa* were found in the area, it is considered that the numbers do not constitute a biogenic reef community (see Section 9.3.3.2)

Other biogenic reefs are composed of horse mussel beds (*Modiolus modiolus)* which forms dense beds at depths of 5-70m in full salinity, moderately tide-swept areas (English Nature 1999b). English Nature (1999b) state that whilst *Modiolus* beds are widespread off northern and north western parts of Britain, true beds are not known to occur to the south of the Humber and only occasional beds have been reported between Berwickshire and the Humber. No *Modiolus* beds were found in the area.

9.3.1.2 Sediments

The seabed sediments collected across the site were largely comprised of coarse to medium sands with varying percentages of gravels and pebbles. The overall composition of sediments within samples were highly variable and poorly sorted, in terms of the range of particle sizes present. The finest sediments, with the highest sand content were found at stations 2, 7, 22, 26 and 30. At these sites the gravel content, determined by particle size distribution (PSD), was 0%. The coarsest sediments were found at stations 9, 42, 33 and 34, which all contained over 55% gravel. In general, the coarsest sediments were found in the northern area of the wind farm boundary, with coarse to medium sands dominated the proposed export cables routes. According to the classification of Folk (1954), the majority of sediments in the wind farm area fall into the category of sandy gravels (sG) or muddy sandy gravels (msG) while the sediments to the south of the wind farm area and the export cables routes would be classified as sands (S), slightly gravely sands ((g)S) or gravely sands (gS). The sediment classification analysis data is presented in Appendix 9.4.

Silt and organic content was low at all sites, with highest recorded organic content values corresponding to sediments with the highest silt content. The minimum silt content was 0% at those stations with high gravel and sand content, together with stations 2, 10, 12, 24, 39, 47, 50, 52 and 53. A maximum value of 21% was recorded from station 46. Organic content ranged from a minimum of 0.5% at station 48 to a maximum of 2.6% at station 46.

The percentage of gravel (2-64mm), sand (0.063-2mm) and silt & clay (<0.063mm) recorded at stations within the study area are presented in Figure 9.3. The distribution of sediment types within the study area is presented in Figure 9.4.

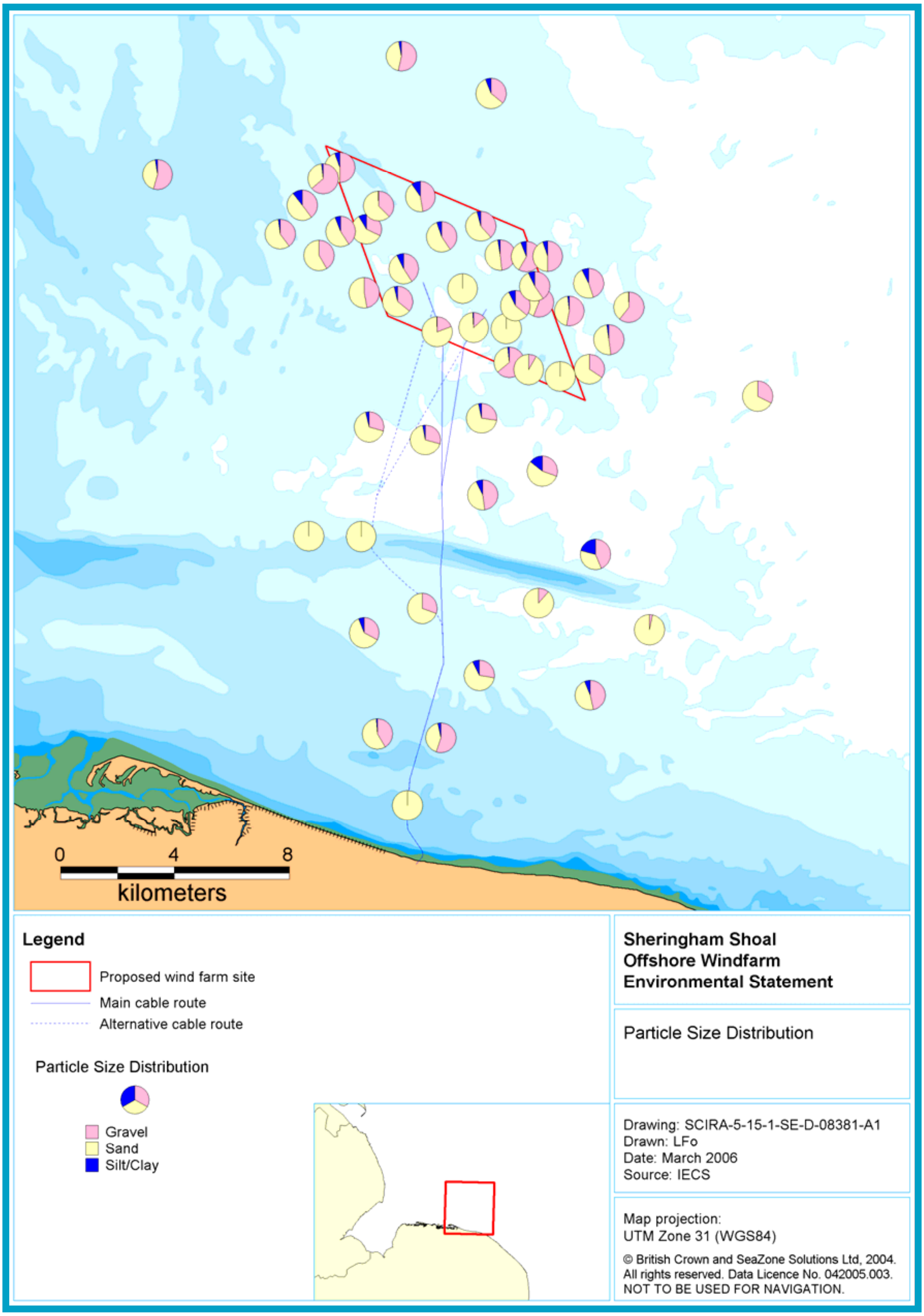

Figure 9.3 Insert figure IECS PSD

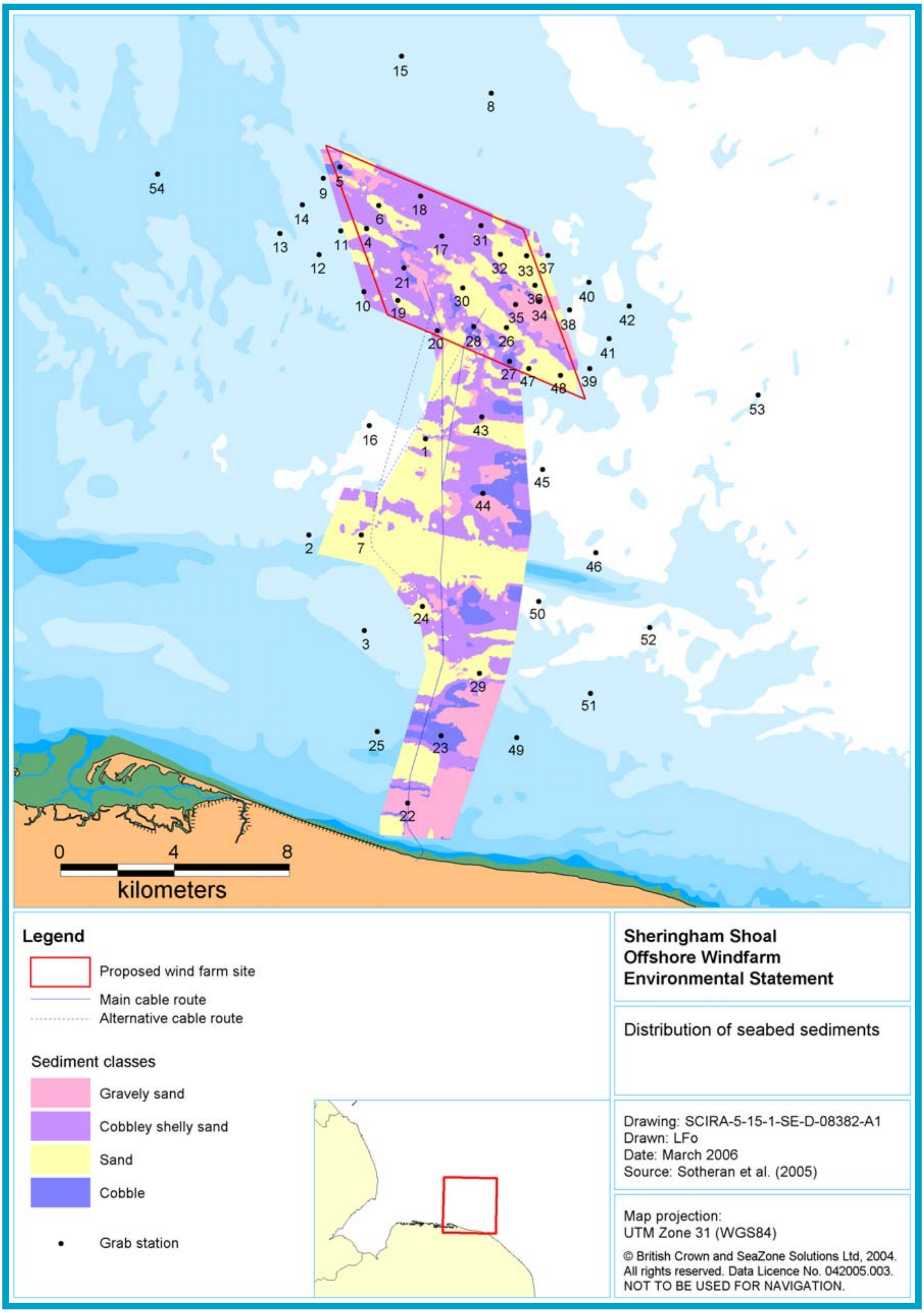

Figure 9.4 Distribution of seabed sediments

9.3.1.3 Sediment chemistry

In the UK, no environmental quality standards for sediment chemistry exist, other than the determinand levels used by CEFAS in relation to the disposal of dredged materials at sea. Therefore, for the purposes of having determinand concentrations against which an assessment of potential impact significance can be made, the 'Canadian Sediment Quality Guidelines for the Protection of Aquatic Life'' have been used. These guidelines were published by the Canadian Council for Ministers of the Environment (CCME) in 1999 and updated in 2001. The purpose of the guidelines is to provide scientific benchmarks for evaluating the potential for observing adverse biological effects in aquatic systems. The guidelines have been derived from available toxological information, reflecting the relationships between sediment concentrations of chemicals and any adverse biological effects resulting from exposure to these chemicals.

The guidelines comprise two assessment levels. The lower level is referred to as the threshold effects level (TEL) and represents a concentration below which adverse biological effects are expected to occur rarely. The higher level, known as the probable effect level (PEL), defines a concentration above which adverse effects are expected to occur frequently. The TELs and PELs are used to identify the following three ranges of chemical concentrations:

- Below the TEL: the minimal effect range within which adverse effects rarely occur i.e. less than 25% of effects;
- Between the TEL and PEL: the possible effect range within which adverse effects occasionally occur; and
- Above the PEL: the probable effect range within which adverse effects frequently occur i.e. more than 50% of effects.

According to the CCME, the TEL is consistent with the definition of a Canadian sediment quality guideline (SQG) and the PEL is recommended as an additional sediment quality assessment tool for identifying sediments in which adverse biological effects are more likely to occur.

The Canadian guidelines do not include effects levels for nickel, a metal commonly found in the marine environment. However, for sediment quality guidelines for the disposal of dredged material at sea, it is assumed that a concentration below 100mg/kg would not be of concern (CEFAS, 2001). The results of the chemical analysis are presented in Table 9.3, along with the SQG and PEL for each determinand.

Table 9.3: Determinand concentrations of five grab stations and Canadian sediment quality guideline values (SQG and PEL)

Determinand	ST7	ST22	ST23	ST24	ST29	Mean	SQG	PEL
PAH Compounds								
Acenaphthene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**6.71**	**88.9**
Acenaphthylene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**5.87**	**128**
Anthracene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**46.9**	**245**
Benzo(a) Anthracene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**74.8**	**693**
Benzo(a) Pyrene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**88.8**	**763**
Chrysene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**108**	**846**
Dibenzo(a,h) Anthracene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**6.22**	**135**
Fluoranthene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**113**	**1,494**
Fluorene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**21.2**	**144**
Naphthalene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**34.6**	**3941**
Phenanthrene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**86.7**	**544**
Pyrene (μg kg^{-1})	<0.35	<0.33	<0.34	<0.29	<0.3	<0.3	**153**	**1,398**
Total PAH (μg kg^{-1})	<5.25	<4.95	<5.1	<4.35	<4.5	<0.3	**<4.5**	**<0.3**
Metals								
Arsenic (mg kg^{-1})	10.2	11.5	20.9	12.6	12.7	13.6	**7.24**	**41.6**
Cadmium (mg kg^{-1})	<0.06	<0.06	1.21	0.08	<0.06	0.3	**0.7**	**4.2**
Chromium (mg kg^{-1})	<5	<5	11	8.78	8.11	7.6	**52.3**	**160**
Chromium (VI) (mg kg^{-1})	<10	<10	<10	<10	<10	<10	**n/a**	**n/a**
Copper (mg kg^{-1})	<5	<5	19.7	<5	<5	<7.9	**18.7**	**108**
Lead (mg kg^{-1})	8.58	6.3	25.2	9.67	9.75	11.9	**30.2**	**112**
Mercury (mg kg^{-1})	<0.15	<0.15	0.17	<0.15	<0.15	<0.2	**0.13**	**0.7**
Nickel (mg kg^{-1})	2.89	3.14	12.3	6.41	5.75	6.1	**n/a**	**n/a**
Zinc (mg kg^{-1})	20.7	21.7	118	30.3	32.1	44.6	**124**	**271**

N.B. Units in underlined text represent elevated concentrations.

Table 9.3 show that although levels of arsenic were elevated at all stations sampled, and mercury was elevated at one station, both were well below the PEL (see Section 9.4.3 for discussion of results).

9.3.2 Subtidal benthic biological resource

9.3.2.1 Infauna

The biological resource was highly variable across the survey area, reflecting the variable and, possibly mobile or frequently disturbed, nature of the seabed sediments. The mean number of infauna species ranged from two at station 48 to 72 (maximum of 80) at station 19 with the lowest number of species being recorded from sand dominated areas, primarily in the south eastern region of the wind farm site and along the export cables routes. The richest sites, where more than 55 species were recorded, were generally in the north western part of the survey area and were largely located outside of the wind farm boundary (see Figure 9.5).

Mean abundance values ranged from two individuals/0.1m^2 at station 48 to 391 individuals/0.1m^2 at station 19 (see Figure 9.6), although the maximum recorded abundance was from station 29. Low abundances (less than 10 individuals/0.1m^2) were generally recorded from the sandy areas to the south, in the area of the cables routes, and corresponded to sites where low numbers of species were recorded. Similarly, the highest abundances were recorded in the areas of greatest species richness to the north west.

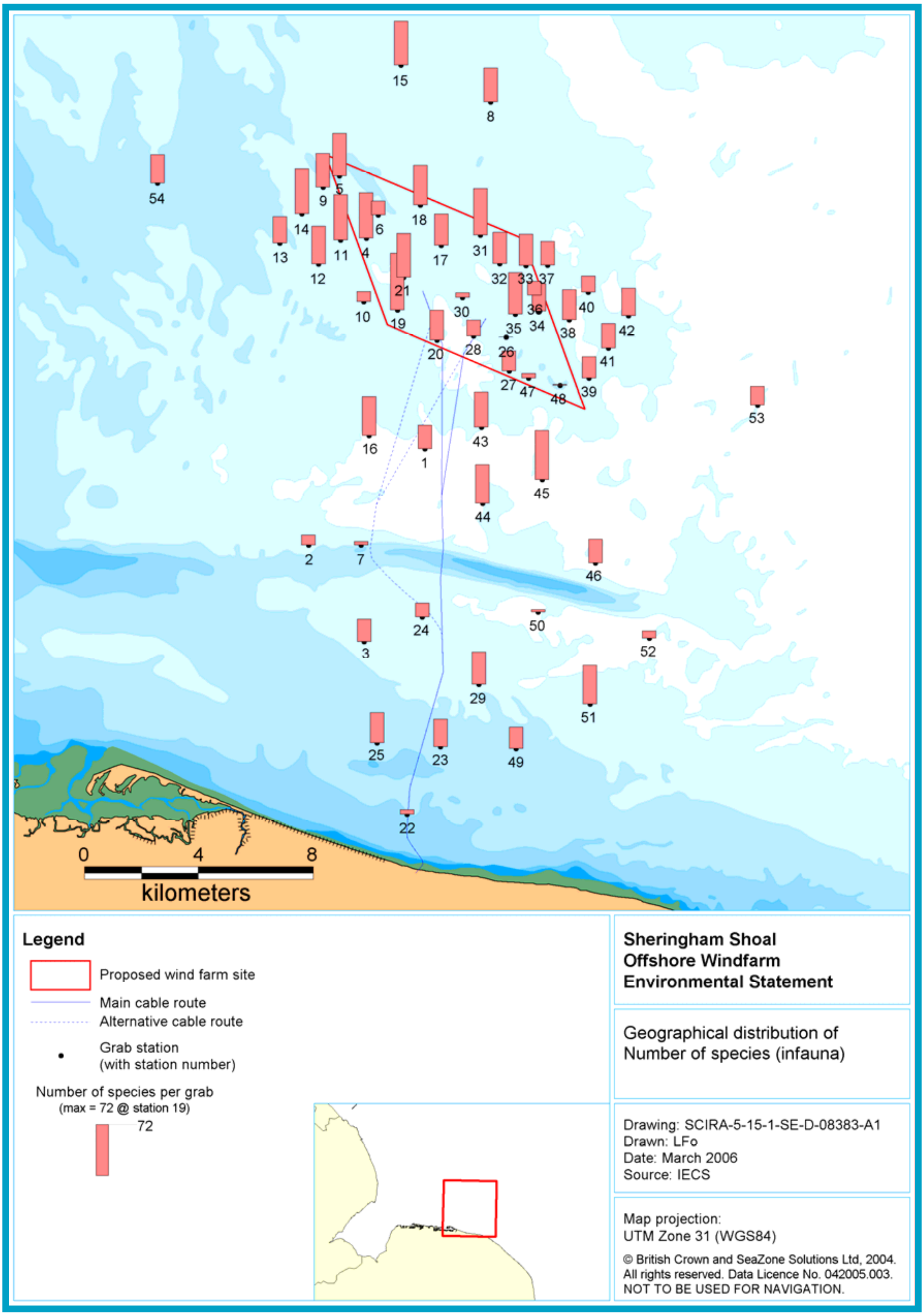

Figure 9.5 Geographical distribution of number of species (infuana)

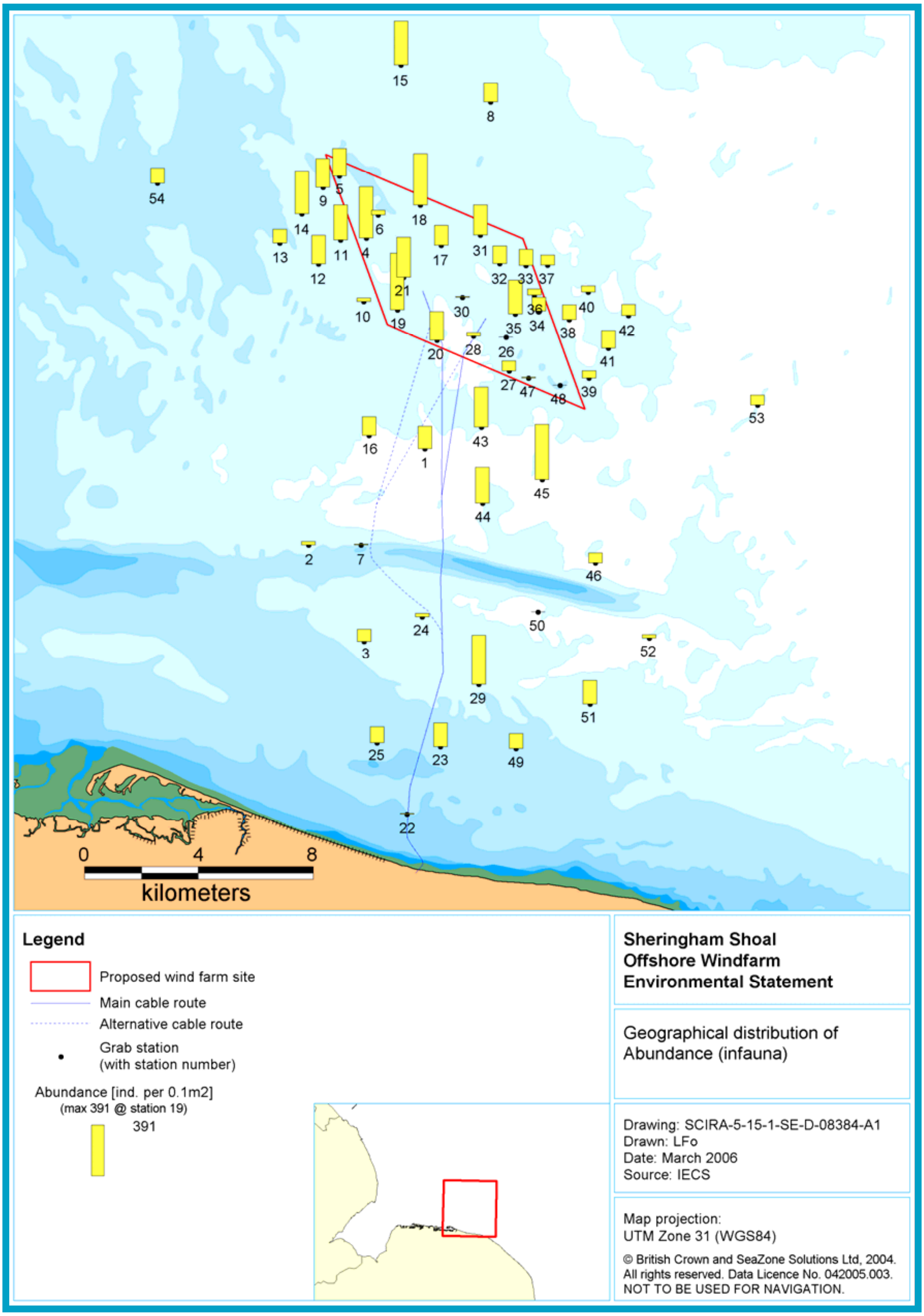

Figure 9.6 Geographical distribution of abundance (infauna)

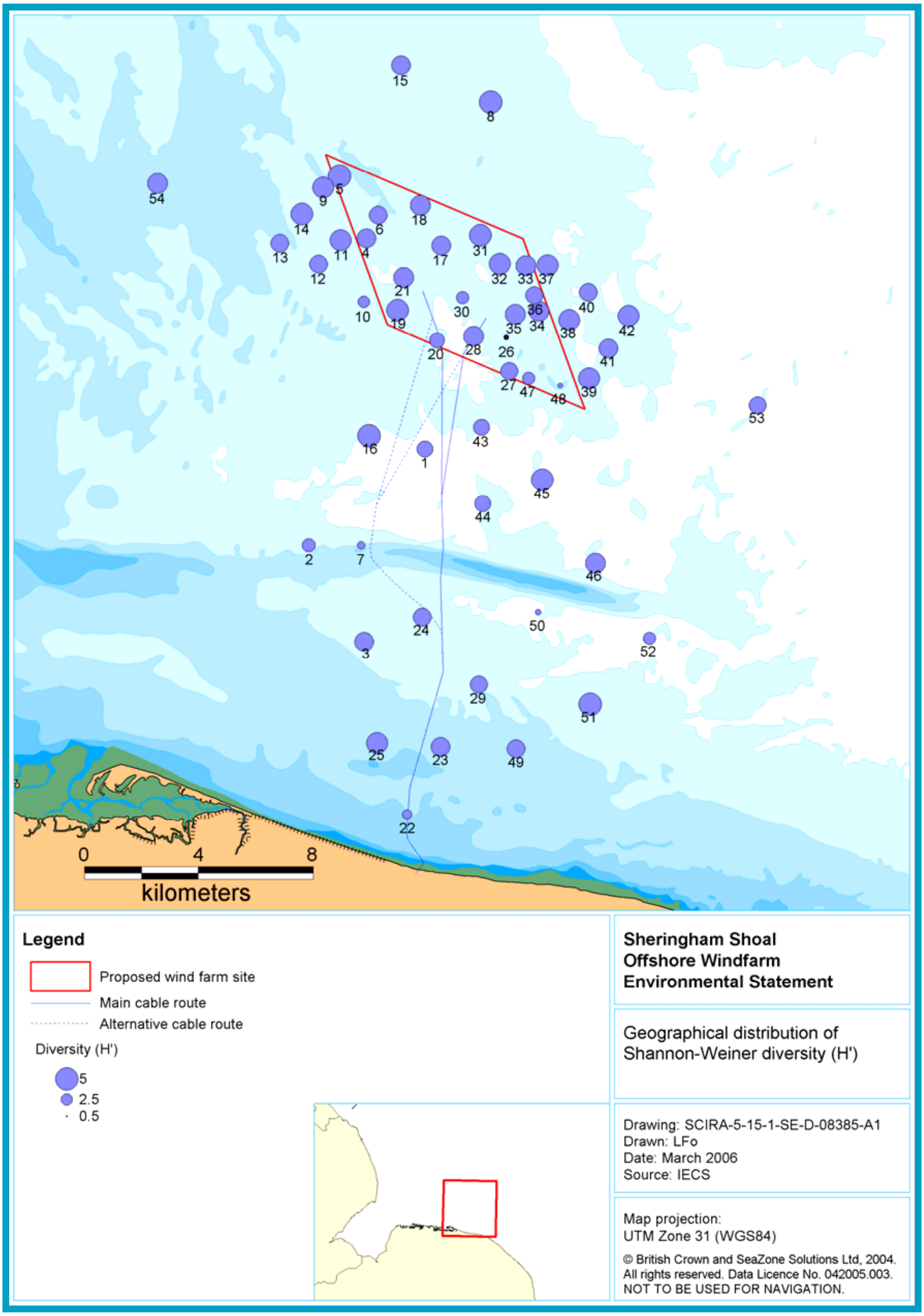

Figure 9.7 Geographical distribution of Shannon-Weiner diversity (H')

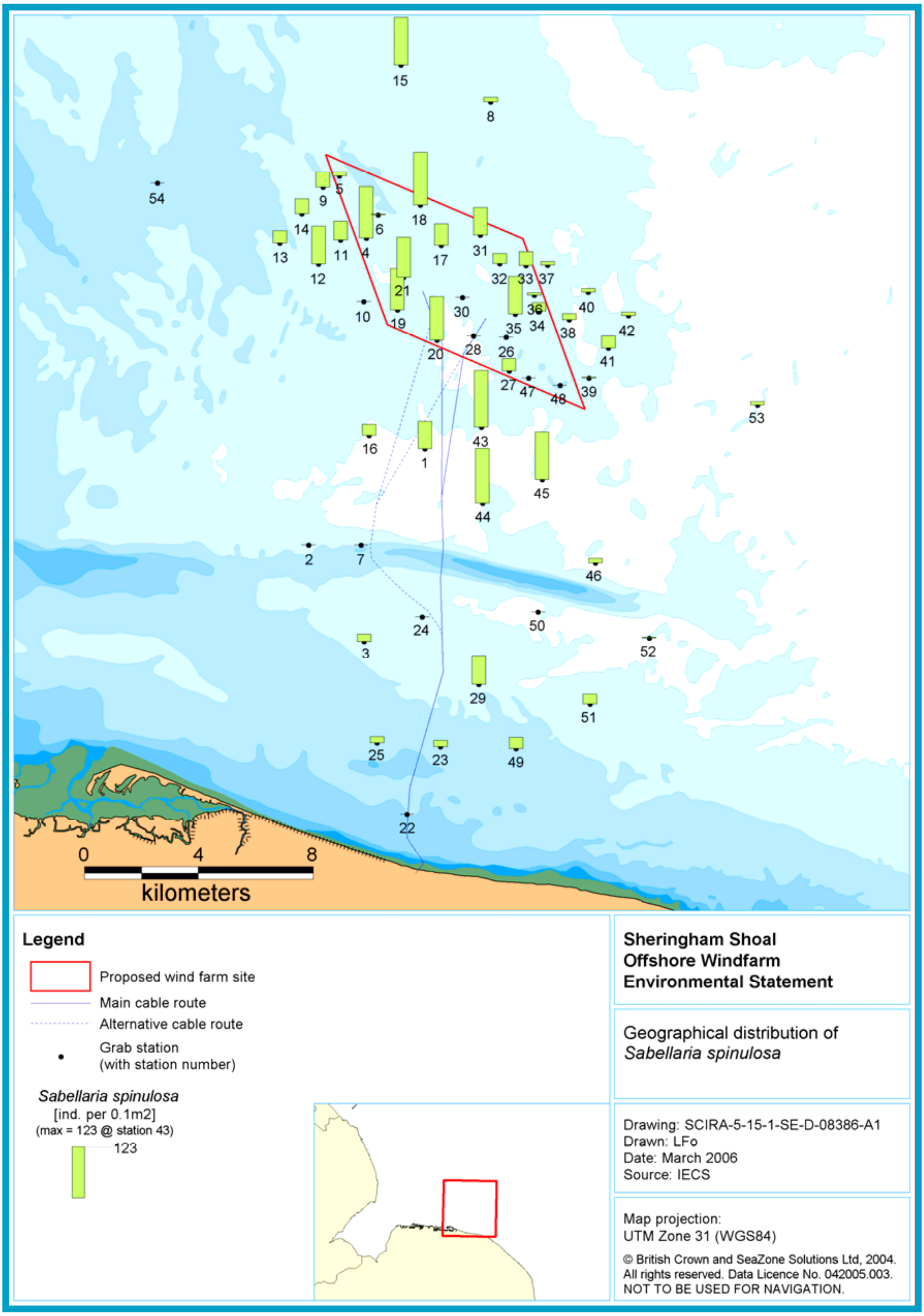

Figure 9.8 Geographical distribution of Sabellaria spinulosa

Shannon-Weiner diversity (H')[18] was highest at station 5 (mean H'=5) with diversity being greater than 4 at the majority of sites (see Figure 9.7). The lowest value (with the exception of station 26) was 1 (station 48), with H' values of less than 2.5 generally being recorded within the sandier areas to the south.

Mean Pielou's evenness (J')[19] values ranged from 0.6 at station 43 to 1 at station 48 with most values being greater than 0.7. These values, together with the low abundance ratio (A/S) indicate an even spread of the individuals between the species and that the communities are not dominated by one or very few species.

The highest densities of *Sabellaria spiniulosa* were associated with the mixed sediments in the north. Mean densities of over 100 individuals/0.1m^2 were only recorded at six sites, with the highest mean density being recorded from station 43 (123 individuals/0.1m^2 - the mean value of the triplicate samples with respectively 220, 81 and 69 individuals/0.1m^2), to the east of the preferred direct cable route (see Figure 9.8).

A total of 267 species were recorded from the survey area as a whole, which were highly variable in their abundance and distribution. The top 80% of the community was composed of 35 species and was dominated by the polychaete *S. spinulosa*, which accounted for 26% of the whole community (see Appendix 9.5) and was present, in abundances ranging from 1 to 220 individuals/0.1m^2, at 47 of the 54 sites. Other species present in significant abundances included the decapod *Pisidia longicornis*, the polychaetes *Polycirrus* spp., *Eumida sanguinea, Pomatoceros lamarcki, Caulleriella zetlandica, Pholoe inornata, Aonides paucibranchiata*, the sipunculan Golfingiidae and the amphipods *Ampelisca diadema* and *Urothroe elegans*. Nematodes and Nemertea were also present in significant numbers with the only abundant mollusc species being the bivalve *Nucula nucleus.* Collectively, these species accounted for 60% of all organisms found throughout the area.

The dominant phyla were the annelids (principally the polychaetes), crustaceans and molluscs, each representing 61%, 20% and 10%, respectively (see Figure 9.9). The most abundant crustaceans were amphipods and decapods, collectively accounting for 98% of the organisms found within this class (Figure 9.10). As described above, *U. elegans, Ampelisca* spp. and *Leptocheirus hirsutimanus* were the most abundant and widespread amphipod species with *P. longicornis* being the most abundant decapod. The molluscs were dominated by the pelecypoda (bivalves) accounting for 63% and the prosobranchia (gastropods) accounting for 29% of the organisms in this class. Commonly occurring species included *N. nucleus, Spisula solida, Abra alba* and *Mya truncata.* Other groups accounted for only 8%.

[18] Shannon-Weiner diversity is a measure of the species richness of a sample (number of species) and the distribution of the number of individuals in each species (how evenly they are distributed).
[19] Pielou's evenness is the Shannon-Weiner diversity (H') divided by species richness.

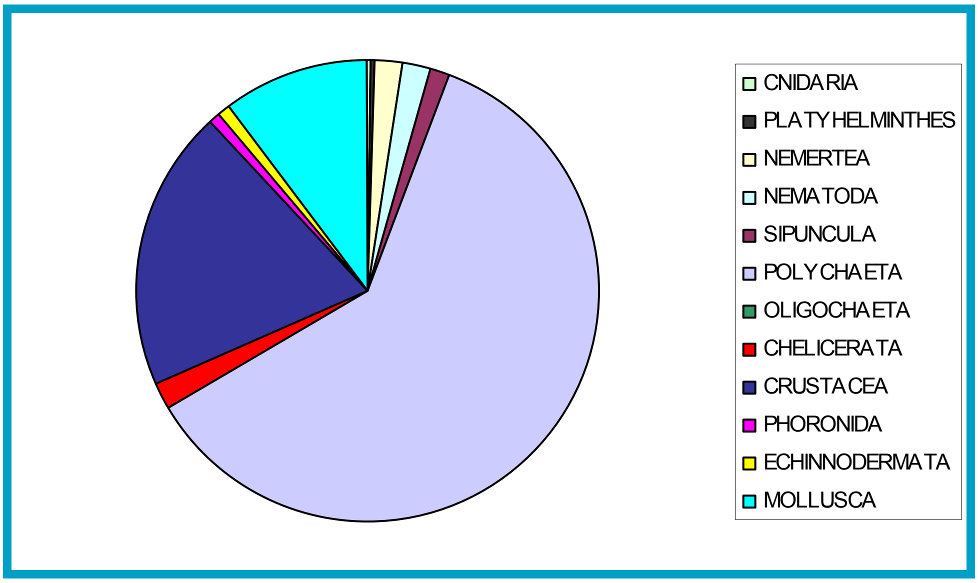

Figure 9.9 Proportional representation of each phyla based on quantitative data.

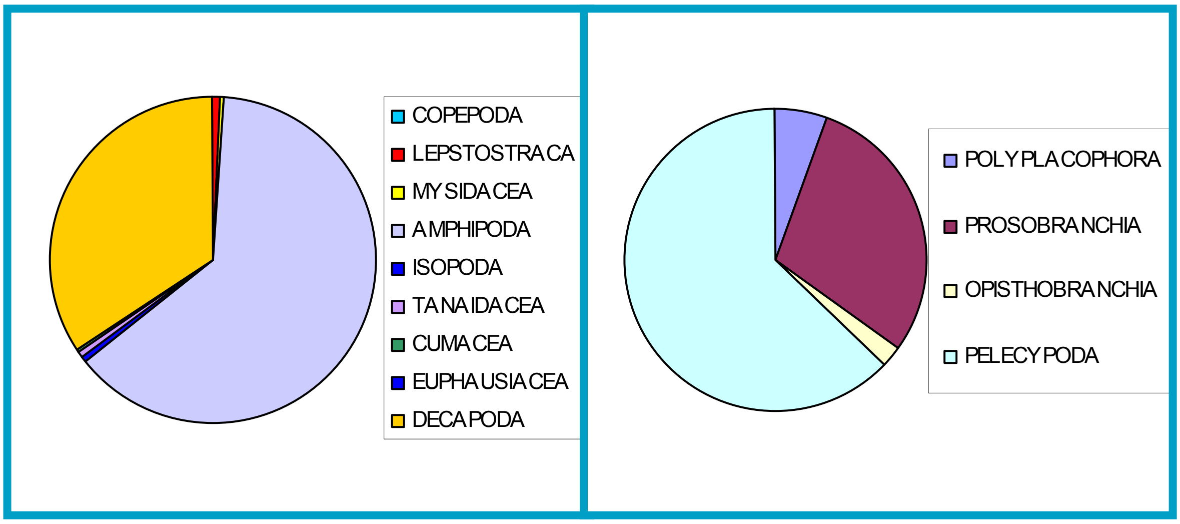

Figure 9.10 Proportional representation of the major classes within the dominant phyla based on quantitative data.

Multi Dimensional Scaling (MDS), using square root transformed data, showed three distinct groups of sites (see Figure 9.10), the most impoverished, in terms of the number of species and abundance, being in group 1. Group 3 stations had comparatively low numbers of species and individuals, generally found in fairly homogenous medium sands. The majority of the stations were in group 2, with mixed sediments where species abundance and diversity was highly variable and it was not considered appropriate to class them as being similar. Cluster analysis was therefore used in order to identify a more refined set of sub-groups.

Cluster analysis (using square root transformed data) reflected the variability in the distribution of the species throughout the area but allowed broad classification of the sampling stations into 12 major groups or community types (see Figure 9.11). Due to the variability in the data, similarity between stations was generally less than 40% and only rarely greater than 60%. Of these, **groups 4** (stations 5 and 54) and **5** (stations 4, 15, 18, 19, 21, 43 and 45) contained the greatest mean number of species (49 and 59, respectively) and were largely situated in the north west of the area. **Groups 1** (stations 26 and 48) and **11** (stations 7 and 22) containing only 1 and 7 species, respectively. **Group 5** also had the greatest mean number of individuals (374/0.1m^{-2}) with 210/m^{-2} being present within **group 6** (stations 9, 11, 14, 23 and 51). Again, **groups 1 and 11** had the lowest mean abundance with values of 1 and 9.5, respectively. The communities within groups **4 and 6** were the most diverse (H' = 4.8 and 4.6, respectively) with groups 1 (H' = 0.5) and 11 (2.1) being the least diverse. The mean Abundance ratio (A/S) is low for all groups (maximum of 6.5 for group 5) indicating a spread of the individuals between the species and that none of the communities are dominated by one or very few species. This is also demonstrated by the high evenness values (J') which are 0.7 (groups 5 and 7) or above for all groups.

Species compositions were variable between groups although the communities within groups 5, 6, 7, 7A and 8 were dominated by *S. spinulosa* with moderate abundances characterising groups 9, 9A and 10. This highlights the widespread distribution of the species. A more detailed description of the composition of each community is given in Appendix 9.5 with a description of the major biotopes being presented in this section.

9.3.3 Biotopes

In terms of the national biotope classification the majority of the communities found can be classed as variants of the *Sabellaria* biotopes SS.SBR.PoR.SspiMx (*Sabellaria spinulosa* on stable circalittoral mixed sediment) (see Table 9.4 and Figure 9.11). Characterising species include typical sublittoral polychaetes such as *Sabellaria spinulosa, Protodorvillea kefersteini, Pholoe synophthalmica, Harmothoe* spp., *Scoloplos armiger, Mediomastus fragilis, Lanice conchilega* and cirratulids. Bivalve species, such as *Abra alba*, tube dwelling amphipods (e.g. *Ampelisca* spp.) and a number of bryozoan species, calcareous tubeworms, pycnogonids and hermit crabs are also usually present. *S. spinulosa* abundance was relatively low at a number of sites making these communities difficult to classify. A number of them are likely to be either impoverished forms of the above *Sabellaria* biotopes, or classified as SS.SCS.ICS (Infralittoral coarse sediment).

A significant number of stations had communities belonging to the SS.SCS.CCS.MedLumVen biotope (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel) (see Figure 9.13). This biotope generally occurs in areas of relatively deep water (over 15-20m) in areas of circalittoral gravels, coarse to medium sands and shelly gravels, sometimes with a small amount of silt. Typical species include *Mediomastus fragilis, Lumbrineris* spp., and *Echinocyamus pusillus* (see Table 9.4). These sites were predominantly found close to the Sheringham Shoal sandbank although this biotope was also present at a number of sites within the proposed wind farm site.

Three other biotopes were present, each represented by one site only. SS.SCS.ICS.MoeVen (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand) was present at station 10 and is characterised by *Moerella* spp, *Glycera lapidum* and venerid bivalves. This biotope is usually present in areas of coarse sediment exposed to strong tidal streams. The grab sample from station 26 did not contain any infaunal organisms and should most likely be classified as SS.SSa.IFiSa.IMoSa (infralittoral mobile clean sand with sparse fauna). This biotope is characterised by the general low abundance and diversity of infauna and is usually found in medium to fine sandy sediments, in shallow water where dunes may have formed. Fauna which may be found include opportunistic amphipods, *Nepthys cirrosa* and *Eurydice pulchra*. Finally, the community at station 22 (the most inshore station) was classed as SS.SSa.IFiSa.NcirBat (*Nepthys cirrosa* and *Bathyporeia* spp. in infralittoral sand).

The inherent variability and patchiness of the described communities is typical for habitats of mixed coarse sediment, and in such areas the epifaunal community is often a better indicator of community type and diversity than the infauna, particularly as such habitats are difficult to sample quantitatively. It is likely that given the dynamic nature of the area the biotopes will vary over time in terms of species composition and abundance, although the broader biotope and habitat complexes may be relatively consistent.

Table 9.4 Description of biotopes

Biotope code and description	Characterising species	Grab sample photo
SS.SBR.PoR.SspiMx *Sabellaria spinulosa* on stable circalittoral mixed sediment	*Sabellaria spinulosa, Protodorvillea kefersteini, Pholoe synophthalmica, Harmothoe* spp., *Scoloplos armiger, Mediomastus fragilis, Lanice conchilega,* cirratulids, *Abra alba, Ampelisca* spp., *Flustra foliacea, Alcyonidium diaphanum,* pycnogonids, hermit crabs, amphipods.	
SS.SCS.CCS.MedLumVen *Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel	*M. fragilis, Lumbrineris* spp., *Glycera lapidum. Echinocyamus pusillus.* Other taxa may include Nemertea, *P. kefersteini, Owenia fusiformis, Spiophanes bombyx, Amphipholis squamata.* Venerid bivalves such as *Timoclea ovata, Moerella* spp. and *Glycymeris glycymeris* may also be present.	

Table 9.4 Description of biotopes

Biotope code and description	Characterising species	Grab sample photo
SS.SCS.ICS.MoeVen *Moerella* spp. with venerid bivalves in infralittoral gravelly sand	*Moeralla* spp. (typically *M. pygmaea, M. donacina*), *Glycera lapidum, Dosinia lupinus, T. ovata, Goodalia triangularis, Chamelea gallina,* nephtyd and spionid polychaetes and amphipods.	
SS.SSa.IFiSa.IMoSa Infralittoral mobile clean sand with sparse fauna	*Nephtys cirrosa, Eurydice pulchra, Gastrosaccus spinifer, Pagurus bernhardus, Liocarcinus depurator, Carcinus maenas, Asterias rubens.*	

Table 9.4 Description of biotopes

Biotope code and description	Characterising species	Grab sample photo
SS.SSa.IFiSa.NcirBat *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand.	*N. cirrosa, Bathyporeia* spp., *Pontocrates* spp. (sometimes). *Magelona mirabilis* may be present in more sheltered areas, *Chaetozone setosa* is common in coarser sediments. *Spio filicornis, S. martinensis* and *Lanice conchilega* may be present, together with actively swimming amphipods.	

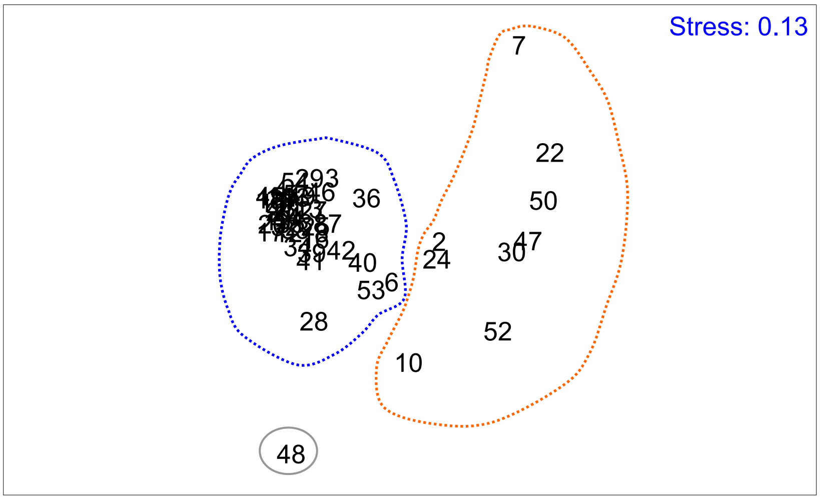

Figure 9.11 MDS plot (√ transformed) based on the species composition of each site (site 26 excluded from the analysis).

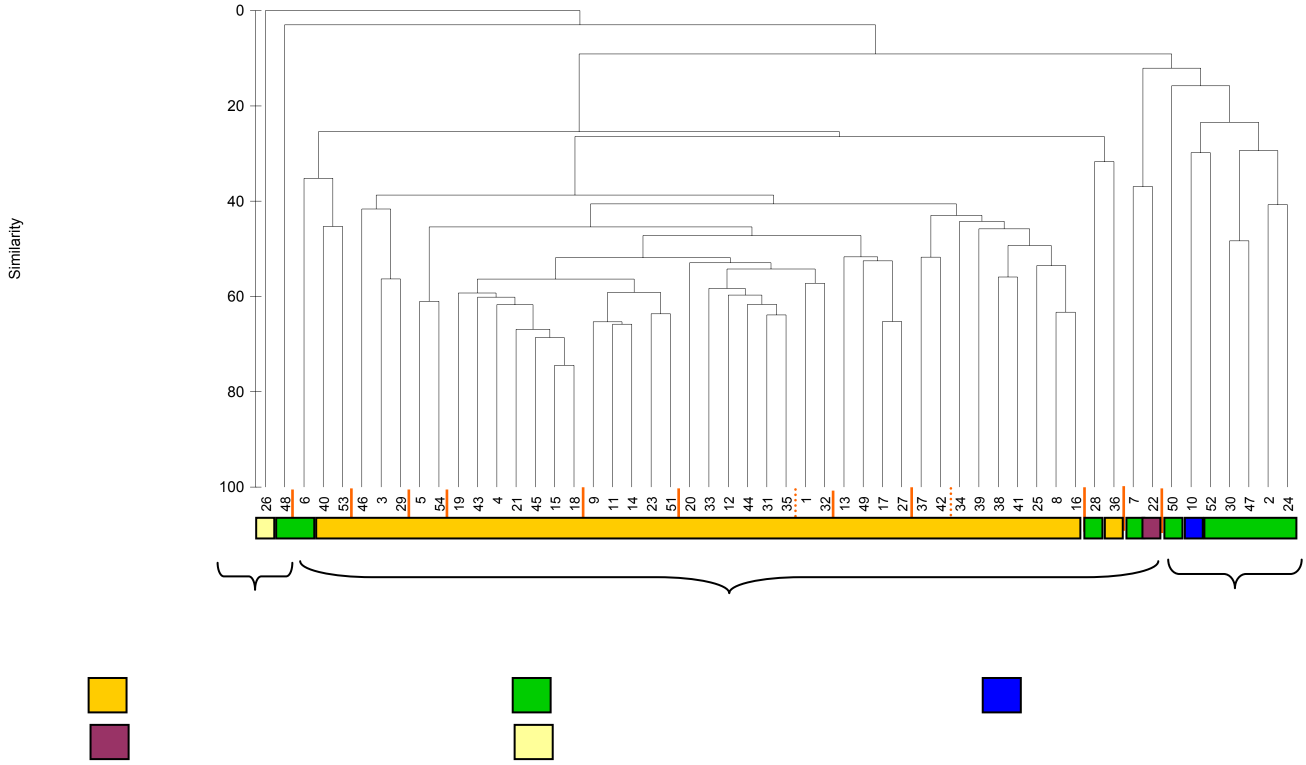

Figure 9.12 Cluster analysis (√ transformed) based on the species composition of each site, showing biotopes..

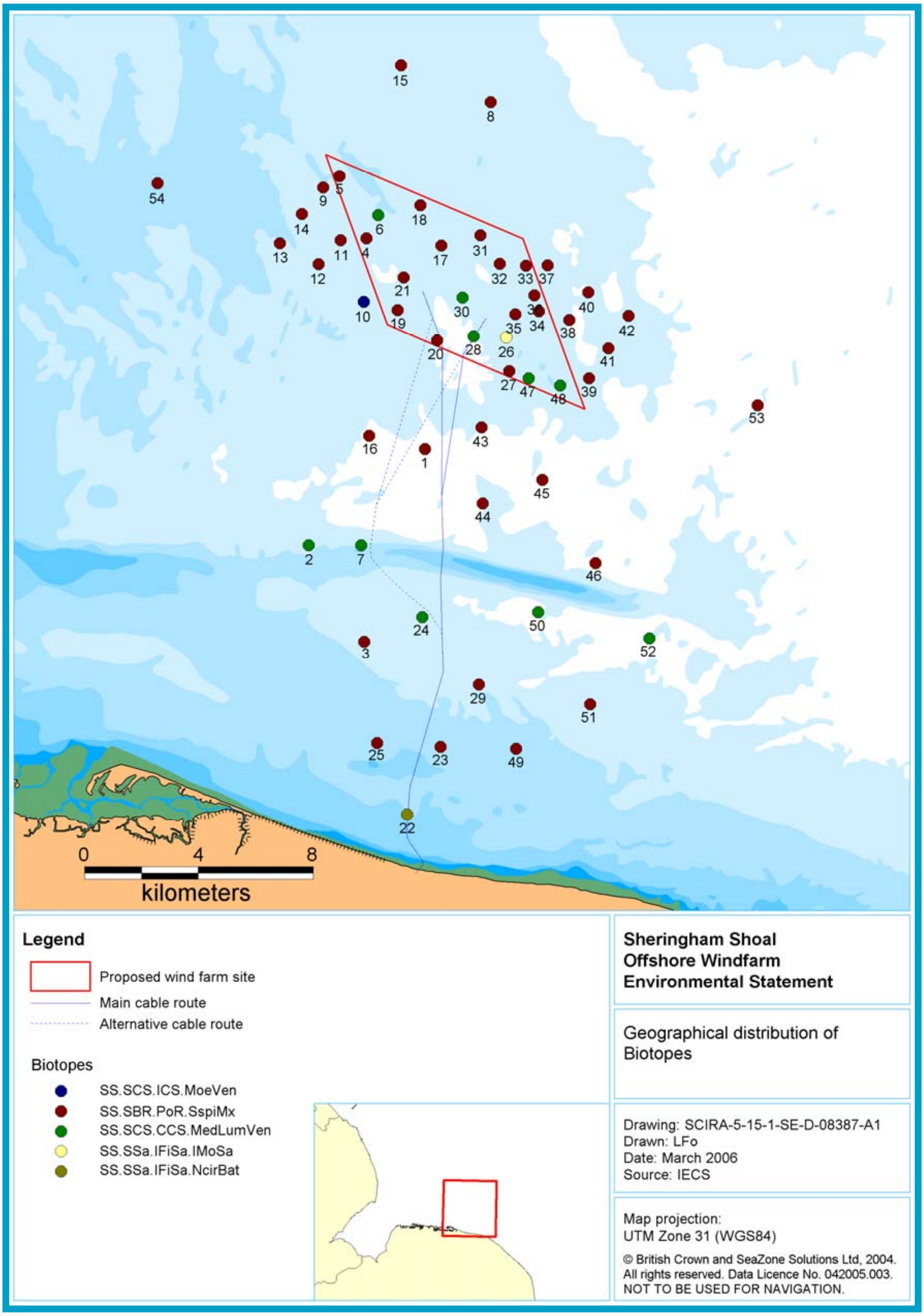

Figure 9.13 Geographical distribution of Biotopes

9.3.3.1 Epifauna

Analysis of the epibenthic communities was carried out on both quantitative data (actual abundances) and qualitative data where the presence or absence of colonial or encrusting species was recorded. Comprehensive characterisation of the fish communities is given in Section 11, Natural Fisheries Resource.

Of the quantitative taxa, the decapod *Pisidia longicornis* was the most abundant, accounting for 21% of the individuals present. Overall, decapods represented 33% of the organisms recorded (see Figure 9.14) with *Necora puber, Pandalus montagui* and *Liocarcinus depurator* commonly occurring. The molluscs were the most abundant group, accounting for 38% of the individuals found, with the most abundant and widespread species being the bivalve *Musculus discors* and the gastropods *Crepidula fornicata* and *Rissoa parva.* Polychaetes represented 12% of the community with *S. spinulosa* being the only species recorded. The sea spiders (pycnogonida), principally *Achelia echinata,* and the Amphipods, principally *Tritaeta gibbosa* and *Atylus vedlomensis* each represented 7% of the community.

The mean number of species across the area as a whole was 18 with a maximum of 40 being recorded from trawl 17 (Plate 9.1) and a minimum of 8 from trawl 2. Abundance values ranged from 12 (trawl 6) to 482 (trawl 15) with a mean value of 126. Pielous index of evenness was greater than 0.5 for all trawls with the majority of values being 0.7 or greater. The abundance ration (A/S) was low for all trawls and these two indices together indicate an even spread of the individuals between the species. Shannon-Weiner diversity (H') ranged from 1.7 (trawl 23) to 3.9 (trawl 19). The biological parameters and diversity of the epifauna were highly variable with the coefficient of variation (%CV) ranging from 16% (H' and J') to 94% (abundance).

Plate 9.1 The content of epifaunal trawl 17.

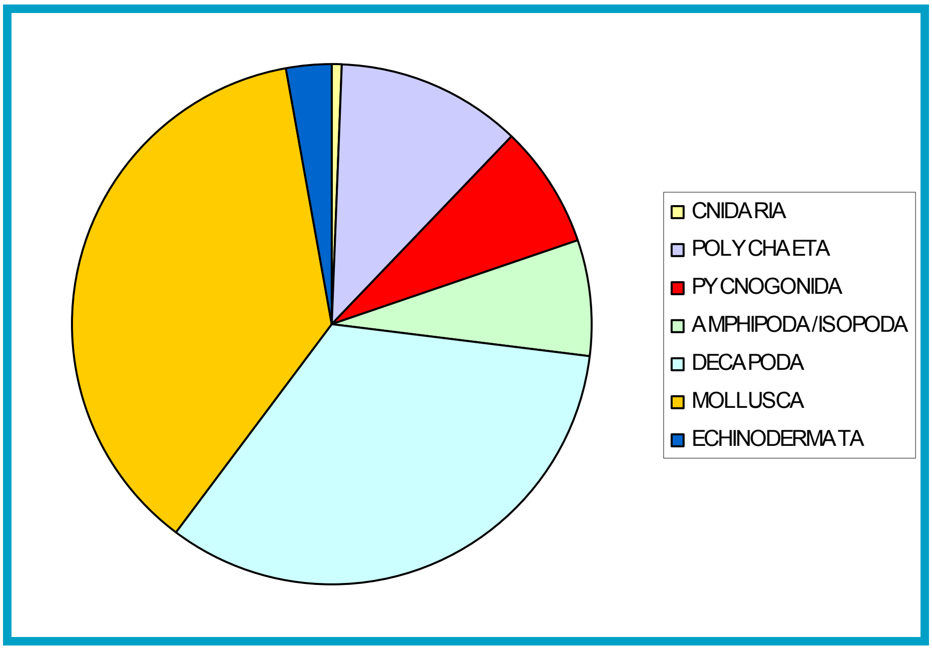

Figure 9.14 Proportional representation of the major phyla present based on semi-quantitative data.

Of the qualitative (encrusting and colonial species) taxa, the most widespread organisms were the bryozoans, principally *Amathia lendigera* (present at all 24 trawl sites), *Flustra foliacea*, *Scrupocellaria reptans* (present at 23 sites), *Crisia aculeata, Electra pilosa* (present at 22 sites) and *Vesicularia spinosa* (present at 20 sites). This group accounted for 48% of the organisms found (based on presence or absence in trawls) (Figure 9.15). Other key taxa included the hydrozoa, accounting for 23% and being primarily represented by *Hydrallmania falcata, Diphasia* sp. and *Abietinaria abietinaria*. The sponges (porifera) and the tunicates accounted for 12% and 11%, respectively, with *Scypha ciliatum* (porifera) and Ascidiidae, Diademnidae and *Dendrodoa grossularia* being the most widespread species. The maximum number of species (44) was recorded from trawl 17, with a minimum of 12 (trawl 8) and a mean value of 28. Other biological parameters such as abundance and diversity indices cannot be calculated for qualitative data.

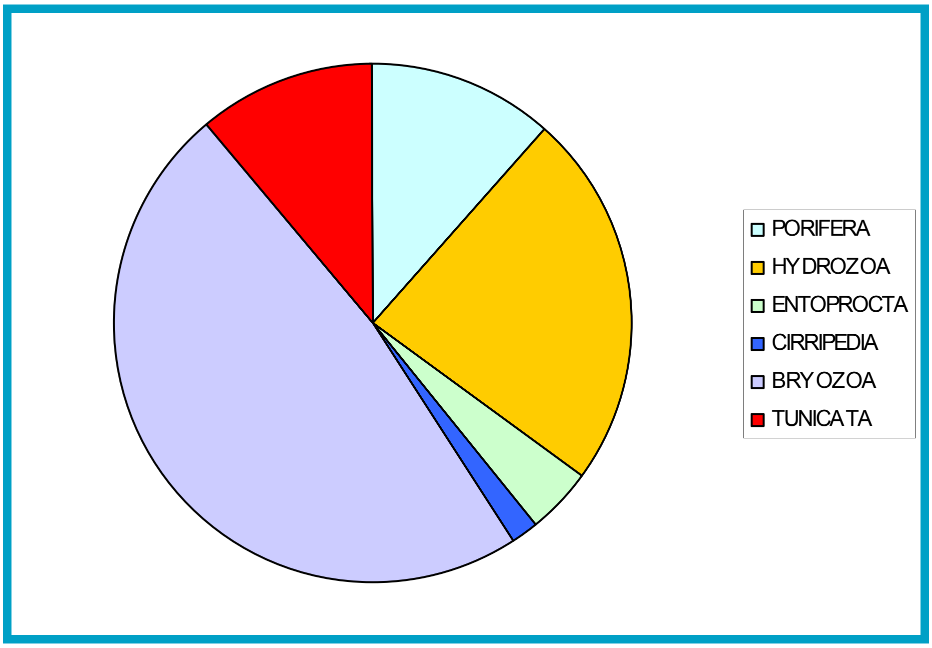

Figure 9.15 Proportional representation of the major phyla based on qualitative data (presence/absence).

A small number of fish species were present in the trawl samples but did not exceed two species or 7 individuals at any one trawl site, with the total number of individuals being 48 for the whole area. These data are, therefore, not considered to be indicative of the fish communities present in the area. A more detailed description of the fish resource is provided in Section 11.

A total of 11 fish species were caught from the area as a whole, the most common being Pogge *Agonus cataphractus* (11 individuals in total). Others included Bull Rout *Myoxocephalus scorpius*, pouting *Trisopterus luscus*, common dragonet *Callionymus lyra*, lemon sole *Microstomus kitt* and the sea snails *Liparis liparis* and *L. montagui*. These species are typical of areas with stony/gravelly or mixed sediments. Other less common species such as dab *Limanda limanda,* lesser weaver *Echiichthys vipera,* spotted ray *Raja montagui* and sole *Solea solea* are more typical of sandy and muddy bottoms.

9.3.3.2 Biogenic reefs

Despite the ecological importance of *S. spinulosa*, the precise definition of a reef is still unclear although Foster-Smith & Hendrick (2003) suggested that abundances of over 375 individuals/0.1m^2 was sufficient to constitute a reef distinct from other biotopes. Additionally, Holt *et al*. (1998) used the following criteria to define biogenic reefs:

- The unit should be substantial in size (generally in the order of 1-2 m across, as a minimum), and somewhat raised in order to disqualify nodule like and scattered, small aggregations such as those commonly formed by *S. spinulosa*.
- The unit should create a substratum/biotope which is reasonably distinct and substantially different to the underlying or surrounding substratum, usually with a greater availability of hard surfaces and crevices on which flora and fauna can grow.

It should be noted, however, that dense aggregations of this species do not necessarily correspond to the occurrence of a visible reef (Foster-Smith & Hendrick, 2003). *S. spinulosa* may also form thin crusts which, although extensive in some cases, are ephemeral in nature. Strong winter storms may cause the disappearance of these crusts with rapid recolonisation taking place during calmer conditions. Such crusts do not form a stable biogenic habitat and establishment of a rich associated community does not occur. They are therefore not considered to be true *S. spinulosa* reefs (Foster-Smith & Hendrick, 2003).

The maximum density of *S. spinulosa* recorded during infaunal (grab) sampling in any one grab was 220 individuals/0.1m^2 (station 43 sample A, mean density 123 ind/0.1m^2) with mean densities of over 100 individuals/0.1m^2 being found at six stations only. Mean densities at the majority of sites (41 of the 54 stations) were less than 50 individuals/0.1m^2. The highest densities of *S. spinulosa* were found either outside or in the northwest corner of the proposed development area (stations 4, 15, 18, 43, 44 and 45) (Figure 9.14).

According to the definition by Foster-Smith & Hendrick (2003), densities of *S. spinulosa* high enough to constitute a reef were not found at any of the sampling stations and, at the majority of stations, the *S. spinulosa* colonisation is considered to be of moderately low quality (in terms of abundance).

As has been recorded during other surveys in the area (Sotheran *et al.*, 2005; Allen *et al.*, 2006), the distribution of *S. spinulosa* is considered to be widespread, patchy and generally low in abundance. Furthermore, it has only been found to exist in ‘low lying crust’ form. Sotheran *et al*. (2005) reported a maximum abundance of 50-90 individuals/0.1m^2 from one site within the proposed wind farm area and found densities of less than 20 individuals/0.1m^2 along the proposed cable route. However, Sotheran *et al.* (2005) did not include sampling stations outside the development area where the maximum density of *S. spinulosa* was found during the present study. This highlights the patchiness of the distribution of *S. spinulosa* in this area.

The spatial distribution of *S. spinulosa* recorded from the benthic survey was consistent with that of the acoustic, video and grab surveys carried out by Sotheran *et al.* (2005). Both studies recorded relatively high abundance of *S. spinulosa* in a few samples within the wind farm site, although Sotheran *et al.* (2005) did not detect any significant densities outside this area. The results of the infaunal sampling were also consistent with those of the epifaunal survey Mazik & Proctor (IECS 2006) (see Appendix 9.6) with the highest density of *S. spinulosa* being recorded from trawl site 17, close to the preferred eastern cable route. Given the relatively low density of *S. spinulosa* in all other benthic samples and trawls, it is considered that the areas of elevated abundance are predominantly comprised of clumps or encrusted communities, rather than extensive reefs or crusts. Video and digital images of the seabed and grab samples appear to indicate that this is typical of many areas within the Greater Wash region.

To confirm the benthic conditions, a dedicated drop down sub-sea video survey was conducted at the four grab stations with the highest densities of *S. spinulosa*. Two station in the northwest corner of the site (stations 4 and 18) and two stations east of the proposed cable route (station 43 and 44) were surveyed wih 5 video drops per location. This survey confirmed that *S. spinulosa* was present in the form of crusts or clumps. These features were found to be patchy within the substrate and did not form a continuous coherent feature (Emu 2006).

No other biogenic reefs or species with the potential to form biogenic reefs were encountered.

9.3.4 Intertidal

As described in Section 2, the preferred route for the export cables is to make landfall in the vicinity of Weybourne Hope, with installation currently planned to involve ducting the cables under the bank. The intertidal zone at Weybourne Hope comprises a shingle beach backed by a steep shingle bank. The shingle beach is highly mobile and, as such, does not provide a suitable habitat for species colonisation and can be described as barren or highly impoverished. Above the high tide line there is limited shingle vegetation (see Section 21). Plate 9.2 and Plate 9.3 show the intertidal zone within the proposed landfall area.

Plate 9.2 The barren shingle beach at Weybourne Hope

Plate 9.3 Proposed landfall site at Weybourne Hope (viewed from cliffs to the east)

9.4 Impacts during construction

9.4.1 Impacts due to habitat disturbance

9.4.1.1 Permanent loss of habitat and species in the footprint of foundations and infrastructure

The installation of turbine foundations and associated infrastructure would result in the direct and permanent loss of habitats and communities present within the footprint of the structures. The size of the footprint would be dependant upon the foundation type selected. The range of foundation options proposed, including the area of the footprint involved, is described in Section 2, Project Details. For the purposes of this assessment the worst case option would be gravity based structures. The area of footprint for each wind farm layout option using gravity based foundations is presented in Table 9.5 along with the percentage of seabed lost within the wind farm and the area of the Greater Wash SEA of 13,100km^2 (as presented in BMT Cordah, 2003).

Table 9.5: Area of seabed lost for each layout option (assuming use of gravity base structures)

No. of Turbines	Area lost per turbine (km^2)	Total area lost (km^2)	Percentage of wind farm area	Percentage of Greater Wash SEA
45	0.0044	0.198	0.56%	0.0015%
63	0.0044	0.277	0.79%	0.0021%
70	0.0044	0.308	0.88%	0.0023%
88	0.0044	0.387	1.10%	0.0029%
108	0.0044	0.475	1.35%	0.0036%

N.B. Areas used in the calculation are based on the worst case scenario

The wind farm site is characterised by a relatively level area of shelly sand and cobbles with southeast to northwest running sandwaves. Typical of this area of the southern North Sea, the seabed is hydrodynamically active and supports sediment types and communities that are considered typical of the area and are consistent with studies carried out by Kenny & Rees (1996), Entec (1999), Allen (2000) and Proctor & Mazic (2005). The survey results have revealed that the mobile sand waves and other predominantly sandy substrates are essentially barren, supporting a small number of errant polychaetes.

In general, the presence and abundance of species recorded within the wind farm area is highly variable and reflects the sediment characteristics found throughout the site and the physical conditions. Geophysical data (see Figure 2.8) shows the presence of mobile sand waves within the site, generally corresponding with the impoverished samples.

The cluster analysis undertaken on the samples taken within and surrounding the proposed wind farm site and cabling routes enable a classification of the species within the sampling stations into 12 major groups or community types. The samples containing the highest number of species and individuals occurred, generally, in the north west of the area surveyed and occurred within the proposed wind farm site and in the surrounding area. There were five groups that were approximately 45% similar to each other and were all dominated by *S. spinulosa*. These sites were found within the proposed wind farm site and close to the preferred direct route for the export cable, but were also found outside the proposed areas.

The areas of till that surround the sand sheet are comparatively richer than the mobile sand areas, supporting moderate assemblages of *S. spinulosa* and other conspicuous epifauna, such as crabs, tunicates, bryzoans and hydroids. *S. spinulosa* favours habitats close to dynamic sand and, under the right conditions, can thrive, forming extensive biogenic reefs. However, within the wind farm site and preferred direct export cable route, no evidence of biogenic reefs were encountered, suggesting that the *S. spinulosa* in this area forms patchily distributed crusts and has not formed an aggregation that would be classed as being of importance to nature conservation.

Side scan sonar images were collected by Envision Mapping Ltd. (Sotheran *at el*, 2005) and again, did not indicate the presence of reef structures. Envision concluded that the wind farm site contains no biological communities of conservation interest elevated above those of coarse and mobile sediments typically found throughout this region. These results have also been discussed with English Nature.

Given that the worst case scenario for loss of seabed within the wind farm area would be 1.35% (magnitude of the effect is low), and that the sampling undertaken has revealed that the fauna within the site consists of a mix of relatively sparse and moderately rich fauna, consisting of species tolerant of a disturbed environment (sensitivity of the benthic community is low), it is anticipated that the direct impact on benthic communities within the footprint of the Sheringham Shoal project would be of **negligible** significance.

9.4.1.2 Direct impact through movement of construction plant

Direct disturbance to the seabed and the potential loss of associated species would arise through the movement of construction vessels. The main cause of this impact would be the feet of the jack up vessels and the anchor patterns required to secure vessels while involved in construction operations. The potential footprint of such activities cannot be calculated in the same way as that of foundation structures, as disturbance may occur in areas later occupied by the foundation or scour protection and factors such as anchor drag (for anchor position vessels) can vary. It is estimated that the maximum additional disturbance of the seabed caused by installation vessels during construction would be 20,000m^2 or 0.06% of the total wind farm, which is less than 5% of that associated with foundation installation.

In this respect it is expected that the communities would recover quickly and that there would be no lack of species for recruitment purposes. The community groupings show that there are similar groups occurring within and outside the proposed wind farm site and this can be expected to also assist in recruitment processes. Studies undertaken within dredging sites (sand and gravel habitats) have shown that recovery is dependent on a number of factors including the sediment type present before and after dredging but also on the intensity of dredging activity. As the disturbance relating to a wind farm site is likely to correspond with localised and low level disturbance the recovery would be expected to be rapid and not subject to subsequent disturbance during the recovery period. Deposits exposed to low levels of dredging intensity within Area 222 and Hastings Area X were found to be indistinguishable from the surrounding sediments in terms of species variety and population densities of macrobenthic invertebrates within a period of 6-7 years after relinquishment (Boyd *et al*, 2004).

The sensitivity of the benthic communities at risk is considered to be low, since the majority of species encountered within the wind farm site boundary have a high recovery rate, and are likely to be tolerant of the levels of disturbance associated with living in a dynamic and periodically disturbed environment. Combined with the temporary and extremely limited potential footprint of construction vessels (magnitude of the effect is negligible), it is considered that the overall impact on the seabed would be one of **negligible** significance.

9.4.1.3 Direct impact through installation of inter-turbine cables

The construction of the wind farm would involve the installation of a network of inter-turbine cables covering a total length of possibly around 100km (the current layout for the 108-3MW option gives a worst case length of 67.2km, however, engineering of the inter-array cable layout is not finalised). With the limited width of the direct impacted area, the impacted area is less than 1% of the wind farm area, i.e. of negligible magnitude.

The direct impacts of cable installation on the seabed would be largely similar to that of other construction activities. During installation there would be a direct impact on benthic infauna and epifauna in the immediate area of trenching, jetting and/or ploughing operations. As previously discussed, the wind farm site is characterised by a high variability of community types ranging from impoverished mobile sand to species rich sites dominated by *S. spinulosa*. The wider distribution of these communities outside of the directly impacted area and the ability of the species to tolerate living in dynamic environments is likely to ensure that recovery is relatively rapid. It is anticipated that any direct impact would be temporary in duration and limited in extent, with no change in sediment composition. The sensitivity of the benthic community is considered to be low, as it is anticipated that the benthic community in the area impacted would quickly recover to pre-impact numbers and diversity following burial of the cables, particularly following the next spawning and recruitment period. The overall impact on the benthic community, through the installation of inter-turbine cables, both within the wind farm and in the context of the wider study area, is therefore considered to be of **negligible** significance.

9.4.1.4 Direct impact through installation of export cables

Two routes for the export cables are currently being proposed. Both routes make landfall in the vicinity of Weybourne Hope. The preferred direct route (approximately 21km) would cross Sheringham Shoal. The alternative western route would avoid Sheringham Shoal and is 1km longer (approximately 22km in total). The cable laying methodology would most likely utilise a cable plough for the majority of the route. However, it may be necessary to use other methods, such as trenching, in areas where the seabed geology would be unsuitable for ploughing. The use of a cable plough minimises the potential footprint of the activity to a limited area either side of the cable trench (see Section 2 for a description of the operation of cable ploughs). In either case, the direct impacted area is limited and the effect is of negligible magnitude in context of the wider study area.

The preferred direct cable route currently passes close (~1km) to an area that supports high numbers of individuals of *S. spinulosa*. It is not considered that the *S. spinulosa* in this area constitutes a biogenic reef (Emu 2006). However, given that other areas supporting high *S. spinulosa* are present adjacent to this site, but further away from the cable route, the potential for the assemblages to develop to a density of conservation importance cannot be discounted. Following further work to establish the importance of this area of *S. spinulosa*, it may be necessary to re-route the export cables within the cable corridors (see Section 2) to ensure that no damage occurs to any structures created by *S. spinulosa*. Given, if necessary the implementation of this mitigation and the relatively rapid recovery rate of the species found within the study area, the sensitivity of the impacted benthic community is considered to be low, and hence the potential impact on the benthic community is considered to be of **negligible** significance.

9.4.2 Impacts due to increased suspended sediment

Increases in suspended sediment concentration and the subsequent settlement of material onto the seabed can lead to a range of impacts on benthic species through the clogging of feeding organs, burial of individuals and reductions in reproductive success. The significance of the impact would be directly related to the sensitivity and recoverability of the species involved. Section 6 describes the levels of suspended sediment increases that may be expected as a result of the construction activities (see also Appendix 6.2).

Within the wind farm, construction activities such as seabed preparation, foundation installation and cable laying would cause the release of differing quantities of sediments into suspension. Suspended sediment would be transported by the prevailing tides and currents, with the distance dependant upon the hydrodynamics at the time of disturbance and the settling velocities of the sediments involved. The more coarse the sediment, the quicker it would settle out of suspension. As the sediments within the wind farm site are predominantly sands and gravels, it is anticipated that the majority of sediments would settle rapidly, over a short distance and local to the construction activity.

Fine materials such as silt and clay have the potential to be transported over greater distances and may not settle out of suspension until different hydrodynamic conditions are encountered. Chalk fines do not readily settle out of suspension. Release of chalk fines would lead to the seawater in the immediate area becoming milky white, as the chalk forms a plume that would be transported the full length of the tidal excursion (see Section 6).

The mobile surface sediment of the site and cable route comprises mainly gravely fine to medium sand. This glacial till overlies Cretaceous chalk bedrock. The upper surface of the chalk slopes down to the north, from surface exposure near the shore to about 20m below the bed to the north of the wind farm site (see Section 2and Plate 2.2). It is not anticipated therefore, that chalk would be encountered at, or near the surface of the seabed within the wind farm boundary. The cable route has been chosen specifically to avoid the area of chalk located to landward of Sheringham Shoal (see Section 2.9.1.1 and Section 6). As such, any increase in suspended sediment would be largely comprised of sandy material and a smaller component of fines. Grab samples and borehole samples obtained from recent survey work indicate silt content below 4% for this surface layer. The depth of this material varies from 0m to about 1m, apart from the areas of sand waves and banks where depths are much greater. A typical depth appears to be around 0.3m.

The high sand/gravel content of the in situ sediment, together with the relatively small disturbance arising from cable ploughing, jetting or trenching to 1m depth, suggests that for most of the cabling operations, the majority of any disturbed sediment would fall directly to the seabed in the immediate location of the cable. Because of the minimal disturbance, fine sand is almost all likely to remain within the bottom 1m to 2m of the water column (even this is probably conservative) and typical settling velocities of around 10mm/s would ensure that the sand settles within half an hour (or less) or becomes part of the ambient near bed transport. Medium or coarse sand would settle within minutes. The vast majority of the disturbed sediment would initially resettle within 20m of the cable, with almost no sand being carried more than 100m from the cable except as part of the natural background transport. As there is already significant ambient sand transport in the vicinity, the small amounts of additional resettled sand will not change the local transport to any significant degree (HR Wallingford, Appendix 6.2).

Suspended sediment levels (for silt, clay and chalk) associated with use of a cable plough and trenching device have been modelled by HR Wallingford (see Appendix 6.2). For ploughing in chalk on a neap tide (a situation only considered to occur very rarely, given the lack of chalk in the footprint), the model shows a plume of chalk extending roughly 9km either side of the plough. Levels of suspended chalk are expected to fall to less than 1mg/l above background within a single flood or ebb excursion. On a spring tide, the extra turbulence causes chalk fine concentrations to fall below 1mg/l (above background) within 4km of the plough. Chalk is crossed along three short sections of the preferred direct route south of the Shoal, totalling approximately 1.6km. (The sea bed geology of the alternative western route has not been mapped in detail).

For seabed sediments with no chalk fines and a high percentage of silt and clay fines, the neap tide footprint would be expected to extend less than 2km, while the spring tide footprint is very small (at a maximum concentration of 1mg/l). As before the neap tide footprint is larger due to the lower rate of turbulent diffusion. The extent of the footprint on both tides is less than that of chalk due to the lower amount of material available per metre length of cable and the settling of silt during periods of slacker flows. This result is applicable to much of the inter-turbine cabling within the wind farm site where there are no exposures of chalk.

Trenching through chalk on a neap tide was also modelled, as this is considered to be the worst-case scenario. The volume of material released by trenching would be much higher, and therefore the extent and persistence of concentrations above 1mg/l (above background) would be much greater. The predicted plume extends more than 10km in either direction at a level of up to 20mg/l (above background) (see Appendix 6.1). This scenario is, however, unlikely to be realised, as the cable route has been designed to avoid areas of chalk at, or near the seabed (see above).

The southern North Sea has a naturally moderate to high turbidity, especially during the winter when background levels can reach over 30mg/l. During the summer months, levels of 10mg/l are more frequently encountered (see Section 6). It is against these naturally occurring background levels that any increases due to construction activities are assessed. The Sheringham Shoal study area is subject to an active bedload transport regime, evidenced by the widespread mobile bed features such as sandwaves, sand ribbons and ripples encountered throughout the region.

The operations associated with installation of the inter-turbine cables and any seabed preparation associated with the gravity based foundations are anticipated to be the greatest potential source of sediment release.

The majority of species that comprise the benthic assemblage within the wind farm boundary are considered to be tolerant of the moderately high, naturally occurring levels of turbidity encountered in the southern North Sea. They are also likely to be tolerant of periods of smothering as a result of the mobile nature of the bed sediments within the study area. Although not present in numbers or density to be considered of high conservation importance, *S. spinulosa* is the most numerically dominant species, and defines the communities present. The sensitivity of this species to the increases in suspended sediment and smothering likely to be encountered during the construction phase has been classified by the Marine Life Information Network (MarLIN). Table 9.6 presents a summary of this information.

Table 9.6: Sensitivity of S. spinulosa to the impacts of increased turbidity and smothering.

	Intolerance	Recoverability	Sensitivity	Evidence / confidence
Smothering	Low *	Immediate	Not sensitive	Moderate
Increase in suspended sediment	Low *	Immediate	Not sensitive	Moderate
Increase in turbidity	Tolerant **	Not relevant	Not sensitive	Low

* The species population will not be killed/destroyed by the factor under consideration. However, the viability of a species population will be reduced.

** The factor does not have a detectable effect on survival or viability of a species.

Source: adapted from http://www.marlin.ac.uk/species/adult_sens_Sabellariaspinulosa.htm

While some members of the benthic community, such as ascidians and tunicates, may show a greater intolerance than *S. spinulosa*, no species recorded is considered to be rare or unique in the wider study area. These species are also associated with the *S. spinulosa* which characteristically requires suspended sediment in order to construct its tubes. The associated species must therefore have some tolerance to increases in suspended sediment concentrations, and the community as a whole is considered to be of low sensitivity. The potential duration of suspended sediment related impacts would be temporary and therefore of low magnitude,. Combining the magnitude and sensitivity using the matrix in Table 8.5, the impact of the suspended sediment on the benthic community is considered to be **negligible**.

In terms of the impacts regarding the limited lengths of disturbed chalk along the cable route, this very fine material is assumed to remain in suspension almost indefinitely, as a plume, and would be transported throughout the entire tidal excursion. It is anticipated that the plume would be initially visible as a milky white suspension, but that concentration of material within the plume would rapidly decrease as it is dispersed over the order of a few tidal cycles, hence the magnitude of the effect is low.

The increase in turbidity resulting from this plume would reduce the penetration of light through the water column. The implications of this are low due to the relative lack of photosynthetic species (i.e. algae). The species of fauna present are thought to be tolerant (sensitivity is low) to increases in suspended sediment as they are within an area of predominantly mobile sediments and highly variable turbidity, and will have adapted to temporary and seasonal increases in suspended sediment (see also Section 10, Natural Fisheries). As such, the potential impact on the benthic resource as a result of export cable laying through chalk is considered to be of **negligible** significance and the chalk plume is considered to be largely aesthetic in nature, as the sea would become discoloured.

9.4.3 Impact due to changes in water quality

Given that the range of construction activities occurring within the wind farm boundary and export cables route would lead to the resuspension of sediments, there would be the potential for any sediment-bound contaminants to be released into the water column. If redeposited onto the seabed, these contaminants could have an adverse impact on the benthic assemblage.

As presented in Table 9.3, sediment samples were taken from grab locations 17, 22, 23, 24 and 29 in order to analyse the concentrations of contaminants at each station. There is, at present, no guideline values for marine sediment contamination effects on benthic species. As such, the

Canadian Sediment Quality Guidelines (SQG) (CCME, 2001) for aquatic invertebrates were used as a point of reference.

Mean concentrations of all PAH and PCB compounds were below the detection limits of 0.35mg kg-1 and 0.14µg kg^{-1}, respectively (see Table 9.3). It should be noted that the detection limits for PAH compounds actually exceed the SQG and the Probable Effects Levels (PEL) for freshwater (Table 9.3). These compounds bind readily to organic matter and therefore generally occur in high concentrations in areas where the silt and organic content of the sediment are high and the particle size is small. However, as demonstrated in Figure 9.3, the silt and organic content are low across the area with the maximum organic content being 2.6%. Therefore, it is unlikely that PAH compounds are present in high concentrations.

Mean concentrations of cadmium, chromium, chromium (VI), copper, nickel, zinc and lead were all below detection limits and their respective SQG and PEL values. Arsenic concentrations ranged from 10.2 to 20.9mg kg^{-1} (mean of 13.6) and exceed the SQG of 7.24mg kg^{-1} at all sites. However, these values are well below the PEL value and, following dilution and dispersion upon disturbance, are not considered to pose a significant threat to the benthos. Mercury exceeded the SQG at station 23 and was potentially higher than the SQG at the other sample locations. However, at these sites, the concentration of mercury was below the level of detection. Similar to arsenic, mercury concentrations, even where exceeding the SQG were below the PEL and, given the large dilution factor of the receiving environment, it is considered that the resuspension upon the benthos would be of negligible magnitude. The potential impact is therefore of **negligible** significance.

Water quality may also be affected by the release of chemicals associated with the construction process. The potential for accidental release of chemicals to occur during the construction stage is low. The major components of the structures are manufactured on land and delivered to site in a finished state. This limits the substances that could be released to fuels, oils and grouting cements. The quantities of such substances, associated with the various construction options being assessed, are described in Section 2.

The Installation Contractor for the wind farm would be contractually obliged to follow published guidance and best working practice during offshore operations. This would include the use and management of grouting cement. An Environmental Management Plan (EMP) would be produced as part of the contract documents to ensure that potential sources and risks of pollution are identified and managed in a way that minimises the risk but also makes provision for rapid responses to accidental releases. Combined with the high diluting factor of the receiving environment, the effective management of potentially polluting substances would result in an effect of negligible magnitude, and hence an impact of **negligible** significance for benthic invertebrates.

9.4.4 Impact due to noise and vibration

The sources and levels of underwater noise associated with the construction and operation of offshore wind farms are discussed in Section 10, Natural Fisheries Resource. The activity that would generate the greatest noise levels would be pile driving. Noise levels of 272 to 288dB @ 1m are estimated to be the worst case scenario for pile driving in the Sheringham Shoal study area. Noise levels at this intensity are likely to be encountered within an impact radius of up to 10m from source (RPS, 2005 and Royal Haskoning, 2005). The physiological impacts of noise on benthic invertebrates is poorly understood. However, the presence of air-filled spaces within the body cavity of many invertebrates means that they may be impacted to some extent (McCauley *et al.,* 2000 and Moriyasu *et al*., 2004). Within the 10m radius of highest impact, the noise levels are likely to induce behavioural changes in benthic species, such as withdrawal of feeding appendages, cessation of reproductive activity and retreat into burrows. Within this area, the risk of mortality would be high and physiological damage would almost certainly occur. However, the area of highest potential impact is also that which would undergo the direct impact of habitat loss associated with the provision of scour protection and/or the formation of scour pits around the monopiles. If gravity based structures are used instead of monopiles, the impact of noise would be less, but the area of direct impact on the seabed would be greater.

The potential impact on the benthic community would be highly localised and limited to a small number of individuals of a widely distributed assemblage. Given the limited area of loss (low magnitude) and the common occurrence of the species present within the wider study area (low sensitivity), the impact is considered to be of **negligible** significance.

9.4.5 Impact due to construction in the intertidal zone

The shingle beach at Weybourne Hope is considered to be barren and of little significance to the benthic ecological resource of the local and wider study area. Consequently, **no impact** is anticipated during construction activities in the intertidal area.

9.4.6 Mitigation

A targeted drop down camera survey will be undertaken at certain locations that could support dense aggregations of *S. spinulosa.* The survey and locations will be agreed with English Nature and the results of the survey will be discussed with them. If biogenic reefs are located within the footprint of any of the project components, Scira will work with English Nature to develop a protocol for micrositing necessary turbines, inter-turbine infrastructure and export cabling to minimise potential adverse impact.

9.5 Impacts during operation

9.5.1 Impact due to changes in coastal processes

Section 6 describes the predicted changes to coastal processes as a result of the operation of the Sheringham Shoal project; including effects on wave climate, currents, sediment transport and scour.

The presence of the turbines and associated infrastructure would cause localised alterations in current flow, leading to increased turbulence during times of peak flow and the formation of scour pits around the base of the foundations. All the foundation types would cause localised scouring of seabed sediments and associated communities. The volume of scour would depend on the type of sediment encountered. In areas of poorly consolidated material, such as mobile sands, the level of scour is likely to be greater than that in areas of stiff glacial till (see Section 6). The levels of scour anticipated for the Sheringham Shoal project are discussed in detail in Section 2, Section 6 and Appendix 6.1.

Scouring of the seabed would impact upon the benthic community and may lead to the loss of sessile species within the impacted area. Following the initial period of scouring, it is anticipated that rates of scour would rapidly decrease as a new equilibrium is reached. The majority of species present within the study area are present throughout the wider area and are able to recover rapidly from disturbance, given that the new surface substrate would be similar. Therefore, it is assumed that the effect is likely to be short term in duration and limited in extent (low magnitude), giving an overall impact of **negligible** significance.

Assuming a final spacing between turbines of at least 600m, and up to 1200m in the dominant tidal flow direction, it is considered unlikely that there will be any overall sheltering effect that could give rise to broad scale accretion or erosion over the area of the wind farm (see Section 6). As such, it is anticipated that there would be a negligible effect on the movement of mobile sediments along the seabed from current baseline conditions and, as such, a **negligible** impact on the benthic community is anticipated.

9.5.2 Impact due to noise and vibration

Although little scientific literature on the subject exists, Vella *et al* (2001) consider that it is highly unlikely that benthic invertebrate fauna would be adversely affected by the low levels of noise and vibration that are associated with operational wind turbines, as they are significantly lower than that generated during construction. Monitoring of turbine towers at Horn's Rev in Denmark has shown that rather than avoiding wind turbine structures, the abundance of species increased in the localised area (Bio/Consult, 2004). Operational noise and vibration impacts upon benthic invertebrates are, therefore, considered to be an effect of negligible magnitude, with an impact of **negligible** significance.

9.5.3 Impact of electromagnetic fields

The potential impacts of electromagnetic fields (EMF) in the marine environment are the subject of ongoing research under the auspices of the Collaborative Offshore Wind Research Into the Environment (COWRIE). The main area of concern relates to impacts on electrosensitive fish species such as elasmobranchs, which may be attracted to the EMF emissions of buried cables or caused to avoid an affected area entirely.

The potential for EMF to have similar effects on benthic invertebrates is extremely limited. Although lacking in research, it is assumed that electro and magnetic sensitivity is of negligible influence on the behaviour, distribution and orientation of the range of benthic species found within the study area. This assumption appears to be supported by the results of monitoring studies carried out at Horns Rev (Bio/Consult, 2004) and North Hoyle (NPower Renewables, 2003), which showed no evidence of a change in the benthic community, during operation, that could be attributed to the presence of the wind farm. It is therefore anticipated that the impact of EMF on the benthic community would be of **negligible** significance.

9.5.4 Impact due to heating effects of buried cables

Resistance of the flow of electrons through a transmission cable can cause the cable to increase in temperature. Sustained high current flows or faults in the cable can lead to excessive overheating, which in turn can impair the efficiency of the cable and reduce its life expectancy through damage to its insulation (CSA, 1995). Electricity transmission cables, such as those used as export cables for the Sheringham Shoal project have a 'thermal rating' applied, where the "normal" level is defined as the current flow level it can support indefinitely[20].

Any increase in the temperature of the transmission cables of the Sheringham Shoal project would depend on the level of current flow that is applied to the system over time. If the system operates at maximum loading consistently, the temperature of the cable would be likely to increase to a greater extent than if the loading was cycled so that maximum levels are only applied over limited time periods.

The effect of radiated heat from cables buried in the seabed has been considered by the Connecticut Siting Council (CSC) as part of planning applications submitted for the 'Cross Sound Cable Interconnector' project, a high voltage DC buried cable system between New England and Long Island New York[21]. Concerns were raised that thermal radiation from the buried cable may have an adverse effect on the surrounding benthos by increasing incidences of shellfish disease. The CSC found that the cable system could cause an increase in temperature at the seabed immediately above the buried cable of 0.19°C and an associated increase in seawater temperature of 0.000006°C. A similar increase in temperature as a result of the Sheringham Shoal project is considered to be well within the natural temperature fluctuations in the southern North Sea and, hence, within the tolerance range of the benthic assemblage within the study

[20] See http://www.eia.doe.gov/cneaf/pubs_html/feat_trans_capacity/w_sale.html
[21] For a transcript of the decision see http://www.ct.gov/csc/cwp/view.asp?a=958&Q=247634

area. Limited temperature changes, as described for the Cross Channel Cable Interconnector, are not considered to pose a risk to shellfish health through increased incidences of disease. Based on the above, it is considered that the effect of increased temperatures as a result of the operation of the Sheringham Shoal project would be of negligible magnitude and hence a **negligible** impact on the benthic community is anticipated.

9.5.5 Recovery of benthic fauna following construction

Given the continuing presence of available habitat, the majority of species recorded during the benthic and epibenthic surveys are considered to be largely tolerant of the levels of disturbance associated with the construction process.

Following completion of the construction phase it is expected that recolonisation of the seabed would rapidly occur, via recruitment of opportunistic colonisers, followed by less mobile species in the time following the closest spawning periods of communities in unaffected areas.

Monitoring studies at the Horns Rev offshore wind farm has shown the presence of a largely similar community, before and after construction, with slight variations that are attributed to either natural variation or highly localised changes in sediment characteristics (Bio/consult, 2005). A similar situation was observed at the North Hoyle Offshore Wind Farm (NPower Renewables, 2003), where major species remained dominant, but overall abundance of organisms decreased. This decrease occurred both within the wind farm and at distant control sites. The decrease could not be attributed to the North Hoyle development and, similarly to Horns Rev, it was considered to be a result of natural changes in sediment distribution and seasonal change in the benthos. Based on current evidence, it is anticipated that a similar scenario would be encountered at Sheringham Shoal. As such, the overall impact on seabed communities following completion of the construction process is expected to be of **negligible** significance.

Following construction, it is not anticipated that there would be any permanent adverse impact on the potential for the *S. spinulosa* in the wind farm area to continue to develop and ultimately form reef-like aggregations. The phenomenon of fast growth of *S. spinulosa* following a period of disturbance has been well documented in recent years. For example, Vorberg (2000) found that re-growth was five times faster than normal growth following experimental destruction of a reef. Further to this it has been suggested that physical factors such as temperature are less important in influencing juvenile settlement than the presence of other *S. spinulosa* secretions, be it from other juveniles, adults or deceased colonies (Wilson, 1970; Schäfer, 1972; Foster-Smith and Hendrick, 2003). It is, therefore, anticipated that there would be **no impact** on *S. spinulosa* during the operation of the wind farm.

9.5.5.1 Colonisation of foundations and associated structures

It is expected that, following installation, any hard structures above the seabed, up to the high water mark and splash zone, would be rapidly colonised by a range of epibenthic species. The actual colonising species are difficult to predict, given the lack of available similar structures in the wider study area. However, examples from monitoring studies of other offshore wind farms can be used as evidence of colonisation.

Monopiles and scour protection were monitored at the Horns Rev wind farm in 2003 and 2004. Published results show that 11 species of algae were recorded in the two years, with distinct variation in both spatial and temporal distribution. Algae were more prevelant on the pile than the scour protection. Those species associated with the scour protection tended to be found in the shallowest areas of the site. A successional pattern was observed on the upper sections of the pile, where the filamentous algae that were dominant in 2003 were replaced by species of *Ulva*. A total of 70 invertebrate species were recorded during the monitoring surveys, of these, 12 were classed as highly mobile (decapods and molluscs) and were only recorded as observations. The spatial and temporal distribution and abundance of species varied greatly between the two years and the assemblages present on each pile were statistically different from the assemblage on other piles. These differences were largely due to the varying dominance of the two most common species, the amphipods *Jassa marmorata* and *Caprella linearis*. Overall, the tube dwelling *J. marmorata* was the most abundant species, with peak abundances of 1,230,537 individuals/m^2. Other commonly encountered species included the edible mussel *Mytilus edulis* and the barnacle *Balanus crenatus*. 14 epifaunal species were recorded in 2004 that had not been encountered in 2003. Of these, the most significant species were *S. spinulosa* and the white weed *Sertularia cupressina* (both considered as red list species) (Bio/consult, 2004).

Similar colonisation studies have been carried out at North Hoyle wind farm, off the coast of North Wales. Here, 59 faunal species and four algae were recorded. As at Horns Rev, a distinct vertical zonation was observed, with up to eight distinct zones occurring on the piles. Dominant species were also very similar to those at Horns Rev with the barnacle *B. cranatus*, the mussel *M. edulis* and the tube dwelling amphipod *J. falcata* dominating. The starfish *Asterias rubens* was also recorded in high numbers and, similarly to Horns Rev, was considered to be the main predatory species on the piles. The species colonising the piles are reported as being common species, frequently encountered on hard surfaces in nearby locations. It is expected that these locations provide recruitment to the wind farm area (NPower Renewables Limited, 2005).

It is anticipated that colonisation of the foundation structures at Sheringham Shoal would follow a broadly similar pattern to both North Hoyle and Horns Rev. Species present on hard substrates in the wider study area would be expected to provide the source of initial colonising species. Mussels, barnacles and tube dwelling amphipods are likely to be the dominant species during the two years following installation, with natural succession occurring thereafter.

While the colonisation of the foundation structures at Sheringham Shoal may provide a localised increase in biodiversity and the abundance of certain species, the wind farm cannot be considered as an artificial reef structure. The spacing between turbines is such that interaction would be highly limited. The assemblage developing on neighbouring turbines are likely to show distinct differences in species richness, abundance and diversity as well as a range of zonation patterns. As such, each structure should be considered as an individual vertical hard surface, as oppose to considering the wind farm as a 'habitat'.

Fouling of the foundation structures can be considered as being of minor beneficial significance, in terms of highly localised increases in biodiversity. However, the assemblage represents an artificial result of an anthropogenic activity, not specifically designed to enhance biodiversity. As such the overall impact of colonisation of the foundation structures and turbine towers is considered to be of **negligible** significance.

For health and safety reasons, some clearance of the fouling community would take place at points of access, e.g. by the use of antifoulants. It is not anticipated that other components of the structure would require clearing, however should the need for clearance arise in the future, the methods by which such activities take place would be agreed as part of the Operations and Maintenance plan. By following the guidance and advice of the regulators during preparation of the plan, the overall impact is anticipated to be of **negligible** significance.

9.6 Impacts during decommissioning

No Regulations have yet been made, and not guidance issued, to further explain the decommissioning provisions within the Energy Act 2004 in relation to offshore wind farms However, it is likely that all of the offshore structures would have to be removed to the seabed i.e. partial removal. The nacelle and towers would be removed in reverse operation to construction using a heavy lift vessel. Cables would be disconnected after being isolated offshore and pulled out of the J-tubes.

Foundation structures could be totally removed, or in the case of monopiles cut off below the seabed. Impacts of a similar nature and significance to that experienced during construction are therefore anticipated. It is likely that the subsea cables would be left buried and notified as being disused, no impacts would therefore be anticipated.

Scira is committed to monitoring the development of the benthic community within the wind farm area. If the monitoring shows colonisation of the foundation structures and surrounding area that would be significantly impacted by the removal of the structures then it may be possible to agree a decommissioning programme that allows for structures to remain on the seabed.

A Decommissioning Plan would be agreed with the DTI and The Crown Estate prior to commencement of construction and reviewed periodically to ensure that it continues to be appropriate.

9.7 Cumulative impacts

The potential impacts associated with the construction and operation of the Sheringham Shoal project are considered to be short term in duration and, in almost all cases, of **negligible** significance. The separation distance between the other wind farm projects in The Wash coupled with the fact that the majority of potential impacts for the Sheringham Shoal project are restricted to within the wind farm boundary, and local surrounding area, mean that impacts during construction, such as sediment plumes, would not interact. In addition the impacts are considered to be short term and reversible, with no long term change predicted.

There would be an aggregated direct and permanent loss of habitat during the operational phase of the wind farms. However, given the common and widespread nature of those species and habitats found at the Sheringham Shoal project, cumulative impacts on the marine benthos are not considered significant in the context of the wider study area.

Overall, it is considered that there would be no cumulative impacts associated with the Sheringham Shoal project and other offshore developments on benthic fauna in the wider study area.

9.8 Monitoring proposals

In terms of the benthic biological resource in the study area, detailed surveys have been undertaken to establish the baseline existing conditions throughout the study area. It is anticipated that monitoring would continue during the initial years of operation. The purpose of the monitoring programme is to evaluate the actual quantifiable effects in relation to the predicted effects. A selection of monitoring sites would be established in conjunction with English Nature and CEFAS. The monitoring sites would cover the area of potential indirect effect of both the Sheringham Shoal site and the export cable route. Survey, sampling and analysis methodology will be the same as for the baseline survey in order to allow like for like comparison.

Monitoring of the intertidal area in the vicinity of the cable landfall is not expected to be required.

9.9 Summary

A number of site specific surveys have been carried out in order to establish the baseline conditions with regard to the marine biological resource within and around the footprint of the Sheringham Shoal project. These have included:

- Acoustic and video surveys, supported by grab sample ground truthing to establish seabed conditions and potential habitats for benthic communities of conservation significance;
- A more extensive grab sampling programme to describe the infauna of the study area;
- A trawl survey to describe the epifaunal community; and
- A walkover of the intertidal area in the vicinity of the proposed cable landfall.

The seabed within the study area is characterised by coarse to medium sands with varying percentages of gravel and pebble content. The overall composition of the sediments is highly variable and poorly sorted. This variable characteristic is reflected in the benthic assemblage recorded during the site-specific surveys.

A total of 267 infaunal species have been recorded with a mean number of species ranging from two to 72. The lowest numbers of species are associated with areas of sand dominated substrate in the southeast of the site. The number of individuals per sample is also highly variable ranging between two to 423. Species present in moderate to high abundances included typical polychaete worms, crustaceans and bivalve molluscs such as *Pisidia longicornis, Polycirrus* spp., *Ampelisca diadema, Eumida sanguinea, Caulleriella zetlandica,* nematodes and *Nucula nucleus.* Twelve community types were identified. Those with very low numbers of species and low abundances were generally found in areas of clean medium sands to the south of the turbine site and along the proposed cable route. Communities with the highest number of species and abundance were generally found in areas of mixed sediments in the north west of the survey area.

The benthic surveys recorded the presence of *S. spinulosa* throughout much of the study area. The maximum density of *S. spinulosa* from any one individual grab sample was 220 individuals/0.1m^2 with mean densities of over 100 individuals/0.1m^2 being found at six sites only. Mean densities at 41 of the 54 stations surveyed were less than 50 individuals/0.1m^2. It is considered that the areas of the site that support more dense assemblages of *S. spinulosa* are predominantly comprised of clumps and encrusting communities rather than extensive reefs or crusts, which may be considered of nature conservation importance. A targeted drop down camera survey at certain locations that could support dense aggregations of *S. spinulosa* was undertaken. The survey and locations were agreed with English Nature and the results of the survey will be discussed with them. This survey confirmed that *S. spinulosa* was present in the form of crusts or clumps. These features were found to be patchy within the substrate and did not form a continuous coherent feature that constitutes a biogenic reef (Emu 2006).

The intertidal area of the proposed landfall site at Weybourne Hope comprises a shingle beach backed by a steep shingle bank. The shingle beach is highly mobile and, as such, does not provide a suitable habitat for species colonisation and can be described as barren or highly impoverished. Significant impacts in this area are not anticipated.

Impacts of greatest potential significance, in the context of the benthic resource, are anticipated to arise during the construction phase of the development. Specifically, the direct impact on habitats and species through the installation of foundations, cables and associated infrastructure are considered the most significant. The sediment types and communities found within the footprint of the Sheringham Shoal project are typical of the wider study area and are consistent with those of studies carried out by Kenny & Rees (1996), Entec (1999), Allen (2000), Lewis *et al.* (2002), Entec, (2003); Sotheran *et al.* (2005) and Proctor *et al.* (2006). No species of conservation significance are present within the footprint of the construction activities, and the assemblage is considered to be well adapted to living in a dynamic and periodically disturbed environment. As such the potential direct impact of habitat loss during construction is considered to be of short term duration and of **minor adverse** significance.

Sediment disturbance and deposition from construction activities such as cable installation could have an adverse indirect impact on the benthic communities, through increased turbidity and smothering. Modeling has shown that the vast majority of disturbed sediment is expected to settle in the immediate vicinity of the disturbance. The amount of fine sediment is limited in the area and outcrops of chalk would only be encountered along a short stretch of the cable route. The benthic community is tolerant to such disturbance and increases in turbidity. The potential impact is considered to be of short term duration and **negligible** significance.

Following construction, there is the potential for scouring of the seabed to occur around the foundation structures, given available seabed material. The extent of scouring would depend on the foundation type selected. For gravity based structures it is considered that scour would lead to instability so scour protection would be placed around the foundation. Similarly, for monopiles in sand areas where significant scour would occur, scour protection would be placed. It is anticipated that scouring would occur immediately following installation until a new equilibrium is established. The scoured area would be readily colonised by species from unaffected areas. As such, the impact is considered to be **negligible**.

It is not anticipated that any other significant impact upon the benthic assemblage would occur during the operation of the wind farm. Following construction a range of benthic species from the wider study area are expected to rapidly colonise the foundations, turbine towers and any scour protection placed on the seabed. This colonisation may serve to cause a highly localised increase in biodiversity, and would provide foraging opportunities and refuge habitats for a range of species.

The impacts associated with decommissioning are anticipated to be largely similar to those of construction, with the exception of piling, which would not take place. As cabling is likely to be left in place following removal of the turbines, the impact on the seabed would be minimal. As such, it is considered that the impact on the benthic assemblage would be **negligible**.

9.10 References

- Allen, J.H. (2000) The analysis and prediction of the shallow subtidal benthic communities along the east coast of England. Unpublished Ph.D thesis, University of Hull, 308pp.
- Allen, J.H., Billings, I., Cutts, N. & Elliott, M. (2002) Mapping, condition and conservation assessment of Honeycomb worm *Sabellaria alveolata* reefs on the eastern Irish Sea coast. Institute of Estuarine & Coastal Studies, University of Hull. Report to English Nature. Report No. Z122-F-2002, 135pp.
- Allen, J.H., Burlinson, F. & Burdon, D. (2006) Humber Gateway offshore wind farm development *Sabellaria* report. Institute of Estuarine & Coastal Studies, University of Hull report to Environmental Resources Management Ltd. Report No. ZBB673-F-2006.
- Bio/Consult (2005) Infauna monitoring. Horns Rev Offshore Wind Farm. Annual Status Report, 2004.
- BMT Cordah Limited (2003) Offshore wind energy generation. Phase 1 proposals and environmental report. DTI. London.
- Boyd, S.E. (2002) Guidelines for the conduct of benthic studies at aggregate dredging sites. Centre of Environment, Fisheries and Aquaculture Science, report to the Department for Transport, Local Government and the Regions.
- Boyd, S.E., Cooper, K.M., Limpenny, D.S., Kilbride, R., Rees, H.L., Dearnaley, M.P., Stevenson, J., Meadows, W.J. and Morris, C.D. (2004) Assessment of the re-habilitation of the seabed following marine aggregate dredging. Centre for Environment, Fisheries and Aquaculture Science. Science Series. Technical Report No.121.
- Canadian Council of Ministers of the Environment. (2001) Canadian sediment quality guidelines for the protection of aquatic life. Summary tables. Updated in Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.
- CEFAS. (2004) Offshore wind farms: Guidance note for Environmental Impact Assessment in respect of FEPA and CPA requirements. Version 2. Prepared by the Centre for

Environment, Fisheries and Aquaculture Science (CEFAS) on behalf of the Marine Consents Unit (MCEU). 45pp.

- Covey, R. (1998) Chapter 6. Eastern England (Bridlington to Folkstone) (MNCR Section 6). In: Hiscock, K (ed.) Marine Nature Conservation Review. Benthic marine ecosystems of Great Britain and the north east Atlantic. Peterborough, Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom. MNCR Series). pp 179-198.
- Ducrotoy, J-P, Elliott, M. & de Jonge, V.N. (2000) The North Sea. Mar. Pollut. Bull. 41(1-6): 5-23.
- Duineveld, G.C.A., Künitzer, A., Niermann, U., De Wilde, P.A.W.J. & Gray, J.S. (1991) The macrobenthos or the North Sea. Neth. J. Sea Res. 28(1/2): 53-65.
- Ellis, J.R. & Rogers, S.I. (1999) Marine fauna off the coast of East Anglia. Trans. Suffolk Nat. Soc. 35: 45-57.
- Emu (2006) Sheringham Shoal Video Survey. Emu Ltd. Report to Scira Offshore Energy Ltd. Report No. 06/J/1/03/0927/0588, April 2006.
- English Nature. (1999a) Habitat Action Plan: *Sabellaria spinulosa* reefs. English Nature (http://www.ukbap.org.uk/UKPlans.aspx?ID=38)
- English Nature. (1999b) Habitat Action Plan: *Modiolus modiolus* beds. English Nature. (http://www.ukbap.org.uk/UKPlans.aspx?ID=37)
- Entec U.K. Limited. (1999) Environmental Statement. Licence application for Area 400. Report to Hanson Aggregates Marine Ltd. 140pp.
- Entec U.K. Limited. (2003) Application for licence to dredge marine aggregates in Area 481 (Inner Dowsing). Environmental Impact Assessment- Scoping report. Report to UMD/Van Oord ACZ, 119pp.
- Foster-Smith, R.L. & Hendrick, V.J. (2003) *Sabellaria spinulosa* in the Wash and North Norfolk Coast cSAC and its approaches. Part III. Summary of knowledge, recommended monitoring strategies and outstanding research requirements. A report to Eastern Sea Fisheries Joint Committee and English Nature, 51pp.
- George, J.D., Chimonides, P.J., Evans, N.J. & Muir, A.I. (1995) Fluctuations in the macrobenthos of a shallow-water cobble habitat off North Norfolk, England. In: Eleftheriou, A., Ansell, A.D. & Smith, C.J. (eds.). Biology and ecology of shallow coastal waters. Proceedings of the 28th European marine biology symposium. Institute of Marine Biology, Crete. Olsen & Olsen, Fredensborg, P 167-179.
- Glémarec, M. (1973) The benthic communities of the European North Atlantic continental shelf. Oceanogr. Mar. Biol. Ann. Rev. 11: 263-289.
- Holt, T.J., Rees, E.I., Hawkins, S.J. & Seed, R. (1998) Volume IX. Biogenic reefs: an overview of dynamic sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science (UK Marine SACs Project).
- Howson, C.M. & Picton, B.E. (Eds). (1997) The species directory of the flora and fauna of the British Isles and surrounding seas. Ulster Museum and The Marine Conservation Society, Belfast and Ross on Wye. Ulster Museum Publication No. 276.
- Jennings, S., Lancaster, J., Woolmer, A. & Cotter, J. 1999. Distribution, diversity and abundance of epibenthic fauna in the North Sea. J. Mar. Biol. Ass. U.K. 79: 385-399.
- Kenny, A. & Rees, H.L. 1994. The effects of marine gravel extraction on the macrobenthos: Early post-dredging recolonization. Mar. Pollut. Bull. 28(7): 442-447.
- Kenny, A. & Rees, H.L. 1996. The effects of marine gravel extraction on the macrobenthos: Results 2 years post-dredging. Mar. Pollut. Bull. 32(8/9): 615-622.

- Kenny, A.J., Rees, H.L., Greening, J. & Campbell, S. 1998. The effects of marine gravel extraction on the macrobenthos at an experimental dredge site off north Norfolk, UK (results 3 years post-dredging). International Council for the Exploration of the Sea. Theme session on recovery and protection of marine habitats and ecosystems from natural and anthropogenic impacts. ICES CM 1998/V:14.
- Künitzer, A., Basford, D., Craeymersch, J.A., Dewarumez, J-M., Dorjes, J., Duineveld, G.C.A., Eleftheriou, A., Heip, C., Herman, P., Kingston, P., Niermann, U., Rachor, E., Rumohr, H. & De Wilde, P.A. (1992) The benthic fauna of the North Sea, species distribution and assemblages. ICES J. Mar. Sci. 49(2): 127-144.
- Lewis, G., Wood, K. & Grainger, B. (2002) Lynn offshore wind farm: Environmental Statement. Report No. Lynn-6113-048-02-32 issue 11. amec.
- London Array Limited (2005) London Array Offshore Wind Farm Environmental Statement: Volume 1; offshore works. Prepared by RPS Limited.
- McCauley, R.D., Fretwell, J., Duncan, A.J., Jenner, C., Jenner, M. –N., Penrose, J.D., Prince, R.I.T., Adhitya, A., Murdoch, J. and McCabe, K (2000) Marine seismic surveys – A study if environmental implications. Australian Petroleum Production and Exploration Association Journal, 40: 692-708
- Moriyasu, M., Allain, R., Benhalima, K. and Claytor, R. (2004) Effects of seismic and marine noise on invertebrates: A literature Review. Canadian Science Advisory Secretariat. Research Document 2004/126
- Northern Ireland Habitat Action Plan. *Sabellaria spinulosa* reefs. (March 2005) http://www.ehsni.gov.uk/pubs/publications/Sabellariaspinulosareefs.pdf
- NPower Renewables Limited (2003) Baseline Monitoring Report. North Hoyle Offshore Wind Farm.
- NPower Renewables Limited (2005) North Hoyle Offshore Wind Farm. Annual FEPA Monitoring Report.
- Proctor, N.V, Mazik, K., Thomson, S. & Allen, J.H. (2006) Baseline study of the marine ecology at the Humber Gateway offshore wind farm development site. Institute of Estuarine & Coastal Studies, University of Hull Report No. ZBB649-F-2006. Report to Environmental Resources Management (ERM), 64pp.
- Rees, H.I., Moore, D.C., Pearson, T.H., Elliott, M., Service, M., Pomfret, J. and Johnson, D., (1990) Procedures for the Monitoring of Marine Benthic Communities at UK Sewage Sludge Disposal Sites. Scottish Fisheries Information Pamphlet No. 18. DAFS 79pp.
- Royal Haskoning. (2002) Cromer offshore wind farm. Environmental Statement.
- Schäfer, W. (1972) Ecology and palaeoecology of marine environments. Chicago. University of Chicago Press.
- Sotheran, I., Foster-Smith, B., Baxter, L. & Foster-Smith, D (2005) Acoustic, video and grab survey of Sheringham Shoal offshore wind farm. Envision Mapping Ltd. Report to Scira Offshore Energy Ltd. Report No. SCIRA-7-4-1-EX-RP-07115-V4. 74pp.
- Thanet Offshore Wind Limited (2005) Thanet Offshore Wind Farm Environmental Statement. Prepared by Royal Haskoning Limited.
- UK Biodiversity Group (1999) UK Biodiversity Action Plan (Tranche 2 Action Plans volume 5 – maritime species and habitats) http://www.ukbap.org.uk/.
- Vela, G., Rushforth, I., Hough, A., England,. R., Styles, P., Holt, T and Thorne, P. (2001) Assessment of the effects of noise and vibration from offshore wind farms on marine wildlife. Report to ETSU. DTI/Pub URN 01/1341.

- Voorberg, R. (2000) Effects of shrimp fisheries on reefs of *Sabellaria spinulosa* (polychaeta) *ICES Journal of Marine Science* 57 1416-1420
- Wilson, D.P (1970) The larvae of *Sabellaria spinulosa* and their settlement behaviour. J. Mar. Biol. Assoc. UK. 59(1): 33-52.

10 Natural Fisheries

10.1 Introduction

This section identifies the natural fish and shellfish resource within the general area of the proposed Sheringham Shoal offshore wind farm site, including the export cables route, in order to establish the baseline conditions. The potential impacts that may result from the construction, operational and decommissioning phases of the project are also identified and mitigation measures proposed where necessary. For a full description of the ecological and fisheries interest in the study area, this section should be read in conjunction with Section 9, Benthic Ecology, and Section 12, Commercial Fisheries.

10.2 Assessment Methodology

10.2.1 Data collection and literature review

The principal data and information sources which have been used to establish the baseline conditions relevant to the natural fish and shellfish resource include:

- Sheringham Shoal benthic and epibenthic faunal surveys (April 2005), and juvenile and adult fish surveys (April, July and September 2005).
- Department for Environment, Food and Rural Affairs (Defra) landings statistics by species by ICES rectangle (34F0, 35F0, 34F1 and 35F1) for years 2000 – 2004.
- Eastern Sea Fisheries Joint Committee (ESFJC) reports and consultation.
- Centre for Environment Fisheries and Aquaculture Science (CEFAS) reports and other research publications.
- International Council for the Exploration of the Sea (ICES) stock assessment reports.
- United Kingdom Offshore Operators Association (UKOOA) fish sensitivity charts (Coull *et al.*, 1998).
- The Cromer Offshore Wind Farm Environmental Statement (Norfolk Offshore Wind, 2002)
- Environmental monitoring reports for established offshore wind farms (Nysted and Horns Rev)
- Academic journals detailing spawning grounds, nursery habitats, feeding and migration for relevant species
- Stakeholder consultation.

10.2.2 Study Area

For the purposes of this assessment the survey area consisted of ICES rectangles 34F0, 35F0, 34F1 and 35F1 that contain, and lie adjacent to, the Sheringham Shoal site and the associated export cable routes (Figure 10.1). This was supplemented by additional information associated with a wider study area (i.e. the North Sea) to establish the natural fish and shellfish resources expected.

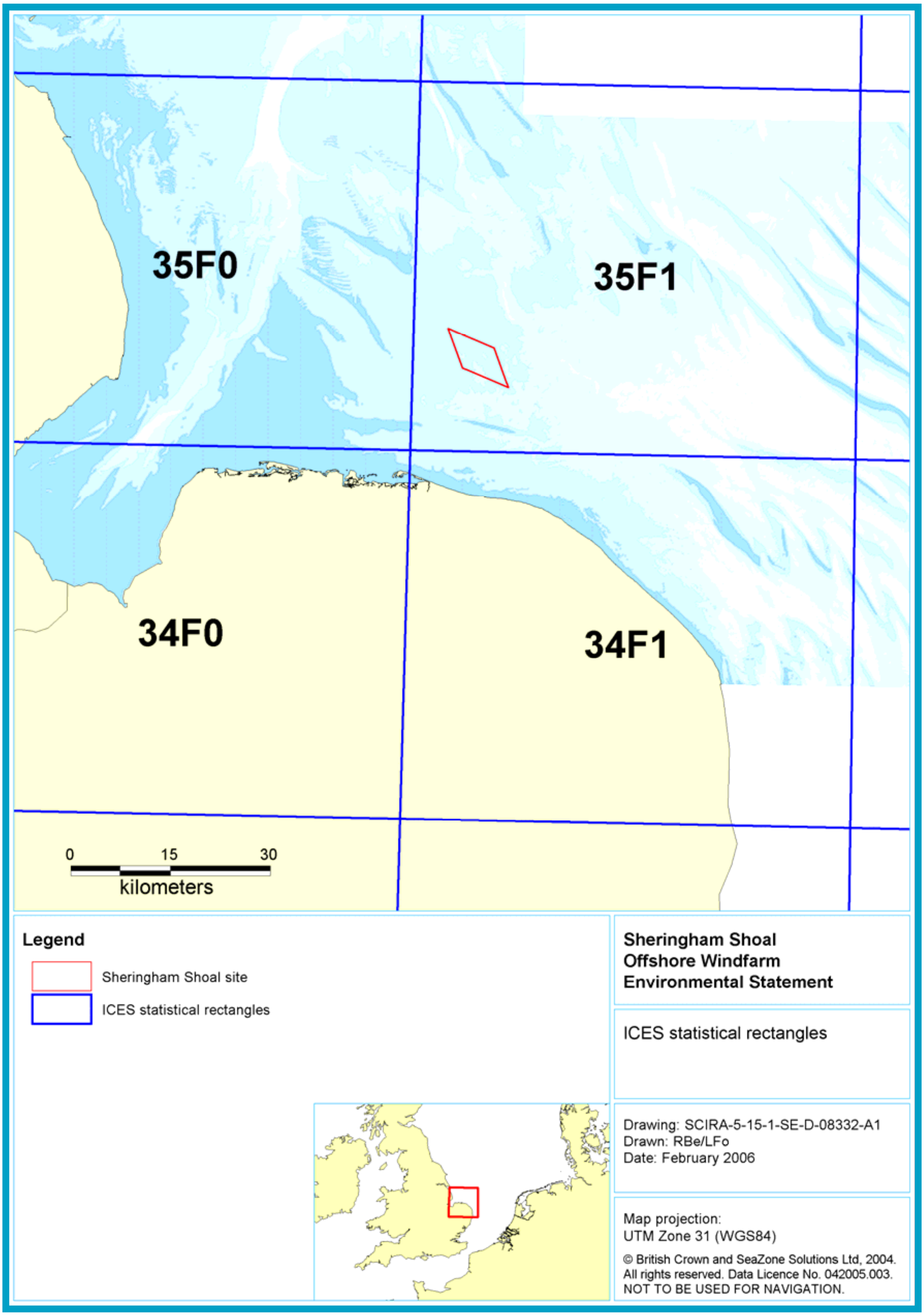

Figure 10.1: Location of wind farm relative to ICES statistical rectangles

10.2.3 Survey and Sampling Methodology

In accordance with the survey specifications agreed with CEFAS (CEFAS, 2004), a series of resource surveys were undertaken. Trawl and epibenthic surveys were undertaken by the Institute of Estuarine and Coastal Studies, University of Hull (IECS) in April, July and September 2005 to describe the seasonal variation of fish and shellfish resources in the area. These were supplemented by a geophysical survey undertaken by Envision Mapping Ltd. that incorporated acoustic ground discrimination, swath bathymetry and sidescan sonar, magnetometry, and underwater video and grab sampling of the proposed site and cable route. Further details of the geophysical survey can be found in Section 6: Hydrodynamics and Geomorphology, and Section 9: Benthic Ecology.

The surveys and the impact assessment were also undertaken in accordance with the latest industry guidelines i.e. CEFAS (2004a), Defra (2005), that recommend the identification and description of the following:

- Spawning grounds of species if significant importance e.g. autumn spawning herring;
- Nursery grounds;
- Feeding grounds;
- Migration routes and overwintering areas e.g. in relation to the crab fishery.

A brief description of the rationale and methods of each survey is provided below. The individual survey reports are included in the appendices. Interpretation of each survey is provided in Section 10.4.1. A detailed methodology for each survey is provided within each survey report (Appendices 9.1, 10.2,10.3 and 10.4).

It is considered that transitory fish communities are likely to be influenced by seasonal changes in the marine environment for example; light, temperature, elevated sediment concentration and local weather patterns. In order to account for this seasonal variation and to describe the temporal baseline for fish communities, the series of surveys from April to September was carried out. These were timed to assess the assemblage during key periods, specifically; the period of spring spawning; adult teleost and elasmobranch assemblages in summer, and the distribution of juvenile stages to identify nursery grounds during the autumn. On the advice of CEFAS, the potential of the site as a habitat suitable for autumn herring spawning was also assessed using acoustic survey techniques and ground truthing with video and grab samples (see Table 10.1).

The trawl stations used were designed to account for coverage across the proposed wind farm site, the export cable route and the predicted tidal excursion (Figure 10.2). Prior to the commencement of the survey, the extent and coverage of the trawl paths was agreed with CEFAS.

Dispensation to use trawl gears within the six mile limit was requested from the ESFJC and issued prior to the commencement of the surveys. The distribution of survey effort by type and purpose is summarised in Table 10.1.

Table 10.1 The distribution of survey effort to assess habitat type, and the fish and epifaunal assemblage

Survey Type	Purpose	March	April	June	July	Sept
AGDS*	Broad scale mapping of the hardness and roughness of the sea floor to identify biotopes and habitat types	×		×		
Swath bathymetry and sidescan sonar**	High resolution broad scale seabed profiling and bathymetry	×		×		
Magnetometer†	Detection and mapping of iron rich deposits and structures on the sea bed e.g. buried ship remains	×		×		
Sub-bottom profiler††	Identification of geological anomalies e.g. chalk, along the export cable route	×		×		
Ground truth (grab and video) sampling	Confirmation of identification of sediment, biotope and habitat types	×		×		
11m Demersal Otter Trawl	To collect information on the abundance, distribution, diversity and spawning condition of fish communities		×			
2m Beam Trawl	To collect quantitative and semi-qualitative information on the epifaunal assemblage, and to supplement information of the juvenile and benthic fish component		×			
7m Commercial Beam Trawl	To collect information on the benthic assemblage of fish species, and to inform the assessment of epifaunal abundance and diversity				×	×
7m Commercial Beam Trawl (pelagic deployment)	To collect information on the pelagic assemblage of fish species					×

*Acoustic Ground Discrimination System (RoxAnn™), **GeoAcoustics GeoSwath ™, †Marine Magnetics Explorer; ††Applied Acoustics AA200 Boomer

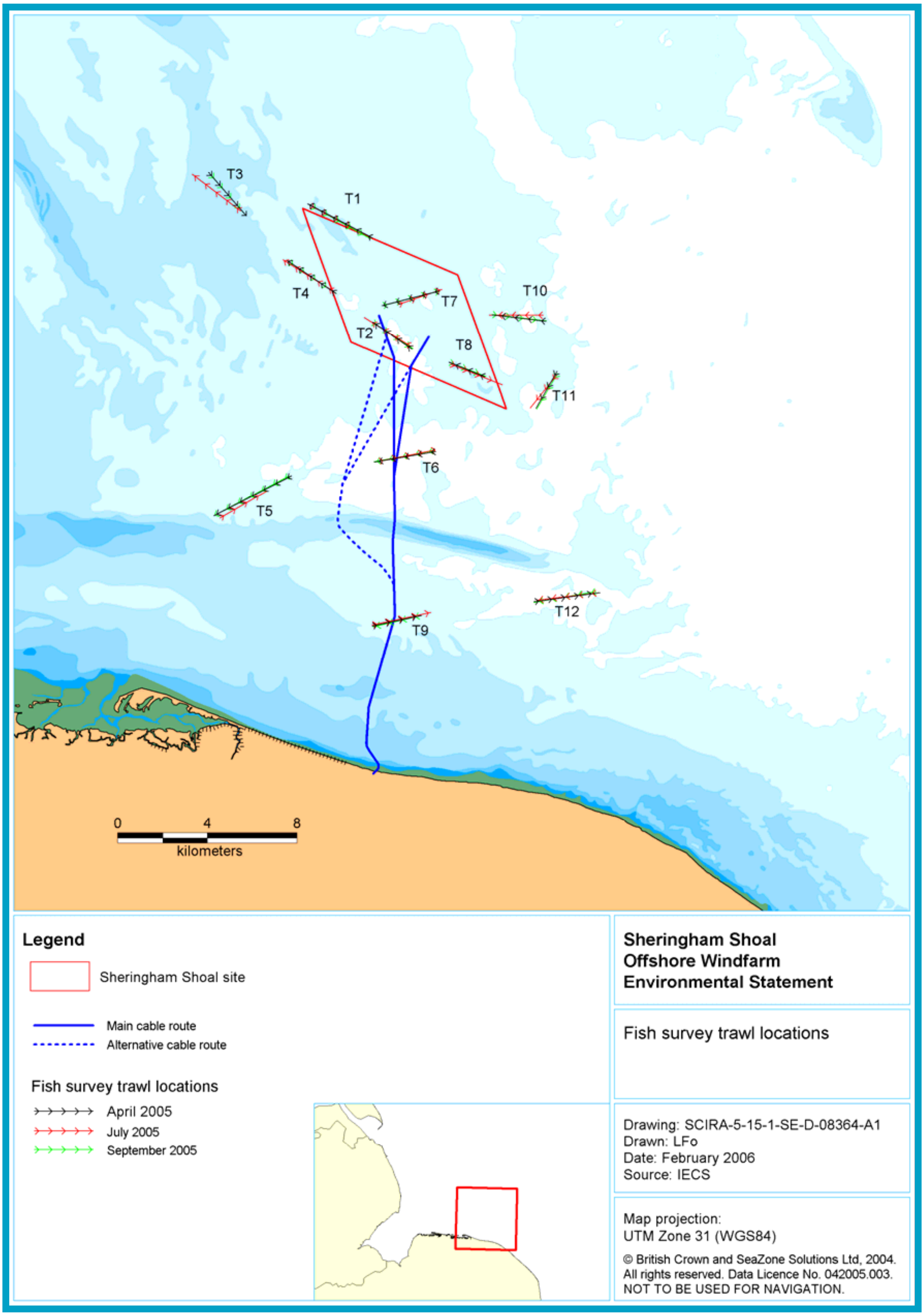

Figure 10.2 Fish survey trawls locations of the three demersal fish surveys.

Plate 10.1 The 7m steel beam trawl used in the July 2005 and the September 2005 fish survey.

A commercial beam trawler from Kings Lynn was chartered for the surveys following agreement with local fishermen's associations and CEFAS. A 7m steel beam trawl and 22mm mesh net with a 10mm liner in the cod end was deployed (Plate 10.1) and towed for 30 minutes at speeds between 3 to 4 knots at each of the 12 predetermined trawl locations. The same trawl coordinates (tows) and methods as used during the April, July and September surveys (see Figure 10.2) were used. A survey log was maintained at all times.

In addition to the trawls on the seabed, the stations were repeated by deploying the beam trawl for 15 minutes duration in midwater. Although this is not a recognised method of sampling pelagic fish species quantitatively, midwater deployment of the gear would determine presence or absence of adult herring in the area in order to inform the assessment of importance to autumn spawning herring.

All fish and shellfish were identified to species level and enumerated. Similarly, all individuals were measured for length and weight, and where possible, gender and sexual maturity were also recorded. With the exception of a few epifaunal invertebrates that required further identification and validation, all specimens were identified on board and returned to the sea.

The significance level (negligible to major adverse or beneficial) of identified impacts are shown in **bold** in Sections 10.4 - 10.7 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section 1: Regulatory and Legislative Context (including the EIA Process and consultation undertaken) for the definition of significance levels.

10.3 Description of the existing environment

10.3.1 Seabed habitat

A general description of the geological details of the site and cable route to shore is provided in Section 2, Project Details - General Geological Characteristics of the Site. The mobile surface sediment of the area is comprised mainly of gravely fine to medium sand, which overlies a bedrock of chalk. These mobile surface sediments vary in thickness from 0.5m near the shore to 10m in the vicinity of the turbine array. The upper surface of the chalk slopes down to the north, from surface exposure near the shore to about 20m below the bed to the north of the wind farm site.

Within the wind farm site there are sand waves up to 3.5m in amplitude over the southern portion, while to the north there are areas with only sand streaks and thin patches across the glacial till surface. Figure 2.7 indicates the general distribution presented by BGS.

The location of the banks and the general bathymetry is apparently relatively stable although analysis of historic data suggests that Sheringham Shoal has experienced some change to depth and extent (see Section 6: Hydrodynamics and Geomorphology).

The presence of mixed sand and gravel sediment types in these coastal waters provides suitable spawning and nursery grounds for a range of fish and shellfish species. Section 9: Benthic Ecology provides a detailed discussion of the seabed sediments of the study area in the context of its importance to the benthic and epibenthic faunal assemblage.

As with previous studies on substrates off the north Norfolk coast relating to offshore wind farm developments (e.g. Norfolk Offshore Wind Farm. Royal Haskoning, 2002) and marine aggregate extraction (www.bmapa.org.uk) the benthic community in the wider region is variable and difficult to define in terms of contrasting features or biotopes. There appears to be considerable variation in the number of species present and the abundance of individuals recorded at neighbouring sampling locations across the region.

Particle size analysis and sediment classification of sediments taken from the grab samples indicated that sand and gravel deposits are widespread throughout the survey area. However, the results of the drop down video pictures showed that shell, cobble and pebble components are also widespread. This mosaic of sediment types is supported by the array of sediment types encountered during the 2m epibenthic trawl survey (see Section 9: Benthic Ecology). Overall, the coarser sediment types present within the survey area are similar to those used by herring for spawning as suggested by CEFAS (2004b). Other demersal spawners found in the vicinity, including for example, sandeels that favour coarse, gravely and shelly sand, could also have exhibited a preference to spawn in the area in the past.

The widespread distribution of medium and coarse sediment types suggests that the area is hydrodynamically active and the biota are characteristically species poor in terms of the epifaunal and infaunal assemblage.

10.3.2 Existing Finfish and Shellfish Assemblages

10.3.2.1 Benthic, Epifaunal and Fish Resource Surveys

In order to establish the broad scale faunal assemblage present throughout the study area during key periods, the surveys of the fish fauna were conducted on a seasonal basis during April, July and September to assess the main spawning period, adult period including elasmobranch assemblages, and the juvenile period respectively. The assemblages present are described below. No species of conservation importance, as designated by the Bern convention, were present in the samples. Commercially important species were present.

10.3.2.2 Spring (April) Fish Survey

The numbers of key fish and shellfish fauna caught during the spring fish survey are presented in Table 10.2 with an example catch shown in Plate 10.2. These are expressed as catch per 30 minute unit effort (CPUE 30). The survey recorded 20 species of fish, of which two species were pelagic (herring, *Clupea harengus*, and sprat, *Sprattus sprattus*). The remaining 18 species were of demersal or benthic origin (e.g. whiting, *Merlangius merlangus;* cod, *Gadus morhua;* and dab, *Limanda limanda*).

Herring and whiting were dominant. Whiting was present at all the trawl stations representing 28% of the total fish abundance. Herring was present in greater numbers, representing 54% of the total abundance, with the remaining 18 species recorded accounting for than 18% of the total abundance.

The presence of herring in the samples obtained by the demersal trawl was not expected. Herring is a migratory pelagic species thought to occupy the waters of the north Norfolk coast in September and October and it should be noted that the demersal trawl used will not have sampled the pelagic species (sprat and herring) quantitatively.

Of the 20 species of fish recorded, six were recorded on a single occasion, with the middle and outer trawl sites (Figure 10.2) exhibiting the greatest density and diversity. The inner trawl stations contained the lowest abundances, whilst the offshore trawl stations exhibited variable density and a high diversity of fish species. Cluster analysis on fish abundance reveals a clearer spatial distribution. Three groups describing the near shore, mid-distance and offshore stations emerged. This result could be attributed to the herring distribution that was centred furthest from shore, and the whiting distribution that was centred around the mid-distance stations.

Being part of an autumn spawning population, the presence of immature (Stage II: maturing virgin (Kesteven, 1960) North Sea herring in the samples in April supports the view that the area is important to herring as a nursery and feeding area (see also the results from the autumn survey below where no herring were recorded). The relevance of the movements of young herring around the North Sea throughout the year (ICES, 2004a) suggests that the area may have some importance in terms of annual migration, feeding and growth.

Given the data available on the densities of whiting recorded within the middle range of the trawl stations, the distribution can not be attributed to any specific prey requirement or general habitat preference. Overall, the fish assemblage is considered as typical for the area during April and is similar in diversity to previous surveys carried out within the general area by IECS (Scott, 1995) at this time of year.

Plate 10.2 An example of a trawl result during the April 2005 fish survey.

The whiting, plaice, dab, cod, sprat and herring were all analysed for length frequency; however, due to the low number of individuals within all of the species groups (except herring and whiting), no clear definition of multiple cohorts could be identified.

Cohort analysis indicated that herring in their first, second, and third years (0-group, 1-group, and 2-group) were present (see Figure 6, April survey report, Appendix 10.2), and two year classes, the 0-gp and the 1-gp, dominated the whiting assemblage. It should be noted that several older year classes were represented in the whiting data (see Figure 5, April Survey Report, Appendix 10.2). The distribution and diversity observed is considered as typical for the time of year when one or two species may be significantly dominant within a relatively low assemblage in terms of diversity.

Of the shellfish represented, the presence of pink shrimp, *Pandalus montagui*, in the catches was generally low with 108 individuals being recorded. The species was most abundant at station 2 and station 5 where 35 individuals were recorded respectively. Lobsters, *Homarus gammarus*, were also present in the catches with a maximum of five individuals being caught at station 4. Seventeen individuals were recorded and measured for carapace length. All individuals were above the 87mm minimum landing size set by ESFJC.

Only one edible crab, *Cancer pagurus*, was caught during the survey, but the velvet crab, *Necora puber*, was much more abundant. Overall, 494 velvet crabs were caught with greatest abundance of 249 and 147 individuals being caught at stations 3 and 4 respectively.

Table 10.2 Catch (numbers) per unit effort (30minutes) for key species during the April 2005 trawl survey

Apr 05	Trawl 1	Trawl 2	Trawl 3	Trawl 4	Trawl 5	Trawl 6	Trawl 7	Trawl 8	Trawl 9	Trawl 10	Trawl 11	Trawl 12
Pink shrimp	0	35	1	0	35	2	0	2	5	0	10	13
Lobster	1	2	4	5	1	2	0	0	1	0	0	1
Edible crab	0	0	0	0	0	0	0	0	1	0	0	0
Velvet crab	3	23	249	147	36	10	5	7	7	2	5	0
Lesser spotted dogfish	0	0	0	0	0	1	0	0	0	0	0	1
Thornback ray	0	0	0	0	0	0	1	0	5	0	2	3
Spotted ray	0	0	0	0	0	0	0	0	0	0	0	1
Herring	114	3	80	225	3	39	92	1	1	5	2	0
Sprat	21	6	7	3	0	12	12	3	6	1	14	22
Cod	0	0	0	0	0	0	0	0	4	0	1	0
Whiting	1	27	3	35	56	117	19	2	9	22	1	1
Lesser weever	0	0	0	0	0	0	0	35	0	0	2	0
Dragonet	0	1	0	1	4	0	0	0	0	0	2	0

The assessment of fish spawning status indicated that the older whiting were approaching spawning condition. Of the other fish sampled, only pogge (*Agonus cataphractus*), a small demersal fish of no commercial importance, was observed to be in spawning condition. Fish observed to be in spawning condition were returned immediately to the sea. It is important to note that none of the herring sampled in April showed advanced gonad development or any sign of spawning activity.

10.3.2.3 April 2m Beam Trawl Epifaunal Survey

Epifaunal species are one of the major components of the faunal assemblage throughout the area. In total, 66 sessile species and 80 mobile species were recorded from the trawls, including 11 species of fish. The following description provides information of the fish and shellfish species recorded during the survey. Section 9: Benthic Ecology provides a more detailed account of the analysis undertaken to describe the epifaunal community.

Given that the proposed development site is considered to be within the potential area of fish spawning grounds, the epifaunal survey was also designed to provide an indication of demersal spring spawning activity in the wind farm site, the cable route and adjacent areas.

Overall, crustacean species were the dominant component of the epifaunal assemblage representing 40% of the total number of species recorded. Molluscs (36%) were also abundant. The velvet crab, an emerging fishery resource, was present in the catches together with the pink shrimp that has provided an occasional fishery resource in the Greater Wash region for many years.

Of the 11 fish species caught from the area as a whole, the most common was the pogge. Others included bull rout, *Myoxocephalus scorpius*, pouting, dragonet, and lemon sole. These species are typical of areas with stony/gravely or mixed sediments. Other species encountered such as dab, lesser weever, *Echiichthys vipera,* spotted ray, *Raja montagui,* and Dover sole, *Solea solea*, are more typical of the softer sediments characterised by sandy and silt. This diversity underlines the variability of surface sediments within the study area (see Section 9: Benthic Ecology).

10.3.2.4 Adult / Elasmobranch (July) Fish Survey

The numbers of key fish and shellfish fauna caught during the July 7m beam trawl survey are presented in Table 10.3. The use of a beam trawl focussed survey effort on demersal species; however, sprat and greater sandeels, *Hyperoplus lanceolatus*, were present in the catches. In addition to these species, the survey recorded 21 species of fish of true demersal or benthic origin. None of the species caught were present in all catches, although dab and dragonet, *Callionymus lyra*, were the most widespread being absent at only one station each. Although dab and dragonet were frequently encountered across the survey area, the lesser weever, was the most abundant representing 71% of catches, although its distribution was not as wide.

Sprat were recorded in the catches suggesting that the beam trawl could determine the presence or absence of similar pelagic species. Herring were not found in any of the beam trawl samples suggesting that the fish encountered earlier in the year may have moved away from the region as part of their annual migration pattern; however, the caveat of the beam trawl selecting against pelagic species should be taken into account.

In terms of species diversity, a maximum of six species were recorded on a single occasion, with the middle and outer trawl sites exhibiting the greatest density and diversity. Cluster analysis, based on presence and absence indicated that there is no spatial relationship between trawl stations, although there is some similarity of catch composition between individual trawls. Overall, there was no defined spatial relationship in species diversity between trawls across the proposed site and the export cables route. There appeared to be no significant relationship between catch composition and water depth or distance from shore.

Highest abundances were recorded offshore, but low abundance of fish was recorded across the survey area. The cluster analysis of fish abundance followed a similar pattern to that observed for the presence and absence dataset, in that there is no clearly defined pattern of abundance related to geographical location and or depth.

Whilst there was no evidence to indicate that the distribution of fish within the survey area is linked to geographical location or indeed depth, sediment type could be important. The results of the March and June acoustic, video and grab survey indicate that the nature of surface sediments across the survey area is locally variable. It is likely therefore that individual trawls covered a range of sand, gravel and cobble sediments during their deployment.

The lesser weever is synonymous with clean sand, which is distributed among other sediment types across the survey area and there is no doubt that the high abundance of the lesser weever in some trawls was key to the analysis in terms of identifying the discreet heterogeneity of sediment types (see also results of the acoustic video and grab survey, Section 9: Benthic Ecology).

For the range of other common species encountered there were no specific distribution patterns of note, although dab and plaice, *Pleuronectes platessa*, were absent at the most inshore trawl station. Whiting was recorded rarely offshore. All of the elasmobranch species sampled; eight lesser spotted dogfish, *Scyliorhinus canicula*, two spotted ray, and two thornback ray, *Raja clavata*, were recorded in the west of the survey area.

Overall, the representation of elasmobranch species in the samples was poor, but the fish assemblage was considered as typical of the area during the summer months and is similar in diversity to previous surveys carried out within the general area by IECS at this time of year (Scott, 1995).

The whiting, plaice, and dab caught were all analysed for length frequency, and whilst other species were analysed, no clear definition of age structure could be identified due to the low number of individuals landed. The data indicate that for the whiting, the assemblage is dominated by the 2005 year class (0-gp). The length frequency data for dab, which was one of the more commonly recorded fish species encountered during the July fish survey, indicated that three year classes (1-gp, 2-gp and 3-gp) are present within the survey area. Abundance at age data indicated that the distribution of dab in the area is dominated by immature fish with a low number of maturing adults.

The age structure of plaice found in the samples also suggests that the assemblage is dominated by immature forms. In general, the year class analysis suggests that for the finfish species encountered during the July fish survey, the assemblage was dominated by immature forms indicating the importance of coastal waters along the north Norfolk coast as a nursery area.

The assessment of fish spawning status in July indicated that no species of commercial interest were in spawning condition, although it must be noted that many of fish sampled were immature. Of the mature fish sampled, none were in spent condition or were in the later stages of spawning suggesting that spawning of those species had taken place earlier in the spring.

A total of 34 lobsters were caught as a bycatch during the survey. These were also analysed for size/ age class determination. The data indicated that a number of size classes above the current minimum landing size (87mm) are present within the survey area and that the sex ratio is 1:1. Only five edible crabs were caught, but velvet crab was, again, more numerous: 386 individuals were caught reflecting the proportional abundance of these species recorded during the earlier survey in April. Highest numbers were recorded from station 1 to station 7 overlapping the site boundary to the west and south (Figure 10.2).

There was a marked increase in the abundance of pink shrimp in the catches over the numbers recorded from the April survey. In all 11,466 pink shrimp were caught with the majority being recorded from stations 3, 4, 5 and 6. This centre of distribution is based west and south of the proposed turbine array (Figure 10.2).

10.3.2.5 Juvenile Demersal and Adult Pelagic (September) Fish Survey

The numbers of key fish and shellfish fauna caught during the September 7m beam trawl survey are presented in Table 10.4. The survey recorded 32 species of fish from the 12 demersal beam trawls, of which two species, sprat and mackerel, *Scomber scombrus*, can be described as truly pelagic. The remaining 30 species were of demersal or benthic origin. In addition, the 12 pelagic (mid-water) trawls recorded four species of fish, three of which were recorded in the demersal beam trawls; sprat, mackerel, greater sandeel, with an additional species; scad, *Trachurus trachurus* also present. The scad, also known as horse mackerel, were all juveniles and the mackerel appeared thin and in poor condition.

Two cephalopod species: a small cuttlefish, *Sepia atlantica,* and the long finned squid, *Loligo forbesii*, were also noted in the pelagic trawls with squid present in most catches recording a maximum of 29 and 16 specimens in trawls 5 and 6 respectively. These were located between the proposed turbine array and the shore (see Figure 10.2).

From the demersal catches, two species; dab and dragonet were present in all hauls. Whiting was common being represented at all but one of the stations, but dragonet was the dominant component of the assemblage, with lesser weever less so. However, while the lesser weaver was recorded at fewer trawl stations, it was very abundant when caught underlining the preference of this species for clean sand and the patchiness sediment types.

Overall, with the exception of trawl 3 in the north west of the survey area (Figure 10.2) where 891 individuals from 11 species were counted, abundance of fish was considered to be moderate to low. The catch from trawl 3 was dominated by the lesser weever (47%), dragonet (25%), and sea scorpion *Taurulus bubalis* (16%).

Only two plaice, *Pleuronectes platessa*, were recorded outside of the offshore area. Dover sole was most abundant inshore. Of the elasmobranch species, three lesser spotted dogfish, three spotted ray, one starry smoothhound, *Mustelus asterias*, and three common smoothhound, *Mustelus mustelus*, were caught. In terms of distribution, the lesser spotted dogfish was recorded only inshore, whilst the two smoothhound species were recorded only within the middle distance trawl (station 5). The spotted ray was only recorded at the offshore stations 7 and 8 within the proposed turbine array (Figure 10.2).

The demersal and benthic fish assemblage is considered as typical for the area during the early autumn and is similar in diversity to previous surveys carried out within the general area by IECS at this time of year (Scott *et al.*, 1995).

From the demersal samples, whiting, plaice, dab, Dover sole, lemon sole, *Microstomus kitt*, and cod, *Gadus morhua*, were caught in sufficient numbers to allow length frequency analysis to be undertaken. Although other species were present the catches, numbers were insufficient to allow clear definition of age class structure. Data for all species analysed indicated that the fish assemblage of species considered to be of commercial or recreational interest, was dominated by juvenile and immature fish. Very few mature fish were present.

Table 10.3 Catch (numbers) per unit effort (30minutes) for key species during the July 2005 trawl survey

Jul 05	Trawl 1	Trawl 2	Trawl 3	Trawl 4	Trawl 5	Trawl 6	Trawl 7	Trawl 8	Trawl 9	Trawl 10	Trawl 11	Trawl 12
Pink shrimp	116	806	2555	2000	4050	1800	49	0	39	51	0	0
Lobster	1	7	17	1	0	4	1	0	2	0	0	1
Edible crab	1	1	2	0	0	0	1	0	0	0	0	0
Velvet crab	74	47	87	125	16	2	31	0	3	1	0	0
Lesser spotted dogfish	0	0	0	0	0	0	1	1	0	2	3	1
Thornback ray	0	0	0	0	0	0	0	0	0	1	0	1
Spotted ray	0	0	0	0	0	0	0	1	0	0	0	1
Herring	0	0	0	0	0	0	0	0	0	0	0	0
Sprat	0	0	0	0	0	1	1	0	0	0	0	0
Cod	1	0	4	0	0	0	0	0	0	0	0	1
Whiting	0	0	0	3	12	2	0	2	2	0	0	6
Lesser weever	0	42	0	2	77	1	237	486	0	9	133	0
Dragonet	15	12	3	13	13	14	3	1	9	0	3	11

Table 10.4 Catch (numbers) per unit effort (30minutes) for key species during the September 2005 trawl survey

Sep 05	Trawl 1	Trawl 2	Trawl 3	Trawl 4	Trawl 5	Trawl 6	Trawl 7	Trawl 8	Trawl 9	Trawl 10	Trawl 11	Trawl 12
Pink shrimp	2350	20250	38500	15800	325000	22050	1825	1993	655	1900	800	6050
Lobster	3	5	10	5	2	10	0	0	1	1	0	0
Edible crab	0	0	0	0	1	1	0	2	0	0	0	1
Velvet crab	69	76	270	215	135	15	54	26	5	6	6	1
Lesser spotted dogfish	0	0	0	0	0	0	0	0	3	0	0	0
Thornback ray	0	0	0	0	0	0	0	0	0	0	0	0
Spotted ray	0	0	0	0	0	0	2	1	0	0	0	0
Herring	0	0	0	0	0	0	0	0	0	0	0	0
Sprat	0	0	0	0	1	2	0	0	0	0	0	0
Cod	0	2	10	3	5	0	0	0	1	0	2	0
Whiting	0	2	11	1	8	6	7	7	4	1	5	1
Lesser weever	0	44	418	1	7	0	27	18	3	0	0	0
Dragonet	51	124	221	81	60	26	50	15	44	19	81	140

The benthic assemblage comprising, dragonets, pogge, gunnel fish, *Pholis gunnellus*, lesser weever and sea scorpion etc, were present across a range of age groups. Given the reduction of fishing effort in recent years and the decline in principal commercial fish populations (predator decline), the ecological function of area may have shifted to favour use by juvenile or adolescent forms of a range of species.

Lobsters caught as a bycatch in September were also analysed for size/ age class determination. The data indicated that from the 37 individuals caught, a number of size classes above the current minimum landing size (87mm) are present within the survey area. The ratio of males to females in the sample was 4:3. Five edible crabs were present in the September samples together with 878 velvet crabs. The abundance of pink shrimp that had been seen to increase significantly from April to July increased further in September. In all, 437,173 individuals were recorded representing a 100 and 4,000 fold increase on the numbers recorded in April for July and September respectively.

The distribution of velvet crab and pink shrimp seen in July was maintained in September suggesting a habitat preference west and south of the proposed site boundary for these species. In the case of pink shrimp, there is clear evidence of a seasonal element to their distribution; however, the local stocks off the north Norfolk and Lincolnshire coasts are known to be very mobile and they may not appear on recognised grounds in commercially viable quantities from year to year (Knapman, 2003; Mander, 2004).

The assessment of fish spawning status in September indicated that no species of commercial interest were in spawning condition, although again, it must be noted that the majority of fish sampled were immature. Of the mature fish sampled, none were in spent condition or were in the later stages of spawning suggesting that spawning of those species had taken place earlier in the year.

Herring can be expected off the north Norfolk coast for a limited period in late September and October (S. Milligan, CEFAS, pers.comm, 2006). The timing of the September survey in the third week of the month was set specifically on the advice of CEFAS (CEFAS, 2004b) to maximise the chance of sampling autumn spawning herring in the vicinity of the Sheringham Shoal wind farm site. No herring were present in the September catches.

10.3.2.6 Fish and shellfish species diversity from Defra Landings Statistics

The southern North Sea constitutes part of an ecosystem that is subject to variability induced by natural and anthropogenic environmental drivers. The fish stocks that it supports are also affected by these drivers and the fishing industry of the region is dynamic in response to patterns and trends that are changeable over time: fish stocks can be influenced by variation driven by both natural and commercial factors. It is important to recognise that the Defra landings statistics from the last five years are unlikely to be wholly representative of the fish and shellfish resources at the commencement of construction activities.

For the purposes of establishing a natural fisheries assemblage baseline, the Defra data in combination with the site specific fish surveys provide a useful reference. It is nonetheless recognised that the Defra landings statistics will not necessarily be wholly representative of the fish and shellfish resources within and around the Sheringham Shoal site. For example, vessels under 10m in length have not been obliged to compile EC daily log sheets and recorded landings of species targeted primarily by the under 10m fleet have the potential to be under-reported (see Section 12, Commercial Fisheries).

The Sheringham Shoal wind farm site and the majority of the export cables routes are located in ICES rectangle 35F1. A shorter inshore section of the export cable route is located in ICES rectangle 34F1 to the south as shown in Figure 10.1. ICES statistical rectangles 34F0 (Inner Wash) and 35F0 (Lincolnshire coast, Docking Shoal and Race Bank) are situated West of the site and its export cable route. Each rectangle is characteristic in terms of the fisheries and natural fisheries resources it supports; e.g. 34F0 is noted for its cockle, *Cerastoderma edule*, mussel, *Mytilus edulis*, and brown shrimp, *Crangon crangon*, fisheries, 35F0 for its crab and brown shrimp fisheries. To the east, rectangles 34F1 and 35F1 are noted primarily for their crab, lobster and whelk, *Buccinum undatum*, fisheries although a fishery for velvet crab is starting to emerge (See Section 12: Commercial Fisheries).

A review of the Defra landings data by species from the four relevant ICES rectangles shows that during the period 2000 - 2004 landings from commercial vessels recorded a total of 48 finfish species, 15 shellfish species and 3 cephalopod species (Table 10.5) which are considered representative of the key fish and shellfish resource of the region and allow, in combination with the site specific survey data and other available literature, the characterisation of the key species likely to be present in and around the wind farm area.

Table 10.5 Species landed by commercial methods 2000 – 2004 (Source: Defra)

Finfish Species	34F0	35F0	34F1	35F1
Bass (*Dicentrarchus labrax*)	✓	✓	✓	✓
Black Seabream (*Spondyliosoma cantharus*)			✓	
Brill (*Scopthalmus maximus*)	✓	✓	✓	✓
Catfish (*Anarhichas spp.*)	✓	✓	✓	✓
Cod (*Gadus morhua*)	✓	✓	✓	✓
Conger Eels (*Conger conger*)		✓	✓	
Dabs (*Limanda limanda*)	✓	✓	✓	✓
Eels (*Anguilla anguilla*)			✓	
Flounder or Flukes (*Platichthys spp.*)		✓	✓	✓
Greater Spotted Dogfish (*Scyliorhinus stellaris*)		✓		
Grey Mullet (*Liza ramado*)		✓	✓	✓
Gurnard and Latchet (*Trigla spp.*)	✓	✓	✓	✓
Haddock (*Melanogrammus aeglefinus*)	✓	✓	✓	✓
Hake (*Merluccius merluccuis*)		✓	✓	✓
Halibut (*Hippoglossus hippoglossus*)		✓	✓	✓
Herring (*Clupea harengus*)			✓	
Horse Mackerel (*Tracharus tracharus*)			✓	
John Dory (*Zeus faber*)	✓	✓	✓	✓
Lemon Sole (*Microstomus kitt*)	✓	✓	✓	✓
Lesser Spotted Dogfish (*Scryliorhinus canicula*)			✓	
Ling (*Molva molva*)	✓	✓	✓	✓
Mackerel (*Scromber scrombrus*)	✓		✓	
Megrim (*Lepidorhombus whiffiagonis*)			✓	
Mixed Demersal	✓	✓	✓	✓
Monks or Anglers (*Lophius piscatorius*)	✓	✓	✓	✓
Norway Pout (*Trisopterus esmarki*)		✓		
Plaice (*Pleuronectes platessa*)	✓	✓	✓	✓
Pollack (*Pollachius pollachius*)	✓	✓	✓	✓
Pout Whiting (*Trisopterus luscus*)	✓	✓	✓	✓
Red Mullet (*Mullus surmeletus*)	✓	✓	✓	✓
Redfishes (*Sebastes marinus*)		✓		
Saithe (*Pollachius virens*)		✓	✓	

Table 10.5 Species landed by commercial methods 2000 – 2004 (Source: Defra)

Finfish Species	**34F0**	**35F0**	**34F1**	**35F1**
Sandeels (*Ammodytes spp., Hyperoplus spp*)	✓	✓		
Sand Sole (*Pegusa lascaris*)		✓		
Sea Trout (*Salmo trutta*)			✓	
Shad (*Alosa alosa*)		✓		✓
Sharks		✓		
Silver Smelt (*Osmerus eperlanus*)	✓			
Skates and Rays (*Raja spp.*)	✓	✓	✓	✓
Smoothounds (*Mustelus spp.*)	✓		✓	✓
Sole (*Solea solea*)	✓	✓	✓	✓
Sprats (*Sprattus sprattus*)	✓	✓	✓	
Spurdog (*Squalus acanthias*)	✓	✓	✓	✓
Tope (*Galeorhinus galeus*)	✓	✓	✓	✓
Triggerfish (*Balistes carolinensis*)			✓	
Turbot (*Scopthalmus maximus*)	✓	✓	✓	✓
Unidentified Dogfish			✓	
Whiting (*Merlangius merlangus*)	✓	✓	✓	✓
Witch (*Glyptocephalus cynoglossus*)	✓	✓	✓	✓
Shellfish Species	**34F0**	**35F0**	**34F1**	**35F1**
Brown Shrimps (Crangon crangon)	✓	✓	✓	✓
Cockles (Cerastoderma edule)	✓	✓	✓	✓
Crabs (Cancer pagarus)	✓	✓	✓	✓
Lobsters (Homarus gammarus)	✓	✓	✓	✓
Mixed Crabs				✓
Mussels (Mytilus edulis)	✓	✓	✓	✓
Nephrops (Nephrops norvegicus)	✓	✓		✓
Pacific oysters (Crassostrea gigas)	✓	✓		
Pink shrimps (Pandalus montagui)	✓	✓		
Portugese oysters (*Crassostrea gigas*)	✓			
Queen scallops (Aeuipecten opercularis)		✓		
Scallops (Pecten maximus)		✓		✓
Spider crabs (*Majidae spp.*)	✓			✓
Velvet crabs (*Necora puber*)	✓	✓	✓	✓
Whelks (Buccinum undatum)	✓	✓	✓	✓

Table 10.5 Species landed by commercial methods 2000 – 2004 (Source: Defra)

Cephalopods	34F0	35F0	34F1	35F1
Cuttlefish (Sepia officinalis)		✓	✓	
Octopus (Octopus vulgaris)		✓		✓
Squid (Loligo forbesii)	✓	✓	✓	✓

10.3.3 Biological Status of Commercially Exploited and Sensitive Species.

10.3.3.1 Introduction

The following sections summarise the biological status of the most important or abundant species of commercial significance within the study area and areas adjacent as identified by Defra landings data (see Section 12: Commercial Fisheries and Table 10.5) and the survey data summarised in Section 10.2.

Although the fishing industry of the Norfolk coast has prosecuted herring fisheries in the past, herring have not been the primary target of a significant commercial fishery in the area of the proposed wind farm for many years. However, the proposed site is thought to lie adjacent to a herring spawning ground (CEFAS, 2004b; S. Rogers, CEFAS, pers.comm., 2006), although literature suggests that the site is situated within a herring spawning ground (as shown in Figure 10.3) (Coull *et al.*,1998). The spawning area identified by Coull *et al.*, (1998) is based on surveys carried out in the 1980s and therefore may not necessarily be representative of the current situation as indicated by the surveys and studies undertaken as part of this EIA (see also Section 9: Benthic Ecology and Section 12: Commercial Fisheries).

From the raw data it is shown that the centre of the distribution of herring spawning from the 1980's surveys was in fact to the north east of the Sheringham Shoal site. Some inconsistencies in the interpretation of the data used to produce the area shown in Figure 10.3 could mean inaccuracies in the definition of the herring spawning boundary (S. Rogers, CEFAS, pers.comm 2006).

The north Norfolk coast is also thought to be important in terms of nursery grounds for several species such as cod, plaice, dab and lemon sole (Coull *et al.*, 1998, Rogers *et al.*, 1998). Skates, rays and dogfish are represented by the information available on thornback ray and spurdog that are known to be in the area. Sprat is included because of its ecological significance as a prey resource. The summaries below are based primarily on published ICES advice (ICES, 2004a, 2004b, 2005a, 2005b), Rogers *et al.*, 1998, and Ellis *et al.*, (2005).

Although they are listed in the Defra landings data, brown shrimp and cockles have been omitted from the list below as it is clear that they do not comprise a significant commercial or ecological component to the natural fish and shellfish resources of the area within and around the proposed site and the export cable route to shore. Fisheries for these species take place some distance from the proposed site; i.e. principally in The Wash and on the Docking Shoal further west. Discussions with the ESFJC and the analysis presented in Section **12**: Commercial Fisheries support this view.

10.3.3.2 *Herring (Clupea harengus)*

Resource Status

Herring are considered to be abundant throughout Northeast Atlantic shelf waters although stocks in the North Sea have fluctuated significantly since the collapse of the stock in the 1970s and its subsequent recovery. During the 1970s herring was over-fished in EU waters to the extent that fishery closures were implemented to ensure the survival of the stocks (ICES, 2004a). Subsequent management measures are credited with the recovery of North Sea herring stocks and the Spawning Stock Biomass (SSB) for 2003 was estimated at 2.2 million tonnes, above the Biological Precautionary Limit (B_{pa}) of 1.3 million tonnes (ICES, 2004a). Fishing mortality decreased throughout the 1990s, to a 2002 level of 0.24. The agreed Total Allowable Catch (TAC) saw an increase from 265,000 to 400,000 tonnes, a further reflection of the improving condition of the herring stock (ICES, 2004a). By weight, herring are the second most important species landed by the European pelagic fleet, but locally, a significant herring drift net fishery has not been prosecuted off the north Norfolk coast for many years. Official catch and effort data are not available as any boats that prosecute herring in the autumn are <10m in length and have not been required to report their catches (CEFAS, pers. comm., 2006)

Herring stocks in European Seas are characterised as being either spring or autumn spawners. The North Sea autumn spawning herring stock is distinct from inshore stocks such as The Wash and the Blackwater Estuary herring which spawn in the spring (Nichols, 1999). A small drift net fishery for herring takes place in The Wash in April and May (ESFJC, pers. comm. 2006), but this is some distance from the proposed development.

Spawning

In general, the North Sea stock spawns in the autumn, while the stock components in the Channel, Baltic Sea, Skagerrak and Kattegat spawn in the spring. Herring return to the same grounds each year to spawn and Figure 10.3 shows the general area of spawning grounds in the area of the development.

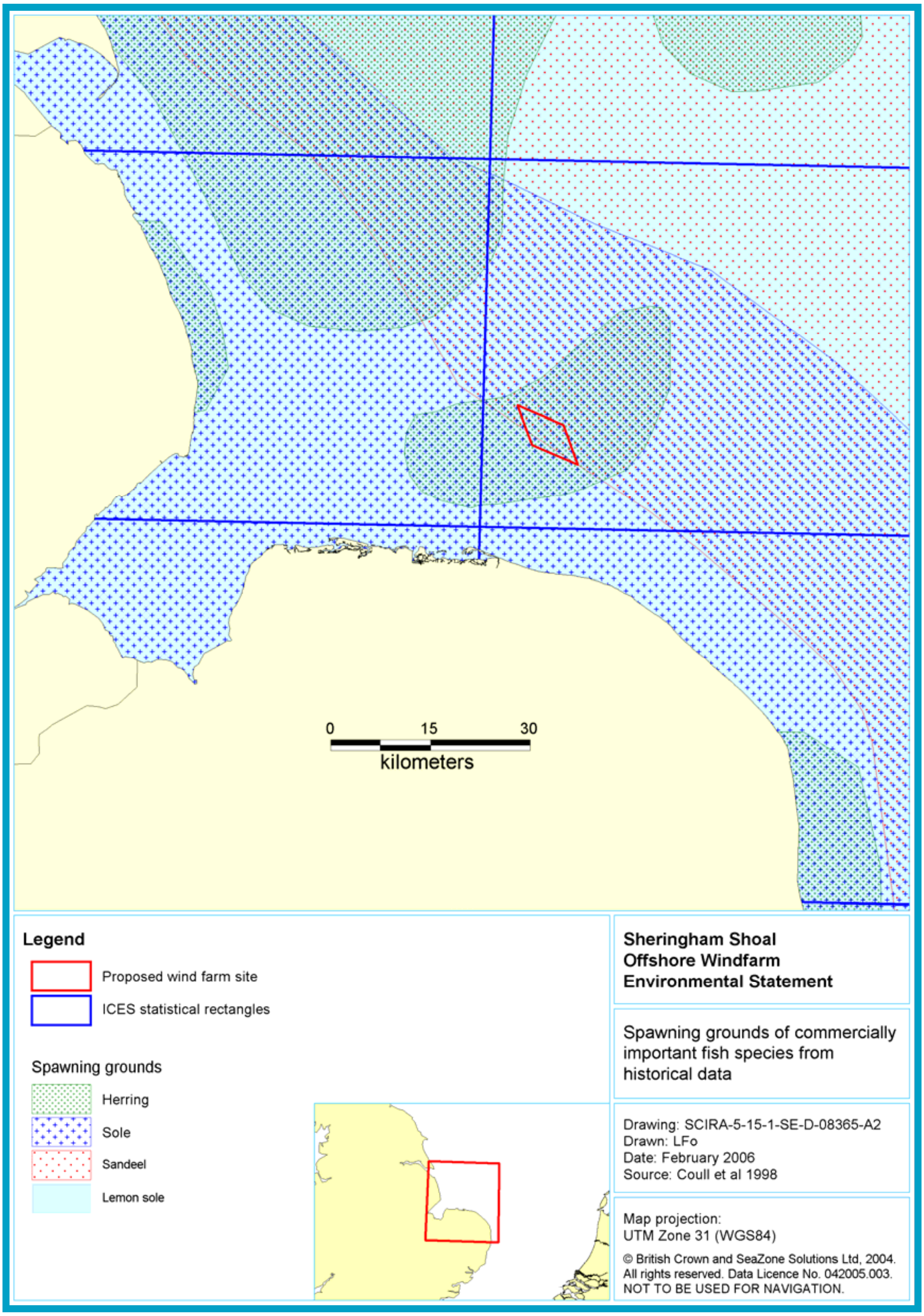

Figure 10.3 Spawning grounds of commercially important fish species (Source: Coull et al 1998)

Eggs are shed on the seabed and form a mat over coarse sand, gravel or shell beds often several layers thick. Species that utilise gravel, coarse and shelly sand habitats for spawning tend not to do so over the large areas suggested by Coull *et al*., (1998) as illustrated by Figure 10.3. Herring spawning is often highly time- and site-specific with the fish often arriving at the same time every year to spawn on the same patch of sea bed that may be extremely small (<1km^2) in area (Parrish *et al.*, 1959; Heath, 1992).

Depending on water temperature, the incubation of herring eggs will take one to three weeks and, on hatching, the planktonic larvae are transported by the prevailing currents north and east from the north Norfolk coast (Bartsch *et al.*, 1989), where they often form large drifts in surface waters.

In general, larval dispersal tends to be away from spawning areas (North and East) following hatching as shown by data collected during the larval and young fish surveys undertaken by European research institutes such as CEFAS (Rogers *et al.*, 1998).

Larval surveys for herring started in the southern North Sea in 1946 and have continued ever since. These were extended to the northern North Sea in 1951 and the surveys of several European countries have been coordinated under the auspices of ICES since 1967. A comprehensive data set of the distribution of larval herring is therefore available to research through ICES.

In studying the advection of herring larvae from spawning grounds Heath and Richardson (1989) illustrated the distribution of spring and autumn herring spawning around the UK. Spawning was recorded off the Yorkshire coast from August to October, and in the Channel from November to January. Bartsch *et al*., (1989), in developing a dispersal model for herring larvae in the North Sea predicted a north easterly drift of larvae away from the Yorkshire/ Lincolnshire spawning grounds that closely matched the distribution of larvae from September 1987 to January 1988, a typical season. Indeed, the combined ICES survey grid used to estimate herring larval production and abundance indices over the same period indicated that the north Norfolk coast in the vicinity of the Sheringham Shoal wind farm was relatively insignificant as a centre for herring spawning compared to all other areas north and south.

On the understanding that the North Sea component of the herring stock spawns in the autumn, CEFAS consider August to October to be the most important months for herring spawning in the area. Survey methodology was agreed with CEFAS (CEFAS, 2004b) and trawl surveys of the area were undertaken by IECS in April, July, and September 2005. The results of these are summarised in Section 10.3.2.1. Although they were not designed to sample pelagic fish quantitatively, they were able to determine the presence or absence of pelagic species.

Immature herring were present to the north west of the site in April; however, no herring were recorded in either the July or September surveys. The acoustic, video and grab surveys undertaken in March and June 2005 identified areas of sand, shelly sand and gravel within the wind farm site (see also Section 6: Hydrodynamics and Geomorphology and Section 9 Benthic Ecology) indicating that some areas of seabed sediments may be suitable for herring spawning within the proposed site boundary, but the trawl survey results suggest that the area north west of the site is currently active as a nursery or spring feeding ground but that neither the site or the export cable route affect an active herring spawning ground.

Migration

The annual migration of herring in the North Sea is well documented as many coastal communities from the north of Scotland to eastern England were dependent on the herring fishery during the 19th and early 20th centuries. Herring shoals first appeared off the Northern Isles of Shetland and Orkney in the spring, moving steadily southwards along Scotland's east Coast, usually reaching waters off the ports of Great Yarmouth and Lowestoft in the autumn months of September and October.

Autumn hatched larvae spend their first winter drifting towards inshore nursery areas, mainly in the eastern North Sea. After spending their first years in coastal nurseries, two year old herring move offshore into deeper waters, eventually joining the adult population in the feeding and spawning migrations to the western areas of the North Sea (DTI, 2001; Blaxter and Hunter, 1982). These migration patterns are generally regarded as being relatively constant over periods of several years despite environmental variation (Corten, 2001).

The abundance of juveniles in different nursery areas around the North Sea is dictated by annual variations in the strength and direction of the drift of the larvae and their variable mortality on route (Nichols, 1999).

Figure 10.4 indicates that the wind farm site and cable route do no fall within the main herring nursery areas. Furthermore, based on the information above, the source of the immature herring in the vicinity of the site in April is not likely to be a local spawning ground.

Prey

The pelagic larvae, which are 8-10mm at hatching, feed on copepods and other small plankton. (Russell, 1976; Daan *et al.,* 1985). Copepods are the predominant prey items during the early juvenile (<3cm total length) stage (Blaxter and Hunter, 1982), but larger prey including euphausids, hyperiid amphipods, juvenile sandeels, and fish eggs are also eaten (Last, 1989). There are no marked differences between the diets of juvenile or adult herring; only the proportions of the different food items change with the size of the herring (DTI, 2001). Amongst the 0-group[22] herring, prey consists largely of post-larval sprat and sandeel (Last, 1989).

*10.3.3.3 Sprat (*Sprattus sprattus*)*

Resource Status

Sprat are most abundant in the relatively shallow waters of the southern North Sea and Skagerrak, and are found in the UK coastal waters as far north as the Orkney Islands. There are no reference points or explicit management measures for sprat, though fisheries for sprat are often restricted in certain areas to minimise the by-catch of juvenile herring (www.ices.dk). ICES surveys and catch data suggest the biomass is thought to have increased over recent years, although with the age composition of the stock shows a predominance of 1-year–old fish. The TAC for sprat was set at 257,000 tonnes in 2003 (ICES, 2004b) and has increased since having been set provisionally at 282,700 tonnes for 2006.

[22] The 0-group (or 0-gp) is the year group that are in their 1st year since hatching. Also referred to in this section are the 1-gp (2nd year), 2-gp (>3 year old) and 3-gp (>4 years old).

Spawning

Most sprat spawn for the first time at the age of around 2 years. Sprats are pelagic batch spawners and individual females release their eggs in offshore areas in batches over a protracted period from May to August (unlike herring that release eggs in a single spawning event). The main spawning areas are considered to be located on the inner German Bight and the east coast of England. Whilst precise information regarding sprat nursery grounds is unavailable, it is thought that the north Norfolk coast is not a significant area (DTI, 2001).

Neither the spawning or nursery areas of sprat are located within, or in close proximity to the wind farm site or export cables route.

Migration

The traditional winter fisheries in coastal waters indicate migrations towards inshore waters for overwintering, though older fish are likely to remain offshore (Bailey, 1980). Sprat shoals also undertake vertical migrations on a diurnal basis, with schools moving to surface waters at dusk (Nilsson et al., 2003). Sprat were caught in low numbers (nine specimens from 12 hauls) during the pelagic deployment of the beam trawl in the September 2005 trawl survey confirming the presence of the species in the vicinity of the wind farm at this time.

Sprats are filter feeding planktivores, but have also been shown to feed on small benthic invertebrates. Larval sprat feed in mid-water on copepods, bivalve larvae and mysids. Depending on the seasonal and spatial composition as well as the abundance of species, the diets of juveniles and adults may differ, e.g. fish eggs including those of cod and sprat have been shown to constitute part of their diet (DTI, 2001).

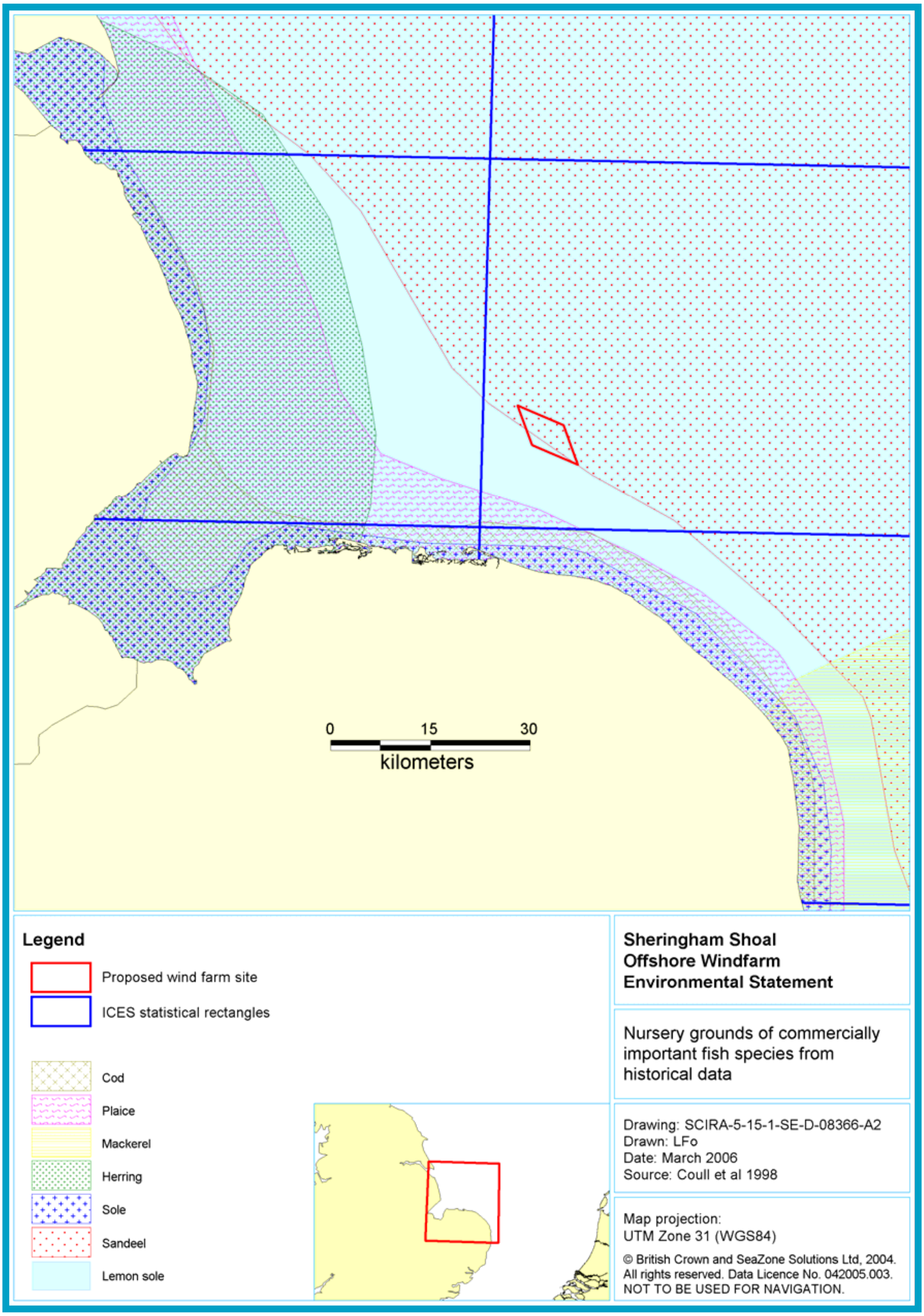

Figure 10.4 Nursery grounds of commercially important fish species (Source: Coull et al 1998)

*10.3.3.4 Whelk (*Buccinum undatum*)*

Resource Status

The common or rough whelk is a boreal species, widely distributed in the North Atlantic shelf waters. It has a shell which can be up to 15cm long, and is often a by-catch of the more commercially valuable lobster. The species is currently widespread and no national measures for its conservation exist (www.arkive.org). Although the whelk fishery in ICES rectangle 35F1 during the 2000 – 2004 period landed 2,493 tonnes (twice that of the crab respective fishery, see Table 12.4) it is the general opinion of the ESFJC (pers. comm.) that the fishery has been exhausted as a result. EU Council Regulation EC 850/98 advises technical measures relating to the whelk fishery. The harvesting of whelks that have a shell length of less than 45mm is prohibited.

Spawning

In mid-May whelks aggregate for mating, often migrating shoreward. Egg-laying begins shortly after fertilization and may extend to the end of August. On average a female will lay 340,000 eggs per egg mass (the number of egg masses laid per female is unknown). Embryos develop in the egg cases and hatch after five to eight months, in late-autumn to late-winter. The embryo survival rate is thought to be around 0.5 to 1%. There is no planktonic larval phase, and given their extremely slow-moving nature, dispersal is limited (www.glaucus.org).

Prey

Whelks are understood to be primarily scavengers and feed readily on dead fish, hence their capture by baited pots. Whelks also prey on sand-dwelling worms and bivalve molluscs.

*10.3.3.5 Edible crab (*Cancer pagurus*)*

Resource Status

The edible crab is widely distributed throughout the north east Atlantic shelf waters and is the most important commercial crab species of Western Europe. Although whelks have been landed in greater quantities from the Greater Wash during the period 2000 – 2004 (see Table 12.4), edible crab is the principal target species off the coast of Norfolk, being found in a variety of habitats and depths during its annual life cycle. Edible crab is an intensively fished stock and it is illegal to land berried females or recently moulted (‘whitefooted’) individuals (www.marlin.ac.uk).

Locally, the species and the fishery are closely monitored in inshore waters (6 nautical miles) by the ESFJC and CEFAS. In UK national waters a shellfish licensing scheme was introduced for all vessels (including the under 10m fleet) in 2004. As from 1st January 2006 all potting vessels have to make returns of landings and effort (including fishing grounds). The combination of these measures together with the addition of data from <10m vessels will allow fishery managers to understand the relationship between inshore and offshore fishing grounds (ICES, 2005a).

As crabs are of considerable commercial value to the fishermen, a five year monitoring program of these two species by the Eastern Sea Fisheries Joint Committee began in 2004. This work involves going to sea with the fishermen to measure their catches and also includes a program of releasing tagged individuals. It is hoped not only to gain information on the total stock composition from this study, but also to better understand the migratory and seasonal patterns thought to occur. Currently, these are poorly understood.

Spawning

Mating and reproduction tends to be spatially variable and temperature dependant on the influx of warm water through the Channel into the North Sea during the late spring and summer (ICES, 2005a). Mating occurs when the females moult and the new shells are still soft. Eggs are released to the female brood pouch two to three months after fertilization during November and December. Following hatching to the planktonic phase in June - July, five phases of metamorphosis occur over a period of 30-40 days before juvenile crabs settle having adopted a demersal habit (Edwards, 1979). Hatching and early development is reliant on sea temperature of 8°C to 9°C. Neither occurs below 7°C (Nichols *et al.,* 1982). Figure 10.5 shows the areas important as crab hatching grounds in relation to the proposed development and the associated cable infrastructure. It is clear that the area around the proposed development is of minor importance to crab spawning by comparison to a wide area further offshore.

Both the hatching and subsequent settlement of larvae out of the water column is known to occur in the offshore area of the Norfolk Fishery (Scott, 1995). Eaton *et al*., (2001) showed that the main area of larval production for crab was in a wide area approximately 70km offshore either side of the 40m isobath between the north Norfolk coast and the southern boundary of the Dogger Bank (Figure 10.5). This area may play an important role in sustaining the Norfolk fishery although Eaton *et al*., (2001) conclude that the crab population south of the Dogger Bank may be a separate self sustaining stock to those distributed further north.

Race Bank is also thought to be an important spawning area for brown crabs off the north Norfolk coast. Despite recent advances in research, many aspects of the reproductive cycle including size at maturity and spawning strategy of edible crab are poorly resolved (Bennett, 1995) although the ESFJC and CEFAS are now addressing this information gap through the dedicated mark, release and recapture studies mentioned earlier.

Earlier studies, also conducted with the aid of tagging, suggested that hatching of larvae takes place offshore before the landward migration of females. Nevertheless, some levels of inshore hatching, although minor to the main concentrations, cannot be discounted (Hall *et al.,* 1991).

Migration

Following extensive tagging studies dating back to the 1900s, it was generally accepted that mature female brown crabs undertook a northerly autumn migration along the east coast of England and Scotland to deeper water to spawn. The larvae were then thought to be carried south by tides and residual currents back to grounds suitable for their settlement and subsequent survival, commonly off the north Norfolk coast. The development of a brown crab fishery off the Humber estuary has confirmed the presence of a large quantity of mature female crabs in that area. Furthermore, studies suggest that the main spawning population is contained to the north by the Flamborough front: a hydrographic feature separating cold mixed water to the north from warmer stratified water further south (Eaton *et al*., 2001). This isolation challenges the earlier hypothesis, suggesting that the crab population off the east coast of England is separated from populations further north.

Approximately two weeks after mating in the late summer and autumn, when the exoskeletons have hardened sufficiently, berried females migrate far offshore to over–wintering grounds, where they are thought to remain buried in the sand and gravel sediments in a dormant state until the following spring or early summer (George *et al*., 1990). Males start their moult cycle following mating, but are largely sedentary by comparison. The relevance of the Race Bank in this relationship remains unclear; however, it is possible that the general trends in terms of timing of behaviour by berried females are similar.

In Spring, and in response to warming sea temperatures, offshore hatching of stage 1 larvae precedes a landward migration of females. The distributions of later larval stages (> stage 1) indicates that there is only a slow drift to the east away from the main spawning area, and a slow south easterly drift from spawning areas nearer the north Norfolk coast (Nichols *et al.,* 1982; CEFAS unpublished data).

It is likely therefore that offshore populations contribute extensively to the inshore stock. The early benthic stages of edible crab settle offshore and migrate to near shore waters. Settlement is thought to occur in the summer months to September (George *et al.*, 1990).

Prey

Edible crabs are often considered omnivorous scavengers, with a diet dependent on local availability of suitable prey items. Despite its reputation as a scavenger, the edible crab mainly feeds on live often sedentary food including small fish, marine worms, and shellfish species such as mussels. However, assessment of prey sources are complicated by the fact that food sources are not always readily identifiable given the shredding and tearing of food prior to ingestion (Edwards, 1979).

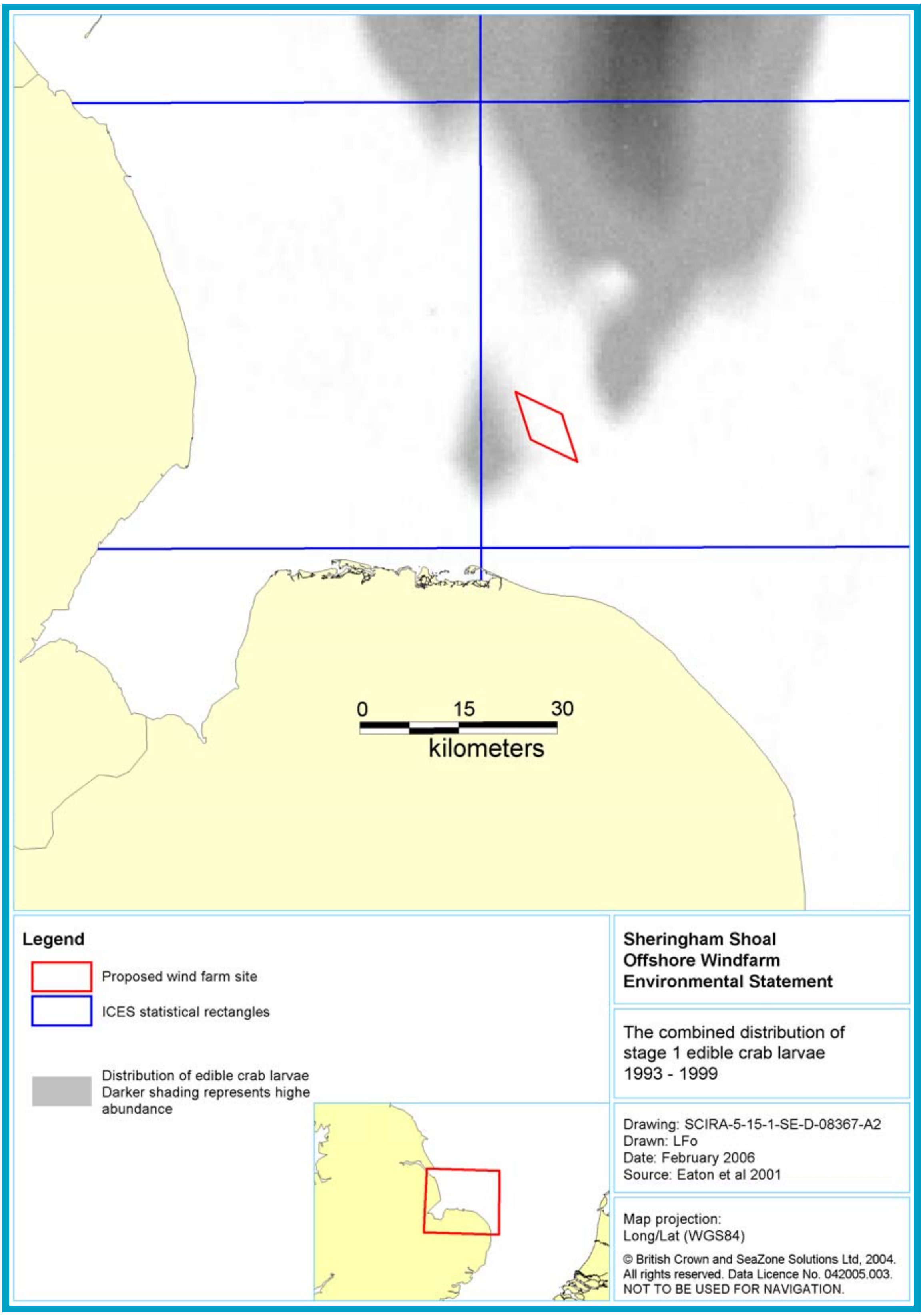

Figure 10.5: The combined distribution of stage 1 edible crab larvae 1993 - 1999

10.3.3.6 *Lobster (*Homarus gammarus*)*

Resource Status

Lobsters are common off the north Norfolk and Lincolnshire coasts, and local stocks provide a significant fishery to north Norfolk. The first phase of an ongoing survey undertaken by ESFJC in 2004 was to ascertain the current state of the north Norfolk lobster resource and local population dynamics. It appears from the results of this study that lobster abundance is notably greater at distances more than 3 miles from the coast, although greater fishing pressure exists with regard to the inshore grounds. Restrictions include prohibiting the landing of berried or soft shelled females and a landed minimum carapace length of 87mm (ESFJC, pers. comm).

Inshore, where lobster fishing is intensive, catch rates are generally low. Offshore, where catch rates are higher, fishing is intensifying, and catch rates must be expected to decline fairly rapidly as the newly exploited stocks are fished down. Large lobsters are rare except on the new offshore grounds, and the catch depends mainly on lobsters just above legal size. On this basis, size distributions imply that the fishing rate is generally high (at least 60-70%). The fishing rate is beyond the optimum, so that increasing effort will only increase landings in the short term, before they fall back to the previous level (Bannister, 1999).

The number of young lobsters entering the stocks i.e. recruitment, still appears to be stable, but the models predict that at the present rate of fishing, stock biomass in most areas will be less than a quarter of the baseline level, and in some areas may be as low as 10% of the baseline (Bannister, 1999). As a result, fishery managers including ESFJC and CEFAS consider that a precautionary approach to stock management is warranted.

Spawning

Mating is thought to occur in the late summer, but females have the facility to store the sperm packet over the winter so the eggs are not fertilised and laid until the following summer. Females moult in order to mate and produce small (around 1mm diameter) eggs from the oviducts through openings at the base of the female's third walking legs. These attach to the swimmeret appendages where they remain attached for the next nine to twelve months. Hatching takes place in spring and summer with the released larvae being planktonic.

Once hatched larvae are planktonic and exhibit three distinct development phases. All these early phases remain in the upper layers of the water column and are subject to wind and surface currents which transport the larvae inshore. Metamorphosis from the larval to a post-larval stage occurs at the fourth molt. After the fourth moult the post-larvae take refuge on the seabed and remain benthic from this point onwards. These post-larvae are strong swimmers and it is currently thought that they make excursions to the sea bottom, sampling the substrate to find a suitable settlement site. From settlement onward, the lobster maintains a benthic habit.

Young lobsters are rarely obtained by sampling and knowledge of their behaviour at this stage of development is scant. It is thought that they occupy a wide range of nursery habitats where shelter can be obtained; e.g. juvenile lobster have been reported in the soft mud sediments of The Wash (ESFJC pers. comm.) where they are thought to construct burrows. It is also thought that they find crevices between rocks or other suitable shelter where they remain during the first years until they reach a size that reduces pressures of predation and permits them to venture further in search of food.

Lobsters reach full maturity after a period of five to eight years. It is thought that lobsters may survive for over 25 years although specimens of such age are rarely encountered.

Migration

There is evidence to support the theory that at least some lobsters undergo an offshore migration, although the reasons behind this are not fully understood. It has been postulated that inshore areas function as the nursery grounds for offshore populations. The lack of a mean size differential between inshore and offshore groups fails to support this theory conclusively. Lobster biology is very similar around the coast, and lobsters generally migrate very little, so that even though lobster stock structure is not well understood the geographic grouping of data is robust and does not influence the assessment results unduly (Bannister, 1999).

Prey

Juvenile lobster feed on a wide range of species including molluscs, echinoderms, polychaetes and algae, whilst the diet of the adult lobster consists primarily of other crustaceans and molluscs.

10.3.3.7 Pink shrimp (Pandalus montagui)

The pink shrimp is found along much of the coast of the British Isles and has been exploited commercially since before its taxonomic identification in 1814. Early accounts from the Wash and Norfolk coast suggest that it was being prosecuted on grounds a considerable distance from shore (Warren 1973). Within the Greater Wash region, the pink shrimp fishery has traditionally been based in the Wash between the Burnham Flats and the Roaring Middle, although pink shrimp are also taken from the Lincolnshire coast in the vicinity of the Inner Dowsing bank and further offshore to the north east in the area known as the Silver Pit. Local stocks are known to be highly mobile (probably in response to environmental cues or foraging behaviour). Pink shrimp fisheries are not known to take place regularly east of the Docking Shoal towards the Sheringham Shoal offshore wind farm site (Knapman, 2003; Mander, 2004).

Resource status

As the pink shrimp resource is not the target of a significant commercial fishery, the current status of the resource on the coastal waters of north Norfolk and the Wash is uncertain. The ICES working group on pink shrimps assesses the deep sea stock of *Pandalus borealis*, a different species that is prosecuted by European fleets in the North Atlantic.

Spawning

Females start to mature at 18 months of age, and ovaries start to develop in the August of their second year. Between August and October, egg masses develop internally before the green eggs appear attached to the swimmerets beneath the tail in November. Up to 3,000 eggs are carried by individual females, but the total number of eggs may be as little as 200 depending on body size. The eggs are carried through December and January and hatching occurs in the spring, peaking in April (Warren, 1973).

Young brood shrimps (all females) grow rapidly in their first season and are first available to commercial bottom trawling in mid-summer when they are less that 25mm in length. During the first year, many brood shrimps develop as mature males; the remainder continue to develop as females. During the course of the year, the males revert to the female gender following mating. These individuals will carry eggs the following year (Warren, 1973).

Migration

Second year females migrate further offshore in the autumn to brood. They return to inshore areas following the hatching their eggs in March and April. In addition to the large spawning migrations, more random movements continue throughout the year (see above) where the shrimps have been observed to rise to mid water and the surface, especially at night.

Prey

The feeding movements of pink shrimp suggest that it is omnivourous feeding on detritus on the seabed and within the water column where phytoplankton and microzooplankton may comprise diet components.

10.3.3.8 Skates and Rays (inc. Thornback Ray (Raja clavata))

Resource Status

Defra catch data for skates and rays is not species specific. Whilst several species of rajids are considered abundant throughout the shelf waters of the north east Atlantic, specific data regarding the resource status of skates and rays within the North Sea is limited.

Although resource data are limited, general information on the slow rate of growth and reproduction of elasmobranch fish (skates and rays) suggests that they are susceptible to over exploitation by commercial and recreational fisheries. Because of this they have become an increasing focus for conservation initiatives. The lack of accurate species specific landings data in many European fisheries and the paucity of biological data have restricted the types of stock assessment that can be undertaken. Analyses of CEFAS groundfish survey data show that many large demersal elasmobranchs have been severely depleted in UK waters (Ellis *et al*., 2005a).

Formerly quite widespread and abundant, especially in the southern and central areas of the North Sea, the thornback ray is now most abundant in the south western North Sea, especially in the Outer Thames and The Wash. Thornback ray occur over a wide variety of sediment types, including mud, sand and gravel (Rousset, 1990) but is less frequent on coarser grounds (Ellis *et al*., 2005b) such as those found in the vicinity of Sheringham Shoal.

Experimental assessments were conducted in 2002 for thornback rays in the North Sea, which suggested that it has become heavily depleted throughout this region (Ellis *et al*., 2003). Based on the reduced distribution area and the decline in abundance in survey data, the North Sea stock is now considered depleted (Heessen, 2003).

Other species have been recorded in the area. Ellis et al., (2005a) list five species of skates and rays in ICES Area IVc (southern North Sea). In addition to the thornback ray that constituted 40% of elasmobranch fish present in the samples, the spotted ray constituted 13%. Others such as the cuckoo ray (*Leucoraja naevus*), the blonde ray (*R. brachyura*), and the undulate ray (*R. undulata*) constituted <1% of elasmobranch fish. The remainder were made up of dogfish, sharks and smooth hounds (see Section 10.3.3.9 below).

Spawning and reproduction

Skates and rays are oviparous, i.e. they fertilise eggs internally before laying encased eggs on the seabed in shallow water. Egg laying (thornback ray) generally takes place over a protracted period in inshore waters from March to September (Clark, 1922) although the egg laying period for an individual may be much shorter (Ellis and Shackley, 1995). Fecundity tends to increase with increasing body size (Walker *et al.,* 1997) leading to a maximum of up to 74 eggs per year (Ellis and Shackley, 1995). Hatching is temperature dependant (Holden, 1975; Holden *et al.,* 1971) occurring after four to six months (Ellis and Shackley, 1995, Clark, 1922).

Whilst little corroborated evidence has been published with regard the geographical spawning habitats of many ray species off the north Norfolk coast, anecdotal evidence offered by local fishermen during consultation suggests that several ray species may spawn within the general area of the wind farm although the results of analysis by Ellis *et al.,* (2005) suggest that this is most probably protracted spawning by thornback ray. Rogers *et al*., (1998) suggest that the north Norfolk coast in the vicinity of the proposed wind farm and its export cable route is not important as a nursery ground for skates and rays.

Migration

The North Sea stock may be best described as series of local concentrations with regular, but limited exchange of individuals. Tagging studies indicate that individual movements may cover up to several hundred kilometres, although the majority of movements appear to extend no further than 50 – 60km from the point of release (Walker *et al.*, 1997). Fishery-independent analysis of distribution of thornback rays by Hunter *et al.*, (2005) demonstrated that the fish were widely distributed in the southern North Sea during the autumn and winter. The range contracted in spring, when the fish moved into shallow estuarine waters.

Prey

Skates and rays are primarily bottom feeders, their diet consisting almost entirely of benthic organisms. The young feed predominantly small crustaceans with larger individuals feeding on larger prey including crabs and small fish such as sandeels, young gadoids, gobies, dragonets and gurnards (Holden and Tucker, 1974; Rea and Shelton, 1982; Ellis *et al*., 1996; Gibson *et al*, 2001).

*10.3.3.9 Dogfish and Smooth hounds (inc. Spurdog (*Squalus acanthias*))*

Resource Status

The dogfish and smooth hounds belong to one of the largest families of shark. Of the species recorded in the southern North Sea (Ellis *et al*., 2005a), the lesser spotted dogfish and the starry smooth hound, *Mustelus asterias*, accounted for the greatest proportion of catches (36% and 6% respectively). The spurdog accounted for 26% of catches in the central North Sea. Information on the resource status and general biology of the spurdog is much stronger than for the other species named, and although there are differences in reproductive strategies between these species, accounts of the spurdog are used to inform much of this assessment.

Spurdogs are considered to be amongst the more abundant of the elasmobranchs in the North Sea. In the early 20th Century, spurdog were considered a nuisance by the herring drift net fishery due to damage caused to nets and catches. Schools of spurdog tend to be segregated by size and sex.

Landings of spurdog increased rapidly during the latter half of the century although landings have since declined. A low fecundity, coupled with an extremely low growth rate, makes the spurdog vilnerable to commercial exploitation. In the North East Atlantic, the stock is considered depleted. The stock biomass is estimated to be at approximately 5% of the biomass 60 years ago (Hammond and Ellis, 2005). Spurdog in the North Sea are currently managed by quota, with the total allowable catch (TAC) reduced by 87% between 1999 and 2005 (ICES, 2005a).

Spawning

The lesser spotted dogfish *Scyliorhinus canicula*, the only species sampled by the Young Fish Surveys reported by Rogers *et al.,* (1998), occupies sand and gravel seabed up to 100 m deep, but the young can be found in coastal areas. The species is oviparous, and despite a preference for sand and gravel seabeds, the lesser spotted dogfish was rare off the north Norfolk coast, only appearing in small numbers off the Suffolk coast.

Spurdog is aplacentally viviparous, giving birth to live young that are reliant on yolk reserves during embryonic development (Hisaw and Albert, 1947). As with skates and rays, fecundity increases with size and maximum estimates range from 16 oocytes to 13 free embryos (Holden and Meadows, 1964; Gauld, 1979). The gestation period lasts for between 22 – 24 months giving average size at birth from 26cm to 28cm and pupping appears to take place from August to December (Ford, 1921).

Migration

Analysis of long established tagging studies (Holden, 1965) suggest a single North East Atlantic stock and changes in the migration patterns of North Sea spurdogs has been reported (Vince, 1991) suggesting that the North Sea component is part of a much larger stock. Spurdog generally tend to migrate northward in the spring and summer, before returning south with the onset of autumn/winter. Seasonal inshore-offshore movements and coastal migrations are directly related to the temperature of the water. Typically, spurdog spend summers in inshore waters and over-winter in deeper offshore areas (Pawson, 1995).

Prey

Spurdogs are opportunistic predators, often swimming in large groups feeding on schools of smaller fish, such as juvenile cod, herring and whiting. Other food sources include flatfishes, ctenophores, jellyfish, polychaetes, crabs, shrimp and squid (Compagno, 1984; Ellis *et al.,* 1996; Rae, 1967). Dogfish are thought to be similarly opportunistic in their feeding habits, although in general, they are not thought to exhibit such schooling behaviour.

*10.3.3.10 Cod (*Gadus morhua*)*

North Sea Resource Status

Cod stocks are considered to be seriously depleted and outside safe biological limits. The 2004 assessment by ICES concluded reduced reproductive capacity and unsustainably harvested reserves. These findings are based on estimates of the number of fish in each age group from international landings, commercial catch rates in relation to fishing effort, and recruitment statistics of young cod to the overall stock from trawling surveys in ICES Sub-area IV (The North Sea). Amalgamation of data concluded that cod SSB[23] is at a level well under the Biomass Limit (B_{lim}) of 70,000 tonnes and the 2001-2003 year classes are all calculated as well below average, representing a resource status close to stock collapse. Cod fishing mortality (F) is at elevated levels and have been above precautionary levels (Fpa) since the early 1980s (ICES, 2004a).

Section **12**: Commercial Fisheries provides an account of cod fishery management. In summary, recent measures of cod stock management within the area of ESFJC jurisdiction have concentrated on a reduction of fishing effort. With effect from May 2003, restrictions were imposed on the <10m fleet as part of the cod recovery programme introduced by Defra and the EU. The <10m fleet has been reduced from a virtually unrestricted cod fishery to restrictions been placed on quotas over the past 3 years of 500kg live weight of cod per month. Vessels >10 metres that fish for cod are restricted to 15 days per month at sea and it is un-likely that these restrictions will ease in the next 2 to 3 years.

Spawning and Nursery Areas

Cod are pelagic spawners i.e. their eggs are released into the water column rather than onto the seabed. They spawn throughout the North Sea, but tend to concentrate spawning activity around the German Bight. The primary period of spawning occurs between January and April, when eggs can be found suspended above the thermocline in the surface layers of the North Sea (Daan, 1978). By June, the larvae have hatched and absorbed their indigenous reserves and are searching actively for food in the upper layers of the water column in eastern and northern North Sea locations. Lateral dispersal of the larvae during these early life stages is largely a function of circulation and bed topography (Brander, 1994).

Figure 10.3 and Figure 10.4, adapted from Coull *et al*., (1998), show no spawning areas within, or in close proximity to, the Sheringham Shoal wind farm site or export cable route. However, a nursery ground covers the inshore section of the cable route.

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[23] An explanation of the terms used below to describe the biological status of commercially exploited species is given in Appendix 10.1.

Following metamorphosis from the larval stages cod quickly develop a demersal habit from approximately 6 months of age when they are around 10cm to 15cm in length. By their first winter after hatching, juvenile individuals move into estuaries and the shallower waters of the eastern coast of the North Sea. In UK waters, Rogers *et al*., (1998) showed that juvenile cod are particularly common in The Wash and estuary of the River Humber. In contrast to Coull *et al*., (1998), Rogers *et al*., (1998) showed that juvenile cod do not appear to be distributed along the north Norfolk coast in the vicinity of the proposed wind farm site or its export cable route.

Migration

Following juvenile aggregation in shallow coastal waters over winter, they tend to disperse in a north westerly direction over deeper parts of the North Sea in summer (Heessen, 1983). The majority of the adult cod stock in the southern North Sea is recruited from nursery areas in coastal waters, yet there remains a certain degree of uncertainty when determining to what extent intra-specific coastal populations affect each other ecologically and genetically, and how coastal populations relate to the larger offshore North Sea cod stock (Munk *et al*., 1999).

Tag and release experiments conducted by various research bodies, including CEFAS and European research institutes, show that the average distance travelled by adult cod from the point of release is limited to approximately 200 miles, but migrations over greater distances have been recorded (Turner *et al*., 2002). Some diurnal vertical movement in the water column is also known to occur, especially in the autumn. Typically fish migrate from the seabed at nightfall and spend hours of darkness feeding in midwater before returning to seabed at dawn (Arnold, 2000).

Prey

Much of the prey of all sizes of cod consists of a variety of small fish and crustaceans. The remainder is made up of smaller quantities of molluscs and worms (Wheeler, 1978). As they grow, cod eat an increasing amount of fish; sandeels, Norway pout, whiting, herring, dab, and even smaller cod. Research on cod predator – prey dynamics by Floeter and Temming (2003), showed that more than 75% of fish found in the stomachs of North Sea cod originated from the least preferred quantile of the prey size range. This implies that prey abundance, rather than prey size, is the main determinant of diet composition.

*10.3.3.11 Whiting (*Merlangius merlangus*)*

Resource Status

Whiting are one of the most numerous and widespread species found in the North Sea (ICES, 2005b) and is caught in mixed trawl fisheries along with cod and haddock. Spatial information on landings (based on 70% of the total) suggests that most of the catch can be attributed to three distinct areas: a northern zone, an area off the eastern English coast, and a southern area extending into the English Channel. The information available to ICES has been insufficient to evaluate the spawning stock size or fishing mortality. Nearly all catch-at-age analyses indicate that the stock is at or near the lowest observed level, and that the spawning stock biomass is below the limit biomass (Blim) of 225,000t. However, all survey-based analyses indicate that the stock is at or near the highest observed level, and stable or increasing (ICES, 2005b).

The precise state of the stock is therefore uncertain but a provisional assessment suggests that the SSB may have declined over the last 20 years. The provisional North Sea TAC for 2006 has been set at 23,800 tonnes, 15% down on the 2005 level.

Spawning

Among the gadoids, whiting has a relatively high fecundity, but the eggs are relatively small (1.0-1.3mm in diameter) (Russell, 1976). A female of 30cm length may produce 400,000 ripe eggs during the spawning season, which is equivalent to 1,700 eggs per gram body weight (Hislop and Hall, 1974). The pelagic eggs, which take about ten days to hatch (Russel, 1976), are shed in numerous batches over a period that may last for up to fourteen weeks (Hislop *et al.*, 1991).

Spawning takes place from January in the southern North Sea to July in the northern part. Hatching will take between 8 and 10 days depending on the prevailing water temperature (Hislop and Hall, 1974; Russell, 1976).

Migration

Whiting are quite ubiquitous throughout the North Sea. Rogers *et al*., (1998) showed that areas from the Humber Estuary to The Wash and around the Thames Estuary are important as nursery grounds. The area in the vicinity of the proposed wind farm and its cable route to shore is not as important although, young whiting were recorded in the surveys reported.

Movements of whiting in the south-eastern North Sea are directed mainly between inshore and offshore environments and further movements occur between the southern North Sea and the eastern Channel (ICES, 2005b).

Prey

The feeding habits of whiting tend to vary with the size of the fish and the availability of prey. They are voracious predators, and studies have shown that fish and crustaceans comprise at least 85% by weight of the diet of whiting of all sizes. The proportion of fish is seen to increase with predator size. The bulk of the fish prey consists of many species including Norway pout, sprat, sandeels, and juvenile herring, cod, haddock, and whiting). Shrimp tend to make up the bulk of crustaceans taken. The ratio of crustaceans to fish consumed tends to be greater in juveniles than in adult whiting and whiting are also known to be cannibalistic (Hislop *et al.,* 1991).

*10.3.3.12 Dover sole (*Solea solea*)*

Resource Status

The stock is considered to be at its full reproductive capacity. The size of the spawning stock is well above the limit level of 25 000 t, but fishing mortality is too high. The stock is therefore at risk of being harvested unsustainably (ICES, 2004a). Within the North Sea several different sub-populations have been distinguished based on egg distribution and tagging experiments. However, these are to a large extent mixed during the feeding season. Assessments examine the North Sea sole as one unit stock.

There are no explicit management objectives for this stock apart from applying the precautionary approach, but a total allowable catch (TAC) is set annually. However, because the species is caught in a mixed fishery, exceeding the TAC for one species may not prevent the fleet from continuing fishing for another and the effectiveness of TAC management may not be fully effective.

Several technical measures constrain the sole fishery indirectly. These include mesh size regulations, gear restrictions and a closed area (Plaice Box and inshore waters), i.e. within the 12-nautical mile limit and in the Plaice Box (see Section10.5.12 below) the maximum aggregated length is 9m and fishing is forbidden for beam trawlers with engine power >300 HP. Furthermore fishing is restricted by a days-at-sea regulation which was introduced in the light of the cod recovery plan (ICES, 2004a).

Spawning

The main period of spawning for Dover sole is during April and May, in shallow inshore waters and close to sandbanks less than 30m deep. Generally, sole spawn earlier in the southern North Sea, with major grounds including the Belgian coast, the Thames Estuary, the Norfolk Banks, the Wadden Sea, and the German Bight (Rijnsdorp *et al.*, 1992).

Females produce between 700 and 800 eggs per gram body weight, which corresponds to about 350,000 eggs for a 35cm fish (Rijnsdorp *et al.*, 1992; Greer Walker and Witthames, 1990). The pelagic eggs are 1.0–1.6mm in diameter.

Sole spawning is temperature dependent and individuals migrate inshore from cooler, deeper waters in order to spawn, a reaction triggered by warmer water temperatures (> 7ºC) towards the end of February (ICES, 1965). Ideal spawning habitats are those exhibiting sandy or gravely seabed substrates. Such substrates are a feature of the Norfolk coast and the proposed wind farm site, and the areas marked in Figure 10.3 are known as sole spawning grounds (Coull *et al.*, 1998). Other areas such as the German Bight and the English channel appear more important (Bolle *et al.*, 1989) and Rogers *et al.*, (1998) show that the north Norfolk coast is only moderately important as a nursery ground for sole.

Migration

The mechanism by which the metamorphosing larvae reach their nursery areas is not well established. It is speculated that they are transported passively but using bottom currents selectively (Marchand and Masson, 1989). In autumn when temperatures fall, sole leave the shallow coastal areas and migrate to the warmer offshore grounds. Particularly in severe winters, they may form dense aggregations in the deeper and less cold parts in the southern North Sea and the eastern Channel (Rijnsdorp *et al.,* 1992). For example, the Silver Pit (some distance north of the wind farm site and east of the Humber Estuary) owes its name to the valuable catches of sole made there during cold winters. From March to May, sole return to inshore waters (Woodhead, 1964). During these spawning migrations, which generally take place at night, the fish may even be seen swimming at the surface (De Veen, 1967) and appear to make use of selective tidal transport (Kruuk, 1963).

Prey

Braber and De Groot (1973) report that amphipods and polychaete worms (especially *Arenicola* and *Nereis sp.*) constitute the main prey resource for sole of all size classes, and that differences in prey preferences between adult and juvenile sole are less pronounced than other species. Also targeted are other types of mobile epifauna, sedentary infauna, young bivalves and protruding siphons and tentacles. Molinero and Flos (1991) suggested that bivalves are favoured over gastropod species. However, it is of note that demersal fish are opportunistic predators, and prey preference often reflects the infaunal species distribution of the local area.

*10.3.3.13 Plaice (*Pleuronectes platessa*)*

Resource Status

The stock has been fairly stable from the late 1950s to the mid 1980s. Year-class strength has not fluctuated strongly from year to year, although occasional strong year classes recruit to the fisheries (e.g. year class 1963, 1985). A strong decrease in abundance occurred between the mid 1980s and the mid 1990s.

The size of the spawning stock varied around 300,000 tonnes between 1957 and 1989. It then declined sharply to just above the limit reference point (Blim = 160,000t). The fishing mortality gradually increased from the 1950s until the late 1990s and has reached the limit reference point (Flim) of 52% per year (ICES, 2004a). Since its recent decline, the stock is considered to be at risk because of reduced reproductive capacity. The present level of fishing mortality is considered not to be sustainable.

To reduce discard mortality of undersize plaice returned to the sea, a partially closed area, the Plaice Box, was established in Dutch, German and Danish waters of the eastern North Sea in 1989. Beam trawling was prohibited in this area for part of the year for vessels larger than 300 HP. Since 1995 this area has been closed all year round for these vessels; however, small beam trawlers less 300 HP were allowed to continue fishing. Because the Plaice Box encompasses the major concentrations of juvenile plaice, the introduction was expected to enhance recruitment, yield and spawning stock biomass.

Spawning

Peak spawning time shifts from early January in the eastern Channel to mid-February in the German Bight and off Flamborough (Rijnsdorp, 1989). The number of eggs that a 35 cm female produces may vary from 60,000 to 100,000, corresponding to about 265 eggs per gram body weight and fecundity of medium-sized females (<=40cm) has increased since the 1950s (Rijnsdorp, 1991). The pelagic eggs are 1.7–2.2mm in diameter (Russell, 1976).

Studies on the distribution of plaice spawning activity (Fox *et al*., 2005) indicated that stage 1 (early) eggs are distributed mainly in the English Channel and the southern North Sea. The Wash and north Norfolk coast are on minor importance by comparison.

Migration

Larval stages of plaice remain in the pelagic phase for three to four months. This results in long exposure to residual currents, and the young plaice may settle in areas far away from the spawning area. Settling on the bottom happens only after complete metamorphosis to the adult form (Russell, 1976). Rogers *et al*., (1998) show that the Wash and north Norfolk coast are important as nursery areas.

Plaice make selective use of tidal currents in various stages of their life. Metamorphosing larvae enter estuarine nursery areas by migrating to midwater during the flood tide and settling at the bottom during the ebb (Rijnsdorp *et al.,* 1985; Kuipers, 1973). Juvenile plaice in the Wadden Sea move with the flood tide onto sandy flats to feed and move back to the surrounding channels on the ebb tide (Kuipers, 1973).

Adult plaice are also known to make use of tidal stream transport during their seasonal migrations between spawning and feeding grounds; they move downstream with the tide in mid-water, and stay on the bottom during the opposing tide, showing little or no movement (Greer Walker *et al*., 1979).

Part of the North Sea plaice population spawns in the Channel and returns to its feeding grounds in the North Sea afterwards. Progeny of this group enters the North Sea as eggs and early larvae by passive drift (Houghton and Harding, 1976). In the North Sea, spawning-feeding migrations occur along a north-south axis. The distances over which the plaice migrate increase with fish size and age. Tagging experiments revealed that several spawning populations mix during the summer feeding season and separate to spawn (De Veen, 1978; Hunter *et al*., 2004).

Prey

The diet of plaice larvae in the Southern Bight consists of appendicularians such as *Oikopleura dioica* and *Fritillaria borealis*, but several stages of copepods, algae, and bivalve post-larvae are also eaten (Ryland, 1964). Polychaete worms, especially sessile species such as *Pectinaria koreni* and tails of *Arenicola*, and bivalves are important food groups for larger plaice. Other important prey includes small crustaceans (e.g. amphipods, mysids and small shrimps), siphons of bivalve molluscs (e.g. *Abra spp., Mya spp*. and *Venus spp*.), and, in certain areas, brittle stars (*Ophiura spp*.) (De Clerck and Buseyne, 1989; Rijnsdorp and Vingerhoed, 2001)). Plaice are typical daylight feeders. The adults do not feed during the spawning period (De Clereck and Buseyne, 1989, Rijnsdorp, 1989).

10.3.3.14 Species of Conservation Interest

The June 2004 Guidance Note prepared by CEFAS on behalf of the MCEU (CEFAS, 2004) identifies the major anadromous and catadromous species of conservation interest in the Greater Wash area. River lamprey, *Lampetra fluv*iatilis*;* Sea lamprey, *Phoximus phoximus;* shad, *Alosa spp*.; salmon, *Salmo salar*; and smelt, *Atherina presbyter* are listed as being of high interest i.e. they are species present in the area and need to be considered. Common skate, *Raja batis;* angel shark, *Squatina squatina;* basking shark, *Cetorhinus maximus;* and sturgeon, *Acipenser sturio,* are considered as those species that were historically present in the area although may not be present now, and those species that may only occasionally occur in the area. These species may need to be considered, but data are likely to be scant.

Rare and vagrant species recorded off the east coast were reviewed by Potts and Swaby in 1999 with no more recent publications apparently available. Almost by definition, records are invariably of individual fish and few, if any, are recorded regularly. The reasons explaining their rare occurrence are not known, but records show that low abundance of species such as shad or blue fin tuna, *Thunnus thynnus,* in these coastal waters is long established and it is therefore unlikely that present marine industries are likely to have a significant effect on their distribution. This being the case, it is impractical to identify or implement specific mitigation measures in this regard.

The common skate is extremely rare in the southern and central North Sea and is listed as Endangered (provisional) on the IUCN Red Data List Species. Thornback ray is more commonly encountered in the region, and once skinned in preparation for sale is often labelled under the generic term “Skate”.

Common skate, like thornback rays, are vulnerable to capture by static and towed fishing gear, and is taken both in target fisheries for rays and as a by-catch in other fisheries. The slow growth rate and late age at maturity of skate mean that recruitment of juveniles to the mature stock is reduced in heavily fished areas. Subsequently, reproduction rates tend to suffer leading to further depletion of the stock.

The current stock status of the common skate is unknown as too few are caught in research cruises to make analysis possible. Commercial landings data regarding skates and rays are not species specific, being grouped under a common name. Yet skates and rays do constitute a relatively large proportion of the finfish caught in both 34F1 and 35F1 (30.25% and 41.93%) so it must be assumed that skate are present in the area.

Of the species protected under the Habitats Directive, the twaite shad, *Alosa fallax*, and Atlantic salmon are the only species thought to be present in the southern North Sea (English Nature, 2004). Although classed as a depleted stock, it is thought that the southern North Sea is not an important habitat for Atlantic salmon, as it prefers grounds north of the study area (CEFAS and The Environment Agency, 2000).

Salmon and twaite shad are stated as ‘of community interest whose conservation requires the designation of special areas of conservation (SAC’s) Annex II of the Directive’ and ‘species of community interest whose taking in the wild and exploitation may be subject to management measures’ under Annex V. At present there are no SAC’s assigned for the protection of shad and salmon in the areas of the wind farm site or export cable routes.

In terms of the wind farm site, neither the fish surveys conducted on behalf of Sheringham Shoal nor the Defra landings data, recorded any presence of salmon. Licensed coastal fisheries for salmon exist along the Suffolk coast and further north off Northumberland and Scotland, but no fisheries of this type are licensed along the Norfolk coast suggesting that it does not constitute part of a recognised route of migration. Given this information, and in the absence of viable sample numbers from the surveys undertaken, it can be assumed that the Sheringham Shoal site is not significant as a favoured habitat or migration route of salmon.

Twaite shad also features under Appendix III of the Bern Convention whereby exploitation of the particular species is regulated to prevent any danger of stock collapse. Measures include closed seasons, temporary or local prohibition of exploitation and market regulation. The summary of species recorded from Defra landings statistics (Table 10.5) record shad from rectangles 35F0 and 35F1 during the period 2000 – 2004, although it is likely that these records represent single fish.

River lampreys, *Lampetra fluviatilis,* are of importance to conservation and are protected but are not subject to a commercial fishery. River lampreys were put forward for inclusion in Schedule 5 of the WCA in the fourth quinquennial review by JNCC in 2002. *L. fluviatilis* is an Annex II species under the Conservation (Natural Habitats & c.) Regulations 1994.

Some of these species, such as the Allis shad, *Alosa alosa*, and the sea lamprey, *Petromyzon marinus,* are also legally protected under Schedule 5 of the WCA. These species are not targeted by commercial fisheries, but may be encountered incidentally. The grouped Action Plan for Commercial Marine Fish (http://www.ukbap.org.uk/UKPlans.aspx?ID=332) offers specific information on the pressures jeopardising population health for a number of similar species. Cod, herring, mackerel, plaice and sole are included in the Action Plan, along with the common skate and twaite shad. Tope, *Galeorhinus galeus*, is categorised as vulnerable by the IUCN Red Data List.

10.4 Impacts during construction

10.4.1 Introduction

Using the baseline described in the above sections, and in accordance with current EIA guidance (i.e. CEFAS, 2004a; Defra, 2005) the following sections address the potential impacts of the wind farm and export cable route. Construction activities include among others: foundation installation, cable burial and scour protection during the construction phase.

The following potential construction impacts are identified:

- Direct habitat loss from foundation and scour installation;
- Temporary habitat loss from cabling installation;
- Physiological trauma from underwater noise during piling;
- Smothering of sensitive life stages and habitats from re-suspension of sediments; and
- Accidental spillage of construction materials.

These are addressed in turn and where appropriate, mitigation is proposed.

The design details and the specification the proposed wind farm within its design envelope are described in Section 2: Project Description. A range of potential impacts are therefore described with assessment of significance based on the worst realistic case based in the information currently available.

10.4.2 Direct Habitat Loss

The construction phase of the Sheringham Shoal project would result in the direct loss of areas of seabed in the immediate area of each of the turbine foundation footprints and associated infrastructure, such as scour protection.

Direct habitat loss resulting from the removal of the seabed through its preparation for receiving the turbine foundations, or by the placing of scour protection around turbine foundations is one of the most significant environmental issues to be addressed. Table 2.5 and Table 2.7 in Section 2, Project Description, sets out the total footprint of the various foundation options being considered by adding the area of seabed covered with foundation structure to the area covered by scour protection to provide an estimate of the total area of disturbance. These areas range from 20 - 595m^2 for monopile foundations to an estimated worst case scenario of 1950m^2 - 4400m^2 for gravity bases per turbine. This equates to 0.03% to 1.35% of the wind farm area respectively. Given the greater area of footprint associated with the gravity foundations, the impact assessment, in terms of the worst realistic case of direct impacts on the seabed, is based upon the most intrusive use of this form of foundation across the entire wind farm site.

10.4.2.1 Impacts and effects of habitat loss

It is expected that the new habitats produced as a result would be colonised quickly by communities of benthic organisms and other associated species including commercially important species of fish and shellfish. Monitoring reports from the Danish offshore wind farm at Nysted (e.g. Birklund, 2005) describe the rate of re-colonisation of introduced habitats by epifaunal species (including edible crabs). Reports from the Danish Offshore Wind farm at Horns Rev (e.g. Leonhard and Pedersen, 2005) describe effects and recovery on both the epifauna and fish species. These are described below.

Deployment of gravity foundations at Nysted Offshore Wind Farm off the Baltic coast of Denmark started in 2002 and the construction work including placement of stone ballast in the foundation chambers and around the foundations as scour protection ended in the spring of 2003. The first post-construction survey of the fouling community on foundation masts and the introduced hard habitats was conducted in October 2003. A similar investigation was carried out October 2004 and was supplemented with surveys at a control site with the aim of providing data on a natural hard bottom community on a stone reef close to the wind farm.

Common mussels, barnacles (Cirripediae) and red macroalgae dominated the fouling community in the wind farm in 2004. The biomass of the community increased significantly over the two year study period due to a rapid growth of the mussels, but the biomass was below that at the anemometry mast deployed in 1997, and at the control site.

At Horns Rev, on the North Sea coast of Denmark, a similar invertebrate succession has emerged since the wind farm was built and commissioned in 2001. Juvenile edible crabs were found on the monopiles and larger individuals were often observed in caves and crevices among stones in the scour protection in 2003 and 2004. Growth of edible crabs was demonstrated between 2003 and 2004, and the presence of juveniles of other crab species and egg masses of invertebrates indicate that the turbine foundations are being used as spawning and nursery grounds.

The fish community at Horns Rev in 2004 showed an increase in the number of fish species from 2003. Bib, *Trisopterus luscus*, a gadoid similar to whiting was observed foraging on crustaceans on the scour protection together with schools of juvenile cod. Gunnelfish and dragonet were also found to be common within crevices between the rocks. Pelagic and semi-pelagic fish like sprat, mackerel and sandeel, *Ammodytes sp*., were observed with increasing frequency between years.

It is expected that the rate of regeneration of habitat and re-colonisation by species at Sheringham Shoal would be dependent on several issues, but the coarse sand and cobble habitats are similar to those at Horns Rev and a similar rate of recovery in response to the direct loss of existing habitat is expected. In terms of direct habitat loss on natural fish and shellfish resources, impacts from the construction phase are expected to be **negligible**.

In terms of effects on spawning grounds and nursery grounds from direct habitat loss, as discussed in Section 10.3, and based on advice from CEFAS (CEFAS, 2004b) and Coull *et al*., (1998), herring could utilise the seabed in the vicinity of the proposed wind farm as a spawning area, although no evidence of this was found in the site specific surveys. Between 0.03% and 1.35% of the area of habitat within the site boundary would be lost to the construction of the turbine array and scour protection (see Table 2.7). The magnitude of any effect is therefore considered to be minimal in the context of the seabed and suitable habitats found within the site boundary and within ICES rectangles 34F0 and 35F0. (see Figure 10.3).

Some eggs would be destroyed if located within the footprint of the cables or foundations during their construction, however it is considered that the proportion of eggs and larvae lost would be insignificant compared to those lost to natural mortality and predation. Overall, on a local, regional and national scale, impacts due to permanent habitat loss are considered to be of **negligible** significance.

10.4.3 Temporary Habitat Loss

Other construction activities on the seabed such as the installation of cables, jacking up spuds and the placing of pig anchor points used in the cable installation process would lead to temporary loss or temporary disturbance of the seabed. Inter-connector cables and export cables to shore would be buried to a depth of at least 1m below the surface of the seabed. Methods of installation of the inter-connector cables within the turbine array and the export cables are described in Section 2: Project Description. These include jetting, trenching and ploughing.

10.4.3.1 Impacts and effects of cable installation

The ploughing method of installation has the least environmental impact due to the furrow being backfilled to maintain the stratified composition of the marine sediments. Trenching and jetting have a greater environmental impact as the backfill of the resulting trench tends to lose its structure e.g. by trenching, the trench walls can collapse over the cable once it is laid, and the stratified composition of the sediment may be lost. Stability is improved when jetting because the liquification of sediments leaves the trench wall in a more stable condition.

Suspended sediment and settlement velocities remain as potential impacts. The higher energy of jetting or trenching could lead to an increase in the amount of fine sediments that would be re-suspended during cable installation, and epifauna and infauna in the immediate vicinity of cable installation tend to suffer fatal effects through deep burial or fragmentation. This could have an environmental effect if a shellfish ground, or a fish spawning ground were to be affected.

The preferred method is ploughing; however, the other methods may have to be employed should hard ground be encountered or should engineering requirements dictate. For example, at the southern end of the export cable route where chalk has been shown to be at shallow depth beneath glacial till, trenching may be required. Jetting may be necessary around turbine bases, to allow the feed of the inter-connector cables to the tower sections.

The worst realistic case would involve the use of jetting through sand and gravel sediments between each turbine base and the possible requirement to trench the export cables through any potentially hard ground to shore (particularly the shallow chalk bed close to shore). Conceivably, this would cause the greatest impact with the potential to affect shellfish resources and fish spawning grounds through direct loss over a 20m wide footprint (although the trench created would be much narrower) and smothering of sensitive receptors by re-suspended sediments over a similar area (see Section 10.4.5). The plume from such operations in substrates other than chalk is likely to be insignificant in terms of that produced by other operations such as demersal trawling.

Trenching through chalk has the potential to create a plume that could be carried up to 10km from the source, but concentrations of resuspended chalk particles are likely to be reduced to background levels within six tidal cycles. Section 10.4.5 and Section 6: Hydrodynamics and Geomorphology provide further information on the dispersion of resuspended sediments.

Based on the maximum length of internal cabling required (in the order of 70km) and the length of the export cable route to shore (in the order of 22km) it is possible to estimate the maximum area that would be affected by temporary habitat loss from cabling; i.e. approximately 1.8 km^2 representing 5.1% of the total site area.

Basing assessment against the worst realistic case outlined above, studies have indicated that the infilling of troughs produced by the action of the drag head during marine aggregate extraction operations can take at least 12 months with full recovery of a mature species assemblage in strong tidal channels taking place in 1 – 3 years if left undisturbed (Van der Veer *et al*., 1985). Kenny *et al*., (1998) found while studying the long term effects of marine gravel extraction on the re-colonisation of benthic invertebrates in the vicinity of Race Bank that dominant species re-colonised within 8 months of dredging. However, the biomass remained significantly lower than its pre-dredged state after 2 years. At 3 years, equilibrium in sediment transport was reached leading to a significant increase in community biomass at the site. The paper concluded that removal of the seabed in areas where there is a high degree of sediment transport may be of little long term biological significance. This was attributed to the potential speed of physical and biological recovery following removal.

Given the low area of maximum disturbance and the relatively quick rate of recovery, the significance of temporary habitat loss due to cable installation for natural fisheries resources is considered **negligible**.

10.4.4 Construction noise and vibration

Many natural and anthropogenic sources of noise are produced within the marine environment covering a wide range of sound levels. Potential noise and vibration from human activity sources include; commercial shipping movements, military activities, dredging, oil and gas exploration and production, and commercial fishing. Table 10.6 gives examples of levels and frequencies from anthropogenic noise sources (compiled from Nedwell and Howell, 2004).

Table 10.6 Examples of anthropogenic underwater noise levels at source (Nedwell and Howell, 2004)

Source	Max. level at source (dB)	Freq. (Hz)
Seismic surveying – air guns	210 - 259	10- 1000
Cable trenching	178	-
Tug – barge 18km/hr	162	630
Tanker	177	100
Fishing vessel	150 -160	-
Piling (4.3m – 6.5m diameter monopile foundations)	272 - 288	-

The main sources of noise and disturbance during the construction phase of the project would be from pile driving (should that design of foundation be selected), turbine installation, cable laying and increased vessel movements. However, although there is potential to generate noise from these or various other elements of the project, it is considered likely that the only source that could be considered significant would be associated with the installation of piled foundations.

Studies undertaken by Nedwell *et al.*, (2004) as part of the COWRIE funded study showed that noise levels of 272 dB re 1μPa @ 1m from the source were recorded during the construction of the Kentish Flats Round 1 offshore wind farm. For the larger diameter monopile foundations similar to those likely to be installed at Round 2 offshore wind farm sites including Sheringham Shoal, a noise level of 288 dB re 1μPa @ 1m from source was predicted by the model employed by Nedwell *et al.,* (2004).

In addition to the potential impact on the auditory organs of fish, the eyes of certain species and gas sacs of some larval stages are also likely to be sensitive to the vibrations associated with underwater sound. In cases of high intensity sound, these air-filled spaces may be susceptible to damage and possible mortality.

Table 10.7 *Examples of hearing specialisation and sensitivity of selected finfish species (Source: Nedwell et al 2004)*

Common name	Specific name	Family	Swimbladder connection	Sensitivity
Herring	*Clupea harengus*	Clupeoidea	Prootic auditory bullae	High
Sprat	*Sprattus sprattus*	Clupeoidea	Prootic auditory bullae	High
European eel	*Anguilla anguilla*	Anguillidae	None	Medium
Cod	*Gadus morhua*	Gadidae	None	Medium
Atlantic mackerel	*Scomber scomber*	Scombridae	None	Medium
Haddock	*Melanogrammus aeglefinus*	Gadidae	None	Medium
European hake	*Merluccius merluccius*	Merluccidae	None	Medium
Plaice	*Pleuronectes platessa*	Pleuronectidae	No swimbladder	Low
Thornback ray	*Raja clavata*	Rajidae	No swimbladder	Low
Dab	*Limanda limanda*	Pleuronectidae	No swimbladder	Low
Sculpin	*Cottus scorpius*	Cottidae	No swimbladder	Low

With regard to potential effects on shellfish, there is little literature specifically relating to the effect of noise on shellfish species. Whilst the absence of swimbladders suggests low sensitivity, the presence of air-filled spaces could imply that noise could cause physiological damage to shellfish in the immediate vicinity of activities such as pile driving.

Hearing specialists are most likely to be impacted by construction noise associated with offshore wind farm development. The fish surveys indicate that herring and sprat, being hearing specialists, and being recorded in considerable numbers during the April trawls, as the species group most likely to be affected by the noise generated during pile driving.

The impact on herring, and other sensitive fish could range from stimulating avoidance reactions through to physiological damage and mortality depending on the proximity of the fish to the source of the noise. Nedwell *et al.,* (2004) have reported that experiments with caged fish in the vicinity of pile driving activities with a source level of 240-260dB per 1μPa @ 1m showed that fish died instantaneously due to the hyper-expansion and contraction of the swim bladder and that fish exhibited tissue damage resulting in mortality up to 1km away from source.

A study on the effects of sound from geophysical surveys, found that hearing specialists would exhibit a strong avoidance reaction at 180dB of received noise (Pearson *et al.,* 1992). Once disturbed by the noise, the fish, which can detect sound source directions, would increase swimming speeds away from the noise source.

Assuming as the worst realistic case, that 7.5m diameter monopiles would be installed at Sheringham Shoal (see Section 2: Project Description), the noise levels of 288 dB re 1μPa @ 1 m predicted (Nedwell *et al.,* 2004) may be exceeded. Given attenuation over distance, it is likely that a sound level of 180dB, capable of causing avoidance reaction by hearing sensitive fish, would be received around 6km from the source. For highly sensitive species such as herring, this could be as much as 8km (Royal Haskoning, 2005 and RPS, 2005).

It is estimated that a risk of physical injury would occur at around 800m from piling operations and high mortality risk would occur at around 200m. It is likely, therefore, that hearing specialists would be displaced for an area of 6-8km from piling throughout its duration.

On the basis of an 8km area of effect from noise, it is considered possible that during any spawning migration towards the area while piling was taking place, hearing specialists such as herring could be discouraged from approaching to within 8km. Theoretically, this could lead to opportunistic spawning in offshore areas of suitable habitat, or the abandonment of local spawning for that season leading to gamete resorption and reinvestment of energy reserves over the winter. Other species not as sensitive to sound such as cod, plaice and thornback ray are not expected to exhibit such an avoidance response (see Table 10.6).

Should the instinct to spawn override other strategies, Nedwell *et al.,* (2004) state, "*In many cases the noise (from pile driving) may cause an effect which is of no environmental significance. For instance, a behavioural effect in which fish or mammals are simply displaced from the area of the piling to another area of similar habitat for a limited period may well be unimportant*".

In order to reduce the potential for fish mortality to occur during piling, 'soft start' mitigation techniques could be used, where the power and frequency of hammering is built up slowly, from a low energy start-up, over at least 30 minutes (Parvin and Nedwell, 2005). This would give a sufficient period of time to enable hearing sensitive species to detect the source of the sound and move away from the area within which physiological damage and mortality could occur. Although widely accepted and used in mitigation of effects on marine mammals, there are few objective data supporting the soft start technique in terms of effects on fish. Acoustic monitoring could be used therefore to develop and validate the soft start procedure (Parvin and Nedwell, 2005).

The long term impact of displacement or mortality due to noise and vibration as a consequence of construction activities would be of **minor adverse** significance over the relatively short term construction period as the magnitude of the effect is small in terms of the areas affected when compared to the wider marine environment of the Lincolnshire and north Norfolk coast.

The sensitivity of early life stages that may use the area as a nursery ground has not been determined and is poorly understood. It is possible that they would be more sensitive than the adult stages due to the delicate nature of soft tissues during early development prior to metamorphosis to the adult form. However, advection of larvae away from spawning areas of the north Norfolk coast, especially herring, has been investigated in detail (see Section 10.3.3.2). Following any herring spawning in the autumn, hatching and advection of larvae away from the site will take place from October onwards.

Spawning of other species found in the area in the late spring and early summer tends to be dominated by pelagic spawning species including cod and plaice. These species adopt various spawning strategies, but tend to spawn small batches of eggs over protracted periods and large areas rather than spawn in a single annual event at a specific site. Both the eggs and larvae of the majority of pelagic spawning species would be dispersed quickly away from the site in the surface waters by wind and tide driven currents. Subsequently, although it is possible that the early life stages of fish and shellfish may be highly sensitive to the effects of underwater noise from piling, their distribution over wide areas in the pelagic environment leads to the conclusion that the magnitude of any effect would be small. Effects on the early life stages of demersal and pelagic spawning fish from construction noise are therefore considered **negligible**.

Non-hearing specialists among fish do not possess a swimbladder or highly developed acoustico-lateralis systems and include flatfish such as dab, plaice, sole, shellfish and elasmobranches such as the skates and rays. All these species are predominantly demersal in habit over wide areas and the sensitivity of these species to underwater noise is considered to be low and therefore of **negligible** significance.

10.4.5 Suspended Sediment and Dispersion

Dispersion of fine sediment, including chalk fines, as a result of the construction of wind turbine foundations and the installation of cabling was identified as a potentially significant environmental impact with respect to the important shell fisheries of the north Norfolk coast, important spawning and early life stages of epifauna and fish species areas. Construction activities which disturb the seabed and can lead to the re-suspension of surface sediments which are dispersed and deposited in the surrounding area include:

- Any necessary seabed levelling for gravity base foundations;
- Inter array and export cable installation;
- placement of scour protection around turbine foundations; and
- the placement of jack up bases and anchors by construction vessels.

Fishermen in the area have expressed strong concerns regarding the effects of construction activities, particularly the effects of cable installation on the important north Norfolk crab fishery. The most sensitive time of the year for the adult stage of edible crabs in coastal waters is during pairing and mating. Fishermen fear that exposure of edible crabs to increased levels of suspended sediment during this period may cause paired crabs to separate and move away from breeding grounds. If impact levels are sufficiently high to cause failed pairings to occur, the level of recruitment of crabs to the breeding stock could fall in the following season.

Fine sediment would be released into the water column due to disturbance of the bed. Within the study area there are a range of surface and near-surface sediment types that may be disturbed, including small quantities of silt within the mobile surface sediment, large percentages of silt and clay within the channel infills and boulder clay beds, and chalk fines from the nearshore exposures of Cretaceous Chalk.

Sediment dispersion modelling was undertaken using site specific characteristics by HR Wallingford (see Appendix 6.1). A number of scenarios were modelled including:

- Ploughing through chalk using neap and spring tide flow conditions;
- Ploughing through silt/clay/sand mix using neap and spring tide flow conditions; and
- Trenching through chalk using neap tide flow conditions.

The results for ploughing chalk during a neap tide show the dispersion footprint extends for around 9km in each direction, with concentrations dropping to levels of less than 1mg/l (above background) within a single flood or ebb excursion. The higher turbulence spring tide simulation causes the chalk concentrations to drop below 1mg/l (above background) within 4km of the cable route.

Results for fines arising from other bed types with high percentages of fines show the neap tide footprint extends less than 2km, while the spring tide footprint is very small. As before the neap tide footprint is larger due to the lower rate of turbulent diffusion. The extent of the footprint on both tides is less than that of chalk due to the lower amount of material available per metre length of cable and the settling of silt during periods of slacker flows (chalk is assumed to have zero settling). This result is also applicable to much of the inter-turbine cabling within the wind farm site where there are no exposures of chalk.

The worse case scenario is considered to be the dispersion of chalk during trenching on a neap tide. The volume of material released by trenching is higher than other methods, and therefore the extent and persistence of concentrations above 1mg/l (above background) is much greater. The predicted plume extends more than 10km in either direction at a level of up to 20mg/l (above background). It should be noted that the model predicts a gradual drift of the plume towards the shore over the six tides, but that the plume has dispersed to less than 1mg/l concentration before the end of the model run.

The footprint of silt deposition was found to extend over a wide area, but at an undetectable rate. Even under slack water conditions, the maximum rate of deposition over the six tide simulation was less than 0.5mm in the areas of greatest deposition, and in most of the footprint area the rate was far less. This result is anticipated as the deposited fines would be re-suspended on each tide, with no measurable material left in place.

Dispersion and deposition of coarser sediment was not modelled as sand would only be carried a few metres from the point of disturbance. The sediment distribution of the unconsolidated surface layer in large parts of the area affected by the cabling is predominantly gravely sand with a small amount of silt. Grab samples and borehole samples obtained from recent survey work indicate silt content below 4% for this surface layer. The depth of this material varies from 0m to about 1m, apart from the areas of sand waves and banks where depths are much greater. A typical depth appears to be around 0.3m.

The high sand/gravel content of the in situ sediment, together with the relatively small disturbance arising from cable ploughing or trenching to 1m depth, suggests that for most of the cable route the majority of any disturbed sediment would fall immediately to the bed in the immediate location of the cable. Because of the minimal disturbance, fine sand is almost all likely to remain within the bottom 1m -2m of the water column and typical settling velocities of around 10mm/s would ensure that the sand settles within half an hour or becomes part of the ambient near bed transport. Medium or coarse sand would settle within minutes. The vast majority of the disturbed sediment would initially resettle within 20m of the cable, with almost no sand being carried more than 100m from the cable except as part of natural sediment transport. As there is already significant ambient sand transport in the vicinity, the small amounts of additional resettled sand would not change the local transport to any significant degree.

The presence of surface sand/gravel along much of the cable route restricts the extent of fine sediment dispersion, and the modelled results are only applicable to those limited areas where chalk (1.6km) or other competent beds are exposed or have only a very thin surface layer of mobile sand. The plotted model results are therefore conservative for a 1m depth of burial, but still show that suspended sediment would be quickly dispersed. In the areas where the export cables are proposed to be buried up to 3m (shoals / sand waves) the cable is installed in (mobile) sands only, with no disturbance of the underlying chalk or other beds. The percentage of fine sediment (silt and clay) recorded from sediment samples is less than 4% and therefore dispersion from these areas is assumed to be very low in comparison with the areas modelled.

10.4.5.1 Impact on the north Norfolk crab fishery

Scott, (1995) found that the hatching area for edible crabs covers an area of about 550km^2 within the overall area prosecuted by the north Norfolk offshore crab fishery. Eaton *et al*., (2001) suggested a wider area further north towards the Dogger Bank, but also indicate a smaller area of importance to crab hatching in the vicinity of the Race Bank based in CEFAS crab larval surveys in 1976, 1993 and 1999.

The area identified by Scott, (1995) was defined on the basis of a zone of aggregation of crab larvae noted in the 1995 plankton surveys. The analysis concluded that the region between the Dudgeon Shoal, Race Bank and East of the Dudgeon Shoal is vital to the north Norfolk Fishery in terms of the location of over-wintering females and the role of these populations in sustaining the fishery.

Using the highly conservative assumption that the vast majority of disturbed sediment during construction of the wind farm would fall within 20m of the source of disturbance, the maximum worse case area affected by the settlement of suspended sediments on potentially sensitive areas including those used as mating grounds, spawning grounds and nursery grounds, can be estimated by summing the area of each foundation footprint and the area of the inter-connector and export cable route together with a 20m buffer zone. Using this calculation and assuming that the smaller 'local' crab hatching ground with an area of 550km^2 identified by Scott *et al.,* (1995) is directly relevant to the north Norfolk crab fishery, the maximum proportion that could be affected potentially by the smothering would be 0.93% by area. This figure should however be put into context since even under slack water conditions, the maximum depth of deposition of re-suspended sediment over the six tide simulation undertaken was less than 0.5mm in the areas of greatest deposition, and in most of the footprint area the rate was far less.

The Biology and Sensitivity Key Information Sub-programme indicates that the edible crab's sensitivity and intolerance to sediment related impacts is relatively low (www.Marlin.org.uk, 2006), as shown in Table 10.8.

Table 10.8 The Sensitivity and tolerance of edible crab, Cancer pagurus, to smothering and increased suspended sediment concentrations. Source: //www.Marlin.org.uk

Impact	Intolerance	Recoverability	Sensitivity	Evidence/Con-fidence
Smothering	Low	Very High	Very Low	High
Increase in suspended sediment	Low	High	Low	Low
Increase in turbidity	Tolerant	Not Relevant	Not Sensitive	Very Low
Displacement	Tolerant	Not Relevant	Not Sensitive	Moderate

The preferred plough method of cable installation for the export cable would further minimise sediment disturbance and re-deposition. Given the relatively small area of chalk and fine sediments affected, the short term nature of operations, and the seasonality of crab movements, the magnitude of the potential effects of cabling on the north Norfolk crab fishery is considered small. This, combined with the low to very low sensitivity of edible crab to smothering and increases in suspended sediment respectively leads to the conclusion that a **negligible** impact on the north Norfolk crab fishery is anticipated.

10.4.5.2 Impact on the herring spawning ground

CEFAS advises that the proposed wind farm site borders a herring spawning ground (CEFAS, 2004b) while Coull *et al.,* (1998) (see Figure 10.3) indicate that the proposed site is positioned centrally within it, although the accuracies of these boundaries are not certain (see Section 10.3.3.1). It is not possible to calculate the exact area of the spawning ground, but an informed estimate suggests that it could account for approximately 15% and 5% of ICES rectangles 35F1 and 35F0 respectively. This equates to an area of approximately 618km^2.

Although the project survey data do not support the alleged importance of the area as an active herring spawning ground, even given a worst case scenario that the entire wind farm site lies within an area important to herring spawning, calculations of direct habitat lost due to installation and the potential area of loss affected by smothering give a maximum of less than 1% of the estimated spawning ground area shown by Coull *et al*. (1998). The magnitude of effect is therefore considered to be extremely small. As the importance of the area for herring spawning is based on historical survey data last collected in the 1980s, and the current survey data do not support this assumption, the sensitivity of herring spawning to suspended sediments from construction operations is not considered relevant. **No impact** is anticipated.

10.4.5.3 Impact on the natural fish resource

Early life stages of epifauna and fish species important to the natural resources of the area could be adversely affected by fine chalk particles released into suspension, or their settlement on the seabed. However, even though the route required for the export cables needs to go through a short section (1.6km for the preferred route) of inshore area that contains chalk the amount of disturbance of sediment is low to moderate for the plough and trenching techniques (see Section 6 & Appendix 6.2). Although some chalk would be displaced, the material that re-deposits on the seabed close to the source would be coarser sediments such as sand. Due to the small size of the chalk particles, they would tend to remain in suspension and be dispersed away from the site, with their concentration falling to background levels within six tidal cycles (see Section 6: Hydrodynamics and Geomorphology).

The majority of fish species found in the Sheringham Shoal study area are considered to be tolerant of the moderately high levels of turbidity commonly encountered during storm events, and the short term increases in suspended sediment concentrations predicted during the worse case scenario (i.e. trenching) are not considered to rise above background levels for a significant period. On this basis, the magnitude of effect is not considered significant as the maximum areas affected are highly localised. The potential impact of increases in suspended sediment or smothering on the natural fish resource is considered to be of **negligible** significance.

10.4.5.4 Impacts due to release of sediment-bound contaminants

The re-suspension of sediments during construction works has the potential to result in the release of sediment-bound contaminants in the water column which may be toxic to fish and shellfish. Section 7: Marine and Coastal Water Quality concluded that the impact on water quality as a result of the construction of the Sheringham Shoal project would have an overall impact of negligible significance from re-mobilisation of contaminated sediments. As such the impact on the fish resource of the study area is also considered to be of **negligible** significance.

10.4.6 Accidental spillage of construction materials

During the construction period, there is the potential for pollution from spills or leaks of fuel, oil and construction materials such as grout and drilling lubricants. Section 7: Marine and Coastal Water Quality concluded that it is not possible to assess the significance of a particular pollution incident as this is dependant on the nature of the incident (e.g. location, scale, type of pollutant). However, the approach which will be taken is to rigorously implement pollution prevention measures to minimise the possibility of any pollution incident. This assessment proceeds on the assumption that effective prevention measures will be deployed.

It is anticipated that grouting material would be used during the installation of a number of the foundation options being considered (see Section 2). Information on the sensitivity of receptors on the seabed to the effects of spillages of grout are described in Section 9, Benthic Ecology. Considering that the magnitude of any effect in the water column is likely to be less than that on the seabed, there is expected to be **no impact** or at most, an impact of **negligible** significance from accidental spillage of construction materials on the fish and shellfish resource of the study area.

10.5 Impacts during operation

10.5.1 Introduction

Research reports by COWRIE, together with studies of existing offshore wind farms such as the Horns Rev and Nysted developments (where extensive results of post construction monitoring have been placed in the public domain through a series of technical reports) suggest that the impacts and effects on natural fish and shellfish resources during the operational phase of the proposed wind farm at Sheringham Shoal are likely to be similar.

The operational impacts identified during the EIA are:

- the potential for electromagnetic fields from the cable infrastructure to affect the behaviour or sensitivity of species such as elasmobranch fish;
- operational noise from the turbines being transmitted through foundations and into the marine environment; and
- those impacts associated with the introduction of artificial habitats e.g. scour protection.

These are addressed in turn and where appropriate, mitigation is proposed in the following sections.

As the final design details and the specification for the proposed wind farm within its design envelope are to be confirmed, a range of potential impacts are described; however, the assessment of significance of effects is based on the worst realistic case.

10.5.2 Electromagnetic fields

The COWRIE 1.5 Electromagnetic Fields Review (Gill *et al.,* 2005) specifically considers the potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms.

The results of the COWRIE Phase 1 (CMACS, 2003a) work demonstrated that the EMF emitted by industry standard AC offshore cables had a magnetic (B) field component and an induced electric (iE) field component. These EMF components were assessed as being within the range of detection by EM-sensitive aquatic species but whether any potential impact would result remained unknown.

CMACS (2003a) found the following for a cable modelled with perfect shielding/earthing:

- There is no direct generation of an E field outside of the cable;
- B-fields generated by the cable created ‘induced’ E-fields (iE) outside of the cable, irrespective of shielding;
- B-fields are present in close proximity to the cable and the sediment type in which a cable is buried has no effect on the magnitude of the B-filed generated;
- The magnitude of the B-field within millimetres of the cable, referred to as its ‘skin’, is approximately 1.6μT, which would be superimposed on any other B-fields in the surrounding area e.g. the Earth’s geomagnetic field of 50μT; and
- The magnitude of the B-field associated with the cable falls to background levels within 20m.

Considering the results of the modelling in respect of its significance to electro sensitive fish the report found the following:

- The EMF emitted by an industry standard subsea cable will induce E-fields that will be retained within industry standard cables;
- The iE-fields calculated from the B-field were also within the range of detection by elasmobranchs;
- Changing the permeability or conductivity of the cable may effectively reduce the magnitude of the iE-field;
- To reduce the iE-field such that it is below the level of detection of elasmobranchs would require a material of very high permeability, which would minimise the potential for avoidance reaction but may still result in an attraction response;
- The relationship between the amount of cabling present, producing iE-fields and the available habitat of electro sensitive species is an important consideration.

Gill *et al*., (2005) concluded that for E-fields, there are many electro sensitive fish that are potentially capable of responding to anthropogenic sources of an E-field; however, it is uncertain whether an artificial E-field would result in a response in a fish or have any adverse effect. Their conclusion regarding review of literature available for magnetic fields was that information was limited, but it did suggest that B-field emissions of the magnitude that might be expected to be associated with wind farm cables could interact with coastal organisms at a cellular or behavioural level.

In general, two types of cable have been used in offshore wind farms to date. 33kV cables have been used as inter connector cables within the turbine array to deliver the DC power generated to the offshore substation(s). From this point 132kV export cables carry the AC power from the substations to shore based terminals prior to distribution to the National Grid network.

CMACS, (2003a) and Gill *et al.*, (2005) have shown that the electromagnetic fields (B-Fields, and iE-Fields) detectable from the 33kV inter-connector cables have a greater potential to effect sensitive species than the larger capacity 132kV export cables. For the purposes of this assessment, the worst realistic case would be the installation of the greatest length of 20kV - 50kV inter-connector cables that would comprise in the order of 70km of cabling within the turbine array.

10.5.2.1 Impacts of electromagnetic fields on sensitive species

B-fields

Gill *et al.,* (2005) concluded that all Elasmobranchii, Holocephali and Agnathans possess the ability to detect magnetic (B) fields. Teleost fish species that are likely to be affected by the B-field include European eel, salmon, sea trout, tunas, mackerel and plaice.

Of the elasmobranchs, thornback ray, spotted ray and spurdog are known to be present off the north Norfolk coast. There is currently no available evidence to show whether the magnitude of the B-field produced by a wind farm cable would have a detrimental impact on the normal behaviour of magnetically sensitive fish. The type of cable to be used in the Sheringham Shoal project would reduce the B-field emission well below the magnitude of the Earth’s geomagnetic field. As such, the impact of B-fields on magnetically sensitive species is considered to be of **negligible** significance.

iE-fields

Electro sensitive species would most likely be able to detect the iE-field emitted by a shielded cable up to a distance of around 20m from the source. Exposure to the strongest magnitudes of the iE-field can be reduced by burial, although it is not fully understood whether or not elasmobranchs would be able to detect these fields and the requirement for further studies through COWRIE have been acknowledged. iE-Field sensitive species found in the vicinity of the wind farm include thornback ray, European eel, cod, plaice and salmon (Gill *et al.,* 2005).

Monitoring studies at the Nysted wind farm off Denmark indicated a behavioural change in swimming patterns (direction of migration) by European eel to the 132kV buried cable; however, the results were inconclusive. The fish could equally have been moving away from cold or shallow water (ENERGI E2 A/S, 2005).

The EM-Fields produced by the cables would be greatest while turbines are operating at their optimum speed. This would not occur all of the time and there would be times of low wind strengths when EM-Field emission from the cables would be virtually zero.

Current understanding is that the levels of EM-Fields anticipated would at most cause a highly localised impact on fish, and the review by Miller (2005) concluded from studies and observations made during Danish and German monitoring of offshore wind farms that no significant adverse effect on fish species by EM-Fields was evident. Although the sensitivity of a limited number of species has been reported in the literature, definition of significant effects has been inconclusive. For the purpose of this assessment, it is considered therefore that the impact of iE-field emission on sensitive species would be of **negligible** significance.

Further monitoring of the natural fish resource may be required during operation of the Sheringham Shoal project in order to better understand the significance of any impact. Monitoring requirements and the efficacy of them will be discussed with CEFAS.

10.5.2.2 The potential scale of cable infrastructure

In calculating the potential area of seabed that may be affected by EMF emission from inter-turbine and export cables, it is necessary to consider the area of the turbine array most likely to be affected by EM-Fields. The combined length of the cables is converted into an area by multiplication of their track length by the 20m width either side of the cables where EM-Fields are likely to be encountered (i.e. approximately 40m width in total).

Table 10.9 presents the potential, precautionary area of impact of EM-Fields in relation to the area of ICES rectangle 35F1.

Table 10.9 The potential area of impact (km^2) of EMFs by the development in relation to ICES statistical rectangle 35F1

Length of internal cabling x width of cable corridor	Length of export cables x width of cable corridor	Potential area affected	Area of ICES rectangle 35F1	Percentage of ICES rectangle 35F1 affected
47.5km x 40m = 1.90km^2 (minimum)	2 x 22.8km x 40m = 1.82km^2	3.72 km^2	3091km^2	0.12%
67.2km x 40m = 2.69km^2 (worst case)	2 x 22.8km x 40m = 1.82km^2	4.51km^2	3091km^2	0.15%

The cable layout of the inter-turbine array cables for the Sheringham Shoal project would depend on the turbine layout eventually decided, but indicative calculations on the length of cabling required for several array designs are presented in Section 2 (see also: Scira report). For the worst realistic case in the order of 70km of inter-connector cabling would be required. The cable would consist of 20kV - 50kV 3-core copper conductors, insulation/conductor screening and steel wire armoured, buried to a minimum target depth of 1m.

There are two options for the export cable route, detailed in Section 2. The preferred direct route is 21km long and the alternative western route 22km long. The export cabling consists of two copper core XLPE armoured 132kV - 150kV subsea cables with a fibre optic communications cable. This would be buried to a minimum depth of 1m save over Sheringham Shoal where, should the direct route be chosen, the cable would be buried where possible to a depth of 3m. The export cables would be buried up to 100m apart.

Until the final choice of cable design is made, it is not known what the exact magnitude of B and iE-field emissions would be. However, it is considered likely to be in line with the predictions made in the COWRIE report of 1.5μT for the B-field, well below the naturally occurring magnitude of the Earth's geomagnetic field, and 2.5μV/m for the iE-field. This implies that the B-field would potentially be detectable to magnetically sensitive fish species and that the iE-field would be within the minimum range that could either attract or repel electro sensitive fish species (0.5 - 100μV.m; Gill *et al*., 2005). The impact of the EMF would be highly localised, as the effects would only be detectable within approximately 10-20m either side, or above each cable within or from the wind farm. Based on current understanding of EM-fields and the scale of operation in the wider area, it is considered that the significance of effects of EM-fields on sensitive species would be **negligible to minor adverse**.

10.5.3 Operational noise and vibration

Studies of other offshore wind farms (e.g. Westerberg, 1999) suggest that fish habituate over time to the noise and vibration of the turbines and that fish numbers actually increase within the wind farm. This may however be due to the aggregating effect of the turbine structures. Hearing specialists such as herring are known to tolerate, and even be found in the near vicinity of relatively noisy structures, such as oil and gas platforms (Valdermarsen, 1979 cited in CMACS, 2003b).

Hoffman (2000) states that turbines will produce low frequency noise and vibration stimuli in the near-field that fish would perceive as hydrodynamic motion around the turbine foundations. However, this motion would not impair the ability of the fish to distinguish between the motion generated by the turbine and that produced by other predator and prey organisms.

It is considered likely that the initial 'start-up' of the turbines would result in an immediate startle response amongst hearing sensitive species if the process were sudden. This would be followed by a short period of avoidance.

Henriksen *et al.,* (2001) studied the operational underwater noise produced at the Middlegrunden, Vindeby and Bockstigen-Valar offshore wind farms. Measurements were taken at different wind speeds and when the turbines were and were not operating. Table 10.10 presents these data (see also CMACS, 2003b).

Table 10.10 Peak underwater source levels and frequencies of turbines at three Scandinavian offshore wind farms

Wind Farm/Turbine Type	Wind Speed (m/s)	Source Level (dB re: 1 µPa2/Hz)	Noise Frequency (Hz)*
Middlegrunden, Denmark 20 x 2MW 'Bonus' turbines (concrete foundations)	13 6 6	115 101 111	125 125 25
Vindeby, Denmark 5 x 0.55MW 'Windworld' turbines (steel monopile foundations)	8 8	108 108	160 16
Bockstigen – Valar, Sweden 11 x 0.45MW 'Bonus' turbine (concrete foundations)	13 13	113 130	125 25

* Frequencies given are the centre frequencies of 1/3-octave bands

The figures presented Table 10.10 are comparable with the sound levels associated with offshore oil and gas drilling platforms, but are significantly less than that produced by most boats and ships (CMACS, 2003b).

Danish operational noise measurements for turbines mounted on monopile and gravity foundation types at Bocksigen – Valor, Gotland and Middlegrunden showed maximum underwater noise levels at 20m from the source were 95dB (monopile) and 125dB (gravity) at frequencies <500Hz. Background noise levels within the same frequency range were 70-80dB (Anon., 2000).

Pearson *et al*., (1992) reported that noise at a level of 180dB is required to stimulate behavioural changes in hearing specialists such as herring. Following an initial 'start up' reaction, fish would be expected to habituate to the noise produced by operating turbines and would return to the area within a relatively short period of time. Monitoring reports from the Nysted and Horns Rev offshore Wind Farms off Denmark (ENERGI E2 A/S, 2005; Birklund, 2005) illustrate the presence and possible attraction of fish to turbine structures. The impact of operational noise and vibration on the natural fish resource is therefore assessed as **negligible**.

10.5.4 Artificial habitats

Any concrete or steel structure in the sub-tidal region around the coast of the UK soon becomes colonised by a range of benthic invertebrate species which facilitate an increase in mobile species utilising the increased habitat stability and complexity. The presence of hard structures, especially if covered in a potential prey resource, is known to promote aggregations of fish in the area surrounding the structure (e.g. Marine Conservation Society, 2000). Aggregations of fish from the surrounding area, however, does not directly equate to increased fish biomass in the surrounding area.

The area of available new habitats through seabed take and the installation of scour protections was calculated and presented in Section 10.6. It is anticipated that the pattern of colonisation by fouling communities and species already observed at operational offshore wind farms e.g. Horns Rev and Nysted off Denmark (ENERGI E2 A/S, 2005; Birklund, 2005) would also occur at Sheringham Shoal. This has the potential to lead to an increase in fish numbers within the turbine array during its operational phase. This is particularly likely amongst species such as bass and whiting that tend to shoal near reefs, wrecks and other submerged structures. The provision of scour protection would act to further increase habitat potential over time and increase the site's attractiveness to fish and shellfish, especially crustaceans such as crabs and lobster that would seek refuge within the rocky habitat created and would feed on the detritus and colonising invertebrate fauna.

The worst realistic case i.e. 108 turbine bases with scour protection is likely to have the greatest effect. This would provide feeding and refuge potential to fish and shellfish species that would potentially be considered as a beneficial impact of the Sheringham Shoal project throughout its operational life.

The aggregating effect of the turbine structures would increase the number of fish within the site boundary rather than increase the biomass and productivity of the fish resource in the wider area. This may lead to positive implications for the site as a trawl refuge. For shellfish resources the benefits through provision of cryptic habitat may well be greater (see also Section 9, Marine Ecology). As such, the potential impact could be considered to be of **minor beneficial** significance.

10.6 Impacts during decommissioning

10.6.1 Introduction

Although guidance on the assessment of decommissioning of offshore wind farms in the UK is not yet clear; it is readily acknowledged by regulators (and developers) that the removal of the operational and salvageable components is desirable so that the environment can be allowed to return to its natural state as much as possible, and removable components can be recycled or disposed of responsibly in accordance with the relevant licence conditions. It is conceivable, however that the fouling and epibenthic communities around scour protection measures and submerged hard structures such as gravity bases would have matured and it may be counter productive to natural fish and shell fish resources to remove them. For monopiles it may be possible to remove foundations at seabed level.

The decommissioning impacts identified during the EIA are:

- impacts and effects due to noise and vibration; and
- temporary disturbance of seabed habitats.

These are addressed in turn and where appropriate, mitigation is proposed in the sections below.

10.6.2 Noise and vibration from Decommissioning

The noise and vibration elements associated with the decommissioning of the Sheringham Shoal project would be largely similar to that experienced during construction such as increased vessel movement, jack-up operations etc. There would not, however, be any pile driving, so the level of noise and vibration experienced in the construction phase would be greatly reduced. While it is anticipated that, on occasion, there could be noise produced above the 180dB re 1μPa at 1m threshold level required to cause avoidance reactions in hearing specialist fish, such noises would be limited in frequency of occurrence, duration and extent.

It is envisaged as a worst realistic case that operations such as cutting and the associated vessel movements to facilitate the removal of turbines, towers and bases from their foundations would only cause a temporary displacement of fish and shellfish from the area immediately affected. Taking into consideration the sensitivity of species to construction noise (see Section 10.4.4), and the threshold required to initiate an avoidance response in sensitive species, the potential impact of increased noise and vibration from decommissioning on the natural fish resource is considered to be short term and therefore of **negligible** significance.

10.6.3 Disturbance of habitats

It is anticipated that cabling would remain in place following decommissioning, so no significantly elevated suspended sediment levels would be expected due to excavation and cable termination.

With reference to the removal of foundation bases, it is anticipated that the impact on fish species in terms of temporary displacement from seabed habitats would be localised and short in duration. In the event that scour protection measures around turbine bases are required, it is possible that this would be left in situ due to the habitat that has been created. Once the turbines and towers have been removed, and the decommissioning vessels have moved on, fish and shellfish would readily return to the area of disturbance. In the short term, fish may be attracted by the foraging opportunities that would arise as a result of this temporary disturbance of the seabed.

In the absence of scour protection measures, the loss of the foundation bases and associated fouling communities that would have developed to maturity upon them would mean that the area loses a component of its added attraction to fish and shellfish. This decrease in the potential of the wind farm as a fish aggregation device would lead to a decrease in the number of fish and shellfish present at this location; particularly the gadoid species that are the most attracted to upright structures.

Complete removal of structures providing a mature habitat for fisheries resources and the effective removal of a trawl refuge may result in a **minor adverse** impact at decommissioning. Prior to decisions on decommissioning being made, these matters will, however, be discussed with the competent authorities to agree the most appropriate course of action so that environmental effects are minimised.

10.7 Cumulative effects

10.7.1 Cumulative construction-related Impacts due to noise and vibration

In addition to the Sheringham Shoal project, there are three other offshore wind farm proposals off the north Norfolk coast and in proximity to the Sheringham Shoal site namely; Race Bank to the north-west, Docking Shoal and the Norfolk wind farm to the south-east that have full consent. Several other sites are planned, these include Triton Knoll, Dudgeon, Lincs, Lynn and Inner Dowsing, however, these are not considered due to either the distance separating the schemes or that their construction programmes are not expected to overlap with the Sheringham site. At the time of writing no information was available on the site specific characteristics of Docking Shoal or Race Bank.

With regard to piling noise, and assuming that the Round 1 sites will be operational by the time Round 2 construction starts, the worst realistic case would be if piling activities were carried out simultaneously at Race Bank, Docking Shoal, and Sheringham Shoal. It is anticipated that hearing specialists such as sprat and herring, would be displaced up to 8km from the piling operation on each wind farm for the duration of piling (Royal Haskoning, 2005, RPS, 2005). While any spatial displacement patterns of shoals of hearing specialist species such as herring would depend on their aversion response, they would not necessarily overlap. Given the assessment of impacts at the Sheringham Shoal site and the mitigation such as soft start the cumulative effect of noise during construction is anticipated to be of **negligible to minor adverse** impact.

It is anticipated that the cumulative impact of construction noise from all three wind farms in parallel would be of **negligible** significance in terms of shellfish and fish resources, but the construction of the offshore wind farms over consecutive years could have an effect of **minor adverse** significance on sensitive species as the impact would be imposed over a longer period.

10.7.2 In-combination construction related impacts

A major concern of the fishing industry in the area is that construction of the offshore wind farm programme would add further adverse impacts to a region with a long history of ongoing aggregate extraction and other marine activities such as commercial shipping and offshore gas field operations.

Aggregate extraction is an established industry in the Greater Wash area. Activities associated with industrial scale aggregate extraction may lead to increased turbidity through the re-suspension of fine sediments in the water column; however, seabed preparation for turbine foundation installation and cabling methods such as ploughing are low in intensity by comparison.

Although turbine installation could add to levels of sediment already suspended in the water column from aggregate extraction and trawling activities, the in-combination effect with offshore wind farm construction in the area in terms of raising suspended sediment concentrations beyond 30mg/l to levels that could lead to significant effects on natural fish and shellfish resources is not considered significant. The location of the Sheringham Shoal site in ICES rectangle 35F1 is spatially isolated from the main areas of activity of Round 2 Offshore Wind and marine aggregate extraction in the Greater Wash and ICES rectangle 35F0 further east and far beyond the extent of the potential plumes likely from the construction activities.

Because of its relative isolation of the site with regard for sediment transport in suspension, in-combination effects from the re-suspension of sediments from the Round 2 offshore wind farms in the Greater Wash are considered **negligible** with respect to the Sheringham Shoal proposal.

10.7.3 Cumulative operational-related impacts due to noise and vibration

The operational noise and vibration produced by the wind farms would be highly localised within each array. Based on the environmental monitoring reports of the Danish offshore wind farm sites (ENERGI E” A/S, 2005; Birklund, 2005) it is anticipated that the impact of operational noise for the Sheringham Shoal project would be of negligible significance within the wind farm. Given the anticipated extent of noise and vibration impacts and expected habituation, there would be a **negligible** impact in terms of the cumulative effect of operational noise with the other proposed north Norfolk coast wind farms.

10.7.4 Cumulative operational-related impacts due to EM-Field emissions

For the purposes of this assessment, it has been assumed that all the wind farms will gain consent and that the associated cabling would produce a similar level of EM-Fields over a similar area. Based on a search, there are no other seabed cables in the vicinity of the Sheringham Shoal site. It is anticipated that export cables such as Race Bank would emit EM-Fields in a manner similar to that of the Sheringham Shoal export cables. With the proposed wind farms and other subsea cabling in this section of the southern North Sea, it is likely that electro sensitive species, such as thornback ray and European eel, would potentially encounter more than one EM-Field source on a number of occasions.

Allowing for the ongoing COWRIE studies and post-construction monitoring for Round One and Round Two offshore wind farms a precautionary approach has been adopted to this assessment. Table 10.11 indicates the area of potential impact of EMF emissions of the proposed north Norfolk coast wind farms. The same assumptions are made for each wind farm.

Assuming that there is a 20m impact zone on each side of the export cables (see 10.4.3.1), dual export cables are considered as two separate zones of impact 40m across, except for Cromer where the cables are buried closer to each other so just one zone of impact 40m across is assumed.

Table 10.11 Comparisons of potential areas for EM-Field emissions from the north Norfolk wind farms

Wind Farm	Area of interconnector cables (km^2)	Estimated length of export cable (km) and no. of cable channels	Estimated area of impact of export cable (km^2)	Total area of potential EMF effect (km^2)
Sheringham Shoal	1.90 (min) 2.69 (max)	2 X 22.8	1.82	3.72 (min) 4.51 (max)
Cromer	1.07 1.29	1 X 6.8	0.27	1.34 1.56
Race Bank	5.63 6.83	2 X 59	4.72	10.35 11.55
Docking Shoal	7.99 9.69	2 X 47	3.76	11.75 13.45

N.B. figures are estimates only and may change once design specifications are finalised

In reality the area of impact would almost certainly be very much less than the figures quoted but considering the worst case scenario and adopting a precautionary approach, the cumulative area that may impact on particularly sensitive fish species, such as elasmobranchs, is within the range 27.16 to 31.07km^2. This equates to 0.44% to 0.50% of the combined area of ICES rectangles 35F1 and 35F0.

The potential impact of sensitive species having repeated encounters with EMF emissions is unknown. However, in terms of overlap between each wind farm, given that EMF emissions drop to zero within a few metres of the cables, it is concluded that there would be a **negligible** cumulative impact on sensitive fish species.

10.8 Monitoring proposals

Any monitoring proposals required as condition of consent would be undertaken to the same specification as those undertaken for the baseline surveys so that direct comparison can be made. The surveys and analysis of natural fisheries resources undertaken to date have the capability to be taken forward through the construction and post construction phases of the development. The dialogue that has been established with the competent authority, statutory consultees and their advisors will continue.

The results of the latest "in-field" studies being commissioned by COWRIE on the effects of EM-Fields on elasmobranchs will be considered, prior to any further monitoring on this subject.

In addition to the findings of this Environmental Statement, the monitoring conditions of existing FEPA licences relating to consented offshore wind farms and the monitoring reports of other European offshore wind farms (e.g. Nysted and Horns Rev in Denmark) will be considered to inform future monitoring proposals.

10.9 Summary

Data on the natural fish and shellfish resource within study area was collected from a number of sources including commercial fisheries information from ESFJC, CEFAS and Defra (landings statistics), published literature, site specific fish surveys carried out for the Sheringham Shoal site and the results of surveys undertaken for other offshore wind farms. The site-specific surveys targeted fish and shellfish species during April, July, and September. Data from acoustic, benthic and epibenthic surveys have also been used to supplement the fish surveys.

In excess of 70 species were caught during the three surveys periods. The most numerous species encountered during the April survey were immature herring and whiting that are of importance to commercial fish resources. Non-commercial fish species dominated the July and September surveys. The demersal and benthic fish assemblage is considered as typical for the area and is similar in diversity to previous surveys carried out within the general area by IECS at these times of year.

Whilst there is no evidence to indicate that the distribution of fish within the survey area is linked to geographical location or indeed depth, a consideration to take into account is sediment type. While the sediment characteristics may be suitable for herring spawning in small areas within the wind farm site, the lack of any herring in the fish surveys in either July or September make it very unlikely that spawning took place in the vicinity of the site in 2005. As herring return to a specific area in the autumn to spawn year after year, the results of the summer and autumn surveys indicate that herring do not use the wind farm area or the cable route as a spawning ground.

The data for all species indicate that the fish assemblage, in terms of those species considered to be of commercial or recreational interest, is dominated by juvenile and adolescent fish with few mature adults present. The benthic assemblage of non commercial fish species was represented by a wide range of age groups. No species of conservation importance, as designated by the Bern convention, were caught.

The most notable feature from the trawl survey results was the increase in abundance of pink shrimp within the survey area from April to September. By comparison, edible crabs, velvet crabs and lobsters showed no clear seasonality of abundance. The distribution of pink shrimp and velvet crabs tended to centre to the south and west of the proposed boundary of the Sheringham shoal turbine array.

Noise created during the construction period, in particular through pile driving, is anticipated to be the source of the greatest potential risk of an impact upon sensitive fish species in the form of physiological damage and, in extreme cases, lethal effects. However, by adopting working practices, such as soft-start piling, these impacts can be reduced effectively, and a **minor adverse** impact is anticipated

Increased suspended sediment concentrations caused through the cable installation process particularly have the potential to impact upon shellfish. The short term nature of construction would alleviate the significance of any effects upon crab and shrimp migration, and the settlement of juveniles. Effects would be further reduced by the localised nature of sediment deposition around the turbine foundations and cable route to shore. If chalk is encountered during the cable installation, any resulting plume would be reduced to insignificant concentrations (<1mg/l above background) within six tidal cycles. Any residual effects are expected to have a localised minor adverse impact on shellfish.

Potential impacts during the operation of the wind farm include underwater noise and vibration, the fish aggregating effect of the structures, and the influence of EM-Fields on sensitive species. The impacts of EM-Fields are under investigation and not yet fully understood. The recent COWRIE report on the matter was inconclusive pending further industry and Government funded collaborative research. Further “in-field” studies are anticipated as part of the next COWRIE commissioned work into the subject area.

Cumulative and in-combination effects relating to construction activities; in particular, underwater noise and the re-suspension of sediments are not considered significant due to the distance separating Sheringham Shoal from the other wind farm sites in the Greater Wash area.

10.10 References

- Anon., (2000). Offshore wind turbines – VVM. Underwater noise measurements, analysis and predictions. SEAS distribution AmbA. Odegaard and Danneskiold-Samsoe A/S. Report No. 00.792 rev 1. (ODS ref. 99.1314) 29pp.
- Arnold, G.P. (2000). Movements of plaice and cod. Handout, CEFAS Lowestoft, 3pp.
- Bailey, R.S. (1980). Problems in the management of short-lived pelagic fish as exemplified by North Sea sprat. Rapports et Procès-Verbaux des Réunions du Conseil International pour l'Exploration de la Mer 177, 477-488.
- Bannister R.C.A. (1999). A Review of Shellfish Resources and their Management. Dr Walne Memorial Lecture, CEFAS Lowestoft.
- Bartsch, J., Barnder, K., Heath, M.R., Munk, P., Richardson, K. and Svendsen, E. (1989). Modelling the advection of herring larvae in the North Sea. Nature, 340, 632 – 636.
- Bennett, D.B., (1995). Factors in the life history of the edible crab (Cancer pagurus L.) that influence modelling and management. ICES Marine Science Symposia, 199, 89-98.
- Birklund, J. (2005). Surveys of hard bottom communities on foundations in Nysted Offshore Wind Farm and Schonheiders Pulle in 2004. DHI Water and Environment. Report to Energi E2 A/S, 52pp.
- Blaxter J. H. S. and J. R. Hunter. 1982. The biology of the clupeoid fishes. Advances in Marine Biology. 20. 1-223.
- Bolle, L.J., Rijnsdorp, A.D., and De Clerck, R. (1989). Monitoring juvenile stocks of flatfish iin the Wadden Sea and coastal areas of the southwestern North Sea. Helgolander Meeresuntersuchungen 43: 461-477.
- Braber, L. and de Groot, S. J. (1973). The food of five flatfish species (Pleuronectiformes) in the southern North Sea. Netherlands Journal of Sea Research 6, 163–172.
- Brander, K. (1994). Spawning and Life History Information for North Atlantic Cod stocks. ICES Cooperative Research Report, 205.
- BWEA, (1994). Best Practice Guidelines for Wind Energy Development. The British wind Energy Association. 24pp.
- CEFAS, (2004). Offshore Wind Farms: Guidance note for Environmental Impact Assessment in respect of FEPA and CPA Requirements. Prepared by CEFAS on behalf of the MCEU. June 2004, 45pp.
- CEFAS, (2004b). Summary of CEFAS current position on fish and (shell)fisheries EIA for the Sheringham Shoal Offshore Wind Farm site based on: Draft Scoping Report, June 2004; Meeting minutes dated 19 July 2004. SCIRA-3-3-0-EX-2M-06524-VI.
- CEFAS and The Environment Agency (2000). Salmon Stocks and Fisheries in England and Wales, 1999. Preliminary assessment prepared for ICES, April 2000. 58pp.
- Clark, R.S. (1922). Rays and Skates (Raiae) No. 1. Egg capsules and young. Journal of the Marine Biological Association of the United Kingdom, 12: 577-643.
- CMACS (2003a). A baseline assessment of electromagnetic fields generated by offshore wind farm cables. COWRIE Report EMF-01-2002 66.

- CMACS (2003b). Chapter 5: Biological Environment in: Seascape Energy. Burbo Offshore Wind Farm Environmental Statement.
- Corten, A. (2001). The role of conservationism in herring migrations. Reviews in Fish Biology and Fisheries, 11(4): 339 – 361.
- Compagno, L.J.V. (1984). FAO Species Catalogue. Vol. 4, Part 1 Sharks of the World. FAO Fisheries Synopsis 125: 1-249. Food and Agriculture Organisation of the United Nations: Rome.
- Coull, K.A., Johnstone, R., and Rogers S.I. (1998). Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOOA Ltd.
- Daan, N. (1978). Changes in Cod Stocks and Cod Fisheries in the North Sea. Rapports et Procès-Verbaux des Réunions du Conseil International pour l'Exploration de la Mer, 172, 39–58.
- Daan, N., Rijnsdorp, A.D., and Van Overbeeke, G.R. (1985). Predation by North Sea herring Clupea harengus on eggs of plaice Pleuronectes platessa and cod Gadus morhua. Transactions of the American Fisheries Society, 114: 499-506.
- De Clerck, R. and Buseyne, D. (1989). On the feeding of plaice (Pleuronectes platessa L.) in the southern North Sea. ICES CM 1989/G:23. 21pp.
- Defra, (2005). Nature Conservation Guidance on Offshore Wind farm Development. A guidance note on the implications of the EC Wild Birds and Habitats Directives for developers undertaking offshore wind farm developments. Version R1.9. 124pp.
- De Veen, J.F. (1967). On the phenomenon of soles (Solea solea L.) swimming at the surface. Journal du Conseil pour l'Exploration de la Mer, 31: 207-236.
- De Veen, J.F. (1978). On selective tidal transport in the migration of North Sea plaice (Pleuronectes platessa) and other flatfish species. Netherlands Journal of Sea Research 12: 115-147.
- DTI, (2001). North sea fish and fisheries. Technical Report TR_003, Technical report produced for Strategic Environmental Assessment – SEA2. 72pp.
- Eaton. D.R., Addison, J.T., Milligan, S.P., Brown, J. and Fernand, L.J., (2001). Larvae surveys of edible crab (Cancer pagurus) off the east coast of England: implications for stock structure and management. ICES CM 2001/J:14. 10pp.
- Edwards, E. (1979). The edible crab and its fishery in British waters. Farnham, England: Fishing News Books Ltd. 142pp.
- Ellis, J.R., Dulvy, N.K., Jennings, S., Parker-Humphreys, M., and Rogers, S.I. (2005a). Assessing the status of demersal elasmobranches in UK water: a review. Journal of the Marine Biological Association of the United Kingdom, 85: 1025 – 1047.
- Ellis, J.R., Cruz-Martinez, A., Rackman, B.D., and Rogers, S.I. (2005b). The distribution of chondrichthyan fishes around the British Isles and implications for conservation. Journal of Northwest Atlantic Fishery Science, 35.
- Ellis, J.R., Cruz, A., Rackham, B.B. and Rogers, S.I. (2003). The distribution of chondrichthyan fishes around the British Isles and implications for conservation. Journal of Northwest Atlantic Fishery Science, 35: 195-213.
- Ellis, J.R., Pawson, M.G. and Shackley, S.E. (1996). The comparative feeding ecology of six species of shark and four species of ray (Elasmobranchii) in the North-East Atlantic. Journal of the Marine Biological Association of the United Kingdom, 76: 89 – 106.
- Ellis, J.R. and Shackley, S.E. (1995). Observations on egg laying in the thornback ray, Raja clavata. Journal of Fish Biology, 46: 903 – 904.

- ENERGI E2 A/S (2005). Review Report 2004. The Danish Offshore Wind Farm Demonstration Project: Horns Rev and Nysted Offshore Wind Farm Environmental Impact Assessment and Monitoring. 135pp.
- English Nature. (2004). Southern North Sea Marine Natural Area Profile: A contribution to regional planning and management of the seas around England. Peterborough: English Nature.
- Envision (2005). Acoustic, video and grab sample survey of Sheringham Shoal Offshore Wind Farm. Envision Mapping Ltd report prepared for Scira.
- Floeter, J. & Temming, A. (2003). Explaining diet composition of North Sea cod (Gadus morhua L.): Prey size preference vs. prey availability. Cananian Journal of Fishisheries and Aquatic Sciiences, 60: 140-150.
- Ford, E. (1921). A contribution to our knowledge of the life histories of the dogfishes landed at Plymouth. Journal of the Marine Biological Association of the United Kingdom 12(3): 468-505.
- Fox, C., Taylor, M., Dickey-Collas, M., Van Damme, C.J.G., Bolle, L., Daan, N., Rohlf, N., Kraus, G., Munk, P., Fossum, P., and Bailey, N. (2005). Initial results from the 2004 ichthyoplankton survey of the North Sea. ICES CM 2005/AA:04.
- Gauld, J. (1979). Reproduction and fecundity of the Scottish-Norwegian stock of spurdogs, Squalus acanthias (L.). ICES CM 1979/H:54. 9pp.
- Gibson, R., Hextall, B. and Rogers, A. (2001). Photographic guide to the sea and shore life of Britain and north-west Europe. Oxford University Press, Oxford 422pp
- Gill, A.B., Gloyne-Phillips, I., Neal, K.J. & Kimber, J.A. (2005). The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms – a review. COWRIE-EM FIELD 2-06-2004.
- George, J.D., Evans, N.J., Clark.P.F., Harrison, K., Chimonides, P.J. & Pitkin, B.R. (1990). Studies on the biology and ecology of the edible crab (Cancer pagarus L.) in North Norfolk. A report for Anglian Water Services. British Museum (Natural History), London. 95 pages.
- Greer Walker, M. and Witthames, P. (1990). The fecundity of sole (Solea solea L.) from ICES areas IVb and 1987 and 1988 and VIId in 1988. ICES CM 1990/ G:37. 6pp.
- Greer Walker, M., Harden Jones, F.R., and Arnold, G.P. (1979). The movements of plaice (Pleuronectes platessa L.) tracked in the open sea. Journal du Conseil International pour l'Exploration de la Mer 38(1): 58-86.
- Hall, S.J., Basford, D.J., Robertson, M.R., Raffaelli, D.G. & Tuck, I., (1991). Patterns of recolonisation and the importance of pit-digging by the crab Cancer pagurus in a subtidal sand habitat. Benthic Ecology Progress Series, 72, 93-102.
- Hammond, T.R. and Ellis, J.R. (2005). Baysian Assessment of North East Atlantic Spurdog using a Stock Production Model, with Prior Intrinsic Population Growth Rate Set by Demographic Methods. Journal of North West Fishery Science, 35.
- Heath, M.R. (1992). Field investigations into the early life stages of fish. Advances in Marine Biology (28).
- Heath, M.R. and Richardson, K. (1989). Comparative study of the early life survival variability of herring, Clupea harengus, in the North-eastern Atlantic. Journal of Fish Biology, 35, 49 – 57.
- Heessen, H.J.L. (ed) (2003). Development of Elasmobranch Assessments – DELASS:DG Fish Study Contract 99/055.

- Heessen, H.J.L. (1983). Distribution and abundance of young cod and whiting in the south-eastern North Sea in the period 1980 – 1982. ICES CM 1983/G:30, 4pp.
- Henriksen, O.D., Teilmann, J., Dietz, R. and Miller, L. (2001). Does underwater noise from offshore windfarms potentially affect seals and harbour porpoises? Poster presented at the 14th biennial conference on the biology of marine mammals" Vancouver, Canada.
- Hisaw, F.L. and Albert, A. (1947). Observations on the reproduction of spiny dogfish, Squalus acanthias. Biological Bulletin, 92: 187-199.
- Hislop, J.R.G. and Hall, W.B. (1974). The fecundity of whiting, Merlangius merlangus L., in the North Sea, the Minch, and Iceland. ICES Journal du Consiel de la Mer, 36, 162 – 165.
- Hislop, J.R.G., Robb, A.P., Bell, M.A., & Armstrong, D.W. (1991). The diet and food consumption of whiting (Merlangius merlangus) in the North Sea. ICES Journal of Marine Science, 48, 139-156.
- Hoffman E., Astrup J., Larsen F., Munch-Petersen S., and Strottrup J. (2000). The effects of marine wind farms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. Baggrundsrapport nr. 24. Report to ELSAMPROJEKT A/S. Danish Institute for Fisheries Research.
- Holden, M.J. (1965). The stocks of spurdogs (Squalus acanthias L.) in British Waters and their migrations. Fishery Investigations, Series II, 24(4), MAFF, London, 20pp.
- Holden, M.J. (1975). The fecundity of Raja clavata in British waters. Journal du Conseil International pour l'Exploration de la Mer, 36: 110 - 118.
- Holden, M.J. and Meadows, P.S. (1964). The fecundity of the spurdog (Squalus acanthias L.). Journal du Conseil International pour l'Exploration de la Mer 28: 418-424.
- Holden, M.J. and Tucker, R.N. (1974). The food of Raja clavata Linnaeus 1758, Raja montagui Fowler 1910, Raja naevus Muller and Henle 1841, and Raja Brachyura Lafont 1873 in British waters. Journal du Conseil du Exploration de la Mer, 35(2): 189 – 193.
- Holden, M.J., Rout, D.W. and Humphreys, C.N. (1971). The rate of egg laying by three species of ray. Journal du Conseil pour l'Exploration de la Mer, 33: 335 – 339.
- Houghton, R.G., and Harding, D. (1976). The plaice of the English Channel: spawning and migration. Journal du Conseil International pour l'Exploration de la Mer 36: 229-239.
- Hunter, E., Metcalfe, J.D., Arnold, G.P., and Reynolds, J.D. (2004). Impacts of migratory behaviour on population structure in North Sea plaice. Journal of Animal Ecology 74:377–385.
- Hunter, E., Buckley, A.A., Stewart, C. and Metcalfe, J.D., (2005). Migratory behaviour of the thornback ray, Raja clavata L., in the southern North Sea. Journal of the Marine Biological Association of the UK. 85: 1095-1105.
- ICES, (2005a). Report of the Study Group on the Biology and Life History of crabs (SGCRAB). ICES SGCRAB Report 2005. ICES CM 2005/G:10 Ref. D. 63pp.
- ICES (2005b). Report of the Study Group on Stock Identity and Management Units of Whiting (SGSIMUW), 15-17 March 2005, Aberdeen, UK. ICES CM 2005/G:03. 50 pp.
- ICES, (2004a). Report of the ICES Advisory Committee on Fishery Management and Advisory Committee on Ecosystems, 2004. ICES Advice. 1(2). 1544 pp.
- ICES, (2004b). Annual Report for 2003. International Council for the Exploration of the Sea. May 2004. ISSN 0906-0596. 295pp.
- ICES, (1965). Report of the Working Group on sole. ICES Cooperative Research Report 5: 1-126.

- Kenny, A.J., Rees, H.L., Greening, J., and Cambell, S., (1998). The effects of marine gravel extraction on the macrobenthos at an experimental dredge site off north Norfolk, UK. (Results 3 years post dredging). ICES CM 1998/V,14, 8pp.
- Kesteven, G.L. (Ed)., (1960). Manual of field methods in fisheries biology. FAO. Manuals in Fisheries Sciences, 1. FAO Rome, 152pp.
- Knapman, P.A. (2003). Eastern Sea Fisheries District Annual Report 2003. Kings Lynn. Eastern Sea Fisheries Joint Committee. 44pp.
- Knudsen, F.R., Enger, P.S. and Sand, O. (1994). Avoidance responses to low-frequency sound in downstream migrating Atlantic salmon smolt, Salmo Salar. Journal of Fish Biology 45, 227-233.
- Kuipers, B. (1973). On the tidal migration of young plaice (Pleuronectes platessa) in the Wadden Sea. Netherlands Journal of Sea Research 6(3): 376-388.
- Kruuk, H. (1963). Diurnal periodicity in the activity of the common sole Solea vulgaris Quensel, juveniles on the French Atlantic coast. Journal of Fish biology, 30: 91-104.
- Last. J. M. (1989). The food of herring, Clupea harengus, in the North Sea, 1983-1986.
- Journal of Fish Biology. 34. 489-501.
- Leonhard, S.B. and Pedersen, J. (2005). Hard Bottom Substrate Monitoring at Horns Rev Offshore Wind Farm. Annual Status Report 2004. BioConsult A/S report for Elsam Engineering, 79pp.
- Mander, M. R. (2004). Eastern Sea Fisheries District Annual Report 2004. Kings Lynn. Eastern Sea Fisheries Joint Committee. 58pp.
- Marchand, J. and Masson, G. (1989). Process of estuarine colonisation by 0-group sole (Solea solea): hydrological conditions, behaviour and feeding activity in the Vilaine Estuary. Rapports et Proces-Verbaux des Reunions du Conseil International pour l'Exploration de la Mer 191: 287-295.
- Marine Conservation Society. (2000). Habitats Factsheet: Artificial Reefs. SP08/00
- Miller, I. (2005). Offshore wind farms – the European Experience. CCW Policy Research Report 05/03. 51pp.
- Molinero, A. and R. Flos. (1991). Influence of sex and age on the feeding habits of the common sole Solea solea. Marine Biology 111, 493-501.
- Munk, P., Larsson, P. O., Danielssen, D. S. & Moksness, E. (1999). Variability in frontal zone formation and distribution of gadoid fish larvae at the shelf break in the northeastern North Sea. Benthic Ecology Progress Series, 177, 221–233.
- Nedwell, J. and Howell, D. (2004). A review of offshore wind farm related underwater noise sources. Subacoustech Report Reference: 544R0308, COWRIE, The Crown Estate.
- Nedwell, J., Langworthy, J. & Howell, D. (2004). Measurements of underwater noise during construction of offshore wind farms and comparison with background noise. COWRIE report no. 544 R 0411.
- Nichols, J.H. (1999). Saving North Sea herring. Handout, CEFAS Lowestoft, 4pp.
- Nichols, J.H., Thompson, B.M. & Cryer, M. (1982). Production, drift and mortality of the planktonic larvae of the edible crab (Cancer pagurus) off the north-east coast of England. Netherlands Journal of Sea Research, 16, 173-184.
- Nilsson, L.A.F., Thygesen, U.H., Lundgren, B., Nielsen, B.F., Nielsen, J.R., and Beyer, J.E., (2003). Vertical migration and dispersion of sprat (Sprattus sprattus) and herring (Clupea harengus) schools at dusk in the Baltic Sea. Aquatic Living Resources, 16(3), 317-324.

- Oh, C.W., Hartnoll, R.G. and Nash, R.D.M., (1999). Population dynamics of the common shrimp, Crangon crangon (L.), in Port Erin Bay, Isle of Man, Irish Sea. ICES Journal of Marine Science, 56, 718-733.
- Parrish, B.B., Saville, A., Craig, R.E., Baxter, I. G. and Priestley, R. (1959). Observations on herring spawning and larval distribution ion the Firth of Clyde in 1958. Journal of the Marine Biological Association of the United Kingdom, 38:445 – 453.
- Parvin, S.J. and Nedwell, J.R. (2005). A brief review of mitigation strategies for reducing the impact of piling noise during construction of the Greater Gabbard wind farm. Subacoustech Report No.636R0104. 12pp.
- Pawson, M. (1995). Biogeographical Identification of English Channel Fish and Shellfish Stocks. Fisheries Research Technical Report. MAFF Direct Fisheries Research, Lowestoft, 99: 72pp.
- Pearson, W.H., Skalski, J.R, & Malme, C.I. (1992) Effects of sound from geophysical survey device on behaviour of captive rock fish (Sebastes spp.). Canadian Journal of Fisheries and Aquatic Science, 49: 1343-1356.
- Potts, G.W. and Swaby, S.E., (1999). Fish: other species. In JNCC (1999): Coasts and Seas of the United Kingdom.: Region 6. Coastal Directories Electronic Platform (CD), Joint Nature Conservation Committee, Peterborough.
- Rae, B.B. (1967). The food of the dogfish, Squalus acanthias L., Marine Research, 4: 1–19.
- Rae, B.B. and Shelton, R.G.J. (1982). Notes on the food of nine species of elasmobranch (Part I) and nine species of demersal teleost (Part II) fishes from Scottish waters. ICES CM 1982/G:56.
- Rijnsdorp, A.D. (1991). Changes in the fecundity of female North sea Plaice (Pleuronectes platessa L.) between three periods since 1900. ICES Journal of Marine Science 48: 253-280.
- Rijnsdorp, A.D. (1989). Maturation of male and female North Sea plaice (Pleuronectes platessa L.). Journal du Conseil International pour l'Exploration de la Mer 46: 35-51.
- Rijnsdorp, A.D.,Vingerhoed, B. (2001). Feeding of plaice, Pleuronectes platessa, and sole Solea solea in relation to the effects of bottom trawling. Journal of Sea Research, 45: 219-230.
- Rijnsdorp, A.D., Van Stralen, M., and Van der Veer, H.W. (1985). Selective tidal transport of North Sea Plaice larvae, Pleuronectes platessa in coastal nursery areas. Transactions of the American Fisheries Society 114:461-470.
- Rijnsdorp, A.D.; Van Beek, F.A.; Flatman, S.; Millner, R.M.; Riley, J.D.; Giret, M.; De Clerck, R. (1992). Recruitement of sole stocks, Solea solea (L.), in the northeast Atlantic. Netherlands Journal of Sea Research, 29(1-3): 173-192.
- Rogers, S.I., Millner, R.S. and Mead, T.A. (1998). The distribution and abundance of young fish on the east and south coast of England (1981 to 1997). CEFAS Science Series Technical Report No. 108, 130pp.
- Rousset, J. (1990). Population structure of Thornback rays Raja clavata and their movements in the Bay of Douarnenez. Journal of the Biological Association of the United Kingdom, 70: 261-268.
- Royal Haskoning (2005). Sheringham Shoal Offshore Wind Farm Seismic Survey: Interpretive report. Report 9P5074/R/DBRE/PBor.
- Royal Haskoning (2002). Environmental Statement: Cromer Offshore Wind Farm. Norfolk Offshore Wind Ltd.

- RPS (2005) London Array Offshore Wind Farm Environmental Statement: Volume 1; offshore works.
- Russell, F.D. (1976). The eggs and planktonic stages of British marine fishes. Academic Press, London. 524 pp.
- Ryland, J.S. (1964). The feeding of plaice and sand-eel larvae in the southern North Sea. Journal of the Marine Biological Association of the United Kingdom 44: 343-364.
- Scott, C. (1995). Mablethorpe to Skegness Sea Defences Beach Nourishment: Marine Environmental Baseline Survey. Institute of Estuarine and Coastal Studies Hull University. Report to the National Rivers Authority Anglian Region. Project No. 9139952/243. Report No. ZO53-95-F.
- Turner, K., Righton, D. and Metcalfe, J.D. (2002). The dispersal patterns and behaviour of North Sea Cod (Gadus morhua) studied using electronic data storage tags. Hydrobiologica, 483(1-3): 201-208.
- van der Veer, H.W., Bergman, M.J.N., and Beukema, J.J., (1985). Dredging Activities in the Dutch Waddensea: effects on macrobenthic infauna. Netherlands Journal of Sea Research, 19:183-190.
- Vince, M.R. (1991). Stock identity in the Spurdog (Squalus acanthias L.) around the British Isles. Fisheries Research 12: 341-354.
- Walker, P., Howlett, G., Millner, R. (1997). Distribution, movement and stock structure of three ray species in the North Sea and eastern English Channel. ICES Journal of Marine Science, 54; 797-808.
- Warren, P.J. (1973). The Fishery for the pink shrimp Pandalus montagui in the Wash. Laboratory Leaflet (new series) No.28. Fisheries Laboratory Lowestoft, Suffolk, 50pp.
- Westerberg, H. (1999). Impact studies of sea-based wind power in Sweden. Technische Eingriffe in Marine Lebensraume.
- Wheeler, A. (1978). Key to the Fishes of Northern Europe. London: Frederick Warne Ltd.
- Wheeler, A. (1969). The Fishes of the British Isles and North west Europe. Michigan State University Press.
- Whitehead, P.J.P., Bauchat, M.L., Hureau, J.L., Nielsen, J. and Tortonese, E. (eds)., (1989). Fishes of the North Eastern Atlantic and the Meditterranean. Volumes I, II and III. Unesco, Paris.
- Woodhead, P.M.J. (1964). Changes inn the behaviour of sole, Solea vulgaris, during cold winters, and the relation between the winter catch and sea temperatures. Helgolander Wissenschaftliche Meeresuntersuchungen 10: 328-342.

11 Marine Mammals

11.1 Introduction

This section describes the existing environment regarding marine mammals, namely seals and cetaceans[24], and details the potential impacts of the construction, operation and decommissioning phases of the proposed Sheringham Shoal project.

11.2 Assessment Methodology

11.2.1 Data collection

Data on marine mammals for the North Sea and the site have been obtained from the following sources:

- Small Cetacean Assessment in the North Sea (SCANS) (Hammond *et al*. 2002);
- Atlas of Cetacean Distribution in Northwest European Waters (Reid *et al*, 2003);
- Boat based bird survey undertaken between March 2004 and January 2006 (29 surveys in total);
- Aerial based survey undertaken between November 2004 and August 2005 (seven surveys in total);
- Norfolk Biological Record Centre (NBRC) data;
- Joint Nature Conservation Committee (JNCC) Directory, 1995; and
- English Nature (EN) communication.

The SCANS project was a major international collaborative programme, conducted throughout the region in July 1994. It provides a baseline assessment of abundance of the major species, although limited to one year (Hammond *et al*., 2002). The Atlas of Cetacean Distribution in Northwest European Waters, undertaken by Reid *et al*., (2003) combined the results from different data sources including SCANS and data held by the Sea Watch Foundation.

The boat-based and aerial seabird surveys carried out as part of this EIA between November 2004 and January 2006 and between November 2004 and August 2005 respectively (see Section 8, Ornithology) recorded incidental sightings of marine mammals within the immediate area of the proposed wind farm. These surveys were designed and conducted primarily for sea birds, and hence not optimised for recording marine mammals. The survey results are, therefore, indicative. It is not possible to quantify the amount of under-sampling.

Data of sightings have been provided by the NBRC. These are opportunistic sightings taken from the coast and/or records of carcasses on the beach. Data for the coastline from Blakeney Point, along the north Norfolk coast to Hopton on Sea, to the south of Great Yarmouth, were considered for the years between 1990 and 2005.

[24] Whales, dolphins and porpoises

11.2.2 Impact assessment

The impact assessment has been undertaken on the basis of the above cited data and an extensive literature review including recent findings of research on seal and cetacean behaviour associated with human disturbance and operational wind farms. This includes a number of COWRIE funded reports such as CMACS (2003), Nedwell *et al*. (2003) and Nedwell and Howell (2004) and studies undertaken in Denmark before and after the construction of Hons Rev Offshore wind farm (Tougaard *et al*., 2003a and 2003b).

Owing to the migratory behaviour of cetaceans the study area for marine mammals is relatively wide, covering a large portion of the central and southern North Sea.

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 11.4 - 11.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section 3 for the definition of significance levels.

11.3 Description of the existing environment

11.3.1 Marine mammal abundance and distribution

JNCC records for the period between 1980 and 1995, for the Flamborough Head to Great Yarmouth region, indicate that ten cetacean species have been observed along the coasts or in nearshore waters (within 60km of the coast) of the region, and little more than 10% (three out of 26 species) of the UK cetacean fauna was either present throughout the year or has been recorded annually as seasonal visitors. Resident or regularly visiting species were identified as the minke whale *Balaenoptera acutorostrata*, harbour porpoise *Phocoena phocoena* and white-beaked dolphin *Lagenorhynchus albirostris* (JNCC, 1995).

The region from Flamborough Head to Great Yarmouth does however include a significant portion of the UK population of common seal *Phoca vitulina*. They are concentrated in The Wash and are the only significant common seal population in England. In addition, haul-out sites are found at Donna Nook in Lincolnshire and at Blakeney Point and Scroby Sands in Norfolk. Grey seal *Halichoerus grypus* are less numerous and there is only one main breeding site, at Donna Nook (JNCC, 1995).

English Nature note that species which may be affected by the proposals include common and grey seal, with harbour porpoise and minke whale also known to occur in the area. Such information is based on site managers' reports on strandings and observations made from shore. No full records of such observations are available (EN Correspondence, May 2005)

A brief description of the behaviour, distribution and estimated North Sea population size is provided for each species which is known to occur or which has been observed, even if occasionally, within the proposed site. Figure 11.1, Figure 11.2 and Figure 11.3 provide an illustration of the numbers and species recorded during both the boat and aerial bird surveys.

11.3.1.1 Harbour porpoise

Harbour porpoise (see Plate 11.1) is the smallest and by far the most numerous of the cetaceans found in the North Sea. Typically they occur in small groups of one to three animals and are mainly confined to shelf waters, although sightings have occurred in deep water (Reid *et al*., 2003).

The main diet is small fish (usually less than 40cm length) such as young herring, sprat, sand-eel, whiting, saithe, and pollack, although particularly in winter months, prey such as dab, flounder, sole, and cod are taken (Royal Haskoning, 2005).

Although breeding can commence as early as March, the main season occurs between May and August, with a peak in June.

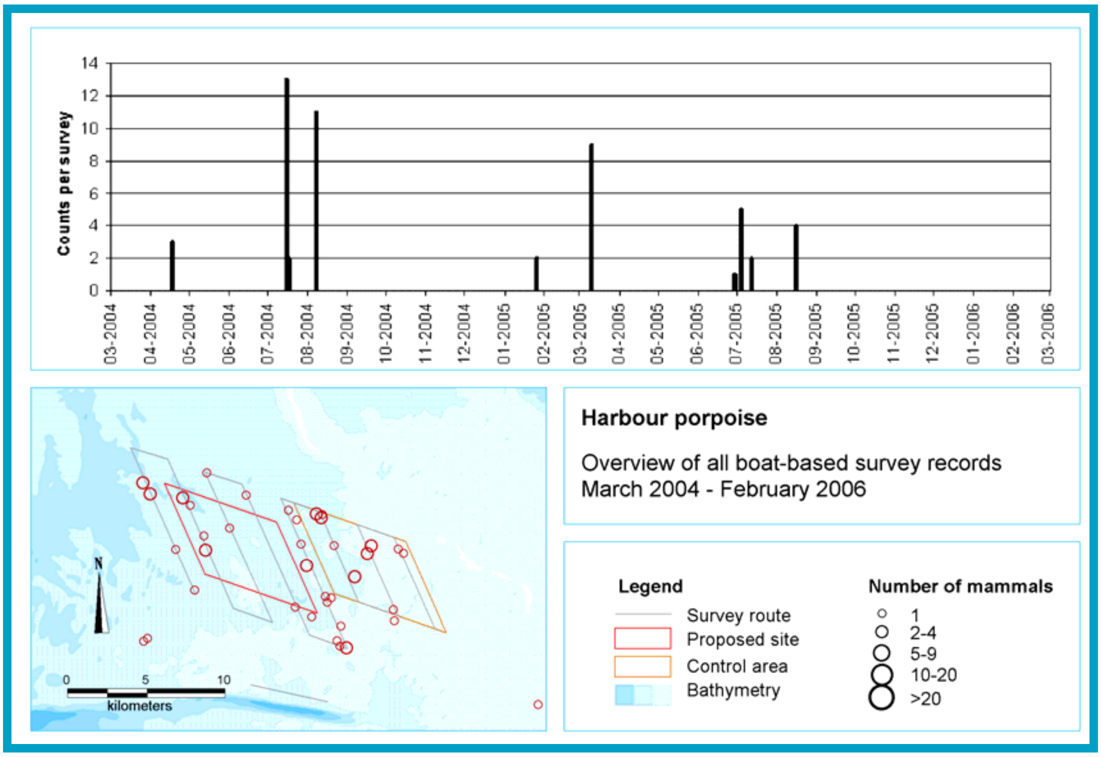


Figure 11.1 Temporal and spatial overview of all boat-based survey records of Harbour porpoises.

The North Sea population has been estimated at 280,000 animals (Hammond *et al*. 2002). SCANS data for the shelf waters along the eastern coast of England from north Norfolk to Aberdeenshire report a population abundance of 36,280 (with 0.57 coefficient of variation). The Norfolk Biodiversity Action Plan reports that the species is found off the Norfolk coast but its local status is not known (www.norfolkbiodiversity.org).

Sightings of harbour porpoise occurred relatively frequently during the boat based bird survey with the species having been recorded during 10 out of the 29 surveys (Figure 11.1). The number of individuals varied from a minimum of 1 on 29th June 2005 to a maximum of 13 on 15th July 2004. Harbour porpoises were observed close to or at the proposed site during the January/February 2005 and March 2005 aerial surveys. The data provided by NBRC confirm that porpoise is the most common species in the area with records of sightings available every year since 1995. The number of sightings is variable (from a minimum of 2 in 2004 to a maximum of 56 in 1997).

Plate 11.1 Harbour porpoise

11.3.1.2 Minke whale

Minke whale *Balaenoptera acutorostrata* are usually seen singly or in pairs, although when feeding they can aggregate in groups of 10-15 individuals. The species occurs both on the continental shelf and in offshore waters and feeds on schooling fish and crustaceans. It is the most common mysticete (baleen whale) in Northern European shelf waters (Reid *et al.,* 2003).

Minke whale occur throughout the northern and central North Sea as far south as the Yorkshire Coast. The species is rare in the southern part of the North Sea south of a line from Humberside to the north coast of Jutland in Denmark (Reid *et al*., 2003). The NBRC reports one sighting in 1997 and English Nature advised that the species is known to occur in the area (EN communication, May 2005). Although minke whale may be an occasional visitor, the study area is not considered to be important for this species.

11.3.1.3 White-beaked Dolphin

White-beaked dolphin *Lagenorhynchus albirostris* is common in British and Irish waters and is found most abundantly in the central and northern North Sea across to north-west Scotland, although it also occurs less commonly in the southern North Sea (Reid *et al.,* 2003). From line transect surveys undertaken in July 1994 (Hammond *et al*., 2002) for the North Sea and English Channel, no white-beaked dolphins were recorded in the North Sea south of 54° N (between Flamborough head and Hornsea). NBRC data report sightings of migrant white-beaked dolphin in 1994 and 1995. The 1995 sightings were at different locations along the coast. The species was recorded once in 1998 along the Norfolk coast (NBRC data).

11.3.1.4 Bottlenose dolphin

In British and Irish waters the bottlenose dolphin *Tursiops truncatus* is most frequently sighted within 10km of land, although it does also occur in offshore waters. In the UK the species is most frequent in North East Scotland and the Irish Sea. The species is scarcely reported in the central and southern North Sea and it occurs seasonally along the south coast of England (Royal Haskoning, 2005).

11.3.1.5 Sperm whale

The sperm whale *Physeter macrocephallus* has a worldwide distribution and is primarily found in deep water. This species is considered to have low numbers around the UK (Reid *et al.,* 2003). Two records of sperm whale were provided by the NBRC as vagrant/accidental. Both records are not confirmed. Overall, the study area is not considered important for sperm whales.

11.3.1.6 Fin whale

Fin whale *Balaenoptera physalus* has a worldwide distribution mainly in temperate and polar seas. In North-Western Europe fin whale are mainly distributed along or beyond the 500m depth contour. No records are presented by the Atlas of Cetacean Distribution in Northwestern European Waters (Reid *et al*, 2003). The NBRC reports two sightings in 1998 within the same grid reference. The study area is not considered to be important for this species.

11.3.1.7 Northern bottlenose whale

Northern bottlenose whale *Hyperoodon ampullatus* is generally recorded in deep water. In the UK, most sightings have been made North and West of Scotland, mainly along the continental shelf and it is rarely seen in the shelf waters of the North Sea (Reid *et. al*., 2003). One record of a dead bottlenose whale was made to the NBRC in 2002. The study area is not considered to be important for this species.

11.3.1.8 Cuvier's beaked whale

Cuvier's beaked whale *Ziphius cavirostris* is one of the least recorded species in terms of sightings at sea, this is most likely due to its deep-diving and inconspicuous surfacing behaviours. Reid *et al*. (2003) reports of only six sightings in British and Irish waters mainly off Scotland and western Ireland. A stranded Cuvier's beaked whale has been recorded by the NBRC in 2002. Overall, the study area is not considered to be important for this species.

11.3.1.9 Common seal

The British population of common *seal Phoca vitulina* is estimated to be in the order of of 50-60,000 animals (UK Special Committee on Seals, Advice, 2004). Duck and Thomson (2004) estimate that the Lincolnshire and Norfolk coast holds >95% of the English common seal population.

Overall, the English east coast population appears to be growing. It has increased at an average annual rate of 7.2% between 1989 and 2002, with decreases in 1988 and 2002 because of phocine distemper virus (PDV) epidemics (Duck and Thomson 2004). The population of The Wash was particularly hit by these epidemics with a reduction of 52% following the 1988 epidemic and of 22% in 2002 (although this had limited effect in the rest of the UK).

Common seal come ashore in sheltered waters typically on sandbanks and in estuaries but also in rocky areas. They give birth to their pups in June and July and moult in August. At these, as well as other times of the year, common seals haul out on land regularly in a pattern that is often related to the tidal cycle. Common seal pups are born having shed their white coat and can swim almost immediately (UK Special Committee on Seals, Advice 2004).

Major common seal moulting and haul out sites on the east coast of the UK include Donna Nook, the Wash and Blakeney Point (see Plate 11.2). Together, these sites support an estimated 7% of the total UK population of the species, a figure that makes the population important at an international level and qualifies this area of the coast as a Special Area of Conservation (SAC) under Article 3 of the EC Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the EC Habitats Directive) (see Section 11.3.2).

Common seal normally feed within 40-50km of their haul out sites. They take a wide variety of prey including sandeels, whitefish, herring and sprat, flatfish, octopus and squid. Diet varies seasonally and from region to region.

A study undertaken by Sharples and Hammond (2004) on ten harbour seals in The Wash reveals that the majority of the seals travelled repeatedly to offshore sites 75-120km away from the haul-out with an average 10 days foraging trip. This is longer than the distance recorded for seals in Scotland. In addition, in The Wash, seals were much more site faithful both in respect of areas used to haul-out and areas used to forage. No seasonality in behaviour was apparent. The preferred feeding sites were observed offshore of the Humber area.

Sightings of seals (both common and unidentified) within and/or close to the proposed site were made during ten out of the 29 boat based surveys (Figure 11.2) and during three of the seven aerial surveys. NBRC data confirm the presence of high numbers of seals along areas of low-lying coast and particularly at Blakeney Point.

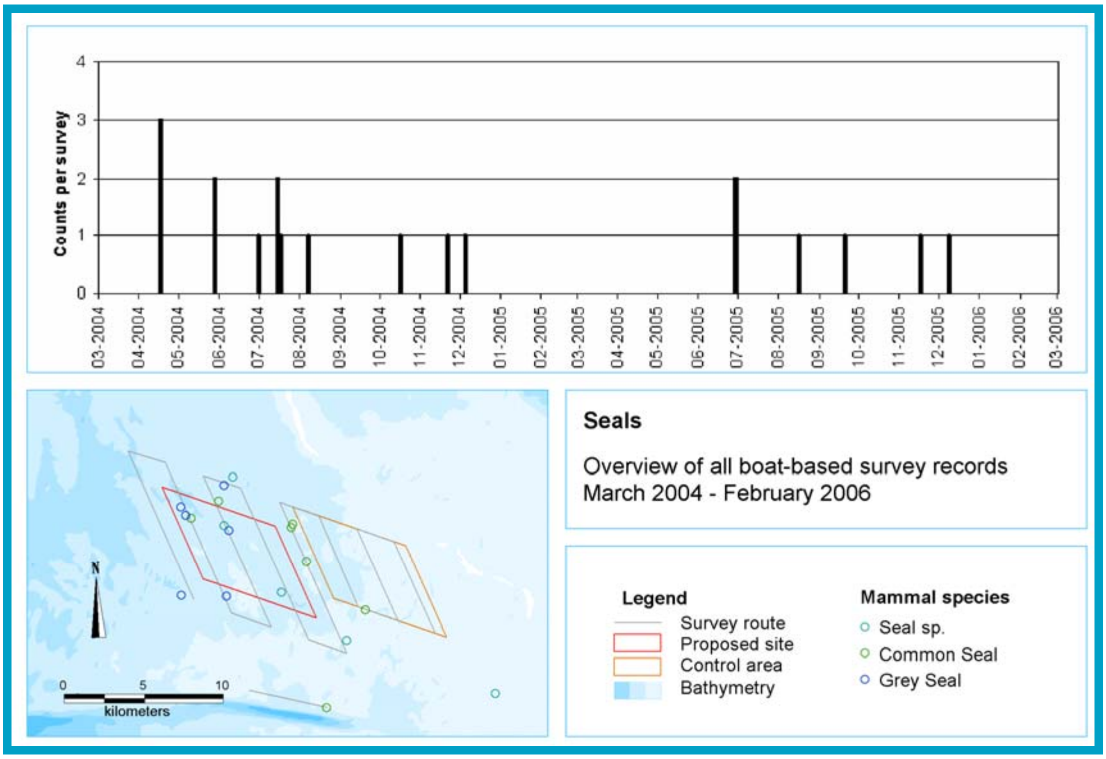


Figure 11.2 Temporal and spatial overview of all boat-based survey records of Seals.

Plate 11.2 Seals at Blakeney Point, along the north Norfolk Coast. Source: Scira 2004

11.3.1.10 Grey seal

The UK population of grey *seal Halichoerus grypus* is estimated to be in the order of 120,000, about 45% of the global population (English Nature, 2004). Grey seal haul-out on land especially on outlying islands and remote coastlines exposed to the open sea between foraging trips and for breeding. They tend to form large aggregations at haul-out sites. Pupping occurs around January in the southern North Sea, while moulting occurs in February and March. Grey seal feed mostly on fish that live on or close to the seabed, primarily sandeels, whitefish (cod, haddock, whiting, ling), and flatfish (plaice, sole, flounder, dab) but vary in prey species taken both seasonally and from region to region.

Tracking of individual seals has shown that they can feed up to several hundred miles offshore during foraging trips lasting several days. Individual grey seals based at a specific haul-out site often make repeated trips to the same region offshore but will occasionally move to a new haul-out and begin foraging in a new region.

The main grey seal breeding colonies in the UK are in Scotland, while along the English eastern coast, breeding colonies are found at the Farne Islands and Donna Nook (Duck, 2004), although occasionally pups are born along the Norfolk and Suffolk coast. No significant colony is found along the north Norfolk coast and The Wash. NBRC data reports the presence of grey seals along this stretch of coast, and particularly at Blakeney Point, although with fewer records than common seals.

11.3.2 Conservation interests

All cetaceans are listed on Annex IV of the EC Habitats Directive and are given full protection under Article 12. Harbour porpoise and bottlenose dolphin are also listed in Annex II of the Directive, requiring member states to designate SACs.

All small cetacean species are covered under the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) (1992) and the UK Wildlife and Countryside Act 1981 (as amended).

Common and grey seals are both listed on Annex II of the EC Habitats Directive and are a qualifying feature of SACs in areas of prime importance for the maintenance of the population.

Both species are protected by the Conservation of Seals Act 1970. This Act provides for closed seasons in which killing of seals is not permitted. This coincides with the pupping periods of UK residents species and it is from 1st June to 31st August for common seals and from 1st September to 31st December for grey seals. The law also allows complete protection to be given, e.g. following epidemics.

A summary of the relevant conservation legislation and agreements is provided in Table 11.1.

Table 11.1 Summary of the relevant conservation legislation and agreements

Species	BONN Convention 1983 (Appendix I)	BERN Convention (Appendix II)	EU Habitats Directive (AnnexII)	ASCOBANS	UK Wildlife and Countryside Act 1981	OSPAR (Annex V)	CRoW Act 2002 (Section 74)	Conservation of Seals Act 1970	Norfolk Biodiversity Action Plan	UKBAP
Long-finned pilot whale	√	√	√	√	√		√			√
White-beaked dolphin	√	√	√	√	√		√			√
Bottlenose dolphin	√	√	√	√	√		√			√
Harbour Porpoise	√	√	√	√	√	√	√		√	√
Common seal			√					√		
Grey seal			√					√		

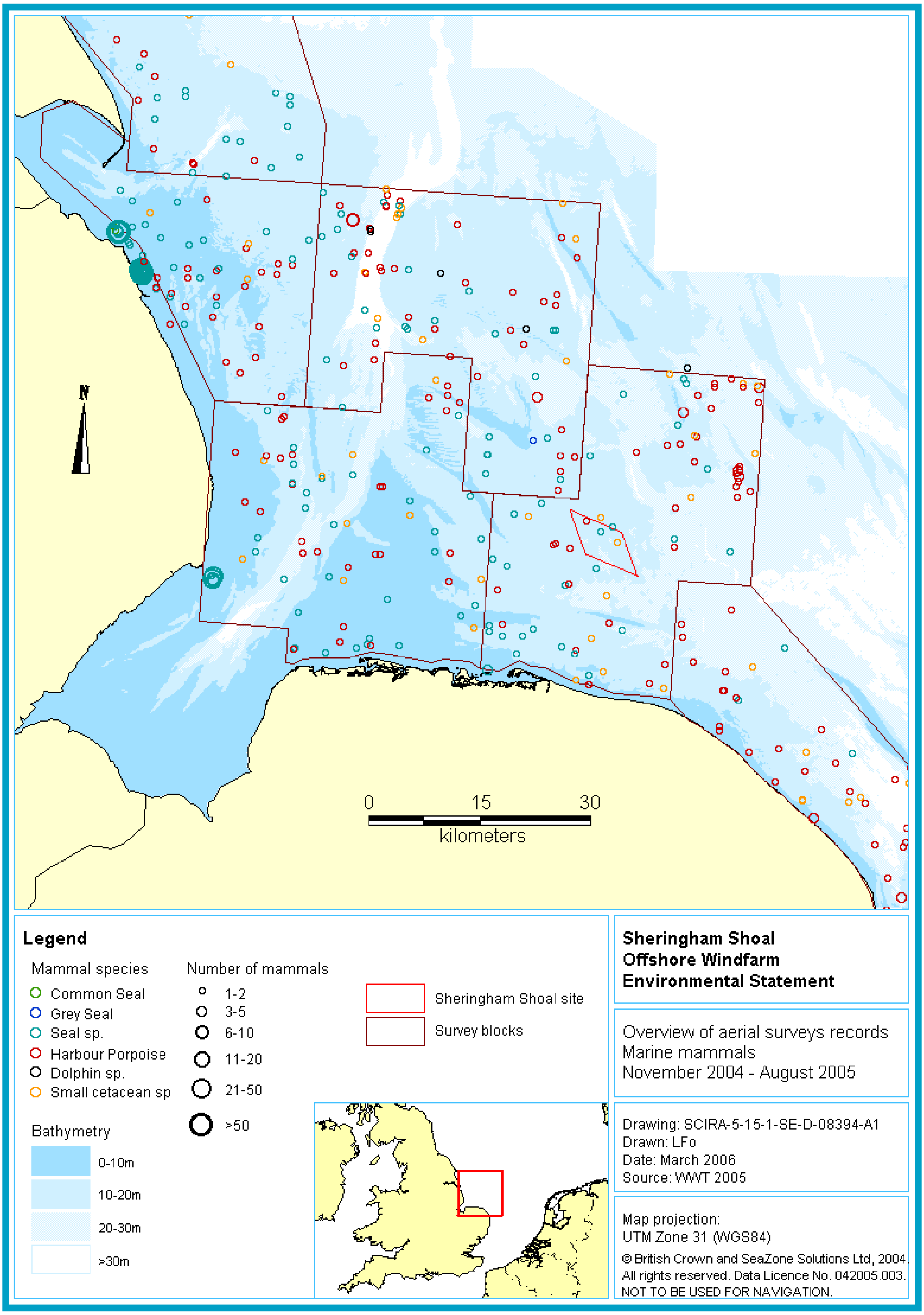


Figure 11.3 Seals and cetaceans observed during the seven aerial bird surveys carried out between November 2004 and August 2005

11.4 Impacts during construction

11.4.1 Impact due to noise

Ambient noise levels would increase during construction. It is anticipated that the noisiest activities of the construction phase would be the driving of monopile foundations and cable trenching.

Cetaceans rely on sound as their primary sense for communication, navigation and orientation with significant variations in the perceived noise level from species to species, and therefore in their response to sound. Nedwell (2003) reports that marine mammals, in general, perceive a higher level of noise than certain fish species (salmon, cod and dab) and that, amongst the marine mammals, harbour porpoise perceives the highest level, at a mean of about $53dB_{ht}$

Man-made sounds may disrupt cetaceans by causing behavioural shifts and, under extreme conditions, physiological damage and increased risk of mortality. Common behavioural responses of cetaceans to undersea noise include the cessation of all vocalisation; deviation from course and temporary abandonment of an area (e.g. Richardson *et al*., 1995).

Whilst deviation is not necessarily disadvantageous, as it can prevent physical injury if it takes the animal beyond the zone of auditory damage, it may not always be possible or it might have an adverse impact on vulnerable individuals (e.g. pregnant or lactating females). The permanent or even temporary abandonment of a noisy area may also impact negatively on the survival of a group of individuals or a vulnerable species if the area is important for reproduction, as a nursery area or even as a source of food (Scott, 2004).

Where individuals do not withdraw from noisy areas, noticeable changes in cycles of feeding and respiration have been documented. Such factors may potentially combine and cause the animal stress, which in turn may result in reduced resistance to disease and endocrine imbalances which may negatively impact on reproduction (Scott, 2004).

Piling noise has been reported to have such diverse consequences as little or no effect (Nedwell *et al*., 2003), avoidance (Tougaard, *et al.,* 2003a, Feist, *et al*., 1992) and mortality (Vagle, 2003) for marine animals. It is most likely that the significant factors which affect the noise level include pile diameter, local geology and bathymetry (Nedwell and Howell, 2004).

Trenching produces noise by the motion of the plough through the sea floor and by the onboard machinery and high powered sub-bottom profilers.

Few measurements of trenching noise and its effect on marine mammals are available. However, measurements of noise during deep water pipe laying near Shetland were undertaken (Nedwell *et al*., 2001) and the possible implications for marine mammals has been extrapolated by Nedwell and Howell (2004). The authors estimate that harbour porpoise is likely to display avoidance reactions to trenching noise at a distance of at least 500m. Trenching noise levels have been recorded during the installation of the cables at North Hoyle at a distance of 160m (Nedwell *et al*., 2003). It was noted that the noise was highly variable and apparently dependent on the physical properties of the seabed and that all of the measurements were below the level at which a behavioural reaction would be expected. However, no measurements of shallow water cable laying noise have been published and therefore no reliable conclusions can be ascertained.

The assessment below reviews this literature and concentrates on harbour porpoise and common seal, as these have been recorded most frequently within the site. In addition, the harbour porpoise is the main species occurring in coastal north European waters and is one of the most sensitive species to underwater noise.

11.4.1.1 Harbour porpoise

The most detailed study to date is that of Tougaard *et al*. (2003a), which was conducted prior to and during the construction of the then largest offshore wind farm at Horns Rev in Denmark. The study used visual sightings and acoustic click detectors called T-PODs to determine the abundance, activity and behavioural changes of harbour porpoises within the wind farm site and surrounding area. Attention was focused on the foundation work, which entailed the driving of steel monopiles into the seabed.

Evidence of the following changes was observed:

- Acoustic activity by the porpoises decreased dramatically on the entire Horns Rev at the onset of ramming operations and returned to higher levels a few hours (3-4 hours) after each ramming operation was completed. The porpoises thus either left the area during this period or changed their behaviour in ways which resulted in fewer acoustic signals being picked up by the detectors.
- A general effect on the behaviour of animals was seen during the construction period and at distances of up to 10-15km from the construction site. This is expected, as a large number of other construction activities were continuously ongoing in the period as well as a large number of service vessels continuously present in the area. Compared to observations before and after construction there was a decrease in non-directional swimming, a behaviour assumed to correlate with feeding activity.

11.4.1.2 Harbour Seal

Most studies on the reaction of harbour seal to noise have been conducted on hauled-out animals, and very little is known about the effects of noise on seals in the water. Furthermore, it has rarely been possible to determine whether the reactions recorded were to the emitted noise or were caused by a visual stimulus.

The reaction of hauled-out seals to disturbances varies from alert postures to rushing into the water, depending on factors like ambient conditions, noise levels and type of visual cue. As newborn pups are unable to follow their mother into the water, disturbances can cause separation and may lead to the death of the pup (Richardson *et al*., 1995). However, seals normally habituate rapidly to repeated stimuli that lack significant consequences for the animals (Bonner, 1982). Seals in the water most often react to disturbances by moving away or by diving (Hoffman *et al*., 2000).

Recent studies on harbour seal distribution at sea undertaken by SMRU (e.g. Sharples and Hammond, 2004), in Denmark (e.g. Tougaard *et al*., 2003b) and the Netherlands indicate that harbour seals forage much further offshore than previously believed. In the case of The Wash, it was observed that seals travelled up 75-120km offshore during foraging trips (Sharples and Hammond, 2004). It is therefore possible that the proposed wind farm site is within the foraging range of harbour seals hauling out along the north Norfolk coast (e.g. Blakeney Point). Should this be the case, it is possible that the construction phase could disrupt foraging behaviour to some extent.

A study was undertaken on the movements of seals before and during the construction of the Horns Rev wind farm in Denmark by Tougaard *et al*. (2003b) with the use of satellite tracking. Although no clear conclusion could be drawn from the collected data, it was observed that tagged seals also moved across the reef during the construction period, thus suggesting that the construction did not have any large-scale influence on the seals in the area.

As species afforded legal protection under a suite of conservation legislation and Directives, potential adverse impacts on marine mammals that present a risk of damage or mortality must be considered as being significant. At the time of writing this ES, considerable research is being carried out into the impact of construction phase noise (particularly that of piling) on marine mammals and fish. This research is being carried out under the guidance of the JNCC, English Nature and CEFAS. Scira is aware of these discussions and is committed to ensuring that the outcomes of this research are applied where they are relevant to the Sheringham Shoal Project.

Central to this commitment is the issue of mitigation. From the currently available information, it is apparent that potentially significant disturbance of individual marine mammals during construction must be considered. As such, mitigation must be tailored to minimising the level of disturbance encountered, as far as reasonably practicable. Potential mitigation measures that may be applicable during the construction of the Sheringham Shoal project include (but are not limited to):

- Operational measures for pile/foundation installation;
- Marine mammal detection measures, linked with operational response; and
- Discouragement of marine mammals.

These are discussed further below.

11.4.1.3 Operational measures

Soft start

Soft start piling is a commonly recommended mitigation measure for many forms of piling, acoustic survey and sonar studies (e.g. JNCC, 2004). The procedure involves starting the piling at a level well below full power in order to avoid introducing sudden high peak pressure noise. This may be achieved by 'dry firing' the hammer (i.e. raising and dropping the hammer without compression), which would reduce noise levels by around 50%. The power and frequency of hammer blows is then gradually ramped up over a period of not less than 20 minutes.

Warnings

Warning blasts, using low powered explosives have been used in some industries to discourage marine mammals from an area (e.g. Richardson, 1995). However, the inherent danger of using explosives means this mitigation is unlikely to be considered suitable.

Muffling of noise at source

There are a range of measures that could be used to limit the production of noise at source. These include bubble curtains and trees, muffling of the hammer and use of a vibrating hammer head.

Bubble curtains and trees have been used in shallow water piling operations with limited success (e.g. Wursig *et al*., 2000). The applicability and economic feasibility of using bubble curtains and trees in deep water subject to currents and tidal patterns, as encountered at the Sheringham Shoal site is highly questionable and would require further study before being applied.

The hammer itself could be softened or cushioned to reduce its impact with the pile and, hence, the noise produced. This is likely to cause an increase in the time taken to fully drive individual piles and increase the duration and potential impact period of the piling operation.

Rapidly vibrating hammers can be used to install piles with a large, if not total decrease in the levels of impulsive noise encountered in standard pile driving. Nedwell *et al,* (2003) have suggested that this approach may be an effective mitigation measure. However, the availability of such technology for offshore installations may limit its applicability.

11.4.1.4 Detection measures and operational response

There are a range of mechanisms available for the detection of marine mammals. These include trained marine mammal observers (MMO), who would be stationed on construction vessels. MMOs are most effective in calm sea states. Palka (1996) has reported that sightings of porpoise were 80% lower in sea state 2 and 3 than in sea state 0. MMOs are, however, the only reliable way of detecting non-vocalising whale species and seals.

Other detection devices either passively or actively detect marine mammals. Passive devices, such as hydrophones, Passive Acoustic Monitoring arrays (PAM) and T-PODS all can be used to detect the vocalisations of marine mammals. Depending on how they are deployed, distances of mammals from operations can be extrapolated. Passive devices would not be applicable for non-vocalising species. Active detection would include the use of sonar to locate and identify mammals.

Operational responses to confirmed detection of marine mammals by any of the above methods may include the application of defined exclusion zones, within which no construction work could take place without certain types of mitigation being applied. Delays to commencement of piling could be applied until a detected mammal has moved out of the area or there could be operational shut down protocols in place to cease piling if mammals are detected within the exclusion zone range. Again, the use of such measures, in particular shut down procedures, needs to be carefully assessed in terms of their applicability and practicality on a site specific basis.

11.4.1.5 Discouragement

There are various methods of actively ‘discouraging’ marine mammals from a construction area prior to increased noise propagation. These measures can include Acoustic Harassment Devices (AHD) or physical barriers such as nets. AHDs operate by producing high amplitude noise to irritate mammals and make them leave an area. AHDs have been associated with aquaculture sites and the fishing industry. While they are successful to a degree, it is also thought that mammals can habituate to the effect of the AHD and come to represent a “dinner-bell effect”, whereby, the AHDs are associated with the presence of easy prey resource (e.g. Richardson *et al*, 1995).

From the above discussion, it is clear that a range of mitigation measures may be applicable to the Sheringham Shoal project. As previously discussed, Scira is committed to maintaining open and active communication with the JNCC and English Nature on this issue. As understanding of the impacts of noise on marine mammals increases and the feasibility and applicability of site specific mitigation is studied in more detail, it is anticipated that Scira will be able to commit to an agreed package of mitigation measures that would minimise, as far as reasonably practicable, the risk of physical injury and mortality to individual marine mammals.

11.4.1.6 Monitoring requirements

Given the uncertainty on the effects of offshore construction activities on foraging seals and the current proposals for a number of wind farms off the Norfolk and Lincolnshire coasts, the SMRU proposes to undertake a monitoring programme of harbour seals for the period 2005-2007 in the Wash, at Blakeney Point and Donna Nook (Thompson et al., 2005). This monitoring programme would provide evidence on the short or medium term effects of wind farms on coastal seal populations. Scira welcomes the proposal and is committed to collaborate with SMRU during this research work.

Any additional monitoring requirements identified as part of the ongoing studies in the Thames SEA area would also be considered in discussion with English Nature and JNCC.

11.4.2 Impact due to collision risk

There is no published information on ship collisions with cetaceans and seals in the North Sea (Hammond *et al*, 2003). Although a possibility, the small and infrequent size of seal and cetacean populations in the area, as well as the small size of species most often found, suggests the incidence of ship collision with construction vessels to be unlikely. However, given the protected status of all marine mammals, a collision resulting in the accidental death of a mammal must be considered as being of significant impact.

It is considered that a direct relationship exists between shipping intensity, vessel speed and the number and severity of collisions with marine mammals (Laist *et al*., 2001). This is of particular relevance to large whales, which are not as mobile as small cetaceans and, therefore, more prone to collision. It is possible to make certain assumptions about the risk of collision (after Laist *et al*., 2001 and Sakhalin Energy Investment Company Limited, 2005) as follows:

- All types and sizes of vessel can hit marine mammals;
- Vessels over 80m in length cause the most severe or lethal injuries;
- Serious injuries rarely occur to marine mammals if struck by vessels travelling at speeds below ten knots;
- Mammals struck by vessels are rarely seen prior to impact, or are seen too late to avoid impact; and
- The risk of collision increases in poor visibility.

The vessels involved in construction activities would not be travelling at speeds over ten knots while on site, further reducing the potential for a fatal collision.

Given the relatively low importance of the wind farm area for marine mammals, the high agility of the species likely to be encountered (seals and porpoise), and the low speeds at which the vessels would be travelling within the site, it is anticipated that the risk of a significant collision with a marine mammal would be **negligible**. Procedures will be put in place to report any accidental collision that may occur, however unlikely, to the necessary authority.

11.5 Impacts during operation

11.5.1 Impact from operational noise

11.5.1.1 Airborne noise

It has been reported that operational wind farms produce broadband low frequency noise above ambient levels (fldegaard & Danneskiold-Samsöe, 2000) which is at the lower end of the threshold frequency spectra of selected representative cetaceans (Richardson *et al*., 1995). In addition, it has been demonstrated that wind turbines with different foundation types emit sound with different characteristics (fldegaard & Danneskiold-Samsöe, 2000). Acoustic measurements of the noise emitted by one offshore wind turbine have been made by Westerberg (1994). Amongst other results, Westerberg observed that although higher wind speeds meant that higher noise levels were emitted, the relative level of noise above ambient did not change because ambient noise levels increased in line with wind speed.

Given the distance of the construction activities from seal haul out sites, the impact of operational, airborne noise on marine mammals is considered to be of **negligible** significance.

11.5.1.2 Underwater noise on Harbour Porpoise

The research undertaken to date on the effects of wind farm operational noise on marine mammals is not conclusive. Different studies reach varying conclusions, possibly due to local conditions. The study undertaken by Henriksen *et al*. (2001) on the auditory sensitivities of odontocete species for different frequencies in relation to the characteristics of the sound emitted from wind turbines indicates that the maximum detection distance for harbour porpoise is likely to be in the region of 50m. However, from sound recordings made at the wind farms at Vindeby in Denmark and Gotland (Bockstigen) in Sweden, it was predicted that noise from a wind turbine would be audible to marine mammals only up to 20m from its foundations (Bach *et al*., 2000).

Monitoring studies undertaken during the first operational year at Horns Rev wind farm indicate that there was no statistically significant change in sighting rates inside the wind farm area (Tougaard *et al*, 2004). During the second year of monitoring, porpoise were also seen across the entire Horns Rev area. However, Tougaard *et al*. (2005) argue that it is not possible to conclude that the wind farm has little effect on porpoise without analysing other dynamic environmental variables such as tide and salinity in determining the fine-scale distribution of porpoises and their prey in the area.

11.5.1.3 Underwater noise on Seals

Henriksen *et al*. (2001) have also predicted that seals may hear the noise emitted from wind farms at a distance of up to 1km. Another study by Laidre *et al*. (2001) discusses how seals are likely to use the wind farm area during operation. They note that because grey seal have large home ranges they do not use the wind farm area very often and that harbour seal, which have a more localised habitat, does use the wind farm area.

A study has been undertaken through video monitoring at the Rodsand seal sanctuary in Denmark during the operational phase of the Nysted offshore wind farm, located some 4km away. It was observed that more seals were present during operation than during the baseline survey, which was undertaken prior to the wind farm construction (Clermont Edrén *et al*., 2005). This study and other on-going research projects for the Nysted and Horns Rev wind farms preliminary indicate that there is no obvious adverse effect on seals during the operational phase (Clermont Edrén *et al*. presentation, 2005).

Figure 11.4 Harbour Seal close to the Horns Rev offshore wind farm during operational phase.

On the basis of the current research on the effects of operational noise on marine mammals, it is difficult to draw a definite conclusion. Under the assumption that harbour porpoise would detect the operational noise from 50-20m of each turbine (although the generated sound may not necessarily cause avoidance), it is anticipated that the majority of the wind farm area could remain accessible, where the average distance between turbines is more than 800m. This seems to be confirmed by monitoring observations during the operational phase of Horns Rev wind farm.

Avoidance reactions may occur for seals, although this does not appear to be confirmed by the available evidence.

The available monitoring appears to suggest that although some individual mammals may choose to avoid passing within tens of metres of operational turbines, there is no clear evidence that significant displacement or disturbance of marine mammals occurs during the operation of a wind farm. As such, given the relatively low numbers of individuals recorded as part of the baseline surveys and the apparent lack of significant avoidance reported, it is anticipated that the impact of operational noise on marine mammals would be of **negligible** significance.

11.5.2 Impact from electromagnetic fields

The results of model simulations showed that a cable with perfect shielding i.e. where conductor sheathes are grounded, does not generate an electric field (E-field) directly. However, a magnetic field (B-field) is generated in the local environment by the alternating current in the cable. This, in turn, generates an induced E-field close to the cable within the range detectable by electro-sensitive fish species.

The B-field generated by a subsea power cable may be of sufficient intensity to affect species that use Earth's geomagnetic fields to orientate themselves in their environment. Cetaceans appear to be sensitive to variations in the Earth's magnetic field as live strandings and disruptions have been correlated to anomalies in the geomagnetic field (Klinowska, 1990; Kirschvink *et al*., 1986). CMACS (2003) demonstrated that the magnitude of the B-field associated with a possible transmission cable buried at a depth of 1m falls to background levels within 20m. Earlier studies demonstrated that cables at a burial depth of 1m create a magnetic field on the seabed above the cable that is smaller than the Earth's geomagnetic field (Soerensen and Hansen 2001). However, the alternating field generated by the cable is different from the background geomagnetic field and may, therefore, be perceived differently. There is currently no evidence of responses by cetaceans to AC electromagnetic fields.

With respect to harbour porpoise, it has been suggested that this species does not depend on geomagnetic cues for navigation, where alternative cues such as temperature, salinity and bathymetry are perhaps more efficiently used for navigation in the relatively shallow waters where they occur (Kirschvink *et al*., 1986). There is currently no evidence that seals are influenced by, or use electromagnetic fields.

Although knowledge of the potential impacts on marine mammals is currently limited, the limited use of the area by large migrating whales and the minimal distance over which the B-field is recorded over background levels, suggest that a **negligible** impact is likely on seal and cetacean populations due to electromagnetic fields.

11.6 Impacts during decommissioning

The impacts associated with the decommissioning of the wind farm on cetaceans and seals would be similar to those of construction, with the exception of any need for piling, therefore the need for extensive mitigation measures would be reduced.

It is likely that the increase in knowledge regarding the behaviour of marine mammals to construction activities will ensure that potentially significant impacts are minimised.

11.7 Cumulative effects

The Wash has been identified as strategic area for Round Two offshore developments, and a number of wind farms have been proposed. The most significant cumulative impact for marine mammals is likely to be associated with the construction noise, should more than one of these wind farms be constructed within the same period as the Sheringham Shoal project. For instance, should the proposed Docking Shoal wind farm, which is located less than 15km from the Sheringham Shoal site, be built in the same period, an adverse cumulative effect may be anticipated on marine mammals in terms of extent of the affected area, intensity and duration of generated noise.

As discussed Scira is aware of the studies currently being carried out in the Thames to further understand the individual and cumulative impacts of construction noise on marine mammals. It is Scira's intention to utilise the outcome of these studies to ensure that the potential impact on marine mammals in the Sheringham Shoal study area and the wider region (for cumulative impacts) has been appropriately assessed and that practical mitigation measures are applied. This will ensure that Scira limit the potential for a significant adverse impact on individual marine mammals and the marine mammal population as a whole. Until such time as these further studies are completed, the overall impact on marine mammals cannot be accurately predicted. However, given suitable mitigation measures as agreed with JNCC and English Nature, it is anticipated that potentially impacts can be effectively reduced to an acceptable level (negligible to minor adverse).

11.8 Summary

Data on marine mammals for the North Sea and the site have been obtained from the following sources:

- Small Cetacean Assessment for the North Sea (SCANS) (Hammond et al. 2002);
- Atlas of Cetacean Distribution in northwest European waters (Reid et al, 2003);
- Boat based and aerial survey undertaken as part of the ornithological data collection;
- Norfolk Biological Record Centre (NBRC) data;
- JNCC Directory, 1995; and
- English Nature communication.

The impact assessment has been undertaken on the basis of the above cited data and an extensive literature review, including recent findings of research on seal and cetacean behaviour associated with human disturbance and operational wind farms.

The region of the North Sea of interest to this study is relatively unimportant for cetaceans. JNCC report that little more than 10% of the UK cetacean fauna was either present throughout the year or has been recorded annually as seasonal visitors in the area between Flamborough Head and Great Yarmouth (JNCC, 1995). Resident or regularly visiting species were identified as the minke whale *Balaenoptera acutorostrata*, harbour porpoise *Phocoena phocoena* and white-beaked dolphin *Lagenorhynchus albirostris*.

The region is, however, significant for seals. In particular, The Wash hosts the main common seal *Phoca vitulina* population in England and has been accordingly designated as an SAC under the EC Habitats Directive. Grey *seal Halichoerus grypus* are less numerous in the area.

Site specific data indicate that the most common species in the area are harbour porpoise and common seal. Records of harbour porpoise sightings from the coast (NBRC data) are available every year since 1995, with sightings varying from a minimum of 2 in 2004 to a maximum of 56 in 1997. The species has been recorded during 10 out of the 29 boat based bird surveys and on two occasions during the aerial bird surveys. Sightings of common seals within and/or close to the proposed site were made during ten out of the 29 boat based bird surveys and during three of the aerial surveys. NBRC data confirm the presence of high numbers of seals along low-lying coast and particularly at Blakeney Point.

During construction, the most likely effects would be due to construction generated noise and traffic movement increases to and from the site. As cetaceans rely on sound as their primary sense for communication, navigation and orientation, the construction activities, and particularly piling works, have the potential to significantly affect harbour porpoise and seals.

The most detailed study to date on the effects of wind farm construction on harbour porpoise was that of Tougaard *et al*. (2003a), which was conducted prior to and during the construction of the then largest offshore wind farm at Horns Rev in Denmark. The study concluded that acoustic activity by the porpoises decreased dramatically on the entire Horns Rev at the onset of piling operations and returned to higher levels a few hours (3-4 hours) after each piling operation was completed. A general effect on the behaviour of animals was observed during the construction period and at distances of up to 10-15km from the construction site.

Most studies on the reaction of harbour seals to noise have been conducted on hauled-out animals, and very little is known about the effects of noise on seals in the water. The closest haul-out site is at Blakeney at a distance of some 30km. The initial evidence from a study undertaken at the Rodsand seal sanctuary in Denmark during the operational phase of the Nysted offshore wind farm indicates that there was no adverse effect on seals (Clemont Edren *et al*, 2005).

Scira is aware of the studies currently being carried out in the Thames to further understand the individual and cumulative impacts of construction noise on marine mammals. It is Scira’s intention to utilise the outcome of these studies to ensure that the potential impact on marine mammals in the Sheringham Shoal study area and the wider region (for cumulative impacts) has been appropriately assessed and that practical mitigation measures are applied. This will ensure that Scira limit the potential for a significant adverse impact on individual marine mammals and the marine mammal population as a whole.

During the operational phase, the most likely effects on marine mammals are due to operational noise, generated electromagnetic fields and habitat changes.

The research undertaken to date on the effects of the wind farm operational noise on marine mammals is not conclusive. Henriksen *et al.*, (2001) suggest that the maximum detection distance for harbour porpoises is likely to be in the region of 50m; while Bach *et al.*, (2000) predicted that noise from a wind turbine would be audible to marine mammals only up to 20m from its foundations. A number of studies and on-going research projects for the Nysted and Horns Rev wind farms in Denmark preliminary conclude no obvious adverse effect on seals during the operational phase (Clermont Edrén *et al.*, 2005). On the basis of the current knowledge, the relatively low presence of cetaceans and seals within the Sheringham Shoal proposed area and the distance from significant haul-out sites, it is concluded that the adverse effects due to operational noise are likely to be **negligible**.

The knowledge of the potential impacts of electromagnetic fields on marine mammals is currently limited. It has been suggested that harbour porpoise does not depend on geomagnetic cues for navigation (Kirschvink *et al.*, 1986), and there is no evidence that seals are influenced by, or use electromagnetic fields. Overall, given the limited use of the area by large migrating whales it is suggested that a **negligible** impact is likely on seal and cetacean populations due to electromagnetic fields.

The impacts associated with the decommissioning of the wind farm on cetaceans and seals would be similar to during construction.

The most significant cumulative impact for marine mammals is likely to be associated with the construction noise, should more than one of these wind farms be constructed within the same period as the Sheringham Shoal wind farm. By utilising the output of the studies being carried out in the Thames, Scira anticipate that further work will be carried out, in consultation with the relevant regulators, to further understand the potential individual and cumulative effects of construction noise on marine mammals. All practicable mitigation recommended through the studies that are of relevance to the Sheringham Shoal site will be applied to ensure that the potential impact are **negligible**.

11.9 References

- Bach, S., Teilmann, J. & Henriksen, O.D., 2000. VVM-redeg¿relse for havmølleparker ved Rødsand. Teknisk rapport vedr¿rende marrsvin. Rapport til SEAS. 41 pp.
- Bonner, W N, 1982. Seals and man. A study of interactions. Univ. Wash. Press, Seattle, WA, p170.
- Clermont Edrén S M, Teilmann J, Dietz R, Tougaard J, Harder P, Tougaard S, Carstensen J, 2005. Aerial aurveys, satellite tracking and video monitoring of seals. Results from the investigation at Nysted and Horns Rev Offshore Wind Farm. National Environmental Research Institute, Fisheries and Maritime Museum.
- CMACS, 2003. A baseline assessment of electromagnetic fields generated by offshore wind farm cables. COWRIE Report EMF - 01-2002 66.
- Duck C D, 2004. Grey seal pup production in Britain in 2003. SOOC Briefing paper 04/2 on Scientific Advice on Matters related to the Management of Seal populations: 2004, UK Special Committee on Seals, Advice 2004.
- Duck C D and Thompson D, 2004. The status of British Common Seal populations. SCOS Briefing paper 04-5 on Scientific Advice on Matters related to the Management of Seal populations: 2004, UK Special Committee on Seals, Advice 2004.
- Engell-Soerensen K., 2002. Possible effects of the offshore wind farm at Vindeby on the outcome offishing: The possible effects of electromagnetic fields and noise. Bio/consult as report prepared for SEAS, Doc. No. 1920-003-001-rev.2.

- English Nature, 2004. The Southern North Sea Marine Natural Area. External Relations Team, English Nature, Northminster House, Peterborough PE1 1UA.
- Feist, B., et al. 1992. Potential Impacts of Pile Driving on Juvenile Pink (oncorhynchus gorbuscha) and Chum (O. keta) Salmon Behaviour and Distribution, University of Washington, School of Fisheries, 1992.
- fldegaard & Danneskiold — Sams¿e A/S, 2000. Underwater noise measurements, analysis and predictions. R¿dsand Offshore Wind farm EIA Technical Background Report: Underwater Noise, Dec 2000. Report no. 00.792 rev.1.
- Gill, A.B. & Taylor, H., 2001. The potential effects of electromagnetic fields generated by cabling between offshore wind turbines upon elasmobranch fishes. CCW Science Report No. 488.
- Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Jørgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F. and Øien, N., 2002. Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. Journal of Applied Ecology, 39: 361-376.
- Hammond, P.S., Gordon, J.C.D., Grellier, K., Hall, A.J., Northridge, S.P., Thompson, D., Harwood, J., 2002. Background information on marine mammals relevant to Strategic environmental Assessments 2 and 3. Report by the Sea Mammal Research Unit for the DTI.
- Henriksen, O.D., Teilmann, J., Dietz, R. & Miller L., 2001. Does underwater noise from offshore wind farms potentially affect seals and harbour porpoises? Poster presented to the 14th biennial conference on the biology of marine mammals, Vancouver, Canada.
- Hoffman E, Astrup J, Larsen F, Munch-Petersen S, 2000. Effects of marine wind farms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. Report to ELSAMPROJEKT A/S May 2000 for Danish Institute for Fisheries Research.
- Joint Nature Conservation Committee, 1995. Coast and Seas of the United Kingdom. Region 6 Eastern England: Flamborough Head to Great Yarmouth edited by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson.
- Joint Nature Conservation Committee, 2004. Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys, April 2004.
- Kirschvink, J.H., A.E. Dizon, & J.A. Westphal., 1986. Evidence from strandings for geomagnetic sensitivity in cetaceans. J. exp. Biol. 120:1-24.
- Klinowska M, 1990. Geomagnetic orientation in cetaceans: behavioural evidence. In J A Thomas & RA Kastelein (EDS) Sensory abilities of cetacean. Plenum Press, New York.
- Laist, D. W., Knowlton, A.R., Mead, J.G., Collet, A.S., and Podesta. M. (2001) Collisions between ships and whales. Marine Mammal Science, 17 (1):30-75.
- Laidre, K., Henriksen, O.D., Teilmann, J. & Dietz, R., 2001. Satellite tracking as a tool to study potential effects of an offshore wind farm on seals at R¿dsand. Technical report for the Ministry of the Environment and Energy, Denmark.
- Nedwell, J., et al., 2001. Report on measurements of underwater noise from the Jack Bates drill rig." Tech. Rep. 462 R 0202, Subacoustech Ltd., Hampshire, UK, 2001.
- Nedwell, J., Langworthy, J., and Howell, D., 2003. Assessment of sub-sea acoustic noise and vibration from offshore wind turbines and its impact on marine wildlife; initial measurements of underwater noise during construction of offshore wind farms, and comparison with background noise. Subacoustec report to COWRIE, reference 544R0424. May 2003. Subacoustech Ltd, Chase Mill, Winchester Road, Bishop's Waltham, Hampshire S032 1AH, UK. 55pp.

- Nedwell, J.R. and Howell, D.M., 2004. A review of offshore wind farm related noise sources. Subacoustech report to COWRIE, reference 544R0310. May 2004. Subacoustech Ltd, Chase Mill, Winchester Road, Bishop's Waltham, Hampshire S032 1AH, UK.
- Palka, D. (1996) Effects of Beaufort sea state on the sightability of harbor porpoises in the Gulf of Maine. Report of the International Whaling Commission, 46: 575-582.
- Reid, J.B., Evans, P.G.H. and Northridge, S.P., 2003. Atlas of Cetacean Distribution in North-west European Waters. Joint Nature Conservation Committee, Peterborough. 76pp.
- Richardson, W.J., Greene Jr., C.R., Malme, M.I., and Thomson, D.H., 1995. Marine mammals and noise. Academic Press, London & New York. 576pp.
- Sakhalin Energy Investment Company Limited (2005) Marine Mammal Protection: A framework for mitigation and monitoring related to Sakhalin Energy Oil and Gas operations, Sakhalin Island, Russia.
- Sharples R J and Hammond P S,, 2004. Distribution and movements of harbour seals around Orkney, Shetland and the Wash. SCOS Briefing Paper 04/10 on Scientific Advice on Matters related to the Management of Seal populations: 2004, UK Special Committee on Seals, Advice 2004.
- Scott K, 2004. International Regulation of Undersea noise. Published in the ICLQ vol 53, April 2004 pp 287 - 324
- Soerensen, H.C., and Hansen, L.K., 2001. Social acceptance, environmental impact and politics. *Draft report November 2001 WP 2.5*
- Thompson D, Hammond P, and Matthioploulos J., 2005. An investigation of the effects of offshore wind farm developments on harbour seals on the English east coast. Proposal. Sea Mammal Research Unit, University of St Andrews.
- Tougaard, J., Carstensen, J., Henriksen, O.D., Skov, H., and Teilmann, J., 2003a. *Short-term effects of the construction of wind turbines on harbour porpoises at Horns Rev*. Technical report to TechWise A/S. HME/362-02662. Hedeselskabet, Roskilde, Denmark.
- Tougaard J, Ebbesen I, Tougaard S, Jensen T, and Teilmann J, 2003b. Satellite tracking of Harbour Seals on Horns Rev. Use of the Horns Rev wind farm area and the North Sea. A report to Techwise A/S, March 2003.
- Tougaard J, Carstensen J, Henriksen O D, Teilmann J., Hansen J R, 2004. Harbour Porpoises on Horns Rev - Effects of the Horns Rev Wind Farm Annual Status Report 2003 to Elsam Engineering A/S NERI Technical Report Final version June 2004.
- Tougaard J, Carstensen J, Wisz M S, Teilmann J, Bech N I, Skov H, Henriksen O D, 2005. Harbour Porpoises on Horns Rev - Effects of the Horns Rev Wind Farm. Annual Status Report 2004 to Elsam Engineering A/S. NERI Technical Report July 2005.
- UK Special Committee on Seals, Advice 2004. Scientific Advice on Matters related to the Management of Seal populations: 2004 available on http://smub.st-and.ac.uk.
- Vagle, S., 2003. On the Impact of Underwater Pile-Driving Noise on Marine Life, Ocean Science Productivity Division, Institute of Ocean Sciences, DFO/Pacific, 2003.
- Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, T. & Thorne, P.. 2001. Assessment of the effects of noise and vibration from offshore wind farms on marine wildlife. Report to ETSU (Department of Trade and Industry), W/13/00566/00/REP.
- Westerberg, H., 1994. Fiskeriundersokningar vid havsbaserat vindkraftvert 1990-1993. Goteborgsfilialen, Utredningskonteret I Jonkoping. Sweden National Board of Fisheries. Rapport 5 – 1994. 44pp.

12 Commercial Fisheries

12.1 Introduction

This section describes the existing environment relating to the commercial fishing activities. It goes on to consider the potential impacts on these activities that could result from the construction, operation and decommissioning of the Sheringham Shoal offshore wind farm project. Mitigation measures are described where appropriate.

12.1.1 Assessment Methodology

The existing environment section was drafted by Brown & May Marine Ltd. based on a variety of information sources including field work, observer trips and consultation undertaken by Brown & May Marine Ltd.

12.1.1.1 Approach

The collection and analysis of data and evidence relating to determination of the existing environment followed the CEFAS 'Guidelines for Environmental Impact Assessment', version 2, June 2004 and subsequent amendments. Considerable emphasis was placed on obtaining information from local fishermen with a track record of fishing in areas relevant to the wind farm development and from undertaking observer trips aboard local vessels.

The fishing vessels present in the area, their origin and type of activity were identified. The operating patterns of vessels targeting the area were determined. The landings associated with these vessels in terms of species and their volume and value were recorded. These findings enabled the team to assess the likely impacts on commercial fisheries of constructing, operating and decommissioning the Sheringham Shoal wind farm development.

Cumulative impacts are assessed by detailing other known developments in the area likely to cause impacts on commercial fisheries. Other businesses associated with these vessels and their landings were also identified to determine any indirect impacts resulting from impacts on commercial fisheries.

Due to the relative infancy of the UK offshore wind industry, the prediction of the potential significances of the impacts of wind farm developments on commercial fishing is, to some degree speculative, as at present there is insufficient reliable evidence and data on effects to reliably apply quantitative modelling of the potential impacts on commercial fishing. Furthermore, the inherent limitations and sensitivities of fisheries statistics and the unpredictability of potential factors which could influence future fishing patterns also preclude the use of quantitative modelling. The assessment of potential residual impacts is therefore largely qualitative.

12.1.1.2 Study Area

The overall (regional) study area, comprising 11 ICES (International Council for the Exploration of the Sea) rectangles is illustrated in Figure 12.1. This area was defined on the basis of the vessel operational ranges from base ports of relevance to the wind farm. The boundaries of the overall study area were also defined to provide comparative data between the site and adjacent areas with respect to evaluation of potential inter-site cumulative impacts.

Below this regional study area, the **general** wind farm area consisting of four ICES rectangles was considered (35F1, 35F0, 34F1 and 34F0). The **immediate** wind farm area within ICES rectangles 35F1 (including the wind farm site) and 34F1 (including a section of cable route) was then considered in greater detail.

The wind farm site boundaries shown in Figure 12.1 include a 100m buffer zone around the boundary of the turbine array. For the purpose of the cable assessment, the cable corridor was defined as shown, within which the cables would be installed.

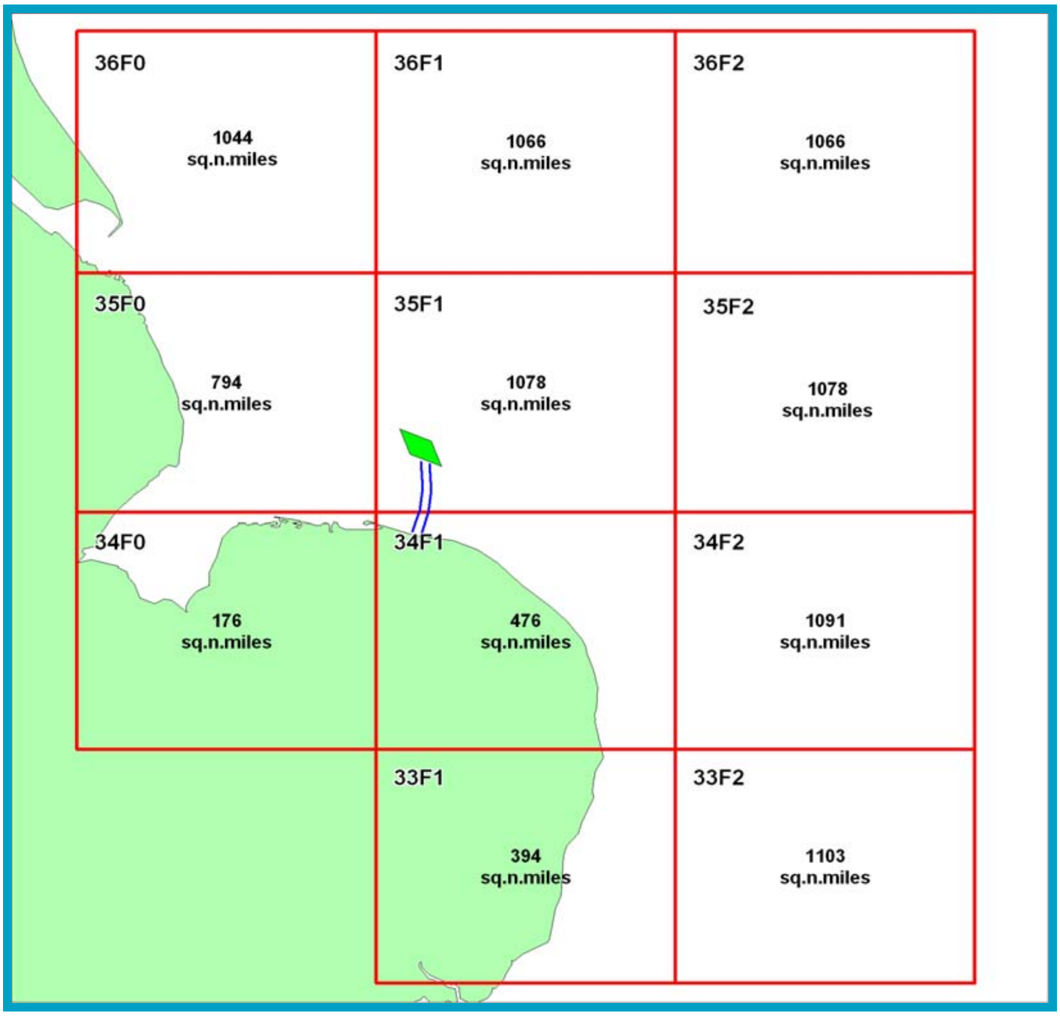


Figure 12.1 Sea areas (n.miles²) of ICES rectangles comprising the Overall Study Area

12.1.1.3 Data and Information Sources

The primary sources of data and information used in determining the existing commercial fisheries environment and for the assessment of impacts included:

- Landings, effort and value data by ICES rectangle for the years 2000 – 2004 as collated by Defra for the ICES rectangles covering the overall study area.
- Data and information provided by the Eastern Sea Fisheries Joint Committee (ESFJC).
- Sea Fisheries Inspectorate (SFI) data, Surveillance Section.
- A series of observer trips undertaken onboard local vessels based at Wells, Blakeney, East Runton and Cromer.
- Sheringham Coast Watch observations, 2004.
- ICES and CEFAS (Centre for Environment, Fisheries and Aquaculture Research) data and research publications.
- SEAFISH (Sea Fish Industry Authority) surveys and publications.
- Consultations and meetings with:
    - District Sea Fisheries Inspectors, Kings Lynn and Lowestoft.
    - ESFJC, Environmental Officers and Area Fisheries Inspectors.
    - CEFAS staff, CEFAS Laboratory, Lowestoft.
    - National Federation of Fishermen's Organisations representatives, Grimsby and Lowestoft.
    - North Norfolk & Wells Fishermen's Association.
    - North Norfolk Shellfishermen's Association.
    - Brancaster Saithe Fishermen's Society.
    - Lowestoft (Inshore) Fishing Vessel Owners Association.
    - Full-time fishing vessel skippers operating from local ports.
    - Local first sale buyers.
    - Wells Harbour Master.
    - National Fishermen's Federation – Holland.
    - National Fishermen's Organisation – Belgium.

With regard to the above data sources, the following general qualifications should be noted:

- ICES rectangles align to 1° of longitude and 30' of latitude and, as such, are not exactly square. The eleven rectangles selected to represent the total study area as shown in Figure 12.1, shows the sea area of each rectangle derived using GIS and manual plotting on WGS84 datum ARCS charts. This method was confirmed as appropriate by Defra.
- The areas of the ICES rectangles relative to the wind farm and cable corridor areas are large. It should also be recognised that fishing effort is not usually evenly distributed within rectangles. Defra data by ICES rectangle is therefore recognised as a baseline and relative indicator of the existing commercial fishing environment within the overall wind farm area rather than an absolute determinant of fishing activity.
- The Defra data represents a minimum baseline indicator of activity which should be used with caution for the following reasons: Under-10m vessels are not obliged to submit daily log sheets. The statistics compiled by Defra are therefore based upon data collected by local SFI and ESFJC Inspectors. Whilst there is a quota allocation system for pressure stocks for under-10m vessels, no quotas are set for crabs, lobsters and whelks. The collection of landings data therefore relies upon the cooperation of fishermen and buyers and the manpower resources of the local Sea Fisheries Inspectorate (SFI) and Eastern Sea Fisheries Committee (ESFJC).
- The fishing vessel list published by Defra includes all registered fishing vessels. Port observations indicate that significant numbers of vessels, whilst still registered and listed, are not actively engaged in fishing.
- The over-flight surveillance data provided by Defra should be qualified in terms of frequency and duration of the SFI surveillance flights over the area, and the fact that they only take place during daylight hours. Generally, surveillance flights over the area are at approximately weekly intervals and focus upon identifying over-10m vessels. For example, 62 flights were undertaken in daylight hours over ICES rectangle 35F1 in 2004. The sightings are therefore an indicator of the spatial distribution of activity, rather than an absolute measure of effort.
- The jurisdictional area of the Eastern Sea Fisheries Committee (ESFJC) extends from specified tidal river boundaries to six miles offshore covering the coastline from Donna Nook Lincolnshire to Dovercourt in Essex. Much of the local data, particularly those from under-10m vessels as published by Defra, are collected by ESFJC inspectors. In view of the extensive local knowledge of the ESFJC staff and their close working relationship with the local fishermen who fish the area, considerable value has been placed upon the statistics, information and advice provided by the ESFJC.

Significant emphasis has also been placed on obtaining information directly from local fishermen through individual interviews, group meetings and by undertaking observer trips on a selection of vessels carrying out typical fishing trips in the immediate area of the site. The trips were undertaken on potting and netting vessels operating from Wells and Blakeney, and on beach launched boats from East Runton and Cromer. Meetings were also held with local first sale buyers and processors and with officers of local and national fishermen’s organisations.

A high level of cooperation was provided by local fishermen. Concerns were raised regarding confidentiality and the fishermen’s wish to remain unidentified is respected.

A significant study into the impacts of offshore wind farm developments on the fishing industry is currently being conducted by CEFAS and Seafish and is expected to report in the first half of 2006. This study has involved extensive consultation with the UK fishing industry and should illustrate experiences and concerns to date. This report has not been available to the authors of this report.

12.1.1.4 Assessment of impact significance

The significance level (negligible, minor, major adverse or beneficial) of identified impacts are shown in **bold** in Sections 12.3 - 12.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Table 3.2 in Section 1 for definitions of significance levels.

For this section, the significance of impact relates to the commercial fisheries sector as receptor. The nature of the impact will ultimately relate to changes in the costs associated with fishing (including time costs) or on the volume and value of target resources caught. These impacts on commercial fisheries are considered in the context of existing fisheries management measures which also impact upon commercial fishing operations.

An impact is assessed as 'negligible' where its influence will not be detected over and above existing annual variation. Impacts are assessed for specific fleets (eg. 'local' Norfolk-based vessels) or for specific sectors within a fleet (eg. 'local' static gear / netting or potting vessels).

There are many naturally occurring variables that impact on a commercial fish stock and affect the year on year 'catchability' of target resources. Fishing mortality only removes a proportion of a stock's total biomass each year; the levels of natural mortality and recruitment to the stock generally have a greater influence on the status of a stock than fishing pressure. Many target stocks are also assessed and managed at a significantly larger scale than the study area, namely the Southern North Sea (ICES sub area IVc). This means that some localised impacts may be insignificant when considered at a stock level and therefore fishing opportunities may not be significantly affected.

There are therefore instances where an impact assessed as being 'minor adverse' with respect to natural fisheries may be assessed as being 'negligible' to commercial fisheries as the catchability of those resources has not been significantly reduced.

12.2 Description of Existing Environment

12.2.1 SFI Over-flight Sightings

Figure 12.2 and Figure 12.3 show the combined sightings by nationality and vessel/gear type for the past five years, 2000 – 2004 for the 11 ICES rectangles covering the region.

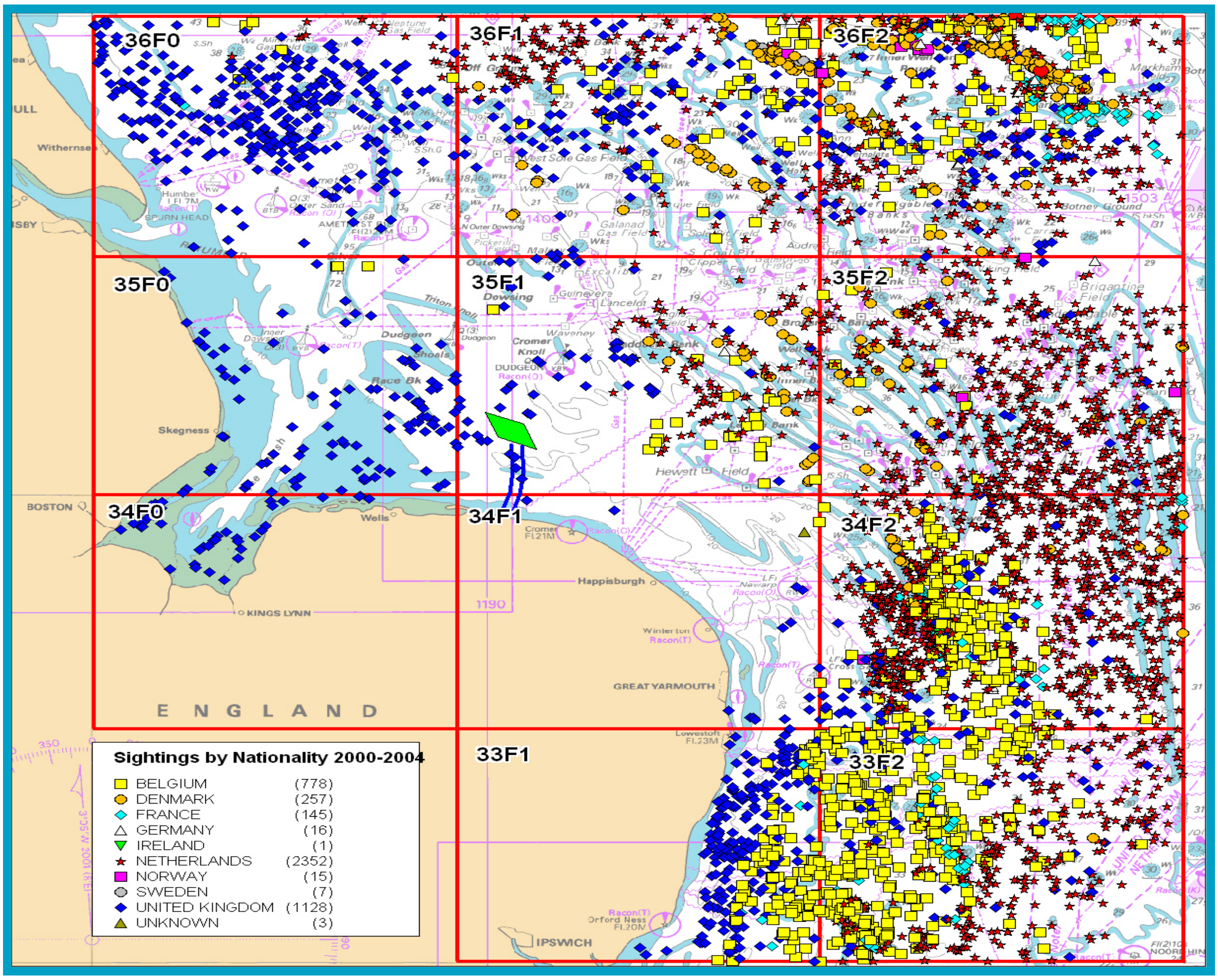


Figure 12.2 Combined surveillance sightings by nationality, 2000 – 2004 (Source Defra).

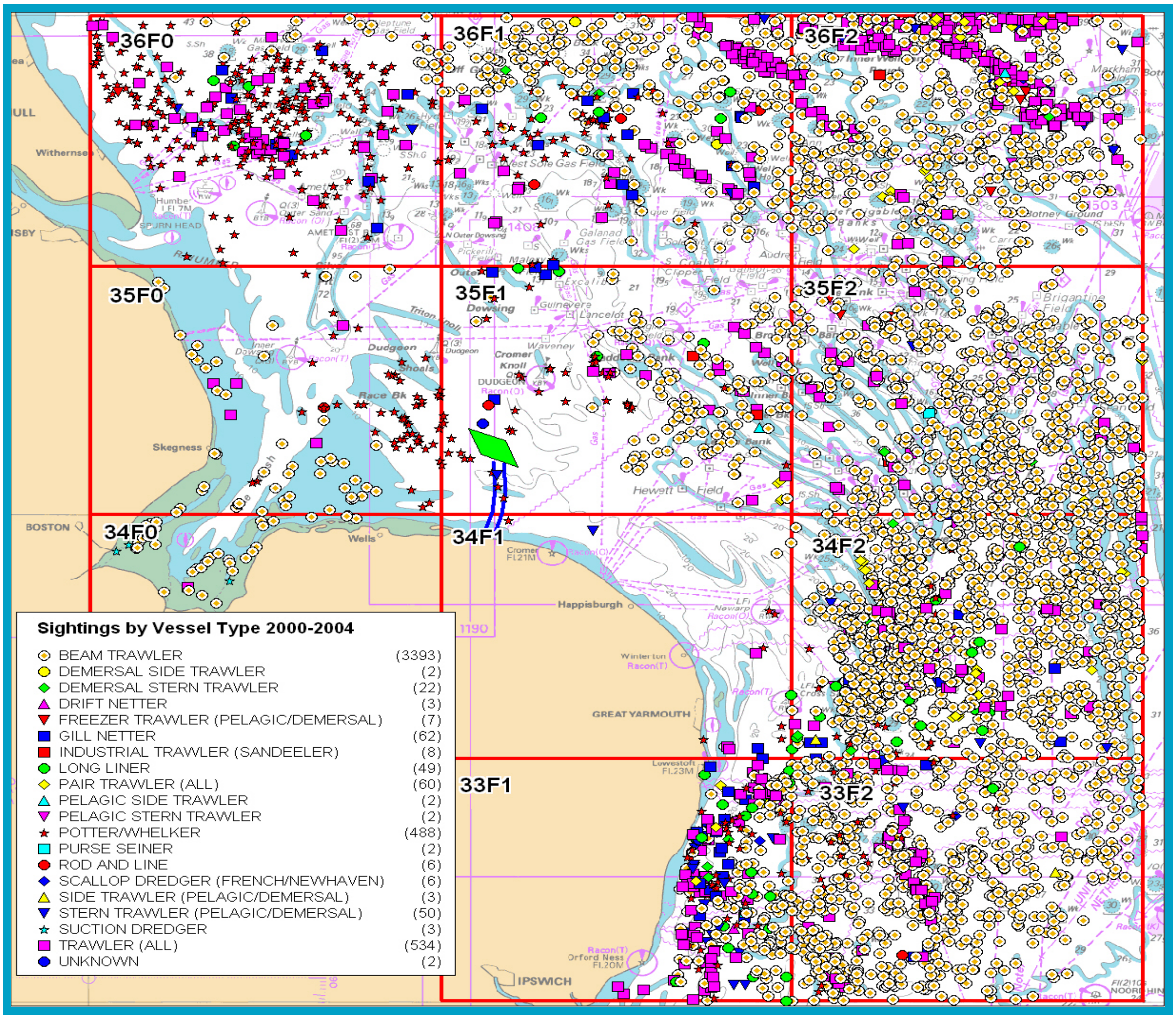


Figure 12.3 Combined surveillance sightings by vessel / gear type, 2000 – 2004 (Source Defra)

Figure 12.2 and Figure 12.3 show that 20 categories of vessels / gears from ten nationalities are recorded as fishing in the overall study area.

The figures illustrate the predominance of Dutch and Belgian beam trawling in the southern North Sea although none were observed within approximately 10n. miles of the wind farm site. Dutch and Belgian beam trawlers are prohibited from fishing within the 12 mile limit and therefore are excluded from areas encompassing the wind farm site and cable corridor. At consultation meetings it was stated by Dutch and Belgian fishermen's representatives that there was "no possibility" of Dutch or Belgian beam trawlers operating within the wind farm site or within its immediate vicinity.

Since 2000, only UK registered vessels were observed as operating within or immediately adjacent to the wind farm site and cable corridor. Sightings are, for the most part, concentrated on the important potting areas of the Docking Shoal, Race Bank, North Ridge, Dudgeon Shoals, Cromer Knoll and to the north and east of the Humber Estuary.

No fishing vessels were observed in the wind farm site although some observations of potters were recorded along the cable corridor. This apparent lack of sightings should however be taken in the context of the frequency of the flights relative to the frequency in which pots are hauled. Flights are also undertaken in daylight, and as such, would not generally observe long-liners which normally fish at night.

12.2.2 Navigation Survey

Figure 12.4 is extracted from radar surveys undertaken in February and October 2004 for the Navigation Safety Assessment, which shows vessel movements within the site and in adjacent areas. A total of 20 tracks passed through the site over the 28 days of surveying corresponding to an average of 0.7 ships per day.

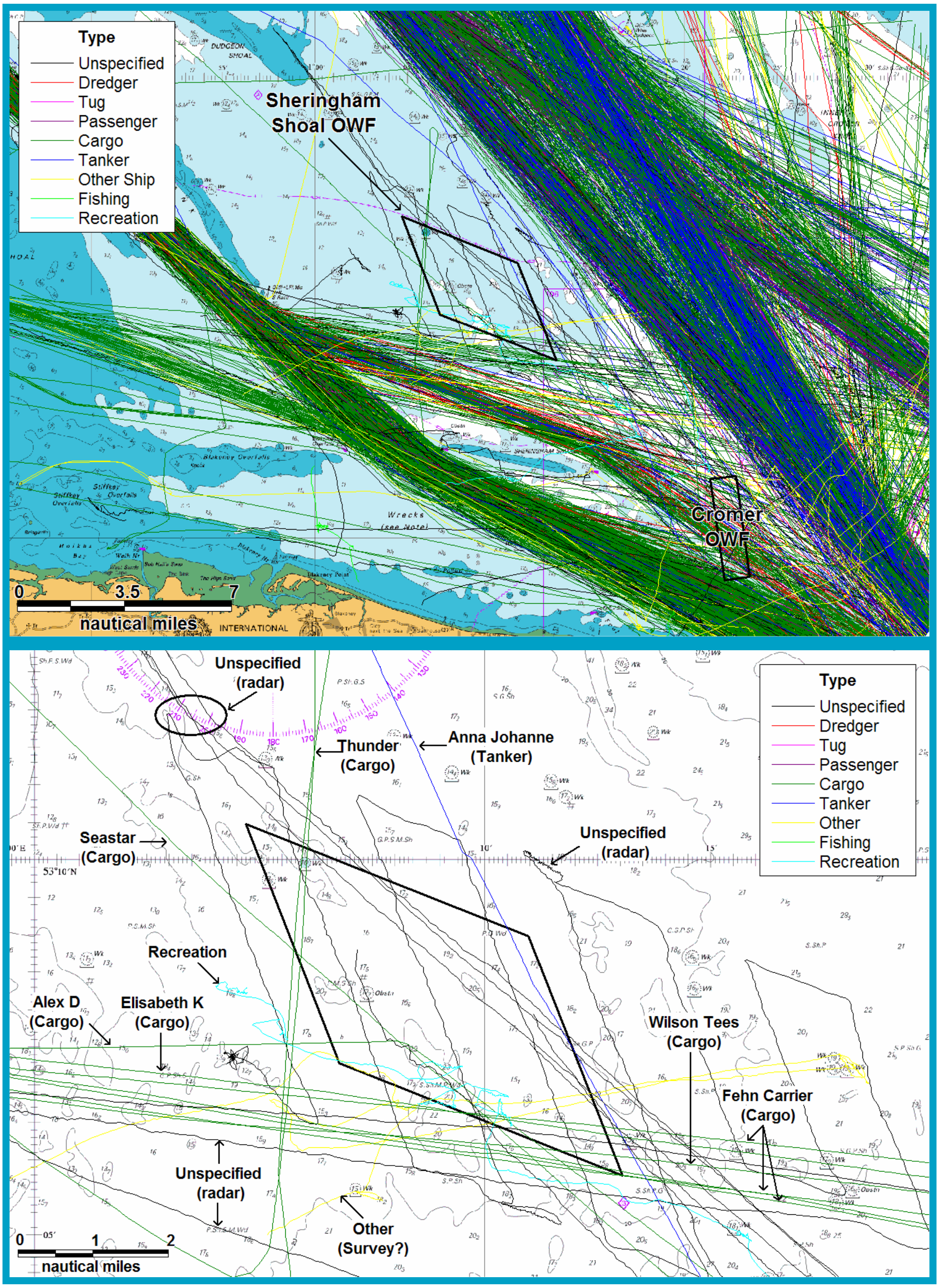


Figure 12.4 Radar Survey Vessel Tracks (Source: Scira, Navigation Safety Assessment)

The 28 day maritime traffic survey indicated limited fishing in the area mainly by small inshore vessels. There was also limited recreational vessel activity in the area, which may include recreational fishing vessels. Further details of the navigational survey and assessment can be found in Section 14, Shipping and Navigation.

12.2.3 Satellite Tracking

Figure 12.5 summarises the tracking data for vessels of over 24m in length in ICES rectangles 35F1 and 34F1 for 2004. Prior to 2004, there was some doubt as to the accuracy of the data as the original on-board transmitters proved not to be 100% tamperproof. The two vessels tracked within the site are a UK vessel, tracked for two days in November, and a Danish vessel tracked for one day in January. As shown in Figure 12.5 the bulk of the vessels plotted in 35F1 were in the north east segment of the rectangle, some 10nm from the wind farm site.

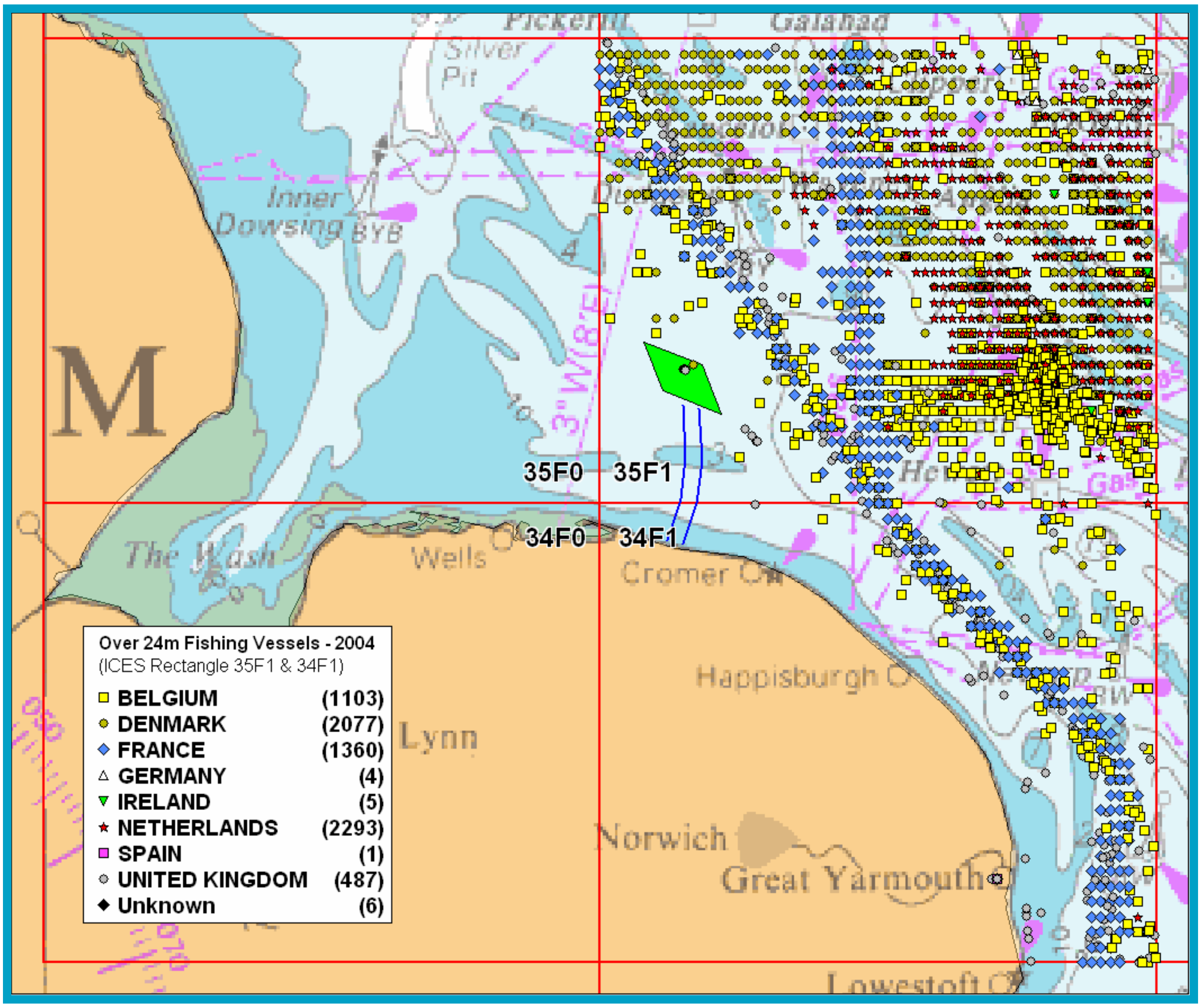


Figure 12.5 Satellite tracked positions of over 24m fishing vessels 2004 (Source: Defra)

12.2.4 Sheringham Coast Watch Sightings

The Coastwatch station is manned between 08.30hrs and 18.00hrs in summer months and between 08.30hrs and 16.00hrs in winter months. Vessel positions are manually recorded in logbooks by bearing and distance from the station. Distances are mainly estimated visually, by quarter or half n.mile unit, although radar is also used for more distant sightings or in poor visibility.

Figure 12.6 is derived from the 2004 records of Sheringham Coastwatch station. The sightings plotted are only those identified as engaged in a fishing activity. This can be interpreted as steaming and fishing activity as visual sitings at distance may not be able to differentiate.

A total of 706 observations of fishing vessels were recorded, of which 671 were crab boats. The highest number of observations occurred between the 1st July and 1st October.

The greatest concentrations of observations were recorded within the 3 mile limit with the number decreasing with distance from the station. Whilst it is to be expected that the open beach launched vessels based at Cromer and Sheringham operate predominantly within the 3 mile limit, account should be taken of the distance limitations of visual observations and the fact that the station is only manned during daylight hours.

Of the 706 observations, 87 (12.3%) were observed within the cable corridor.

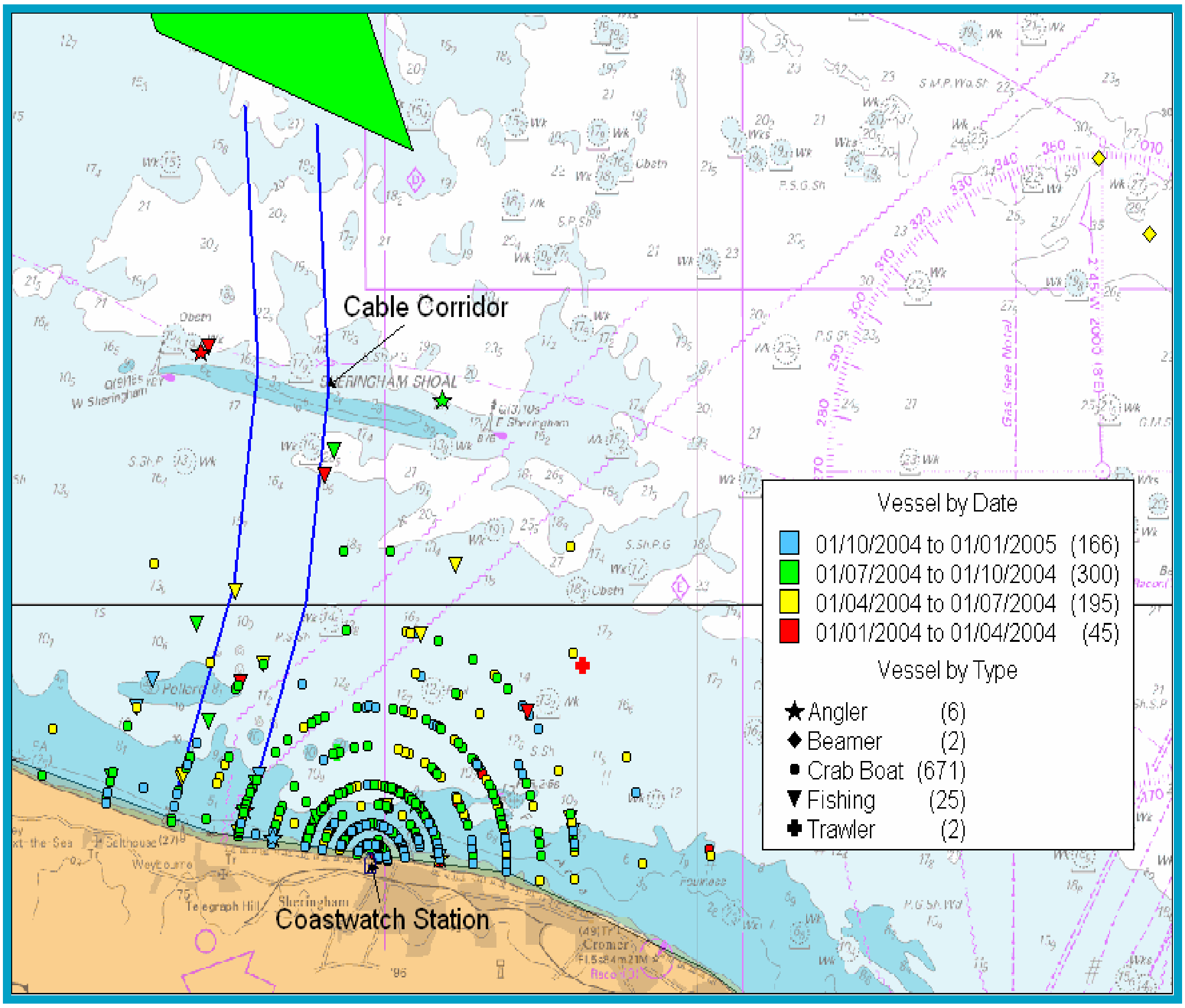


Figure 12.6 Observations of fishing vessels by Sheringham Coast Watch Observations of fishing vessels by Sheringham Coast Watch

12.2.5 DEFRA & ESFJC Landings Values Data

ICES rectangle areas are large relative to the area of the wind farm site and fishing activity is not equally distributed within these areas.

Figure 12.7 and Figure 12.8 present the annual landed value by UK vessels for 34F1 (averaged over 5 years 2000-2004). Rectangle 34F1 includes a short inshore section of the cable corridor and the figures illustrate the importance of potting, which is predominantly by vessels based at Cromer and Sheringham.

In 35F1, which includes the wind farm site and the majority of the cable route, most of the UK landed value is also from potting (Figure 12.9). Figure 12.10 shows relatively high recorded values for Grimsby-based vessels. As indicated in satellite and radar records, these larger vessels operate in the northern quadrants of the rectangle and rarely fish within the site area.

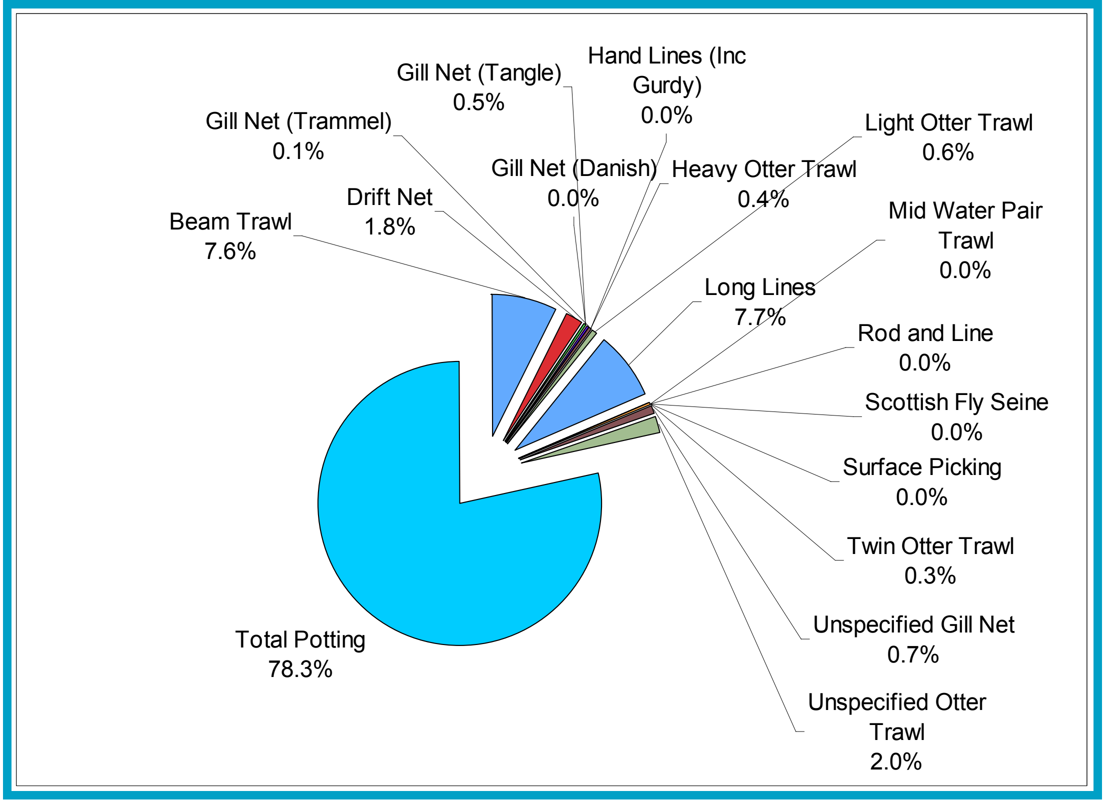


Figure 12.7 *Fishing values by method - 34F1 (Source: Defra)*

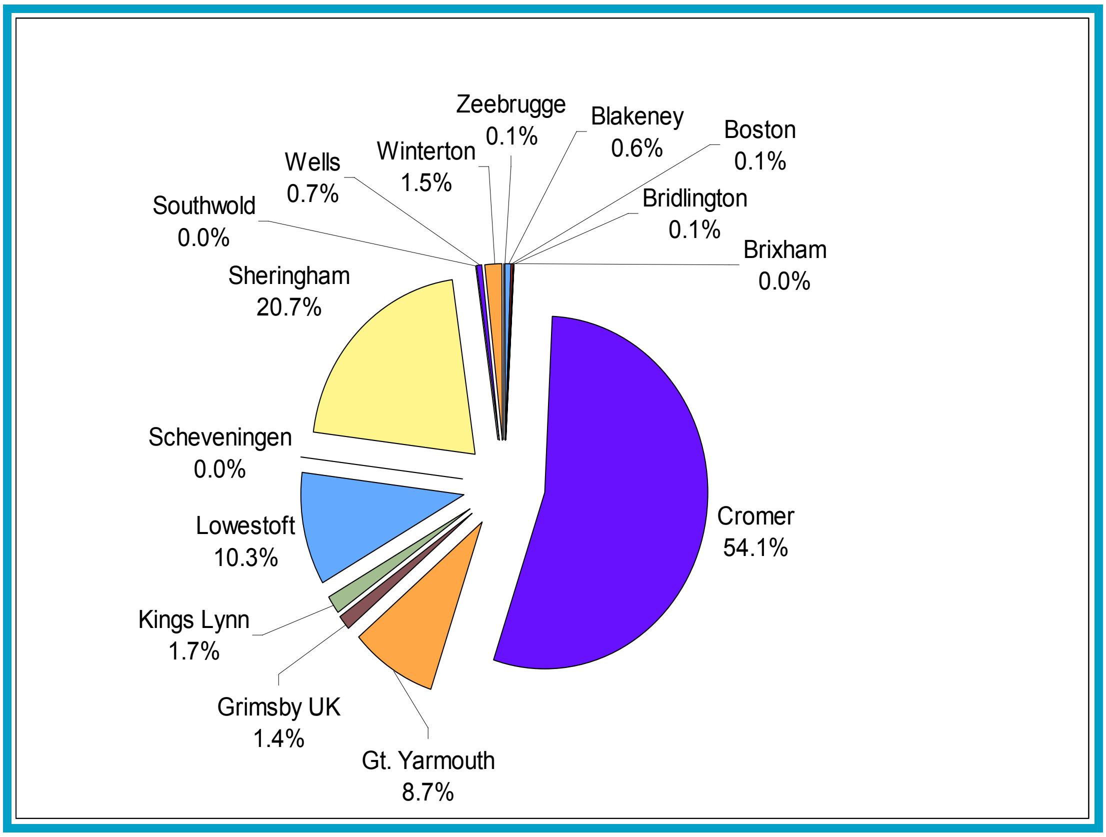


Figure 12.8 Fishing values by landing port - 34F1 (Source: Defra)

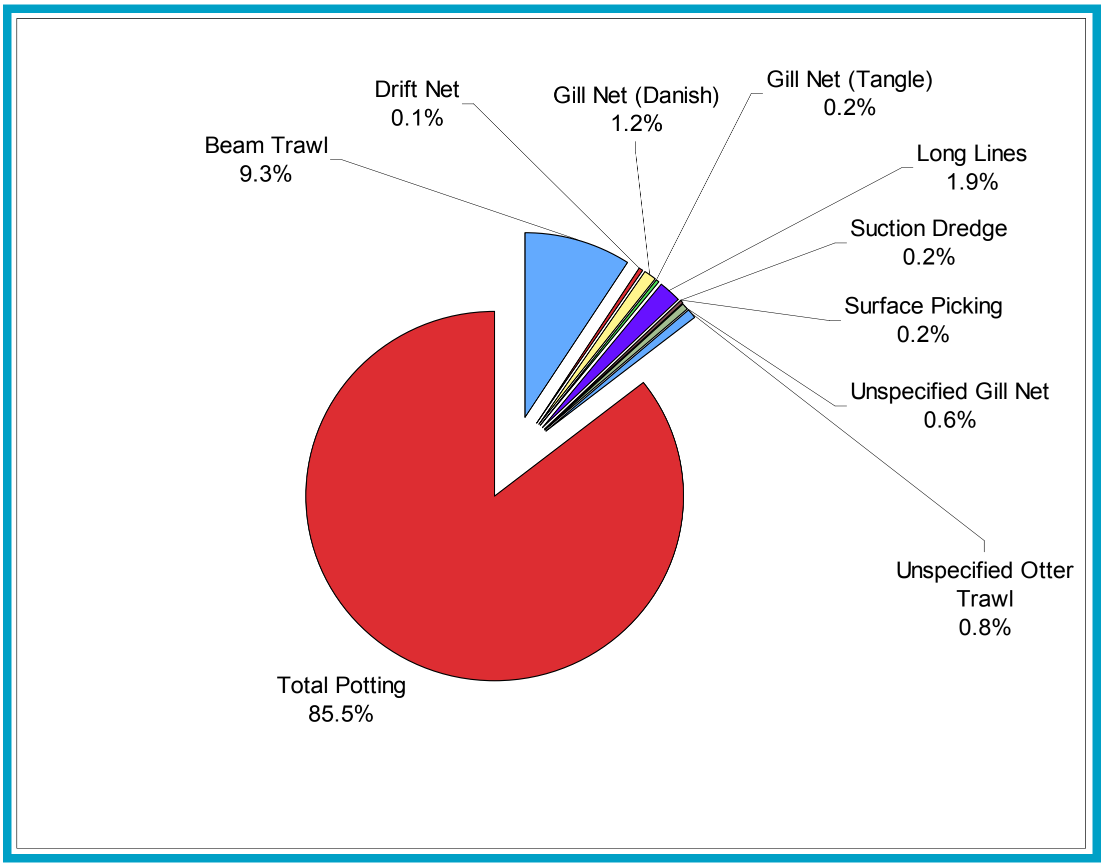


Figure 12.9 Fishing values by method - 35F1 (Source: Defra)

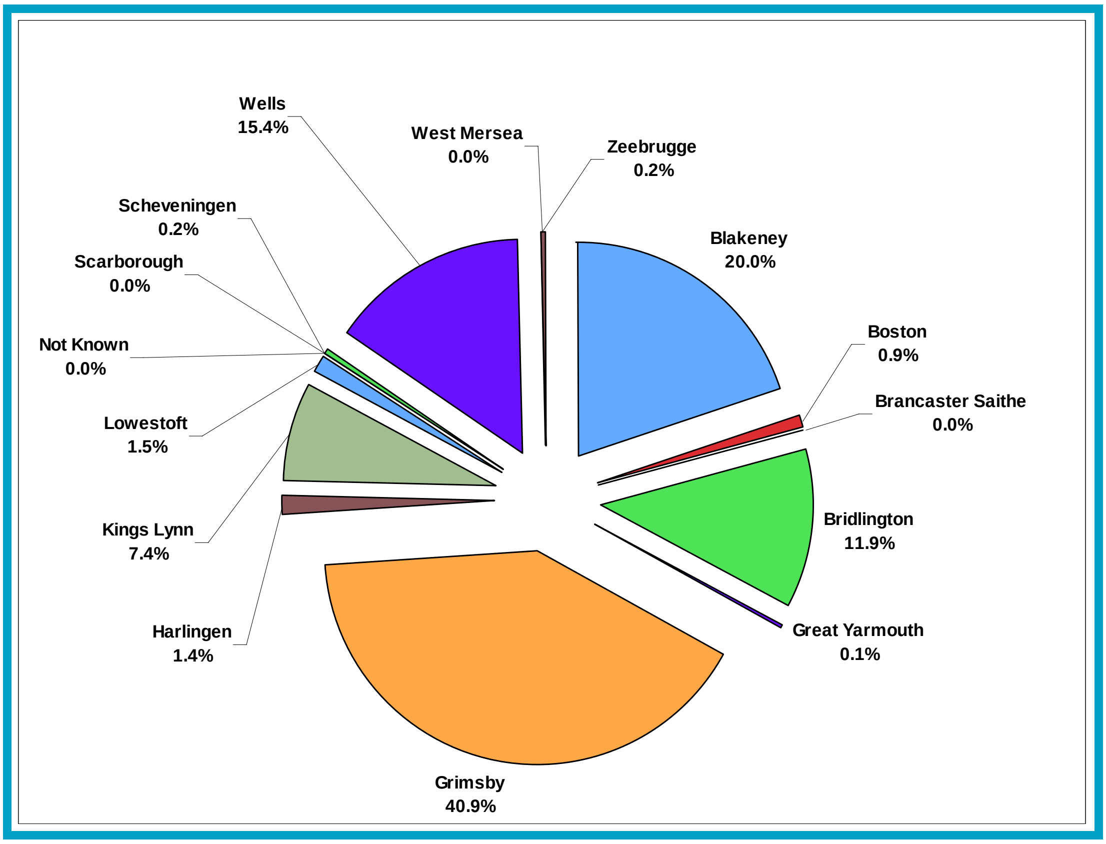


Figure 12.10 Fishing values by landing port - 35F1 (Source: Defra)

12.2.6 Seasonality of Activity

Figure 12.11 and Figure 12.12 illustrate the seasonality of effort and landings values by UK vessels in rectangles 34F1 and 35F1 based on five year averages. In 34F1 activity and values are largely concentrated in the spring and summer months. This is to be expected as the better weather enables more fishing days by these predominantly small vessels in the summer months. The pattern in 35F1 is similar, although there is a further spike of activity in November; this relates to increased crab fishing prior to the seasonal closure of crab processing by the Cromer Crab Company (pers. com.: Wells Fishermen).

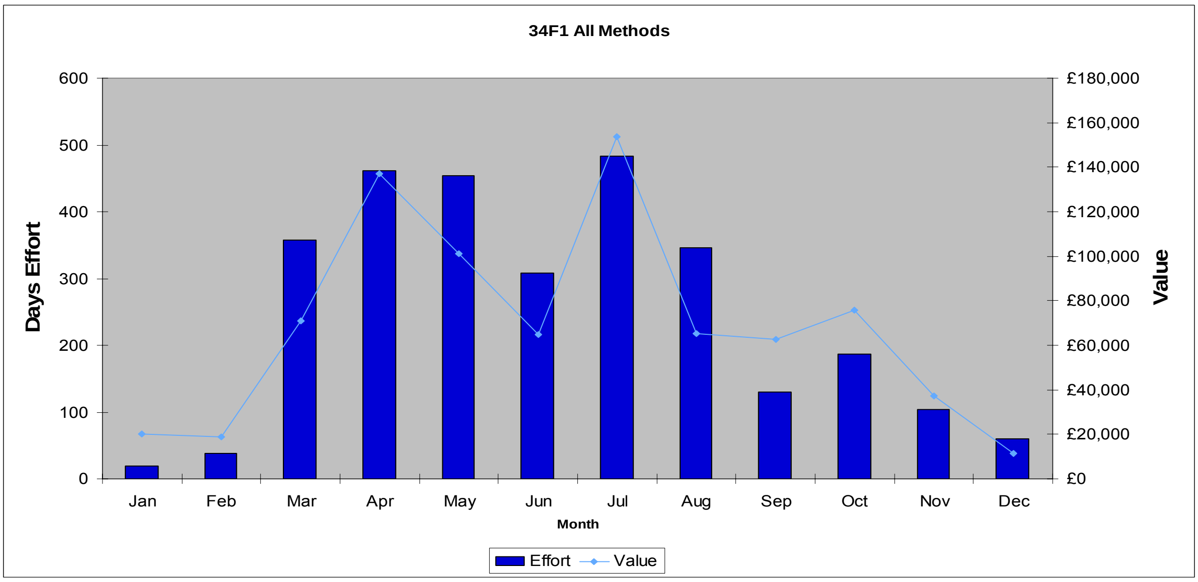


Figure 12.11 Five year av. monthly effort & value: all methods: 2000 – 2004: 34F1 (Source: Defra)

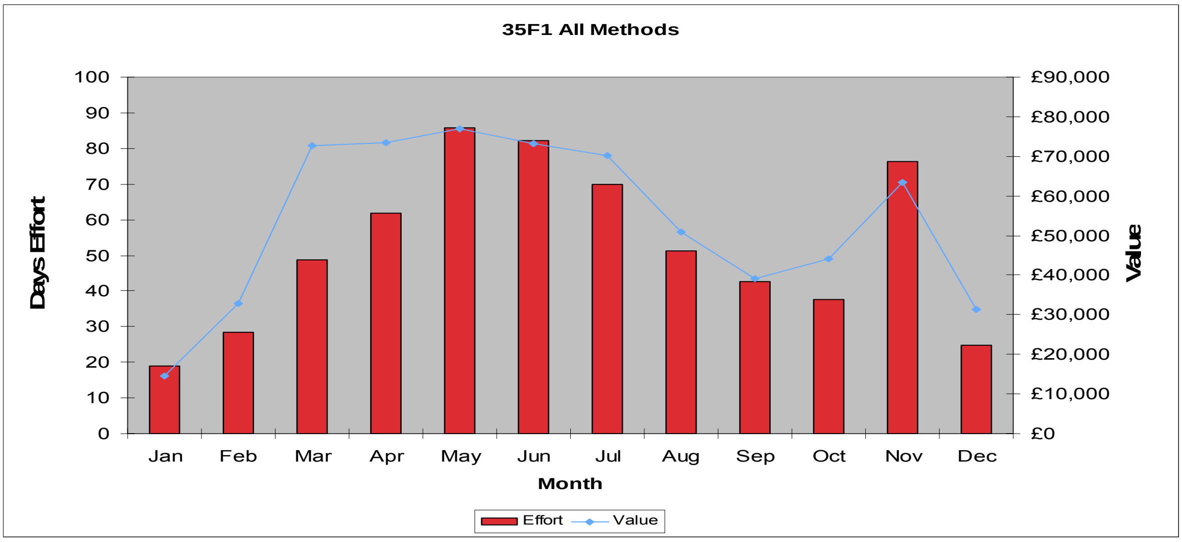


Figure 12.12 Five year av. monthly effort & value: all methods: 2000 – 2004 35F1 (Source: Defra)

12.2.7 Vessels

Vessels that fish the areas of the wind farm site and the export cable corridor mainly operate from north Norfolk ports or launch sites. Table 12.1 below gives the base ports / launch sites, numbers, length range and principal fishing methods of these north Norfolk vessels.

Table 12.1 Operational north Norfolk fishing vessels (Source: ESFJC)

Base	No.	Length Range (m)	Principal Methods
Boston / Kings Lynn	36	8.0 – 17.8	Beam Trawling, Shellfish Dredging
Brancaster	7	6.7 - 10.9	Potting,
Wells	12	7.3 - 11.2	Potting, Netting
Blakeney / Morston Quay	6	7.1 -10.3	Potting, Netting
Cley	1	5.2	Potting
Weybourne	2	7.0	Potting
Sheringham	8	4.7 – 6.5	Potting
West Runton	3	4.9 – 5.7	Potting
East Runton	6	5.8 – 6.5	Potting
Cromer	11	6.4 – 8.9	Potting
Overstrand	5	6.1 – 6.6	Potting

The Kings Lynn and Boston vessels' trawling and dredging activities are largely concentrated in the shallower waters of the Inner and Outer Wash including the Docking Shoal. The vessels are shallow in draft; specifically designed for this Wash fishery. Gears such as suction dredges are also limited to this area of operation by water depth. The design characteristics of these vessels and their gears therefore limit these vessels from targeting alternative species or to fish areas beyond these traditional grounds.

Plate 12.1 Blakeney based potter (Source: B&MM)

The vessels operating out of the tidal ports of Wells and Blakeney are for most part under 10 metre vessels whose principal activity is potting (Plate 12.1), although some vessels also practice netting. The majority of boats based at Wells and Blakeney have the capacity to fish at distances of some 20 - 25 miles offshore. The number of fishing vessels berthing in the port is restricted to a maximum of 14 (Pers. comm. Wells harbourmaster). Of these, two were observed to be in a condition that clearly indicated that they were not currently engaged in fishing. Whilst the maximum number of vessels from Wells and Blakeney that may fish the site is 18, discussions with local skippers suggest that only 6-7 vessels regularly fish within the site.

The remaining landing locations along the north Norfolk coast are beach launch sites. The vessels at these are, with one exception, smaller than those based at Wells and Blakeney and are primarily engaged in potting. Most of the beach launched vessels are open boats generally operated single handed and generally work inside the 6 mile limit with the greater concentration of effort being along the coast within the 3 mile limit. Some of these vessels may therefore operate in part of the cable corridor area, but would not fish as far as the wind farm site.

Lowestoft fishermen report that four Lowestoft long-liners, will occasionally fish the area of the wind farm and cable corridor. These vessels fish at night during June and July.

The concentration of fishing vessel activity within the cable corridor has been shown to be greatest between the shore and the 3 mile limit. The majority of the activity within this inshore area is from vessels from beach launch sites between Cley and Overstrand which total some 36 boats. These local potters and netters tend to have individual fishing areas based on gentlemen's agreements.

12.2.8 Operating Practices

Local north Norfolk boats that fish the immediate areas of the wind farm site operate from Wells and Blakeney. Due to tidal restrictions, the normal fishing trip duration of Wells and Blakeney vessels is in the order of 11-15 hours. As these vessels land live lobsters and crabs, fishing trips rarely exceed one tidal cycle.

Potting

During observer trips, steaming times to the first hauled shanks (fleets) of pots ranged from 0.5 - 2.5 hours, although it is understood that vessels can spend up to 3 hours steaming to the furthest grounds. Steaming times between shanks of pots varied from 10 – 30 minutes. Individual shank lengths range from approximately 550 – 725m.

The period over which pots are left fishing on the seabed between haulings (the 'soak time') varies with the time of year, the weather, the number deployed and the locations of fishing grounds. During winter months soak times can be longer due to weather constraints. Typical soak times for the pots of Wells and Blakeney vessels were reported to be 2-4 days, with the number of pots deployed ranging from 800 – 1,500 per vessel.

Plate 12.2 Beach launched potters – Cromer (Source: B&MM)

The trips of beach launched vessels (Plate 12.2) are generally of shorter duration than those of the Wells and Blakeney boats and sailing and landing times are not restricted by tide. The observed durations of trips were 5 – 7 hours. The number of shanks hauled, re-baited and re-shot ranged from 11 on a single handed boat, to 13 on the largest beach launched vessel with a crew of three. The numbers of pots per shank ranged from ten for the smaller boats to 25 for the largest vessel.

Netting

A number of the north Norfolk boats have the capacity to engage in netting as well as potting. Netting involves the use of a series of monofilament net panels into which the fish become entangled. Nets can be either bottom set for the capture of demersal species such as cod and skate or top set for catching pelagic species such as herring and mackerel. Nets can either drift with the tide, being set across the tidal flow or anchored and set in line with the tidal flow. The nets are hauled using hydraulic haulers.

Individual nets are generally 100m in length, normally joined together in fleets of up to 500m.

Long-lining.

Long-lining, as the name suggests, involves a long main line onto which are attached a number of short snoods (a short length of line tied to the main line) to which are attached hooks which have been baited prior to sailing usually with squid or herring. The individual long-line units are 730m in length, which can be joined together to form lines of up to 3.6km. The lines are set across the tide being anchored at each end. These long-liners generally fish at night during June and July in the development area (Personal Comms).

12.2.9 Fishing Grounds

The majority of the fishing activity in areas of 35F1 relevant to the wind farm site is by local vessels based at Wells and Blakeney. In terms of landings values however, as shown by Table 12.2 and Table 12.3, it is the fishing grounds within adjacent rectangle 35F0, which are of primary importance, representing 81.5% and 59.6% of landing values into Wells and Blakeney respectively (5 year average).

*Table 12.2 Averaged Annual (2000-2004) Landings Values by rectangle into **Wells** (Source: Defra)*

	2000	2001	2002	2003	2004	Av.	%
35F0	£528,978	£470,407	£674,675	£661,745	£687,412	£604,643	82%
35F1	£61,953	£206,102	£135,793	£63,113	£27,168	£98,826	13%
34F0	£133	£81,402	£63,315	£3,773	£0	£29,725	4%
34F1	£0	£23,740	£0	£0	£4,034	£5,555	1%
Other	£0	£8,813	£1,228	£302	£0	£2,069	<1%
34F2	£0	£2,025	£0	£0	£0	£405	<1%
36F1	£0	£1,000	£0	£0	£0	£200	<1%
Total	£591,064	£793,489	£875,011	£728,933	£718,614	£741,422	100%

*Table 12.3 Averaged Annual (2000-2004) Landings Values by rectangle into **Blakeney** (Source: Defra)*

	2000	2001	2002	2003	2004	Av.	%
35F0	£278,534	£256,803	£264,997	£238,405	£179,863	£243,720	60%
35F1	£90,219	£118,808	£138,114	£169,254	£125,973	£128,474	31%
34F0	£19,175	£41,556	£36,858	£22,800	£36,046	£31,287	8%
34F1	£298	£24,562	£0	£370	£176	£5,081	1%
Other	£0	£0	£0	£0	£600	£120	<1%
Total	£388,226	£441,729	£439,969	£430,830	£342,658	£408,682	100%

The ICES rectangle which includes the wind farm site (35F1) accounts for 13% of landings to Wells amounting to an average value of £100,000 and 31% of landings to Blakeney with an annual value averaging £128,000.

The landings from the cable route corridor (34F1) by vessels to each of these landing points only amount to just over £5,000 for each. Most fishing in this inshore area is by the beach-launched vessels from Cromer.

Within 35F0, the grounds known as Race Bank, Fingers, North Ridge and Dudgeon Shoals have been identified as primary potting grounds for the Wells and Blakeney vessels as well as parts of Docking Shoal. In rectangle 35F1, Cromer Knoll and Sheringham Shoal have been identified as important potting grounds. Whilst these banks and shoals labelled in Figure 12.13 are important fishing areas, both potting and other static gear methods are carried out to varying degrees in other areas devoid of obvious natural seabed features.

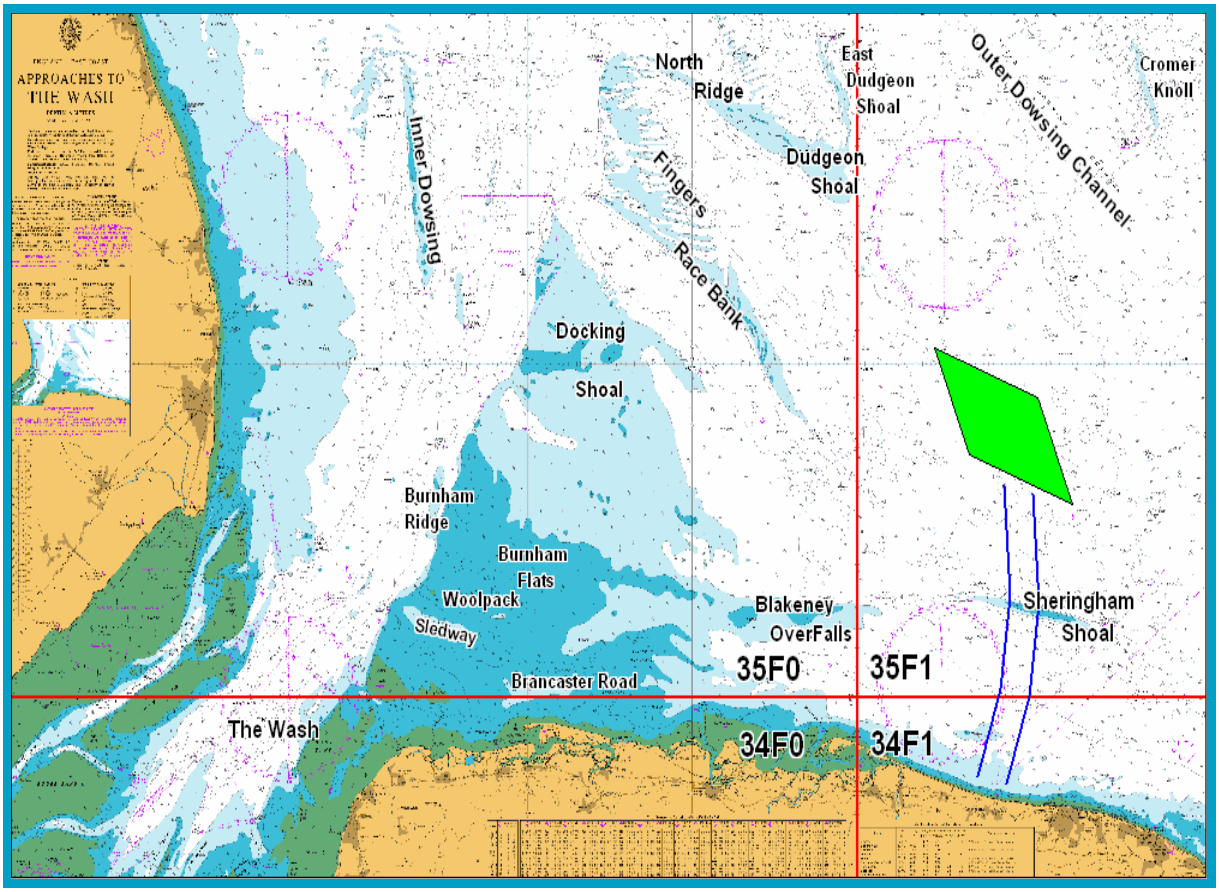


Figure 12.13 Principal fishing areas (source: Local skipper interviews, plotters and observer trips)

12.2.10 Key commercial species

Table 12.4 and Table 12.5 along with Figure 12.14 and Figure 12.15 present the volume of each species caught in recent years in ICES rectangle 35F1 (containing the wind farm site) and 34F1 (containing the section cable route nearest land) respectively.

Whelk and crab dominate landings in 35F1 with whelks representing the highest weight, followed by crabs, brown shrimp, cockles, skates and rays and lobsters. The majority of the whelk landings are by Grimsby and Bridlington potting vessels, which primarily operate in the northern quadrants of the rectangle, away from the wind farm site. Local Norfolk based fishermen stated the recent level of potting has been such that by mid 2004, whelks in the local area had been over-exploited with the consequence that there has been minimal whelking activity by local vessels during the latter half of 2004 and 2005 (pers. comm. 2005).

Note: Section 10 on Natural Fisheries Resources describes the resource status, spawning, migration and prey associated with the key commercial species mentioned above. Brief summaries for the key shellfish species (crab, lobster, whelk and brown shrimp) are presented below.

The principal fishing activity within both the wind farm site and along the cable route is potting, targeting crabs and lobsters, with landings reflecting the relative abundances of these species. Finfish landings account for less than 10% of landings by volume with the landings data indicating the occasional targeting of cod, herring and skates & rays.

Within the rectangle 35F0, adjacent to the wind farm site, the highest proportion of the landings is crabs followed by brown shrimps and cockles. The majority of the weight of landings from 34F0, covering the Inner Wash were cockles, mussels and brown shrimp.

No catch quotas exist for these shellfish species, but ESFJC by-laws impose minimum landing sizes to avoid over-fishing these shellfish resources. ESFJC also impose a 'no shrimp trawling' zone which includes the cable route corridor out to the ESFJC boundary of 6 n. miles.

The status of shellfish resources are not the subject of such significant scientific assessment as pressure stock finfish species, but in recent years it is recognised that shellfish resources are generally in a healthier state than finfish resources. ESFJC crustacean landings statistics do however indicate that catch per unit effort (CPUE), an indicator of stock abundance, has decreased in recent years for both potting and shrimping. Potting CPUE has been seen to decrease from 88kg/pot/yr in 2002 to 71.4kg/pot/yr in 2004 with a reasonably constant level of effort. Shrimping has decreased from an average of 454.7kg/day to 262.3 kg/day and effort has also decreased significantly. The prices received in both potting and shrimping have, however, increased from 2002 to 2004 by 25% and 7% respectively.

Crab (mainly Edible crab, *Cancer pagurus,* and velvet crab, *Necora puber*)

Edible crabs are the principal target species off the coast of Norfolk, being found in a variety of habitats and depths. A velvet crab fishery has developed more recently with landings entering the live trade to the continent. Substantial velvet crab landings were recorded by ESFJC in 2004, but accounted for only £40,000 from a total of £1.15 million for crab landings in the district as a whole.

It has been suggested that the crab population of the north Norfolk coast is a separate, self-sustaining stock and may even provide recruitment of adult crabs through the gradual movement northwards of mature females throughout their life (ESFJC, 2005). Mating tends to take place between July and September each year. Eggs are spawned two to three months after fertilization. Hatching occurs during the summer months, with the planktonic phase lasting approximately 30 days.

Local edible crab stocks consist of a female component which moves into shallower waters during the summer months, probably to moult and mate, whereas the male component is more sedentary in nature. Migration tends to be slower after summer, with maximum distances of 2km/day by both sexes in the autumn months. Following spawning, berried females migrate offshore to over–wintering grounds, where they are thought to remain until spring or early summer (George *et al.*, 1990).

More recent studies conducted with the aid of tagging suggest that hatching and release of larvae takes place offshore before a landward migration of females (ESFJC, 2005). Nevertheless, some levels of inshore hatching cannot be discounted (Hall *et al.*, 1991).

*Table 12.4 Landings (tonnes) by species, 2000 – 2004, ICES rectangle **35F1** (Source: Defra)*

Species	2000	2001	2002	2003	2004	Total	%
WHELKS	453.07	705.36	354.40	678.36	301.80	2493.00	60.42%
CRABS	124.99	256.88	244.91	324.31	298.75	1249.82	30.29%
BROWN SHRIMPS	30.60	54.69	45.78	13.58	9.10	153.75	3.73%
COCKLES	0.00	0.00	53.00	0.00	0.00	53.00	1.28%
SKATES AND RAYS	11.81	11.97	13.22	9.42	6.12	52.53	1.27%
LOBSTERS	6.87	4.97	13.58	8.47	8.29	42.17	1.02%
SPURDOG	15.22	3.30	0.00	0.10	8.09	26.71	0.65%
PLAICE	0.82	9.50	0.00	7.76	1.08	19.17	0.46%
COD	5.69	1.81	0.07	0.69	2.94	11.20	0.27%
MUSSELS	0.00	0.00	0.00	9.00	0.00	9.00	0.22%
SOLE	0.00	2.94	0.00	1.07	0.12	4.13	0.10%
WHITING	0.14	0.88	0.00	0.54	0.43	1.99	0.05%
DABS	0.00	1.14	0.00	0.65	0.00	1.80	0.04%
TOPE	0.74	0.53	0.03	0.03	0.01	1.35	0.03%
LEMON SOLE	0.21	0.24	0.00	0.33	0.49	1.27	0.03%
OTHERS	0.72	1.50	0.00	0.99	1.93	5.14	0.13%

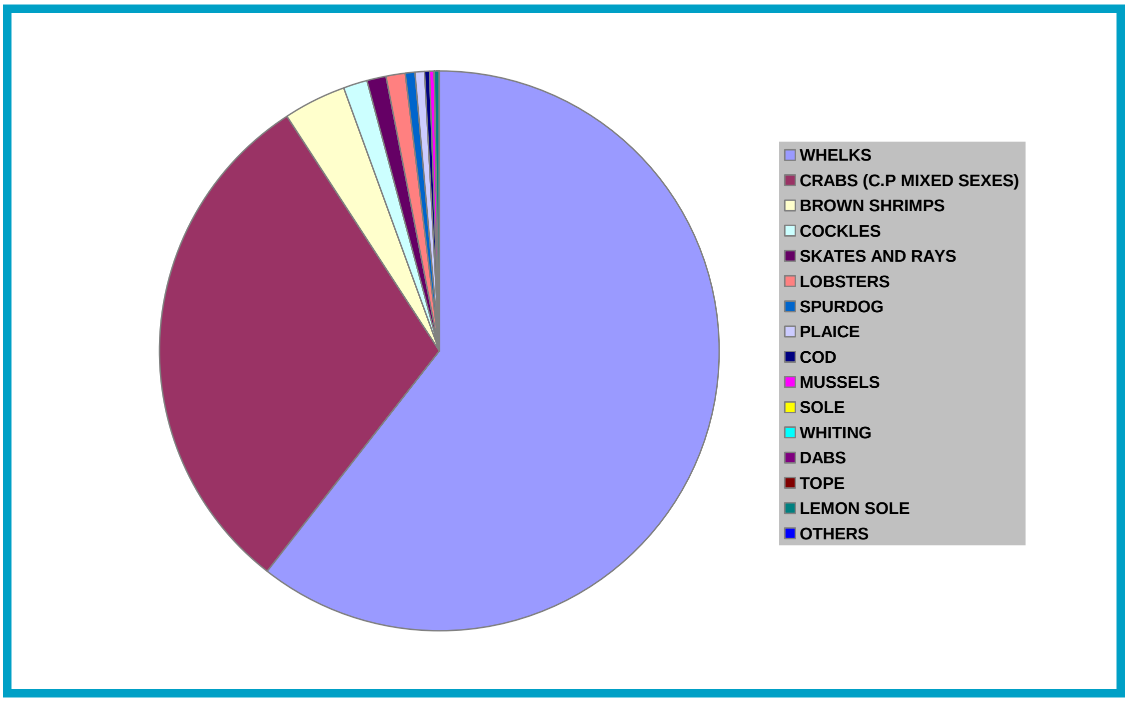


*Figure 12.14 Landings (tonnes) by species, 2000 – 2004, ICES rectangle **35F1** (Source: Defra)*

Table 12.5 Landings by species, 2000 – 2004, ICES rectangle **34F1** (Source: Defra)

Species	2000	2001	2002	2003	2004	Total	%
CRABS	479.25	417.23	374.68	194.10	140.73	1606.00	72.27%
BROWN SHRIMPS	35.37	37.75	44.67	16.34	19.40	153.52	6.91%
LOBSTERS	26.55	15.89	2.43	10.44	50.60	105.92	4.77%
SKATES AND RAYS	33.07	16.28	19.77	17.27	19.05	105.45	4.75%
COD	52.77	15.84	4.02	15.27	6.94	94.83	4.27%
HERRING	35.70	2.35	12.03	5.44	0.32	55.84	2.51%
SPURDOG	8.22	7.17	3.91	0.51	1.30	21.10	0.95%
SPRATS	0.32	1.34	8.30	0.12	8.10	18.18	0.82%
SOLE	15.05	0.86	0.21	0.37	0.66	17.15	0.77%
WHELKS	0.11	2.09	9.19	0.75	0.00	12.14	0.55%
TOPE	1.31	0.73	1.46	0.77	1.14	5.41	0.24%
BASS	1.43	0.13	0.33	0.60	0.58	3.08	0.14%
WHITING	0.87	0.84	0.47	0.30	0.46	2.95	0.13%
PLAICE	0.41	0.56	0.42	0.50	0.79	2.69	0.12%
DABS	0.98	0.44	0.11	0.30	0.04	1.87	0.08%
OTHERS	5.22	3.53	0.54	2.55	4.28	16.11	0.73%

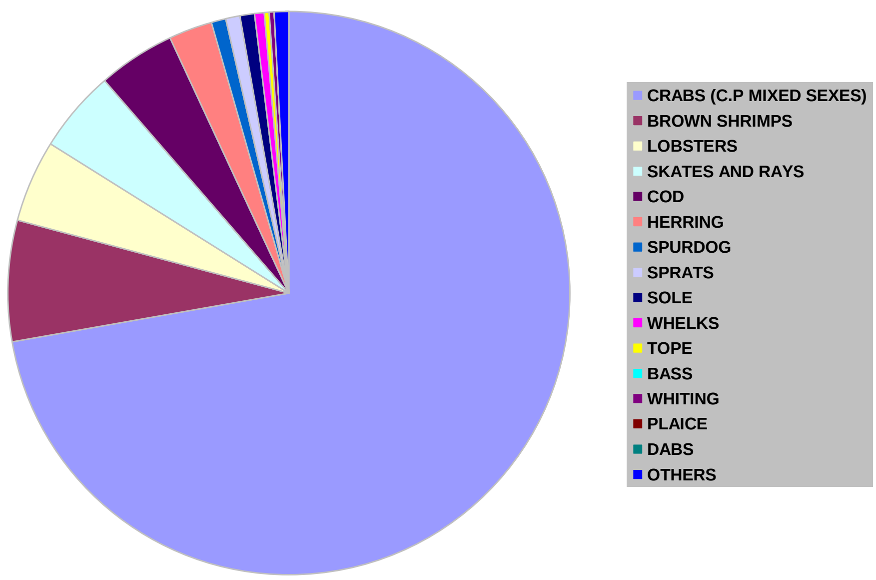


Figure 12.15 Landings by species, 2000 – 2004, ICES rectangle 34F1 (Source: Defra)

Lobster (*Homarus gammarus*)

Lobsters are common locally with stocks providing a significant fishery to north Norfolk. An ongoing survey undertaken by ESFJC in 2004 suggests lobster abundance is notably greater offshore as opposed to inshore, although greater fishing pressure exists inshore.

Mating is thought to occur in the late summer, but females have the facility to store the sperm packet over the winter so the eggs are not fertilised and laid until the following summer. The hatched planktonic larvae are subject to wind and surface currents which push the larvae inshore. After the fourth moult the post-larvae take refuge on the seabed and remain benthic from this point onwards. It is thought that young lobsters occupy coarse sediments and fine mud, where they construct burrows. Lobsters reach full maturity after a period of five to eight years.

Whelk *(Buccinum undatum*)

Whelk is currently widespread and no national measures for its conservation exist (www.arkive.org). In mid-May whelks aggregate for mating, often migrating shoreward. Egg-laying begins shortly after fertilization and may extend to the end of August. Embryos develop in the egg cases and hatch after five to eight months, in late-autumn to late-winter. There is no planktonic larval phase, and given their extremely slow-moving nature, dispersal is limited (www.glaucus.org).

Brown Shrimp (*Crangon crangon*)

The brown shrimp occurs on the lower shore and in shallow sublittoral locations on fine, muddy sand and gravel. It is also often found in estuarine areas especially during the juvenile phases.

Brown shrimp post-larvae are thought to remain in the bottom sediments during the winter. As sea temperatures rise in late February and March, the post-larvae become active and follow tidal currents into the estuaries (Boddeke, 1989).

12.2.11 Angling Charter Vessels

Angling charters target a variety of areas, particularly wrecks and subsea features where species of interest to sport fishers (bass, tope, skate, spurdog, cod, etc.) are present. Two vessels based at Brancaster and Wells were identified as undertaking commercial angling charters (www.norfolkfishingtrips.co.uk, www.safetyboatservices.co.uk). These vessels may on occasion target 'marks' (fishing locations) in the area of the wind farm site.

12.2.12 Summary

The data and information obtained suggest that the wind farm location is not a primary fishing area and does not support as much fishing effort as the banks and shoals to the west of the site. No significant trawling activity has been observed within the proposed wind farm area and only limited long lining on a seasonal basis has been reported. There is, however, a history of vessels mainly from Blakeney and to a lesser extent Wells undertaking some seasonal static gear fishing within the area of the wind farm site. Between six and seven of these local potting vessels would regularly visit the site targeting crabs and lobsters.

In relation to the cable route the highest levels of activity occurs over the inshore section out to approximately the 3 mile limit by small beach-launched fishing vessels. Whilst the level of this activity declines further offshore, the Sheringham Shoal is a recognised fishing area.

12.3 Impacts during construction

12.3.1 Potential Impacts

The June 2004 Guidelines referred to paragraph 12.1.1.1 state that for the construction, operation and decommissioning phases of wind farm developments, with regard to commercial fishing the following aspects should be examined:

1. Complete loss or restricted access to traditional grounds
2. Interference with fishing activities
3. Increased steaming times to fishing grounds
4. Removal of obstacles from the sea bed post construction
5. Adverse impacts on commercially exploited populations
6. Safety issues for fishing vessels
7. Any other concerns raised by local fishermen and fishing organisations

12.3.2 Construction Phase

12.3.2.1 Loss of or restricted access to Traditional Grounds

During the construction phase, marine traffic including fishing vessels would be notified of operations, which is likely to result in avoidance of construction areas. To ensure the personnel carrying out construction activities and those navigating in this sea area are not exposed to unnecessary risk, 500m safety zones will be established around all offshore structures (see Section 14, Shipping and Navigation). Assuming a worst case scenario based on a 500m zone around the wind farm site boundary gives a maximum construction area exclusion of 14.4 nm². However, marine traffic, including fishing vessels, would access some of this sea area i.e. where construction vessels are not operating or where structures are not located.

The potential impact of loss of fishing area, from construction phase exclusion from the wind farm site, would be almost entirely confined to the six or seven local potting vessels based at Wells and Blakeney that are understood to fish the site on occasion.

The vessels that have a history of deploying gear in the construction site are expected to deploy their gear in alternative areas during the period of exclusion. These vessels would sustain a negative impact if locating and fishing alternative areas results in a reduction of gross earnings or increases in operating costs.

Alternative fishing grounds exist both nearer to and further from Wells and Blakeney than the wind farm area. The net impact on steaming times of exclusion during construction phase is therefore expected to be negligible.

Landings data suggest that ICES rectangle 35F1 accounts for around 13% of landed value for Wells vessels and 31% for Blakeney vessels. As landings from this rectangle only account for a small proportion of landings and alternative fishing opportunities exist, the impact on earnings of lost or restricted access to fishing areas during the construction phase is not expected to be significant.

The duration of cable installation operations is expected to be a minimum of 13 days for each of the two cables. The cable laying vessels would work within a temporary construction corridor 1200m wide. An anchor handling tug would be used to place an array of anchors which the cable laying barge uses to pull itself along with the cable burying plough in tow. The anchors are lifted and reset progressively as the cable is paid out and the barge moves forward. The inshore vessels would therefore be temporarily displaced from steaming or fishing from a slowly moving segment (about 1200m in length) of the construction corridor as the cable laying operations advance along the corridor.

The concentration of fishing vessel activity within the cable corridor has been shown to be greatest between the shore and the 3 mile limit. The majority of the activity within this inshore area is from vessels from beach launch sites between Cley and Overstrand which total some 36 boats. The local potters and netters tend to have individual fishing areas which are generally respected by other local boats and the temporary exclusion would therefore likely to be of most significance to the Cromer and Sheringham based boats.

Between the inshore areas and the site, temporary exclusion along the cables route would primarily affect vessels from Wells and Blakeney and one of the Cromer vessels, particularly along the sections over the Sheringham Shoal. There could also be some impact on the four Lowestoft long-liners.

In addition to maintaining good engineering practice in relation to construction and cable-laying, to minimise potential disruption to fishing vessels, the timing and location of construction activities would be accurately and regularly communicated to fishing interests by the developers.

SCIRA has made a commitment to continue the ongoing liaison with the fishing vessels that have a proven track record of fishing the wind farm site and the cable route corridor, in order to investigate appropriate practical assistance measures for those vessels that are identified as being impacted during the construction phase.

With implementation of the mitigation measures described above, the impact of loss of fishing area during construction at the wind farm site is expected to be **minor adverse** for the six or seven vessels from Wells and Blakeney.

With simultaneous laying and ploughing used, the impact of cable laying along the cable route corridor is assessed as **negligible.**

12.3.2.2 Interference with Fishing Activities

Interference with fishing activities relates to the potential fouling of static gear float lines and surface set nets by construction vessels transiting to and from the site. Typical soak times for the pots of Wells and Blakeney vessels are between two and four days. There are therefore significant periods when gear is left unattended and marked with surface marker buoys. While the gear is set on the seabed, snagging of the lead line can occur. This has the potential to damage and displace an entire fleet of pots leading to the loss of up to 40 pots.

As shown by the navigation risk assessment, there are clearly defined shipping routes to the north and south of the site. It is therefore proposed that construction vessels should follow such routes and be restricted to entering and leaving the site along a specified site transit route, or as otherwise agreed. With the implementation of this and standard offshore fisheries liaison practices, there should be a **negligible** impact from interference with fishing activities.

With appropriate liaison and notification programme, it is not envisaged that there would be any significant interference to fishing activities in addition to temporary loss of fishing area described above and that the interference impact would be **negligible.**

12.3.2.3 Increased Steaming Times

The maritime traffic surveys and surveillance sightings show few instances of fishing vessels steaming through the site. The 2004 satellite tracking records only eight sightings within the site, seven of which were the same vessel recorded over a period of two days.

The vessels with the greatest potential to be impacted by increased steaming times are those based at Wells and Blakeney. As detailed above, the majority of the landings into Wells and Blakeney are obtained from ICES rectangles to the west and south of 35F1. Steaming to these areas would not involve steaming around the construction site.

Whilst some Wells and Blakeney vessels may, to a limited extent, deploy gear north east of the site, other fishing locations en-route could give steaming routes that would avoid the need to steam around the site. The potential impact is therefore expected to be **negligible**.

Due to the limited time of installation and the size of the safety zone around the installation vessels the impact of increased steaming times associated with the cable route would also be **negligible**.

12.3.2.4 Construction Debris

The 2004 Guidelines make reference to construction related debris on the seabed. In the past offshore oil and gas related debris on the seabed has been a cause of damage to, and on occasions, complete loss of fishing gear. Current standard offshore operating policies however require all waste and debris to be taken ashore and accidentally dropped objects to be recorded and recovered.

Policies and procedures have been developed by offshore operators and contractors to address and mitigate disturbances to the sea bed such as lay-barge anchor mounds and trenching spoil.

SCIRA will undertake the appropriate post construction surveys and contractually bind installation contractors to comply with such practices so that debris impacts on commercial fishing will be **negligible**.

The installation and post installation survey procedures will comply with the debris avoidance standards of the marine cable industry to ensure that the impacts from construction debris will be **negligible**.

12.3.2.5 Impacts on Commercially Exploited Populations

Section 10 details the construction impact on the natural fish resource which includes the commercially exploited populations. Impacts include:

- Habitat Disturbance
- Noise and vibration
- Increased Suspended Sediment Concentrations
- Release of Sediment Bound Contaminants
- Accidental Spillage of Construction Materials

It has been determined that the key commercial species targeted in the immediate wind farm and cable route area are crustacean species including edible crab, velvet crab, and lobster. As Section 10 indicates, many other species may use some part of the area concerned at various life stages such as spawning or nursery areas. The impact of the construction phase for the Sheringham Shoal development on these additional commercial species is assessed as negligible as the area represents only a very small proportion of this type of habitat when considered regionally.

Table 12.6 below presents the potential impacts associated with the key crustacean species. The table illustrates that most of the potential impacts identified are assessed as negligible.

Table 12.6 Potential impacts on commercially exploited crustacean species during construction

Potential impact	Mitigation	Assessed impact
Habitat Disturbance	Footprint of turbines only amounts to a worst case scenario of $0.047km^2$ equating to <1% of the wind farm area	**Negligible**
Noise and vibration	With 'soft start' piling, avoidance response may be possible if level is disturbing to shellfish.	**Negligible**
Increased Suspended Sediment Concentrations	No chalk in area of array reduces risk of extensive smothering. Use of cable plough in export cable leads to narrow zone of impact, which would be localised and short-term. Impacted area represents only 0.2% of total hatching area of north Norfolk fishery.	**Minor adverse**
Release of Sediment Bound Contaminants	Impact on water quality through re-mobilisation is assessed in Section 7 as negligible.	**Negligible**
Accidental Spillage of Construction Materials	Adoption of good practice gives minimal risk of accidental pollution	**Negligible**

Some concern has been expressed by fishermen over an increased turbidity and suspended solids concentrations resulting from cable jetting. This concern is based on experience with previous cable-laying operations in the area as it was found to alter the distribution and concentration of crab and lobster, resulting in reduced catch rates on traditional grounds.

Increased suspended sediment concentrations are assessed as leading to a 'minor adverse' impact for shellfish. This impact is identified as being highly localised and short-term with the potential for minor adverse impacts from smothering only if a substantial increase in suspended sediment concentrations occurs when juvenile shellfish are newly settled. The impact on the commercial fishery of such a localised and short-term smothering event is expected to be insignificant for overall recruitment to the fishery as a whole. Consequently there are **negligible** impacts on the commercial fishery from adverse impacts on commercially exploited populations.

12.3.2.6 Fishing Vessel Safety

The safety aspects relating to fishing vessels during the construction phase are addressed in the Navigation Risk Assessment. As stated above a Safety Zone of 500m will be enforced around all offshore structures associated with the wind farm site. The standard best practice procedures for offshore safety, liaison, notification, marking and monitoring will also be implemented with temporary 500m avoidance areas around working vessels proposed during construction.

The navigation risk assessment has indicated that with the necessary mitigation measures the navigational risks to fishing vessels during construction as **negligible**.

12.3.3 Indirect impacts

Indirect impacts resulting from impacts on the commercial sector can occur to both upstream and downstream businesses. Upstream businesses include boat builders, gear suppliers and marine engineers; downstream businesses include fish merchants, processors, distributors and retailers.

Due to the small scale of the local fleet, few dedicated upstream businesses exist. As local fishing opportunities would continue throughout construction and operation, the impact on any dependent upstream businesses is assessed as **negligible**.

There are a small number of local merchants and processors purchasing landings from local vessels, the largest being the Cromer Crab Company, which employs around 160 people at its processing factory, rising to nearer 200 at peak times ("Shelling out for Crab company" at www.rural.shapingthefuture.org.uk). While certainly utilising local landings a company of this scale would not be dependent upon one source of product as it would source raw material from all over the UK to smooth variations in supply. Any localised and short-term impact on the catching sector would therefore have a **negligible** impact on this large processor.

At least two of the local vessel owners identified as having a history of deploying pots within the site area have invested in purpose built facilities to undertake value added processing of the catches from their vessels (pers. coms: local vessels owners). For those few operators that are reliant on their own catch, a minor downturn in their own vessels' landings would result in impacts on their processing operations. Specifically this will amount to the loss of profit associated with the reduced raw material throughput and is assessed as being a **minor adverse** impact.

12.4 Impacts during Operation

12.4.1 Loss of or restricted access to Fishing Area

The impact of lost fishing area is dependent upon the feasibility of conducting fishing operations within the site.

This assessment assumes all towed and drifting gears will not be able to fish within the wind farm array, but some static gears will be able to operate. This situation does, however, remain the subject of debate. The Seafish/CEFAS study on fishing/wind farm interactions is yet to be published and there are no official guidelines available at the time of writing.

The Navigation Risk Assessment recommends that all towed methods, i.e. trawling, seining and shellfish dredging should not operate within a minimum safe distance of 500m from wind farm structures. In view of gear drift distances and fouling risks, it is assumed that drift netting will not be possible within the array.

Pending further safety assessment, it is possible that static gears such as potting, traps and fixed lines will be able to operate within the site to within 100m of the turbines and other associated structures.

It is noted however that some of the local static gear fishermen consulted were of the opinion that it would be unsafe to fish within the site, citing risks associated with adverse weather, tidal flow rates and gear fastening. Others considered that some vessels would attempt to fish within the site. The precise action of fishermen is unclear, but it is expected that at least some would fish the site if target resources are present.

Evidence from vessel surveillance presented earlier indicates that the activity within the site area is predominantly static gear fishing with minimal towed gear activity. The impact on these static gear vessels is expected to vary between the short and long-term as the development is colonised by a variety of species including those of commercial value.

The lost fishing area as a result of the 100m exclusion around the turbine amounts to a minimum of 1.4km^2 or 4% of the entire wind farm area with 45 turbines and up to 3.5km^2 or 10% with 108 turbines. A small proportion of the total wind farm array area would therefore be unavailable to those static gear fishermen that may fish the site.

The turbine structures and associated foundations may also be of moderate long-term benefit to crab and lobster stocks through habitat creation. Adult crab and lobster are territorial; therefore an increased availability of cryptic habitat would enable a larger stock to inhabit the area if available habitat is currently a limiting factor. This may in turn ultimately prove beneficial to commercial fishermen. Such a positive effect would counteract the access restrictions imposed on a very small fishing area and may even lead to more potting vessels using the area than at present.

While no formal safety zones would exist along the export cable route, trawlers would be made aware of and therefore would avoid the immediate area containing buried cables for safety reasons. With a small area being affected and very limited trawling activity in the area overall the impact on commercial fisheries from lost fishing area along the export cable route is assessed as **negligible**.

Seafish is currently undertaking a study into the safety and practicalities of operating commercial fishing methods within wind farms, the conclusions of which are expected to be published in early 2006. In association with local fishermen, SCIRA also proposes to undertake a site specific assessment of the feasibility of operating static gears within the site.

In view of the factors discussed above, assuming static fishing would be undertaken within the site, for the vessels currently fishing the area the impact of loss of fishing area during operation of the wind farm is expected to be **negligible.**

12.4.2 Interference to Fishing Activity

The need to adapt to fishing between turbine rows may involve a temporary interference to traditional practice. For example, it is possible that pot shanks, long-lines and net fleets would need to be shortened. Modifications to hauling and shooting practices may also be required.

SCIRA proposes to undertake a practical assessment into the working of the static gears within the wind farm site. This would involve using local vessels to simulate working their gears in a range of weather and tidal conditions between turbine rows. The positions of the turbines and their safety zones would be input onto the vessels GPS plotters. Should such trials prove that gear modifications are required, SCIRA is prepared to investigate providing practical assistance to assist legitimately impacted vessels.

With the assistance described above, the interference to fishing activities will be minimised and the impact on commercial fisheries is expected to be **minor adverse** for the six or seven vessels currently fishing the site.

12.4.3 Increased Steaming Times

The Navigation Risk Assessment concludes that under suitable weather and visibility conditions, fishing vessels would be able to transit through the wind farm site, although individual skippers would obviously make their own individual risk assessments. If the consensus is against steaming through the site, the significance of the impact would be as discussed in 12.3.2.3 above, but over the life of the wind farm as opposed to the construction period. If however skippers decide to steam through the site, the significance of the impact would be **negligible**.

12.4.4 Impacts on Commercially Exploited Populations

Section 10, Natural Fisheries, provides details on the operational impact relating to:

- Electromagnetic fields
- Noise and vibration
- Alteration of Habitat

The impact on commercial fisheries from these aspects are assessed as being **negligible**. Specific discussion relating to the key commercial shellfish species currently targeted is given below.

Electromagnetic fields

With regard to the impact of electro-magnetic fields on commercial species, the extensive review for COWRIE referred to in Section 10 found few studies considering EMF responses by shellfish. Additionally, recent monitoring reports for in situ wind farms focus on fin fish survey by trawl and therefore tend not to consider shellfish resources.

Decapod species (crab, lobster and prawn) are known to be sensitive to magnetic fields (B-sensitive). The brown shrimp *Crangon crangon* has been recorded as being attracted to the B fields of the magnitude expected around wind farms (ICES, 2003). The comparative strength of this attraction to other factors and consequences in terms of abundance and distribution of these species is not known.

Noise & vibration

It is understood that decapod crustaceans are tolerant of noise and vibration at the levels expected during wind farm operation. Operational noise and vibration would be more continuous than construction or vessel noise and therefore species are more likely to develop a tolerance. Overall the impact of noise and vibration on commercially exploited populations is assessed as being negligible.

Alteration of habitat

In terms of alteration of habitat, it is anticipated that introduction of various hard substrate types with greater cryptic character may be of long term benefit to the current commercially exploited populations of decapod crustaceans. Following colonisation by fouling organisms, the wind farm development would therefore potentially have a 'minor beneficial' impact on these species in terms of habitat alteration if habitat availability is currently a limiting factor in the area.

The hard-bottom monitoring of the Horns Rev wind farm (Leonard & Pedersen, 2004) found the presence of both juvenile and mature edible crab along with other shellfish species. Mature individuals were found between stones used in scour protection with juveniles found on the turbine towers. The researchers concluded that the introduced hard substrate of the wind farm was being used as a hatchery and nursery habitat for species including the edible crab. Studies off the Dutch Coast have also shown that mature individuals of Cancer pagurus quickly invaded newly established artificial reefs (Leewis and Hallie, 2000). This work suggests that the hard substrate of wind farm sites act in a similar way for decapod species.

Additionally some important commercial species such as cod are known to aggregate around man-made structures such as oil platforms despite significant noise and vibration in the area. This behavioral response in conjunction with the expected limits to trawling in the wind farm may also result in the site forming a trawl refuge for species targeted by trawl. This may be of relatively minor benefit to these fisheries as a whole, but would create additional fishing possibilities for static gear vessels fishing the site.
Overall Sheringham Shoal is assessed as having a negligible impact on commercially exploited populations during operation.

12.4.5 Fishing Vessel Safety

Section 14, Shipping and Navigation, presents details of the Navigation Risk Assessment. This has determined that towed and drifting fishing gears would not fish the site for safety reasons, but it may be safe for static gears to be operated within it. A 100m safety zone around structures is proposed for recreational craft and static gear vessels. This situation is however dependent upon the practical trials to be undertaken by SCIRA.

The relevant navigational notification, markings and lights required for the project have been discussed with Trinity House Lighthouse Services (THLS), such that navigational risk to all vessels including fishing vessels will be minimised. Assuming that the fishing activity in the area remains constant after the project, the frequency of fishing vessel collisions with the wind farm structures was assessed to be in the order off 1 in 5,000 years (see Section 14, Navigation). The impact on fishing vessel safety is therefore assessed as being **negligible**.

12.5 Angling Charter Vessels

The angling charter vessel operators interviewed were of the opinion that there would not be any negative impacts to them from the wind farm development and most probably there would be net financial benefits. The owners of each of these vessels when interviewed were of the opinion that there would be an interest in tourist trips to the wind farm site. This has occurred at Scroby Sands where high speed RIBS are used for tourist trips amongst the turbines (www.coastalvoyager.co.uk).

During construction the impact on angling is expected to be **negligible** as many other marks can be targeted when access to the wind farm site is restricted.

Due to the possible aggregating effect of the turbines and the trawl refuge created by the wind farms during operation, the impact of the development for angling vessels is assessed as '**minor beneficial**'.

The potential loss of good sport fishing habitat will be a factor for consideration in the decommissioning plan and may lead to certain structures being left in situ if agreed under decommissioning provisions negotiated with the Secretary of State, and if environmentally and socio-economically beneficial to do so. As with construction, any disruption to angling charter vessels in wind farm areas during decommissioning should be **negligible**.

12.6 Impacts during Decommissioning

With current technology, it is expected that the significance of the impacts of the decommissioning phase would not be greater than those discussed for the construction phase. The experiences of the total removal of the gas platforms and associated structures in the southern North Sea have shown that removal takes less time than installation and generally causes less disturbance to the seabed. As discussed in Section 10, any potential electromagnetic effects from the cables would cease and noise and vibration from piling would not be an issue.

As the potential effects of the additional habitat and the trawl refuge are assessed as being of minor benefit during operation, their removal during decommissioning could be viewed as negative. The most beneficial option to commercial fisheries may be the removal of the majority of the above seabed structures with the retention of rock material, if this can be done without causing damage to the hard substrate habitat created. It is anticipated that buried cables would be left in situ leading to no significant seabed disturbance or interference with fishing activities in these areas.

When compared to pre-construction, there is likely to be an increased risk of seabed obstruction following decommissioning. These obstructions should relate to structures present during the operational life of the project and, therefore, well known to those fishing the area. With ongoing recognition of the presence of any remaining cables or structures on charts, adverse impacts are expected to be **negligible**.

Standard procedures for sweeping and levelling the seabed post decommissioning would be applied if required. With the following of such standard procedures, it is to be expected that there would be a **negligible** long term impact from decommissioning.

Overall the impact of decommissioning on commercial fisheries is assessed as **negligible**.

12.6.1 Cumulative Impacts

The Round 1 and Round 2 wind farm developments that could potentially contribute to the cumulative impacts on commercial fishing are shown in Table 12.7.

It is understood that the Triton Knoll and Dudgeon East sites may be relocated: therefore, no assessment of cumulative effects is currently possible. The Lincs Inner Dowsing, Lynn-Skegness and Scroby Sands sites are beyond the normal fishing areas of the vessels identified as having a track record of fishing the SCIRA site. The following assessment therefore concentrates on the potential cumulative impacts of the SCIRA Sheringham Shoal, Cromer, Docking Shoal and Race Bank developments.

The three main aspects where cumulative impact may occur are: loss of fishing area, adverse impacts on commercially exploited species and increased steaming times. It has not been possible to obtain information relating to the planned construction methods and schedules or proposed turbine layouts from other developers. As such it is not possible to assess the cumulative interference to fishing activities impacts. Data on the fishing activities within these sites has been requested from the developers of these sites; however no information has been forthcoming.

12.6.1.1 Construction Phases

Table 12.7 presents the potential cumulative impacts of the construction phases of the SCIRA Sheringham Shoal, Cromer, Docking Shoal and Race Bank projects assuming that their construction occurs simultaneously.

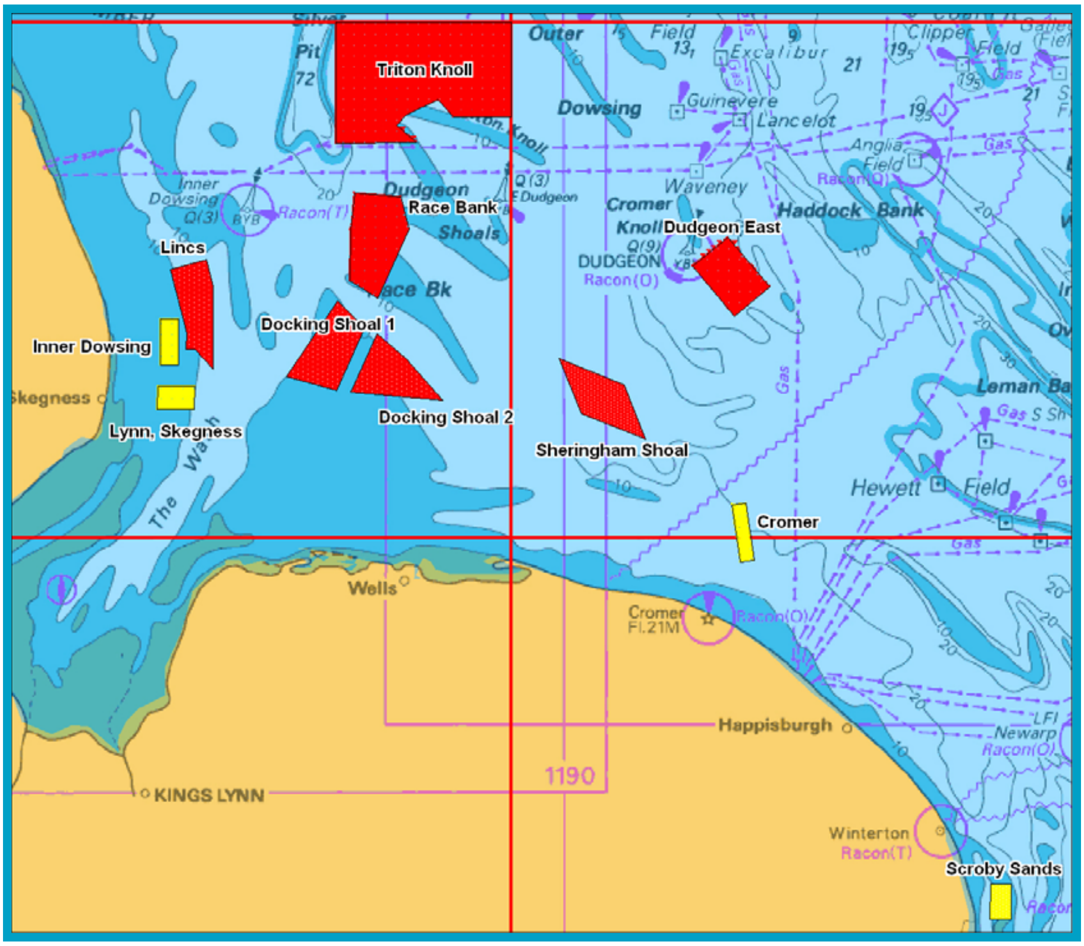


Figure 12.16 Greater Wash Wind Farm Development Sites (Source: Crown Estate)

Table 12.7 Potential cumulative impacts on commercial fisheries during construction

Potential impact	Comment	Assessed impact
Loss of fishing area	For vessels fishing the site, exclusion from the docking shoal area would create a cumulative minor adverse effect. For inshore vessels operating along the export cable route, additional exclusion from the Cromer site would create a cumulative minor adverse effect.	**Minor adverse**
Increased steaming times	Due to the limited construction periods proposed and the navigation routes to be agreed, cumulative impacts are limited to minor adverse.	**Minor adverse**
Impacts on commercially exploited populations	No significant adverse impacts identified for important commercial species that would extend beyond the immediate wind farm areas to create a cumulative impact.	**Negligible**

Loss of Fishing Area

Any cumulative loss of fishing area would only occur if the construction phases of more than one development coincide. Whilst it is unlikely that construction would occur simultaneously, particularly in view of the potential shortage of installation vessels, the worst case scenario would be for all five wind farm construction phases to occur at the same time. If this were to occur, certain of the Blakeney and Wells vessels displaced from the SCIRA site during construction may suffer a degree of cumulative impact as they would also be displaced from the grounds they fish on the Docking Shoal and Race Bank areas. In view of the limited number of vessels involved and the time span, the impact is expected to be **minor adverse.**

The closer inshore Cromer site is within an area largely fished by beach launched potters, which generally do no venture as far as the SCIRA, Race Bank and Docking Shoal sites and as such there is unlikely to be a cumulative impact. Furthermore the Cromer site is small in comparison to the SCIRA site and the cumulative impact is therefore unlikely to exceed **minor adverse**.

Increased Steaming Times

Due to the locations of the main ports and beach launch sites along the north Norfolk Coast relative to main fishing grounds, whilst some diversions around individual sites may be necessary during construction phases, in view of the relatively short time scales involved, it is not expected that there would be any significant cumulative impacts on steaming times above **minor adverse**.

Commercially exploited populations

Minor adverse cumulative impacts are only identified in Section 10 (Natural fisheries) in relation to sensitive migratory species such as sprat and herring. These are not species targeted by local vessels operating on the Sheringham Shoal site.

The minor adverse impact of increased suspended sediment concentrations identified during construction is limited to the immediate wind farm area. Overall the 173km^2 of the wind farms under consideration amount to only 1% of the total hatching area of the north Norfolk shellfish fishery. The cumulative effect is therefore assessed as **negligible.**

12.6.1.2 Operational Phase

Table 12.8 presents the potential cumulative impacts of the operational phases of the SCIRA Sheringham Shoal, Cromer, Docking Shoal, and Race Bank developments.

Table 12.8 Potential cumulative impacts on commercial fisheries during operation

Potential impact	Comment	Assessed impact
Loss of fishing area	Little overlap in gear types and fishing areas, but loss to mobile gears counterbalanced by creation of areas only accessible by static gears.	**Negligible**
Increased steaming times	If policy of Vessels below 300 tones permitted to steam through sites, negligible.	**Negligible**
Impacts on commercially exploited populations	EMF & noise/vibration impacts are localised and cumulatively negligible Habitat alteration creating cryptic substrate and trawl refuge so having a minor beneficial impact	**Minor beneficial**

Loss of Fishing Area

The principal commercial fishing activity within the area of the Sheringham Shoal site is potting, which subject to further investigation and consultation, is expected to be allowed access within the wind farm during its operational phase. At present the policies of the other developers in respect of fishing vessels access are not known.

Whilst there is negligible trawling within the project site, it is understood that shrimp trawling occurs on the Docking Shoal. As there is little evidence of shrimp trawling having occurred within the Sheringham Shoal site, it is unlikely that there would be a direct cumulative impact on shrimp trawling between the Docking Shoal and Sheringham Shoal projects.

The lack of trawling within a number of sites may have a cumulative beneficial effect by eliminating trawling related crab and lobster mortalities. The creation of additional hard substrate at other sites that is accessible and within the range of potters currently using Sheringham Shoal may also lead to minor beneficial impact for potters. This counterbalances the greater restrictions for vessels operating mobile gears and leads to an assessment of a **negligible** impact for commercial fisheries.

Increased Steaming Times

Assuming all of the developers adopt the policy of allowing the size of fishing vessels currently operating in the region to steam through their sites there should be a **negligible** cumulative impact on steaming times.

Impacts on Commercially Exploited Populations

The operational impacts on commercially exploited populations are from EMF, noise & vibration and alteration of habitat. As the first two impacts do not extend beyond the immediate area of the wind farms and are deemed negligible for key commercial species, there is no cumulative impact for these species.

In terms of habitat alteration, impacts of individual wind farms are assessed as being of minor benefit to the key commercial shellfish species. Cumulatively the addition of further suitable habitat, along with additional trawl refuge areas should result in increased opportunities. Overall this leads to **minor beneficial** cumulative impacts for commercial fisheries due to benefits and opportunities created for static gear fisheries by this habitat creation.

12.6.1.3 Decommissioning Phase

It would be unlikely that a number of sites would simultaneously decommission. It is also possible that here would be sufficient flexibility in decommissioning scheduling to prevent cumulative impacts to render any impacts on commercial fisheries **negligible**.

12.7 Summary

This assessment assumes a 500m safety zone from structures for all towed and drifting gears and a 100m safety zone from all structures for static gears within the wind farm array.

The following potential impacts (based on the 2004 CEFAS guidelines) were considered for construction, operation and decommissioning phases of the wind farm development:

1. Complete loss or restricted access to traditional grounds
2. Interference with fishing activities
3. Increased steaming times to fishing grounds
4. Removal of obstacles from the sea bed post construction
5. Adverse impacts on commercially exploited populations
6. Safety issues for fishing vessels

All potential impacts identified during the construction phase are assessed as **negligible** to commercial fisheries other than loss of fishing area which is assessed as being **minor adverse** for the 6 or 7 inshore static gear vessels that regularly operate in the wind farm site area. Should these minor adverse impacts result in reduced landings this would in turn have a **minor adverse** impact on any of these vessel operators that have processing operations that are reliant on their own catch.

All potential impacts identified during the operational phase are assessed as **negligible** to commercial fisheries other than interference to fishing activity for those static gear vessels operating in the area, which is assessed as being **minor adverse.**

Impacts on commercial fisheries during decommissioning are expected to be **negligible**.

Cumulative impacts are assessed by considering other Round 1 and 2 wind farm developments proposed for the region that are within range of the vessels fishing the SCIRA site ie. SCIRA Sheringham Shoal, Cromer, Docking Shoal and Race Bank.

During construction cumulative loss of fishing area and increased steaming times may cause **minor adverse** impacts, while impacts on commercially exploited species is deemed **negligible**.

During operation, assuming access is permitted for the static gear vessels concerned, impacts on fishing area and streaming times are assessed as **negligible.**

For the key decapod (crab and lobster) species currently targeted the creation of hard, cryptic substrate is assessed as being of potential **minor beneficial** impact.

Cumulative impacts from decommissioning are assessed as having **negligible** impact on commercial fisheries.

In addition to the monitoring programme proposed, including assessments of the resulting impacts on commercial fisheries, SCIRA also proposes to work with potentially affected fishermen to establish the feasibility of operating static gears within the site.

12.8 References

- Brown & May Marine Ltd., 2005. Sheringham Shoal Offshore Wind Farm Commercial Fisheries: Existing Environment.
- Cefas, 2004. Offshore Wind farms: Guidance note for Environmental Impact Assessments in respect of FEPA and CPA requirements.
- Defra SFI fisheries statistics, 2000-2004
- Edwards E. (1979) The Edible Crab and its Fishery in British Waters
- ESFJC Annual Reports 2000-2004
- ESFJC Lobster Tagging Survey Preliminary Report, 2005.
- Defra fishing vessel list, 2005 Available from http://statistics.defra.gov.uk/esg/publications/vessels/default.asp
- Leewis, R. and F. Hallie, 2000. An Artificial Reef Experiment off the Dutch Coast. – In A. C.
- Jensen et al. (eds.): Artificial Reefs in European Seas: 289–305.
- Leonhard S.B. and Pedersen, J., 2004 Hard Bottom Substrate Monitoring: Horns Rev Offshore Wind Farm, Annual Status Report 2003. Elsam Engineering

13 Landscape, Seascape and Visual Resources and Character

13.1 Introduction

This section presents the results of the assessment of landscape, seascape and visual impacts as a result of the offshore components of the development, during construction, operation and decommissioning. The cable landfall and landside infrastructure are assessed in, Section **25**.

The section considers effects upon: landscape character and resources, including effects on the aesthetic values of the landscape, caused by changes in its elements, characteristics, character and qualities; seascape character and resources, including effects on the aesthetic values of the seascape, caused by changes in its elements, characteristics, character and qualities; and visual amenity, including effects upon potential viewers and viewing groups caused by change in the appearance of the landscape or seascape as a result of development.

13.2 Assessment Methodology

13.2.1 Introduction

The landscape/ seascape and visual impact assessment has been carried out by a team from ERM including Chartered Landscape Architects.

The landscape/ seascape and visual impact assessment has been carried out in accordance with the Guidelines for Landscape and Visual Impact Assessment produced jointly by the Landscape Institute and the Institute of Environmental Management and Assessment (2002) and The Guide to Best Practice in Seascape Assessment (2001), plus other relevant guidance notes and documentation (eg unpublished guidance by Scottish Natural Heritage (SNH) on assessing cumulative impacts). A selected list of relevant guidance is provided below:

- Planning Policy Statement (PPS) 22 (2004): Renewable Energy.
- Guidelines for Landscape and Visual Impact Assessment, 2nd Edition (2002), Landscape Institute and Institute of Environmental Assessment.
- Visual Assessment of Wind Farms – Best Practice (2002), University of Newcastle, Scottish Natural Heritage commissioned report.
- Guide to Best Practice in Seascape Assessment (2002), Countryside Council for Wales, Brady Shipman Martin and University College of Dublin.
- Guidance: Cumulative Effect of Wind Farms (2005), Scottish Natural Heritage.
- Visual Analysis of Wind Farms: Good Practice Guidance (Draft 2005), Horner and MacLennan, and Envision.
- Offshore Wind Energy Generation: Phase 1 Proposals and Environmental Report (2003), BMT Cordah Ltd.
- Guidance on the Assessment of the Impact of Offshore Wind Farms: Seascape and Visual Impact Report (Draft 2005), Enviros Consulting Ltd, for DTI.

The final reference (DTI, 2005) was published following completion of the bulk of the field work and assessment.

The methodology is applicable to the assessment of short term impacts during the construction of the project, and to long term impacts during its operation, and during its future decommissioning.

A clear distinction is drawn between impacts on landscape/ seascape resources and character and visual impacts.

- Landscape/ seascape impacts relate to the effects of the proposals on the physical and other characteristics of the landscape/ seascape and its resulting character and quality. Landscape/ seascape resources and character are considered to be of importance in their own right and are valued for their intrinsic qualities regardless of whether they are seen by people.
- Visual impacts relate to the effects on the existing visual amenity and views experienced by people, e.g. residents, workers, tourists etc on land and on boats at sea, from key viewpoints throughout the study area. Effects on visual amenity as perceived by people are therefore clearly distinguished from, although closely linked to, effects on landscape/ seascape resources and character.

The area covered by the land and its interface with the sea is referred to by the term 'landscape' and the area of sea, and interface with the land, is referred to by the term 'seascape'. There is overlap between the two terms at the coast. The assessment has ensured that landscape and seascape character areas (see Sections 13.3.2 and 13.3.3) are seamless and relate directly to one another. In reality the boundaries between different landscape or seascape character areas are gradual transitional zones.

Key terms and definitions used in the assessment are stated below.

- Landscape/ seascape character is the distinct and recognisable pattern of elements that occurs consistently in a particular type of landscape/ seascape, and how this is perceived by people.
- Landscape/ seascape value is the relative value or importance attached to a landscape/ seascape (often as a basis for designation or recognition), which expresses national or local consensus, because of its quality, special features including perceptual aspects such as scenic beauty, tranquillity or wildness, cultural associations or other conservation issues.
- Landscape/ seascape quality (or condition) is based upon judgements about the physical state of the landscape/ seascape and about its intactness from visual, functional, and ecological perspectives. It also reflects the state of repair of individual features and elements which make up the character in any one place.
- Landscape/ seascape sensitivity (or capacity) is the degree to which a particular landscape/ seascape character type or area is able to accommodate change without unacceptable adverse effects on its character. Sensitivity varies according to the type and nature (scale) of the change being proposed, and in general where there is high sensitivity there is low capacity. The converse is also true.

As the final design for the wind farm is not yet known, the assessment examines the effects of the wind farm based on the fact that the chosen turbines may vary in size, number and layout, between the limits as described in Section **2**. Images are presented illustrating the two extremes (i.e. 45 x 7MW machines, with a hub height of 97m and a rotor diameter of 150m, and 108 x 3MW machines, with a hub height of 72m and a rotor diameter of 90m). Some images are also presented showing a turbine between the two extremes (70 x 4.5MW machines, with a hub height of 82m and a rotor diameter of 120m). The reason for presentation of various options is that the worst case scenario could be considered to be a smaller number or taller turbines, or a larger number of smaller turbines. Each image is labelled as to what size and number of turbines it is showing.

Heights for wind turbines are given in relation to Mean High Water Level (MHWL). This is the average of high tide water level between Spring tides (i.e. about two days after full moon or new moon: Mean High Water Spring (MHWS)), and Neap tides (i.e. the lowest tides between these two times: Mean High Water Neap (MHWN)). The height of the turbine hubs above sea level will vary according to the state of the tide, with the turbine masts appearing taller at low tide and smaller at high tide, depending upon how much of the mast is exposed. The mean tidal range in the area (measured at Cromer) is 2.7m (See Section **6**).

Table 6.1 summarizes the tidal Levels at the site based on nearby ports. For the ZVI's and visuals the Cromer reference is used.

MHWS and MHWN at Cromer equal respectively to +5.2mCD and +4.1mCD (i.e. relative to Chart Datum). Consequently, the MHWL for Cromer equals +4.65m CD. The MHWL is situated 1.9m above Ordnance Datum (AOD, Newlyn). This means, for the hub height relative to AOD 1.9m has been added to the hub height above MHWL.

The ZVI and seascape visuals are based on Land-Form Profile data by Ordnance Survey (reference: Ordnance Datum). Therefore the hub height of all turbines has been raised by 1.9m compared to the MHWL references to compensate for the tidal effects. Figure 13.1 illustrates these tidal and datum dependencies.

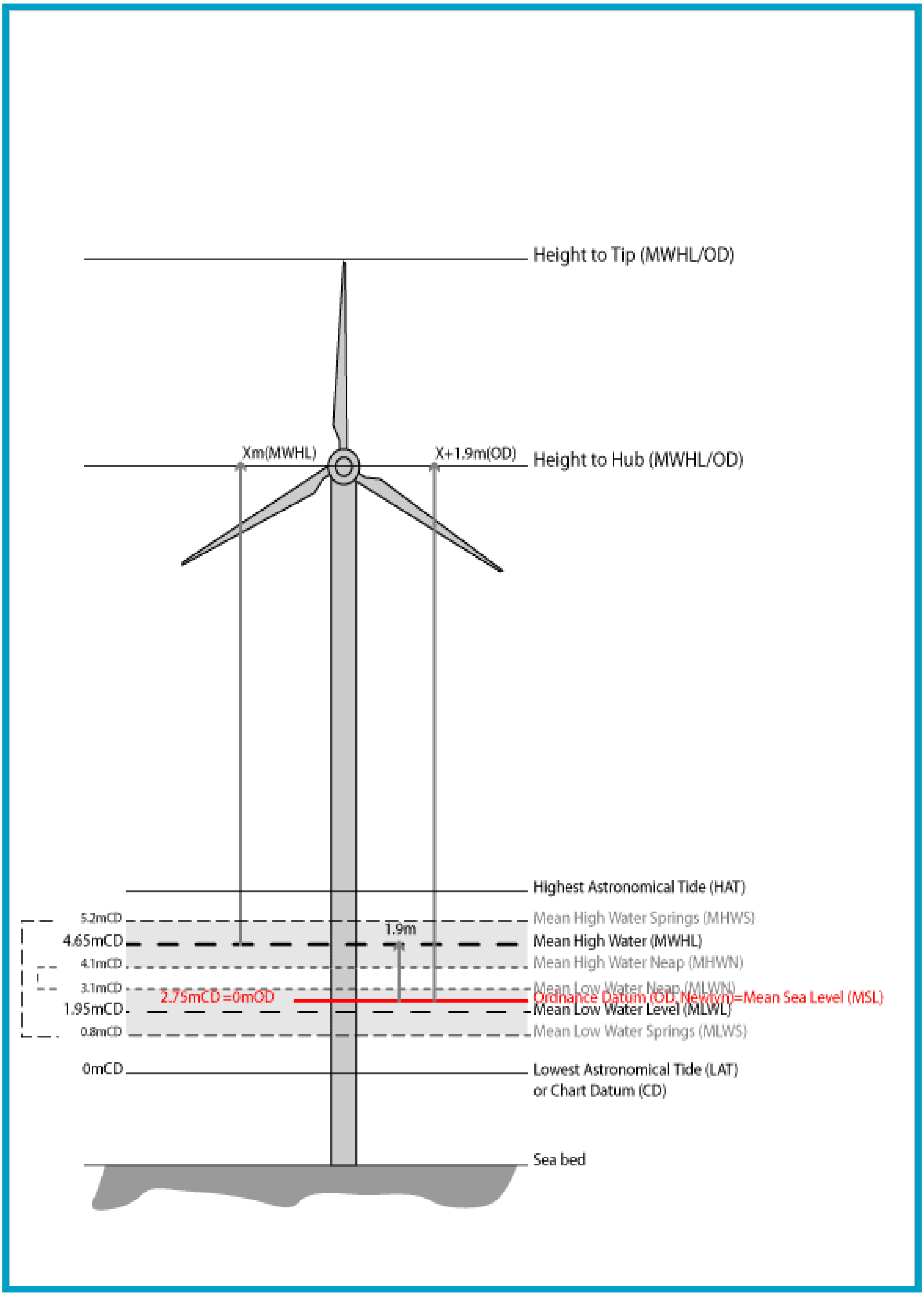


Figure 13.1 Overview of various reference water levels.

13.2.2 Desk Study

A desk study was carried out in summer 2005 to review existing seascape and landscape character areas and types which had already been identified in the area (including the Countryside Character Areas identified by the Countryside Agency – see Figure 13.7) and the guidance contained within the documents on landscape/ seascape sensitivity and capacity to accommodate development. This covered the areas of sea and land within 35km of the development boundary for which information was available within the project timescale. The document Guidance on the Assessment of the Impact of Offshore Wind Farms: Seascape and Visual Impact Report (Draft 2005, Enviros Consulting Ltd for DTI, Section 4.3, page 23) recommends that 35km should form the study area boundary for Round Two offshore developments, as beyond this distance potential effects would not be significant. Existing assessments were reconciled and clarified where there is overlap at the interface of sea and land. The baseline local landscape/ seascape character areas are reported and an assessment made of landscape/ seascape quality, capacity and sensitivity to change.

A review of maps, structure and local plans was undertaken to identify relevant policies and designations within the land based part of the study area, and to identify viewpoint locations for illustration, and to identify viewpoint locations for illustration. For the purposes of the landscape/ seascape and visual impact assessment, designated sites include protected areas of landscape, townscape or protected coast (e.g. Areas of Natural Beauty (AONBs), Heritage Coast), visible archaeological or cultural heritage resources including Conservation Areas and Scheduled Ancient Monuments (SAMs). Key relevant designations across the 35km study area are shown on Figure 13.6. Impacts on the settings of Listed Buildings are unlikely to be significant due to the 17-22km distance of the proposed wind farm from the shore, and are not therefore considered further.

A field visit was carried out to the study area in July 2005 to undertake reconnaissance, produce a photographic record, identify the seascape and landscape resources and character areas present across the study area, and identify proposed viewpoints to be used for the assessment, and for the preparation of photomontages and wirelines. The study area for this assessment was taken to include representative areas of accessible land within 35km of the site boundary which would potentially be affected by views of the proposed offshore wind farm. The extent of the study area is represented by the zone of theoretical visual influence (ZVI) maps shown on Figure 13.15 to Figure 13.18 (Appendix 13.1).

Theoretical computer generated Zone of visual influence (ZVI) maps, wireframes and photomontages were generated by Scira using their 3D model of the proposed development, and digital terrain models, based on Landform Profile Data from the Ordnance Survey (OS), and presented on a 1:50,000 OS raster data map base, the Landranger map series. ERM used these graphics to inform the assessment and to help in the selection of viewpoints for assessment and illustration. The methodology used for the production of the ZVIs, wireframes and photomontages is described in Section 13.2.3.

Visual receptor locations were identified initially by studying maps and information about important locations where people appreciate views (famous hilltop viewpoints, tourist destinations, popular seafronts, designed landscapes etc.), followed up by field work and discussions and agreement with consultees. Viewpoints were chosen, from where the theoretical ZVIs indicated there would be visibility, to represent views from and included residential properties, recreational areas, transport routes and places of work in the area. The predicted sensitivity of each receptor group to the anticipated change was identified. Ferry routes were identified, but were not visited as part of the assessment. The 3D animated model (this will be available on the internet and as a CD-ROM to accompany the application) prepared by Scira was used to represent views from ferries. A map of the viewpoints is provided in Figure 13.15 in Appendix 13.1.

Consultation was undertaken with the local authority (North Norfolk District Council), the Countryside Agency, the North Norfolk AONB Area Officer, and English Heritage and a meeting was held with NNDC to explain the proposals and to agree viewpoints for visualisations. A number of photomontages and wirelines were prepared to illustrate the project, together with cumulative wirelines which show two other proposed projects in the area. The viewpoints cover a wide spectrum of potential public views, from both nearby, and further afield up to 35km away from the site.

13.2.3 Methodology for Production of ZVIs, Wirelines and Photomontages

The ZVI is the area within which a proposed development may have an influence or effect upon visual amenity. The ZVIs presented in this report are theoretical in that they do not take account of intervening vegetation, buildings or minor changes in topography, such as road cuttings. ZVI maps produced for this project were produced as follows.

- All ZVI analysis was calculated using landform based on a digital terrain model derived from the Ordnance Survey 'Landform Panorama' 50m DTM data.
- Heights which were used in the model were based on the average of MHWS and MHWN, (i.e. MHWL for Cromer relative to Ordnance Datum (OD). ZVIs and photomontage/wireline views are represented in this report at OD.
- ZVIs were generated for tips for the 7MW machines (172m to tip above MHW, 97m to hub above MHW), and for the 3MW machines (117m to tip above MHW, 72m to hub above MHW).
- The actual dimensions of the turbine that would be used are as yet unknown, but it is possible that a 4.5MW machine would be used (142m to tip above MHW, 82m to hub above MHW). The ZVI for this would be between those for the 7MW and 3MW machines.
- The tidal range between MHWL (+4.65mCD) and MLWL (+1.95mCD) in this area is 2.7m (measured at Cromer), and the range between Mean Low Water Neaps (MLWN) and Mean High Water Neaps (MHWN) is 1.0m (see Table 6.1).
- WindPro software was used for the calculation of ZVI intervisibility. The software does incorporate earth curvature in calculating intervisibility.
- The resulting ZVI map was overlaid on OS 1:50,000 mapping using Adobe Photoshop.
- For the purpose of the model used here the term intervisibility is used to indicate mutual visibility between the wind farm and locations within the landscape and seascape which fall within a 35km radius of the site. The term also relates to mutual visibility between different wind farm sites. The accuracy of the model is determined by the accuracy of the DTM data data, and does not take into account other factors such as detailed landform (e.g. man made cuttings and embankments), vegetation or buildings and atmospheric conditions. The DTM data used (Land-Form Profile) of Ordnance Survey is referenced to OD (Newlyn).

13.2.3.1 Site Photography, Panorama Stitching and Perspective Matching

Details of the photomontage methodology are set out below.

Photographs from each viewpoint were taken to include an extent of about 180 degrees by taking multiple overlapping images. The locations for all viewpoints were recorded with a global positioning system (GPS). The compass reading for the direction of the viewpoint was taken from the central image, or in between the two middle images for each viewpoint. Photographs were taken by professional photographers with a digital single lens reflex (SLR) camera and 50mm equivalent lens (Nikon E8400 8Mpixel).

For each viewpoint, software called the Panorama Factory was used to combine the individual photographic frames into single panoramas. This software was also used to match the colours and lighting between adjacent frames to achieve a seamless transition. The software bends the images onto a cylindrical or spherical background based on the type and make of camera and on the camera settings (e.g. focal length) used. If the resultant images did not align properly, the overlapping regions of the images were adjusted manually.

Matching computer-generated panoramas were constructed. The parameters for these computer generated wireframes were based upon the recorded viewpoint and camera details. A perspective match was achieved between the computer-generated panoramas and the photographs by iteratively adjusting the perspective parameters (particularly viewcone and azimuth) until all major features in the image were aligned satisfactorily. These panoramas showed the surrounding landform based on a digital terrain model derived from the Ordnance Survey 'Landform Profile' 50m DTM data. Where appropriate, objects in the landscape such as electricity pylons were used as additional markers. The WindPro software does not take earth curvature into account when producing wireframes. Windpro was used to generate multiple wireframe images (to match the corresponding photographs). These were stitched together using the Panorama Factory in the same way as the photographs. Each (partial) panorama montage covers a horizontal field of view of at least 60 degrees.

13.2.3.2 Rendering and Output

Once accurate perspective parameters were available, these were fed into the Windpro rendering software. The software does take earth curvature into account when producing renderings. A full model at the scale of the wind farm was built within this rendering software with each turbine having randomly rotated blades. Since the rendering software cannot render a true cylindrical projection the rendering was undertaken in panels, 40 degrees wide each, to minimise errors created by perspective transformation.

For each viewpoint, the date and exact time of photography was used to calculate sun azimuth and elevation to ensure a correct lighting model. Other adjustments to the lighting model were made by eye to match the weather conditions at each viewpoint.

The renderings with the wind turbines based on the photographs were stitched together with the Panorama Factory to produce a cylindrical image to achieve a smooth transition from one perspective to the other. The final photomontages were generated using Adobe Photoshop.

In interpreting the photomontages two important issues must be considered:

- There is an element of judgement inherent in the representation of changes shown in a photomontage. While the data sources are largely factual or based on the judgement of independent professionals, the finished image is ultimately what the developer and consultant believes to be a reasonably accurate visual impression of the development proposal during similar weather conditions.
- Each photomontage incorporates the lighting conditions represented by the base photograph. It therefore only truly represents the appearance of the proposed development as it would appear at that time on that day. The perception of change and the visual character of elements of the scheme would vary with different weather or lighting conditions.
- viewing angles and distances to the windfarm are indicated on the visuals
- the viewing distances (related distance between the eye and visual to get a realistic view) are presented in Table 13.12.

The use of a 50mm lens is generally recommended in taking photographs for photomontages. However, as with all lenses, a certain amount of distortion which can result in shrinkage of the image from that seen by the naked eye will occur in the process of taking the photograph. Field work was therefore essential in order to examine and assess the likely effects.

13.2.4 Prediction and Evaluation of Impacts

13.2.4.1 Introduction

The criteria described below have been used in determining significance levels for this ES as described in, Section **1** of this ES.

The assessment of landscape/ seascape and visual impacts involves three steps:

- determining the sensitivity of the landscape/ seascape or viewer group (i.e. the receptor) to the type of change envisaged;
- predicting the magnitude of change that would take place in the landscape/ seascape or view; and
- evaluating the significance of that change taking into account the sensitivity of the affected receptor and the magnitude of change.

13.2.4.2 Receptor Sensitivity

The sensitivity of a landscape/ seascape is dependent upon the location and the context of the view, on any specific values represented by protected features or designations that apply. It is also relevant to consider how widespread the type of landscape/ seascape that is affected is in the wider area, and the degree to which any impact would affect a unique or valued resource i.e. the significance of the view. Sensitivity also takes account of the inherent nature, quality, condition and capacity to accommodate change of the type envisaged.

The sensitivity of a viewer group depends on their occupation and viewing opportunity. Hence a person enjoying an outdoor recreation, such as walking, and residents with a permanent view are considered to be of higher sensitivity than office workers or travellers with only a passing interest in the environment. The number of people who may be affected within the viewing group is also relevant and this must be considered in the context of the numbers of people in the wider area and their frequency of viewing opportunity, for example, how often and how many people travel along roads or visit footpaths.

Sensitivity is described as **Low, Medium** or **High** and these definitions are illustrated by the examples below.

13.2.4.3 Landscape/ Seascape Sensitivity

- **Low**: a land/seascape that is not valued for its scenic quality and will generally be tolerant of the type of change envisaged;
- **Medium**: a land/seascape with a local plan designation or one that is locally valued and contributes positively to the character of the area, and one that may have the capacity to accommodate a degree of the type of change envisaged; and
- **High**: a land/seascape protected by a regional (structure plan) or national designation and/or widely acknowledged for its value; a landscape with distinctive character that could be altered by the type of change envisaged.

13.2.4.4 Sensitivity of Visual Receptors

- **Low**: a viewing location where visual receptors have only a passing interest in their surroundings such as locations where there are travellers on busy roads not known for their scenic value, or employees in an office or factory; a location on a rural road used for local non-recreational journeys; or a point on a footpath used only occasionally by local people;
- **Medium**: locations where there are users of reasonably well used paths, bridleways and open spaces such as beaches; users of roads acknowledged as of scenic value; locations where there are a small numbers of viewers with a proprietary interest such as residents; and

- **High**: locations where there are users of widely known and well-used recreational facilities; or more than small numbers of residential viewers.

13.2.4.5 Magnitude of Change

The magnitude of change in a landscape/ seascape or view depends on the nature and scale of the development, and its duration and reversibility. It may also be relevant to consider the likelihood of the change occurring if there is uncertainty and the degree of confidence with which the magnitude of change can be predicted.

In the case of landscape/ seascape impacts, other factors relevant to magnitude would include the extent of loss or change in important landscape/ seascape features or characteristics, the degree of fit between any new features and those existing and the contrast they present with the character of the area in which the change is taking place, and the effect on the character and setting to neighbouring character areas.

The magnitude of change to a view would also depend on the proportion of the view that is affected and the prominence of the new features taking into account distance and contrast in form, colour, cultural associations and the like.

Magnitude is described as **Low, Medium** or **High** and these definitions are illustrated by the examples below.

13.2.4.6 Magnitude of Landscape/ Seascape Change

- **Low**: just perceptible long term changes in components of a landscape/ seascape or more noticeable temporary and reversible changes;
- **Medium**: clearly perceptible long term changes or losses in important features of a character area but which result in only relatively subtle changes in character; or changes in a small part of a character area of but which have a clear effect on the immediate locality. Clearly perceptible changes in the setting to a neighbouring character area which are sufficient to influence its own character; and
- **High**: clearly perceptible changes for example resulting from loss of features making an essential contribution to a character area, introduction of new large scale features into a character area where these are not typical, or changes exerting an overriding influence on a neighbouring character area.

13.2.4.7 Magnitude of Visual Change

- **Low**: just perceptible changes in view;
- **Medium**: clearly perceptible change in a view offering an either distinct contrast in part of the view or a wide ranging more subtle but still evident alteration;
- **High**: a notable change in a view affecting a substantial part of the view.

13.2.4.8 Evaluation of Significance

The significance of effects is determined by cross-referencing the sensitivity of the receptor (landscape/ seascape or viewer group) with the magnitude of change expected as a result of the development. Impacts can be **Minor, Moderate,** or **Major**. They may also be positive or negative depending on whether the change is judged as likely to be perceived as adverse or beneficial by the majority of those experiencing it. Where the assessment team considers that there may be fundamentally contrasting perceptions of benefit or adverse impact by different constituencies this is also noted.

The evaluation of significance in landscape, seascape and visual assessment requires the exercise of careful professional judgement and experience as there are no defined thresholds available, or limits upon levels of acceptable significance comparable to those in some other areas of impact assessment. Each impact, and the degree of significance is evaluated on a case by case basis using the diagram shown in Figure 13.2 as a guide. Boundaries between levels are blurred and it is up to professional judgement to decide where each case falls.

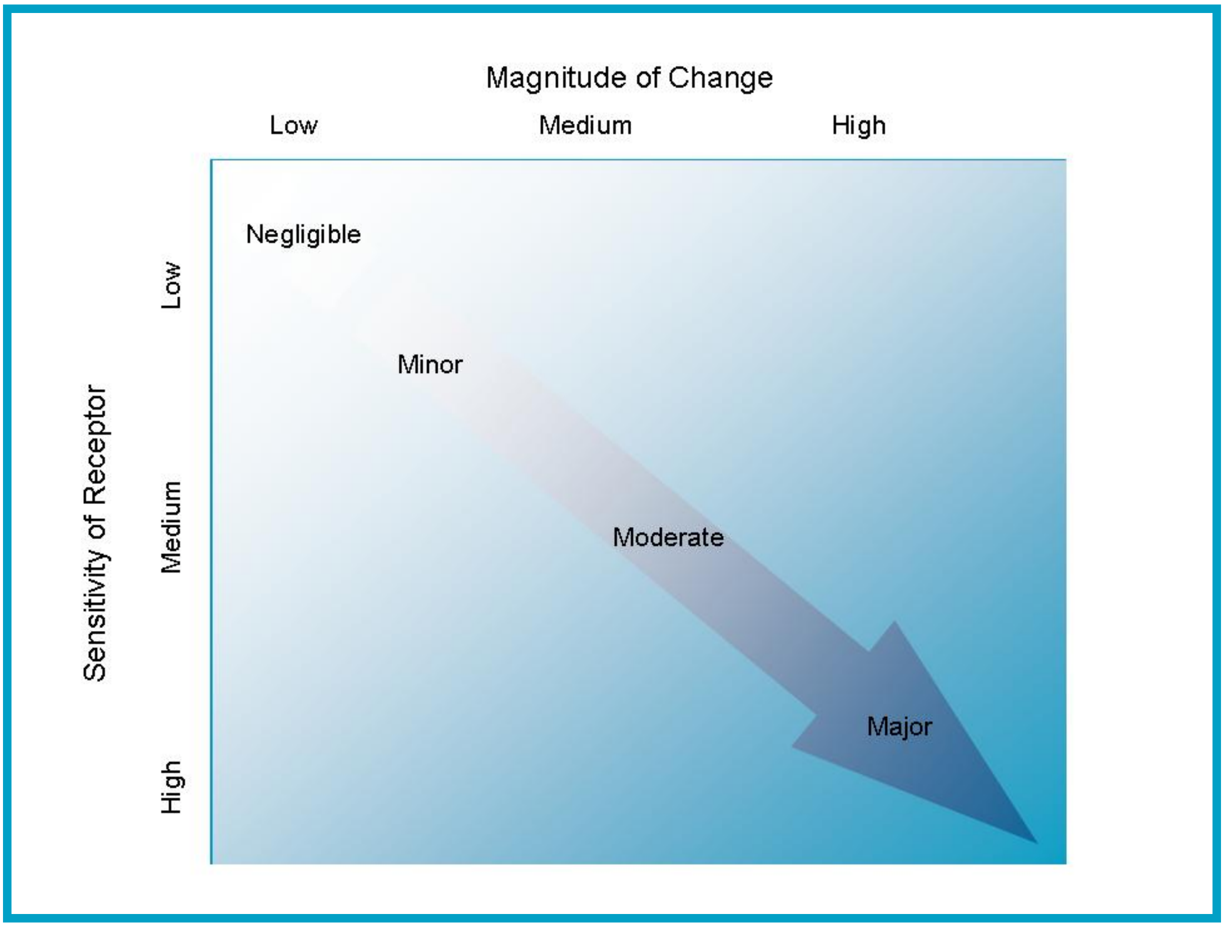


Figure 13.2 Significance of Effects (Source: ERM)

The significance is determined in two steps. In the first step evaluations are made per viewpoint. This leads to impacts on viewpoint level. The significance levels for the assessments per viewpoint (shown italic) are made according to the following definitions (see Table 13.13):

Negligible: the impact is not significant;

Minor: the impact is of slight significance;

Moderate: the impact is of medium significance; and

Major: the impact is of substantial significance.

In the second step an overall evaluation is made for the Designated Sites and Landscape Character Areas and Types, see Table 13.10 and Table 13.11. The significance level (**negligible** – **major**) of identified impacts for these areas are shown in bold in Sections 13.4 - 13.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section **1** for the definition of significance levels.

In this assessment, impacts upon seascape are generally considered to be adverse as the new development will be alien to the existing undeveloped character of the sea in this area. Impacts upon the landscape will all be indirect and distant, as the development is offshore, but where they affect undeveloped or semi-natural coastlines these will generally be at odds with the existing rural character, and will therefore be adverse. Beneficial impacts on the landscape may arise where a development can be seen to enhance the landscape of an area or to fit in and reinforce its existing qualities.

In terms of the direction of visual impacts, it is acknowledged that people vary in their attitude to the presence of wind farms in their views, with some people finding them attractive and interesting, and others disliking them. The visual assessment therefore focuses on the degree of significance of the change rather than its direction, as whether it is considered adverse or beneficial can depend on the eye of the beholder. Section 8, page 78 Evaluation of Seascape and Visual Impacts – from Assessing Significance of Guidance on the Assessment of the Impact of Offshore Wind Farms: Seascape and Visual Impact Report (Draft 2005), Enviros Consulting Ltd, for the DTI provides further information on significance. Section 11, page 94 of the same document discusses Public Perception Before and After Studies. See also related comment at the end of Section 13.5.2.4.

13.2.5 Cumulative Assessment Methodology

Cumulative landscape and visual impacts resulting from the proposed scheme and two other proposed schemes/groups of schemes in the area were assessed from a selection of viewpoints. The location of these other schemes, off the coast at Cromer, and the Docking Shoal/Race Bank off the coast north of Burnham Overy Staithe are shown on Figure 13.3. The Cromer site is consented but not yet constructed (30 x 3.6MW turbines, 6.5km offshore, in a grid of 3 rows, north to south alignment, 750m between each turbine, 100m to hub, 140m to tips). Information about the sizes and numbers of turbines was received from Centrica/AMEC for the Docking Shoal/Race Bank proposed Offshore Wind Farms. This information was used to make possible wind farm layouts for Docking Shoal/Racebank. These layouts have also been used for the cumulative assessment.

There are several other wind farms and wind farm sites in the study area.

- The Triton Knoll and Dudgeon sites have no land based overlap of their ZVIs with that for the Sheringham Shoal site and so significant cumulative impacts on the landscape or views will not occur. Impacts will therefore be confined to the seascape and to views from the sea by as experienced by people who work at sea and recreational sailors. Recreational sailors are of higher visual sensitivity and will stay close to the shore, between the wind farm and the coast. Their view to the landscape from the sea will stay the same. Most ships further from the coast will be commercial, and workers will be of lower sensitivity to change in their views. There are low numbers of commercial ships out at sea.
- The Lincs, Inner Dowsing, Lynn, Skegness and Lynn 2 sites have a very small area of overlap amounting to a stretch of under 10km of coast between Scolt Head Island and Wells-Next-The-Sea, and again significant cumulative impacts on the landscape or views are not expected. Views from the eastern 5km of this coast out to sea are screened by coniferous plantation forestry along Holkham Meals. The stretch of coast between Scolt Head Islands and Burnham Overy Staithe is obscured by a wide expanse of mud flats and dunes, although some visual receptors will be present along Peddars Way and North Norfolk Coast Path and Scolt Head Island Nature Reserve.
- Cumulative landscape and visual impacts with Scroby Sands Offshore Wind Farm will be insignificant as there is almost no overlap in ZVIs due to the distance between the sites, and the orientation of the coastlines.

In addition, as the location of some of the wind farm sites, including Dudgeon and Triton Knoll were subject to potential change at the time of writing of this ES, these developments could not be assessed for cumulative impacts in detail. This assumption is consistent with the incremental or 'Building Block Approach' as described in Greater Wash Round 2 Offshore Wind Farms: Cumulative Effects, Scoping Report (2003), Posford Haskoning, which acknowledges that some Round 2 sites are progressing faster than others and therefore information on all sites will not be available at the time of a project specific EIA. All reasonable information that is available has been used in this assessment and it will be incumbent on later applicants to take into account any additional information available within their cumulative assessments.

Cumulative ZVIs were produced by Scira (see Figure 13.37 to 13.39 in Appendix 13.1), and are presented as overlays with the ZVI for the proposed wind farm, in a colour scheme which enables the overlap with each different wind farm to be examined (see section 13.7).

Cumulative wire frames/photomontages showing the proposed development and the two other wind farms/wind farm groups are also provided (see Figure 13.40 to 13.42 in Appendix 13.2).

Combined, successive and sequential cumulative visual impacts are described, based on the methodology set out in guidance produced by Scottish Natural Heritage (Cumulative Effects of Wind Farms (2005), Scottish Natural Heritage), and Guidance on the Assessment of the Impact of Offshore Wind Farms: Seascape and Visual Impact Report (Draft 2005) Enviros Consulting Ltd for the DTI, Section 9 Cumulative Impact Assessment, page 82.

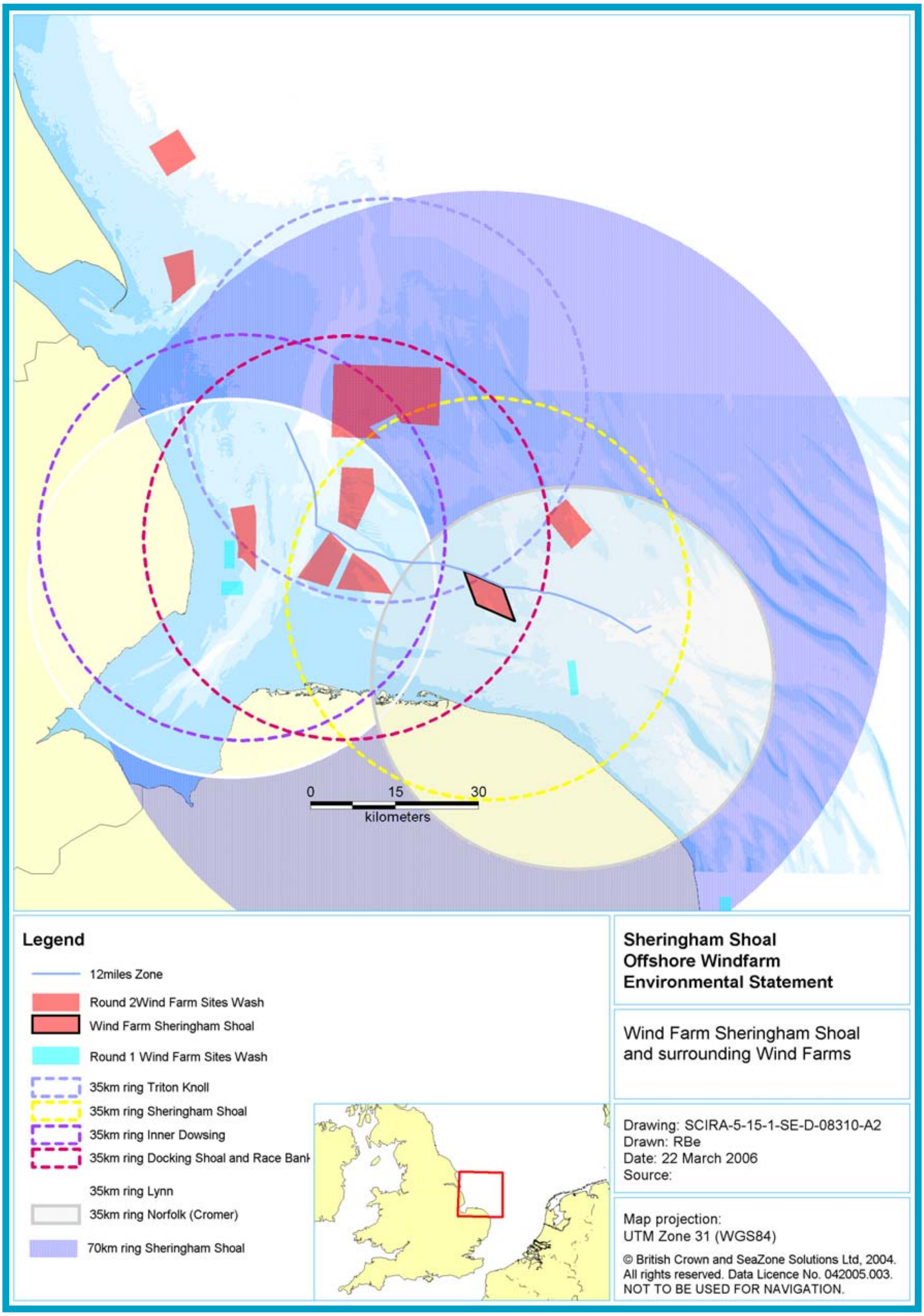


Figure 13.3 Cumulative Wind Farm Sites in the Area. CIrcles of 35km around Scira (yellow) and neighbouring wind farms within 70km contour. Overlap of yellow circle with other circles onshore show area's of potential combined or successive impacts. Circles around Dudgeon and Triton Knoll are dashed (on the move) (Source: Scira)

Combined and successive effects are from static viewpoints, whereas sequential effects relate to viewers who are moving.

- Combined effects occur where a static observer is able to see two or more developments from one viewpoint within the observer's arc of vision at the same time.
- Successive effects occur where two or more wind farms may be seen from a static viewpoint but the observer has to turn to see them.

Sequential effects occur when the observer has to move to another viewpoint, for example when travelling along a road or footpath, to see the different developments. Sequential effects may range from frequent (the features appear regularly and with short time lapses between, depending on speed and distance) to occasional (long time lapses between appearances due to a lower speed of travel and/or longer distances between the viewpoints).

The difference between combined and successive impacts is illustrated in Figure 13.4.

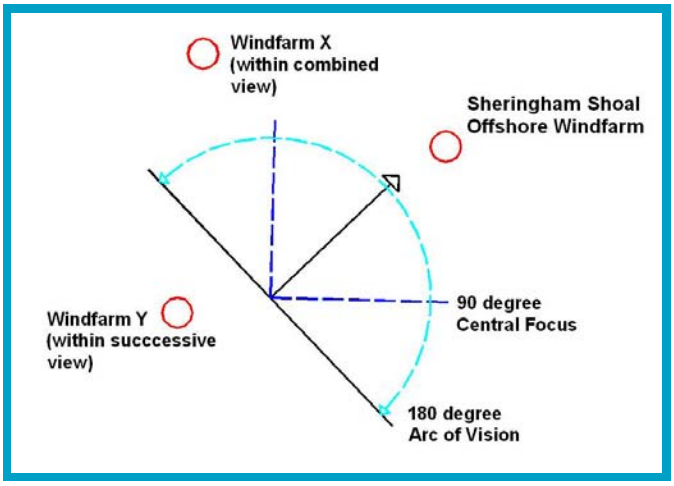


Figure 13.4 Illustration of Combined and Successive Impacts (Source: ERM)

To assess if the views are combined or in succession a viewing arc model is created. If the viewer is standing stationary, with Sheringham Shoal Offshore Wind Farm as the focus of the view, any wind farm within 90 degrees either side of the centre of the view is considered to cause a combined cumulative impact. Anything behind this 180 degree arc is considered to cause a successive cumulative impact, as the viewer has to turn to see it (ie it is behind the viewer).

13.3 Description of the Existing Environment

13.3.1 Relevant Designations and Policy

The location of landscape designations throughout the study area are shown on Figure 13.6. Relevant designations and associated policy are described below. Further detail is provided in North Norfolk Local Plan at http://www.northnorfolk.org/downloadfiles/proposals_map.pdf

Table 21, page 9-48 of the Strategic Environmental Assessment (SEA) titled Offshore Wind Energy Generation: Phase 1 Proposals and Environmental Report (2003), BMT Cordah Ltd, identifies thresholds for significant effects on seascape units. Where the seascape unit has a high sensitivity, as it the case of the Norfolk coast which is designated as an Area of Outstanding Natural Beauty and as a Heritage Coast (see Figure 18 (Annex 2) in the same document), '**medium** effects' are possible for schemes between 13-24km offshore, and '**major** effects' at less than 13km offshore. The document states that these distance thresholds are not prescriptive, but are indicative and therefore need to be considered within the scope of any EIA. This has been done in the assessment presented in this section.

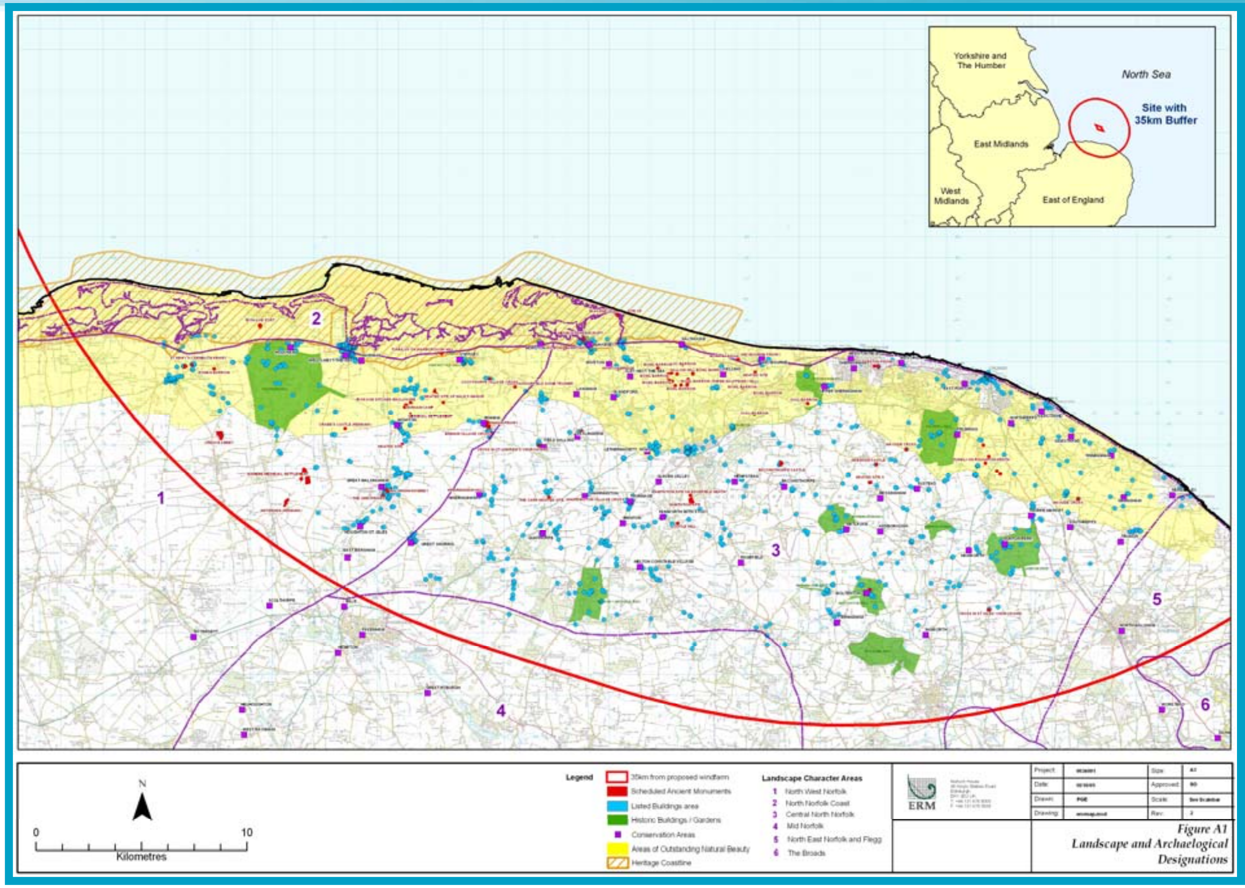


Figure 13.5 Landscape and archaeological designations

13.3.1.1 Norfolk Coast Area of Outstanding Natural Beauty (AONB)

Most of the Norfolk coast is of national landscape importance, having been designated by the Countryside Commission (now Countryside Agency) as an Area of Outstanding Natural Beauty (AONB) in April 1968. The AONB occupies 450km^2. The designation affords special status in the control of development and establishes the primary purpose as the conservation and enhancement of natural beauty, which includes protecting flora, fauna and geological as well as landscape features. The AONB covers much of the area of coast which would be affected by views of the proposed wind farm, and its extent is shown on Figure 13.6.

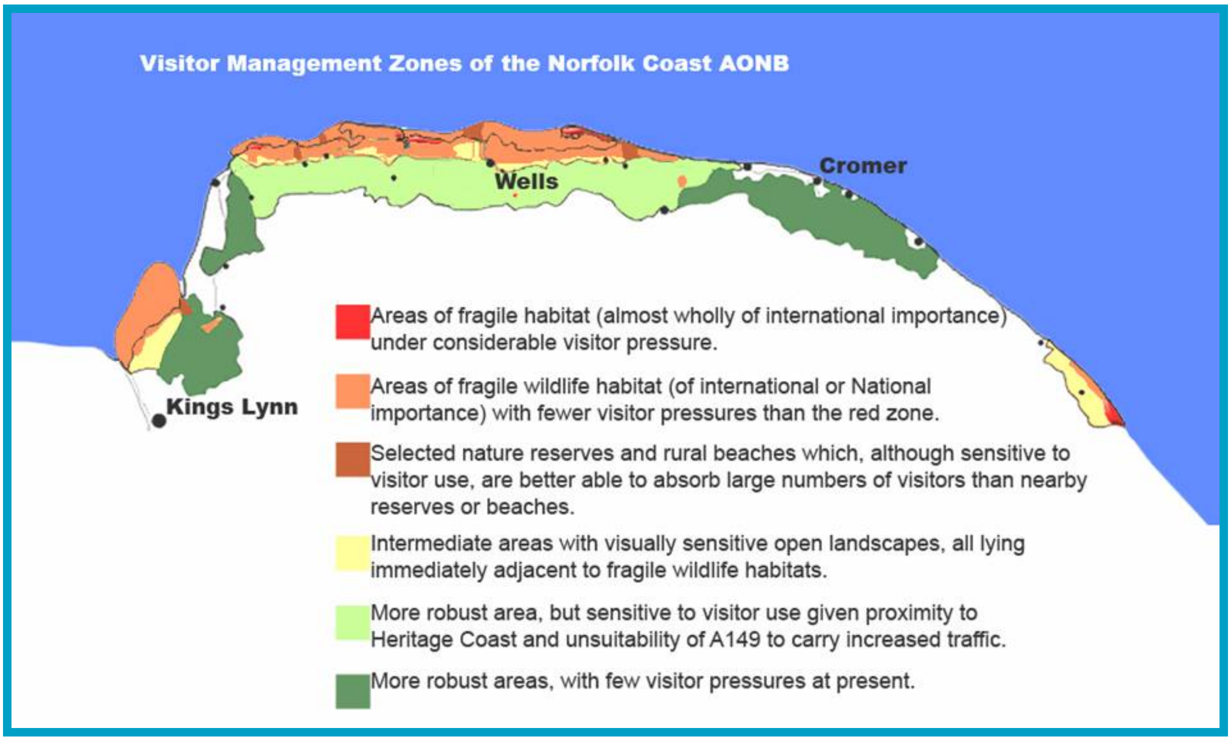


Figure 13.6 Norfolk Coast AONB (Source: Norfolk Coast Partnership)

The key indicates landscape and habitat sensitivity in relation to existing visitor use, as identified by Norfolk Coast Partnership. This gives an indication of likely sensitivity to the proposed development, with the most sensitive landscapes being the less developed open marshes, also designated as being of international importance for their wildlife value, and the less sensitive areas being the farmland further inland away from the coast. The most sensitive viewpoints lie within both the upper band, where there will be few people, but those that there are will be of high sensitivity, and the middle bands, where more people are present.

Policies relating to the AONB are set out in the structure and local plan as follows:

Structure Plan Policy:

'Policy ENV.2: development which will be detrimental to the character of Areas of Outstanding Natural Beauty, the Heritage Coast and the Broads will not be permitted unless there is an overriding proven national need for the development and there are no suitable alternative sites.'

Local Plan Policy:

'Policy 20: Norfolk Coast Area of Outstanding Natural Beauty: in the Norfolk Coast Area of Outstanding Natural Beauty the prime planning consideration will be the conservation and enhancement of the beauty of the area, and development proposals that will be significantly detrimental to it will not be permitted.'

13.3.1.2 Other Areas of Non Statutory Landscape Importance

Planning policies of relevance are as follows:

Structure Plan Policy

'Policy ENV.3: in the areas of important landscape quality, the Brecks, the river valleys, the remaining length of undeveloped coast, the Wash area, historic parks and gardens and their settings, broadleaved woodland, heath and common land, proposals for development will only be acceptable where they can be shown to conserve and are sensitive to the appearance and character of these areas.'

Structure Plan Policy:

'Policy ENV.4: the distinctive character of the Norfolk countryside and coast will be protected for its own sake and proposals for development in these areas but outside the areas of special protection will only be acceptable where they do not significantly harm the character of these areas.'

13.3.1.3 Norfolk Heritage Coast

The marshland coast is widely considered to be the finest example of its kind in Britain, and probably Europe. Consequently, this area was defined as a Heritage Coast by the Countryside Commission in April 1975, following the agreement of the Council together with the Borough Council of King's Lynn and West Norfolk and the County Council.

Heritage Coasts are a non-statutory landscape definition, unlike the formally designated AONB, and are defined by agreement between the relevant maritime local authorities and the Countryside Agency. Most are part of a National Park or AONB. These special coastlines are managed so that their natural beauty is conserved and, where appropriate, the accessibility for visitors is improved.

The shifting shoreline of the Norfolk Heritage Coast, which spans about 63.2km of coast between Holme next the Sea and Weybourne is important for coastal ecology and has almost isolated the historic little ports of Cley and Blakeney from the open sea. Its salt marshes are considered to be a last true wilderness in lowland Britain. The Heritage Coast includes a Ramsar site (a site that has been designated under the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (known as the Ramsar Convention) to protect internationally important wetlands), a Biosphere Reserve, a Site of Special Scientific Interest, a Special Protection Area and Special Area for Conservation (SAC).

13.3.1.4 Undeveloped Coast

Approximately 30% of the coastline in England and Wales is developed. Much of this development took place before the Town and Country Planning Act 1947 came into force, but since then there has been increasing emphasis on protecting and conserving the undeveloped coast for both its landscape value and nature conservation interest. The undeveloped coast in North Norfolk has numerous nature conservation and landscape designations, and policies constraining development in these areas have largely been effective. However, this situation has tended to concentrate development pressures on those stretches of the coast without such designations. Given the physical and/or policy constraints that apply to most parts of the undeveloped coast, it is generally not expected to accommodate new development that could be satisfactorily located inland or in existing developed areas.

Local Plan Policy:

'Policy 26: Undeveloped Coast: in the Undeveloped Coast development proposals that do not require a coastal location or will be significantly detrimental to the appearance or character of the area will not be permitted.'

13.3.1.5 Areas of High Landscape Value (AHLV)

The Structure Plan key diagram identifies almost all of North Norfolk as an Area of Important Landscape Quality with only a small area of countryside around North Walsham excluded. A thorough study of North Norfolk's landscape was undertaken by NNDC in order to provide a detailed local interpretation of landscape quality. The areas of important landscape quality which were identified were designated as Areas of High Landscape Value (AHLV). The AHLV supplements the AONB designation which identifies areas of national landscape importance. Areas included within the AHLV designation include localised landscapes of a marginal or transitional nature where they are surrounded by landscape of higher quality or where their inclusion links one area of higher quality to another. The AHLV covers the majority of inland NNDC, out with the coastal area which is designated as AONB.

Local Plan Policy:

'Policy 21: Area of High Landscape Value: the appearance and character of the Area of High Landscape Value will be conserved and enhanced. Development proposals that will be significantly detrimental to its appearance or character will not be permitted.'

13.3.1.6 Archaeology and the Landscape Setting of Archaeological Features

(See also Section **0** Landscape and Visual Character).

Scheduled Ancient Monuments

Some nationally important archaeological sites are given special protection as 'Scheduled Ancient Monuments' under the Ancient Monuments and Archaeological Areas Act 1979, as amended. Further detail about SAMs is provided in North Norfolk Local Plan Part F18 - Scheduled Ancient Monuments at http://www.northnorfolk.org/planning/5446_5215.asp. Besides Scheduled Ancient Monuments, North Norfolk contains other sites of regional and local archaeological importance.

All archaeological remains are important for research, education, leisure or tourism and it is therefore necessary to safeguard these. The landscape setting of a site is one component of its value, and as such the Council will not permit development which will adversely affect their settings. The Council's archaeological policy below applies to Scheduled Ancient Monuments and other sites or structures of archaeological or historical significance, including those included in the 'County Sites and Monuments Record' as maintained by the County Council's Norfolk Museum Service (Landscape Archaeology Section) at Gressenhall.'

Local Plan Policy*:*

'Policy 45: Archaeology: in the case of development proposals affecting sites where important archaeological remains may exist, the Council will require the results of an archaeological field evaluation to be submitted prior to determining any planning application. Where the physical preservation of remains in situ is not justified, the Council will consider imposing a planning condition on any planning permission granted requiring an agreed programme of archaeological work to be carried out. Development proposals that will have a significantly adverse effect on Scheduled Ancient Monuments or other nationally important sites and monuments, or their settings, will not be permitted. In the case of development proposals affecting other sites of archaeological interest, the Council will seek preservation of remains in situ as first preference. Where preservation in situ is not feasible, or merited, planning permission may be granted subject to satisfactory provision being made for excavation and recording.'

Historic Parks and Gardens

Since the 1980s, 'English Heritage has compiled a national 'Register of Parks and Gardens of Special Historic Interest' that make a rich and varied contribution to our landscape. Of the 38 Historic Parks and Gardens identified in the County of Norfolk, 15 are to be found in the Local Plan area. In addition to the register compiled by English Heritage, a further 18 Historic Parks and Gardens of local interest have been identified. All Historic Parks and Gardens form an important part of North Norfolk's landscape character and heritage.

Local Plan Policy:

'Policy 25: Historic Parks and Gardens: development proposals that will be detrimental to the appearance or character of Historic Parks or Gardens, or their settings, will not be permitted.'

Further detail is provided in North Norfolk Local Plan Part F21, Schedule 8 - Historic Parks and Gardens at http://www.northnorfolk.org/planning/5446_5222.asp

Conservation Areas

There are currently about 80 Conservation Areas in North Norfolk, many of which lie within the study area for the proposed wind farm. A Conservation Area is an area of special architectural or historic interest, the character or appearance of which it is desirable to preserve or enhance. The majority of Conservation Areas relate to the built environment of villages and towns. They are often centred upon Listed Buildings. Important groups of other buildings, open spaces, trees, historic street patterns and village greens can all contribute to the special character of an area which merits designation as a Conservation Area. Landscape and buildings surrounding a Conservation Area can contribute to its setting and provide attractive views into and out of the area. These views and the overall setting need to be protected to ensure that new development in the vicinity does not harm the character or appearance of the Conservation Area.

Local Plan Policy:

'Policy 42: Development in Conservation Areas: *within Conservation Areas development proposals will not be permitted unless they preserve or enhance the appearance or character of the Conservation Area. Development proposals affecting the setting of a Conservation Area or views into or out of the Conservation Area will be considered against the same criteria.'*

Further detail is provided in North Norfolk Local Plan Part F16 Schedule 5 - Conservation Areas at http://www.northnorfolk.org/planning/5446_5216.asp

13.3.1.7 Registered Common Land

'Common land' is land on which members of the community have rights of use. Common land appearing now on County registers is that which has been recognised as such under the 1965 Registration of Commons Act. Common land is generally publicly accessible, and therefore was considered in the selection of viewpoints.

Much of the common land and other areas of generally open access (beaches etc) is now formally open to public access, or is in the process of being formalised as open access land, as a result of the CROW Act (Countryside and Rights of Way Act 2000).

13.3.1.8 Rights of Way

Of particular significance to the rights of way network in the area are linear routes of strategic importance, and circular routes of more local importance. In North Norfolk there are two strategic routes, or long-distance footpaths, namely the 'Norfolk Coast Path' (part of the Norfolk Coast Path is also part of the Peddars Way) and the 'Weavers Way'. Circular walks can be within or around a single village or involve the linking of several villages, long-distance paths or open-access sites.

The Peddars Way and Norfolk Coast Path start in Suffolk at Knettishall Heath Country Park and follows the route of a Roman road to Holme-next-the-Sea on the North Norfolk coast. At Holme the Peddars Way meets the Norfolk Coast Path as it passes from Hunstanton to Cromer.

13.3.1.9 North Norfolk Landscape Character Assessment

The character of the rural landscape varies considerably throughout North Norfolk and is a valued part of the area's heritage. The North Norfolk Landscape Character Assessment, completed in 1995, identifies the broad character areas and landscape types which can be found in North Norfolk and provides a guide on how the landscape can be conserved and enhanced.

Further detail is provided in Section 13.3.2 below, and in North Norfolk Local Plan Part E1 Annex 1 - North Norfolk Landscape Character Assessment at http://www.northnorfolk.org/planning/5446_5205.asp

13.3.2 Description of Existing Landscape Resources and Character Areas

13.3.2.1 National Scale Landscape Resources and Character – Countryside Character Areas

The Countryside Agency has prepared a Character Map of England, which defines national scale landscape character areas across the whole of England. Those areas which are relevant to the study area (i.e. which lie within 35km of the site centre) for this project are shown in Figure 13.7, and extracts from the descriptions detailing their key characteristics, as provided by the Countryside Agency, are included on Table 13.1 below.

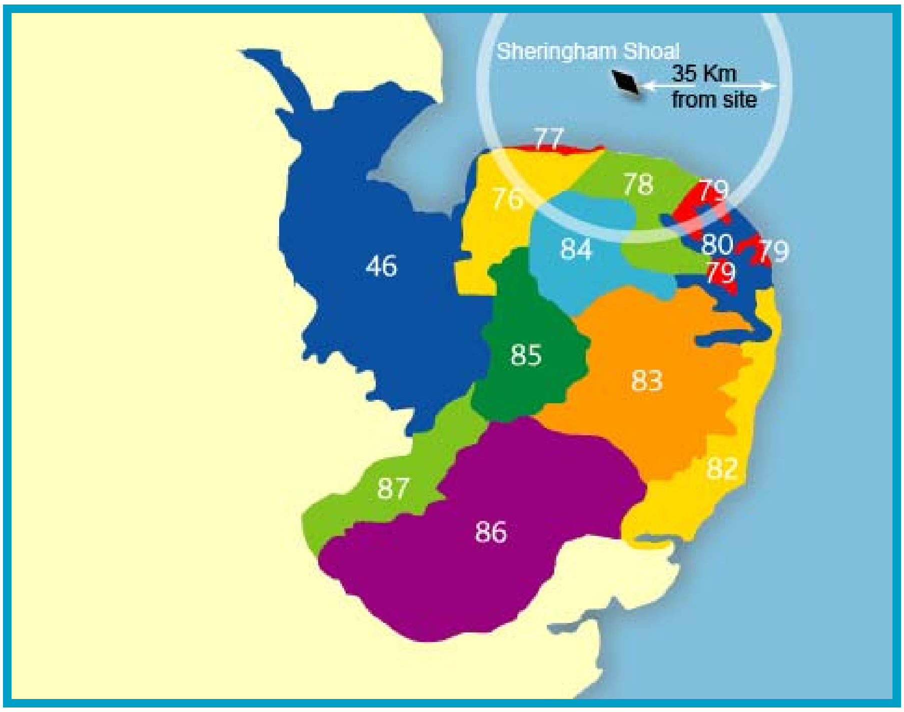


Figure 13.7 Countryside Character Areas – National Level (Source – The Countryside Agency)

The closest edge of the site is located off the coast of Central North Norfolk Countryside Character Area (No. 78). To the east is North East Norfolk and Flegg (No. 79), to the south is Mid Norfolk (No. 84), and to the west are the North Norfolk Coast (No. 77) and North West Norfolk (No. 76).

Full details about the Countryside Agency Countryside Character Areas are available at http://www.countryside.gov.uk/LAR/Landscape/CC/the_east/index.asp

Table 13.1 The Countryside Agency Countryside Character Areas – National Level.

Countryside Character Area	Key Characteristics
North West Norfolk 76	Large-scale arable and grassland landscape on big rolling upland terrain, with frequent long views over remnant heath and large belts of mixed woodland. Very open, apparently 'high' and remote, contrasting with smaller scale to east and within river valleys. Huge estates giving a unified and well-managed quality to the landscape, enhanced by the rectilinear network of late enclosure, contrasting with the open heath of the north/south Lower Greensand Ridge on the western edge. Comparatively few, straight roads which often have wide verges especially in the northern part of the area and with uniform hawthorn hedges set well back and well-maintained. Few hedgerow trees or copses. Large and widely spaced villages, often clustered around a green or common, frequently with isolated outlying farms with Georgian farmhouses. Usually clay tiled and in flint but with 'carstone' and/or chalk on the western escarpment.
North Norfolk Coast 77	Great variety of texture and detail in coastal landscapes, including intertidal sand and mudflats, sand dunes, shingle banks, saltmarsh, reedbeds, tidal creeks and harbours. Wild, remote and open, with long sweeping views. Influence of sea: awareness of the dynamic nature of the marine landscape, its smells and sounds, the salt winds and seabirds and the effects of longshore drift. Lack of settlements and roads on the coastal marshes but distinctive flint villages strung along the coast road. North face of Cromer Ridge and coast road separate coastal strip from inland areas. Almost no transitional zones to areas of different landscape character, but great variety within.
Central North Norfolk 78	Distinctive steep northern slope and more gentle southern face of Cromer Ridge, with outlying spurs and hills, is most distinctive topographical feature. Variable geology, with extensive sand and gravel soils. Topography variable with notably vigorous minor undulations and some flat areas. Predominantly arable, with variable field sizes, generally medium rather than large; relatively well-wooded, often a reflection of sporting interest within the estates, but with little ancient woodland. Remnant ancient countryside with patchwork field system which has been sporadically rationalized, particularly towards the west. Sinuous lanes and mixed hedges, with sunken lanes a feature of the Cromer Ridge. Large number of small- to medium-size 18th century estates, with more parkland north of river Wensum and a notable parkland belt between the rivers Wensum and Bure. Dispersed villages and isolated farmhouses within complex minor road network. Red brick and flint with pantiled or pegtile roofs. Cohesive 17th and 18th century vernacular architecture. Denser settlement pattern south of river Wensum. Great density and stylistic variety of churches often associated with small villages or estates. Areas of heathland, especially along Cromer Ridge and in west, reflecting lighter soils north of river Wensum. Coastal holiday resorts of Cromer and Sheringham.

Table 13.1 The Countryside Agency Countryside Character Areas – National Level.

Countryside Character Area	Key Characteristics
North East Norfolk and Flegg 79	Great variety of texture and detail in coastal landscapes, including intertidal sand and mudflats, sand dunes, shingle banks, saltmarsh, reedbeds, tidal creeks and harbours. Wild, remote and open, with long sweeping views. Influence of sea: awareness of the dynamic nature of the marine landscape, its smells and sounds, the salt winds and seabirds and the effects of longshore drift. Lack of settlements and roads on the coastal marshes but distinctive flint villages strung along the coast road. North face of Cromer Ridge and coast road separate coastal strip from inland areas. Almost no transitional zones to areas of different landscape character, but great variety within.
Mid Norfolk 84	As for Central North Norfolk 78 above.

13.3.2.2 Local Landscape Resources and Character - North Norfolk District Council Landscape Character Assessment

Part E, Annex 1 of the current North Norfolk Local Plan includes a landscape character assessment of the county. The District has been divided into seven character areas, namely the:

- North Coast Levels,
- Cromer Ridge,
- Central Farmlands,
- Western Farmlands,
- Wensum Valley,
- Walsham Plain,
- Fenland Margins.

Within these areas a number of landscape types are defined. These are not geographically specific and are determined by the patterns of land use, vegetation and other land-cover elements that have strong influence on landscape character. The following landscape types are identified:

- fenland,
- marginal coastal farmlands,
- sand dunes,
- marshland,
- heathland,
- pastoral landscape,
- open arable farmland,
- enclosed farmland,
- parkland.

The Cromer Ridge and North Coast Levels are the main character areas which are of relevance to the project. Extracts from their descriptions are included in Table 13.2 below, and illustrated in Figure 13.8 below.

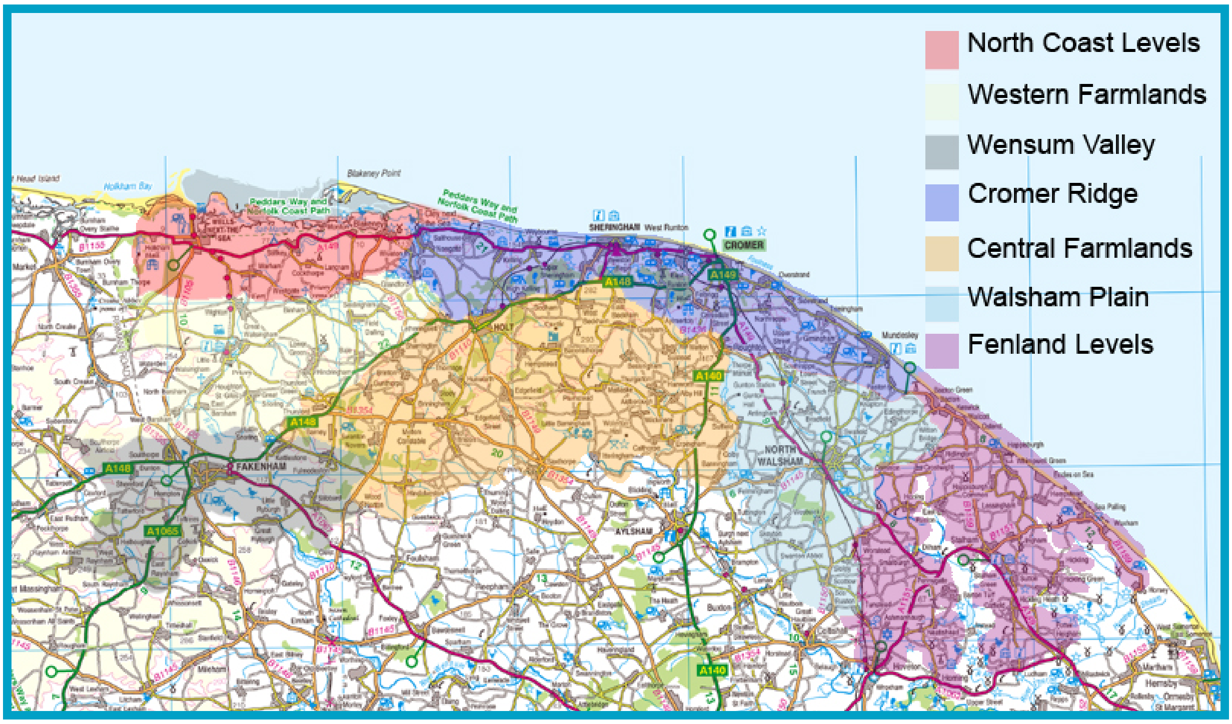


Figure 13.8 North Norfolk District Council Landscape Character Assessment (Source: NNDC)

13.3.2.3 Revised North Norfolk Landscape Character Assessment (Unpublished Draft)

The District Council is currently undertaking a new study to assess the character of the local landscape (Landscape Character Assessment for North Norfolk District Council Local Development Framework: Draft Version (NNDC, 2005)). This will be used to formulate policies to protect and enhance the landscape and to inform decisions about development site allocations, and may be used to prepare a Supplementary Planning Document in due course. The study is not yet publicly available, but some relevant extracts were provided by NNDC.

The study is being undertaken by NNDC staff in conjunction with the Norfolk Coast AONB Partnership, the Broads Authority and Norfolk Landscape Archaeology. The purpose of the study is to: provide an assessment of the differing landscape character areas in the District so that these can be taken into account when considering planning applications; inform a strategic policy on landscape protection in the Core Strategy of the Local Development Framework; inform decisions on individual site allocations in the Site Specific Proposals document; assist with decisions on applications for telecommunications masts, wind turbines etc; and inform decisions regarding countryside stewardship schemes, Conservation Area designations and enhancement schemes.The landscape types which are identified in the draft are shown on figure 13.9.

Table 13.2 North Norfolk District Council Character Areas – Local Level

Character Area	Key Characteristics
Cromer Ridge	'Between Cley-next-the-Sea and Mundesley the land rises into a distinctive ridge. This dominant physical feature is formed by a glacial terminal moraine, which rises up to form a line of impressive low cliffs along the coast. The irregular, hummocky landform is typical of such glacial features. The landscape is remarkably well-wooded, particularly from Cley-next-the-Sea to Cromer. Both deciduous and mixed woodland and coniferous plantations are found. Many of the woods are part of the 18th century parklands which are associated with established country houses and estates, such as Bayfield Hall, Sheringham Hall, and Felbrigg Hall. Large tracts of land were formerly heathland. This is reflected today in many of the place names, such as Salthouse Heath, Kelling Heath, Weybourne Heath and Roughton Heath. Areas of heathland are still found throughout this character area, with pasture on the poor soils being speckled with gorse and birch scrub, and woodland areas interspersed with considerable expanses of heath land vegetation. The flowering gorse is a particularly spectacular feature. However, much of this heathland has been brought into cultivation. The landscape is now dominated by a landscape type defined as enclosed farmland. Views across arable land, and locally occurring pasture, are contained by woodlands and by rises and falls in the landform. Medium or large fields are patterned with thorn hedges of the enclosures period, although some hedgerows are becoming thin and gappy. These landscapes have more visual interest than the expansive open arable farmland, which occurs, in this character area, around Mundesley, Southrepps and Trunch. Here, there are few woodlands, and hedgerows have largely disappeared. Slight rises in the landform afford long views over open arable farmland. Denuded hedge-banks indicate where Enclosures Act hedges once divided the fields and the skyline is broken by occasional isolated oak trees.'
North Coast Levels	'The North Coast Levels extend along the North Norfolk coastline from Holkham and Wells-next- the-Sea to east of Blakeney and Cley-next-the-Sea. Much of this area is designated as being of international and national importance for nature conservation. The most dominant landscape type is marshland. Freshwater marshes occur around Cley-next-the-Sea and Blakeney, but the greatest part of the marshland is salt-marsh. The landscape is exposed and open, with long views and huge skies across level grasses and reedbeds. The mud-flats are divided by sinuous creeks and pools which form the rich, undisturbed feeding grounds for birds. These marshes have formed behind a shingle bank, a prominent coastal feature which runs from Weybourne to Blakeney Point. Continuously ebbing and flowing tides dramatically and repeatedly change the appearance of this landscape. Around Holkham and Wells-next-the-Sea, the sculptural forms of sand dunes rise up from Holkham Bay. The coniferous woodlands, planted behind the dunes by Lord Coke, form a distinctive landscape feature, and have created a valuable wildlife habitat which is managed as a nature reserve. Across these flat expanses of marginal coastal farmland, poor grazing land separates the dunes from rising ground further inland. Vegetation is sparse and pastures are divided by ditches and dikes which are important components of the local landscape character. A pattern of open fields, predominantly pasture with some arable, has formed between the villages. Hedgerows are sparse, and field boundaries are mostly fenced. Heathland vegetation is common on locally steep slopes and along field boundaries. The landform rises gently to the south, to form the low ridge beyond which the landscape character changes as the sea disappears from view.'

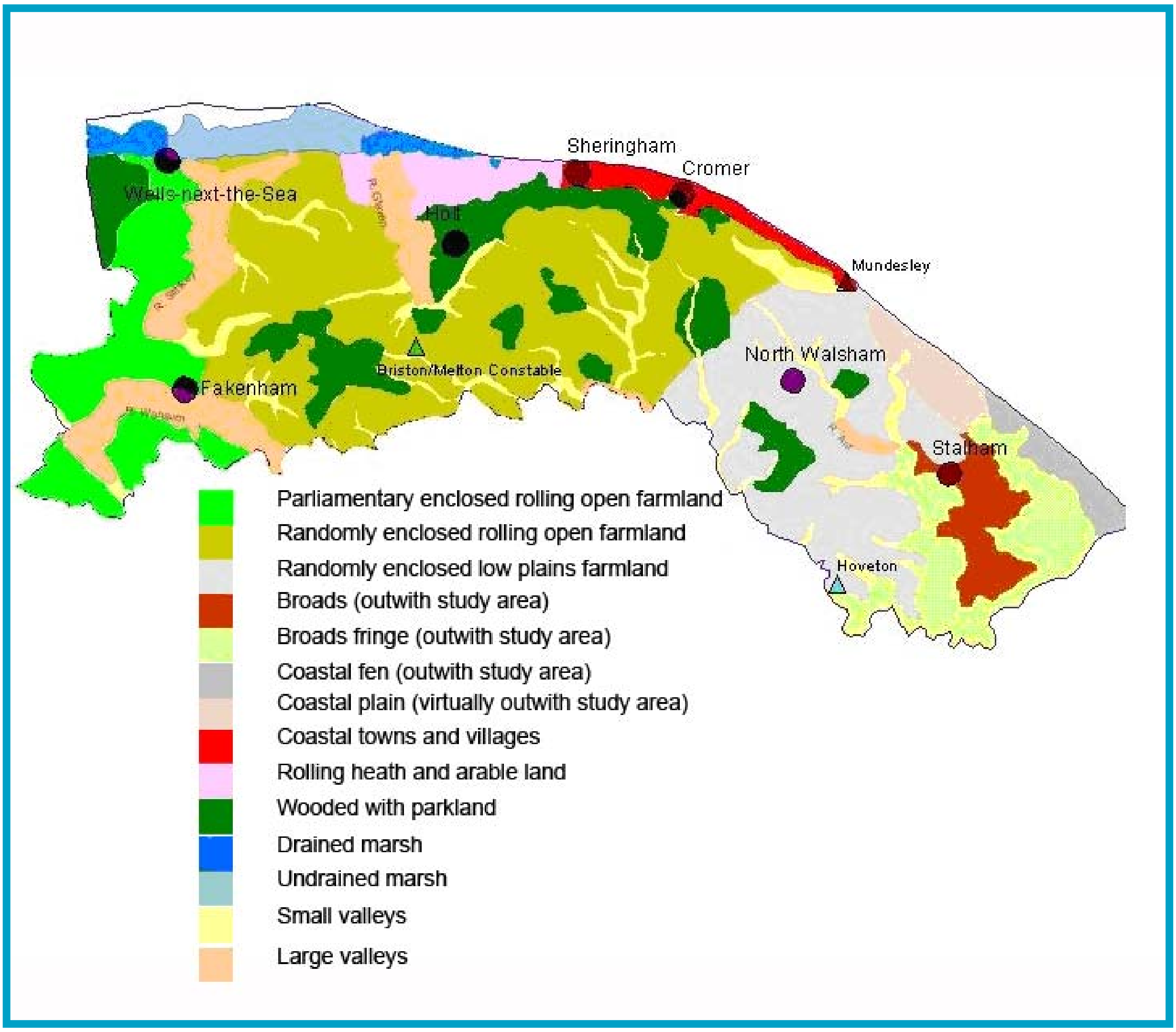


Figure 13.9: Landscape Character Assessment of the North Norfolk District (Draft) (Source: NNDC)

For each landscape type the key characteristics are described, a description of the landscape character and an analysis of the condition and strengths/weaknesses/opportunities and threats, are provided, and a sensitivity grade is given.

The document includes a small amount of guidance on wind farm development, but this all relates to land based development, and is largely discussed for landscape types where there are existing onshore wind farms. Key issues are the potential intrusion of turbines (and associated lighting) into rural skylines, the detraction from ‘wilderness’ qualities in undeveloped landscapes (marsh, fen), issues of appropriate siting, scale, design and colour. It is understood that as the document evolves, further information and guidance will be provided on wind development in the region.

The document does not include ‘seascape’ areas as such, but the relationship between land and the adjacent coast and sea areas is very much considered to be part of the landscape character. It is understood that an accompanying seascape assessment may be developed in the future. Relevant extracts for the most relevant types (i.e. those found closest to the proposed wind farm) are provided in Table 13.3 below.

Table 13.3: NNDC Landscape Types/Condition/Sensitivity

Landscape Type	Condition	Sensitivity	Relevant Extracts of Notes and Guidance
Coastal towns and villages	Good to poor (coastal landscape)	High to medium (coastal landscape)	Views out towards the sea are a feature. Caravan parks are prevalent along cliff tops, which impinge upon views. Views available over this type from a number of vantage points such as Beeston 'Bump'. No guidance on wind development.
Rolling heath and arable land	Good (skyline)	High (skyline)	Slopes and hills provide long sea and landward views. Masts etc punctuate views. 'Siting of wind turbines in this type could be detrimental to the character of this type and those adjacent.' 'Avoid developments which impinge upon open skyline views.'
Drained marsh	Good (skyline)	High (skyline)	Views constrained north and south by rising land / banks or sea walls. Windmill at Cley. 'Man made structures can have disproportionate effects on the 'wildness' of the landscape.' 'Avoid developments which impinge upon open skyline views.'
Undrained marsh and sand spits	Good	High	Sea walls form significant features ending the type and breaking views of the horizon. 'Man made structures can have disproportionate effects on the 'wildness' of the landscape.' 'Avoid developments which impinge upon open skyline views.'

13.3.3 Description of Existing Seascape Resources and Character Areas

13.3.3.1 National Seascape Resources and Character – National Seascape Units

In order to combat the often adverse effects that the ad hoc coastal management practices were having on neighbouring shorelines, MAFF (now Defra) commissioned research to determine a more appropriate approach to implementing flood and coastal defence. This research suggested that the coastline could be divided into major sediment cells. A sediment cell is a length of coastline that is relatively self-contained, as far as the movement of sand and shingle is concerned, and where interruptions to such movements should not have a significant effect on adjacent sediment cells. The boundaries of the sediment cells generally coincide with the mouths of major estuaries or prominent coastal headlands, and are used as a basis to define National Seascape Units for this assessment.There are 11 major sediment cells around the coast of Wales and England. The site is located in The Wash National Seascape Unit as identified on figure 13.10.

Figure 13.10 National Seascape Units (Source: Seascape and Visual Impact Assessment Guidance for Offshore Wind Farm Developers in England and Wales)

13.3.3.2 Local Seascape Units

The following Seascape Units (see figure 13.10) were identified in the seascape and visual assessment which was undertaken for Cromer Offshore Wind Farm (2002), which is the nearest wind farm to the site at Sheringham Shoal (source: Cromer Offshore Wind Farm Environmental Statement (2002), Posford Haskoning). These units are also appropriate to this study as the section of coast which would be affected is similar. In order that the 35km radius from the site is covered, the identification of seascape units has been extended to the west, to the western tip of Scolt Head Island. Seascape Units south of Mundesley, ie the Stalham Levels, are outwith the scope of this assessment. Seascape units can be deemed to extend to the limit of visual significance out to sea and onto the land. The extent on land is represented by the extent of visibility within the 35km ZVI (see Figure 13.15 and Figure 13.17 in Appendix 13.1). At sea, the seascape units are taken to extend for 35km out to sea from the coast, with the boundaries between them being perpendicular to the coast.

Large ships pass by all sections of the coast periodically, and there are oil rigs located offshore which are visible when conditions are clear. These man made objects on the distant horizon act as both transitory and more permanent points of interest in views from the shore. Scroby Sands Offshore Wind Farm has already been built east of the coast to the south east, about 60km away, but there are no other existing offshore wind farms in the area at present.

Figure 13.11 Seascape Units (Source Cromer Offshore Wind Farm ES, 2002)

Table 13.4 Seascape Units Identified for Cromer Offshore Wind Farm.

Seascape Unit	Extent and Key Characteristics
North Coast Levels	Blakeney to Burnham Overy Staithe and westwards. Low coastline of extensive salt marshes and broad sandy beaches. Landward component extends inland over gently rolling landscape, with limited intervisibility between the land and the sea. Dynamic coastline, changing with the state of the tide. Panoramic views available out to sea from the coastline. Absence of development or any visually intrusive elements, creating a harmonious and unified seascape unit. Designated as AONB and Heritage Coast.
Salthouse Coastline	Blakeney eastwards towards Weybourne. A relatively confined unit laterally, of about 8km width. Distinctive man made shingle ridge, which prevents views from the marshes behind it towards the sea, and protects the hinterland from the sea. Marshes extend inland beyond the shingle ridge. Straight coastline, with a steeply shelving shingle beach. Panoramic views available from north facing slopes behind Cley-next-the-Sea and Salthouse, contrasting the absence of views from the marshes. Absence of development or any visually intrusive elements, creating a harmonious and unified seascape unit. Designated as AONB and Heritage Coast.

Table 13.4 Seascape Units Identified for Cromer Offshore Wind Farm.

Seascape Unit	Extent and Key Characteristics
Cromer and Sheringham Ridge	Weybourne to beyond Cromer, a distance of about 12-13km. Gently convex shoreline. Crumbing cliff coastline, subject to erosion and encroachment by the sea. Foreshore of shingle to the west and sand to the east, with gently shelving beaches. Distinctive low hills and cliffs afford panoramic views across the sea, with views screened in places by development. Woodland on the Cromer ridgeline forms the southern boundary of the seascape unit. Significant development along the coastal strip, including Sheringham and Cromer, plus caravan and camping sites and cliff top car parks, which act as detractors, resulting in a less harmonious character. Designated as AONB, except built up areas of Sheringham and Cromer, whose quality is reduced by the proliferation of tourist infrastructure.
Eastern Plateau	Overstrand to Mundesley, about 9-10km. Crumbling cliff line, rising to about 40-50m, with gently convex alignment. Broad sand and shingle foreshore at low tide, with groynes and sea defences. Hinterland extends over a gently rolling landscape, which is more open that further west, is crossed by lanes and connects scattered villages. Views out to sea are confined to locations in close proximity to the cliff top. Intervisibility between this seascape unit and adjacent units is strong. Intimate plateau villages, but the immediate coastal fringe has a neglected quality with nondescript buildings being the main detractor. Northern part designated as AONB, except Mundesley.

These seascape units broadly (but not precisely) match up with the boundaries and scale of the Countryside Character Areas at the coast, and reflect the change in the underlying solid geology of the area, between chalk to the west and clay to the east, which is a strong determinate of both the landform, and the nature of the coast line.

Table 13.5 Countryside Character Areas and adjacent Seascape Units

Countryside Character Areas	Adjacent Seascape Units (approximate coincidence)
North Norfolk Coast 77 and North West Norfolk 76 (inland)	North Coast Levels and Salthouse Coastline
Central North Norfolk 78 and Mid Norfolk 84 (inland)	Cromer and Sheringham Ridge
North East Norfolk and Flegg 79	Eastern Plateau

13.3.3.3 Summary of Landscape and Seascape Character Unit Value, Quality, Sensitivity and Capacity

*Table 13.6 Condition, Quality, Sensitivity and Capacity * of Landscape Units*

Countryside Character Area	Relevant Local Character Area/ Type (approx)	Value	Quality/ Condition	Sensitivity to Change	Capacity to Accept Change*
North Norfolk Coast 77	North Coast Levels Undrained marsh and sand pits/ Drained marsh	High (AONB)	High	High (open, wild, remote landscape)	Low
North West Norfolk 76 (inland)	Western Farmlands Parliamentary enclosed rolling farmland/ Woodland with parkland/ Large valleys	High (northern part is AONB)	High	Medium (more robust landscape	Moderate (away from coastal influences)
Central North Norfolk 78	Cromer Ridge Coastal towns and villages/ Rolling heath and arable land/ Large valleys/ Small valleys	High (northern part is AONB, except built up areas)	High (lower around the periphery of towns)	Medium (well wooded landscape)	Moderate (away from coastal influences)
Mid Norfolk 84 (inland)	Central Farmlands/ Wensum Valley Randomly enclosed rolling farmland/ Small valleys	High (northern part is AONB)	High	Medium (well wooded landscape)	Low (away from coast, and screened by woodland)
North East Norfolk and Flegg 79	Walsham Plain Randomly enclosed low plains farmland/ Coastal plain	High (northern part is AONB, except built up areas)	High	Low (oblique angle from proposed development)	Low (oblique angle from proposed development, and only very short section of coastal strip within ZVI)

- (Note): *Capacity* relates to changes which take place within the Countryside Character Areas, and not to the offshore developments outside these areas and a long distance away. This note applies to Table 13.6 and Table 13.7.

Table 13.7 Condition, Quality, Sensitivity and Capacity * of Seascape Units

National Seascape Unit	Local Seascape Unit	Value	Quality/ Condition	Sensitivity to Change	Capacity to Accept Change*
The Wash	North Coast Levels	High (AONB)	High	High (open, wild, remote coastline), but limited visibility between land and sea	Low
	Salthouse Coastline	High (AONB)	High	High at coastal edge (open, wild, remote coastline). Limited visibility between inland and sea	Low
	Cromer and Sheringham Ridge	High (AONB, except built up areas)	High	Medium (coastline more developed, cliffs allow panoramic vistas over seascape). High visibility between land and sea in places	Moderate (coastline more developed, but closest coast to site)
	Eastern Plateau	High (western part AONB, except built up areas)	High	Medium (coastline more developed, cliffs allow panoramic vistas over seascape). High visibility between land and sea in places, but at an acute angle	Moderate (coastline more developed)

* (Note): *Capacity* relates to changes which take place within the Countryside Character Areas, and not to the offshore developments outside these areas and a long distance away.

13.3.4 Description of Existing Visual Environment and Key Viewer Groups

13.3.4.1 Visibility

The study area is within the Thames Shipping Forecast area, and the closest Inshore Water Area is The Wash (see Figure 13.12). The Met Office issues a Shipping Forecast, on behalf of the Maritime and Coastguard Agency every day. The part of the forecast that is of relevance here is the visibility data, which is given as 'dense fog, fog, poor, moderate or good'. Figure 13.13 indicates the visibility records for years 1999-2003. The X axis is the percentage of time that visibility reaches the distance in kilometres shown on the Y axis. The north coast of Norfolk is characterised by in the order of 63% of the time (230 days per year) when visibility was greater than 15km or more. For 52% of the time (190 days) the visibility was less than 20km, and for 37% of the time (135 days) it was less than 15km. Using these figures, the location of the wind farm 17-22km from the nearest section of shore means that for in the order of 43% of the time, i.e. on approximately 157 days of every year, it would not be visible from any part of the coastline. For viewpoints further than 17km away, the number of days when visibility of the wind farm would be available would reduce further with increasing distance from the site. The turbines extend to 22km from the shore so there would be some days when only the closer rows of turbines are visible, i.e. when visibility is part way between 17 and 22km.

Figure 13.12 Shipping Areas and Inshore Water Areas (Source: Met Office) http://www.bbc.co.uk/weather/coast/shipping)
For further detail contact http://www.met-office.gov.uk/corporate/contact/contact.html

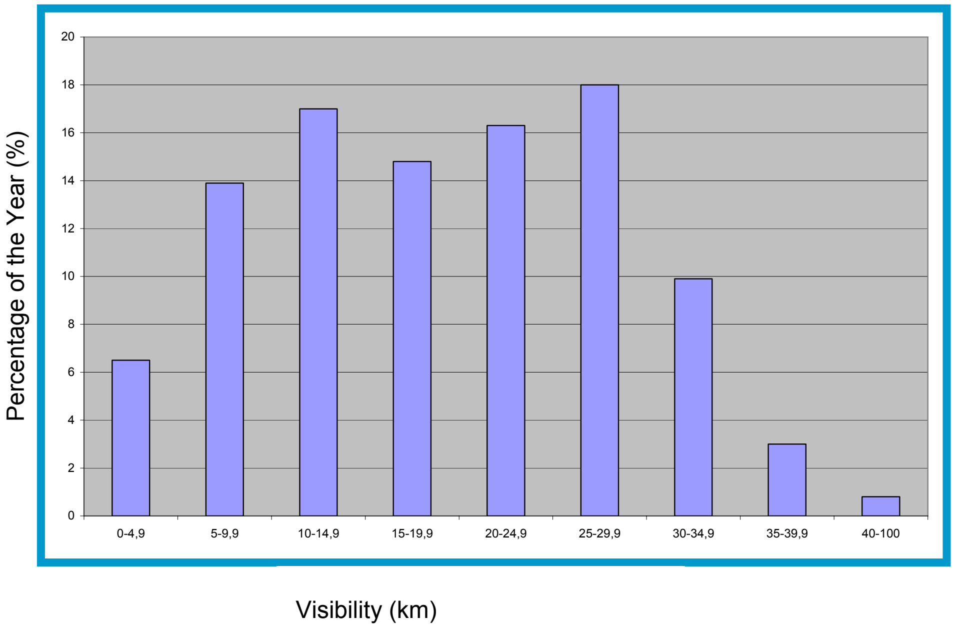


Figure 13.13 Met Office Visibility Data for 1999-2003 (Source: Met. Office, via Scira)

13.3.4.2 Visual Receptors

Visual receptors were selected to be representative of the both the land, the coastline and the sea areas within the 35km radius study area, reflecting places, and routes frequented by the public, including the ferry route from Hoek van Holland to Hull. The selected viewpoints were chosen through field work and a study of maps, in consultation with interested statutory authorities, to represent key locations where the public, and where large groups, or smaller numbers of highly sensitive viewers congregate or pass through. The coastline has a high recreational value, reflected by its designation as an AONB, and as a result there are numerous coastal cliff top or beachside car parks, viewpoints from low hills which are popular for recreational walks, as well as seaside promenades and piers in the coastal towns. There are hotels, guesthouses and campsites in many locations along the coast, and a busy coastal road which connects a number of towns and small villages. Many of the people in the area are there to appreciate its scenic quality and are drawn by the presence of the attractive range of accommodation, seaside beaches and marshes, as well as the availability of places from which to partake in boating and water sports.

People are of varying sensitivity to change, but in general residential and some recreational viewers (walkers moving slowly through the landscape) are considered to be of highest sensitivity, and travellers and workers are considered to be of lower sensitivity. The fact that this is a recreational area means that many of the viewers will be of high sensitivity to change.

The attitude to and perception of renewable energy will also vary from person to person (see Section 11, page 94, Public Perception Before and After Studies from Assessing Significance of Guidance on the Assessment of the Impact of Offshore Wind Farms: Seascape and Visual Impact Report (Draft 2005), Enviros Consulting Ltd, for the DTI. Wind turbines out at sea may be considered dramatic sculptural features by some, but others will dislike the effects on the skyline, and the presence of new man made objects within the sea.

The East of England Tourist Board advises that although the visual perception of a wind farm is highly subjective, its setting is a key factor in relation to its impact on tourism. For example, a wind farm offshore from a well-developed seaside resort would potentially add interest to the beach experience, while the same development off a wild, undeveloped coastline may be significantly detrimental.

Much of the appeal of the north Norfolk coast is based on its wild, remote and ‘unspoilt’ feel, therefore the potential impact on its attractiveness depends on the visibility of the turbines along the coast. It is anticipated that the wind farm would be more acceptable at developed locations such as Sheringham, and more intrusive along the undeveloped areas of the AONB.

Recent surveys have demonstrated that onshore and offshore wind farms have no detrimental effect on tourism. In 2004, Greenpeace commissioned a survey of visitors for the Scarweather Sands wind farm proposal off Porthcawl, (Greenpeace, 2004). Of the 650 tourists visiting Porthcawl who were asked whether the proposed wind farm would make them more or less likely to return, 83% of the respondents said it would make no difference, 13% said more likely and just 4% less likely. This is reinforced by a MORI survey of visitors conducted in Argyll in Scotland in 2002. The survey found that 91% of the respondents said the presence of wind farms would make no difference to their decision to visit the area again (Sustainable Development Commission, 2005).

Surveys like those discussed above need to be considered with caution, as sampling techniques can weight views, but they do demonstrate the generally mixed nature of responses to the visual impacts resulting from wind farms.

Figure 13.14 Locations of viewpoints

13.3.4.3 Selected Viewpoints

The following viewpoints were selected to represent the impacts upon viewers across the area. The locations of each of the viewpoints are shown on

Figure 13.14 and photographs of the existing view from each location are included in Figure 13.20 to Figure 13.33 in Appendix 13.2).

Remark: Please note that the figures mentioned in the table below consist of several subfigures indicated as Fig.13.20a, Fig.13.20b, etc) See appendix 13.2.

Table 13.8 Selected Viewpoints

Viewpoint	Grid Ref	Description	Receptor	Sensitivity (no. of people)	Visualisation
Cromer Pier Viewpoint 1 Figure 13.20	219 423 Elevation 10m	Landward end of pier	Recreation and shoppers	High (Large)	Cumulative photomontage and photomontage Full view
Wells–Next-The-Sea, Harbour Railway Viewpoint 2 Figure 13.21	915 440 Elevation 5.7m	Location on embankment near the station	Recreation and shoppers	High (Large)	Cumulative photomontage and photomontage Full view
Beeston Hill Viewpoint 3 Figure 13.22	168 433 Elevation 62.5m	Seat and trig point on hill top	Recreation	High (Moderate)	Photomontage, full view, elevated viewpoint
Viewpoint in Oak Wood, Sheringham Hall, National Trust Viewpoint 4 Figure 13.23	133 424 Elevation (viewing platform) 95 (ground level 70m)	Viewpoint above Sheringham Hall in Oak Wood – elevated platform	Recreation	High (Moderate)	Cumulative photomontage and Photomontage Full view, elevated viewpoint
Cley Marshes Nature Reserve, car park (Cley next the Sea) Viewpoint 5 Figure 13.24	048 453 Elevation 6.5m	Top of shingle bank above car park north of Cley	Recreation	High (Moderate)	Photomontage Full view
Overstrand, car park (the Paston Way) Viewpoint 6 Figure 13.25	248 411 Elevation 25.2m	Cliff top car park	Recreation	High (Moderate)	Wireline Full view

Table 13.8 Selected Viewpoints

Viewpoint	Grid Ref	Description	Receptor	Sensitivity (no. of people)	Visualisation
Incleborough Hill Viewpoint 7 Figure 13.26	188 424 Elevation 69.6m	Seat on top of hill	Recreation	High (Moderate)	Wireline Full view, elevated viewpoint
Sheringham, Peddars Way Viewpoint 8 Figure 13.27	159 435 Approx elevation 10m	Peddars Way Coast Path, on seafront	Recreation, residents, shoppers	High (Large)	Wireline Full view
Sheringham Coast Watch – hut Viewpoint 9 Figure 13.28	149 435 Elevation 46m	Cliff top location from coast watch hut	Recreation, workers in hut	Medium (Moderate)	Wireline Full view, elevated viewpoint
Weybourne, Peddars Way, on shingle beach Viewpoint 10 Figure 13.29	110 437 Elevation 6.5m	View from top of shingle beach	Recreation	High (Moderate)	Wireline Full view
Holgate Hill, south west of Weybourne Viewpoint 11 Figure 13.30	105 420 Elevation 52.2m	Footpath just to south of road where the road emerges from the trees and a clear view is available	Road users, recreation	Medium (Moderate)	Wireline Partial view, elevated viewpoint
A148, cross roads near Bale Viewpoint 12 Figure 13.31	998 345 Elevation 87.6m	Location where there is a clear view from the road between hedgerows etc across fields	Farmers, road users	Medium (Moderate)	Wireline No view, elevated viewpoint
Blakeney, car park Viewpoint 13 Figure 13.32	028 442 Elevation 4.5m	Car park on north side of village	Residents, recreation	High (Large)	Wireline Clear view

Table 13.8 Selected Viewpoints

Viewpoint	Grid Ref	Description	Receptor	Sensitivity (no. of people)	Visualisation
Morston – car park near ferry Viewpoint 14 Figure 13.33	007 442 Elevation 5.9m	National Trust car park and marina	Recreation	High (Moderate)	Wireline Clear view
Stiffkey Salt Marshes, car park on marshes, near campsite Viewpoint 15 Figure 13.34	965 439 Elevation 5.5m	Car park by marshes, Green Way	Recreation	High (Moderate)	Wireline Clear view
A149 St Withburga Church, Holkham Hall Viewpoint 16 Figure 13.35	878 439 Elevation 15.7m	View from road in front of St Withburga Church	Road users	Medium (Moderate)	Wireline Partial view
Beeston Regis Heath (Stone Hill) Viewpoint 17	170 418 Elevation 91.5m	Seat at view point on top of hill	Recreation	Medium (Few)	Clear view, elevated viewpoint
Dead Man's Hill, Peddars Way Viewpoint 18	124 437 Elevation 21.6m	View from Dead Man's Hill on Peddars Way	Recreation	Medium (Moderate)	Clear view, elevated viewpoint
Muckleburgh Hill Viewpoint 19	104 433 Elevation 27m (summit 68m)	Corner of road near museum, north east of Muckleburgh Hill summit	Recreation, users of army base	Medium (Moderate)	Clear view, elevated viewpoint. Views represented by that from Holgate Hill
Holt, church Viewpoint 20	081 388 Elevation 65.5m	Open ground around church	Residents	High (Large)	No view due to intervening buildings and trees, elevated viewpoint

Table 13.8 Selected Viewpoints					
Viewpoint	Grid Ref	Description	Receptor	Sensitivity (no. of people)	Visualisation
West Beckham – mast at Camp Farm road junction Viewpoint 21	139 388 Elevation 95.2m	View from junction over fields, representing view from hinterland	Road users and farmers	Low (Few)	No view due to woodland, elevated viewpoint
A148 Viewpoint 22	044 380 Elevation 53.9m	View from cross roads across fields	Road users	Medium (Moderate)	No view, elevated viewpoint
Holkham Park (hall) Viewpoint 23	884 429 Elevation: 11.5m	View from front of hall	Recreation	High (Moderate)	No view because of trees
Beacon Hill Road Viewpoint 24	834 409 Elevation 52.1m	View from minor road above Burnham Market	Residents	High (Large)	No view as trees on horizon, elevated viewpoint
Gibraltar Point Viewpoint, National Nature Reserve Viewpoint 24	564 584	South of Skegness	Recreation	High (Moderate)	No view as very long distance (>35km)
Passenger Ferry Viewpoint 25 Figure 13.36	Elevation: sea level +20m	Nearest points to proposed wind farm	Travellers	Medium (Moderate)	Screen shot-animation

Note: All figures referred to in Table 13.8 can be found in Appendix 13.2.

13.3.4.4 Viewing angles and distances for photomontages / wirelines

Table 13.9 shows per viewpoint the viewing angles and distances for the corresponding photo montages and wirelines. The viewing angle reflects the part of the total (360 degrees) view that can be seen on the picture. The viewing distance shows the recommended spacing between the visual and the viewer's eyes needed to get a realsitic picture of the wind farm in its surroundings.

Table 13.9 Viewing Angles and Distances

Viewpoint / Grid Ref	Description of Viewpoint	Figure number	Viewing Angle (horizontal)	Recommended viewing distance (cm), based on A3 sheet
Cromer Pier 19km Viewpoint 1 219 423 Elevation 10m	Landward end of pier	Fig 13.20 Fig 13.40 (cumulative)	68 122 (total), 68 per page	28 28
Wells–Next-The-Sea, Harbour Railway 25km Viewpoint 2 915 440 Elevation 5.7m	Location on embankment near the station	Fig 13.21 Fig 13.41 (cumulative)	67 96 (total), 54 per page	29 38
Beeston Hill 17km Viewpoint 3 168 433 Elevation 62.5m	Seat and trig point on hill top	Fig 13.22	68	28
Viewpoint in Oak Wood, Sheringham Hall, National Trust 19km Viewpoint 4 133 424 Elevation (viewing platform) 95 (ground level 70m)	Viewpoint above Sheringham Hall in Oak Wood – elevated platform	Fig 13.23 Fig 13.42 (cumulative)	68 149 (total), 74 per page	28 25
Cley Marshes Nature Reserve, car park (Cley next the Sea) 18km Viewpoint 5 048 453 Elevation 6.5m	Top of shingle bank above car park on coast north of Cley next the Sea	Fig 13.24	60	33
Overstrand, car park (the Paston Way) 21km Viewpoint 6 248 411 Elevation 25.2m	Cliff top car park	Fig 13.25	68	28

Table 13.9 Viewing Angles and Distances

Viewpoint / Grid Ref	Description of Viewpoint	Figure number	Viewing Angle (horizontal)	Recommended viewing distance (cm), based on A3 sheet
Incleborough Hill 18.5km Viewpoint 7 188 424 Elevation 69.6m	Seat on top of hill	Fig 13.26	68	28
Sheringham, Peddars Way 17km Viewpoint 8 159 435 Approx elevation 10m	Peddars Way Coast Path, on seafront	Fig 13.27	67	29
Sheringham Coast Watch –hut 17km Viewpoint 9 149 435 Elevation 46m	Cliff top location from coast watch hut	Fig 13.28	67	29
Weybourne, Peddars Way, on shingle beach 17km Viewpoint 10 110 437 Elevation 6.5m	View from top of shingle beach	Fig 13.29	69	28
Holgate Hill, south west of Weybourne 19km Viewpoint 11 105 420 Elevation 52.2m	Footpath just to south of road where the road emerges from the trees and a clear view is available	Fig 13.30	67	29
A148, cross roads near Bale 27.5km Viewpoint 12 998 345 Elevation 87.6m	Location where there is a clear view from the road over fields between hedges	Fig 13.31	68	28
Blakeney, car park 19.5km Viewpoint 13 028 442 Elevation 4.5m	Car park on north side of village	Fig 13.32	84	21

Table 13.9 Viewing Angles and Distances

Viewpoint / Grid Ref	Description of Viewpoint	Figure number	Viewing Angle (horizontal)	Recommended viewing distance (cm), based on A3 sheet
Morston – car park near ferry 21km Viewpoint 14 007 442 Elevation 5.9m	National Trust car park and marina	Fig 13.33	67	29
Stiffkey Salt Marshes, car park on marshes, near campsite 22km Viewpoint 15 965 439 Elevation 5.5m	Car park by marshes, Green Way	Fig 13.34	68	28
A149 St Withburga Church, Holkham Hall 27.5km Viewpoint 16 878 439 Elevation 15.7m	View from road in front of St Withburga Church	Fig 13.35	65	30
Passenger Ferry to Hull 5km at nearest point Viewpoint 26 Elevation: sea level +20m	Nearest points to proposed wind farm	Fig 13.36	35	60

Note: All figures referred to in Table 13.9 can be found in Appendix 13.2.

13.4 Impacts During Construction

13.4.1 Introduction

A description of the construction programme and activities is given in Section **2**. Key sources of landscape, seascape and visual impacts during the construction phase include:

- presence and movement of sea based construction equipment, including boats and jack up barges;
- lighting during hours of construction, and at night if the works site is to be lit during hours of darkness;
- excavations into the sea bed in order to construct the foundations, and any associated
- visible pollution (silt) created by this activity; and
- the construction of the cable route from the wind farm to the land.

During this time there would be potential for:

- direct impacts on the seascape as a result of construction at the wind farm site and cable route;
- indirect impacts on the seascape as a result of the presence of construction activities in adjacent seascapes; and
- impacts on visual amenity as a result of the presence of sea based construction activities in views.

Land based construction activities and impacts are described in Section **25**.

These potential impacts are described below.

13.4.2 Potential Impacts on Landscape and Seascape Resources and Character, Visual Amenity and Views During Construction

Construction activities may alter the landscape and seascape resources and character of the site of the wind farm at sea and the surrounding areas from which views of the construction activities may potentially be seen, including areas out at sea, as identified by the 35km radius ZVI map (Figure 13.15, to Figure 13.18 in Appendix 13.1). These ZVI maps identify the extent of visibility for the completed site, but it is likely that the extent of visibility for the site during construction would be very similar. This extent is therefore described in some detail below.

As stated in Section 2 of this ES, there are various alternatives in terms of size of layout, varying from a smaller number of wider spaced larger turbines to a larger number of more closely spaced smaller turbines which are still under consideration. ZVIs have therefore been generated for each extreme and are presented in Figure 13.15, to Figure 13.18 in Appendix 13.1.

The ZVIs take no account of localised screening by vegetation or buildings, or minor topographical variations, such as where a road or railway passes through a localised cutting. The ZVI is therefore a maximum worst case scenario, as many localised views would be screened, in this instance by woodland along the ridge of higher ground which lies to the south of Sheringham (the Cromer Ridge, between Cley-next-the-Sea and Cromer). Woodland along here includes Hundred Acre Wood, Weybourne Wood, Sheringham Wood and Great Wood.

Roads and farmland within the area are typically hedge lined and these characteristic bushy hedgerows, together with associated hedgerow trees and other copses of trees provide localised screening. This assessment was undertaken during the summer months and the visualisations included represent summer views, with trees in full leaf (see 13.20 to Figure 13.32 in Appendix 13.2). It must be noted however, that in winter time when there are no leaves on deciduous vegetation, screening would be reduced, and the extent of views would be closer to that indicated by the ZVIs shown (see Figure 13.15 to Figure 13.18 in Appendix 13.1).

The ZVI for the tallest turbines (7MW) presents the worst case scenario, and the extent of this is described below. The ZVIs for the smaller and more closely spaced turbines are very similar to those for the larger turbines along the coast, but the areas of potential visibility of the smaller turbines are reduced in extent further inland, as seen when comparing Figure 13.15 to Figure 13.18 in Appendix 13.1. As actual views on the ground from the hinterland are very frequently screened by vegetation and/or buildings, the true differences between the two ZVIs are slight.

It is a matter of personal opinion whether a larger number of more closely spaced but overall shorter turbines is better or worse than a smaller number of more spread out, but overall taller and larger turbines. This factor would be relevant during construction, as if more turbines are to be installed it is likely that the overall construction process may take longer, or a greater construction workforce and quantity of equipment may be required over a shorter duration of time. Conversely the larger turbines may take longer to construct per item. The details for the construction period are not fully defined and may take place two seasons in the worst case (see Section **2**). The ZVIs indicate almost continuous visibility along the length of the coastline and from 2-3km inland between Brancaster Staithe and Overstrand. The extent of visibility is variable along the coast and is dictated by local variations in topography, with clear views being available from north facing slopes, with south facing slopes being screened by the landform. Highpoints along the coast afford particularly clear views, but also screen areas of land to the south of them. These include locations such as Incleborough Hill, Beeston Hill, east of Sheringham, Skelding Hill (Sheringham Coast Watch Lookout Station). Clear views would only be available when the atmospheric visibility is sufficiently good in order to be able to see the wind farm.

East of Overstrand and up to Bacton, potential visibility is confined to a narrower coastal strip and is patchy in places, being screened by the topography from the west. The coast curves to a east south east orientation here and views of the wind farm would be more oblique.

Generally speaking, there is greater potential for views from the western part of the study area than from the east, as the eastern portion is screened by a north east to south west orientated band of rolling farmland which runs between Briston and Baconsthorpe. To the south and east of this ridge of higher land there is no potential for views.

There is a ridge of higher land which runs between Hindringham, Gunthorpe and Briston in a north north west to east south easterly direction, and this screens potential views from south of here, with the exception of from some higher land around Fakenham.

A further band of higher ground runs between Holkham/Wells-next-the Sea/ Warham St Mary and Warham All Saints, in an east south easterly direction, through Great Walsinghan to Houghton St Giles and Great Snoring. This screens land between North Creake, West Barsham and East Barsham from potential views.

Further west, another area of high ground which runs from Brancaster Staithe and west of Burnham Market limits views from the west, and beyond the modelled 35km radius ZVI.

Visibility from the sea, as experienced by recreational sailors and workers on commercial ships, or on oil platforms will have uninterrupted views of the wind farm. Atmospheric visibility and the distance from the site will affect the clarity of views. Recreational sailors will generally sail close to the coast, and their views to the coast will remain the same. Workers in commercial ships out at sea will be of lower sensitivity to change.

13.4.2.1 Proposed Construction Mitigation Measures

There are a few mitigation measures which can be implemented during construction which would help reduce impacts upon the landscape/ seascape and on views. There is limited need for extensive mitigation measures, as the fact that the wind farm would be constructed 17-22km from the nearest land area in a location in the country where haze and fog do obscure distant views for at least part of the time. The temporary nature of construction related impacts would limit their significance. + limited visibility due to “bad” weather Best practice measures (see Sections **2** and **7**) would be used to reduce the extent of any visible pollution or discolouration of the sea during the works which would be required to install the wind turbines in the seabed.

13.4.2.2 Residual Effects on the Landscape and Seascape

The construction activities detailed in Section **2** would have a temporary negative impact on the landscape and seascape in all character areas within view of the site which are not screened by intervening vegetation or buildings (see ZVI Figure 13.15 to 13.18 in Appendix 13.1). Direct impacts would only affect the wind farm site itself, and the cable route to the land. Surrounding areas may experience indirect effects as a result of changes in their landscape/ seascape setting. The significance of the indirect impacts would be greatest in those areas that are closest to the site which are of highest sensitivity to change (eg the less developed open, treeless rural areas which are perceived to have semi-wild undeveloped characteristics, such as the marshes), and in specific places where there is clear intervisibility between the site and adjacent landscape and seascape character areas (eg places like Sheringham which are at the interface of the land and the sea, and which would therefore be most affected by changes at sea).

The bulk of the works (i.e. the construction of the wind farm itself) would be carried out 17-22km from the shore and therefore the residual short term effects associated with construction should be reasonably accommodated and are therefore assessed as of generally **minor** significance.

13.4.2.3 Residual Effects on Views

It would be possible to see views of construction boats, jack up barges and machinery from all areas included within the ZVI (*Figure 13.15, Figure 13.16, Figure 13.17 and Figure 13.18* in Appendix 13.1) which are not screened by intervening vegetation or buildings.

The construction activities at sea would therefore have temporary, negative effects on the viewing experience of all the viewer groups identified in Table 13.8 particularly those living and working on the coast nearest to the wind farm. Residents, as the most sensitive receptors, would experience the most significant effects, including residents who live on the seafront at Sheringham. Effects in this location are assessed as being of up to short term **moderate** significance at the worst case. Elsewhere effects would be less significant. The works would be visible when the atmospheric visibility exceeds 17km (see Figure 13.13) which is estimated to be approximately 57% of the time.

13.5 Impacts During Operation

13.5.1 Introduction

The permanent features of the sea based components of the development including the turbines, offshore substation(s) and a meteorological mast which may:

- displace existing seascape resources;
- create new seascape resources;
- affect the landscape and seascape character of surrounding areas; and
- intrude into views.

This would result in a change in the landscape/ seascape character and the amenity of viewer groups. The assessment is informed by the mapped ZVI (see Figure 13.15 to Figure 13.18 in Appendix 13.1) and by a series of visualisations of the wind farm presented in Figure 13.20 to Figure 13.35 in Appendix 13.2.

The wind farm would comprise between 45x7MW machines (172m high to tip and 97m high to hub) and 108x3MW machines (117m to tip and 72m high to hub) (exact machine to be determined at final design stage: see discussion and full details in Section **2**).

The turbines would be painted a marine grey and would have a yellow railing around a circular platform at the base. There would also be an anemometer/ meteorological mast about 90m high above mean sea level (already consented) and a number of offshore transformer stations around 20m x 20m x 10m in height (see Section 2).

Several other features of the operating wind farm are relevant to the assessment:

- turbines at 3.5km intervals around the outer perimeter of the site would be topped with a constant red light to indicate the presence of the site to aircraft, located on the nacelle. These are low range and low intensity and are set at an angle so aircraft can see them, and are unlikely to be visible from the shore (see Section 2 for full details);
- each turbine would have a number of yellow flashing navigation lights located at about 12m above mean sea level on the outer edge of the railings. These would operate during dusk, dawn and darkness, but would go off during daylight hours; and
- boats attending the site for servicing and maintenance would typically comprise 12 man catamarans, which would attend the site once a day during favourable sea conditions in order to undertake maintenance.

The wind turbines would be operational for the majority of time (estimated to be at least 90% of the time). The navigation lights would operate during darkness and aircraft warning lights would be operational at all times. Boat traffic and associated human activity would typically be present on a daily basis.

Permanent impacts would result from the displacement of the open sea with the wind farm and associated permanent infrastructure over the lifespan of the wind farm (assumed to be 40 years).

13.5.2 Effects on Landscape and Seascape Character, Visual Amenity and Views

13.5.2.1 Indirect Effects on Designated Sites

Figure 13.19 shows the predicted extent of visibility of the proposed development from designated sites throughout the area. Effects are described in Table 13.10

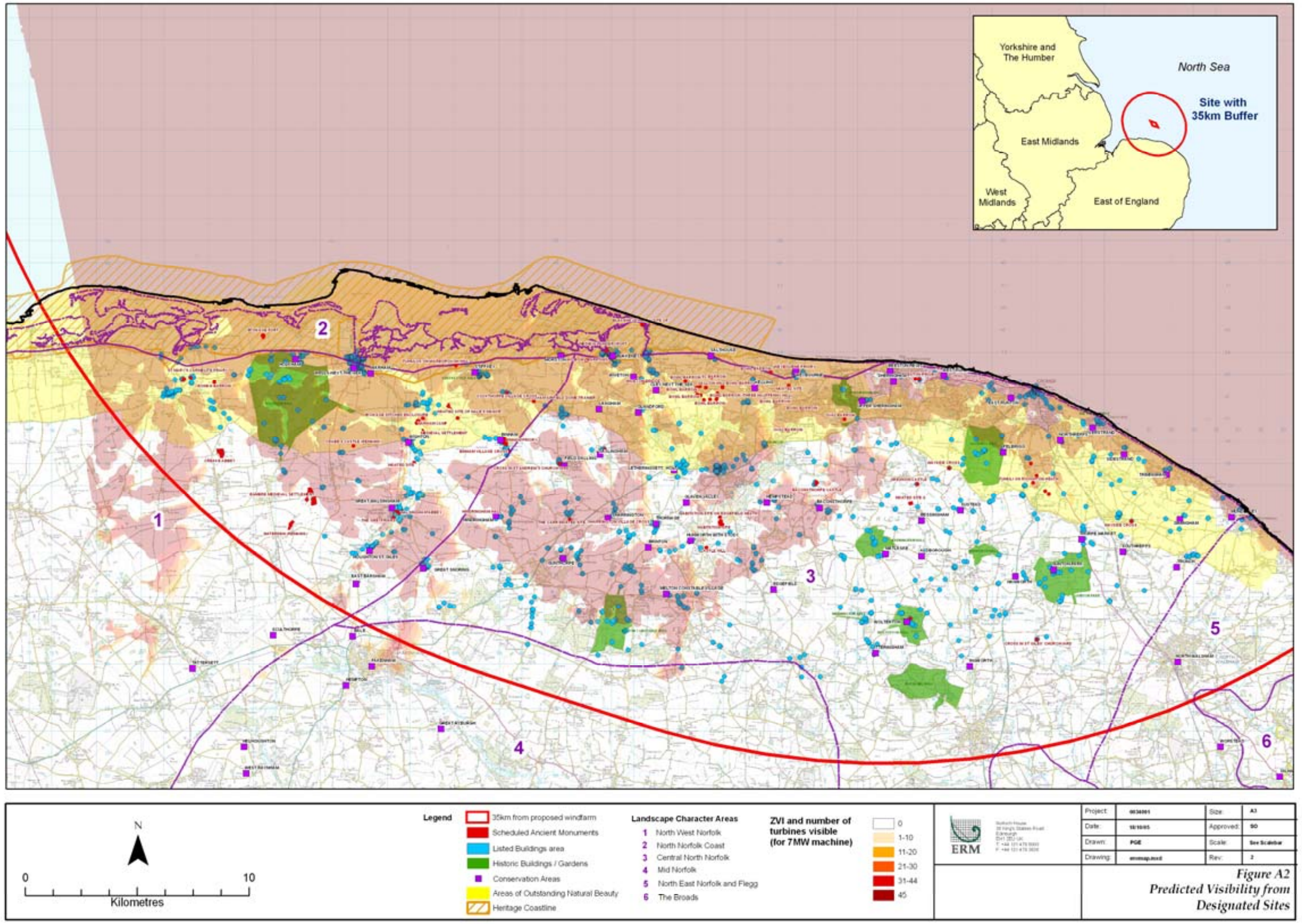


Figure 13.19 Predicted visibility from designated sites

Table 13.10 Indirect Effects on Designated Sites

Designated Area	Effects
AONB	The development would be visible from the coastal edge for the majority of the AONB, and as a result would affect its landscape character, through indirect effects on its setting, as indicated on Figure 13.6. The ZVI indicates potential visibility from inland, but in practice this would be limited to highpoints and hills such as Beeston Hill, as vegetation screens many of the views from inland, and as a result the landscape character of the inland areas of the AONB would not be affected. **Minor** to **moderate** (only at closer and elevated points) effects would result on the coastline between Brancaster Staithe and Mundesley. The areas of the AONB which lie inland of the coastal strip would not be affected, as there are few views available out to sea from the hinterland.
Heritage Coast (non statutory)	The Heritage Coast would be affected from Brancaster Staithe to Weybourne along its coastal edge, resulting in **minor** to **moderate** (at closer points) effects overall.
SAMs	Figure 13.6 indicates which of the SAMs lie within the theoretical 35km ZVI. Most of these are located inland away from the immediate coastal edge and as a result would be screened from seaward views by vegetation. The fact that the proposed wind farm is located 17-22km offshore means that there would be effects of no greater than **minor** significance on the setting to any of these ancient monuments. Effects would be **negligible** for the majority of sites.
Designed Landscapes	Figure 13.6 indicates which of the Designed Landscapes lie within the theoretical 35km ZVI. Most of these are located inland away from the immediate coastal edge and as a result would be screened from seaward views by vegetation. The fact that the proposed wind farm is located 17-22km offshore means that there would be effects of no greater than **minor** significance on the setting to any of these landscapes.
Conservation Areas	Figure 13.6 indicates which of the Conservation Areas lie within the theoretical 35km ZVI. Most of these are located inland away from the immediate coastal edge and are set within the context of other undesignated components of the villages, often screening the Conservation Areas from seaward views. The fact that the proposed wind farm is located 17-22km offshore means that there would be effects of no greater than **minor** significance on the setting to any of these Conservation Areas. Effects would be **negligible** for the majority of areas.
Listed Buildings	The settings to Listed Buildings are not considered to extend beyond a few km of any of the buildings present in the study area, and as a result no significant effects on Listed Buildings are predicted.
Other Non Statutory Designations	Undeveloped Coast: see Heritage Coast above. Areas of High Landscape Value: see AONB above. Away from the coast effects would be **minor** or **negligible**. Registered Common Land and land accessible to the public under the CROW Act: **minor** or **negligible** depending on location. Trees and buildings would often screen views from these areas, as common land is generally associated with villages (e.g. village greens). Rights of Way: variable across the area, but of greatest significance on Peddars Way which follows the coast. Users would experience a changing sequence of views of the wind farm, at some distance offshore when conditions are clear resulting in effects of **moderate** significance in places.

13.5.2.2 Indirect Effects on the Landscape Character Areas and Types

The specific impacts on the resources and character of each landscape character area have been assessed, based upon the predicted changes immediately after completion of the works, and with implementation of the mitigation proposed (see Section 13.5). There would be no direct effects on any landscape character area from the offshore elements of the scheme. Indirect effects and effects due to the inter-relationships between different character areas are discussed.

The presence within the sea of the wind farm development and associated meteorological mast and transformer stations would affect the landscape character of character areas within its ZVI, due to changes in outlook from and the setting of these areas. Effects would be greatest along the coastline nearest to the site where intervisibility between the site and onshore areas is greatest, and would diminish with distance, particularly distance inland, due to the shape of the landform, tree cover and buildings preventing views of the sea from inland areas in many places. Indirect effects upon the landscapes along the coast nearest to the proposed wind farm would result from changes to views, as well as operational effects such as the motion of the turbines, lighting, reflection from turbine blades and boat and traffic.

The location of the project 17-22km offshore diminishes the significance of landscape impacts when compared to a land based site, but as the development would be located in an area where there is no other existing development of this scale (other than occasional passing ships, and a number of oil rigs) it would affect the perception and views of an undeveloped seaward setting to the coast and permanent effects on the landscape would arise. Indirect effects on the landscape character would only be apparent when the atmospheric visibility exceeds the closest distance between Sheringham Shoal Offshore Wind Farm and the land (i.e. 17km) (see Section 13.3.4, Figure 13.13) estimated to be in the order of 57% of the time.

Indirect impacts on landscape character areas within 35km of the site are described in Table 13.11 and are summarised below.

- Central North Norfolk 78/ Cromer Ridge/ Coastal towns and villages/ Rolling heath and arable land/ Large valleys/ Small valleys: indirect effects of up to **moderate** significance along immediate coastal edge, decreasing to **negligible** inland as woodland vegetation and landform screens views of sea from the hinterland;
- North Norfolk Coast 77/ North Coast Levels/ Undrained marsh and sand pits/ Drained marsh: indirect effects of up to **moderate** significance along immediate coastal edge, decreasing to **minor** or **negligible** inland, as shingle bank on seaward edge and marsh vegetation screens views of sea from the hinterland;
- Mid Norfolk 84 (inland)/ Central Farmlands/ Wensum Valley/ Randomly enclosed rolling farmland/ Small valleys: **negligible**, as although the theoretical ZVI indicates extensive views, there are few areas where the coast can be seen from Mid Norfolk due to screening by vegetation;
- North West Norfolk 76 (inland)/ Western Farmlands/ Parliamentary enclosed rolling farmland/ Woodland with parkland/ Large valleys: indirect effects of **negligible** significance due to the fact that there are few areas where the coast can be seen from North West Norfolk; and
- North East Norfolk and Flegg 79/ Walsham Plain/ Randomly enclosed low plains farmland/ Coastal plain: indirect effects of **negligible** significance due to the fact that there are few areas where the coast can be seen due to the presence of vegetation, distance from and oblique angle to the wind farm.

It is considered that the significance of effects upon the landscape would be similar for all possible alternatives in terms of turbine size and layout, due to the fact that the proposal is so far offshore. The detail of what can be seen would vary, but the overall significance would not vary (see discussion in Section 13.4.2).

Table 13.11 Indirect Effects on Landscape Character Areas and Types

Country-side Char. Area	Approx Local Char. Area/Type	Value	Quality/ Condition	Sensitivity	Magnitude of Change	Summary of Effects
Central North Norfolk 78	Cromer Ridge Coastal towns and villages/ Rolling heath and arable land/ Large valleys/ Small valleys	High (northern part is AONB, except built up areas)	High (lower around the peripher y of towns)	Medium (well wooded landscape, away from coastal influences)	Medium along coastal edge	**Up to moderate** adverse along immediate coastal edge, decreasing to **negligible** inland as woodland vegetation and land form screens views of sea from the hinterland
North Norfolk Coast 77	North Coast Levels Undrained marsh and sand pits/ Drained marsh	High (AONB)	High	High (open, wild, remote landscape)	Medium, but just along closest parts of coastal edge	**Up to moderate** adverse along immediate coastal edge, decreasing to **minor** or **negligible** inland as shingle bank on seaward edge and marsh vegetation screen views of sea from the hinterland
Mid Norfolk 84 (inland)	Central Farmlands/ Wensum Valley Randomly enclosed rolling farmland/ Small valleys	High (northern part is AONB)	High	Medium (well wooded landscape, away from coast, and screened by woodland)	Low or none	**Negligible** – although theoretical ZVI indicates extensive views, there are few areas where the coast can be seen from Mid Norfolk due to screening by vegetation
North West Norfolk 76 (inland)	Western Farmlands Parliamentary enclosed rolling farmland/ Woodland with parkland/ Large valleys	High (northern part is AONB)	High	Medium (more robust landscape, away from coastal influences)	Low or none (vegetation screens changes)	**Negligible** – although theoretical ZVI indicates extensive views, there are few areas where the coast can be seen from North West Norfolk
North East Norfolk and Flegg 79	Walsham Plain Randomly enclosed low plains farmland/ Coastal plain	High (northern part is AONB, except built up areas)	High	Low (oblique angle from proposed development and only very short section of coastal strip within ZVI)	Low or none, confined to narrow coastal strip	**Negligible** – theoretical ZVI indicates limited visibility from this area. Presence of vegetation, distance from and oblique angle to wind farm results in **negligible** effects

13.5.2.3 Direct and Indirect Effects on the Seascape

An area of 35km^2 of open sea would be affected by development of the wind farm, by the presence of turbines, meteorological mast and transformer substations which form the offshore wind farm, and by associated boat activities during its operation. The direct effects on the seascape would be as a result of the loss of the open sea resource within the seascape area in which it is located (Cromer and Sheringham Ridge), and the changes in the immediate seascape character that this would cause. The development would have a large scale man made character and this would be most apparent within the site or immediately adjacent to it. Further away from the site the surrounding seascapes would experience indirect effects, their extent varying depending upon the daily variations in atmospheric visibility, as a result of changes in their setting and the installation of visible man made infrastructure within an undeveloped area. The significance of the effect would decrease with distance away from the offshore wind farm, and with decreased atmospheric visibility. The significance of the effect on seascape resources and character would be direct and **major** at the site itself, but would be indirect out with the site and would decrease when assessed in the context of the wider area. The effect is likely to be tolerable over the 40 year lifespan of the offshore wind farm.

Boat movements to and from the site would add an increased level of activity to the area, and between the coastal port used by the boats and the wind farm site itself (possibly Yarmouth or Lowestoft).

Lighting of the turbines for reasons of navigational and aircraft safety would affect an area which is currently dark at night, and would be seen from surrounding seascape and from the shore when atmospheric conditions are clear (and depending on the range of the lights). The use of low intensity and directional lighting would reduce the visibility from the shore as far as possible.

It is considered that the significance of effects upon the seascape would be similar for all possible alternatives in terms of turbine size and layout. The detail of what would change would alter, but the overall significance would not vary (see discussion in Section 13.4.2).

A summary of the direct and indirect effects on the seascape are provided in Table 13.12.

Table 13.12 Direct and Indirect Effects on Seascape Units.

Seascape Unit	Local Seascape Unit	Value	Quality/ Condition	Sensitivity to Proposed Change	Magnitude of Change	Summary of Effects
The Wash	North Coast Levels	High (AONB)	High	High (open, wild, remote coastline)	Medium	**Moderate** - indirect
	Salthouse Coastline	High (AONB)	High	High (open, wild, remote coastline)	Medium	**Moderate** – indirect near the site, decreasing with distance from the site, and rising to **major** nearest to the site
	Cromer and Sheringham Ridge	High (AONB, except built up areas)	High	Medium (closest coast to site, coastline more developed, cliffs allow panoramic vistas over seascape)	High	**Major** to **moderate** – direct displacement of $35km^2$ of open sea within this seascape unit. Decreasing with distance from the site Indirect effects of **major** significance close to the site itself
	Eastern Plateau	High (western part AONB, except built up areas)	High	Medium (coastline more developed, cliffs allow panoramic vistas over seascape)	Low	**Minor** – further away and coast orientated away from the site

13.5.2.4 Effects on Visual Amenity and Views

See also discussion and description of ZVIs in Section 13.4.2, particularly in relation to the variable size and layout of the turbines depending upon what is chosen, and the varying extent off the ZVI as a result.

It is acknowledged that the final choice of turbine would alter the nature of visual impacts, but it is considered that the degree of significance of the effects would remain similar overall. The choice of a larger number of smaller turbines, at a higher density, over a smaller number of larger turbines, at a lower density, would be a matter of personal preference. The smaller turbines may appear as a white blur on the horizon more often, as their overall height and bulk would be less, and as a result they may fade into the distance more frequently than the larger turbines. The larger turbines have a greater theoretical ZVI, but in practice, views from the hinterland would almost always be screened by vegetation. Their bulk and form is likely to be more readily apparent more frequently, but some viewers may consider this preferable to seeing the sometimes more difficult to identify blur of the smaller turbines.

Visual effects at selected viewpoints (locations shown on figure 13.20) are identified in Table 13.12. For each viewpoint the table identifies distance from the site, grid reference (based on the Ordnance Survey British National Grid System) and elevation, the types of receptors present and their sensitivity (taking into account how many people are affected). It then notes reference to the relevant visualisations, comments on the change in view and provides an evaluation of the significance of the resulting effect.

The most significant visual effects would be permanent and of **major** significance, and would affect a very few sensitive residential and recreational receptors on the coast closest to the site at Beeston Hill, Cley Marshes, and on Peddars Way in Sheringham. It would not be possible to see the wind farm at all times, with the closest edge of the site being visible for approximately 55-59 % of the year at these locations.

Some recreational viewers at the viewpoints and on footpaths and travellers on roads would also experience localised **major** and **moderate** effects from the presence of the wind farm in views of the sea, but these would be more transient, as people would be passing through the landscape and not therefore subject to prolonged viewing periods. The significance of effects on visual receptors would decrease with distance from the site.

Views experienced by people out at sea (recreational sailors and workers on commercial ships or rigs) would also be affected. Workers are considered to be of low sensitivity to change, so effects would be slight or insignificant. The wind farm would become a new point of reference and navigational aid. Users of yachts will tend to sail close to the coast and their view back towards the coast will not be affected, although they will see the wind farm when they look out to sea. Both of these groups of views will experience changes in their sequences of views as they move across the sea.

Proposed views are indicated with wirelines and photomontages in Figure 13.20 to Figure 13.36 in Appendix 13.2

Note: All figures referred to in *Table 13.13* below can be found in Appendix 13.2.

Table 13.13 Effects on Selected Viewpoints.

Viewpoint / Grid Ref	Description of Viewpoint	Receptor	Sensitivity (Number)	Visualisation	Magnitude of Change	Sig. of Effect (% time visible)
Cromer Pier 19km Viewpoint 1 219 423 Elevation 10m	Landward end of pier	Recreation and shoppers	High (Large)	Cumulative photomontage and Photomontage Full view	See figure 13.20 Medium	Moderate (busy viewpoint, but other distractions as urban area) 63%
Wells–Next-The-Sea, Harbour Railway 25km Viewpoint 2 915 440 Elevation 5.7m	Location on embankment near the station	Recreation and shoppers	High (Large)	Cumulative photomontage and Photomontage Full view?	See Figure 13.21 Low	Minor (far away and view across marshes) 32%
Beeston Hill 17km Viewpoint 3 168 433 Elevation 62.5m	Seat and trig point on hill top	Recreation	High (Moderate)	Photomontage, full view, elevated	See figure 13.22 High	Major (busy elevated viewpoint) 63%

Table 13.13 Effects on Selected Viewpoints.

Viewpoint / Grid Ref	Description of Viewpoint	Receptor	Sensitivity (Number)	Visualisation	Magnitude of Change	Sig. of Effect (% time visible)
Viewpoint in Oak Wood, Sheringham Hall, National Trust 19km Viewpoint 4 133 424 Elevation (viewing platform) 95 (ground level 70m)	Viewpoint above Sheringham Hall in Oak Wood – elevated platform	Recreation	High (Moderate)	Photomontage Full view, elevated	See figure 13.23 Medium	Moderate (fewer receptors and within woodland, short viewing duration) 63%
Cley Marshes Nature Reserve, car park (Cley next the Sea) 18km Viewpoint 5 048 453 Elevation 6.5m	Top of shingle bank above car park on coast north of Cley next the Sea	Recreation	High (Moderate)	Photomontage Full view	See Figure 13.24 High	Major (view from open beach, away from urban influences) 63%
Overstrand, car park (the Paston Way) 21km Viewpoint 6 248 411 Elevation 25.2m	Cliff top car park	Recreation	High (Moderate)	Wireline Full view	See Figure 13.25 Medium	Moderate (oblique view, from elevated cliff tops) 48%
Incleborough Hill 18.5km Viewpoint 7 188 424 Elevation 69.6m	Seat on top of hill	Recreation	High (Moderate)	Wireline Full view, elevated	See Figure 13.26 Medium	Moderate (popular recreational viewpoint, but with some screening by gorse) 63%

Table 13.13 Effects on Selected Viewpoints.

Viewpoint / Grid Ref	Description of Viewpoint	Receptor	Sensitivity (Number)	Visualisation	Magnitude of Change	Sig. of Effect (% time visible)
Sheringham, Peddars Way 17km Viewpoint 8 159 435 Approx elevation 10m	Peddars Way Coast Path, on seafront	Recreation, residents, shoppers	High (Large)	Wireline Full view	See Figure 13.27 High	Major (close view from busy urban seafront) 63%
Sheringham Coast Watch – hut 17km Viewpoint 9 149 435 Elevation 46m	Cliff top location from coast watch hut	Recreation, workers in hut	Medium (Moderate)	Wireline Full view, elevated	See Figure 13.28 High	Moderate (close and elevated view, but viewers generally in transit rather than stationary) 63%
Weybourne, Peddars Way, on shingle beach 17km Viewpoint 10 110 437 Elevation 6.5m	View from top of shingle beach	Recreation	High (Moderate)	Wireline Full view	See Figure 13.29 Medium	Moderate (close, but quieter beech location, and screening by shingle bank except when on beach itself) 63%
Holgate Hill, south west of Weybourne 19km Viewpoint 11 105 420 Elevation 52.2m	Footpath just to south of road where the road emerges from the trees and a clear view is available	Road users, recreation	Medium (Moderate)	Wireline Partial view, elevated	See Figure 13.30 Medium	Moderate (close view, but receptors less sensitive as generally travelling in cars) 63%
A148, cross roads near Bale 27.5km Viewpoint 12 998 345 Elevation 87.6m	Location where there is a clear view from the road over fields between hedges	Farmers, road users	Medium (Moderate)	Wireline No view, elevated	See Figure 13.31 No visible change	Negligible in summer (trees obscure view) 32%

Table 13.13 Effects on Selected Viewpoints.

Viewpoint / Grid Ref	Description of Viewpoint	Receptor	Sensitivity (Number)	Visualisation	Magnitude of Change	Sig. of Effect (% time visible)
Blakeney, car park 19.5km Viewpoint 13 028 442 Elevation 4.5m	Car park on north side of village	Residents, recreation	High (Large)	Wireline Clear view	See Figure 13.32 Medium	Moderate (view across marshes, partly obscured by shingle bank at coast) 63%
Morston – car park near ferry 21km Viewpoint 14 007 442 Elevation 5.9m	National Trust car park and marina	Recreation	High (Moderate)	Wireline Clear view	See Figure 13.33 Medium	Moderate (view across marshes, partly obscured by boats in foreground and shingle bank at coast) 48%
Stiffkey Salt Marshes, car park on marshes, near campsite 22km Viewpoint 15 965 439 Elevation 5.5m	Car park by marshes, Green Way	Recreation	High (Moderate)	Wireline Clear view	See Figure 13.34 Low	Minor (more distant view across marshes from quieter marsh location) 48%
A149 St Withburga Church, Holkham Hall 27.5km Viewpoint 16 878 439 Elevation 15.7m	View from road in front of St Withburga Church	Road users	Medium (Moderate)	Wireline Partial view	See Figure 13.35 No visible change	Negligible in summer (trees obscure view) 32%
Beeston Regis Heath (Stone Hill) Viewpoint 19km Viewpoint 17 170 418 Elevation 91.5m	Seat at view point on top of hill	Recreation	Medium (Few)	Clear view, elevated	Medium	Minor (elevated, but viewpoint is not that well used) 63%

Table 13.13 Effects on Selected Viewpoints.

Viewpoint / Grid Ref	Description of Viewpoint	Receptor	Sensitivity (Number)	Visualisation	Magnitude of Change	Sig. of Effect (% time visible)
Dead Man's Hill, Peddars Way 17km Viewpoint 18 124 437 Elevation 21.6m	View from hill on Peddars Way	Recreation	Medium (Moderate)	Clear view, elevated	High	Moderate (closest land to wind farm, but viewers largely in transit as walking along coastal path, and no car park near by) 63%
Muckleburgh Hill 18km Viewpoint 19 104 433 Elevation 27m (summit 68m)	Corner of road near museum, north east of Muckleburgh Hill summit View represented by Holgate Hill (see above)	Recreation, users of museum	Medium (Moderate)	Clear view, elevated	High	Moderate (relatively close and elevated viewpoint, but military infrastructure in foreground detracts from seaward views) 63%
Holt, church 23km Viewpoint 20 081 388 Elevation 65.5m	No view due to intervening buildings and trees	Residents	High (Large)	No view, elevated	No visible change	Negligible (buildings obscure view) 48%
West Beckham – mast at Camp Farm road junction 21.5km Viewpoint 21 139 388 Elevation 95.2m	Representative countryside hinterland view - no clear view due to woodland	Road users and farmers	Low (Few)	No view, elevated	No visible change	Negligible in summer (trees obscure view) 48%
A148 25km Viewpoint 22 044 380 Elevation 53.9m	View from cross roads across coast	Road users	Medium (Moderate)	No view, elevated	No visible change	Negligible in summer (trees obscure view) 32%

Table 13.13 Effects on Selected Viewpoints.

Viewpoint / Grid Ref	Description of Viewpoint	Receptor	Sensitivity (Number)	Visualisation	Magnitude of Change	Sig. of Effect (% time visible)
Holkham Park (hall) 28km Viewpoint 23 884 429 Elevation: 11.5m	View from front of hall – no view because of trees	Recreation	High (Moderate)	No view	No change	Negligible (no view) 32%
Beacon Hill Road 32km Viewpoint 24 834 409 Elevation 52.1m	View from minor road above Burnham Market	Residents	High (Large)	No clear view, elevated viewpoint	No view as trees on horizon, elevated viewpoint	Negligible (no view) 14%
Gibraltar Point Viewpoint, National Nature Reserve >35km Viewpoint 25 564 584	South of Skegness	Recreation	High (Moderate)	Very long distance	See Figure 13.36 No visible change (too far away)	Negligible (no view) 4%
Passenger Ferry to Hull 5km at nearest point Viewpoint 26 Elevation: sea level +20m	Nearest points to proposed wind farm	Travellers	Medium (Moderate)	Screen shot animation	See Figure 13.37 High	Moderate (close view but in transit on a boat – would become a new landmark on the journey for ferry goers) 94%

The attitude to and perception of renewable energy will also vary from person to person (see Section 11, page 94, Public Perception Before and After Studies from Assessing Significance of Guidance on the Assessment of the Impact of Offshore Wind Farms: Seascape and Visual Impact Report (2005), Enviros Consulting Ltd, for the DTI. Wind turbines out at sea may be considered dramatic sculptural features by some, but others will dislike the effects on the skyline, and the presence of new man made objects within the sea.

13.5.2.5 Proposed Mitigation Measures

The following measures would be taken to help reduce the impacts resulting from the wind farm, although the reduction in impact that these would result in would not significantly alter the assessment made above:

- the location, 17-22km (8-12 nautical miles) offshore;
- a muted grey would be used for the colour of external surfaces, which would blend into the colour of the sky and sea and would not stand out when viewed from a distance;
- non reflective surfaces would be used;
- external clutter would be minimised;
- there would be no external advertising on the turbines, except any notices required for operational safety;
- lighting would be designed to meet the minimum requirements for operational safety and to fit neatly onto the turbines and minimise clutter; and
- lighting would be carefully designed so as not to contribute to light pollution/ glare to the sky or to disrupt the horizon in longer distance views of the scheme. Low intensity and directional lights would be used where permitted.

13.6 Impacts during Decommissioning

13.6.1 Introduction

After 40 years the offshore wind farm would have reached the end of its design life and would be decommissioned, as described in Section 2 of this ES.

13.6.2 Potential Impacts on Landscape and Seascape Resources and Character, Visual Amenity and Views

The effects during the process of removal would be the same as those during the construction period (see Section 13.4) as similar machinery, jack up barges, boats etc would be required.

There would be no impacts on landscape and seascape resources or visual amenity once all infrastructure is removed.

13.6.2.1 Proposed Mitigation Measures

The mitigation measures detailed in Section 13.4 (mitigation measures during the construction period) would be followed where applicable. In addition:

- all visible land and sea based facilities would be removed after 40 years; and
- the components would be recycled where possible, or disposed of to a location where they do not result in landscape/ seascape and visual impacts in another location.

13.6.2.2 Residual Effects on Landscape and Seascape Resources and Character, Visual Amenity and Views

Residual effects would be as described above in Section 13.6.

13.7 Cumulative Effects

13.7.1 Potential Cumulative Impacts on Landscape and Seascape Resources and Character, Visual Amenity and Views

The preceding sections have addressed the impacts of Sheringham Shoal Offshore Wind Farm on the landscape/ seascape and visual environment. Legislation requires an ES to also address the cumulative impacts of a proposal together with other developments present or planned in the area.

As noted in Section 2, there are two other wind farms/groups of wind farms within proximity of Sheringham Shoal whose details are known, namely: Norfolk (known as Cromer) Offshore Wind Farm which is consented but not built at a distance of 12km away; and Docking Shoal/Race Bank Offshore Wind Farms (two adjacent wind farms, in 3 groups of turbines, see Figure 13.3), currently the subject of the EIA process, with the nearest turbine of the group being about 14km away.

As stated in Section 2, the Triton Knoll and Dudgeon sites were examined, and it was found that there is no land based overlap of their ZVIs with that for the Sheringham Shoal site, so significant cumulative landscape or visual impacts will not occur. The Lincs, Inner Dowsing, Lynn, Skegness and Lynn 2 sites were found to have a very small area of overlap amounting to a stretch of under 10km of coast between Scolt Head Island and Wells-Next-The-Sea. Views from the eastern 5km of this coast out to sea are screened by coniferous plantation forestry along Holkham Meals. The stretch between Scolt Head Islands and Burnham Overy Staithe is screened by a wide expanse of mud flats and dunes, although some visual receptors will be present along Peddars Way and North Norfolk Coast Path and Scolt Head Island Nature Reserve. Significant cumulative impacts on the landscape or upon views are not therefore predicted. Cumulative landscape and visual impacts with Scroby Sands Offshore Wind Farm were considered insignificant as there is almost no overlap in ZVIs due to the distance between the sites, and the orientation of the coastlines.

Significant cumulative impacts with the wind farms listed above are considered unlikely to occur. A more detailed assessment was therefore made of the cumulative impact of Sheringham Shoal Offshore Wind Farm, together with the Cromer and Docking Shoal/Race Bank sites assuming they are both in place. It should be noted that only one has consent and that the other may not go ahead. Equally other wind farms which are not yet formally within the consenting system may come forward in advance of the Sheringham Shoal project. Plans of the two site areas are shown in Figure 13.3. There are no known onshore wind farms or other major offshore developments which are proposed or in planning at present, and therefore cumulative impacts together with onshore development have not been examined.

Three types of cumulative effect are considered: combined, successive and sequential (see Section 13.2.4). The significance of cumulative impacts is evaluated by reference to the guide in Table 13.14, and is applied in combination with professional judgement.

Table 13.14 Significance of Cumulative Impacts.

Visibility from Viewpoint	Combined View (180 degree arc)	Successive/ Sequential View (360 degree arc)
Sheringham Shoal and other wind farms visible far away eg > 20km	**Minor**	**Negligible**
Sheringham Shoal and other wind farms visible at a moderate range (eg 10-20km)	**Moderate**	**Minor**
Sheringham Shoal and other wind farms visible at close range (eg 0-10km)	**Major**	**Moderate**

If there are three or more wind farms visible at any one time, including Sheringham Shoal Offshore Wind Farm, then significance is increased by a grade.

The potential for cumulative impacts on viewpoints within a 35km radius from the Sheringham Shoal site is considered. The theoretical cumulative ZVIs are shown in 13.37 to Figure 13.2039 in Appendix 13.2 and indicate those parts of the 35km ZVIs for the other wind farms which overlap with the 35km ZVI for that at Sheringham Shoal. A combined ZVI for all three developments is shown in 13.40 in Appendix 13.2. This illustrates that there are substantial areas of potential overlap between the ZVIs from which between one or two wind farms would be visible in addition to that at Sheringham Shoal.

13.7.1.1 Cumulative Effects During Construction

The extent of cumulative effects would depend upon the phasing of other construction projects in the area and their proximity to the site for the proposed wind farm. Other known developments (see above) are located north of the coast near Cromer (name: Cromer, developer Norfolk Offshore Wind) and Burnham Overy Staithe (name: Docking Shoal/Race Bank, developer: Centrica/Amec). These are 12km and 14km away from Sheringham Shoal Offshore Wind Farm respectively and it is not therefore expected that cumulative effects during construction would arise. The Cromer Wind Farm may be built before the Sheringham Shoal Wind Farm, and the Docking Shoal/Race Bank Wind Farms would probably be constructed later. Again, cumulative effects would only be apparent when the atmospheric visibility exceeds the closest distance between Sheringham Shoal Offshore Wind Farm and any other site (i.e. when it exceeds 12km) (see Section 13.3.4, Figure 13.13).

13.7.2 Residual Cumulative Effects on Landscape and Seascape Resources and Character, Visual Amenity and Views

13.7.2.1 Combined and Successive Cumulative Effects

Figure 13.39 in Appendix 13.1 indicates the extent of land from which views of other wind farms would be available in blue. The green areas indicate where Sheringham Shoal Offshore Wind Farm would be visible in combined views with other wind farms, and the yellow areas indicate where the Sheringham Shoal site would add a view of a wind farm to an area where there would currently be no view. These areas are small in extent and are predominantly located offshore, along the coastal strip and on the higher areas of land in the western sector of the ZVI.

The cumulative ZVI for Cromer Offshore Wind Farm is indicated on Figure 13.37 in Appendix 13.1. There is a high degree of coincidence between the ZVI for the Sheringham Shoal site (shown in yellow) and the Cromer site (shown in blue), as is indicated by locations on the map shown in green, where the two colours overlap. Cromer Offshore Wind Farm is much closer to the shore (7km offshore) and further east than the Sheringham Shoal site. As a result it has greater visibility than Sheringham Shoal from eastward facing slopes, and Sheringham Shoal is more visible from westward and north westward facing slopes. As with the Sheringham Shoal ZVI, views from the eastern part of the 35km ZVI are largely screened by landform (the Cromer Ridge and hills between Briston and Baconsthorpe).

The cumulative ZVI for Docking Shoal/Race Bank Offshore Wind Farms north of the coast at Burnham Market is indicated on Figure 13.19 in Appendix 13.1. There is a high degree of coincidence between the ZVI for the Sheringham Shoal site (shown in yellow) and the Docking Shoal/Race Bank sites (shown in blue), as is indicated by locations on the map shown in green, where the two colours overlap. The Docking Shoal/Race Bank Offshore Wind Farm group is about the same distance from the shore (18km) and further west than the Sheringham Shoal site. As a result it has greater visibility than Sheringham Shoal from westward facing slopes, and Sheringham Shoal is more visible from eastward and north eastward facing slopes. As with Sheringham Shoal Offshore Wind Farm ZVI, views from the eastern part of the 35km ZVI are largely screened by landform (the Cromer Ridge and hills between Briston and Baconsthorpe).

Combined (or simultaneous) effects occurring as a result of the three proposed offshore wind farms/wind farm groups would affect views from the sea, from numerous points along the coast and in longer distance views from highpoints across the area where tree cover does not result in views of the sea being screened. As the wind farms would all be seen within the same 180 degree view from all selected viewpoints, all views would be combined, and none would be successive.

Cumulative impacts on the viewpoints considered for the development at Sheringham Shoal are presented in Table 13.14. This table identifies, for selected viewpoints, the distance to the nearest edge of the Sheringham Shoal site and the distance to the nearest edge of any other wind farm visible from the same point. Thus, at the first viewpoint at Cromer Pier, Sheringham Shoal Offshore Wind Farm would be visible 19km away, and Cromer would also be visible 7km away. Where the second wind farm would be visible in a combined view it is highlighted in grey. Wind farms that would only be visible in successive views are not highlighted (there are none of these in this instance). So, at Wells-next-the-Sea, 25km from the Sheringham Shoal site, the Cromer site would be visible at 35km also in a combined view, and the Docking Shoal/Race Bank sites would be visible in a combined view, at 20km.

The assessment of combined and successive impacts was assisted by the preparation of cumulative wirelines/photomontages (Figure 13.40 to Figure 13.42 in Appendix 13.2) from three viewpoints at:

- Cromer Pier, 19km from the nearest edge of the Sheringham Shoal site, recreational viewers (see figure 13.40in Appendix 13.2);
- Wells-next-the-Sea, 25km from the nearest edge of the Sheringham Shoal site, recreational viewers (see Figure 13.41 in Appendix 13.2); and
- Oak Wood, 18km from the nearest edge of the Sheringham Shoal site, recreational viewers (see Figure 13.42 in Appendix 13.2) (representing the view from Dead Man's Hill, which is near by).

The cumulative wirelines are presented in Figure13.40 to Figure 13.42 in Appendix 13.2. Each comprises four sets of views covering the four compass quadrants. The assessment of combined and successive cumulative impacts is presented in Table 13.15.

Table 13.15 Cumulative Views from Selected Viewpoints within 35km and Percentage of Time Visible

Viewpoint Location	Distance to Sheringham Shoal	Cromer	Docking Shoal/ Race Bank	Significance and Percentage of Time When Two or More Sites Visible
Cromer Pier	19km 63%	7km 94%	OW	**Moderate** (Cromer site would dominate and Sheringham Shoal site would be seen in the distance). Two sites seen 63% of the time.
Wells-next-the-Sea	25km 32%	35km 4%	20km 48%	**Minor**. Two sites would be seen 32% of the time, and three seen 4% of the time.
Dead Man's Hill (represented by visualisation from Oak Wood)	17km (18km from Oak Wood) 63%	14.5km 80%	30km 14%	**Moderate** (both the Cromer and Sheringham Shoal sites would be seen at moderate distances). Two sites seen 63% of the time and three seen 14% of the time.

Note: All distances are given in kilometres to the nearest edge of each wind farm
0W – indicates that viewpoint is outwith other wind farm's 35km ZVI.
NV – indicates that other wind farm is not visible

Significance: Neg = negligible; Min = minor; Mod = moderate; Maj = Major

Where the second wind farm would be visible in a combined view it is highlighted in grey. Wind farms that would only be visible in successive views are not highlighted.

13.7.2.2 Sequential Cumulative Impacts

Two routes have been identified as representative of those presenting the potential for impacts on sequential views through the ZVI:

- A149 (from west to east); and
- A148 (from west to east).

The impact on these routes is illustrated by tracing the line of these two routes on Figure 13.37 to Figure 13.39 in Appendix 13.1. The figures show the geographical location of each route in relation to the Sheringham Shoal site and a representation of the visibility of each wind farm along the route. Sections passing through yellow shading are where only the Sheringham Shoal site would be visible; those shaded green are where the Sheringham Shoal site and a second wind farm would both be visible; sections passing through blue shading indicate that only the other wind farm would be visible. From the sections which pass through the colourless areas no wind farms would be visible. For the purposes of this assessment it has been assumed that the average speed whilst travelling along the roads is 60kmp/h.

The figures indicate that there would be numerous sections of the routes assessed where the Sheringham Shoal site and at least one other proposed wind farm would be visible. The durations of these sequential impacts range from short flashes to longer periods. All locations from which two or more wind farms are visible are considered to experience significant impacts. Both the A149 and the A148 would be significantly affected, although roadside vegetation would screen many views particularly in the summer months.

The greatest impacts would be on the A149. Driving from west to east cumulative sequential views of all three wind farms would occur wherever there are open views of the sea.

In assessing sequential cumulative views, it is also important to note that these would be affected by roadside vegetation and other local obstructions, and that significance would decrease with increasing distance from the wind farms, and that changes may only affect the viewer when travelling in certain directions.

Boat users out at sea will also experience sequential cumulative impacts.

13.7.2.3 Proposed Mitigation Measures

There are no ways to reduce permanent and operational cumulative impacts, except by changing the site location for one or more of the developments, or by not proceeding with the development.

13.8 Monitoring Proposals

There is no requirement for monitoring proposals for landscape/seascape and visual amenity.

13.8.1 Baseline Situation

The study area includes the area of sea, and land within north Norfolk which lies within 35km of the edge of the proposed wind farm. Within the seascape oil rigs and ships are present, but there are no other offshore wind farms in this area at this time, except that at Scroby Sands, which is on the limit of the study area boundary to the south east. Much of the coastal strip is designated as an Area of Outstanding Natural Beauty, and as a Heritage Coast, reflecting its high landscape quality and sensitivity. The coastline varies between cliffs to the east, and dunes, mudflats and marshes further west. Views from inland out to sea are limited by vegetation, especially in the vicinity of Sheringham and Cromer, which is the closest section of the coast to the site. This results in the main views of the sea being available from the coastal edge and isolated high points (such as Beeston Hill, and Oak Wood). There are very limited views from the hinterland out to sea, especially in the summer months.

13.8.2 Effects on Seascape Resources and Character

The seascape of the site would be directly affected by the presence of turbines, meteorological mast and offshore transformer substations which form the offshore wind farm, and by associated boat activities during its operation. A total area of $35km^2$ of open sea would be occupied by turbines in a currently undeveloped location. The significance of the effect on seascape resources and character would be direct and **major** at the site itself, but would be indirect outwith the site and would decrease when assessed in the context of the wider area.

13.8.3 Effects on Landscape Resources and Character

There would be no change to landscape resources as a result of the offshore wind farm and no mitigation would be required. There would be an indirect residual effect of up to **moderate** significance on the landscape character along nearest coastal edge as a result of the offshore wind farm, decreasing to low or **negligible** further inland. The majority of the hinterland is not affected by the presence of the sea or features within it and will not be affected by the wind farm. The location of the wind farm 17-22km offshore and the frequent presence of low levels of visibility in the area would reduce the potential impacts on landscape character along the coastal strip.

13.8.4 Effects on Visual Amenity and Views

There would be a change to visual amenity and to views from key viewpoint locations throughout the study area, largely along the coastal edge, by day and by night when lighting may be visible, but only when atmospheric conditions are clear. The location of the wind farm 17-22km offshore, and the frequent presence of low levels of visibility in the area would help to reduce the significance of the effects, and the extent of affected views will be limited by the characteristic bushy hedgerows and extensive woodland cover throughout much of the AONB. Impacts of up to *major* significance would only result at very few of the closest locations when weather is clear enough to permit visibility, about 55-59% of the time. Most viewpoints fall into the 15-20km distance bracket, when views would be available about 63% of the time, or the 20-25km distance when views would be available about 48% of the time. Views from the land and from ships would be affected by the presence of the wind farm to a lesser degree along a significant proportion of the horizon. The effect would decrease to **negligible** with increasing distance from the site, and with distance inland as vegetation etc obscures views of the coast from the land. The effect for the AONB as a whole would be **minor** to **moderate**.

13.8.5 Cumulative Effects

The cumulative impact assessment sets out the degree of combined, successive and sequential views and indicates that ther would be some views and locations from which the proposed Sheringham Shoal project and other wind farms, for example Cromer or the Docking Shoal/ Race Bank group, may be visible at the same time. This would be dependant on which of the proposed wind farms are built in the area. There would be no land based viewpoints from which the proposed Sheringham Shoal project and the cumulative sites would be seen together, as Cromer is 12km and Docking Shoal/Race Bank 14km respectively, from the proposed Sheringham Shoal wind farm.

13.8.6 Choice of Turbine Size and Density

It is acknowledged that the final choice of turbine would alter the nature of landscape, seascape and visual impacts, but it is considered that the degree of significance of the effects would remain similar overall. The choice of a larger number of smaller turbines, at a higher density, over a smaller number of larger turbines, at a lower density, would be a matter of personal preference. The smaller turbines may appear as a white blur on the horizon more often, as their overall height and bulk would be less, and as a result they may fade into the distance more frequently than the larger turbines. The larger turbines have a greater zone of theoretical visual influence, but in practice, views from the hinterland would almost always be screened by vegetation. Their bulk and form is likely to be more readily apparent more frequently, but some viewers may consider this preferable to seeing the sometimes more difficult to identify blur of the smaller turbines. Effects on the landscape and seascape would be directly linked to their visibility.

13.9 References

- BMT Cordah Ltd (2003), Offshore Wind Energy Generation: Phase 1 Proposals and Environmental Report.
- Countryside Council for Wales, Brady Shipman Martin and University College of Dublin (2002), Guide to Best Practice in Seascape Assessment.
- Enviros Consulting Ltd, for DTI (2005), Guidance on the Assessment of the Impact of Offshore Wind Farms: Seascape and Visual Impact Report.
- Greenpeace (July 2004), Scarweather Sands Opinion Survey.
- Horner and MacLennan, and Envision (2005), Visual Analysis of Wind Farms: Good Practice Guidance.
- Landscape Institute and Institute of Environmental Assessment (2002), Guidelines for Landscape and Visual Impact Assessment, 2nd Edition.
- MORI Scotland, for Scottish Renewables Forum & the British Wind Energy Association (2002),Tourist Attitudes towards Wind Farms: Research Study.
- Planning Policy Statement (PPS) 22 (2004): Renewable Energy.
- Posford Haskoning (2002), Cromer Offshore Wind Farm Environmental Statement.
- Posford Haskoning (2003), Greater Wash Round 2 Offshore Wind Farms: Cumulative Effects, Scoping Report.
- University of Newcastle, Scottish Natural Heritage commissioned report (2002), Visual Assessment of Wind Farms – Best Practice.
- Scottish Natural Heritage (2005), Guidance: Cumulative Effect of Wind Farms.
- Sustainable Development Commission (2005), Wind Power in the UK.

Appendix 13.1

Appendix 13.2

14 Shipping and Navigation

14.1 Introduction

This section provides a summary of the work undertaken to assess the potential impact of the Sheringham Shoal Wind Farm on shipping and navigation during construction, operation and decommissioning. Full details of the Navigation Risk Assessment (NRA) are provided in Appendix 14.1.

There are five alternative wind farm layouts for EIA purposes. The preferred option is 70 x 4.5MW turbines, however the underlying assessment assumes 108 turbines with 5m diameter foundations, a meteorological mast and two substations, which is considered to be the "worst case" layout from a navigational risk perspective as it presents the largest obstruction from a collision perspective.

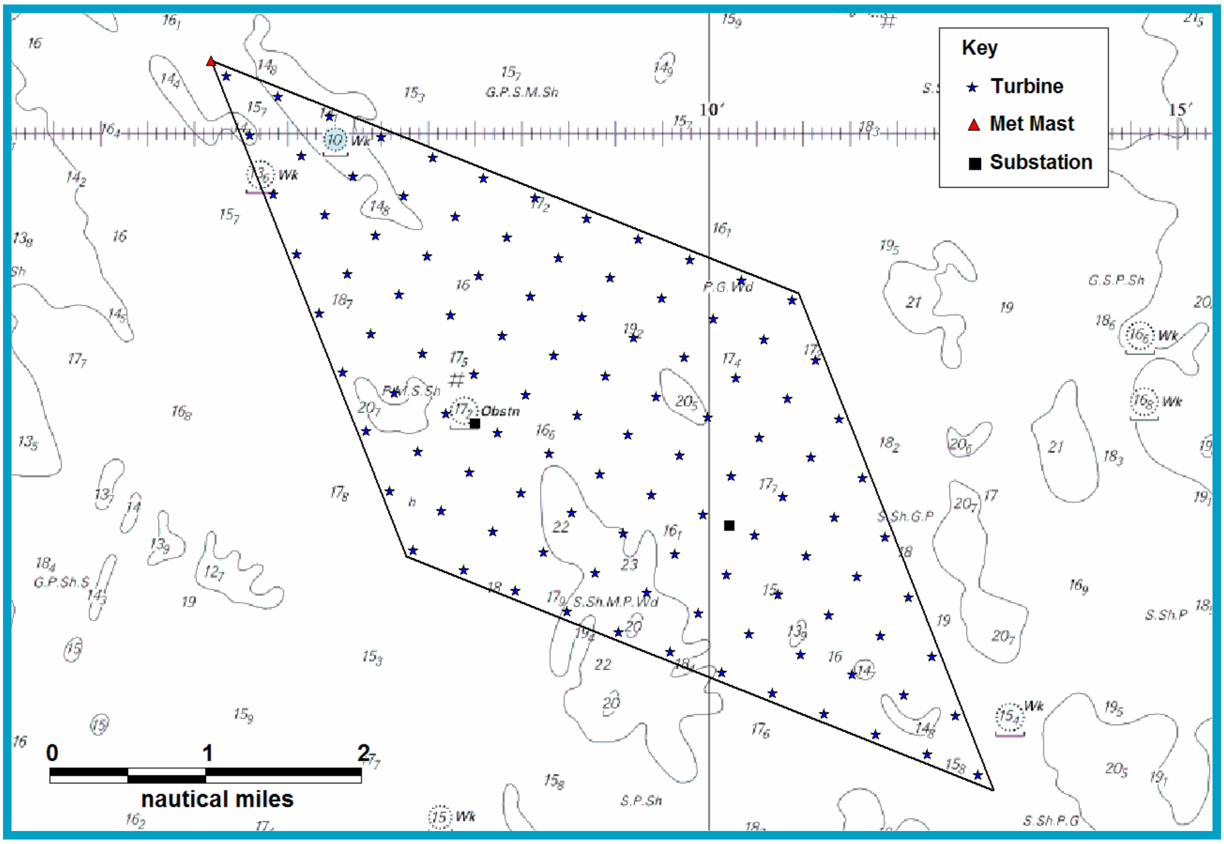


Figure 14.1 Layout of Sheringham Shoal OWF used within NRA (Worst case scenario)

14.2 Assessment Methodology

The assessment methodology adopted for the navigational impact study was in line with MGN 275(M). Work was also carried out to assess the cumulative and in-combination effects giving account to the Round 1 Norfolk Offshore Wind Farm (Cromer), which has already been given planning consent, and other known Round 2 applications in this area.

14.2.1 Data collection

A review of the existing environment was carried out to provide input into the navigational impact assessment. The following information was gathered:

- Local ports
- Anchorages
- Routeing measures
- Navigational aids
- Wrecks, Obstructions and Spoil Ground
- Oil and Gas developments
- Metocean characteristics

14.2.1.1 Existing databases and information

The key source data used in undertaking the NRA were as follows:

- UK Coastal Atlas (RYA, 2005)
- Commercial Fisheries Study (Scira, 2005)
- MAIB accident data (MAIB 2005)
- RNLI accident data (RNLI 2005)
- Dredging data – Crown Estate and British Marine Aggregate Producers Association (BMAPA)
- Search and Rescue (SAR) Framework
- MCA Draft wind farm Shipping Route Template (MCA, 2005)
- North Hoyle Trials (MCA 2004 and MCA 2005)
- Kentish Flats Trials (Port of London Authority 2005)
- www.maritimedata.co.uk developed by the Department of Trade and Industry (DTI)

14.2.1.2 Maritime Traffic Survey

A 28-day maritime traffic survey was carried out from the Cromer Lighthouse in two periods as follows:

- Wednesday 9 February to Friday 18 February 2005 (9 days)
- Saturday 8 October 2005 to Thursday 27 October 2005 (19 days)

Further data on shipping also considered within this NRA included a 5-day radar survey carried out between 18-24 August 2003 based at Trimingham and an additional 14 days of AIS survey data collected in the area over the period 27 May to 9 June 2005.

The 28-day dedicated survey was conducted 24 hours per day with the exception of the first and last days which were both half days. The radar was manned between approximately 07.00 and 22.00, with all targets acquired manually. During the manned period a visual lookout was maintained and observations were summarised in the logbook. During the unmanned period, radar targets were acquired automatically by defining an automatic acquisition area covering the area of interest. The AIS system tracked targets 24 hours per day during the survey period.

For the majority of time the radar display range scale was set to 24nm which facilitated the tracking of all targets in the surrounding area of the proposed wind farm site. The radar range varied based on conditions and target details but typically vessels were tracked up to 20nm from the survey location. The AIS system automatically tracked all targets within range, which again varied depending on conditions, but was typically 20-30nm which provided good coverage of the site which was at a range of around 10nm.

The radar and AIS data was combined into a single data set, with the AIS track being given priority when recorded by both systems as this tended to have greater range (92% of all vessels were tracked by AIS).

Detailed analysis of the vessel tracks passing within 15nm of the site boundary during the survey was undertaken, and the results are described in paragraph 14.3.1.

14.2.2 Hazard Review

A hazard review was carried out to identify reasonably foreseeable navigational possibilities by which the siting, construction, establishment and decommissioning of the wind farm could cause or contribute to an obstruction of, or danger to navigation. This concluded that the following vessel types required particular attention within the navigation risk assessment:

- Merchant vessels
- Fishing vessels
- Recreational vessels
- Dredging vessels

In addition, the risk of anchor or trawl gear interaction with subsea cables (intra-field and to shore) were identified for assessment.

14.2.3 Risk collision modelling

The basis of the risk assessment work conducted has been the COLLRISK modelling package (developed by Anatec UK Ltd). The model is calibrated with shipping data and accident statistics for up to 2005 and is the only model that runs with the ShipRoutes database. The package can be used to assess the change in risk associated with the wind farm for the main maritime users in this area.

14.2.4 Experts workshop

Finally, a workshop was held with a number of stakeholders and consultations were held with local fishermen. The report of the workshop is included in Appendix 14.1.

14.2.5 Impact assessment

Assessment of the environmental impact of the proposed wind farm on shipping and navigation has been assessed according to the methodology described in Section 1, Regulatory and Legislative Context. The significance level (negligible to major adverse or beneficial) of identified impacts are shown in **bold** in Sections 14.4 to 14.7 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, and/or relevant regulations and guidelines.

14.3 Description of the Existing Environment

14.3.1 Maritime Traffic Survey Results

Detailed analysis of the vessel tracks passing within 15nm of the site boundary during the dedicated 28-days radar survey (as described under 14.2.1.2) yielded the following results.

An average of 84 vessels per day were logged within this range. Figure 14.2 provides an overview of the tracks gathered during the 28 day period. Figure 14.3 provides a detailed view of the vessel tracks in relation to the project site.

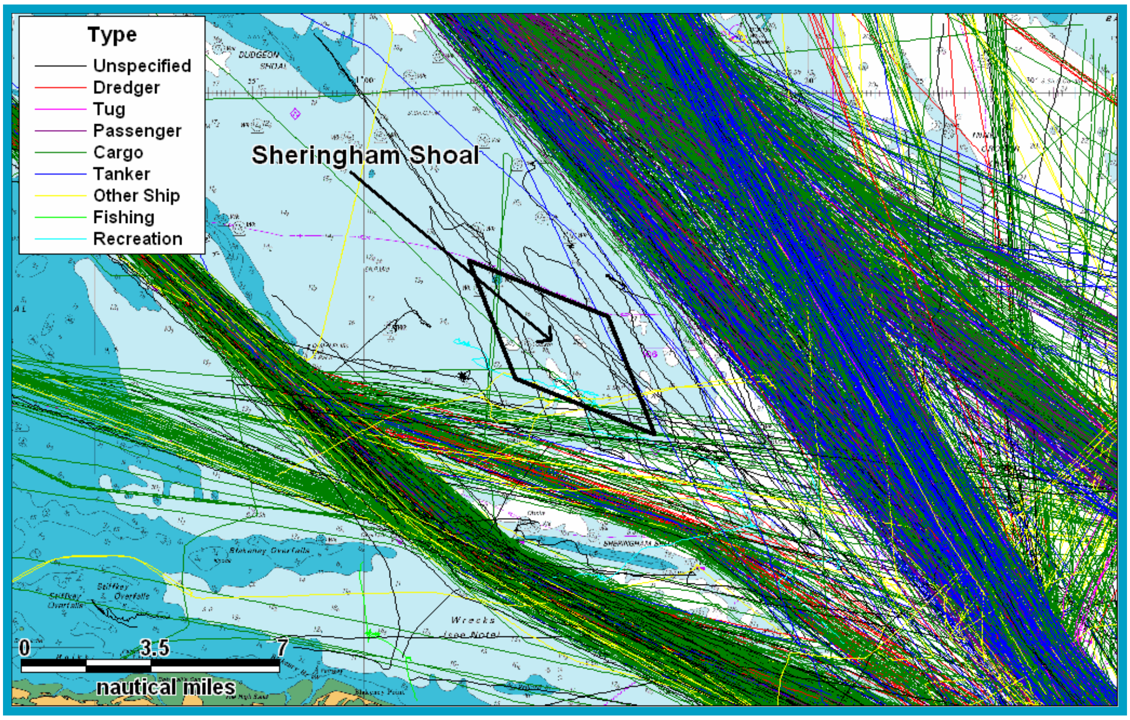


Figure 14.2 Overview of Tracks recorded during Survey (28 Days)

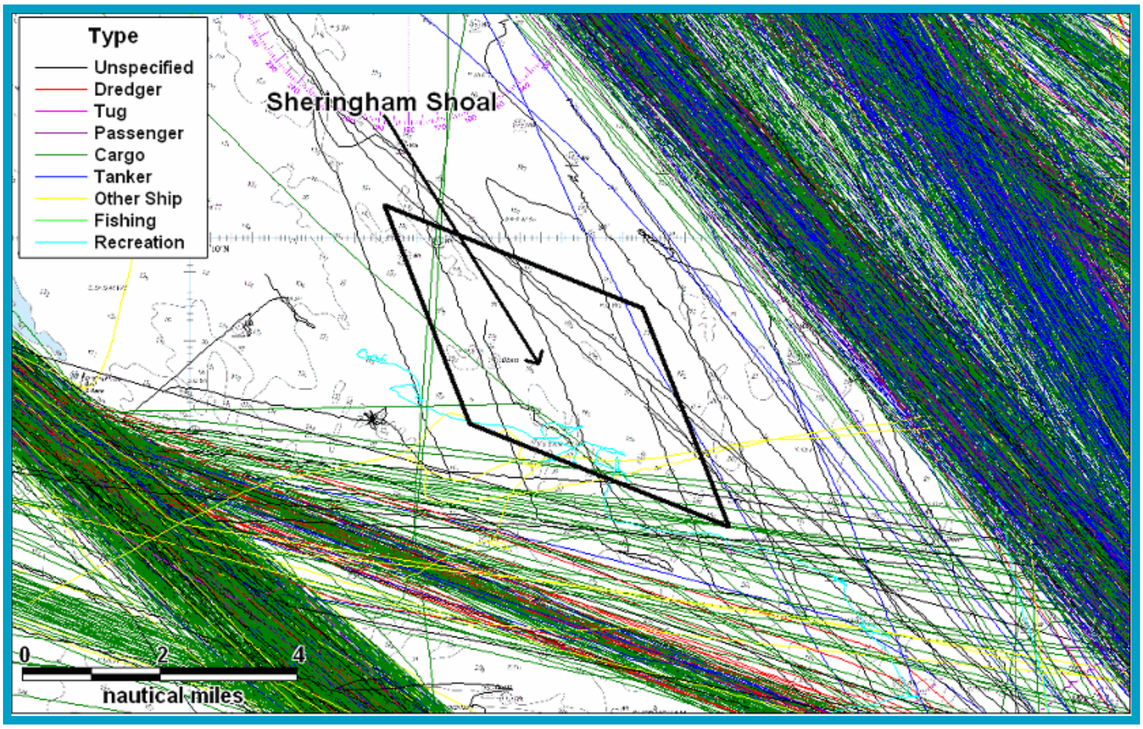


Figure 14.3 Detailed View of Tracks relative to Sheringham Shoal Offshore Wind Farm Site

A total of 20 tracks passed through the site over the 28 days of surveying corresponding to an average of 0.7 ships per day.

In addition to the 28-day survey, additional survey data was used as follows:

- 5-day radar survey carried out between 18-24 August 2003 based at Trimingham
- 14 days of AIS survey data collected in the area over the period 27 May to 9 June 2005.

Both these data sources corroborated the dedicated 28 day radar and AIS survey as indicated by Figure 14.4 and Figure 14.5.

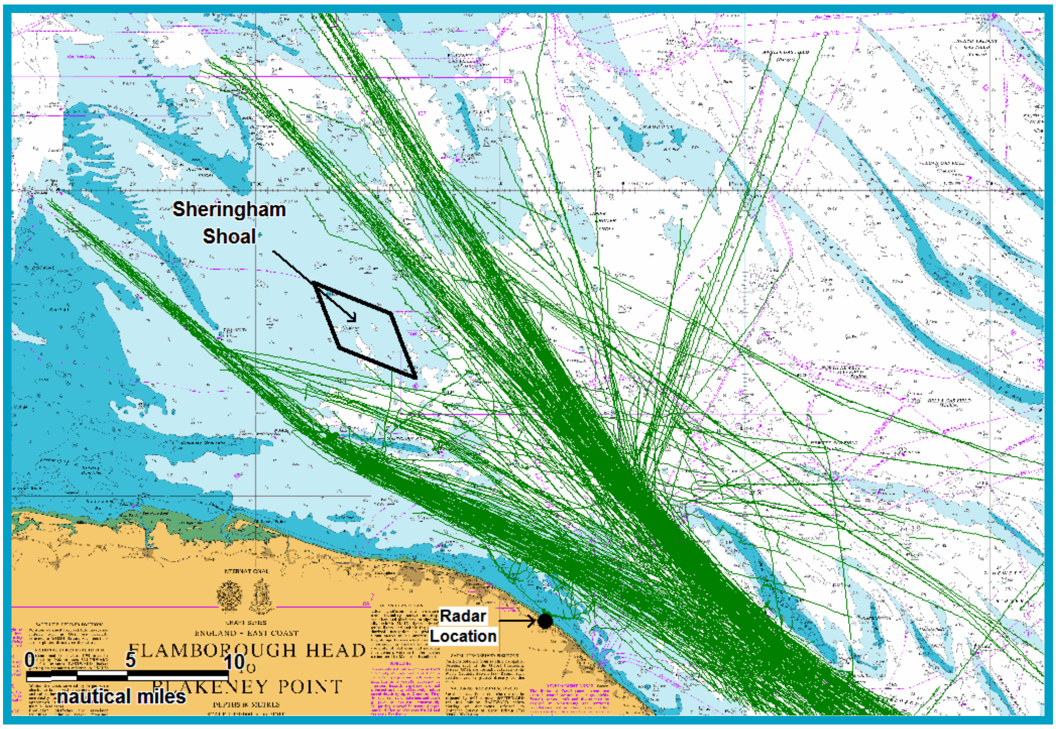


Figure 14.4 Tracks from 5-Day Survey carried out from 18-24 August 2003

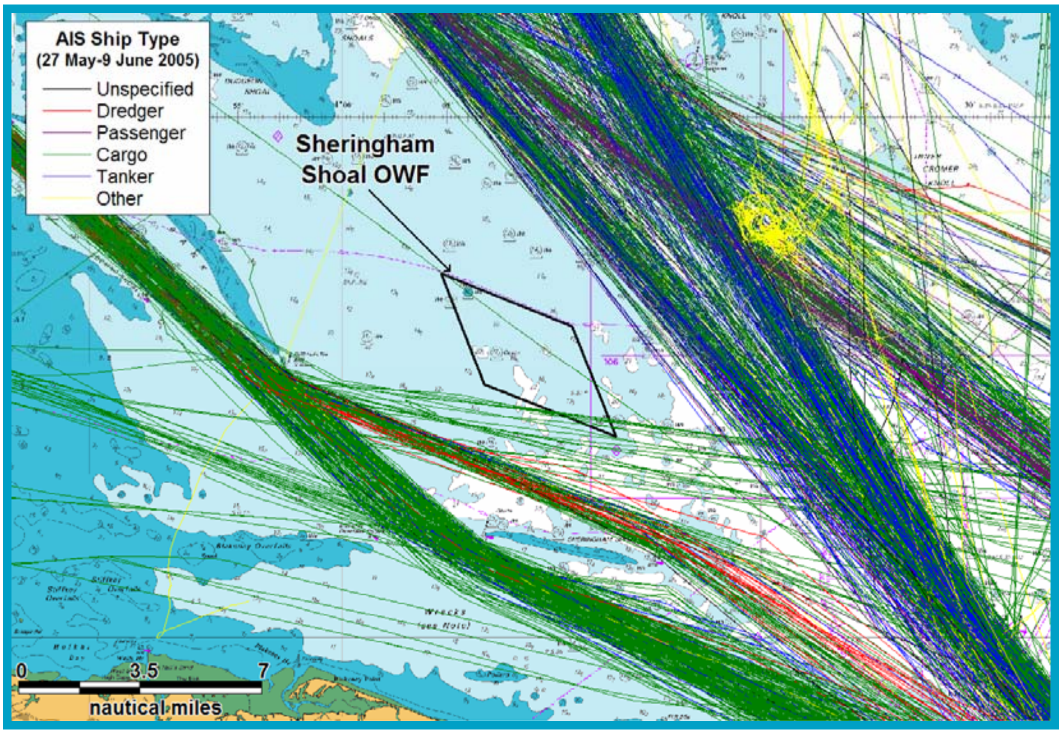


Figure 14.5 Tracks from Additional 14-Day AIS Survey

14.3.2 Description of Merchant Shipping Activities

The 28-day survey provided comprehensive information on the merchant vessel activity in the vicinity of the Sheringham Shoal site. Based on statistical analysis of the survey data, six main routes were identified passing the proposed site, as presented in Figure 14.6.

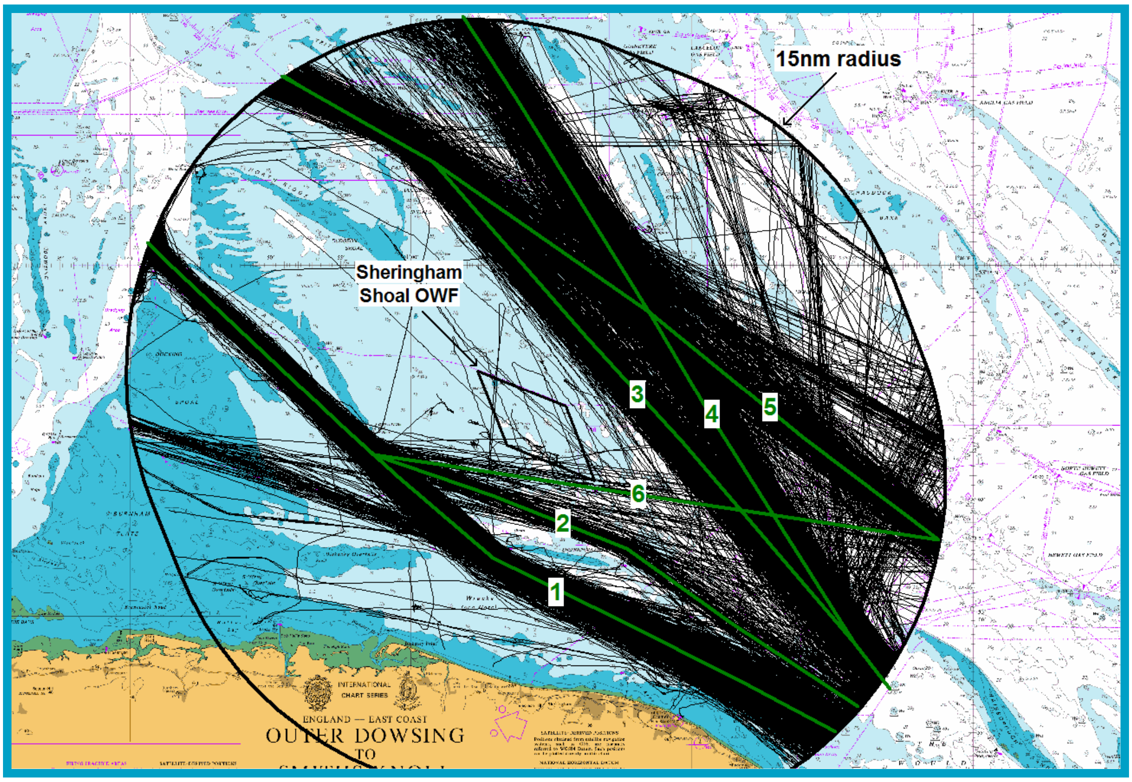


Figure 14.6 Main Routes passing Sheringham Shoal OWF Site

A description of the six main routes is presented below:

- Route 1 is used by vessels heading through the Race Bank Channel and The Would, passing to the south of the Sheringham Shoal and hence south and west of the proposed site. (It is noted this route splits to the west of the site with a minority of vessels taking a shorter route to/from The Wash via Docking Shoal.)
- Route 2 is similar to Route 1 as it is used by vessels passing through the Race Bank Channel and The Would, however, this traffic passes north of Sheringham Shoal and therefore passes closer to the southern edge of the proposed site.
- Route 3 is a NW/SE route to/from Humber which passes to the NE of the proposed site. This traffic also heads via The Would, inshore of Haisborough Sand.
- Route 4 is a NW/SE route through the Outer Dowsing Channel which passes to the NE of the proposed site. Like Route 3, this traffic heads via The Would, inshore of Haisborough Sand.
- Route 5 is a NW/SE route mainly heading to/from Humber which passes offshore (East) of Haisborough Sand and hence passes NE of the Sheringham Shoal OWF site.
- Route 6 is an East/West route heading between the south end of the Race Bank Channel and the channel between the Leman Bank and Smiths Knoll.

The Closest Points of Approach (CPAs) of the route centres to the wind farm site boundary are presented in Table 14.1, which also provides the estimated numbers of ships using the routes on a per annum and per day basis.

Table 14.1 Mean Position of Main Routes referenced from Site Boundary

Route ID	CPA	Bearing	Ships per Year	Ships per Day
1	4.0	224	8500	23
2	2.2	200	1620	4
3	2.6	52	6712	18
4	5.1	62	7274	20
5	5.3	34	5500	15
6	0.3	189	404	1

The widths of the routes were also calculated to provide an indication of the behaviour of shipping in this area. An illustration of the lane widths containing 90% of the shipping on each route is presented below. This illustrates that the majority of the traffic within the 90% limits tended to navigate well clear of the proposed wind farm location, the only exception being route 6 which clips the Southeast corner.

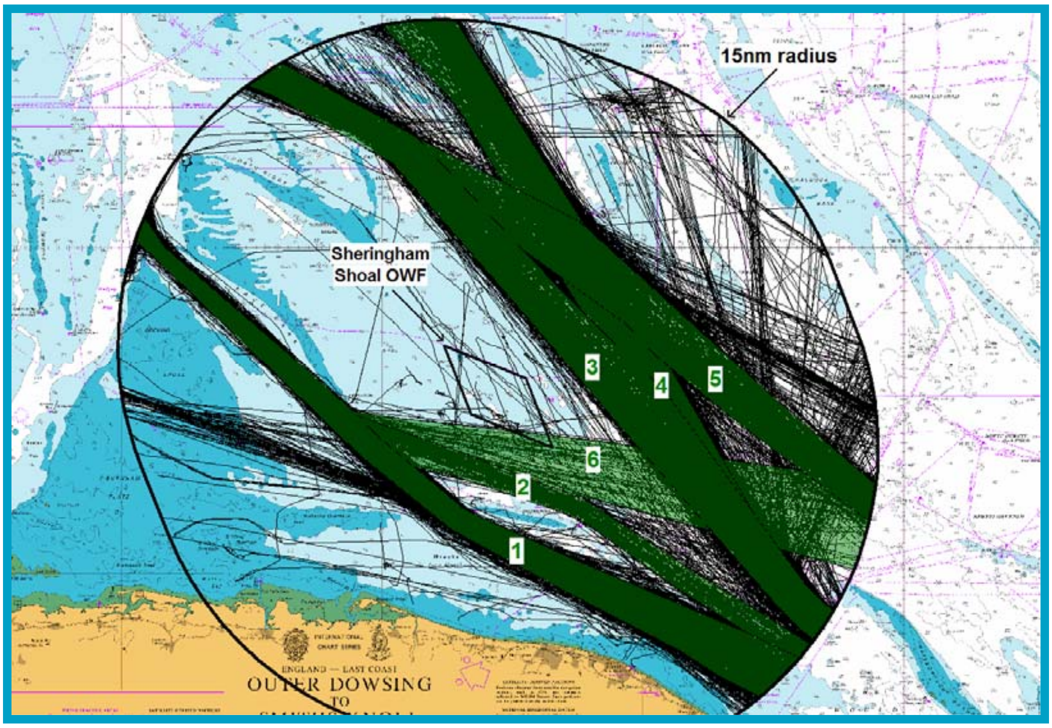


Figure 14.7 90% Lanes overlaid on Survey Tracks

14.3.3 Description of Fishing Activities

The 28-day maritime traffic survey indicated limited fishing in the area mainly by small inshore vessels. A more detailed assessment of fishing activity levels in the area of the Sheringham Shoal wind farm site was carried out in the separate commercial fisheries study (Scira 2005) which used a variety of data sources including:

- Meetings and consultation with local fishermen's organisations, inspectors and harbour masters.
- Observer trips onboard local vessels.
- Landings, effort and value data by ICES rectangle for the years 2000-04 as collated by DEFRA for the ICES rectangles covering the overall study area.
- Sea Fisheries Inspectorate Surveillance data.

This study indicated that the wind farm site does not encompass primary fishing grounds (see Figure 14.8) with the main fishing activity within the wind farm area being predominantly by local North Norfolk based boats with occasional activity from Lowestoft long-liners.

The study concluded that based on the available evidence there is little scope for any substantial increase in the numbers of locally based vessels or in their fishing effort or landings. Similarly there is sufficient stability and long term commitment amongst the local potting fleet to suggest that there is unlikely to be any dramatic decline in vessel numbers or effort levels within the foreseeable future.

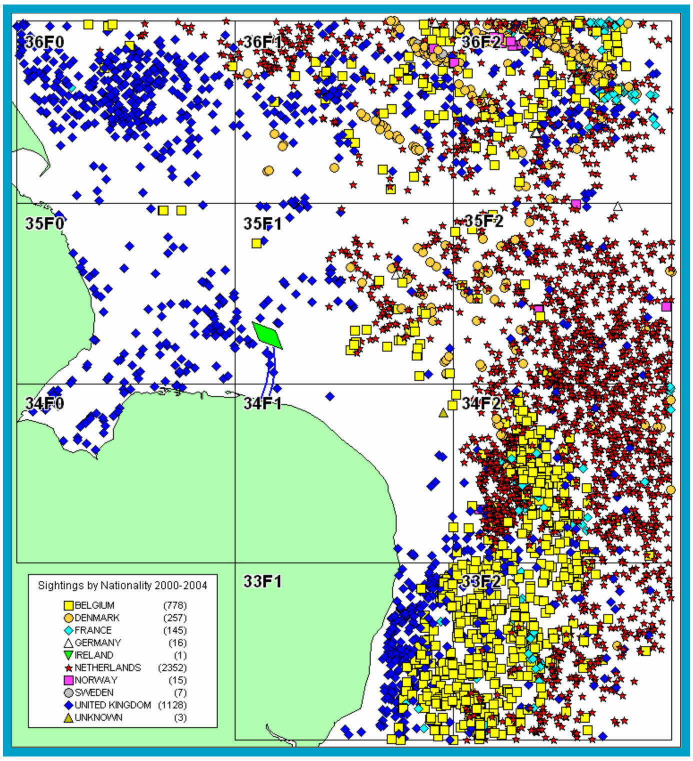


Figure 14.8 Surveillance Sightings in vicinity of Site (2000-04)

14.3.4 Description of Recreational Vessel Activities

Recreational activities were assessed based on the radar tracking and visual observation made during the 28-day maritime traffic survey. From these sources it was established that there were low levels of recreational activity in this area during the period of the survey. To assess the effects of seasonal variation and lower performance of radar tracking of small vessels at range, consultation was held with the Royal Yachting Association (RYA) and Cruising Association (CA) to gather further data.

The RYA, supported by the CA, have identified recreational vessel activity and facilities in the Greater Wash area. Based on the information received and discussion held, it was identified that the proposed wind farm site is outside of the main sailing areas and cruising routes but is partially within a racing area. Wells next-the-Sea is the largest harbour in the area used by locals and visiting yachts. Wells Sailing Club is the nearest club to the site (14nm Southwest of the site) and organises both dinghy and yacht racing. The nearest training centre is Blakeney Point Sailing School (11nm South Southwest of the site).

The recreational activities and facilities in the area are summarised in Figure 14.9.

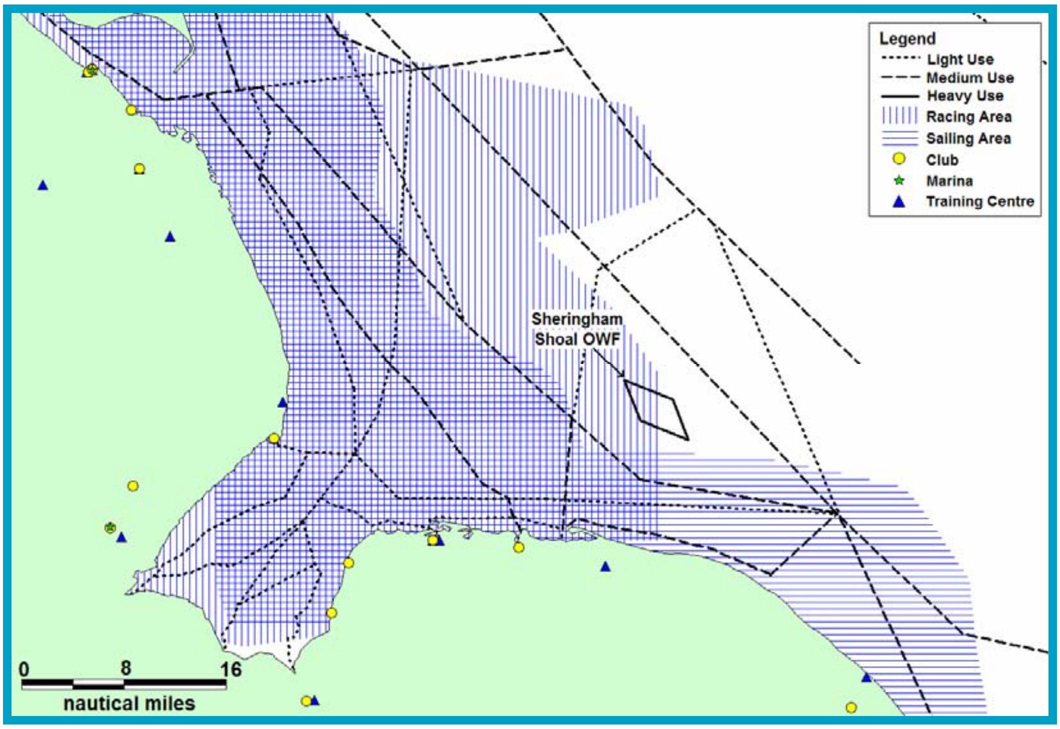


Figure 14.9 Recreational Information for Sheringham Shoal Offshore Wind Farm Area

14.3.5 Description of Dredging Activities

It was observed from the 28-day survey that dredging vessels mainly passed to the south of the wind farm site, either side of the Sheringham Shoal and in avoidance of other shallows in this area such as the Race Bank.

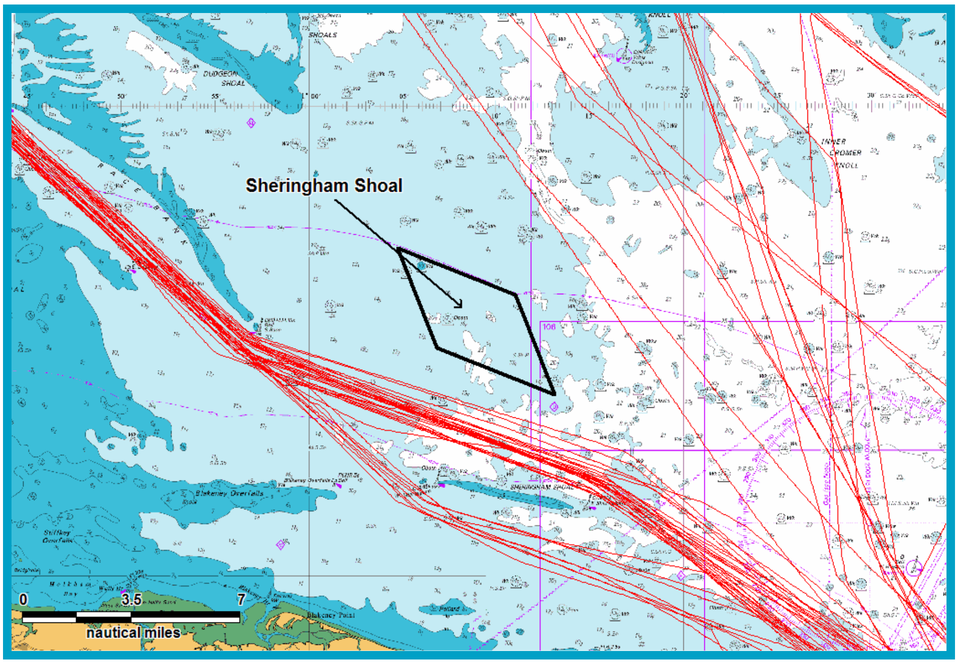


Figure 14.10 Dredging tracks based on the Traffic Survey (28 Days)

Further information was also obtained from BMAPA and Crown Estate on the levels of activity in this area (see Figure 14.11). This highlights the dredging license areas (red borders) and the current active dredge areas (red shaded regions) in the Humber region relative to the Sheringham Shoal wind farm. The dredging routes identified by the companies are shown as green lines and again indicate that these vessels tend naturally to avoid the project location.

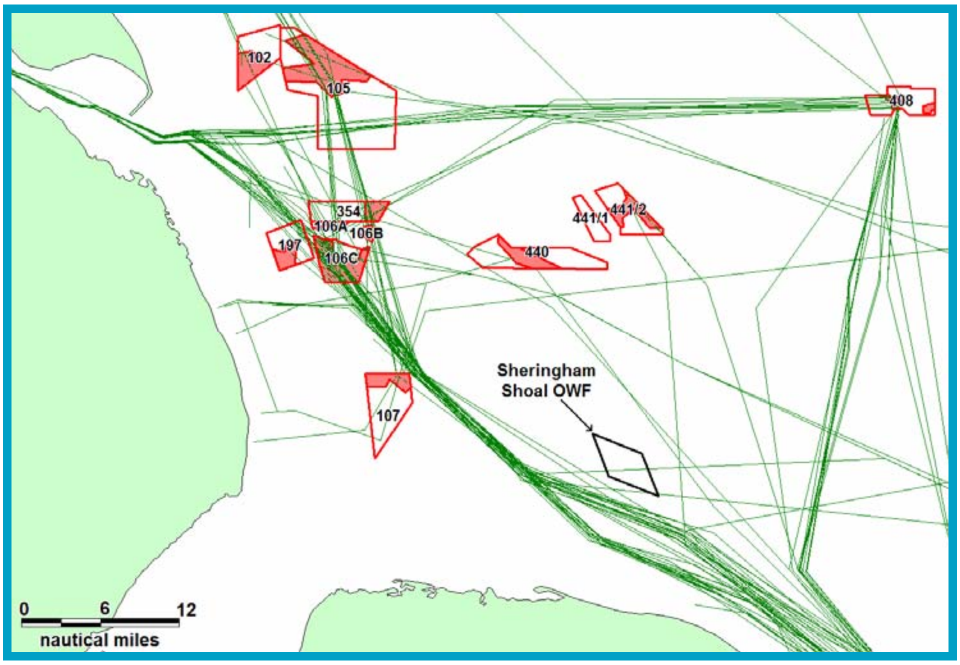


Figure 14.11 Dredging Data from BMAPA and The Crown Estates

Only two dredger transit routes were observed to pass through the proposed site using this data. Both vessel tracks were associated with a Hanson vessel en route between Licence Area 106 and Amsterdam but it is considered these vessels could equally have followed route 6.

14.4 Impacts During Construction

During the construction phase there would be an increased level of vessel activity within the wind farm area and along the proposed cable routes.

The presence of construction vessels within the area is likely to pose an additional navigational risk. To ensure that the personnel carrying out these activities and those navigating in this sea area are not exposed to unnecessary risk, 500m temporary avoidance areas will be established around all working vessels and notified to mariners during these phases of the development in addition to permanent 500m safety zones around all offshore wind farm structures. These measures would provide a means of hazard warning during construction activities so as to secure the safety of those working in the wind farm and those onboard other vessels that may be navigating in the area. These temporary avoidance areas and permanent safety zones will apply to all vessel types not involved in the wind farm operations.

There would also be a number of additional vessel movements to the operations centres in order to supply and re-crew the operations. All marine traffic movements will be carried out in accordance with good practice and managed so as to minimise any disruption or risk to existing marine traffic and fishing activities. Both structures and vessels will be equipped with navigational aids in accordance with Trinity House recommendations. The presence, number and type of construction vessels will also be advertised via Notice to Mariners prior to construction activities on the site commencing.

Hazard workshops and/or risk assessments will be carried out as part of the project-planning process to further manage the risks during this phase of the development. These tasks will be used to identify the hazards associated with the construction activities, rank them appropriately with the aim of identifying mitigation measures and operating procedures.

The suggested composition for the workshops is as follows:

- Project Team
- Contractor Representatives (barges, cable-laying, etc.)
- Local Port Representatives
- Coastguard (MCA)
- Fishing Representative
- Yachting Representative
- RNLI Representative

This process will build mutual understanding of the activities and operating constraints of the different parties involved and allow effective procedures to be developed. Separate workshops should be held for each phase of the project as well as for distinct activities.

The construction company appointed will have its own internal Health and Safety procedures that they will adhere to during the work, providing additional security. It is also industry good practice that experience and lessons learned from the construction of other offshore wind farm sites be considered prior to Sheringham Shoal being constructed.

Presuming the successful incorporation of the outlined mitigation measures, a **moderate adverse impact** is envisaged to occur during the 1 to 2 years construction period.

14.5 Impacts During Operation

14.5.1 Impact on Merchant Vessel Navigation

Based on the findings of this work it is concluded that the Sheringham Shoal offshore wind farm in isolation would have a **minor adverse** impact on shipping navigation, with only a proportion of the ships using Route 6 (total volume of 1.1 per day on average) altering their passage in order to increase their clearance from the south of the wind farm perimeter. There is sea room available to the south of the site for this action to take place.

Based on Anatec's experience of assessing the impact on navigation of numerous offshore developments, it is anticipated that the mean position of this route from the site boundary would increase from 0.3nm to approximately 1.5nm. The route is also expected to narrow slightly as the vessels that currently pass through the site will also mark their position to the south of the site.

An illustration of the revised lanes based on the Sheringham Shoal offshore wind farm development in isolation is presented in Figure 14.12.

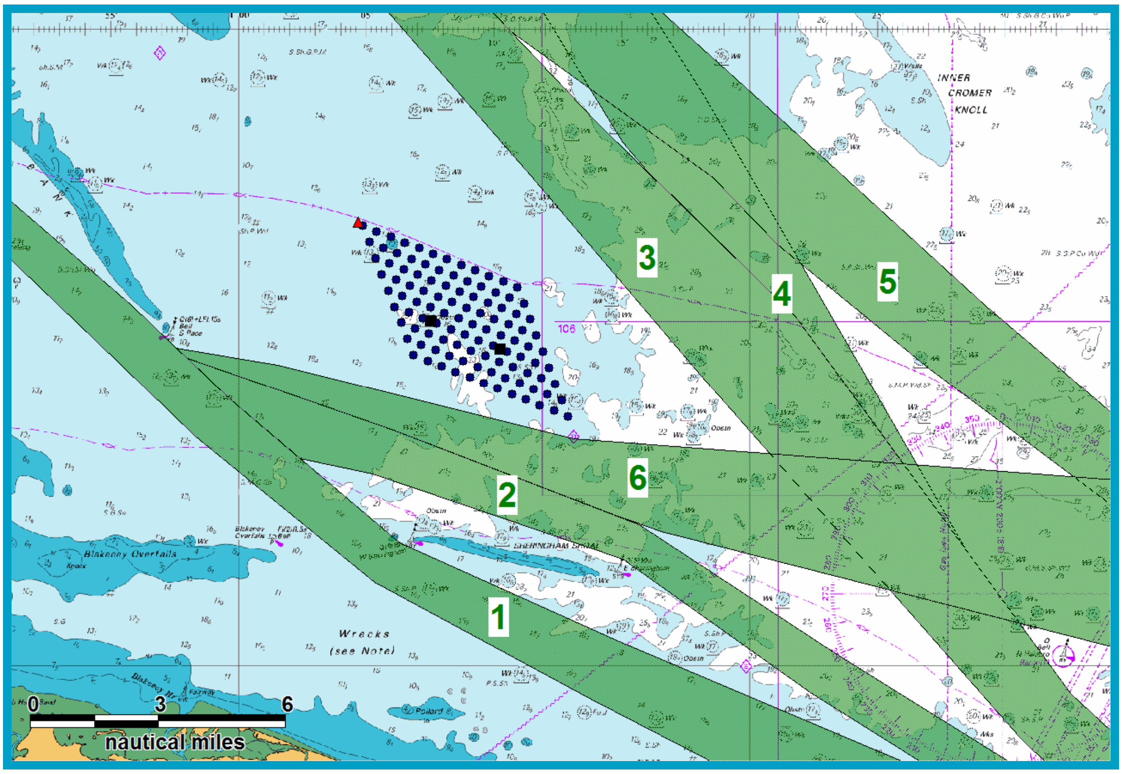


Figure 14.12 Anticipated Impact of Sheringham Shoal OWF in Isolation

These conclusions are confirmed by the risk assessment which had the following key results:

- Based on the anticipated change in routeing pattern (cumulative impact including Cromer site), the increase in the baseline risk level in terms of serious vessel-to-vessel collisions in the area within 15nm of the site was estimated to be 1.4%, corresponding to an additional one collision in 245 years on average.
- The frequency of passing powered ship collision was estimated to be 1 in 2,000 years which is close to the historical average for offshore installations in the UK. The turbines in the southeast corner of the array were identified to be most at risk as these have the highest exposure to close-passing shipping routes.

- The frequency of passing drifting ship collision was also assessed to be low at 1 in 3,800 years. As with powered collisions, the turbines towards the southeast corner of the array were identified to be most at risk as a vessel breaking down when passing south of the wind farm would be liable to drift towards the structures under the influence of the wind.

14.5.2 Impact on Fishing Vessel Navigation

Based on the best available data it was concluded that the overall impact of the wind farm on fishing activity would be **minor adverse** as there was limited activity levels within or around the proposed wind farm area. This is supported by the commercial fisheries study which indicated that the wind farm site does not encompass primary fishing grounds with the main fishing activity within the wind farm area being predominantly by local North Norfolk based boats with occasional activity from Lowestoft long-liners.

Based on the fisheries study it was also identified that there is little scope for any substantial increase in the numbers of locally based vessels or in their fishing effort or landings. Similarly there is sufficient stability and long term commitment amongst the local potting fleet to suggest that there is unlikely to be any dramatic decline in vessel numbers or effort levels within the foreseeable future. Therefore the low impact of the wind farm will be relatively consistent over time.

Assuming that the fishing activity in the area would remain constant after the development, the frequency of fishing vessel collisions with the wind farm structures was assessed to be in the order of 1 in 5,000 years.

14.5.3 Impact on Recreational Vessel Navigation

The risks associated with recreational craft interaction with the Sheringham Shoal structures (blade/mast and vessel/structure collisions) were qualitatively assessed and overall the impact was concluded to be **minor adverse** given the mitigation measures which will be implemented. The main mitigation measure is ensuring the minimum rotor blade clearance for the Sheringham Shoal turbines is 22m above Mean High Water Springs (MHWS), which meets the MCA requirement laid out in MGN 275 as well as the recommendations of RYA. Other mitigation measures include the provision of navigational aids in accordance with Trinity House requirements as well as a notification to the Hydrographic Office so that the wind farm structures are marked navigation charts of the area.

14.5.4 Impact on Dredging Vessel Navigation

It was identified that dredging activities were not conducted in proximity to the wind farm site and therefore overall the impact would be **negligible**. Dredgers on passage through the area were treated as cargo vessels and included within the merchant vessel assessment.

14.5.5 Impact on Sub-sea Cables

It is assumed the cable will be suitably protected for the sea bed conditions and fishing activity in the area through burial to a safe depth, currently estimated to be between 1-3m, and periodic inspection and maintenance to ensure it remains buried to the required minimum depth.

There are no designated ship anchoring areas in the vicinity; therefore the main risk is considered to be if a ship were to anchor over the export cable in an emergency, such as in stress of weather. The relatively small merchant vessels that pass to the south of the site are unlikely to have anchors that penetrate more than 1m. Similarly, the anchors of small fishing and recreation vessels are unlikely to have the potential to penetrate 1m below the sea bed. As the cable will be buried and marked on Admiralty Charts the risk of anchor snagging is considered to be **negligible**.

The fisheries study (Scira 2005) concluded that the majority of the fishing activity along the cable corridor is potting, with occasional activity by other methods, mainly by local vessels based at Sheringham, Cromer, Wells and Blakeney. There was very little trawling activity in the area.

As a result, during the operational phases, it was not expected that there would be any significant impact on commercial fishing activity from the export cables. The overall effect is therefore categorised as **negligible**.

14.5.6 Impact on Visual Navigation and Collision Avoidance

The impact of the wind farm on visual navigation and collision avoidance was found to be **minor adverse**. The main impact was identified to be associated with a crossing encounter involving the minor route passing to the south of the wind farm (see Figure 14.13). Analysis showed there was significant sea room for this to be navigated in a safe manner. It was also identified to be a low frequency scenario based on the results of the vessel-to-vessel encounter assessment.

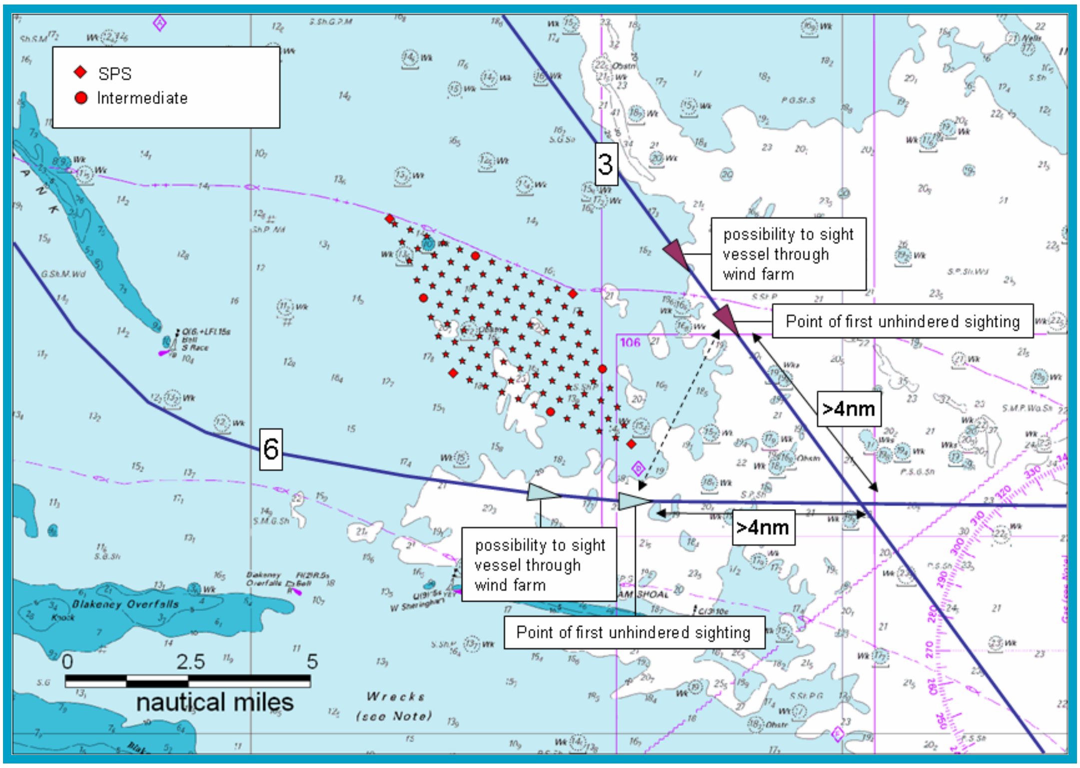


Figure 14.13 Assessment of Visual Navigation Impacts

The wind farm was not found to impact on the ability of vessels to sight navigational aids in this area, including the Cromer lighthouse.

14.5.7 Impact on Communications, Radar and Positioning Systems

An assessment was carried out of the potential effects of the proposed development on communications, radar and positioning systems based on recent trials conducted by the MCA (MCA 2005).

It was identified that there would be minimal impact on Very High Frequency (VHF) radio, Global Positioning Systems (GPS) receivers, cellular telephones, and Automatic Identification Systems (AIS). As with any similar obstruction, UHF (and microwave) systems would suffer from masking if turbines were within the line of sight transmissions.

It was also identified that the turbines themselves would present clear and readily identifiable radar returns from distance giving mariners unambiguous and early warning of the presence of the turbines.

Based on current understanding, the impact of the turbines on radar was considered to be **minor adverse** as the vast majority of vessels would pass more than 1.5nm from the edge of the wind farm, which is the approximate onset range for radar interference. In terms of regular shipping, only one minor route would pass within this range and currently accounts for about 404 vessels per annum. It is anticipated that mariners would alter course slightly to the south of the site, passing approximately 1.5-2nm from the nearest turbines. There would be ample sea to accommodate this natural avoidance action. It is also noted that the risk of visual obscuration was assessed to be **minor adverse** giving account to the probability of visibility less than 1km for this area being relatively low at 1.2% of the year. However, as it is recognised that there is uncertainty surrounding the radar impact issue and there are current trials planned to investigate this further, the overall impact level is concluded to be **moderate adverse**, pending receipt of further information.

Figure 14.14 provides an overview of the 108 turbine layout with perimeter range rings to illustrate that the vessels already tend naturally to avoid the development location as they avoid existing shallow waters in this area.

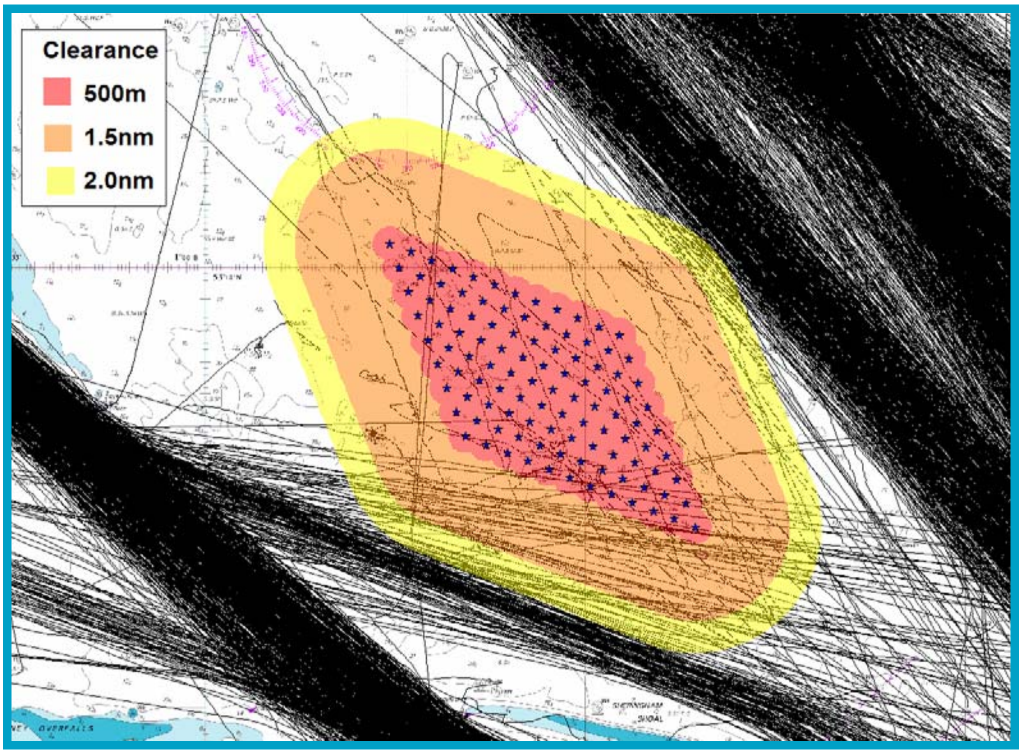


Figure 14.14 Assessment of Impact on Radar

14.5.8 Impact on Search and Rescue Operations

As required by MGN 275 (M) a review of the potential impact of the proposed development on search and rescue (SAR) operations was carried out. This was based on data received from the Marine Accident Investigation Branch (MAIB) and Royal National Lifeboat Institution (RNLI). Both data sets indicated that historically the levels of response in this area tended to be low (see Figure 14.15 and Fugure 14.16.

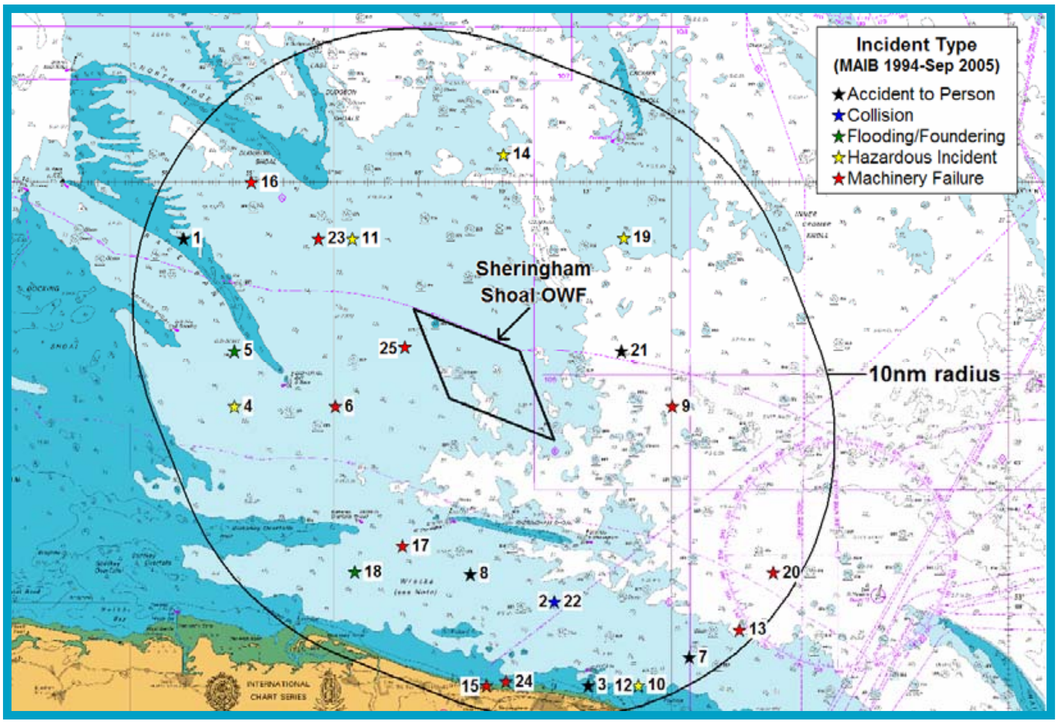


Figure 14.15 MAIB Incident Locations by Type within 10nm (1994-Sep 20005)

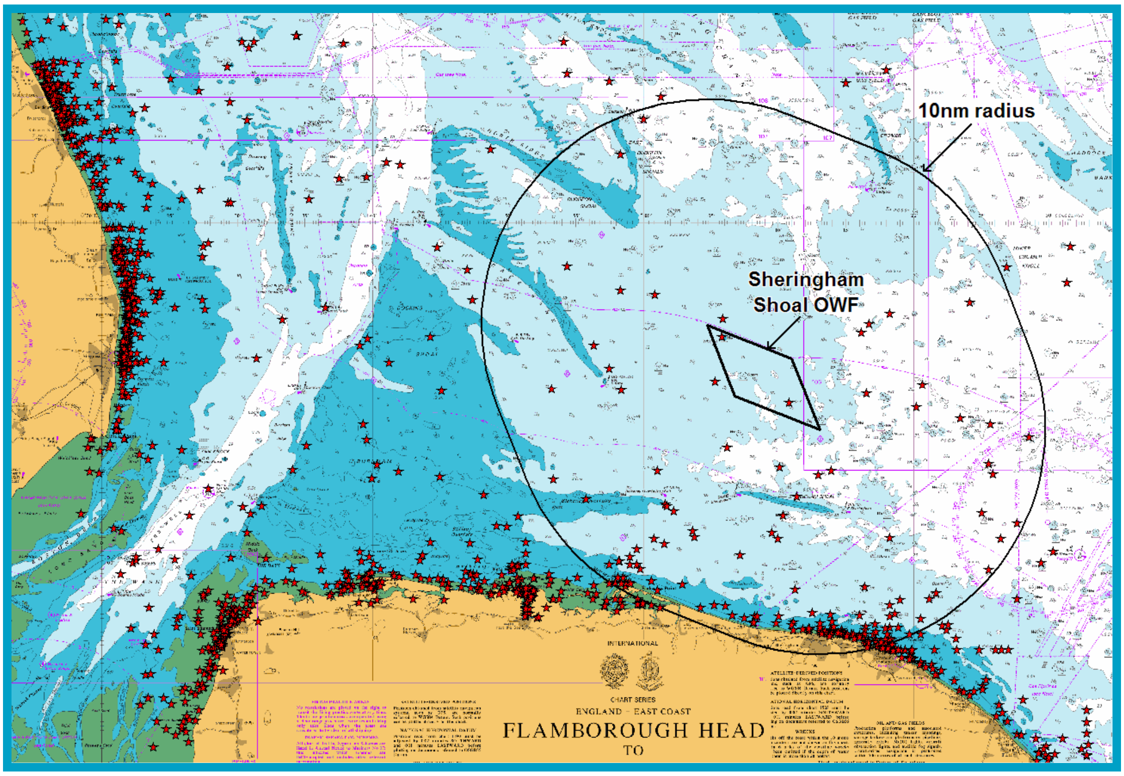


Figure 14.16 RNLI Launches 1995-2004 in Greater Wash Area

A review of the assets in the area of the wind farm site indicated that the closest SAR helicopter bases are located at Leconfield and Wattisham which are operated by the RAF (see Figure 14.17). These bases have Sea King helicopters with a maximum endurance of 6 hours giving a radius of action of approximately 300nm which is well within the range of the Sheringham Shoal wind farm. At each of these locations, one helicopter is available at 15 minutes readiness between 0800 and 2200 hours, with another available at 60 minutes readiness between 0800 hours and evening civil twilight (ECT). Between 2200 and 0800 hours, one helicopter is held at 45 minutes readiness.

All RAF SAR helicopters are equipped for full day/night all weather operations over land and sea (some limitations exist with regard to freezing conditions, but in general terms the helicopters are all weather capable) and have a full night vision goggle (NVG) capability. Crews are well practised in NVG operations which is a major enhancement to search capability. In addition, all RAF SAR helicopter rear crew are medically trained, with the winchman trained up to paramedic standard.

Up to 18 persons can be carried, however this is dependent on weather conditions and the distance of the incident from the helicopter's operating base. All RAF SAR helicopters are equipped with VHF (Marine and Air Band), UHF, HF and Mountain Rescue radios. They are also capable of homing to all international distress frequencies.

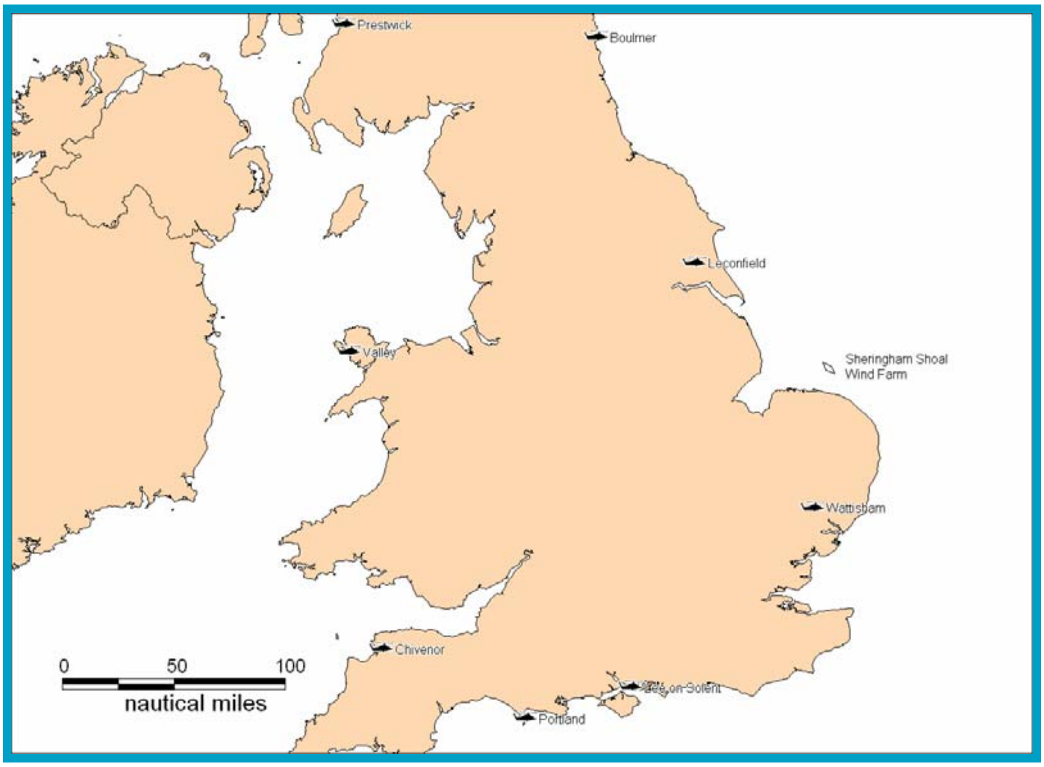


Figure 14.17 SAR Helicopter Bases in relation to Sheringham Shoal Wind Farm

Table 14.2 Nearby SAR Helicopters.

Base	Operator	Type	Response		Range (nm)	Speed (kts)	Capacity (persons)	Range to OWF
			Day	Night				
Leconfield	RAF	Sea King	15	45	300	110	18	72nm
Wattisham	RAF	Sea King	15	45	300	110	18	61nm

Based on the information presented above (see Table 14.2), the day-time response to the wind farm would be approximately 50 minutes from Wattisham and 55 minutes from Leconfield. At night time this would increase by 30 minutes in each case due to the additional response time at the base. It is noted that these calculations are based on still air and would vary depending on the prevailing conditions.

A similar review of the RNLI stations was conducted which identified that those nearest to the Sheringham Shoal Offshore Wind Farm development are as follows:

- Wells
- Sheringham
- Cromer

The locations of each are presented in Figure 14.18 which also highlight other nearby stations.

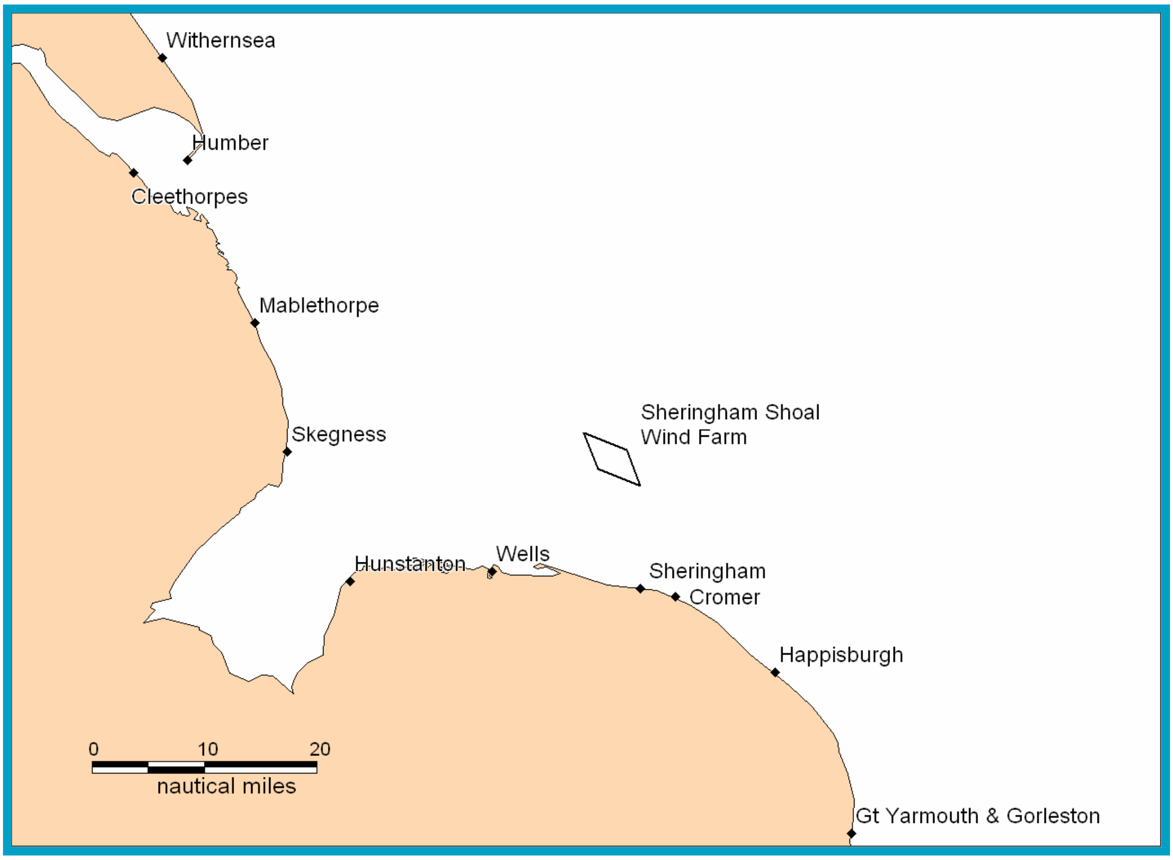


Figure 14.18 RNLI Bases in Proximity to the Sheringham Shoal Wind Farm

At each of these stations crew and lifeboats are available on a 24-hour basis throughout the year.

The Sheringham RNLI station is soon to upgrade from their Atlantic 75 to an Atlantic 85 with a top speed of 35-40 knots. On the basis of 30 knots they anticipate a response time of 30 minutes to the site. It was noted during consultation with the Sheringham RNLI that their lifeboat response is serviceable in all weather conditions.

The Cromer RNLI station has a 47ft Tyne ALB and a D Class ILB. The 47ft Tyne has an average speed of 17 knots and can be launched from the pier at Cromer using their tipping cradle. The Cromer ALB is serviceable in all weather conditions (6 to 10 minutes launch) for responding to emergencies giving a total response time in the order of 1 hour. Recovery of the vessel up the slipway in heavy weather is difficult and in these conditions the boat tends to return to Wells or Great Yarmouth. The D Class ILB at Cromer is not suited for response to the wind farm.

At some time in 2006, the ALB at Cromer is to be upgraded to a Tamar type boat which would have a speed in the order of 25 knots improving the response time by around 15 minutes, to 45 minutes.

The RNLI at Wells has a 12m Mersey Class ALB and a D Class ILB. The ALB has a range of 140 nautical miles and a speed in the order of 16 knots. The vessel is kept on a launching carriage and in sufficient tide can be launched in around 6 to 10 minutes giving a response time of approximately 1 hour. If response is required when the tide is out, this time can increase in the order of 20 to 30 minutes giving an estimated response time of 1.5 hours to the site. The D Class ILB at Wells is not suited for response to the wind farm.

The following table provides a summary of the information received from the RNLI on the lifeboats at each of the nearby stations.

Table 14.3 Lifeboats held at Nearby RNLI Stations.

Station	Asset Details	ALB	ILB	Distance to Centre of Farm	Typical response time
Sheringham	ILB	--	A75 [1]	11.5 nm	30 mins
Cromer	ALB & ILB	47 ft Tyne [2]	D	13.5 nm	1 hr
Wells	ALB & ILB	12 m Mersey	D	14.5 nm	1 hr or 1.5 hrs when tide is out

Based on this assessment work it was concluded that the overall impact on search and rescue was limited although it was highlighted that the issue of remotely locking the blades in a “Y” position for helicopter search and rescue response requires to be resolved during turbine design. This relates to the recovery of personnel requiring rescue (this includes those employed in the wind farm as well as members of the public). Discussions on this topic are ongoing within the industry and Scira is actively participating in them.

14.6 Impacts During Decommissioning

Through assessment it was identified that the impact during decommissioning of the wind farm would be similar to those associated with construction activities and on this basis they would be managed in a similar manner in both these phases.

14.7 Cumulative Effects

The cumulative effect of other wind farm developments in the area was also assessed as part of this Navigation Risk Assessment. Within this process, consideration was given to the wind farm sites presented in Table 14.4 and Figure 14.19.

Table 14.4 Other Proposed Greater Wash Wind Farms.

Name	Round	Distance (nm)
Cromer	1	6.3
Docking Shoal	2	7.2
Race Bank	2	11.0
Lincs	2	20.1
Lynn	1	21.3
Inner Dowsing	1	22.2

Triton Knoll and Dudgeon East wind farms have not been included in this assessment as the status of these projects is still under discussion with The Crown Estate.

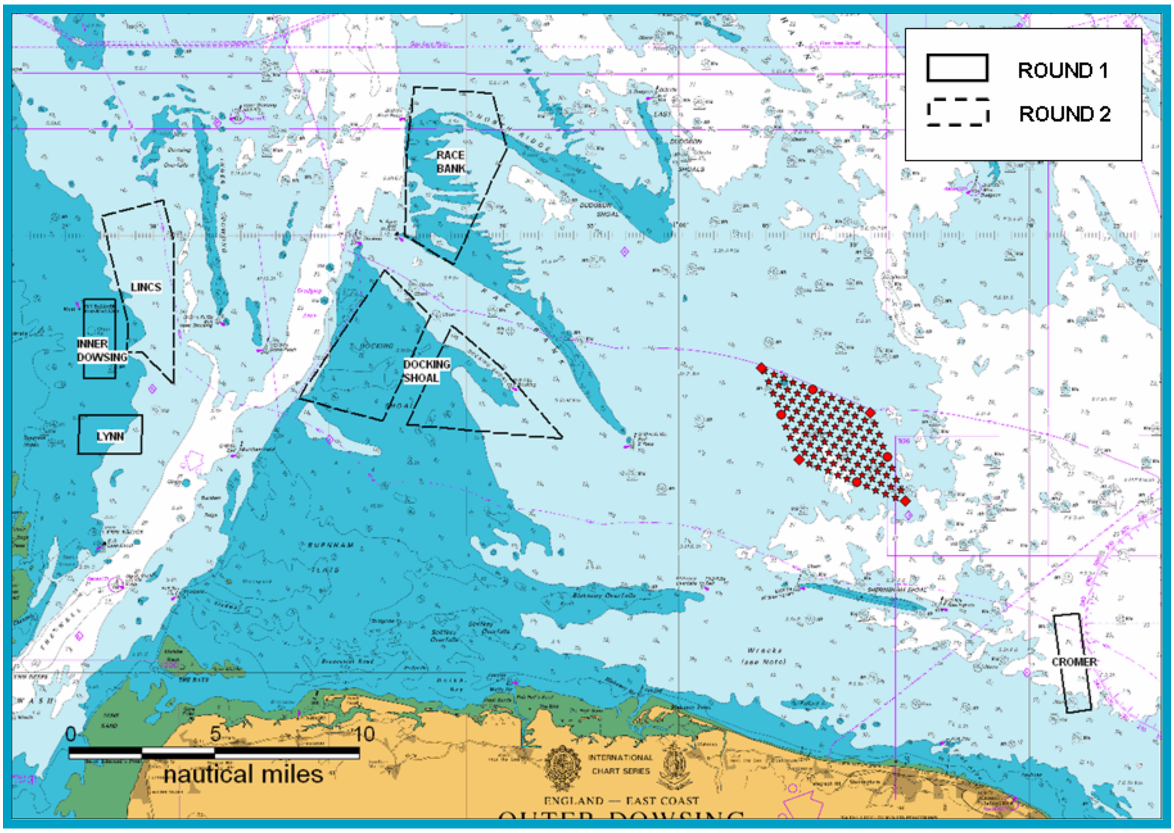


Figure 14.19 Wind Farm Boundaries in Greater Wash SEA

From this work it was concluded that due to the distance from the round 1 Cromer site and the known round 2 wind farms in this area to the Sheringham wind farm area, the cumulative effects were likely to be limited. This conclusion is based on the MCA Shipping Route Template (MCA 2005) which indicates that adjacent wind farms would only begin to have cumulative impacts when within 5nm of a proposed site.

However, the conclusion is further based on the understanding that the vessels passing the Sheringham Shoal wind farm already tend to avoid a number of the other proposed wind farm sites as they avoid the shallows in this area, e.g. Docking Shoal and Race Bank.

The main cumulative impact would relate to the displacement of Route 2 which is as a result of the construction of the Cromer wind farm. Further assessment of this indicated that vessels on this route can either adopt a more coastal route (Route 1) or move to the North to pass between both sites with mean passing distances of 1.5 - 2nm as indicated in Figure 14.20. It is noted that this impact would occur independently of the Sheringham Shoal development.

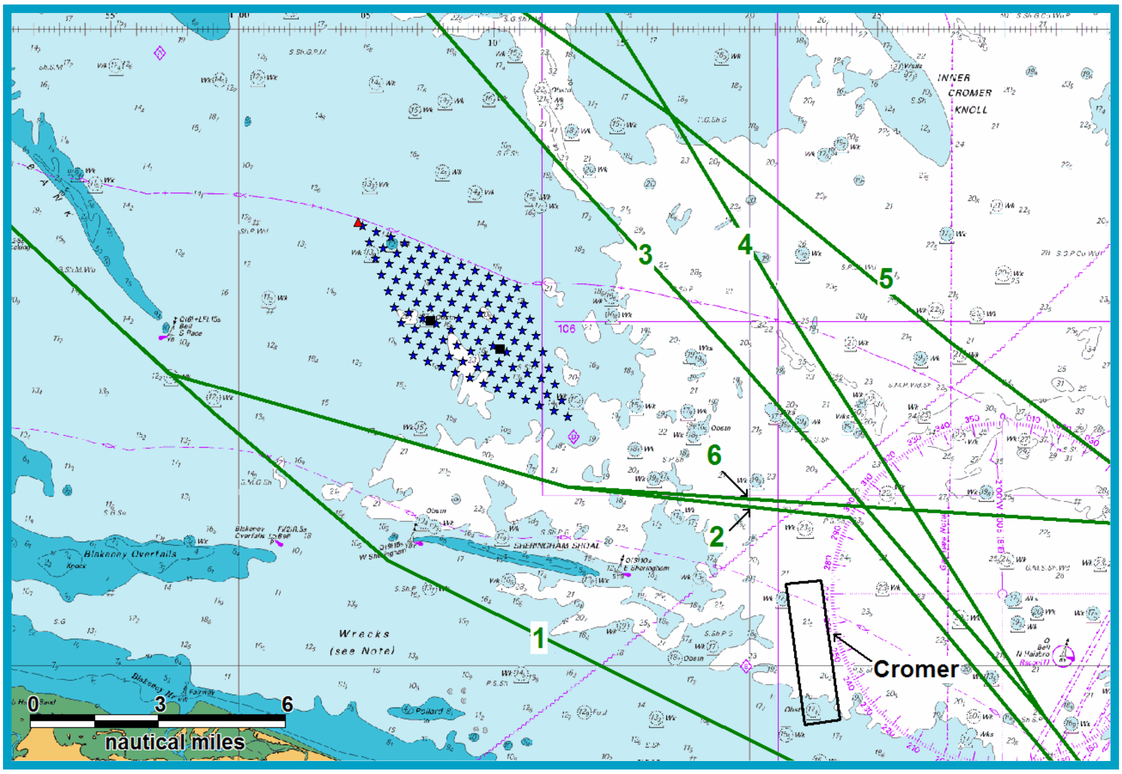


Figure 14.20 Anticipated Mean Route Positions – Cumulative Impact

As there is adequate sea room for this avoidance the cumulative and in-combination effects were concluded to be **minor adverse**.

14.8 Mitigation Measures

14.8.1 Navigation Aids

Throughout the project marine navigational marking will be provided in accordance with Trinity House requirements, which will comply with the IALA standards and the additional requirements of MGN 275(M).

The following is based on information received and through consultation held with Trinity House. The impacts cited in the sections above have assumed the successful implementation of these mitigation measures.

14.8.1.1 Construction

During the construction of an offshore wind farm, working areas will be established and marked in accordance with the IALA Maritime Buoyage System (MBS). In addition to this, and where advised by Trinity House, additional temporary marking will be deployed.

Notices to Mariners, Radio Navigational Warnings-NAVTEX and/or broadcast warnings as well as Notices to Airmen will be promulgated in advance of and during construction / decommissioning of any individual structure/farm.

14.8.1.2 Decommissioning

As per construction.

14.8.1.3 Marking of Individual Structures

As requested by Trinity House, all the structures within the wind farm (including the substations) will be coloured yellow (BS No. 381 C 356) all round from the level of Highest Astronomical Tide (HAT) to the height of the Aid to Navigation (or the equivalent height on the unlit structures).

In the event that the Meteorological Mast is constructed before the other structures in the wind farm, it will be marked as a standalone structure by means of a Morse "U" every 15seconds white light, with a 10 nautical mile nominal range. The light will be exhibited about 12m above HAT and exhibited at least at night and when the visibility is 2 nautical miles or less.

In line with the requirements set out in MGN 275(M), each of the structures will be marked with clearly visible unique identification characteristics. The identifications characteristics will each be illuminated by a low-intensity light visible from a vessel thus enabling the structure to be detected at a suitable distance to avoid a collision with it. This will be such that under normal conditions of visibility and all known tidal conditions, they are clearly readable by an observer, stationed 3 metres above sea levels, and at a distance of at least 150m from the turbine. The light will be either hooded or baffled so as to avoid unnecessary light pollution or confusion with navigation marks.

14.8.1.4 Aids to Navigation for Marking the Wind Farm

Trinity House has identified four Significant Peripheral Structure (SPS) on the periphery of the Sheringham Shoal Offshore wind farm (Meteorological mast M1 and turbines A9, L9 and L1) based on the 108 turbine layout. As advised each SPS will be fitted with Fl Y 5s lights of 5 nautical miles nominal range. The SPS will also be equipped with omni-directional fog signals, with a character of 1 blast of two seconds duration every 30 seconds, to be sounded when the visibility is 2 nautical miles or less. The fog signals will have an IALA usual range of 2 nautical miles.

Additionally, intermediate structures (G9, L5, F1 and A5) will be marked by Fl Y 2.5s lights of 2 nautical miles nominal range. Any other layout options that are chosen will also be lit in a similar manner in agreement with THLS.

All lights will be visible through 360 degrees to shipping and exhibited at least during the hours of darkness and when the visibility is 2 nautical miles or less. The lights will be at least 12 metres above HAT but below the level of the turbine blades. If more than one lantern is needed on a structure to meet the all round visibility requirement, then all the lanterns on that structure will be synchronised with each other.

An overview of location of the SPSs and intermediate structures is provided below.

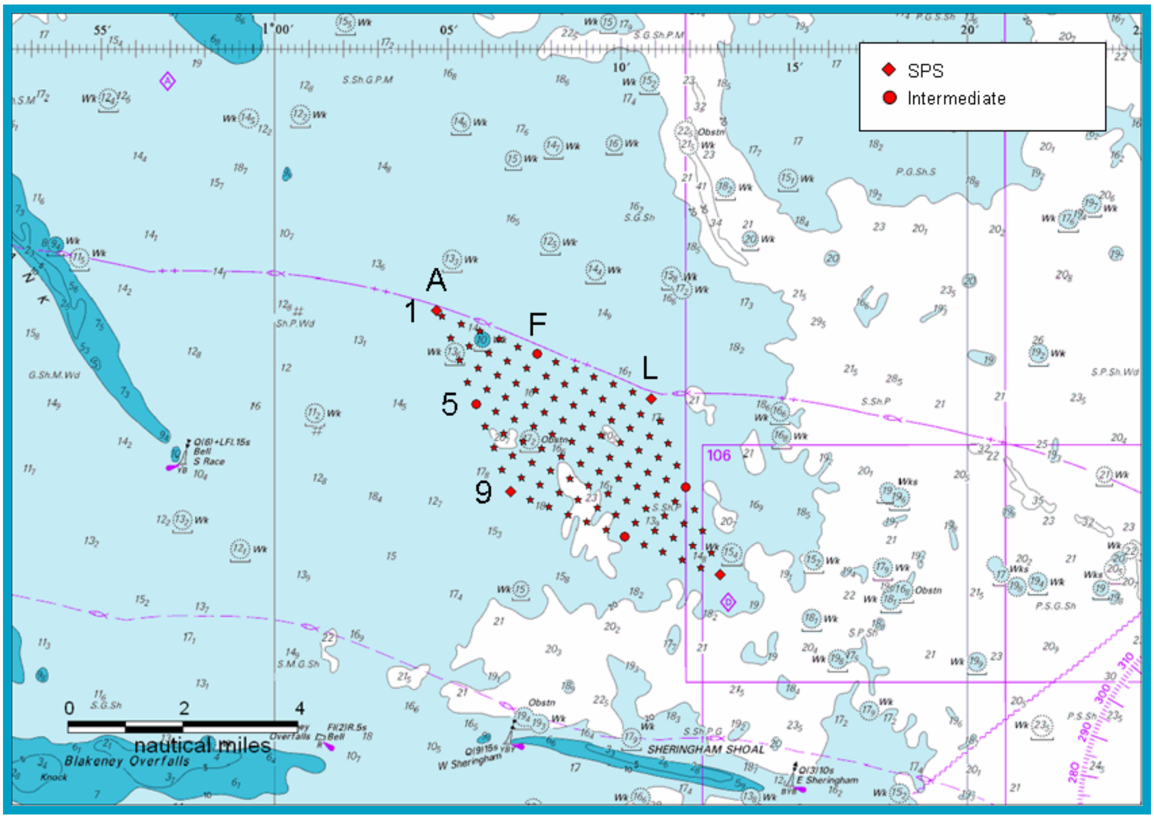


Figure 14.21 Proposed SPS and Intermediate Structure Locations for the 108 turbine layout

In addition to the above, a dialogue has taken place with Trinity House regarding the use of AIS as an Aid to Navigation (as per IALA Recommendation A-126), and whether there is the need to have any additional navigational aids within this area and any other requirements deemed necessary. Feedback from Trinity House indicates the following:

- Fitment of an AIS transceiver is probably desirable but presently the necessary UK legislation to declare AIS as an aid to navigation has not been put in place, although this is being addressed.
- They do not consider it necessary to mark the wind farm with a buoy to the SE corner as suggested in one of the stakeholder meetings.
- Radar Beacons (RACON) are not required.

Scira is committed to satisfying any reasonable requests made by Trinity House on Marine Navigational Marking requirements which have the objective of improving maritime safety

14.8.1.5 Contingency Plans for Aids to Navigation

Scira will ensure that they have a reliable maintenance and casualty response regime in place to ensure the required availability targets are met. This will include having the necessary Aids to Navigation (AtoN) spares on hand and provision will be made at the design stage, where necessary, to ensure safe access for repair / replacement of aids. The response plan will give account to the Casualty Response Priorities laid down by Trinity House.

The Aids to Navigation on wind turbines will comply with IALA Recommendations and have availability targets as detailed in Annex 2 of the Provision and Maintenance of Local Aids to Navigation for Renewable Energy Installations Farms and Fields, prepared by Trinity House (Trinity House 2000).

14.8.2 Safety Zones and Temporary Avoidance Areas

The requirement for safety zones was considered as outlined under Section 95 of the Energy Act 2004 in order to secure the safety of:

- the renewable energy installation or its construction, extension or decommissioning,
- other installations in the vicinity of the installation or the place where it is to be constructed or extended,
- individuals in or on the installation or other installations in that vicinity, or
- vessels in that vicinity or individuals on such vessels

The additional requirement for notification of temporary navigation avoidance areas was considered in accordance with normal offshore good construction practice to secure the safety of:

- construction vessels and support craft and their associated equipment
- individuals in or on those construction vessels and support craft
- other vessels navigating in the vicinity
- individuals in or on those other vessels

14.8.2.1 Construction and Decommissioning

During the construction and decommissioning phases of the development there would be large construction vessels, working personnel and support craft in operation within and around the wind farm area. Further, heavy lifting, piling and cable laying operations would be carried out which have inherent dangers. To ensure that the personnel carrying out these activities and those navigating in this sea area are not exposed to unnecessary risk, permanent 500m safety zones will be established around all offshore wind farm structures and temporary 500m avoidance areas around working vessels during these phases of the development. These measures will provide a means of hazard warning for construction activities in addition to regulating the rights of navigation near structures. These safety zones and avoidance areas will apply to all vessel types not involved in the wind farm operations. The temporary avoidance areas will be notified via Notices to Mariners.

14.8.2.2 Normal Operations

During normal operation of the wind farm there would be minimal working activities with the exception of general and emergency maintenance/repair activities and as such the benefits and requirements for safety zones and temporary avoidance areas were reassessed giving account to the vessels likely to be present within and around the wind farm.

For transiting merchant vessels, based on the 28-day traffic survey conducted at the site, it was observed that traffic tends naturally to avoid the wind farm area and follows well defined routes in avoidance of the shallow waters in the surrounding area. The main risks associated with these vessels are collision due to errant watch keeping, machine failure or the effects of sudden weather changes. As a result of this, and the greater response times associated with course/speed alterations of these vessels, a 500m safety zone will be applied to ensure the safety of life at sea. This will also ensure that the larger superstructure of these vessels stays well clear of the turbine blades.

It is noted that the normal safe passing of merchant vessels near a surface structure as determined by the master of the vessel will naturally tend to be greater than 500m.

Recreational craft are considered more likely to be capable of navigating safely within the wind farm. These vessels will tend to operate within the wind farm at lower speeds and at closer ranges to the turbines. A 100m safety zone will be applied to each structure in the wind farm for these vessels. This will serve as a means to prevent recreational craft moving alongside, anchoring or mooring to the structures which will in ensure safety to life. It is noted that 22m air clearance between the rotors and MHWS has already been assured.

It is foreseeable that fishing vessels will navigate within the wind farm in a similar manner to recreational craft. From review of information received on fishing practices within wind farms, it is considered safe (subject to prevailing conditions) to permit certain types of fishing, e.g. potting, up to a 100m range from the turbines and other structures.

The proposed 100m safety zone for recreational craft and potting vessels during normal operation of the wind farm will also ensure that there will be a reasonable working area around each structure that will be clear of shipping and fishing gear should it be necessary to access the structures or conduct maintenance operations or emergency repair works to the turbines, met mast or substations.

However, for other types of fishing activity such as trawling, a 500m safety zone will be put in place to reduce the risk of fishing gear becoming snagged on the wind farm structures below the water surface.

Due to the risk to the vessels and associated crew members and cables, a similar 500m safety zone will also apply around vessels involved in maintenance activities in the wind farm or along the cable route.

During operation of the wind farm there will be procedures in place for vessels working at the farm to monitor passing traffic, recreational and fishing vessels, etc. Any observed breaches of the safety zone provisions will be reported in line with the regulatory requirements.

14.8.2.3 Safety Zone and Temporary Avoidance Area Summary

In summary the safety zones temporary avoidance areas proposed for the project are as follows:

- Construction/Decommissioning:
  - Permanent 500m safety zone will be established around all offshore structures
  - Temporary 500m avoidance areas will be notified around all working vessels during the construction and decommissioning phases via Notice to Mariners.
- Operation:
  - Safety zone of 100m around each individual turbine/substation/met mast for all vessels not associated with the wind farm.
  - Safety zone of 500m for merchant shipping, and specific activities which by their nature represent a risk to the wind farm structures, e.g. towed gears such as otter trawls and beam trawls, dredging activities and anchoring of certain vessels.
  - Temporary 500m avoidance areas will be notified around all working vessels during wind farm maintenance activities via Notice to Mariners.

It is envisaged that recreational vessels and potters will be permitted up to the 100m safety zone.

The proposed 100m safety zone during normal operation of the wind farm will also ensure that there will be a reasonable working area around each structure that will be clear of shipping and fishing gear should it be necessary to access the structures or conduct maintenance operations or emergency repair works to the turbines, met mast or substations.

The existence of the safety zones and avoidance areas will be published electronically and via Notices to Mariners.

14.9 Monitoring Proposals

During construction, maintenance and decommissioning monitoring of shipping will be carried out to gather information on the localised behaviour of shipping in and around the wind farm. In addition periodic traffic surveys will be carried out to ensure the base assumptions made within the assessment of navigational impact are appropriate.

This will provide further input into the navigational safety impact reviews that will be undertaken over the life of this development to ensure all risks are appropriately managed.

14.10 Summary

A detailed review of the navigational impact of the Sheringham Shoal wind farm was carried out by Anatec UK Ltd. This was primarily based on the MGN 275 notice issued by the MCA. In addition to this, consideration was also given to the cumulative and in-combination effects, giving account to the Round 1 Norfolk Offshore Wind Farm (Cromer), which has already been given consent, and other known Round 2 applications in this area.

Background data was gathered to provide details on the following:

- Local ports
- Anchorages
- Routeing measures
- Navigational aids
- Wrecks, Obstructions and Spoil Ground
- Oil and Gas developments
- Metocean characteristics

In addition a 28-day traffic survey was carried out for the area based on AIS and radar (see Figure 14.22), which was complemented by two further survey data sets which included a 5-day radar survey carried out between 18-24 August 2003 based at Trimingham and an additional 14 days of AIS survey data collected in the area over the period 27 May to 9 June 2005.

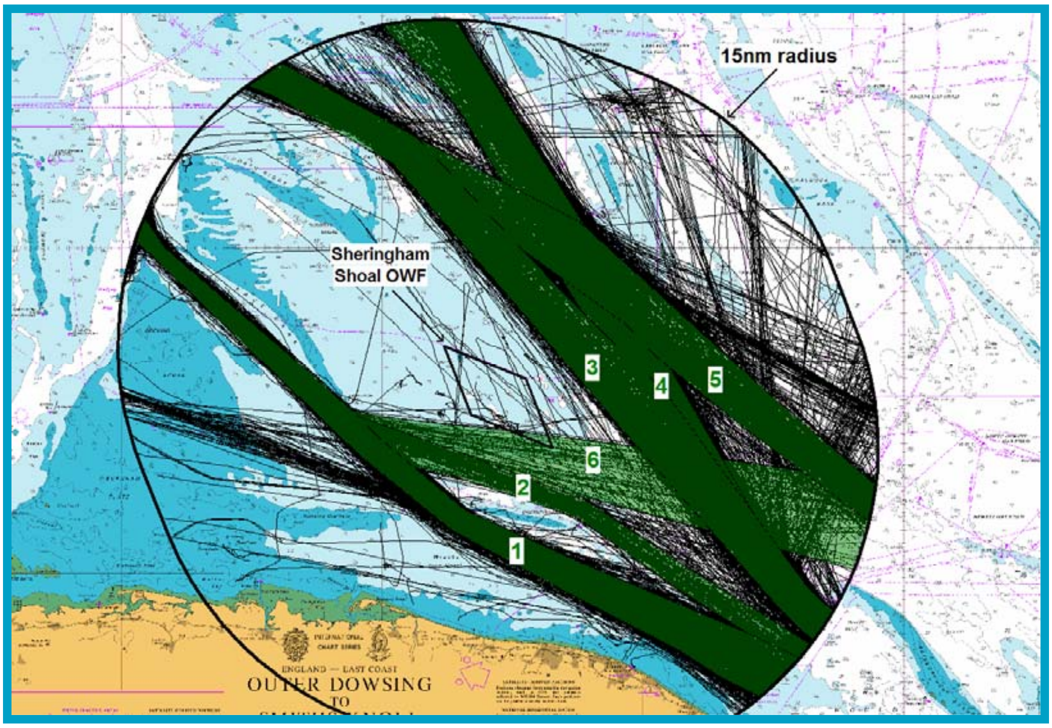


Figure 14.22 90% Lanes overlaid on Survey Tracks (28-day dedicated survey)

Based on this and the use of risk assessment, the following residual impact levels were derived:

Table 14.5 Summary of Navigational Impacts of Sheringham Shoal Wind Farm (Operational Phase).

Vessel Type	Impact	Notes
Fishing	**Minor adverse**	Limited fishing in this area. Use of safety zones to reduce risks within the wind farm.
Merchant	**Minor adverse**	Shipping tends naturally to avoid the site in avoiding the shallows in this area. Use of safety zones to reduce risks within the wind farm.
Recreational	**Minor adverse**	Limited recreational activity in this area. Use of safety zones to reduce risks within the wind farm.
Dredging	**Negligible**	No dredging activity in this area.
Cable Interaction	**Negligible**	Negligible activity in this area with potential to snag on the buried cable.
Visual Navigation and Collision Avoidance	**Minor adverse**	Low impact as the majority of shipping tends naturally to avoid the wind farm location. Impact on crossing vessels to the SE was assessed in detail and found to be minor.
Communications, Radar and Positioning	**Moderate adverse**	Pending results from on-going trials
SAR	**Moderate adverse**	Pending further discussions on the implications of being able to lock the turbines remotely in a “Y” position.

Overall, the main conclusion from the assessment is that the impact of the wind farm on shipping and navigation will be low giving account to the aforementioned mitigation measures and recommendations of the navigation risk assessment report. However, further information is being sought on the means of locking the blades in a "Y" position to assist in SAR response and the impact of the wind farm on radar. Both these are currently under consideration on an industry-wide basis.

It was also concluded that similar impacts would result during the construction and decommissioning phases of this development.

All the above findings are based on the "worst case" layout of 108 turbines with 5 m diameter foundations, and on the fact that the navigational impact of other layouts being considered would therefore be less.

14.11 References

- MAIB Accidents, Injuries and Hazardous Incidents, 1 Jan 1994 to 27 Sep 2005, received from MAIB in October 2005.
- MCA / Qinetiq: Results of the EM Investigations and assessments of marine radar, communications and positioning systems undertaken at the North Hoyle Wind Farm by QinetiQ and the Maritime & Coastguard Agency; 29 September 2004.
- MCA, Draft Wind farm: Shipping Route Template, 7 May 2005.
- MCA, Offshore Wind Farm Helicopter Search and Rescue Trials undertaken at the North Hoyle Wind Farm, May 2005.
- Port of London Authority: Interference to radar imagery from offshore wind farms, A Report compiled by the Port of London Authority based on experience of the Kentish Flats Wind Farm Development, 2nd NOREL WP4, 31 March 2005.
- RNLI Incident Data in Round 2 Strategic Areas, 1995 to 2004, received from RNLI in November 2005.
- RYA, 2005: UK Coastal Atlas of Recreational Boating published by RYA, supported by Trinity House and Cruising Association.
- Scira Offshore Energy, Commercial Fisheries, Doc Ref: SCIRA-EX-RPT-70037, 1st Draft, 28 July 2005.
- Search and Rescue Framework for the United Kingdom of Great Britain and Northern Ireland, June 2002.
- Trinity House Lighthouse Service: Marking Offshore Wind Farms, November 2000.

15 Marine Archaeology – (Desk Based Assessment)

15.1 Introduction

15.1.1 Project Background

Wessex Archaeology (WA) was commissioned by Scira Offshore Energy Ltd. (Scira), to prepare a desk-based assessment of the potential effect on archaeological remains of a proposed offshore wind farm (OWF) development known as Sheringham Shoal.

Refer to Section 2 for the project description.

This assessment deals with the cultural heritage implications of the construction of the offshore elements of the scheme, which can be defined as:

- The turbines and foundations;
- The inter-turbine cables; and
- The marine export cable (from the turbines to the mean high water springs [MHWS] mark.

15.1.2 Project Aims

The aim of this assessment is to inform the overall Environmental Assessment for the OWF and associated cable routes. This was achieved through:

- An Archaeological Desk-based Assessment of the archaeological potential of the same area.
- A review of magnetometer data collected by Envision Mapping Ltd. (Envision) and supplied by SCIRA, for potential marine archaeological sites and materials in the area proposed for the OWF and the cable routes; and
- A Stage 2 (Recording and Sampling) geotechnical assessment of vibrocores collected along the cable route and within the wind farm

The Archaeological Desk-based Assessment:

- Provides a statement of the known and potential archaeological resource within the vicinity of the wind farm and cable routes;
- Assesses the likely impact of the proposed development on the archaeological resource;
- Assesses the significance of effect of those impacts;
- Determines appropriate mitigation.
- The objectives of each element are set out under the relevant heading below.

15.2 Methodology

15.2.1 Introduction

This assessment is intended to inform the preparation of an Environmental Statement that will accompany the application for the wind farm. The methodology adopted reflects best practice in carrying out archaeological desk-based assessments, as codified by the Institute of Field Archaeologists (IFA) Standard and Guidance for Archaeological Desk-based Assessment (IFA 1999).

Although much of this assessment is derived from desk-based (i.e. secondary) sources, provision was also made for the archaeological interpretation of new primary data arising from a marine geophysical and geo-technical survey of the OWF area and proposed cable routes.

The approach adopted also reflects the requirements of Environmental Assessment arising from European Council Directive 85/337/EEC as amended by Directive 97/11/EC.

15.2.2 Study Areas

In order to assess the archaeological potential of the various aspects of the Sheringham Shoal OWF development, in relation to both coastal and maritime archaeological remains, two study areas were established for the collation of information. These were termed the Marine Study Area and the Coastal Study Area. The Study Areas are illustrated in Figure 15.1.

These Study Areas were designed to include the given positions of the wind farm, the areas to be traversed by the preferred and alternative options for the marine export cables and the area around the landfall of the cables. Various sources were consulted for information relating to each Study Area.

The Marine Study Area (MSA) is comprised of the wind farm plus a 2 kilometre buffer around it, and the cable routes (direct and western) with a 2 kilometre buffer to either side (Plate 15.1). The terminus for MSA is at the MHWS mark.

The Coastal Study Area (CSA) is located at the terminus of the cable routes and comprises a 500m buffer around the landward end of this terminus at the MHWS mark (Plate 15.2). The CSA is not intended to provide an archaeological assessment of the terrestrial component of the scheme, but is aimed at ensuring a seamless overlap between the marine and terrestrial environments. The results of the archaeological assessment of the CSA are described in Section 26.

The significance level (negligible – major) of identified impacts for the assessments are shown in bold in Sections 15.7 - 15.8 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section 3 for the definition of significance levels.

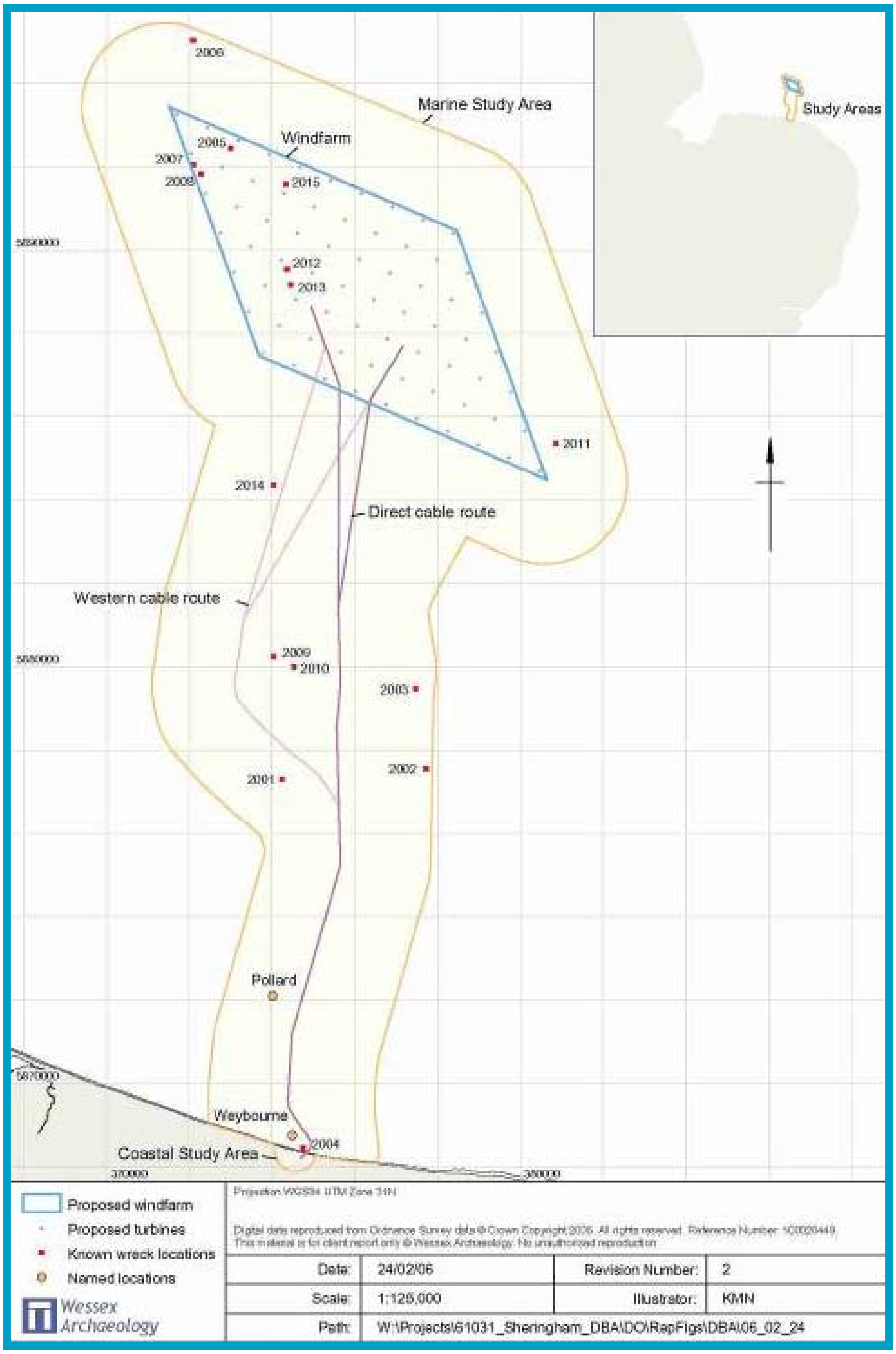


Figure 15.1 Marine and Coastal Study Areas and Maritime sites (Source: Wessex Archaeology)

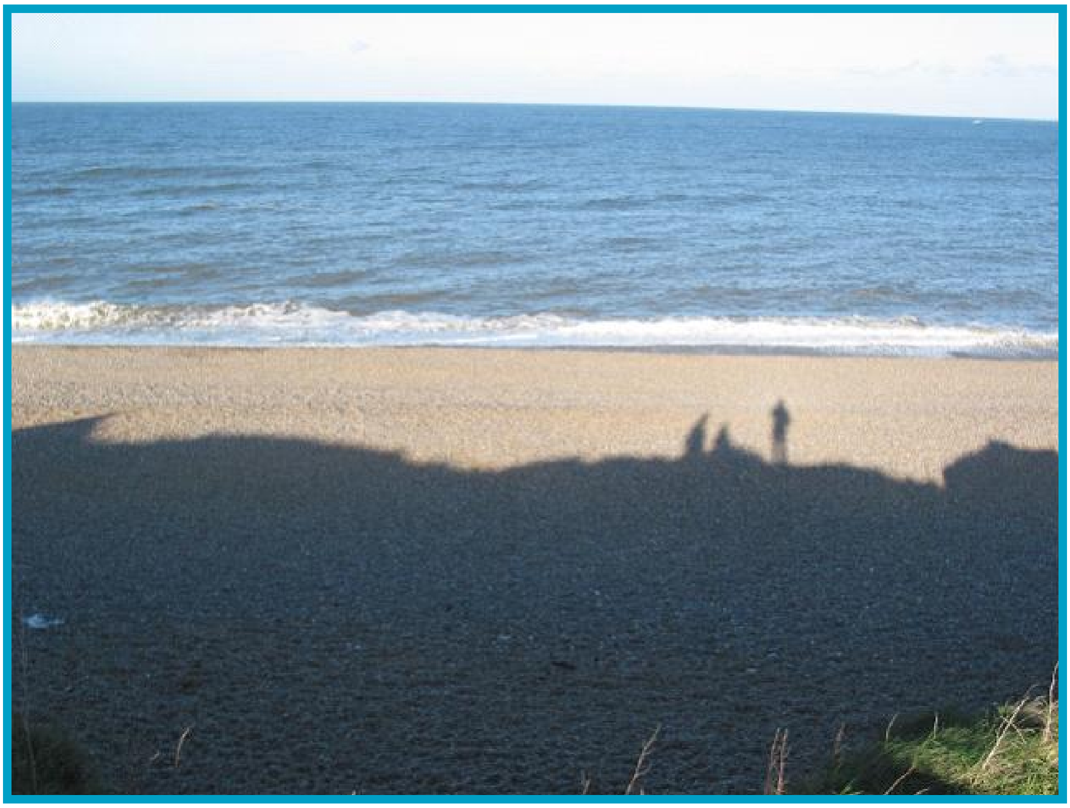


Plate 15.1 View out to the marine study from Weybourne beach (source: Wessex Archaeology)

Plate 15.2 Weybourne beach, where the pipeline is to come ashore (Source: Wessex Archaeology)

15.2.3 Sources

Archaeological records for the Marine Study Area and Coastal Study Area were collated from:

- Records of wrecks, obstructions and casualties (documented losses) from the National Monuments Record (NMR);
- Records of known terrestrial sites and finds from the NMR;
- Records held by the United Kingdom Hydrographic office (UKHO);
- Records of known archaeological sites and finds from the Norfolk Historic Environment Record (HER), Norfolk Museums & Archaeology Service, Norwich;
- The Norfolk Record Office, Norwich;
- The Norwich Millennium Library;
- Geophysical data (Magnetometer) provided by Envision Mapping Ltd.; and
- The geo-technical report on the Stage 2 (Recording and Sampling) of vibrocores (Wessex Archaeology 2005a).

Cartographic and other navigational sources, including historical charts, surveys and sailing instructions, were collated from the UKHO, relevant local Record Offices and from Wessex Archaeology's own library (see References and Appendix 15.8). Particular reference was made to:

- Unpublished historical charts and surveys held by the UKHO;
- Published charts held by the UKHO;
- Sailing directions held by the UKHO;
- Ordnance Survey maps; and
- Historical maps held by Norfolk Record Office.

15.2.4 Maritime Records

In order to assess the maritime archaeological resource within the Marine Study Area records of wrecks and casualties were obtained, principally from the NMR and UKHO (Appendices 15.2 and 15.3).

All records of wrecks, obstructions and geophysical anomalies were translated into point data and viewed within the project base map. The results are presented in Figure 15.1

15.2.5 Terrestrial Records

Terrestrial archaeological records were obtained from HER and the NMR. For information relating to the Coastal Study Area refer to Section 26.

15.2.6 Chronology

Archaeological dating of remains follows three distinct chronologies:

- Absolute (or calendar) dates, which are suffixed with BC (Before Christ), generically known as big BC. Such dates can be considered as part of our present day calendar, i.e. a date of 3,523 BC occurred 5,529 years before 2006.
- Calibrated radiocarbon dates, which are either related to our modern calendar as BC dates, or presented as BP (before present) dates. BP dates are calculated in years before 1950, and take into account the increased radioactivity background count following the proliferation of nuclear testing after this date. Therefore, a calibrated date of 4,500 BP indicates a point in time 4,556 years before 2006 (i.e. 2,550 BC).
- Uncalibrated radiocarbon dates, which are suffixed with bc (i.e. little bc), and are the original radiocarbon determinations based on the half-life of C14 without compensating for changes in the background count.

15.2.7 Marine Geophysical Assessment

A staged approach to the geophysical assessment of the Sheringham Shoal Offshore Wind Farm and cable routes was adopted, with an initial assessment of magnetometer data collected between March and June 2005. Further, more detailed geophysical investigations are planned prior to construction.

15.2.7.1 Technical Specifications

This geophysical review is limited to the magnetometer data acquired by Envision Mapping Ltd. using a Marine Magnetics Explorer magnetometer. This system is considered by WA to be of a suitable specification for providing data for an archaeological assessment.

A broad scale magnetometer survey was run to detect and locate large metallic objects such as wrecks, etc. Survey lines for the wind farm were run at approximately 150m line spacings in a nw-se direction. Survey lines for the cable routes were run at approximately 150m line spacings in a nw-se direction and at varying line spacings of between 300 - 1000m in a north-south direction

Based on comments by WA on the geophysical survey specifications (Wessex Archaeology 2004), a series of n-s magnetometer survey lines were run over the known wreck sites in order to ‘box’ them in and confirm their position (Envision 2005).

The data were logged every second and their position recorded with the survey vessel’s navigation system differential GPS during the March surveys, and with a CSI differential GPS receiver for the June surveys.

All positions were given in WGS 84 UTM zone 31N.

Later, a finer scale survey will be run at critical locations to search for much smaller objects.

15.2.7.2 Data Processing

WA was commissioned to review the magnetometer survey lines near the known wrecks believed to cover the recorded losses and reported obstructions listed in Appendix 15.2.

A total of nine lines running across the wind farm in a nw-se direction and nine n-s lines were reviewed (Figure 15.2). One new anomaly was detected.

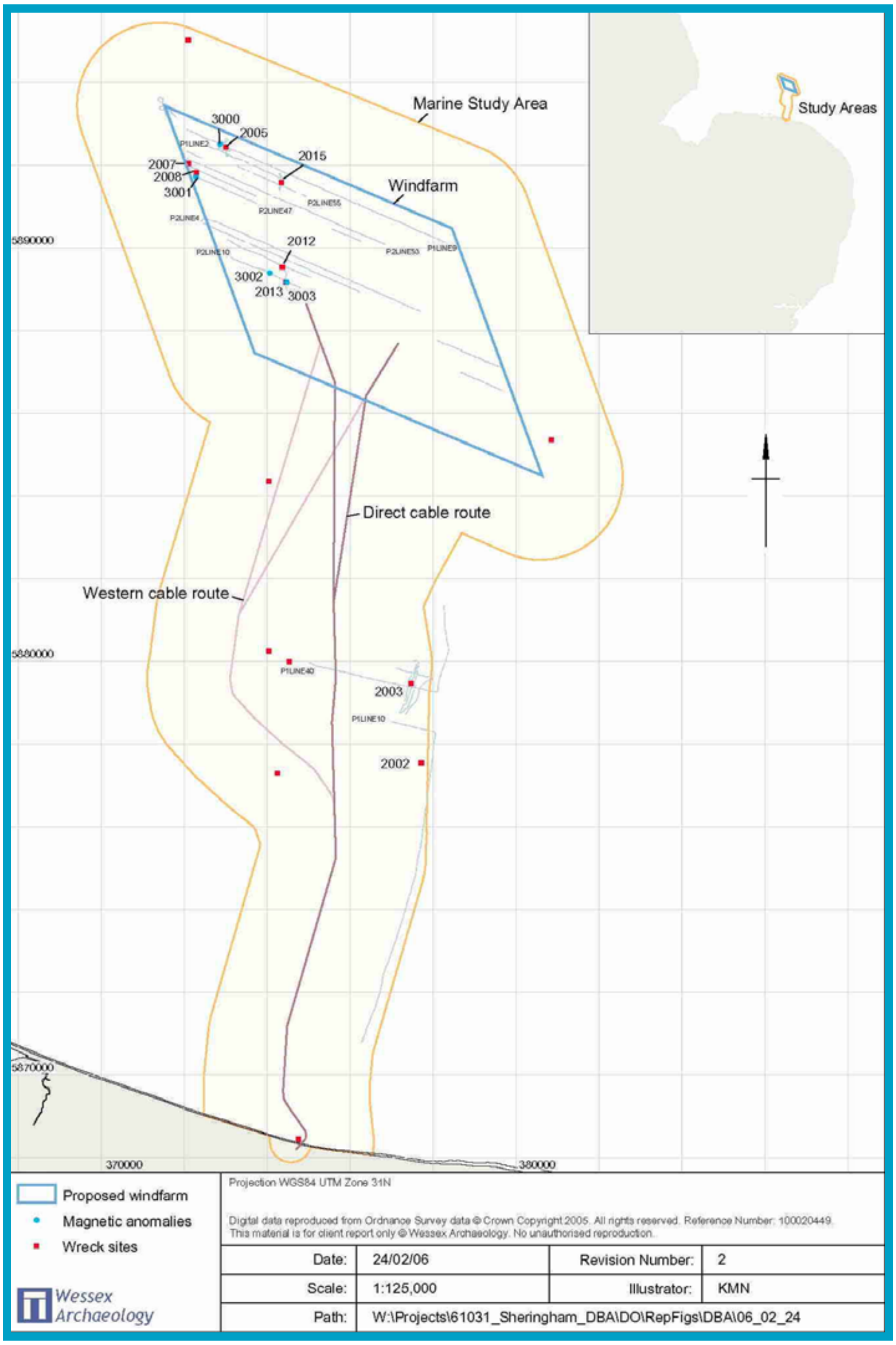


Figure 15.2 Evaluated magnetometer survey lines and magnerometer results (Source: Wessex Archaeology)

The position, description and amplitude of the anomalies noted were recorded in a gazetteer, which is presented in Appendix 15.4.

15.2.7.3 Data Quality

The magnetometer data were generally of sufficient quality to allow for the identification of large magnetic anomalies, although in terms of survey coverage and navigation tracking, the magnetometer survey is not comprehensive enough for archaeological assessment. However, further pre-construction geophysical surveys and analysis will provide sufficient survey coverage for this assessment.

15.3 Marine Geotechnical Assessment

The proposed export cable routes follow palaeo river channels on the seabed in order to reduce as far as possible the dispersion of chalk during installation of the cables. Suspended chalk fines might have adverse effects on the nearby biology. To compensate for the loss of archaeological information during cable installation, WA advised on a series of vibrocores along the cable routes. These vibrocores were taken by Fugro and assessed by WA for archaeological data relating to submerged terrestrial prehistoric archaeology within the area.

15.3.1 Summary of Marine Geotechnical Assessment

A Stage 1 initial rapid archaeological assessment of the vibrocores identified sections of 20 cores containing sediments of archaeological potential (Wessex Archaeology 2005b). These cores were transferred to Wessex Archaeology where Stage 2 recording and sampling of the cores was carried out between 31st October and 8th November 2005. A full report of the marine geotechnical assessment, WA 61032: Stage 2 Archaeological Recording and Sampling of Vibrocores (Wessex Archaeology 2005a), can be found in Appendix 15.5.

The Stage 2 assessment identified four major sedimentary units within the vibrocores and established that the sedimentary sequence is typical of the Southern North Sea. The phasing that has been described for the area suggests four major periods of deposition probably of Upper Cretaceous, Pleistocene, Holocene and Recent date.

15.4 Geological and sea level change baseline

An understanding of sea level change, climate, and the environment is necessary to assess the potential for the exploitation of the MSA by our early ancestors at times when sea levels were lower and the area was dry land. The following section presents an outline of geology and sea level change of the wider southern North Sea.

The baseline geology of the MSA is inferred from the BGS publications of the geology of East Anglia and Spurn and is represented in Figure 15.3 and

Figure 15.4. It is discussed in greater detail in Appendix 15.6 and Sections 2 and 6.

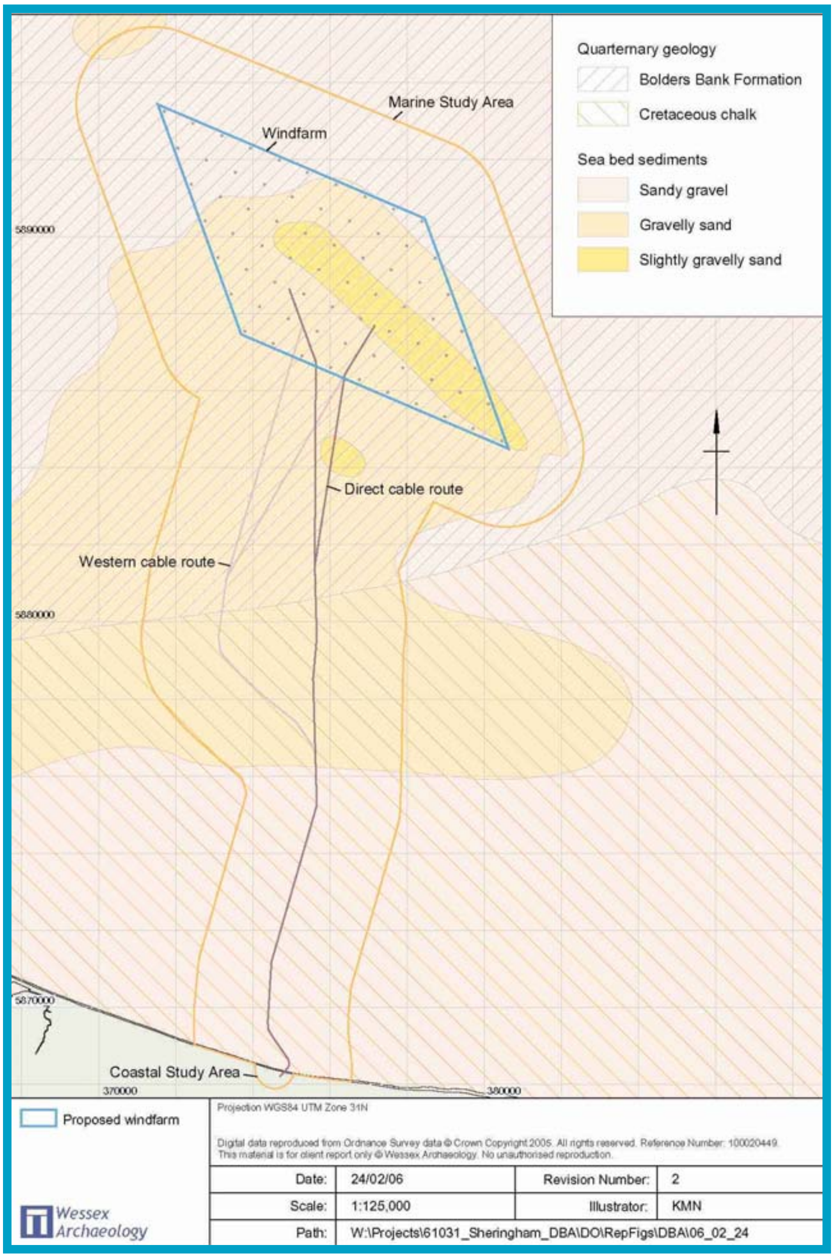


Figure 15.3 Marine Geology (Source: Wessex Archaeology)

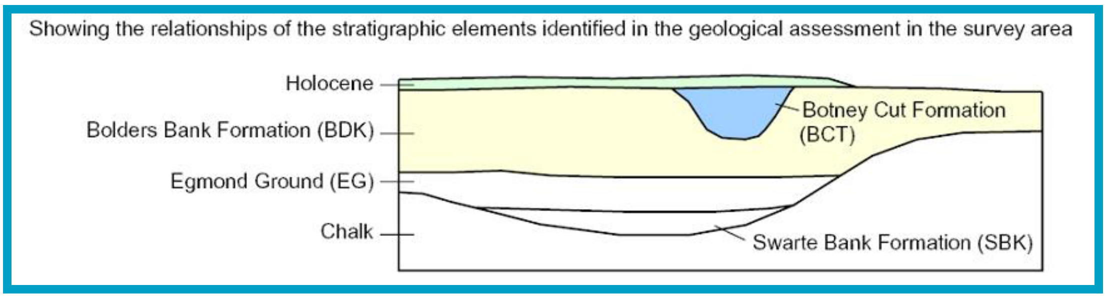


Figure 15.4 Schematic illustration of stratigraphic elements.

In general, the underlying geology in the northern half of the MSA is made up of Cretaceous Chalk. Overlying it are the Swarte Bank, and Egmond Ground formations which are in turn covered by a blanket deposit of Devensian glacial till, known as the Boulders Bank formation. In some places the Boulders Bank formation is cut by glacial valleys filled with the Botney Cut formation, deposited prior to the most recent marine transgression.

In the southern half of the wind farm area Cretaceous Chalk is cut by the infilled Weybourne Channel (Royal Haskoning, 2005), which is likely to be pre-Devensian (Chroston, 1999).

A blanket deposit of Holocene sands and gravels overlies the MSA (Royal Haskoning, 2005) and forms the Sheringham and Pollard Shoals (Figure 15.3). These sediments are likely to have formed as a lag deposited at the end of the last glaciation (Hamblin et al., 1992).

15.4.1 Lower, Middle and Early Upper Palaeolithic

Over the past 680,000 years climatic conditions have varied greatly with a resultant effect on the environment and sea level. Three major ice ages have occurred during this period, the Anglian (c. 478,000 BP to 423,000 BP), Wolstonian (c. 380,000 BP to 130,000 BP) and the Devensian (c. 70,000 BP to 13,000BP.

During these periods sea levels are estimated to have been as much as 120m below present day levels and vast areas of today's seabed would have been exposed as the sea was taken up in the expanding ice caps and glacial zones. At the height of these ice ages human exploitation of the regions covered by ice sheets is unlikely, but archaeological evidence suggests that areas at the ice margins were being exploited by humans during the Devensian (Chisham, 2003), and the same may be assumed for earlier periods.

15.4.2 Late Upper Palaeolithic to Roman

During the Devensian glacial maximum (c. 22,000 BP) the whole of the North Sea basin was above sea level. At that time the MSA lay close to the southern margins of the British ice sheet, within an area of tundra that would have been affected by harsh periglacial conditions. As the climate warmed, and the ice sheet retreated the North Sea basin became a vast plain crossed by numerous rivers, and with extensive areas of bog and wetland. Continued warm up saw soils form and forests replace the tundra. (Spikins 2000).

By the Middle Mesolithic (c. 6,000 BC) sea level rise was such that the MSA will have become increasingly coastal, and by the Late Mesolithic (c. 5,400 BC) it is likely that the MSA was starting to flood.

After the Mesolithic the sea level continued to rise and by the Roman period (43-410 AD) the coast of Britain had assumed its current form. During the Neolithic, Bronze Age and Iron Age therefore, at least some parts of what is the current seabed along the line of the marine export cables were dry land.

15.5 Archaeological baseline

15.5.1 Introduction

The archaeological baseline for the MSA is summarised below. See Appendix 15.7 for more detail and the chronology used in discussing the archaeology of the Marine Study Area.

15.5.2 Lower Palaeolithic to Early Upper Palaeolithic (680,000 - 22,000 BP)

This period spans the geological stages from the Cromerian to the Devensian, a period of approximately 660,000 years during which climatic and environmental conditions in Britain varied considerably and the southern North Sea would have provided favourable conditions for human habitation at different times within this period.

During the warmer stages of the Cromerian Britain would have been habitable and able to support large mammals. Evidence for the earliest known hominid occupation of Britain is at Pakefield in East Anglia and dates to c. 680,000 BP.

The occupation of Britain continued until the beginning of the Anglian glaciation (c. 478,000 BP). The MSA would not have been inundated at this time, but it is unlikely that the north coast of Norfolk would have been occupied as a result of the cold conditions.

Archaeological evidence for hominid activity in Britain during the Wolstonian (380,000 BP) and Ipswichian (110,000 BP) periods is limited, and there is none from East Anglia or North Norfolk.

Evidence for the presence of modern humans exists for the period c. 40,000 and 38,000 BP at a number of sites, but thereafter was unoccupied due to its proximity to the Devensian ice sheet until c. 13,500 BP.

No material from the Middle and Early Upper Palaeolithic has been reported from within the MSA.

The impact of the successive glaciations upon pre-Devensian sites is such that few intact sites are known on land, and fewer are likely to have survived offshore. However, substantial quantities of derived Lower and (to a lesser extent) Middle Palaeolithic material has been found within Britain – typically within river gravels. Similar finds may exist within the Swarte Bank and Egmond Ground formations and later deposits that include reworked elements of these sediments.

15.5.3 Late Upper Palaeolithic and Mesolithic (13,500 BP - 4,000 BC)

The absence of known finds suggests that during the last glacial maximum (c. 18,000 BP) the whole of Britain and much of the rest of Northern Europe became largely depopulated as people retreated to southerly refugia.

The re-population of Britain is likely to have started at around 13,500 BP) as the Devensian ice sheet retreated. Southern regions would have been the first to see the return of people, who gradually moved north as the climate ameliorated. Abundant stone tools and butchered animal bone have been found in cave sites in Britain dating to 13,000 BP (Chisham, 2003).

The cultural transition that marks the start of the Mesolithic corresponds with the start of the Younger Dryas / Loch Lomond stadial (10,000 BP). The Late Upper Palaeolithic and Mesolithic populations were hunter-gatherers and lived a nomadic lifestyle with no fixed settlements. Thus the archaeological signature left by these people is one of scatters of flint tools and animal bone that relate to camp sites, hunting stands, butchery sites, etc.

There is a strong link between Mesolithic sites and natural resources, with river valleys that provided water, game to hunt and a means of navigating through the landscape, being favoured activity areas. Thus the river systems indicated by the numerous palaeovalleys that cross the MSA (Figure 15.5) and later, as the sea level rose, the proximity of the coast with its resources would have made the MSA an attractive area for Late Upper Palaeolithic and Mesolithic hunter-gatherers.

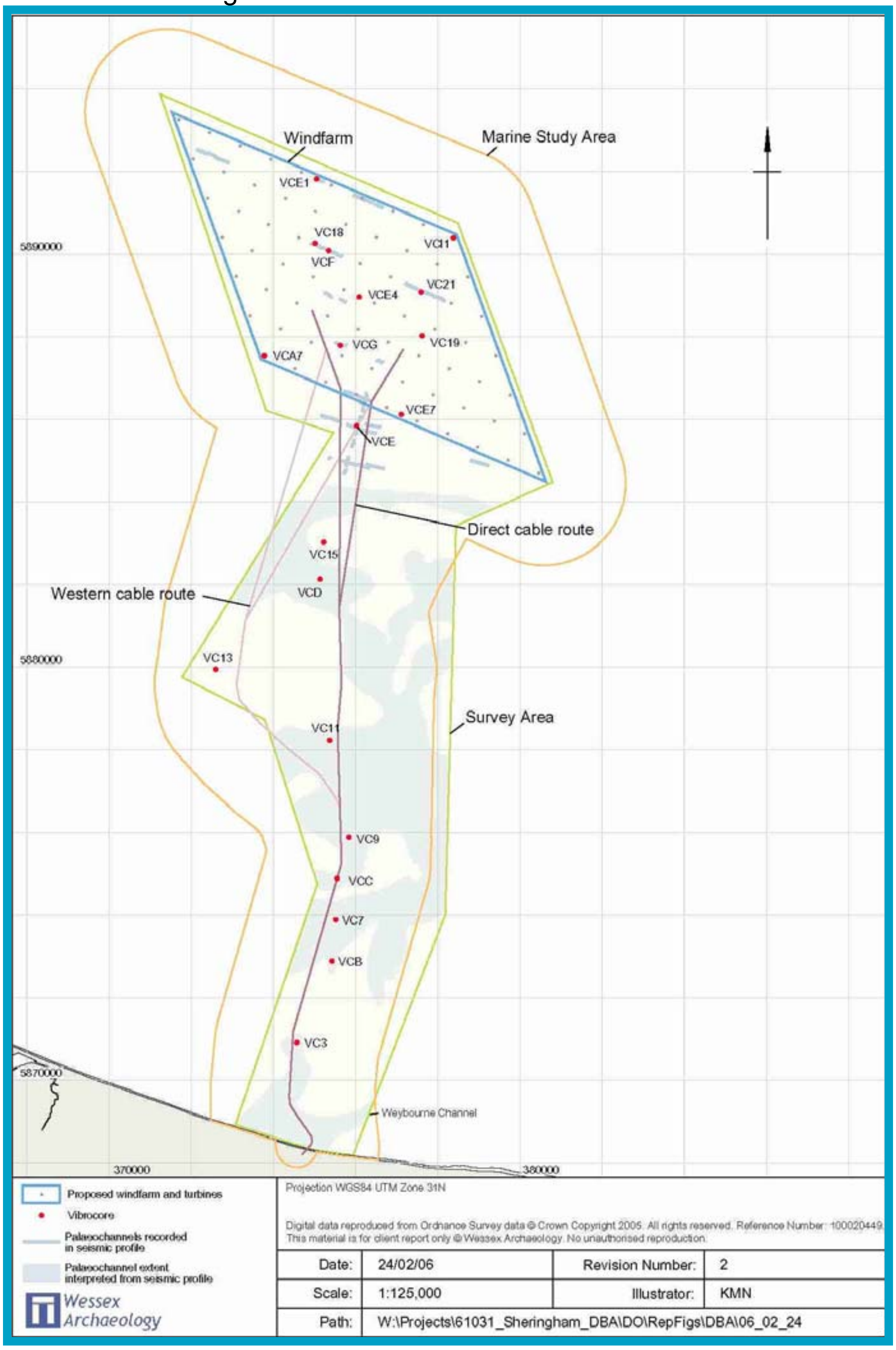


Figure 15.5 Vibrocore and palaeochannel locations

No material from the Mesolithic has been found in the MSA. However, Mesolithic flint tools have been found from this period in the vicinity of Weybourne and Sheringham, and Mesolithic finds are known from the bed of the North Sea (notably from Dogger Bank). It is likely that Late Upper Palaeolithic and Mesolithic soils and sites may be expected in association with the Boulders Bank and Botney Cut formations deposited as the Devensian glaciers retreated

By the end of the Mesolithic sea level had risen to the extent that the wind farm area would have been submerged. Thereafter the archaeological potential for this area is purely maritime. However along the marine export cable routes elements of dry land would have persisted (albeit with a steady decline) for the next 4,000 years.

15.5.4 Neolithic to Roman (4,000 BC - 410 AD)

The adoption of farming during the Neolithic (4,000 - 2,400 BC) lead to a steady increase in the population and the establishment of permanent settlements. Although the wind farm area would have been inundated by this time, even by the end of Neolithic the sea level would still have been several metres below its current level, and the coastline would have been at least 500m to seaward of its current position. No evidence of Neolithic occupation has been reported within the MSA.

The Bronze Age is marked by the introduction of metal tools and changes to the style of the field monuments. No evidence for Bronze Age activity has been recorded within the MSA. However, in 1999 an Early Bronze Age wooden circle, dubbed Seahenge, was found to the west of the MSA at Holme-next-the-Sea. Originally built on dry ground, it was found within beach deposits below the current high water mark. This site provides clear evidence of the potential for Bronze Age and earlier remains within the submerged elements of the export cable routes.

The Iron Age is marked by the manufacture of iron tools, the appearance of the first towns and the widespread occurrence of hill forts. By the start of the Iron Age (700 BC), the sea will have risen to about its present level and the MSA and cable route will have been fully inundated. No evidence for Iron Age activity has been recorded within the MSA, although coastal activity in the form of small scale industrial processes such as salt making and fishing are likely to have been a feature of this period in the area. Salterns and fish traps are thus the most likely form of Iron Age terrestrial site from within the MSA, and they are both likely to occur close to the current shoreline.

15.5.5 Saxon to Modern (410 AD -)

No archaeological material from the Saxon period (410-1066 AD) has been recorded within the MSA. However, in 2004 the Norfolk Survey identified a large number of fish traps, quays and jetties, among other maritime constructions along the north Norfolk coast dating from Saxon and later periods, which suggests that there is potential for coastal activity for this period within the study areas.

Since the Post Medieval period a successful fishing industry has thrived on the north Norfolk coast in the area around Weybourne. Material associated with this industry is possible from within the MSA.

The First and Second World Wars saw a huge amount of activity across the south and east coasts of Britain, and the area around Weybourne was no exception. Within the MSA there are two machine gun emplacements (WA1010 and WA1012) and a pillbox (WA1005) all of which have been largely broken up by the sea.

15.5.6 Marine Archaeology

The potential for wrecks within the MSA covers a long period of time, perhaps dating as far back as the inundation of the area during the Late Mesolithic (5,000 – 4,000 BP). A more detailed discussion of the marine archaeological potential of the MSA can be found in Appendix 15.8.

Estimates of the number of shipping losses around the coast of the UK, for all periods, vary between 100,000 and 500,000. This gives an average of between eight and forty wrecks for every mile of coastline, although concentrations may be expected in areas of higher shipping activity and navigational hazards. Sheringham Shoal is a region of conspicuously shallow water, with depths of as little as 2.8 metres below CD at its centre. The number of known wrecks around its edges, both within and outside the MSA attest to the hazard posed by the bank.

In considering the potential for shipwrecks within the area affected by the proposed wind farm development, it should be noted that such sites often occupy an extended area beyond the confines of any hull remains, depending on the circumstances of loss and the effects of post-depositional processes. The extended area may contain significant elements of structure, artefacts and stratified deposits and must be considered as an integral part of the wreck site.

The shipwreck potential of the MSA comprises;

- possible unknown and undocumented wrecks from various periods dating back to the Iron Age or earlier; and
- possible stray finds of ship-borne debris from various periods.

15.5.6.1 Known Wrecks and Recorded Shipping Losses

The results of the UKHO and NMR searches are described in below and compared to the magnetic survey, which is described in terms of individual anomalies detected, and their magnetic characterisation.

A total of 15 known marine sites have been identified from the documents within the MSA (WA 2001-2015). These sites are listed in the gazetteer in Appendix 15.2 and their positions shown on Figure 15.1.

Table 15.1 Comparison of Known Wreck and Recorded Losses with Magnetometer Data within the Marine Study Area

WA ID	UKHO/NMR ID	UTM Easting	UTM Northing	Date lost	Name	Description	Relation to Geophysical survey	Magnetic anomaly detected?
2001	UKHO 9199/ NMR 907541	374244	5877294	13/10/1910	Heathfield	A British merchant steamer built in Hartlepool in 1875. Ran aground in gale force winds. Carrying a cargo of coal from Blyth to Savona. Now totally broken up	±600m west of western cable route. Outside geophysical survey area	-
2002	UKHO 9438/ NMR 907543	377707	5877545	18/01/1915	George Royle	A steam ship built in 1882, stranded carrying a cargo of coal. Now upstanding by approximately 5m	±1.8km east of direct cable route. Outside geophysical survey area	-
2003	UKHO 9211/ NMR 907546	377458	5879468	28/06/1915	Zephyr	A British three-masted schooner built in 1865 in Jersey. Carrying a cargo of china clay from Fawley to Goole	Covered by additional magnetometer lines	No anomaly detected
2004	UKHO 10616/ NMR 907511	374750	5868440	10/08/1915	Rosalie (probably)	A British steam collier built in 1914. On passage from Tyne to San Francisco when torpedoed by UB-11	±200m east of direct cable route land terminus. Outside geophysical survey area	-
2005	UKHO 9266/ NMR 907582	372995	5892429	19/07/1941	HMS Umpire	A U class British patrol submarine built in Chatham Dockyard in 1941. Rammed and sunk by the trawler Peter H Kendricks. Now lying almost upright and fairly broken up	WA Line P1l02, WA Line P1L09 & additional magnetometer lines	Anomaly detected by WA Line P1L09 & additional magnetometer lines

Table 15.1 Comparison of Known Wreck and Recorded Losses with Magnetometer Data within the Marine Study Area

WA ID	UKHO/NMR ID	UTM Easting	UTM Northing	Date lost	Name	Description	Relation to Geophysical survey	Magnetic anomaly detected?
2006	UKHO 9275	372089	5895018	20/08/1941	Czestochowa	A Polish steam ship built in 1930 in Gothenburg. Carrying cement from London to the Tyne and Reykjavik when torpedoed. Exists now as broken wreckage.	Wind Farm Buffer Zone. Outside geophysical survey area	-
2007	UKHO 9263/ NMR 892354	372093	5892035	Unknown, located in 1945	Unknown	A well defined wreck	WA Line P2L47 & WA Line P2L48	Anomaly not detected
2008	UKHO 9264/ NMR 642490	372291	5891814	Unknown, located in 1950	Unknown	Possible wreck of a bomber aircraft	WA Line P2L53, WA Line P2L47 & additional magnetometer line	Anomaly detected
2009	UKHO 9212/ NMR 642449	374032	5880237	Unknown, located in 1954	Unknown	A vessel reported to have struck a submerged object. Scattered minor debris remaining	Covered by additional magnetometer line 50m east of site	No anomaly with archaeological potential detected
2010	UKHO 9515/ NMR 892338	374519	5879991	Unknown, located in 1992	Unknown	A small area of wreckage	Outside geophysical survey area	-
2011	UKHO 9517/ NMR 642468	380845	5885348	Unknown, located in 1992	Unknown	A wreck - no other information available	Wind Farm Buffer Zone. Outside geophysical survey area	-

Table 15.1 Comparison of Known Wreck and Recorded Losses with Magnetometer Data within the Marine Study Area

WA ID	UKHO/NMR ID	UTM Easting	UTM Northing	Date lost	Name	Description	Relation to Geophysical survey	Magnetic anomaly detected?
2012	UKHO 9528	374359	5889533	Unknown, located in 1993	Unknown	Undefined wreckage	Covered by additional magnetometer lines	No anomaly with archaeological potential detected
2013	UKHO 9529	374442	5889160	Unknown, located in 1993	Unknown	Possibly a small container	11m south of WA Line P2L10	No anomaly with archaeological potential detected
2014	UKHO 9530	374028	5884349	Unknown, located in 1993	Unknown	Clearly defined wreck	200m west of direct cable route. Outside geophysical survey area	-
2015	UKHO 9262/ NMR 642484	374329	5891574	Unknown	Unknown	A wreck now totally dispersed	65m south of WA Line P2L55 & covered by additional magnetometer lines	No anomaly with archaeological potential detected
2016	1383875 Weybourne	374478	5868757	1671	Unknown	Wreck of craft which stranded on the Norfolk coast in the vicinity of Salthouse and Runton; a wooden sailing vessel.	Named Location	-
2017	927484 Weybourne	374478	5868757	1744	Rye	British sixth rate ship of the line. Ran aground due to bad piloting	Named Location	-

Table 15.1 Comparison of Known Wreck and Recorded Losses with Magnetometer Data within the Marine Study Area

WA ID	UKHO/NMR ID	UTM Easting	UTM Northing	Date lost	Name	Description	Relation to Geophysical survey	Magnetic anomaly detected?
2018	1355793 Weybourne	374478	5868757	1762	Fortune	Wreck of English cargo vessel, which stranded at Weybourne after sinking offshore; a wooden sailing vessel.	Named Location	-
2019	1385932 Weybourne	374478	5868757	1762	Ann	Wreck of English wooden sailing cargo vessel which stranded near Salthouse en route from London in ballast.	Named Location	-
2020	1320832 Pollard	374478	5868757	1770	Unknown	Passenger vessel with no hands on board. Thought to be New England built	Named Location	-
2021	1217311 Weybourne	374478	5868757	1793	Good Intent	British craft that had travelled from Ostend	Named Location	-
2022	1339622 Pollard	374478	5868757	1804	James	Wreck of English sloop which stranded near Holt en route from Newcastle-upon-Tyne to Rochester with coal; a wooden sailing vessel.	Named Location	-
2023	1344109 Pollard	374478	5868757	1815	Neptune	English craft from Sunderland. Blown ashore during a violent gale	Named Location	-
2024	1351034 Pollard	374478	5868757	1823	Expedition	English cargo vessel	Named Location	-

Table 15.1 Comparison of Known Wreck and Recorded Losses with Magnetometer Data within the Marine Study Area

WA ID	UKHO/NMR ID	UTM Easting	UTM Northing	Date lost	Name	Description	Relation to Geophysical survey	Magnetic anomaly detected?
2025	1351091 Pollard	374478	5868757	1823	Ann	A craft travelling from St. Petersberg to London, lost in a gale	Named Location	-
2026	1315933 Weybourne	374006	5872108	1829	Unknown	English wooden billyboy that capsized off Weybourne	Named Location	-
2027	927950 Weybourne	374478	5868757	1868	Bee	English schooner built in Hull in 1837, lost in string winds	Named Location	-
2028	1348446 Weybourne	374478	5868757	1893	Ida	Norwegian barque built in Kristiansand in 1875. Stranded and lost in strong winds	Named Location	-
2029	1348665 Weybourne	374006	5872108	1894	Majestic	An English dandy built in 1882 in London, lost in heavy weather	Named Location	-
2030	1348669 Weybourne	374006	5872108	1894	Precursor	English fishing vessel, lost in gale force winds	Named Location	-
2031	1348674 Weybourne	374006	5872108	1894	Wellesley	English fishing vessel built in London in 1878, lost in gale force winds	Named Location	-
2032	927590 Weybourne	374478	5868757	1915	Rosalie	Welsh cargo vessel. Struck by a torpedo from a German U-boat but rescued by the British navy and towed to be beached near Sheringham	Named Location	-

Table 15.1 Comparison of Known Wreck and Recorded Losses with Magnetometer Data within the Marine Study Area

WA ID	UKHO/NMR ID	UTM Easting	UTM Northing	Date lost	Name	Description	Relation to Geophysical survey	Magnetic anomaly detected?
2033	929120 Weybourne	374478	5868757	1916	St Francois	French dandy built in 1896	Named Location	-
2034	1329573 Weybourne	374006	5872108	1942	Tiger Moth	British training aircraft built in 1938/9	Named Location	-
2035	1328672,1327800,1328682,1328669,1328084, 1321723, Weybourne	374006	5872108	1941	Queen Bee	British aircraft built in 1940/41, hit by anti aircraft	Named Location	-
2036	1352748, 1352765, 1352754 Pollard	374478	5868757	1941	Queen Bee	British aircraft built in 1940/41, hit by anti aircraft	Named Location	-

15.6 Impacts during Construction

15.6.1 Introduction

This section identifies and assesses the potential impacts of the construction of the proposed wind farm and cable routes upon archaeological material.

Aspects of marine construction that may impact on the archaeological material comprise:

- Foundations for turbines, scour protection, and offshore substation(s).
- Inter-array cables.
- Site to shore export cables.
- Anchoring and jack up, etc. by construction and maintenance vessels.

The direct seabed impact will vary greatly depending on which generator and foundation type is chosen. The largest foundation width is the octagonal shaped gravity base (GBS) with a diameter of 55m and a height of 6 m, although it is understood that this is not Scira's preferred option.

Scour protection may also be required to ensure the integrity of the foundations. At this stage Scira has estimated conservatively that scour which could affect a maximum area of 9m diameter around a monopile if protection is not implemented. Scira have not estimated a depth as this can vary greatly depending on the sediment.

In addition to the direct impact on the seabed caused by installation, the impacts of seabed preparation should be considered. This can include the removal of large rocks and the placing mudmats on the seabed for piles to rest on.

Numerous vessels are used during the construction of wind farms. These include vessels that anchor conventionally and jack-up vessels. Anchors, their cables and jack-up spuds (feet) will impact the seabed, sometimes to a depth of several metres and over an extended area. This will impact upon any archaeology within the footprint of these works.

In addition to impacts originating directly from the process of construction, of the wind farm and cable route there is the possibility of other impacts on archaeological sites. These include potential changes in the scour patterns that may expose previously buried sites.

15.6.2 General Mitigation Measures

The following general measures are designed to mitigate the impact of the wind farm development on known sites and unknown sites, and palaeo-landscapes within the MSA.

It is proposed that all aspects of any further archaeological work are detailed in a Written Scheme of Investigation (WSI), the aim of which is to put in place the archaeological mitigation measures suggested below or to be agreed between SCIRA and the regulator. The WSI would make provision for other forms of archaeological mitigation that might be required in the light of pre-construction investigations, including field investigation, post-fieldwork activities, archiving and dissemination of results. It would be subject to the acceptance by Norfolk County Council's Principal Archaeological Officer and English Heritage's Maritime Team.

The WSI will be accompanied by a Finds Reporting Protocol (Protocol) which will set out the procedure for reporting finds of cultural material made during construction when an archaeologist is not on site, including the legal requirements for the reporting of such discoveries.

The aim of the WSI and Protocol is to reduce any adverse effects of the development upon the historic environment by enabling people working on the project to report their finds in a manner that is convenient and effective.

The construction contractor/s will be responsible for the execution of the WSI and Protocol.

The WSI will make provision for the institution of Temporary Exclusion Areas around areas of possible archaeological interest, for prompt archaeological advice and, if necessary, for archaeological inspection of important features prior to further construction in the vicinity.

The WSI will include provisions to stabilise, record and report archaeological finds and contexts, with consideration given for their long-term conservation and appropriate museum deposition.

The WSI will also provide for the reporting of archaeological discoveries to the Norfolk HER. It will comply with the Merchant Shipping Act 1995, including notification of the Receiver of Wreck, and accord with the JNAPC Code of Practice for Seabed Developers.

The Protocol will be appended to the WSI for the construction phase referred to above.

In view of the potential for the presence of drowned land surfaces and associated prehistoric sites, and as yet unknown wrecks within the MSA, it is proposed that there be archaeological involvement during the pre-construction cable route clearance, and any similar activity undertaken within the vicinity of the wind farm. The methodology involved in the laying of the marine cables (both within the wind farm and along the export cables) and installing the turbines is such that a watching brief will not be productive.

15.6.3 Potential disturbance to Lower Palaeolithic to Mesolithic (680,000 BP - 4,000 BC)

The earliest known evidence of hominid occupation in the UK is from East Anglia and dates to c.680,000 BP. During each interglacial subsequent to that date it is likely that hominids occupied the now submerged landscape of the North Sea basin and north Norfolk, although no evidence of this has been found within the MSA. There is also no direct evidence for the presence of Mesolithic populations (and hence sites) within the MSA, but the area would have offered a rich variety of favoured topographic features, and hence some activity may be postulated.

The most likely archaeological remains for much of this period would be in the form of derived artefacts within the general body of the Swarte Bank, Egmond Ground and Boulders Bank formations. The suggested presence of clays and peats within the Swarte Bank formation increases the likelihood that in situ sites could survive. The Weybourne Channel deposits could contain, in situ, both middle Palaeolithic material and derived Lower Palaeolithic artefacts.

The proposed turbine foundations would penetrate the seabed deeply enough to have an impact upon the Swarte Bank, Egmond Ground and Boulders Bank formations, regardless of the foundation type chosen. The impact will vary depending on the foundation type.

Any prehistoric deposits, land-surfaces and artefacts that are present in the footprint of the various elements of the scheme at depths reached by construction would be impacted directly by seabed preparation or pile preparation. There may also be indirect impact caused by erosion triggered by construction activities.

A Stage 3 Assessment (laboratory assessment of pollen, foraminifera and diatoms) of samples identified in the Stage 2 report will be carried out in order to provide palaeo-environmental and chronological evidence about the Southern North Sea. The extent of this assessment will be agreed with the regulator.

In the area of the wind farm, several wind turbine sites are located within palaeochannels located by seismic survey (Brew 2005). It is suggested that further geotechnical work at these sites should, where necessary be supplemented by archaeological recording and sampling of the lower part of these sequences to obtain chronological and palaeo-environmental data relating to the earliest phase of sedimentation within the palaeochannels. The extent of this assessment to be agreed with the regulator.

The scheme will affect seabed sediments that may contain archaeological material dating from the Lower Palaeolithic to the Mesolithic, and if present this material is likely to be of high national and probably international importance. There is currently insufficient evidence to fully understand the likely potential for the presence of sites of this date within the MSA. All that may be said at this stage is that if a site or find did lie within the footprint of the development impact then the significance of the effect would be high. However, the likelihood of finding any material from this date is limited, and if the mitigation measures suggested above are implemented the scale of the residual impact and therefore the significance of the effect is likely to be **negligible**.

15.6.4 Potential disturbance to Neolithic to Roman (4,000 BC – 410 AD)

By the start of the Neolithic the wind farm area is likely to have been completely inundated and by the Roman period the coastline had reached a point close to its present position. This is thus the last period for which there is some possibility for the presence of submerged terrestrial sites within the MSA.

Evidence suggests that throughout the Neolithic the north coast of Norfolk in the vicinity of the study areas was not densely populated and that this may have been as a result of the poor soil for farming in the area. However, there is evidence for a greater human population within the region during the Bronze Age. In the vicinity of the MSA, a circular 'henge' monument has been found below the high water mark further up the coast.

It is possible that there was Bronze Age and Iron Age activity within the near-shore elements of the MSA although no recorded archaeology has been found within the MSA for this period..

Any sites that do exist are not likely to be covered by thick layers of sediment. Therefore the laying of the marine export cables across the seabed, inter-tidal zone and up the beach is likely to impact any sites that lie along the line of the route. In view of the likelihood that palaeo-landscapes discussed above continue into the intertidal zone, any vibrocore surveys undertaken as part of geo-technical investigations within the inter-tidal zone should be archaeologically assessed. The extent of the assessment will be agreed with the regulator.

A watching brief should be conducted for any excavations related to the cable landfall within the inter-tidal zone, with sufficient time allowed to enable further work (possibly excavation) to be undertaken where sites or archaeological material are encountered. A watching brief is a formal programme of observation and investigation conducted during any operation carried out for non-archaeological reasons where there is a possibility that archaeological deposits may be disturbed or destroyed.

Sites of this period are likely to be at least of high local, and more likely of regional or national importance. However, the likelihood of finding material from this date is limited, and if the mitigation measures suggested above are implemented the scale of the residual impact and therefore the significance of the effect is likely to be **negligible**.

15.6.5 Potential disturbance to Saxon to Modern (410AD –)

The nearby town of Weybourne is likely to have originally been a Saxon settlement. The main area of archaeological potential within the MSA between the Saxon period and the present is likely to relate to the fishing industry. No archaeological material from this period has been recorded within the MSA but the 2004 Norfolk Survey identified a large number of fish traps, quays and jetties, among other maritime constructions along the north Norfolk coast, dating from Saxon and later periods.

A watching brief should be conducted for any excavations related to the cable landfall within the inter-tidal zone, with sufficient time allowed to enable further work (possibly excavation) to be undertaken where sites or archaeological material are encountered. A watching brief is a formal programme of observation and investigation conducted during any operation carried out for non-archaeological reasons where there is a possibility that archaeological deposits may be disturbed or destroyed.

The laying of the marine export cables across the seabed, inter-tidal zone and up the beach is likely to impact any such sites that lie along the line of the route. The scale of this impact will depend on the type of site, but if the mitigation measures suggested above are implemented is not likely to be high. As a result, the residual impact of the installation of the marine export cables upon sites of at least of high local and probably of regional importance is likely to be **negligible**.

15.6.6 Potential disturbance to Known and Unknown Wrecks

Of the 15 known wreck sites listed in Appendix 15.2 and shown on Figure 15.1, six (WA2005, 2007, 2008, 2012, 2013 and 2015) are located within the area of the wind farm. Of these six sites, two are defined as 'dead' by the UKHO. The status of the remainder is classified as "unknown". WA2005 is defined as a British U-class submarine and WA2008 may be a Royal Air Force bomber, both of which would be protected under The Protection of Military Remains Act 1986.

Two other sites are located within the wind farm buffer zone and the remaining seven within the cable buffer zones; the closest to the cable route being WA2004, the Rosalie, which lies approximately 190m from the southern terminus of the cable route. We are aware the installation of the cables around this wreck needs extra attention. Before construction a survey will be done to get detailed information about the exact location and profile of the wreck. The cable route will be adjusted, if necessary.

It should be noted that the remains of 'dead' sites may well be present under the seabed, where they cannot be detected by sidescan sonar or boomer survey methods, but still may be impacted upon by seabed activities.

Any number of the wrecks listed under recorded losses in the gazetteer in Appendix 15.3 may be located within the MSA. Of particular interest is the early unknown sailing vessel (WA2016) and the sixth rate ship of the line Rye (WA2017). Any such unidentified site would have to be assessed on discovery.

In addition to the known wreck sites and recorded losses there is potential for the presence of unknown and undocumented wrecks from various periods. The importance of these remains would have to be assessed on a site by site basis as they are found, but levels of importance ranging from low to high are likely.

Any shipwrecks that are present in the footprint of the various elements of the scheme at depths reached by construction would be impacted directly by seabed preparation or pile preparation. Possible impacts include:

- Direct damage to wreck structure and contents;
- Disturbance to relationships between structures, artefacts and their surroundings;
- Destabilisation of sites prompting renewed corrosion, decay, etc.; and

Erosion leading to damage, disturbance and instability in the medium to long term.

Construction may also impact upon unknown wrecks and ship-borne debris. It should be noted that repeated discoveries of apparently discrete items from a specific area might indicate the presence of a coherent site or shipwreck.

Although measures should be taken to deal with unanticipated discoveries, it would not be reasonable to consider the possible impact on such material as a priori constraint on proposed construction.

The geophysical review carried out as part of the Archaeological Desk-based Assessment was sufficient for the limited identification of cultural heritage. Further geophysical surveying may be required prior to the commencement of construction work. Archaeological input into the survey specification and methodology should ideally be sought.

The scope of the archaeological assessment of any future geophysical data will be agreed with the regulator. It is proposed that any such future assessment would focus on the areas of seabed to be affected by the scheme. This will provide further information on the existing wreck sites and obstructions, and identify previously unknown wrecks within the development area. It will also allow for the identification of more ephemeral anomalies that may represent partially buried or wooden wrecks, and debris.

In order to prevent damage to known wreck sites and geophysical anomalies with archaeological potential it is appropriate to place Construction Exclusion Areas (CEA) around such sites. The size of the CEAs are determined on a site by site basis, and will depend on the extent of the known or suspected archaeology.

It may be possible to move, reduce or remove any CEA established as a result of this assessment if further geophysical survey work is carried out prior to construction. Such survey work could include geophysical survey and/or diver or Remotely Operated Vehicle (ROV) surveys.

The following are proposed as Construction Exclusion Areas from the results of the Archaeological Desk-based Assessment (see also Figure 15.6):

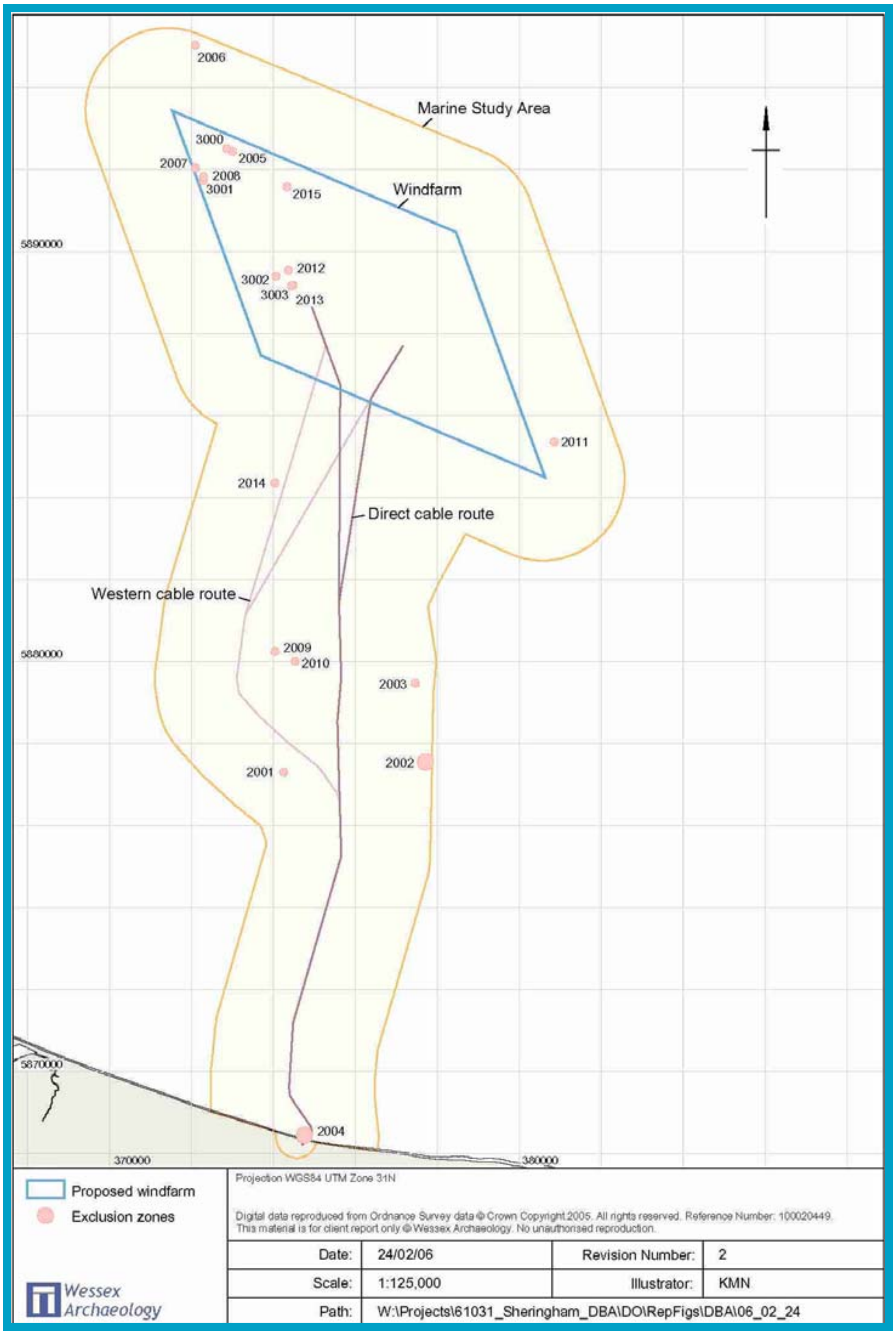


Figure 15.6 Suggested Construction Exclusion Areas (Source: Wessex Archaeology)

Table 15.2 Recommended Construction Exclusion Areas

UKHO & NMR Records	UTM Easting	UTM Northing	MS Area	Sidescan sonar contact (LxWxH) / Magnetometer signal	Recommended Exclusion Areas
WA2001 Heathfield	374244	5877294	Cable Route	87m x 12m x 6m	100m radius
WA2002: George Royle	377707	5877545	Cable Route	110m x 20m x 0m	200m radius
WA2003: Zephyr	377458	5879468	Cable Route	50m x 10m x 2m	100m radius
WA2004 Rosalie (probably)	374750	5868440	Cable Route	115m x 16m x 8m	200m radius
WA2005: UKHO HMS Umpire	372995	5892429	Wind Farm	54m x 19m x 4.2m	100m radius
WA3000	372853.44	5892505	Wind Farm	500nT	100m radius
WA3001	372278.94	5891707.5	Wind Farm	40nT	100m radius
WA3002	374056.31	5889390	Wind Farm	25.9nT	100m radius
WA3003	374467.84	5889167.5	Wind Farm	18.3nT	100m radius
WA2006: Czestochowa	372089	5895018	Wind Farm Buffer Zone	79m x 13m x 9m	100m radius
WA2007: Unknown	372093	5892035	Wind Farm	62m x 18m x 1.4m	100m radius
WA2008: Unknown. Possible aircraft	372291	5891814	Wind Farm	None	100m radius
WA2009 Unknown	374032	5880237	Cable Route	None	100m radius
WA2010 Unknown	374519	5879991	Cable Route	30m x 15m	100m radius
WA2011 Unknown	380845	5885348	Wind Farm Buffer Zone	70m x 20m	100m radius
WA2012: Obstruction	374359	5889533	Wind Farm	49m x 12m x 0.5m	100m radius
WA2013: Obstruction	374442	5889160	Wind Farm	5m x 3m x 2.1m	100m radius
WA2014 Unknown	374028	5884349	Cable Route	56m	100m radius
WA2015: Unknown	374329	5891574	Wind Farm	None	100m radius

Construction Exclusion Areas will be marked on scheme masterplans, including contract documents.

A Temporary Exclusion Areas (TEA) may be placed around any area of possible archaeological interest encountered during construction. This is to allow archaeological advice to be sought and, if necessary for the archaeological inspection of the material prior to further construction in the vicinity.

If a wreck of historical and/or archaeological importance were to be discovered in the course of construction, it may be necessary for it to be designated at short notice, despite any possible impact on construction activities.

Similarly, any military vessels or aircraft discovered in the course of construction will be automatically protected under the Protection of Military Remains Act 1986. It would then be an offence to carry out any unauthorised excavations within the immediate vicinity of such remains.

If the scheme plans cannot be altered to avoid an archaeological site then the site should be subject to a process of evaluation to establish its importance and extent, followed (if necessary) by a level of recording appropriate to the importance of the site. This work would be required prior to the construction works that will affect the site.

There is some potential for impact on discrete items of ship-borne debris. Such items cannot be anticipated and if small, will be lost within the volume of material excavated as part of any seabed preparation. Larger items may be identified and retrieved. Such items will be stabilised, recorded and reported under the Finds Reporting Protocol. The Protocol will include guidelines for distinguishing debris of no archaeological merit from more significant finds which may warrant further investigation.

Notwithstanding these precautions, features of archaeological interest may be encountered in the course of construction. In such instances, Scira will:

- comply with the Merchant Shipping Act 1995 in respect of reporting and ownership of wreck, including notification of the Receiver of Wreck;
- observe the JNAPC Code of Practice for Seabed Developers; and
- observe the Protocol for Reporting Finds of Archaeological Interest (BMAPA/EH 2005).

The impact on known and/or potential wreck material depends upon the proximity of the archaeology to the turbines and cable routes. When turbine positions are confirmed, a pre-construction survey may result in micrositing of turbines to avoid any impact upon known and/or potential wreck material found within close proximity to turbine positions. The scale of the potential impact considered under the Rochdale envelope principle (see section 1) ranges from major adverse (a direct ‘hit’ from a turbine) to negligible (a peripheral ‘hit’ from a cable). After confirmation of turbine positions, the successful implementation of the mitigation measures suggested above should reduce the scale of potential impacts through avoidance and thus the significance of the effect the scheme may have on wreck material of minor to major archaeological importance is likely to be **minor**.

15.7 Impacts during Operation

15.7.1 Introduction

This section identifies and assesses the potential impacts of the operation of the proposed wind farm and cable routes on archaeological material.

15.7.2 Impacts during Operation

Maintenance for the wind farm and buried cables could involve the use of anchored or jack-up vessels stationed at the required point of maintenance.

As during construction, the activities may impact upon archaeological material, and it is therefore suggested that the Finds Reporting Protocol should apply to all maintenance activities. However, as maintenance activities are likely to be confined to areas of the seabed that have already been disturbed no impacts on the archaeological resource during operation are anticipated.

15.8 Impacts during Decommissioning

15.8.1 Introduction

This section identifies and assesses the potential impacts of the decommissioning of the proposed wind farm and cable routes on archaeological material.

15.8.2 Impacts during Decommissioning

The decommissioning of the wind farm could involve the use of anchored or jack-up vessels and equipment to recover foundation platforms and other scheme elements.

These activities may impact upon archaeological material, and it is therefore suggested that the Finds Reporting Protocol should apply to all decommissioning activities. However, as decommissioning activities are likely to be confined to areas of the seabed that have already been disturbed **no impacts** on the archaeological resource during operation are anticipated.

15.9 Summary

Wessex Archaeology has carried out a thorough assessment of the possible effects of the proposed wind farm upon the archaeological heritage, using desk-based sources, marine geo-technical data and marine geophysical data. The assessment has addressed the overall development of the landscape from the start of the Lower Palaeolithic, indicating the likely interplay of glacial and post-glacial processes, sea-level change and the potential for maritime remains. The impact assessment was undertaken on the basis of the assessment methodology described above.

The potential for archaeological material was assessed by reference to an area surrounding the wind farm area and marine cable routes (direct and western) referred to as the Marine Study Area, and an area surrounding the cable landfall which has been referred to as the Coastal Study Area. Information was sought from a wide range of local and national bodies, including the Historic Environment Record (HER) maintained by Norfolk Museums & Archaeology Service, the National Monuments Record (NMR), and by the United Kingdom Hydrographic Office (UKHO).

The proposed export cable routes are to follow palaeo river channels on the seabed in order to reduce as far as possible the impacts of nearby biology of the dispersion of chalk during installation of the cables. To compensate for the loss of archaeological information during cable installation, WA advised on a series of vibrocores along the cable routes. These vibrocores were assessed by WA for archaeological data relating to submerged terrestrial prehistoric archaeology within the area and the results of a Stage 2 Assessment (Recording and Sampling), and a limited geophysical review formed part of the discussion of the archaeological potential of the area. A Stage 3 Assessment (laboratory assessment of pollen, foraminifera and diatoms) will be carried out. The extent of this assessment will be agreed with the regulator.

The known and potential archaeological resource within the vicinity of the Marine Study Area was identified as:

- 15 known and recorded wrecks;
- 21 recorded vessel losses for which there are no known seabed remains;
- Possible unknown and undocumented wrecks from various periods dating back to the Iron Age or earlier;
- Possible stray finds of ship-borne debris from various periods;
- Two magnetometer anomalies corresponding with known wrecks.
- Two magnetometer anomalies corresponding with known obstructions.
- The potential for the presence of drowned land surfaces (and associated sites) from the Lower Palaeolithic to the Iron Age (500,000 BP – 43 AD).
- Potential Lower Palaeolithic to Modern material within the inter-tidal zone, including World War II archaeology.

The assessment has identified possible significant adverse effects on archaeological sites and materials, but makes a number of recommendations regarding mitigation and monitoring, including measures to further clarify the potential for as yet unknown sites and provision for dealing with archaeological material discovered in the course of construction, such that the residual effect of the scheme will be **negligible**.

The residual effect may even be positive if the proposed mitigation measures are implemented because additional information about human habitation and maritime activity in the area is likely to add to understanding, appreciation and future conservation of the historic environment of Norfolk.

For the maritime elements of the development the following mitigation has been proposed:

- Placing Construction Exclusion Areas around the wreck sites and significant geophysical anomalies.
- The agreement with the regulator of the scope of any further archaeological assessment of future geophysical and/or geotechnical surveys.
- The implementation of a WSI and Finds Reporting Protocol for the construction phase of the scheme.

Further mitigation may be necessary on the basis of the results of the above work.

For the inter-tidal area the following mitigation has been proposed:

- The archaeological assessment of any vibrocore surveys undertaken as part of geo-technical investigations within the inter-tidal zone. The extent of the assessment will be agreed with the regulator
- A watching brief for any excavations related to the cable landfall within the inter-tidal zone.

The assessment has addressed as far as possible impacts on known and unknown wrecks that lie within the Sheringham Shoal OWF and cable routes. Based on current information the assessment has addressed possible impacts on these known sites and geophysical anomalies. Provision has been made to establish Construction Exclusion Areas around all known wrecks and anomalies suspected of being of archaeological interest A WSI and Finds Reporting Protocol will be prepared, setting out procedures for dealing with any features that appear to be of archaeological importance which are discovered in the course of construction.

15.10 References

- Arnold, C. J., 1988, An Archaeology of the Early Anglo-Saxon Kingdoms, Routledge, USA
- Bond, R., Penn, K. & Rogerson, A., 1990, 4:The North Folk; Angles, Saxons and Danes, Poppyland Publishing
- Brookes, P., Weybourne, 1984, Peaceful mirror of a turbulent past, Poppyland Publishing
- Cameron, T. D. J., Crosby, A., Balson, P. S., Jeffery, D. H., Lott, G. K., Bulat, L. & Harrison, D. J., 1992, The geology of the southern North Sea, NERC, UK
- Castleden, R. & Green, C. Eds., 1998, North Norfolk Coast, The Geographical Association
- Chisham, K., 2004, Early Mesolithic environmental change and human activity-A case study of the Kennet Valley, Unpublished PhD thesis, Department of Archaeology, University of Reading
- Coles, B. J., 1998, Doggerland: a Speculative Survey, Proceedings of the Prehistoric Society 64, pp. 45-81
- Cox, F.C., Gallois, R.W. & Wood, C.J., 1989, Geology of the country around Norwich, British Geological Survey
- Davies, J. A., 1996, Where the eagles dare: Iron Age of Norfolk, Proceedings of the Prehistoric Society 62, pp. 63-92
- Envision Mapping Limited, 2005, Acoustic, Video and Grab Survey of Sheringham Shoal Offshore Windfarm, Report Ref: SCIRA-7-4-1-EX-RP-07115-V4
- Flemming, N. C., 2002, The scope of Strategic Environmental Assessment of the North Sea areas SAE3 and SEA2 in regard to prehistoric archaeological remains, Department of Trade and Industry
- Gurney, D., 2002, Outposts of the Roman Empire, Norfolk Archaeological Trust
- Hamblin, R. J. O., Crosby, A., Balson, P. S., Jones, S. M., Chadwick, R. A., Penn, I. E. & Arthur, M. J., 1992, The geology of the English Channel, Nerc, UK
- Institute of Field Archaeologists, 1999, Standard and Guidance for Archaeological Desk-Based Assessment, IFA guidance paper
- Ketton-Cremer, R.W., 1969, Norfolk in the Civil War, Faber & Faber Ltd.
- Larn, R. & Larn, B., 1997, Shipwreck Index of the British Isles: The East Coast of England, Lloyds register of shipping
- Margeson, S., Seillier, F. & Rogerson, A., 1994, The Normans in Norfolk, Norfolk Museums Service
- Royal Haskoning, 2005, Sherringham Shoal Offshore Windfarm Seismic Survey-Interpretative Report (Unpublished), Scira Offshore Energy
- Sampson, A., 1988, Processes affecting the North Norfolk's cliffs and coastal defences, Sherringham Museum Trust
- Spikins, P., 2000, GIS models of past vegetation: an example from Northern England, 10,000-5000 BP. Journal of Archaeological Science 27:219-234.
- Wessex Archaeology, 2004, Sheringham Shoal Offshore Wind Farm, Comments on Geophysical Survey Specifications, Report Ref. 57270.02
- Wessex Archaeology, 2005, Area 485 Southernmost Rough Aggregate Dredging Licence Application, Archaeological Assessment, Report Ref: 59590.02

- Wessex Archaeology, 2005a, Sheringham Shoal Offshore Windfarm, Stage 2 Archaeological Recording and Sampling of Vibrocores, Report Ref: 61032.01
- Wessex Archaeology, 2005b, Sheringham Shoal Offshore Windfarm, Stage 1 Archaeological Assessment of Vibrocores, Report Ref: 61030.01
- Wessex Archaeology, 2006, Sheringham Shoal Offshore Windfarm Archaeological Desk-Based Assessment, Report Ref: 61031.02 Watson, C., 2005, Seahenge: an archaeological conundrum, English Heritage
- Wilson, D., 1970, The Vikings and their Origins, Thames and Hudson
- Wilson, D. M., 1976, The archaeology of Anglo-Saxon England, Methuen and Co. Ltd.
- Wymer, J.1999, The Lower Palaeolithic Occupation of Britain, Wessex Archeology and English Heritage
- Wymer, J., 1999, The Lower Palaeolithic Occupation of Britain, Wessex Archaeology and English Heritage

16 Military and aviation

16.1 Introduction

This section describes the military and aviation interests of relevance to the Sheringham Shoal offshore wind farm site related to strategic Ministry of Defence radar interests located along the East coast and civil aviation interests such as airspace and helicopter routes in the vicinity.

16.2 Assessment Methodology

Consultation has been undertaken with the Ministry of Defence (MoD) Defence Estates to establish the potential effects of the operational wind farm on their radar and strategic defence interests. Defence Estates initially objected to the location of the Scira proposed offshore wind farm (March 2004), stating that ”the site lies within line of sight and 74km of Air Defence Radar head at Trimingham”. In view of MoD’s objection, Scira commissioned QinetiQ to undertake a radar interference and mitigation study to assess the impact of the proposed development (original layout) on the MoD air defence radar as well as the benefit of two alternative layouts being discussed at that time (radial and stretched) in mitigating the impact (Qinetiq, 2004).

The existing civil aviation routes and radar installations were identified from a desk study and consultation has taken place with the Civil Aviation Authority (CAA), National Air Traffic Services (NATS) and the local helicopter operator (Bristow Helicopters) to ascertain the civil interests in the area and the likelihood of conflict with the project. NATS undertook a specific study to identify potential radar interference with the project.

The definition of significance levels and the methodology used for determining impact as outlined in Section 3.6, The Environmental Impact Assessment Process is not applicable here. The potential impacts have been assessed internally by organisations outside the control of Scira, and the considerations that have led to the given conclusions have not been disclosed to Scira.

16.3 Description of the existing environment

16.3.1 Military radar

The nearest air defence radar station is at Trimingham (on the cliff between Mundesley and Overstrand), approx. 20km south–south–east from the project site. The air defence radar is currently the Type 93, but is likely to be upgraded to the Type 101 in the 2006-2008 timeframe. For this reason the impacts of the radar are assessed as if the facility were a Type 101 as shown in Plate 16.1 below.

Plate 16.1 The antenna for the AR327 air defence radar (Type 101).

The proposed wind farm is well within the critical range of 74km from the nearest air defence radar station.

Turbines in a wind farm may adversely affect radar in three ways: clutter, shadowing and tracking degradation. Clutter is an effect which shows the turbines on radar screens due to the movement of the blades, creating 'false' reflections, although recently developed software appears to have solved this problem. Radar shadowing (holes, masking, obscuration) means that the radar experiences losses in signals from targets in the 'shadow' cone behind any obstacle e.g. a wind turbine. At 25km distance the losses may be in the order of magnitude of several percent. Tracking degradation means a decreasing intermittent primary return from receptors. A number of solutions are being developed, both in terms of hardware (e.g. stealth rotor blades) and complementary software to be used by the radar station (e.g. Advanced Digital Tracking ADT).

There are a number of other RAF bases and radars in Norfolk, for example RAF Coltishall, however the Ministry of Defence has confirmed that they have no concerns regarding these installations. Their only concern relates to the Air Defence Radar head at Trimingham.

16.3.2 Civil Airspace

Consultation has been undertaken with the CAA, NATS and Bristow Helicopters, which is one of the main helicopter operators in the area servicing the offshore oil and gas industry. It was confirmed that the wind farm site is outside the Helicopter Main Routes, which are located further to the east, although helicopter operations in the area are not exclusively confined to these routes. There are two main concerns for operating helicopters in the vicinity of offshore wind farms. The first is in bad weather when aircraft radar is used to approach an offshore platform and the presence of a wind farm close to the installation would impede this. There are however no platforms in the vicinity of the proposed site. The second is interference with a radar being used by air traffic controllers to ensure aircraft separation. In this case the radar at Cromer is used by Anglia Radar to perform the task in this area and the proposed site could cause a problem.

Discussions with NATS revealed that the wind farm is located in direct line of sight from the Primary Radar service at Cromer, and moreover located within the 30km radar safeguarding zone. If wind turbines are within this range of a civil aviation radar, they can cause some back-scattering. This means the wind farm has the potential for generation of 'false radar plots' which can impact on the provision of services.

Another civil radar is located at Norwich airport. Due to the distance of over 50km between the project site and the airport no safeguarding issues have been highlighted. The runways are located east–west and northeast–southwest, therefore the radars are not directed towards the wind farm and radar interference is not considered to be an issue.

16.4 Impacts during construction

There would be no adverse effects on radar during construction as the turbine blades would not generally be moving. There are also no conflicts between helicopter routes or general airspace during construction.

16.5 Impacts during operation

16.5.1 Clutter and shadowing

Further clarifications from MoD indicated that their main concern was related to shadowing (crossing and down shadow effects) and their secondary concern of radar clutter immediately above the wind farm, which, taken together, could potentially degrade their low-level radar coverage to the point where the air defence system is compromised in its ability to maintain the integrity of UK airspace.

The study has shown that with regard to shadowing the MoD's acceptance criteria (tracking index 4 or more) are well satisfied by both the original layout and the stretched alternative for a number of alternative flights paths considered. The alternative radial layout met these criteria for two out of three flight paths considered (see Figure 16.1).

Regarding the secondary issue of clutter, which was originally perceived by the MoD not to be a major cause for concern as systems for coping with clutter were already in place, the study has shown that the required tracking index of 4 may be met, although the probability of doing so is quite low. The probability for a minimum track quality of 4, while an object is flying up to 1000m above the wind farm, is 12% for the original layout, 15% for the stretched layout and 22% for the radial layout. The more general issue of distinguishing higher altitude targets from wind farm clutter is currently the subject of separate research effort by the MoD to understand and mitigate the apparent obscuration effect. Therefore, compared with the original proposed layout the stretched layout does not provide any marked improvement whereas the radial layout does not meet MoD acceptance criteria on down shadow effects (see Figure 16.1).

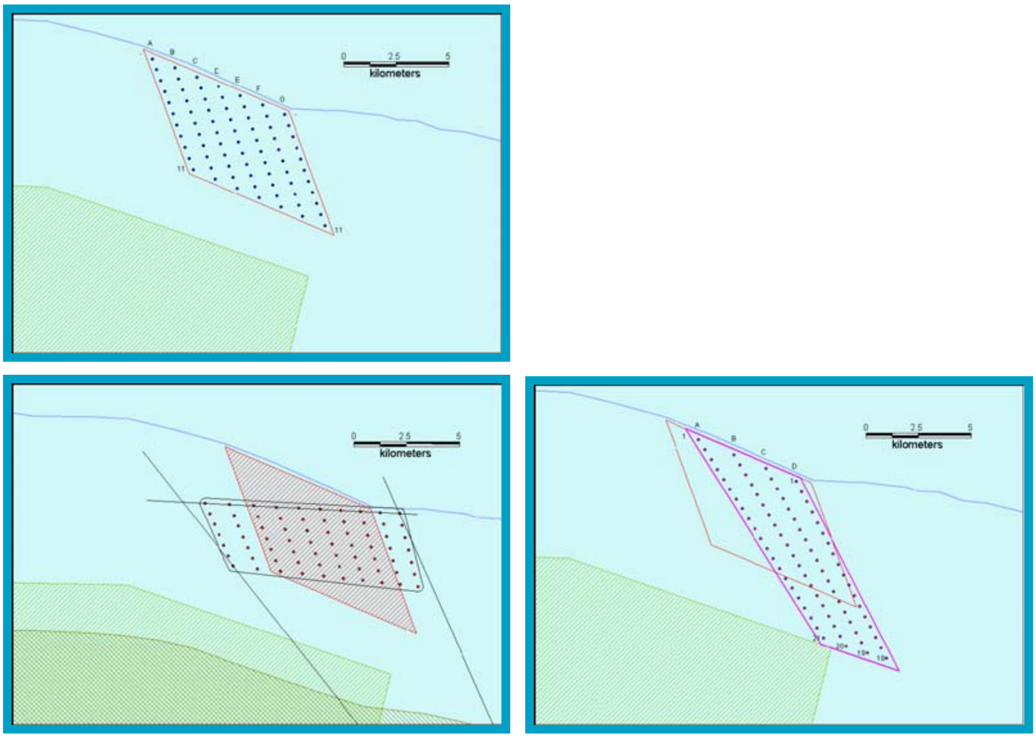


Figure 16.1 Original lay-out, stretched lay-out and radial lay-out, as assessed by QinetiQ in term of impact on clutter and shadowing. The original lay-out proves to be best.

Initial discussions on the study results with Defence Estates (Defence Science and Technology Laboratory and the Air Warfare Centre), concluded that both parties endorsed the rationale behind the approach taken by QinetiQ but believed that more detailed modeling and validation work was required if the results were to be relied upon. Unfortunately, further discussions have not taken place as Defence Estates shifted their focus from an individual site specific mitigation strategy to a more collective strategy involving discussions with the other relevant wind farm developers in the Wash.

One solution designed to mitigate the MoD's concerns for the whole of the Greater Wash would consist of an additional radar station at Donna Nook on the Lincolnshire coast. Alternatively, if field trials prove successful, new software designed to be installed on the Type 101 radars may also mitigate the MoD's concerns. These options are currently the subject of a DTI funded study. Results are expected in the Spring of 2006. MoD has indicated that they would lift the objection provided both technical and financial solutions have been found.

Scira has agreed to follow one of the mitigation options described above and awaits the outcome of the feasibility study, as well as high level discussions taking place under the auspices of the Working Group on Wind Energy, Defence and Civil Aviation Interests represented by DTI, MoD, CAA and the BWEA.

16.5.2 Helicopter Routes and Airspace

The operational wind turbines of the site have the potential to generate 'false radar plots' which could impact on the provision of services of the Cromer civil radar. Based on project information provided by Scira, radar plots with the (virtual) reflections of the wind turbines ('false plots') were generated by NATS. These plots were analysed and assessed by users of NATS' radar services, such as NATS department of Air Traffic Control and against the current safeguarding and planning guidelines, as well as other regulatory constraints.

NATS concluded that, although the proposed development is likely to impact NATS' electronic infrastructure, they are unlikely to object to the project wind farm. This statement forms a non-binding indication of their response.

No issues regarding radar or airspace interference with the operations at Norwich airport or the local helicopter operator have been identified.

The operational wind farm will be lit according to the guidelines set out by the CAA (see Section 2) and the exact configuration of lights and notifications will be agreed in advance. **No impacts** are anticipated.

16.6 Impacts During Decommissioning

No impacts during decommissioning are anticipated.

16.7 Cumulative Effects

In terms of military interests a cumulative assessment of the effect of all wind farms in the Greater Wash has been undertaken (see above). A cumulative impact assessment regarding civil aviation interests has not been undertaken by NATS, as it is unknown where and how the neighbouring wind farms will be developed. Therefore NATS agreed to de-couple the Sheringham Shoal project from others in the Greater Wash.

16.8 Summary

Operational turbines in a wind farm can adversely affect radar in three ways: clutter, shadowing and tracking degradation. Clutter is an effect which shows the turbines on radar screens (due to the movement of the blades), creating 'false' reflections. Radar shadowing causes the radar to experience losses in signals from targets in the 'shadow' behind a wind turbine. Tracking degradation means a decreasing intermittent primary return from receptors. The Ministry of Defence (MoD) objected to the location of the Scira proposed offshore wind farm (March 2004), because it lies within line of sight and 74km of Air Defence Radar head at Trimingham. A study undertaken by QinetiQ investigated the adverse radar effects and discussions were initiated with MoD on the results of this study. The MoD has however, since, decided to follow a more collective mitigation strategy to the problems in discussion with other wind farm developers within the Wash, since many of them would cause the same issues. A DTI funded study is due to report in Spring 2006 on both hardware and software options aimed at mitigating the wind farm effects on the air defence radar based at Trimingham.

Consultation with the relevant authorities and helicopter operator in the area and studies investigating the potential for radar interference have shown that there are no significant conflicts between the project and civil airspace or radar.

16.9 References

- QinetiQ 2004: Impact assessment of the Sheringham Shoal offshore wind farm development on MOD defence radar

17 Other Human Activities

17.1 Introduction

This section describes the other human activities within the Sheringham Shoal wind farm study area, which include oil and gas activities, marine aggregate extraction, marine disposal sites, military exercise areas, telecommunications cables, pipelines and unexploded ordnance. Interference to telecommunications is also discussed in this section. Commercial fisheries, navigation and coastal tourism and recreation are discussed in Sections 12, 14 and 27 respectively.

17.2 Assessment Methodology

Data collation and consultation has been undertaken with key stakeholders in order to establish the presence of relevant offshore and near shore infrastructure and activities and identify potential conflicts. A conflicts check has also been carried out by The Crown Estate. In addition, BACTEC International Ltd has undertaken a risk assessment regarding the possibility of unexploded ordnance within the area of works (See Appendix 17.1).

Consultation was undertaken with Ofcom, the BBC, T-Mobile, Cable and Wireless, Orange and British Telecom to identify any telecommunications or fixed links that may be affected by the project. No objections were raised and therefore this issue is not considered further.

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 17.4 – 17.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section 3 for the definition of significance levels.

17.3 Description of the existing environment

17.3.1 Oil and gas operations and ancillary structures

The southern North Sea is an important area for oil and gas extraction dominated by offshore gas fields. The sector is regulated by the DTI though a licensing process. The Sheringham Shoal wind farm site falls partially within block 21 and 27 of quadrant 48. Block 21 is currently under license to Warwick Energy Exploration Ltd. It is unlikely that the area will be subject to future prospecting or drilling due to the limited prospects.

Block 27 of quadrant 48, located to the west of the proposed site, has been awarded to Bridge E&P at the 23rd licensing round, which closed on 9th June 2005. Other activity includes two wells drilled in 2005, due north of Cromer by Century Oil. Therefore there is a possibility that seismic surveys and exploratory drilling could take place following lease of the block.

There are no oil or gas pipelines traversing the proposed site or cable routes, the nearest passing over 15km away to the north and east, terminating respectively at the gas terminals at Theddlethorpe and Bacton.

17.3.1.1 Aggregate extraction and marine disposal sites

Aggregate extraction activities are licensed by The Crown Estate following a positive Government View regulated by the Office of the Deputy Prime Minister (ODPM). There are currently no licensed aggregate extraction areas close to the proposed wind farm site. A number of licensed areas exist to the north west, the closest being South Inner Dowsing (Area 107) owned by British Dredging Limited (RMC Marine) and Area 440 owned by Westminster Gravels Ltd. Both areas are 25km from the site.

There are no marine disposal sites located within the vicinity of the proposed wind farm site or any areas nearby subject to capital or maintenance dredging activities.

17.3.2 Outfall and Telecommunications cables

There are two discharge consent sites within 250m of the landfall site at Weybourne Hope. These are operated by Anglian Water Services Ltd and are identified as Sewage Discharges-Final/Treated effluent- Water Company.

Telecommunications cables have been laid in the southern North Sea at numerous locations. Concentration of cables run from the East Coast directly across to the Netherlands. The proposed wind farm site lies within an area of low density cabling with no active cables passing directly through the site. A marine communications cable passes just to the east of the landfall site, which comes ashore at the Weybourne car park. This cable is not in service but should be treated as live (Openreach Sub sea Operations Group).

17.3.3 Military exercise areas and Unexploded Ordnance

There are no military practice and exercise areas (PEXA) within the vicinity of the proposed wind farm site.

The north Norfolk Coast and the adjacent sea area have, however, been subject to considerable military activity in the past, in particular from activities during World War II. Specific activities in the locality include.

- The local Anti Aircraft Gunnery School at Weybourne.
- The coastal defence battery at Sheringham.
- The coastal defence line along the beach minefields of Sheringham, Weybourne and Cromer.
- Naval actions off Sheringham and Cromer.
- Cargoes dispersed from sunken ships.
- British laid minefields to protect Convoy Routes.
- German mines laid by aircraft, warships and submarines.

The hazardous items likely to be encountered as a result of these activities include:

- Sea mines.
- Naval gun ammunition, depth charges and torpedoes.
- Air delivered bombs.
- Aircraft machine gun ammunition and rockets.
- Land based defence gun ammunition.
- Land and ship based anti aircraft gun ammunition.
- Munitions on wrecks from attacking aircraft, ships and coastal artillery.
- Munitions in the holds of wrecks.

- Munitions from the holds of wrecks broken up by the sea and weather.

Whilst many of the hazards will have been removed after WWII, ordnance has been washed ashore and dealt with in the past 60 years. Even so, unexploded ordnance could still remain buried in the seabed and the beaches.

17.4 Impacts during construction

17.4.1 Impacts on existing infrastructure, dredging and disposal activities

No impacts on marine aggregate extraction, marine disposal activities or dredging activities are predicted due to significant distance separation.

17.4.2 Impacts on oil and gas exploration activities

No impacts are anticipated on oil and gas exploration activities. Discussions will be held with the owners of the nearby exploration blocks where necessary.

17.4.3 Impacts on pipelines and telecommunication cables

No impacts on pipelines or telecommunications cables are predicted due to absence of interests in the area of works.

17.4.4 Impacts due to unexploded ordnance

From the desk study undertaken by BACTEC, it is evident that there is an Unexploded Ordnance (UXO) threat in the area proposed for the construction of the wind farm and along the routes of the export cables including the landfall. The threat is the result of past military activities on land in the local area and at sea in local waters.

Construction activities, which would have contact with the seabed either directly such as jack-up vessels, or via the placement of material such as foundations, scour protection or cables run the risk of disturbing ordnance with potentially damaging consequential effects.
The overall risk to the site from unexploded ordnance is calculated by assessing both the probability of occurrence and the consequences of detonation. The level of risk posed by unexploded ordnance in the areas of work is be demonstrated in Table 17.1.

Table 17.1 Level of Risk from UXO

Type of Ordnance	Level of Risk			
	Negligible	Low	Medium	High
Land/Beach Mines			*	
Air Delivered Bombs		*		
Anti Aircraft Ammunition/ Coastal Artillery		*		
Other Munitions	*			
Mines (sea) Ground/Floating			*	

Although the Health & Safety at Work Act and the Construction (Design & Management) Regulations of 1994 do not specifically require a search for UXO, there is an obligation on those responsible for intrusive works to ensure that a comprehensive threat assessment is undertaken and risk mitigation measures are taken with regard to all underground hazards on site.

As part of the Contract, a non–intrusive marine survey (e.g. by magnetometer) would be undertaken to identify any metallic objects which could be UXO. Follow up target investigations and clearance based on the results would be carried out under the auspices of the MOD or specialist contractor where necessary. In addition, the following procedures will be implemented for all construction personnel.

a) Site Specific Safety Instructions: to cover Unexploded Ordnance Incidents with the necessary allocation of responsibilities and procedures for reporting incidents, medical support and casualty evacuation.

b) Ordnance Safety and Awareness Briefing: to cover the identification of unexploded bombs (UXB) and what actions need to be taken.

c) Site un-exploded ordnance (UXO) Regulations/Aide Memoire: to ensure procedures are in place before intrusive engineering operations commence as to the actions to be taken and the procedures for calling out the Emergency Services together with listed contact telephone numbers etc.

Due to the advances in survey methods for the detection of UXO and an increased awareness, the chance of an inadvertent detonation of an item of ordnance has been reduced significantly. Consequently there has been no documentary evidence of any UXO exploding as a result of construction works in the United Kingdom since the 1950s. However, as with all unexploded devices, the potential consequences of an explosion are extremely severe, particularly to the personnel and equipment carrying out the engineering works (BACTEC, 2004).

Given successful implementation of the stated mitigation measures by the chosen Contractor, a **negligible** impact is predicted.

17.5 Impacts during Operation

No additional excavations or significant seabed activities are anticipated and therefore **no impacts** during operation are expected. If maintenance during operation is required, precautions and mitigation measures associated with unexploded ordnance would be implemented where necessary.

17.6 Impacts during Decommissioning

Tidal action, seabed conditions and the movement of sand waves, bottom trawling and wave action in shallow waters caused by bad weather all contribute to the movement of objects on the seabed. This means that there is a limited risk of ordnance moving into the Sheringham Shoal Site. This possibility would therefore be addressed prior to decommissioning of the turbines and wind farm infrastructure. Given suitable mitigation measures, a **negligible** impact is anticipated in respect of UXO. **No impacts** are expected for the export cables as these would most probably be disconnected and left in situ.

17.7 Summary

Other human activities include oil and gas activities, marine aggregate extraction, marine disposal sites, military exercise areas, telecommunications cables, pipelines and unexploded ordnance.

The Sheringham Shoal site is not currently licensed for oil and gas exploration and production and it is considered extremely unlikely that any oil and gas reserves will be identified within this study area in the future. There are currently no licensed aggregate extraction or marine disposal activities ongoing within the study area. The proposed export cable routes do not cross any telecommunications cables. There are currently no military practice and exercise areas in the vicinity of the offshore works.

A desk top risk assessment of the unexploded ordnance threat concluded that as a result of historic war time activities, unexploded ordnance may be present in the Sheringham Shoal area including mines, aircraft delivered bombs and anti-aircraft munitions.

A non–intrusive survey will be undertaken by the Contractor as necessary to identify any potential unexploded ordnance and target investigations and follow up clearance carried out as necessary. In addition, all construction personnel will be given specific safety instructions and ordnance safety and awareness briefings.

Impacts on other human activities are predicted to range from **no impact** to **negligible**.

17.8 References & Appendix

- BACTEC International Ltd, 2004, Explosive Ordnance Threat Assessment of Sheringham Shoal Offshore Wind Farm.

18 Socio-economic Assessment

18.1 Introduction

Recent studies have demonstrated that offshore wind farms can have significant socio-economic effects in terms of providing employment, wind energy market development and possibly local tourism (for example Douglas-Westwood, 2005). This section assesses the potential beneficial and detrimental effects arising from the construction, operation and decommissioning phases of the Sheringham Shoal wind farm on the socio-economic environment. This assessment concentrates on the economic but also social and human environment.

18.2 Assessment Methodology

The study is performed on national (UK), regional and local level. The regional and local study areas for this assessment include:

- the East of England region (see Figure 18.1);
- the Yorkshire and Humberside region (see Figure 18.1); and
- the local area of north Norfolk.

At this stage it is not known which port would be utilised or which contractors and suppliers would be selected. Decisions on these issues would be subject to competitive tendering further to the receipt of the required consents. Due to the location of the wind farm however, it is known that potential ports include the port of Great Yarmouth in the East of England region and/or the ports of Hull and Grimsby/Immingham in the Humber region. The East of England and the Humber regions have therefore been considered in this assessment while the East Midlands region has been excluded.

The local area of north Norfolk has been considered because it is the closest area to the wind farm and is where the onshore cabling works would take place. Therefore the potential impacts in terms of tourism and traffic and transport disruption have been assessed for this area only.

The impact of the proposed wind farm on the economic value of shipping and commercial fisheries is summarised based on conclusions reached in Sections 12 and 14.

The assessment has been undertaken through:

- Data collation and literature review in order to provide background information on the existing environment within the three study areas include the following:
    - Regional Intelligence Unit, Office for National Statistics, DTI and the Office for National Statistics, Regional competitiveness and State of the regions 2005 (Lad, 2005);
    - East of England Development Agency website data;
    - Yorkshire Forward website data; and
    - Data obtained during consultation.
- The economic impact assessment has been based on the recently published studies analysing the supply chain and the economic effects of wind farms developments, together with the internal project information for the Sheringham Shoal development. Amongst other literature, the following studies have been used:
    - Scroby Sands – Supply Chain Analysis, a report to Renewables East (Douglas-Westwood and ODE, 2005);
    - POWER – Offshore Wind Supply Supply Chain Study for the East of England, a report to Suffolk County Council (Douglas-Westwood, 2005);
    - Developing Yorkshire and Humber's offshore wind resources, a report to Yorkshire Forward (DULAS and ECOTEC, 2003);

- Renewable Supply Chain Study, for the DTI (DTI, 2004); and
- Offshore Wind Onshore Jobs – A new Industry for Britain (Greenpeace, 2004).

- Consultation with key organisations to obtain specific information and data (e.g. local knowledge) and to discuss the potential impacts in relation to their organisations' interests. The following organisations have been consulted at dedicated meetings:
  - North Norfolk District Council;
  - Norfolk County Council;
  - East of England Energy Group;
  - Renewable East; and
  - Yorkshire Forward.

The comments and issues discussed at these meetings have been incorporated and addressed in the impact assessment sections (Section 18.3.2 and 18.3.4).

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 18.4 - 18.6. Impacts are quantified as far as possible in terms of levels of investment and expenditure in pounds sterling (£), or by the number of man-years generated. The economic rationale for the figures quoted is provided in the relevant section. See Section 1 for the definition of significance levels.

Figure 18.1 East of England and Yorkshire and Humber Regions

18.3 Description of the existing environment

The existing environment of each of the two regions (East of England and Yorkshire and Humberside) is described in terms of socio-economic indicators and features of their economies in comparison to national figures. The data provided in the key figures tables have been reproduced from the datasets developed by the Regional Intelligence Unit, Office for National Statistics (http://www.nwriu.co.uk).

The national situation has been discussed contextually in order to provide a comparison with the regional information.

The local area of north Norfolk is considered for the subsection on tourism and recreational activities, while a description of shipping and commercial fisheries is included in the final subsections.

18.3.1 The receiving environment

18.3.1.1 East of England region

The East of England region covers the counties of Bedfordshire, Essex, Cambridgeshire, Hertfordshire, Norfolk and Suffolk. It covers an area of 19,120km2 and contains a population of some 5.5 million.

The region hosts seven major seaports which handle over half of the UK's containerised traffic. Of these, Great Yarmouth, Lowestoft, Kings Lynn and Harwich/Felistowe have been identified as suitable commercial construction ports for the Round 2 wind farm developments (DTI, 2003).

In particular, Great Yarmouth is the principal UK base for the offshore oil and gas industry in the southern North Sea and possibly for the offshore renewable sector. For example, it has recently been used for the construction phase of the Scroby Sand offshore wind farm.

The port, which is operated by Great Yarmouth Port Authority, offers approximately 6,000m of commercial quays on both sides of the River Yare, adjoining a large port/industrial area known as South Denes. In addition, an Outer Harbour extension is proposed to further develop the trading operations of the port and to stimulate the local economy. The availability of public funding for the project was announced by the Government in January 2005 (Great Yarmouth Port Authority, 2005b).

18.3.1.2 Yorkshire and Humberside region

The Yorkshire and Humberside region covers the counties of North Yorkshire, Humber, South Yorkshire and West Yorkshire. It covers an area of 15,400km2 and has a population of approximately 5M people (2002). The majority of the region's geographical area is rural and includes former coalfield areas.

The region's key seaport are the Humber Ports, including the deep water ports of Hull and Immingham operated by Associated British Ports (ABP). These are estimated to handle almost one quarter of the UK's seaborne trade (ABP, 2005). In addition, actions are being undertaken to develop the Humber Trade Zone, by promoting the port and related activities, and targeting infrastructure improvements in and around the docks at Immingham, Hull, Grimsby and Goole (Humber Forum, 2005).

18.3.2 Population characteristics

18.3.2.1 East of England region

The East of England comprises the fastest growing population in the UK. Between 1982 and 2002 the population increased by 11.2% against a national average of 5.2%.

The percentage of the population described as economically active is 81.9%, well above the national average of 78.9%. However, there are pockets of aging population in the region, exemplified by Norfolk, and north Norfolk in particular. The proportion of the economically active population is only 64% in Norfolk and only 57.8% in north Norfolk. The latter can be attributed to a higher percentage of retired people and the dispersed rural population (North Norfolk District Council, 2005).

18.3.2.2 Yorkshire and Humberside region

The region's population is concentrated in its cities and urban areas. Recently, it has experienced a change well below the national average. Between 1982 and 2002, its population increased at a rate of 1.5% against a national growth of 5.9%. However, large disparities in population changes within the sub-regions are evident.

The regional economic activity rate of 78.4% is slightly below the national figure (see Table 18.1).

Key figures are illustrated in Table 18.1.

Table 18.1 Population statistics

	EoE	Y&H	UK
Population (thousands) 2001	5,420	4,983	59,229
Population change (percentage) 1982-2002	11.2	1.5	5.9
Economic Activity Rate 2003 (percentage)	81.9	78.4	78.8

Source: Regional Intelligence Unit, Office for National Statistics

18.3.3 Economic activity and wealth creation

18.3.3.1 East of England region

The economy of the East of England has a value of £82 billion, which is equivalent to approximately 10% of the UK (1999). Its economy is interlinked with and dependent upon the London economy. However the region also has links to the East Midlands and South East regions through infrastructure, cross-boundary business sectors, clusters (e.g. public and private environmental organisations in Peterborough) and supply chains.

In the UK, the East of England has one of the highest expenditure on research and development, at over 3% of regional gross domestic product (GDP). The East of England has ten universities, including the world-renowned University of Cambridge.

The East of England's Gross Domestic Product (GDP) per capita is significantly above the UK average (14% higher than the national average) and, at the same level as the South East, is the second highest after London.

Renewable East and the East of England Development Agency are keen to attract offshore wind energy developers in the region. The strength factors that the region has to offer to this sector are:

- Port infrastructure - the port of Great Yarmouth has a track record of wind farm developments (i.e. Scroby Sands and Lowestoft);
- Prime expertise in the offshore sector associated with the oil and gas operations and transferable to the wind energy - including offshore installation, commissioning operation and maintenance ; and
- Expertise in onshore installations which is relevant for connection of the wind farm to the public grid.

In order to assist the developers and local companies, a database of supply chain companies suitable for the energy sector, called Mapergy, has been developed by the East of England Energy Group and is available on www.eeegr.com.

18.3.3.2 Yorkshire and Humberside region

The Yorkshire and Humber region accounts for 7.5% of the UK's GDP. In the past two decades the region has suffered from the decline of traditional extractive, manufacturing and heavy industries with substantial job losses. This has left its GDP per capita below the European average. GDP per capita was 86% of the UK average in 1999, the third lowest of any English region (see Table 18.2).

The losses experienced in traditional activities have been partly balanced by growth in financial, legal and telephone-based services. Although jobs in the manufacturing sector fell, employment in the manufacturing sector still represents 30.9% of the regional gross value added (GVA). The region still hosts many organisations with high level expertise in advanced engineering manufacturing which could be of interest for the offshore wind energy sector. This includes the National Metals Technology Centre, Castings Technology International and Avesta Polarit, one of the largest stainless steel producers.

In addition, there are nine universities with several industry-collaborative technology centres, including the research centre of surface engineering at the University of Hull, the materials research institute at Sheffield Hallam University and the centre for precision technologies at the University of Huddersfield.

Yorkshire Forward and the Regional Development Agency recognise the importance of sustaining the Advanced Engineering and Metals supply chain businesses within the region and are promoting sustained new business and jobs linked to knowledge, technology and innovations. Yorkshire Forward considers this to be a valuable asset for the offshore wind energy sector (pers.comm.Yorkshire Forward).

The Yorkshire and Humber region key elements that make it an attractive potential for the offshore wind energy sector are:

- Port facilities - Hull and Grimsby/Immingham have the capabilities to accommodate the types of activities required including assembly and lay-down area during construction; and
- Manufacturing capabilities - the region has valuable skill resources in manufacturing and engineering and numerous possible supply chain producers are located in the region.

Key figures are illustrated in Table 18.2.

Table 18.2 Economics statistics

	EoE	Y&H	UK
Gross Domestic Product per head (£) (1999)	114	86	100
Gross Domestic Product (1999) (billion £)	81.8	57.6	771.9
Gross Domestic Product (1999) (percentage)	10.6	7.5	100

Source: Regional Intelligence Unit, Office for National Statistics

18.3.4 Employment, unemployment and labour market

18.3.4.1 East of England region

Overall, the East of England is a prosperous region and employment rate is above the national average. The employment rate for the working age population was of 78.5% in 2003, well above the national average of 74.7% (Office for National Statistics, 2005).

Unemployment rate in East of England has generally been below national average in recent years (data analysed since 1999). However, within the region there are pockets of high unemployment.

Of interest for this study is the existing energy sector in the East of England because of the potential job transfer. A survey conducted in 2002 (EEEGr, 2003) reports that direct, indirect and induced employment related to the oil and gas sector was 15,300 in 2002, with the majority in Norfolk and Waveney. In Norfolk, employment in this sector is concentrated in the coastal area, particularly around Great Yarmouth and Lowestoft and there is significant expertise in the area including operators, contractors and suppliers to the industries. However oil and gas operations in the North Sea are in decline.

Some of the regional and local expertise developed for the offshore oil and gas sector could potentially be transferred to the offshore renewable energy sector. This would be beneficial to maintain and diversify employment (Greenpeace, 2004; East of England Development Agency 2002; and EEEGr, 2003).

18.3.4.2 Yorkshire and Humberside region

The region has experienced modest growth in employment over the last 20 years. The employment rate is 74.1% compared to the UK average of 74.7%. Employment by sector highlights that key sectors are manufacturing, distribution, hotels and catering, education, social work and health services and financial and business services.

The average regional unemployment in 2003 was 5.5%, significantly up on national average of 5.1%. Although decreasing, unemployment rate has generally been higher than national rates in recent years (since 1999).

Key figures are illustrated in Table 18.3.

Table 18.3 Labour statistics Employee Jobs: by industry (percentage) 2001

	EoE	Y&H	UK
Agriculture, hunting, forestry and fishing.	1.5	0.9	1.0
Mining, quarrying, (inc. oil and gas extraction)	0.2	0.4	0.3
Manufacturing.	14.4	17.9	14.2
Electricity, gas, water.	0.6	0.6	0.5
Construction.	4.9	5.1	4.5
Distribution, hotels and catering repairs.	25.6	24.2	24.3
Transport, storage and communication.	6.6	5.9	6.1
Financial and Business Services.	19.1	14.2	19.6
Public administration and defence.	4.1	4.9	5.2
Education, social work and health services.	18.2	21.2	19.1
Other.	4.8	4.8	5.2
Whole economy (=100%) (thousands)	2,271	2,085	25,456

Unemployment Rates 2003 (percentage)

	EoE	Y&H	UK
Unemployment Rates. 2003 (percentages)	4.2	5.5	5.1
Change between 1999-2003 (percentage) *(Calculated from National Statistic spring quarter data of 1999 and 2003)*	-5	-22	-21

Source: Regional Intelligence Unit, Office for National Statistics

18.3.5 Disadvantaged areas and social deprivation

18.3.5.1 East of England region

Despite relatively high employment and low unemployment rates, within the region there are pockets of deprivation and a significant number of people who experience social exclusion. The most deprived areas are scattered throughout the region and largely in coastal areas. The largest concentrations of deprived areas are within the Norfolk towns of Norwich and Great Yarmouth

(ODPM, 2004). In accordance with the English Indices of Deprivation 2004[25], Great Yarmouth is the fifth most deprived non-metropolitan District in England in terms of local concentration and the severity of multiple deprivation (Norfolk County Services, 2005 and ODPM, 2004).

18.3.5.2 Yorkshire and Humberside region

Although some areas are relatively prosperous, deprivation across Yorkshire and the Humber remains widespread with five of the region's districts in the worst 10% of concentration across the Indices of Deprivation. Much of Yorkshire and the Humber's severe deprivation is concentrated within towns and cities and in the former coalfields of the Region (ODPM, 2004).

18.3.6 Education and skills pool

18.3.6.1 East of England region

In the East of England there are concentrations of exceptionally highly-skilled individuals employed in the high-tech businesses and research establishments. However, the region as a whole suffers from skill shortages. One in eight employers in the East of England has identified a skills gap in their workforce and there appear to be a mismatch between the skills of their current workforce and the skills needed to meet current business objectives (DTI, 2005a).

The traditional energy sector (oil and gas) also reports skill gaps and reports that positions for skilled professionals are hard to fill in the area (including control and instrument technicians, control and instrument engineers, electrical and electricity generation technicians and engineers, and production personnel) (IFF, 2004). In the renewables sector however, employers report far fewer recruitment problems. This could be because the numbers needed to be recruited tend to be relatively small and because the sector has intrinsic appeal (IFF, 2004). In addition, the IFF study (2004) reports that it is not uncommon to find employers with skills and experience in one area of operation looking to transfer these skills into likely growth areas, such as the renewables sector (IFF, 2004).

18.3.6.2 Yorkshire and Humberside Region

The gradual shift from traditional activities to a more service oriented industrial structure and activity is increasing the demand for more highly skilled workers. Although the occupational structure in the region has changed considerably, the region still has a lower share of employment in high skill occupations than other parts of the UK (Yorkshire Forward, 2005b).

Survey research suggests a divergent view about skill's suitability amongst the workforce in Yorkshire and Humber. A positive situation is indicated by the low percentage of hard-to-fill vacancies, skill shortage vacancies and internal skills gaps reported in the Employer Skills Survey for England 2001. Conversely, significantly higher figures are reported in the North Yorkshire and West Yorkshire Employer surveys (Yorkshire Forward, 2005b).

18.3.7 Tourism and recreation

18.3.7.1 North Norfolk District

The district of North Norfolk is located within the East of England region in the north eastern corner of East Anglia (See Figure 18.1). It is bounded by the North Sea to the east and north and to the south by the Broadland and Great Yarmouth Districts. King's Lynn and West Norfolk District are located to the west. The land within the District is predominantly rural in character with a broad agricultural base but a declining manufacturing industry.

Its 68km coastline is characterised by the low-lying coast designated by the Countryside Agency as an Area of Outstanding Natural Beauty (AONB) to the north and by cliffs with features of geological interest to the south of Sheringham. North Norfolk offers numerous opportunities for

[25] The Indices of deprivation are developed by the ODPM on the basis of factors including income deprivation, employment deprivation, health deprivation and disability, education, skills and training deprivation, barriers to housing and services, living environment deprivation and crime.

tourism and recreational activities mainly because of its rural character and unspoilt coastline. Cromer represents one of the main tourist attractions and recreational destinations. Other popular seaside towns and villages include Sheringham to the north and Overstrand and Mundesley to the south.

In addition, the north Norfolk coastline provides a variety of recreational opportunities (e.g. leisure crafts, SCUBA diving, swimming, surfing, wind surfing, jet-skiing and angling). These activities are most popular in the summer months between May and August inclusive but may occur all year round.

18.3.7.2 Economic value of tourism in North Norfolk

The economic value of tourism in north Norfolk has been estimated by the East of England Tourist Board using the Cambridge Economic Impact Model for 2003. The model utilises information from national tourism surveys and regionally based data, combining them with key factors such as the accommodation stock and occupancy rates and estimates the volume of stays and day visit tourism, the respective values and the employment supported by tourism. These outputs are summarised in Table 18.4 for north Norfolk and Table 18.5 for Norfolk.

Table 18.4 Tourism in North Norfolk

	Number of visitors	Visitor spend (£)
Staying visitors	959,700	133,612,000
Day visitors	8,548,368	223,498,035

Source: East of England Tourist Board, 2003a

Table 18.5 Tourism in Norfolk

	Number of visitors	Visitor spend
Staying visitors	4,914,000	737,307,000
Day visitors	46,324,853	1,240,515,441

Source: East of England Tourist Board, 2003b

The East of England Tourist Board reports in 2003 that the total business turnover for the area was of £415,522,000 with a total full time equivalent jobs of 7,069 and total actual jobs of 9,995 in 2003 (East of England Tourist Board, 2003a).

18.3.8 Shipping

The North Sea is intensively used by commercial and recreational vessels. Within the area of interest, the majority of merchant vessels are associated with the East Coast ports (e.g. Humber, Great Yarmouth, Tees and the Wash) and the ports in north-west Europe (e.g. Rotterdam, Amsterdam, Zeebrugge). Next to the merchant vessels the site is used by fishing vessels, recreational vessels and dredging vessels. In in-depth analyses of the movements of the these vessels in and around the proposed site and the related navigation issues was conducted in February 2005 by Anatec for Scira Offshore Energy with the objective of recording the vessels' usage of the proposed Sheringham Shoal site and environs, (Anatec, 2006 and see Section 14, Shipping and Navigation).

18.3.9 Fisheries

A study on commercial fisheries within the wind farm and cable route areas has been undertaken and is fully reported in Section 12 (Commercial Fisheries). Key findings of this study suggest that the wind farm location is not a primary fishing area and does not support as much fishing effort as the banks and shoals to the west of the site. No significant long lining or trawling activity has been observed within the proposed wind farm area. There is, however, a history of vessels mainly from Blakeney and to a lesser extent Wells undertaking some seasonal static gear fishing within the area of the wind farm site. Between six and seven of these local potting vessels would regularly visit the site targeting crabs and lobsters.

In relation to the cable route the highest levels of activity occurs over the inshore section out to approximately the 3 mile limit by small beach-launched fishing vessels. Whilst the level of this activity declines further offshore, the Sheringham Shoal is a recognised fishing area.

18.4 Social and economic impacts during construction

18.4.1 Introduction

This section assesses the social and economic impacts of the construction of the Sheringham Shoal wind farm. The impacts can be linked to three main project phases: the construction, operational and decommissioning stages. The construction phase would be relatively short, approximately 24 to 36 months. The operational phase will be considerably longer, up to 40 years. The decommissioning stage would take approximately the same time as the construction stage. The development stage prior to consent is also considered.

In terms of the economic impacts there would be three distinct effects:

- Direct effects on local employment, i.e. staff (man hours) that would be employed directly by the operator, contractors and manufacturers of Sheringham Shoal wind farm.
- Indirect or supplier effects: the new wind farm would also require local goods and services, which would be supplied by local businesses such as security, catering, hotel facilities or maintenance, and;
- Induced effects: namely the social and economic impact that relates to the new spending power generated from direct and indirect employees. A significant amount of the earning capacity of these individuals would be expected to be spent locally, for example shopping, housing, leisure and local taxes. This would in turn support more local jobs and more local wealth. This effect is sometimes also referred to as the multiplier effect. Based on an average multiplier in the UK between 1.2 and 1.7 (English Partnerships 2004), every £1 that is locally spent might be expected to have an impact on the local economy of between £1.2 and £1.7, or in other words: every direct or indirect job that is created by the new wind farm, would create more employment and jobs elsewhere in the local economy.

18.4.1.1 Supply chain effect (Direct and Indirect effects)

Several reports have been published recently, analysing the supply chain and the economic effects of (offshore) wind farm developments. According to these reports a substantial investment into offshore wind capacity is currently planned in the UK in general and in the Thames Estuary and the Greater Wash in particular (both areas within the East of England and Yorkshire and Humber region's area of influence). The total expected expenditure with respect to the offshore wind developments in both areas is over £11 billion (Douglas-Westwood, 2005). With respect to the local and national social and economic impacts of these investments it is essential to understand how much of the expenditure is spent locally or within the UK and how many jobs would be created in the local areas and in other parts of the UK. Although it is clear that part of the expenditure would go to specialised suppliers and contractors overseas (primarily mainland Europe), the studies indicate that a substantial part of the expenditure and job creation would benefit the local and national economy. The analyses of the Scroby Sands offshore wind farm development reveal that 40% of the total required man-hours were sourced locally (from the East of England) and that another 34% of the man-hours came from the rest of the UK. In terms of the total expenditure the picture was slightly different: 16% was spent locally and 32% was spent in the rest of the UK (Douglas-Westwood and ODE, 2005).

Another important finding of the above studies is that there is substantial room for local and UK companies to get more involved in offshore wind energy developments. Although there is only a limited number of locally based companies that can offer tailored services to the offshore wind energy sector at present, it is considered that a great number of companies could relatively easily adapt to the new required skills, products and services on the basis of their existing capabilities This is particular relevant for companies working in the offshore engineering, the offshore oil and gas industry and manufacturing (metals) sectors.

In the development stage of the project, most of the work is related to the preparation of the business case, obtaining the required consents (including the EIA, stakeholder consultation, etc) and preparing the basic design. This work has been done in the UK and the Netherlands and part of this work is sourced from the region (for example from SLP in Lowestoft). The impact in terms of employment is set out in Table 18.16.

By far the majority of the total investment and expenditure is related to the construction stage; approximately £300 million for the wind farm and another £85 million for the cables including the landfall cables. This work would be subject to competitive tender (and possibly sub-contracting) and therefore it is difficult to specify at this stage where the work would be done and how much could be locally sourced. On the basis of past offshore wind farm projects (e.g. Scroby Sands) and the availability of existing manufacturers and facilities, it is anticipated that part of the construction stage including the manufacturing of the nacelles, blades, towers and foundations would be sourced mainly outside the UK. However, other parts, comprising the transport, assembly and installation are most likely to be sourced locally.

18.4.1.2 Impact on employment

The employment estimates for the construction phase are mainly based on the supply chain and job creation study undertaken for Scroby Sands offshore wind farm development (Douglas-Westwood and ODE, 2005). Although at present (September 2005) it is not known where for example the manufacturing would be done and who would be awarded contracts it is believed that the Scroby Sands analyses is the most accurate information available to base estimates on. In addition to this study, discussions with the developer and other relevant parties have been held along with a literature review (see assessment methodology, Section 19.2).

In Table 18.8 an estimate is given of the staff requirements for the development and construction stages of the Sheringham Shoal wind farm. A break down is given between the man-years that would be sourced from the local area, the rest of the UK and overseas. The local area is defined as the area covering the East of England or the Yorkshire and Humber Region. It is estimated that approximately 27% of the required jobs would be sourced locally and another 43% from the rest of the UK. This is equivalent to 203 man-years on a local level and another 315 man-years for the rest of the UK.

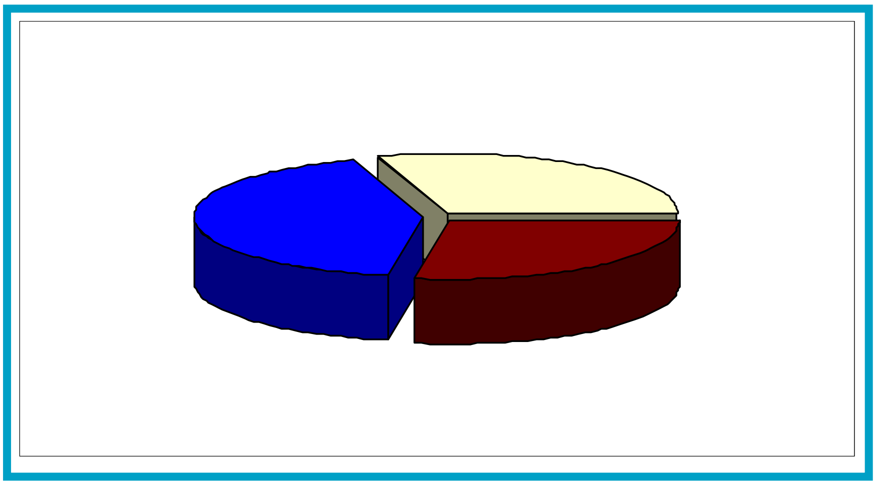


Figure 18.2 Distribution of estimated direct personnel requirements into local, UK and outside UK areas.

The estimates are based on the findings of Scroby Sands (Douglas-Westwood and ODE, 2005) being extrapolated for the Sheringham Shoal development using the number of turbines as a starting point (Scroby Sands 30 turbines; Sheringham Shoal 75 turbines) instead of the installed capacity (Scroby Sands 60MW, Sheringham Shoal 315 MW).

Table 18.6 Estimated direct personnel requirements for development and construction stage.

	Regional man-years	Other UK man-years	Non UK man-years	Total Man-years	Local%	UK%
Development Design	5	22	12	39	13%	56%
Environmental Monitoring	4	0	-	5	91%	9%
Insurance/Legal	1	2	-	3	20%	80%
Surveys	4	0	-	4	95%	5%
Project Management	54	75	7	136	40%	56%
Detailed Design	7	6	29	42	16%	14%
Procurement & Manufacture	0	141	59	201	0%	70%
Transport & Delivery	1	2	7	10	6%	23%
Onshore Pre-Assembly	36	13	7	56	65%	22%
Onshore Installation	52	-	-	52	100%	0%
Offshore Installation	8	25	74	107	8%	23%
Commissioning	26	18	20	64	41%	28%
Other Misc. Costs	6	10	6	22	25%	45%
TOTAL	**203**	**315**	**222**	**740**	**27%**	**43%**
Indirect employment	**101**					

Both the jobs (man-years) for the development and construction stage are classified as 'direct effect' impacts. On top of these direct effects there would be positive 'indirect or supplier' effects and 'induced effects'. Based on a regional multiplier of 1.5 (English Partnerships, 2004) the Sheringham Shoal project would bring over the period of the development and construction stage approximately another 101 man-years of work to the region. As explained before, this is based on the assumption that for every local direct man-year work, the total local employment effect would be 1.5 regional man-years work (hence a multiplier of 1.5).

Although the figures for man years requirements given in the different literature sources and the estimates in the Sheringham Shoal budget are remarkable consistent, the figures presented in this assessment should still be treated as an best estimate, mainly because it is not known which suppliers and contractors would be commissioned for the different elements of the project and what local expertise, skills and resources would be available. However, the research undertaken for this study and the consultation process has revealed that both the East of England and the Yorkshire and Humber region are very well placed to provide a substantial amount of the work to the offshore wind energy, including the Sheringham Shoal wind farm.

Key characteristics of the East of England and the Yorkshire and Humber Regions with respect to the potential supply of services to the wind energy sector are:

- Availability of ports, including proximity to site, storage areas, quayside and loading facilities.
- Expertise in the offshore oil and gas industry that may be transferred to offshore wind developments.
- Manufacturing capabilities with respect to casting steel, bearings and gears, metal structures and fasteners, etc.
- Skilled labour force as well as abundance in qualified labour resources.
- Several other on- and off-shore wind farm developments in the region which would support the development of capacity building within local companies.

In conclusion, the effect of job creation on the local economy is anticipated to be of short term **minor beneficial** significance. As certain parts of the East of England and Yorkshire and Humber region contain highly deprived areas, it is felt that job creation in these particular areas would be of **moderate beneficial** significance.

18.4.2 Impact of local spend

During the construction and operation phases, the purchase of materials, equipments and services would have an effect on the creation of temporary and permanent jobs within the local and national environment and consequentially on indirect and induced effects. It is anticipated that a substantial part of the required materials and especially services to support the construction phase (such as cable installation, foundations, other contracting, transport, accommodation and security) would be sourced locally. At this stage it is difficult to provide precise financial figures for the local spend, however given the total project investment (approximately £385 million) the effects to the local economy are expected to be **minor beneficial**.

18.4.3 Impact on tourism and recreational activities

During construction, disruption to tourism and recreational activities could occur as the wind farm site would not be accessible and a higher number or vessels would transit between the construction port and the site (See Section 14 on Shipping and Navigation). Disruption may occur to local traffic during the onshore works (see Section 1 on Traffic and Access). However, given the limited and temporary nature of the activities, the distance of the wind farm offshore and the onshore cable laying operation being constructed outside the main tourist season (see Section 2), the impact on tourism and recreational activities is anticipated to be of **negligible** significance.

During the construction stage Scira will install an exhibition for educational purposes, e.g. near a nice viewpoint that will attract attention from tourist as well as from local residents. It is anticipated that this ill have a **beneficial** effect.

18.4.4 Impact on commercial fisheries

An assessment of the effects of the construction phase on commercial fisheries has been undertaken in Section 12 (Commercial Fisheries). During the construction phase, all marine traffic including fishing vessels would be excluded from the construction areas within the wind farm site. To ensure the personnel carrying out construction activities and those navigating in this sea area are not exposed to unnecessary risk, 500m safety zones will be established around all offshore structures and temporary avoidance areas around working vessels during this phase of the development (see Section 14, Navigation).

The potential impact of loss of fishing area, due to exclusion from the construction wind farm site, will be almost entirely confined to the six or seven local potting vessels based at Wells and Blakeney that are understood to fish the site on occasion. With implementation of the proposed mitigation measures, the impact of loss of fishing area during construction at the wind farm site is expected to be minor adverse for the six or seven vessels from Wells and Blakeney.

With simultaneous laying and ploughing used, the impact of cable laying along the cable route corridor is assessed as negligible.

The impacts on commercially exploited populations, as described in Section 12 (Commercial Fisheries), are assessed as negligible.

Consequently it is estimated that the total socio-economical impact of the construction stage on commercial fisheries will be **minor adverse to negligible.**

18.5 Socio-economic impacts during operation

18.5.1 Impact on employment

When the wind farm is constructed and commissioned it would be in operation for approximately 40 years. In this stage some staff would be involved in the operation but most of the work is related to the maintenance of the turbines. It is expected that approximately 35 Full Time Equivalent (FTE) jobs would be required on an annual basis in the operation and maintenance stage (information based on internal business plan and budgets of Scira for Sheringham Shoal development and personnel communication with key staff in Scira). It is most likely that the majority of the required staff would come from the local area.

Given these assumptions, the direct employment effect of the operational stage of the project would be approximately 1400 man-years. These jobs are classified as 'direct effect' impacts. In addition to this direct effect there would be positive 'indirect or supplier' effects and 'induced effects'. Based on a regional multiplier of 1.5 (English Partnerships, 2004) the Sheringham Shoal project would bring over the period of the operational stage approximately another 700 man-years of work to the region. This is equivalent to approximately 18 Full Time jobs sustained over 40 years.

In addition, the operation and maintenance (O&M) requirements for the offshore wind energy may stimulate the development of a sustainable local industry to service this sector. The required services, including mechanical and electrical engineering, and dedicated maintenance and service vessels, are most likely to be delivered through local companies (see also Section 18.7.2). For example, the existing companies in the East of England region related to the offshore oil and gas sector have skills and experience that could be readily utilised or easily adapted for the offshore wind energy sector. Overall, it is considered that local companies have an important advantage and could benefit from O&M requirements and the development of an offshore wind energy sector.

Table 18.7 Estimated local direct and indirect personnel requirements for operation and maintenance stage.

Phase	Local man-years (total FTE)
Operation and maintenance, Direct effects	1400 (35 FTE)
Operation and maintenance, Indirect effects	700 (18 FTE)
TOTAL EMPLOYMENT EFFECT	**2100 (53 FTE)**

Overall, the effect of job creation on the local economy is anticipated to be of **minor to moderate beneficial** significance. As certain parts of the East of England and Yorkshire and Humber region contain highly deprived areas, it is felt that job creation in these particular areas would be of **moderate beneficial** significance.

18.5.2 Impact on tourism and recreational activities

During the operational stage of the wind farm the impacts on tourism and recreational activities would be associated with the visibility of wind turbines and perception of them. It is known that the Sheringham Shoal wind farm would be visible from the north Norfolk Coastline under certain meteorological conditions (see Section 13, Seascape and Visual Impact Character).

The East of England Tourist Board advises that although the visual perception of a wind farm is highly subjective, its setting is a key factor in relation to its impact on tourism. For example, a wind farm offshore from a well-developed seaside resort would potentially add interest to the beach experience, while the same development offshore of a wild, undeveloped coastline may be significantly detrimental.

Much of the appeal of the north Norfolk coast is based on its wild, remote and ‘unspoilt’ feel, therefore the potential impact on its attractiveness depends on the visibility of the turbines along the coast. It is anticipated that the wind farm would be more acceptable at Sheringham, and more intrusive along the AONB.

Recent surveys have demonstrated that onshore and offshore wind farms have no detrimental effect on tourism. In 2004, Greenpeace commissioned a survey of visitors for the Scarweather Sands wind farm proposal off Porthcawl, (Greenpeace, 2004). Of the 650 tourists visiting Porthcawl who were asked whether the proposed wind farm would make them more or less likely to return, 83% of the respondents said it would make no difference, 13% said more likely and just 4% less likely. This is reinforced by a MORI survey of visitors conducted in Argyll in Scotland in 2002. The survey found that 91% of the respondents said the presence of wind farms would make no difference to their decision to visit the area again (Sustainable Development Commission, 2005).

In conclusion, a **negligible** effect on tourism and recreational activities is anticipated and no significant reduction in local tourism revenues is expected.

On the contrary, beneficial effects may arise as the wind farm could become a local attraction. It is possible that the interest of the wind farm would encourage local charter boats to provide trips to the wind farm. In addition, Scira Offshore Energy is investigating the possibilities to open or participate in an information centre which would provide information on wind and renewable energy and details on the Sheringham Shoal development. It is also possible that such information could be combined with local exhibitions/information boards on other subjects including local history, archaeology and wildlife. Although it is not possible to quantify the effect on local tourism revenues as this would depend on the number of visitors that the information centre and wind farm would attract, it is anticipated that the project would have a **minor beneficial** impact on local tourism.

18.5.3 Impact on commercial shipping during operation

Anatec undertook a survey of maritime traffic in the vicinity of the Sheringham Shoal wind farm in 2005. The survey concludes that an average of less than one ship per day (8 vessels in 9 days) intersected the wind farm site and these vessels mainly crossed the south east edge of the site. It is estimated that the majority of these vessels were travelling between ports in The Wash and Humber and north west Europe. During operation of the wind farm, it is anticipated that these vessels would probably divert towards Route no.2 to the south of some 2.2nm (see Section 14. Shipping and Navigation). The increase in the length and time of their journey is considered to be negligible.

The main conclusions are that that based on the findings of the study the Sheringham Shoal offshore wind farm would have a minor adverse impact on the activities of fishing, merchant and recreational vessels. The impact on dredging vessels would be negligible. It is important to note that there is sea room available, especially to the south, for the ships to use, if they need to stay away from the proposed site. Therefore the overall conclusion is that in terms of economical impact on shipping the total impact is **minor adverse to negligible**.

18.5.4 Impact on Fisheries

The most significant effect of the Sheringham Shoal project on commercial fisheries would be associated with access restrictions to the wind farm site, thus loss of fishing area (see also Section 12). The impact of lost fishing area will be dependent upon the operator's access policy with respect to fishing within the site and the feasibility of conducting fishing operations within the site. It seems reasonable to assume that static fishing will be permitted within the site and hence for the vessels currently fishing the area the impact of loss of fishing area during operation of the wind farm is expected to be negligible.

In terms on overall impacts on commercially exploited fish populations Sheringham Shoal is assessed as having a negligible to minor beneficial impact.

The total socio-economic impact in the operational stage (including the cumulative impacts) on local commercial fisheries has been estimated to be **negligible** (see Section 12).

18.6 Impacts during decommissioning

At the end of the economical life span of the wind farm, the wind turbines, mast and foundations need to be decommissioned. At this stage it is not known how the decommissioning would be undertaken or if for example the foundations and cables could be used for another development. The impacts during the decommissioning phase are anticipated to be of similar nature to those discussed for the construction phase, although the number of jobs that would be created would be most likely significantly less. The effect of job creation on the local economy is anticipated to be of **minor to moderate beneficial** significance.

18.7 Cumulative Effects

18.7.1 Development of a renewable energy market in England (national and regional effects)

The Sheringham Shoal wind farm, as well the other Round One and Two wind farms, have stimulated the initial development of a renewable energy sector in the UK and thus employment in the renewable sector.

Long-term predictions on the effects of the wind energy sector on employment have been made by Greenpeace (2004) for the following scenarios:

- 10% of the electricity from offshore wind by 2020 will create additional employment of approximately 25,000 jobs by 2020;
- 20% of the electricity from offshore wind by 2020 will create additional employment of approximately 49,000 jobs by 2020;
- 30% of the electricity from offshore wind by 2020 will create additional employment of approximately 76,000 jobs by 2020.

Key long-term benefits for the UK are however dependent on its capacity to attract manufacturers to the country. The development of a renewable energy sector would be beneficial also in terms of job diversification although it is considered that the range of skills in other sectors such as oil and gas, aerospace and shipbuilding could be applied.

In addition, the development of offshore wind in the UK should create world-class capabilities with potential beneficial effects on export jobs and export economic returns (DTI, 2004). If the total UK wind market will develop into a substantial market for a longer period of time, it is very likely that more foreign companies (like General Electric and Vestas for example) will establish manufacturing activities in the UK. It could be that these new manufacturing facilities (and indeed the existing facilities in the UK) will be used for export purposes as well.

It is not possible however to estimate the beneficial effects of one wind farm on the potential development of a renewable market and national employment in detail. However, within the current UK plans (Round Two wind farms) the development of Sheringham Shoal represents a significant step towards these achievements. It is clear that the development of more offshore wind farms in the region and on other locations in the UK, would help develop a UK based supply chain for the sector. More offshore wind energy developments will foster continuity in the demand for services and will create a positive business outlook helping to attract investments and long term commitments from the business community. Such effects are considered to be of beneficial significance.

18.7.2 Local cumulative impacts

Given the number of proposed/planned wind farms within the Wash strategic area, it is possible that the need for O&M operations would stimulate local companies to develop dedicated services for the offshore wind sector. These could then be made available to other areas of the UK. Such cumulative effect would be **beneficial** to the local economy.

A cumulative impact on seascape may be generated by the offshore wind farms which would be visible along the north Norfolk coast and so affect tourism. This includes Sheringham Shoal, Cromer and Docking Shoal/Dungeon wind farms. The significance of such effect is discussed in details in the Section 13, Seascape and Visual Character).

18.8 Monitoring Proposals

No monitoring requirements are anticipated over and above normal business commercial monitoring by the developer.

18.9 Summary

The regions of the East of England and the Yorkshire and Humber have been considered in this socio-economic assessment in terms of direct and indirect socio-economic effects. The local area of north Norfolk has been considered for the local impact on tourism and recreation and commercial fisheries. In addition the socio-economic effects on the national level has been taken into account as well.

Key characteristics of the East of England and the Yorkshire and Humber Regions with respect to the potential supply of services to the wind energy sector are:

- Availability of ports, including proximity to site, storage areas, quayside and loading facilities.
- Expertise in the offshore oil and gas industry that may be transferred to offshore wind developments.
- Manufacturing capabilities with respect to casting steel, bearings and gears, metal structures and fasteners, etc.
- Skilled labour force as well as abundance in qualified labour resources.
- Several other on- and off-shore wind farm developments in the region which would support the development of capacity building within local companies.

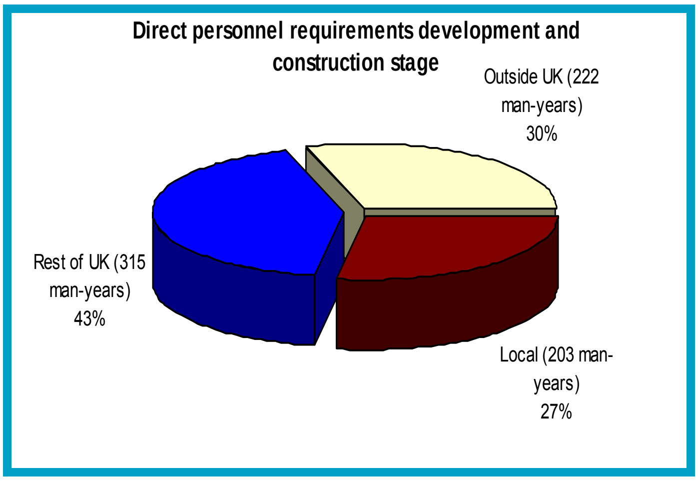


Figure 18.3 Direct personnel requirements development and construction stage (Douglas-Westwood and ODE, 2005).

It is anticipated that the proposed Sheringham Shoal wind farm will have positive socio-economic effects in both the development and construction stage and the operational stage. Employment generated by the Sheringham Shoal wind farm construction phase has been estimated on the basis of the supply chain and job creation study undertaken for Scroby Sands offshore wind farm development (Douglas-Westwood and ODE, 2005). It is estimated that the development and construction stage will generate over 500 direct man-yeas of work in the UK, of which more than 200 direct man-years in the local area (see Section 18.4). In addition, the Sheringham Shoal project will generate another 100 indirect man-years of work for the region (see also Figure 18.2). The local area is defined as the area covering the East of England and/or the Yorkshire and Humber Region.

On top of this direct effect there would be positive ‘indirect or supplier’ effects and ‘induced effects’. Based on a regional multiplier of 1.5 (English Partnerships, 2004) the Sheringham Shoal project would bring over the period of the development and construction stage approximately another 100 man-years of work to the region.

It is estimated that over the lifespan of the project (40 years) the operational and maintenance stage will generate approximately 1400 man years of work (paragraph 18.4). This is equivalent to approximately 35 Full time jobs (FTE) sustained over 40 years. Next to that another 700 indirect man-man years (18 FTE) will be generated, again mainly within the region.

In conclusion, the effect of job creation on the local economy is anticipated to be of **minor to moderate benefic**ial significance. As certain parts of the East of England and Yorkshire and Humber region contain highly deprived areas, it is felt that job creation in these particular areas would be of **moderate beneficial** significance.

In addition, it is anticipated that the purchase of materials, equipments and services such as cable installation, foundations, other contracting, transport, accommodation and security would have a **beneficial** effect on the local economy.

Impact on tourism and recreational activities would be associated with disruption during construction. However, given the limited and temporary nature of the activities, the distance of the wind farm offshore and the construction of the onshore cable route outside the main tourist season, the impact on tourism and recreational activities is anticipated to be of **negligible** significance.

Table 18.8 Summary of estimated employment effects

Phase	Local man-years
Development and construction stage, Direct effect	203
Development and construction stage, Indirect effect	101
Operation and maintenance stage, Direct effect	1400
Operation and maintenance stage, Indirect effect	700
TOTAL EMPLOYMENT EFFECT	**2404**

An assessment of the effects of the construction phase on commercial fisheries has been undertaken and it concluded that a **minor adverse to negligible** effect may be anticipated in terms of potential commercial loss and economic impact.

During the operational stage of the wind farm the impacts on tourism and recreational activities would be associated with the visibility of wind turbines and perception of them. Recent surveys including Greenpeace (2004) and a MORI (2002, Sustainable Development Commission, 2005) have demonstrated that onshore and offshore wind farms have no detrimental effects on tourism. Therefore, no significant negative effect on tourism and recreational activities is anticipated and no significant reduction in local tourism revenues is expected.

On the contrary, beneficial effects may arise as the wind farm could become a local attraction. Although it is not possible to quantify such effect, it is anticipated that the project would have a **minor beneficial** impact on local tourism.

It is anticipated that a limited number of vessels would be affected by the Sheringham Shoal wind farm during operation, therefore the impact on shipping and its economic value is considered to be of **minor adverse to negligible** significance.

The impact of the Sheringham Shoal wind farm on local commercial fisheries has been estimated to be of **negligible** significance during operation.

The impacts during the decommissioning phase (paragraph 18.6) are anticipated to be of similar nature to those discussed for the construction phase, although the number of jobs that would be created would be most likely significantly less.

The Sheringham Shoal wind farm, as well the other Round One and Two wind farms, have stimulated the initial development of a renewable energy sector in the UK and thus employment in the renewable sector. Such cumulative effect is considered **beneficial** at national level. However, key long-term benefits for the UK are dependent on its capacity to attract manufacturers to the country and to develop a UK based supply chain for the sector.

Given the number of proposed/planned wind farms within the Wash strategic area, it is possible that the need for O&M operations would stimulate local companies to develop dedicated services for the offshore wind sector. Such cumulative effect would be beneficial to the local economy.

18.10 References

- ABP, 2005. Humber Estuary Services, Commercial Services, available on http://www.humber.com/commercial/index.asp
- Anatec, 2006 Sheringham Shoal Offshore Wind Farm, Navigational Risk Assessment
- Beal, 2005. Benchmark or watermark, presentation given to UK Offshore Wind 2005.
- Department for Transport, 2005. Eastern regional factsheet, available on www.dtf.gov.uk.
- Department of Trade and Industry (DTI), 2005a. Opportunities for the East of England available on www.dti.gov.uk.
- Douglas-Westwood and ODE, 2005. Scroby Sands - Supply Chain Analysis. A Report to Renewables East, commissioned by the DTI. DWL Report Number 334-04, July 2005.
- Douglas-Westwood, 2005. POWER Offshore Wind Supply Chain Study for the East of England. A Report to Suffolk County Council, report number 333; June 2005. Available on www.offshore-power.net
- DTI, 2003. Economies of scale, engineering resource and load factors, prepared by Garrad Hassan for DTI, London.
- DTI, 2004. Renewable Supply chain gap analysis, DTI, London.
- DTI, 2005b. Opportunities for Yorkshire and the Humber available on www.dti.gov.uk.
- DULAS and ECOTEC, 2003. Developing Yorkshire and Humber's offshore wind energy. A draft final report to Yorkshire Forward, C2520, July 2003.
- East of England Development Agency, 2002. A Centre of Excellence for Renewable Energy in the East of England, Douglas-Westwood Limited.
- East of England Observatory, 2005 data available on www.eastofenglandobservatory.org.uk.
- East of England Observatory, 2005b Social Exclusion in the East of England available on www.eastofenglandobservatory.org.uk.
- East of England Tourist Board, 2003a. Economic Impact of Tourism. North Norfolk- 2003, produced by EETB Research Services.
- East of England Tourist Board, 2003b. Economic Impact of Tourism. Norfolk 2003, produced by EETB Research Services.
- EEDA, 2005. People, places and community available on www.eeda.org.uk.
- EEEGr, 2003. The Energy Sector in the East of England "Impact Study 2000", – Final Report, produced by OTM Consulting.
- English Partnership, 2004. Additionality Guide available on www.englishpartnership.co.uk
- GE Wind Energy, 2002. Gunfleet Sands Offshore Wind Farm Environmental Statement produced by Hydrosearch.
- Great Yarmouth Port Authority, 2005a. About us on www.gypa.co.uk.
- Great Yarmouth Port Authority, 2005b. News on www.gypa.co.uk.
- Greenpeace, 2004. Offshore onshore jobs - a new industry for Britain, Greenpeace and ESD.
- HM Treasury, 2005a Employment in East of England, available on www.hm-treasury.gov.uk.
- Humber Forum, 2005. Humber Trade Zone Development Group available on www.humberforum.co.uk.

- IFF Research Ltd, 2004 East of England Skills for Energy, Research Report produced for Department of Trade and Industry (DTI), Learning and Skills Council Norfolk, Cogent, ECITB, Energy & Utility Skills and SEMTA, Nov 2004.
- Lad M, 2005. Regional competitiveness & state of the regions, DTI and the office of National Statistics, April 2005.
- London Array Ltd, 2005. London Array Environmental Statement produced by RPS.
- Metoc. 2000. An assessment of the environmental effects of offshore wind farms. ETSU W/35/00543/REP.
- National Statistics, 2005a. Labour Market Statistics March 2005: East on www.statistics.gov.uk.
- Norfolk County Services, 2005. Deprivation in Norfolk, 2004. The English Indices of Deprivation 2004, Published by the Department of Planning and Transportation Norfolk County Council.
- North Norfolk District Council, 2005. Economic development strategy to 2007 available on www.northnorfolk.org.uk.
- Office of the Deputy Prime Minister (ODPM), 2004. The English Indices of Deprivation 2004.
- Office of the Deputy Prime Minister (OPDM), 2005a. Sustainable communities in Yorkshire and Humber available on www.odpm.gov.uk.
- Trade Yorkshire, 2005. Shipping and Distribution available on www. tradeyorkshire.com.
- Yorkshire Forward, 2005a. Useful Statistics available on www.yorskhire-forward.com.
- Yorkshire Forward, 2005b. Framework for Regional Employment and Skills Action- Yorkshire and Humber available on www.yorkshire-forward.org.uk.

19 Nature Conservation Designations (Onshore)

19.1 Introduction

This section outlines the location and interest features of the nature conservation designations above mean high water within 2km of the Sheringham Shoal onshore works, including the cable connection pit, cable route and switch room.

The potential impacts to the interest features of the identified sites, arising from the construction, operation and decommissioning activities are assessed and discussed within Section 20 ‘Geology, Water Resources and Land Quality’ and Section 0 ‘Terrestrial Ecology’.

19.2 Assessment Methodology

A review of all statutory and non-statutory nature conservation designations located within 2km of the proposed onshore works was carried out. This included the identification of the following designations:

- Statutory international/European sites including Ramsar sites, Special Protection Areas (SPA) and Special Areas of Conservation (SAC);
- Statutory national sites including Sites of Special Scientific Interest (SSSI) and National Nature Reserves (NNR); and
- Non-statutory sites, including areas of woodland listed on English Nature’s Ancient Woodland Inventory (AWI) and County Wildlife Sites (CWS).

Details on all statutory sites and AWI sites were obtained from a review of the Multi-Agency Geographic Information for the Countryside website (www.magic.gov.uk). Details relating to County Wildlife Sites were obtained from Norfolk Wildlife Trust and Norfolk County Council.

19.3 Description of the Existing Environment

The proposed onshore works are not located within any areas of land designated as statutory or non-statutory nature conservation sites. The location and interest features of sites within the wider study area are discussed below.

19.3.1 Statutory International and European Sites

The following statutory international and European sites are located within 2km of the proposed onshore works, the boundaries of which are illustrated on Figure 19.1:

- North Norfolk Coast Ramsar site;
- North Norfolk Coast SPA;
- North Norfolk Coast SAC; and
- The Wash & North Norfolk Coast SAC.

Information relating to the selection and designation of Ramsar sites, SPAs and SACs are provided within Section 5 ‘Nature Conservation Designations’. The location of the identified sites overlap with the marine environment, therefore the interest features have also been discussed in detail within Section 5.

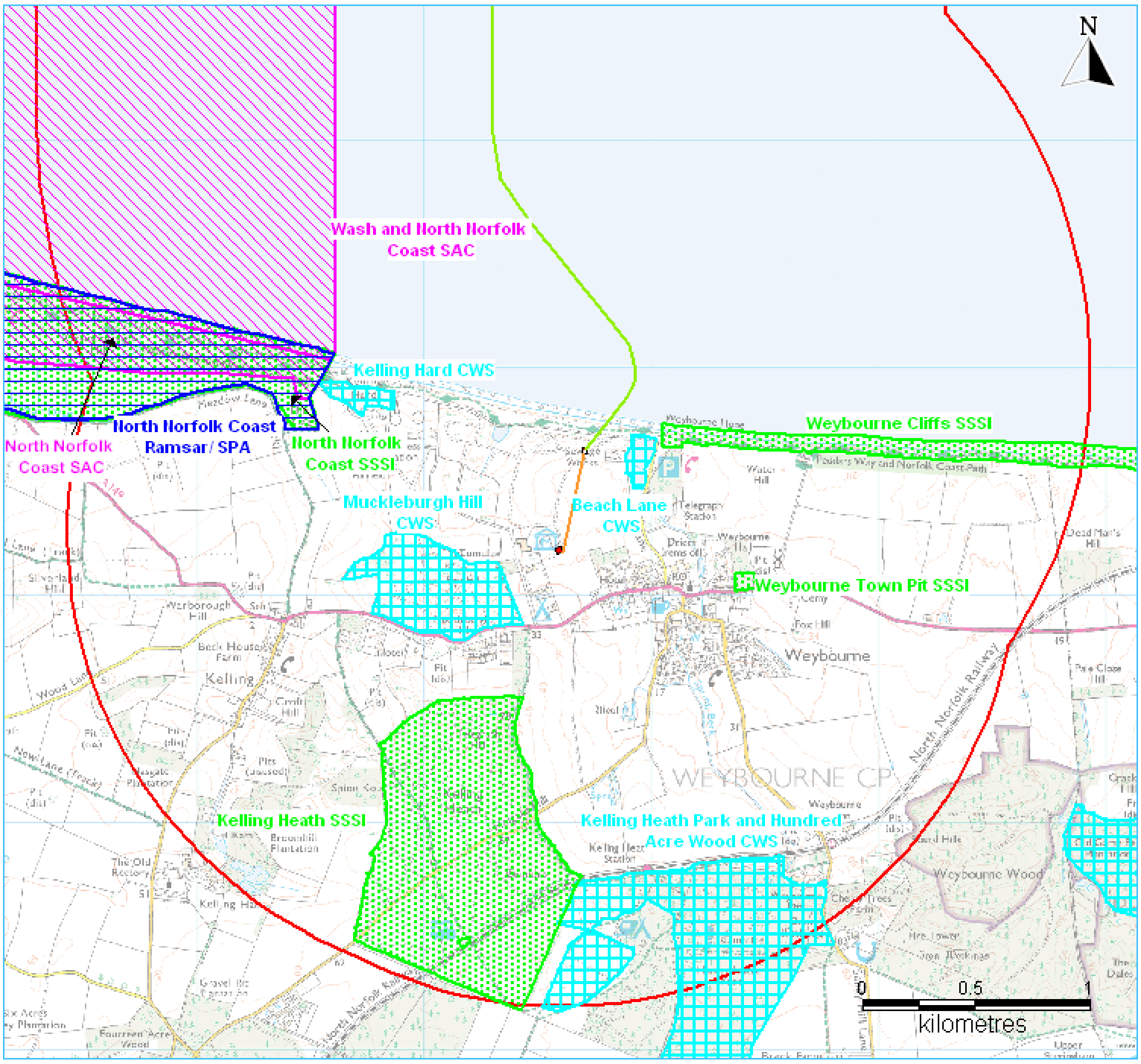
As can be seen from Figure 19.1, the boundaries of the sites overlap to some degree. The proposed onshore works are located outside of the outlined Ramsar, SPA and SAC sites, approximately 1,150m to the south-east.

19.3.2 Statutory National Sites

The following statutory national sites are located within 2km of the proposed onshore works, the boundaries of which are illustrated on Figure 19.1:

- North Norfolk Coast SSSI;
- Weybourne Cliffs SSSI;
- Weybourne Town Pit SSSI; and
- Kelling Heath SSSI.

SSSIs are a statutory national designation awarded to the country's best biological and geological sites and there are currently around 4,000 in England. SSSIs are notified and afforded protection under the Wildlife and Countryside Act 1981 (as amended by the Countryside and Rights of Way Act 2000).There are no other statutory national sites, such as NNRs within 2km of the proposed onshore works.



Legend

- 132 KV Land Cable
- 132 KV Marine Cable
- Cable Connection Pit
- Switch Room
- Ramsar Site and Special Protection Area (SPA)
- Special Area of Conservation (SAC)
- Site of Special Scientific Interest (SSSI)
- County Wildlife Site (CWS)
- 2km Buffer

Sheringham Shoal Offshore Windfarm Environmental Statement

Nature Conservation Designations (onshore)

SCIRA-Figure 19.1
Nature Conservation Designations (Onshore)
Date: January 2006

Map projection:
British National Grid (NTS)

Ramsar, SPA, SAC, SSSI boundaries ©English Nature. CWS boundaries provided courtesy of Norfolk Wildlife Trust and Norfolk County Council.

Figure 19.1 Nature Conservation Designations (onshore)

19.3.2.1 North Norfolk Coast SSSI

The North Norfolk Coast SSSI extends for approximately 40km between Hunstanton and Weybourne. The area consists primarily of intertidal sands and muds, saltmarshes, shingle banks and sand dunes. There are also extensive areas of brackish lagoons, reedbeds and grazing marshes. The site, much of which remains in its natural state, constitutes one of the largest expanses of undeveloped coastal habitat of its type in Europe (English Nature, 1986a).

The site hosts a wide range of rare and local plan species and it is of great ornithological interest with nationally and internationally important breeding colonies of several species. The area is particularly valuable for migratory birds and wintering waterfowls. Otter (*Lutra lutra*) breed and hunt throughout the site and natterjack toad (*Bufo calamita*) are reported to have bred in two locations within the site. Red squirrel (*Sciurus vulgaris*) were also recorded at the site until 1981 (English Nature, 1986a). Further information relating to the presence of protected species within the area of the actual proposed onshore works are provided within Section 0 'Terrestrial Ecology'.

The SSSI boundary is co-incidental with that of the North Norfolk Coast Ramsar/SPA and is located approximately 1,150m to the north-west of the proposed onshore works at its nearest point.

19.3.2.2 Weybourne Cliffs SSSI

Weybourne Cliffs is designated as a geological SSSI and extends for approximately 4km along the coast to the north of Weybourne. At its nearest point, the SSSI is located approximately 330 metres to the east of the proposed cable connection pit.

The cliffs afford the best Pleistocene sections showing the pre-Cromerian deposits of the Cromer Forest bed. In addition, the marine 'crags' have yielded both large and small mammal remains, of Pastonian and probably also pre-Pastonian age (English Nature, 1985).

19.3.2.3 Weybourne Town Pit SSSI

Weybourne Town Pit SSSI covers approximately 0.62 hectares of land at Weybourne village and is designated for its geological interest due to the presence of Pleistocene 'Marly Drift'; a chalk-rich glacial till of supposed Anglian age (English Nature, 1983). The site is located approximately 780m to the south-east of the proposed onshore works.

19.3.2.4 Kelling Heath SSSI

Kelling Heath is a biological and geological SSSI and consists of approximately 88 hectares of mainly dry, acid heath-land. The site is located approximately 600m to the south of the proposed onshore works.

The ecology of the site includes areas of dry, acid heath-land dominated by heather (*Calluna vulgaris*) with frequent bell heather (*Erica cinerea*) and western gorse (*Ulex gallii*). Small areas of acidic grassland, with wavy hair-grass (*Deschampsia flexuosa*), and of hawthorn (*Crataegus monogyna*) and blackthorn (*Prunus spinosa*) scrub are present. Young silver birch (*Betula pendula*) and Scot's pine (*Pinus sylvestris*) are thinly scattered over the entire heath and a band of secondary woodland, dominated by pedunculate oak (*Quercus robur*), is present along a steep escarpment at the eastern margin of the site (English Nature, 1986b).

In terms of its geological interest features, Kelling Heath provides perhaps the best example of a glacial outwash plain in England. The site has a steep ice-contact slope and is dissected by deep dry valleys, and is a geomorphological site of national importance (English Nature, 1986b).

19.3.3 Non-Statutory Sites

The following non-statutory sites are located within 2km of the proposed onshore works, the boundaries of which are illustrated on Figure 19.1:

- Beach Lane CWS;
- Muckleburgh Hill CWS;
- Kelling Hard CWS; and
- Kelling Heath Park and Hundred Acre Wood CWS.

There are no other non-statutory sites, such as Ancient Woodland Inventory (SSSI) areas within 2km of the proposed onshore works.

CWS are a non-statutory designations listed within the North Norfolk Local Plan and are material considerations during planning applications. The sites were identified by Norfolk Wildlife Trust and consist of areas of semi-natural habitat remaining in Norfolk outside of SSSIs.

19.3.3.1 Beach Lane CWS

Beach Lane CWS is an area of reed bed occupying a shallow silty pool and is located approximately 170 metres to the east of the proposed cable connection pit. The reed bed is dominated by common reed (*Phragmites australis*) and is generally brackish (Norfolk Wildlife Trust, 2004a).

19.3.3.2 Muckleburgh Hill CWS

Muckleburgh Hill CWS is an area of remnant heath-land located approximately 660 metres to the south of the proposed onshore works. The exposed low hilltops in the centre of the site support acidic grassland and heath-land, however the remaining areas are dominated by bracken (*Pteridium aquilinum*), scrub and secondary woodland (Norfolk Wildlife Trust, 2004b).

19.3.3.3 Kelling Hard CWS

Kelling Hard CWS is located approximately 770 metres to the north-west of the proposed onshore works and comprises a mosaic of unimproved, slightly calcareous and neutral grassland, swamp and marshy grassland (Norfolk Wildlife Trust, 2004c).

19.3.3.4 Kelling Heath Park and Hundred Acre Wood CWS

Kelling Heath Park and Hundred Acre Wood CWS is a large site comprising semi-natural broad-leaved woodland and dry heath with associated scrub (Norfolk Wildlife Trust, 2004d). The site is primarily used as a caravan park and is located approximately 1460 metres to the south of the proposed onshore works.

19.4 Impacts during Construction, Operation and Decommissioning

The proposed onshore works have been located and designed to avoid any statutory and non-statutory nature conservation sites, therefore, no direct impact to any of the outlined sites is envisaged.

The potential in-direct impact to the interest features of the outlined nature conservation sites during the construction, operation and decommissioning of the onshore elements of the proposed wind farm are discussed within Section 20 ‘Geology, Water Resources and Land Quality’ and Section 0 ‘Terrestrial Ecology’.

19.5 Summary

The proposed onshore works have been located and designed to avoid any statutory and non-statutory nature conservation sites.

A review of the presence and interest features of any sites located within a 2km buffer of the works was carried out in order to enable an assessment of any potential impacts.

To the west of Kelling Hard, the coastline is protected under a series of statutory designations, comprising of the North Norfolk Coast Ramsar/SPA/SAC/SSSI and the Wash and North Norfolk Coast SAC. The international and European elements of the designation are primarily associated with its ornithological importance, however at a national level, the site also supports a variety of coastal habitats and protected flora and fauna. The onshore works would be located approximately 1,150m to the south-east of the designated site.

Three additional national statutory sites; Weybourne Cliffs SSSI, Weybourne Town Pit SSSI and Kelling Heath SSSI, are located approximately 330m, 780m and 600m from the proposed onshore works respectively. All three sites are designated for their geological interest features. In addition, Kelling Heath SSSI is also listed for its biological importance due to the presence of dry, acid heath-land.

Four non-statutory County Wildlife Sites (CWS) are located within 2km of the onshore works. The nearest of these; Beach Lane CWS is located approximately 170m to the east of the proposed landfall point and consists of an area of reed-bed.

No direct impact to any of the outlined sites is envisaged during the construction, operation or decommissioning activities relating to the onshore works. Potential in-direct impacts relating to the interest features of these sites are discussed in more detail within Section 20 'Geology, Water Resources and Land Quality' and Section 0 'Terrestrial Ecology'.

19.6 References

- English Nature (1983). Weybourne Town Pit Site of Special Scientific Interest citation.
- English Nature (1985). Weybourne Cliffs Site of Special Scientific Interest citation.
- English Nature (1986a). North Norfolk Coast Site of Special Scientific Interest citation.
- English Nature (1986b). Kelling Heath Site of Special Scientific Interest citation.
- HMSO (1981). The Wildlife and Countryside Act 1981
- HMSO (2000). Countryside Rights of Way Act (CRoW)
- Multi Agency Geographic Information for the Countryside (2006). Magic website www.magic.gov.uk [date last accessed: 10 January 2006].
- Norfolk Wildlife Trust (1994a). County Wildlife Site (Ref No: 1156) 'Beach Lane' citation (survey date: 04/05/1994).
- Norfolk Wildlife Trust (1994b). County Wildlife Site (Ref No: 1106) 'Muckleburgh Hill' citation (survey date: 29/07/1994).
- Norfolk Wildlife Trust (1994c). County Wildlife Site (Ref No: 1107) 'Kelling Hard' citation (survey date: 01/08/1994).
- Norfolk Wildlife Trust (1994d). County Wildlife Site (Ref No: 1150) 'Kelling Heath Park and Hundred Acre Wood' citation (survey date: 07/07/1994).

20 Geology, Water Resources and Land Quality

20.1 Introduction

This section details the existing geology, water resources and land quality in the vicinity of the onshore works including the cable connection pit, cable route and switch room. The potential impacts from construction, operation and decommissioning activities of the onshore works are assessed, and where necessary, mitigation measures identified.

20.2 Assessment Methodology

A desk based assessment of the geology, water resources and land quality has been undertaken to establish the existing environment in the vicinity of the onshore works, involving the collation and review of existing information from the following data sources:

- Geological Map Sheet 131: Cromer, Solid & Drift Geology, British Geological Survey, 2002;
- Geology of the country around East Anglia and adjoining areas;
- OS map Explorer 252, Norfolk Coast East, Cromer & North Walsham;
- Environment Agency River Corridor Survey data for Sheringham, Weybourne, Elling, Holt
- Environment Agency website (www.environment-agency.gov.uk); and
- Kelling to Lowestoft Ness Draft Shoreline Management Plan.

Publicly available information for the site has also been obtained from the Environment Agency and Local Planning Authority (Landmark Information Group Ltd, 2005). The search area included the cable connection pit, switch room and cable route and a zone 250m either side.

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 20.4 – 20.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section 3 for the definition of significance levels.

20.3 Existing Environment

20.3.1 Geology

The foreshore around Weybourne Hope and to the west and east comprises shingle beaches within increasing sand content towards Sheringham. The proposed landfall site is in an area of sand and gravel beaches. The hinterland of the Weybourne Hope landfall site is a low-lying coastal plain. The coast comprises of soft glacial cliffs to the east and a wide complex coastal plain of salt-marshes, intertidal flats, beaches and shingle barriers to the west. The cliffs are retreating, supplying large amounts of sediment to the coastal zone (EA data, 1991-1999).

North Norfolk District Council has surveyed the beach surface along 13 shore normal profiles, from Weybourne to Cromer. Profiles at the western end of their survey frontage are most relevant, and show level changes of ±1.5m and an erosional trend of approximately 0.4m/year (source: HR Wallingford, 2005).

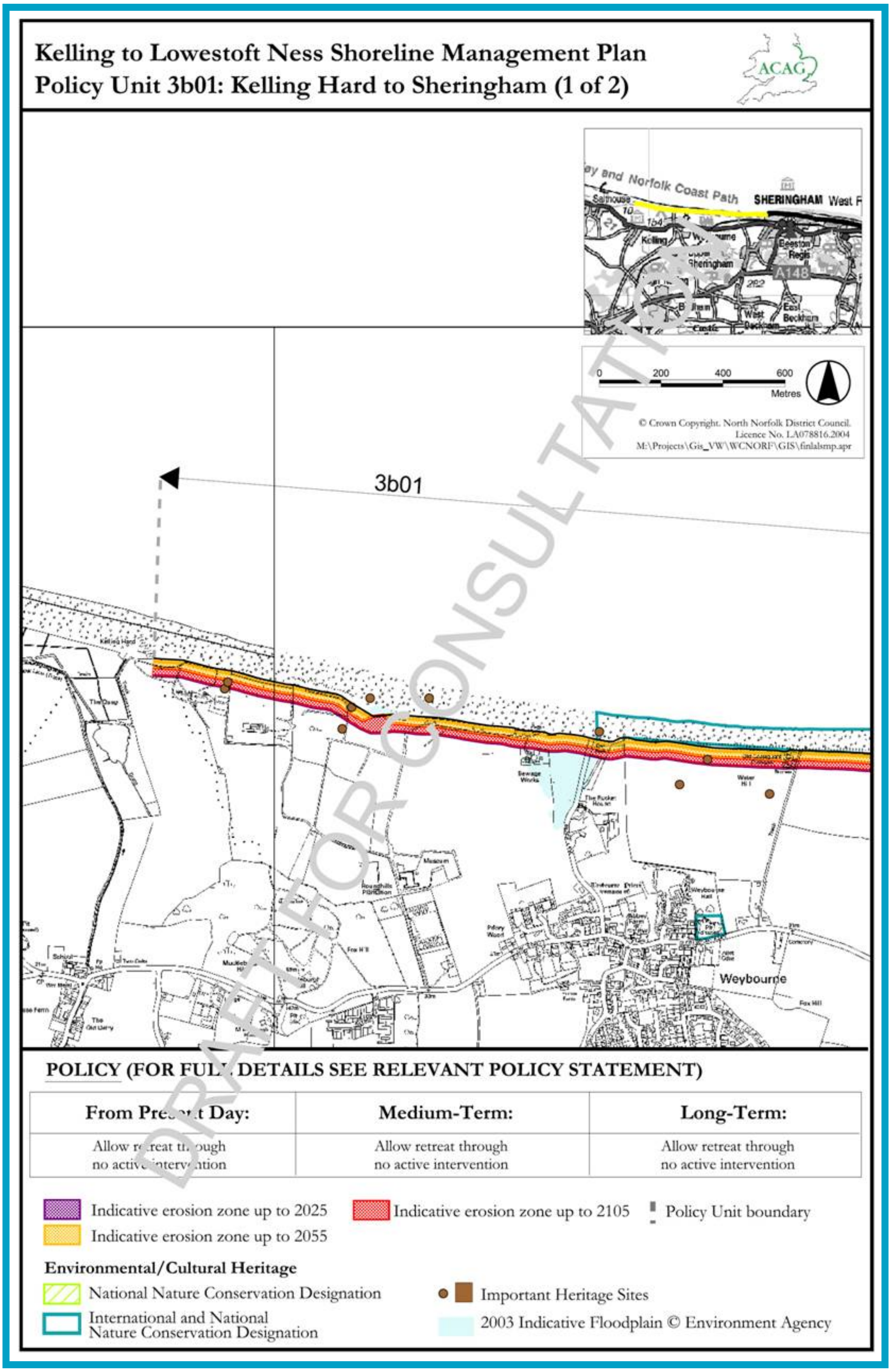


Figure 20.1 Kelling to Lowestoft Ness Shoreline Management Plan, Policy Unit, 3b01; Kelling Hard to Sheringham (Courtesy of North Norfolk District Council)

As presented in Figure 20.1 the predicted rate of regression at the site is slow relative to the North Norfolk Coastline in general.

The higher hinterland behind the coastal plain comprises unconsolidated Pleistocene glacial sediments. The materials are likely to be highly variable even over short distances, comprising till, sand and gravel spreads, and the possibility of chalk rafts at shallow levels buried beneath the ground surface within the till/sand and gravel matrix (Landmark Information Group Ltd, 2005). Borehole records suggest these sediments are up to 10m thick on top of underlying glacial sediment. The cliffs comprise chalk towards the base of the cliffs with Weybourne crag above and then till deposits.

The potential for changes to land stability has been identified as low to moderate for dissolution stability hazards, very low for landslide ground stability hazards and moderate for potential running sand ground stability hazards (Landmark 2005).

20.3.1.1 Geological Designations

There are three Sites of Special Scientific Interest (SSSI) notified for their geological interest within the study area namely: Weybourne Cliffs SSSI situated to the east of the landfall at a distance of 210m; Weybourne Town Pits SSSI situated to the south east at a distance of 950m, and Kelling Heath SSSI to the west at a distance of more than 1km (see Figure 20.2). A summary of the geological interest features of the sites is provided within Table 20.1.

Table 20.1 Geological SSSI Interest Features

Site Name	Grid Reference	Summary of Geological Interest Features
Weybourne Cliffs	TG111437 – TG152435	The cliffs afford the best Pleistocene sections showing the pre-Cromerian deposits of the Cromer Forest bed. The marine 'crags' have yielded both large and small mammal remains, of Pastonian and probably also pre-Pastonian age.
Weybourne Town Pits	TG111437	Type locality for the Pleistocene 'Marly Drift', a chalk-rich glacial till of supposed Anglian age.
Kelling Heath	TG101420	Kelling Heath provides perhaps the best example of a glacial outwash plain in England. The site has a steep ice-contact slope and is dissected by deep dry valleys, and is a geomorphological site of national importance.

20.3.2 Water Resources

20.3.2.1 Surface Water

There are relatively few water-bodies within the onshore works study area. These are confined to Spring Beck, which flows through Weybourne and feeds the reed-bed to the west of the Weybourne beach car park and several springs and man-made drainage ditches scattered throughout the study area, as shown on Figure 20.2. The Environment Agency does not monitor water quality within any of the watercourses within 250m of the proposed cable route and onshore facilities.

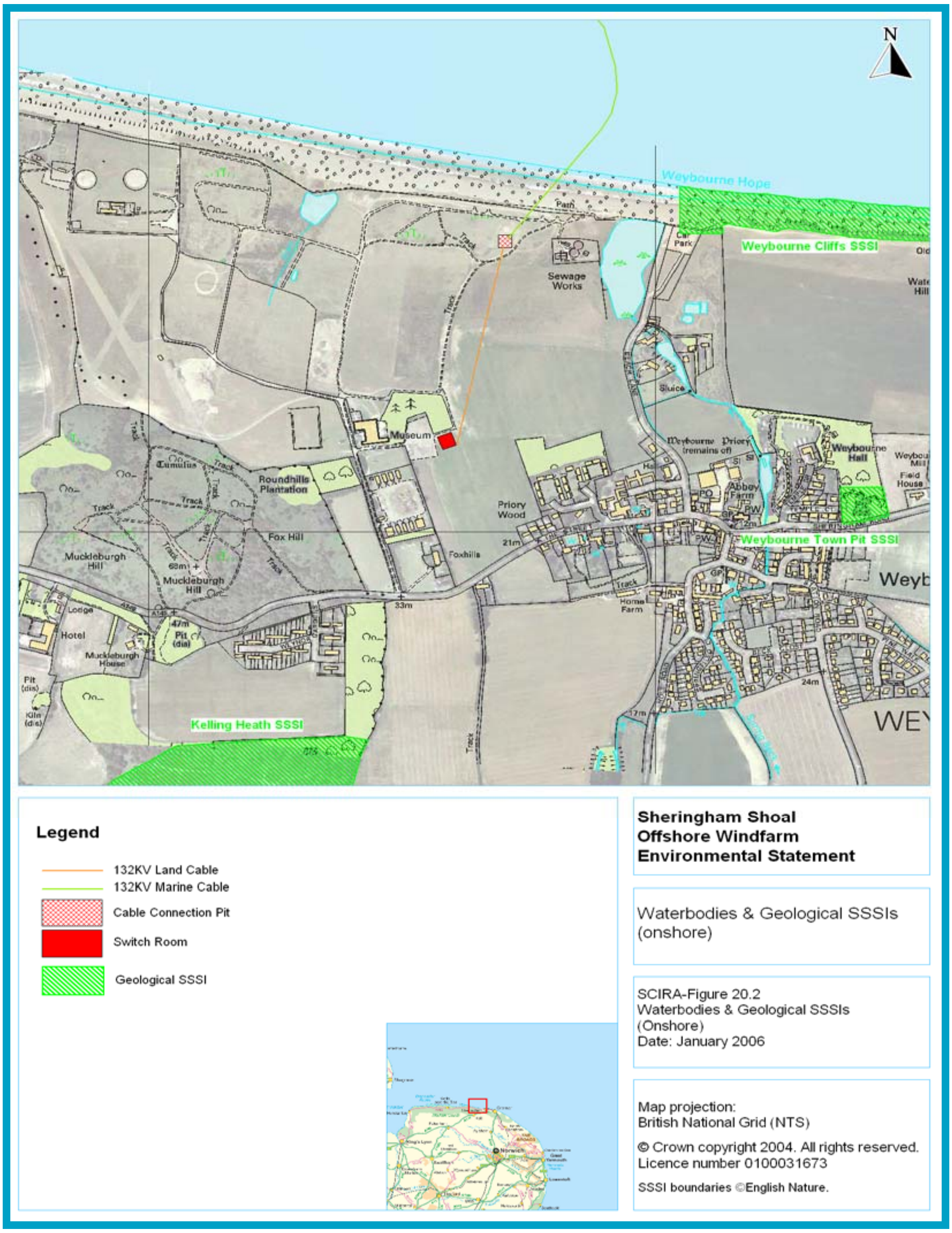


Figure 20.2 Waterbodies & Geological SSSIs

20.3.2.2 Groundwater

The Upper Chalk beneath the proposed onshore works is regarded as a major aquifer. This is a highly permeable formation, usually with a known or probable presence of significant fracturing. A major aquifer may be highly productive and able to support large abstractions for public supply and other purposes. A geology log for High Lodge, Weybourne shows 15m of undifferentiated drift, 10m clay and then upper chalk. Clay may act to confine the aquifer. However, consideration should be given to the impact and vulnerability of upper drift deposits which appear to be within 3m of the surface.

20.3.2.3 Flood Risk

The connection pit and switch room onshore infrastructure are located above the 5m flood contour as classified by the Environment Agency as at risk from flooding within the 1 in 200 year flood risk boundary (www.environment-agency.gov.uk). Hence, risk from flooding in this area is not anticipated within the anticipated 40 year life of the project. Marine cables would be utilised to connect the offshore works through the landfall to the connection pit, situated in excess of 5m above sea level.

20.3.2.4 Soil conditions and environmental breaches

Soils within the area have been classified by the Environment Agency as being of high leaching potential. These are permeable, coarse textured and moderately shallow soils, which may readily transmit non-absorbed pollutants, and liquid discharges. A review of publicly available information indicates that there have been two recorded pollution incidents in the last 12 years within 250m of the onshore works area. The first incident in 1993 is recorded as Category 2, i.e. significant. The source of the pollutant was unknown and no further data is publicly available. The second incident in 1998 is recorded as Category 3, i.e. minor and is recorded as being a result of crude sewage entering the River Glaven.

As part of the onsite investigation works a contaminated land survey will be undertaken (see Section 20.4.3) to identify any areas of pollution that may be disturbed by the works.

20.3.2.5 Additional Infrastructure

There are two discharge consent sites within 250m of the landfall site and cable route. These are operated by Anglian Water Services Ltd and are identified as Sewage Discharges- Final/Treated effluent- Water Company, and shown on Figure 20.3.

There are no water abstractions, or registered landfill sites within 250m of the onshore works.

20.3.3 Land Quality

20.3.3.1 Historic Land Use

Historically, during the World War II the site was used as an army camp, playing host to a large force of men, a radio station as well as an anti aircraft artillery range. The site was one of the main live firing ranges for ACK-ACK command in World War II. In 1986, work began to demolish nearly 200 old buildings on the site which were beyond repair, 45,000 tons of rubble was cleared away to make way for the conversion to the Museum seen today.

20.3.3.2 Present Land Use

In 1988, the Muckleburgh Collection museum was established as a privately owned working military museum which is located in the centre of the study area around the old military camp NAAFI building which underwent several years of restoration. The onshore infrastructure pass directly through this privately owned land, part of the 300 acre site owned by the museum.

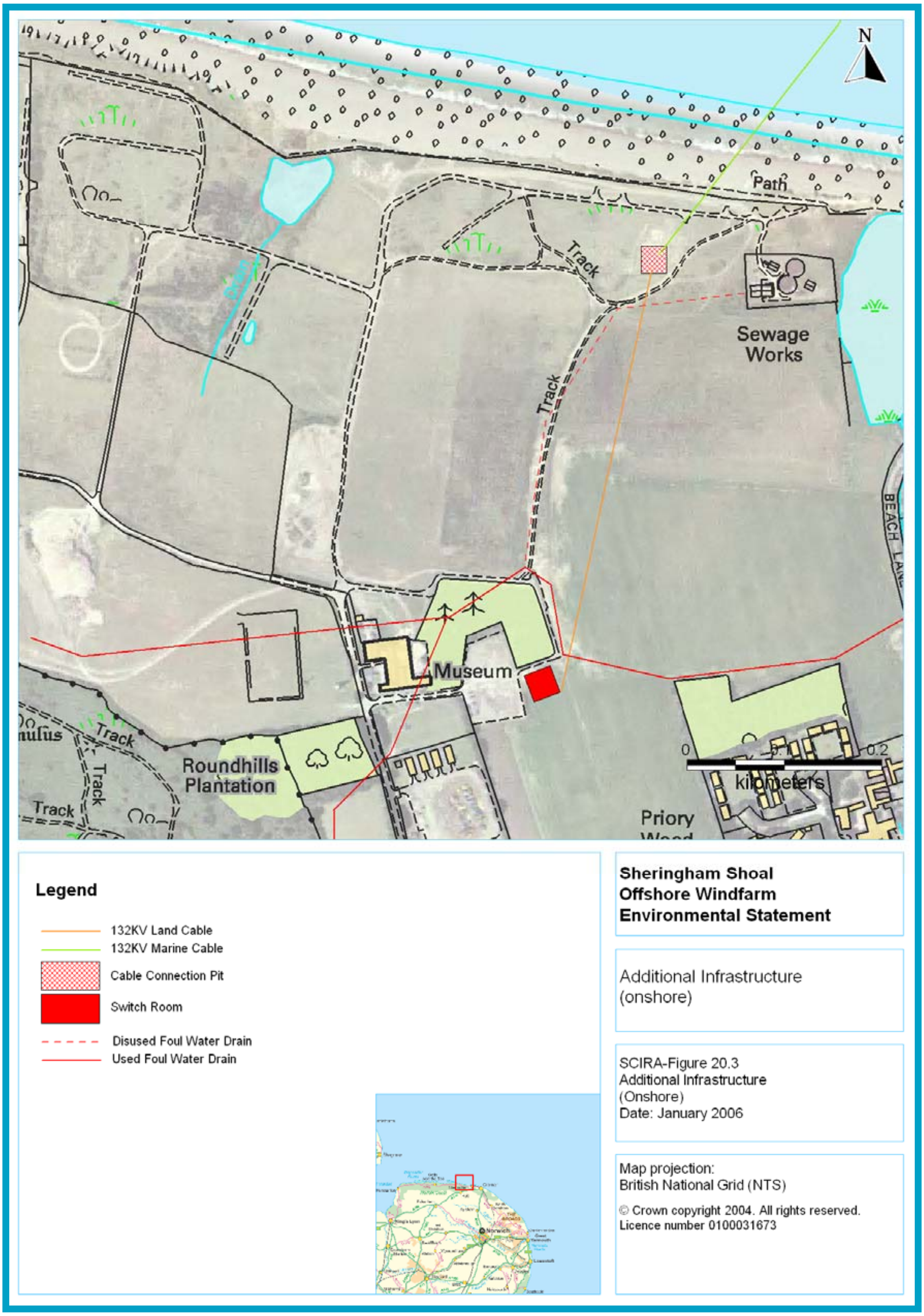


Figure 20.3 Additional Infrastructure

20.4 Impacts during Construction

20.4.1 Disturbance to Geological SSSIs

It is considered that the construction and installation of the onshore works would have no impact on the existing geological interest features of the identified SSSIs due to the distance separation between the works and the nearest SSSI which is a minimum of 210m. **No impact** is therefore envisaged to the geological SSSIs.

20.4.2 Accidental Pollution

Potential impacts on surface water quality and land quality may result during the construction period due to accidental pollution events involving fuel oils or chemicals and run off from stockpiles of excavated material.

There are no onshore water features within the immediate area of the proposed works or construction compounds. Good construction measures and implementation of relevant codes of practice and guidance for demolition and construction sites would be observed during the installation of the onshore works in order to minimise impacts on the land quality and water resources of the surrounding area.

Pollution prevention guidelines to be adhered to by the Contractor include:

- PPG 1 General Guidance for the Prevention of Water Pollution;
- PPG 5 Works in, Near or Liable to Affect Watercourses;
- PPG 6 Working at Construction and Demolition Sites;
- PPG 8 Safe Storage and Disposal of Used Oils; and
- Control of Water Pollution from Construction Sites – A Guide to Good Practice (CIRIA 2001).

Any accidental spillage of fuel or chemicals that occur will be cleaned up immediately and the Environment Agency informed, if the incident is deemed to be significant by the Contractor. In addition, equipment will be used in accordance with the manufacturer's recommendations, including servicing frequencies to ensure optimum operation.

The mitigation measures outlined above would ensure a **negligible impact** on the geology, water resources and land quality in the area.

20.4.3 Impacts of Remobilisation of Soils and Contaminants

The desktop review of land quality did not identify any areas of known significant contamination, which would be directly affected by the cable infrastructure. There is however a potential for areas of contamination on the site due to its historic use as a former military base.

Following consultation with the Environmental Protection Officer (EPO) of North Norfolk District Council (NNDC), a ground investigation and risk assessment in relation to contaminated land for the cabling route and building construction is currently been undertaken.

The results of the ground contamination survey will be provided to the NNDC EPO once available and if necessary a suitable level of mitigation will be discussed and agreed. Areas of identified contamination will be dealt with in accordance with the statutory guidelines and legislation.

Given successful implementation of any mitigation measures identified in the survey, the impact is considered to be **negligible**.

20.4.4 Impacts of Disposal of Construction Wastes

During the cable trench and connection pit excavations, the top-soil and sub-soil would be stored separately and subsequently replaced. The majority of the soil arising from the cable trench and connection pit construction would be replaced following the installation of the onshore cables and pit. However some surplus material is expected due to the use of sand, tiles within the trench. Any surplus material that may be considered to be waste under the Waste Management Licensing Regulations 1994 would be dealt with accordingly.

The following good construction methods will be adopted as regards storage and disposal of any arisings:

- The Contractor will have a Duty of Care with regard to any waste generated on site, meaning that they will be responsible for the safe storage, transportation and eventual disposal, if required, of the waste;
- Waste will be stored in designated areas away from surface water drains. Skips will be covered to prevent rainwater accumulation and waste/litter blown out;
- Wastes will be segregated to avoid potential cross contamination by ‘contaminated’ and ‘inert’ wastes where appropriate;
- No burning or disposal of wastes on site will take place; and
- Any waste carriers and receiving landfill sites will be registered.

The impact, given implementation of the above measures, is considered to be **negligible**.

20.5 Impacts during Operation

20.5.1 Potential Cable Exposure

Once the infrastructure is installed and operational there would be no structures to impact on the geology of the beach or cliffs or geology of the site since all aspects would be buried. There is a potential risk to the cable itself, resulting from any large-scale failure of the existing beach protection, which may result in the cable becoming exposed. This situation would be monitored. As described in Section 2, the cables would be directionally drilled under the shingle bank and designed to take into account future set back of the shingle bank. The detailed construction methodology would be discussed and agreed with the NNDC Coastal Protection Engineer following consent.

No impact on the geological interest features of the area is predicted due to burial of cables using appropriate construction methods.

20.5.2 Impacts from Leaks and Spillages

Cooling oil, lubricating oils and other fuels may be stored and/or used in the switch room. The potential exists that spillage/leakage may occur and impact the immediate area. The following operational strategy will be followed in order to minimise the risks of leaks and spillages:

- All fuel and chemical storage will be in accordance with the Environment Agency’s ‘Pollution prevention guidelines’. i.e. bunded;
- Appropriate spillage control kits will be located at the switch room site and staff trained in their use; and

The impact, given successful implementation of the above measures, is considered to be **negligible**.

No impact on water resources during operation is predicted.

20.6 Impacts during Decommissioning

Impacts during decommissioning are as for construction, but likely to be of shorter duration and magnitude. It is anticipated that the cable would remain in situ as part of any decommissioning plan and notified as such. The switch room would be decommissioned and the building could be used as part of the museum complex, in consultation with the landowner. **No impacts** are anticipated.

20.7 Summary

Information on the geology, water resources and land quality in the vicinity of the onshore works was collated in order to assess the impacts from the construction, operation and decommissioning activities on these resources.

There are a number of interest features in the area, including three Sites of Special Scientific Interest (SSSI) designated for geological interest. The immediate area of the works is devoid of water features, however further afield, typical water features include reed-beds and drainage ditches. The construction activities would not directly impact on any of these features due to the distance separation of the works and the implementation of good construction practices and pollution prevention guidance.

Historically, during World War II the site was used as a military barracks and anti-aircraft firing range. It now plays host to the UK's only working military museum and houses, the Muckleburgh Collection. There is therefore a risk of areas of historic contamination on the site. Site investigations will be undertaken and the results provided to NNDC Environmental Protection Officer. Any contaminated areas identified will be dealt with according to standard practices and in agreement with NNDC.

At the decommissioning stage, it is anticipated that the cable would be disconnected and left in situ unless otherwise advised by NNDC and/or the landowner. The switch room would be dismantled or used as part of the working museum.

20.8 References

- Geological Map Sheet 131: Cromer, Solid & Drift Geology, British Geological Survey, 2002
- Geology of the country around East Anglia and adjoining areas
- OS map Explorer 252, Norfolk Coast East, Cromer & North Walsham
- Environment Agency River Corridor Survey data for Sheringham, Weybourne, Elling, Holt
- Environment Agency website (www.environment-agency.gov.uk)
- Kelling to Lowestoft Ness DRAFT Shoreline Management Plan
- H R Wallingford Report: EIA and Coastal and Seabed Processes 2005

21 Terrestrial Ecology

21.1 Introduction

This section provides information on the existing ecological interests within close proximity to the Sheringham Shoal onshore works including the cable connection pit, cable route and switch room.

Potential impacts on these ecological interests arising from the construction, operation and decommissioning activities have been assessed and mitigation measures outlined where appropriate. An assessment of the potential impact to the ecological interest features of the sites identified within Section 0 ‘Nature Conservation Designations (Onshore)’ is also included.

21.2 Assessment Methodology

21.2.1 Data Collection and Collation

An ecological data collection exercise was carried out during the EIA scoping stage to gather any available data and information on designated nature conservation sites and species of conservation importance that could be present in the vicinity of the site. The following groups and organisations were contacted for data:

- English Nature;
- Environment Agency;
- Royal Society for the Protection of Birds (RSPB);
- Norfolk County Council Ecology Manager;
- Norfolk Wildlife Trust;
- Norfolk Biological Records Centre;
- North Norfolk District Council Countryside Planning; and
- Forestry Commission.

The results of the data search were utilised to inform the ecological surveys requirements and as background data for the terrestrial ecology impact assessment.

21.2.2 Ecological Surveys

21.2.2.1 Introduction and Study Areas

A programme of ecological surveys were designed and informed following the scoping and data collection stages in order to give into full consideration to all protected habitats and species, as required by Planning Policy Statement 9 ‘Biodiversity and Geological Conservation’ (ODPM, 2005a).

Norfolk Wildlife Services was commissioned by Scira Offshore Energy to carry out the ecological surveys. The survey programme was organised in two stages. The initial stage of surveys was carried out during March and April 2005 and involved a Phase 1 Habitat survey and a great crested newt (*Triturus cristatus*) survey. The study area for the first stage of surveys is shown on Figure 21.1 as ‘Stage A Study Area’. Following the identification of potential onshore cable route options, further surveys were undertaken during June and July 2005 within the area of the proposed onshore works, as also shown on Figure 21.1 as ‘Stage B Study Area’.

Figure 21.1 Ecological Survey Study Areas

This second stage of surveys included a detailed botanical survey and surveys for badgers (*Meles meles*), water vole (*Arvicola terrestris*), breeding birds and reptile habitat. Habitat opportunities for other protected species, such as bats, otters (*Lutra lutra*) and wintering birds were recorded during all ecological surveys.

The full Norfolk Wildlife Services survey report is provided as Appendix 21.1 'Habitat and Wildlife Surveys Weybourne/Muckleburgh'.

21.2.2.2 Phase 1 Habitat Survey

A Phase 1 Habitat Survey was undertaken on 25 March and 19 April 2005 and covered the area shown within Figure 21.1 as 'Stage A Study Area'. The survey was conducted following the methodology outlined within the 'Handbook for Phase 1 habitat survey' (NCC, 1990). All habitats and plant communities within the study area were recorded and mapped using annotated, coded maps indicating broad habitat and boundary features.

21.2.2.3 Detailed Botanical Survey

A detailed botanical survey was carried out within the area of the proposed onshore works on 9 July 2005. This involved detailed mapping of the habitats present according to NCC (1990) and the production of a botanical species list for each habitat type. Species abundance was scored using the ACFOR scale, were Abundant = 75-100%, Common = 50-75%, Frequent = 25-50%, Occasional = 5-25% and Rare = 0-5% (Kent and Coker, 1992). Areas of particular interest were mapped as target notes to provide supplementary information. Where possible, habitats were assigned National Vegetation Classification (NVC) codes.

The survey was conducted at a time of year optimum for vegetation surveys and there were no significant constraints involved.

21.2.2.4 Badger Survey

A badger survey was undertaken on 9 July 2005 within the area of the proposed onshore works. The survey involved searching for and recording any evidence of badger activity including setts, runs/tracks, hairs, prints, feeding signs and dung pits. Searches were extended up to 500m beyond the study area to include habitats that appeared suitable for badgers, such as woodland, thick hedgerows, rough grassland and scrub.

21.2.2.5 Water Vole Survey

All wetland areas within the area of the proposed onshore works were surveyed for evidence of water vole activity. This included all ponds, ditches, streams and seepage areas. Evidence of water voles that were searched for included latrines, droppings, burrows, feeding stations and runs, as recommended within the Water Vole Conservation Handbook (Strachen, 1998).

21.2.2.6 Breeding Bird Survey

Breeding bird surveys were conducted within the area of the proposed onshore works on the mornings of 10 and 12 July 2005, commencing 09:45 and 06:05 hours respectively. Each survey visit lasted approximately three hours.

The survey area was walked through slowly and birds showing signs of breeding, such as a nest with young and adults with recently fledged young, were recorded on a field map. Adult birds showing signs indicative of probable or possible breeding, for example presence in suitable habitat and singing, alarm calling and carrying food, were also recorded.

Additionally any other species of note (with special regard for Wildlife and Countryside Act Schedule 1 species) recorded within the areas were also noted. All species showing behaviour indicative of breeding were recorded on field maps using British Trust for Ornithology (BTO) codes (Gilbert *et al.* 1998). The surveys were conducted late in the breeding season outside the limits indicated within Gilbert *et al.* (1998), which recommends visits from mid April to mid May and mid May to mid June.

21.2.2.7 Great Crested Newt Survey

Detailed surveys to determine the presence or absence and population size of great crested newts were undertaken during April 2005 following the guidelines within 'Great Crested Newt Mitigation Guidelines' (English Nature, 2001). The study area for the great crested newt survey is shown within Figure 21.1 as 'Stage A Study Area'.

To determine presence/absence the English Nature guidance (2001) suggests a minimum of four survey visits using a variety of survey methods, such as torch survey, bottle-trapping and egg searches. However, it is also noted within the guidelines that the surveyor planning the survey should decide what level of effort is required, according to the objectives of the survey and local conditions. Any deviation from the survey methodologies outlined within the English Nature guidelines have been justified, as appropriate.

An initial day-time survey was carried out to identify the location of water-bodies within the study area and to make an initial assessment of their suitability to support great crested newts. Twelve ponds and one drain which were assessed as being suitable were then subject to detailed surveys for great crested newts. Where feasible and appropriate, all water-bodies identified as suitable were surveyed on four occasions. Survey methods employed during the day-light visits involved egg searches and habitat assessments, which included observations regarding the presence of predatory species such as fish. Night-time visits involved searching for newts and eggs by torchlight. Full details of the survey are provided within Appendix 21.1 'Habitat and Wildlife Surveys Weybourne/Muckleburgh'.

21.2.2.8 Reptile Habitat Survey

The habitats within the area of the proposed onshore works were assessed for their potential to support reptiles using Common Standards Monitoring criteria (JNCC, 2004). The survey was undertaken on 10 July 2005.

The key habitat features outside of hibernation time include the presence of suitable open patches and variation in vegetation structure and topography close to ground level. These can be created by mosaics in vegetation, or interfaces between vegetation such as scrub and grassland.

For successful hibernation, reptiles need structures that provide deep crevices which provide protection from low temperatures. Suitable features include south-facing banks, tumuli, tree root systems, mammal burrows or debris piles. For grass snakes (*Natrix natrix*) there needs to be suitable egg-laying sites, such as mounds of rotting vegetation, muck heaps, deadwood or crevices in sunny ground.

21.2.2.9 Assessment of Impacts

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in bold in Sections 21.4 to 21.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. The definition of significance levels and the methodology used for determining impact is outlined in detail within Section 3.6, The Environmental Impact Assessment Process.

The assessment of impacts to terrestrial ecology was undertaken with reference to the Institute of Ecology and Environmental Management (IEEM) 'Guidelines for Ecological Impact Assessment in the United Kingdom' (2006).

21.3 Description of the Existing Environment

21.3.1 Nature Conservation Designations

As discussed within Section 0 'Nature Conservation Designations (Onshore)' and illustrated on Figure 19.1, the location of the proposed onshore works are within 2km of the following nature conservation designations with ecological interest features:

- North Norfolk Coast Ramsar/Special Protection Area (SPA)/Special Area of Conservation (SAC)/Site of Special Scientific Interest (SSSI);
- The Wash & North Norfolk Coast SAC;
- Kelling Heath SSSI;
- Beach Lane County Wildlife Site (CWS);
- Muckleburgh Hill CWS;
- Kelling Hard CWS; and
- Kelling Heath Park and Hundred Acre Wood CWS.

21.3.2 Habitats and Botanical Species

The proposed onshore works are primarily located within the Muckleburgh Collection Tank Museum. The museum is located on a site that was previously occupied by a military camp. Most of the original buildings and service roads have been demolished and the site now consists predominantly of semi-improved neutral and acid grassland, interspersed with areas of hard standing and bare ground associated with the museum, tall ruderal vegetation and a block of coniferous plantation woodland. The shingle shoreline gently rises over an undulating terrain to an altitude of approximately 20m at the southern limit of the proposed works.

The majority of the land immediately surrounding the area of proposed works comprises grassland of various types with small scattered blocks of woodland to the north of the A149. To the west is a large area of open water known as 'The Scrape'. To the south-west is the Muckleburgh Hills County Wildlife Site, details of which are provided within Section 0 'Nature Conservation Designations (Onshore)'. A large reed bed (Beach Lane County Wildlife Site), car park and access road to the east leads to the village of Weybourne to the south-east of the proposed works. Further to the south of the A149, the area becomes dominated by land under arable cultivation, interspersed with large blocks of woodland, remnant heath-land and parkland.

Descriptions of the habitats recorded within the vicinity of the proposed onshore works are provided below and illustrated on Figure 20.1. Further information relating to the wider survey area is provided within Appendix 21.1 'Habitat and Wildlife Surveys Weybourne/Muckleburgh'.

- <u>Conifer plantation</u>: To the north of the car park there is a small block of Scot's pine (*Pinus sylvestris*) plantation, planted in approximately 1975. The middle part of the plantation has little or no ground flora, and includes much bare ground and a litter layer of needles. The edge of the plantation has little botanical interest. Species present include selfheal (*Prunella vulgaris*), wild strawberry (*Fragaria vesca*), bramble (*Rubus fruticosus*) and ragwort (*Senecio jacobaea*).
- <u>Semi-improved grassland</u>: The majority of the habitat within the area of the proposed onshore works consists of semi-improved, neutral to slightly acidic grassland on well-drained soils. The grassland is well grazed by rabbits and is subject to regular disturbance by large military vehicles. This combination of factors maintains the grassland in its present state and prevents widespread succession. The sward is dominated by Yorkshire fog (*Holcus lanatus*).

Herbs are present in quite low diversity, and include creeping cinquefoil (*Potentilla reptans*), white clover (*Trifolium repens*) and ground ivy (*Glechoma hederacea*). Other coarser herbs present include creeping thistle (*Cirsium arvense*), ragwort, hogweed (*Heracleum sphondylium*) and common nettle (*Urtica dioica*). A slight maritime influence is evident in the presence of curled dock (*Rumex crispus littoreus*). More open areas of the sward contain frequent wild centaury (*Centaurium erythraea*) and lesser trefoil (*Trifolium dubium*).

Recently disturbed areas have further species not present elsewhere, including bird's foot trefoil (*Lotus corniculatus*), ribwort plantain (*Plantago lanceolata*), creeping buttercup (*Ranunculus repens*) and common cudweed (*Filago vulgaris*). Creeping cinquefoil (*Potentilla reptans*) and several common species of cranes' bills are more common here than elsewhere.

Previous surveys have discovered occasional bee orchids (*Ophrys apifera*) in the eastern part of the grassland. No sign of bee orchids was found during the 2005 surveys and it is considered that the population is likely to be defunct. Hoary mullein (*Verbascum pulverulentum*) was found in similar habitat to the unimproved neutral grassland immediately east of the site. Neither hoary mullein or bee orchid are nationally or regionally scarce (Norfolk Wildlife Trust, 2001, and subsequent).

- <u>Supralittoral sediment</u>: The northern edge of the site is bordered by a shingle bank and beach, overlying intermittent, low, soft, maritime cliffs to the east and west of the landfall location. The shingle supports areas of remnant shingle vegetation on its landward base. In places, particularly to the west of the proposed works, the shingle is partly vegetated with SD1 *Rumex crispus – Glaucium flavum* shingle NVC community. To the east of the proposed works the shingle vegetation is far less frequent and in places entirely absent. The community is very open but the most constant component is curled dock.

  Yellow-horned poppy (*Glaucium flavum*) is also fairly common along the shoreline and is a nationally and regionally scarce species (Norfolk Wildlife Trust, 2001, and subsequent).

  Other species present include buck's horn plantain (*Plantago coronopus*), which is very common, perennial sow thistle (*Sonchus arvensis*) and spear-leaved orache (*Atriplex prostrata*). Infrequent components of the shingle flora include sea fern grass (*Catapodium marinum*) and biting stonecrop (*Sedum acre*).

  A small rise of approximately 1m is located behind the shingle, on which a more permanent, heavily rabbit grazed sward is present. Here the dominant species are creeping cinquefoil and buck's horn plantain; sheep's fescue (*Festuca ovina*), common couch (*Elytrigia repens*) and Yorkshire fog. In a rather more acid area this maritime-influenced community also includes a small area of Cladonia heath.

- <u>Ruderal communities and bare ground</u>: Semi-permanent track-ways dissect the Muckleburgh site and are fringed with taller ruderal vegetation including Alexanders (*Smyrnium olusatrum*), teasel (*Dipsacus fullonum*), hogweed and bramble.
- <u>Hedgerows</u>: There are no hedgerows within the area of the proposed onshore works.
- <u>Wetland habitats</u>: There are no ponds, ditches, streams or any other water features within the area of the proposed onshore works.
- <u>Other habitats</u>: Areas of hard standing and occasional buildings associated with the former military camp and the museum are scattered throughout the site.

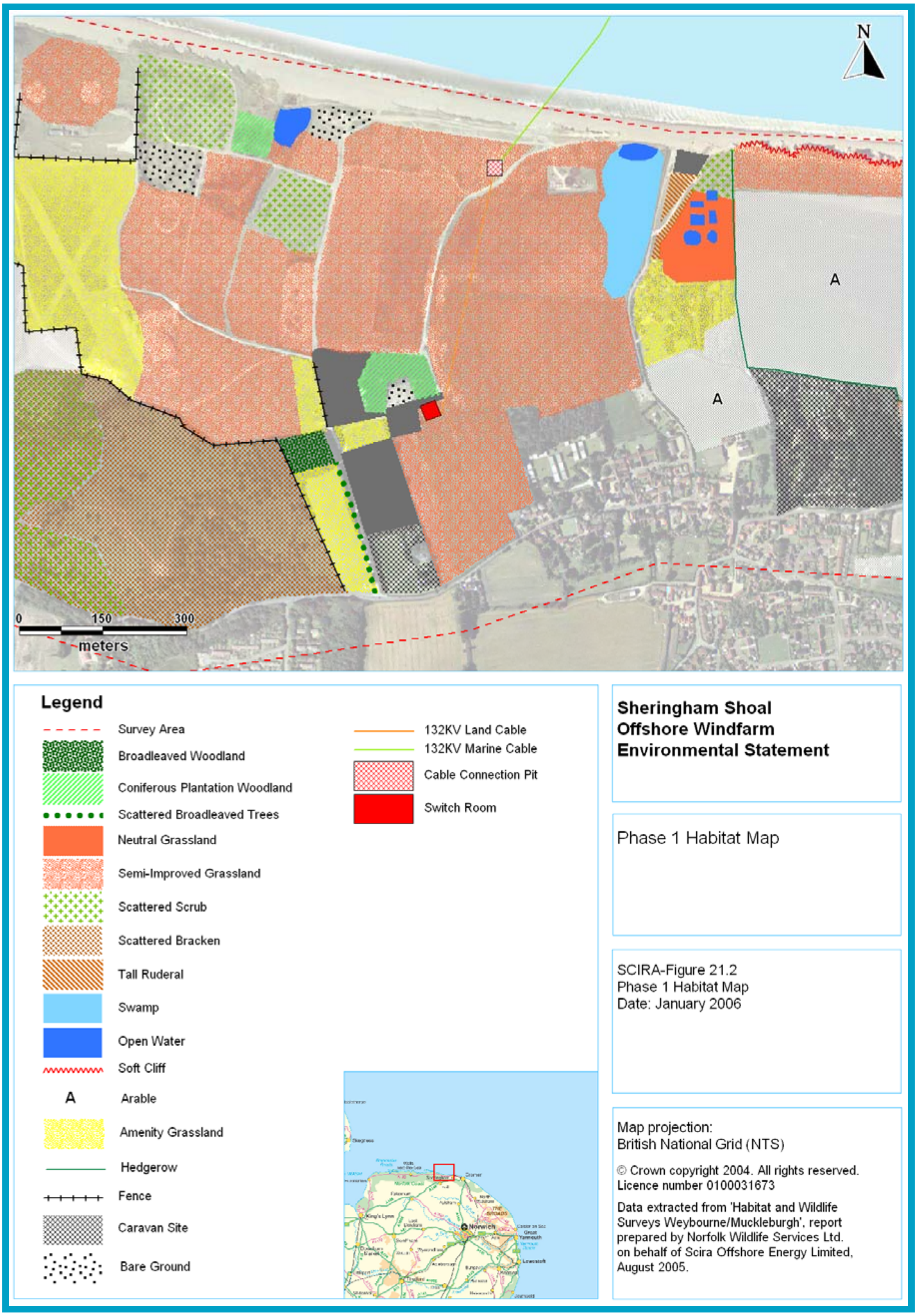


Figure 21.2 Phase 1 Habitat Map

21.3.3 Faunal Species

21.3.3.1 Badger

Badgers are fully protected by the Protection of Badgers Act 1992, which subsumed all previous legislation covering this species. This Act makes it an offence inter alia to wilfully kill, injure or take a badger, to damage or obstruct access to a badger sett or to disturb a badger when it is occupying a sett.

Badgers are known to be scarce within the north Norfolk area. Their known distribution within the Holt-Cromer Ridge area and is limited to occasional records from Hempstead, Little Barnigham and Northrepps (Vine, 1993).

Within the area of the proposed onshore works the habitat for badgers is limited, although the Scot's pine plantation adjacent to the car park provides some suitable habitat. Within the wider study area, potential habitat include areas of deciduous woodland, hedgerows and scrub.

No evidence or signs of badgers were found during the badger survey within the area of the proposed onshore works or the wider study area surveyed.

21.3.3.2 Water Vole

Water vole habitat is protected under the 1981 Wildlife and Countryside Act. This protection makes it an offence to intentionally damage, destroy or obstruct access to any structure or place, which water voles use for shelter or protection, or to disturb them while they are using such a place. The scope of this legislation is expected to be extended and changes will be introduced to help protect the species from killing, injuring and taking, as well as the habitat.

No records of water vole are known directly from the areas surveyed, however there are a number of records from neighbouring localities, mainly to the east, within the Weybourne area (source: Norfolk Wildlife Trust).

There is no potential habitat for water vole within the area of the proposed onshore works. Areas of suitable habitat were surveyed and assessed within approximately 500m of the proposed works. Within this wider area, suitable habitat comprised of several ponds, ditches and a coastal seepage.

No evidence of water vole was found during the surveys within the proposed site or surrounding area.

21.3.3.3 Otter

Otters and their places of rest and shelter are protected under the Wildlife and Countryside Act, 1981, and are listed under the Conservation (Natural Habitats &c.) Regulations, 1994 (Schedule 2).

Otter are known to occur within the North Norfolk Coast SSSI (English Nature, 1986), however precise records on the locations are not known. The Environment Agency have reported that the nearest record is located on the River Glaven at Letheringsett (TG062388), more than 5km to the south-west of the proposed onshore works. Otter have also been recorded at High Kelling, within grid square TG1039 in 2001 (source: Norfolk Biological Records Centre).

There are no areas of suitable habitat for inhabitation by otter within the area of the proposed onshore works and no evidence of the species was recorded during the ecological surveys carried out.

21.3.3.4 Red Squirrel

Red squirrel (*Sciurus vulgaris*) and their habitat are fully protected under the Wildlife and Countryside Act 1981 making it an offence to intentionally kill, injure or capture, intentionally or recklessly disturb them while they are occupying a structure or place used for shelter or protection or damage, destroy or obstruct breeding sites or other places of shelter and protection.

Red squirrel have historically been recorded within the Kelling area, however the most recent record is dated 1973 (source: Norfolk Biological Records Centre).

It is considered highly unlikely that red squirrel are still present within the area of the proposed onshore works.

21.3.3.5 Brown Hare

Brown hare (*Lepus capensis*) are not afforded any degree of legal protection, but are listed as a species of principle importance under Section 74(2) of the CRoW Act 2000. Brown Hare are UK and Norfolk Biodiversity Action Plan (BAP) species.

Brown hare have been previously recorded within the Kelling and Weybourne areas fairly regularly, with the most recent record dated 2003 (source: Norfolk Biological Records Centre).

No brown hare were recorded during the ecological surveys, however the habitats available within the area of the proposed onshore works could be utilised by this species.

21.3.3.6 Bats

All British bats are protected under the Wildlife and Countryside Act, 1981 (Schedule 5) and are listed under the Conservation (Natural Habitats &c.) Regulations,1994 (Schedule 2). It is therefore an offence deliberately to capture, kill or disturb them, or to damage or destroy a breeding or resting place.

Recent records of pipistrelle (*Pipistrellus pipistrellus*), barbastelle (*Barbastella barbastellus*) and brown long-eared bat (*Plecotus auritus*) have been recorded within the Weybourne area to the east of the proposed works, in grid squares TG1142 and TG1143. Natterer's bat (*Myotis nattereri*) have also been recorded in the Weybourne area historically (record dated 1972). Barbastelle, pipistrelle, noctule (*Nyctalus noctula*) and brown-long eared bats have also been recorded regularly, further to the south-west, within Holt (source: Norfolk Biological Records Centre). No existing bat records are associated with the area of the proposed onshore works.

During the ecological surveys, it was noted that several of the remaining military buildings used in the maintenance of the museum's vehicles have potential as bat roosting sites. No other potential roosting habitat was identified during the surveys.

21.3.3.7 Birds

The Wildlife and Countryside Act 1981 protects all wild birds and their nests and eggs. In addition, certain rare breeding birds, listed on Schedule 1 to the 1981 Act, are also protected against disturbance whilst building a nest or on or near a nest containing eggs or young.

The RSPB have provided records of avocet (*Recurvirostra avosetta*), ruff (*Philomachus pugnax*) and Sandwich tern (*Sterna sandvicensis*) to the west of the proposed onshore works, at Kelling Hard, grid reference TG095438. The status of breeding was predominantly unconfirmed, with the exception of four confirmed records of avocet breeding.

Figure 20.3 presents the results of the breeding bird surveys carried out at the site. All species showing behaviour indicative of breeding are presented using British Trust for Ornithology (BTO) codes. The more interesting observations are discussed further below.

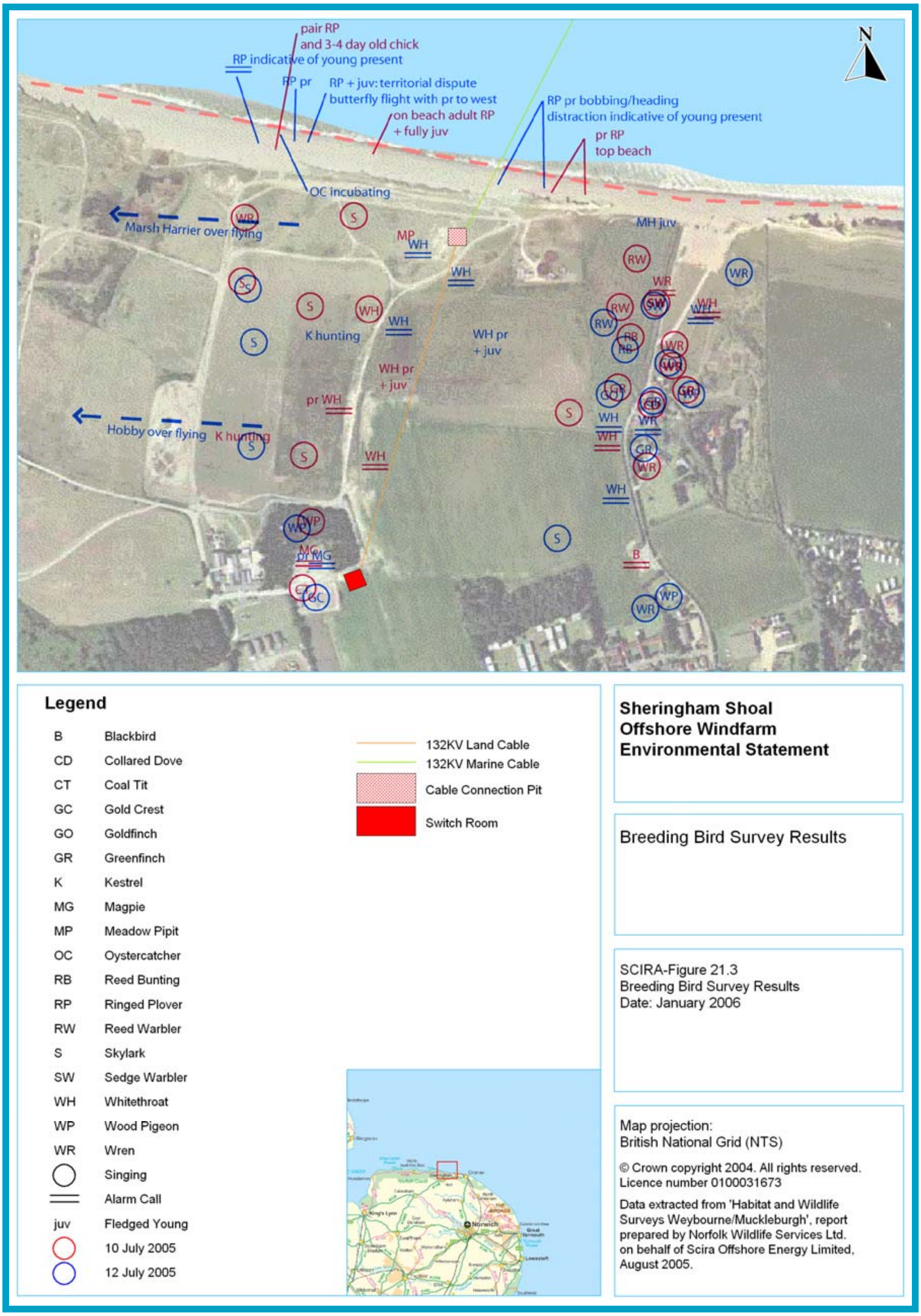


Figure 21.3 Breeding Bird Survey Results

Several Scheduled birds breed within and adjacent to the North Norfolk Coast SPA/Ramsar site and avocet has been noted as previously breeding to the west of the Muckleburgh Collection. During the surveys, avocet were noted within ‘The Quag’; a large water-body to the west of the proposed works.

An immature marsh harrier (*Circus aeruginosus*) and a hobby (*Falco subbuteo*) (both Schedule 1 birds) both over-flew the site on the 12 July 2005 survey. To the landward side of the beach fence (north-west corner of survey area) a pair of ringed plovers (*Charadrius hiaticula*) were observed with a hatchling estimated to be 3-5 days old. On the beach itself a fully fledged young with an adult was observed with territorial disputes, comprising butterfly flights and aggressive tail-fan display; ongoing with a neighbouring pair. Also on the beach, to the north-east corner of the survey area, was a pair, one head-bobbing and alarm calling indicative of young being present nearby.

The grassland within the museum held at least three singing skylarks (*Alauda arvensis*), with other singing birds beyond the survey borders. Areas of bramble dominated scrub, particularly along the eastern section of the survey area, held 3-4 pairs of whitethroat (*Sylvia communis*) with at least one fully-fledged immature observed. A kestrel (*Falco tinnunculus*) was observed on each day hunting over the grassland.

The surveys were conducted late in the breeding season (most passerines having fledged young at this time of the year) and unsurprisingly activity was generally fairly low. However, given the habitat present within the survey areas the majority of breeding species were probably recorded with the exception of a few passerines, such as dunnock (*Prunella modularis*), robin (*Erithacus rubecula*), mistle thrush (*Turdus viscivorus*), blackcap (*Sylvia atricapilla*) and linnet (*Acanthis cannabina*), which almost certainly breed in the area although no signs indicative of breeding were recorded.

The wintering bird interest of the saltmarsh, reed bed, tidal lagoons and mudflat habitats within the designated nature conservation sites to the west of the proposed onshore works is well documented and discussed in detail within Section 5 ‘Nature Conservation Designations (Offshore)’ and Section 19 ‘Nature Conservation Designations (Onshore)’.

The habitats within the area of the proposed onshore works are of negligible interest for wintering birds.

21.3.3.8 Great Crested Newts and Other Amphibians

Great crested newts and their aquatic and terrestrial habitat are fully protected under both UK and EU legislation, are listed as UK and Norfolk BAP species and are a species of principle importance under Section 74(2) of the CRoW Act 2000.

Other common amphibians, such as smooth newt (*Triturus vulgaris*), common toad (*Bufo bufo*) and common frog (*Rana temporaria*) are protected under the WCA 1981 in respect of Schedule 9(5) only, relating to sale.

The nearest existing great crested newt record is from Holt, grid reference TG090396, over 3km from the survey area (source: Norfolk Biological Records Centre).

Ponds and other water features identified during the initial stage of surveys were assessed for their suitability to support great crested newts. Table 21.1 provides a summary of the assessments carried out and the presence or otherwise of great crested newts and other amphibians. The location of the ponds and water-bodies are shown on Figure 21.4.

Table 21.1 Great crested newt water-body assessment and amphibian presence summary

Water body	Suitability rating	Summary	Detailed notes
Pond 1	Low	Large pond used by water birds. Smooth newt recorded.	Pond 1 is a large scrape (the Quag) within an area of marshy grassland. The lack of submerged vegetation and close-cropped surrounding vegetation, due to usage by wading birds, makes this unlikely habitat for the great crested newt (e.g. Oldham *et al*., 2000).
Pond 2	Low	Common toad recorded.	Pond 2 is a small field corner pond. The water is shallow and dominated by reeds. The lack of open water makes this an unlikely great crested newt breeding site (e.g. Oldham *et al.* 2000).
Pond 3	Low	No amphibians recorded.	Pond 3 is a small, shallow body of water immediately to the north of Pond 1. Shallow water, lack of submerged vegetation, lack of terrestrial (structural) habitat make this water body unlikely great crested newt habitat (e.g. Oldham *et al.,* 2000).
Pond 4	Medium	Smooth newt, common toad and common frog recorded.	Pond 4 (The Scrape) contains a greater volume of water and submerged vegetation. The terrestrial habitat is structurally diverse. This pond does have potential to support the great crested newt (e.g. Oldham *et al.,* 2000).
Pond 5	Low	No amphibians recorded.	Pond 5 is a small area of open, saline water at the seaward end of the Beach Lane County Wildlife Site reedbed. Other than reeds, there is no other aquatic vegetation. This pond is unlikely great crested newt habitat (personal observation).
Pond 6	Low	Garden pond. Not assessed.	Pond 6 was originally a mill pond, but now lies within a private garden. Garden ponds are not usually used by the great crested newt, most probably because they frequently contain fish (major predators of newt eggs and larvae) and also because they are generally smaller than ponds that are used by this species. As Pond 6 is a large water body, it was considered as a survey target. However, the discovery that this pond supports roach precluded it from survey.
Pond 7	Low	No amphibians recorded.	Pond 7 is shaded and heavily silted. Although the water is clear, there is no aquatic vegetation.
Pond 8	High	Common frog and common toad recorded.	Ponds 8-13 are small water-bodies created between 1987 and 2003 and located within an area of unimproved neutral grassland and scrub. Roach are present in some of the ponds. They have been created by the site owner, a local naturalist, for the purposes of wildlife conservation. One of these ponds (Pond 13) contains roach, however, the others are free of fish. This, and the structural nature of the terrestrial habitat make these ponds potentially suitable for great crested newt (e.g. Oldham et al., 2000, Langton *et al.,* 2001).
Pond 9	High	No amphibians recorded.	
Pond 10	High	Common frog and common toad recorded.	
Pond 11	High	Common frog and common toad recorded.	
Pond 12	High	Common frog and common toad recorded.	
Pond 13	High	Smooth newt, common frog and common toad recorded.	
Drain	Medium	No amphibians recorded.	Alongside Meadow Lane and running northwards from this is a series of drainage ditches within coastal grassland.

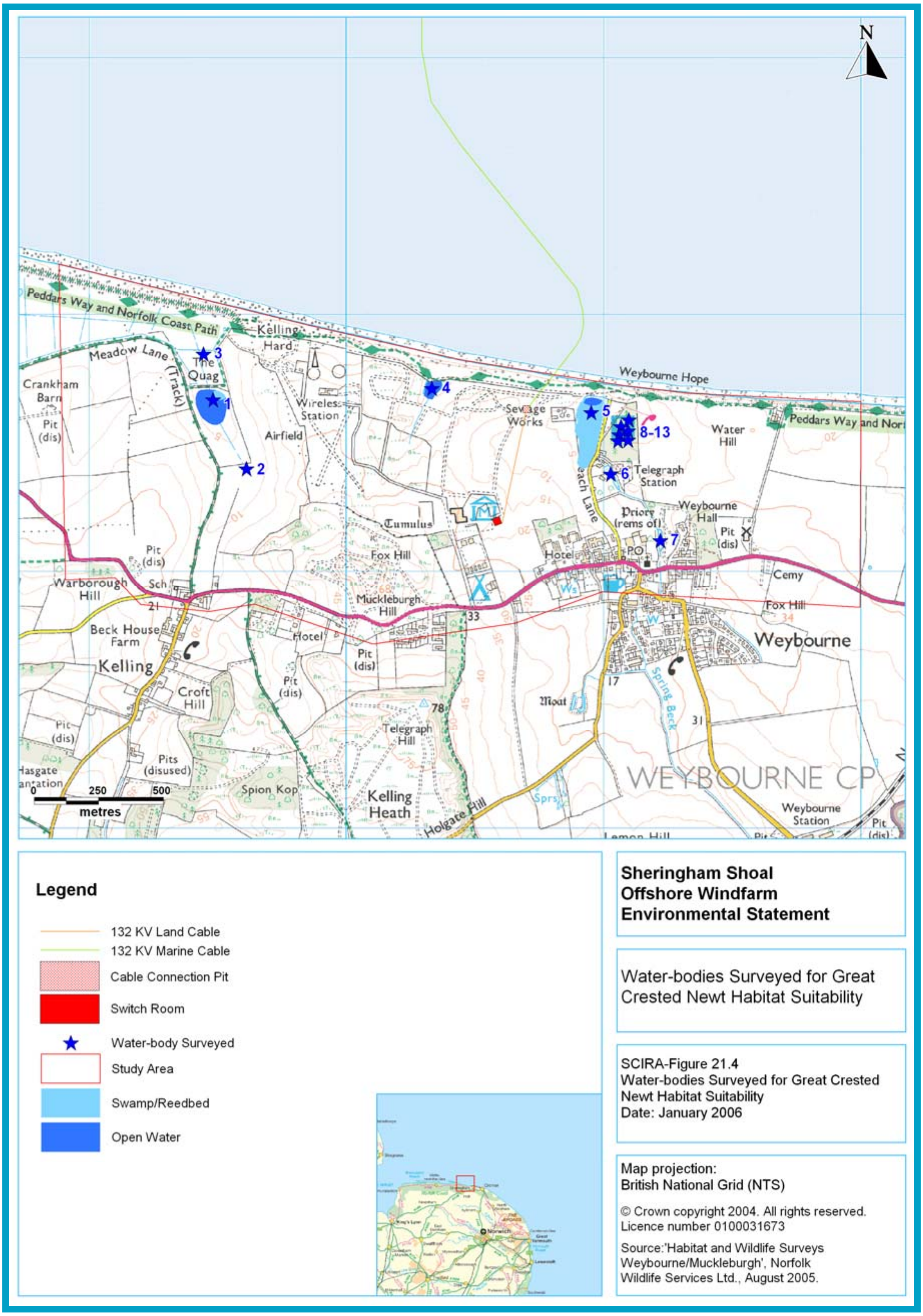


Figure 21.4 Water-bodies Surveyed for Great Crested Newt Habitat Suitability

No evidence or sightings of great crested newts were record in any of the surveyed water bodies on any of the survey visits and it is considered that the species are not present within the area of the proposed onshore works. Other amphibians recorded within the water-bodies included smooth newt, common toad and common frog.

21.3.3.9 Reptiles

Reptiles are given partial protection under the Wildlife and Countryside Act 1981, which prohibits inter alia the intentional killing, injuring or taking of protected species.

No direct ecological records are available, however four reptile species; common lizard (*Lacerta vivipara*), slow worm (*Anguis fragilis*), grass snake and adder (*Vipera burus*), are known from the coastal areas of north Norfolk (Norfolk Wildlife Services, 2005). Historic records of adder within the Weybourne area and viviparous lizard at Kelling Heath, dated 1972 and 1977 respectively were the most recent records made available during the ecological data search (source: Norfolk Biological Records Centre).

The area of the proposed works appears to have moderate potential for reptiles, although the populations are likely to be small. The soil is free-draining and the vegetation is varied, with areas of bare sparse vegetation and some patches of scrub and brambles for cover. There are also abundant rabbit holes, on north-facing slopes and in relatively flat areas, which may provide suitable hibernation sites. An area of bramble-dominated scrub with some underlying rubble at the northern end of the survey area could potentially support common lizard, slow-worm and possibly adder.

21.4 Impacts during Construction

21.4.1 Impact to Ecological Nature Conservation Designations

Due to the location and limited spatial extent of the proposed onshore works, it is considered that there would be **no impact** to the ecological interest features of any of the outlined nature conservation designations. No mitigation measures are therefore considered necessary.

21.4.2 Impact to Coastal Habitats

Coastal vegetated shingle is an Annex 1 Habitat under the EU Habitats Directive and is identified as a habitat of principle importance within ODPM Circular 06/2005 ‘Biodiversity and Geological Conservation – Statutory Obligations and their Impact within the Planning System’.

Areas of vegetated shingle are present in fragments along the shoreline within the area of the landfall. The nationally scarce yellow-horned poppy is also scattered along the shingle shoreline. It is possible that small areas could be damaged or permanently lost during the installation of the landfall cable across the shingle bank, however it is noted that due to the limited constructed footprint, that any potential impact would be minor.

There are no other sensitive coastal habitats such as saltmarsh or mudflats within the study area that could be impacted during the construction phase.

The following mitigation will be carried out:

- Prior to the onset of the construction phase, the construction footprint across the shingle bank will be re-surveyed by an ecologist. If any areas of vegetated shingle, including areas of yellow-horned poppy are within the area of the construction footprint, these areas will be trans-located and monitored to ensure their successful re-establishment.

Presuming the successful incorporation of the outlined mitigation, a **short-term minor adverse impact** is envisaged to coastal habitats and their associated botanical species.

21.4.3 Impact to Grassland Habitats

The installation of the connection pit and cables between the pit and new switch room would predominantly result in the temporary disturbance of a relatively narrow corridor of semi-improved grassland of low ecological significance. A small area of this grassland habitat would also be permanently lost in respect of the switch room itself.

The following mitigation measures will be implemented to ensure that the impact to the grassland habitat is minimised:

- The cable trenching working corridor will be minimised wherever feasible.
- Top-soil and sub-soil will be carefully separated and stored during the cable trenching process.
- Following the cable installation, the disturbed grassland will be fully reinstated to its former condition. This will include re-seeding with a diverse mix of native species of local provenance.

The residual impact to the grassland habitats present within the vicinity of the onshore works is considered to be **short-term** and **negligible** due to the low ecological value of the habitat.

21.4.4 Impact to Other Habitats

The remaining areas of habitat to be disturbed comprise of small areas of bare ground and tall ruderal vegetation, scattered within the grassland habitat, of negligible ecological significance.

The construction of the onshore works would not impact upon any ditches, ponds or other water features.

21.4.5 Impact to Breeding Birds

The potential impact to breeding and nesting birds is considered to be minor and related to the disturbance and small loss of areas of grassland and shingle beach habitat only. No trees or scrub would be lost or disturbed during the construction phase.

As discussed within Section 2 'Project Details', the majority of the onshore construction phase is envisaged to take place during winter months. The bird breeding season typically runs from March to August. If all the works are completed outside of this breeding season, there would be **no impact** and no specific mitigation would be required.

However, if the onshore works do need to occur during the bird breeding season there could be potential impacts relating to nesting birds. Under the Wildlife and Countryside Act 1981, it is an offence to kill or injure any wild bird, to damage or destroy a nest or to take or destroy birds eggs.

The following mitigation measures will be incorporated in order to prevent any loss or damage to nesting birds and their nests, which could be present, if works are required during the breeding season:

- Within the grassland habitat, all areas within the construction footprint will be cut prior to the onset of the breeding season and maintained short. This will deter the majority of passerine species, such as skylarks, from nesting within the area. Maintaining short grassland vegetation within the construction footprint could however prove attractive to other ground-nesting species such as lapwing (*Vanellus vanellus*). The possibility of this occurring is considered to be very low as lapwing were not recorded during the breeding bird surveys or identified during data searches, and size of the construction footprint is relatively small.
- The construction of the landfall cable across the shingle beach could also potentially impact upon ringed plover, which were recorded at this location during the breeding bird survey. Habitat management cannot be undertaken to deter this species from nesting on the shingle

beach, however it is considered that the likelihood of a nest being constructed within the limited construction footprint is small. In addition, the level of human disturbance preceding the construction phase is likely to detract ringed plover from nesting in this area. As a precautionary measure the construction footprint within the grassland and shingle beach habitat will be checked by an experienced ornithologist for nests immediately prior to construction. Should a nest be discovered, work in this area will delayed until the chicks have hatched.

Assuming the successful implementation of the outlined mitigation measures, **no impact** is envisaged to breeding birds.

21.4.6 Impacts to Reptiles

The ecological surveys identified that the grasslands within the area of the proposed onshore works are of some suitability for reptiles. Based on the habitats available and the limited (known) distribution of reptiles within the area, it is not expected that the area will support significant populations.

However, in order to ensure that reptiles are taken into full consideration during the construction phase, further surveys to determine the presence/absence and population size of reptiles within the area are scheduled to be undertaken during spring/early summer 2006. If reptiles are recorded during the surveys, an appropriate mitigation strategy will be discussed and agreed with English Nature and submitted to North Norfolk District Council as supplementary information.

Potential impacts relating to reptiles, if present, would be related to short-term, reversible impacts relating to habitat disturbance only. The mitigation strategy would be designed to ensure that reptiles are not harmed and that disturbance is minimised. Following the construction phase all areas of disturbed habitat within the connection pit and cable zone would be reinstated to its former condition. The loss of a small area of grassland associated with the switch room is considered to be of negligible significance.

The incorporation of a suitable mitigation strategy, if required, would aim to ensure that disturbance to reptiles during construction would be minimised and that no reptiles would be put at risk. Therefore, at this stage, the impact is considered to be of **negligible** significance.

21.4.7 Impacts to Other Faunal Species

The ecological surveys carried out confirmed that no badgers, water vole, otter or great crested newts are present within the study area. In addition, the construction of the onshore works would not involve any disturbance to potential bat roosting or wintering bird habitat. Therefore **no impact** is envisaged during the construction phase to these species and groups.

21.5 Impacts during Operation

The operation of the onshore elements of the proposed Sheringham Shoal wind farm would have **no impact** on the ecological interests of any of the outlined nature conservation sites, or on any of the habitats or species identified as being present.

21.6 Impacts during Decommissioning

At this stage, it is considered that works relating to the decommissioning of the wind farm would result in similar impacts as outlined for the construction stage, for which mitigation would be undertaken as appropriate at that time.

21.7 Summary

A detailed programme of ecological surveys were undertaken in order to ascertain the presence or absence of habitats or species of ecological significance. The surveys highlighted that the predominant habitat to be disturbed during the construction of the onshore works comprises of semi-improved grassland of low ecological significance. Mitigation works would be incorporated in order to minimise any disturbance to this habitat and re-instate it following completion of the works. The installation of the landfall across the shingle beach could potentially impact upon areas of vegetated shingle, including small patches of the nationally scarce yellow-horned poppy. This area would be resurveyed prior to construction and areas of the habitat trans-located if required under the supervision of an ecological watching brief.

Mitigation measures in the form of habitat management would also be incorporated to ensure that no harm to any breeding birds occurs during the construction phase. The ecological surveys also highlighted the presence of suitable reptile habitat, therefore further surveys will be undertaken in order to inform an appropriate level of mitigation, if required. No other protected faunal species, such as great crested newts, water voles, badgers or bats would be harmed or disturbed during the construction of the onshore works.

No impact during operation is envisaged to ecological interests. In addition, no impact to the ecological interests of any nature conservation sites is envisaged during any stage of the works.

21.8 References

- ENGLISH NATURE (1986). North Norfolk Coast Site of Special Scientific Interest citation.
- ENGLISH NATURE (2001). Great crested newt mitigation guidelines. August 2001.
- GILBERT G, GIBBONS DW, EVANS J (1998). Bird Monitoring Methods. RSPB, Sandy.
- INSTITUTE OF ECOLOGY AND ENVIRONMENTAL MANAGEMENT (IEEM) (2006). Guidelines for Ecological Impact Assessment in the United Kingdom. Final Draft, 3 February 2006.
- JOINT NATURE CONSERVATION COMMITTEE (JNCC) (2004). Common Standards Monitoring Guidance for Reptiles and Amphibians. JNCC, Peterborough.
- KENT, M, AND COKER, P (1992). Vegetation description and analysis – a practical approach. John Wiley & Sons, New York.
- LANGTON, T, BECKETT, C and FOSTER, J. (2001). Great Crested Newt Conservation Handbook. Froglife, Halesworth.
- NATURE CONSERVANCY COUNCIL (1990). Handbook for Phase 1 habitat survey – Field Manual. Nature Conservancy Council, Peterborough.
- NORFOLK WILDLIFE SERVICES (2005a). Great Crested Newt and Phase 1 Habitat Survey Weybourne/Muckleburgh. Norfolk Wildlife Services, Norwich.
- NORFOLK WILDLIFE SERVICES (2005b). Habitat and Wildlife Surveys Weybourne/ Muckleburgh. Norfolk Wildlife Services Ltd. August 2005.
- NORFOLK WILDLIFE TRUST (2001). County Wildlife Site Handbook. NWT, Norwich.
- Office of the Deputy Prime Minister (ODPM) (2005a). Planning Policy Statement 9. Biodiversity and Geological Conservation.
- ODPM (2005b). Government Circular: Biodiversity and Geological Conservation – Statutory Obligations and their Impact within the Planning System. ODPM Circular 06/2005 / Defra Circular 01/2005. 16 August 2005.
- OLDHAM R S, KEEBLE J, SWAN M J S & JEFFCOTE M (2000) Evaluating the suitability of habitat for the Great Crested Newt (*Triturus cristatus*). British Herpetological Society.
- STATUTORY INSTRUMENT (1994). Conservation (Natural Habitats etc) Regulations 1994 (SI 1997/1166). HMSO.
- STATUTORY INSTRUMENT (2000) Countryside and Rights of Way Act 2000. HMSO.

- STATUTORY INSTRUMENT (1983). Wildlife and Countryside Act 1981. HMSO.
- STRACHAN R (1988) Water Vole Conservation Handbook. English Nature/Environment Agency.
- VINE, A E (1993) Badgers in Norfolk. Norfolk Bird and Mammal Report 1992. Norfolk and Norwich Naturalists' Society

22 Landscape and Visual Character

22.1 Introduction

This section describes the existing landscape and visual character of the local area proposed for the cable landfall and associated infrastructure. The potential impacts upon the local landscape, its character and constituent features and the level of visual impact on the people who view it are assessed. Mitigation measures have been discussed where necessary. This section should be read in conjunction with Section 13 'Seascape and Visual Character'.

22.2 Assessment Methodology

22.2.1 Introduction

The assessment of landscape and visual impacts has been carried out via a desk based review of planning policy and guidance pertaining to landscape characterisation and identification of the range of visual receptors within the locality. Site observations have been made and consultation undertaken with North Norfolk District Council and Norfolk Landscape Partnership. It is considered that this methodology is applicable to the assessment of short-term impacts during the construction of the project, and to long-term impacts of limited extent during operation.

For the purpose of the landscape and visual impact assessment, designated sites include protected areas of landscape, townscape or protected coast (e.g. Areas of Outstanding Natural Beauty (AONBs), Heritage Coast) and visible archaeological or cultural heritage resources including Conservation Areas and Scheduled Ancient Monuments (SAMs). The presence of these sites was identified within a study area encompassing approximately a 5km radius surrounding the area of the proposed onshore works.

A field visit was carried out to produce a photographic record, identify landscape resources, and identify proposed viewpoints to be used for the assessment. Visual receptor locations identified included residential properties, recreational areas and routes, transport routes and places of work in the area.

22.2.2 Prediction and Evaluation of Impacts

The criteria described below have been used in determining significance levels for the landscape and visual impact assessment. Reference should also be made to Section 3 'Regulatory and Legislative Context', which outlines the EIA process and methodology.

The assessment of landscape/ seascape and visual impacts involves five basic steps:

- a description of the baseline landscape and visual amenity of the area;
- a description of those elements that the project has the potential to influence or change landscape character or the visual amenity of the area;
- determining the sensitivity of the landscape/ seascape or viewer group (i.e. the receptor) to the type of change envisaged;
- predicting the magnitude (a combination of the scale of the proposed change as well as the nature and duration of the proposed changes) of change that will take place in the landscape/ seascape or view; and
- evaluating the significance of that change taking into account the sensitivity of the affected receptor and the magnitude of change and any proposed mitigation.

22.2.2.1 Receptor Sensitivity

Sensitivity is described as **Low, Medium** or **High** and these definitions are illustrated by the examples below. Further information relating to the determination of receptor sensitivity is provided within Section 13 'Seascape and Visual Character'.

Landscape Sensitivity

- **Low**: a landscape that is not valued for its scenic quality and is tolerant of the type of change envisaged;
- **Medium**: a landscape with a Local Plan designation or one that is valued by local people as contributing positively to the character of their area, and one that has the capacity to accommodate a degree of the type of change envisaged; and
- **High**: a landscape protected by a regional or national designation and/or widely acknowledged for its value; a landscape with distinctive character that would be altered by the type of change envisaged.

Viewer Group Sensitivity

- **Low**: a group of viewers whose activity means they have only a passing interest in their surroundings such as travellers on busy roads not known for their scenic value, or employees in an office or factory; a rural road used for local non-recreational journeys; a footpath used only occasionally by local people;
- **Medium**: users of reasonably well used paths, bridleways and open spaces such as beaches; users of roads acknowledged as of scenic value; small numbers of viewers with a proprietary interest such as residents; and
- **High**: users of widely known and well-used recreational facilities; more than small numbers of residential viewers.

The above methodology has been primarily used for the assessment of the operational works, rather than the short term and limited construction activities.

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 22.4 - 22.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section 1 for the definition of significance levels.

22.3 Description of the Existing Environment

22.3.1 General Setting

The area in the immediate vicinity of the onshore works at Weybourne is characterised by a shingle beach foreshore backed by a gently rising coastal plain. To the east and west of the landfall point the shingle bank gives way to a cliff line, which is steep and high to the east and lower lying to the west. The coastal plain which forms the former military base comprises open land with large areas of bare soil, rough grassland and scrub. Natural landscape and man made features enclose the study area with Weybourne Beach car park, access road (Beach Lane) isolated houses and a telecommunication mast to the east; the buildings of Muckleburgh museum, the A148 and the wooded Muckleburgh Hill to the south and west; and shingle bank and open sea to the north.

22.3.2 Landscape Designations and Policy Context

There are several landscape designations within and adjacent to the study area, as indicated on Figure 22.1. The entire study area with the exception of the village of Holt is included within the Norfolk Coast Area of Outstanding Natural Beauty (AONB). In addition the western edge of the

North Norfolk Heritage Coast lies just within the study area. The area to the south of the A148 is designated as an Area of High Landscape Value within the Local Plan. The relevant designations and associated policy are described below.

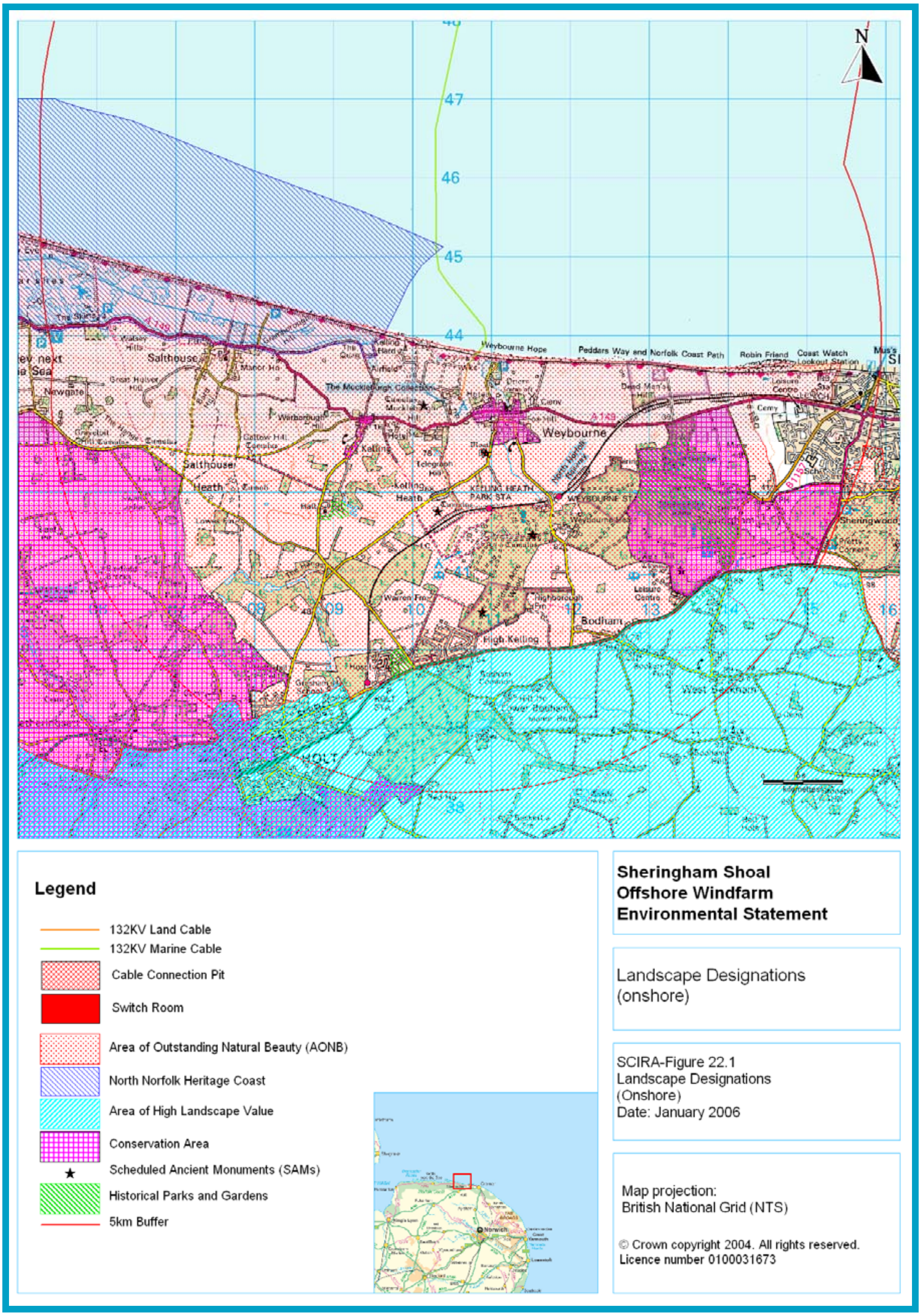


Figure 22.1 Landscape Designations

22.3.2.1 Norfolk Coast AONB

The Norfolk Coast AONB includes the silt expanses of the Wash, the north-facing coastal marsh and dunes of the Heritage Coast and the rapidly eroding clay cliffs east of Weybourne. The characteristics of the north Norfolk coast are described in the AONB Management Plan (Norfolk Coast Area of Outstanding Natural Beauty Management Plan 2004 – 2009) as follows:

'The coastal plain of the north Norfolk coast in particular has a wilderness quality rare in lowland England, distinct from but complemented by the rising backdrop of largely agricultural land, which includes open chalk downland, quiet, secluded river valleys and the woodlands and heath of the Cromer Ridge. The coastal areas of north Norfolk are marked by the sharp contrast between the flat marsh area and the open farmed chalklands separated by the coastal road. Elsewhere the transition between the distinctive landscapes covers a wider area'.

'The AONB's perceived qualities of remoteness, as an area apart from the pattern of life elsewhere and of tranquillity - its quiet and peaceful atmosphere and relaxed pace of life - are qualities reflected in art and literature, and are often mentioned today as those that people particularly value.'

Structure Plan Policy ENV.2 states that: '*development which will be detrimental to the character of Areas of Outstanding Natural Beauty, the Heritage Coast and the Broads will not be permitted unless there is an overriding proven national need for the development and there are no suitable alternative sites.'*

Local Plan Policy 20 states that: *'in the Norfolk Coast Area of Outstanding Natural Beauty the prime planning consideration will be the conservation and enhancement of the beauty of the area, and development proposals that will be significantly detrimental to it will not be permitted.'*

22.3.2.2 North Norfolk Heritage Coast

Heritage Coasts are a non-statutory landscape definition, although they are recognised within the statutory planning system. The shifting shoreline of the Norfolk Heritage Coast, which spans approximately 63.2km of coast between Holme-next-the-Sea and Weybourne to the west of the proposed onshore works, is important for coastal ecology and has almost isolated the historic little ports of Cley and Blakeney from the open sea. Its salt-marshes are considered to be a last true wilderness in lowland Britain. Its landscape type corresponds to the North Norfolk landscape type of the AONB. Structure Plan Policy ENV. 2 stated above in relation to the AONB includes the Heritage Coast designation. There is no specific policy for the North Norfolk Heritage Coast (Countryside Agency, 2005).

22.3.2.3 Area of High Landscape Value

To the south and immediately adjacent to the study area is an Area of High Landscape Value, listed within the North Norfolk Local Plan. This supplements the AONB designation and is considered an area of important local landscape quality. Areas outside the AONB and Area of High Landscape Value tend to have a weak landscape structure and are intruded on by inappropriate development. Local Plan Policy 21 states that '*The appearance and character of the Area of High Landscape Value will be conserved and enhanced. Development proposals that would be significantly detrimental to its appearance or character will not be permitted*'.

22.3.2.4 Conservation Areas

There are four Conservation Areas listed within the North Norfolk Local Plan centered on Holt, Kelling, Weybourne and Upper Sheringham (see Figure 22.1). These are areas of special architectural or historic interest, the character or appearance of which it is desirable to preserve or enhance. They are primarily concerned with groups of buildings and their settings, rather than specific listed buildings which are protected under separate legislation. The proposed onshore works are not in any of the Conservation Area locations but are in close proximity to the Weybourne area, and therefore should be considered. The North Norfolk Local Plan Policy 42 states that '*Within Conservation Areas development proposals will not be permitted unless they preserve or enhance the appearance or character of the Conservation Area. Development proposals affecting the setting of a Conservation Area will be considered against the same criteria'*.

22.3.2.5 Scheduled Ancient Monuments

Policy 45 on Archaeology of the Local Plan states that: '….*development proposals that will have a significantly adverse effect on Scheduled Ancient Monuments or other nationally important sites and monuments, or their settings, will not be permitted'.* Further information relating to Scheduled Ancient Monuments (SAM) within the study area is provided within Section 26 'Archaeology and Cultural Heritage'.

22.3.2.6 Other Areas of Non Statutory Landscape Importance

ENV 3 states that*: 'in the areas of important landscape quality, the Brecks, the river valleys, the remaining length of undeveloped coast, the Wash area, historic parks and gardens and their settings, broadleaved woodland, heath and common land, proposals for development will only be acceptable where they can be shown to conserve and are sensitive to the appearance and character of these areas.'*

Structure Plan Policy ENV 4 states that: *'the distinctive character of the Norfolk countryside and coast will be protected for its own sake and proposals for development in these areas but outside the areas of special protection will only be acceptable where they do not significantly harm the character of these areas.'*

22.3.2.7 Undeveloped Coast

Local Plan Policy 26 states that: *'in the Undeveloped Coast development proposals that do not require a coastal location or will be significantly detrimental to the appearance or character of the area will not be permitted'.*

22.3.2.8 Rights of Way

Public access to the wider countryside depends upon public rights of way. The County Council, as Highway Authority, has a statutory duty to assert, protect and maintain public rights of way. The Council has powers to create, divert or extinguish public footpaths and bridleways through Public Path Orders and may also deal with obstructions of public rights of way.

Of particular significance to the rights of way network in the area are linear routes of strategic importance, and circular routes of more local importance. In north Norfolk one of the two strategic routes includes the Norfolk Coast Path which runs along the northern boundary of the study area.

Local Plan Policy 113 on Rights of Way states that "*The Council will encourage the retention and extension of the existing public rights of way network, and seek to ensure that all routes are appropriately signposted, waymarked and kept free from obstruction*".

22.3.3 North Norfolk Landscape Character Assessment

The North Norfolk Landscape Character Assessment, completed in 1995, identifies the broad character areas and landscape types which can be found in north Norfolk and provides a guide on how the landscape can be conserved and enhanced. The Cromer Ridge is the main character area which is of relevance to the project. This name is given due to the land rising into a distinctive ridge between Cley-next-the-Sea and Mundesley. Further details are provided within Section 13 'Seascape and Visual Character'.

22.4 Impacts during Construction

22.4.1 Impact on the Local Landscape and Visual Character

The main sources of landscape and visual impacts during the construction phase would include the presence of construction plant (excavators, vehicles, fencing, etc.) and associated activity. No significant landscape or visual features of the area would be removed, with site clearance involving only top-soil and sub-soil. Vegetation removal would be restricted to the temporary disturbance of grassland habitat. No trees or hedgerows would be impacted by the works. Other elements would include the use of the Muckleburgh Collection car park area for storage of plant and materials. A temporary security fence is also likely to be required around this compound area.

Direct and indirect landscape and visual impacts of these new elements would be minor and short term, with a working corridor of approximately 20m being required for the cable installation and a construction programme of approximately four months. The area is frequented by visitors using the Muckleburgh Collection museum, Weybourne car park, beach and Norfolk Coast Path. The majority of the works would be contained within the Muckleburgh Collection grounds which are some 500 - 600m away from the primary visual receptors. On completion, all remaining construction materials would be removed from the work sites, and the disturbed area would be reinstated to the original condition.

In order to minimise impacts the following mitigation measures will be implemented where possible.

- If required, the construction compound will be enclosed within fencing to screen low level views from surrounding areas, or will be located away from any sensitive visual receptors (such as houses, the Norfolk Coast Path, and visitors to the Museum);
- Lighting of compounds and works sites will be restricted to agreed working hours and that which is necessary for safety and security; and
- Roads providing access to land based site compounds and works areas will be regularly cleaned, as required.

Overall, the landscape and visual impact of the construction activities are anticipated to be short term **minor adverse**.

22.5 Impacts during Operation

22.5.1 Landscape and Visual Impact

The significance of any landscape and visual impacts is related to the sensitivity of the landscape to the change, the magnitude of that change (a combination of scale, nature and duration of change) and the capacity of the landscape to accommodate change. The only element of the onshore works that would have a potential long-term effect on the landscape and visual character of the area is the switch room, as the cable route and connection pit would be buried.

The location of the switch room is discussed within Section 2 'Sheringham Shoal Offshore Wind Farm' and shown on Figure 2.4. The switch room building would be brick built with a pitch roof. The maximum dimensions would be 20m by 10m with a height of 5m.

The switch room would be sited within the Norfolk Coast AONB where the relevant planning policies universally state that, '*development proposals that will be significantly detrimental to it* [the designation] *will not be permitted'*. In addition, Policy 13 (d) on the Design and Setting of Development in the countryside requires that developments '*are located so as to be easily assimilated into the landscape or are well related to an existing group of buildings'*.

The key visual receptors would potentially include visitors to the Muckleburgh Collection museum, Weybourne car park, beach users, users of the Norfolk Coast Path and nearby residences. The locations of these receptor viewpoints are shown on Figure 22.2. Photographs from each of the identified viewpoints are provided in Appendix 22.1. Views experienced by other potential receptors to the south of the museum would be screened by existing buildings and vegetation (e.g. Weynor Gardens).

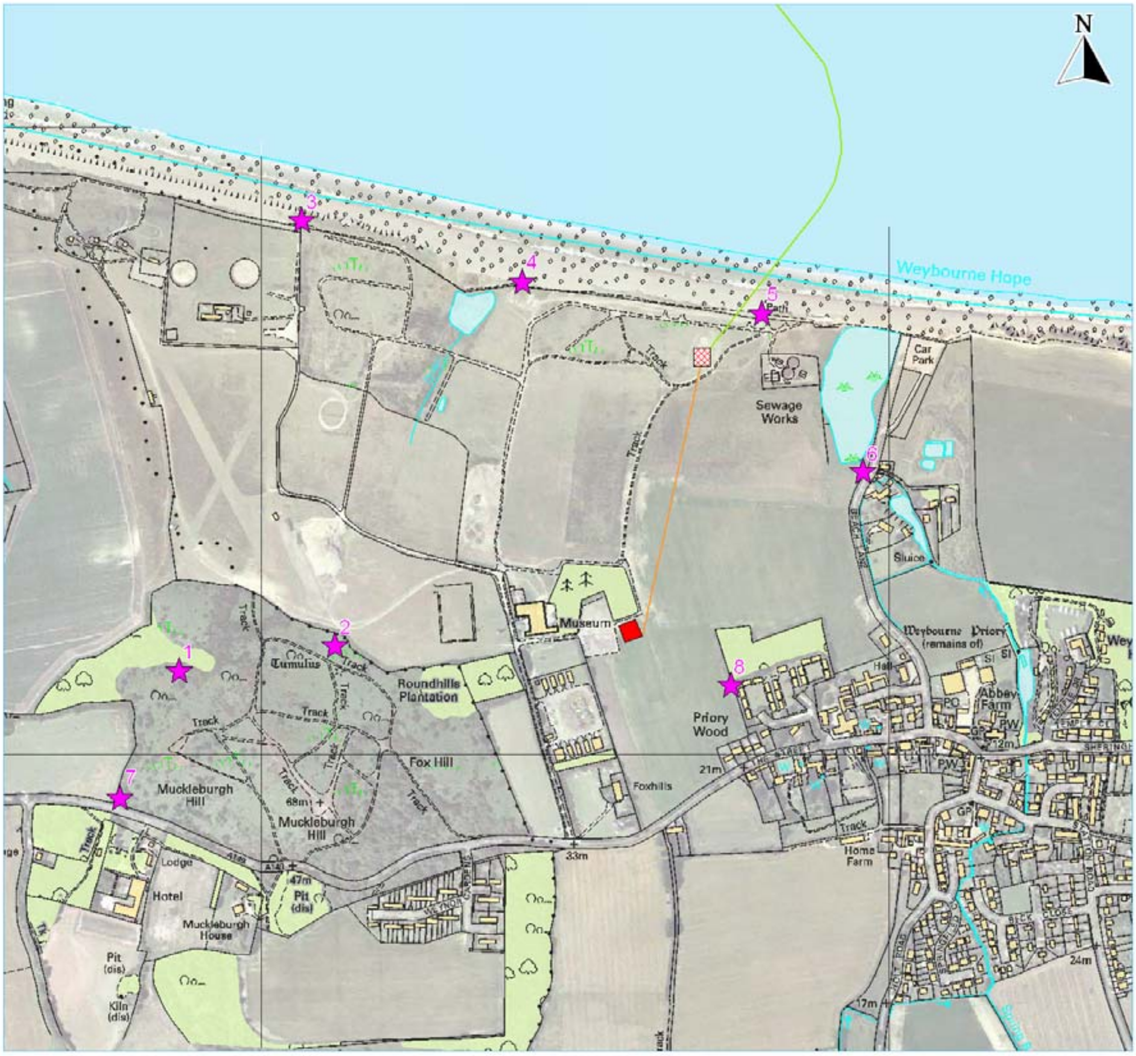
The proposed switch room would be located to the east of the Muckleburgh Collection car park, to the south of a small coniferous plantation. The building in this location would be a new element in the landscape and would result in a change in the landscape character and the amenity of the viewer groups. The plantation woodland immediately to the north is approximately 8-10m in height and so would shield views to the switch room option from several viewpoints, such as users of the Norfolk Coast Path. Following a meeting with representatives from North Norfolk District Council (NNDC), the following outline mitigation strategy has been agreed in principle in order to minimise the visual impact and reduce any adverse effect on the AONB.

- The building would be cut and sunk in order to reduce the final height by approximately 1-2m, providing that access could still be maintained to the building.
- The existing slope would be re-structured in order to provide a slight embankment screening to the east and south of the switch room.
- The existing woodland would be extended to the east and south of the building, using a combination of Scot's pine and Austrian pine. Clearance between the trees would need to be maintained for the underground cabling in order to protect the integrity of the cables from damage by tree roots.
- The final landscape design would be discussed and agreed with the NNDC Countryside and Parks Manager, following consent and prior to construction works taking place.

The visual effect of the switch room would vary according to the different receptors identified. The affect to the receptors located at each of the identified viewpoints have been assessed in. The results of the assessment are tabulated in Table 22.1 below. For each viewpoint the table identifies:

- Location of the viewpoint;
- Distance to the switch room;
- A brief description of the viewpoint;
- The types of receptors present;
- The sensitivity of the receptors;
- The magnitude of change of view resulting from the switch room (before mitigation); and
- An evaluation of the significance of the resulting effect, taking into account the outlined mitigation measures.

The proposed location of the switch room is shown in Plate 22.1 along with photomontages of the switch room and mitigation planting.



Legend

- 132KV Land Cable
- 132KV Marine Cable
- Cable Connection Pit
- Switch Room
- Viewpoints

Sheringham Shoal Offshore Windfarm Environmental Statement

Sensitive Visual Receptors (onshore)

SCIRA-Figure 22.2
Sensitive Visual Receptors (Onshore)
Date: January 2006

Map projection:
British National Grid (NTS)

Figure 22.2 Sensitive Visual Receptors

Table 22.1 Operational Effects on Selected Viewpoints					
Viewpoint / Grid Ref / Distance to Switch Room	Description of Viewpoint	Receptor	Sensitivity (of Receptor)	Magnitude of Change before mitigation	Impact Significance (following mitigation)
Viewpoint 1 Muckleburgh Hill TG 09874314 Distance: 0.68km	Location to the North West of Muckleburgh Hill	Walkers	High	Negligible	Negligible
Viewpoint 2 Muckleburgh Hill TG 10114316 Distance:0.45km	Location on the north east of Muckleburgh Hill	Walkers	High	Negligible	Negligible
Viewpoint 3 Norfolk Coast Path TG 10064385 Distance:0.83km	Western part of the Norfolk Coast Footpath	Recreation (Walkers/ beach users)	High	Negligible	Negligible
Viewpoint 4 Norfolk Coast Path TG 10404376 Distance: 0.59km	Norfolk Coast Footpath, west of proposed site	Recreation (walkers/ beach users)	High	Negligible	Negligible
Viewpoint 5 Norfolk Coast Path TG 10784371 Distance: 0.56km	Eastern part of the Norfolk Coast Footpath	Recreation (walkers/ beach users)	High	Low	Negligible
Viewpoint 6 Beach Lane/ Weybourne Car Park TG 10964346 Distance:0.48km	Road leading to Weybourne beach car park.	Recreation (Walkers/ beach users)	Medium	Medium	Minor
Viewpoint 7 Muckleburgh Hill TG 09774293 Distance:0.84km	A149, entrance to Muckleburgh Hotel and Lodge	Walkers/ hotel users	Low to Medium	Negligible	Negligible
Viewpoint 8 Priory Wood TG 10754311 Distance:0.20km	Priory Wood holiday chalet accommodation	Residential (sensitive receptor)	Medium	Medium	Minor

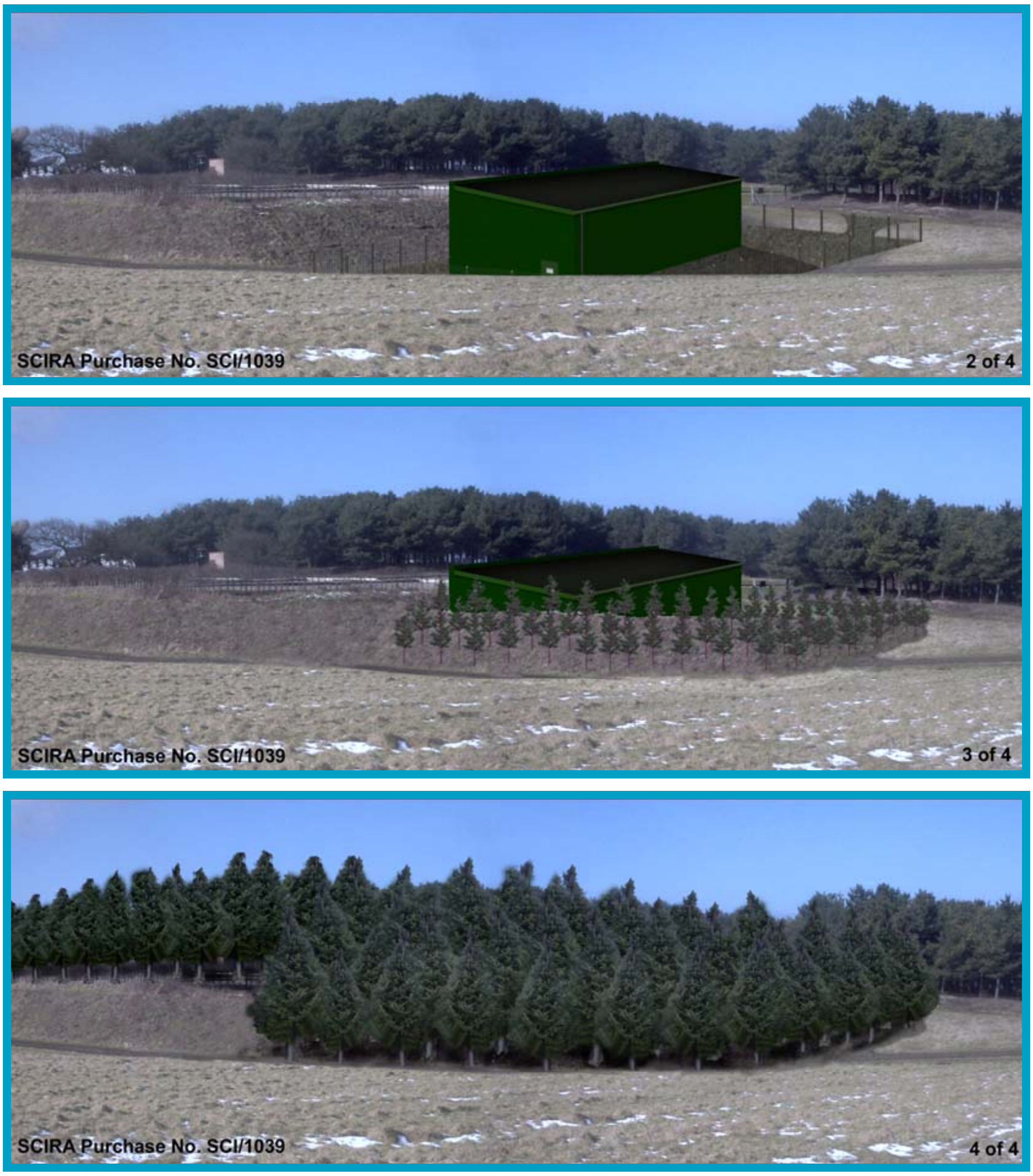


Plate 22.1a-d Photomontage of proposed new Switch Room Building at "The Muckleburgh Collection" Weybourne, Norfolk (viewed from south).

To conclude, the proposed switch room building would constitute a new element of the landscape but would be screened to a large extent by the block of coniferous plantation to the north and the Muckleburgh Collection to the west. Mitigation measures will be incorporated to screen the switch room from receptors to the east and south, by way of tree planting and re-grading of the existing local topography. The incorporation of the outlined mitigation strategy which has been discussed and agreed with NNDC would reduce the impact to a **minor adverse** significance.

Due to the limited extent of the proposed development and the incorporation of the outlined mitigation, it is considered that the potential impact to the value of the landscape designations outlined are **negligible.**

22.6 Impacts during Decommissioning

The underground cable and connection pit would remain in situ and the switch room either demolished or could possibly be used as part of the museum in consultation with the landowner. Impacts would therefore range from **no impact** to short term **minor adverse** if demolition takes place with impacts being of a similar nature to those identified during the construction phase.

22.7 Summary

The assessment process has defined the full extent of the likely landscape and visual effects arising from all phases of the Sheringham Shoal onshore works.

The construction phase would result in some disruption and visual impact to receptors for the four month duration including users of the Norfolk Coast Path, Weybourne car park and nearby residences. These impacts are anticipated to be of short-term and **minor adverse** significance.

The nature of the onshore development, being fairly isolated and largely underground would mean that the long-term landscape and visual effects would be related to the new switch room building only. The proposed switch room would be screened to some extent by the existing coniferous plantation and the museum but it would still represent a new element in the landscape to receptors to the east and south. Mitigation measures would be incorporated in order to minimise the impact, which would involve extending the existing woodland and lowering the height of the building by cutting and sinking the switch room. The residual impact to receptors would be of **minor adverse** significance and limited to an isolated area of residential receptors at Priory Wood and along Beach Lane. Elsewhere impacts would be of **negligible** significance.

The potential impact to landscape designations identified within the study area, such as the Norfolk Coast AONB, North Norfolk Heritage Coast, Area of High Landscape Value, Conservation Areas and Public Rights of Way are considered to be **negligible** due to the limited extent of works.

22.8 References

- North Norfolk Local Plan Part E1 Annex 1 - North Norfolk Landscape Character Assessment. Available at http://www.northnorfolk.org/planning/5446_5205.asp
- North Norfolk Local Plan Proposals Map. Available at http://www.northnorfolk.org/downloadfiles /proposals_map.pdf
- Countryside Agency – Heritage coasts. Available at http://www.countryside.gov.uk/LAR.Landscape/DL/heritage_coasts.asp

23 Archaeology and Cultural Heritage

23.1 Introduction

This section sets out the existing baseline environment regarding the known and potential archaeological resource above Mean High Water Spring (MHWS) mark in the vicinity of the export cable landfall and onshore works. An assessment is made of the potential impacts of the onshore proposals on this resource.

23.2 Assessment Methodology

23.2.1 Introduction

A desktop archaeological assessment has been undertaken for the area associated with the infrastructure works including land specifically within a 500m radius of the proposals. This assessment has been supported by information provided by Wessex Archaeology who undertook the marine archaeological assessment including an assessment of the Coastal Study Area (CSA), which incorporated a 500m search area above Mean High Water in the area of the landfall (see Section 14 'Marine Archaeology').

Data were collected and collated from a wide range of local and national bodies, and included Scheduled Monuments (SM), the National Monument Record (NMR), the Norfolk Sites and Monument Register (SMR), local archives, historic maps, any available aerial photography and the UK Hydrographic Office. Information collected as part of the Norfolk Coastal Survey undertaken in 2004 has also been used. Consultation was carried out with English Heritage and Norfolk Landscape Archaeology, the advisory arm of Norfolk County Council. Consideration was also given to relevant legislative and policy guidance.

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 23.4 - 23.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures. See Section 1 for the definition of significance levels.

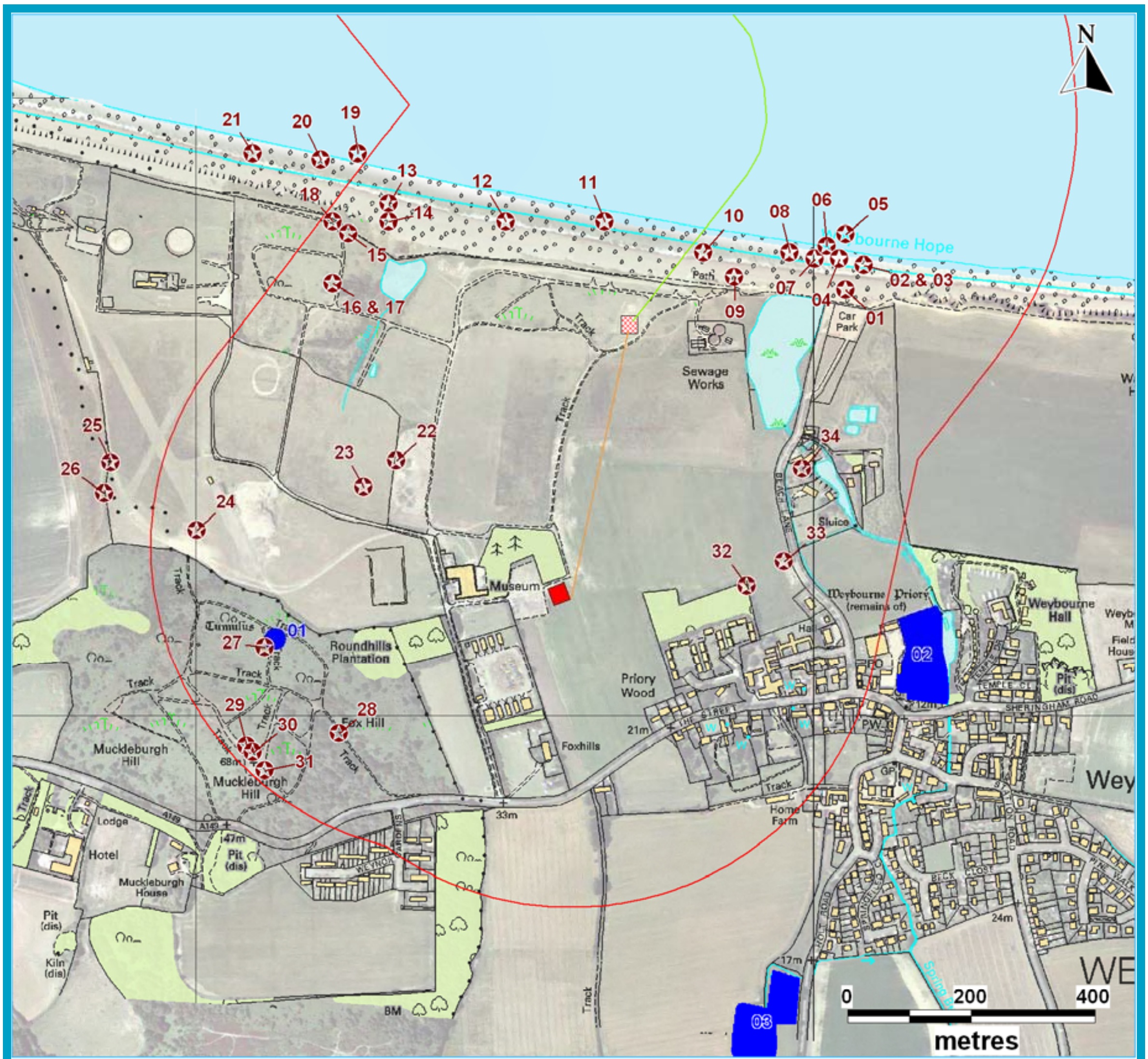
23.2.2 Legislation and guidance

A number of relevant Acts of Parliament and Planning Policy Guidance documents specific to the protection of archaeological and historical sites are relevant to the assessment including:

- Ancient Monuments and Archaeological Areas Act (1979).
- Planning (Listed Buildings and Conservation Areas) Act (1990).
- Regional Spatial Strategy (RSS) for the East of England, (draft 2005).
- PPG15 Planning and the Historic Environment (1994).
- PPG16 Archaeology and Planning (1990); and
- PPG20 Coastal Planning (1992).

23.3 Existing Environment

The presence of known archaeological sites and features identified during the desk-based assessment are shown on Figure 23.1.



Legend

- 132KV Land Cable
- 132KV Marine Cable
- Cable Connection Pit
- Switch Room
- 500m buffer from onshore works
- Scheduled Monuments
- National Monuments Record (NMR) and Norfolk Sites and Monuments Register (SMR)

Sheringham Shoal Offshore Windfarm Environmental Statement

Archaeology and Cultural Heritage (Onshore)

SCIRA-Figure 23.1
Archaeology and Cultural Heritage (Onshore)
Date: January 2006

Map projection:
British National Grid (NTS)

Scheduled Monument and NMR data provided by English Heritage. SMR data provided by Norfolk Landscape Archaeology.

Figure 23.1 Archaeology and Cultural Heritage

Table 23.1 summaries the presence of any sites listed as Scheduled Monuments within the study area and Table 23.2 lists any areas included on the National Monuments Record (NMR) or the Norfolk Sites and Monuments Register (SMR). Unique reference numbers have been provided within both the tables and the figure and are referred to throughout this section.

Table 23.1 Scheduled Monuments within the study area

Ref no.	English Heritage Reference and Site Name	Location	Parish	Grid Reference
SM 01	SM 21372: Bowl Barrow on the North Side of Muckleburgh Hill	Muckleburgh Hill	Kelling	TG 1013 4311
SM 02	SM 21390: Weybourne Priory	Weybourne	Weybourne	TG 1117 4308
SM 03	SM 21391: Moated Site 380m SSW of Rosedale Farm	Rosedale Farm	Kelling	TG 1092 4250

Table 23.2 National Monument Record (NMR) and Site and Monument Register (SMR) located within the study area

Ref no.	NMR / SMR ID	Name/Description	Age / Period	Grid Reference
01	SMR 1105	World War II defensive structures, Pillbox and underground military headquarters.	World War II	TG 1105 4369
02	NMR 1417181	Spigot mortar base.	World War II	TG 1108 4373
03	NMR 1417178	Vickers Machine gun emplacement; now in fragments in sea.	World War II	TG 1108 4373
04	NMR 1417173	Vickers machine gun emplacement. Now destroyed.	World War II	TG 1104 4374
05	SMR 19437	Pillbox. No visible evidence of it remains.	World War II	TG 1105 4378
06	SMR 32503	World War II Pillbox.	World War II	TG 1102 4376
07	SMR 6256	Flint flake, pot boilers and animal bones (including ox)	Prehistoric	TG 11004374
08	NMR 132115	Flint flake and animal bones.	Prehistoric	TG 1096 4375
09	SMR 17649	Old Woman's Field. Roman coins.	Roman	TG 1087 4371
10	NMR 132114 / SMR 6274	Roman pottery. Found in 1885, reports of other Roman pottery found in the vicinity- none recovered.	Roman	TG 1082 4375
11	SMR 23247	Medieval coin found on beach in neighbourhood of Weybourne Hope.	Medieval	TG 1066 4380
12	SMR 6286	Human remains, likely to be modern.	Unknown	TG 105 438
13	NMR 1417166	Vickers machine gun emplacement.	World War II	TG 1031 4383
14	SMR 24265	Gun emplacement and pillbox.	World War II	TG 1031 4380
15	NMR 1417162	Vickers machine gun emplacement. A variant on the standard type.	World War II	TG 10245 43780
16	NMR 1417161	Vickers machine gun emplacement.	World War II	TG 1022 4370

Table 23.2 National Monument Record (NMR) and Site and Monument Register (SMR) located within the study area

Ref no.	NMR / SMR ID	Name/Description	Age / Period	Grid Reference
17	SMR 32501	Pillbox and rectangular military building.	World War II	TG 1022 4370
18	SMR 32500	Gun emplacement and slit trench	World War II	TG 1022 4380
19	SMR 35709	Burial site. HSR found on clay deposit on beach, in intertidal zone. Skull fragment, long bone, rib and vertebra. Heavily stained and probably of considerable antiquity.	Undated	TG 1026 4391
20	SMR 24264	World War II pillboxes, located within area of defences at coast at Weybourne Camp.	World War II	TG 102 439
21	NMR 1417167	Type 22 pillbox. Now completely broken up by the sea.	World War II	TG 1009 4391
22	SMR 39345	Roman coins at Weybourne Camp.	Roman	TG 10323 43413
23	SMR 32502	Rare World War I (1916-18) pillbox in hedge on north side of lane.	World War I	TG 1027 4331
24	SMR 11335	Weybourne Camp. Fort; Fortification; Gun emplacement. Radar station; Aircraft hanger; Anti aircraft defence site; Bank (earthwork); Barbed wire obstruction; Barracks; Battery; Beach Defence; Bomb crater; Command post; gun emplacement; Military airfield; Military building; Military coastal defences; Nissen hut; Pillbox; Practice trench; Slit trench; Tank trap; Trench; Weapons pit; Army camp; Artillery school; Military airfield; Military camp.	Post medieval World War II	TG 1000 4330
25	SMR 32477	Anti aircraft battery; Barbed wire obstruction; Gun emplacement	World War II	TG 0986 4341
26	SMR 32476	Large World War II gun emplacement and observation point.	World War II	TG 0985 4336
27	NMR 132150 / SMR 6249	A bowl barrow located on the north side of Muckleburgh Hill. It is visible as an earthern mound standing to a height of circa 1.5 metres and covering a circular area of circa 22 metres in diameter.	Bronze Age	TG 1011 4311
28	SMR 6251	Pit and quarry.	Undated	TG 1023 4297
29	SMR 6250	Muckleburgh Hill, Kelling. Iron age pottery and Roman sherds.	Iron age / Roman	TG 1008 4295
30	NMR 132116	A group of bowl-shaped pits of supposed ancient origin on Muckleburgh Hill.	undated	TG 1009 4294
31	SMR 17390	Found south-east side of Muckleborough Hill, eroded out of slope. Late Bronze Age/Iron Age sherds in heavily flint-gritted fabric. West Harling style.	Late Bronze Age/Iron Age	TG 1011 4291

Table 23.2 National Monument Record (NMR) and Site and Monument Register (SMR) located within the study area

Ref no.	NMR / SMR ID	Name/Description	Age / Period	Grid Reference
32	NMR 132140 / SMR 6277	(Associated finds) - Sherds (including grey ware and 2 types of folded beakers) found while filling in drainage trenches. Possibly from a small pit. c.350 yds north-west of All Saints Church.	Roman	TG 1089 4321
33	SMR 34692	Beach Lane Pumping Station associated finds comprising ditch, gully, post hole and burnt mound.	Undated / Bronze Age	TG 1095 4325
34	SMR 15109	Windmill / watermill.	851 to 1065 1540 to 1900	TG 1098 4340
n/a	NMR 1394968	Rampart – Weybourne to Clay general description (not mapped).	N/A	TG10 43 (Linear)

Human occupation of Britain by Lower Palaeolithic to Later Upper Palaeolithic people occurred at different times between about 680,000 and 16,000 years ago. During this time climatic and environmental conditions in Britain have varied considerably and the area around the fringes of the southern North Sea would at times have provided favourable conditions for human habitation at different times within this period. There is however no evidence as yet for the human occupation of the north Norfolk coast during this period.

The cultural transition that marks the start of the Mesolithic corresponds with the start of the Younger Dryas / Loch Lomond stadial (10,000 BP). The Late Upper Palaeolithic and Mesolithic populations were hunter-gatherers and lived a nomadic lifestyle with no fixed settlements. Thus the archaeological signature left by these people is one of scatters of flint tools and animal bone that relate to camp sites, hunting stands, butchery sites, etc.

No material from the Mesolithic has been found in the MSA. However, Mesolithic flint tools have been found from this period in the vicinity of Weybourne and Sheringham.

The archaeological chronology of relevance to the terrestrial components of the site and extent of the onshore works covers the Neolithic period (4,000-2,400 BC) to the modern day.

Although, no evidence of Neolithic occupation has been found within the CSA, four finds spots have been identified in Weybourne and Sheringham, none of which are associated with settlements. This may lend support to the theory that the local areas' landscape of Anglian till made poor agricultural soil. Two flint flakes (reference numbers 07 and 08) have been recovered along the coastline adjacent to the Weybourne car park, as shown on Figure 23.1. These are of unknown date but could be from this period (Wessex Archaeology, 2005).

The Bronze Age is marked by the introduction of metal tools and changes to the style of the field monuments – including the replacement of long barrows with round barrows. No evidence for Bronze Age activity has been recorded within the CSA. However, there are a number of Bronze Age funerary monuments on the higher ground to the south and south west of the CSA, the occurrence of which indicates the presence of Bronze Age populations in the area during this period.

There is no recorded evidence for Iron Age or Bronze Age activity associated along the coastal part of the study area, however a bowl barrow on the northern side of Muckleburgh Hill has been dated as Bronze Age, with other associated features including Iron Age pottery and late Bronze Age/Iron Age sherds in heavily flint-gritted fabric. This site is a Scheduled Monument (reference number SM01), with associated features listed on the NMR and SMR (reference numbers 27, 29 and 31). A burnt mound and pottery has been dated as Bronze Age along Beach Lane at reference number 34. Outside of the study area, further to the east, a later Iron Age hoard of gold staters has been found. One of a handful found in Norfolk, these hoards have been found concentrated mainly in the north and west of the county. Indicative of a period of upheaval, the location of hoards are impossible to predict.

The Roman invasion (43 AD) initially had little effect on the day to day lives of the Iron Age population of Norfolk. Evidence of Roman activity is restricted within the study area to a few pieces of Roman pottery and a scatter of coins recorded on the coast close to Weybourne car park (reference numbers 09 and 10), close to All Saints Church (32), Weybourne Camp (22) and Muckleburgh Hill (29). The only physical evidence of Roman occupation in the area is the remains of a signal station to the west of the CSA at Kelling Hard, out with the study area.

The town of Weybourne is likely to have been a Saxon settlement (410 -1066AD), the remnants of which are evidenced by the Saxon church that has been incorporated into later buildings. There is also documentary evidence of a windmill of late Saxon age (851 AD to 1065 AD) along Beach Lane (reference number 34). In 2004 the Norfolk Coastal Survey identified a large number of fish traps, quays and jetties, among other maritime constructions along the north Norfolk coast dating from Saxon and later periods, which suggests that there could be some potential for coastal activity of this period within the 500m buffer zone.

During the Post Medieval period, a phase of shipbuilding and improvements of costal defences was undertaken by Henry VIII. The fortifications shown on a map of 1588 lie in line with Weybourne village. The fortifications are no longer visible and it is likely that any remains would have been destroyed in the east coast floods of 1953. However, during the 2004 Norfolk Coastal Survey, volunteers re-discovered the remains of the earthworks related to the 16th century Black Joy Forte at Cley-next-the-Sea, highlighting the possibility of survival of the Weybourne fort. (Wessex Archaeology, 2005).

The First and Second World Wars saw a huge amount of activity throughout the south and east coast of Britain, with a number of military camps being established including the one at Weybourne.

A rare World War I pillbox is listed to the north west of the Muckleburgh Collection museum (reference number 23).

World War II defences were peppered along the coast and these included mortar bases, pillboxes, coastal batteries, anti aircraft batteries, anti tank blocks, silt trenches and machine gun emplacements at a density of approximately 10 per mile along this stretch of coast.

Within the study area there are several machine gun emplacements, pillboxes and a mortar base (reference numbers 01 to 21). A number of the Pillboxes have been broken up by the sea, with little or no visible evidence remaining.

To the north of Muckleburgh Hill, there are numerous features listed in association with the former Weybourne Camp (reference numbers 23, 24 and 25). The Weybourne Camp originally started out as a temporary summer camp for the Anti-Aircraft Division of the Territorial Army in 1935 and extended towards the cliffs to the east of Kelling Hard.

Plate 23.1 Remains of World War II Pillbox

23.4 Impacts during Construction

23.4.1 Damage and Disturbance to Known and Unknown Archaeological Resources

The movement of heavy construction vehicles, haul route creation, cable trenching and topsoil disturbance would result in disturbance to the soil matrix within which known and potential archaeological sites, finds and features are or may be present. The desk based assessment has identified the known features or finds of archaeological importance and there is potential for other currently unknown features of archaeological interest to be found, based on the history of the site.

Under PPG16: Archaeology and Planning, there is a presumption in favour of the physical preservation of nationally important archaeological remains. Where preservation in situ is not justified it is reasonable for planning authorities to require the developer to make appropriate and satisfactory provision for excavation and recording of remains

Although much of the site was previously occupied by a military base and subsequently demolished, there are parts of the study area, primarily along the northern part of the cable route, that have not been disturbed which could contain features.

The County Archaeologist has advised that the construction be subject to an archaeological watching brief during the excavation of the trench. In the event of finds or features being revealed, sufficient time and flexibility will be provided within the work programme to enable the appropriate level of recording to be undertaken. The County Archaeologist will also be informed directly and agreement be reached as to the most appropriate course of action.

Given the successful implementation of this mitigation measure a **negligible impact** on archaeological and cultural heritage during construction is anticipated.

23.5 Impacts during Operation

No new disturbance works would take place during the operation of the wind farm project, therefore, **no impacts** to the archaeological resource during operation are anticipated.

23.6 Impacts during Decommissioning

The onshore works would be left in situ and notified as disused, unless otherwise agreed with the Local Planning Authorities, therefore **no impacts** are envisaged.

23.7 Summary

An archaeological desk-based assessment was undertaken and included an area of approximately 500m radius from the proposed onshore works. The desk-based assessment identified a number of predominantly post-medieval and World War II sites and buildings within the study area, with areas of Roman pottery and coins being recorded in the vicinity of the landfall point. There is also a potential for currently unidentified archaeological sites and finds to exist, with evidence from within the wider study area of Iron Age activity and Saxon settlement. As advised by the County Archaeologist, a watching brief will take place during the excavation works for the onshore cable and associated infrastructure. If finds or features are found the most suitable course of action would be agreed with the relevant authorities.

23.8 References

- Wessex Archaeology 2005, Sheringham Shoal Offshore Wind Farm, Archaeological Desk Based Assessment

24 Tourism and Recreation

24.1 Introduction

This section describes the existing tourism and recreational resource in north Norfolk, along with a description of potential impacts from both the coastal and onshore elements of the Sheringham Shoal proposed cable route.

24.2 Assessment Methodology

A desk based assessment has been undertaken to establish the existing tourism and recreation activities, at the site and within the surrounding area in order to identify and evaluate potential impacts. A number of sources of information have been reviewed including:

- Leisure and Tourism Data – North Norfolk District Council (NNDC) and;
- Peddars Way/ Norfolk Coast Path National Trail Website: http://www.nationaltrail.co.uk/PeddarsWay/downloads.asp?PageId=26

Consultation has also been carried out with relevant bodies and organisations operating in the area. Organisations consulted include North Norfolk District Council, Norfolk Tourist Board and the National Trail Manager for Peddars Way.

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 24.4 - 24.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section 1 for the definition of significance levels.

24.3 Description of the Existing Environment

The Peddars Way and the Norfolk Coast Path combine as one of Britain's newer National Trails. The Peddars Way runs from Knettishall Heath in Suffolk to Holme-next-the-Sea on the north Norfolk coast where it joins the Norfolk Coast Path running from Hunstanton along the coast to Cromer. The National Trail totals some 150km (93 miles).

Over two thirds of the Path runs through either an Area of Outstanding Natural Beauty (AONB) or an Environmentally Sensitive Area (ESA) giving an indication of the quality of landscape through which it passes (see Figure 22.1). The Peddars Way and Norfolk Coast Path National Trail is jointly promoted and funded by the Countryside Commission and Norfolk and Suffolk County Councils. The National Trail is maintained by the two Councils in their respective counties. A National Trail Manager employed by Norfolk County Council, co-ordinates the overall management of the route.

The main tourist areas in north Norfolk include the coastal towns of Cromer, Sheringham, Blakeney, Cley, Holt and Walsingham.

Cromer and Sheringham, to the east of Weybourne have been popular seaside resorts for almost 200 years. Both towns have a European Blue Flag for clean beaches and bathing waters.

Blakeney and Cley to the west of Weybourne are centres for wildlife and a focus for birdwatchers, with organised boat trips operating to observe the seals off Blakeney Point. North Norfolk forms part of the largest coastal nature reserve in England and Wales. Bitterns and terns, oyster catchers, avocets and marsh harriers are among the species which make North Norfolk a prime site for bird watching.

Holt is a small Georgian town which is a focus for many arts and crafts. Walsingham is world renowned as a centre of pilgrimage by people of many faiths. There are several religious buildings in the village (http://www.visitnorfolk.co.uk).

The numerous tourism and recreational features along the stretch of coast between Sheringham and Kelling are summarised within Table 24.1 and comprise caravan and camping sites, country parks, viewpoints, public footpaths and bridleways, fishing and museums.

Table 24.1 Tourism and recreation features within study area

Feature	Details & Location
Footpaths	• Peddars Way and Norfolk Coast Path – length of coastline within study area. • Numerous Public Rights of Way (footpaths and bridleways) within study area. • Other permitted paths, e.g. within Kelling Heath.
County Parks and Open Access	• Sheringham Park (National Trust) – includes nature trails, visitor centre parking and trails. • 360^0 viewpoint and Gazebo at Oak Wood, Sheringham Hall. • Trails within Hundred Acre Wood.
Parking	• Public car park (pay and display) at Weybourne Beach. • Public car park within Sheringham Wood.
Fishing	• The coasts along Weybourne and Kelling are both used by recreational beach anglers.
Caravan & Campsites	• Campsite to the west of Weybourne along A149. • Caravan Park to east of Bodham along the A148. • Campsite and Caravan Park to west of Hundred Acre Wood.
Other	• North Norfolk Railway – a privately run railway used by several steam train companies running between Holt and Sheringham. • Muckleborough Collection Museum – located to the west of Weybourne (seasonal opening). • Leisure centre to east of Bodham along the A148. • Falconry Centre at The Hangs. • Horse-riding centre to east of Hundred Acre Wood.

Walking and cycling are amongst the most popular informal recreational activities along the coast. It has been assumed that the car park visitor numbers at Weybourne predominantly represent users of Weybourne Hope beach and the National trail. Visitor numbers are shown in Table 24.2 (by car park tickets sold) and indicate that the car park, beach and National Trail are used throughout the year, with numbers ranging from 650 cars in November to 3100 in September. The numbers indicate a continual flow of visitors, with only a minor increase in numbers during the summer months of June to September.

Table 24.2 Table to show number of visitors to the car park at Weybourne beach

Year	Month	Number of Car Park Tickets Sold
2004	April	1470
	May	1140
	June	1960
	July	1470
	Aug	2610
	Sept	3100
	Oct	1140
	Nov	650
	Dec	490
2005	Jan	815
	Feb	650
	Mar	815

Source: North Norfolk District Council (These figures are based on ticket sales and exclude season ticket and permit holders).

Table 24.3 Number of trips by staying visitors – 1999

	Trips by domestic residents ('000)	Trips by overseas residents ('000)	Total trips ('000)
Long holidays	*419*		
Short holidays	*259*		
All holidays	678	24	702
Business	23	4	27
VFR	100	5	105
Other	9	0.9	10
TOTAL	**810**	**34**	**844**

Source: North Norfolk District Council, 1999 (http://www.northnorfolk.org/tourism).

Table 24.3 provides a breakdown of staying visitors by purpose of visit in the North Norfolk district. In total, staying visitors accounted for 844,000 trips, 3.9 million nights and £101.3 million expenditure in 1999.

In addition, the north Norfolk coastline provides a variety of water based recreational opportunities including sailing and powered leisure craft, SCUBA diving, swimming, surfing, wind surfing, jet skiing and angling (Norfolk Offshore Wind, 2002).

The summer months from May to August are found to be the most popular with beach users, with August proving the busiest (NNDC 1999). Some beach launching of small fishing boats does take place at Weybourne Hope, and it is known that some diving takes place on Sheringham Shoal (pers comm. Peterborough BSAC).

24.4 Impacts during Construction

24.4.1 Disruption to Leisure Craft, Diving and Angling Vessels

Disruption to recreational sea based activities, such as boating and scuba diving is not anticipated to be significant. It is, expected that recreational vessels would keep clear of construction vessels and barges etc. in a good seamanship manner. Communication by VHF radio will also be possible to warn any approaching recreational craft if necessary. There are, for example, similar communications between survey ships in this area and diving vessels in instances where divers may be down on wrecks in the vicinity of a planned hydrographic survey. All vessels will display the relevant international marks and lights to indicate their activity, for example cable laying vessels will indicate that they have limited manoeuvrability. Given good communications and prior warning, for example, a press release in various monthly diving, angling and sailing magazines, **negligible** impacts are anticipated from construction vessels and surface activities. Refer to Section 14 ‘Shipping and Navigation' for further discussion regarding recreational vessels.

24.4.2 Reduction in Visibility during Recreational Diving due to Sediment Plume

Section 6 ‘Hydrodynamics and Geomorphology' details the likely extent of the sediment plume emanating from the laying of both the inter-turbine and the site to shore cables. The north Norfolk waters often exhibit low visibility conditions generated from storm conditions and periodic algae blooms. Divers utilising these waters are used to such conditions and carry the requisite safety equipment including torches, and “buddy” lines (to connect two divers in low visibility) and surface marker buoys (small buoys dragged along the surface to indicate the location of the diver). Diving on wrecks is generally undertaken in slack water conditions and therefore movement of sediment loaded water would not occur, although it is acknowledged that dive activities do occur either side of slack water when the tides are flowing.

Again, good prior warning including details of the construction activities and programme will mean that divers and clubs are aware of the work and can avoid the area at the particular time of construction. Notices at the known launching slipways and in the national dive magazines should avoid any adverse impacts.

24.4.3 Impacts to Onshore Recreation and Tourism

The main visitor attractions within the immediate vicinity of the onshore landfall works, include the Norfolk Coast Path and the Muckleburgh Collection museum. The cable connection pit and cable route are located on the privately owned land of the museum and therefore direct disruption to users for much of the duration of works would not occur. Temporary restrictions on the use of a relatively small area of intertidal and beach area would be in place when the export cable is brought ashore.

The majority of the onshore works would where possible be constructed during the winter months (October to February) in order to avoid the main tourist season at the Muckleburgh Collection museum. The installation of the cable through the shingle beach would be undertaken at the same time as the offshore cable connection and would last approximately 5-6 days for each of the two cables. The total duration of the onshore works is anticipated to be in the order of 16 weeks.

It is likely that during the construction phase use and access to the beach and the National Trail would be restricted in the localised area of the construction works. If the path requires temporary diversion or closure an application to the Highways Authority would be sought to enable this. Alternative access would be provided and the area of works delineated by fencing or other method to ensure the safety of walkers and beach users. In addition, the following measures will be undertaken:

- Construction works, information and dates to be published on site ;
- Close liaison with the Area Highway Officer and National Trail Manager to agree alternative access arrangements.

Given successful implementation of the above mitigation measures impacts are anticipated to be short term and of **minor adverse** significance.

24.5 Impacts during Operation

During the operational stage of the wind farm the impacts on tourism and recreational activities would be associated with the visibility of wind turbines and perception of them. It is known that the Sheringham Shoal wind farm would be visible from the north Norfolk coastline under certain meteorological conditions (refer to Section 13 'Seascape and Visual Character').

The East of England Tourist Board advises that although the visual perception of a wind farm is highly subjective, its setting is a key factor in relation to its impact on tourism. For example, a wind farm offshore from a well-developed seaside resort would potentially add interest to the beach experience, while the same development offshore of a wild, undeveloped coastline may be significantly detrimental.

Much of the appeal of the north Norfolk coast is based on its wild, remote and 'unspoilt' feel, therefore the potential impact on its attractiveness depends on the visibility of the turbines along the coast. It is anticipated that the wind farm would be more acceptable at Sheringham, and more intrusive along the AONB.

Recent surveys have demonstrated that onshore and offshore wind farms have a slightly positive effect on tourism. In 2004, Greenpeace commissioned a survey of visitors for the Scarweather Sands wind farm proposal off Porthcawl, (Greenpeace, 2004). Of the 650 tourists visiting Porthcawl who were asked whether the proposed wind farm would make them more or less likely to return, 83% of the respondents said it would make no difference, 13% said more likely and just 4% less likely. This is reinforced by a MORI survey of visitors conducted in Argyll in Scotland in 2002. The survey found that 91% of the respondents said the presence of wind farms would make no difference to their decision to visit the area again (Sustainable Development Commission, 2005).

In conclusion, **no impacts** on tourism and recreational activities are anticipated.

In addition, **beneficial effects** may arise as the wind farm could become a local attraction. It is possible that the interest of the wind farm would encourage local charter boats to provide trips to the wind farm. In addition, Scira Offshore Energy is investigating the possibilities to participate in an information centre which would provide information on wind and renewable energy and details on the Sheringham Shoal development. It is also possible that such information could be combined with local exhibitions/information boards on other subjects including local history, archaeology and wildlife.

24.6 Impacts during Decommissioning

The cable would remain in situ therefore **no direct impact** on recreation or tourism is anticipated. Given, discussions with the landowner, the switch room may be used as part of the Muckelburgh Collection and therefore there could be a potential **beneficial** impact to the tourist facitlities.

24.7 Summary

Tourism and recreation play an important role in the economy of north Norfolk with the coastal towns and more remote coastline being popular all year round. The north Norfolk coastline provides a variety of recreational opportunities including, sailing and use of powered craft, SCUBA diving, swimming, surfing, wind surfing, jet skiing and angling. Clear seasonal variations are evident, with the summer months between May and August inclusive being the most popular, and August proving the busiest.

The main visitor attractions within the immediate vicinity of the onshore works include the Norfolk Coast Path and the Muckleburgh Collection with the beach being well used and easily accessible with car parking facilities.

During construction disruption to recreational vessels, including yachts, powered craft, diving and angling vessels will be minimised through effective communication of the proposals in the diving, angling and yachting press, in addition to site notices.

Some disruption to the Norfolk Coast Path and beach would be experienced over the duration of the landfall works. A temporary diversion of the path along a relatively small section would be put in place. This would be discussed and agreed with the Area Highway Officer and the National Trail Manager and an application made for closure or diversion as necessary. The duration of the works is anticipated to be in the order of 5-6 days for each of the two cables and therefore only short term disruption is anticipated. Much of the onshore cable laying works is located on private land and would not lead to access disruption. Notices would be posted to provide information on the works, programme and a point of contact for relevant recreational groups and associations. The total onshore construction works are anticipated to last approximately 16 weeks.

During operation, it is not anticipated that the presence of the wind farm would deter tourists and visitors from the area and some visitors may be attracted to the coast in order to view the wind farm, although it is acknowledged that much of this coastline is popular due to its quiet and relatively remote nature.

Overall, the impacts on recreational activities and tourism are anticipated to be of temporary nature and limited spatial extent and are therefore considered to be of **minor adverse** significance.

24.8 References

- http://www.visitnorfolk.co.uk
- Peddars Way/ Norfolk Coast Path National Trail Website: http://www.nationaltrail.co.uk/PeddarsWay/downloads.asp?PageId=26
- Posford Haskoning/ EDF 2002, Norfolk Offshore Wind Farm Environmental Statement

25 Traffic and Access

25.1 Introduction

This section describes the effects of the onshore infrastructure which involve the installation of the cables and construction of a new switch room, works on the local transport infrastructure. It describes the existing local transport network and the possible impacts upon local traffic during the construction, operation and decommissioning phases of the project, along with any required mitigation measures.

25.2 Assessment Methodology

A desk based assessment has been undertaken to establish the existing traffic and access within the vicinity of the onshore works and the surrounding area in order to identify and evaluate potential impacts.

Consultation has been undertaken with the Norfolk County Council Highways Development Control in order to inform the assessment and to design a scheme of appropriate traffic management strategies during construction.

The environmental effects of traffic and access have been assessed with reference to Guidance Note No.1 Guidelines for Environmental Assessment of Road Traffic (1993) issued by the Institute of Environmental Assessment.

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 25.4 - 25.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section 3 for the definition of significance levels.

25.3 Existing Environment

25.3.1 Local Road Network

The study area is predominantly rural, with mainly Class A and B roads serving the main towns and villages, with tracks adjacent to the proposed onshore works. The A148 which forms the southern boundary of the study area serves Holt and runs between Cromer and Fakenham. The A149 runs parallel to the coast and approximately 1km inshore from it, through the villages of Weybourne and Kelling. A number of unnamed B roads run roughly in a north-south direction and link Weybourne and Kelling to Holt. Features of the local road network are shown on

Legend

- 132KV Land Cable
- 132KV Marine Cable
- Cable Connection Pit
- Switch Room

Sheringham Shoal Offshore Windfarm Environmental Statement

Local Road Network

SCIRA-Figure 25.1
Local Road Network
Date: January 2006

Map projection:
British National Grid (NTS)

Figure 25.1 Local Road Network

The North Norfolk Railway runs from Sheringham to Holt. It is a private railway line served by a private collection of steam trains based at Sheringham and is a major tourist attraction to the area.

There are no trunk roads or motorways in north Norfolk, but the North Norfolk Local Plan identifies the A148 between Cromer and King's Lynn as one of only three primary routes in the district. Primary routes are roads of national importance which form part of the 'primary route network' of the country, i.e. are the main arteries of the UK road network. In addition, there are six other A-roads which, whilst not being part of the primary route network are considered by the Council to be "principal" roads. This includes the A149 between Cromer and Great Yarmouth. The Local Plan does not report any major road schemes in the study area that are identified in the Norfolk Structure Plan.

The local road network is used by residents, tourists and visitors. No official traffic data is available in relation to the area of interest.

25.4 Impacts during Construction

25.4.1 Increased Traffic on the Local Road Network

Impacts during construction on traffic and access would be related to the increased number of vehicles travelling to and from the construction site. Plant requirements and traffic movements would include Heavy Goods Vehicles (HGVs) for the delivery of the cable, warning tiles and tape, with further HGVs for delivery of sand. Contractors using private vehicles would access the site on a daily basis.

The anticipated traffic movements for each of the constituent elements of the construction phase, i.e. switch room, connection pit, cable trenching, beach cable and anchoring, of the onshore works has been assessed.

Table 25.1 below outlines the number and types of vehicles anticipated during the construction phase for each stage.

Table 25.1 Anticipated traffic during construction

Construction element	Traffic requirements		Construction timescale
Switch room	Low Loader extendible with crawler digger Delivery of JCB and dumper truck Delivery of canteen shack and toilet Mixer Lorry loads of concrete for floor Sand and cement powder mixer Delivery of Bricks/Concrete blocks Delivery of roof material 6 x personnel cars	1 x lorry 2 x lorry 1 x lorry 30 x cement mixer lorry 1 x lorry 1 x lorry 1 x lorry	It is estimated that it would take approximately 16 weeks to construct and install the switch room.
Connection pit	Cement floor base	2 x cement mixer lorry	It is estimated that it would take approximately 2 weeks to construct the jointing pit.
Cable trenching	Cables Cement 4 – 6 personnel cars	2 x lorry 64 x cement mixer lorry/dry-mix lorry	It is estimated that it would take approximately 3 weeks to install cable trenching.
Landing of Cable on beach and anchoring	Sand bags Shuttering Winch rollers 6 Personnel cars	1 x lorry 2 x lorry 1 x lorry	It is estimated that it would take approximately 7 days for each beach cable installation and anchoring.

The construction of the connection pit and switch room and the cable installation would be programmed to run simultaneously and it is anticipated that the total time required would be approximately 16 weeks.

The landing cable and beach anchoring stage would be programmed to coincide with the offshore cable installation, but this will probably differ from the laying of the cable on land and the construction of the onshore works.

A total of 100-120 lorry movements would be anticipated during the construction of the onshore works.

Some abnormal loads would be required to deliver the excavators and other construction plant and the cable reels. Access to the site would be via the large existing 7m wide access road to the Muckleburgh Collection. It is not anticipated that any modifications to the access point would be required.

In order to reduce the potential impact of increased traffic numbers, good practice measures would be incorporated. This would include the timing of construction traffic movements to avoid peak traffic periods, where deemed necessary. In addition, appropriate signage to inform the public of construction vehicles leaving access points would be installed.

The construction works are unlikely to result in a significant increase in traffic and a minor adverse impact on the local road network is predicted for the short-term duration of the works (approximately 16 weeks). It is anticipated that the wider traffic network would be able to accommodate the additional traffic numbers due to the relatively small increases in traffic movements. Abnormal load movements would be agreed subject to normal notification periods.

Further to discussions with NCCHDC, no significant problems are considered with the proposal from a highway safety or network management perspective. Norfolk County Council, Highways Development Control would wish to agree the route subject to the normal notification for abnormal loads for each movement. Prior to construction, a traffic management plan would be agreed with Norfolk County Council.

Given the above mitigation measures and further discussion with North Norfolk Highways Authority, to agree any additional measures, a short tem **minor adverse** impact on the road network is envisaged.

25.5 Impacts during Operation

Once the site is mobilised, traffic would be restricted to light vehicles for maintenance staff only. **No impact** on the local road network is anticipated.

25.6 Impacts during Decommissioning

It is anticipated that much of the onshore works would be left in situ with the cable being notified as disused. The switch room could be used as part of the museum collection or as otherwise agreed with the landowner. No significant impacts on the local road network or access are anticipated.

25.7 Summary

The study area is predominantly rural, with mainly Class A and B roads serving the main towns and villages, with tracks adjacent to the proposed onshore works. Access to the site would be via the A149 and the existing access used for the Muckleburgh Collection.

Disruption to the local traffic network is anticipated to be minimal during the installation of the onshore works and delivery of plant and materials. In total approximately 100-120 Heavy Goods Vehicles over a period of 16 weeks are expected. All works would be undertaken in accordance with requirements of the Norfolk County Council Highways Development Control. This would include further discussion following consent and prior to construction commencing to agree other traffic requirements with regard to notification of movements for abnormal loads. Prior to construction, a traffic management plan would be agreed with Norfolk County Council.

A short term **minor adverse** impact on the local road network and access is envisaged.

Once the site is mobilised, traffic would be restricted to light vehicles for maintenance staff only, therefore **no impact** on the local road network is anticipated.

25.8 References

- Institute of Environmental Assessment (1993) Guidance Note No.1 Guidelines for Environmental Assessment of Road Traffic.
- Landranger 133, Ordnance Survey, North East Norfolk, Cromer & Wroxham 1:50,000.

26 Noise, Dust and Air Quality

26.1 Introduction

This section sets out the existing environment and the potential impacts from noise and air emissions during the construction, operation and decommissioning of the onshore cable works for the Sheringham Shoal Offshore Wind Farm project. Mitigation measures are discussed where necessary. Due to the nature of the works (i.e. minor excavations) the need to assess vibration is not considered necessary as there are unlikely to be significant emissions of perceptible vibration beyond the site.

26.2 Assessment Methodology

26.2.1 Noise

26.2.1.1 Construction

Standards and guidance used to assess the potential noise impacts during the construction phase of the onshore works include:

- British Standard (BS) 5228: Part 1: 1997 'Noise and Vibration Control on Construction and Open Sites – Code of Practice for basic information and procedures for noise and vibration';
- World Health Organisation (WHO) 'Guidelines for Community Noise' (WHO, 1999).

BS 5228: Part 1 provides a methodology for undertaking predictions of potential noise emissions from both mobile and fixed plant on a site, taking account ground topography, the 'on-time' (proportion of the assessment period that the plant operates), screening by buildings or other physical barriers and the nature of the ground between source and receiver. In this instance no allowance has been made for screening by structures thereby presenting a conservative prediction.

Annex C of the Standard also provides source noise data for various items of plant and machinery typically operating on such sites; this data is now quite old and whilst it may be expected that modern plant and machinery would be quieter, the use of the older plant data further a conservative assessment of the potential noise emissions from the site.

The items of equipment identified may alter after appointment of the Installation Contractor, due to alterations in working methods, equipment availability etc. The results, however, provide a good indication of the potential impacts on noise sensitive receptors during the construction phase.

The WHO guidance presents health-based guideline values for community noise levels in non-industrial areas, based on recent research and investigations, with the intention that community noise exposure is reduced and the potential for nuisance or annoyance reduced. The guidance states that for outdoor living areas i.e. gardens, noise levels should not exceed 50 dB L_{Aeq} during the daytime and evening, at which level moderate annoyance may still be experienced.

26.2.1.2 Operation

The switch room components have not yet been decided, but there is potential for a reactive power compensator to be included. The assessment of noise levels resulting from the operation of the switch room, the only part of the operational onshore development that would potentially have any noise impact, follows:

- British Standard (BS) 4142: 1997 'Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas'.

This guidance provides a methodology for assessing the impacts of noise from industrial premises on non-industrial receptors and whilst the switch room is not an industrial premises, the method of comparing source noise against existing background noise levels at the receptors provided by this Standard, and the consequent indication of the likelihood of complaint, makes this the most suitable assessment methodology to use in this instance. The assessment is made by comparing existing measured or predicted ‘background’ (dB L_{A90}) noise levels against a ‘rating’ noise level (dB $L_{Ar, Tr}$) from the site. The rating level is derived from the ‘specific’ noise (dB L_{Aeq}) of the site or equipment under investigation to which is added a +5 dB penalty if the noise contains distinct, discrete noises or audible tones or is unusual enough to attract attention. The assessment states that a rating level 5 dB greater than existing background noise levels is of marginal significance and a difference of +10 dB is likely to lead to complaints whilst a difference of -10 dB indicates that complaints are unlikely.

The L_{A90} is the 90th percentile noise level, or the noise level exceeded for 90% of the measurement period. It is a statistical parameter rather than a measure of sound energy and as such is much less likely to be adversely influenced by short-term, high-energy impulsive noises. This is the parameter generally used to define ‘background’ noise.

The L_{Aeq} is an energy equivalent noise level; it is effectively a single-figure, average noise level for a variable noise over a defined measurement period. It is more likely to be adversely influenced by short-term high-energy noises and is generally used to describe the ‘ambient’ noise, that is, the noise from all sources.

26.2.2 Dust and Air Quality

A qualitative assessment of dust and air emissions impacts has been undertaken on the basis of professional expertise, and experience of similar projects elsewhere. Emissions include vehicle exhausts and fugitive dust from excavations.

26.2.3 Vibration

The construction methods adopted for the installation of the cable and the separation distance between the construction works and receptors indicates that the works will not produce any discernible vibration at the sensitive receptors. Similarly, the type of operational equipment likely to be installed in the plant room will not generate any discernible vibration. It is therefore judged that no vibration impact will occur; therefore no specific assessment has been undertaken.

The significance level (negligible – major adverse or beneficial) of identified impacts are shown in **bold** in Sections 26.4 - 26.6 and are considered to be the residual impact following successful implementation of the cited mitigation measures, good construction or operational practice, or relevant regulations and guidelines. See Section 1 for the definition of significance levels.

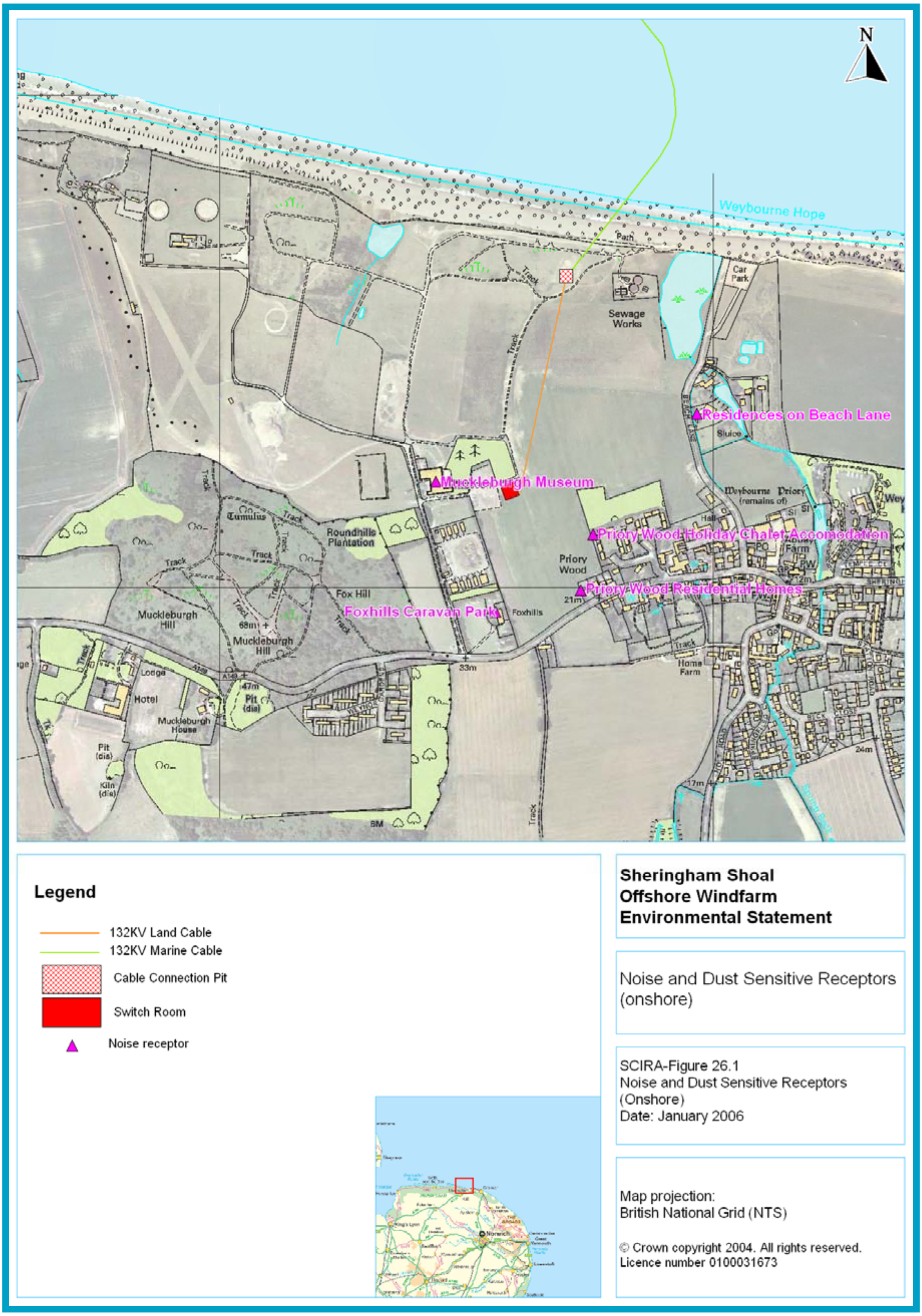


Figure 26.1 Noise and Dust Sensitive Receptors

26.3 Existing Environment

26.3.1 Noise

The area of the onshore works is predominantly rural and set in a coastal location. Any significant existing ambient noise is attributable principally to traffic movements on the A148, a primary route between Cromer and either Kings Lynn or Cambridge, and other minor local roads.

Residential properties are situated close to the proposed onshore works in the village of Weybourne and include three houses along Beach Lane, a number of houses along The Street, Foxhills Caravan Park and holiday chalets which have year round access at Priory Wood, as shown on Figure 26.1.

Other non-residential receptors include users of the Muckleburgh Collection museum (open March to October) and users of the beach frontage and Norfolk Coast Path.

The estimated distances of the closest noise sensitive receptors to the proposed onshore works are presented in Table 26.1.

Table 26.1 Distance of noise sensitive receptors from the proposed onshore cable route

Location	Distance from Cable Route (m)
Muckleburgh Museum (Open March to October)	110m
Residences on Beach Lane	320m
Priory Wood holiday chalet accommodation	200m
Priory Wood residential homes	250m
Foxhills Caravan Park	240m

There are not known to be any significant local sources of noise other than the local roads and it was noted during site visits that the A149 is a fairly frequently used road during the day carrying existing heavy goods vehicle traffic. Experience of noise levels in similar locations indicates that existing ambient noise levels will be in the range of 50 to 55 dB L_{Aeq} during the day, approximately equivalent to a 'background' noise level of 47 to 52dB L_{A90}. For the purposes of this assessment the lower noise level of 50 dB L_{Aeq} is taken to represent existing 'ambient' noise levels and 47dB L_{A90} is taken to represent existing 'background' noise levels: this would be commensurate with the recommended guideline values suggested by the WHO. It is not anticipated that night time working would be necessary and therefore night time have not been assessed. Working hours would be agreed with NNDC.

26.3.2 Dust and Air Quality

The rural nature of the area limits the likely emissions to those associated with road traffic. No direct emissions other than vehicle exhausts would be generated, primarily influenced by vehicles passing along the A149.

26.4 Impacts during Construction

26.4.1 Noise

Noise during construction of the onshore works would be largely due to the following construction plant activities:

- Stripping of topsoil;
- Excavation of cable trench;
- Placement of cables and connecting works;
- Burying cables;
- Resurfacing/ grading works by a variety of construction vehicles; and
- Construction of the brick built switch room.

The construction will take place as four distinct phases as follows:

- Phase 1 - Switch room construction, 16-week anticipated construction time;
- Phase 2 - Jointing Pit, 2-week anticipated construction period;
- Phase 3 - Cable trenching, 3-week anticipated construction period;
- Phase 4 - Landing of cable on beach and anchoring, 5-6 days for each of the two cables.

26.4.1.1 Impacts on Surrounding Roads due to Construction-Related Traffic

It is intended that the first three phases outlined above will be run concurrently. In preparation for the construction works, very limited numbers of heavy goods vehicles or transporter lorries will be required to bring construction plant and ancillary equipment to the site; the small numbers involved suggests that there will be a negligible impact as a result of these vehicle movements. No movement of excavated material off-site will occur.

During phase 1, approximately 30 cement mixers (60 vehicle movements) will be required for the construction of the switch-room floor. For phase 2, 2 cement mixers will be required and for phase 3, 64 mixers (128 vehicle movements) will be required for cementing of the cable trench.

In order to present a conservative prediction of noise impacts, it is assumed that all the cementing works will occur over a period of 5 days; this breaks down to approximately 3 cement mixer movements per hour over the working week. In addition, during the cable laying, 30 to 35 lorries will bring sand for cable protection. This is approximately 70 heavy goods vehicles movements over a three week period or one lorry every 3 hours. It has already been established that the A148 is a busy main A-road and it is judged that the small number of additional heavy goods vehicle movements arising from the construction works will not create any significant additional noise or vibration impact for local residents.

There are expected to be between 5-10 private vehicles daily belonging to construction workers which are not expected to have any noise impact on the local roads.

26.4.1.2 Impacts due to On-Site Construction Works

Table 26.2 presents a list of the predicted machinery to be used on site during construction, and the levels of noise emitted. This work would take place during normal working hours (7am to 7pm).

Table 26.2 Construction equipment and machinery - total noise emitted at 10m

Vehicles/Plant	BS 5228 Reference Table	Assessment Period	dB L_{Aeg} at 10m	On-time (%)	dB L_{Aeg} at 10m corrected for on–time
Dozer (ground levelling)	C.3. no.71	12 hour	85	25	79
Dump truck	C.3.no.98	12 hour	73	40	69
Wheeled excavator/loader	C.3.no.84	12 hour	82	25	76
Trucks unloading x 2	C.7.no.112	12 hour	88	10	77
Total Noise Level					**82**

Free-field site noise levels at the nearest receivers are calculated using formula D.2 in BS 5228: Part 1, assuming the ground between source and receiver to be soft, noise-absorbing ground ('free-field' refers to a noise level free from the influence of reflected noise from walls or other physical structures. The opposite situation is termed a 'facade' noise level and is taken, by general convention, to be 2.5 to 3 dB higher than the corresponding free-field noise level). Table 26.3 presents the predicted daytime free-field noise levels at the noise sensitive receptors identified in Table 26.1.

Table 26.3 Predicted daytime free-field noise levels for receptors in the area of the onshore cable works

Nearest noise sensitive receivers	Receiver Noise Level (dB $L_{Aeq,\ 12hr}$)
Muckleburgh Museum (open March to October)	54
Residences on Beach Lane	42
Priory Wood residential homes	45
Foxhills Caravan Park	45
Priory Wood holiday chalet accommodation	47

The results of the calculations show that predicted free-field construction noise levels at the receptors are generally within the range of 42 to 54 dB $L_{Aeq,\ 12h}$. The impacts of the construction works are therefore judged to be of **negligible** significance for most of the nearest noise sensitive properties (up to -8 dB below existing ambient) but of **adverse minor** significance (+4 dB greater than ambient) at the museum. However the museum is not residential and since agreement has already been reached with the owners of the museum regarding the wayleave across the land, no complaints would be anticipated.

Maximum impacts would occur only for short periods when the construction works are at their closest to the receptor positions and would diminish as the works move away from the receptors. Due to the short-term nature of the works and the lack of construction during periods of quiet i.e. evenings, night time and weekends, the potentially significant adverse impacts are unlikely to be a cause for complaint from local residents provided suitable control and mitigation measures are employed (see below).

It is anticipated that the public coastal footpath would be temporarily diverted away from the immediate work site and it is therefore judged that noise impacts for footpath users, due to their transient and short-lived exposure to any noise, will be of minor adverse significance. Any adverse impacts would diminish once the works have crossed, and moved away from, the footpath.

Noise levels and working hours will be agreed with NNDC and the following mitigation measures carried out:

- Residents of potentially affected properties within 200m of the construction works would be informed in writing in advance of the proposed works commencing. This information would include a timetable of works, a schedule of working hours, the extent of works, and a contact name, address and telephone number in case of complaint or problem;
- An information board would be displayed at the site to provide a contact name and telephone number, to which the public can channel their queries. Any complaints or concerns would be attended to as soon as possible;
- The principles of Best Practicable Means (BPM) as defined in BS 5228: Part 1 and COPA will be applied to all site operations and activities;
- All plant and machinery would meet the relevant British Standards i.e. all equipment would be maintained in good working order and be fitted with the appropriate silencers, mufflers or acoustic covers;
- The movement of vehicles to and from the site would be controlled and vehicle engines would not be revved unnecessarily near residential property or allowed to idle whilst not in use;
- Equipment would not be left running between work periods;
- All personnel involved in the construction works would be made aware of the need to keep noise to a minimum through appropriate instruction or training;
- Potentially noisy activities would be kept as far away as possible from noise sensitive locations and frequent stoppages would be included in such works;
- Directional noise sources will be oriented where possible with the emission source directed away from noise sensitive receptors;
- If appropriate, site cabins and other static structures will be placed closest to noise sensitive receptors to provide a degree of noise screening from the site;
- Materials would be lowered rather than dropped;
- Liaison with the Environmental Health Officer would be undertaken to determine acceptable noise limits or to agree periods when unavoidable noisy works might required outside normal working hours. Except in emergencies, any such activities during unsociable hours will additionally be communicated to potentially affected residents before hand and will include an explanation of the reasons for the works, their expected duration and details of a suitable site contact in the event of query or complaint; and
- For users of the coastal path, warning signs at the beginning of the path (or other suitable location) will allow users to avoid the noisy works should they wish.

With the implementation of these control measures, timely and meaningful dialogue with local residents, the application of BPM and the restriction of construction activities to normal weekday periods when local residents will be more tolerant of noise disturbance, it is expected that potential nuisance from the construction works will be minimised but there may unavoidably be periods when short term **minor adverse impacts** would be expected.

26.4.2 Impacts on Dust and Air Quality

Potential construction impacts will arise from exhaust emissions from contractors' vehicles and HGVs, notably particulate matter (PM) and oxides of nitrogen (NO_x), and from fugitive dust generation from the excavation activities.

Emissions of pollutants to air from construction vehicle exhausts are dependent on the number of vehicles present, the extent or “on time” use, and the condition of the vehicles. All site vehicles would comply with the requirements of Directive 2002/88/EC (The Non-Road Mobile Machinery Regulations, 2004) in respect of the exhaust emission standards. As it is envisaged that the number of vehicles used on site at any one time would be less than ten, only limited emissions would be expected to occur.

Trenching would be carried out within the private land of the Muckleburgh Collection museum, and it is anticipated that the potential for significant release of dust and particulate matter is limited. Although fugitive dust releases from construction activities are not well quantified, they tend to consist of particulate matter in the relatively large size fraction range, and concentrations fall off rapidly with distance from the source. Nevertheless, due to the exposure of bare soil during the works and trafficking over unmade access tracks, and as some properties are situated close to the works, there is a potential for nuisance to be caused to local residents. Release of dust from such excavation work is more likely to occur during periods of dry weather, and in instances where large areas of soil are exposed. If works are undertaken in dry weather, water spraying would be undertaken if necessary on bare disturbed areas in order to minimise the potential generation of airborne dust. In addition, if appropriate, wheel washing of vehicles would take place prior to accessing the public highway.

Given these mitigation measures implemented as construction good practice, the low number of vehicle movements involved and the short term nature of the works, impacts on dust and air quality are anticipated to be of **negligible** significance.

26.5 Impacts during Operation

During operation of the onshore works, the only potential source of noise could be from equipment within the switch room. There is a potential for a reactive power compensator to be included but no requirement for transformers. Discussions will be held with the Environmental Protection Officer at NNDC once the final equipment details are known. The design of the building will be such that any necessary noise attenuation is designed in to ensure that noise levels are within the agreed limits. Noise limits would be set to ensure compliance with criteria noise levels agreed with the local authority.

Given this mitigation, the impacts on the local noise environment are anticipated to be **negligible**.

There would be **no impact** on dust and air quality during the operation of the switch room.

26.6 Impacts during Decommissioning

It is anticipated that the onshore cable would remain in situ, with the switch room either being used as part of the museum buildings or demolished. No significant impacts over and above those experienced during construction are anticipated.

26.7 Summary

Noise during the installation of the onshore cable route could arise from the operation of both fixed and mobile plant and machinery involved in the excavation of the cable trench or from the movements of delivery vehicles to and from the site. There are a number of noise sensitive receptors in proximity to the works including residential properties and users of the beach and Norfolk Coast Path. Exposure to elevated noise levels at these locations is anticipated to be of short duration while excavation works are adjacent to the receptor. The adverse noise levels would decrease significantly as the construction works move away from the receptors.

Short-term localised **minor adverse** impacts are anticipated from on-site plant and equipment during the construction works and **no impact** is anticipated as the result of the movements of delivery vehicles or the arrival and departure of site operative vehicles at the beginning and end of the day. Suitable control of construction activities, the application of the principles of BPM and regular dialogue and liaison with both the local authority and local residents will ensure that the potential for nuisance to be caused by these activities will be minimised.

The lack of significant sources of vibration associated with the construction activities and the separation distance to residential properties indicates that no construction-related vibration will be discernible at the nearby sensitive receptors and are unlikely to be a cause for complaint from local residents. The low levels of additional heavy goods vehicles and delivery vehicles visiting the site, compared to existing traffic levels, are not expected to give rise to any vibration nuisance.

Direct emissions to air during construction would be from vehicle exhausts and dust from excavation works and stockpiles of material. Mitigation measures will be implemented as part of good construction practice to ensure all emissions to air are minimised. A **negligible** impact on dust and air quality as part of the onshore works is anticipated.

During operation, the only source of noise would be from the switch room. The building would be designed so as to ensure adequate attenuation of noise generated by equipment inside. **No impacts** are anticipated.

26.8 References

- British Standards (BS) 4142: 1997 "Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas", British Standards Institute, London.
- "Guidelines for Community Noise", 1999, World Health Organisation (WHO), Geneva.
- British Standard (BS) 5228: Part 1: 1997 "Noise and Vibration Control on Construction and Open Sites –Code of Practice for basic information and procedures for noise and vibration control", British Standards Institute, London.
- Control of Pollution Act (COPA), 1974, HMSO, London
- The Non-Road Mobile Machinery (Emissions of Gaseous and Particulate Pollutants) (Amendment) Regulations 2004. Statutory Instrument 2004 No. 2034.

27 Information for Appropriate Assessment

27.1 Introduction

The aim of this section is to provide a review of the potential impacts of the Sheringham Shoal offshore wind farm, as identified in this Environmental Statement, in terms of likely significant effects on the interest features of the Natura 2000 sites that may be affected by the proposals, especially those that comprise the Wash and North Norfolk Coast European Marine Site (EMS).

This work has been undertaken in order that relevant information[26] can be made available to the Competent Authorities (DTI and MCEU) should they be required to undertake an Appropriate Assessment under Regulation 48 of the Conservation (Natural Habitats & c.) Regulations 1994 (the 'Habitats Regulations').

If a plan or project not connected to the management of a European site is likely to have a significant effect on that site, the competent authority is required to carry out an Appropriate Assessment to determine whether the plan or project, either alone or in combination with other plans or projects, will have an adverse effect on the site's integrity. The rationale to be applied when considering the need for an Appropriate Assessment as described under Regulation 48(1) of the Habitats Regulations is explained in the following section. The procedure for the consideration of plans or projects affecting the interest features of the Natura 2000 series of designated European sites is detailed in Regulations 48 – 53 of the Habitats Regulations.

Natura 2000 is the European network of classified Special Protection Areas (SPAs) and Special Areas of Conservation (SACs). A European site is either a SAC or a SPA, where it has been agreed that it is a Site of Community Importance (SCI). The habitats and species of the north Norfolk Coast and its waters are protected by a combination of European sites (see Sections 5 and 0: Nature Conservation Designations). An 'interest feature' within a site can be defined as a natural or semi-natural feature, for which a Natura 2000 site has been selected. This includes any Habitats Directive Annex I habitat, or any Annex II species, designated under the Habitats Directives, as well as any population of an Annex I bird species for which an SPA has been designated under the Birds Directive.

Relevant guidance documents on Appropriate Assessment have been referred to, including:

- PPS9 (ODPM, 2005a) and its supporting document: Biodiversity and geological conservation – statutory obligations and their impact within the planning system (ODPM, 2005b). PPS9 sets out planning policies on the protection of biodiversity and geological conservation through the planning system.
- English Nature's Habitat Guidance Notes (EN, 1997, 1999 and 2001).
- Natura 2000. Managing activities and impacts within the UK's network of marine Special areas of Conservation (SACs) (EN *et al*., 2001).

[26] Regulation 48(2) requires that a person applying to carry out a plan or project, which requires Appropriate Assessment, shall provide information to the Competent Authority as may be reasonably required for the purposes of the assessment.

27.2 Requirement for Appropriate Assessment

An Appropriate Assessment is a specific decision-making process required by the Habitats Regulations where a plan or project, not connected to the management of a European site, is likely to have a significant effect on such a site. The aim of the Appropriate Assessment is to determine whether the proposals would adversely affect the integrity of the Natura 2000 site for the interest features for which it was designated.

The phrase “the integrity of the site” is not defined in the Habitats Directive or the Habitats Regulations; however, it is usually taken to mean the coherence of the site’s ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it was classified. An adverse effect on integrity is likely to be one that prevents the site from maintaining the same contribution to favourable conservation status of the qualifying feature(s) for which it was designated.

The favourable conservation status of the site is defined through the site's conservation objectives which are published in the relevant advice documents. In the case of the Sheringham Shoal offshore wind farm, this is English Nature’s advice given under Regulation 33(2) of the Habitats Regulations for the Wash and North Norfolk Coast European Marine Site (English Nature 2000). The citation for the North Norfolk Coast SAC (English Nature, 2005a) and the Wash and North Norfolk Coast SAC (English Nature, 2005b) do not provide conservation objectives for the qualifying habitats and species they list; however, conservation objectives for the European interest features of the North Norfolk Coast SSSI have been made available (Peter Lambley, English Nature, pers comm.).

The conservation objectives have been used to assess the significance of potential effects of the proposed Sheringham Shoal wind farm on the Wash and North Norfolk Coast European Marine Site and the North Norfolk Coast SAC.

27.2.1 Levels of consideration leading to Appropriate Assessment

English Nature (1999) describes the key steps in deciding whether an Appropriate Assessment is necessary. These are set out at three levels: Preliminary Consideration, Fuller Consideration, and Appropriate Assessment. Initially, it should be determined whether the qualifying feature is likely to be affected either directly or indirectly by the plan or project. If a significant effect is considered likely, fuller consideration using further analysis and information is required to justify that conclusion. If a likely significant effect can be justified as a result, an Appropriate Assessment is required and it is advisable to scope the Appropriate Assessment so that irrelevant factors may be identified and omitted. Similarly, if it is concluded that a significant effect is unlikely, this also requires further analysis and justification before the decision that an Appropriate Assessment is not required can be made.

The relevant Sections of this Environmental Statement have assessed and described the potential impacts and effects that the proposed development could have on the natural environment and resources within the development site boundary and adjacent areas. These provide the preliminary consideration. This Section aims to inform further consideration of the key issues identified in relation to the relevant interest features.

Sections 5 and 0 provide descriptions of the designated sites located in close proximity to the marine and terrestrial components of the proposed development. The Wash and North Norfolk Coast EMS is comprised of the Wash and North Norfolk Coast SAC, Gibraltar Point SPA, the Wash SPA and the North Norfolk Coast SPA. The North Norfolk Coast SAC lies adjacent to the Wash and North Norfolk Coast SAC but does not form part of the EMS. Of these sites, the Wash and North Norfolk Coast SAC, the North Norfolk Coast SPA and the North Norfolk Coast SAC are considered to be the most relevant in respect of the Sheringham Shoal project.

27.3 The Wash and North Norfolk Coast SAC

The Wash and North Norfolk Coast qualifies as a SAC for the following Annex I habitats, as listed in the EU Habitats Directive:

- Large shallow inlets and bays;
- Sandbanks which are slightly covered by seawater all the time (referred to as sub-tidal sandbanks);
- Mudflats and sandflats not covered by seawater at low tide (referred to as inter-tidal mudflats and sandflats);
- Reefs;
- Samphire (glasswort) *Salicornia* spp. and other annuals colonising mud and sand;
- Atlantic salt meadows (*Glauco-Puccinellietalia*);
- Coastal Lagoons; and
- Mediterranean and thermo-Atlantic halophilous scrubs (*Arthrocnemetalia fructicosae*). Referred to as Mediterranean saltmarsh scrubs.

The Wash and North Norfolk Coast also qualifies as a SAC for the following Annex II species, as listed in the EU Habitats Directive:

- Common seal (Phoca vitulina), also known as harbour seal; and
- Otter (Lutra lutra).

27.3.1 The Wash and North Norfolk Coast SAC Interest Features relevant to the proposed development

This section describes and explains the importance of each of the SAC interest features (habitats and species) of the Wash and North Norfolk SAC relevant to the proposed development. Each interest feature is subsequently considered in terms of Appropriate Assessment, unless otherwise stated.

27.3.1.1 Large shallow inlets and bays

Large shallow inlets and bays are large indentations of the coast which are generally more sheltered from wave action than the open coast. They are relatively shallow and usually average less than 30m in depth. They form complex systems inter-linking the terrestrial and aquatic environments and are composed of an interdependent mosaic of sub-tidal, inter-tidal and surrounding terrestrial habitats. The Wash is the largest embayment in the UK, and is connected via sediment transfer systems to the north Norfolk Coast. Together, the Wash and north Norfolk Coast form one of the most important sedimentary marine areas in the UK and European North Sea coast and include extensive areas of varying, but particularly sandy sediments subject to a range of conditions.

Consultation with English Nature (pers. comm. Ian Reach) has concluded that as The Wash is distant from the Sheringham Shoal site boundary, and the development is unlikely to have an effect upon it. Further consideration of effects on large shallow inlets and bays is not therefore required for the purpose of Appropriate Assessment.

27.3.1.2 Sandbanks which are slightly covered by seawater all the time

The habitat consists of soft sediment types that are permanently covered by shallow sea water, typically at depths of less than 20m below chart datum. The diversity and types of community associated with this habitat are determined by sediment type and a variety of other physical factors including geographical location, the relative exposure of the coast, and differences in the depth, turbidity and salinity of the surrounding water.

The shallow sandy sediments are typically colonised by a burrowing fauna of worms, crustaceans, bivalve molluscs and echinoderms. Where coarse stable material is present epifaunal attached species may include foliose algae, hydroids, bryozoans and ascidians.

Mixtures of sand and associated hard substrate can lead to the presence of very rich communities. Mobile fauna at the surface of the sandbank may include shrimps, prosobranch molluscs, crabs and fish. Sandeels, an important food for seabirds, live in shallow sandy sediments and may be important nursery areas for fish: the sublittoral sandbanks also provide important nursery grounds for young commercial fish species, including plaice, cod and sole.

In the Wash and North Norfolk coast SAC, sandy sediments occupy most of the sub-tidal area, resulting in one of the largest expanses of this habitat type in the UK. It provides a representative example of this habitat type on the more sheltered east coast of England. The sub-tidal sandbanks vary in composition and include coarse sand such as that found in the vicinity of the proposed development and along the north Norfolk Coast through to mixed sediments at the mouth of The Wash outside the current area of assessment. Sub-tidal communities present include large areas of dense brittle star *Ophiothrix fragilis* beds. Species include polychaetes such as the sand mason *Lanice conchilega* and the bivalve tellin *Angulus tenuis*. Key sub-features comprise gravel and sand communities and muddy sand communities. In general this composition is reflected in the results of the surveys described in Section 9: Marine Ecology, and Section 10: Natural Fisheries.

27.3.1.3 Mudflats and sandflats not covered by seawater at low tide

Inter-tidal mudflats and sandflats are submerged at high tide and exposed at low tide. They form a major component of estuaries and embayments in the UK but also occur along the open coast such as that found in the vicinity of the Sheringham shoal and the export cable route to shore where the physical structure of the intertidal is characterised by the mobile, coarse sand beaches typical of wave-exposed coasts. This habitat type can be divided into three broad categories: clean sands, muddy sands and muds, although in practice there is a continuous gradient between them.

Muddy sands tend to occur at the mouths of estuaries or behind barrier islands, where sediment conditions are more stable. Mudflats form in the most sheltered areas of the coast, usually where large quantities of silt derived from rivers are deposited in estuaries. The sediment is stable and communities are dominated by polychaete worms and bivalve molluscs. The high biomass of intertidal species in such sediments provide important feeding areas for waders and wildfowl. Clean sand communities occur at mid- to low-tide levels on beaches on the open coast and in bays around the UK where wave action or strong tidal streams prevent the deposition of finer silt or where the supply of silt in suspension is low.

Along the north Norfolk coast, sandy intertidal flats predominate, with some soft mudflats, in the areas sheltered by barrier beaches and islands. The biota includes large numbers of polychaetes, bivalves and crustaceans.

Inter-tidal sand and gravel communities found along the north Norfolk coast are found in the more wave exposed areas. Such communities are characterised by species of burrowing amphipods and some polychaete worms that are able to tolerate the abrasive action of the mobile coarse sediment. These communities are particularly widespread on the north Norfolk coast and make up some 40% of the intertidal area. Where the sediment consists of medium to fine-grained sand, which remains damp throughout the tidal cycle, amphipods and polychaetes increase in abundance and diversity and bivalves may be present. These richer amphipod and polychaete dominated communities are found in the mid and lower shore. Such communities form important feeding areas for birds.

On the north Norfolk coast, the sand mason worm forms dense raised mounds which have not been recorded from other sites. They have an important role in stabilising the sediment and providing crevices and attachment points for a range of other species, thereby increasing the diversity of otherwise fairly barren coarse sandy sediments. The species richness associated with these *Lanice* mounds provide a favoured feeding area for birds and a settlement site for mussel seed. Once formed into extensive mounds the *Lanice* mounds are relatively stable and may provide a useful indicator for monitoring the condition of the intertidal sandflats.

In less exposed areas, muddy sand communities occur on flats that remain water-saturated throughout the tidal cycle; however, they are found more frequently in the relatively sheltered areas of the Wash than the exposed reaches of the north Norfolk coast where the communities of coarser sands and gravel predominate.

27.3.1.4 Reefs

Mixed sediments (mixed muds, sands, gravels with shells and stones) constitute a key component of the Wash and the surrounding coastal areas. This substratum provides a relatively stable surface upon which species can settle and further stabilise the seabed.

Sabellaria spinulosa is relatively common over a wide area extending from the Wash along the north Norfolk coast. It is a tube dwelling polychaete worm that forms colonies from tubes formed from sand grains. Further details on its ecology and habit are provided in Section 9: Marine Ecology, and are summarised below.

Sabellaria spinulosa often forms crusts on sand influenced rocks in inshore waters along this stretch of coastline. In the mouth of the Wash, significant accumulations of this species are present such that they form reefs which stand proud of the seabed extending for hundreds of metres; however, the extent of reef habitat has been shown to diminish outside the Wash and its approach channel (see: Section 9: Marine Ecology). The Wash is particularly important as it is currently the only known location of well developed stable *S. spinulosa* reef in the UK. The reefs are also particularly important components of the sub-tidal as they support highly diverse communities compared with the surrounding areas. A large number of mobile species including other polychaetes, shrimps, and crabs are also associated with the *Sabellaria* reef. It is considered that the *S.spinulosa* is an important food source for the commercially exploited pink shrimp, *Pandalus montagui*.

Other areas of mixed sediment within the Wash are dominated by abundant, but low incrustations of *S. spinulosa*. These are often associated with the sand mason worm *Lanice conchilega* and a wide variety of epifaunal species.

27.3.1.5 Samphire (glasswort) and other annuals colonising mud and sand

The feature described as glasswort, (*Salicornia* spp.) and other annuals covering sand and mud is generally termed pioneer saltmarsh. This is composed of a small number of species of which glasswort (also known as samphire) is the most important. In north Norfolk it often grows on sandier substrates both in sheltered situations behind barrier beaches and islands, as at Scolt Head Island and in Blakeney Harbour, but also in more exposed situations as between Wells and Blakeney. In north Norfolk it covers about 216 ha of the estimated 2127 ha. of saltmarsh between Holme and Blakeney Point (Burd, 1989).

27.3.1.6 Atlantic salt meadows (Lower, middle and upper saltmarsh)

In north Norfolk, saltmarshes form an almost continuous belt over 35km long covering about 2200 ha, of which at least 1600 ha can be considered as Atlantic salt meadow (Burd, 1989). The marshes are mostly accreting slowly with some localised areas of erosion as a result of changes in wave climate. Some of the north Norfolk saltmarshes are more than 6000 years old and are therefore more mature than others in eastern England. Saltmarshes of north Norfolk are some of the most botanically rich in Britain and contrast markedly with the grass dominated marshes of The Wash.

The slow rate of vertical accretion and lack of successional changes in north Norfolk mean that plant communities have a high degree of stability. There is now almost no grazing which has maintained species diversity and there are now transitions to Mediterranean scrubs. In places where freshwater springs and seepages occur, notably at Brancaster and Titchwell, a tidal reed swamp community occurs with reed and associated species such as sea purslane and sea aster.

The saltmarshes associated with the barrier islands of north Norfolk e.g. Scolt Head Island, include a range of habitat types, which support transitions from upper salt meadows with sea rush *Juncus maritimus* to terrestrial habitats, occurring in association with a complete range of saltmarsh and other habitats.

27.3.1.7 Coastal lagoons

Coastal lagoons are areas of shallow, coastal salt water, wholly or partially separated from the sea by sandbanks, shingle or, less frequently, rocks. Lagoons show a wide range of geographical and ecological variation; five main sub-types have been identified in the UK, on the basis of their physiography, as meeting the definition of the Annex I habitat type. Of these types, a number of small percolation lagoons are represented along the north Norfolk Coast.

Percolation lagoons are normally separated from the sea by shingle banks. Seawater enters by percolating through the shingle or occasionally by over-topping the bank (e.g. in storms). The water level shows some variation with tidal changes, and salinity may vary. Since percolation lagoons are normally formed by natural processes of sediment transport, they are relatively transient features, which may be eroded and swept away over a period of years or decades or may become infilled by movement of the shingle bank.

The most notable of the lagoons are Blakeney Spit Pools, a lagoon system of six small pools between a shingle ridge and saltmarsh. The bottom of each pool is shingle overlain by soft mud. The fauna of the lagoons includes a nationally rare species, the lagoonal mysid shrimp *Paramysis nouveli*.

27.3.1.8 Mediterranean saltmarsh scrubs

In the EC this habitat is restricted to France, Greece, Italy, Portugal, Spain and the UK. In the UK it is restricted to the south and east coasts of England. Only three localities are known to support extensive examples of this habitat type, and these have been selected as SACs. In strandline situations the community consists largely of bushes of shrubby seablite *Suaeda vera* and sea purslane. However, particularly where the shingle- saltmarsh transition is flatter nationally rare species such as matted sea lavender, *Limonium bellidifolium*, rock sea lavender, *L. binervosum*, sea heath *Frankenia laevis* and the lichen *Xanthoria parietina* form a very characteristic community.

27.3.1.9 Common seals (Harbour Seals)

The Wash and North Norfolk Coast SAC holds some 9% of the total UK common seal population and is the largest colony of common seals in the UK. The extensive intertidal mud and sand flats of the Wash and the north Norfolk coast provide ideal conditions for breeding and haul-out sites of the common seal (Brown *et al*., 1997) and between 20% to 30% of the local population haul out at Blakeney Point approximately 25km west of the proposed cable route (see Section 11: Marine Mammals). The subtidal sandbanks provide important feeding areas for the seals during the summer breeding and moulting season when they tend to forage within a few kilometres off the haul-out sites (Thompson, 1993). Common seals are known to be opportunistic feeders, preferring relatively distinct feeding habitats rather than specific prey species (English Nature, 2000).

English Nature's site specific conservation objectives at a site level focus on maintaining the condition of the habitats used by the qualifying species. Habitat condition in this case will be delivered through appropriate site management, including the avoidance of damaging disturbance. However, in reporting on favourable conservation status, account will need to be taken both of habitat condition and the status of common seals in the SAC.

Accordingly, English Nature uses annual counts for the common seals, together with available information on population and distribution trends, to assess whether the SAC is continuing to make an appropriate contribution to the favourable conservation status of the species.

In addition to focussing on avoiding deterioration to the habitats (and populations) of the qualifying species, the Habitats Directive also requires that actions are taken to avoid significant disturbance to the species for which the site was designated. Such disturbance (e.g. from construction activities that produce underwater noise, or from operational sources such as EM-Fields) may cause alterations in population trends and/or distribution patterns.

27.4 North Norfolk Coast SAC

The North Norfolk Coast SAC qualifies as a SAC for the following Annex I habitats, as listed in the EU Habitats Directive;

- Coastal lagoons;
- Perennial vegetation of stony banks (coastal shingle vegetation);
- Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*);
- Embryonic shifting dunes;
- Shifting dunes along the shoreline with *Ammophila arenaria* (`white dunes`);
- Fixed dunes with herbaceous vegetation (`grey dunes`); and
- Humid dune slacks.

The North Norfolk Coast also qualifies as a SAC for the following Annex II species, as listed in the EU Habitats Directive:

- Otter (Lutra lutra); and
- Petalwort (Petalophyllum ralfsii).

27.4.1 North Norfolk Coast SAC Interest Features relevant to the proposed development

27.4.1.1 Coastal lagoons

See description of coastal lagoons in section 27.3.1.7

27.4.1.2 Perennial vegetation of stony banks (coastal shingle vegetation)

The north Norfolk coast provides the only classic British example of a barrier beach system where extensive areas of saltmarsh have developed behind sand and shingle bars. Scrub vegetation often forms an important feature of the upper saltmarshes, and extensive examples occur where the drift line slopes gradually providing a transition to dune and shingle. In strandline situations the plant community consists largely of bushes of shrubby seablite *Suaeda vera* and sea purslane *Atriplex portulacoides*. However, particularly where the shingle- saltmarsh transition is flatter, nationally rare species such as matted sea lavender, *Limonium bellidifolium*, rock sea lavender, *L. binervosum*, sea heath *Frankenia laevis* and the lichen *Xanthoria parietina* form a very characteristic community.

27.4.1.3 Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)

The north Norfolk coast, together with the Wash and north Norfolk coast, comprises the only area in the UK where all the more typically Mediterranean species that characterise Mediterranean and thermo-Atlantic halophilous scrubs occur together. The vegetation is dominated by a shrubby cover up to 40cm high of scattered bushes of shrubby sea-blite *Suaeda vera* and sea-purslane *Atriplex portulacoides*, with a patchy cover of herbaceous plants and bryophytes. This scrub vegetation often forms an important feature of the upper saltmarshes, and extensive examples occur where the drift-line slopes gradually and provides a transition to dune, shingle or reclaimed sections of the coast. At a number of locations on this coast perennial glasswort *Sarcocornia perennis* forms an open mosaic with other species at the lower limit of the sea-purslane community.

27.5 North Norfolk Coast SPA

The North Norfolk Coast SPA qualifies under Article 4.1 of the EU Birds Directive by supporting:

- Internationally important populations of a regularly occurring Annex 1 species.

It also qualifies under Article 4.2 of the EU Birds Directive in that it supports:

- Internationally important assemblage of waterfowl and seabirds; and
- Internationally important populations of regularly occurring migratory species.

The qualifying species as given in the North Norfolk SPA citation (1989) are listed in Section 8: Ornithology together with relevant population data.

27.5.1 Interest Features of the North Norfolk Coast SPA relevant to the proposed development

The North Norfolk Coast SPA is among the ten most important wetland sites in Britain for numbers of waterfowl and the most important for numbers of wildfowl. A complex barrier dune system protects remote, extensive and varied tracts of saltmarsh which, together with shallow seas and large areas of intertidal mud and sand, support a rich invertebrate fauna, which in turn supports internationally important bird assemblages throughout the year. At several locations there are interlocking complexes of grazing marsh, reedbed and lagoons that are also vital to these key bird assemblages.

English Nature (2000) combines the description of the internationally important assemblage of waterfowl and seabirds with that of internationally important populations of regularly occurring migratory species. This format is followed here providing the two category descriptions below.

27.5.1.1 Internationally important populations of the regularly occurring Annex 1 species

The north Norfolk coast is of importance for internationally important breeding populations of marsh harrier, *Circus aeruginosus*, Montagu’s harrier, *Circus pygargus*, avocet *Recurvirostra avosetta*, sandwich tern, *Sterna sandvicensis*, common tern *Sterna hirundo* and little tern *Sterna albifrons*.

The shallow waters in and around the complex series of harbours and inlets of the north Norfolk coast support large populations of small fish such as sandeels and sprats. These populations of small fish represent a vital food resource for the breeding tern populations and are necessary to ensure breeding success.

Intertidal mud and sand habitats support high densities of invertebrates and are an important feeding habitat for the internationally important population of breeding Avocet.

The large tracts of saltmarsh along the north Norfolk coast are an important feeding habitat for the internationally important breeding population of marsh harriers that nest in adjacent freshwater reedbeds. Principal prey species are the breeding populations of skylark and meadow pipit as well as large post-breeding flocks of juvenile starlings.

The sparsely vegetated or unvegetated sand and shingle spits, bars and beaches are important nesting areas for all the breeding tern species. The most important locations are Scolt Head Island and Blakeney Point, approximately 30km and 12.5km west of the cable landfall at Weybourne Hope respectively.

27.5.1.2 Internationally important assemblage of non-breeding waterfowl including regularly occurring migratory species

The assemblage is defined as comprising of regularly occurring migratory species of waterfowl present in internationally important numbers together with any additional waterfowl species present in nationally important numbers. Qualifying species are as listed in Section 8: Ornithology.

The large areas of both inter-tidal mud and sand and saltmarsh on the north Norfolk coast support high densities of marine invertebrates which in turn provide a food source for exceptional numbers of non-breeding waterfowl. Large waterfowl populations are particularly vulnerable to disturbance in both feeding and roosting areas. Excessive disturbance can result in reduced food intake and/or increased energy expenditure.

Inter-tidal mud and sand habitats support high densities of invertebrates such as cockles and mud snails, *Hydrobia ulvae,* and the very high biomass of a variety of such species enables the site to support high populations of wading birds and wildfowl throughout the year. In addition, the remote and undisturbed nature of these habitats provide secure roost sites for internationally important numbers of pink-footed geese, *Anser brachyrhynchus,* and dark-bellied brent geese, *Branta bernicula bernicla*.

The large areas of saltmarsh in the North Norfolk Coast SPA provide important feeding, roosting and breeding habitat for many of the bird species for which the site is important.

Vegetation height and the species composition of the sward combine to provide a rich feeding habitat for species such as bewick goose, *Branta bernicla* and wigeon, *Anas penelope*.

Some wading birds, especially redshank, *Tringa totanus*, feed extensively on saltmarsh invertebrates. Higher areas of saltmarsh provide important height tide roost sites.

Sand and shingle spits, bars and beaches occur at a variety of locations on the north Norfolk coast. These provide vital high tide roost sites for important populations of wading birds including species such as oystercatcher, *Haematopus ostralegus,* and ringed plover, *Charadrius hiaticula*. Additionally, on the highest tides, a significant part of the internationally important wader populations from The Wash SPA use the sand and shingle habitats at Holme, Thornham and Titchwell as a high tide roost - the main species involved are grey plover, *Pluvialis squatarola*, knot, *Calidris canutus*, and bar-tailed godwit, *Limosa lapponica*. Holme, Thornham and Titchwell lie between 30km and 40km west of the cable landfall at Weybourne Hope.

27.6 Conservation objectives for the relevant SAC and SPA interest features

The conservation objectives for the Wash and North Norfolk Coast European Marine Site relevant to the proposed development at Sheringham Shoal are provided below and should be read in the context of other information given in this Environmental Statement, particularly Section 8: Ornithology; Section 9: Marine Ecology; and Section 10: Natural Fisheries. The favourable condition tables presented in the Regulation 33(2) Advice (English Nature, 2000) provide information on favourable condition for each of the features of relevance set out below.

As the North Norfolk Coast SAC does not form part of the European Marine Site, conservation objectives for its qualifying features are not published in English Nature (2000); however, conservation objectives for the European interest features in the North Norfolk Coast SSSI have been made available (Peter Lambley, English Nature, Pers. Comm.).

The conservation objective for **Sandbanks which are slightly covered by seawater all the time** is, subject to natural change, maintain the sandbanks which are slightly covered by seawater all the time in favourable condition, in particular:

- Gravel and sand communities; and
- Muddy sand communities.

The conservation objective for the **mudflats and sandflats not covered by seawater at low tide** is, subject to natural change, maintain the mudflats and sandflats not covered by seawater at low tide in favourable condition, in particular:

- Sand and gravel communities;
- Muddy sand communities; and
- Mud communities.

The conservation objective for the **reefs** interest feature of relevance; *Sabellaria spinulosa* reef; is, subject to natural change, to maintain subtidal mixed sediment communities in favourable condition i.e. subject to natural change, the extent, distribution and species composition of *S. spinulosa* reef should not deviate significantly from an established baseline. Any significant change in extent or species composition may indicate changes in siltation.

The conservation objective for **Glasswort and other annuals colonising mud and sand** is, subject to natural change, maintain Glasswort and other annuals colonising mud and sand in favourable condition, in particular:

- Annual Salicornia saltmarsh community;
- Annual seablite, Suaeda maritime, saltmarsh community; and
- Ephemeral saltmarsh vegetation with Sagina maritima saltmarsh community.

The conservation objective for **Atlantic salt meadows** is, subject to natural change, maintain Atlantic salt meadows in favourable condition, in particular:

- Low marsh and low-mid marsh communities; and
- Mid and mid-upper marsh communities.

The conservation objective for **Coastal lagoons** is not published in the Regulation 33(2) advice (English Nature, 2000) as the document has not been updated since its initial publication, since which time coastal lagoons have been added to the designation. However, the conservation objectives for the European interest features in the North Norfolk Coast SSSI, including those for coastal lagoons, have been made available by English Nature. That is, the conservation objective for **all the European interest features** of the North Norfolk Coast SSSI (including Coastal lagoons) is, subject to natural change, to maintain each in favourable condition.

In addition, the views about management (VAM) for the North Norfolk Coast SSSI published by English Nature (English Nature, 2005c) clearly indicate that maintaining salinity and water depths are a key management priority for the purpose of maintaining or achieving favourable condition. This is particularly relevant where the management of coastal processes occurs, e.g. the shingle ridge in front of the lagoons is being actively managed by the Environment Agency as part of its programme of coastal defence work.

The conservation objective for **Mediterranean saltmarsh scrubs** is, subject to natural change, maintain Mediterranean saltmarsh scrubs in favourable condition, in particular:

- shrubby seablite (Suaeda vera) saltmarsh community;

- shrubby seablite (Suaeda vera) and Limonium binervosum saltmarsh community; and
- transitional communities.

The conservation objective for **Common seals** is, subject to natural change, maintain in favourable condition the habitats of Common seals, in particular:

- Intertidal mudflats and sandflats.

The **North Norfolk Coast SPA** has two conservation objectives. First, subject to natural change, maintain in favourable condition the habitats of the internationally important populations of regularly occurring Annex 1 bird species, under the EU Birds Directive, with particular reference to:

- Coastal waters;
- Intertidal mud and sand;
- Saltmarsh;
- Sand and shingle; and
- Tidal reedbed.

Second, subject to natural change, to maintain in favourable condition the habitats of the internationally important assemblage of over 20,000 waterfowl including the internationally important populations of regularly occurring migratory bird species, under the EU Birds Directive, with particular reference to:

- Intertidal mud and sand;
- Saltmarsh; and
- Sand and shingle.

In the absence of published conservation objectives for the relevant qualifying features of the **North Norfolk Coast SAC**, conservation objectives developed for the European interest features in the North Norfolk Coast SSSI (Peter Lambley, English Nature, pers. comm.) state that, subject to natural change, maintain in favourable condition the following features:

- Coastal lagoons;
- Mediterranean and thermo-Atlantic halophilus scrubs (Sarcocornetea fructosi); and
- Perennial vegetation of stony banks (vegetated shingle).

Reference is also made to the conservation objective of the North Norfolk Coast SPA for shingle habitats above.

27.7 Favourable Condition and Appropriate Assessment

Favourable condition tables are supplied as an integral part of English Nature's Regulation 33 advice package (English Nature, 2000). They are intended to supplement the conservation objectives only in relation to the management of established and ongoing activities and with respect to future reporting requirements on monitoring the condition of the site and its features. The tables do not provide a comprehensive basis for assessing plans and projects as required under Regulations 20 and 48-50, but they do provide a basis to inform the scope and nature of any Appropriate Assessment that may be needed. English Nature considers that other data outside those recorded during its own condition monitoring programme, such as results from dedicated surveys and compliance monitoring of plans and projects, will also play an important role in assessing the condition of interest features.

27.8 Potential impacts on the interest features of the European Sites

27.8.1 Impacts during construction

The following impacts have been identified as having the potential to have significant effects during construction upon marine (sub-tidal) and coastal (intertidal and terrestrial) receptors:

- Disturbance and displacement of habitats and species from underwater piling noise;
- Re-suspension of sediments and potential smothering or displacement of habitats and species from cable laying and associated activities;
- Temporary habitat loss from cable installation across the seabed and the shingle beach; and
- Potential displacement of Annex 1 tern species, Sterna spp., from feeding grounds north east of the Sheringham Shoal offshore wind farm during the breeding season.

27.8.1.1 Underwater noise during construction

Common seals are interest features of the Wash and North Norfolk Coast EMS. Their description and impact assessments relevant to the construction, operation and decommissioning of the Sheringham Shoal offshore wind farm are included, together with an assessment of cumulative impacts in Section 11: Marine Mammals. Otters are also an interest feature however there are no otters within the study area relating to the onshore works. The predicted effects of underwater noise from construction activities on the common seals interest feature are detailed below.

The worst realistic case in terms of the production of underwater noise from piling operations would be the installation of 108 monopile foundations for 3MW turbines. The installation of turbines larger than 3MW would reduce the number of turbines required and hence, fewer foundations would be installed.

The effects of underwater noise on sensitive marine receptors are becoming better understood through industry funded research administered through COWRIE. Lethal and sub-lethal effects on fish are now well documented (see Section 10.4.) and the effects of noise on sea mammals (pinnepeds and cetaceans) is also the topic of research (see Section 11.4). Of direct relevance to this assessment is the potential of construction noise to affect the local seal population. English Nature (2000) indicates that between 500 and 750 common seals, *Phoca vitulina*, use Blakeney Point as a haul out site during the August moult.

English Nature's conservation objectives at site level focus on maintaining the habitats used by the qualifying species. Habitat condition is delivered through appropriate site management including the avoidance of damaging disturbance. In reporting favourable condition status, account needs to be taken both of habitat condition and the status (counts) of common seals in the SAC. The Sheringham Shoal project would not have any effect on the habitats used as haul out sites by the common seal population; in particular, Blakeney Point, which is approximately 30km from the wind farm. Underwater noise could however, have an effect on individuals foraging outside the SAC boundary as individual foraging ranges can extend to distances up to 120km from haul out areas (Sharples and Hammond, 2004).

A study was undertaken on the movements of seals before and during the construction of the Horns Rev wind farm in Denmark by Tougaard *et al*. (2003b) with the use of satellite tracking. Although no clear conclusion could be drawn from the collected data, it was observed that tagged seals moved in close proximity to the Horns Rev site during the construction period. This suggests that construction operations (and hence underwater noise) did not have any large-scale influence on the seals in the area.

Mitigation for the potential effects of underwater noise on common seals (and other marine mammals) is presented in Section 11.4.1: Impacts due to noise. This includes soft start procedures, audible warning before the onset of piling operations via acoustic harassment devices (AHDs), and reduction of noise at source through the use of bubble curtains, trees, muffling of the hammer and use of a vibrating hammer head, for example.

In addition, due to recent discussions between English Nature, the JNCC and the wind farm developers in the Thames SEA area, regarding potential impacts on marine mammals, Scira will consider the need to undertake further survey or monitoring if the results and recommendations of studies being commissioned in the Thames are shown to be relevant to the Sheringham Shoal site. Until the results are published, the significance of the potential effect of underwater noise on common seals remains uncertain. Dialogue with JNCC, English Nature and other regulators will continue during the interim period.

27.8.1.2 Re-suspension of sediments from cabling and foundation installation at the wind farm site

Based on the conclusions presented in Section 6, Hydrodynamics and Geomorphology, the sediment distribution of the unconsolidated surface layer in large parts of the area affected by the cabling is predominantly gravely sand with a small amount of silt. Grab samples and borehole samples obtained from recent survey work indicate the silt content of the surface layer to be below 4%. The depth of the surface layer varies from 0m to about 1m, apart from the areas of sand waves and banks where depths are much greater.

The high sand/gravel content of the in situ sediment, together with the relatively small disturbance arising from cable ploughing or trenching to 1m depth, suggests that for most of the cable route the majority of any disturbed sediment will fall immediately to the bed in the immediate location of the cable. The vast majority of the disturbed sediment will initially resettle within 20m of the cable, with almost no sand being carried more than 100m from the cable except as part of natural sediment transport. As there is already significant ambient sand transport in the vicinity, the small amounts of additional resettled sand would not change the local sediment transport patterns to any significant degree. The turbine array, the associated inter-connector cabling and the ground preparation for foundations is situated approximately 8km from the Wash and North Norfolk Coast EMS boundary at its closest point and, given the above, no significant impact from the re-suspension of sediments from cabling and foundation installation at the wind farm site on the interest features of the EMS is considered likely.

27.8.1.3 Re-suspension of sediments from the installation of the Export cables

The wind farm’s power output would be transmitted from the offshore substation(s) via two export cables to landfall in the vicinity of Weybourne Hope. The two marine export cables are anticipated to be installed 100m apart over the majority of the cable route to shore at a depth between approximately 0.5m to 3m, depending on ground conditions.

Two cable route options are currently being considered, namely:

- A preferred direct route from the wind farm to landfall crossing Sheringham Shoal (approximately 21km) approaching within approximately 700m of the EMS eastern boundary; and
- An alternative western route avoiding Sheringham Shoal (approximately 22km) located on the periphery of the north eastern boundary of the EMS.

The direct and preferred export cable route avoids the Wash and North Norfolk Coast EMS boundary and is governed by the outcrop at the seabed of ‘softer’ geological formations (such as the Weybourne Channel) to allow easier burial and avoidance of chalk substrate. The direct route is preferred because of its shorter length and because there would be no need to cross the Wash and North Norfolk Coast EMS boundary. Latest information from English Nature indicates that the Sheringham Shoal is not on the shortlist of sites to be put forward to the European Commission for potential designation as an SAC (see Section 5: Nature Conservation Designations).

Between the Sheringham Shoal and the wind farm site, the preferred cable route is positioned to cross predominantly glacial till at surface whereas south of Sheringham Shoal it crosses heterogeneous tills, sands and clays. Closer to shore the cable route follows the outcrop of the Weybourne Channel sand and gravel deposits that are overlain by silt and sand. These are likely to extend to the coast in the vicinity of Weybourne Hope; however, chalk is encountered for approximately 1.6km south of the Sheringham Shoal. This route was dictated by the extent and orientation of the chalk outcrop (Royal Haskoning, 2005), but the chalk may be covered by recent sediments or a sand/gravel lag up to 2m thick (see Figure 2.19).

When approximately 1km from shore, the cable route is approximately 700m from the EMS boundary. It is during this section of the traverse that chalk at or near the surface of the seabed is most likely to be encountered, and when chalk fines are most likely to enter suspension in the water column. (The underlying chalk is buried approximately 10m beneath the surface within the turbine array and does not become exposed until approximately 7km further south (approximately 1.6km south of the Sheringham Shoal)).

The alternative western export cable route passes around the western end of the Sheringham Shoal joining the preferred route at a point further south (see Figure 2.19). This crosses the boundary of the Wash and North Norfolk Coast EMS at its north eastern extent i.e. the junction between the eastern and northern EMS boundary approximately 10km from shore.

South of the Sheringham Shoal and approximately 8km from shore, the two export cable route options merge at a point approximately 2km east of the Wash and North Norfolk Coast EMS boundary and travel southward to landfall on Weybourne Hope.

For the alternative route, a temporary construction corridor of approximately 1200m would be required to facilitate cabling operations, and this would impinge further into the EMS boundary, although it is expected that disturbance of sediments (and habitats) in the corridor would be minimal being used only for placement of the anchor arrays which the cable laying barge vessel uses to pull itself along. In order to minimise sediment seabed disturbance the cable plough method of installation is likely to be used, although a final decision has not yet been made.

The rate at which the cables would be buried is dependant on seabed formations, geology, tidal currents and weather; however, it is anticipated that each cable would take a minimum of 13 days to install. There would be no cable crossing requirements.

Section 6: Hydrodynamics and Geomorphology indicates that chalk fines in suspension would be most likely to remain in suspension for the longest period and be carried furthest from the source. These could impact upon shellfisheries and the benthic ecology of the sand and gravel key sub-features of the Wash and North Norfolk Coast EMS should plume dispersion extend over a wide area. The results for ploughing chalk during a neap tide show the dispersion footprint would extend for around 9km in each direction, with concentrations dropping to levels of less than 1mg/l (above background) within a single flood or ebb excursion. The higher turbulence spring tide simulation predicted that the chalk concentrations would drop below 1mg/l (above background) within 4km of the cable route.

The worse case scenario is considered to be the dispersion of chalk during trenching on a neap tide. The volume of material released by trenching is higher than other methods, and therefore the extent and persistence of concentrations above 1mg/l (above background) is much greater. The predicted plume would extend more than 10km in either direction at a level of up to 20mg/l (above background). It should be noted that the model predicted a gradual drift of the plume towards the shore over six tides, but the plume dispersed to less than 1mg/l concentration above background before the end of the model run (see Appendix 6.2).

The footprint of silt deposition was found to extend over a wide area, but at an undetectable rate. Even under slack water conditions, the maximum rate of deposition over the six tide simulation was less than 0.5mm in the areas of greatest deposition, and in most of the footprint area the rate was far less. Furthermore, the deposited fines will be re-suspended on each tide, with no measurable material left in place.

From this, it is concluded that effects on the relevant interest features of the Wash and North Norfolk Coast EMS (i.e. sandbanks that are slightly covered by seawater all the time and sandflats not covered by seawater at low tide) and the sand and gravel community key sub features they contain would not be affected by the re-suspension of sediments from cabling operations and their subsequent transport and deposition to a significant extent.

27.8.1.4 Temporary marine and terrestrial habitat loss from cable installation

The installation of export cables to shore could temporarily disturb marine sediments and associated habitats and species within the SAC, but only to a very small extent due to the narrow frontage of the eastern SAC boundary that lies parallel to the proposed cable route, see figure 5.3. Overall, the sediment types and communities found within the footprint of the Sheringham Shoal project are considered typical of the wider study area and are consistent with those of studies carried out by Kenny & Rees (1996), Entec (1999), Allen (2000), Lewis *et al.* (2002), Entec, (2003); Sotheran *et al.* (2005) and Proctor *et al.* (2006).

The assemblage is considered to be well adapted to living in a dynamic and periodically disturbed environment, with rapid recovery and recolonisation from adjacent areas. Given this, the impact of the cable installation through the EMS is considered to be short term and not significant in the context of the wider area (see Section 6, Marine Ecology).

Within the wind farm site and preferred direct export cable route, no evidence of biogenic reefs were encountered, suggesting that the *S. spinulosa* in this area forms patchily distributed crusts and has not formed an aggregation that would be classed as being of importance to nature conservation.

Some important terrestrial habitats in the North Norfolk Coast SPA and SAC continue their distribution outside (but adjacent to) the boundary of the European marine site. These are comprised mainly of freshwater habitats and areas of sparsely vegetated or unvegetated sand and shingle above the highest water mark. Vegetated shingle is identified as a habitat of principle importance within PPS9 and ODPM Circular 06/2005 ‘Biodiversity and Geological Conservation – Statutory Obligations and their Impact within the Planning System’.

At landfall, the cable route would be ducted under the shingle beach of Weybourne Hope. The shingle beach is indicative of the glacial till, coarse gravel and sand sediments found further offshore, but some fragments of Weybourne Hope exhibit vegetation of note such as the yellow horned poppy, *Glaucium flavum.* In places, particularly to the west of the proposed cable landfall works, the shingle is partly vegetated with the SD1 *Rumex crispus – Glaucium flavum* shingle NVC community. To the east of the proposed works the shingle vegetation is far less frequent and in places entirely absent. The community is very open but the most constant component is curled dock (see Section 0: Terrestrial Ecology).

The area immediately behind the shingle beach experiences a small rise in topography (approximately 1m in height). This comprises a heavily rabbit grazed sward that does not constitute a continuation of the north Norfolk saltmarshes, the Atlantic Salt meadows, or the Meditterranean saltmarsh scrubs that qualify as interest features of the Wash and North Norfolk Coast EMS. There are no other sensitive coastal habitats within the study area that could be impacted during the construction phase.

Due to the installation method proposed for the cable landfall, outside the European site boundary, it is not possible for terrestrial areas of the coastal strip above mean high water spring tide level to be damaged or permanently lost.

Therefore, due to the location (i.e. distant from the European site boundary and the position of interest features within it), and limited extent of the proposed onshore works, it is considered that no significant effect would arise due to temporary habitat loss during cable installation.

27.8.2 Impacts during operation and decommissioning

27.8.2.1 Underwater noise during operation

Section 11.5 describes the relevant studies carried out to assess the current understanding of operational noise on common seals. It is thought that seals may be able to detect operational underwater noise from offshore wind farms at a distance of up to 1km. Studies at the Rodsand seal sanctuary, located approximately 4km from the Nysted offshore wind farm, Denmark showed that more seals were present at the sanctuary during wind farm operation than were present before its construction. Ongoing monitoring at both the Nysted and Horns Rev offshore wind farms indicate that there is no obvious adverse effect on common seals during the operational phase. Therefore potential impacts at Sheringham Shoal are not considered to be significant.

27.8.2.2 Underwater noise during decommissioning

Section 11.6 states that the impacts associated with decommissioning of the wind farm on common seals would be similar to those of construction. A detailed Decommissioning Plan would be agreed with the DTI and Crown Estate, prior to commencement of construction and taking into account legislation and guidelines that are expected under the provisions of the Energy Act. It is currently expected that the Decommissioning Plan would include for the complete removal of all offshore structures deployed in the wind farm above the seabed including the complete removal of gravity base structures and the cutting of monopile foundations to an agreed depth beneath the seabed. The Decommissioning Plan would contain detailed and appropriate mitigation measures as agreed with the regulators to ensure the impacts on the common seals are acceptable. On this basis, the impact of underwater noise during decommissioning on the common seals found within the Wash and North Norfolk Coast EMS is not expected to be significant.

27.8.2.3 Impacts of cabling during operation and at decommissioning

There is currently no evidence that common seals are influenced by, or use electric magnetic (EM) fields. The effects of EM-fields on sensitive fish species are the subject of industry and government funded research (see Section 10: Natural Fisheries Resources), but as the Wash and North Norfolk SAC (part of the EMS) is not notified for these species or habitats specific to them, Appropriate Assessment is not applicable.

It is expected that buried cables would not be lifted during decommissioning, but would be left in place and notified to the relevant authorities in line with current practice. Therefore, the marine sand and gravel key sub-features, and the terrestrial interest features, namely the perennial vegetation of stony banks (vegetated shingle), and the shrubby seablite, *Suaeda vera,* key sub-features associated with shingle strandlines would not be adversely affected, by EM-fields during the operational or decommissioning phases.

27.8.2.4 Potential displacement or barrier effect of foraging Annex 1 tern species

The interest features of the North Norfolk Coast SPA include internationally important Annex 1 bird populations namely; sandwich tern, *Sterna sandvicensis*, common tern, *Sterna hirundo* and little tern, *Sterna albifrons*. Effects on breeding success are key attributes of the SPA favourable condition table. Effective management of such impacts is measured by changes in breeding success that are attributable to disturbance or predation. Although breeding success in these terms can be interpreted as the consequence of direct effects on the beach within the SPA, remote and indirect effects may also result in a reduction in breeding success. This could become manifest through the displacement of parent birds from feeding grounds through the turbine array having a barrier effect that could affect the foraging success of adults, thus affecting food supply to chicks.

Results of Horns Rev radar analysis indicated that migrating birds deviated at distances of 1-2 km to avoid the site. It is specifically mentioned that observers saw terns (and Gannets) taking evasive action in this way (Christensen & Hounisen 2004), although Sandwich Terns have also been observed passing through (Christensen *et al.* 2003). Observations from the wind farm at Yttre Strengtund in Sweden showed that both Common and Arctic Terns passed through the site on migration, flying between the turbines without making any deviation (Petterson 2005). Thus, it may be anticipated that preferred flight lines of birds across the site would not be disrupted by the presence of turbines, if suitable corridors between the turbines are available.

The proposed turbines at the Sheringham Shoal wind farm will be positioned between 570m and 1120m apart, depending on turbine size and orientation (bird flight direction). With the 108 x 3 MW layout as the assumed worst case situation for the barrier effect, the minimum distance between turbines is 570m. With a rotor diameter of 90m, this gives a minimum gap of 480m between rotors.

The collated bird data shows a prevailing NE-SW flight direction for both Sandwich Terns and Common Terns (see Section 8, Ornithology), strongly suggesting movement through the site away from, and back to, the colonies in the direction of Dudgeon Shoal.

Even if the preferred flight lines of the terns would be disrupted by the presence of the turbines, relatively small deviations in course by flying birds at some distance from the site would be required to take them past the wind farm. Given that Sandwich terns are capable of routinely flying large distances to foraging grounds, such small deviations are thought unlikely to have any costs to individual fitness and ultimately breeding productivity. The impact of displacement and barrier effect is therefore not predicted to be significant.

27.8.2.5 Other qualifying bird species

Section 8: Ornithology shows that few qualifying wildfowl or waders were encountered during the ornithological assessment. Because of such low encounter rates, the likelihood of any adverse effects upon them is considered very low and not significant**.**

27.9 Implications for Integrity

Table 27.1 includes the relevant parts of the favourable condition tables for the Wash and North Norfolk Coast European Marine Site, including all the sub-features that could be impacted, when the impact could occur, a brief summary of the effect and whether the effect is considered to be significant in terms of Appropriate Assessment.

Table 27.1: Summary of potential impacts on Favourable Condition Targets for the Wash and North Norfolk Coast European Marine Site.

Interest feature	Attribute	Target	Possible Significant Impact	Impact During	Impact Assessment	Significance of effect on site integrity
Reefs	Extent and distribution of CMX.SspiMx biotope (*Sabellaria spinulosa* reef)	Extent and distribution of biotopes should not deviate significantly from an established baseline, subject to natural change.	Changes to characteristic biotopes by deposition of re-suspended sediments leading to significant deviation from the baseline.	Construction	*Sabellaria spinulosa* reef is remote from the wind farm site and cable route. The chalk plume would be retained within the tidal excursion and disperse to 1mg/l above background within 6 tidal cycles (3 days).	Not significant (see **Section 9**)
	Species composition of characteristic biotope CMX.SspiMx (*S.Spinulosa* reef)	Presence and absence of composite species should not deviate significantly from and established baseline, subject to natural change.	Changes to characteristic biotopes by deposition of re-suspended sediments leading to significant deviation from the baseline.	Construction	*Sabellaria spinulosa* reef is remote from the wind farm site and cable route. The chalk plume would be retained within the tidal excursion and disperse to 1mg/l above background within 6 tidal cycles (3 days).	Not significant (see **Section 9**)

Table 27.1: Summary of potential impacts on Favourable Condition Targets for the Wash and North Norfolk Coast European Marine Site.

Interest feature	Attribute	Target	Possible Significant Impact	Impact During	Impact Assessment	Significance of effect on site integrity
Subtidal sandbanks	Sediment character	Average Particle Size Analysis (PSA) parameters should not deviate significantly from an established baseline, subject to natural change.	Deposition of fine re-suspended sediments from foundation preparation and cable installation activities.	Construction	Chalk plume would be retained within the tidal excursion and disperse to 1mg/l above background within 6 tidal cycles (3 days).	Not significant (see **Section 6**)
	Gravel and sand communities	Distribution and extent of characteristic biotopes should not deviate significantly from the baseline, subject to natural change.	Changes to characteristic biotopes by deposition of re-suspended sediments leading to significant deviation from the baseline.	Construction	Cable installation along western route would be short term and footprint minimised.	Not significant (see **Section 9**)
Intertidal mudflats and sandflats	Sand and gravel communities	Distribution and extent of characteristic biotopes should not deviate significantly from an established baseline, subject to natural change.	Changes to characteristic biotopes by deposition of re-suspended sediments leading to significant deviation from the baseline.	Construction	Cable installation along western route would be outside the EMS boundary, of short term and the footprint minimised.	Not significant (see **Section 9**)

Table 27.1: Summary of potential impacts on Favourable Condition Targets for the Wash and North Norfolk Coast European Marine Site.

Interest feature	Attribute	Target	Possible Significant Impact	Impact During	Impact Assessment	Significance of effect on site integrity
Common seals (*Phoca vitulina*)	Disturbance	No significant reduction in numbers or displacement of common seals from an established baseline, subject to natural change	Reduction of numbers of common seals using Blakeney Point as a result of disturbance from underwater noise .	Construction	Soft start procedures during piling combined with AHD warnings and muffling of constriction noise at source.	Not significant (see **Section 11**) Further discussions to take place with English Nature regarding most appropriate mitigation measures.
Internationally important Annex 1 bird populations Sandwich terns (*Sterna sandvicensis*), Common tern (*Sterna hirundo)* and Little tern (*Sterna albifrons*)	Predation and disturbance in nesting areas	No significant reduction in breeding success attributable to human disturbance or predation	Breeding success could be affected by displacement of parent birds from feeding grounds by barrier effect of the turbine array thus affecting food supply to chicks.	Operation	Flight corridors for foraging tern species are incorporated in to the wind farm layouts. (See Section 8.5.3)	Not significant (see **Section 8**)

Table 27.1 shows that the potential effects of the Sheringham Shoal offshore wind farm relate to the North Norfolk Coast SPA and the Wash and North Norfolk Coast SAC interest features such as Annex 1 bird (tern) breeding colonies and the common seals that use Blakeney Point as a haul out site. None of these impacts have been assessed as being significant as part of the EIA process and therefore the issue of 'adverse effect on integrity' should not require further consideration.

27.10 Cumulative and in-combination effects

The potential impacts of the Sheringham Shoal offshore wind farm on the interest features and their conservation objectives within the Wash and North Norfolk Coast European Marine Site are at worst minor in terms of scope and significance. This is due primarily to the distance of the majority of the proposed development from the EMS boundary. The potential impacts in the context of other planned, built or consented wind farms within the Greater Wash strategic development area and other maritime operations such as commercial fisheries (Section 12), shipping and navigation (Section 14) and other human activities (Section 1) are discussed in their respective sections within this Environmental Statement.

English Nature is of the opinion that to a large extent the Wash is remote from the Sheringham Shoal wind farm. Subsequently, consideration of the large shallow inlets and bays interest feature for the purposes of Appropriate Assessment is not required (Ian Reach, English Nature, pers comm.).

The key sub feature of the large shallow inlets and bays interest feature that is classified as mixed subtidal sediment communities includes the *Sabellaria spinulosa* reef (CMX.SspiMx) biotope. Although English Nature has made clear the irrelevance of much of the interest feature to the Sheringham shoal wind farm proposal, it also has made clear the international importance of this biotope within the region. As a result, extensive surveys have been carried out by wind farm developers and marine aggregate companies operating in the Greater Wash.

The results of these surveys have shown that the Sheringham Shoal site is not located within or near to the extent of reef distribution. Although small clumps of *S.spinulosa* were observed in the survey area (see Section 9: Marine Ecology), the overall conclusion is that the Sheringham Shoal wind farm site and cable routes contain no biological communities of conservation interest other than those of coarse and mobile sediments typically found throughout this region.

It is considered unlikely that cumulative or in-combination effects on the interest features of the Wash and North Norfolk Coast EMS could be attributed wholly or partly to the proposed wind farm development at Sheringham Shoal. Cumulative and in combination effects of the Sheringham Shoal wind farm with other wind farms in the area (and other maritime operations) on the interest features of the EMS are not considered to be significant.

Discussions are ongoing with English Nature regarding the effects of construction noise on marine mammals and Scira will consider the potential effects from construction of a number of wind farms at the same time within the Wash SEA area.

27.11 Summary

Overall, the range of potential impacts that the Sheringham Shoal offshore wind farm could have on the Wash and North Norfolk Coast European Marine site is limited given the distance of the wind farm to the EMS boundary and the short term and reversible effects of construction e.g. piling, and cable installation.

Where the potential for a significant impact has been identified in this Environmental Statement, actions have been proposed to mitigate any effects. As a result, no significant impacts on the interest features of any European sites on the north Norfolk coast have been identified as part of this exercise. It is considered that the Sheringham Shoal wind farm, either alone or in combination with other plans or projects (including for example, other wind farms and maritime activities), would not have a significant effect on the interest features for which the component SPAs and SACs of the Wash and North Norfolk Coast EMS were designated. No significant effects are predicted and therefore it is not considered that any further evaluation under the Habitats Regulations is required.

27.12 References

- Brown, A.E., Burn, A.J., Hopkins, J.J., and Way, S.F. (1997). The Habitats Directive: selection of Special Areas of Conservation in the UK. JNCC Report 270.
- Burd, (1989). The saltmarsh survey of Great Britain. Norfolk. Peterborough: Nature Conservancy Council. Research and Survey in Nature Conservation, No.17.
- Christensen, T.K., Hounisen, J.P., Clausayer, I. & Petersen, I. K. (2003). Visual and radar observations of birds in relation to collision risk at the Horns Rev offshore wind farm. Annual Status Report 2003. NERI report commissioned by Elsam Engineering A/S 2003/2004.
- Christensen, T.K. & Hounisen, J.P. (2004). Investigations of migratory birds during operation of Horns Rev offshore wind farm. Annual Status Report 2004. NERI report commissioned by Elsam Engineering A/S 2005.
- EN, SNH, CCW, EHS (DOE(NI)), JNCC & SAMS (2001). European Marine sites – ecological sensitivity and management requirements. Managing activities and impacts within theUK's network of marine Special Areas of Conservation (SACs). English Nature, Peterborough.
- English Nature (1986). North Norfolk Coast Site of Special Scientific Interest (SSSI). Citation notified under Section 28 of the Wildlife and Countryside Act 1981 as amended. 4pp.
- English Nature (1997). The Appropriate Assessment (Regulation 48). The Conservation (Natural Habitats &c.) Regulations, 1994*. Habitats regulations guidance note HRGN 1*. 6pp.
- English Nature (1999). The Determination of Likely Significant effect under The Conservation (Natural Habitats & c.) Regulations 1994. *Habitats regulations guidance note HRGN 3*. 5pp.
- English Nature (2000). English Nature's advice for the Wash and North Norfolk Coast European marine site given under Regulation 33(2) of the Conservation (Natural Habitats &c.) Regulations 1994. 167pp.
- English Nature (2001). Alone or in combination. *Habitats regulations guidance note HRGN 4*. 2pp.
- English Nature (2005a). EC Directive 92/43 on the conservation of Natural Habitats and of Wild Fauna and Flora. Citation for Special Area of Conservation (SAC). The Wash and North Norfolk Coast UK00117075. 2pp.
- English Nature (2005b). EC Directive 92/43 on the conservation of Natural Habitats and of Wild Fauna and Flora. Citation for Special Area of Conservation (SAC). The North Norfolk Coast UK0019838. 2pp.
- English Nature (2005c). Views about management, Countryside and Rights of Way Act 2000, Schedule 11(6). A statement of English Nature's views about the management of North Norfolk Coast site of Special Scientific Intererst (SSSI). 6pp.

- Harris, S, Morris, P, Wray, S & Yalden, D (1995). A review of British mammals: population estimates and conservation status of British mammals other than cetaceans. Joint Nature Conservation Committee, Peterborough.
- Office of the Deputy Prime Minister (2005a). Planning Policy Statement 9: Biodiversity and Geological Conservation. Crown Copyright. 7pp.
- Office of the Deputy Prime Minister (2005b). Biodiversity and Geological conservation - Statutory obligations and their impact within the planning system. ODPM Circular 06/2005, Defra Circular 01/2005. 88pp.
- Pettersson, J. (2005). The impact of offshore wind farms on bird life in Southern Kalmar Sound, Sweden. Report to Swedish Energy Agency.
- Sharples R J and Hammond P S, (2004). Distribution and movements of harbour seals around Orkney, Shetland and the Wash. SCOS Briefing Paper 04/10 on Scientific Advice on Matters related to the Management of Seal populations: 2004, UK Special Committee on Seals, Advice 2004.
- Sotheran, I., Foster-Smith, R., Baxter, L. and Foster-Smith, D. (2005). Acoustic, Video and Grab Survey of Sheringham Shoal Offshore Windfarm. SCIRA-7-4-1-EX-RP-07115-V4. Envision Mapping Ltd. Newcastle upon Tyne, UK.
- Thompson D, Hammond P, and Matthioploulos J., (2005). An investigation of the effects of offshore wind farm developments on harbour seals on the English east coast. Proposal. Sea Mammal Research Unit, University of St Andrews.
- Thompson, (1993). Harbour seal movement patterns. In: I.L. Boyd, ed. Marine Mammals. Advances in behavioural and Population Biology. Symposium of the Zoological Society of London, 66, 225-239. Oxford: Clarendon Press.
- Tougaard J, Ebbesen I, Tougaard S, Jensen T, and Teilmann J, (2003). Satellite tracking of Harbour Seals on Horns Reef. Use of the Horns Reef wind farm area and the North Sea. A report to Techwise A/S, March 2003.

28 Summary

28.1 Introduction

Scira Offshore Energy (Scira) is proposing to construct and operate an offshore wind farm, known as Sheringham Shoal, sited 17km offshore from the coastal town of Sheringham on the north Norfolk Coast. Scira is a project specific company formed by Hydro from Norway, Econcern from the Netherlands and SLP Energy from the UK.

This section provides a summary of the proposed project, the consent requirements and the findings of the Environmental Impact Assessment (EIA) process. Mitigation measures and monitoring proposals that have been committed to by Scira are also provided.

28.2 Project Details

The proposed wind farm would be located approximately 17 to 23km offshore from the north Norfolk coastal town of Sheringham and approximately 5km north of the offshore sand bank known as Sheringham Shoal. The wind farm would comprise between 45 and 108 turbines located in water depths of approximately 15m to 22m at lowest astronomical tide (LAT).

The wind farm turbines would be connected via an inter array network of cables which would link at one or two offshore transformer substations located within the wind farm. From these stations power would be exported via two marine cables which would make landfall in the vicinity of Weybourne Hope on the north Norfolk coast. Two routes for the site to shore export cables are being considered; a preferred direct route which passes directly across Sheringham Shoal and an alternative western route which passes to the west of the shoal.

Onshore, the cables would be connected to a new switch station situated in the grounds of the Muckleburgh Collection, approximately 800m inland. From the switch room a new electrical connection would be required in order to pass electricity into the existing 132kV distribution network and/or 400kV transmission network. This new grid connection (from the switch station to distribution and/or transmission network/s) would be the subject of a separate consent.

Figure 28.1 provides an overview of the project and the key project characteristics are summarised in Table 28.1.

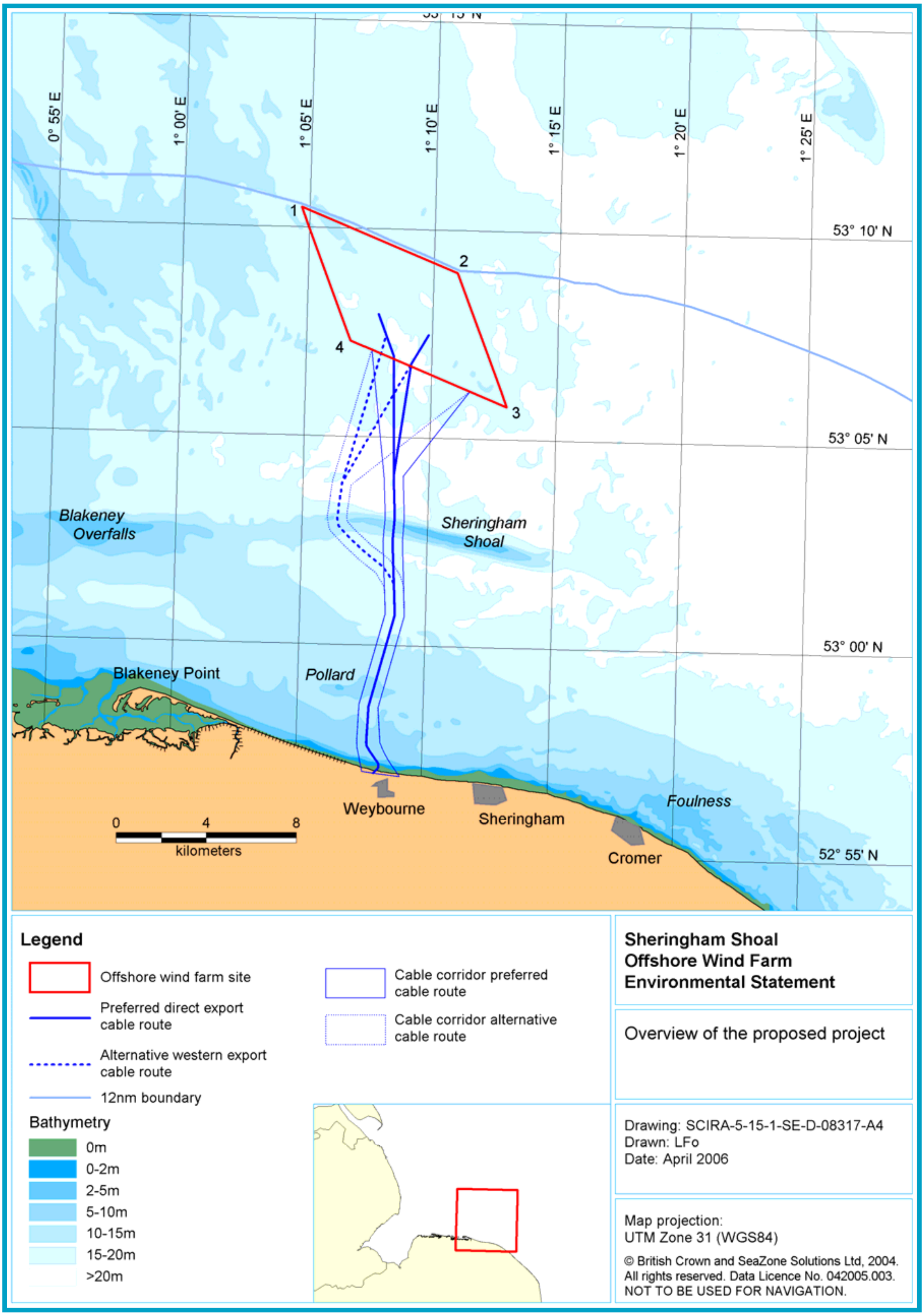


Figure 28.1 Overview of the proposed project.

Table 28.1: Key project characteristics	
Nominal output	240 - 315MW
Min/max number of turbines	45 – 108
Min/max nominal turbine capacity	3 – 7MW
Total area	35sq.km (10sq. n.miles)
Total perimeter	Approx. 24km (13n.miles)
Minimum distance to shore	Approx. 17 km (9n.miles)
Approximate net yield of the wind farm	0.83TWh/yr - Equivalent to about 176,000 households
CO_2 Offset	An estimated 28M tonnes over the 40 years lifetime
Offshore cable length (dependent on final route chosen)	Approx. 21km (preferred direct route) 22km (alternative western route)
Cable burial depths	1-3m depending on ground conditions
Landfall location	Vicinity of Weybourne Hope
Onshore cable route (buried)	Approx. 800m to new switch room

A number of layout options for the wind farm are being considered which would depend on the type of turbine that is chosen. The nominal capacity of the turbine (7 – 3MW) would determine the number required (45 – 108 respectively) in order to reach the proposed nominal total output of 315MW. Table 28.2 provides information on the characteristics of the wind turbines depending on the wind farm layout options.

Table 28.2: Indicative Layout Options

Layout Options	**45 x 7MW**	**63 x 5MW**	**70 x 4.5MW**	**88 X 3.6MW**	**108 x 3MW**
Indicative number of turbines	45	63	70	88	108
Turbine rated capacity (MW)	7	5	4.5	3.6	3
Rotor diameter of turbine (m)	150	126	120	107	90
Hub height (m above MHWS)	97	85	82	75.5	67

Each turbine would comprise a three bladed rotor mounted on the hub of a nacelle which would be located on two or three tower sections, depending on the size of turbine selected. The sections would be mounted on a pre-installed foundation.

As the size of the turbines is still to be fixed and further investigations need to be carried out into the site ground conditions there are a range of foundations which could be used for the turbines. These include:

- Monopile (5 -7.5m diameter);
- Multi – Pile tripod structure (3 piles, each 1 - 3m diameter);
- Multi – Pile quadruped structure (4 piles, each 1 - 3m diameter);
- Gravity Base precast concrete structure (30 - 55m diameter);
- Suction Caisson (alternative to piles on mono or multi - piled structures); or
- A combination of the above.

It is expected that a single solution, combining the total lowest cost with due consideration for environmental and technical requirements, would be adopted. The scheme would incorporate protection against scour of the seabed around the foundations and cables in the vicinity of the turbines.

A number of installation methods for the project have been addressed including piled or drilled monopiles and the use of a number of burial methods for the cables including the ploughed method or the trenched/jetted method. All cables would be buried between 1 – 3m depending on the ground conditions. At the landfall the cables would be ducted under the shingle bank and jointed at a cable connection pit. From here the cables would be buried in a 1m deep trench to the new switch room as shown in Figure 28.2.

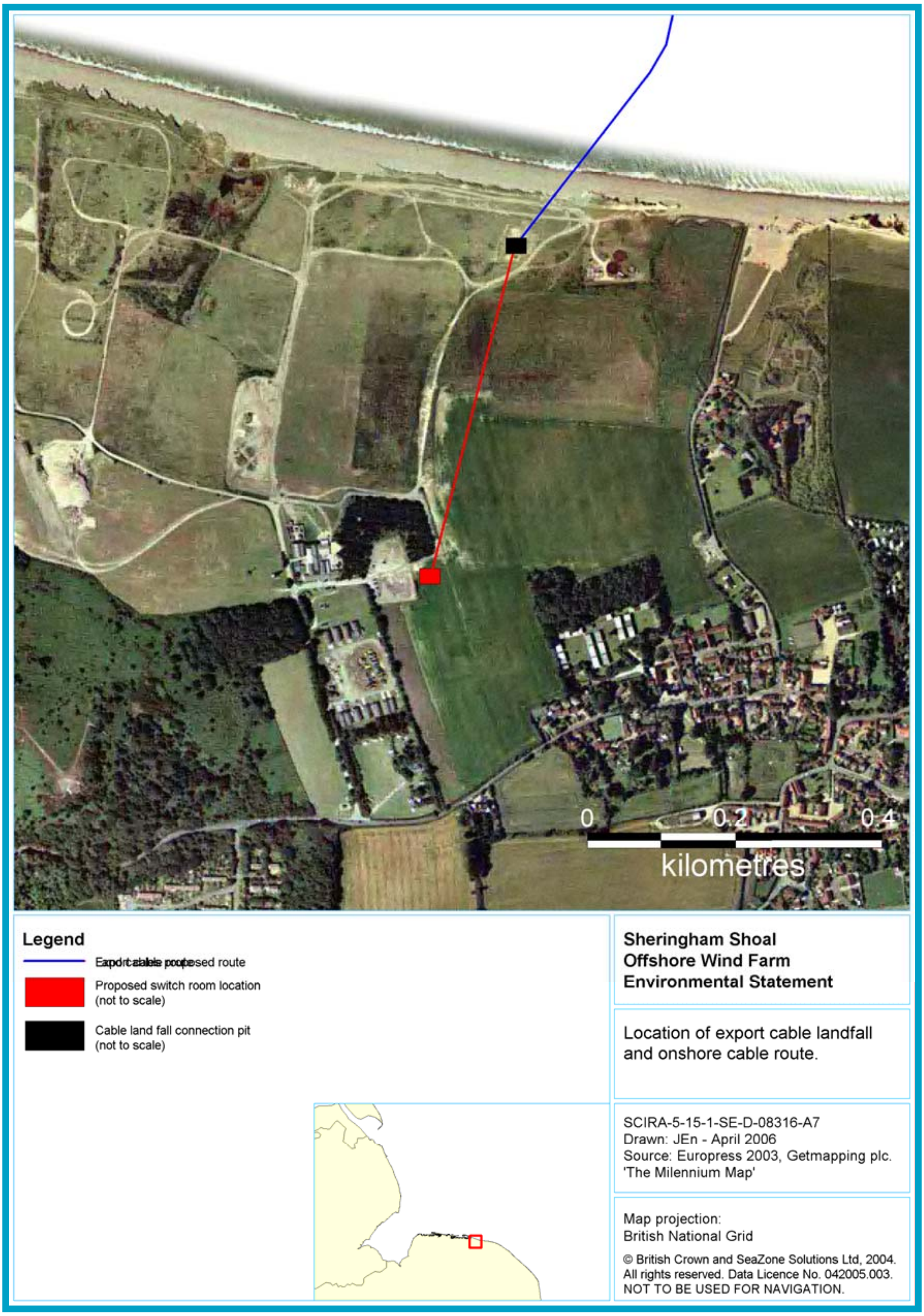


Figure 28.2   Location of proposed export cable landfall and onshore cable route

28.2.1 Consent requirements

An Agreement for Lease under the Crown Estate Act (1961) is already in place between The Crown Estate and Scira Offshore Energy Ltd. (Scira). This Agreement grants Scira a seven year option to develop an offshore wind farm at the Sheringham Shoal site, within which time Scira is required to obtain all necessary consents. Once all consents are obtained, the Agreement would be converted into a full Lease of the seabed for the wind farm and ancillary elements such as cables. The Lease would be for 40 years after which the wind farm would be decommissioned.

There are a number of consents that will be required for all phases of development i.e. construction, operation and decommissioning. The main consents that Scira intends to apply for are set out in Table 28.3.

Table 28.3 Statutory consents applied for by Scira

Act of Parliament	Consent type	Competent Authority
Section 36 - Electricity Act 1989	For construction and operation of an offshore wind power generating station within territorial waters adjacent to Great Britain, including all ancillary infrastructure.	Department of Trade and Industry (DTI)
Section 5 - Food and Environment Protection Act (FEPA) 1985	For depositing articles or materials in the sea/tidal waters below MHWS (mean high water springs) around Great Britain, including the placement of construction material or disposal of waste dredgings.	Department of Environment, Food and Rural Affairs (DEFRA) through the Marine Consents Environment Unit (MCEU)
Section 34 - Coast Protection Act (CPA) 1949	To make provision for the safety of navigation in relation to the export cable route and inter-array cables.	DEFRA through MCEU.
Section 90 Town & Country Planning Act 1990	Deemed planning permission sought as part of the section 36 application for the onshore elements of the works.	DTI

Conditions may be imposed on consents granted under any of the above legislation to control the implementation and operation of the development in order to protect environmental receptors.

The connection from the proposed switch station to the national or local electrical grid would be the subject of a separate consent.

28.2.2 The need for renewable energy

The central aim of the UK Government's energy policy is to establish a supply of energy that is diverse, sustainable and secure and is offered at competitive prices. Key to this goal is a 60% reduction of CO_2 emissions by 2050. The development of renewable energy plays a key role in the Government's strategy for carbon reduction. In 2000, the Government proposed an initial ten year strategy, which included a target to generate 10% of the UK's electricity from renewable sources by 2010. Revised targets in 2003 proposed that 15% of the UK electricity supply should come from renewable sources by 2015, with an aspiration of 20% of renewable energy supply by 2020. The Government's targets for renewable energy will help the UK to meet its international obligations, but also obtain greater security of energy supply through the promotion of indigenous electricity generation. The construction of wind farms, (both on- and offshore) is expected to be the largest contributor to the development of the renewable energy sector and wind energy will provide the greatest contribution to the 2010 target of all of the renewable energy technologies.

The 10% renewable energy target by 2010 is expected to require the generation of 33.6TWh per annum (Ecofys, 2003), and the proposed Sheringham Shoal project, once operational, will contribute 0.8 TWh to this target (Calculations based on BWEA 2005, applied load factor: 30%).

In addition, the proposed wind farm would help the UK move towards its goals by reducing emissions of carbon dioxide by approximately 28,000ktonnes over its 40 year lifetime (based on avoided emissions from coal powered plants. BWEA, 2005). Furthermore, the proposed project would reduce the emissions of other air quality pollutants by 74ktonnes of SO_2 and 27ktonnes of NO_x (Ecofys, 2003).

28.2.3 The Environmental Impact Assessment

The EIA has been prepared in accordance with the Electricity Works (Environmental Impact Assessment) Regulations 2000 (SI 2000/1927). In addition, the requirements and advice of the DTI in its Guidance Note ‘Offshore Wind farm Consents Process’ (DTI, 2004) have been followed, together with guidance issued by CEFAS, MCEU and others.

Impact identification and evaluation was carried out via a number of methods and techniques including data collation and literature review, consultation, reference to relevant guidance and standards, original data collection and analysis including multivariate analysis and computer modelling, as well as experience of similar schemes. Details of the assessment methodology and data sources are provided for each parameter in the relevant section. The following site specific surveys were undertaken as part of the EIA.

- Oceanographic survey;
- Geophysical survey;
- Shallow geotechnical surveys;
- Fisheries and epifaunal survey;
- Marine water and sediment quality;
- Benthic survey;
- Bird surveys (aerial and boat based, radar);
- Terrestrial survey (extended Phase 1 habitat survey); and
- Seascape and visual character assessment.

In order to provide a consistent framework for considering and evaluating impacts, significance levels have been assigned to each impact. The assigned definitions are set out Table 28.4.

Table 28.4 Terminology for classifying environmental impacts

Impact Significance	Definition
Major adverse	The impact gives rise to serious concern and it should be considered as unacceptable.
Moderate adverse	The impact gives rise to some concern but is likely to be tolerable depending on scale and duration.
Minor adverse	The impact is undesirable but of limited concern.
Negligible	The impact is not of concern.
No Impact	There is an absence of one or more of the following: impact source, pathway or receptor.
Minor beneficial	The impact is of minor significance but has some environmental benefit.
Moderate beneficial	The impact provides some gain to the environment.
Major beneficial	The impact provides a significant positive gain.

A number of criteria have been utilised to determine the significance of the environmental impacts. These are:

- Magnitude of the impact i.e. local, regional or national;
- Spatial extent of the impact i.e. small scale or large scale;
- Duration of the impact i.e. short term or long term;
- Reversibility of the impact including species or habitat recoverability, sensitivity and tolerance;
- Conservation or protected status;
- Probability of occurrence of the impact;
- Confidence in the impact prediction; and
- The margins by which set values are exceeded e.g. water quality standards.

Under the Conservation (Natural Habitats, & c.) Regulations 1994 (SI 1994/2716 as amended), the relevant Competent Authority must consider the effect of a development on the integrity of a European site (including candidate and proposed sites), if the development is considered likely to have a significant effect on that site. Of relevance to this project is the Wash and North Norfolk European marine site, which includes the Wash and North Norfolk Coast SAC, and the North Norfolk Coast SPA. Information to enable the carrying out of an Appropriate Assessment is included in Section 27, should the DTI, as the Competent Authority, consider that this is necessary.

28.2.4 Operation and maintenance requirements

A detailed operation and maintenance strategy has not yet been established and would be determined at a later stage, taking account of issues including turbines selected and procurement strategy. Such a strategy would also determine whether there should be a requirement for offshore manning on a regular or permanent basis.

Under the provisions of the Energy Act 2004, it is proposed that a safety zone would apply around each turbine and offshore structure. The purpose of the zone would be to minimise any interaction between sea users and the installations by unauthorised vessels in order to ensure safety at sea.

Ideally, the design of the wind farm would be such that human intervention would be minimised, involving a supervisory role only with occasional call outs for breakdowns and repairs, together with requirements for scheduled maintenance at approximately 3, 6, and 12-monthly intervals.

Nacelle mounted cranes would normally be able to load and offload items requiring repair or replacement, but specialised vessel support could be required to load and offload the replacement parts onto the wind turbines. In the extreme instance an external crane could be required to load/offload critical parts. In addition, occasional surveys would be required to check the burial depth of the inter turbine and export cables, and scour protection (if needed) would be monitored.

28.2.5 Decommissioning requirements

A detailed Decommissioning Plan has not yet been prepared, but would be agreed with the DTI and The Crown Estate, prior to commencement of construction. It would take account of legislation and guidelines that are expected under the provisions of the Energy Act 2004. It is currently expected that the decommissioning plan would include for the complete removal of all offshore structures deployed in the wind farm above the seabed. It is expected that buried cables would be left in place and notified, in line with current practice in other marine industries.

Decommissioning would involve dismantling of structures, probably in reverse order involving similar plant to that used during construction and undertaken in accordance with the relevant guidelines, legislation and good practice in order to minimise environmental impacts and ensure pollution prevention. Where possible, consideration would be given to decommissioned structures and materials being reused or recycled. In some instances, it may be considered that leaving material or structures on the seabed would be the best environmental option (such as gravity based structures and scour protection material) in order to minimise disturbance to the habitats and species that may have substantially colonised the areas.

The Decommissioning Plan would be regularly updated in light of any changes to legislation or best practice and in particular would be thoroughly reviewed as the wind farm approaches the end of its operational life.

It is proposed that the onshore cable would be isolated, left in-situ and notified as such. The switch room would be decommissioned and all switch equipment and cables isolated. The switch room might be incorporated into the general facilities of the Muckleburgh museum, depending on discussions with the landowner.

28.3 Summary of Environmental Impacts

The following sections summarise the potential environmental impacts associated with the construction and operation of the Sheringham Shoal project. As discussed above, decommissioning impacts are anticipated to be of a similar nature to construction, although in general of a shorter duration and smaller magnitude, and have been discussed for each environmental parameter within the ES. They are not included specifically in the summaries below.

The following environmental parameters have been assessed:

- Hydrodynamics and geomorphology;
- Marine and coastal water quality;
- Ornithology;
- Marine ecology;
- Natural fisheries resource;
- Marine mammals;
- Commercial fisheries;
- Landscape, seascape and visual resources and character;
- Shipping and navigation;
- Marine archaeology;
- Military and aviation;
- Other human activities;
- Socio-economic activities;
- Geology, land quality and water resources;
- Terrestrial ecology;
- Landscape and visual character;
- Terrestrial archaeology and cultural heritage;
- Coastal tourism and recreation;
- Traffic and access; and
- Noise, dust and air quality.

The EIA has addressed the range of impacts of all the project options and layouts currently being considered including the options considered to be the worst realistic case relevant to each environmental parameter. Cumulative impacts from other wind farm developments or other existing or planned projects or activities in the area have also been described. A description of the mitigation measures that will be committed to by Scira are listed for each environmental parameter, such that environmental impacts can be avoided, reduced or minimised. Where necessary, monitoring requirements are also listed. It is anticipated that detailed monitoring programmes would be prepared in consultation with the relevant authorities following consent award and in line with any consent conditions.

28.4 Potential impacts associated with the offshore wind farm and export cable route

28.4.1 Hydrodynamics and geomorphology

It is considered that the all the proposed foundation options using up to 7.5m diameter monopiles, multi-leg, suction caisson or gravity bases are likely to have some localised impact on the waves, currents and corresponding sediment transport regime in the immediate vicinity of the turbines and cabling, but are unlikely to have any significant or measurable far field impacts. This general conclusion concurs with the findings for the already consented Round 1 wind farms set within similar nearshore situations and recent industry research.

Localised issues of concern for all foundation options are:

- Increased suspended sediments, including chalk fines, during foundation installation, cable laying and decommissioning;
- Increased suspended sediments, not including chalk fines, during bed excavation for gravity base foundation installation and removal;
- Ongoing scour potential around turbine foundations throughout operational life, possibly requiring protection in some areas;
- High potential for future exposure of cables throughout operational life due to sand wave activity within the main site and large scale bed mobility across Sheringham Shoal; and
- High potential for future exposure of the export cables at the landfall due to shoreline erosion requiring protection measures.

The potential for broad scale changes to the seabed as a result of the combined effect of all the turbines depends on the dimensions and spacing of the foundations, plus the seabed stability and the wave/current conditions. The proposed wind farm is anticipated to have between 45 and 108 turbines founded on monopiles, multi-piles, suction caissons or gravity base foundations with spacing of 570m to 1120m (depending on direction and size of turbine). A rough rule of thumb for the extent of disturbance to the current field suggests that the current would be affected for a distance of only 75m leeward of each monopile, although turbulent vortices may be apparent over a greater distance. This indicates that these foundations can be considered as independent of each other in respect of the impact on the currents. Wave effects are considered to be similarly restricted in the spatial extent of their impact with monopiles.

Understanding of the impacts of large gravity bases or more complex, multi-leg foundations is less well defined. Overall flow reductions of around 2% for the wind farm site are estimated from desk assessment of large gravity bases. This level of change is considered to be insignificant in terms of general sediment transport process

Assessment of the potential sediment transport patterns along the routes of the cables concluded that the cables would pass through areas of large scale bed mobility (sand waves and banks) requiring that the cables should be deeply buried to reduce the potential for future uncovering, and that monitoring should be undertaken to assess this issue in the future. As the maximum practicable depth of burial is about 3m, it is likely that future exposure will occur across the Pollard Bank, Sheringham Shoal and within the south eastern sand wave area of the wind farm site. Monitoring and a management plan for reburial are required.

From an environmental impact perspective the existing natural mobility of the sediment indicates that the turbines are unlikely to have a significant impact beyond their immediate area following construction, over the design life or during decommissioning. Changes due to the structures are likely to be less than those experienced due to natural variation and are therefore insignificant. This is likely to be true for both the seabed and the shoreline.

There is evidence that the background levels of suspended sediment concentration at the wind farm, and along the cable route are believed to be moderate (10mg/l to 30mg/l seasonal range of mean values), so the transient impact of plumes arising from the installation process may be significant under specific circumstances. The preferred cable route is directed through the "Weybourne Channel" and over the Pollard Bank in order to minimise laying through chalk, reducing the potential impact of dispersed chalk fines within the immediate near shore zone. It has been shown by numerical modelling that increases in suspended sediment levels due to cable laying are small, localised and short lived. Increases are considered very low and probably insignificant for ploughing, but potentially more significant for trenching.

The beach at Weybourne Hope is subject to strong drift and cross-shore profile change in response to the high energy wave and tidal environment. It is also subject to ongoing erosion, with a historic retreat rate of about 0.4m/year, including the low cliffs at the rear of the beach. The design and installation of the cable landfall will take account of the envelope of beach profile change and the future erosion.

The proximity to the other wind farm sites, cables, pipelines and dredging areas would not result in any cumulative impacts with regard to coastal or seabed processes.

Monitoring

1. Monitoring of the seabed around the foundations immediately after construction to provide guidance on the need for placement of scour protection.
2. In areas of large scale bed mobility, monitoring of the cables after burying to be undertaken to confirm that their integrity is not compromised by future uncovering and subsequent exposure to the strong tidal currents.

28.4.2 Marine and coastal water quality

There are five designated bathing water areas and one designated shellfish water area locatedwithin the vicinity of the Sheringham Shoal project, the nearest being located at Sheringham and Blakeney respectively. Both the bathing waters and shellfish waters meet mandatory standards.

Impacts on water quality due to re-suspension of sediments during the construction phase are considered to be potentially most significant. However, the exposed location of the site, the localised extent and nature of the sediment disturbance and the distance of construction activities in relation to the designations (between 8 and 17km) is such that no impacts on the designated sites are anticipated. The low sensitivity of the water quality outside these designations also ensures that impacts are of **negligible significance**. The disturbance of short lengths of areas of surface and near surface chalk on the export cable route could lead to a visible milky plume, however this would be of an aesthetic nature only.

The impact of re-suspension of sediment contaminants and bacteria has also been assessed as **no impact,** predominantly due to the low risk of bacterial contamination and the general low level of contamination found within the sediments in the areas to be disturbed.

Adherence to standard pollution prevention guidance, site environmental plans and best practice will reduce risks to water quality from accidental spillage.

Impacts on water quality during the operational phase are considered to be **negligible**, given adherence to standard pollution prevention guidance and good practice during maintenance.

During decommissioning, impacts on water quality would largely be associated with the removal of the offshore structures. Re-suspension of sediment is therefore a potential risk and impacts are likely to be similar to those described for the construction phase above. It is anticipated that the export cables would remain in situ once disconnected.

28.4.3 Ornithology

Potential impacts of the proposed development upon the seven key bird species of concern are described below in relation to the risk of collision and the level of disturbance and displacement.

28.4.3.1 Sandwich Tern

With little specific use of the wind farm and buffer area by foraging Sandwich Tern, and the availability of alternative areas, the significance of disturbance during construction and displacement during operation is considered **minor adverse**. It may be anticipated that preferred flight lines of Sandwich Tern across the site would not be disrupted by the presence of turbines, especially since preferred flight lines have been considered and incorporated in the design layouts. Only a low proportion (13%) of Sandwich Tern were recorded in the zone potentially occupied by the turbines and the risk of collision was deemed to be of **minor adverse** significance irrespective of whether the site population (number of passage movements), the regional population, or the background mortality levels of the UK population likely to pass through the site was used in calculations. Overall, the presence of the Sheringham Shoal wind farm may conceivably have a *minor* adverse impact upon Sandwich Terns.

28.4.3.2 Common Tern

With limited use of the wind farm and buffer area by foraging Common Tern, and the availability of alternative areas there was a **negligible** significance of disturbance during construction and a **minor adverse** significance of displacement during operation. A highly precautionary approach to assess collision risk was conducted as though the birds were part of the breeding population in the SPA. The relatively low proportion (16%) of Common Tern recorded in the zone potentially occupied by the turbines provided the same **minor adverse** significance as for Sandwich Tern.

28.4.3.3 Little Gull

The high proportion (54%) of Little Gull on the surface was thought to result from birds breaking passage under unfavourably calm conditions. With no feeding activity ever observed there was little specific use of the wind farm and buffer area by foraging birds. The significance of disturbance and displacement during construction and operation was considered to be **negligible.** Only a low proportion (10%) of Little Gull were recorded in the zone potentially occupied by the turbines and the risk of collision was deemed to be of **negligible** significance. Overall, the presence of a wind farm at the proposed Sheringham Shoal site is unlikely to have a detectable negative impact on Little Gulls.

28.4.3.4 Razorbill

With the peak period of occurrence in October, when construction activity is likely to reduce due to adverse weather, disturbance during construction was deemed to be **negligible**. With evidence of disturbance from boats, the effect of displacement in the longer term during operation was assessed as of **minor adverse** significance. With the complete lack of birds within the range of turbine blades, it was concluded there is a **negligible** risk of individual mortality through collision.

28.4.3.5 Gannet

With little specific use of the wind farm and buffer area by foraging Gannet (<1% feeding), there was a **negligible** significance of disturbance during construction and a **negligible** significance of displacement during operation. Only a low proportion (10%) of Gannet were recorded in the zone potentially occupied by the turbines and the risk of collision was considered to be **negligible**.

28.4.3.6 Lesser Black-backed Gull

With no specific use of the wind farm and buffer area by foraging Lesser Black-backed Gull, there was a **negligible** significance of disturbance during construction and **negligible** significance of displacement during operation. A highly precautionary approach to assessment was conducted as though the birds were part of the local breeding population. The moderate proportion (27%) of Lesser Black-backed Gull recorded in the zone potentially occupied by the turbines did not greatly influence the risk of collision, which was concluded to be **negligible.**

28.4.3.7 Guillemot

Guillemots showed negligible active use of the study area (1 feeding record) and passed through rapidly. Without specific use the impact of temporarily disturbance during construction was deemed to be **negligible**. Given the availability of alternative areas the impact of displacement in the longer term during operation was assessed as *minor* adverse. With the complete lack of Guillemot within the range of turbine blades, it was concluded there is a **negligible** risk of individual mortality through collision.

Overall, the presence of proposed wind farm is not anticipated to have a detectable short or long-term negative impact on any of the seven key species listed above.

No cumulative impacts, over and above that determined for the proposed development at the proposed Sheringham Shoal site itself, are anticipated.

Monitoring
1. Boat-based surveys during the summer and autumn are deemed suitable to establish density and population sizes of birds of concern during construction and operation. Given the importance of Sandwich Tern, species specific monitoring effort, over and above determination of density and population size may be worthwhile to determine the nature and magnitude of any residual impact. This will be further discussed with English Nature.

28.4.4 Marine Ecology

The seabed within the study area is characterised by coarse to medium sands with varying percentages of gravel and pebble content. The overall composition of the sediments is highly variable and poorly sorted. This variable characteristic is reflected in the benthic assemblage recorded during the site-specific surveys.

A total of 267 infaunal species have been recorded with a mean number of species ranging from 2 to 72. The lowest numbers of species are associated with areas of sand dominated substrate in the southeast of the site. The number of individuals per sample is also highly variable ranging between 2 to 423. Species present in moderate to high abundances included typical polychaete worms, crustaceans and bivalve molluscs such as *Pisidia longicornis, Polycirrus* spp., *Ampelisca diadema, Eumida sanguinea, Caulleriella zetlandica,* nematodes and *Nucula nucleus.* Twelve community types were identified. Those with very low numbers of species and low abundances were generally found in areas of clean medium sands to the south of the turbine site and along the proposed cable route. Communities with the highest number of species and abundance were generally found in areas of mixed sediments in the north west of the study area.

The benthic surveys recorded the presence of *S. spinulosa* throughout much of the study area. It is considered that the areas of the site that support more dense assemblages of *S. spinulosa* are predominantly comprised of clumps and encrusting communities rather than extensive reefs or crusts, which may be considered of nature conservation importance.

The intertidal area of the proposed landfall site at Weybourne Hope comprises a shingle beach backed by a steep shingle bank. The shingle beach is highly mobile and, as such, does not provide a suitable habitat for species colonisation and can be described as barren or highly impoverished. Significant impacts in this area are not anticipated.

Impacts of greatest potential significance, in the context of the benthic resource, are anticipated to arise during the construction phase of the development. Specifically, the direct impact on habitats and species through the installation of foundations, cables and associated infrastructure are considered the most significant. The sediment types and communities found within the footprint of the Sheringham Shoal project are typical of the wider study area and are consistent with the findings of other studies. No species of conservation significance are present within the footprint of the construction activities, and the assemblage is considered to be well adapted to living in a dynamic and periodically disturbed environment. As such, the potential direct impact of habitat loss during construction is considered to be of short term duration and of **minor adverse** significance.

Sediment disturbance and deposition from construction activities such as cable installation could have an adverse indirect impact on the benthic communities, through increased turbidity and smothering. Modelling has shown that the vast majority of disturbed sediment is expected to settle in the immediate vicinity of the disturbance. The amount of fine sediment is limited in the area, and outcrops of chalk would only be encountered along a short stretch of the cable route. Research and studies have shown that the benthic community is tolerant to such disturbance and increases in turbidity with a rapid rate of recovery. The potential impact is considered to be of short term duration and **negligible** significance.

Following construction, there is the potential for scouring of the seabed to occur around the foundation structures, given available seabed material. The extent of scouring would depend on the foundation type selected. For gravity based structures it is considered that scour would lead to instability so scour protection would be placed around the foundation. Similarly, for monopiles in sand areas where significant scour would occur, scour protection would be placed. It is anticipated that scouring would occur immediately following installation until a new equilibrium is established. The scoured area would be readily colonised by species from unaffected areas. As such, the impact is considered to be **negligible**.

It is not anticipated that any other significant impact upon the benthic assemblage would occur during the operation of the wind farm. Following construction a range of benthic species from the wider study area are expected to rapidly colonise the foundations and any scour protection. This colonisation may serve to cause some highly localised increase in biodiversity, and would provide foraging opportunities and refuge habitats for a range of species. This is, however, considered to be of **negligible** significance.

The impacts associated with decommissioning are anticipated to be largely similar to those of construction, with the exception of piling, which would not take place. As cabling is likely to be left in place following removal of the turbines, the impact on the seabed would be minimal. As such, it is considered that the impact on the benthic assemblage would be **negligible**.

Mitigation measures during construction
1. A targeted drop down camera survey will be undertaken at certain locations that could support dense aggregations of *S. spinulosa.* The survey and locations will be agreed with English Nature and the results of the survey will be discussed with them. If biogenic reefs are located within the footprint of any of the project components, Scira will work with English Nature to develop a protocol for micrositing necessary turbines, inter-turbine infrastructure and export cabling to minimise potential adverse impact.

Monitoring during operation
1. A detailed monitoring survey programme will be developed and implemented (during the initial years of operation) following consultation with the appropriate authorities. It will follow the methodologies used in the baseline surveys undertaken for the project be based on comments received in response to publication of the Environmental Statement (ES) and the conditions outlined in the consenting documents relating to the project.
2. The development of the benthic community within the wind farm area will be monitored to assess the colonisation of the foundation structures and surrounding area to determine whether that would be significantly impacted by the eventual removal of the structures.

28.4.5 Natural fisheries

In excess of 70 species were caught during the site-specific surveys during April, July, and September 2005. The most numerous species encountered during the April survey were immature herring and whiting that are of importance to commercial fish resources. Non-commercial fish species dominated the July and September surveys. The demersal and benthic fish assemblage is considered as typical for the area and is similar in diversity to previous surveys carried out within the general area by IECS at these times of year.

Whilst there is no evidence to indicate that the distribution of fish within the survey area is linked to geographical location or depth, sediment type needs to be taken into consideration. While the sediment characteristics may be suitable for herring spawning in small areas within the wind farm site, the lack of any herring in the fish surveys in either July or September make it very unlikely that spawning took place in the vicinity of the site in 2005. As herring return to a specific area in the autumn to spawn year after year, the results of the summer and autumn surveys indicate that herring do not use the wind farm area or the cable route as a spawning ground.

The data for all species indicate that the fish assemblage, in terms of those species considered to be of commercial or recreational interest, is dominated by juvenile and adolescent fish with few mature adults present. The benthic assemblage of non commercial fish species was represented by a wide range of age groups. No species of conservation importance as designated by the Bern convention were found.

The most notable feature from the trawl survey results was the increase in abundance of pink shrimp within the survey area from April to September. By comparison, edible crabs, velvet crabs and lobsters showed no clear seasonality of abundance. The distribution of pink shrimp and velvet crabs tended to centre to the south and west of the proposed boundary of the Sheringham shoal turbine array.

Noise created during the construction period, in particular through pile driving, is anticipated to be the source of the greatest potential risk of an impact upon sensitive fish species in the form of physiological damage and, in extreme cases, lethal effects. However, by adopting working practices, such as soft-start piling, these impacts can be effectively reduced and a **minor adverse** impact is anticipated.

Increased suspended sediment concentrations, caused through the cable installation process in particular, have the potential to impact upon shellfish. The short term nature of construction and the highly localised increases in sediment concentrations and settlement are such that a **minor adverse** impact on crab and shrimp migration, and the settlement of juveniles is anticipated. If chalk is encountered during the cable installation, any resulting plume would be reduced to insignificant concentrations (<1mg/l above background) within six tidal cycles. Any residual effects are expected to have a localised **minor adverse** impact on shellfish.

Potential impacts during the operation of the wind farm include underwater noise and vibration, the fish aggregating effect of the structures and the influence of EM-Fields on sensitive species. The impacts of EM-Fields are under investigation and not yet fully understood. The recent COWRIE report on the matter was inconclusive pending further industry and Government funded collaborative research. Further "in-field" studies are anticipated as part of the next COWRIE commissioned work into the subject area.

Cumulative and in-combination effects relating to construction activities; in particular, underwater noise and the re-suspension of sediments are not considered to be significant due to the distance separating the other wind farm sites in the Greater Wash area and other potentially disturbing activities, such as marine aggregate extraction.

Mitigation measures during construction
1. In respect of noise and vibration generated by piling, 'soft start' techniques would be used, where the power and frequency of hammering is built up slowly, from a low energy start-up, over at least 30 minutes (Parvin and Nedwell, 2005).

28.4.6 Marine Mammals

Site specific and historic data indicate that the most common marine mammal species in the area are harbour porpoise and common seal with The Wash, including the low lying coast and Blakeney Point hosting the main common seal population in England. Records of harbour porpoise sightings from the coast are available every year since 1995, with sightings varying from a minimum of 2 in 2004 to a maximum of 56 in 1997. The species was recorded during ten out of the 29 boat based bird surveys and on two occasions during the aerial bird surveys. Sightings of common seals within and/or close to the proposed site were made during ten out of the 29 boat based bird surveys and during three of the aerial surveys.

During construction, the most likely effects are anticipated to be due to construction generated noise and traffic movement increases to and from the site. As marine mammals rely on sound as their primary sense for communication, navigation and orientation, the construction activities, and particularly piling works, have the potential to significantly affect harbour porpoise and seals.

The most detailed study to date on the effects of wind farm construction on harbour porpoise, conducted prior to and during the construction of the then largest offshore wind farm in Denmark (Tougaard *et al*, 2003a), concluded that acoustic activity by the porpoises decreased dramatically in the area at the onset of piling operations and returned to higher levels a few hours (3-4 hours) after each piling operation was completed. A general effect on the behaviour of animals was observed during the construction period and at distances of up to 10-15km from the construction site.

Most studies on the reaction of harbour seals to noise have been conducted on hauled-out animals, and very little is known about the effects of noise on seals in the water. The closest haul-out site is at Blakeney at a distance of some 30km. The initial evidence from a study undertaken in Denmark during the operational phase of an offshore wind farm indicates that there was no adverse effect on seals (Clemont Edren *et al*, 2005).

Scira is aware of the studies currently being carried out in the Thames to further understand the individual and cumulative impacts of construction noise on marine mammals. It is Scira's intention to utilise the outcome of these studies to ensure that the potential impact on marine mammals in the Sheringham Shoal study area and the wider region (for cumulative impacts) has been appropriately assessed and that all practical mitigation measures are applied. This will ensure that Scira limits the potential for a significant adverse impact on individual marine mammals and the marine mammal population as a whole.

During the operational phase, the most likely effects on marine mammals are due to operational noise, generated electromagnetic fields and habitat changes.

The research undertaken to date on the effects of the wind farm operational noise on marine mammals is not conclusive and a number of studies and on-going research projects for wind farms in Denmark preliminary conclude no obvious adverse effect on seals during the operational phase (Clermont Edrén *et al*, 2005). On the basis of the current knowledge, the relatively low presence of cetaceans and seals within the Sheringham Shoal proposed area and the distance from significant haul-out sites, it is concluded that the adverse effects due to operational noise are likely to be **negligible**.

The knowledge of the potential impacts of electromagnetic fields on marine mammals is currently limited. It has been suggested that harbour porpoise does not depend on geomagnetic cues for navigation (Kirschvink *et al*, 1986), and there is no evidence that seals are influenced by, or use electromagnetic fields. Overall, given the limited use of the area by large migrating whales it is suggested that a **negligible** impact is likely on seal and cetacean populations due to electromagnetic fields.

The most significant cumulative impact for marine mammals is likely to be associated with the construction noise, should more than one of the wind farms be constructed within the same period as the Sheringham Shoal wind farm. By utilising the output of the studies being carried out in the Thames, Scira anticipate that additional work will be carried out, in consultation with the relevant regulators, to further understand the potential individual and cumulative effects of construction noise on marine mammals. All practicable mitigation measures recommended through the studies that are of relevance to the Sheringham Shoal site will be applied to ensure that the potential impact is **negligible**.

Mitigation measures during construction
1. Preventative measures in respect of noise generated by piling similar to those identified by the JNCC's Guidelines on Minimising Acoustic Disturbance to Marine Mammals (JNCC, 2004) including the soft start procedure will be implemented. 2. Scira will utilise the outcome of studies currently being carried out in the Thames to further understand the individual and cumulative impacts of construction noise on marine mammals to ensure that the potential impact on them in the Sheringham Shoal site area and the wider region (for cumulative impacts) has been appropriately assessed and that all practical mitigation measures are applied.

Monitoring during construction
1. The SMRU monitoring programme for harbour seals in the region over the period 2005-2007 is expected provide evidence on the short or medium term effects of wind farms on coastal seal populations. Scira will collaborate with SMRU during this research work. 2. Scira will consider the need to undertake further survey or monitoring if the results and recommendations of studies on impacts to marine mammals being carried out in 2006 in the Thames are relevant to the Sheringham Shoal site.

28.4.7 Commercial Fisheries

The data and information obtained suggest that the wind farm location is not a primary fishing area and does not support as much fishing effort as the banks and shoals to the west of the site. No significant trawling activity has been observed within the proposed wind farm area and only limited long lining on a seasonal basis has been reported. There is, however, a history of vessels mainly from Blakeney and to a lesser extent Wells undertaking some seasonal static gear fishing within the area of the wind farm site. Between six and seven of these local potting vessels regularly visit the site targeting crabs and lobsters.

In relation to the cable route the highest levels of activity occurs over the inshore section out to approximately the 3 mile limit by small beach-launched fishing vessels. Whilst the level of this activity declines further offshore, the Sheringham Shoal is a recognised fishing area.

This assessment assumes a 500m safety zone around all wind farm structures for towed and drifting gears and a 100m safety zone around all structures for static gears within the wind farm site.

The following potential impacts were considered for construction, operation (and decommissioning) phases of the wind farm development:

- Complete loss or restricted access to traditional grounds;
- Interference with fishing activities;
- Increased steaming times to fishing grounds;
- Removal of obstacles from the sea bed post construction;
- Adverse impacts on commercially exploited populations; and
- Safety issues for fishing vessels

All potential impacts identified during the construction phase are assessed as **negligible** to commercial fisheries other than loss of fishing area which is assessed as being **minor adverse** for the 6 or 7 inshore static gear vessels that regularly operate in the wind farm site area. Should these minor adverse impacts result in reduced landings, this would in turn have a **minor adverse** impact on any of these vessel operators that have processing operations that are reliant on their own catch.

All potential impacts identified during the operational phase are assessed as **negligible** to commercial fisheries other than interference to fishing activity for those static gear vessels operating in the area, which is assessed as being **minor adverse.**

Impacts on commercial fisheries during decommissioning are expected to be **negligible**. Cumulative impacts are assessed by considering other Round 1 and 2 wind farm developments proposed for the region that are within range of the vessels fishing the Sheringham Shoal, Cromer, Docking Shoal and Race Bank sites.

During construction cumulative loss of fishing area and increased steaming times may cause **minor adverse** impacts, while impacts on commercially exploited species are deemed to be **negligible**.

During operation, assuming access between turbines is permitted for the static gear vessels concerned, impacts on fishing area and streaming times are assessed as **negligible.**

For the key decapod (crab and lobster) species currently targeted, the creation of hard, cryptic substrate is assessed as being of potential **minor beneficial** impact.

Cumulative impacts from decommissioning are assessed as having **negligible** impact on commercial fisheries.

Mitigation measures during construction

1. Scira will maintain good engineering practice in relation to construction and cable-laying, and accurately and regularly communicate the timing and location of construction activities to fishing interests to minimise potential disruption to fishing activities.
2. Scira will continue ongoing liaison with operators of the fishing vessels that have a proven track record of fishing the wind farm site and the cable route corridor, in order to investigate appropriate practical assistance measures for those vessels that might legitimately be impacted during the construction phase.
3. In respect of noise and vibration generated by piling, 'soft start' techniques would be used, so avoidance response may be possible if level is disturbing to shellfish
4. Increase in suspended sediments will be minimised through site selection to avoid chalk, where practicable, and use of cable plough for cable installation to provide narrow zone of impact, which would be localised and short-term.
5. Accidental spillage of construction materials will be minimised through adoption of good practice measures.
6. Scira will enforce a Safety Zones of 500m around the wind farm and 1200m around the cable installation vessels, and implement the standard best practice procedures for offshore safety, liaison, notification, marking and monitoring.

Mitigation measures during operation
1. Scira propose to work with the fishermen potentially affected by the wind farm to establish the feasibility of operating static gear within the site

28.4.8 Landscape, seascape and visual resources and character

The study area includes the area of sea, and land within north Norfolk which lies within 35km of the edge of the proposed wind farm. Within the seascape oil rigs and ships are present. There are no other offshore wind farms in this area at this time, except at Scroby Sands, which is on the limit of the study area boundary to the south east. Much of the coastal strip is designated as an Area of Outstanding Natural Beauty, and as a Heritage Coast, reflecting its high landscape quality and sensitivity. The coastline varies between cliffs to the east, and dunes, mudflats and marshes further west. Views from inland out to sea are limited by vegetation, especially in the vicinity of Sheringham and Cromer, which is the closest section of the coast to the site. This results in the main views of the sea being available from the coastal edge and isolated high points (such as Beeston Hill, and Oak Wood). There are very limited views from the hinterland out to sea, especially in the summer months.

The seascape of the site would be directly affected by the presence of turbines, meteorological mast and offshore transformer stations which form the offshore wind farm and by associated boat activities during its operation. A total area of 35km^2 of open sea would be occupied by turbines in a currently undeveloped location. The significance of the effect on seascape resources and character would be direct and **major** at the site itself, but would be indirect outwith the site and would decrease when assessed in the context of the wider area.

There would be no change to landscape resources as a result of the offshore wind farm and no mitigation would be required. There would be an indirect residual effect of up to **moderate** significance on the landscape character along nearest coastal edge as a result of the offshore wind farm, decreasing to low or **negligible** further inland. The majority of the hinterland is not affected by the presence of the sea or features within it and would not be affected by the wind farm. The location of the wind farm 17-22km offshore and the frequent presence of low levels of visibility in the area would reduce the potential impacts on landscape character along the coastal strip.

There would be a change to visual amenity and to views from key viewpoint locations throughout the study area, largely along the coastal edge, by day and by night, when lighting may be visible, but only when atmospheric conditions are clear. The location of the wind farm 17-22km offshore, and the frequent presence of low levels of visibility in the area would help to reduce the significance of the effects and the extent of affected views would be limited by the characteristic bushy hedgerows and extensive woodland cover throughout much of the AONB. Impacts of up to major significance would only result at a very few of the closest locations when weather is clear enough to permit visibility, about 55-59% of the time. Most viewpoints fall into the 15-20km distance bracket, when views would be available about 63% of the time, or the 20-25km distance when views would be available about 48% of the time. Views from the land and from ships would be affected by the presence of the wind farm to a lesser degree along a significant proportion of the horizon. The effect would decrease to negligible with increasing distance from the site, and with distance inland as vegetation, topography and structures obscures views of the coast from the land. The effect on the AONB as a whole would be **minor** to **moderate**.

The cumulative impact assessment sets out the degree of combined, successive and sequential views and indicates that ther would be some views and locations from which the proposed Sheringham Shoal project and other wind farms, for example Cromer or the Docking Shoal/ Race Bank group, may be visible at the same time. This would be dependant on which of the proposed wind farms are built in the area. There would be no land based viewpoints from which the proposed Sheringham Shoal project and the cumulative sites would be seen together, as Cromer is 12km and Docking Shoal/Race Bank 14km respectively, from the proposed Sheringham Shoal wind farm.

It is acknowledged that the final choice of turbine would alter the nature of landscape, seascape and visual impacts, but it is considered that the degree of significance of the effects would remain similar overall. The choice of a larger number of smaller turbines, at a higher density, over a smaller number of larger turbines, at a lower density, would be a matter of personal preference of the viewer. The smaller turbines may appear as a white blur on the horizon more often, as their overall height and bulk would be less and, as a result, they may fade into the distance more frequently than the larger turbines. The larger turbines have a greater zone of theoretical visual influence, but in practice, views from the hinterland would almost always be screened by vegetation. Their bulk and form is likely to be more readily apparent more frequently, but some viewers may consider this preferable to seeing the sometimes more difficult to identify blur of the smaller turbines.

Mitigation measures during construction
1. Best practice measures would be used to reduce the extent of any visible pollution or discolouration of the sea during the works which would be required to install the wind turbines in the seabed.

Mitigation measures during operation
1. External surfaces would be non reflective, coloured a muted grey, which would blend into the colour of the sky and sea. There will be no external advertising on the turbines, except any notices required for operational safety. 2. Lighting will be designed to meet the minimum requirements for operational safety so as not to contribute light pollution / glare to the sky or to disrupt the horizon in longer distance views of the scheme. Low intensity and directional lights will be used where permitted.

Mitigation measures during decommissioning
1. All visible land and sea based facilities would be removed after 40 years 2. The components would be recycled where possible, or disposed of to a location where they do not result in landscape/ seascape and visual impacts in another location.

28.4.9 Shipping and navigation

The navigational risk assessment undertaken in accordance with MGN 275 included a 28 day traffic survey of the area which was complemented by two further survey data sets which included a five day radar survey carried out in August 2003 based at Trimingham and an additional 14 days of AIS survey data collected in the area during late May and early June 2005. Impacts during the construction phase are considered to be **moderate adverse** given the implementation of safety zones and mitigation measures such as Notice to Mariners and hazard workshops and risk assessments. Based on this data and the use of risk assessment modelling, the following impact levels were derived during the operational phase of the project:

- For fishing vessels there would be a **minor adverse** impact, due to the limited fishing in this area and the use of safety zones to reduce risks within the wind farm.
- For merchant vessels there would be a **minor adverse** impact, as shipping tends naturally to avoid the site due to the shallows in this area. Use of safety zones also reduces risks within the wind farm.
- For recreational vessels there would be a **minor adverse** impact due to the limited recreational activity in this area and the use of safety zones to reduce risks within the wind farm.
- There would be **negligible** impact on dredging vessels since there is no dredging activity in this area.
- There would be **negligible** impact in terms of cable interaction, as there is negligible activity in this area with potential to snag on the buried cables.
- For visual navigation and collision avoidance the impact would be **minor adverse;** since the majority of shipping tends naturally to avoid the wind farm location the impact would be low, but impact on crossing vessels to the SE was assessed in detail and found to be minor.
- For communications, radar and positioning, the impact is assessed as **moderate adverse** whilst awaiting results from on-going investigations.
- For Search and Rescue (SAR), the impact is assessed as **moderate adverse** whilst awaiting further discussions on the implications of being able to lock the turbines remotely in a “Y” position.

Overall, the main conclusion from the risk assessment is that the impact of the wind farm on shipping and navigation would be minor, taking account of the proposed mitigation measures and recommendations of the navigation risk assessment. However, further information is being sought on the means of locking the blades in a “Y” position to assist in SAR response and the impact of the wind farm on radar. Both these are currently under consideration on an industry-wide basis.

The above findings are based on the “worst case” layout of 108 turbines with 5m diameter foundations, and on the fact that the navigational impact of other layouts being considered would, therefore, be less.

Mitigation measures during construction and operation
1. The design will ensure that the minimum rotor blade clearance for the turbines is 22m above Mean High Water Springs (MHWS), which meets the MCA requirements and RYA recommendations. 2. Marine navigational marking will be provided in accordance with Trinity House requirements, which will comply with the IALA standards and the additional requirements of MGN 275(M). 3. Working areas will be established and marked in accordance with the IALA Maritime Buoyage System (MBS) and additional temporary marking will be applied where advised by Trinity House. 4. Notices to Mariners, Radio Navigational Warnings-NAVTEX and/or broadcast warnings as well as Notices to Airmen will be promulgated in advance of and during construction (/ decommissioning) of any individual structure/farm. 5. Scira will enforce 500m temporary avoidance areas around all working vessels and notified to mariners during these phases of the development in addition to permanent 500m safety zones around all offshore wind farm structures. These temporary avoidance areas and permanent safety zones will apply to all vessel types not involved in the wind farm operations. 6. Scira is committed to satisfying any reasonable requests made by Trinity House on Marine Navigational Marking requirements which have the objective of improving maritime safety.

Monitoring
1. Shipping will be monitoring to gather information on activity and behaviour in and around the wind farm. In addition periodic traffic surveys will be carried out to ensure the base assumptions made within the assessment of navigational impact are appropriate. This will provide further input into the navigational safety impact reviews that will be undertaken over the life of this development to ensure all risks are appropriately managed.

28.4.10 Marine archaeology

The known and potential archaeological resource within the vicinity of the Marine Study Area (surrounding the wind farm and both marine cable routes) comprises:

- 15 known and recorded wrecks;
- 21 recorded vessel losses for which there are no known seabed remains;
- Possible unknown and undocumented wrecks from various periods dating back to the Iron Age or earlier;
- Possible stray finds of ship-borne debris from various periods;
- Two magnetometer anomalies corresponding with known wrecks;
- Two magnetometer anomalies corresponding with known obstructions;
- The potential for the presence of drowned land surfaces (and associated sites) from the Lower Palaeolithic to the Iron Age (500,000 BP – 43 AD);
- Potential Lower Palaeolithic to Modern material within the inter-tidal zone, including World War II archaeology.

The assessment has identified possible significant adverse effects on archaeological sites and materials, but makes a number of recommendations regarding mitigation and monitoring, including measures to further clarify the potential for as yet unknown sites and provision for dealing with archaeological material discovered in the course of construction, such that the residual effect of the scheme will be **negligible**.

Mitigation measures during construction
For the maritime Elements: 1. Placing Construction Exclusion Areas around the wreck sites and significant geophysical anomalies. 2. The agreement with the regulator of the scope of any further archaeological assessment of future geophysical and/or geotechnical surveys. 3. Implementation of a Written Scheme of Investigation (WSI) and Finds Reporting Protocol for the construction phase of the scheme. For the inter-tidal area: 4. Archaeological assessment of any vibrocore surveys to be undertaken as part of geo-technical investigations within the inter-tidal zone; the extent of the assessment being agreed with the regulator. 5. A watching brief on any excavations to be undertaken in respect of the part of the cable landfall within the inter-tidal zone

Based of the results of the above work further mitigation may be necessary.

Mitigation measures during operation
1. In the event that replacement of cables is required, these are expected to follow the routes initially laid. If new route are selected mitigation measures would be as for construction.

28.4.11 Military and aviation

The Ministry of Defence (MoD) objected to the location of the Scira proposed offshore wind farm (March 2004), because it lies within line of sight of and 74km from Air Defence Radar head at Trimingham. A study undertaken by QinetiQ investigated the adverse radar effects and discussions were initiated with MoD on the results of this study. However, the MoD has since decided to follow a more collective mitigation strategy to the problems in discussion with other wind farm developers within The Wash, since many of them would cause the same issues. A DTI funded study is due to report in Spring 2006 on both hardware and software options aimed at mitigating the wind farm effects on the air defence radar based at Trimingham.

Consultation with the relevant authorities and the helicopter operator in the area, and studies investigating the potential for radar interference, have shown that there are no significant conflicts between the project and civil airspace or radar.

Mitigation measures during operation
1. The MoD has concerns about the impact of presence of wind farms in the region on its radar systems, and is implementing a feasibility study of options. Scira has agreed to follow one of the mitigation options, and awaits the outcome of the study as well as the discussions taking place between the DTI, MoD, CAA and BWEA.

28.4.12 Other human activities

The Sheringham Shoal site is not currently licensed for oil and gas exploration and production, and it is considered extremely unlikely that any oil and gas reserves will be identified within the study area in the future. There are currently no licensed aggregate extraction or marine disposal activities ongoing within the study area. The proposed export cable routes do not cross any telecommunications cables. There are currently no military practice and exercise areas in the vicinity of the offshore works.

A desk top risk assessment of the unexploded ordnance (UXO) threat concluded that, as a result of historic war time activities, unexploded ordnance may be present in the Sheringham Shoal area. This includes mines, aircraft delivered bombs and anti-aircraft munitions.

A non–intrusive survey will be undertaken by a specialist contractor as necessary to identify any potential unexploded ordnance and to target investigations. Follow up clearance would be carried out as necessary. In addition, all construction personnel will be given specific safety instructions and ordnance safety and awareness briefings.

Impacts on other human activities are predicted to range from **no impact** to **negligible**.

Mitigation measures during construction
1. Prior to construction a comprehensive threat assessment will be undertaken and risk mitigation measures taken with regard to all underground hazards on site. A non–intrusive marine survey would be undertaken to identify any metallic objects which could be UXO. Follow up target investigations and clearance based on the results would be carried out, where necessary, by a specialist contractor.
2. All construction personnel will be given Site Specific Safety Instructions to cover UXO, Ordnance Safety and Awareness Briefings and Site UXO Regulations/Aide Memoire.

28.4.13 Socio-economic activities

The regions of the East of England and the Yorkshire and Humber have been considered in this socio-economic assessment in terms of direct and indirect socio-economic effects. The local area of north Norfolk has been considered for the local impact on tourism and recreation and commercial fisheries.

It is anticipated that the proposed Sheringham Shoal wind farm would have positive socio-economic effects in both the development and construction stage and the operational stage. Employment generated by the wind farm construction phase has been estimated on the basis of the supply chain and job creation study undertaken for Scroby Sands offshore wind farm development (Douglas-Westwood and ODE, 2005). It is estimated that the development and construction stage would generate over 500 direct man-years of work in the UK, of which more than 200 direct man-years in the local area. In addition, the Sheringham Shoal project would generate another 100 indirect man-years of work for the region. The local area is defined as the area covering the East of England and/or the Yorkshire and Humber Region.

On top of this direct effect there would be positive 'indirect or supplier' effects and 'induced effects'. Based on a regional multiplier of 1.5 (English Partnerships, 2004) the Sheringham Shoal project would bring over the period of the development and construction stage approximately another 100 man-years of work to the region.

It is estimated that over the lifespan of the project (40 years) the operational and maintenance stage would generate approximately 1400 man years of work. This is equivalent to approximately 35 full time jobs (FTE) sustained over 40 years. In addition to that another 700 indirect man-man years (18 FTE) would be generated, again mainly within the region.

In conclusion, the effect of job creation on the local economy is anticipated to be of **minor** to **moderate beneficial** significance. As certain parts of the East of England and Yorkshire and Humber region contain highly deprived areas, it is felt that job creation in these particular areas would be of **moderate beneficial** significance.

Impact on tourism and recreational activities would be associated with disruption during construction. However, given the limited and temporary nature of the activities, the distance of the wind farm offshore and the construction of the onshore cable route outside the main tourist season, the impact on tourism and recreational activities is anticipated to be of **negligible** significance.

An assessment of the effects of the construction phase on commercial fisheries has been undertaken and it concluded that a **minor adverse** to **negligible** effect may be anticipated in terms of potential commercial loss and economic impact.

During the operational stage of the wind farm the impacts on tourism and recreational activities would be associated with the visibility of wind turbines and perception of them. Recent surveys including Greenpeace (2004) and a MORI (2002, Sustainable Development Commission, 2005) have demonstrated that onshore and offshore wind farms have no detrimental effects on tourism. Therefore, no significant negative effect on tourism and recreational activities is anticipated and no significant reduction in local tourism revenues is expected.

On the contrary, beneficial effects may arise as the wind farm could become a local attraction. Although it is not possible to quantify such effect, it is anticipated that the project would have a **minor beneficial** impact on local tourism.

It is anticipated that a limited number of vessels would be affected by the Sheringham Shoal wind farm during operation, therefore the impact on shipping and its economic value is considered to be of **minor adverse to negligible** significance.

The impact of the Sheringham Shoal wind farm on local commercial fisheries has been estimated to be of **negligible** significance during operation.

The Sheringham Shoal wind farm, as well the other Round One and Two wind farms, have stimulated the initial development of a renewable energy sector in the UK and thus employment in the renewable sector. Such cumulative effect is considered **beneficial** at national level. However, key long-term benefits for the UK are dependent on its capacity to attract manufacturers to the country and to develop a UK based supply chain for the sector.

Given the number of proposed/planned wind farms within the Wash strategic area, it is possible that the need for O&M operations would stimulate local companies to develop dedicated services for the offshore wind sector. Such cumulative effect would be beneficial to the local economy.

Mitigation measures during construction
1. All marine traffic including fishing vessels would be excluded from the construction areas within the wind farm site. To ensure the personnel carrying out construction activities and those navigating in this sea area are not exposed to unnecessary risk, 500m safety zones will be established around all offshore structures and temporary avoidance areas around working vessels during this phase of the development

28.5 Potential Impacts associated with the landfall and onshore cable infrastructure

28.5.1 Geology, water resources and land quality

There are a number of interest features in the area, including three Sites of Special Scientific Interest (SSSI) designated for geological interest. The immediate area of the works is devoid of water features, however further afield, typical water features include reed-beds and drainage ditches. The construction activities of the onshore works would not directly impact on any of these features due to the distance separation between the works and the interest features. Implementation of good construction practices and pollution prevention guidance would also minimise impacts on the surrounding area.

Historically, during World War II the site was used as a military barracks and anti-aircraft firing range. It now plays host to the UK's only working military museum and houses, the Muckleburgh Collection. There is therefore a risk of areas of historic contamination on the site. Site investigations will be undertaken and the results provided to NNDC Environmental Protection Officer. Any contaminated areas identified would be dealt with according to standard practices in consultation with the North Norfolk District Council (NNDC) Environmental Protection Officer.

Mitigation measures during construction

1. Good construction practice and implementation of relevant codes of practice and guidance for demolition and construction sites would be observed during the installation of the onshore works in order to minimise impacts on the land quality and water resources of the surrounding area.
2. Good construction methods would also be adopted with regard to storage and disposal of any soil arising from the installation.
3. The results of the ground contamination survey (currently underway) will be discussed with the NNDC EPO once available in order to agree upon a suitable level of mitigation. Areas of identified contamination will be dealt with in accordance with the statutory guidelines and legislation.
4. Any accidental spillage of fuel or chemicals that occur will be cleaned up immediately and the Environmental Agency informed, if the incident is deemed to be significant by the Contractor

Mitigation measures during operation

1. Pollution prevention measures will be adopted to prevent spillage/leakage of oils and chemicals which might impact the immediate area.

28.5.2 Terrestrial ecology

A detailed programme of ecological surveys were undertaken in order to ascertain the presence or absence of habitats or species of ecological significance. The surveys highlighted that the predominant habitat to be disturbed during the construction of the onshore works comprises semi-improved grassland of low ecological significance. Mitigation works would be incorporated in order to minimise any disturbance to this habitat and re-instate it following completion of the works. The installation of the landfall across the shingle beach could potentially impact upon areas of vegetated shingle, including small patches of the nationally scarce yellow-horned poppy. This area would be resurveyed prior to construction and areas of the habitat trans-located if required under the supervision of an ecological watching brief.

Mitigation measures in the form of habitat management would also be incorporated to ensure that no harm to any breeding birds occurs during the construction phase. The ecological surveys also highlighted the presence of suitable reptile habitat, therefore further surveys will be undertaken in order to inform an appropriate level of mitigation, if required. No other protected faunal species, such as great crested newts, water voles, badgers or bats would be harmed or disturbed during the construction of the onshore works. Overall, impacts on terrestrial ecology are anticipated to be of short tem **minor adverse** significance.

No impact during operation is envisaged to ecological interests. In addition, no impact to the ecological interests of any nature conservation sites is envisaged during any stage of the works.

Mitigation measures during construction
1. Prior to construction, the footprint across the shingle bank will be re-surveyed by an ecologist. If any areas of vegetated shingle, including areas of yellow-horned poppy are within the area of the construction footprint, these areas will be trans-located and monitored to ensure their successful re-establishment.
2. Mitigation measures will be implemented to ensure that the impact to the grassland habitat is minimised. These will include minimising the cable trenching working corridor; careful separation and storage of top-soil and sub-soil during the cable trenching process; full reinstatement of disturbed grassland to its former condition following cable installation, including re-seeding with a diverse mix of native species of local provenance.
3. The majority of the onshore construction phase is envisaged to take place during winter months when the museum is closed and outside of the bird breeding season (March to August). If works are required during the breeding season mitigation measures will be incorporated in order to prevent any loss or damage to nesting birds and their nests.
4. The construction footprint within the grassland and shingle beach habitat will be checked by an experienced ornithologist for nests of the ringed plover immediately prior to construction. Should a nest be discovered, work in this area will delayed until the chicks have hatched.
5. Further surveys to determine the presence/absence and population size of reptiles within the area are scheduled to be undertaken during Spring/early Summer 2006. If reptiles are recorded during the surveys, an appropriate mitigation strategy will be discussed and agreed with English Nature and submitted to North Norfolk District Council as supplementary information. The mitigation strategy would be designed to ensure that reptiles are not harmed and that disturbance is minimised. Following the construction phase all areas of disturbed habitat within the connection pit and cable zone would be reinstated to their former condition.

28.5.3 Landscape and visual character

The construction phase activities including construction plant and human presence would result in some disruption and visual impact to receptors including users of the Norfolk Coast Path, Weybourne car park and nearby residences. The construction period is anticipated to be approximately four months duration and as far as possible undertaken outside the summer period. Given good construction practice and care to ensure a tidy, well contained site, landscape and visual impacts are anticipated to be of short-term and **minor adverse** significance.

The nature of the onshore development, being fairly isolated and largely underground, would mean that the long-term landscape and visual effects would be related to the new switch room building only. The proposed switch room would be screened, to some extent, by the existing coniferous plantation and the museum, but it would still represent a new element in the landscape experienced by receptors to the east and south. Mitigation measures would be incorporated in order to minimise the impact, which would involve extending the existing woodland and lowering the height of the switch room by placing the building within an excavated area. The residual impact to receptors would be of **minor adverse** significance and limited to an isolated area of residential receptors at Priory Wood and along Beach Lane. Elsewhere impacts would be of **negligible** significance.

The potential impact to landscape designations identified within the study area, such as the Norfolk Coast AONB, North Norfolk Heritage Coast, Area of High Landscape Value, Conservation Areas and Public Rights of Way are considered to be **negligible** due to the limited extent of works and the proposed mitigation which has been discussed and agreed with NNDC.

Mitigation measures during construction
1. If required, the construction compound will be enclosed within fencing to screen low level views from surrounding areas, or will be located away from any sensitive visual receptors (such as houses, the Norfolk Coast Path, and visitors to the Museum). 2. Lighting of compounds and works sites will be restricted to agreed working hours and that which is necessary for safety and security. 3. Roads providing access to land based site compounds and works areas will be regularly cleaned, as required.

Mitigation measures during operation
The following outline mitigation strategy has been agreed in principle with North Norfolk District Council (NNDC) in order to minimise the visual impact. 1. The switch room would be set in an excavated area in order to reduce the final height by approximately 1-2m, providing that access could still be maintained to the building. 2. The existing slope would be re-structured in order to provide a slight embankment screening to the east and south of the switch room. 3. The existing woodland would be extended to the east and south of the building, using a combination of Scot's pine and Austrian pine. Clearance between the trees would need to be maintained for the underground cabling in order to protect the integrity of the cables from damage by tree roots. 4. The final landscape design would be discussed and agreed with the NNDC Countryside and Parks Manager, following consent and prior to construction works taking place.

28.5.4 Archaeology and cultural heritage

An archaeological desk-based assessment was undertaken which included an area of approximately 500m radius from the proposed onshore works. The desk-based assessment identified a number of predominantly post-medieval and World War II sites and buildings within the study area, with areas of Roman pottery and coins being recorded in the vicinity of the landfall point. There is also a potential for currently unidentified archaeological sites and finds to exist, with evidence from within the wider study area of Iron Age activity and Saxon settlement.

As advised by the County Archaeologist, a watching brief will take place during the excavation works for the onshore cable and associated infrastructure. If finds or features are found the most suitable course of action would be agreed with the relevant authorities.

Mitigation measures during construction
1. The County Archaeologist has advised that the construction be subject to an archaeological watching brief during the excavation of the trench. In the event of finds or features being revealed, sufficient time and flexibility will be provided within the work programme to enable the appropriate level of recording to be undertaken. The County Archaeologist will also be informed directly and agreement be reached as to the most appropriate course of action.

28.5.5 Tourism and recreation

The main visitor attractions within the immediate vicinity of the onshore works, include the Norfolk Coast Path and the Muckleburgh Collection with the beach being well used and easily accessible with car parking facilities.

Some disruption to the Norfolk Coast Path and beach would be experienced over the duration of the landfall works. A temporary diversion of the path along a relatively small section would be put in place. This would be discussed and agreed with the Area Highway Officer and the National Trail Manager. The duration of the works at the landfall are anticipated to be in the order of 5-6 days for each of the two cables and therefore only short term disruption is anticipated to the National Trail and an application made for closure or diversion as necessary. Much of the onshore cable laying works is located on private land and would not lead to access disruption. Notices would be posted to provide information on the works, programme and a point of contact for relevant recreational groups and associations. The total onshore construction works are anticipated to last approximately 16 weeks.

During operation, it is anticipated that the presence of the wind farm would not deter tourists and visitors from the area and some visitors may be attracted to the coast in order to view the wind farm, although it is acknowledged that much of this coastline is popular due to its quiet and relatively remote nature.

Overall, the impacts on recreational activities and tourism are anticipated to be of temporary nature and limited spatial extent and are therefore considered to be of minor adverse significance.

Mitigation measures during construction
1. Construction works will be undertaken outside of the main tourist season (May to August), wherever feasible; 2. Construction works, information and dates will be published on site and in local papers in advance of projected start; 3. The working area on the beach will be delineated by fencing, or other method to ensure the safety of walkers and beach users, and alternative access will be provided and signs will be posted; 4. Close liaison with the Area Highway Officer and National Trail Manager will be maintained to agree alternative access arrangements.

28.5.6 Traffic and access

The area potentially affected is predominantly rural, with mainly Class A and B roads serving the main towns and villages, with tracks adjacent to the proposed onshore works. Access to the site would be via the A149 and the existing access used for the Muckleburgh Collection.

Disruption to the local traffic network is anticipated to be minimal during the installation of the onshore works and during delivery of plant and materials. This would consist of approximately 100 - 120 Heavy Goods Vehicles over a period of 16 weeks. All works would be undertaken in accordance with requirements of the Norfolk County Council, Highways Development Control. This would include further discussion following consent and prior to construction to agree other traffic requirements with regard to notification of movements for abnormal loads. Prior to construction, a traffic management plan would also be agreed with Norfolk County Council.

A short term **minor adverse impact** on the local road network and access is envisaged.

Once the site is mobilised, traffic would be restricted to light vehicles for maintenance staff only, therefore **no impact** on the local road network is anticipated.

Mitigation measures during construction
1. The potential impact of increased traffic numbers will be minimised through incorporation of good practice measures. These would include the timing of construction traffic movements to avoid peak traffic periods where deemed necessary, and installation of appropriate signage to inform the public of the likely presence of construction vehicles.
2. A traffic management plan will be agreed with Norfolk County Council's Highways Development Control prior to construction commencing.
3. The route for construction traffic and the notification requirements for abnormal loads movements will be agreed with Norfolk County Council, Highways Development Control.

28.5.7 Noise dust and air quality

Noise during the installation of the onshore cable route could arise from the operation of both fixed and mobile plant and machinery involved in the excavation of the cable trench or from the movements of delivery vehicles to and from the site. There are a number of noise sensitive receptors in proximity to the works including residential properties and users of the beach and Norfolk Coast Path. Exposure to elevated noise levels at these locations is anticipated to be of short duration while excavation works are adjacent to the receptor. The adverse noise levels would decrease significantly with distance between construction works and the receptors.

Short-term localised **minor adverse impacts** are anticipated from on-site plant and equipment during the construction works and **no impact** is anticipated as the result of the movements of delivery vehicles or the arrival and departure of site operative vehicles at the beginning and end of the day. Suitable control of construction activities and regular dialogue and liaison with both the local authority and local residents will ensure that the potential for nuisance to be caused by these activities will be minimised.

The lack of significant sources of vibration associated with the construction activities and the separation distance to residential properties indicates that no construction related vibration will be discernible at the nearby sensitive receptors and are unlikely to be a cause for complaint from local residents. The low levels of additional heavy goods vehicles and delivery vehicles visiting the site, compared to existing traffic levels, are not expected to give rise to any vibration nuisance.

Direct emissions to air during construction would be from vehicle exhausts and dust from excavation works and stockpiles of material. Mitigation measures will be implemented as part of good construction practice to ensure all emissions to air are minimised. A negligible impact on dust and air quality as part of the onshore works is anticipated.

During operation, the only source of noise would be from the switch room. The building would be designed so as to ensure adequate attenuation of noise generated by equipment inside. No impacts are anticipated.

Mitigation measures during construction

1. The anticipated temporary diversion of the public coastal footpath away from the immediate working areas will reduce the noise impacts for footpath users. Any adverse impacts would diminish once the works have crossed, and moved away from, the footpath.
2. Noise levels and working hours will be agreed with North Norfolk District Council in addition to the following mitigation measures:
    - Residents of potentially affected properties within 200m of the construction works would be informed in writing in advance of the proposed works commencing. This information would include a timetable of works, a schedule of working hours, the extent of works, and a contact name, address and telephone number in case of complaint or problem;
    - An information board would be displayed at the site to provide a contact name and telephone number, to which the public can channel their queries. Any complaints or concerns would be attended to as soon as possible;
    - The principles of Best Practicable Means (BPM) as defined in BS 5228: Part 1 and COPA will be applied to all site operations and activities;
    - All plant and machinery would meet the relevant British Standards i.e. all equipment would be maintained in good working order and be fitted with the appropriate silencers, mufflers or acoustic covers;
    - The movement of vehicles to and from the site would be controlled and vehicle engines would not be revved unnecessarily near residential property or allowed to idle whilst not in use;
    - Equipment would not be left running between work periods;
    - All personnel involved in the construction works would be made aware of the need to keep noise to a minimum through appropriate instruction or training;
    - Potentially noisy activities would be kept as far away as possible from noise sensitive locations and frequent stoppages would be included in such works;
    - Directional noise sources will be oriented where possible with the emission source directed away from noise sensitive receptors;
    - If appropriate, site cabins and other static structures will be placed closest to noise sensitive receptors to provide a degree of noise screening from the site;
    - Materials would be lowered rather than dropped;
    - Liaison with the Environmental Health Officer would be undertaken to determine acceptable noise limits or to agree periods when unavoidable noisy works might required outside normal working hours. Except in emergencies, any such activities during unsociable hours will additionally be communicated to potentially affected residents before hand and will include an explanation of the reasons for the works, their expected duration and details of a suitable site contact in the event of query or complaint;

Mitigation measures during construction
• Warning signs will be posted at the beginning of the coastal path (or other suitable location) to allow users of the path to avoid the noisy works should they wish.
3. The above measures will be implemented together with timely and meaningful dialogue with local residents, and the restriction of construction activities to normal weekday periods, when local residents will be more tolerant of noise disturbance, will minimise the potential nuisance from the construction works.
4. Where excavation works are undertaken in dry weather, water spraying will be carried out, if necessary, on bare disturbed areas in order to minimise the potential generation of airborne dust. If appropriate, wheel washing of vehicles will take place prior to accessing the public highway.

Mitigation measures during operation
1. Once the final equipment details of the switch room are known, the building will be designed such that any necessary noise attenuation will ensure that noise levels are within the limits to be agreed with the Environmental Protection Officer at North Norfolk District Council.

28.6 Conclusion

Overall given the successful implementation of the stated mitigation measures as commited to by Scira, as well as further dialogue with interested parties and Regulators, it is predicted that the Sheringham Shoal wind farm project would have no long term unacceptable impacts. The project would however make a significant contribution to both regional and national renewable energy targets and reduce CO_2 emissions.